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**An archaeological investigation of raised field agriculture in the
Lake Titicaca Basin of Peru**

Erickson, Clark Lowden, Ph.D.

University of Illinois at Urbana-Champaign, 1988

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AN ARCHAEOLOGICAL INVESTIGATION OF RAISED FIELD AGRICULTURE
IN THE LAKE TITICACA BASIN OF PERU

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Anthropology
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AN ARCHAEOLOGICAL INVESTIGATION OF RAISED FIELD AGRICULTURE
IN THE LAKE TITICACA BASIN OF PERU

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University of Illinois at Urbana-Champaign, 1988
Donald W. Lathrap, Thesis Director

ABSTRACT

The remains of raised fields found throughout various regions of the Americas are a remarkable tribute to the farming and engineering skills of the prehispanic inhabitants of these areas. Raised field agriculture enabled dense populations to exist under environmental conditions that are today considered to be marginal for agricultural production.

This dissertation focuses on the evolutionary history and ecology of raised field agriculture in the Lake Titicaca Basin of Peru. Raised field origins, their relationship to population, and the social organization and labor necessary for their construction and maintenance are addressed. Specific issues regarding 1) the process of intensification of agriculture and agricultural change and 2) the relationship between social organization and intensive agricultural systems are investigated.

The results of archaeological survey, excavation and experimentation conducted between 1981 and 1986 indicate that 1) raised field agriculture appears relatively early; 2) raised field agriculture, although intensive in terms of cropping frequency and high production rates, is not necessarily labor intensive; 3) long-term sustained yields relative to low total

labor input make this a very efficient agricultural system; and 4) the construction and management of raised fields are well within the means of individual farming families and locally organized social groups, and do not necessarily require the mechanisms of a centralized bureaucracy to ensure their use and functioning.

Thermoluminescence dates from ceramics within raised fields provided critical data of construction and use periods of the agricultural system. Two phases were defined by the excavations. Phase I began sometime before 1000 B.C. and lasted until A.D. 400, and was associated with the early farming cultures in the basin and the later Fukara culture. Phase II began ca. A.D. 1000 and lasted until ca. A.D. 1450, and was associated with the Late Intermediate Aymara Kingdoms of the zone.

It is argued that raised field agriculture developed early as a outgrowth of a wetland-oriented economy similar to that practiced by the ethnic group referred to in the colonial and ethnographic literature as "Uru." This economy provided a stable and rich base for early sedentary occupation of the lake shallows and a preadaptation for early raised field farming.

This is dedicated with gratitude to
Kay L. Candler

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Dan Brinkmeier dedicated himself to the project, much of the time spending his own funds. His openness and humor made him very popular in the community. Because of his excellent artistic skills and energy, combined with his special expertise in

agricultural communications, we were able to produce materials for project public relations and teaching raised field agriculture. Above all, he is a good friend.

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I take full responsibility for the contents of this dissertation.

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CHAPTER 1

INTRODUCTION

1.1 THEORETICAL ISSUES AND THE ORGANIZATION OF THIS THESIS

Raised field agriculture is one of the most sophisticated and complex forms of pre-Columbian agricultural technology discovered in the Americas (Figure 1). It is a remarkable tribute to the farming and engineering skills of the indigenous inhabitants of the New World, enabling dense populations to exist under harsh environmental conditions for agriculture. It provided the subsistence base for several important prehistoric states which developed in the Central Andes, the highland basins of Ecuador and Colombia, highland Mexico, and the Maya region; also for lesser-known highly organized societies in the lowland tropical forest regions of the Americas.

Those who have studied raised fields and other forms of traditional intensive agriculture have generally focused on describing and classifying these features in terms of their morphology, distribution, state of preservation, and environmental context. Few studies have been successful in determining the evolutionary history of these systems and the mechanisms behind their origins, growth and abandonment.

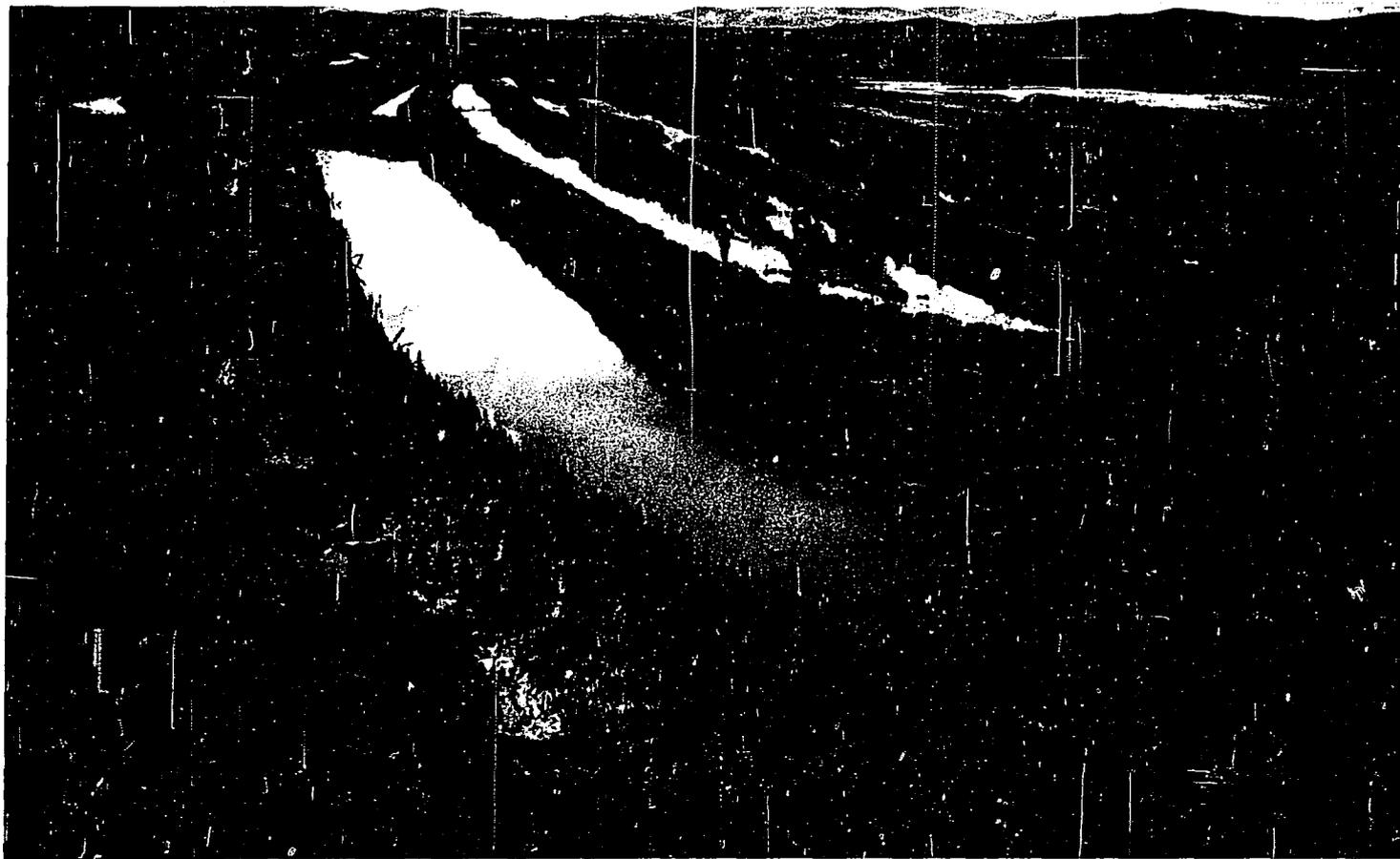


Figure 1: Reconstructed raised fields at the Illpa Agricultural Experimental Station planted in potatoes, ocas, ollucus, isañus, tarwi, quinua, cañihua, peas, broad beans, barley, winter and spring wheat, and onions.

Two ideas have had much influence in the interpretations of prehistoric intensive agricultural systems and are generally accepted as explanations for the origin and evolution of these systems. The first is the thesis presented by Ester Boserup in The Conditions of Agricultural Growth (1965) which argues that all agricultural change, in this case intensification, is a result of population pressure forcing the adoption of more productive systems, which require a higher labor input and function less efficiently in terms of labor input/out. The other thesis is that advanced by Karl Wittfogel in Oriental Despotism (1957) in which centralized bureaucracies are seen to develop as a result of intensive agricultural systems because of the inherent need created by these systems. Although most now agree that intensive agricultural systems did not cause centralized bureaucracies, there still is an acceptance of the idea that intensive agricultural systems are, of necessity, associated with centralized authority. Modified versions of these traditional ideas have been commonly applied to interpret prehistoric raised field and other forms of past intensive agriculture.

This thesis addresses the issue of raised field origins, their relationship to population, and the social organization necessary for their construction and maintenance. My argument is as follows: 1) that intensive raised field agriculture appears relatively early because it is a natural outgrowth of sedentary hunting and gathering economies associated with rich wetland environments; 2) that raised field agriculture, although

intensive in terms of cropping frequency and high production rates, is not necessarily labor intensive as presented in the literature, and therefore would be expected to appear early; and 3) that the construction and management of raised field agriculture is well within the means of individual farming families and local social groups, and does not necessarily require centralized bureaucratic mechanisms or state administration to ensure its use and functioning.

The thesis relies on data obtained from archaeological survey, excavation, and experimentation in the pampa (Quechua: flat area or plain, in this case lake and river plain) of Huatta, Department of Puno, a Quechua-speaking region located in the Lake Titicaca Basin of southern Peru, to evaluate these hypotheses. Background information on raised field agriculture in the Lake Titicaca Basin is presented in Chapter 1. This discussion of raised fields includes the archaeological remains, classification of forms, and the previously-proposed chronologies for the evolution of raised field agriculture. The difficult agricultural environment of Huatta, in addition to present-day use of the landscape by indigenous Quechua and Aymara inhabitants of the Lake Titicaca Basin, is discussed in Chapter 2. It is argued that these factors were the same as those faced by raised field farmers of the past.

In Chapter 3, excavations of stratigraphic profiles in raised fields are described and interpreted. The physical stratigraphy and soils are analyzed and the cultural and natural

formation processes are presented. The chronology of raised field agriculture is discussed in terms of stratigraphy and dating by thermoluminescence and comparative ceramic analysis. A chronological framework of a two-phase sequence of raised field use, with two periods of hiatus, is presented.

Details of the results of raised field experiments are presented in Chapter 4. The social organization of labor for construction and maintenance is analyzed. Using figures for labor costs involved in raised field construction and maintenance, labor efficiency of this form of agriculture is evaluated. Production data is used to determine potential prehistoric carrying capacity within the area of raised field remains in the Lake Titicaca Basin. Based on the labor and production data, the total overall efficiency of raised field agriculture is addressed, along with the issue of labor intensity.

In Chapter 5, various theoretical perspectives on the intensification of agricultural systems are presented. Boserup argues for a unilineal model of agricultural change that is based on changing levels of cropping intensity due to changes in population pressures. Extensive agricultural (long fallow) systems are viewed as having low labor inputs, low overall productivity, and a relatively high efficiency and are associated with low population densities. Intensive agricultural (short or no fallow) systems are viewed as having high labor and capital inputs, higher overall productivity, but with a loss of

efficiency and are associated with high population densities. The ideas of Boserup and her supporters are discussed in detail in relation to the archaeological data on the chronology of raised field agriculture in the Americas. An alternative multilineal model based on ecological, ethnographic, and experimental data is offered to explain raised field agricultural intensification.

The social organization of intensive agriculture is discussed in Chapter 6. Wittfogel's ideas on the development of irrigation agriculture have had considerable impact on archaeology and many have adopted his ideas on centralization of agriculture, if not his complete hypothesis. Wittfogel has argued that despotic states arise through necessity because of the very nature of irrigation systems, that these systems require a certain amount of bureaucratic or administrative management, leading to political centralization. Many archaeologists and geographers have rejected many of the implications of Wittfogel's hypothesis, but many still accept his ideas on the need for centralization of intensive agricultural systems. Andean forms of agricultural organization of labor from ethnographic and ethnohistoric cases are discussed as analogous forms of labor organization that may have been employed in prehistoric raised field agriculture. Finally, physical evidence (site spatial distribution and canal systems) is presented to document what we can determine about the prehistoric social organization of raised field agriculture. The analysis indicates that sophisticated

agricultural systems do not necessarily have to be highly centralized or state controlled.

In Chapter 7, a short culture history of the evolution of agriculture and complex social organization in the Lake Titicaca region is presented as background to the chronology of raised field use in the Lake Titicaca Basin. The archival, ethnohistoric, and ethnographic data on the Uru, Chipaya, and Fukina are also discussed and the archaeological evidence of these cultural groups is evaluated. A model for the origin of raised field agriculture in the Lake Titicaca Basin is proposed, using the wetland-oriented economy of the Uru, Chipaya, and Fukina as an analogy to early raised field agriculturalists.

The conclusion of this dissertation is presented in Chapter 8. The theoretical issues revolving around the intensification of prehistoric agriculture is evaluated in light of the evidence from Huatta. In addition, the more general implications of this dissertation in terms of methodology and theoretical issues are discussed.

1.2 RAISED FIELD AGRICULTURE: AN INTRODUCTION

1.2.1 Background

The scientific study of raised field agriculture is relatively new. Several factors have contributed to the recent archaeological interest in of what are today considered "marginal" environments for agriculture. Technological

innovations, primarily the ready availability of high-resolution aerial photographic coverage of the tropical wetland areas of the Americas, provided large new data bases. A recent trend in New World archaeology placed more emphasis on the economic support and organization of past cultures, such as agriculture and settlement patterns. This redirection of research, especially in the tropical forest areas of Mesoamerica and South America, led to questions such as: "how were urban and ceremonial centers supported?", "what did people eat?", and "why do we find so many sites in swamps?". Possibly the most significant factor was a change in archaeological preconceptions; a decade ago, archaeologists did not believe that there was anything worthy of study in the "marginal" swamps and marshes, the (literally and figuratively) "backwaters" of complex society.

Raised field agricultural studies began with the investigation by William Denevan in 1961-1962 (Denevan 1966) in the Llanos de Mojos of eastern Bolivia. Denevan first noticed raised fields while studying the cultural geography of the flooded savannas in the Beni Region. His interest aroused, he then began a search for new raised field sites, and encouraged many other scholars to do the same. Investigations of raised fields generated further research on both past and present traditional agricultural systems, including terracing, sunken fields, irrigation, etc. (see Denevan 1980a, 1980b, 1982). In addition, these studies have spawned research on analogous agricultural systems that are still functioning in various parts

of the world. Although relatively new, controlled experimentation to determine how the system operated, potential crop production, carrying capacity, labor investments, etc. is beginning to have an impact on the field (Puleston 1977a; Gomez-Pompa et al. 1982; Muse and Quintero 1987; Erickson 1985). One of the most promising aspects of these investigations is that some of these prehistoric agricultural systems are now being considered as viable alternative to western technologies for development (de la Torre and Burga 1986; Denevan 1985; Erickson 1985, 1986; Garaycochea 1986a). Now there is a legion of archaeologists, cultural anthropologists, and cultural geographers who spend hours poring over aerial photographs of "their area" in search of traces of ancient intensive agriculture, to publish yet another article reporting on a "new" case of sophisticated prehistoric land management.

1.2.2 Definitions

A raised field has been defined as "any prepared land involving the transfer and elevation of earth in order to improve cultivating conditions" (Denevan and Turner 1974:24). The concept of raised field is very broad, and includes features with diverse morphologies, environmental conditions, and functions; there have been several attempts to classify the hundreds of types of raised fields (ibid., Denevan 1970, 1980b, 1982; Parsons and Bowen 1966, Parsons and Denevan 1967). Much of the debate regarding

the proper name for these agricultural features relates to their specific functions in particular environments, and an attempt to define them without including reference to the environmental context is difficult.

The terms "drained" and "drainage" commonly appear in discussions of this form of agriculture. However, use of the term "drained" implies that drainage was the primary purpose for which the fields were constructed. I believe that terminology such as "reclamation," and "drainage," commonly reserved for lands considered to be "marginal," reflects our western biases against wetlands. To a Mayan living in the wetlands of Pulltrouser Swamp at 1000 B.C., the annual rise and fall of the rivers resulted in the flooding of backwaters and swamps, which provided excellent fishing and hunting, fresh annual deposition of alluvial deposits on the floodplains, high humidity, and a year-round growing season. These phenomena were considered blessings, and supported a relatively comfortable life based on raised field agriculture.

Canals do provide a place for drainage of excess water but, more importantly, they also conserve water, capture, produce and recycle nutrients, provide an attractive habitat for wildlife, create a rich zone for hunting and gathering, and provide more favorable crop microclimates. I prefer using the term "canal" over "ditch." Others have used the term "swale" (Smith et al. 1968) to describe these features, but this could be confused with the geomorphological term for natural riverine topography.

In this thesis, I use the terms raised fields, raised field system, or raised field agriculture to encompass both canal and raised field surface or raised field platform in this dissertation.

The raised fields of the Lake Titicaca region are also referred to as waru waru (Quechua) and camellones (Spanish).

1.2.3 Distribution of Raised Fields in the Lake Titicaca Basin

The best study of the distribution of the raised fields of the Lake Titicaca Basin is that of Smith et al. (1968:353-356), based on aerial photographs (of 1:65,000 scale [1955] and 1:15,000 [1955] for part of the south-west lake shore) combined with limited ground survey (Figure 2). They estimate a total of 82,056 hectares, of which 45-50% or 32,822 to 41,028 hectares is cultivable platform surface. This area of raised fields is much larger than any other reported raised field complex in the world. Of these 82,056 ha of raised fields, some 56,533 ha, over 68%, lie within the zone of the pampa of Huatta (Figures 2 and 3). The cerro (Spanish: hill) of Huatta is located slightly south-east of the center of this block.

Nearly all of the raised fields are located on the flat, poorly drained, lacustrine and alluvial plains surrounding the lake (Figure 4). The largest of these are the pampas of Huatta-Juliaca, Taraco, Ilave, the Lago Umayo-Rio Illpa, Rio Cabanillas, Huancane, Asillo, and Pomata in Peru; and the pampas of the Rio Desaguadero and Koani (Aygachi) in Bolivia

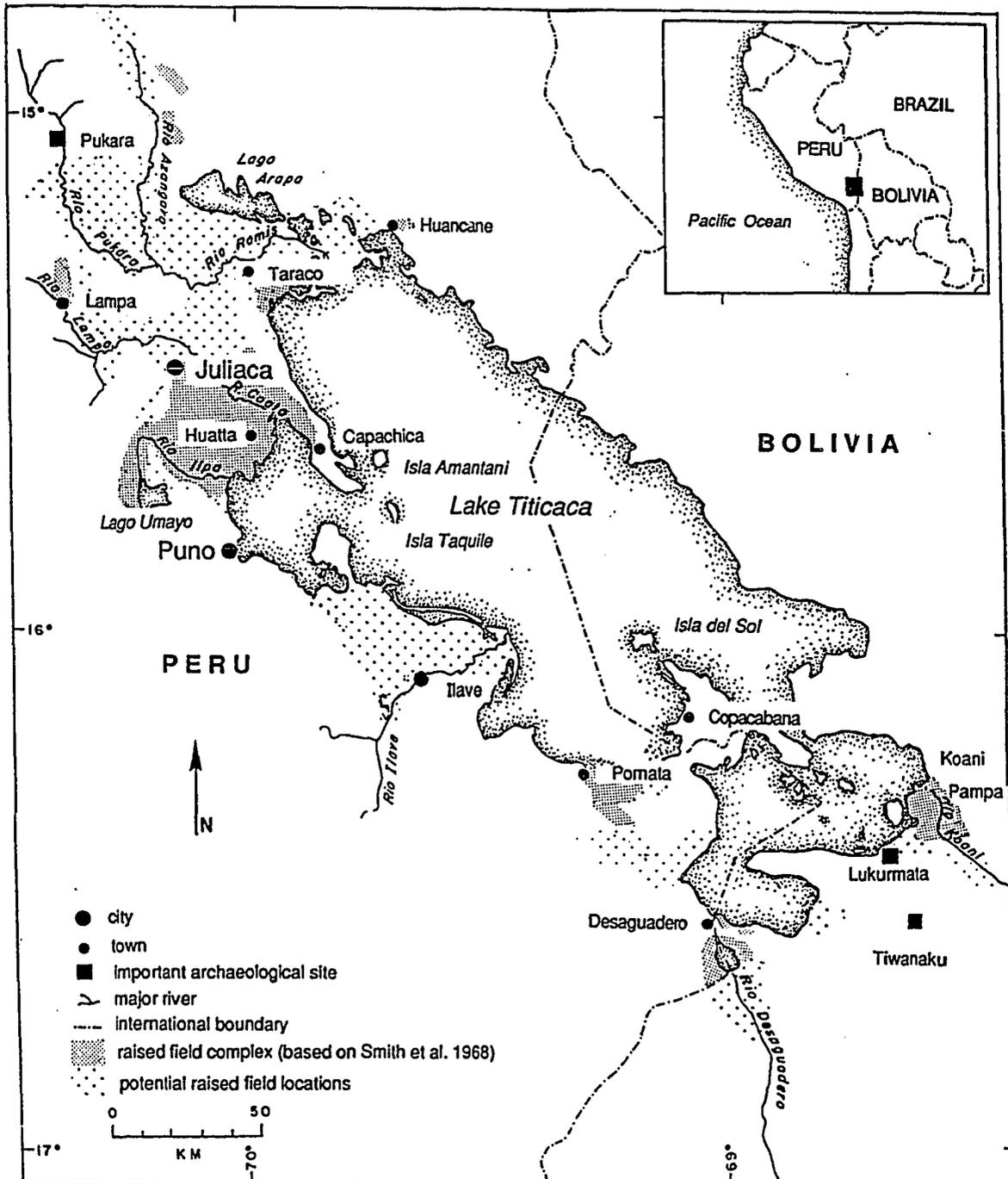


Figure 2: Map of the Lake Titicaca Basin showing important locations, distribution of prehistoric raised fields and potential raised field locations (partially based on Smith et al. 1968).

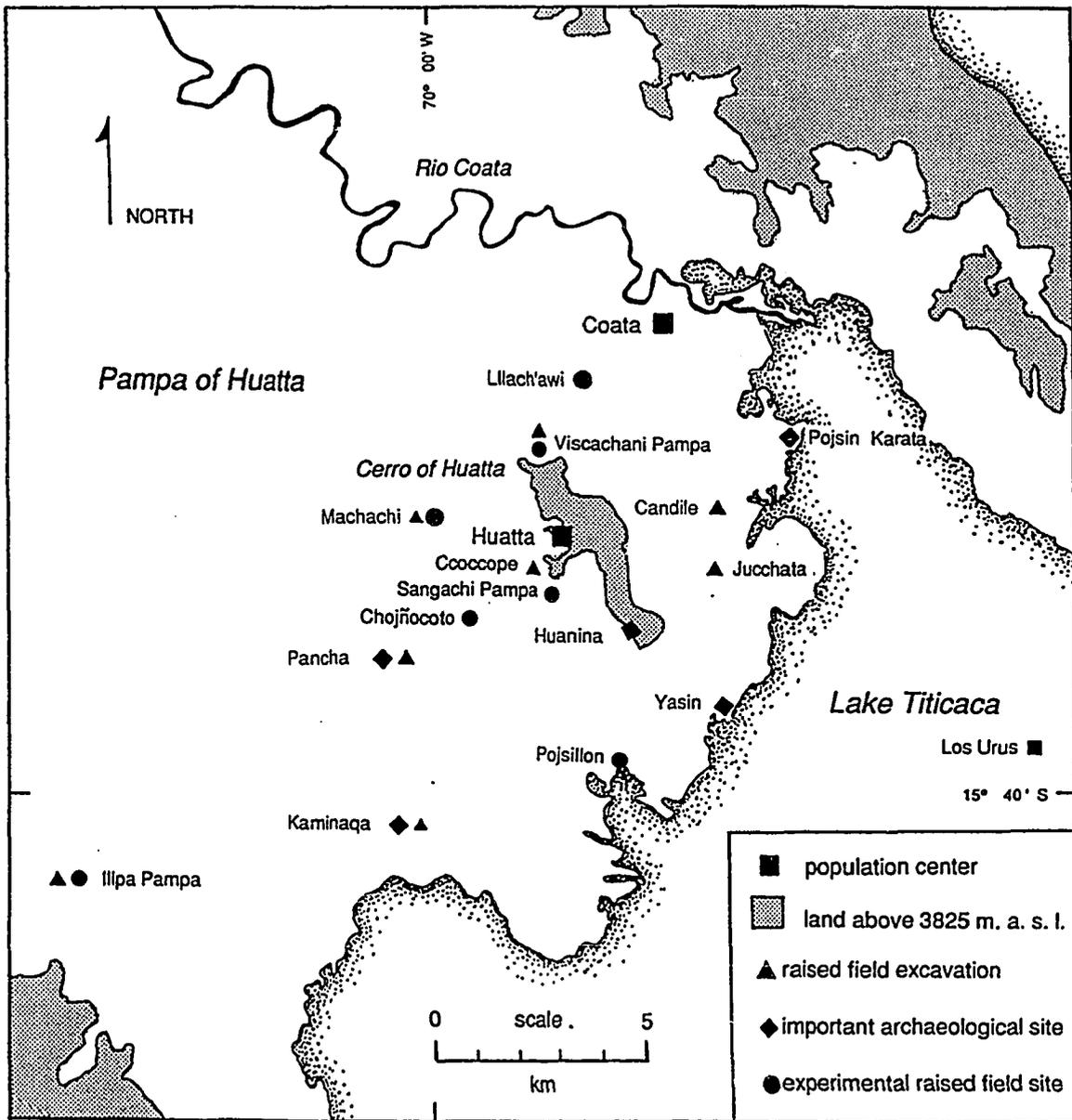


Figure 3: Map showing locations of important places in the Huatta area mentioned in the text.

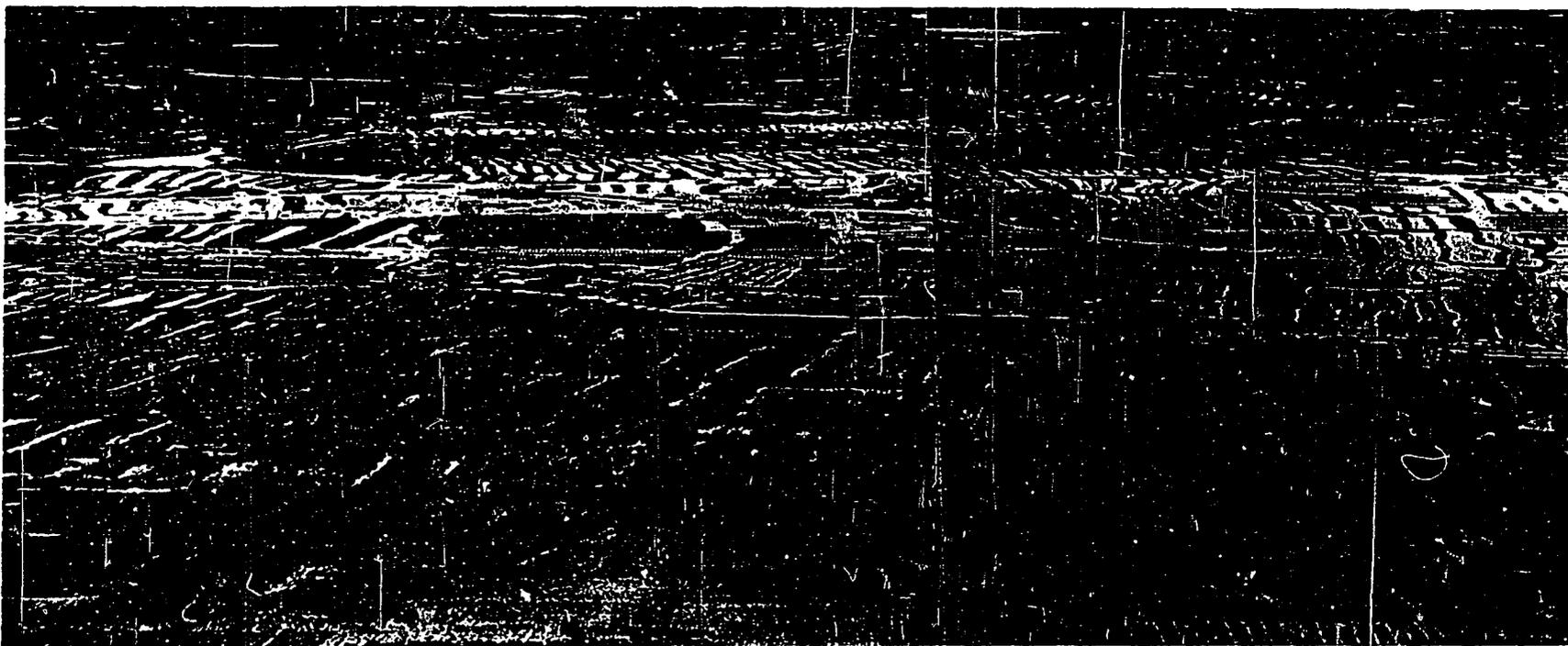


Figure 4: Raised fields of Viscachani Pampa, north of the cerro of Huatta (March, 1986). Canals between raised fields are filled with water. The darker fields in the center are reconstructed experimental raised fields.

(Table 1). Smith et al. note that there are many areas with isolated raised fields, organized in small concentrations outside of these large pampas (ibid. 355). They note that over 92% of the raised fields are within 30 kilometers of the lake, 98% are located below 3850 meters above sea level (m.a.s.l.); their lower limit, Lake Titicaca, is located at 3803 m.a.s.l.. Some raised field remains were found at 3890 m.a.s.l. north-east of Ayaviri near Lago Orurillo (ibid.).

Smith et al. note that this is only a rough estimate, on the conservative side, because of the difficulty of identifying raised fields on the large-scale maps, and because fields have been effaced by post-abandonment cultivation and erosion (ibid. 353, also see Garaycochea 1983). Ground survey of many areas around the lake, analysis of more recent aerial photographic coverage with improved scale, and excavation of trenches in raised fields indicate that this figure is very conservative. Using the more recent 1:17,000 aerial photographs (SAN 1970) of the pampa of Taraco, raised fields can be seen in many areas not reported by Smith et al. Much of the pampa of Ilave has canal networks that may have been associated with raised fields that are now destroyed. Brief visits and field surveys have located small and medium sized blocks of raised fields in Cabanillas and the Rio Cabanillas Valley, Acora (Ignacio Garaycochea pers. com), near the city of Huancane, between Nicasio and Juliaca, between Pomata and Desaguadero in Peru, and near Iwawe on the Taraco Peninsula in Bolivia. I believe that many of these

Table 1: Estimates of the area of prehistoric raised field remains in the Lake Titicaca
 *
 area.

location	hectares	acres	miles ²
Peru: northern area			
main block: Juliaca-Paucarcolla	56,533	139,637	222.4
scattered: Cabanillas-Lampa-Ayabacas-Taraco	3,276	8,091	12.4
scattered: Laguna Orurillo-Huancane	4,494	11,100	18.1
Peru: southern area			
Desaguadero	6,501	16,057	25.1
Pomata	5,108	12,617	19.7
scattered	2,192	5,141	8.5
Peru: totals	78,104	192,916	306.2
Bolivia:			
Aygachi-Koani Pampa area	3,014	7,535	11.8
other areas	938	2,345	3.7
Peru and Bolivia: totals	82,056	202,796	321.7

*
 after Smith et al. 1968:355, Table 1.

isolated blocks of raised fields represent larger blocks of fields that have not been preserved. Large areas along the floodplains of the Rio Ramis, Rio Azangaro, Rio Pukara, Rio Lampa, Rio Cabanillas, and Rio Coata show no evidence of raised fields on the aerial photographs, although these areas would be perfect locations for raised field agriculture. These rivers have medium to large discharges and carry substantial sediment loads, which could easily bury raised fields under meters of alluvial sediments or erase them as channels migrated across the floodplains. Preserved raised fields are found adjacent to the present day channels of the smaller rivers, such as the Rio Illpa and Rio Koani, indicating that the state of preservation probably depends on how active the river is.

Smith et al. relied heavily on aerial photographs from 1955, a year when lake levels were high (1968:363). Traces of thousands of hectares of raised fields can be clearly seen in the aerial photographs of the Bay of Puno lakeshore near Huatta, taken in 1970 and 1978 when lake levels were very low. This area is covered by Lake Titicaca most years, but during periodic droughts, it is available for cultivation. Since most of the Bay of Puno, some 540 km² (Gilson 1964:114), is less than 5 meters deep, much of this area has high potential for prehistoric raised fields. I argue in Chapter 7, that this would have been the prime agricultural land for prehistoric farmers using raised field agriculture.

In addition to problems of calculations of the horizontal

surface area of raised fields, excavation data presented in Chapter 3 demonstrate that there is superposition of raised fields within most raised field blocks. This further complicates estimations of total area of raised fields in the Lake Titicaca Basin.

I also have located on aerial photographs raised fields at relatively high altitudes (ca. 3900 meters) outside of alluvial and lacustrine landscapes. In small upland basins between rolling hills in the Hatuncolla-Llunco-Sillustani area, the traces of small blocks of raised fields can be seen. These small depressions in the uplands probably have much the same conditions as the pampa during the wet season, when water accumulates. Since present cultivation is most intense in the uplands, most of the evidence of these raised fields have probably been long destroyed.

1.2.4 Classification of Raised Fields

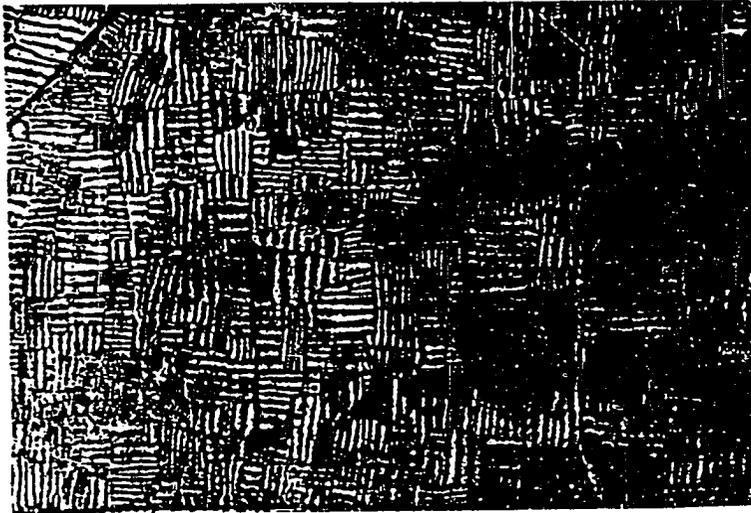
The raised fields of the Lake Titicaca Basin are extremely variable in size and morphology (Smith et al. 1968; Lennon 1982, 1983; Kolata 1986; Erickson 1986). The eroded raised field platforms have convex or flat surfaces, and the canals most commonly have concave or "V" shaped bases. The difference in height between raised field platform and canal base in the Huatta area depends primarily on the state of preservation. In badly-eroded or sediment-covered areas, field-canal boundaries can sometimes only be detected by slight vegetational differences

caused by the differing humidity and soil characteristics of the canals and platforms. In other areas, such as north of the mouth of the Rio Illpa, the fields are very well preserved and maintain up to 2 meters difference between canal and platform. In most of the Huatta pampa, the raised fields are only approximately 20 cm tall.

Smith et al. (1968:359-361, Figure 3) have classified the Lake Titicaca raised fields into six major morphological patterns, "open checkerboard," "irregular embanked," "riverine," "linear," "ladder," and "combed fields." The following is a summary of the typology of raised fields developed by Smith et al. for the Titicaca Basin, with comments on this typology in relation to the raised fields of the Huatta and Illpa pampas (Figures 5 and 6).

1.2.4.1 Open Checkerboard Pattern

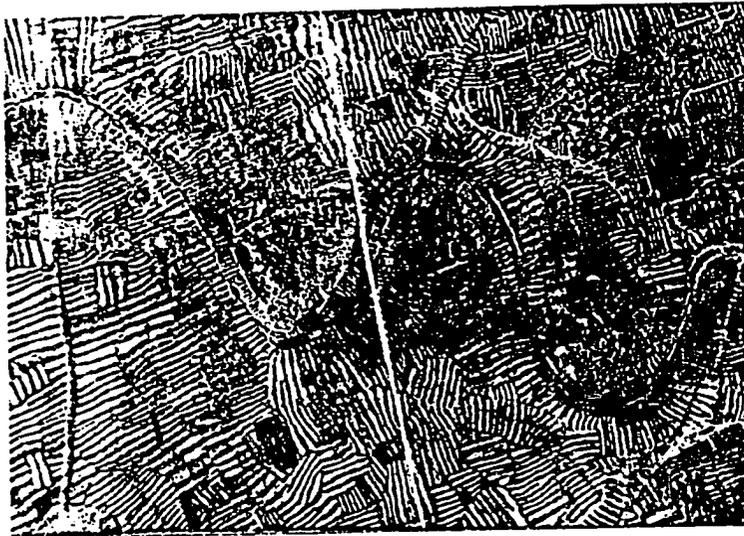
The most common field type in the Lake Titicaca Basin, especially in the large blocks of fields near Huatta, the Rio Desaguadero and Requena, is the open checkerboard form. The term "open checkerboard" was first used to describe fields in Colombia (Parsons and Bowen 1966:329). These are groups or unbounded "bundles" of 5-20 raised field platforms oriented perpendicular to each other (Smith et al. 1968:357). The canals are open and water flows freely between blocks. The fields and canals range from 2-200 meters in width and from 2-40 meters in length (ibid). They note that the dimensions can be drastically



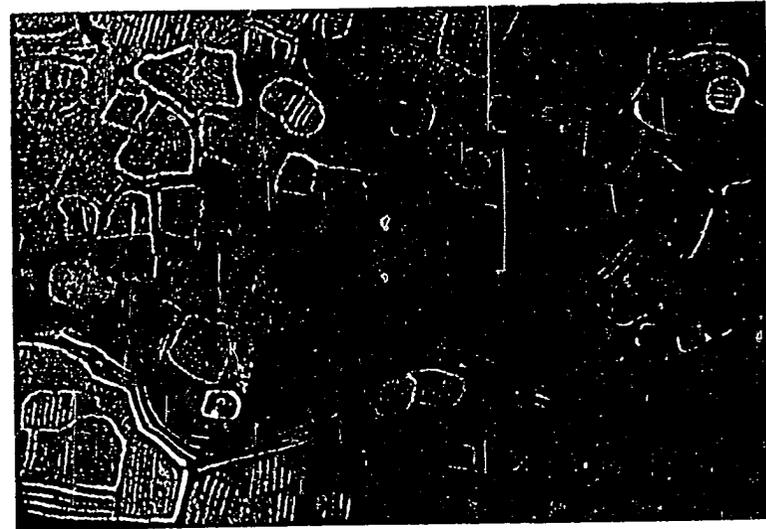
A. open checkerboard (Candile)



B. irregular embanked (Huanina)

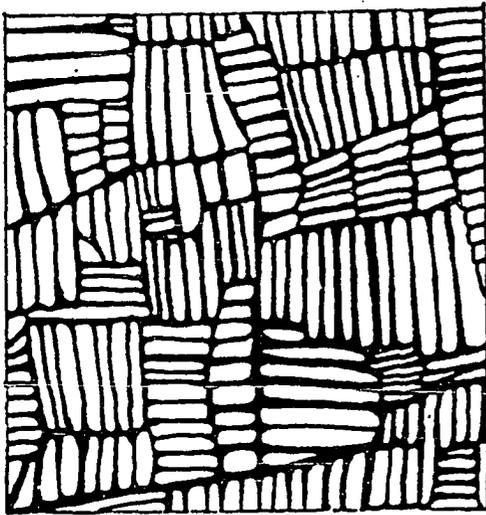


C. caño or riverine (Coata)

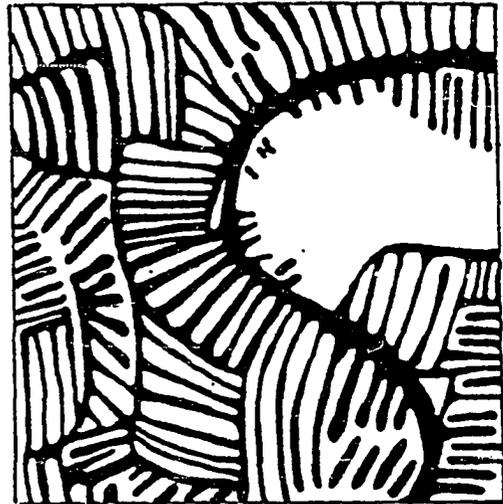


D. irregular embanked (Kaminaqa)

Figure 5: Examples of patterns of prehistoric raised fields in the Huatta area on aerial photographs:



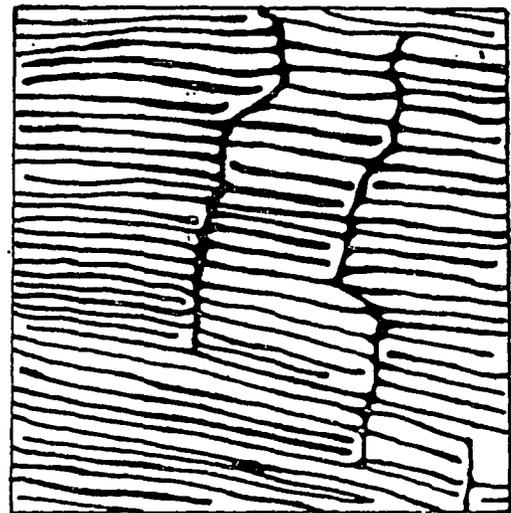
A. Open checkerboard
(Candile SAN 176-70-1005)



B. Riverine (Coata SAN 176-70-1007)



C. Irregular embanked
(Huanina SAN 176-70-1003)



D. Linear (Capachica SAN 176-70-945)

0 100
meters
approximate scale

Figure 6: Patterns of prehistoric raised fields in the Huatta area based on sections of aerial photographs.

different in adjacent field blocks. According to Smith et al., these fields are most commonly located "on the poorly drained or seasonally flooded land at the margin of the existing lakes and in plains well away from the foothills" (ibid.).

The open checkerboard form is the predominant pattern in the Huatta pampa. The canals and raised fields within the open checkerboard blocks are unbounded, as defined above, but it should be noted that most of the canals have no apparent outlet. At the ends of many canals, there is a segment of unmodified pampa (ie. no fields or canal) that functions as a form of spillway; that is, after canals have filled to the optimum levels, the excess water can enter adjacent blocks. This excess can be from direct rainfall, local runoff, river flooding, or lake flooding. These fields are always oriented north-south or east-west, probably for microclimate manipulation (Erickson 1988).

1.2.4.2 Irregular Embanked Pattern

A less common form is that of the irregular embanked pattern restricted to Pomata, Huatta, and between Vilque and Atuncolla (Smith et al. 1968:357). The characteristic trait of this form is the enclosing (partially) circular, oval, or irregular embankment or dike surrounding the bundle of fields. These are generally found in poorly drained areas where the open checkerboard pattern is not found, except in rare sites such as Requena (Smith et al. 1968).

Lennon (1982:69-70) argues that embankment structures for reducing the effects of flooding, such as artificial levees and the irregular embanked raised fields, are the best evidence of man's complex hydraulic organization of the pampa. Through analysis of aerial photographs, Lennon (1982:179) found this form most common in the lake area sample, with few embankment structures in the river area.

In the Huatta area, irregular embanked fields are most common along the waterlogged lake edge margin, a strip approximately 1 km wide from Paucarcolla to Coata. Another block of irregular embanked raised fields are found within Warijon Pampa and Quinientos Hectareas, south of the cerro of Huatta. These forms are also found scattered within the blocks of open checkerboard, as noted by Smith et al. (1968). Many of the embanked fields of Huatta are also "regular," essentially an open checkerboard form of field with an enclosing embankment. Many of the open checkerboard fields of Huatta also are semi-bounded (as noted by Lennon) and could be considered "embanked." There appears to be a broad continuum between open checkerboard and irregular embanked raised field types.

Smith et al. (1968) suggest that this form of raised field is associated with a form of low-level water management without canal systems. These forms may have aided in protecting the fields against encroachment of annual lake inundation (ibid). Lennon believes that they may have been microcatchment basins for runoff and rainfall, protection against flooding and wave action

and flowing water (following Smith et al.), and boundaries for individual landholdings (Lennon 1982:180, 189). Lennon is probably correct in suggesting that these are microcatchment basins; I would add, following Smith et al., not only for the storage of runoff or rainwater, but also to prevent the encroachment of salty lake water into the raised fields (see Erickson 1988). They may also have been important for raising fish (see Chapter 7). And, as Lennon suggests, it is likely that they define individual landholdings or family units.

1.2.4.3 Riverine Pattern

The riverine or caño pattern (Parsons and Bowen 1966:329) is found on natural levees, perpendicular to present and abandoned channels of rivers on the pampa (Smith et al. 1968:359). Smith et al. suggest that this form of raised field functioned to drain water on these low topographical features.

In the Huatta pampa, the riverine pattern is associated with the naturally elevated levees of every abandoned or seasonal river and stream channels. This is the only form of raised field that is not always oriented to a cardinal direction. Most of these raised fields are very short, extending only as far as the edge of the levee. Although these fields do "drain" the levee raised fields, it should be noted that many of the canals have no outlet, or have low obstructions at the lower end. These obstructions maintain a certain level of water in the canals, which may actually be slightly higher than the adjacent natural low spots. This is clearly the case along the old channel of the

Rio Kaminaqa in Machachi Pampa.

Along active river channels, the Rio Coata and Rio Illpa, these fields are poorly preserved, and most have been covered completely by river sediments.

1.2.4.4 Linear Pattern

Another rare form of raised fields are the narrow, long (up to 400-500 meters) parallel fields and canals known as the "linear pattern" (Smith et al. 1968:359). These commonly begin at the base of hillslopes and extend into the pampa near Capachica, Desaguadero, and Hacienda Machacmarca near Lago Umayo. Smith et al. indicate a similarity in patterning between these fields on the pampa and the bounded series of terraces that define a single plot on the hillside. Fields of this type in Pomata have a mean width of 8.7 meters (Smith et al. 1968).

Linear patterns are not common in the Huatta pampa. Some of these fields are located at the base of the talus slope of the cerro of Huatta, oriented perpendicular to the pampa-slope juncture. These are very short (20-30 meters), nothing like the very long fields in the pampa of Capachica. They appear to drain the lowlying lands at the base of a slopes where water accumulates. The orientation away from the hill provides the most efficient removal of this excess water. These areas also generally have good soils, primarily topsoil eroded from the slopes above them. Many of these fields, especially those portions abutting the hillslope, are probably buried under

several meters of colluvium and alluvium. The linear fields in Huatta do not appear to have a relationship to the present day landholdings on the hillside.

1.2.4.5 Ladder Pattern

The ladder pattern is characterized by a series of short parallel raised field platforms that form "rungs" between two long platforms and/or canals. These field platforms are much wider than those of other forms: generally 15-25 meters (with maximum of 35 m); and the lengths of fields (widths of the "ladders") range from 30-70 meters (56 meters mean) (Smith et al. 1968). These platforms often have a very squat rectangular, almost square shape. They are only common in the Pomata area.

Smith et al. (ibid.) suggest that this pattern also mirrors the arrangement of terraced fields on the hillslopes, suggesting that they may be contemporaneous.

The ladder pattern is not found in the pampa of Huatta. Some of the more organized forms of the isolated irregular embanked raised fields have a similar shape to those of Pomata, but do not occur in large blocks with similar orientation and size. At times, narrow blocks of open checkerboard with short fields, similar to the ladder pattern, have been built between blocks of larger fields.

1.2.4.6 Combed Pattern

These fields are narrow, "roughly parallel and curvilinear ridges" organized into bundles of 5-35 platforms that are 20-150

meters in length. This form is characteristic of the pampa of Aygachi or Koani Pampa (ibid).

Combed fields, although not common, do occur in the Huatta Pampa. These fields are found along the seasonally flooded abandoned river channels. The most common are 2-4 long platforms and deep canals which follow the winding courses of the river channels. They appear to be attempts to improve or manipulate these seasonal channels, possibly as a form of dike or artificial levee, although most have breaks every few hundred meters which would have allowed water to flow freely. Some of these raised fields impede the flow of water from the canals of "riverine pattern" fields. It should be noted that, although permanent, raised fields could easily have been modified (cut or filled in) as necessary for hydrologic control. Sometimes curvilinear fields are found within a block of the irregular embanked pattern. Lennon (1982:196) reports the presence of embanked curvilinear fields, which appear to be associated with prehistoric occupation mounds at the mouth of the Rio Illpa.

The curvilinear or combed field patterns discussed above may be a form of channel improvement and/or diversion measures suggested by Lennon (1982:71, 216). Lennon also suggests that this form may have facilitated fish drives (ibid. 196).

1.2.4.7 Description of the Major Canals

Lennon (1982; 1983) discusses some of the forms of major canals in his interpretation of aerial photographs of the Lake

Titicaca raised fields. He considers channel improvement through the widening, deepening and straightening of abandoned or seasonal natural channels (ibid. 71, 191-194, 210); diversion channels which disperse flood water away from the main river channels (ibid. 71, 210-212); feeder canals for distributing water throughout the raised fields blocks (ibid. 172, 195, 213); and small field canals between raised field platforms. Lennon assigns specific hydraulic functions to all canals within the raised fields system.

I classify the canals of Huatta into two groups, called "small" and "major." Small canals include the canals between raised fields (Lennon's "field canals") and canals surrounding and connecting raised field blocks (Lennon's "feeder canals"). At a higher hierarchical level are what I refer to as "major" canals. These canals cross large blocks of raised fields, and many are several kilometers in length. The systems of major canals can be divided into two types: 1) modified natural water courses (usually abandoned river channels and seasonal streams) (Lennon's "channel improvement" and "diversion" canals), and 2) straight man-made canals. The first type is found throughout the pampa, especially near the lake edge. They are commonly sinuous or zig-zag because of the original form of the abandoned water course. Modifications include deepening, diking with raised fields parallel to the course of the channel, and the construction of spillways or dams on subsidiary canals. In places, they have been straightened. The second type of canal is

very different. These lie along very straight lines, usually radiating in several directions from a central point in the pampa or on the hillside.

During our investigations in Huatta, we did not excavate trenches through the major canals. One small test unit in a major canal in Viscachani Pampa was excavated to 70 cm below surface to see if the bottom of the sediments could be reached, but this was unsuccessful. Other major canals were cored down to 80 cm below surface without reaching the base of the sediments.

Unlike the canals in the Llanos de Mojos (Denevan 1966; Plafker 1963, Erickson 1980) where excavated soil was used to construct parallel causeways, the major canals of Huatta lack causeways. Rather, soil from canal excavation was apparently integrated into raised field blocks on either side of the canal. In places there are short segments of "dikes" created from the canal soils. They probably did not serve as true dikes because they are broken in many places and would not have held water. These structures probably functioned as small raised fields. Causeways have been reported at Hacienda Machacmarca near Lago Umayo (Smith et al. 1968; 1981) and from Koani Pampa (Kolata 1986), but these structures do not appear to have been common in the Lake Titicaca Basin. They may have been used as walkways or for the control of water levels within raised field blocks, as is suggested for the Llanos de Mojos (Erickson 1980:736-738) and the chinampas of the Valley of Mexico (Gibson 1964; Coe 1964, Armillas 1971).

The most obvious use of the major canals would have been for drainage of large areas (Lennon 1983). The abandoned river channels, although nearly choked with sediments, can still carry a considerable amount of water, and if re-excavated, would drain a large area. The straightening of the natural channels may have been an attempt to move water more rapidly through the system to the lake. This was discussed by Farrington (1983) for the major channelization projects of the Inca in the Urubamba Valley of Cuzco. Kolata (1982, 1986) reports that the Rio Koani of Koani Pampa was channelized to provide a larger and better-drained area of reclaimed pampa lands. The Koani channelization, several kilometers long, represents a major water control effort. Most channelization projects in the Lake Titicaca Basin were much more modest, usually modifications of abandoned river channels.

Associated with the major canals are smaller canals between raised fields, usually perpendicular to the major ones. These canals rarely empty directly into the larger canals; almost always there is a low dam or spillway between them or no outlet at all. This suggests that the goal was to conserve as much water as possible, and drain only the excess (discussed in Chapter 4).

The system of large canals may also have been used to bring water into raised field blocks. Temporary openings in the spillways could easily have been cut or filled as necessary. Although no detailed topographic map has been completed for Viscachani Pampa, water flowed long distances across the pampa

and collected in the reconstructed raised field area during the massive flooding of 1985-1986. A sod causeway for pedestrian travel was constructed across one of the large canals; this, acting as a dam, obstructed the flow of water. The water level on the side away from the main field block was 30 cm higher than on the other, indicating a strong canal gradient towards the main raised field block.

Other non-drainage related functions can also be suggested for the major canal systems. Transportation within the pampa is certainly a problem during the rainy season, and the canals would have provided an excellent means of communication by balsa (totora reed boat). While the raised fields were in use, the deep canals would have provided an efficient means of moving harvest production from field site to storage facilities. Prehistoric canals in the community of Yasin (part of the Huanina system) are still used today by the inhabitants of the pampa for moving their balsa and wooden fishing boats from the lake to houses far into the pampa. These canals stretch into the shallows of the lake and are referred to as "caminos de los abuelos" ("roads of the grandfathers") by Huattekño families, who regularly use boats to fish, hunt, and harvest totora and llachu. Without these canals through the vegetation-choked shallows, the boats would get tangled up and/or run aground in low water.

As discussed in Chapter 7, these canals also provide a means for fish to move in and out of the pampa from the shallows of the lake. This potential for pisciculture could have

augmented the value of raised fields, as they could also be used to produce fish.

Other possible explanations for these canals related to prehistoric social organization are discussed in Chapter 6.

1.2.4.8 Discussion

I have suggested that the different forms of raised fields could be related to chronology (e.g. less organized forms predate the more organized forms, and narrow fields predate wide fields), different functions (e.g. irregular embanked were constructed to drain wet areas, and open checkerboard to conserve water in the drier pampa), and/or ethnicity (Erickson 1985; 1986). I believe that all three factors probably have some importance in explaining the variety of raised field forms in the Lake Titicaca Basin. I will demonstrate in Chapter 3 that the process of continual construction and maintenance is responsible for much of the size variation. Internal differences and general lack of uniformity within many large areas of raised fields may reflect an individual farmer's or small cooperative work group's concept of what makes a "proper" raised field. Functional differences in field forms can be inferred from the fact that certain forms are associated with specific soil and hydrological conditions (Erickson 1988). Ethnic differences will be more difficult to document, since we have not yet defined prehistoric ethnic boundaries, but the various inventories of forms in the Pampa Koani, Pomata, and Huatta raised fields may reflect prehistoric cultural differences.

1.2.5 Previous Attempts to Date Raised Fields

The earliest published comment on the age of the raised field systems of the Lake Titicaca Basin is by Soria Lens (1953-4:90). He argues that because of the sophistication of the system, and because "similar" drainage systems are found at the site of Tiwanaku, the fields must be related to Tiwanaku culture.

Smith et al. (1968) conclude that the raised fields of the Lake Titicaca Basin are prehispanic because: 1) there are no references to them by the early chroniclers, 2) the areas with the best-preserved raised fields have been used as pasture since at least the early 19th century, and most likely earlier, 3) the fields could not have been constructed with the Spanish-introduced plow, but rather the indigenous chakitaqlla, 4) the fields are poorly preserved and often buried under river alluvium, and 5) the raised fields are very labor intensive, and thus would have been constructed under population pressure, and, conversely would have been abandoned during the depopulation after the Spanish Conquest (1968:363-364). They argue that, because of the variety of forms, the raised fields could have been constructed by various prehispanic cultures.

Associating raised fields with the "Colla" chullpas of Machacamarca near Lago Umayo, Smith et al. infer that these raised fields must date to the Pre-Inca Colla and/or Lupaca cultures of the Late Intermediate Period (ibid. 365). Although they believe the bulk of the fields were constructed by the Collas and Lupacas, and used during the Inca period, they suggest

that some raised fields may be even older, citing the "geographical proximity" of the fields in Koani and Desaguadero to the sites of Tiwanaku and Chiripa. The patterns of terraces on hillslopes are similar to those of the raised fields, and they suggest that both agricultural features may have been constructed by the same cultures.

Kolata (1982,1983, 1986, 1987, Kolata and Graffam 1987) has documented that the Koani Pampa raised fields are probably related to Tiwanaku. His conclusions are based on the association of raised fields to occupation mounds on the pampa and excavations within raised fields at the site of Lukurmata. On the surface of the occupation mounds, only Tiwanaku IV and V ceramics (A.D. 400-A.D. 1000) are found. In the archaeological excavation of several occupation mounds, Kolata found mixed construction fill containing Tiwanaku IV and V with some post-Tiwanaku burials (1986a:753). Further evidence is provided in the form of occupation mounds, dated with Tiwanaku IV and V ceramics, that are structurally merged into raised field blocks. Ceramics associated with Chiripa culture (ca. 1250 B.C. to A.D. 100), although recovered from a disturbed context, hint at the possibility that the construction of raised fields could have begun as early as 1000 B.C.. Inca and Late Intermediate Period ceramics and chullpas are found on the surrounding uplands, and in small quantities on the surfaces of the pampa occupation mounds, but Kolata argues the raised fields are not associated with these periods. Kolata's arguments regarding the level of

organization of the raised fields are discussed in Chapter 6. Recent excavations in raised fields at Lukurmata demonstrate a very complex superposition and rebuilding of fields. Most likely, these date to Tiwanaku IV and Tiwanaku V periods based on the in situ association of ceramics (Kolata and Graffam 1987).

I suggest that, based on evidence excavated in Huatta, there were at least two major periods of intensive raised field construction and use. The first, Phase I, began approximately 1000 B.C. and lasted until A.D. 300. After a period of less intensive use, raised fields again became important around A.D. 1000 until A.D. 1450. My interpretations of the dating and evolution of raised field systems are presented in Chapter 3 and Chapter 7.

CHAPTER 2

THE AGRICULTURAL ENVIRONMENT OF THE LAKE TITICACA BASIN

2.1 GENERAL BACKGROUND

2.1.1 The Altiplano

The altiplano is a lacustrine and alluvial plain with scattered outcrops of Devonian, Permian, Jurassic, Cretaceous, and Tertiary rocks (Newell 1949:18-19). The puna above the flat altiplano is a peneplain erosion surface above approximately 4000 meters above sea level (m.a.s.l.) dating to the Pliocene. Within the plain is the "Titicaca Trough," a synclinal structure with thick Tertiary sandstone red beds in which Lake Titicaca lies. The altiplano at 3500-4500 m.a.s.l. extends some 800 km by 50-160 km from northwest Argentina to north of Lake Titicaca, between the Cordillera Oriental, with high peaks reaching 5000 to 6000 meters above sea level, and the discontinuous volcanic Cordillera Occidental (Carter 1971:7; Hill 1959:789).

Rainfall is variable throughout the altiplano, ranging from 1800 mm/year in the north to 300 mm/year in the south. Temperatures are warmer in the north and cooler in the south. Various environmental zonation schemes have been presented for this region; most are based on differences in temperature and rainfall, and the vegetation associated with them (Bòlsi 1968:58; Tosi 1960; Cardenas 1968:5-6; Wennergren and Whitaker 1975:84-5). One classification divides the altiplano into two major

vegetation zones according to moisture availability (the moist puna, and the dry puna) trending NW to SE parallel to the Andes mountain chain (Cabrera 1968; Winterhalder and Thomas 1978:39). The moist puna zone, located in the central part of the altiplano (including the Lake Titicaca Basin) includes 1) low mats of herbaceous vegetation, cushion plants such as yareta (Azorlla) and rosette formations with shrubs and grasses, 2) perennial "bunch" or tufted grasses, perennial bunch grasses, 3) Distichia moors where humidity is constant, and 4) vegetation in rocky areas (Weberbauer 1936, cited in Winterhalder and Thomas 1978:40). The dry puna is similar but with a greatly reduced rainfall and a predominance of xerophitic vegetation such as tola (Lepidophyllum or Baccharis).

Ellenberg (1979) notes that the ecology of the altiplano and the Andes in general have been greatly modified by man over the past 10,000 years. In a survey of the natural ecosystems of the altiplano, Ellenberg points out that

under natural conditions, a large part of the Andean highlands would be covered with forests or woodlands. This is especially true for the Subalpine and Oreal belt around Lake Titicaca, and in the region to the northwest. ie. for the fairly humid parts of the altiplano (ibid. 407).

He goes on to note that the native stands of Polylepis, Buddleia, Escallonia, and Eugenia in nearly all of the humid altiplano easily tolerate the present climate and soils of the altiplano, and should not to be considered relicts of more favorable climates of the past, but as "witnesses to the actual possibility

of woodland growth" (ibid. 407). Tosi (1960) came to the same conclusion in his investigation based on the Holdridge methodology for classification of ecological zones (Holdridge 1947). Ellenberg considers man's influence to be the major determining factor of the present day ecology in the altiplano. After massive deforestation, grazing animals prevented the re-establishment of young native trees. Tussock grasses such as Festuca, Calamagrostis, and Stipa have become the most common species in the Andes because they are favored by regular burning and more palatable species have been consumed by grazing domestic animals. (ibid 411).

2.1.2 Lake Titicaca

2.1.2.1 General Description

The Lake Titicaca Basin covers an estimated 57,340 km² arranged on an NNW-SSE axis 427 km long, with a maximum width of 200 km (Boulangé and Aquize 1981:272). The lake itself is located between 15° 13' 19" and 16° 35' 37" South, and between 68° 33' 36" and 70° 02' 13" West. It covers 8559 km² (Boulangé and Aquize 1981:272) and is 175 km long (NNW-SSE) by 50 km wide (WNW-NNE). The lake lies in the Titicaca Trough, a surface created by block faulting and stream erosion and filled with Cretaceous and Tertiary sediments (Newell 1949:1). The maximum recorded depth is 281 meters, with a mean depth of 107 meters (Richardson et al. 1977:3,8).

The present Lake Titicaca is a remnant of a much larger

lake (Lake Ballivian) formed during the Late Pliocene or pre-glacial Early Pleistocene, with a level approximately 100 meters above that of present-day Lake Titicaca. Lake Ballivian also included Lake Poopo and covered much of southwest Bolivia (Newell 1949:82). Some glacial outwash covers the sediments of Lake Ballivian, but no glaciers ever reached the present shores of Lake Titicaca (Newell 1949:84-5). The level of Lake Ballivian fell substantially sometime during the late, post-glacial Pleistocene, and Lake Titicaca and Lake Poopo were formed. Wave-cut terraces are evidence that downcutting of the outlet at Desaguadero in the Recent Period caused the lake to fall a further 8 meters, separating Lake Arapa and Lake Umayo from Lake Titicaca (Newell 1949:91-3).

Direct precipitation provides 58% of the incoming water, and rivers and streams provide the remaining 42% (Kessler and Monheim 1968). Drainage through Lake Titicaca's only outlet, the Rio Desaguadero, accounts for only 1.5% of the water leaving the lake; the rest, 90%, is lost through evaporation and 9% is lost from infiltration, which creates a very closed lake system (Carmouze and Aquize 1981:311). The water level of Lake Titicaca fluctuates widely. Since 1912 there has been an average annual fluctuation of 0.5-1.0 meters; the minimum and maximum levels since 1912 (when recording of the lake level began) differ by 5 meters (Hill 1959).

The lake is considered a moderately eutrophic tropical lake with a moderately high, relatively aseasonal mean daily net

primary productivity of $1.45 \text{ gC.m}^{-2} \cdot \text{day}^{-1}$ (Richardson et al. 1977:3-4; 61). The phytoplankton are primarily greens and blue-greens. Relative isolation, environmental extremes, and fluctuating dissolved solids (ibid. 50) contribute to the dearth of fauna of higher taxa. The largest populations are of endemic Cyprinodonts of the genus Orestias which underwent adaptive radiation, and one species of Trichomycterus (ibid 48; 4); potential fish yield is 50,000 metric tons/year (ibid. 4). The lake is alkaline, varying between pH 8.3-8.7 (ibid. 51); with the present climate, the levels of dissolved solids are increasing (ibid 3, 25).

2.1.2.2 Climate of the Immediate Lake Vicinity

The lake is noted for its thermoregulatory effects on the surrounding region (Monheim 1965; Kessler and Monheim 1968; Carmouze et al. 1983:144; ONERN-CORPUNO 1965 Volume 1 Chapter 2; Boulange and Aquize 1981:282). In Richardson et al.'s calculation of the 1973 heat budget of the lake (1977), the mean temperature of the epilimnic layer was always above the mean air temperature. The variation in temperatures near the lake is $10-12^{\circ} \text{C}$, while at the upper edges of the basin, the temperature may vary 20°C (Boulange and Aquize 1981:282). This results in some 60-180 frost-free days/year, while in areas away from the lake (at 4000 m and above), there are between 0 and 60 frost-free days/year. Grace (1983:5) notes that the mean annual minimum temperatures near the lake are $3-6^{\circ}$ warmer than in other areas

of the altiplano, and that there are 30 more frost-free days a year near the lake than in areas several kilometers from the lake. Also related to higher temperatures and less fluctuation is precipitation, which is heaviest over the lake surface (792-945 mm/yr) and surrounding land (compared to 650-700 mm/year for the entire basin) (Kessler and Monheim 1968, Boulange and Aquize 1982:283). Kessler and Monheim (1968:275) report rainfall of 1150 mm/yr for a certain part of the lake east of Capachica, but the average for the area is around 600 mm/yr (Hill 1959:793). The heaviest rainfalls occur between the months of December and March, and the driest months are May through November (Boulange and Aquize 1981:282; Monheim 1963).

ONERN-CORPUNO's study (1965 Volume 1, Chapter 2), classifies the climate of the northwest portion of the Lake Titicaca Basin into four subtypes. Climatic Subtype A occurs in the relatively narrow zone around the shores and islands of Lakes Titicaca and Arapa, including some of the areas most densely covered by the remains of raised fields. This climate is characterized by average temperatures that oscillate between 9.5 °C and 5.5 °C, with the average range of 4 °C between extremes. This relatively small variation between minimum and maximum temperatures is attributed to the thermoregulatory effects of Lake Titicaca, which acts as a heat sink, moisturizing and warming the winds that cross over the lake as discussed above. Climatic Subtype B is restricted to the zones of Oruillo, Asillo and Azangaro, lying 3,950 to 4,100 meters a.s.l. with an average

minimum temperature of 6 °C and average maximum of 13 °C, a 7 °C range. Frosts are more common and the frost-free agricultural period is shorter than in Subtype A. This is also an area of prehistoric raised fields and qochas. The area is topographically buffered and the surrounding hills contain the humidity and warmth carried in by winds from the northeast. Climate Subtype C, or the "Clima del Altiplano," occurs in areas outside of the influence of Lake Titicaca's regulatory effects. The average minimum and maximum temperatures are 3 °C and 13 °C, respectively; the average range of variation is 10 °C. This area is affected by cold and semi-dry winds from various directions, and by frequent radiation frosts, or cold air inversions on clear windless nights when the soil is dry. Although native species of grasses suitable for grazing survive in this area, it is not suitable for most agriculture and only the most frost-resistant crops can be cultivated successfully. This area includes the largest blocks of prehistoric raised field remains in the Huatta pampa. Climate Subtype D is characteristic of the high altitude zones of the Lake Titicaca Basin, and is not appropriate for agriculture. Average temperatures range from 6 °C to 0 °C, with frequent frosts occurring year round (ONERN-CORPUNO 1965: Vol. 1, Chapter 2 p. 168-70). Grace (1983) presents similar data, but indicates that the lake's climate influences a somewhat larger territory, in particular the pampa around Huatta. Unfortunately, the accuracy and precision of these studies are limited by both the relatively small number of data collecting stations and the

relatively short time depth of recorded data. Nor is there sufficient data at present to define microclimates within these gross categories.

ONERN-CORPUNO uses the Lifezone System of classification, developed by Holdridge (1947) and applied to Peru by Tosi (1960), to classify the lakeshore areas, the pampas and the Capachica Peninsula as Humid Montaine Meadows or Forest (ONERN-CORPUNO 1965 Volume 4, Chapter 6:1-6). The location of the lifezone Humid Montaine Meadows or Forest corresponds to that of Climatic Subtypes A, B and C discussed above.

2.1.3 Limitations to Agriculture

2.1.3.1 Climate

The altiplano environment provides many limitations to agriculture. The climate is characterized by irregular rainfall, widely fluctuating daily temperatures, frequent radiation frosts, distinct wet and dry seasons, frequent local hailstorms, and at times, high velocity winds. This combines with generally thin, infertile soils, poor drainage, and the annual flooding of Lake Titicaca and its tributaries to make agriculture an extremely risky endeavour. Even in the relatively protected areas around Lake Titicaca, there is an "almost total loss of a crop on the average of once every five years, and a loss so appreciable during three years that only a single crop during the five-year period is considered a really good one" (Weil 1974:54)

Irregular rainfall is the basis of most of the agricultural

problems. Short droughts, called veranillos, can occur at any time during the growing season. For example, during February of 1982, there was no rainfall in Huatta. This event was particularly harmful because rainfall in February is necessary for tuber growth and development. Dry conditions are also conducive to severe radiation frosts, which destroyed many crops during February, 1982. Long-term droughts are also a problem. Annual rainfall can range from virtually nothing, such as in 1956-1957, to the heavy continuous rainfall which caused massive flooding in 1985-1986. There appears to be a relationship between sunspot activity and changes in rainfall on the altiplano, but this relationship is poorly understood (Kessler and Monheim 1968, Monheim 1963). Apparently there is also a relationship between droughts in the altiplano and El Niño events on the Pacific coast (Caviedes 1984; Guillet 1987), but, again, the mechanics of this relationship are not understood.

The areas most affected during years of excessive rainfall are the lowlying zones of the lake plain and the various river floodplains. Because of the extremely low relief of the pampa, vast areas of potential farmland are inundated by slight changes in the lake level or increased discharges of the major rivers. The massive flooding of 1985-1986 destroyed the adobe houses of approximately 10,000-20,000 families and inundated more than 70² km of normally dry lands used for cultivation and pasture.

Mean temperature also varies greatly in the altiplano. Wide fluctuations are caused by the lack of atmospheric buffer at this

high altitude, and frequent radiation frosts and the rarer advection frosts can occur anytime during the growing season to wreak havoc with farmers' fields. Sudden hailstorms, which occur frequently during the growing season, can also destroy crops quickly. One hailstorm in Faon, part of the District of Huatta, in 1977, battered the mature seed heads from the cereal crops just before harvest; it is also said that some large hailstones penetrated even the metal house roofs.

2.1.3.2 Soils

Many soils are considered Azonal, with poorly-developed horizons. These shallow soils are generally poor for agriculture, and their fertility is quickly depleted by the practice of over-cropping, continuous cultivation with little or no fallow, and lack of soil improvement by farmers such as application of organic fertilizers. Although annual flooding sometimes improves soil fertility, the resultant bodies of standing water can also leach valuable nutrients from the soil and cause compaction of soil texture; the most fertile soils of the pampa are usually waterlogged throughout the growing season.

2.1.3.3 Conclusions

As discussed above, the difficult environmental conditions for agriculture are greatly ameliorated by Lake Titicaca. The substantial influence of the lake on local climate is partially due to its relatively large size (8,448 km²) and depth (mean of 100 m), which reduce fluctuations in local air temperature

(Carmouze et al. 1983:136, 144). Annual rainfall is higher and more predictable around the lake. The temperature fluctuates less, and average temperatures are generally higher. Soils, although waterlogged at times, tend to be more fertile. As a result, the highest rural population densities in the altiplano occur around the lake, where the most productive agriculture can be practiced (Ogilvie 1922; Tschopik 1963:502-503).

Today, some of the highest non-urban populations in the Andes live along the lake edge or in the lake. The 1981 census reports that of the 893,581 inhabitants of the Department of Puno, 44% live at or near the lake edge, creating a population density of 28 inhabitants/km² (Instituto Nacional de Estadística in Hanek 1982:1). The District of Coata has an especially high population density, primarily occupying the numerous moqos, or prehistoric occupation mounds, at the mouth of the Rio Coata. Another dense occupation is found in the District of Huatta's lake zone, in Yasin, Uchuymoro and Los Urus. The same is true for the lakeshores in the Ilave and Taraco Peninsulas. Most of these lake edge inhabitants are both farmers and fishermen, although some specialize in fishing or raising cattle. Because of the large biomass created in the shallow lake, fishing, hunting and gathering are important economic pursuits.

In Huatta, temporary and permanent house sites are all placed on slight rises along the lake edge or in the lake. Most of these sites are occupation mounds, many of which, if not all, date back to the Early Horizon and Early Intermediate Period.

The larger occupation mounds (eg. Yasin Mogo, Uchuymoro, Chajana, Chacolla, Allan, Karata, Pojsin Karata) are favored locations for agricultural plots because of the improved microclimate created by the lake. On some of these mounds, double cropping (with cereals cultivated in the winter season) has been reported. Frost never affects these protected locations, although the seasonal rise of the lake usually affects the fields to some extent. The fertile ground made available during a drought is sometimes cultivated, but this is generally considered a risky practice. This strategy is usually followed only when a drought is severe enough to ruin the crops in all other areas.

2.2 PHYSICAL ENVIRONMENT AND AGRICULTURE IN HUATTA

Few environmental studies have been conducted in the Huatta area. The largest recent investigation was completed in 1965 by the Oficina Nacional de Evaluación de los Recursos Naturales and the Corporación de Puno (ONERN-CORPUNO). A large area of the northern Titicaca Basin was examined by a team of geologists, agronomists, economists, soil scientists, agronomists, botanists and hydrologists, who published their findings in five volumes (ONERN-CORPUNO 1965). The ONERN-CORPUNO study area includes Huatta and Taraco, where the largest blocks of prehistoric raised fields are located, but unfortunately, these areas are discussed only in very general terms. There are several limitations to

this study's usefulness. An insufficient number of research locations were investigated and the study did not adequately sample the complex ecological zones (for example, only 2 stations were used to define the soils of the thousands of hectares of pampa where the raised fields are located). Nor was the sample adequate to discuss the cyclical dynamics and seasonal variations of the lake area ecology. The classifications, and of course the resulting analyses, are oriented to western technology and perceptions (as Smith et al. 1981, 1968, have pointed out). Land near Requena, in the Taraco Peninsula, has been classified as appropriate for "limited wildlife use only," yet this is the site of the largest prehistoric raised fields known in the New World. Partially a result of this ethnocentric orientation, the environment is treated as a "natural" one; in fact, it is among the most man-altered landscapes on the continent of South America because of the massive prehistoric construction of terraces and raised fields. Regardless of these defects, ONERN-CORPUNO's study remains the most comprehensive reference for the ecology of the northern Lake Titicaca Basin, and it is used frequently in the following discussion of the ecology of the Huatta area.

2.2.1 Pampa

The pampa surrounding Huatta is a vast lowlying plain subject to seasonal inundation (Figure 3). It covers approximately 56,000 hectares of Pleistocene lake plain, bounded by the shore of Lake Titicaca to the east, the hills of Juliaca

to the west, the Capachica Peninsula to the north, and the hills of Caracoto to the south. Fingers of pampa stretch south towards Hatuncolla and Lago Umayo along the Rio Illpa, and west along the Capachica Peninsula. The elevation of the lake is an estimated average 3802 meters above sea level.

The soils of the pampas around Huatta belong to the Soil Series Titicaca of the Titicaca Association, part of the Andean Gley Humic Planosols, and the soils along the lake edge belong to the Limno Series of the Limno Association (ONERN-CORPUNO 1965: Volume 3, Chapter V:19-21). Both soil series are of recent lacustrine and secondary local alluvial deposition, and generally have poor drainage, and a high natural water table. The surface is considered flat, with only 1-2^o slope. The soils are relatively deep, with a 10-40 cm thick A horizon of sandy loam. The B Horizon is generally well-defined, with higher concentrations of clay and incipient gley formation. Below the B Horizon, strata of parent material are found, ranging from sandy loams, sands, or fine-textured clays (ibid.).

Characteristic of these soils is a moderately acidic pH in the upper profile, and a strongly alkaline (pH 8.5) subsoil. The upper profile contains 1.0-4.0 % organic matter, and levels of nitrogen are directly related to the organic matter content. Phosphorus values may range from high to low. Levels of Potassium are considered high. As a result, the fertility is considered to be moderate. The limitations to agriculture in areas with these soils are the fluctuating temperatures, strong

wind, and high water table; that is, the soils themselves do not preclude cultivation. ONERN-CORPUNO recommends that these areas be used only for natural and cultivated pasture.

The vegetation (grasses) of the pampa are of the Festuchetum and Muhlebergetum Association (ONERN-CORPUNO 1965: Volume 4, Chapter VI:14). In the zone of Huatta, the Muhlebergetum is predominant. The primary species in this association are Muhlebergia ligularis and Festuca dolychophylla, with secondary species Calamagrostis heterophylla, Carex simplex, Distichlis humilis, and at times, Trifolium amabile and Bromus sp. are found. The native grass species are considered relatively productive and good for pasture, supporting 1-2 sheep/ha in the Huatta area.

At first glance, the large plain seems a homogeneous landscape, but this is deceptive. The pampa contains a very complex micro-topography of lakes, old river levees, abandoned meander scars, delta formations, and archaeological features.

Two active rivers, the Rio Coata and Rio Illpa, cross the pampa to the north and south, respectively. The Rio Coata, with the Rio Cabanillas and Rio Lampa as tributaries, drains a watershed of approximately 5128 km² (Boulangue and Aquize 1981:277) and has a discharge of 30 m³/sec (Kessler and Monheim 1968:280). The Rio Illpa drains a much smaller basin (1488 km²), but this includes Lago Umayo (covering 29 km²) (Boulangue and Aquize 1981:279). The old Pleistocene lake bed which includes Huatta and the pampa has become a broad floodplain between the

shifting courses of these two rivers. Major differences in hydrology between the riverine and lacustrine environments are discussed by Lennon (1982).

In the geologic past, the Rio Coata probably flowed along the base of Sangachi (the southwest extension of the hill of Huatta) and entered the lake a few kilometers south of the present mouth of the river. Another abandoned channel, the seasonal Rio Kaminaqa, lies south of the Sangachi channel, and may be older. A more recently abandoned channel, the seasonal Rio Cojelaque, lies just south of the present channel of the Rio Coata. Similarly, abandoned channels of the Rio Illpa can be distinguished slightly north and east of the present channel. These topographic features were (and still are) major hydrologic features during the season of cultivation, and were often incorporated into the structure of raised field systems.

The largest lakes in the Huatta pampa are Quivillaca, Mayu Esquina, and Joche. These are very shallow (2 meters maximum) seasonal lakes. Thousands of lowlying basin-shaped depressions, called gochas, (usually less than 1 hectare in area, and less than 1 meter deep) also hold seasonal water. These are scattered throughout the pampa, with a major concentration between Caracoto and Huatta. A large number of these features may be at least partially artificial, since many have been integrated into prehistoric agricultural features. They appear very similar to the system of functioning gochas described for the Pukara area north of the lake (Flores and Paz 1983, Rosas 1986). Others are

associated with prehistoric occupation mounds, and were obviously borrow pits, sources of the adobe mud and ch'ampa sod blocks used for construction. Like modern borrow pits, these would have been valuable reserves of water for agricultural and domestic use. Today, many of these prehistoric waterholes are still maintained for human and animal use. Many have stands of totora and llachu, which are used for forage, thatching, and mat-making. Some of the larger and deeper ponds support the same aquatic faunal and floral communities as Lake Titicaca (see below).

Most, if not all, of the major eroded river levee formations have been used as permanent or temporary occupation sites. Those without recent constructions show extensive evidence of prehistoric occupation. The natural levees have been further built up through adobe construction and reconstruction over many generations. They vary in length up to 500 meters, and in height up to 10 meters, although most are less than 2 meters high (Erickson 1988). A few of the largest mounds, such as Pancha and Umanchiri, can be seen for a long distance and are quite imposing features on the otherwise flat pampa. Today most of the mounds are used for small agricultural fields, selected for their excellent drainage and reduced risk of inundation. They are also the sites of modern corrals for cattle and sheep, and temporary shelters for the herders, during the rainy season. Several of the larger mounds near Huatta (Yasin, Uchuymoro, and Pojsin Karata) have dense permanent occupations, and Coata, a large regional market town, is constructed on the artificially built-up

levee at the mouth of the Rio Coata.

The primary economic use of the pampa today is grazing. All Huatteenos have access to pasture in this zone through either parcialidad membership or kinship relations. The pampa is also important as the source of ichhu grass, the raw material for cordage and roofing. Limited hunting is done during the wet season, when water birds inhabit the numerous lakes of the pampa. Huatteenos consider the pampa very marginal for agriculture because of frosts, poor and saline soils, and flooding; as a result, relatively little of the pampa is cultivated. A campesino will only plant in the pampa if there is extra seed and time after his fields on the hillslopes have all been planted. The most favored locations for pampa cultivation are the large prehistoric occupation mounds, some of which are continuously cropped. The occasional private fields in the low pampa, like the recent communal parcialidad fields in the pampa, appear to be primarily symbolic claims to a plot of land that may be in dispute (Candler and Erickson 1987). Although the crops planted in the pampa are somewhat resistant to frost (ruki potatoes, quinoa, cañihua, and barley), they are not generally expected to yield much.

2.2.2 Hill and Hillslope

The pampa is surrounded by ranges of hills to the north, south, and west. The cerro (Spanish "hill") of Huatta is an outcrop of eroded sedimentary beds, approximately 2 km E-W and

5.5 km N-S, 118 m at its highest point. These beds have been tilted to nearly vertical, and consist primarily of strata of limestone and coarse, loosely consolidated, gravel and pebbles.

A substantial portion of the hill of Huatta is bare rock outcrop, useless for agriculture. Between these outcrops, and especially on the lower slopes, relatively mature soils have developed from colluvium; these areas are the most heavily cultivated. In most cases, the soil has been overcultivated, and erosion has removed most of the thin topsoil. Because of the reduced fertility of these soils, farmers should use long fallow periods or apply organic fertilizers (which are only available in insufficient quantities). However, the hill is better protected from frosts and is less vulnerable to inundation and waterlogging, and is, therefore, more desirable than the pampa. The hill's limited fertility is offset by the lower climatic risk.

Most of the fields on the hillslope are bounded by low stone walls. These walls have grown as many generations of farmers cleared the stones from their fields. Walls that roughly follow the contours of the slope help prevent erosion, and sometimes function as psuedo-terraces or lynchettes. Grassy borders between fields also reduce erosion and create improved agricultural microclimates.

In some parts of the cerro of Huatta, rustic terraces are found. Most of these are in small valleys and gulleys between rock outcrops. They have been largely destroyed through erosion

and neglect, but their surfaces are still the best fields on the upper slopes of Huatta. The best-constructed terraces are clearly associated with the major archaeological sites of Huatta, Huanina, and Viscachani, and may have been occupation terraces.

Irrigation is rarely used in Huatta today. There are several springs which are crudely channelized for occasional irrigation of small plots. One small system operated by a single family at the base of Nuñuri irrigates approximately 0.5 hectare, and the excess is sometimes utilized by several families at the base of the hill. There may have been a network of canals associated with the series of springs above the town of Huatta, but if so, today this has been destroyed by pathways and fence lines. Excess water from the town well is used to irrigate pasture below the springs, and is often temporarily diverted for adobe making in the dry season. Although cultivation in Huatta is based primarily on rainfall, the primitive irrigation systems reduce the damage of short-term droughts and permit an earlier planting on the cerro.

Occupation is concentrated on the hill of Huatta. The town of Huatta covers approximately 20 hectares. The second most densely populated zone surrounds the cerro, at the base of the hillslope. This area contains the best-developed agricultural soils, and water for domestic use can be obtained easily.

2.2.3 Lake

The third major ecological zone in the Huatta area is the lake environment. In terms of biomass production, the lake, especially the wide littoral zone, is a significant economic resource today; in prehistoric times it would have been the major focus of hunting and gathering groups, retaining importance even after the introduction of agriculture and construction of raised fields. The edge and shallows of Lake Titicaca, combined with both seasonally inundated and permanently waterlogged lands near other lakes and rivers throughout the lake basin, provide a vast wetland resource base for human populations (discussed in detail in Chapter 4).

Today, Quechua and Aymara inhabitants of the lake edge practice a mixed economy which combines farming and pastoralism with the hunting, fishing, and gathering of wetland resources. Archaeological evidence from Chiripa (Erickson 1976; Erickson and Horn 1977) and Huatta sites (Erickson 1988) indicate that this subsistence economy has been practiced for at least 3000 years. Agriculture is very limited along the lake edge today. Although recognizing the agricultural potential of the black, organic soils of the lake edge and bottom, farmers commonly cite problems with seasonal flooding and naturally high watertables as the principle deterrents to cultivation. Government land use survey has classified most of this zone as "marginal" or "suitable for wildlife use only" (ONERN-CORPUNO 1965; 1983). Farming is usually restricted to areas that are not annually inundated

(natural levees and mogos, prehistoric occupation mounds), and occasionally on the lake plains during periods of low water levels or droughts. A very labor-intensive system of cattle raising has been developed by the lake edge farmers, who harvest aquatic plants by hand and transport the forage to the animals. Many animals have adapted to the wet conditions of the zone and wade into the water to graze on emergent and submerged lake plants.

Fishing, especially of the ubiquitous carachi that inhabits the shallow waters, is an important household activity and many individuals are full-time professional fishermen. Totora reeds for mats, roofing, cattle forage, human food, and boatmaking are regularly collected from private and communal stands within the shallows. Hunting the abundant aquatic birdlife inhabiting the totora swamps and collecting their eggs are other common activities. These wetland products provide items of barter for agricultural items and exotics, and for some, cash incomes.

The settlement pattern is characterized by household clusters and small communities densely concentrated on the various natural islands and mogos. Mogos are artificial man-made islands, resulting from the accumulation of thousands of years of occupation midden and adobe and pituku (sod block) construction debris. Communication among settlements and fishing or collection areas is usually by boat; people sometimes wade short distances through the shallow water.

The inhabitants of "Los Urus" of the Bay of Puno, officially

one of the parcialidades (subcommunities) of the District of Huatta, live on "floating islands," a combination of mogos, natural rock islands, and massive accumulations of totora reeds that do indeed float in the shallows. Some of these people even farm there, scooping organic muds from the lake bottom to form a planting medium around the settlements (see Chapters 6 and 7). The Urus are accomplished fishermen, mat makers, and hunters within the dense totora swamps.

This wetland zone is very dynamic because of the intense human exploitation of the zone and the natural rise and fall of the water level, both annually and cyclically during periods of drought and flooding. Faunal and floral biomass is high because of the rich lake soils, temperatures which fluctuate less than the surrounding environments, and diverse ecotone conditions. Much of this biomass is economically important to the human population and the carrying capacity is very high. As discussed in Chapter 3, the soils of this zone are man-made, at times to a depth of several meters. Prehistoric man is also responsible for the micro-topography of the lake plain and lake edge, eroded raised field platforms and silted-in canals. Some of this landscape modification has artificially extended the wetland environment of the lake edge far into the pampa (discussed in Chapters 3, 5 and 7).

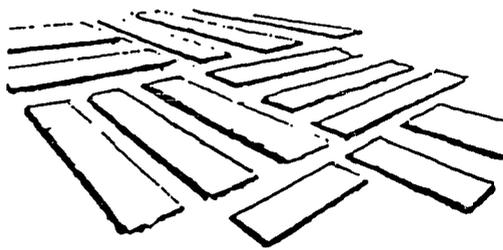
CHAPTER 3

STRATIGRAPHIC PROFILES OF RAISED FIELDS

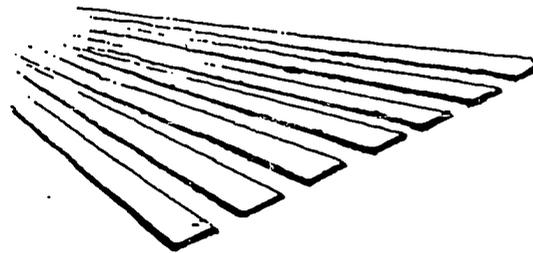
3.1 METHODOLOGY

Stratigraphic profile trenches were excavated in raised fields in order to recover data on raised field morphology, collect pollen and soil samples, and recover chronological information (Figures 7-10). Simple probing with a soil probe sample tube proved to be unsatisfactory for a detailed description of the strata within the raised fields. Nine field locations, which typify the major field types and different environmental conditions, were selected for test excavation. The first series of stratigraphic trenches (Pocsillon, Viscachani A, Viscachani B, Faon, Jucchata, Ccoccope, Candile, and Machachi) were excavated in areas where experimental raised field construction was planned. These exploratory trenches also provided data on the local water table conditions, soil types, and prehistoric raised field morphology that served as a basis for their reconstruction. The last three locations (Pancha A, Pancha B, and Kaminaqa) were selected because of their proximity to habitation mounds. Due to the paucity of datable in situ artifactual remains and carbon in the experimental raised field locations, these trenches were selected with the hope of finding datable carbon or artifactual remains within a secure stratigraphic context.

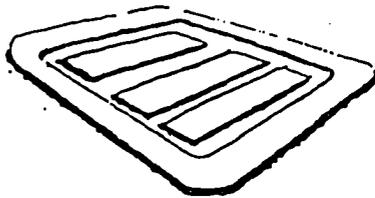
IN THE HUATTA AREA



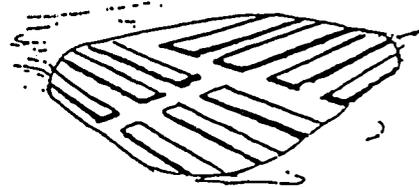
OPEN CHECKERBOARD



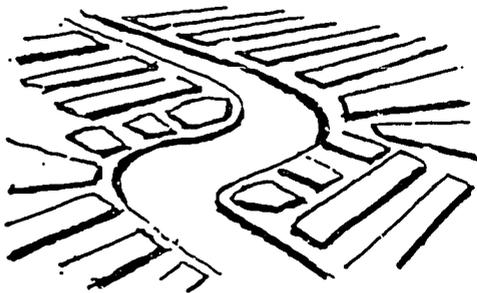
LINEAR



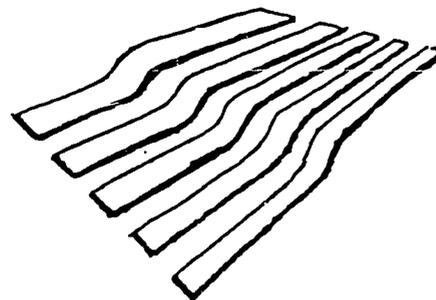
EMBANKED



GOCHA



RIVERINE / CAÑO



CURVILINEAR

Figure 7: Patterns of raised fields in the Huatta area.

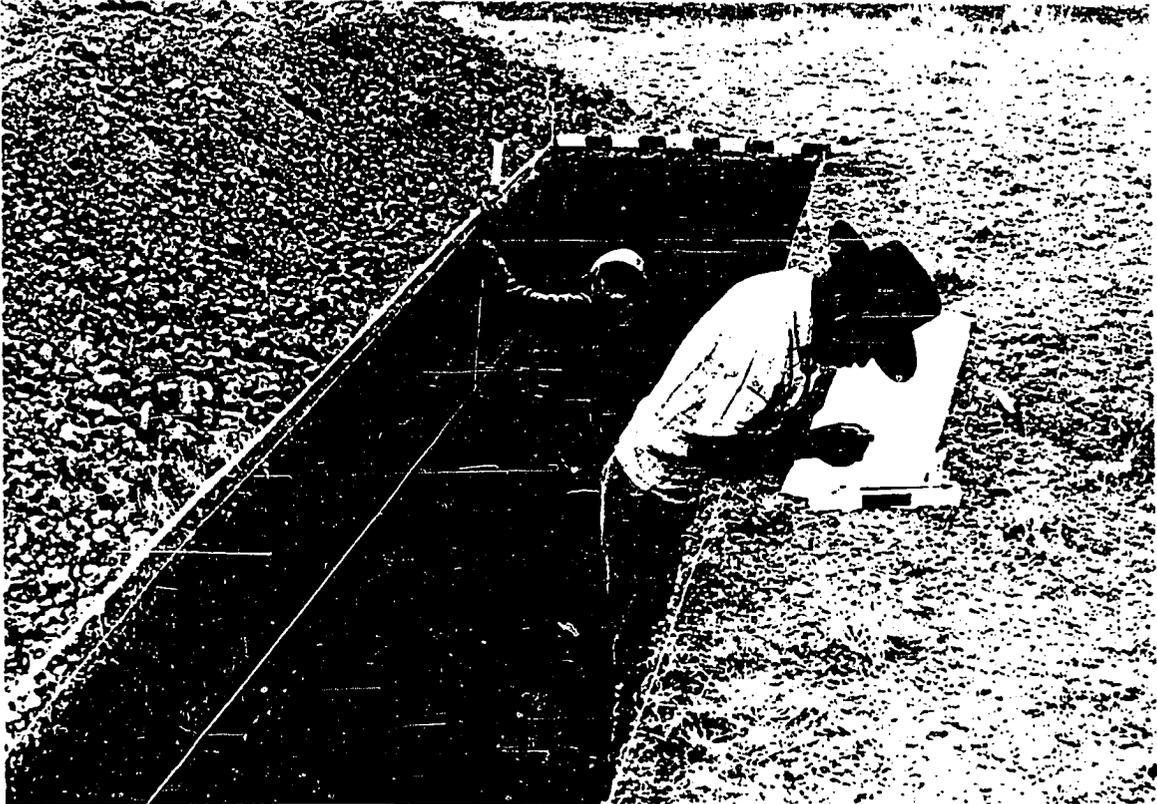


Figure 8: Mapping of stratigraphic profiles in Unit A at Juchata.



Figure 9: Excavation of Unit A at Viscachani Pampa. The trench extends from the center of one raised field to the center of another.



Figure 10: Unit NOPQ at Pancha showing portions of two small wavelength Phase I raised field platforms under larger wavelength Phase II raised fields visible at the surface. The meter scale is at the center of the Phase II canal.

Most of the raised field excavation sites were first mapped with a transit. The transit was used to establish several benchmark datum points. These were marked with cement and used to map the raised fields in the area. Excavation trenches were gridded from the benchmarks, and the transit was used to control the mapping of their stratigraphy. Trenches were laid out with north-south or east-west axes, since these were the orientations of the perpendicularly-cut raised fields. Most extended from the center of one raised field platform to the center of an adjacent platform, usually a distance of 8-10 meters, and were made 1 meter wide to allow sufficient room to excavate and to provide sufficient light to map the profiles. In two cases, the trenches crossed several raised field platforms. This method proved to be the most efficient in terms of data collection since the canal was the best-preserved feature in all excavation units; the raised field platforms were in all cases reduced through erosion to less than their original elevation. Because of the large dimensions of the raised field platform and canal of Unit D at Viscachani Pampa, the trench was only excavated from the center of the canal to the center of the raised field platform.

Natural stratigraphy was followed during excavation. When the natural strata were especially thick, artificial levels of 10-20 cm were sometimes introduced. Artifacts found in situ were piece-plotted with precise horizontal and vertical coordinates. Shovel, pick, trowel, chakitaqlla (Quechua: Andean footplow) and rawkana (Quechua: Andean hoe) were used during excavation. A

total of 85.7 cubic meters of earth was excavated in the 11 stratigraphic units. In all of the trenches, with the exception of Candile, Machachi and Illpa, the soil was screened through 1/4-inch mesh screen to recover cultural material. Screening was tedious (especially in the heavy clays and silts of pampa), but necessary for the recovery of artifactual remains, which are rarely found in most prehistoric agricultural contexts.

All trenches were excavated to the base of the deepest canal sediment stratum. In many cases, trenches were continued further into the subsoil to determine the local geomorphological structure and to verify that no earlier cultural strata were present. In almost all trenches, the high water table was a major problem. Percolation of water into the trenches was slow enough to allow excavation, but covered the lower strata if left overnight. The trenches were bailed by hand with buckets so the profiles could be mapped.

Strata were mapped at a scale of 1:100. Where stratigraphy was confusing or complex, both of the long profile walls were drawn. After the profile was drawn, soil and pollen samples were taken from each stratum. Artifacts recovered in situ were mapped, using the transit in most cases, for control of horizontal and vertical position. All ceramic materials (potsherds and burned clay) that had been left in situ for mapping were carefully removed and placed in plastic bags along with a small sample of soil matrix for thermoluminescence dating. Some carbonized wood were also collected for radiocarbon dating.

3.2 TERMINOLOGY USED IN DESCRIPTIONS AND INTERPRETATIONS

In the complex profiles of several of the stratigraphic trenches, there is clear evidence that there were distinct periods of raised field construction, documenting both major and minor changes in raised field form. Where major changes, such as a doubling of raised field wavelength, is documented by the presence of superimposed raised field systems in a single stratigraphic trench, the term "phase" is used. Wavelength is the measure of distance between the centers of adjacent contemporary canals or the distance between the centers of adjacent contemporary raised field platforms. Since the centers of canals are easily determined, these are used for wavelength calculations. Phase I is used to indicate an earlier, shorter wavelength raised field system and Phase II is used to indicate a later, longer wavelength raised field system. Both are determined by the presence of the superposition of raised fields within a single stratigraphic profile. "Stage" is used to refer to one of multiple, distinct construction, use and field maintenance periods within a single phase of raised fields. Stages are most commonly indicated by superposition of construction fill strata within raised field platforms without a change in wavelength.

The time period between construction stages is interpreted as several generations of continuous raised field construction and use, probably less than several hundred years; whereas the

time between phases is much longer, probably more than a period of several hundred years, and there appear to have been periods of raised field disuse or reduction in use between each phase. These periods of disuse or reduction in use or maintenance are referred to as "abandonment" in the figures used to reconstruct the events documented in each profile. The concept of abandonment is discussed in more detail in Chapter 7. Some of the raised field stratigraphic trenches document only a single phase of raised field use, but show evidence of several construction stages within that phase. Whether the Phase I or Phase II raised fields of one excavation unit are contemporaneous with the raised fields of another unit is often not clear, but this appears to be the case (discussed below). The single-component raised fields are likely to be contemporaneous with the Phase II raised fields in stratigraphic trenches where multicomponent use is documented.

Description and interpretation of the soil stratigraphy of each excavation trench will begin with the lowermost stratum and will proceed through the uppermost stratum.

3.3 DESCRIPTIONS OF STRATIGRAPHIC PROFILES OF RAISED FIELDS

3.3.1 PPu7-64 Candile Unit A

(Figures 11-13)

Candile is located in the pampa 1 km east of the cerro of Huatta and 2 km east of the town of Huatta, near the present edge of Lake Titicaca. The raised fields of the Candile pampa are primarily of the open checkerboard pattern, bundles of 5 to 10 raised field platforms ranging in width from 3 to 10 meters. To the east, the fields change to a linear pattern perpendicular to the edge of the lake. The area is within 1 km of the present mouth of the Rio Coata, and during the rainy season these fields are at the very edge of Lake Titicaca. Associated with the raised fields are numerous small prehistoric occupation mounds, some of which are still used as house sites. Because of their proximity to the lake and river, the raised fields of this zone are badly eroded and the canals have almost completely filled with sediments.

Unit A of Candile was a 7.5 x 1.0 x 0.9 meter trench, oriented east/west, excavated perpendicularly through two raised field platforms and the canal between them.

The lowest stratum in the profile of Unit A was only present in the west end of the excavation unit. Stratum E, a brown/dark brown loam was mixed with calcium carbonate concretions, forming a compact dense layer. Above this was Stratum D, a dark brown waterlogged sandy loam, possibly deposited as lacustrine or



Figure 11: Aerial photograph showing the context of excavation Unit A at Candile.

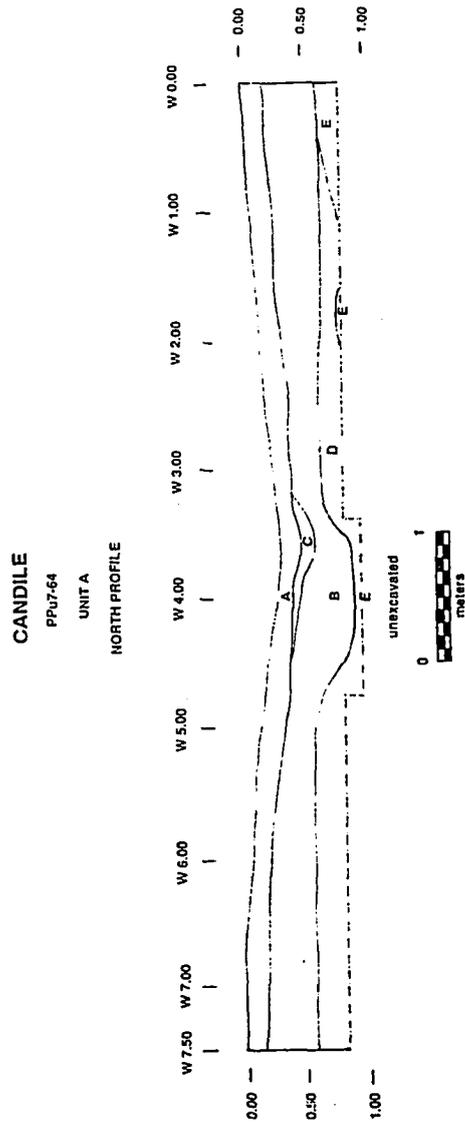


Figure 12: Stratigraphic profile of Unit A, Candile.

Candile
PPu7-64
Unit A
North Profile

- A: dark yellowish brown (10YR3/4) sandy clay loam; organic staining; yellowish mottling; rootlets of chinca and chiji; friable; humus; pH 8.77 in east and west sections; pH 6.70 in center section.
- B: very dark grayish-brown (10YR3/2) sandy clay loam; rootlets of chinca and chiji; some yellowish-brown rootlet staining compact; pH 8.26 in raised field; pH 7.04 in canal; gradual boundary.
- C: black (10YR2/1) sandy clay loam; some rootlets; high organic matter content; pH 6.36; clear boundary.
- D: dark brown (10YR3/3) sandy loam; homogeneous; waterlogged; pH 6.60; clear boundary.
- E: brown/dark brown (10YR4/3) loam; waterlogged, calcium carbonate concretions of 1-4 cm diameter; some yellow brown mottling; pH 9.19; abrupt boundary.

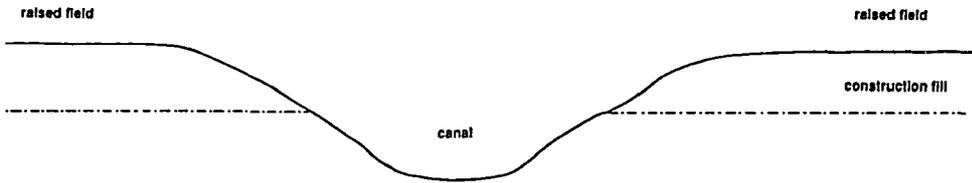
Figure 12: (Continued) Description of the stratigraphic profile of Unit A, Candile.

CANDILE UNIT A

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION



III. ABANDONMENT, EROSION, AND SEDIMENTATION



Figure 13: Reconstruction of stages of construction and abandonment based on profile of Unit A, Candile.

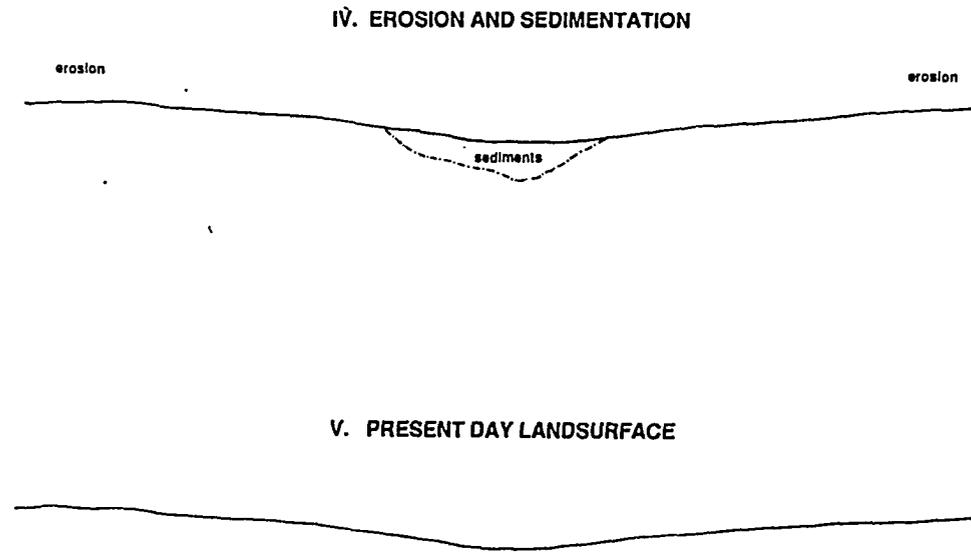


Figure 13: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit A, Candile.

backwater sediments associated with the Rio Coata. Stratum B, a very dark grayish-brown sandy clay loam with yellowish-brown rootlet staining lies above Stratum D.

The raised field construction at Candile is of a single phase, possibly continuous over several generations of farmers. There are no clear internal features within the major stratigraphy to indicate construction stages or other phases. Evidence of raised field cultivation is the canal from W 3.2 to W 4.8 cut into Strata B and D. This excavated material, the sandy clay loams of Stratum B, was used as fill for the raised fields. The raised fields were approximately 7.5 meters in wavelength, and were at least 90 cm high from canal base to raised field surface. The uneven boundary of Strata D and E suggests human disturbance, possibly a Phase I raised field construction, but the subsoil of Stratum E is relatively infertile and very difficult to work due to calcium carbonate cementing. This uneven boundary most likely formed naturally.

After these raised fields were abandoned, the canal gradually filled with alluvial and lacustrine sediments. Stratum C, a lense of black sandy clay loam, probably originally formed as a layer of organic muck during a period of decreased erosion and sedimentation. Stratum A, a dark yellowish-brown sandy clay loam with yellowish rootlet staining finally developed as an A Horizon.

3.3.2 PPU7-65 Machachi Pampa Unit A

(Figures 14-16)

Machachi Pampa is located 3 km west of the town of Huatta on the plain between Huatta and Caracoto. This pampa also has a variety of raised field forms, predominantly of the open checkerboard and the irregular embanked patterns. The raised field blocks are of variable dimensions, and most are bounded by an embankment or canal, creating a complex system of hydrology, both natural and human manipulated. The Rio Kaminaga, a seasonal watercourse, crosses the pampa east of the excavation unit. Various segments of this river appear to have been channelized utilizing low artificial levee embankments; parts of the channel also appear to have been straightened. A number of very straight artificial canals also cross the pampa; presumably they were used to control water levels within the raised field blocks. Some of these canals have been carefully integrated into the organization of the raised field blocks, while others appear to have been constructed later than raised field blocks. There is also a relatively large gocha or lake, perhaps an artificial reservoir, which would have been used to control water levels.

Unit A was excavated between the crests of two narrow (5-6 meter wavelength) eroded raised field platforms and included the canal between them. The unit was oriented east/west and measured 5.0 x 1.0 x 1.0 meters. The raised fields of Unit A appear to be of a single phase, and without distinct stages of construction.

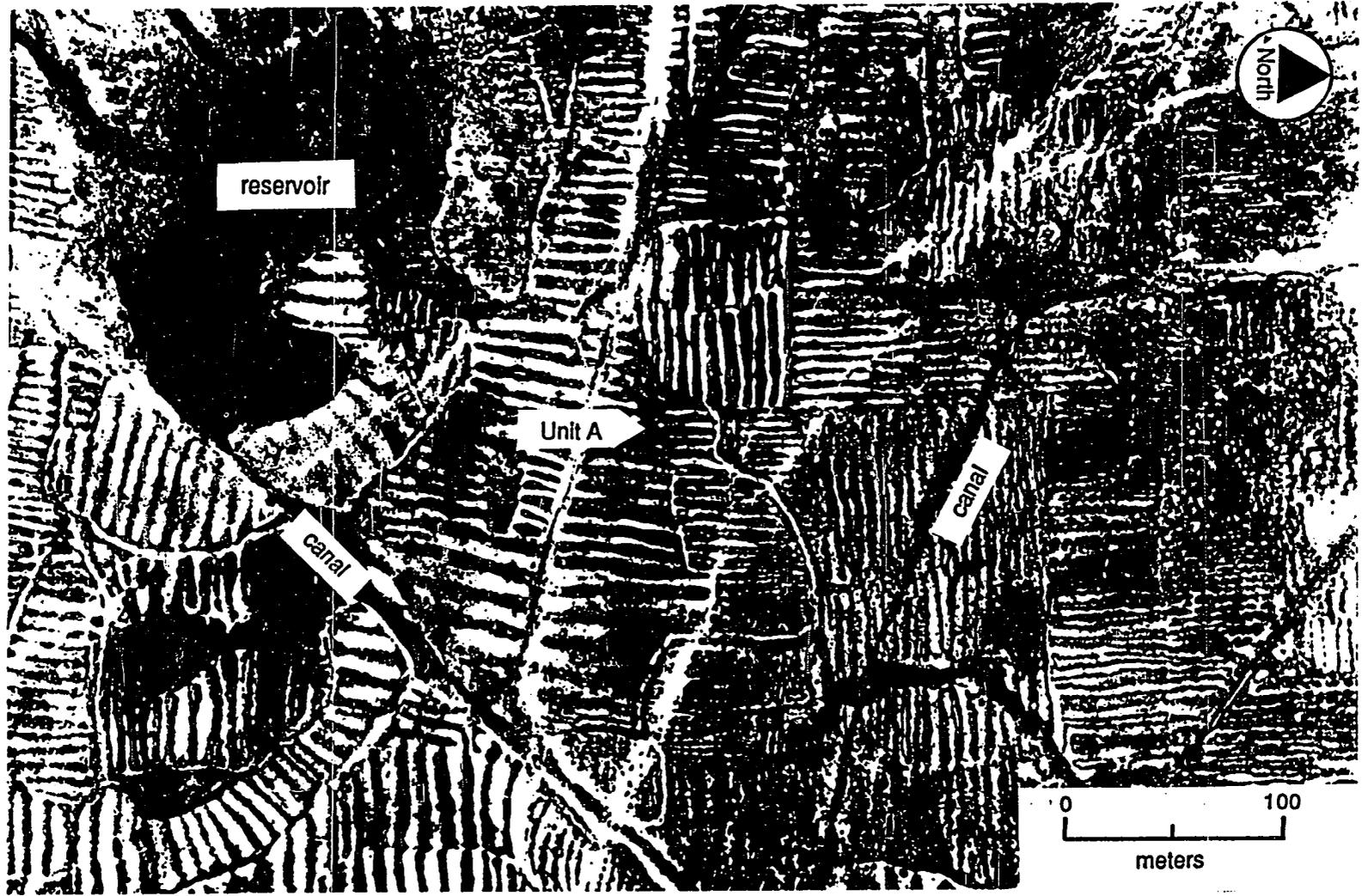


Figure 14: Aerial photograph showing the context of excavation Unit A at Machachi Pampa.

MACHACHI

PPU7-65

UNIT A

SOUTH PROFILE

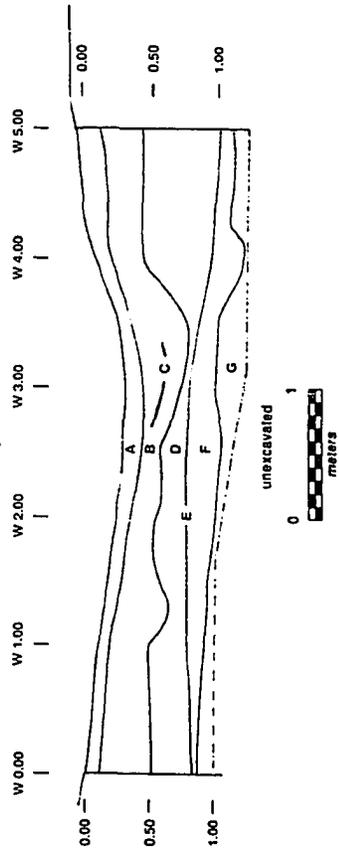


Figure 15: Stratigraphic profile of Unit A, Machachi Pampa.

Machachi Pampa:
FPu7-65
Unit A
South Profile

- A: dark brown (7.5YR3/2) clay loam; rootlets of chinca and chiji; humus; yellowish-brown mottling.
- B: dark reddish-brown (5YR2.5/2) clay loam; blocky structure when dry; some calcium carbonate concretions; gradual boundary
- C: black (7.5YR2/0) clay loam; thin (1-2 cm) strata of possibly buried humus; abrupt boundary.
- D: dark yellowish-brown (10YR4/4) sandy silt loam; very dark brown (10YR2/2) inclusions of 5mm; yellowish brown (10YR5/8) oxidized mottling; laminar structure in lower section; abrupt boundary.
- E: brown/dark brown (10YR4/3) sandy clay; 2-5 cm thick stratum; laminar structure; abrupt boundary.
- F: dark yellowish-brown (10YR4/4) sandy silt loam; yellowish brown (10YR5/8) oxidized mottling; abrupt boundary.
- G: dark reddish-brown (5YR3/2) silty sand; waterlogged; abrupt boundary.

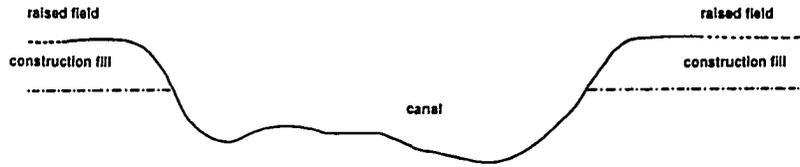
Figure 15: (Continued) Description of the stratigraphic profile of Unit A, Machachi.

MACHACHI UNIT A

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION



III. ABANDONMENT, EROSION, AND SEDIMENTATION

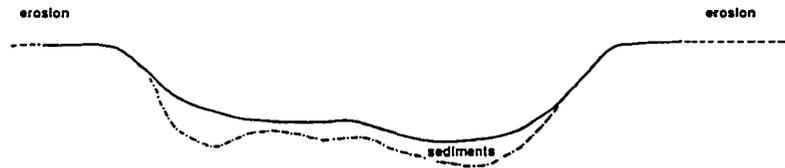


Figure 16: Reconstruction of stages of construction and abandonment based on profile of Unit A, Machachi Pampa.

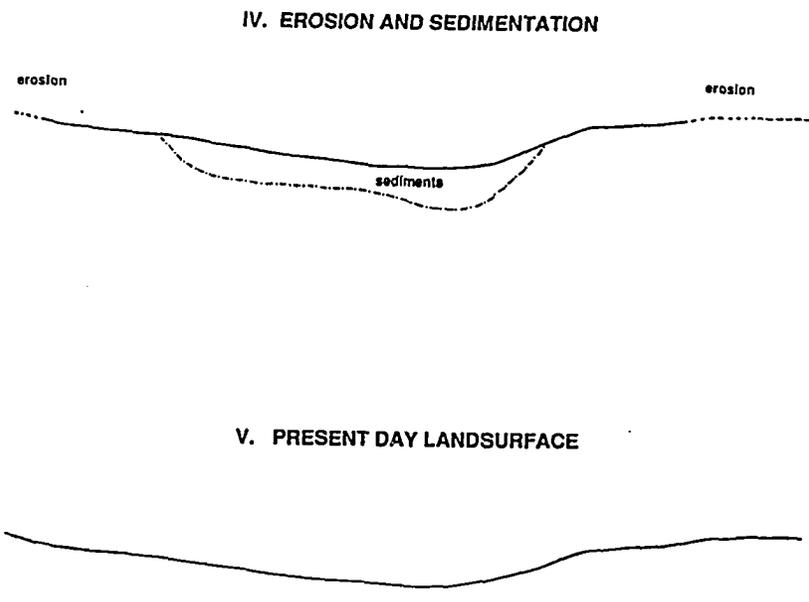


Figure 16: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit A, Machachi Pampa.

Stratum G, a dark reddish-brown waterlogged silty sand, is the lowermost sediment within the profile. Stratum F, a dark yellowish-brown sandy silt loam with yellowish-brown mottling lies between Stratum G and Stratum E, a thin layer of banded laminar brown/dark brown sandy clay. Above this lies Stratum D, a dark yellowish-brown sandy silt loam with dark brown inclusions and yellowish-brown mottling. The lower portion of this layer shows laminar sediment banding. Strata D, E, F and G represent a series of alluvial sediments, possibly deposited in the backwater environment of the old river course.

The canal excavated into Stratum D from 1 W to 4 W is evidence of early raised field construction. The irregular base of the canal suggests that it was periodically re-excavated during canal cleaning or expanded at several different times. To the east of 1 W and west of 4 W, the original surfaces can be seen as the interface between Strata D and B. These areas were not disturbed during the during the construction or cultivation of the raised fields. Stratum B, a dark reddish-brown clay loam with some calcium carbonate concretions, was the raised field fill which also later eroded into the canals. No additional raised field improvements can be seen in the profile. Stratum C, a thin black organic-rich clay loam, was probably deposited during a period of stabilization, after the canals half-filled with erosional sediments. Stratum A, a dark brown clay loam with rootlets of chinca and chiji (Quechua: pampa grasses) formed in the upper portion of Stratum B after weathering.

3.3.3 PPu7-58 Viscachani Pampa Unit A

(Figures 17-19)

Viscachani Pampa is located north of the hill of Huatta, and 2 km northwest of the town, in a shallow depression. This area was probably a shallow lake in the past, and is still seasonally waterlogged and often partially inundated. The raised fields within this pampa are part of a very complex integrated system of raised fields, all in an excellent state of preservation. There are a wide variety of forms and sizes. The most common is the embanked form, but many raised fields of the open checkerboard pattern are interspersed within the others. Many large, deep, straight canals criss-cross the pampa here, dividing the raised field into distinct blocks. In nearly all cases, these canals are integrated into the agricultural system, indicating they were constructed at the same time or possibly before the raised fields were built. As discussed in the section on functions of raised fields, these canals do not appear to "drain" the lowlying area, but were used to bring water into area.

Two stratigraphic units were excavated here, Unit A and Unit D. Unit A was located between the centers of two narrow raised field platforms in a well preserved-block of fields surrounded by an embankment. The stratigraphic trench included all of the canal and half of the adjacent raised field platforms. The



Figure 17: Aerial photograph showing the context of excavation Unit A and Unit D at Viscachani Pampa.

VISCACHANI PAMPA

PP47-58

UNIT A

EAST PROFILE

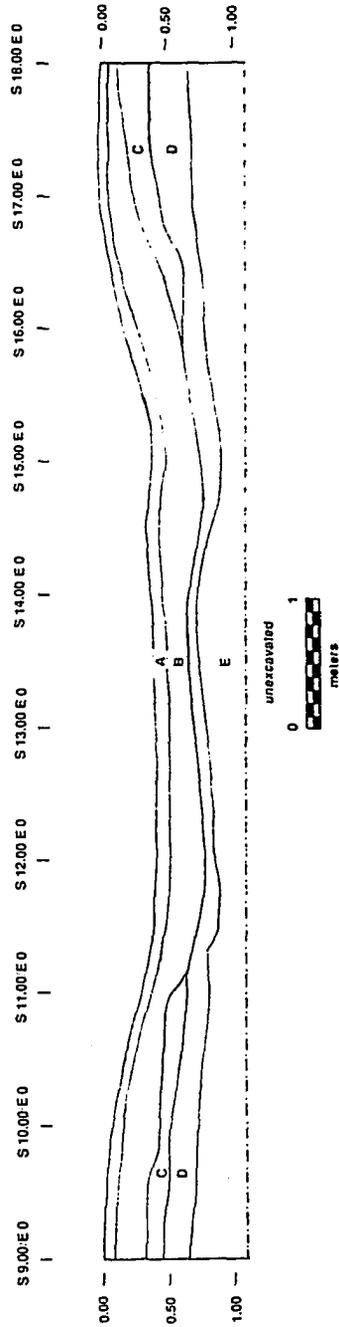


Figure 18: Stratigraphic profile of Unit A, Viscachani Pampa.

Viscachani Pampa
PPu7-58
Unit A
East Profile

- A: dark brown (10YR3/3) sandy clay loam; chinca and chiji rootlets; humus; friable.
- B: very dark grayish-brown (10YR3/2) sandy clay loam; blocky prismatic structure; some rootlets; pH 6.95 in center section; gradual boundary.
- C: dark grayish-brown (10YR4/2) sandy clay loam; dark yellowish brown (10YR4/6) mottling; clear boundary.
- D: dark brown (7YR3/2) [in upper section] to dark yellowish brown (10YR4/3) [in lower section] sandy clay loam, moist, similar to Stratum B; organic stains; clear boundary.
- E: yellowish brown (10YR5/4) clay loam; waterlogged, no organic staining; small 1-2 cm calcium carbonate concretions, compact; abrupt boundary.

Figure 18: (Continued) Description of the stratigraphic profile of Unit A, Viscachani Pampa.

VISCACHANI PAMPA UNIT A

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: STAGE A



III. EROSION, SEDIMENTATION, AND RAISED FIELD CONSTRUCTION: STAGE B

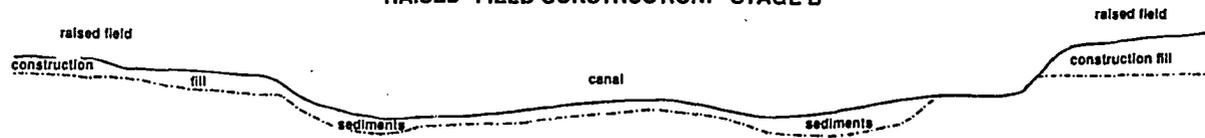
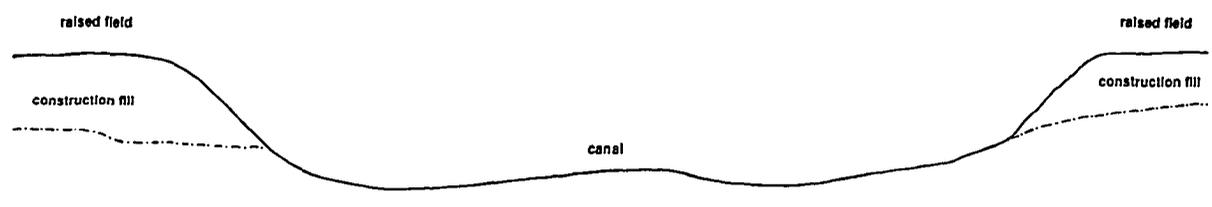
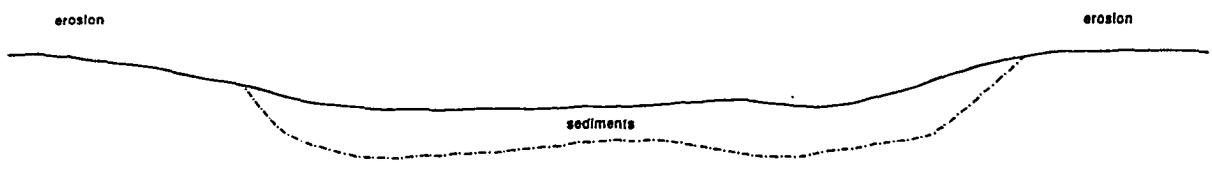


Figure 19: Reconstruction of stages of construction and abandonment based on profile of Unit A, Viscachani Pampa.

IV. RAISED FIELD CONSTRUCTION: STAGE C



V. ABANDONMENT, EROSION, AND SEDIMENTATION



VI. PRESENT DAY LANDSURFACE

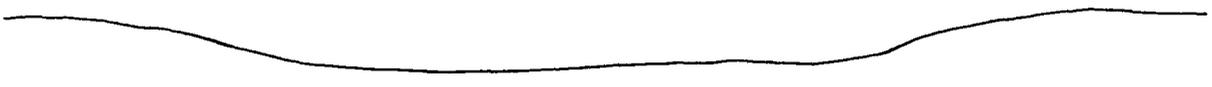


Figure 19: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit A, Viscachani Pampa.

excavation unit was oriented north/south and measured 9.0 x 1.0 x 1.1 meters.

The stratigraphy of Unit A indicates a single phase of raised field construction and use, but this phase can be subdivided into several distinct stages of raised field improvement. The lowermost stratum, Stratum E, is a compact yellowish-brown clay loam with calcium carbonate concretions. It was below the water table in September of 1982. Above Stratum E in the north section of the profile is Stratum D, the lower part of which is a dark yellowish-brown sandy clay loam. This appears to be a buried A Horizon or a buried accumulation of organic muck because it contains dark organic staining. A sherd found in the middle of this stratum indicates that this was once an original surface.

Evidence of the first raised field construction (Stage A) in Unit A is the wide canal excavated into Strata E and D which provided construction fill for two raised field platforms, one at S 11.2 which extends beyond the limits of the profile trench to the north, and the other at S 17.5, extending beyond the limits of the trench to the south. This first construction fill, the upper portion of Stratum D, is a dark brown sandy clay loam with organic stains. These raised fields were probably 40 cm tall. A second sherd was found near the interface with Stratum F in the south section. These platforms eroded, and this material probably combined with alluvial sediments to partially fill the canals. During use of these fields, the base of the canal filled with sediments represented by Stratum D in the center section of

the profile. These sediments are composed primarily of material which eroding into the canal from the adjacent raised field platforms because of its similarity to stratum D in the raised field construction fill. In addition, this eroded material is probably combined with alluvial sediments carried by flowing water. In a second stage of raised field construction (Stage B), the canal sediments were partially excavated to provide additional construction fill (Stratum C), to increase the platform elevation to approximately 60 cm above the canal base. A final, third, addition of construction fill to the raised fields (Stage C) is seen in Stratum B, a very dark grayish-brown sandy clay loam with dark yellowish-brown mottling in the north and south sections, where organic material accumulating as sediment was removed from the canals to increase the elevation of the raised fields to at least 80 cm.

After abandonment, the raised fields eroded and sediments filled the canal with very dark grayish-brown sandy clay loam, Stratum B in the center section of the profile. After some time, an A Horizon (Stratum A, a dark brown sandy clay loam) formed on the surface of the eroded raised field platform and canal.

In the raised fields of the profile of Unit A (and also Unit D), sediment originating from outside the local system was continually deposited in the canals. This was periodically removed by the prehistoric farmers to increase the elevation of the raised fields and, at the same time, clean the canals. The amount of sediment deposited since the first evidence of raised

field construction is considerable. The large amount of construction fill eventually used for the raised field platforms did not come just from the soil removed to create the initial Stage A canal. The raised field platforms were approximately 4 meters wide and the canal was 5 meters wide. The larger canal-to-raised field platform ratio was probably necessary to obtain sufficient fill for the initial construction, to elevate the planting surfaces above the seasonally high water table in this low-lying pampa. With sediments continually collecting in the canals between the platforms, the farmers had a source of construction fill which enabled them to continue elevating the fields.

The sherds from Unit A were submitted to the TL laboratory but were found to be undatable. A small concentration of wood charcoal, found within Stratum D in the south section of the raised field construction fill, is interpreted as evidence of a prehistoric earth oven (wathia) similar to that used by contemporary Quechua farmers to bake new potatoes in the field during harvest. This sample was submitted to the radiocarbon laboratory of the Illinois Geological Survey but was found undatable due to manganese replacement of all the carbon in the sample.

3.3.4 PPU7-58 Viscachani Pampa Unit D

(Figures 17, 20, and 21)

The second raised field profile trench at Viscachani Pampa was Unit D, located 300 meters southwest of Unit A. The raised fields in this area were relatively very well-preserved, with a maximum height of 70 cm from the base of the sediment-filled canal to the eroded field surfaces. Unit A measured 6.0 x 1.0 x 1.2 meters and was oriented north/south. Because of the large size of raised fields (16 meter wavelength) in this part of Viscachani Pampa, the trench profiled only the northern quarter of an east/west oriented raised field platform and the southern half of the adjacent canal to the north. The raised field in the profile of Unit D appears to represent a single phase of construction.

The lowermost stratum of Unit A is Stratum L, a grayish-brown sandy loam. Above Stratum L in the south section of the profile is Stratum G, a compact brown clay with laminar structure indicating an alluvial origin. Stratum G, a thin 1 cm layer of brown clay, Stratum F a grayish-brown sandy loam with rootstain mottling, and Stratum E, a thin 1 cm layer of brown clay, formed as sediments on Stratum L. The inclination of these strata is probably the result of ridge and swale topography associated with an abandoned river channel and levee, possibly that of the Rio Coata.

The first evidence of raised field construction (Stage A) is a large wide canal that was created by excavating through Strata

VISCACHANI PAMPA

PPu7-58

UNIT D

WEST PROFILE

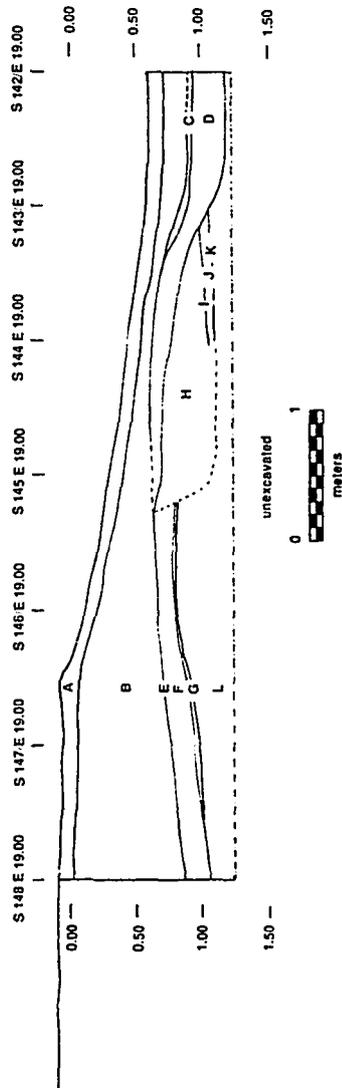


Figure 20: Stratigraphic profile of Unit D, Viscachani Pampa.

Viscachani Pampa

PPu7-58

Unit D

West Profile

- A: brown/dark brown (10YR4/3) sandy clay loam; friable in center section, humus; more compact on south section; rootlets of chiji and chinca.
- B: very dark grayish-brown (10YR3/2) sandy clay loam; rootlet stains; pH 9.22 in south section; gradual boundary.
- C: very dark gray (10YR3/1) sandy clay loam; thin stratum; clear boundary.
- D: very dark grayish-brown (10YR3/2) sandy clay loam; friable non-compact; waterlogged; pH 7.68; clear boundary.
- E: brown (10YR5/3) clay; compact thin stratum of 1 cm. thickness; clear boundary.
- F: grayish brown (10YR5/2) sandy loam; rootstains; clear boundary.
- G: brown (10YR5/3) clay; compact thin stratum of 1 cm thickness; clear boundary.
- H: grayish brown (10YR5/2) sandy loam; rootstains; clear boundary.
- I: brown (10YR5/3) clay; compact thin stratum of 1 cm.; gradual boundary.
- J: grayish brown (10YR5/2) sandy loam; rootstains; gradual boundary.
- K: brown (10YR5/3) clay; compact laminar structure; gradual boundary.
- L: grayish brown (10YR5/2) sandy loam; rootstains; clear boundary

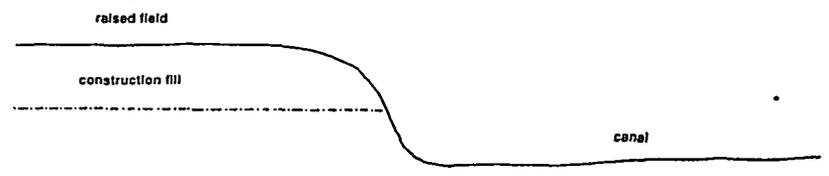
Figure 20: (Continued) Description of the stratigraphic profile of Unit D, Viscachani Pampa.

VISCACHANI PAMPA UNIT D

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: STAGE A



III. SEDIMENTATION AND RAISED FIELD CONSTRUCTION: STAGE B

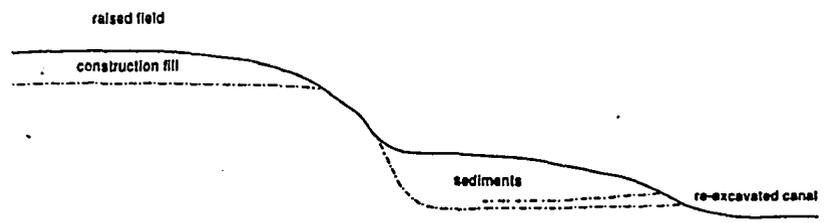
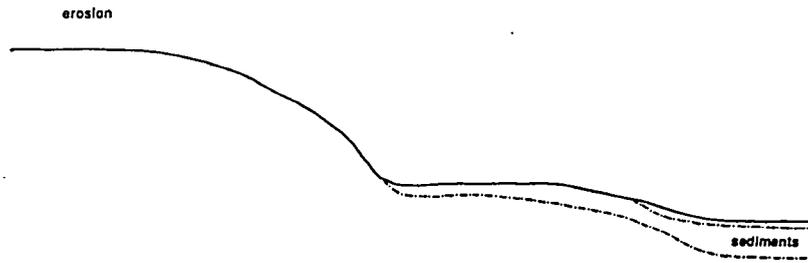


Figure 21: Reconstruction of stages of construction and abandonment based on profile of Unit D, Viscachani Pampa.

IV. ABANDONMENT, EROSION, AND SEDIMENTATION



V. EROSION AND SEDIMENTATION



VI. PRESENT DAY LANDSURFACE



Figure 21: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit D, Viscachani Pampa.

E, F, G and L, extending in the profile from S 145.3 to the northern limits of excavation. The earth from this canal was used to fill the swale at the southern section of the profile and elevate a large raised field platform 8 meters wide with a wavelength of 16 meters. The fill of this raised field was the lower part of Stratum B at the south end of the profile. This canal gradually filled with sediments. The base of the canal contains Stratum K, a brown clay with laminar structure, followed by Stratum J, a grayish-brown sandy loam, and Stratum I, a thin brown clay layer. A large part of the sediments in the canal are Stratum H, a grayish-brown sandy loam with rootstain mottling. This sediment-filled canal was later re-excavated to the north of S 143.5. The material from this canal was used as construction fill for the Stage B fields, Stratum B, a very dark grayish-brown sandy clay loam. The canal partially filled with sediments, Stratum D, a very dark grayish-brown friable sandy clay loam. Stratum C, a very dark gray sandy clay loam with organic matter staining, probably is a mixture of alluvial and lacustrine sediments, material eroded from the adjacent raised fields, and the accumulation of organic mucks in the canal base. Later the canal was filled to its present level with material identical to the construction fill, Stratum B, a very dark grayish-brown sandy clay loam. The uppermost layer is Stratum A, a 10-12 cm A Horizon with humus and rootlets of chinca, ichhu and chiji. The height between canal and raised field surface in Phase II would have been at least 125 cm when the raised fields

were in use and the canals free of sediment. As in the case of Unit A at Viscachani Pampa, their location in a depression probably caused rapid sedimentation. The periodic removal of these organic rich sediments provided additional material to increase the elevation of the raised field surfaces.

The single phase of raised field construction documented in Unit D of Viscachani Pampa is difficult to understand. In other locations where large raised fields were present in the profiles, there were shorter wavelength Phase I raised fields stratigraphically below them, demonstrating an evolution from small to large fields through time. In this case, the initial fields are huge, 16 meter wavelength, fields and no clear evidence of smaller early fields are present. If there were earlier fields, they may have been destroyed in the excavation of the large and deep canals present in the profile. The sloping strata E, F, G, and L may be the edge of an early short wavelength raised field, but this does not compare to other Phase I profiles.

3.3.5 PFu7-47 Kaminaga Unit C

(Figure 22-24)

The pampa of Kaminaga is adjacent to the present shoreline of Lake Titicaca, an area that is seasonally inundated. This pampa is often under water throughout most of the year. The most common form of raised field in Kaminaga Pampa is irregular

embanked, oval or round blocks of raised fields surrounded by a low dike which was also used as a planting platform. Severe inundation and wave action has heavily eroded most of these fields and sediments have filled the canals. The blocks of raised fields are of variable dimensions, ranging from 50 to 200 meters in diameter. The raised fields within the embankments are oriented either north-south or east/west. The alternation of oriented blocks of raised fields is very similar to the open checkerboard pattern in drier areas of the pampa. On the aerial photographs, there appears to be a superposition of later embanked raised fields constructed on or integrated with older embanked raised fields and non-embanked narrow raised fields.

Also within the zone are abandoned river courses, probably earlier channels and mouths of the Rio Illpa and/or Rio Coata, which flood during the wet season. Several were straightened and channelized in prehistoric times, presumably for access by balsa boat to the lake from the various occupation mounds. Along the flooded levees and in the channels of these rivers are long raised fields of the curvilinear form. These are rows of narrow (1.0-2.0 meters wide) parallel raised fields of lengths ranging from tens of meters to hundreds of meters.

One of the better preserved embanked raised fields was selected for excavation. Unit C was located approximately 300 meters north of the site of Kaminaqa, a 300 x 150 x 4 meter prehistoric occupation mound 8 km southwest of the town of Huatta (Erickson 1988). Unit C measured 13.0 x 1.0 x 1.2 meters and

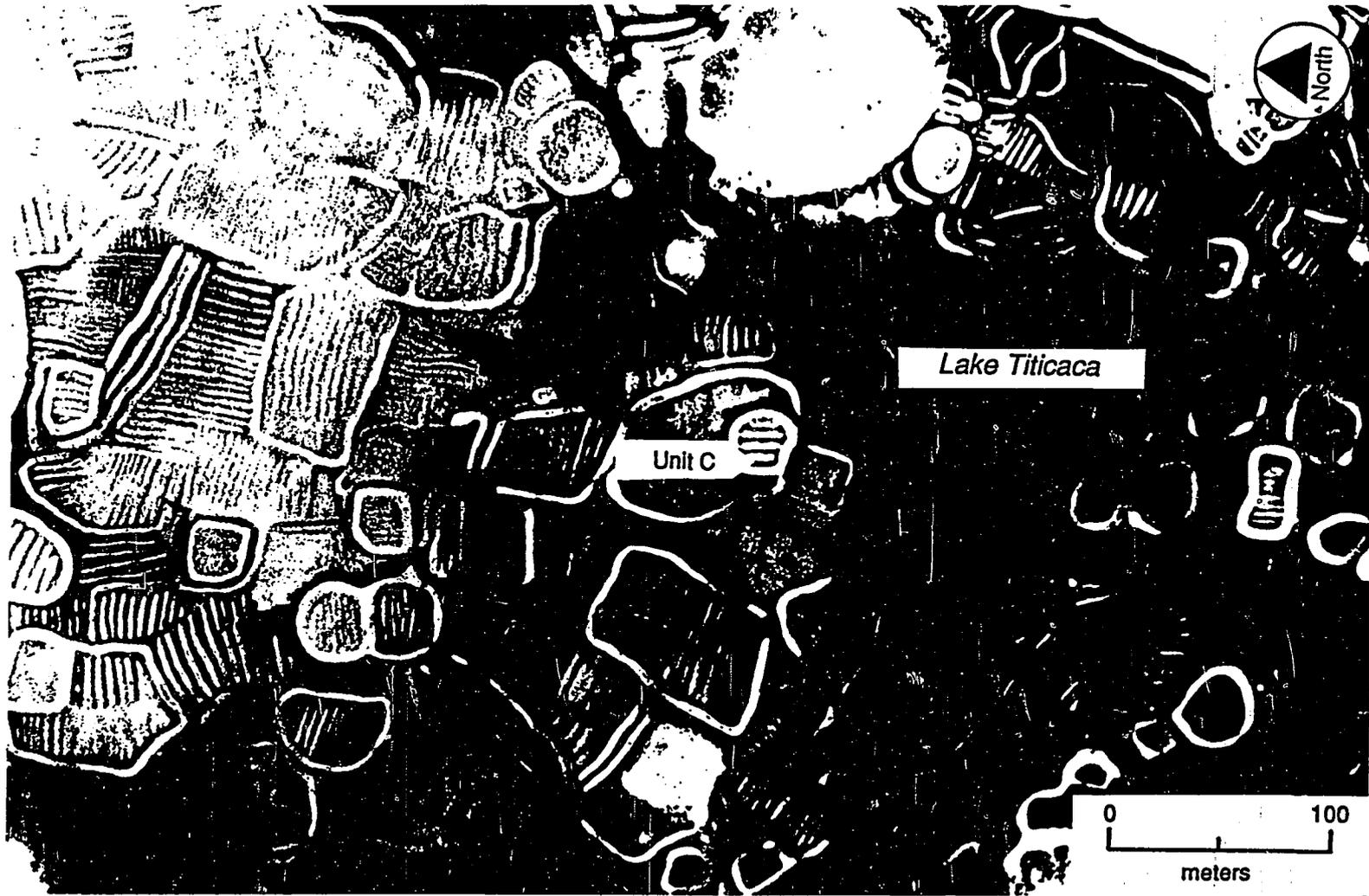


Figure 22: Aerial photograph showing the context of excavation Unit A at Kaminaga.

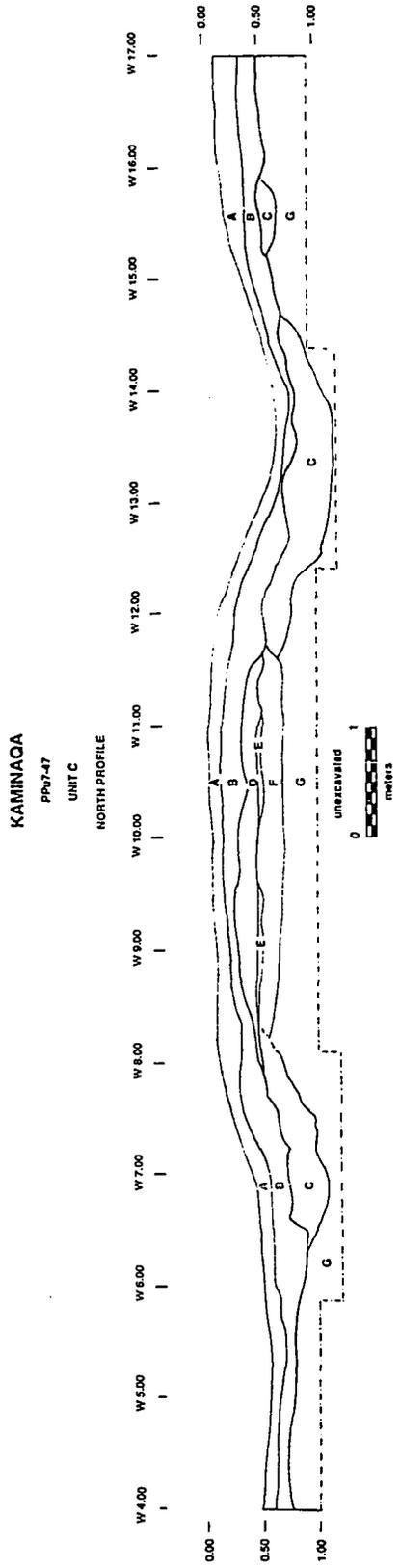


Figure 23: Stratigraphic profile of Unit C, Kaminaga.

Kaminaqa
PPu7-47
Unit C
North Profile

- A: very dark grayish-brown (10YR3/2) sandy loam in canals and sandy clay loam in raised fields; compact; humus; rootlets of chinca and chiji; pH 7.67 in raised fields; pH 5.86 in canals.
- B: dark brown (10YR3/3) sandy clay loam; compact; calcium carbonate concretions of up to 1 cm diameter in raised field sections; columnar structure when dry; rootlets; gradual boundary.
- C: dark brown (10YR3/3) to very dark grayish-brown (10YR3/2) sandy loam; relatively homogeneous; gradual boundary.
- D: very dark gray (10YR3/1) clay loam; organic brown (10YR4/3) mottling; includes thin organic lense; clear boundary.
- E: dark brown (10YR3/3) clay loam, uneven base; homogeneous; clear boundary.
- F: brown/dark brown (10YR4/3) clay; blocky structure when dry; yellow brown root stains; relatively homogeneous; pH 7.78; abrupt boundary.
- G: brown (10YR4/4) clay in upper section and changing to a sandy clay loam with calcium carbonate concretions in lower section; waterlogged; pH 7.70 in upper section and pH 6.38 in lower section; abrupt boundary.

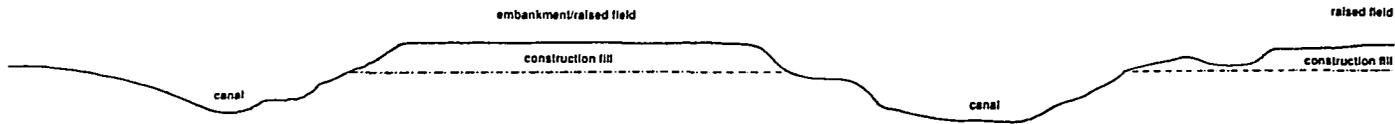
Figure 23: (Continued) Description of the stratigraphic profile of Unit C, Kaminaqa.

KAMINAQA UNIT C

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: STAGE A



III. RAISED FIELD CONSTRUCTION: STAGE B

EROSION AND SEDIMENTATION

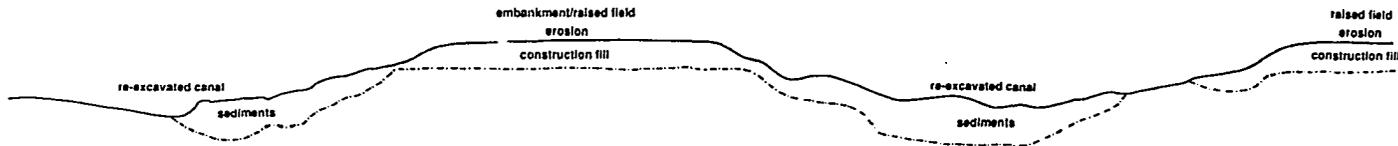


Figure 24: Reconstruction of stages of construction and abandonment based on profile of Unit C, Kaminaqa.

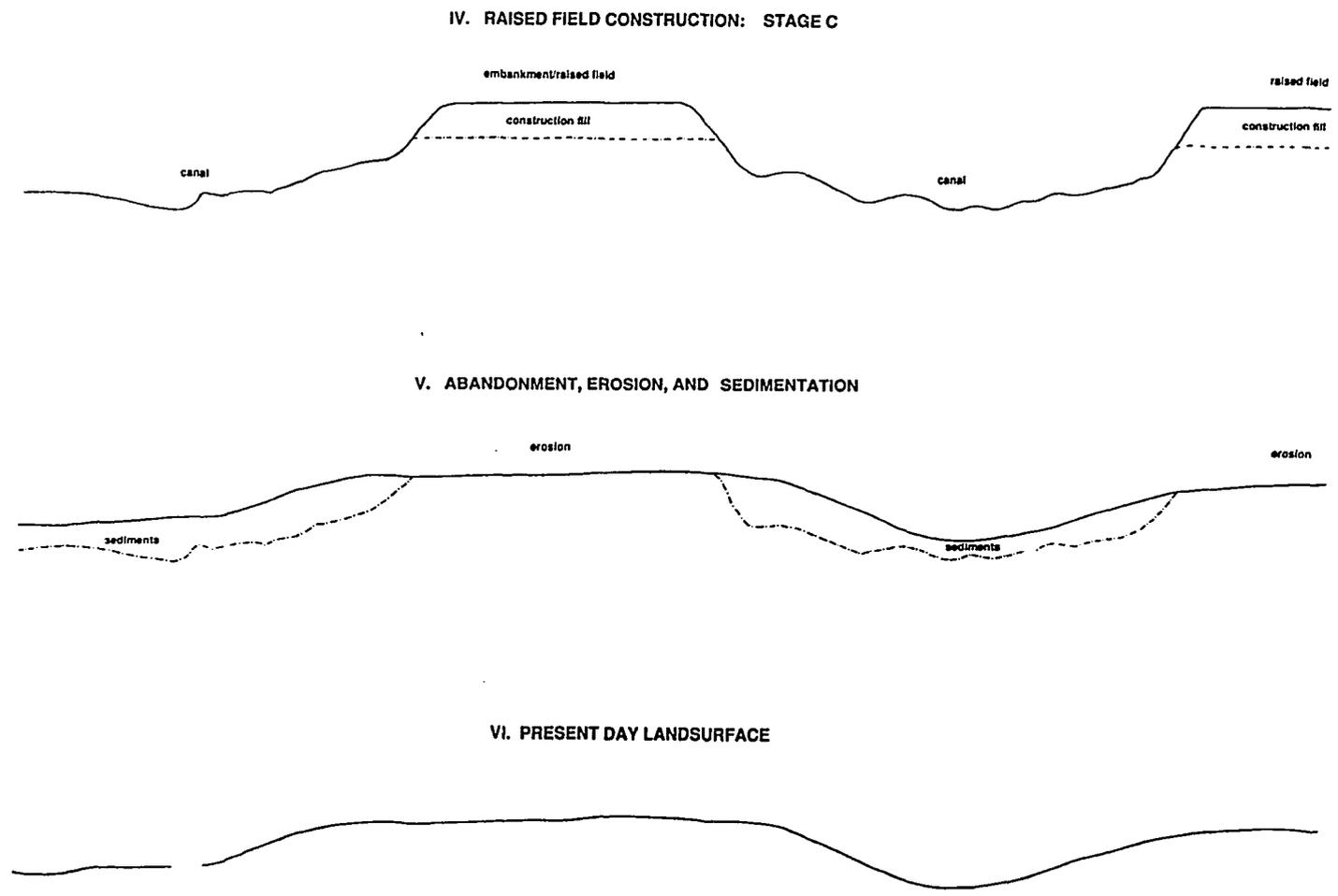


Figure 24: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit C, Kaminaga.

perpendicularly cut half of a raised field platform, the embankment to the east, the canal between them and the canal to the east.

The lower profile of Unit C documents several major sedimentary alluvial deposits. The waterlogged subsoil, Stratum G, a brown sandy clay loam with calcium carbonate concretions in the lower section and a brown clay in the upper section, probably represents a lacustrine sediment. Stratum F, a brown/dark brown clay lies above Stratum G and appears to be a buried A Horizon or lacustrine organic sediment, the surface when the raised fields were initially constructed.

The raised fields in the profile of Unit C at Kaminaqa appear to be of a single phase, with several stages of construction to increase the elevation of the planting surfaces. Excavation of the outer embankment canal, centered at W 7.0, and the inner canal at W 13.3, occurred during Stage A. These canals were approximately 2.5 meters wide and 60-70 cm deep. Earth from these canals was used as construction fill for the raised fields and embankment. This resulted in increasing the thickness of Stratum F (possibly double) and this Stage A fill may include Stratum E, a thin dark brown clay loam in the embankment.

The canal bases filled with sediments eroded from the adjacent Stage A raised fields or sediments carried in from outside the embanked field block during heavy flooding. This sediment, Stratum C, a dark brown to very dark grayish-brown sandy loam, nearly filled the canal, possibly during a period of

disuse of these raised fields.

A second stage of elevating the raised fields, Stage B, began with the partial excavation of the canal sediments, evidenced in the irregular upper boundary of Stratum C. This addition of 20 cm of construction fill to the surface of the embankment is visible as Stratum D, a very dark gray clay loam with brown organic staining.

Stage C of raised field construction is indicated by Stratum B, a dark brown sandy clay loam with calcium carbonate concretions. The height from canal base to embankment and raised field surface was increased to at least 80 cm. These incremental construction stages increased the elevation of the surfaces of the raised fields to levels that would withstand the seasonal inundation in a "normal" year. In addition, the tall embankment would have been a barrier to the flow of saline lake water into the raised field block, conserving the sweet rainwater within the raised field block (see Erickson 1988).

After final abandonment of these raised fields, the planting surfaces eroded and, with sediments deposited by the lake, again partially filled the canals. On the surface, Stratum A, a relatively well-developed A horizon, formed. A very dark grayish-brown sandy loam is found on the canals, and a sandy clay loam is found on the raised field surfaces.

Several TL samples were taken from the excavation of Unit C, but were unsuitable for dating. One sherd was recovered from below the embankment canal, probably driven into the soft muck

of the canal and underlying subsoil during an early episode of canal maintenance.

Although the stratigraphic profile only documents one major phase of raised field construction, aerial photographs for this area suggest that these fields are superimposed on an older, more extensive raised field embankment block (Figure 22). The superposition is evidenced by the better preservation of the Unit C block in contrast to the badly eroded block on the aerial photographs. The block with Unit C also was constructed by excavating a canal around its embankment, which, on the aerial photograph, clearly cuts the raised field platforms of the other block. This interpretation is supported by the sizes of the raised field blocks; the Unit C block has long wavelength fields, in contrast to the short wavelength fields of the other block. This other block possibly represents Phase I raised fields, while Unit C may be Phase II raised fields.

3.3.6 PPU7-60 Ccoccope Pampa Unit A

(Figure 25-27)

Ccoccope Pampa is located at the foot of the hill of Huatta, 1 km southwest of the town. The raised fields are of an irregular open checkerboard pattern, relatively well-organized bundles of raised fields oriented north/south and east/west. The orderly pattern is disrupted in places by riverine or caño pattern and embanked pattern raised fields, associated with the eroded

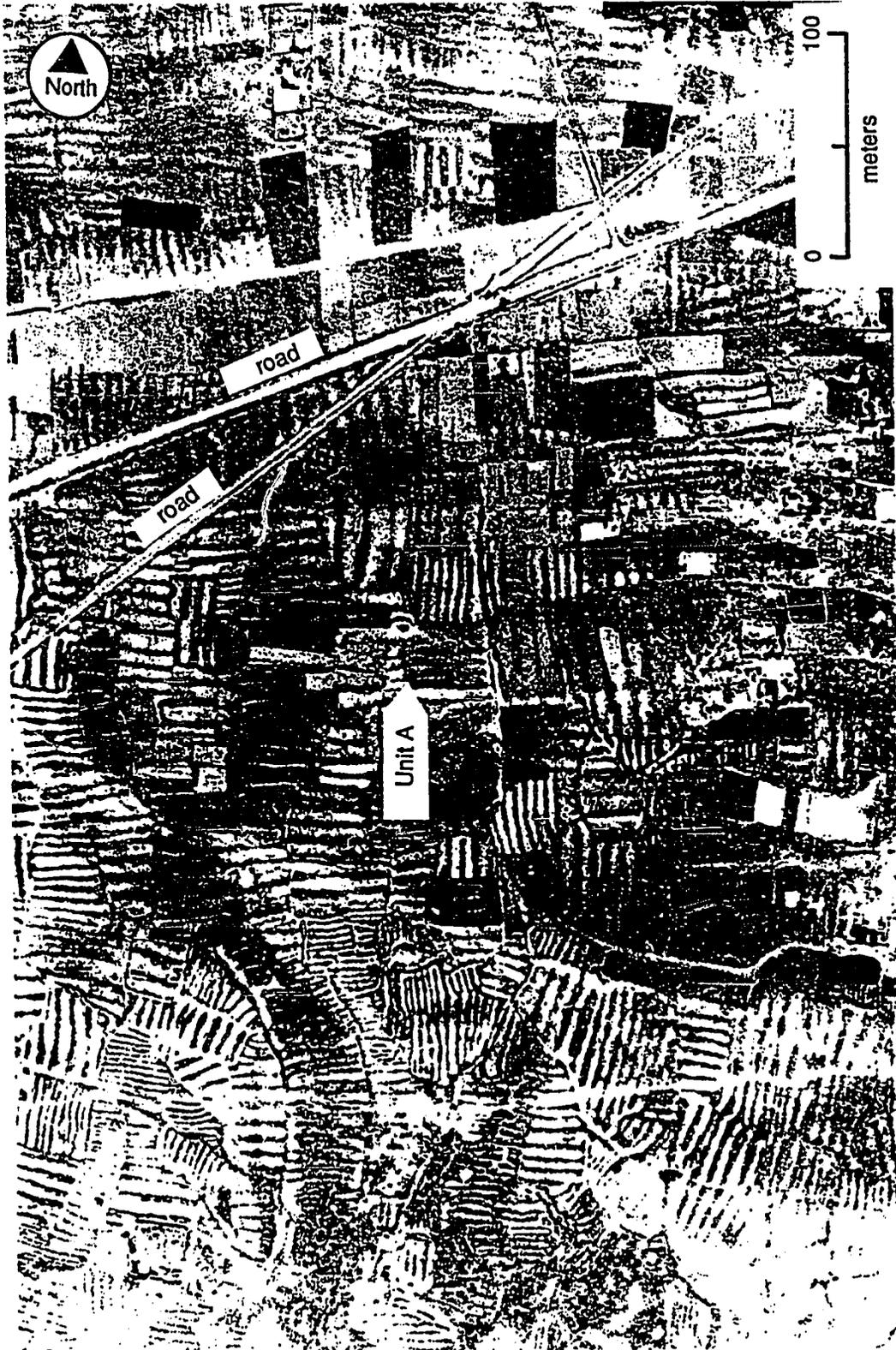


Figure 25: Aerial photograph showing the context of excavation Unit A at Coccope Pampa.

CCOCCOPE

PPu7-60

UNIT A

EAST PROFILE

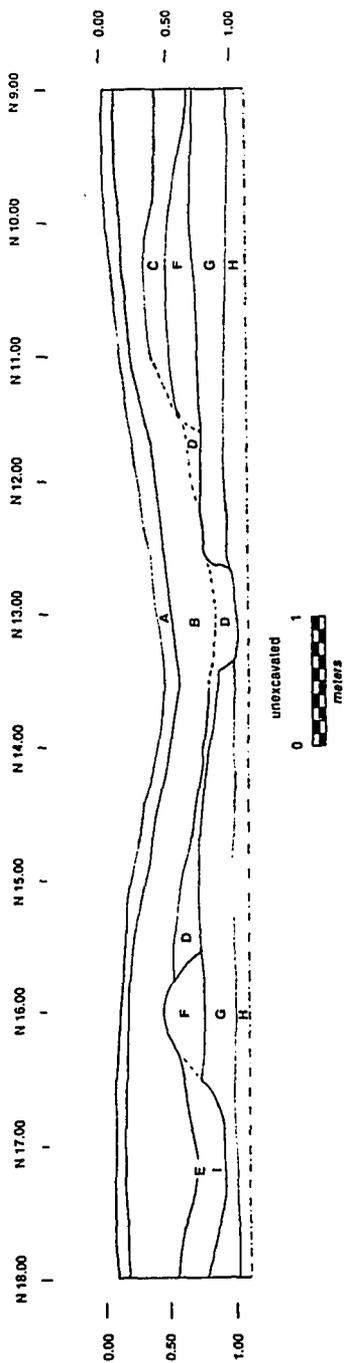


Figure 26: Stratigraphic profile of Unit A, Ccooccope Pampa.

Cocope Pampa:
PPu7-60
Unit A
East Profile

- A: dark brown (10YR3/3) sandy clay in center section and sandy clay loam in north and south sections; humus; chiji and chinca rootlets; friable, homogeneous; pH 5.44 in canal; pH 6.69 in raised fields.
- B: very dark gray (10YR3/1) sandy clay in center section and sandy clay loam in north and south sections; fine pea gravel; white calcium (?) mottling; pH 8.39 in canal; pH 7.76 in raised field fill; gradual boundary.
- C: brown/dark brown (10YR4/3) clay; not clear in the north section; pH 7.94; gradual boundary.
- D: dark yellowish-brown (10YR3/4) clay loam; pea gravel; clear boundary
- E: dark gray (10YR4/1) clay loam; only present in north section; thin (1 cm) laminar stratum; abrupt boundary.
- F: brown/dark brown (10YR4/3) clay loam; dense consistency; calcium carbonate concretions; white calcium mottling; gradual boundary.
- G: dark brown (10YR3/3) clay loam; some fine sand and pea gravel; abrupt boundary.
- H: dark brown (10YR3/3) sandy loam; organic stains; mottling; gradual boundary.
- I: very dark gray brown (10YR3/2) sandy loam (check); pH 7.79; clear boundary.

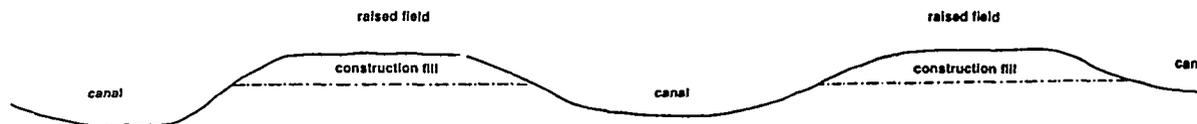
Figure 26: (Continued) Description of the stratigraphic profile of Unit A, Cocope Pampa.

CCOCOPE UNIT A

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: PHASE I



III. ABANDONMENT, SEDIMENTATION, AND

RAISED FIELD CONSTRUCTION: PHASE II

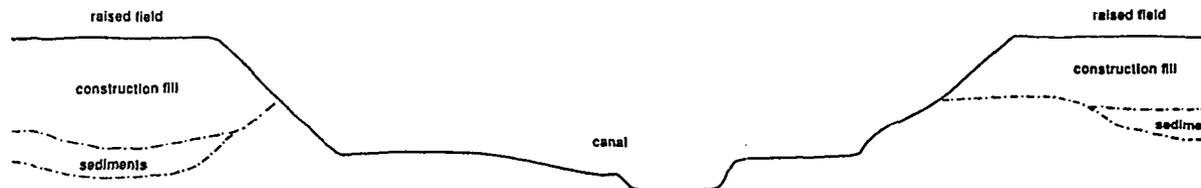
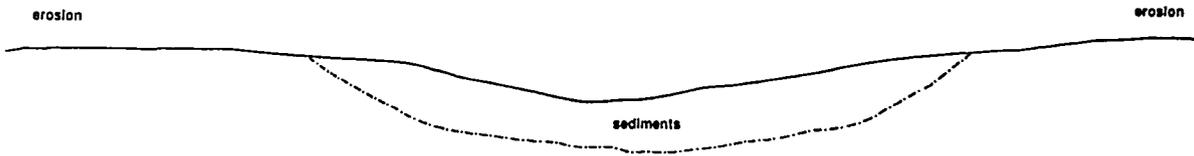


Figure 27: Reconstruction of stages of construction and abandonment based on profile of Unit A, Ccoccope Pampa.

IV. EROSION AND SEDIMENTATION



V. ABANDONMENT, EROSION AND SEDIMENTATION



VI. PRESENT DAY LANDSURFACE.



Figure 27: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit A, Ccoccope

topographic features of an abandoned river channel. The raised fields have approximately 9 meter wavelengths, and a height of 45 cm, measured from sediment-filled canal to eroded surface of the raised field platforms. The raised fields of Coccope Pampa are near the abandoned meander channel of a river, possibly a previous channel of the Rio Coata. This is now a seasonal watercourse called the Wilpa Mayu. A large stratum of sand is cut by the road as it crosses this abandoned river course near the profile trench.

Unit A was excavated between the crests of two east/west-oriented raised fields and included the canal between them. The unit was oriented 5 degrees west of north and measured 9.00 x 1.00 x 1.10 meters. The profile of Unit A shows two distinct periods of raised field construction, Phase I and Phase II.

Stratum H, a dark brown sandy loam with organic rootstain mottling and calcium carbonate concretions is the lowermost stratigraphic layer. This stratum lies below Stratum G, a dark brown clay loam with pea gravel. Stratum F, a brown/dark brown clay loam with calcium carbonate concretions and dense texture lies above Stratum G. These three sedimentary strata, F, G, and H, judging by their relatively coarse texture classes, are of alluvial origin. Evidence of the earliest raised field construction here is a wide canal cut into Stratum F and Stratum G at N 16.5 to N 18.0. The north quarter of another canal can be seen at the extreme south section of the profile between N 9.0 and N 9.5. These are designated as Phase I canals. Another Phase

I canal was probably located somewhere centered near N 13.0, but evidence of this canal would have been destroyed by the excavation of the large Phase II canal at N 11.5 to N 14.5. The construction fill of the Phase I raised fields includes the upper half of Stratum F, a brown/dark brown clay loam with calcium carbonate concretions, removed from the lower subsoil during canal excavation. The wavelength of these raised fields is estimated to be 3-4 meters. In a period when the Phase I raised fields were apparently no longer in use, the canals filled in with sediment, Stratum I, a very dark brown sandy loam. The uppermost sedimentation of the Phase I canals produced Stratum E, a thin dark gray clay loam with laminar structure indicating water deposition.

A later period of raised field construction, Phase II, is also evident in the profile. A wide canal is visible in the central section of the profile, between N 11.5 and N 15.8. This canal cut into Stratum F (90 cm BD in the profile). The earth from this canal excavation was used to increase the wavelength to 8-9 meters, by filling alternate Phase I canals and incorporating them into the wider Phase II planting platforms. This construction fill is Stratum C, a brown/dark brown clay (not clear in the north section) and Stratum B, a very dark gray sandy clay loam with calcium carbonate concretions and pea gravel from the subsoil strata. Extrapolation from the size of the canals indicates that the height of the raised field surface from the canal base would have been 1.5 meters. This is assuming that the

earth removed from the canals was uniformly placed on both adjacent raised field platforms.

The base of the Phase II canal filled in with sediments (Stratum D, a dark yellowish-brown clay loam), which probably eroded from the adjacent raised field platforms. This may have happened during use of the raised fields or shortly thereafter.

After the final period of Phase II raised field use, the canals gradually filled with sediments, Stratum B (center section of profile), a sandy clay. The boundary of the raised fields and the canal in Stratum B is not clear since much of the material that filled the canal probably eroded directly from adjacent raised field platforms. The areas corresponding to canals in this stratum contained a higher percentage of clay, which suggests a substantial amount of sediments deposited during flooding. Stratum A, a dark brown sandy clay in the center section of the profile, and a sandy clay loam in the north and south sections of the profile, formed long after abandonment and the sedimentation of the canal.

No TL dates are available for this excavation unit.

3.3.7 PPU7-46 Jucchata Unit A

(Figures 28-30).

Unit A was located 150 meters west of the site of Jucchata (PPU7-46), a small (100 x 300 x 2 meter) prehistoric occupation mound approximately 2 km east of the town of Huatta. In years of

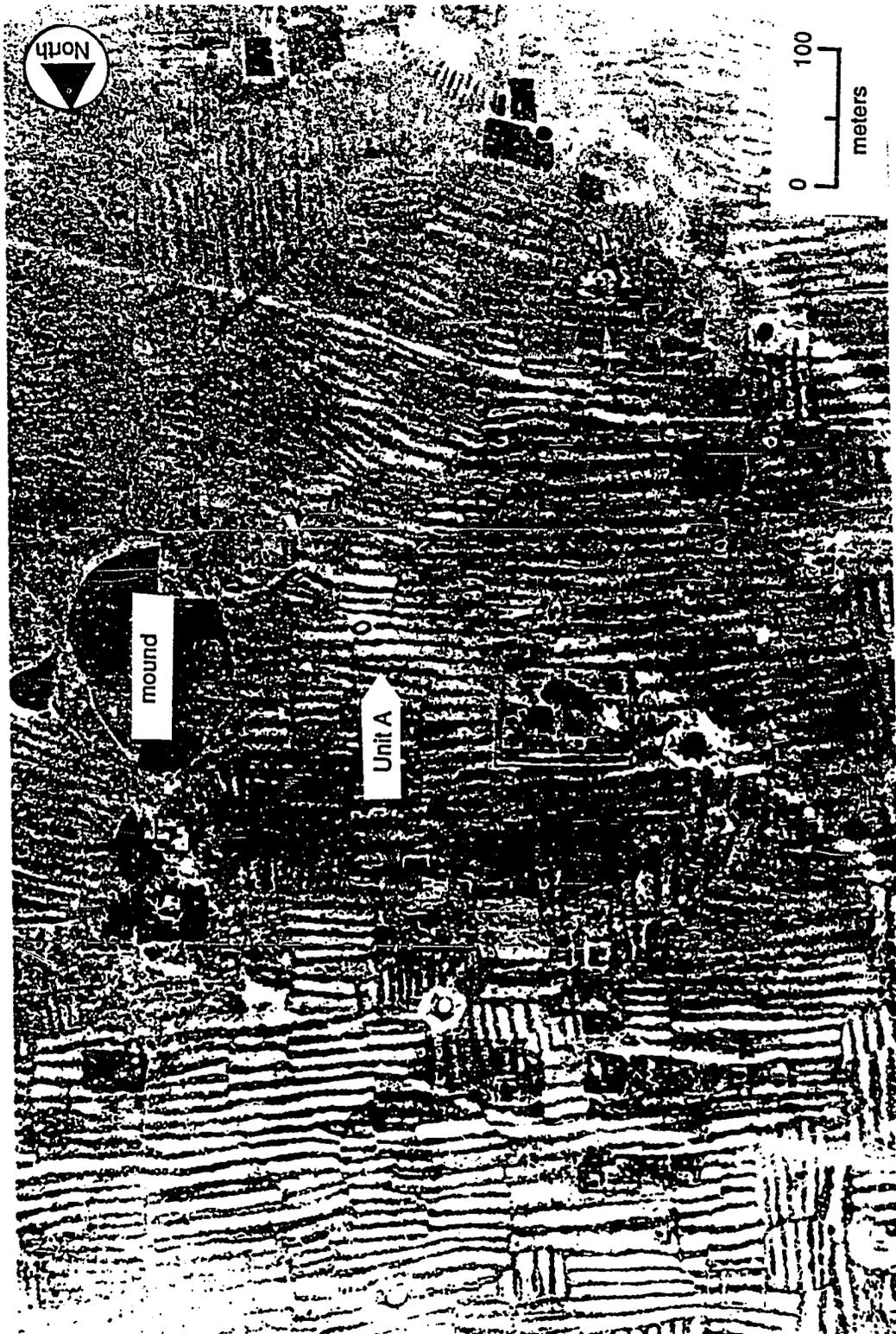


Figure 28: Aerial photograph showing the context of excavation Unit A at Jucchata.

JUCCHATA

PP107-46

UNIT A

EAST PROFILE

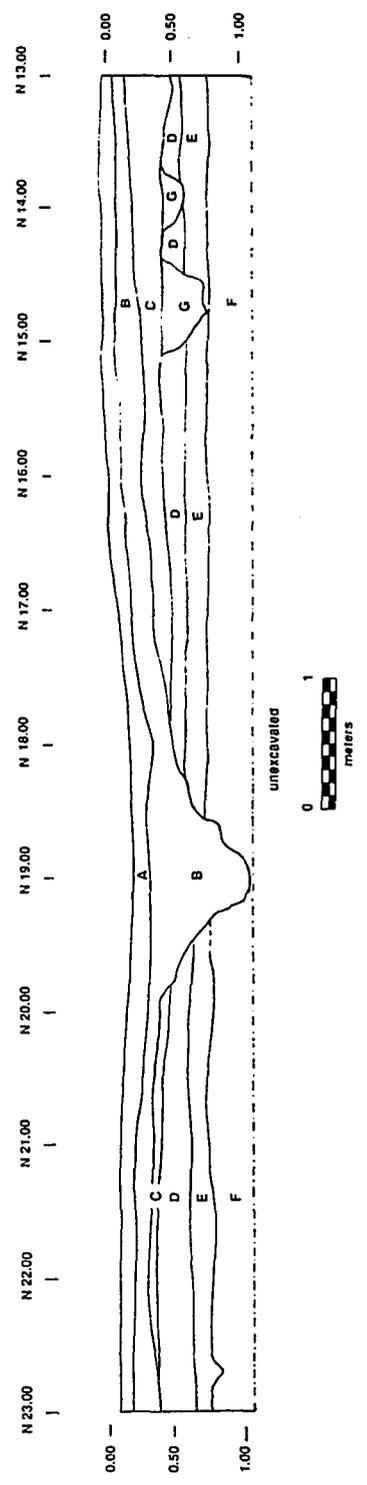


Figure 29: Stratigraphic profile of Unit A, Jucchata.

Jucchata:
PPu7-46
Unit A
East Profile

- A: dark brown (10YR3/3) sandy clay loam; chinca and chiji rootlets; humus; friable; with yellowish-brown oxidized root stains, pH 4.63 in canal; pH 6.23 on raised fields.
- B: very dark grayish-brown (10YR3/2) clay; compact; homogeneous; pH 8.3 in center section; pH 7.54 in north and south section; gradual boundary.
- C: dark brown (10YR3/3) clay; yellowish-brown mottling; some calcium carbonate concretions; pH 8.13; clear boundary.
- D: brown/dark brown (10YR4/3) sandy loam; fine laminar structure; dark yellowish-brown (10YR4/6) mottling, oxidized root stains; pH 8.62; abrupt boundary.
- E: dark reddish brown (5YR3/3) clay; very compact; some calcium carbonate concretions; pH 8.84; abrupt boundary.
- F: brown/dark brown (10YR4/3) clay loam; wet; yellowish red (5YR3/8) mottling; columnar structure; pH 8.82; abrupt boundary.
- G: dark brown (10YR3/3) clay; compact; homogeneous; clear boundary.

Figure 29: (Continued) Description of the stratigraphic profile of Unit A, Jucchata.

JUCCHATA UNIT A

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: PHASE I

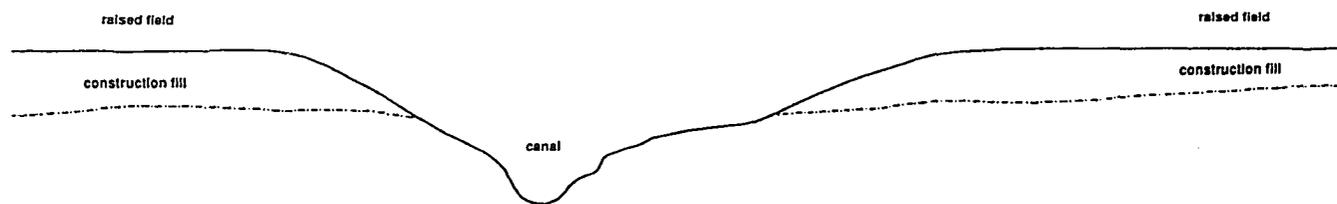


III. ABANDONMENT AND RAISED FIELD CONSTRUCTION: PHASE II-A

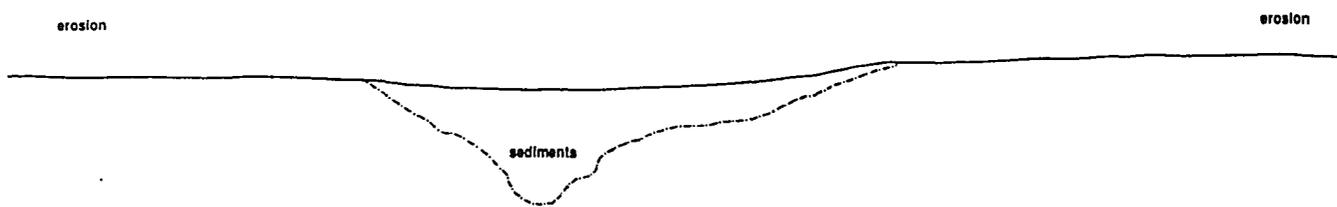


Figure 30: Reconstruction of stages of construction and abandonment based on profile of Unit A, Jucchata.

IV. RAISED FIELD CONSTRUCTION: PHASE II-B



V. ABANDONMENT, EROSION, AND SEDIMENTATION



VI. PRESENT DAY LANDSURFACE



Figure 30: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit A, Jucchata.

heavy rainfall, this low mound becomes an island within Lake Titicaca, and is one of the few areas presently cultivated in this part of the pampa. The prehistoric raised fields associated with this site have eroded raised platforms with a wavelength of 9-10 meters, are 640 meters in length, and are approximately 20 cm higher than the sediment-filled canals. These raised fields are generally parallel, oriented east/west, in a linear pattern. Shallow canals cross the raised field platforms every 80-150 meters. Unit A was oriented north/south, extending between the centers of two raised field platforms to include the canal between them. Unit A measured 10 x 1 x 1 meters.

The lowermost stratum of Unit A is Stratum F, a brown/dark brown clay loam with yellowish-red mottling and calcium carbonate concretions. This stratum lies below Stratum E, a dark reddish-brown very compact clay also containing some calcium carbonate concretions. Next is Stratum E, a brown/dark brown sandy loam with dark yellowish-brown rootstain mottling, and a fine laminar structure. Strata D, E, and F are the original sedimentary strata of Unit A. The horizontal bedding of each, and the fine laminar structure of Stratum D, suggest an alluvial origin, and/or a lacustrine origin in the case of the fine-textured clays of Stratum E. The raised fields of Jucchata are located approximately 3 km downstream from the present mouth of the Rio Coata, a medium-sized river which seasonally carries a substantial sediment load. As mentioned above, the area is also occasionally inundated by the lake.

The first evidence of human modification is the uneven wavy interface between Stratum D and Stratum C, a dark brown clay with yellowish-brown rootstain mottling. Two small canals, centered at N 13.95 and at N 14.60, were cut into Stratum D and Stratum E and it appears that the earth from these canals was used to construct the first (Phase I) raised fields. Why two small canals were constructed adjacent to each other during the same construction phase is not known. The one to the south may have become filled with sediments, and the northern one excavated to replace it or vice versa. These two features may simply be an uneven base of a single truncated large canal. It may also be that these features represent natural erosion channels from intermittent streams crossing the pampa, without any agricultural significance. However, the homogeneity of the sediments in these canals is not characteristic of stream-deposited sediments, and the canals were probably man-made for agricultural activities. The large canal (of later Phase II construction) located at N 18.00 to N 20.00 would have destroyed any stratigraphic evidence of a Phase I canal located there. As has been shown in other stratigraphic profiles, later phase canals were often cut into the smaller, earlier canals. Assuming this to be the case here, the wavelength of the Phase I raised fields at Juchata would have been 4.25 meters. The Phase I canals were narrow in relation to the width of the associated raised fields and may have initially represented more of a "ditching" effort than the actual substantial elevation of raised

fields. The original surface of these Phase I raised field platforms is not clear from the stratigraphy, but must have been at least 40 cm from raised field surface to canal base judging from the canal depth. These Phase I raised fields were not maintained for a period, and sediments filled the canals. Stratum G, is a dark brown compact homogeneous clay with some organic laminar microstrata. These fine clay sediments appear to have been deposited by the lake or the backwaters of the Rio Coata, and through erosion from the adjacent Phase I raised fields planting surfaces.

In Phase II, a large deep canal centered at N 19.00 was excavated through Strata C, D, E, and F to reach the water table and to provide construction fill to elevate the raised field platform. The first additions to Phase II raised field construction fill were Stratum C, a dark brown clay with yellowish-brown rootstain mottling and calcium carbonate concretions, probably mixed in from material excavated in the lower subsoil; and Stratum B in the north and south sections of the profile, a very dark grayish-brown compact homogeneous clay. The wavelength of the Phase II raised fields is approximately 9 meters. The height from canal base to raised field surface was minimally 100 cm, and possibly 120 cm, before the upper surfaces finally eroded. The construction of the Phase II raised fields can be clearly divided into at least two stages. During Stage A (represented by Stratum C), alternate Phase I canals were filled and incorporated into larger Phase II platforms; during Stage B

a second construction fill (Stratum B) was added to the surface of the raised field platforms. Since Stratum C construction fill is clearly cut by the last canal excavation, the Phase II canal may have been enlarged and deepened several times.

After the final period of use and maintenance of the raised fields, the canals filled with very dark grayish-brown homogeneous clay sediments, identical to the upper construction fill of the Phase II raised fields. These sediments are probably a combination of soil eroded from the adjacent raised field surfaces, the accumulation of fine sediments brought in by the river and lake, and the steady accumulation of organic mucks in the canal. A sherd recovered from the base of the canal sediments produced a TL date of A.D. 380 ± 320 years (DUR TL 35-1AS). This would date the later period of use of the Phase II raised fields, or shortly thereafter. Eventually, Stratum A, a dark brown sandy clay loam with yellowish-brown oxidized rootstains and dark organic humus, formed on the surface of the eroded raised fields and canal.

3.3.8 PPU7-28 Pancha Unit M

(Figures 31-33)

The raised fields of Pancha Pampa are very diverse. Most of the area near the prehistoric habitation site of Pancha has microtopography related to abandoned river channel formations such as low wide levees, meander scars, and lowlying backwater



Figure 31: Aerial photograph showing the context of excavation Unit M and Unit NOPQ at Pancha.

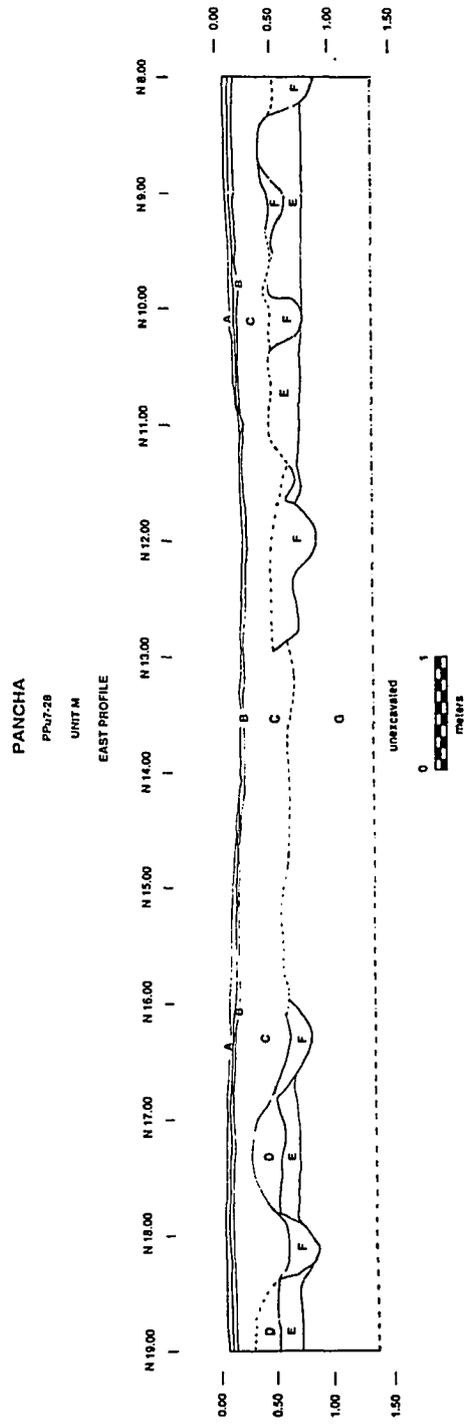


Figure 32: Stratigraphic profile of Unit M, Pancha.

Pancha
PPu7-28
Unit M
East Profile

- A: yellowish brown (10YR5/4) sandy loam; thin plowzone; friable; humus; homogeneous structure.
- B: very dark grayish-brown (10YR3/2) sandy clay loam; blocky structure when dry; rootlets of chinca and chiji; humus; abrupt boundary.
- C: very dark grayish-brown (10YR3/2) silty clay loam; homogeneous; blocky structure when dry; 1 cm diameter white mottling; gradual boundary.
- D: very dark grayish brown (10YR3/2) silty clay loam; homogeneous; blocky structure when dry; 1 cm diameter white mottling; gradual boundary.
- E: very dark gray (10YR3/1) silty clay loam; dark brown (10YR3/3) silty clay mottling; compact; mixture of subsoil and earlier humus; gradual boundary.
- F: very dark brown (10YR2/2) silty clay; compact; homogeneous; fine silt laminar microstrata; brown organic mottling; some rootlets; gradual boundary.
- G: brown/dark brown (10YR4/3) clay; homogeneous, vertical columnar structure, waterlogged; some organic staining in first 20 cm, more compact with depth; abrupt boundary.

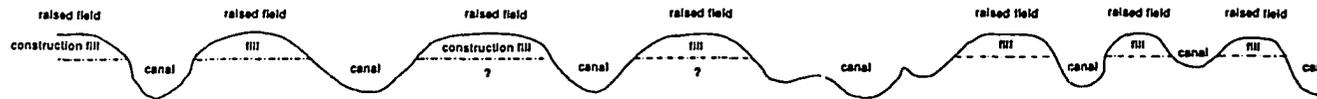
Figure 32: (Continued) Description of the stratigraphic profile of Unit M, Pancha.

PANCHA UNIT M

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: PHASE I



III. ABANDONMENT, EROSION, AND SEDIMENTATION

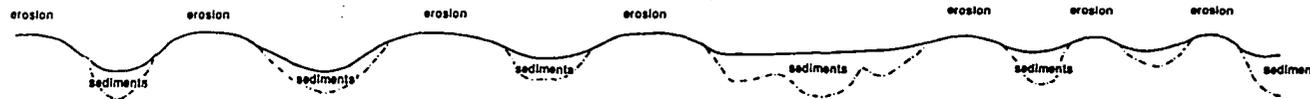


Figure 33: Reconstruction of stages of construction and abandonment based on profile of Unit M, Pancha.

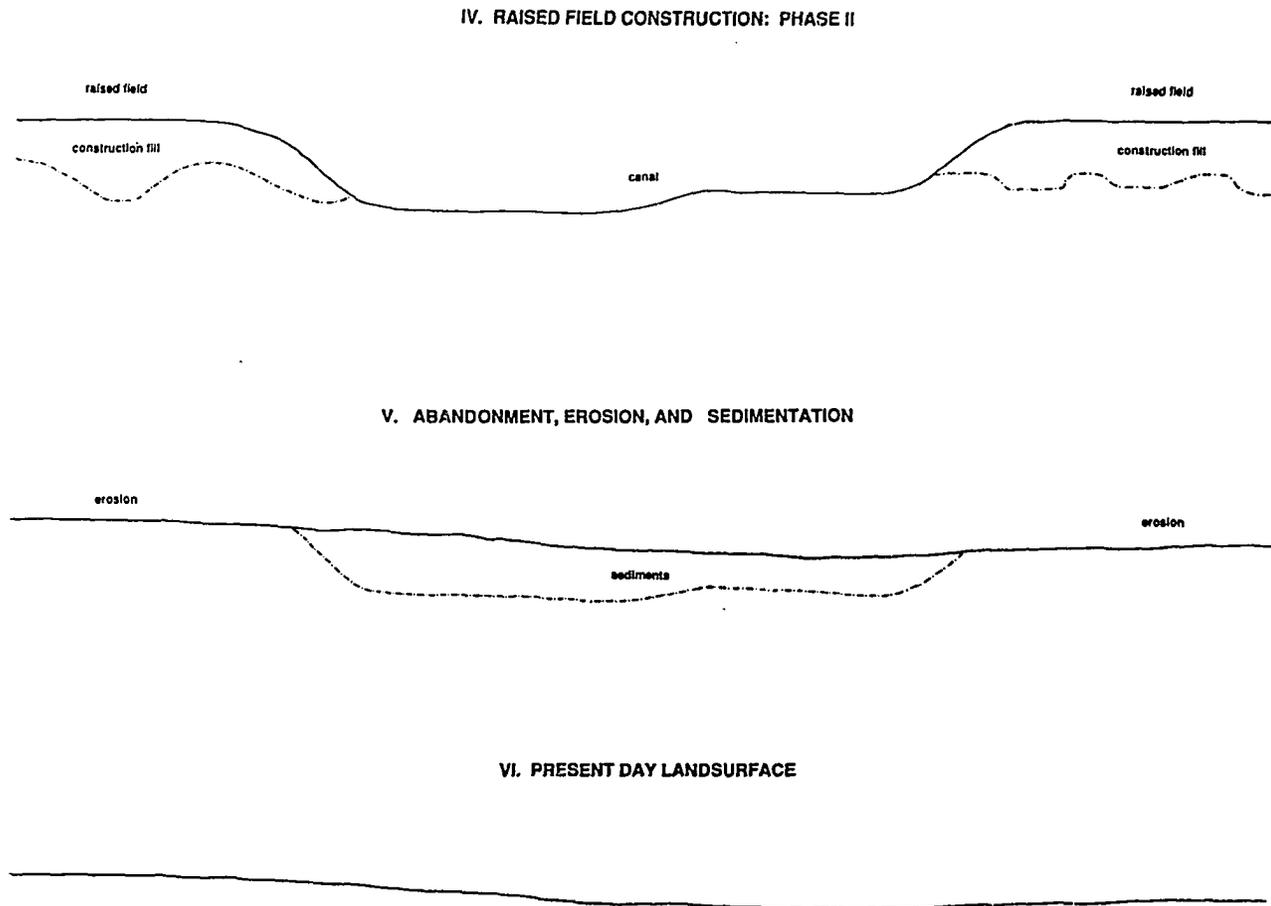


Figure 33: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit M, Pancha.

zones. Most of the raised fields are irregular embanked forms, generally oval blocks, of variable sizes and numbers of raised fields within them, surrounded by a dike and/or canal. Interspersed with this form are some blocks of the open checkerboard type. The diversity of the raised field forms in this area is probably related to the variable microtopography.

Unit M was located in the pampa 200 meters north of the edge of the occupation mound of Pancha (PPu7-28), approximately 4 km southwest of the town of Huatta (Erickson 1988). Unit M was excavated into two very eroded raised field platforms and the canal between them. The excavation unit measured 11.0 x 1.0 x 1.3 meters and was oriented 20 degrees west of north to cut the raised fields and canal perpendicularly.

Within the stratigraphic record of Unit M, two raised field construction phases, again Phase I and Phase II, have been documented.

The lowest layer of Unit M is Stratum G, a brown/dark brown homogeneous waterlogged clay. The fine texture of this stratum and the organic staining in the upper 20 cm indicate that this sediment was deposited in a shallow lake bottom or river backwater. Above Stratum G is Stratum E, 20 cm thick, a very dark gray silty clay loam with dark brown mottling.

Evidence of the earlier raised field construction (Phase I) are 6 canals 40-60 cm wide and 30-40 cm deep with wavelengths of approximately 2 meters. The earth removed from these canals was used as construction fill for small raised fields platforms (1.0-

1.5 meters wide, 60-70 cm tall from canal base to raised field surface). This construction fill between the canals is only faintly visible in the profile as Stratum D, a very dark grayish-brown silty clay loam in the north section of the profile. In the rest of the profile, it is either too similar to the material in Stratum C to be clearly visible or it was disturbed during the Phase II construction. The canal at N 11.3 to N 13.0 was re-excavated several times, probably as it repeatedly filled with sediment. Extrapolating from the location of the 5 best-preserved canals, another Phase I canal should have been centered near N 14.5. If this canal was shallow, evidence of this canal would have been destroyed by the excavation of the later Phase II canal. During a period when the fields were not maintained, the Phase I canals filled with sediments, visible as Stratum F, a very dark brown silty clay with fine laminar microstrata indicating waterborne sediment deposition. A TL sample from near the base of a Stratum F (Phase I) canal sediment dates to 1310 B.C. \pm 660 years (DUR TL 35-5AS).

Some time later, a second phase of raised field construction began. The Phase II raised field platforms have a poorly-defined canal between them. The Phase II canal clearly truncated the sediments (Stratum F) filling the Phase I canals at N 16.5 and N 12.0. The soil excavated from this Phase II canal was used as construction fill, seen as Stratum C, a very dark grayish-brown silty clay loam in the north and south sections of the profile. The base of the canal is not clear, but probably extends 50-60 cm

BD at N 14.0, and may have been excavated to the top of Stratum G. This would explain the unclear boundary between Strata C and G.

During a second period when the fields were not maintained, the fill of the Phase II raised field platforms eroded into the canals between them. This sediment is Stratum C in the center section of the profile, a very dark grayish-brown homogeneous silty clay loam. From the base of these Phase II canal sediments, a TL sample produced a date of A.D. 80 ± 380 years (DUR TL 35-6AS). It is difficult to determine the height of the Phase II raised fields during use because of the severe erosion, but the platforms probably were approximately 70 cm above the canal base. Eventually an A Horizon formed, Stratum B, a very dark grayish-brown sandy clay loam. This stratum was later disturbed by tractor disking, forming Stratum A, a shallow plowzone of yellowish-brown sandy loam.

3.3.9 PPU7-28 Pancha Unit NOPQ

(Figures 10, 31, 34, and 35)

The second profile trench at the site of Pancha was located in a lowlying area at the southern end of the occupation mound. These raised fields abutted the mound and were a likely location for the recovery of in situ artifacts to directly date the raised fields. The raised fields were constructed at the edge of a depression that appears to be part of an old meander scar, possibly an old channel of the Rio Illpa or Rio Coata. This area

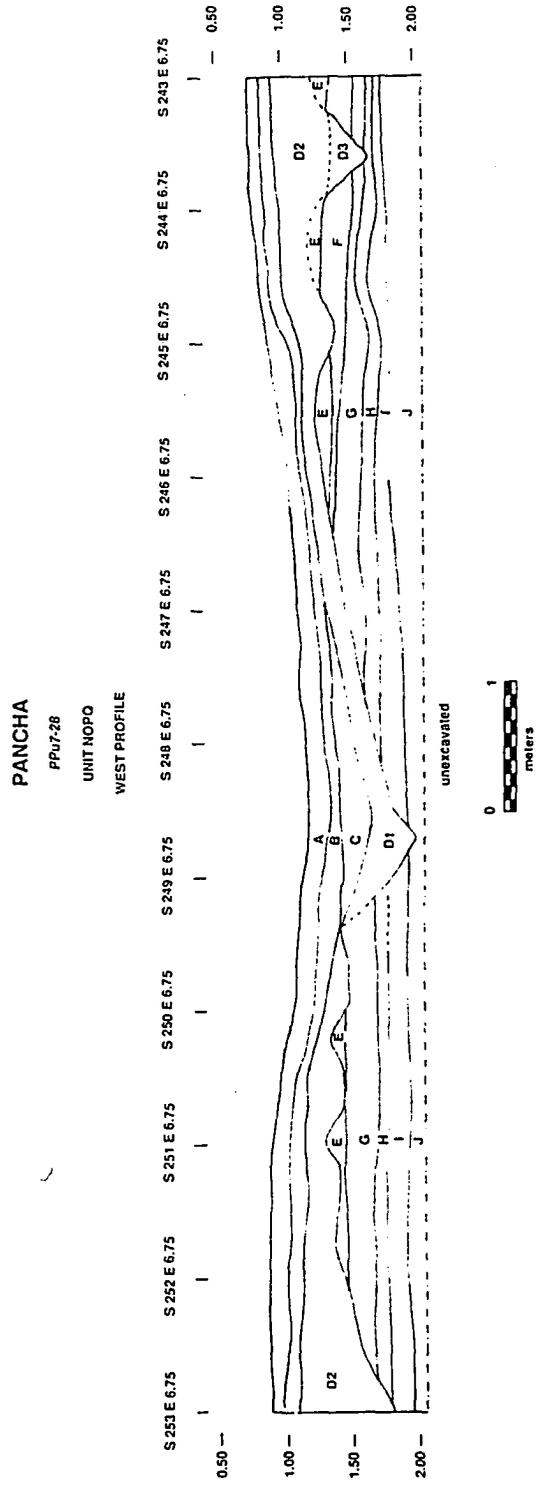


Figure 34: Stratigraphic profile of Unit NOPQ, Pancha.

Pancha
PPu7-28
Units NOPQ

- A: dark brown (10YR3/3) sandy loam; compact, rootlets of chiji and chinca; humus; oxidized rootstains; relatively homogeneous; pH 5.12 in center section.
- B: dark brown (10YR3/3) sandy loam; dark yellowish brown organic rootstains in lower section; compact; gradual boundary.
- C: very dark brown (10YR2/2) sandy loam; compact; pH 6.43; gradual boundary.
- D1: very dark grayish-brown (10YR3/2) sandy clay loam; dark organic staining; relatively homogeneous; pH 6.72; gradual boundary.
- D2: very dark grayish-brown (10YR3/2) sandy loam; relatively homogeneous; compact and dry; pH 9.45; irregular lower boundary.
- D3: very dark grayish brown (10YR3/2) sandy loam; fine horizontal microstrata of alternating clay and silt; compact; dark organic staining; pH 8.70; gradual boundary; identical to south lower section of Stratum D2 but microstrata there not clear.
- E: dark yellowish brown (10YR3/4) sandy clay loam; heterogeneous structure; mixture of subsoil and stratum D; heavy organic mottling; calcium carbonate concretions, especially in base; pH 9.25; gradual boundary.
- F: dark yellowish-brown (10YR3/4) sandy clay loam; similar to Stratum E but with white calcium mottling; clear boundary.
- G: dark brown (10YR3/3) sandy clay loam; yellowish brown (5YR4/6) organic rootstain mottling; pH 9.15; clear boundary.
- H: dark brown (10YR3/3) sandy clay loam; much yellowish-brown organic mottling; pH 8.14; clear boundary.
- I: brown/dark brown (10YR4/3) sandy clay; much organic mottling; clear boundary.
- J: very dark gray (10YR3/1) sandy clay; much organic staining; waterlogged; abrupt boundary.

Figure 34: (Continued) Description of the stratigraphic profile of Unit NOPQ, Pancha.

PANCHA UNIT NOPQ

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: PHASE I



III. ABANDONMENT, EROSION, AND SEDIMENTATION

RAISED FIELD CONSTRUCTION: PHASE II-A

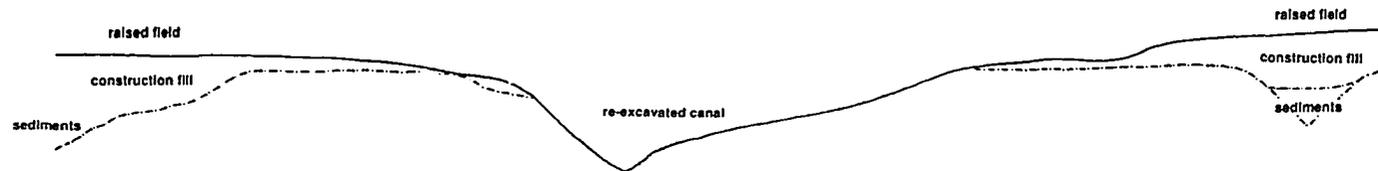


Figure 35: Reconstruction of stages of construction and abandonment based on profile of Unit NOPQ, Pancha.

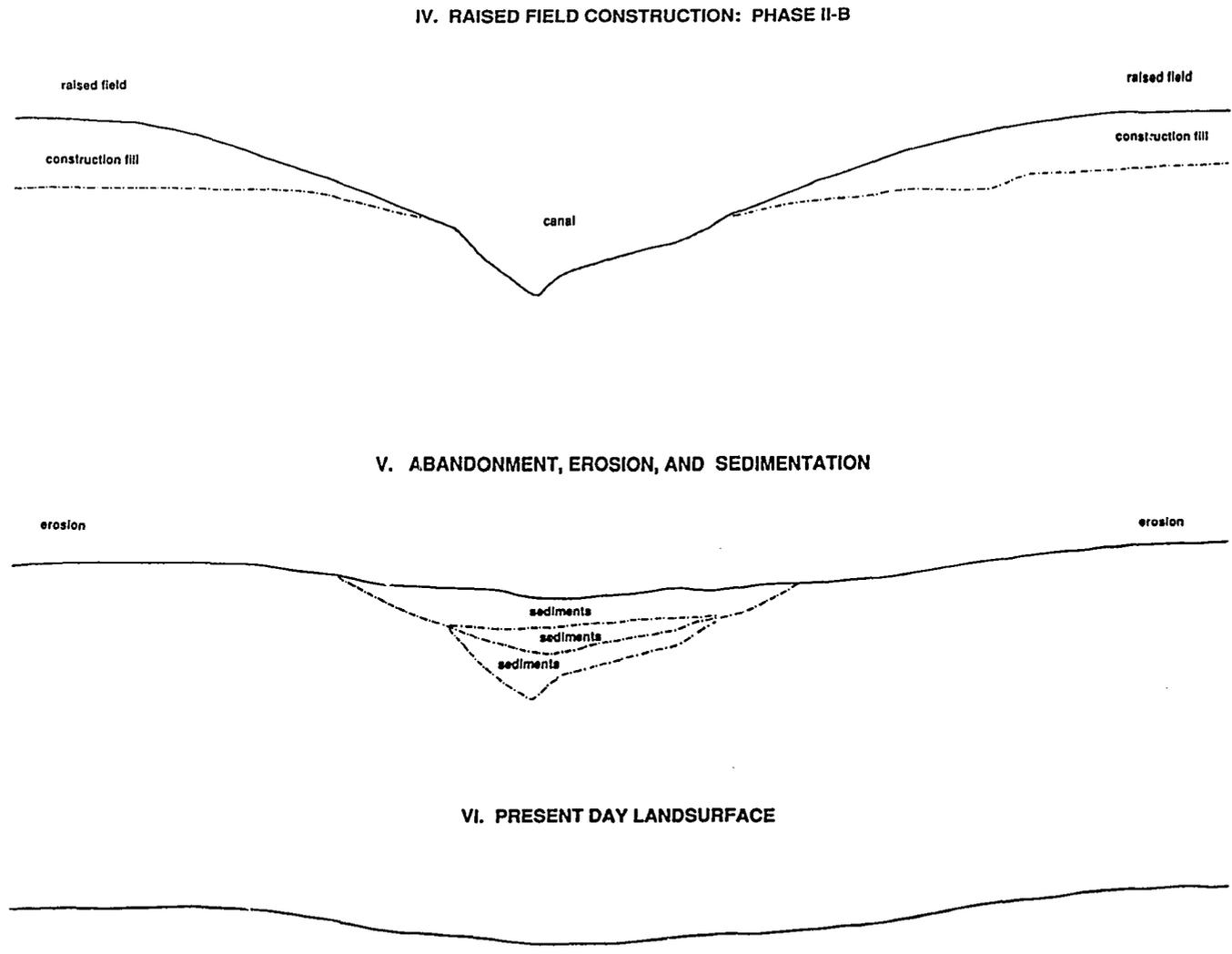


Figure 35: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit NOPQ, Pancha.

may have also been used periodically as a source for borrow material for prehistoric adobe-making and/or mound fill. Excavation Unit N was excavated perpendicular to two east/west oriented raised field platforms, and measured 10.00 x 1.00 x 1.25 meters. Due to the number of artifacts recovered in this unit and the complexity of the stratigraphy, the excavation was extended 1 meter to the west along the entire 10 meter length (Unit OPQ). The new west wall provided the stratigraphic profile.

The lowermost layer in the profile of Unit NOPQ is Stratum J, a very dark gray waterlogged sandy clay with organic staining. This level appears to be an alluvial sediment, possibly from the now-abandoned river course that can be seen on the aerial photographs. Stratum I, a brown/dark brown sandy clay; Stratum H, a dark brown sandy clay loam with yellowish-brown mottling; and Stratum G, a dark brown sandy clay loam, are a series of alluvial backwater sedimentary deposits. There are organic rootstains in the lower portion of Stratum G and the upper portion of Stratum H, indicating that a somewhat stable marsh or backwater lake was present periodically between depositional events.

Two distinct phases are documented in the stratigraphic profile of Unit NOPQ, Phase I and Phase II. The excavation of a series of canals through Strata G, H, I, and J is clear evidence of Phase I raised field construction. The canal centered at S 253 is estimated to be 1.0 meters wide and 60 cm deep (from the

raised field surface) and the canal centered at S 243.6 is 0.8 meters wide and 40-50 cm deep. Another similar Phase I canal was probably present near S 248.5, but evidence of this canal would have been destroyed by the excavation of the Phase II canal. The lower construction fill of the Phase I raised field in the northern section of the profile was Stratum F, a dark yellowish-brown sandy clay loam with calcium mottling. Stratum F was not clear in the southern section, but the upper part of Stratum G probably was the initial fill. Stratum E, a dark yellowish-brown sandy clay loam was added at a later time during Phase I. The Phase I raised fields probably had a wavelength of approximately 5 meters. The height from canal base to raised field surface is estimated to have been at least 50 cm. From Stratum F, construction fill of the raised field at S 244.5, a TL sample produced a date of 400 B.C. \pm 500 years (DUR TL 26-1AS). This would date the initial construction of the Phase I raised fields, as it was recovered from lower construction fill. There was then a period when the Phase I raised fields were apparently not in use, and the canals gradually filled with sediments. The lower portion of the canal located at S 243.5 is filled with thin bands of alluvial or lacustrine sediments, Stratum D3. These banded sediments were not as clear in the canal at S 253. Near the base of the sediments of the canal at S 253.0, a TL date of A.D. 440 \pm 310 years (DUR TL 35-8AS) was obtained. This should date the period when the Phase I canal was not regularly maintained.

After some time, another period of raised field

construction, Phase II, occurred. A much wider field surface was created by capping alternate eroded Phase I canals. These new raised fields had a wavelength of approximately 10 meters, and were at least 1.10 meters high from canal base to raised field surface. Within the construction fill of the Phase II raised fields there is evidence of two distinct stages of construction. The first construction event (Stage A) is represented by Stratum D2 in the south raised field, a very dark grayish-brown sandy clay loam with dark organic staining. During Stage A, what remained of the Phase I canals at S 243.6 and S 253.0 was filled, and the surface was elevated approximately 30 cm. In Stage B of Phase II constructions, Stratum B, a dark brown sandy loam with dark yellowish-brown organic staining, was added to the raised fields, increasing the elevation an additional 20-25 cm.

After the final abandonment of the Phase II raised fields at Pancha the canals filled with two distinct strata of alluvial and/or lacustrine sediments: Stratum D1, a very dark grayish-brown sandy loam; and Stratum C, a very dark brown sandy loam. Stratum B, a dark brown sandy loam with rootstains also eroded into the canals from the surface and edges of the raised fields. The differences in color and soil texture of these sediments filling the Phase II canals may indicate changing local environmental conditions. After the surface of the raised field and canal had stabilized, a thin A Horizon (Stratum A, a dark brown sandy loam with rootlets of chinca and chiii) formed.

Two TL samples were obtained from the Phase II canal

sediments of Stratum D1. They dated to A.D. 1325 \pm 120 years (DUR TL 26-3AS) and A.D. 1540 \pm 90 years (DUR TL 35-7AS). These overlapping samples would post-date the period of use of the Phase II canal.

3.3.10 Pfu7-66 Illpa Unit I

(Figures 36-39)

Two stratigraphic trenches were excavated at the Illpa Substation of the Ministry of Agriculture to guide an experimental raised field reconstruction project. The Illpa pampa is located 14 km west of the town of Huatta and 23 km from the Departmental capital of Puno. The raised fields of the pampa are primarily of the open checkerboard pattern, but there are also many large quadrilateral blocks of fields in an embanked pattern. The raised field systems of this pampa are more directly affected by the hydrology of the Rio Coata than Lake Titicaca. The present course of the river runs approximately 2 km to the south, while the normal lakeshore of Lake Titicaca is located approximately 4 km to the east.

Unit I was located within a large block (approximately 300 x 100 meters) of east/west oriented raised fields enclosed by a low dike or embankment. This block is bordered on two sides by an old meander scar of the Rio Illpa, modified prehistorically through channelization to improve manipulation of hydraulics.

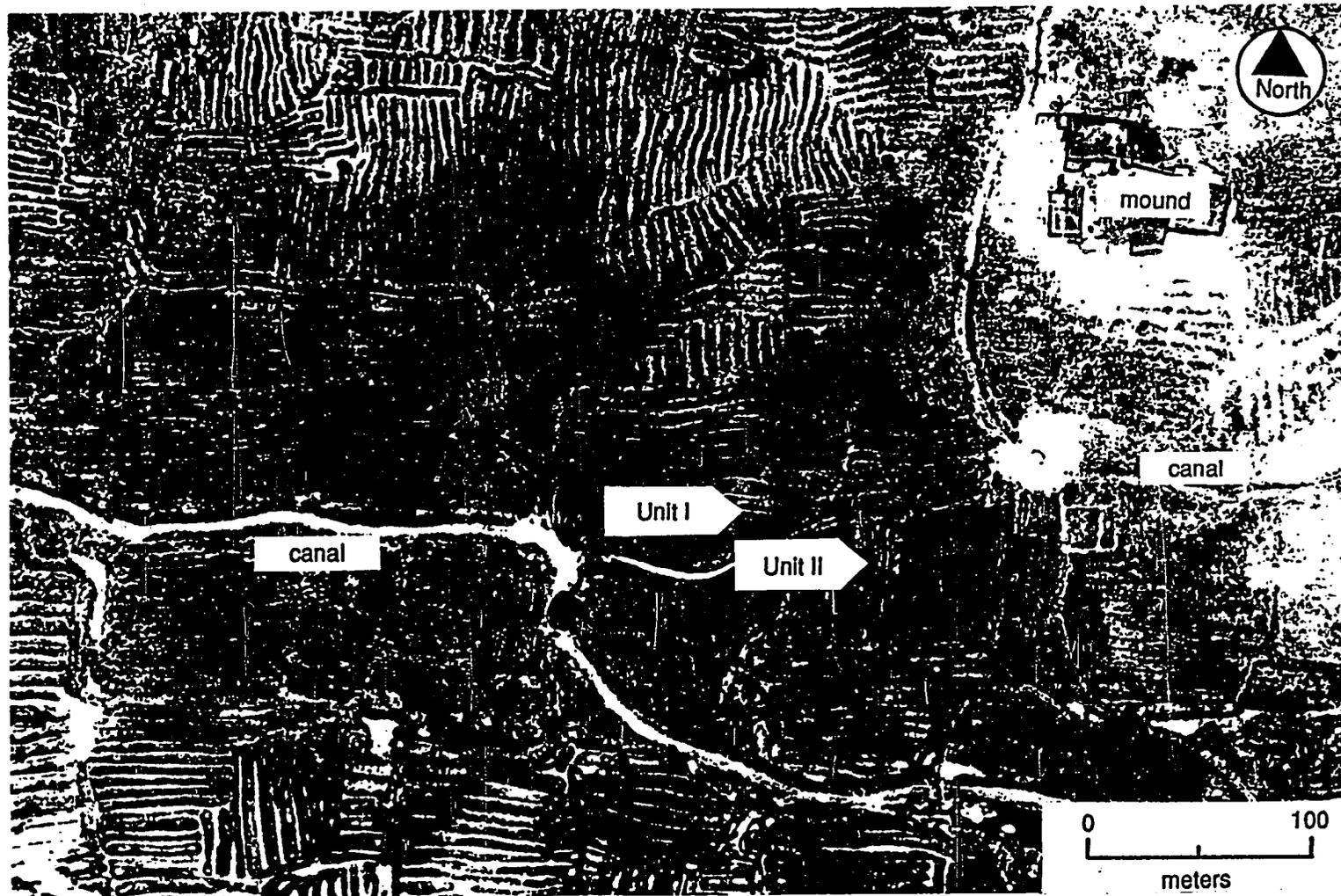


Figure 36: Aerial photograph showing the context of excavation Unit I and Unit II at Illpa.

ILLPA
PPU7-66
UNIT I
WEST PROFILE

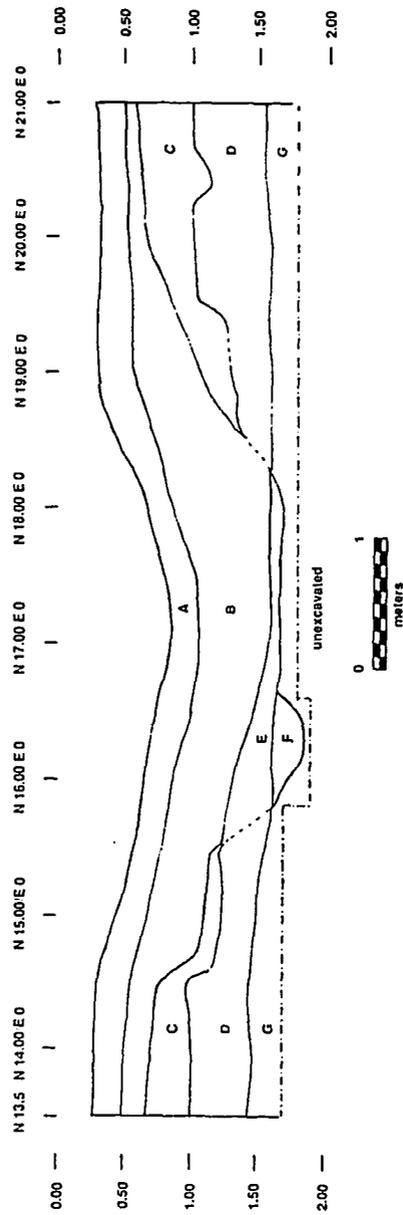


Figure 37: Stratigraphic profile of Unit I, Illpa.

Illpa
PPu7-66
Unit I
West Profile

- A: very dark grayish-brown (10YR3/2) sandy loam; rootlets of chinca and chiji; columnar structure when dry; brownish yellow (10YR6/8) mottling; rootstains; less mottling in raised field sections; pH 6.06 in center section.
- B: very dark grayish-brown (10YR3/2) sandy clay loam; blocky structure; lowest 5 cm has calcium carbonate concretions; pH 7.14; gradual boundary.
- C: dark brown (10YR4/3) loamy sand; slightly laminar structure; dark yellowish brown (10YR4/6) mottling with inclusions of very dark gray (10YR3/1) clay; more clay in lower section; pH 8.35; clear boundary.
- D: very dark gray (10YR3/1) sandy loam; blocky structure when dry; small gastropods; 1-4 cm in diameter calcium carbonate concretions; pH 8.32; clear boundary.
- E: brown/dark brown (10YR4/3) sandy loam; very dark gray (7.5YR3/0) clay mottling and organic stains; pH 8.25; abrupt boundary.
- F: brown/dark brown (10YR4/3) loamy sand; no clay mottling; fine organic rootstains; pH 8.17; gradual boundary.
- G: dark yellowish brown (10YR4/4) sand; very pale brown (10YR7/3) mottling, calcium carbonate concretions; pH 8.58; abrupt boundary.

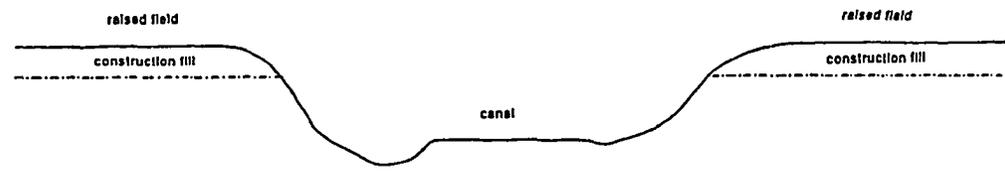
Figure 37: (Continued) Description of the stratigraphic profile of Unit I, Illpa.

ILLPA UNIT I

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: STAGE A



III. SEDIMENTATION AND RAISED FIELD CONSTRUCTION: STAGE B

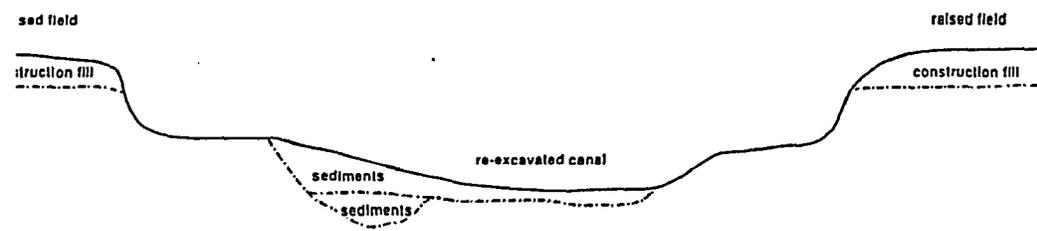
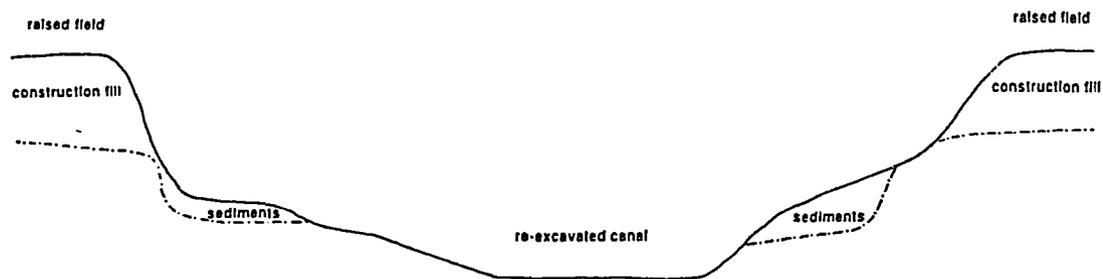
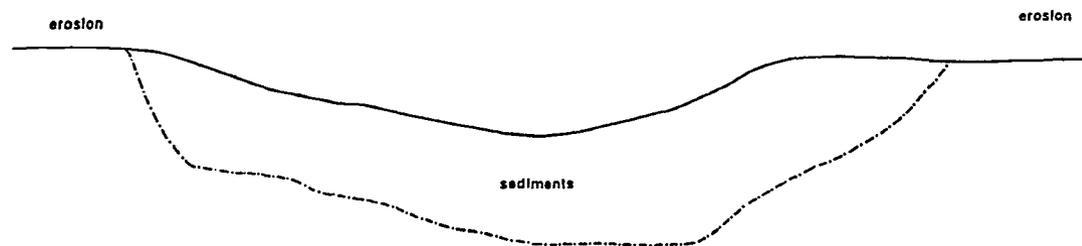


Figure 38: Reconstruction of stages of construction and abandonment based on profile of Unit I, Illpa: Interpretation I.

IV. SEDIMENTATION AND RAISED FIELD CONSTRUCTION: STAGE C



V. ABANDONMENT, EROSION AND SEDIMENTATION



VI. PRESENT DAY LANDSURFACE



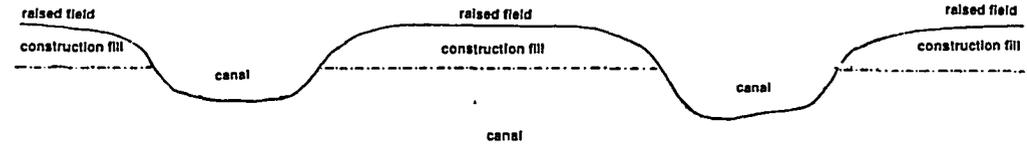
Figure 38: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit I, Illpa: Interpretation I.

ILLPA UNIT I

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: PHASE I



III. SEDIMENTATION AND RAISED FIELD CONSTRUCTION: PHASE II-A

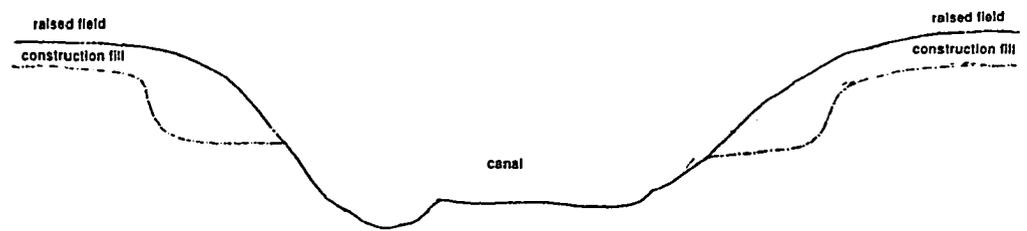
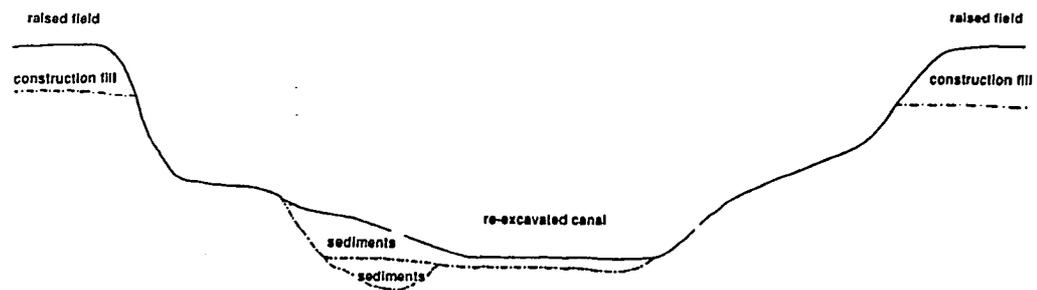
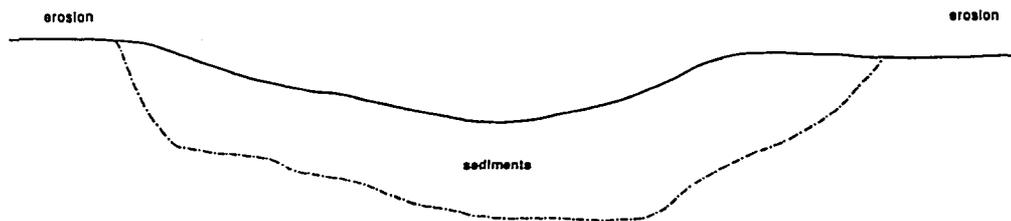


Figure 39: Reconstruction of stages of construction and abandonment based on profile of Unit I, Illpa: Interpretation II.

IV. SEDIMENTATION AND RAISED FIELD CONSTRUCTION: PHASE II-B



V. ABANDONMENT, EROSION AND SEDIMENTATION



VI. PRESENT DAY LANDSURFACE



Figure 39: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit I, Illpa: Interpretation II.

The excavation unit was oriented north/south to cut two raised fields and the associated canal, and measured 7.0 x 1.0 x 1.6 meters.

The lowermost layer in Unit I is Stratum G, a dark yellowish-brown sand with very pale brown mottling and calcium carbonate concretions which form a dense compact structure. Above this is Stratum D, a very dark gray sandy loam with the remains of small gastropods and some calcium carbonate concretions. Strata G and D are probably alluvial sediments. The coarser-textured Stratum G sediments were deposited sometime in the past when the river course was closer to the site and Stratum D was deposited in a backwater environment some distance from the river, similar to the situation today.

There are two interpretations suggested for the raised fields of the stratigraphic profile of Unit I at Illpa. The first implies a single phase of raised field use and construction subdivided into several stages of addition of construction fill and canal re-excavation. The second interpretation proposes a two-phase construction sequence.

3.3.10.1 Interpretation 1 (Figure 38)

A wide and deep canal excavated through Stratum D and into Stratum G is evidence of raised field construction (Stage A). The canal extended from N 14.5 to N 19.5, to a depth of 1.25 meters BD in the profile. When this canal was excavated, Stratum C was probably the A Horizon and Stratum D the top of the B

Horizon. This earth was used to construct the first raised field platform, at the same time doubling the fertile A Horizon as its fill (Stratum C). The result was a very wide canal (5 meters) and narrow raised field (3 meters). It may have been necessary to have a larger canal-to-raised field platform ratio in order to raised the fields to a elevation sufficient to withstand flooding and high water tables.

The raised fields may not have been used for a short period, during which the base of the canal filled with sediment eroded from the adjacent raised field platforms. This sediment is only preserved in the "steps" or "benches," (at N 14.5-N 15.5, and at N 18.5 and N 19.5, as Stratum C) because of later Stage B canal excavation.

During Stage B, a deep canal was excavated through the canal sediments and Stratum D, into the upper part of the subsoil Stratum G, substantially increasing the elevation of the raised field platforms. This canal is clearly documented on the stratigraphic profile between approximately N 15.0 and N 20.5 and extended to a depth of 1.75 cm BD at its south edge. The wavelength created was approximately 8 meters, with the canal slightly wider than the platforms.

The raised fields underwent another period of short-term disuse, during which the lower part of the canal filled with sediments. Stratum F, a brown/dark brown loamy sand with fine organic staining, formed in the base, and a second stage of canal sedimentation can be seen in Stratum E, a brown/dark brown sandy

loam with dark gray clay mottling and organic stains, which formed after Stratum F.

During yet another period of canal cleaning (Stage C), raised field farmers cut into the northern part of Stratum E and this was used as additional construction fill in the raised fields in the north and south of the profile (Stratum B, a very dark grayish-brown sandy clay loam). At this point, the raised field platforms were probably at their maximum elevation and width, with minimally 1.30 cm difference between raised field surface and canal base. These raised fields had approximately 8 meter wavelengths.

The raised fields were not maintained, and the canal gradually filled with sediments, both from direct erosion of the adjacent steep-sided raised field platforms and the deposition of fine alluvial sediments carried in from outside the immediate area (Stratum B, which extends into the canal). As the surface stabilized, Stratum A, a very dark grayish-brown sandy loam, formed as a shallow A Horizon.

3.3.10.2 Interpretation 2 (Figure 39)

Evidence of Phase I raised field construction is documented by the disturbances created in the profile at N 14.5-N 15.5 and N 18.5-N 19.5 in Stratum D. These are portions of the Phase I canals from which material was obtained for construction fill (the rest of these canals were later destroyed by Phase II construction). The A Horizon at the time of construction, Stratum C, was used as fill for the field resulting in a doubled

topsoil, combined with part of Stratum D. The canals and raised field platforms are estimated to have been each 2 meters wide, resulting in a 4 meter wavelength.

Without maintenance, these canals filled with sediments (Stratum C within the canal depressions in the profile) eroding from the adjacent raised field platforms.

The Phase II construction period for Unit I is the same as that discussed above in Interpretation 1 for Stage B-C.

3.3.10.3 Discussion

Although there is more direct stratigraphic evidence to support Interpretation 1, the alternative Interpretation 2 is supported by the other stratigraphic trenches, in particular Unit II of Illpa, located only 50 meters from Unit I (discussed below). In nearly all the profile trenches, with the exception of Units A and D of Viscachani Pampa, the trend of raised field construction is from early (Phase I) short-wavelength fields to late (Phase II) long-wavelength fields. The well-preserved fields in the profile of Unit 1 are large, and one would expect to see a evolutionary progression of smaller fields to larger fields, which is not the case with Interpretation 1. The clearly-documented Phase I raised fields of Unit II are at the same depth below surface as those proposed for Unit I in Interpretation 2, although of somewhat smaller wavelength. In other instances of profiles with both Phase I and Phase II raised fields, the Phase II canals appear to always be cut into

or are enlargements of older Phase I canals, probably the most efficient means of quickly excavating a canal and obtaining good construction fill (ie. organic-rich sediments that accumulated in the Phase I canal). In Interpretation 2, an entire Phase I raised field, in addition to parts of Phase I canals, were removed in the Phase II canal excavation. This may have been necessary because of the need for extra fill to raise the platforms to sufficient elevation to withstand the heavy flooding of this pampa. A similar case of using both Phase I canal sediments and raised field platforms for fill is found in Unit M of Pancha.

3.3.11 PPu7-66 Illpa Unit II

(Figures 36, 40, and 41)

Unit II at Illpa was located to the south of Unit I in a large (100 x 200 meter) block of embanked raised fields oriented east/west. The excavation unit crossed three raised fields and two canals and measured 12.0 x 1.0 x 1.6 meters. The stratigraphy of Unit II documents two distinct phases of construction (Phase I and Phase II), with several stages of improvement within each major phase.

The lowermost layer of Unit II is Stratum N, a yellowish-brown sandy loam with large calcium carbonate concretions, in a compact cemented structure. This stratum is covered by Stratum

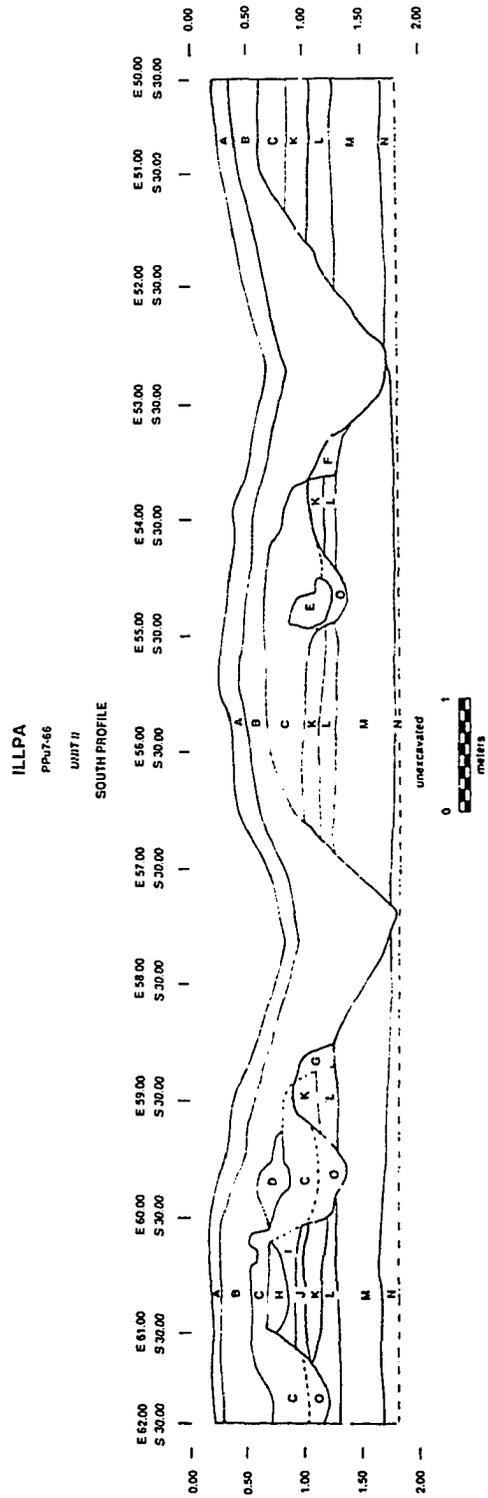


Figure 40: Stratigraphic profile of Unit II, Illpa.

Illpa
PPu7-66
Unit II
South Profile

- A: very dark grayish-brown (10YR3/2) loamy sand in east and west section; dark brown (10YR3/3) loamy sand in center section; humus; rootlets of chinca, chiji, chayiwa, and ichu; compact; pH 8.06 in east and west section; pH 5.70 in center section
- B: very dark grayish-brown (10YR3/2) loamy sand; less rootlets than stratum A; 2-5 cm diameter calcium carbonate concretions from subsoil; prismatic structure; black (10YR2/1) at base in center; pH 8.22 from east and west sections; pH 7.99 from center section; gradual boundary.
- C: dark brown (10YR3/3) sand; compact; homogeneous; pH 8.31; clear boundary.
- D: dark brown (10YR3/3) sand; heterogeneous, some calcium carbonate concretions; clear boundary.
- E: very dark grayish brown (10YR3/2) silty clay; blocky structure when dry; some gastropods; clear boundary.
- F: dark brown (10YR3/3) sandy loam; 1-4 cm clay inclusions; dark gray organic mottling; clear boundary.
- G: dark brown (10YR3/3) sandy loam; homogeneous; clear boundary; gradual boundary.
- H: very dark grayish brown (10YR3/2) loamy sand; blocky structure when dry; pH 8.29; clear boundary.
- I: very dark grayish brown (10YR3/2) silty clay loam; heterogeneous mixture of clay and silt inclusions; calcium carbonate concretions; clear boundary.
- J: dark yellowish-brown (10YR4/4) silty loam; faint laminar structure; homogeneous; abrupt boundary.
- K: dark grayish-brown (10YR4/3) sand; laminar structure with fine microstrata; heterogeneous; some organic root staining; pH 8.56; abrupt boundary.

Figure 40: (Continued) Description of the stratigraphic profile of Unit II, Illpa.

- L: dark yellowish-brown (10YR4/4) loamy sand; laminar structure with microstrata of sandy silt and clay; organic root staining; pH 8.19; abrupt boundary.
- M: dark grayish-brown (10YR4/2) sandy clay loam; homogeneous; blocky structure when dry; gley at base; some laminar microstrata; lower 10 cm of section mixed with calcium carbonate concretions; sherd and lithic cultural inclusions; small gastropods in upper section; pH 8.21; abrupt boundary.
- N: yellowish brown (10YR5/4) sandy loam; large calcium carbonate concretions; heterogeneous; compact; waterlogged; pH 8.37; abrupt boundary.
- O: very dark grayish-brown (10YR3/2) loamy sand; homogeneous; slightly laminar structure; pH 8.20; gradual boundary.

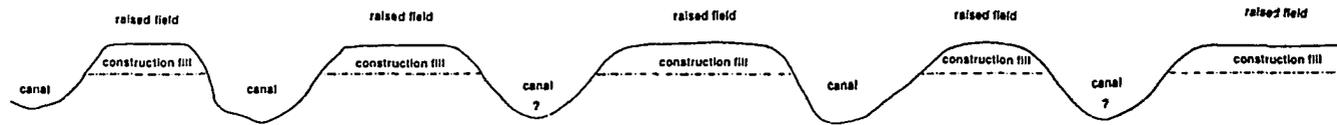
Figure 40: (Continued) Description of the stratigraphic profile of Unit II, Illpa.

ILLPA UNIT II

I. ORIGINAL LANDSURFACE



II. RAISED FIELD CONSTRUCTION: PHASE I



III. ABANDONMENT, EROSION, AND SEDIMENTATION

RAISED FIELD CONSTRUCTION: PHASE II-A

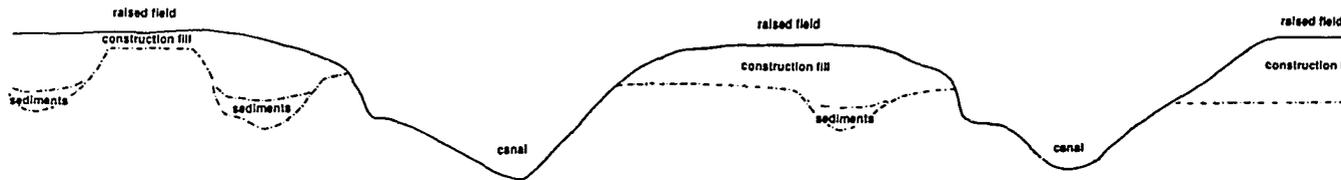


Figure 41: Reconstruction of stages of construction and abandonment based on profile of Unit II, Illpa.

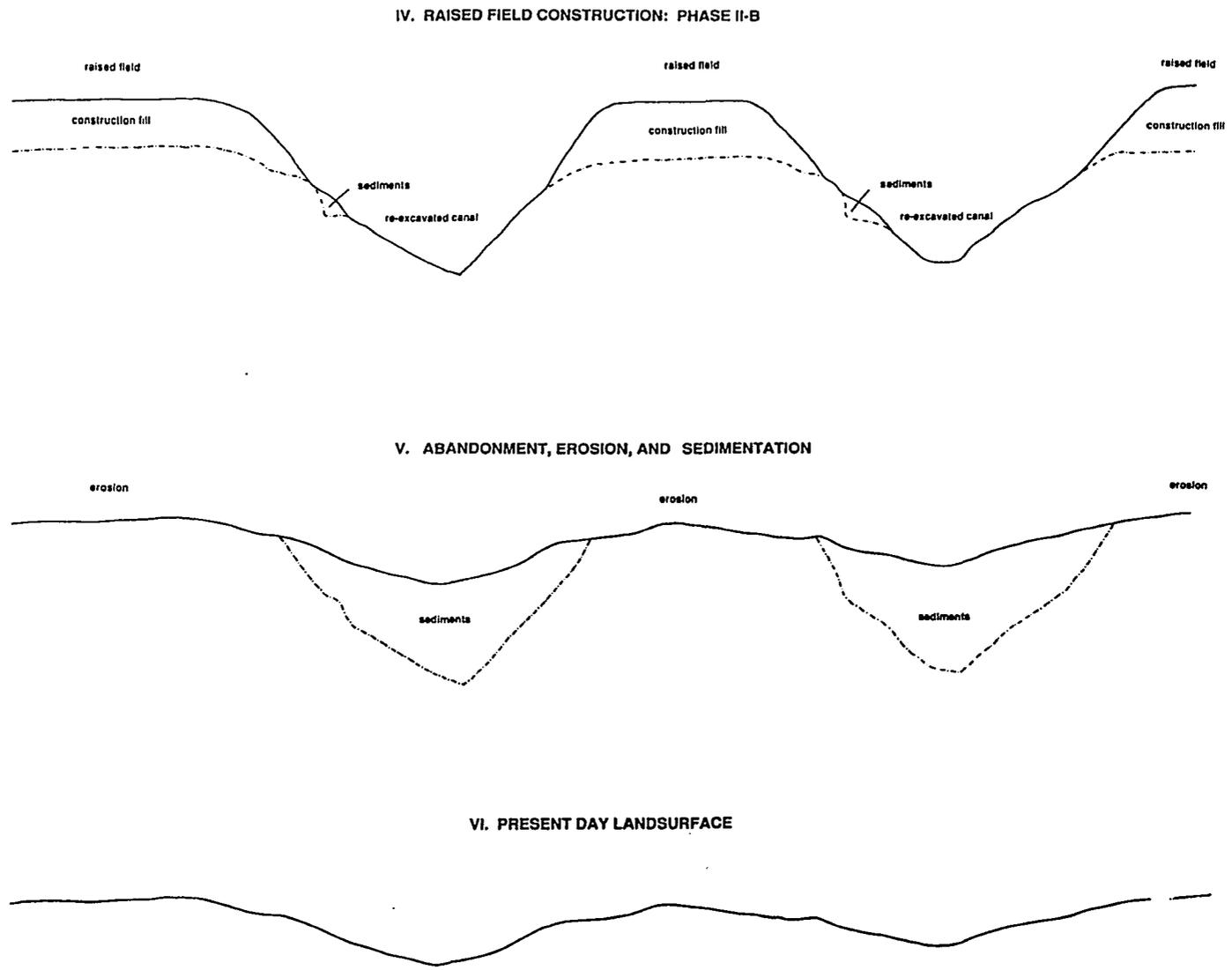


Figure 41: (Continued) Reconstruction of stages of construction and abandonment based on profile of Unit II, Illpa.

M, 50-55 cm of dark grayish-brown sandy clay loam. The lower 10 cm of the stratum has some laminar banding, indicating the alluvial nature of this stratum. It appears to have been deposited in a backwater environment, in contrast to the coarser sediments of Stratum N which were probably deposited when the river was closer to the site. Meander scars of the Rio Illpa are found several hundred meters from the raised field block and may have been active channels during the deposition of these strata.

In the upper section of Stratum M undisturbed by the later canal excavation, numerous sherds were found, in addition to several basalt fragments from hoe blades. This part of Stratum M lacked the distinctive laminar micro-strata that were present in the lower section of the stratum, indicating that the sedimentary structure of the stratum had been disturbed by human activity, possibly cultivation. Since this early concentration of artifacts cannot be stratigraphically associated with the raised fields in the profile, contemporaneous agricultural techniques may not have included mounding. The low elevation of this stratum, in relation to present-day landsurfaces, suggests that this area was a shallow backwater environment, sporadically cultivated in drier years. The sherds and lithics from this stratum were piece-plotted, but their distribution does not indicate an occupation floor or other well-defined activity area. The most likely explanation for the presence of artifacts in this stratum is that this was a lowlying backwater area or shallow lake used for disposing household garbage. An area of some 40

meters to the west of the trench had a small concentration of sherds on the surface, and may have been a prehistoric house site, one possible source of the refuse found in Stratum M.

Several other sedimentary strata were deposited on Stratum M. Stratum L, a dark yellowish-brown loamy sand, has alternating fine bands of organic-mottled clays and sandy silts. Above Stratum L is Stratum K, a dark grayish-brown sand with fine laminar banding and rootstaining. This was probably deposited by alluvial sedimentation over a long period of time. Preserved only in the eastern section of the profile between E 60 and E 61 is Stratum J, a dark yellowish-brown silty loam with weak laminar structure. This was probably the original surface when the first raised fields were constructed.

The first phase (Phase I) of raised field construction is documented in a series of small 1-meter wide and 40-50 cm deep canals (from Phase I field surface to canal base) through Strata J, K, L and partially into Stratum M, centered at E 61.6, E 59.6, and E 55.7. Extrapolating from the wavelength of these canals and raised field platforms, other canals were probably centered at E 57.5 and at E 52.7. Evidence of these two canals would have been destroyed by the excavation of the later, larger, Phase II canals. The earth from the Phase I canals was used to construct low raised fields, approximately 30-50 cm in height, 1 meter wide, and with a wavelength of approximately 2 meters. The construction fill is relatively undisturbed in the raised field platform from E 60 to E 61 in the profile. Two stages of

construction fill are evident here. Stratum I, a very dark grayish-brown silty clay loam with calcium carbonate concretions is the lower construction fill. An upper construction fill, Stratum H, a very dark grayish-brown loamy sand, was later added. The other Phase I raised field construction fill was disturbed by later Phase II construction and cultivation.

These Phase I raised fields were not maintained, and the canals partially filled with alluvial sediments, Stratum O, a very dark grayish-brown laminar banded loamy sand.

A second period of raised field construction subsequently began, Phase II. Canals centered at E 57.5 and E 52.7 on the stratigraphic profile were excavated deep into the subsoil through Strata J, K, L and M, stopping at the interface of Strata M and N. The earth from these canals was used as construction fill to incorporate the eroded Phase I canals centered at E 61.5, E 59.5, and E 54.8 with Phase I raised field platforms into the much larger Phase II raised fields. This created raised fields with a wavelength of approximately 5 meters, and the platforms are 3.5-3.0 meters wide. Two distinct stages of construction are evident. Stage A of raised field construction can be seen in Stratum C, a dark brown compact sand, which elevated the new raised field surfaces to approximately 1.3 meters above the canal base. Stratum D, a dark brown sand, would be construction fill removed from the lower part of the canal, as indicated by the presence of calcium carbonate inclusions and sand from the subsoil. Stratum E, a very dark grayish-brown silty clay, may

be a post-construction disturbance (possibly an animal burrow) or a large block of material (such as sod or clod) incorporated as construction fill.

Stage B of raised field construction appears as Stratum B, a very dark-grayish brown loamy sand with calcium carbonate concretions. This construction fill was removed from the lower portions of the canal and probably included sediments eroded into the Stage A canal. This construction added at least 40 cm to the surface of the raised fields.

The "step" or "bench" under Stratum G may be evidence of canal cleaning or excavation. Stratum G, a dark brown sandy loam probably is what remains of the alluvial sediment that later filled it, only to be almost completely removed during a subsequent re-excavation of the canal.

During the final period when the fields were not maintained, the canal gradually filled with sediments, Stratum B, a loamy sand in the profile. Since the canal stratum is nearly identical to the upper fill of the raised fields, most of the material probably eroded from the adjacent steep-sided raised fields, with the remainder from material (finer sediments such as clays) deposited by water and/or organic material produced and accumulated in the canals. An A Horizon (Stratum A, a very dark grayish-brown loamy sand in the eroded raised field platforms, and a dark brown loamy sand in the canal sections), formed above Stratum B.

3.4 INTERPRETATIONS OF THE RAISED FIELD STRATIGRAPHIC PROFILES

3.4.1 Canal Form

Detailed examination of canal areas in the stratigraphic profiles provides more direct and significant information about the ancient raised field systems as a whole than does analysis of the platform areas. This is because natural processes do not alter the stratigraphic boundaries established by excavation of a canal. Erosional sediments deposited in a canal are laid down as clearly distinct strata, while earth eroded from the platform leaves no evidence of its former boundaries. Re-excavation of a canal can alter the original profile, but is seldom so complete that every trace of the original is erased; evidence of platform amplification is usually less clear, particularly as the soil becomes mixed under cultivation. The dimensions of the canals also provide an indication of the dimensions of the original raised field platforms, as it is assumed that the earth excavated from the canals was used as construction fill. This extrapolation is more meaningful than estimates based on directly comparing the eroded field surfaces.

Three major forms of canals are clearly defined by the cross-sections visible in the stratigraphic profiles: 1) a wide, flat-bottomed canal; 2) a round-bottomed "U" shaped canal; and 3) a wide "V" shaped canal. There is much internal variation within each canal form, and there is a gradation from form 1 to form 3, with form 2 an intermediate between them.

3.4.1.1 Wide, Flat-Bottomed Canals (Figure 42)

Flat-bottomed canals are found in Units A and D of Viscachani Pampa, Unit A at Machachi Pampa, Unit I at Illpa, Phase I and Phase II fields of Unit A at Ccoccope, and the Phase II raised fields of Unit M at Pancha. The width of these canals is generally equal to or greater than that of the adjacent raised fields platforms, indicating that a substantial amount of construction fill was used for these raised fields. The additional fill from the wide canals would have provided sufficient elevation of the platforms so that the planting surfaces would remain above the highest levels of the water table during the rainy season. This is particularly true in the case of Viscachani Pampa, which becomes a shallow lake during the rainy season.

During the construction of experimental raised fields with the Quechua farmers of the communities of Huatta, Coata, and Illpa during 1981-1986, I observed that these wide flat-bottomed canals were the result of an attempt to maximize labor efficiency. Removal of the A Horizon was not difficult, as the thick masses of intertwining roots consolidated the soil so that it could be easily handled as large blocks after being cut with a chakitaqlla. When unconsolidated material below the humus level and root zone was removed, much more time was expended in the effort, drastically lowering overall labor efficiency. In most cases, the simple removal of the A horizon soils in a wide canal provided sufficient material to elevate the surfaces of the

CANAL FORMS BASED ON RAISED FIELD EXCAVATIONS:

WIDE, FLAT - BOTTOMED CANALS

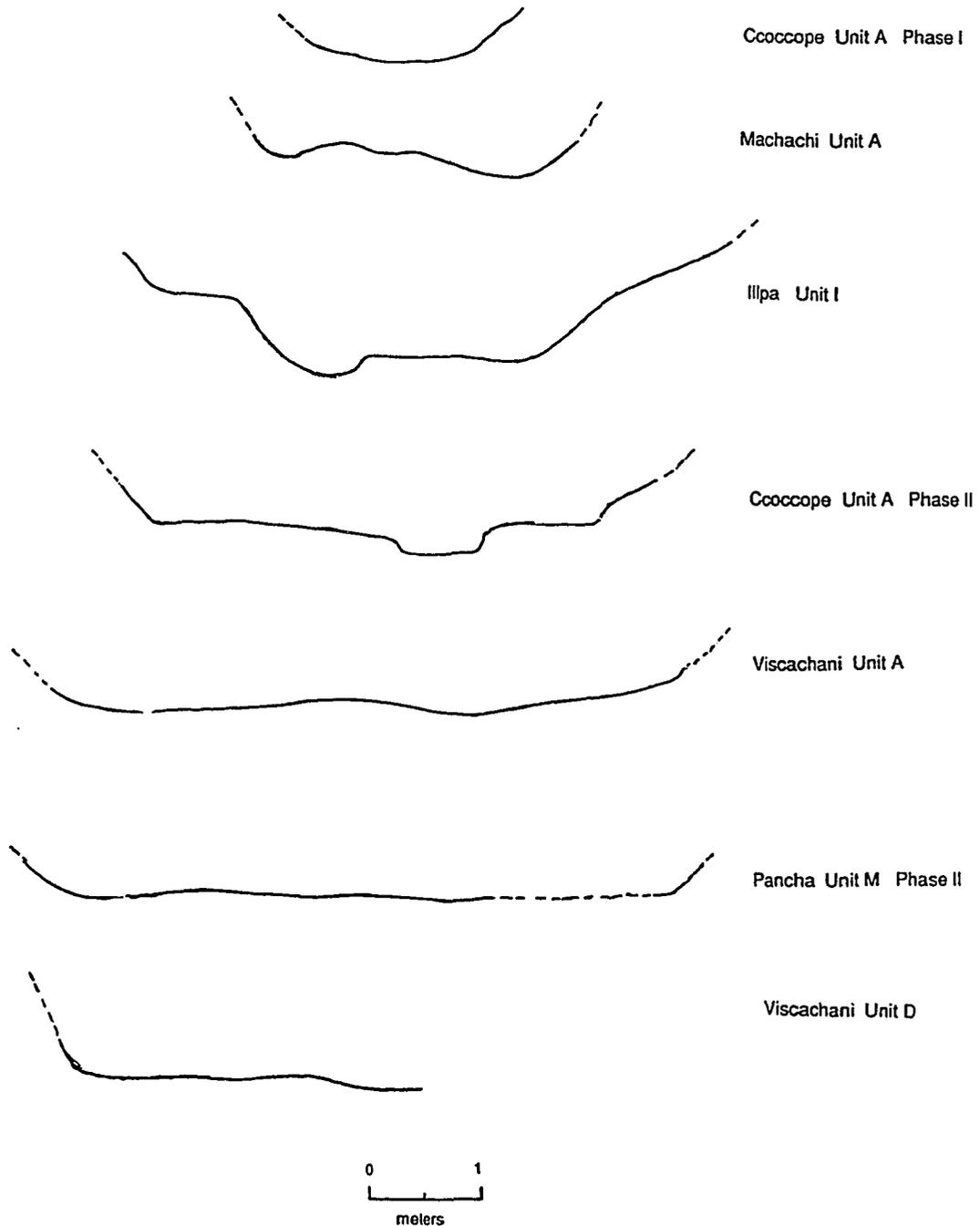


Figure 42: Canal forms determined through excavation: wide-bottomed canals.

raised field platforms adequately. When additional soil was necessary to sufficiently elevate the platforms, it was generally found that the material immediately below the A horizon was much easier to remove than material farther down in the soil profile. When a stratum with high clay content or calcium carbonates was encountered during canal excavation, it was much more efficient to obtain fill by making the canal wider, rather than deeper. This created a flat canal base, which followed the interface with the hard stratum, and relatively steep sides on the raised field platform. The disadvantage of this type of canal excavation is that the steep sides erode rapidly and side wall slumping is common until the surfaces are stabilized through the establishment of vegetation cover.

The wide, shallow flat-bottomed canals also provide more water surface area, which maximizes the efficiency of the canal as a solar heat sink (see Erickson 1988 for an explanation of microclimate effects of canal water). In most locations, the water table was very close to the surface except during years of extreme drought, such as those of 1982-1983. One of the functions of the canal, beyond that of simple drainage, was to reach the minimal level of water table during the growing season; in most cases, it was not necessary to excavate canals very deeply.

It was demonstrated during the experimental reconstruction of raised fields that much labor efficiency is lost if the construction fill for the raised field platforms has to be

carried long distances, for example from the deep center of a large canal to the center of the large raised field platform. It was much easier to remove the construction fill from the edges of the canal closest to the raised field being constructed, which tended to keep canal bases wide and flat. When more soil was taken from the edges of the canals than the center, depressions were created at the edges of the base of a canal such as can be seen in the stratigraphic profile of the canal of Unit A at Machachi and Unit A of Viscachani Pampa.

In terms of hydraulic control, the wide, flat-bottomed canal (and the round-bottomed "U" shaped canal) holds more water. A larger volume of water can be manipulated for both drainage and storage purposes with the same amount of surface area as the "U" and "V" shaped canals of the same depth. This form of canal would have also maximized the potential area for production of green manure by aquatic plants.

3.4.1.2 Round-Bottomed "U"-Shaped Canals (Figure 43)

The second form of canal, the round-bottomed "U"-shaped canal, is found in the profiles of the raised fields of Phase I of Unit A at Jucchata, Unit A at Candile, Phase I of Unit II at Illpa, the Phase I canals of Unit M at Pancha and Unit C at Kaminaqa. These canals are found in areas with a high watertable and frequent flooding, such as Kaminaqa and Candile, but also in areas where there is much less danger from water damage, such as Coccope Pampa.

It appears that this form is associated with a situation

ROUND - BOTTOMED "U" - SHAPED CANALS

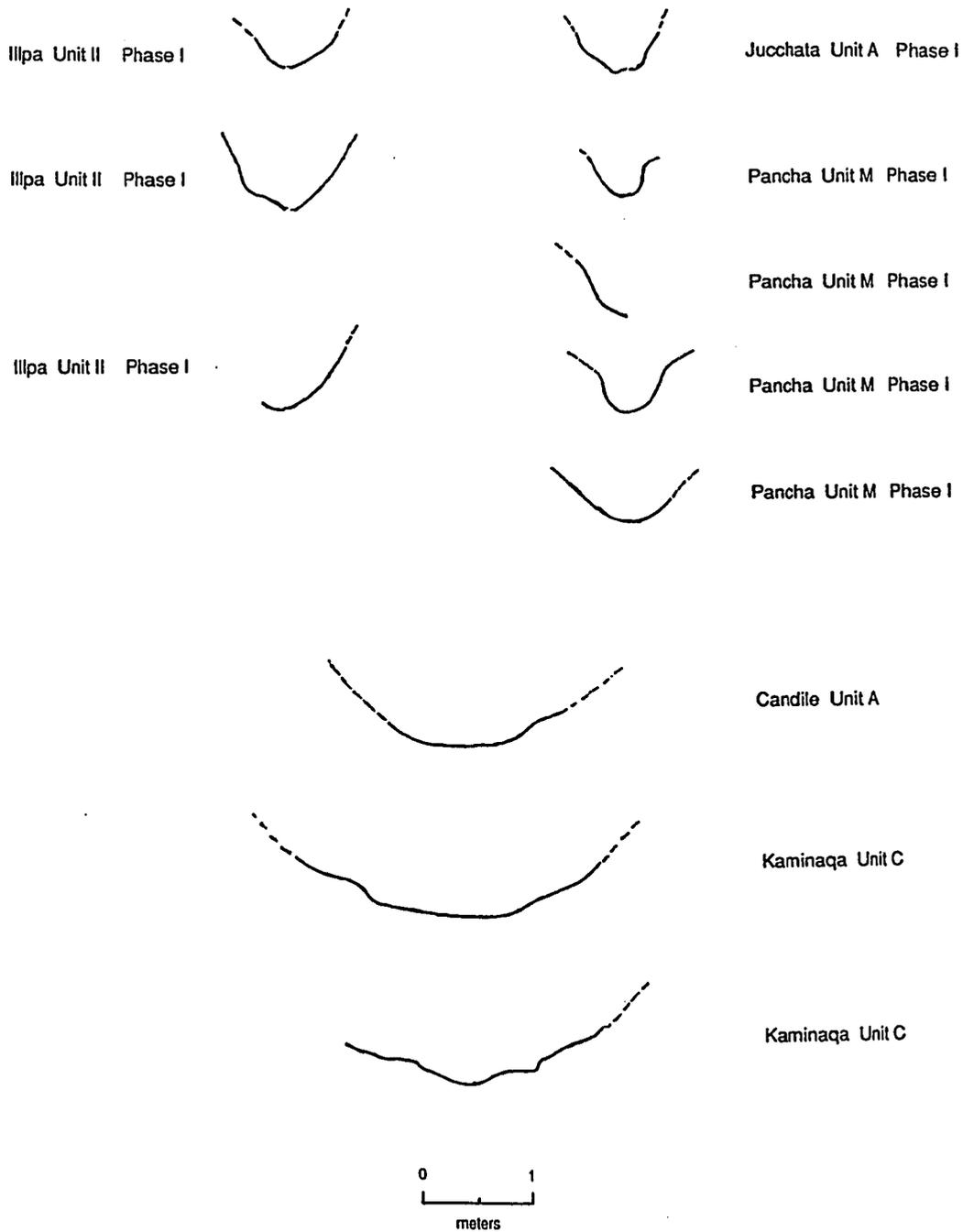


Figure 43: Canal forms determined through excavation: rounded "U"-shaped canals.

where less construction fill was necessary to elevate the raised fields and/or there was less problem excavating deeply into the subsoil strata for the necessary fill. Gently sloping canal and platform sidewalls reduced the impact of erosion and tendency of the walls to collapse. As with the wide, flat-bottomed canal, a larger volume of water is more conducive to higher production of green manure for use in the fields and improved microclimatic modification.

3.4.1.3 Wide "V"-Shaped Canals (Figure 44)

The third form of canal, the "V"-shaped canal, is found in Phase II of Unit A at Jucchata, Phase II of Unit II at Illpa, and in Phase I and Phase II at Unit NOPQ of Pancha. This canal form was a means of rapidly reaching the normal minimum level of the water table to provide access to subsurface moisture for hand irrigation of the fields, for pisciculture, and/or to store heat against potential frost episodes. These narrow-bottomed canals would have quickly concentrated any available water at the beginning of the rainy season and the end of the rainy season in the center of the canal, where it could easily be utilized for irrigation at these critical times. In the experimental raised fields, water collected in the "V"-shaped canals earlier, and remained longer, than in flat canals. This water was also much easier to use for irrigation than shallow water spread out over a wide flat canal base. In addition, the "V"-shaped canal would have been more efficient for the seasonal harvest of fish at the end of the rainy season. . Another advantage of the "V"-shaped

WIDE "V" - SHAPED CANALS

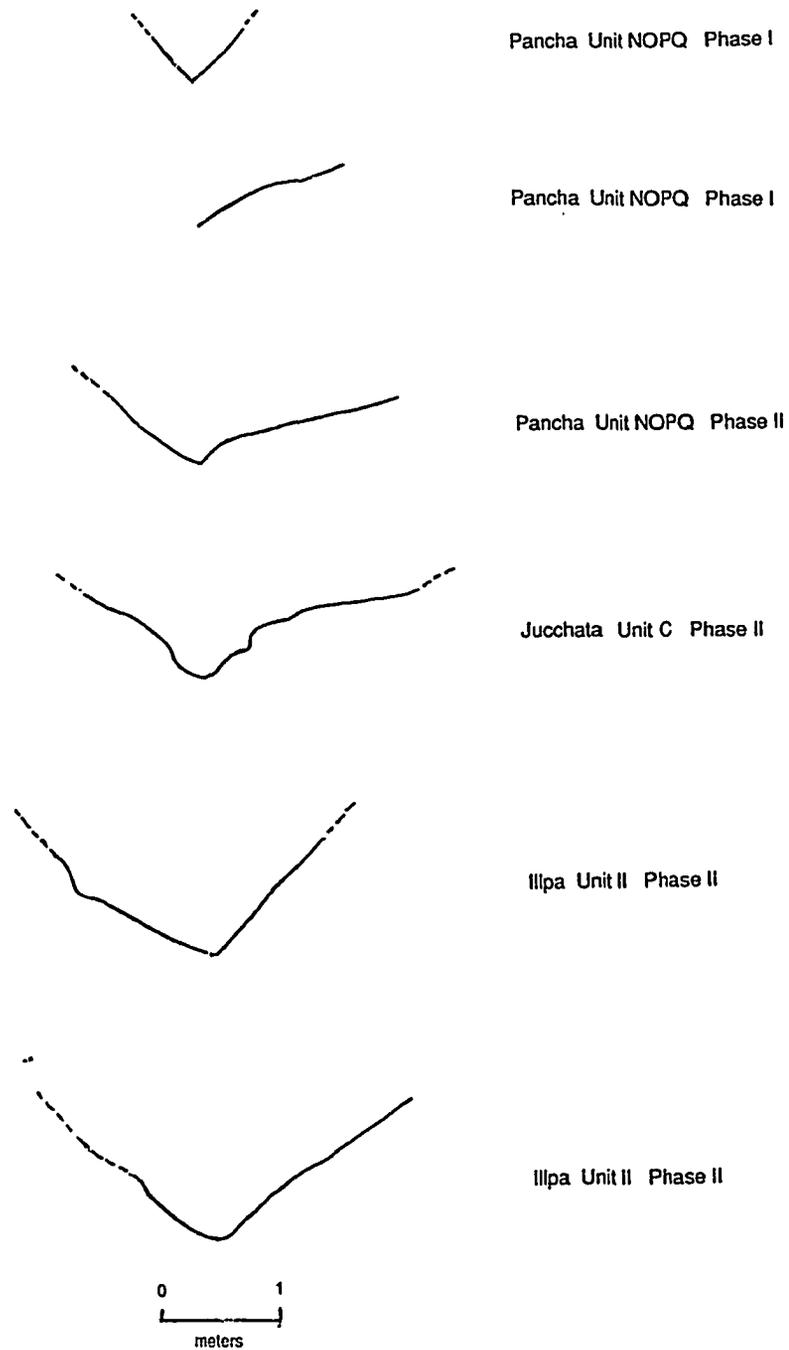


Figure 44: Canal forms determined through excavation: wide "V"-shaped canals.

canal is that the raised field platforms could be larger in relation to the canals, potentially providing a larger net surface area per hectare for cultivation. In addition, crops could have been cultivated on the sloping sides of the raised field platform, increasing the cultivable surface, although these would have a high risk of being flooded since it is difficult to predict the levels of water in the canals. At the same time, reducing canal surface area and quantity of stored water could be detrimental in terms of microclimate management by increasing the risk of frost damage to crops (see Erickson 1988). The rate of evaporation from a "V"-shaped canal is less than from a shallow flat-bottomed canal holding the same amount of water. This could be a crucial factor during short-term droughts and at the end of the growing season.

3.4.2 Discussion of Canal Form

Smith (1983:253) notes that the water table levels in a raised field platform will depend on the soil texture of the construction fill and the raised field platform width (edge to area ratio). Narrow raised fields may have higher water tables than square or irregularly shaped fields. Smith suggests that the optimum field width was determined through the excavation of more and more canals until the optimal water table levels were reached. He indicates that longer, narrow fields would be best suited for subsoil drainage and would have been easier to construct. This interpretation neglects the size and depth of

the canals between the raised fields. Also, it considers the raised field system as simply being "drained" by cutting networks of canals across the area, neglecting that the large volume of soil excavated from the canals was certainly used to elevate the raised field platforms. Calculations based on aerial photographs of the Lake Titicaca raised fields indicate that canals cover approximately half of the surface area of any raised field block (Erickson 1988; Lennon 1982; Stemper 1978). Although these analyses did not consider the effects of severe erosion on the fields and canals, which distorts their surface area, my excavation of stratigraphic profiles supports these conclusions. Although canals in some blocks tended to cover a slightly larger percentage of the area in wetter zones (near the edge of Lake Titicaca) and a slightly lower percentage in drier zones, the area of the canal was generally equal to the area of the platform. Adjustments of moisture levels within fields were probably made by deepening and widening existing canals, rather than through the excavation of additional canals. In the stratigraphic profiles, the evolutionary sequence documented is a progression from short-wavelength raised fields (ie. smaller, closely spaced canals) to long-wavelength raised fields (larger, more widely spaced canals), which contradicts Smith's hypothesis. The narrow raised field platforms with numerous canals may not have been as important for the maintenance of optimal water table levels (suggested by Smith) as they were for the maintenance of the microclimate around the cropped raised field surfaces.

The distribution of canal shape through time shows interesting patterns. Most Phase I canals are roughly of the same size and form, a parabolic "U" to "V" shape of 60-150 cm wide and 30-50 cm deep. When the profiles of all the early canals are plotted together, the uniformity is striking (Figure 00). Slight differences in depth and width appear to be related to wavelength differences (ie. larger canals have longer wavelength, and smaller canals have shorter wavelength). The Phase I canals of the Unit II profile at Illpa are somewhat deeper and wider than the other Phase I canal profiles, but maintain the same general canal morphology. The fields here may represent a response to different soil and hydrological conditions imposed by the riverine environment of Illpa, as discussed by Lennon (1982, 1983).

The profile of the Phase I raised field canals of Unit A at Ccoccope is the only exception. Here, the Phase I canals are wide and shallow and are more similar to some of the later Phase II canals in other profiles.

The single-phase and Phase II canals are much more variable in size and shape. In contrast to the Phase I canals, the Phase II canals are much larger in volume, surface area, and depth. In general, the side walls of the Phase II canals tend to have a more gradual slope. The canals of Unit A at Machachi and Unit A at Viscachani have a shallow, wide cross-section, while those of Unit D at Viscachani, Unit C at Kaminaqa, and Units I and II at Illpa have deep, wide cross-sections.

This suggests that the "U," "V," and flat-bottomed canals do not reflect a series of stages in a process of gradual transformation. Rather, the earlier, smaller canals were "U" or "V"-shaped, and during Phase II, the variability of form suggests an adaptation to local environmental and soil conditions.

3.4.3 Interpretation of Raised Field Form

The raised fields in the profiles excavated in Huatta and Illpa present a wide range of forms in cross-section. Although variable in size, the basic morphology is similar in all the raised fields. The construction fill obtained from the adjacent canal was added to the original A Horizon of the pampa to elevate the raised field planting platform. In several cases, there is clear evidence of several events when construction fill was added to the raised fields.

The original raised field platform shape is often difficult to precisely determine because the raised fields have eroded since they were used. In some cases, the original buried and relatively uneroded raised field surfaces are visible in the profile, such as Phase II of Unit NOPQ at Pancha, Unit A at Kaminaqa, Phase I and Phase II of Unit II at Illpa, Phase II of Unit A at Jucchata, Phase I of Unit M at Pancha, and Unit A at Viscachani Pampa. These examples are all slightly cambered in cross-section. This convex surface provided improved drainage of water from the raised fields to the canal, preventing standing

water and waterlogging of soils in the center of the raised field. This also prevented the buildup of sodic-saline accumulations on the surface (see Erickson 1988). In the experimental raised fields, the highest production rates were from raised fields that had cambered surfaces. The accumulation of standing water on experimental raised fields with flat surfaces resulted in waterlogged soils and limited crop growth in the center of the raised field platforms, and in some cases rotted tubers and roots.

There are some disadvantages of cambered surfaces. A steep-sided, highly-cambered raised field may erode much faster than a flatter raised field. In addition, during the 1982-1983 drought, it was found that flat raised field surfaces absorbed and retained limited precipitation and splash irrigation much better than those with cambered surfaces. Much of the water runoff and water retention properties of both cambered and flat raised field surfaces could be modified through differing crop row orientations. We found that transverse rows could be utilized to improve drainage on flat planting surfaces, and longitudinal rows could be used to inhibit drainage and improve moisture absorption on cambered surfaces. Unfortunately, these row orientations are not preserved in the profiles.

The early Phase I raised fields and their associated canals in the profiles of Unit I at Illpa and Unit NOPQ and Unit M at Pancha are small in size. The smallest are the 2 meter wavelength fields in Unit I of Illpa. Here the raised fields are

only 1 meter wide, which puts them within the upper size range of wacho fields (see Erickson 1988).

3.4.4 Construction Stages

Most of the stratigraphic profiles document several construction stages within each phase of raised field building. The raised field profiles not showing clear distinct stages of construction may indicate a single construction period with no later modifications, but it is also possible that natural soil perturbations by fauna and flora, and especially agricultural cultivation, may have erased the stratigraphic evidence of different construction events. Soil horizonation processes such as leaching may also have removed evidence of construction stages. Since the platforms were used for agricultural purposes, the upper soils were reworked each time the field was cultivated, planted, weeded, or harvested, with each event altering the stratigraphic profile. Some construction fills may also have been so similar to the original platform soil (e.g. those recently eroded from the platform) that their addition to the raised field did not create a clear stratigraphic boundary.

The stratigraphic profiles of Units I and II at Illpa, Unit A and Unit D at Viscachani Pampa, Unit A at Jucchata, Unit NOPQ at Pancha, and Unit A of Kaminaqa clearly document different stages of construction within a single major phase of raised field construction. This was the placement of additional

construction fill (10 to 20 cm) on the older platform surface sometime after the initial construction. This is clear evidence of the gradual incremental building of raised fields, probably over many generations of farmers. A few raised field blocks such as Unit A at Machachi, Phase II of Unit M at Pancha, and Unit A at Candile are exceptions and may have been completely constructed all at once.

The documentation in the stratigraphic profiles of slow incremental growth of raised fields is important to consider in any calculations of labor input in raised field construction (see Chapter 4). If labor input is spread over long periods of time, the initial labor costs can be reduced. During the construction of experimental raised fields, it was found that the most efficient means of obtaining fill for the fields was to cut out large blocks of sod using the chakitaqlla. Below the sod, compact fine-textured sediments with high clay content were normally encountered. This considerably reduced the efficiency of the raised field construction since large blocks of this material could not be easily removed. This soil was heavy mud when wet, and a compact cement-like mass when dry; both conditions made work difficult. With the tools available to them, prehistoric farmers would have had difficulty in using this for fill. The lower limit of canal excavation is the compact, calcium carbonate-cemented subsoil, which is a poor construction fill because of its low fertility and the high labor costs involved in its excavation. In most cases, the removal of

the humus from the old canals and building up the eroded surface 15-20 cm was sufficient to produce a good crop yield in a "normal" year. Proper elevation of the raised field surface depends completely on the local water levels during the wet season. It was found that water could lie within 10 cm of the surface of the experimental raised fields for several months during the growing season without substantial damage to the crops.

The volume of original fill material removed from the first canal excavations for the construction of raised fields is rarely equal to that of the total artificial construction fill of the raised fields themselves, thus much of the fill material was not obtained from the original canal excavation. A very important source of this additional construction fill material was the sediment annually deposited in the canals through seasonal riverine and lacustrine flooding. To a lesser extent, eolian deposits would also have accumulated. Animal remains and droppings (grazing camelids, fish, toads, etc.), would have combined with the remains of the seasonal aquatic plants produced in the canals to form a stratum of rich organic muck. It is possible that manure was brought to the fields (decayed dung collected from camelid corrals, or green manure from the lake or rivers) and added as construction fill. This manure, however, would comprise only a small fraction of the bulk of the construction fill. Another very minor source of fill material would be human refuse (sherds, lithics, organic food remains,

etc.). The initial canal excavation was the primary source of raised field construction fill in the early stages of construction, but later, the addition of sediments and muck accumulating in the canals would become more significant.

In rare cases, it may have been necessary to bring in sod from distant locations in order to build up a platform of sufficient elevation in very low areas. During the construction of experimental raised fields, old raised fields were sometimes used as "borrow" for the reconstruction of other raised fields if the subsoil was difficult to excavate. One independent farmer built raised fields from blocks of rich organic sod which he carried from a dry gocha located about 150 meters away. In terms of labor efficiency, the construction of raised fields using non-local fill would have been low and thus, fill from distant sources probably was not commonly used. Turner and Harrison (1983) and Puleston (1977b) argue that much of the fill for the Maya raised fields was obtained from non-local sources, which greatly increased labor input estimates. Armillas (1971) believes that archaeological sites in the Valley of Mexico were often "mined" for fill to construct chinampas. I believe that the need for such practices was unnecessary, particularly in areas that receive large amounts of annual alluvial deposition, such as the very zones where the majority of Maya raised fields are located.

3.4.5 Processes of Raised Field Growth

It has been stressed above that raised fields are the result of many generations of farmers gradually improving the raised fields through additions of soil to the platform surfaces, which simultaneously increased the depth of the canals. These periodic maintenance events mitigated the short-term accumulation of sediments which hindered drainage of the fields and decreased the canal's capacity as a reservoir. The fertility of the planting surfaces was also continually augmented through the regular cleaning of the canals. The long-term aggradation of sediments, however, presented a problem that could not be resolved through this type of periodic maintenance alone.

Gradual erosion from the raised field surfaces was certainly a continuous process occurring while the fields were being farmed and afterwards. The highest rates of erosion would have occurred in the first few years of cultivation of newly-built fields. The importance of one construction technique in quickly minimizing erosion became clear through work in experimentally rebuilding and re-using raised fields. When sod blocks were carefully placed as a "retaining wall" on the edges of the raised field platforms, the vegetation in the sod soon rooted and formed a "living wall" on the raised fields. When the vegetation became well established, erosion was greatly reduced. Fields stabilized in this manner would not have required as much maintenance as fields without vegetated walls, where the planting surfaces continually

erode into the canals.

Erosion from the planting surface of a well-built raised field would not have been significant, but the lacustrine and riverine sediments continually accumulating in the canals would have been a serious problem. The rate of sedimentation of the Huatta and Illpa pampas is unknown, but it is certainly a continually aggrading landsurface. This process would have been accelerated by building canals, in effect man-made sediment traps, which increased the accumulation of sediments in the pampa. Organic-rich topsoil lost from poorly managed hillslope cultivation could have been recaptured by the canals for raised field cultivation in the pampa. This may be an analogous situation to the recapture of sediments in coastal lowlands as a result of "induced erosion" on many Pacific Islands (Spriggs 1985; Hughes 1985).

Precise rates of sedimentation in the canals during the use of the raised fields is impossible to calculate from the stratigraphic profiles since the canals were periodically "cleaned." However, the sedimentation in some locations can be discussed. In Unit A at Jucchata, a TL sample dating to A.D. 380 ± 320 was found beneath 80 cm of sediments, suggesting 1250-1890 years of sediment accumulation. In Unit M at Pancha, a sherd with a TL date of A.D. 80 ± 380 was recovered from sediments 58 cm below the surface, suggesting 1490-2250 years of sedimentation. Two TL dates from sherds in the lower sediments of the Phase II canal of Unit NOPQ at Pancha (A.D. 1540 ± 90 and

A.D. 1325 \pm 120 were found 70-90 cm BS respectively), suggest 320-745 years of accumulation. From these figures, sedimentation rates of .0356-.0537 cm/year (Unit A, Jucchata), .0026-.0039 cm/year (Unit M, Pancha), and .1208-.2813 cm/year (Unit NOPA, Pancha) can be calculated.

Part of the imprecision of these figures is the unavoidable result of the high sigmas of the TL dates. These rates should not be considered constant because the rate of deposition would decrease as the abandoned canal volume is reduced through time. These calculations do, however, suggest long-term local averages. The variations of sedimentation rates between stratigraphic profiles would be due to locally specific environmental and hydraulic conditions.

As the canals were gradually excavated deeper, and the field surfaces correspondingly elevated, the prehistoric farmers were forced to face the consequences of continual aggradation on the pampa.

There is a limit to the amount of sediment that can be added to the raised field surface. If the platform becomes too elevated, the water table level will lie too far below the rootzone, and the crop will not receive sufficient moisture. This is certainly the case in the present-day chinampa raised fields of the Basin of Mexico, which are periodically planed off to maintain the optimum level of moisture in the crop growing zone (Gibson 1968:320). The disposal of excess sediments from the canals becomes a crucial problem. The labor cost of

transporting the sediments to outside the field system would be excessive. One solution is documented in the raised field stratigraphic profiles in Huatta and Illpa. The shift from Phase I to Phase II raised fields is a response to the excess of accumulated sediments in the canals. Alternating Phase I canals (or in the case of Unit II at Illpa, 2 canals out of 3) were filled with excavated sediment and integrated into the large Phase II raised field platforms. This resulted in new raised fields with larger planting surfaces, and wider and deeper canals. In effect, the wavelength of the raised fields was doubled. The Phase II farmers utilized the basic structure of the Phase I raised fields to produce fields of longer wavelength. This would have been the most efficient use of the agricultural topographic features that had already been established. This solution is documented for the prehistoric chinampa agriculture in the Basin of Mexico (Jeffrey Parsons: personal communication 1984) and late prehistoric Oneota raised fields in the United States Midwest (Gallagher et al. 1985; 1987). Gallagher et al. interpret the multiple construction episodes at the Sand Lake Site in western Wisconsin as a solution to the problem of alluviation. The superposition of raised fields of different construction periods is also documented at the Peñon del Rio site in the Guayas Basin, Ecuador (Martinez 1987), the Kuk site in Highland Papua New Guinea, (Golson 1977), and in the San Jorge River Valley of Colombia (Bray 1983). Kolata and Graffam (1987) also report superimposed raised fields at Lukurmata, Bolivia.

The chronology associated with the construction events superimposing one field system over another, in particular whether there was a period of disuse separating use of the two systems, has not been established for any of the sites mentioned above. In one of the profiles from Huatta, (Unit NOPQ at Pancha), we have dates for the construction and abandonment of the Phase I raised fields, and for the final abandonment of the Phase II raised fields, but no beginning date for that phase. Only the relatively large amount of sediment in the Phase I canals indicates that these were probably out of use for many decades, perhaps centuries. A detailed discussion of raised field chronology is found below.

3.4.6 Drained Fields vs. Raised Fields

In all cases except that of Phase I at Unit A in Jucchata, the agricultural features are truly "raised" fields (as defined in Chapter 1). Phase I of Unit A in Jucchata may represent an example of a case of "drained fields" where small, widely spaced canals were excavated into the pampa, presumably to provide drainage and to lower the local water table. The soil excavated from these canals would have provided little construction fill for the elevation of the planting surface. If sedimentation rates were extremely high in this area, the necessary frequent cleaning of even small canals would have provided a large amount of material which would have substantially elevated the

platforms. Even if their original construction was as a "drained field," these would have become, in effect, raised fields. Later it was necessary to improve them by making them into Phase II raised fields.

3.4.7 Comparison to Other Archaeological Raised Field Profiles

One result of the recent interest in raised fields is the increase in comparative data from several areas of the world. In general, raised field excavations in the past have been very limited investigations, only in rare cases including soil and pollen analysis, absolute dating, or detailed stratigraphic descriptions. Recent investigations, however, have documented raised field stratigraphic profiles from 1) South America: the Llanos de Apure of Venezuela (Zucchi 1975, 1984; Zucchi and Denevan 1974, 1979; the San Jorge Valley of Colombia (Bray et al. 1983, 1985, 1987; Eidt 1984), the Junin area in Central Peru (Hasdoff 1983, Hasdoff and Earle 1985), the Peñon del Rio site in Ecuador (Martinez 1987), highland Ecuador (Knapp 1984; Knapp and Ryder 1985); 2) Mesoamerica: the chinampas of Central Highland Mexico (Parsons et al. 1982, 1985); Bajo Morocoy in Quintana Roo, Mexico (Gleissman et al. 1985), Pultrouser Swamp (Pohl et al. 1985; Harrison and Turner 1982, Turner and Harrison 1983) and Albion Island in Belize (Pohl et al. 1985; Puleston 1977b); 3) the Pacific: Torres Strait, Papua New Guinea (Barham and Harris 1985), and the Kuk site in the Waghi Valley of

Highland Papua New Guinea (Golson 1977; Gorecki 1982).

The general similarity of raised field profiles in other areas to the Huatta and Illpa stratigraphic profiles is striking. A major gap in the literature remains however, in that the majority of the published data (Turner and Harrison 1983; Martinez 1987; Zucchi and Denevan 1979; Stemper 1987; Puleston 1978; Broadbent 1987), with the exception of the work of Bray et al. (1987) and Eidt (1984), only document one or two profiles, which tells us nothing of the range of variation within these complexes of raised fields. Thus, a general similarity is limited to features of general morphology and size, especially similarities in canal form ("V" to "U"-shaped) and raised field platform shape (slightly cambered platforms).

Unfortunately, we are lacking a sufficient body of comparative data from other raised field areas within the Lake Titicaca Basin itself. Excavations of stratigraphic trenches in raised fields by Lennon in the Illpa area (in 1977) and Kolata in the Koani Pampa area (in 1979-80) have not been published. Recent reports (Kolata 1987; Kolata et al. 1987; Kolata and Graffam 1987) summarizes the new excavations in raised fields in the Lukurmata area. These document stratigraphic profiles of raised fields with massive cobblestone bases covered by a layer of impermeable clay. This was the foundation for three layers of sorted gravel, which were finally covered with organic topsoil. These descriptions indicate that the Lukurmata raised fields are very different than those of Huatta and Illpa. We found no

cobblestone field foundations and this construction technique apparently was not used in raised fields in the north Lake Titicaca Basin. There are no cobbles in the pampa of Huatta and Illpa because it consists solely of Pleistocene and Holocene lacustrine and riverine sediments, although it is likely that near the edges of the pampa at the base of slopes, colluvial cobbles may be present.

3.5 THE CHRONOLOGY OF RAISED FIELD AGRICULTURE

3.5.1 Introduction

A major focus of the excavation of trenches in prehistoric raised fields was to directly date the various stages of construction, use, and abandonment. Since most raised fields are not areas where occupation midden would normally be deposited, we did not expect to recover many diagnostic artifacts or sufficient carbon for direct dating. We dug trenches in one block of raised fields immediately adjacent to the site of Pancha with the expectation that proximity to the site would increase the chances of finding datable remains in the agricultural features. The thermoluminescence technique can be an aid in dating small plain sherds, of which we recovered several in good context.

Several archaeological projects have used radiocarbon dating to define a chronology of local raised field systems. Puleston (1978) was able to use radiocarbon to date wooden posts buried in the sediments of the raised field canals. In Papua New Guinea,

preserved wooden agricultural implements have been used to establish radiocarbon dates for several areas (Golson 1977, Goreki 1982). In the Guayas Basin of Ecuador, organic matter accumulated in canal sediments was dated by the radiocarbon method (Parsons and Shlemon 1982).

Our attempt to use radiocarbon to directly date the Huatta raised fields, however, was unsuccessful. Several small carbon samples were collected from raised field excavations of Unit A in Viscachani Pampa and Unit A of Jucchata. The sample from Unit A of Viscachani Pampa was from a feature which appeared to be a hearth/burned zone within the field, probably the remains of an earthen field oven or wathia. The samples were submitted for dating to the Radiocarbon Laboratory of the Illinois State Geological Survey, Urbana. It was found that although the samples contained numerous wood fragments, all carbon had become mineralized, replaced by manganese oxides through mineralization and were not datable. We considered dating the large samples of soil from organic-rich raised field platforms and canals, but lack of funding to ship the samples to the radiocarbon laboratory made this impossible.

The careful recovery of ceramic sherds from good stratigraphic contexts enabled us to use thermoluminescence (TL), an alternative to radiocarbon dating. Pottery was recovered from all excavations in raised fields except Unit D of Viscachani Pampa and Unit I of Illpa. The proveniences were carefully plotted both on the stratigraphic profile, and samples from the

surrounding soil matrix within the strata were collected and bagged with the ceramics. These samples for TL were immediately sealed in light-tight plastic bags to protect them from direct cosmic radiation and other possible contamination. They were then partially dried inside the laboratory to prevent fungus and mold growth.

For TL dating purposes, sherd samples must measure at least 25 mm x 25 mm x 6 mm. They should be recovered at least 50 cm below the surface, from a context which was buried relatively rapidly. Many samples collected during the excavation of raised field trenches met these requirements. A small grant from the Graduate College of the University of Illinois provided the funds to submit 13 samples to the Thermoluminescence Dating and Research Service of the Department of Archaeology, University of Durham, Durham, England. Of these samples, 7 were found to be datable using the inclusion technique of TL dating (Table 2, Figure 45). The rest of the samples had unsuitable TL properties and were rejected by the laboratory.

Most of the ceramic samples were undecorated plain ware body sherds which could not be precisely dated through comparison with established ceramic sequences for the Lake Titicaca Basin. We were able to comparatively date the sherds of samples T-12 and T-3, and the comparative dates strongly support the TL dates obtained for these samples.

Table 2: Thermoluminescence dates from raised field excavations and their contexts.

field #	lab #	site	unit #	stratum	date*	remarks
T-14	DUR TL 26-1AS	Pancha	Unit NOPQ	E/F	400 B.C. \pm 500	Phase I r.f. fill
T-12	DUR TL 35-8AS	Pancha	Unit NOPQ	D2	A.D. 440 \pm 310	Phase I canal fill
T-10	DUR TL 26-3AS	Pancha	Unit NOPQ	D1	A.D. 1325 \pm 120	Abandonment-Phase II
T-11	DUR TL 35-7AS	Pancha	Unit NOPQ	D1	A.D. 1540 \pm 90	Abandonment-Phase II
T-8	DUR TL 35-5AS	Pancha	Unit M	F	1310 B.C. \pm 660	Phase I canal sed.
T-9	DUR TL 35-6AS	Pancha	Unit M	C	A.D. 80 \pm 90	Abandonment-Phase II
T-3	DUR TL 35-1AS	Juchata	Unit A	B	A.D. 380 \pm 320	Abandonment

* Note: All thermoluminescence dates are presented in calendrical years, no calibration is necessary. The overall error is given at the 68% level of confidence.

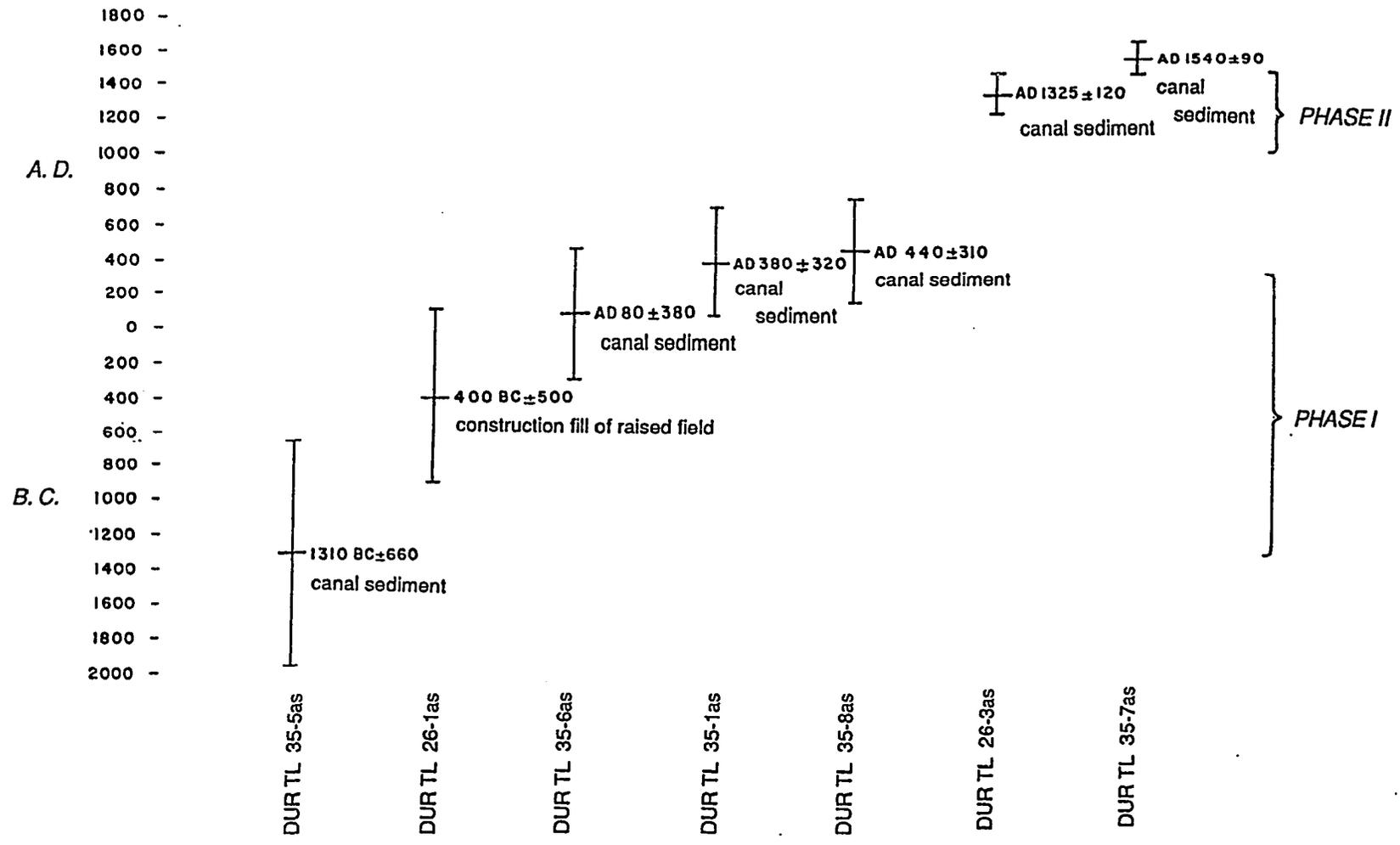


Figure 45: Thermoluminescence dates from raised field excavations in Huatta.

3.5.2 Descriptions, Proveniences, and Interpretations of Thermoluminescence Dates

3.5.2.1 P Pu7-28 Pancha Unit NOPQ

Sample T-14 was recovered from Strata F of Unit NOPQ at 65 cm BS, Phase I raised field construction fill, which was a mixture of original topsoil, and earth removed from the canal. Because of its position at the base of the initial raised field construction fill, this sherd should be associated with the construction of the early raised fields, referred to here as Phase I. The sample dates the construction or initial use of these early raised fields.

The fields were used for several centuries, probably with periodic additions of construction fill to the initial field platforms. The raised fields were then abandoned, and the canals gradually filled with sediments. Sample T-12 was recovered in Stratum D2, the base of the southern Phase I canal in the stratigraphic profile. Because of its location at the very base of the canal, the sherd should be associated with the end of Phase I, the period of disuse or abandonment of the Phase I raised fields. The TL date for this sherd is supported by its diagnostic form and ware, typical of ceramics from the Early Horizon and Early Intermediate Period of the altiplano.

Sometime after abandonment of the Phase I raised fields, a second major period of raised field construction began, Phase II. These platforms were constructed by re-excavating and enlarging

alternate Phase I canals and capping the other sediment-choked Phase I canals with new construction fill. After abandonment of the Phase II raised fields, these canals also filled with sediments. Sample T-10 and Sample T-11 were recovered from 70 cm and 90 cm BS respectively, in Stratum D1, canal sediments between two Phase II raised fields. These TL dates overlap at one sigma and should both date the post-abandonment of the Phase II canals. The wares of these sherds are similar to those of the Inca Period or Late Horizon of the altiplano, which further supports the relatively late TL dates of these samples.

3.5.2.2 PPU7-28 Pancha Unit M

Short wavelength raised fields, referred to here as Phase I, were constructed from earth removed from shallow canals spaced approximately every 2 meters. These fields were later abandoned. Sample T-8 was recovered from 81 cm BD in Stratum F, at the base of canal sediments between Phase I raised fields. This sample should date the final use period, abandonment or post-abandonment of the Phase I raised fields.

Sometime after the abandonment of the Phase I raised fields, another period of raised field construction, Phase II began. These fields were of much longer wavelength and the excavation of the large canal, which cuts through two Phase I canals and erased evidence of intervening Phase I raised fields and canals. These Phase II raised fields in turn were abandoned. Sample T-9 was recovered from Stratum C at 58 cm BD, in canal sediments. This

sample should date the abandonment or post-abandonment of the Phase II canal, but may be too old (discussed below).

3.5.2.3 PPU7-46 Jucchata Unit A:

Sample T-3 was recovered from the Phase II canal sediments of Stratum B, 98.5 cm BD. The sample should date a period of disuse of the raised field canal or shortly after, but may be related to the actual use period of the raised field canal since the sample was found at the base of the canal, just above sterile subsoil. This TL date is somewhat earlier than expected and may be incorrect. A more recent date would correspond to the sherd's characteristics of a late ware, its paste, firing, color, and form. It is most similar to the wares of the Late Intermediate Period and Late Horizon (local Inca). Another in situ sherd, a jar neck fragment with an applique punctated band, was recovered from above sample T-3 in the same Phase II canal, at 57.5 cm BD. This form of plastic decoration, common in the Late Intermediate Period and Late Horizon local Inca ceramics of the Lake Titicaca Basin, provides additional support for attributing the T-3 sample sherd to a more recent time period. A later date for this Phase II canal would also correlate with the other dated Phase II contexts of Unit NOPQ at Pancha.

3.5.2.4 PPU7-66 Illpa: Unit II

Although no sherds from the excavations at Illpa were submitted for TL dating, five Early Horizon/Early Intermediate Period diagnostic sherds were recovered from the upper 20 cm of Stratum M, most from the west end of the trench. The forms include two open bowls with reinforced (thickened) rims, a single out-flaring olla with a handle; and two flat-bottomed bowls or ollas. Stratum M lies below the Phase I raised fields and should pre-date their construction.

From the sediments of a Phase I canal (Stratum O at E59.5), a sherd from a tall necked jar with a handle was recovered. This is tentatively assigned to the Early Intermediate Period. Because of its context in Phase I canal sediments, this sherd should date the abandonment or post-abandonment of the Phase I raised field system.

No sherds were recovered from the Phase II construction fill, thus, dates for the beginning and use of these raised fields at Illpa has not been determined. From the sediments of the Phase II canal at the west end of the trench, we recovered a sherd from an open plate which has many characteristics of Sillustani-Inca red-on-white/cream or brown-on-white/cream wares, dating to the Late Horizon or possibly somewhat earlier (Julien 1983:116-125). This should date the post-abandonment of the Phase II raised field system at Illpa.

3.5.3 The Accuracy of Thermoluminescence for Dating Agricultural Features

The use of TL dating of sherds recovered in situ from excavations in raised fields must be used with some caution. The method cannot be used in certain contexts due to local environmental conditions. Some sherds are found to have characteristics unsuitable for TL dating, and thus cannot be dated or produce unreliable results. The large sigma values of the TL samples for the Huatta stratigraphic profile trenches is also a problem, and the technique cannot be used alone to develop a fine-grained chronology.

As discussed earlier in this chapter on the interpretation of the profile stratigraphy, agricultural fields are generally not the best contexts for the recovery of material for direct dating. The uppermost portions of the fields are continually being reworked by cultivation such as the preparation of seedbeds, planting, banking of plants, weeding and harvest. Older sherds from non-related contexts may be incorporated in new construction fill, and may not be contemporaneous with that construction event. Deep canals were sometimes excavated through earlier strata of construction fill, and the material from these canals used to construct new raised fields. Sherds found in the sediments of the canals may have eroded from older construction fill of the adjacent raised fields. In the Maya area, the presence of Vertisols has been a major problem in the interpretation of raised field remains (Harrison and Turner 1978;

Puleston 1978) and could easily cause artifacts to "move" through the soil.

These problems must be considered seriously, but I do not believe they invalidate the TL dates obtained for the Huatta and raised fields. Although clay content is relatively high, there are no evidence of earth churning in the stratigraphic profiles of raised fields in Huatta and Illpa. The chances of mixing in the Lake Titicaca raised fields due to cracking and reworking of soils because of wet and dry seasonal fluctuations associated with a Vertisol environment are very low.

Except where deep Phase II canals were excavated into older Phase I construction fill, the chance of mixing is assumed to have been minimal. Most agricultural activities would have been relatively shallow, disturbing only the top 10 to 20 cm. It is also assumed that the sediments which continually accumulated in the canals were periodically removed and used as additional construction fill. Because of this, the field platform surfaces were continually capped with new material, effectively sealing off earlier construction events. An extreme example of this is the Phase II capping of Phase I fields and canals at Jucchata, Pancha, Candile, and Illpa with massive amounts of new (and culturally sterile) construction fill. This would tend to reduce the degree to which the soils and associated cultural material were mixed. This is demonstrated by the clear stratigraphic superposition of Phase II raised fields on those of Phase I.

The TL dates of sherds from canal sediments are interpreted

as roughly indicative of the period of temporary or permanent abandonment of the raised fields. I believe that canals in active use would have been kept relatively clean of sediments through routine maintenance (discussed above). The accumulation of sediments in the canals should indicate a period when the fields were not intensively cultivated or period of complete abandonment.

How did the sherds get into the raised field construction fill and canal sediments? Raised fields with a relatively high amount of cultural debris were those located near occupation sites. Units M and NOPQ of Pancha lay between 20-50 meters from the occupation site. Cultural debris was presumably dumped on these fields as organic fertilizer, with extraneous matter such as broken sherds sometimes being accidentally incorporated. Today, Quechua farmers regularly dispose of large amounts of organic and inorganic household garbage in fields near temporary and permanent occupation sites. The most common element is the ash generated by cooking in clay stoves (q'oncha) with animal dung (waykuna). This, combined with broken utilitarian pottery, is dumped in low spots near the house or spread out over agricultural fields. Garbage is never dumped in drainage ditches or canals that are currently being used, but may be used to fill holes or ditches not in use. Presumably the pattern of disposal of disposal of garbage in prehistoric times was analogous.

The best support for the use of TL dating of the construction and abandonment events of the raised fields is that

the group of TL dates are internally consistent within each stratigraphic profile and between profiles. Strata which should date earlier than other strata according to the Law of Superposition have earlier TL dates. In addition, only two sherds (T-12, T-3) that were dated using the TL method had diagnostic attributes that could be directly related to known chronological sequences which supported the TL dates. Radiocarbon dating and relative ceramic dating of prehistoric occupation sites associated with raised field blocks in Pancha and Kaminaga provided support for the TL dates obtained from stratigraphic profiles. Because of these convergent lines of evidence, I believe that most of the TL dates are correct and can be used for the direct dating of the strata in the stratigraphic profiles.

3.5.4 Summary of the Dating of the Raised Fields

The analysis of the raised field stratigraphic profiles has provided us with a chronological framework defining the evolution of raised field agriculture in the Lake Titicaca Basin. The implications of a model of the early evolution of raised fields are discussed in Chapter 7.

Two major phases or periods of raised field construction and use are documented by these trenches, referred to as Phase I and Phase II. Within each of these distinct phases, sub-phases of raised field construction are defined in several raised field profiles. The following interpretations combine the absolute

dating of strata using TL, the relative sequence based on internal stratigraphy, and comparative dating of diagnostic ceramics as supported by the dating of associated archaeological sites (see Erickson 1988).

3.5.4.1 Phase I

The Phase I raised fields are the earliest on the pampa of Huatta. The best data on the chronology of this early phase of raised field construction comes from the stratigraphic profiles at the site of Pancha. In both trenches, Unit M and Unit NOPQ, there is evidence of a superposition of raised fields, an early shorter wavelength raised field system below a later longer wavelength raised field system. The early raised fields of Phase I in Unit NOPQ had a wavelength of approximately 5 meters (canals and raised fields approximately 2.5 meters wide) and an elevation of 0.5 meters. The Phase I raised fields of Unit M were smaller with a wavelength of approximately 2 meters (raised fields and canals of 1.0 meters width). The earliest TL date from the Unit M stratigraphic profile is 1320 B.C. \pm 660 years. The sample dates the sediment from a Phase I canal, possibly after a period of abandonment. This date is very early, but its large sigma value overlaps the next earliest date from Unit NOPQ, 400 B.C. \pm 500 years. This sample comes from the base of Phase I raised field construction fill. I believe that the earlier date is best interpreted on the more recent range of its variation. These two

dates suggest the construction and initial use of the Phase I raised fields as early as 1000 B.C..

The TL date of A.D. 440 ± 310 years came from Phase I canal sediment contexts of Unit NOPQ at Pancha. This sample should date the abandonment or post-abandonment of the Phase I raised fields.

Superimposed raised fields were also documented in Unit I and Unit II of Illpa, and Unit A of Ccoccope. Unfortunately, we have no TL dates from these raised field excavation trenches, but diagnostic sherds from Unit II at Illpa support the sequence based on TL dates developed for Huatta. The Phase I fields of Units I and II at Illpa are very similar to those of Unit M of Pancha. The Phase I fields of Unit A of Ccoccope are more similar to Unit NOPQ of Pancha. All of these Phase I raised fields should be approximately contemporaneous.

A series of radiocarbon dates from associated Early Horizon/Early Intermediate Period occupation mounds clustering between 800-600 B.C. strongly support the TL dates for the Phase I raised fields (see Erickson 1988).

3.5.4.2 Phase II

The length of the period of disuse of the Phase I raised fields is not known. Around A.D. 1000, but possibly before, the eroded Phase I raised fields and sediment-filled canals were modified to increase the raised field and canal surface area and, at the same time, the elevation of the planting platforms. This

period has been designated Phase II. In Unit NOPQ and Unit M of Pancha, Unit A of Ccoccope, Unit I and Unit II of Illpa, and Unit A at Jucchata, the wavelength of the raised fields was increased to approximately 10 meters (raised fields and canals each 5 meters wide). The single phase raised field constructions at Unit A of Viscachani Pampa, Unit A of Machachi, Unit A of Candile and Unit C at Kaminaqa are of similar 10 (approximately) meter wavelengths and probably are contemporaneous (ie. Phase II). The raised fields of Unit D at Viscachani Pampa have a longer wavelength (16 meters) and are much larger, but should date to Phase II.

Unfortunately, we do not have TL dates for the initial construction and use for any of the Phase II raised fields. Two overlapping dates from the very base of Phase II canal sediments, A.D. 80 \pm 90 from Unit M at Pancha and A.D. 380 \pm 320 from Unit A at Jucchata, could either date the use period or abandonment because of their provenience in the base of canals. The early date from Unit A at Jucchata is somewhat of an enigma. This date, A.D. 380 \pm 320 years, is from the base of a Phase II canal sediment. Because the ware and form of this sherd and another undated sherd from the same context is stylistically later, I believe that the date may be too old. The early date for the Phase II canal sediments of Unit M at Pancha may also be too old by several centuries. If the comparative dating of the sherds is wrong, it is possible that both the TL dates for Pancha and Jucchata are correct. This would mean that large, long

wavelength raised fields were also being constructed and used at a early date and that the smaller Phase I raised fields documented in the stratigraphic profiles do not represent the whole range of Phase I raised field morphology. There is no reason to think that the early Phase I farmers could not and did not construct large raised fields. As discussed above, the progression of small to large raised fields would have been a logical step in the evolution of field form to create mature raised field systems.

Large fields may have been constructed during the Early Intermediate Period, but the data indicate that at least the majority of large fields in the profiles belong to Phase II, and are probably post-Tiwanaku and pre-Inca. Two overlapping dates of A.D. 1325 ± 120 years and A.D. 1540 ± 90 years were obtained from samples in sediments of the same Phase II canal of Unit NOPQ at Pancha. These samples should date the final abandonment or post-abandonment of the Phase II raised fields. Analysis of ceramics from associated occupation sites strongly supports these terminal dates, and together they indicate that construction and use of the Phase II raised fields occurred during the Late Intermediate Period. A sherd from Phase II canal sediments of Unit II at Illpa is stylistically related to the Late Horizon, supporting the chronology for abandonment defined by the TL dates from Pancha.

In summary, there are two phases of raised field construction and use in the Huatta area. Phase I began sometime

ca. 1000 B.C., probably reaching a peak around 600-800 B.C. and ended sometime after A.D. 300. The larger raised fields became important in Phase II, possibly beginning before A.D. 1000 and lasting until the arrival of the Inca in the zone, sometime after A.D. 1450. Large raised fields may have been constructed in Phase I, but the data suggests they are associated with Phase II.

3.5.5 Discussion

Relating the TL dates to what we know about the prehistoric cultures of the zone permit us to interpret the significance of the raised fields in terms of local culture history. The remains of early farming cultures of the altiplano, Qaluyu, Wankarani, and Chiripa, indicate an economic orientation towards the lakeshores and wetland zones (see Chapter 7; also Erickson and Horn 1977). The exploitation of lacustrine resources was probably similar to the economy of the present day lakeshore dwellers, which combines agriculture, fishing, hunting, and collecting. Besides increasing the area of arable land around the lakeshore and rivers, the practice of raised field agriculture would have also expanded the ecozone that favored wetland flora and fauna (Erickson 1986). Construction of the raised fields probably began along the shores of the lake and rivers, expanded throughout the seasonally flooded plains, and later expanded into the drier areas of the pampa. The peak in

early raised field use during Phase I apparently coincided with, or perhaps began somewhat earlier than, the rise in importance of the ceremonial center of Pukara in the northern lake basin. The locations of major and minor Pukara settlements on the lake edge suggests an economy based on raised fields and gochas (sunken fields), probably also including andenes (terraces) on hillslopes in close proximity to the lake.

During the period around A.D. 200-300, the southern lake basin culture, Tiwanaku, usurped the power and prestige of Pukara. With the subsequent collapse of Pukara, there is evidence of the abandonment or disuse of the raised fields in Phase I of the pampa of Huatta. I suggest that this abandonment was related to the shift in power from northern to southern capital. I can attribute the lack of diagnostic ceramics of the Tiwanaku period in the pampa of Huatta to one of two factors: a major depopulation or migration out of the area, or the continuation of local non-Tiwanaku ceramic tradition. Alan Kolata (1982, 1986) suggests that the raised fields in Koani Pampa in Bolivia are related to Tiwanaku occupations IV and V, which coincides with the period of abandonment of raised fields in the north. With the collapse of Tiwanaku around A.D. 1000, raised field construction appears to have been stopped in the southern basin, and resurgence of construction of raised fields is seen in the north (Phase II). These raised fields are related to the Lupaca and Qolla ethnic groups. It is highly likely that the final abandonment of these raised fields occurred during the

Inca occupation of the Lake Titicaca Basin. The Spanish and indigenous chroniclers make no reference to raised field agriculture, whereas they wrote detailed descriptions of other forms of indigenous Andean agriculture; thus, when the Spanish arrived, the raised fields were probably in disuse. It is suggested that the abandonment that ended Phase II, in addition to that of Phase I, can be attributed to socio-political changes in the Lake Titicaca Basin.

I would like to emphasize that the "abandonment" may not be the correct term for the hiatus between Phase I and Phase II, nor the period of disuse following Phase II. There is no evidence that there was a complete breakdown or "collapse" of the agricultural system within a relatively short time period. A more accurate concept would focus on degrees of agrarian change, including both agricultural expansion and contraction (Denevan 1985). There was probably no complete abandonment of the raised fields until the Spanish arrived in the Lake Titicaca Basin.

In the Chapter 7 which includes a discussion of the culture history and evolution of raised fields, these ideas will be examined in much more detail; here it can only be emphasized that the direct dating obtained using TL correlate closely with the periods of rise and decline of raised field use in Phase I with a climax and subsequent decline of raised fields with the collapse of Pukara.

CHAPTER 4
EXPERIMENTS IN RAISED FIELD AGRICULTURE

4.1 LABOR ORGANIZATION IN EXPERIMENTAL
AND COMMUNITY RAISED FIELDS

4.1.1 Organization of Labor in the Community of Huatta

Since the raised fields are now abandoned, the original social organization involved in the construction and maintenance of these original raised field systems cannot be directly examined. One advantage of working in the altiplano of southern Peru is that vestiges of indigenous Andean social organization, especially in the organization of labor for agricultural and community projects, still remain. Traditional labor organizations such as ayni, and faena or minka are still common in most indigenous communities in the Department of Puno, including Huatta. The adoption of raised field agriculture by groups with different levels of social organization in Huatta and Coata was an unintentional result of the original experimental fields. This acceptance of raised field technology by individuals, extended families, and communal groups provided an excellent opportunity to examine the organization of labor associated with raised field agriculture. Obviously, the

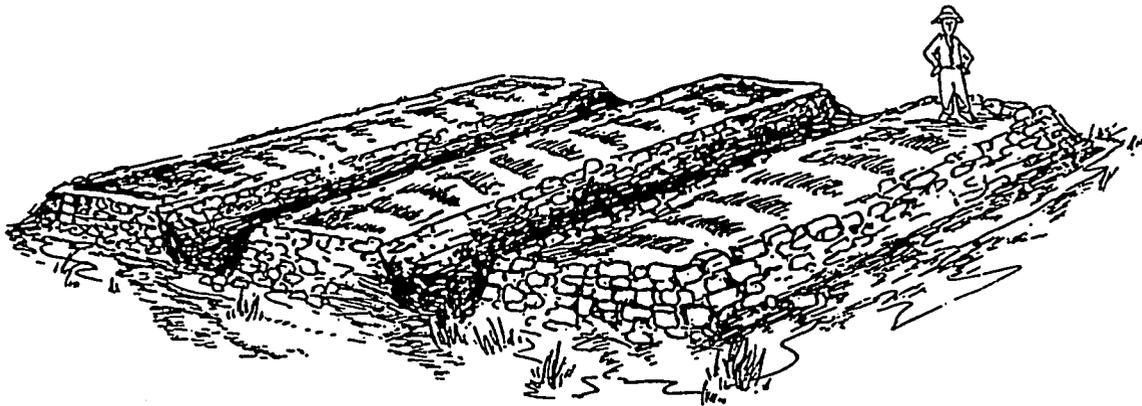
contemporary social structures in the Community of Huatta are not identical to those of prehistory. However, many of the principles of organization have remained the same, and we can obtain a general idea of what sort of social groups could have practiced raised field agriculture in prehistoric times. More important, we can infer what level of organization was necessary for this form of intensive agriculture.

All of the reconstructions of experimental raised field plots, both those of individual families and communities, were based on prehistoric field remains. In most of the areas of reconstruction, excavations were made within the areas to be reconstructed to determine the original field platform and canal morphology (Chapter 3). These data, in addition to experimentation and trial and error, allowed us to refine the reconstruction over several growing seasons to the point where we believe our techniques are similar to those used prehistorically.

The technique for construction of raised fields has been presented elsewhere (Erickson 1985, 1986, 1988; Garaycochea 1986a, 1986b, 1987a; also see Chapter 3). First, the area of raised fields selected for reconstruction is carefully marked off using string to delineate the the borders between prehistoric raised field surfaces and canals. To obtain sufficient fill to elevate the surface of the platform to the optimal height, the area of canals should be equal to that of the platforms. The canals are divided in half longitudinally with the fill from each used to construct adjacent fields (Figures 46 and 47).



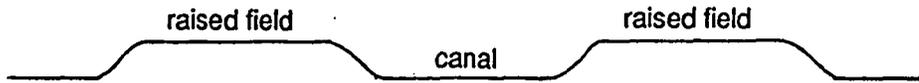
ERODED PREHISPANIC RAISED FIELDS



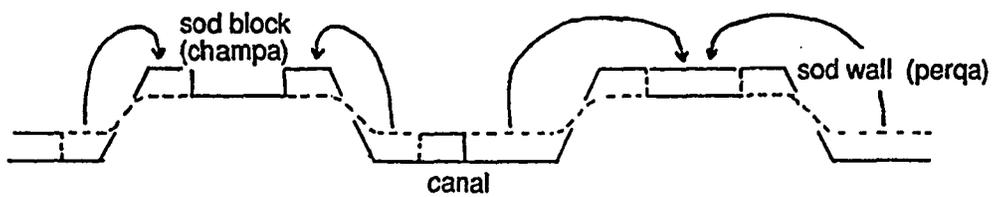
RECONSTRUCTED RAISED FIELDS

Figure 46: A comparison of eroded unreconstructed raised fields and reconstructed raised fields (drawn by Daniel A. Brinkmeier).

UNRECONSTRUCTED RAISED FIELDS



RECONSTRUCTION OF RAISED FIELDS



RECONSTRUCTED RAISED FIELDS

Dry Season



RECONSTRUCTED RAISED FIELDS

Wet Season

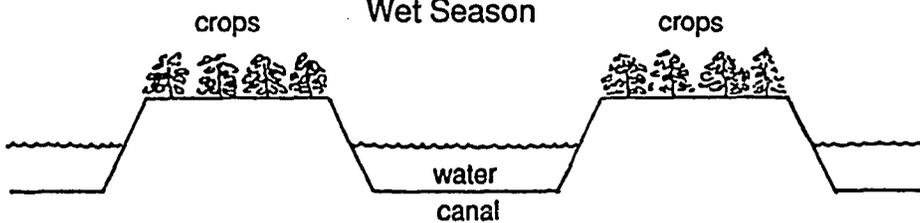


Figure 47: The raised field reconstruction process (after Garaycochea 1987a).

Rectangular sod blocks (ch'ampa) are carefully cut and removed from the canal by teams using the Andean footplow (chakitaqlla) and used to build up a sod wall on the perimeter of the raised field platform. The correct height depends on the average water table during the growing season which varies according to location. Minimally, these walls and the fill between them is 20 cm (the thickness of a single sod block). After the walls are constructed, all topsoil is removed from the canals as blocks and chunks of sod and loose earth and used as construction fill. Ideally, the final surface should have a slight camber to improve drainage. The surface is leveled and the soil pulverized using a wooden clod buster (waqtana) and small hoe (rawkana) (Figure 48). If properly constructed, a field will not need maintenance for many years.

4.1.1.1 Comuneros

The four parcialidades of Huatta are Primera Collana, Segunda Collana, Faon and Yasin. Members of a parcialidad call themselves "comuneros." Of the 640 families of Huatta, approximately 315 families are members. The smallest group, Segunda Collana, has 35 active families; the largest, Yasin, has 150. Each parcialidad has its own political structure with elected president, vice president, secretary, treasurer and representatives. The four parcialidades are responsible for electing a president of the community that represents all of the groups' interests to the national government, and he is also



Figure 48: Traditional Andean tools used in raised field construction: rawkana or hoe (left), chakitaqlla or Andean footplow (center), waqtana or clob breaker (right). Blades made of iron from the leaves of truck springs have replaced the stone and wooden blades used to construct prehistoric raised fields, but the tools basically remain the same.

responsible for coordinating the actions of the four groups.

The number of comuneros is variable, since the level of interest in the activities of the parcialidad waxes and wanes through time. The most important reason for joining the communal organization is for access to community land for grazing or cultivation. Other reasons include participation in social events, opportunities for political advancement, and access to the projects subsidized by the various rural development organizations working in the area.

Huatta does not have a functioning ayllu (local landholding) organization common in other Andean communities. The modern parcialidad is clearly a transformation of the traditional ayllu as it has been shaped by colonial and contemporary processes.

4.1.1.2 Parceleros

Those farmers who do not participate as members of a parcialidad are called parceleros. These tend to be non-Catholics (Adventistas and Evangélicos), storeowners, farmers with lots of productive land, non-resident part-time farmers, or the extremely poor who cannot afford the tools and dues to be a member of a parcialidad. These tend to work as a family, or commonly as an extended family on their own lands or rented lands, and sometimes hire others or rely heavily on ayni and compadre relationships. Ayni is the traditional reciprocal exchange of labor between farmers, usually implemented for labor intensive projects such as agricultural activities and house construction. Many feel that they can advance economically much

better on their own, or have had family or personal problems with other members of the parcialidades.

The labor for construction of communal raised fields can be organized as faena (faena comunal or minka) or tarea which are discussed below.

4.1.1.3 Faena (Minka)

Faena is a day of collective work, where every member must attend or send a representative. Comuneros who do not participate may be fined. A day of faena can last from 5-8 hours depending on the type of work to be done, the season and the weather. Prepared food for a mid-day meal is usually brought by each family, and is often shared among relatives and friends. For special occasions, food from the community reserves (usually viveres from "food-for-work" projects sponsored by local development agencies or the Catholic Church) is prepared at the work site and distributed to all participants.

For raised field construction, faenas were as small as 20 or as large as 150 family representatives. On most days of faena work, more women show up than men. Using closely monitored work lists, Garaycochea (1987b:2) calculates that in the 1986-1987 season, a mean of 60% men and 40% women worked on the raised fields. In the comunal raised fields, out of a total of 463 participants, 64% were men and 36% were women. Of raised fields constructed by parceleros, the participation of women was much

higher (up to 85%) than that of men.

The primary advantage of the faena for raised field construction is that a relatively large group is assembled and everyone works together (Figures 49 and 50; also see Figures 51-52 for completed raised fields with crops). This is especially important when the work involves heavy labor. Enthusiasm is created with conversation, joking, and informal competitions, which also provides opportunities for short breaks and switching tasks. The work tends to be more uniform since participants are working together on the same raised field or on adjacent raised fields. Usually, a single raised field is completely finished before another is begun, gauged so that the day's work results only in completed fields or field sections. Since most of the voting members (or their representatives) of the community are present at a faena, on-the-spot decisions can be made regarding the work, alterations in the construction plan, and additional work days if necessary.

The major disadvantage of faena is that the work done by the participants can be very unequal. Since each member of the parcialidad is only obligated to send a representative, many participants at faenas are women, children and elderly men. Middle aged men also tend to spend more time gossiping and joking as the day progresses. Internal community divisions become accentuated with accusations of who is not doing their share of the work.



Figure 49: Raised field construction in Chojfocoto by the Community of Yasin (October, 1985).



Figure 50: Raised field construction in Illpa (October, 1985).



Figure 51: Large raised fields planted in potatoes in Viscachani Pampa (March, 1985). The Canals and raised fields are 10 meters wide. The maximum depth of water in the canals is approximately 1 meter.



Figure 52: Raised fields with flowering potatoes in Viscachani Pampa (January, 1986).



Figure 53: Narrow raised fields planted in potatoes in Chojfocoto constructed by the Community of Faon (March 1985). Fields are approximately 3 meters wide and 0.6 meters tall (from canal base to platform surface).

4.1.1.4 Tarea

In 1984-1985, the innovative comuneros of Segunda Collana decided to try a different method of labor organization for raised field construction, tarea (Garaycochea 1986a:95; 1987a:393). In this system, each member family is assigned a designated area within a block of raised fields to reconstruct. The most common tarea for raised fields was 5 x 5 meters or 25² m²/member family. Using an average figure of 20 cm depth of soil removed from this area as fill during construction, a calculation of 5 m³ is obtained, approximately what one person can construct in a day. It normally took one full day of labor to complete a tarea, although at times this was extended to 2 days. If the comuneros agreed, additional tareas could be added until planting began.

The advantage of tarea is that the work generally progresses faster and more efficiently. When each family is obligated to finish a designated area, they can do it when they choose and at their own pace. The work is easier in a team, so a group of family members will work to complete the tarea, in contrast to the family head or a single representative working in faena. Another advantage was that the system was considered more "fair" since each family had an equal area to reconstruct. The disadvantage is that the work is not always uniform in quality, as each tarea block tends to reflect the level of interest and ability of the family. The quality of results using tarea usually reflects on the how active the president was in the

reconstruction and quality control. (see Erickson et al. 1986; Garaycochea 1986a, 1986b, 1987a, 1987b). Puleston (1977) in Belize, Ramos (1986a; 1986b) in Asillo, Gorecki (1982) and Steensberg (1980) in Kuk all found that the tarea method was preferred over other methods in raised field construction.

4.1.1.5 Parceleros and Raised Fields on Private Lands

The labor for the individual farmer's reconstruction of raised fields comes from the immediate family, extended family, and compadres. Everyone has reciprocal labor obligations (ayni) and they are used in raised field construction to pay debts. Usually, equal numbers of men and women participate, in addition to numerous children.

The advantage of raised field labor organized on the family level is that the work is usually of very high quality since the farmer has a personal interest in constructing on his private plots. Private fields tend to be much better cared for than communal fields, and receive more regular maintenance. The theft of mature crops near harvest time is a common problem, and private fields are better guarded than community fields. Animals that could do damage are carefully kept out of private raised fields. Innovation involving new construction techniques or forms of the fields is common in the raised field reconstructions of parceleros. The disadvantage is that the area of individual field blocks tends to be small in the first few years, and the area reconstructed grows very slowly. Thus, the microclimatic modifications and hydraulic control possible in

large blocks of raised fields is not as effective in the small isolated private plots.

4.2 LABOR ESTIMATES FOR RAISED FIELD CONSTRUCTION AND MAINTENANCE

4.2.1 Experimental Raised Field Construction 1981-1983

Labor estimates for experimental raised field construction have been calculated for certain days of construction between 1981-1983 (Erickson) and 1983-4 and 1986-7 (Garaycochea). Initial labor estimates for the 1981-1982 season have been presented by Erickson (1985:218-220). The labor necessary for the construction of a single hectare of raised fields is very consistent between the figures obtained for Machachi (two seasons), Candile, Viscachani, and Jucchata. The mean for labor efficiency in these five cases recorded in 1981-3 is $5.15 \frac{m^3}{person/day}$ (Table 3). During reconstruction in Machachi, an average of $1.12 \frac{m^3}{hr/person}$ or $5.6 \frac{m^3}{day/person}$ (based on a 5 hour day), was calculated. In Candile, the figures were somewhat lower, $0.865 \frac{m^3}{hr/person}$, $4.33 \frac{m^3}{day/person}$. A five hour day was used as a basis for calculation because this is the average duration of a work day in Huatta for labor involving the chakitaqlla, and is a common figure for a day of labor-intensive work in many other Andean areas. Most work days days of raised field construction were limited to 5 hours of work, and this will be the figure used for the calculations given below. If a

Table 3: Labor calculations for experimental raised field construction in Huatta, 1981-2 and 1982-3.

field location	depth of fill (cm)	elevation of field from canal base (cm)	fill for ha r.f. and canal (m ³)	rate of constr. (m ³ /pers./day)	ha r.f. and canal (man-days/ha)
Machachi	20	40	1000	5.60	178.57
Machachi	20	40	1000	4.82	207.47
Candile	20	40	1000	4.33	230.95
Viscachani	20	40	1000	5.98	167.26
Jucchata	20	40	1000	5.03	198.75
mean	20	40	1000	5.15	194.17

particular raised field work-day lasted longer or shorter than 5 hours, the figures were adjusted to a 5 hour day. Using the average figure of $5 \text{ m}^3/\text{day}/\text{person}$ for Machachi and Candile, 200 person-days are required to reconstruct one hectare of raised fields and canals with 20 cm of construction fill (Table 3). "One hectare" always includes both the raised fields and canals, unless otherwise specified.

In Viscachani Pampa during 1982-3, larger areas of raised fields were constructed by the comuneros of Segunda Collana. An area of 1405 m^2 (moving 281 m^3 of earth) was reconstructed in 235 person-hours. The labor efficiency figure for this work is calculated to be impressive $6 \text{ m}^3/\text{day}/\text{person}$. Using this figure, a hectare of raised fields and canals could be constructed in only 167 person-days (Table 3). It should be noted that the raised fields reconstructed here were very large, up to 10 meters wide, which normally tends to increase labor costs because of the a longer distance to move the construction fill from canal to raised platform center.

The communal group at Viscachani works very efficiently and constructed raised fields of extremely high quality with very little supervision. The high figure obtained here is attributed to the very high level of enthusiasm expressed by the community of Collana Segunda for raised field construction. This is the best organized communal group in Huatta, which also increased labor efficiency. They continued year after year expanding their raised fields, almost completely on their own, and today have the

largest block in Huatta.

In addition, construction costs for expansion of the Machachi raised fields and for other small blocks of experimental raised fields in Huatta were calculated for the 1982-3 season. In Jucchata, a labor efficiency rate of $5.0 \text{ m}^3/\text{person}/\text{day}$ was obtained for the reconstruction of a 181 m^2 raised field in dry soil conditions. In Machachi, the raised fields constructed in the previous season were expanded another 174 m^2 , and a figure of $4.8 \text{ m}^3/\text{person}/\text{day}$ was calculated. The work done here was undertaken during the end of the rainy season and the soil was very waterlogged, making removal of champa blocks difficult, which decreased the overall labor efficiency. These figures can be converted to 199 person-days and 207 person-days, respectively, to construct a hectare of fields platforms and canals (Table 3).

Several factors help to explain the high efficiency figures obtained in the majority of the experimental reconstruction. The small fields at Machachi, Candile, and Jucchata were reconstructed by a small team of hired local farmers or a small family group. This construction was carefully supervised by the archaeologist. In the case of the family who constructed the raised fields on their own private land at Machachi and Candile, all the harvest was their to keep which served as an additional incentive.

Using the figure of 200 person-days/ha, a single family of 5 able-bodied members could construct a hectare of raised fields

in only 40 days. This would not necessarily be considered labor intensive, especially since the field could produce for many years.

4.2.2 Additional Comparative Data from Huatta

During the growing season of 1984-1985, estimates were made of the labor expended in the construction of additional raised fields in Viscachani Pampa (Garaycochea 1986a, 1987a). Approximately $4 \frac{m}{day/person}$ of soil (20 cm depth of construction fill) of construction fill) was moved during raised field construction. A calculation of 250 person-days/hectare is obtained (Table 4). Garaycochea (1986a:93-96) reports an averages from 3 different field constructions, which when converted to our 5 hour day is $33.2 \frac{m}{person/day}$, or 310 person-days/hectare.

In 1986-1987, labor investment was carefully recorded during the reconstruction of a total of more than 13 hectares ($134,188 \frac{m}{2}$) of raised fields in 10 different communities (Garaycochea 1987b:Table 1). An account of the person-days (jornales) worked was carefully kept by the participants, since this was the basis for calculating their wages. In this season, Garaycochea (1987b:1-2) reports a wide range of labor requirements, ranging from 575 person-days to 1,022 person-days/ha with a average of 786 person-days/ha. Based on Garaycochea's figures of average person-days/ha, I calculate a rate of efficiency of only $1.3 \frac{m}{person/day}$ (assuming an average depth of 20 cm of construction fill).

Table 4: Comparative labor calculations for raised field construction.

example	depth of fill (cm)	area of platform constructed (m ²)	fill for ha r.f. & canal (m ³)	rate of constr. (m ³ /person/day)	ha r.f. & canal (person-days/ha)
¹ Erickson	20	1943	1000	5.0	200
² Garaycochea	20	642	1000	4.0	250
³ Garaycochea	20	1351	1000	3.2	310
⁴ Garaycochea	20	66801	1000	1.3	786
⁵ Ramos	24	8613	1752	1.9	900
⁷ Denevan	20	NA	1000	2.6	769

note: one day = 5 hours

1

based on Erickson (1985) and Table 3.

2

based on Garaycochea (1986b 1987a).

3

based on Garaycochea (1986a) converted to a five hour day.

4

based on Garaycochea (1987b).

5

based on Ramos (1986b).

6

based on Denevan (1982).

4.2.3 Discussion of the Variability of Labor Rates
for Raised Field Construction

The variations in labor calculations for raised field construction in different years is substantial. The low labor requirements (200 person-days/ha --based on Erickson 1985--or 194.17 person-days for all five locations for 1981-1983) may be partially the result of the relatively crude construction methods used during the first season of experimentation. The construction of pergas (sod walls), a more time-consuming activity, was not used in the 1981-1982 fields constructed in Machachi and Candile. Those fields were also relatively narrow (3-4 meters) in comparison to some of the fields reconstructed in later years (up to 10 meters in width). But these early figures are supported by the labor estimates for the Viscachani Pampa fields, which are 5-10 meters wide and built with pergas, and the other small well-constructed raised fields in Jucchata and Machachi during 1982-3. Garaycochea's estimate of $4 \frac{1}{3}$ m /person/day for the fields of Viscachani Pampa constructed in 1983-4, is only slightly lower. The very low average figure of $1.3 \frac{1}{3}$ m /person/day obtained from Garaycochea for the 1986-1987 season is probably the result of the payment of wages. When paid laborers (jornaleros) constructed the Ministry of Agriculture experimental fields at Illpa in 1985-1986, efficient labor rates could be maintained only if they were very closely supervised.

The payment of jornales for community projects encourages the participants to increase or exaggerate the amount of time

spent on a project in order to receive more pay. As a result, overall efficiency in labor is not encouraged.

The high labor figures for the Asillo raised fields reported by Ramos (1986a; 1986b) are probably because of the payment of viveres for the work done. This has the same effect as the payment of jornales in increasing the number of days necessary to complete a hectare of raised fields.

Labor rate variability for raised field construction is also related to several environmental conditions. In Huatta, it was found that the state of preservation of the raised fields was significant in terms of the labor required for reconstruction. The general soil texture of the area to be reconstructed also affects labor efficiency. The soil conditions at the time of construction, and scheduling the work, are other important factors. The scheduling of construction activities to take advantage of optimal soil conditions would have been an important concern of the raised field farmers to minimize the labor input. It should be noted that most of our experimental construction was not done during periods of optimal conditions.

4.2.4 Comparative Labor Estimates

The only comparative labor estimates for raised field construction in the Lake Titicaca Basin itself are from Asillo, approximately 80 km north of Huatta (Ramos 1986a, 1986b). The labor involved in reconstructing these raised fields is calculated as 900 person-days/ha (compared to 1000 person-

days/ha for terraces) (Ramos 1986a). These fields, small blocks totaling $11,798 \text{ m}^2$, were constructed on private lands. Labor efficiency can be calculated from this figure yielding only $1.9 \text{ m}^3/\text{person}/\text{day}$ (Table 4). The project used a tarea quota of $2.5 \text{ m}^3/\text{person}/\text{day}$ (Ramos 1986a:277) which should mean a hectare could be reconstructed in only 700 person-days. Obviously, the average tarea took almost 2 days to complete at this pace.

These raised fields were reconstructed with narrow deep canals (only 26 % of the net area) which may also have increased labor investment, since more subsoil would be used as construction fill.

Very little comparative data is available for raised field construction in other areas. Researchers who have attempted to estimate the labor involved in the raised fields or other prehispanic systems of agriculture (Turner and Denevan 1985; Denevan 1982) have used the figures for manual excavation calculated by Erasmus (1965:285). Erasmus determined that $2.6 \text{ m}^3/\text{day}/\text{person}$ (5 hour day) of earth could be moved by a person using a digging stick. Although this figure is based on excavation with traditional wooden tools, the context was non-agricultural and probably bears little analogy to raised field construction. The experiment was only conducted for a very short time and probably not under ideal soil conditions.

Puleston (1977a, 1977b) calculated his labor figures by reconstructing Maya raised fields in Belize. Wage laborers organized under the tarea method, reconstructed 2.7

³
m /day/person. This figure appears to be low despite the use of metal tools. This is because Puleston, following the prehistoric models, used marl (consolidated and unconsolidated limestone) for the foundations of the fields, which was cut and transported from distant sources to the raised field site. The use of marl made the work considerably less efficient.

Labor estimates for chinampas have been reported as 0.172 ³ m /hr/person (Turner 1983:15) or 0.86 m ³ /hour day/person when converted to a 5 hour day. This estimation was reported in Gomez-Pompa et al. (1982) which is unreliable because the figures on which it is based do not include volume. Work rates for ethnographic drained field construction in Tlaxcala, Mexico, is reported to be 0.83 m ³ /hr/person (or 4.2 m ³ /day/person for a 5 hour day) digging "peaty substance" but when "earth" is encountered, the figure drops to only 0.4 m ³ /hr/person (2.0 ³ m /day/person) (Wilken in Turner 1983:15).

Turner (1983), using extremely conservative figures for limestone excavation (0.40-0.83 m ³ /hr/person) based on the above figures for drained fields in Tlaxcala suggests that a hectare of drained or raised fields could be constructed in 945-3,016 person-days (using a 6 hour day). Adapting his figures to our 5 hour day, the figures become 1,134 to 3,6192 person-days/ha. Turner's use of Wilken's higher labor efficiency figures (see above) are probably reasonable, although from a completely different environment and raised field type. The higher labor rate figure is similar to those of Huatta. Whether 1 meter tall

fill of the Maya raised fields was constructed all at once is debatable. I have demonstrated (Chapter 3) that the raised fields of the Lake Titicaca Basin were constructed incrementally over many generations of farmers.

Another area where experimental and ethnographic raised field construction data has been recorded is from New Guinea (both Papua New Guinea and Irian Jaya). From the Waghi Valley, Gorecki (1982:39-42) reports ditch digging rates of $3.0 \text{ m}^3/\text{person/hr}$ using metal tools, which converts to $15 \text{ m}^3/\text{person/day}$. Steenberg (1980:88-90) provides figures from experiments using wooden tools from which a calculation of a rate of $1.1 \text{ m}^3/\text{person/hr}$ or $5.5 \text{ m}^3/\text{person/day}$ for the same area. Using metal tools, the rate is $3 \text{ m}^3/\text{person/hr}$ or $15 \text{ meters}^3/\text{person/day}$ (ibid.). A figure of $1.43 \text{ m}^3/\text{person/hour}$ or $7.26 \text{ m}^3/\text{person/day}$ is calculated for ditch digging with wooden "earth knives" using Pospisils data (1978:7) for the Kamu Valley. In the Upper Kaguel Valley, Bayliss-Smith (1985:302-303) reports a figure of $0.47 \text{ m}^3/\text{person/hr}$ for large taro field drains and $0.55 \text{ m}^3/\text{person/hr}$ for small drains using steel tools and another case of ditch digging with a figure of $0.8 \text{ m}^3/\text{person/hr}$ or $4.0 \text{ m}^3/\text{person/day}$. What is most impressive about these figures is the high rate of efficiency for wooden tools. The rates of efficiency reported here for wooden tools are very similar to those from experimentation in Huatta.

The calculations of labor efficiency for experimental raised field construction in Huatta are much higher than those reported

for the other raised field contexts in the Americas and is similar to those from New Guinea. This is attributed to the remarkable efficiency of the chakitaqlla as a tool for agricultural activities (Gade and Rios 1972), in particular raised field construction (Erickson 1985). Experience gained in reconstructing the raised fields over a period of 5 years, rather than as an ad-hoc experiment in an unfamiliar technology, also helped increase labor efficiency. Traditional community labor organization in Huatta, possibly very similar to prehistoric labor organization, also provided a strong base for high labor efficiency.

Labor estimates can be expected to vary greatly among different areas due to differences in environmental and social conditions. The main problem with extrapolating estimates of labor in raised field construction to prehistoric situations is that few studies have been on controlled experiments based on prehistoric models. More controlled raised field experiments should indicate that actual labor costs were much less than those derived from artificial situations.

Although our data is based on metal-bladed tools, certain conditions, such as not constructing the raised fields in optimal soil conditions, probably neutralized, to some extent, this advantage.

4.2.5 Cultivation Labor Costs in Raised Field Agriculture

The labor costs for other normal cultivation activities has also been calculated for raised field agriculture (based on a hectare of raised field platform surfaces and canal). This data is derived from fieldnotes written between 1981-1986. The figures provide is only a rough estimate because of the difficulty of keeping careful records of these sporadic activities. The activities presented in Table 5 have a total of 270 man-days/ha of potatoes.

Knapp (1984), using an elaborate methodology, has developed some interesting labor estimates for raised field agriculture in the Highland Basins of Quito. He bases his figures on the annual labor necessary for a present day traditional farm using traditional crops, ditches, and techniques, which he believes to be analogous to raised field farming. Although he gives no labor calculation for initial raised field construction, he estimates that 278 person-days/ha would have been necessary each year to produce a good harvest (in this case, double cropping) on raised fields (Knapp 1983:303). With the high labor costs of the ditch maintenance, or "mucking" of the fields, twice a year, the figure rises to 1,178 person-days/ha/year (ibid. 304).

Knapp's figures for labor, 278 person-days for double cropping production on a hectare of raised field platforms and canals is similar to our figure of 270 person-days/ha (minus irrigation) for a single crop on raised fields in the Lake Titicaca Basin. I believe Knapp's total estimate of 1,178 person-

Table 5: Estimated annual labor costs for raised field activities.

activity	person-days/ha raised fields and canals
¹ preparation of soil	20
² seeding	50
³ <u>aporque</u> (potato banking)	100 (twice during the yr)
⁴ irrigation-normal year	0
-short drought	20 (4 splash irrig.)
-long drought	100 (once a week 5 month)
⁵ harvest	100 (potatoes)
total (minus irrigation)	270

Notes:

1

Preparation of the soil not necessary following tuber harvest and is minimal after harvest of grains. If the raised fields were rebuilt every 10 years (which is probably excessive), the annual labor costs would be 20 person-days/year (based on 200 person days/10 years for original construction or rebuilding). Fields with year round water-filled canals would be "mucked," a more laborious procedure. These cases would be rare since most canals dry out periodically during the dry season or during droughts.

2

This figure is based on planting potato seed and other tubers. Much less time would be needed for most other crops.

3

The figures for aporque are based on potatoes and other tubers. Traditionally in Huatta, other crops are banked only exceptionally wet years. Aporque also incorporates weeding.

4

Irrigation is relatively easy to do because of the close proximity of the water to the field surfaces. General "splash" irrigation was 4 times faster than bucket irrigation of individual plants (5 person/days/ha vs. 20 person/days/ha).

5

This figure depends upon the amount to be harvested. The figure presented is based on a year of excellent harvest.

days/ha (including canal cleaning) excessive for the simple maintenance of a raised field system. Our experiments demonstrated that the labor investment is relatively high in the first year because of the labor involved in the initial construction of the raised field platforms, but drops to almost nothing during subsequent years.

In Huatta, canals used for 6 consecutive years have not required cleaning, and the naturally high soil fertility of the construction fill has not yet required the addition of canal muck. Areas such as Ecuador, with active volcanos and relatively unstable landsurfaces, may have much higher sedimentation rates than those of the Lake Titicaca Basin. I do not believe that these rates of the Huatta area were any greater in the past than they are today. If anything, the rates may be higher now, due to widespread mismanagement of the hillslopes. The destruction and abandonment of terraces, breakdown of sectorial fallow systems, deforestation, and over-grazing by non-Andean domestic animals all contribute to the present severe problems with erosion.

Double cropping and cleaning canals twice a year certainly would have increased labor costs. However, raised fields were not necessarily as labor intensive as Knapp indicates. It may not have been the case that canals were cleaned twice a year; in fact, there is some evidence against it. Only the accumulation of immense amounts of sediments would make such labor necessary, but there are limits to how much could be incorporated in the field platforms. As discussed in Chapter 3,

the practical alternative would be to enlarge the fields, by filling in alternate canals; however, there appears to be no stratigraphic evidence for this in prehistoric highland Ecuador (Knapp 1984:251-265; Knapp and Ryder 1983). The short wavelength (3-5 meters) of the fields, and their lack of superposition indicates that the system here is relatively "immature" in comparison to the Huatta fields and other systems whose complex stratigraphic profiles document distinct changes in field morphology.

The problems of using present day non-raised field agricultural analogies for annual labor investment can be understood through an example from Huatta. The main form of traditional agriculture practiced on the pampa today is wacho technology, where a potato field is made in land that has been fallow for many years (usually 20 or more). The sod is cut with chakitaqllas, and used to construct raised lazy beds. At Candile, the labor involved in this work has been calculated to be 78.13 person-days/ha of wachos and furrows; that is, the soil moved is $12.8 \frac{\text{m}^3}{\text{person/day}}$ (Erickson 1985:219). Another calculation made for several days of labor in Ccoccope during 1882 is 110 person days/ha or $9.1 \frac{\text{m}^3}{\text{person/day}}$. These labor efficiency rates are slightly more than double those for raised fields because it is not necessary to break up or transport the sod blocks for wacho fields. The fields also differ from raised fields in that wachos are only used for one year of production, as they are leveled during the harvest. Under the crop rotation

used in the pampa, the field may or may not be used for a second year in quinua or cañihua, and possibly a third year in barley, afterward the field will be abandoned for 20 years or more. Each year that potatoes are planted on the pampa, the same laborious process of ground preparation must be completed.

In contrast, raised fields are cultivated many continuous years and do not require much labor after the initial construction of the field. As discussed above, the maintenance costs of the experimental fields were very low when the fields were well constructed. If raised field construction in the Lake Titicaca Basin was a gradual process as I have argued (Chapter 5), the raised fields would have been rebuilt or improved with sediment and muck additions periodically. I would suggest that once in every generation (20 years) would be sufficient, but every 10 years may have been the case. The removal of wet mucks would have necessitated a higher labor input than the original sod cutting and moving, but the quantity of added fill would not have been as much as for the original construction. If sod had formed in the canals, the labor involved would be substantially less. Supposing a 10 year cycle for rebuilding (and assuming a 20 cm addition of earth to provide a sufficient new fertile crop medium and the labor involved in the original construction, 200 person-days/ha), the annual labor "maintenance" costs (or Knapp's "ditch mucking") for a hectare of fields and canals would be only 20 person-days/ha. With a 20 year cycle for rebuilding, this figure would drop to 10 person-days/ha. In addition, if part of

the reason for cleaning canals is to maintain continuous cultivation, the fertility in organic muck is much more concentrated than in pampa soils, so less would be needed as fertilizer for the raised fields or the period between "field dressings" could be extended. We also found that the aquatic vegetation (which forms the basis of most of the muck) of the canals usually dries into large light compact sheets which can be easily added to the planting surfaces during the dry season.

4.2.6 Implications of Labor Costs for the Raised Fields of the Lake Titicaca Basin

Denevan (1982:190-1) estimates the potential population that could have been supported by raised field agriculture in several areas of the New World. In his discussion of the Lake Titicaca Basin, he uses a production figure of 3,050 kg./ha/year (based on 10 years of annual potato production in the Department of Puno, presented in Christiansen 1967), one meter tall fields (based on estimates in Mathewson 1978), labor efficiency of 2.6³ m³/day/person (based on digging stick rates of earth removal presented in Erasmus 1965), a field surface area 46% of the total area (based aerial photographic analysis, presented in Stemper 1978), and a total area of raised field cultivating surfaces of 37,746 hectares (adapted from Smith et al. 1968; 1981). He calculates a total of 377 million m³ of earth moved and 145.0 million person-days of labor (Table 6).

I have used Denevan's methodology with figures based on the

Table 6: Comparison of estimates for labor and production in raised field agriculture.

	surface area of fields and canals (ha)	surface area of fields only (ha)	total earth moved 3 (m)	total labor days (person-days)	population supported per cultivated ha	total estimated population (100% usage)
*	WD 82,056	37,746	377 million	145.0 million	5.7	215,000
**	CE 82,056	41,028	287 million	57.4 million	37.5	1,539,801

*
Denevan (WD)

46% area field surface (aerial photos)
 1.0 meter tall fields (estimate)
 $\frac{3}{2.6}$ m /day/person (Erasmus 1965)
 3,050 kg/ha/year
 1,460 calories/person/day

**
Erickson (CE)

50% area field surface (excavation data)
 0.7 meter tall fields (excavation data)
 $\frac{3}{5.0}$ m /day/person (experimental data)
 10,000 kg/ha/year (20,000 kg/ha surface/year)
 1,460 calories/person/day

raised field experiments of Huatta. An average construction rate of $5.0 \text{ m}^3/\text{person}/\text{day}$ is discussed, in detail, above. A 0.7 meter average depth of construction fill is based on excavations from both the Phase I and Phase II raised fields in the stratigraphic profiles (Table 7). Raised field platform surfaces as 50% of the total area of fields and canals is also based on the stratigraphic profiles (see Chapter 3). Estimates of field surface area in comparison to canal area are likely to be unreliable using aerial photographs. These estimates yield a total of 287 million m^3 of earth moved, and a total of only 57.4 million person-days of labor required to build all of the raised fields in the Lake Titicaca Basin.

Both my calculations and those of Denevan (1982), use the estimate of 82,056 hectares of raised fields in the Lake Titicaca Basin. This figure is derived from the analysis of aerial photographs of a scale of 1:65,000 (IGM or SAN 1955), and coverage of a small area southwest of the lake with a scale of 1:15,000 (IGM or SAN 1955) (Smith et al. 1968). The analysis was supported by ground truth in Taraco-Requena, Huatta, Juliaca, Paucarcolla, Lago Umayo, Capachica, Pomata, and Aygachi (Smith et al. 1981:26). Smith et al. note that these figures may be underestimate the extent of raised fields in the Basin, and that many fields may have been destroyed by later cultivation (ibid. 1981:26-8). I believe that this figure substantially underestimates the extent of raised fields in the Lake Titicaca Basin. Although I have not yet been able to precisely determine

Table 7: Estimates of raised field construction fill thickness determined from stratigraphic profiles excavated in Huatta and Illpa.

location of profile	thickness of fill in profile (cm)	estimated thickness of original fill (cm)
Jucchata Unit A-Phase I	-	20?
Jucchata Unit A-Phase II	50	40
Ccoccope Unit A-Phase I	30	40?
Ccoccope Unit A-Phase II	60	80?
Viscachani Pampa Unit A	50	70
Viscachani Pampa Unit D	70	100
Pancha Unit M-Phase I	30	40
Pancha Unit M-Phase II	40	60
Pancha Unit NOPQ-Phase I	20	40?
Pancha Unit NOPQ-Phase II	50	80
Kaminaqa Unit C	60	90?
Machachi Unit A	50	80
Candile Unit A	40	60
Illpa Unit I-Phase I	30?	50?
Illpa Unit I-Phase II	70	100?
Illpa Unit II-Phase I	40	50
Illpa Unit II-Phase II	80	110
mean	48.125	69.4

their extent, the figure traditionally cited for the Basin probably represents only half of the original raised field coverage (see Chapter 1 for more details regarding this calculation).

In addition to the underestimation of horizontal surface area, the superposition of raised fields provides another dimension to consider. In the stratigraphic profiles of prehistoric raised fields (Chapter 3), I have demonstrated that there are at least 2 major periods of raised field use, one field system superimposed on the other. If this is the case over the entire area of known raised fields, the total may be much higher which would also add greatly to the labor investment in the construction of raised fields.

4.3 PRODUCTION ON EXPERIMENTAL RAISED FIELDS IN HUATTA

4.3.1 Potato Production

Careful records were maintained during several consecutive years of potato production in many of the experimental raised field blocks. All harvested potatoes from each raised platform were weighted using "Roman hanging scales." General sampling was attempted, but proved to be inaccurate when compared to the figures for the total production. This may have been due to differential production on the edges and centers of the raised fields.

No data was collected during the flooding of 1985-6, but it

appeared that all of the raised fields, except Pojsillon, produced well, even those in lowlying areas near the lake. It was impossible to collect more precise data since the fields were harvested hurriedly when the water rose to the level of the platforms. Some of the yield was too immature to be used for seed, but was fine for consumption. Several of these raised fields, such as those in Pojsin Karata and Putukuni Pata, were the only fields harvested that year in areas near the Lake.

The results of potato production on experimental raised fields in Huatta are presented in Table 8. These calculations show a wide range of average annual production rates from a low of 8,306 kg/ha in 1984-5 (Erickson 1985) to a high of 13,094 kg/ha in 1983-4 (Garaycochea 1986a). There is also considerable variation among fields in the same year. For example, we recorded a low of 5,186 kg/ha in the fields at Chojñocoto II, and a high of 12,308 kg/ha in the fields at Viscachani Pampa in the growing season of 1984-5 (Garaycochea 1986a:99). A wide range of variation was also recorded within single raised fields blocks.

The potato varieties planted in the experiments during 1981-1982 and 1982-1983 were popular local varieties, primarily non-bitter types, which are less frost resistant. During the later 1983-6 growing seasons, we used a mix of local potatoes and "improved" varieties ("Yungay" and "Mariwa") brought into Puno to replace seed lost in the drought. The improved varieties used in the later years certainly was a factor in the high production rates obtained for these years, but at the same time, we had high

Table 8: Potato production on experimental raised fields in Huatta, Peru.

Field Name	Surface area (m ²)	Yields in kg/ha		
		¹ 1981-2	² 1983-4	³ 1984-5
Machachi	110	6,760		
Candile	73	10,119		
Chojñocoto I	702		13,652	8,573
Chojñocoto II	2025			5,186
Chojñocoto III	1449			11,036
Viscachani Pampa	1405/1625		12,536	12,309
Pancha Pampa	815			10,990
average yield/ha (raised field platform)		16,879	26,188	20,882
average yield/ha (raised field platform and canal)		8,440	13,094	10,441
average yield/ha for 1981-2; 1983-4; and 1984-5:		10,658 kg/ha		

¹ Erickson (1985)

² Garaycochea (1986a)

³ Data collected by Erickson, Garaycochea, Brinkmeier, and Candler in 1986; reported in Garaycochea (1986a).

yields from the local native varieties. We did not use the chemical fertilizers and pesticides usually associated with the higher yields of improved varieties. In comparison to traditional fields, only half the seed is necessary for planting a hectare of raised field since half the area is uncultivated canal. These high production rates are even more impressive when considering that a hectare of raised fields has only half the number of plants of a traditional potato field.

A production average for the three seasons for which we obtained precise data, 1981-2 (8,440 kg/ha), 1983-4 (14,935 kg/ha), and 1984-5 (8,306kg/ha), is 10,560 kg/ha. This figure probably accurately reflects raised field production for "normal" years, although rainfall in these seasons was higher than in several recent years. This calculation is derived from data from 8 different raised field blocks in locations representing the major environmental zones of the pampa.

Ramos (1986b; 1986a) provides comparative potato yields from raised field experiments in Asillo in 1984-1985, 80 km north of Lake Titicaca at 3900 meters above sea level. There the harvest was an average of 10.46 metric tons/ha including the canals, and an average of 14.3 metric tons/ha for the field surfaces alone (1986b:272). These figures, while comparable to the yields in Huatta, are from an area with more severe environmental limitations to agriculture. Some organic fertilizer (sheep dung) was applied at planting, and the potatoes were the frost-resistant variety ruki, which may have offset the disadvantages

of the relatively harsh climate and higher altitude. The Asillo raised fields were reconstructed with a canal to field platform area ratio of 1:2.7 (1986b:275), which increased the cultivating surface area of the fields system.

The potato yields on experimental raised fields in Huatta are more impressive when compared to the average yields reported for the altiplano of the Department of Puno. Accurate assessments of the entire annual harvests are impossible to obtain for the region, but it is more likely that they overestimate rather than underestimate the yield. Data is sporadically collected at various experimental stations, mostly located on old hacienda lands, which are usually more fertile and with better agro-microclimates than the lands of the campesino communities. Most, if not all, of these yields were obtained using organic and/or inorganic fertilizers.

During the years 1955-1964, the average potato production for the Department of Puno is reported as 3,050 kg/ha, while during the same period, the average for the Sierra of Peru is reported as 5,340 kg/ha (Christiansen 1967). For the season 1981-1982, average production figures of 3,000-4,000 kg./ha were obtained for various varieties of potatoes in both campesino communities and government experimental stations (manuscript-Convenio Peru-Canada 1983). For 1983-4, the regional average of potato production was 4,800 kg./ha (Maletta et al. 1984 in Garaycochea 1987a) and 6,087 kg/ha for five districts (including Huatta) on the north edge of Lake Titicaca (Garaycochea 1986a).

The following year, 1984-5, the Ministry of Agriculture reported yields of 4,500 kg/ha (Min. of Ag. 1986 in Garaycochea 1987a) and 6,313 kg/ha for the same five districts (Garaycochea 1986a). These figures may be incorrect because lower averages appear more typical of the zone. An extremely low average production for the Lake Titicaca area, only 1,210 kg/ha, was recorded during the 1972 National Census (Golte 1980:113). during the 1979-1980 season, potato production for Huatta was 3,220 kg/ha for papa dulce and 3,500 kg/ha for papa amarga (Organismo Regional de Desarrollo de Puno 1981). The difference between the production rates of traditionally (and "modern") cultivated fields in the Lake Titicaca Basin and those of the experimental raised fields is striking. It must be repeated that no fertilizers were used on the experimental raised fields, although the long time the fields were not in use certainly is a factor to consider in explaining these high rates of production.

4.3.2 Factors Affecting Production

There has been serious genetic erosion of indigenous crops, and many varieties once common have now disappeared. It is likely that there were species of Andean crops specifically adapted to the conditions of raised field agriculture which disappeared at the same time as the raised field technology. Most cultigens in the Huatta area today are adapted to the hillslopes around the lakes, and may not be typical of what was grown during the climax of raised field agriculture. Crops

specifically adapted to raised field agriculture would probably have produced even higher yields than those obtained during our experimentation. One part of the long term, ongoing research at the experimental station of Illpa is to attempt to select for crop characteristics that would be adaptive to raised field agriculture.

No fertilizers (organic or inorganic) were used on the experimental raised fields. The soil analysis does not indicate that application of fertilizers would be necessary (Erickson 1988). Were fertilizers used on the prehistoric raised fields? Animal dung was and is an important resource to the inhabitants of the altiplano (Winterhalder et al. 1974; Julien 1985). In the Huatta area, most of the dung is dried and saved (waykuna) for cooking fuel, since wood is scarce and other alternatives are too expensive. Many have argued that, in past, there were more trees on the altiplano (Guillet 1987; Ellenberg 1979), which would have provided cooking fuel, so the dung could be used to fertilize the agricultural fields. The flotation analysis for Kaminaqa indicates that wood was present, however, most appears to represent small brush and shrubs, and not necessarily trees (Erickson 1988). Wood would also have been needed for roofing materials and agricultural implements. Therefore, it is not likely that dung produced was used on the raised fields.

4.3.3 Raised Field Efficiency Compared to Other Systems

In terms of yield for labor invested, the rates are very impressive for raised field agriculture. Based on our labor figures of 270 person-days/ha/year and the average potato yield of 10,000 kg/ha, 37 kg of potatoes are produced for every person-day of labor spent on raised fields.

This figure is very impressive when compared to those reported for the Jukumani Aymara of Potosi of only 19 kg/person-day based on 170 person-days/ha/year (Godoy 1984:373) and the Lake Titicaca area of only 19.1 kg/person-day labor based on 183 person-days/ha/year (Golte 1980:33) using the average potato production figure of 3,500 kg/ha/year for the Lake Titicaca Basin. The raised field production efficiency is nearly twice that of traditional field systems used in the Andes.

It is difficult to make adequate comparisons between raised field farming in the altiplano and tropical forest swidden systems. Beckerman (1987:84, Table 3-8) presents figures ranging from 37.6 to 520 person-days/ha/year (converted to a 5 hour day), with an average of 191.2 person-days/ha/year in eleven ethnographic case studies. It must be remembered that the time-consuming labor of cutting forest and brush is now done with metal tools today. These tools would have been unavailable to past swidden farmers and thus, the labor figures may be very conservative.

4.3.4 Prehistoric Raised Field Production in the Lake Titicaca Basin

Denevan (1982:190-1) has calculated the potential production on raised fields using a figure of 37,746 ha of raised field cultivating surface (adapted from Smith et al. 1968; 1981), a 100% utilization, a daily caloric intake of 1,460 per person or 532,900 calories/person/year (Thomas 1976 in Denevan 1982), 1000 cal/kg of potatoes, and a calculation of 46% of total area of cultivating surface (Stemper 1978). From these figures, Denevan calculates that a potential population density of 5.7 persons/ha could have been supported by raised fields, yielding a maximum population of 215,000 in the Lake Titicaca Basin.

Again, I have used Denevan's methodology, calories/kilogram of potato, and daily caloric intake figures, combined with our revised estimates of 50% cultivating surface area and our revised production figures of 10,000 kg/ha of raised fields and canal (20,000 kg./ha of cultivating platform). This yields a density of 37.5 persons/ha or 3,750 persons/km² of cultivated raised field platform (18.77 persons supported by each hectare or 1,875 persons supported by each square kilometer of raised field platforms and canals) and an overall total population estimate for the Lake Titicaca Basin of 1,539,801 supported by raised field agriculture.

Our figures indicate that a single hectare of raised fields surface could produce 20,000,000 calories/year with a single annual crop of potatoes. Based on the figures above, each

individual would have needed only 0.0266 ha of raised fields planted in potatoes each year or 266.45 m^2 of raised field platform surface (0.054 ha or 532.91 m^2 of raised fields and canals). A nuclear family of 5 would need $1,332.37 \text{ m}^2/\text{year}$ (0.133 ha/year) of raised field surface or $2,664.53 \text{ m}^2/\text{year}$ (0.266 ha/year) of fields and canals.

It was hypothesized that the dimensions of the raised field system might express spatially the social units responsible for their construction and maintenance. Lennon (1982:219) has calculated the mean "component area" of raised field blocks in the lake zone of the pampa (1038.96 m^2) and in the riverine zone of the pampa (2339.97 m^2). His "component blocks" are bundles of raised fields oriented in the same direction with or without an encircling embankment. Our calculation for the area necessary to support a family of 5; $2,664.53 \text{ m}^2$, is surprisingly close to the dimension given for riverine zones. These basic units may represent family plots of fields or family tareas, areal obligations for field construction or maintenance.

The Andean concept of topo also may provide some insight into the "component areas" of the raised fields. The topo is a measurement of land necessary to support an individual or married couple for a year (Garcilaso 1987:245-262) whose area is highly variable according to the fertility and production of the zone (Rostworowski 1981:385-386, 1960). During Inca times, a topo was considered to be a fanega of land or 1.59 acres (Miskin 1963:422) ($6,434 \text{ m}^2$ or 0.64 ha). In the Cuzco area, it is

considered to be 44 by 88 varas or approximately 2706 m² (Miskin 1963:422; Lira 1982). Although the topo measurement is variable according to land quality and productive potential, this figure is surprisingly close to the area of raised fields (2,665 m²) necessary to support a family. The raised field block "component area" may represent topo measurements.

Earlier in this chapter, the labor figure for cultivation activities (including rebuilding every 10 years) and annual maintenance of a hectare of raised fields (minus the labor involved in irrigation) was estimated to be approximately 270 person-days/ha of field platforms and canals. One family of 5 working only 54 days a year (or 44 minutes/day/person for a year) could easily maintain a hectare of fields. Since a hectare of field platforms and canals support 18.75 people, the work of a single family of 5 could have support itself and 13.75 additional people. We are not dealing with a simple raised field "subsistence economy," but rather, a system that has the potential to producing enough surplus to support a large non-farming population. This surplus production certainly would have contributed to the urban/ceremonial centers of Pukara and Tiwanaku.

All of this is calculated from the assumption that the 82,000 hectares of raised fields in the Lake Titicaca Basin were utilized at the same time. I have argued (Chapters 3 and 5) that this is extremely unlikely since, they were constructed incrementally and because constant fluctuation of the lake level

would continually alter the area of raised fields available for cultivation. On the other hand, we must also consider that the total prehistoric raised field coverage of the Basin has been grossly underestimated, that raised fields do not need to be fallowed if crop rotation is combined with periodic "mucking" of the fields, and that the crops adapted to raised fields may have been much more productive than those used in the experiments.

These calculations are not meant to be absolute "carrying capacity" limits for the pampas of the Lake Titicaca Basin. The problems involved with relying on static carrying capacity figures have been extensively discussed in the literature (Brush 1975; Hayden 1975; Hassan 1981) and need not be repeated here. What these figures can do is give us a rough idea of the impressively high potential that raised field agriculture had for the prehistoric cultures of the Lake Titicaca Basin. These estimates clearly indicate that raised field agriculture, along with terracing, qochas, and non-intensive forms of agriculture, would have provided the concrete internal base for population growth and high density of population, urbanization, crafts specialization, and external trade. The high limit to population potential for the Lake Titicaca Basin should not be interpreted as a prehistoric population estimate. Rather, it demonstrates a productive potential far beyond what was necessary to support the population. The figures show that it is extremely implausible to suggest the people in the Lake Titicaca Basin ever experienced "population pressure," the common

explanation for prehistoric agricultural change. Today's population in the Department of Puno is 890,000 (1982 Census). Smith (in Cook 1981:44-45, 48) calculates a Late Horizon population in the Chucuito area of 190,000, the most populated zone in the Lake Titicaca Basin according to some chroniclers.

4.4 WETLANDS AND THE ADVANTAGES OF RAISED FIELD AGRICULTURE

The functions of raised field agricultural technology has been discussed in detail by many investigators (Denevan and Turner 1974; Puleston 1977b; Denevan 1970; Parsons and Denevan 1967; Harrison and Turner 1978; and specifically for the Lake Titicaca Basin by Smith et al. 1968; Lennon 1982; Erickson 1985, 1986, 1988; Grace 1983; Garaycochea 1986a). I would like to focus on several key issues regarding raised field function, in particular how raised fields 1) are specifically adapted to wetland environments, 2) mimic wetland environments, and 3) artificially expand wetland environments. A much expanded treatment of raised field functions can be found in Erickson (1986, 1988).

Natural wetlands are highly productive ecosystems, highly valued resources by certain non-Western cultures. Horn (1984:37-56), in a recent survey of primary productivity of wetland and major terrestrial ecosystems, has demonstrated that even using conservative estimates, primary productivity of wetlands is 2.5

times greater than temperate deciduous forests, 4 to 5 times greater than cultivated fields, 5 times greater than temperate grasslands, and 7 to 8 times greater than lakes and streams. Primary productivity figures can be converted to human potential population densities using Casteel's formula (1972) and the result is impressive; 10 people/km² for lakes and streams, 15 people/km² for temperate grasslands, 16.25 people/km² for cropland, 30 people/km² for temperate deciduous forests and 75 people/km² for wetlands (Horn 1984: Table 2-2). A study of the nutritional composition of important wild aquatic plant foods is equal to that of wild terrestrial plant foods (Horn 1984:46-49; Appendix One). In addition, the seasonal availability of aquatic food plants may be longer than terrestrial plants and the labor involved in obtaining these resources may be less than that required for terrestrial plant collection (ibid. 48-56).

4.4.1 Hydraulic Control

Most researchers have stressed drainage as the principal function of raised field agriculture (Denevan and Turner 1974; Denevan 1970; Denevan 1982; Turner and Denevan 1985; Darch 1983). Most of the prehistoric raised field systems recorded in the Americas are found in "wetlands", areas with a high natural water table or areas that are seasonally inundated such as lake or river flood plains areas (Denevan 1982; Turner and Denevan 1985).

Much of the emphasis placed on the need to drain wetlands

can be traced to western cultural attitudes towards wetland areas, particularly swamps. In a enlightening discussion on this, Siemens (1977; also see Horn 1984:1-36) discusses the "abhorrence of the swamp" pervasive in western thought:

Swamps have long had a very bad press in the western world. One reason for that must be that the swamp was blamed as a generator of disease. In any case, it is abhorred in the Middle American tropical lowlands today, as elsewhere. People living a few kilometers away from swamps in northern Belize were found to have images of this natural feature in their minds that made it seem distant, largely unknown, and quite unattractive. The ancient Maya must have thought of swamps in a different way, or had good ways of dealing with their apprehensions. How the swamps might once again be viewed positively and used to advantage is perhaps the most practical question to arise from this whole investigation (ibid. 21).

Discussing the attitudes of nineteenth-century travelers in the swamps of Veracruz, Mexico, Siemens notes that:

They found them intriguing and disquieting...On the one hand, the wetland was feared for the miasmas that engendered yellow fever, on the other, it stimulated romantic flights of fancy. Such commentary is freighted with extratropical predispositions to swampy terrain and to the tropics...Practical wisdom was to drain and to obliterate, as it still is. Prehispanic peoples found ways of using the swamp's hydrologic regime more or less as it was (Siemens 1983:92).

The classic approach to land "reclamation" stresses the need to drain lowlying areas so that they may be farmed with modern techniques. The words "land reclamation," "drainage," "marginal" are often common in discussions of raised field agriculture (Turner and Denevan 1985:13-14; Denevan 1970:647-648, 652-653, Turner and Harrison 1978:363 and others), although there is evidence that Mayans, raised field constructors par

excellence, would not have perceived these wetlands in the same way (see Puleston 1977a, 1977b, 1978; Lathrap et al. 1985).

The wetlands of Lake Titicaca have been classified by ONERN-CORPUNO (1965:Vol. 1, Chapter 1, Mapa de Capacidad de Uso facing p. 94) as Land Use Category VII and VIII at the lake edge, and V within the pampa. Class V is characterized by problems of thin soils lacking organic material, nitrogen, boron, and phosphorus, high soil humidity and poor drainage, and adverse climate (ibid 97-8). ONERN-CORPUNO indicates that these lands could become more productive only with considerable capital investment for fertility improvement and drainage stressing that pastoralism should be the base of this utilization. Class VII is characterized as having "very severe limitations for intensive cultivation" (ibid 99) and should also be relegated to extensive temporary pasture use. Improvement, states ONERN-CORPUNO, is "impractical" and not recommended, primarily due to drainage problems and long term flooding (ibid. 100). Category VIII is similarly considered to have extreme limitations to agriculture, primarily due to permanent inundation, recommended only for wildlife and fishing use (ibid 104).

Ironically, a majority of the prehistoric raised field remains are found within the areas classified by ONERN-CORPUNO as "marginal" or "useless" for agriculture. Some of the best-preserved and largest raised fields, such as those of Requena on the Taraco Peninsula, are located in areas which ONERN-CORPUNO recommends for wildlife use only. Most of the rich lake edge and

lake bottom lands with eroded raised fields east and south of Huatta are included in this category. As Smith et al. indicate, "Perhaps it is just as well that the former ridge-cultivating inhabitants of this lake shore area lacked the benefits of modern land-use surveys" (1968:300). What is considered "marginal" by today's engineers and agronomists appears to have been considered "ideal" by prehistoric raised field farmers.

Although limited drainage of excess water to protect crop root systems would have been necessary, I do not believe that the systematic drainage of the entire zone was practiced or desired by the raised field farmers (Erickson 1986:340-341). Most of the raised field canals within the Huatta plain, and presumably in other areas of the basin, and have no outlet. This is evidence against total drainage as the primary function of the raised fields systems. Most of the raised field systems of the Lake Titicaca Basin have been constructed to actually impede drainage, with dead end canals, reservoirs, and spillways of different elevations to control flooding and yet maintain relatively high water tables. The control, or more importantly, the conservation of water in the raised field system was clearly a major goal of the prehispanic farmers. They created a relatively predictable supply of water for short, and possibly long droughts; an adequate volume of water to function as a heat bank for microclimate modification; a relatively permanent body of water for the production of organic nutrients; and a suitable environment for aquaculture and pisciculture. They created a

relatively permanent man-made wetland environment in the pampas surrounding the lake and rivers of the Lake Titicaca Basin.

Smith et al. (1968) indicate:

The arrangement of ridges and intervening troughs in relation to the lie of the land or in relation to existing watercourses does not, in general, suggest that there was any conscious attempt to carry away excess water. Most types of ridging would definitely have hindered systematic drainage or would have done nothing to assist it. The open checkerboard and the ladder type still hinder effective drainage; the embanked fields show no signs of drainage systems; the riverine and linear types, and the combed patterns of Aygachi, would all assist drainage to a certain extent wherever the linear axes coincided with the direction of slope, as in fact they usually do.

In the surviving areas of ridged fields, there are, on the other hand, 'so many instances in which patterns can be picked out by the existence of standing water or wet, marshy ground that one is tempted to see a conscious aim towards water conservation. In the Pomata area the organization of ridges into a ladder pattern hinders drainage but could have been expressly designed to retain water on the fields. the design of the embanked fields in the same area, but not, so far as one can see, in the Juliaca plain, was often intended to guide water into partial enclosures rather than to exclude flood waters. And the "combed" ridge pattern of Aygachi still have the effect of distributing water extensively over the area of raised fields (1968:361) [emphasis added].

In summary, "...it was water conservation rather than effective and rapid drainage that was sought; and in a few areas it is clear that ridged fields were associated with primitive irrigation systems" (ibid. 363). As Smith et al. stress, raised fields would have hindered drainage more than improved it.

4.4.2 Other Functions of Raised Fields

4.4.2.1 Wildlife Habitat Improvement-Hunting and Collecting

The raised fields created an environment very attractive to wildlife. In a sense, the construction of raised fields on the pampa artificially expanded the rich littoral zone of the lakeshore and lake shallows into areas where it did not previously exist. In chapter 7, the lake edge-littoral zone is discussed in detail, and much of the same qualities in terms of biomass carrying capacity holds also characterize the man-made littoral ecosystem created through raised field construction. Species diversity, carrying capacity, and local microclimate are greatly improved by the creation of a topographical mosaic of raised field platforms and canals, each with its own microenvironmental characteristics in terms of soil and humidity conditions. The area of ecotone, or ecological transitional zones, among these microtopographical environments is greatly expanded. The experimental raised field canals were rapidly colonized by aquatic species such as macrophytes, algae, tadpoles, frogs, ducks, flamingos, and other lacustrine avifauna. Terrestrial wildlife also benefited from raised field construction; nests of field mice, lizards and terrestrial avifauna were found in the fields during the growing season.

The creation of the improved artificial wetland environment in the pampa would have provided an excellent hunting zone for the capture of protein sources to supplement their starchy and

carbohydrate-rich diet of agricultural crops. The Aymara, Quechua, and especially the Urus, have developed an elaborate hunting technology devoted primarily to exploiting the wetlands of the lake edge (LaBarre 1941, 1948, 1963; Tschopik 1963; Horn 1984). The collection of bird eggs is still an important activity pursued by Huatteenos and Urus in the shallows of the lake, while the food remains from the archaeological middens attest to the exploitation of this important ecozone (Erickson 1988).

4.4.2.2 Fishing and Pisciculture in Raised Fields

One of the most important resources of the inhabitants of the Lake Titicaca area is fishing. The expansion of the littoral zone through the construction of canal grid throughout the pampa would have greatly expanded the natural habitat of the economically important lake fish species, the carachi (various species of Orestias). Most of the species of economically important fish are thrive in the habitat of the littoral zone of aquatic vegetation choked shallow water, especially in areas where tributary rivers enter the lake (Hanek 1982; Loubens and Sarmiento 1985; Lauzanne 1982). Although many canals prehistorically did not hold water year round, the potential fish carrying capacity must have been greatly increased in 82,000 hectares surrounding the lake, of which approximately half of this total area would have been devoted to canals. Prehistoric pisciculture in these canals is plausible, but difficult to document. Analysis of canal sediments may provide evidence for

the prehistoric presence of fish, but does not provide proof of their cultivation.

The use of raised field canals for pisciculture has been suggested by many investigators (Thompson 1974; Schorr 1972; Puleston 1977a, 1978), but little data has been provided to document this. I disagree with the emphasis that Thompson and Schorr have placed on pisciculture as the primary reason for raised field construction. The experimental raised fields reported on by Puleston (1977a, 1978) and Zucchi (1975) were rapidly colonized by numerous fish species soon after construction. Although this suggests that raised fields could have been used for pisciculture, it does not provide sufficient evidence to prove it.

It is highly likely that the raised field canals were used to manipulate native fish populations so they could be systematically and efficiently harvested. Fish are commonly found trapped in the pampa lakes, abandoned river meanders, and wells after the water levels drop at the end of the rainy season. These fish swim far up the inundated old canal networks during the wet season, possibly for spawning since the littoral zone is where spawning takes place for the most common species, Orestias agassii, occurs (Loubens and Sarmiento 1985:160). In the spring of 1985, approximately 50 small carachis were found in the canals of the reconstructed raised field block at Chojñocoto. These fields were located some 3 kilometers from the lake edge that year, and even farther from the nearest river.

The design and structure of the raised field canal systems would have been ideal for the capture of fish. These could have been easily captured through the indigenous technology documented in the ethnographic literature on the Aymara, Quechua and Uru of Lake Titicaca and Poopo (Tschopik 1963; Horn 1984; LaBarre 1941, 1948, 1963). In addition, fish could have been contained within the dead end canals and embanked field blocks to mature and fatten for harvest during the dry season. This, in addition to hunting and collecting, would have greatly increased the protein in the diet of the raised field farmers.

The presence of fish in the canals would have also had indirect effects on improving raised field fertility. The importance of fish feces in the production of organic matter and soil nutrients in fish pond agriculture in Asia is well documented. The presence of fish would have also drawn other economically important predators that could have been hunted.

CHAPTER 5

INTENSIFICATION

5.1 INTRODUCTION

5.1.1 Background

Archaeologists, cultural anthropologists and cultural geographers have frequently used Boserup's hypothesis of population pressure and intensification as a major explanatory model for cultural change (Sanders and Price 1968) the origins of agriculture (Cohen 1977), and agricultural change (Barlett 1976; Spooner 1972, Harrison and Turner 1978; Turner and Harrison 1983). Others, in particular Dummond (1961; 1965), independently developed some of these ideas, but did not have the impact that Boserup's formulation had on the field. Because of this attention, I will present Boserup's hypothesis on agricultural change in detail, and comment on it in the context of how her hypothesis has been used and the controversy that it has stirred up over the past 2 decades. Following this discussion, I will present a synthesis of what I believe to be the most productive approaches to the study of prehistoric agricultural change.

5.1.2 Definitions of Intensification

In the recent literature, the key to understanding agricultural change has been closely linked with the vague

concept of intensification. Intensification in a general sense as been defined as " an increase in subsistence productivity by a group living in the same area over a specified period of time" (Farrington 1985:1) and "any change in the food procurement regime throughout prehistory, whether it can be contained within such general topics as the extinction of large mammals or the origins of agriculture" (Farrington 1985:1). For this chapter, I will restrict the use of intensification to refer to agricultural change, specifically "an increase in productivity [food or other staple] per unit of land and/or per unit of labour" (Farrington 1985:1). Boserup would specify the definition the notion of cropping frequency, "the gradual change towards patterns of land use which make it possible to crop a given area of land more frequently than before" (1965:43), but I prefer to broaden the concept to include the production of higher yield from a single cropping. This usage follows that of recent geographers, who define agricultural intensity as:

the amount of food obtained by cultivating a constant land area over a specified period of time. In this respect, agriculture may be intensified in two ways. The frequency of cultivation (planting to harvest) over the period of time may be increased, or the amount of production per cultivation may be increased. Both intensification processes tend to take place simultaneously, although as high levels of agricultural intensity are obtained, a tendency exists to shift to efforts that increase production per cultivation (Harrison 1978:10 citing Turner et al 1977).

Intensive agriculture has been defined as

any mode of cultivation in which the frequency of cropping per unit of land exceeds the frequency of fallowing. Swidden is an extensive mode of agriculture in that the frequency of fallowing exceeds the frequency

of cultivation. Specific cropping techniques, labor, or productivity are not essential to the definitions (Turner 1974:123).

In the case of the prehistoric raised field agriculture which is not currently practiced in the Lake Titicaca Basin, it is impossible, to determine the cropping frequency used when these systems were operating. Therefore, we will not be addressing the question of whether or not raised field agriculture is "intensive" following the definition given above; however, I will show that it is an implementation of a more productive agricultural system (intensification).

Labor intensive agriculture is agriculture where labor inputs into the system are very high. Labor efficiency, which is synonymous with labor intensiveness has been defined as "the success of a given subsistence method in minimizing the number of man-hours required for each unit of production" (Bronson 1975:55). This can be measured by comparing inputs (total labor, and if necessary, the labor involved in producing the capital) to production outputs, which in this dissertation will be measured in terms of kilograms/man-days. As discussed below, labor intensive agriculture is assumed in the literature to have a lower production output to labor input ratio than non labor intensive agriculture or as according to the Law of Diminishing Returns, "increased labor will not give proportional increases in output" (Grigg 1979:70). Land efficiency is "the extent to which the subsistence method minimizes the quantity of land required for each unit of production" (Bronson 1975:55).

Agricultural intensification is contrasted to agricultural expansion, which is "an increase in the amount or type of land under cultivation," and "is not itself an increase in the intensity of agriculture because the land area does not remain constant" (Harrison 1978:10; also see Hammond 1978).

For the following discussion, I will make the distinction between intensive agriculture and labor intensive agriculture. It is important to note that the definition of intensification used in this dissertation implies increasing productivity from a constant land area, but does not necessarily imply an increase in labor intensity to increase the yields a given land area.

5.2 EXPLANATIONS OF AGRICULTURAL CHANGE

5.2.1 Hypotheses of Agricultural Change: Malthus and Boserup

The publication of Ester Boserup's The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure in 1965 had considerable impact on anthropological explanations of prehistoric agricultural change. Previous to Boserup's hypothesis of agrarian change, the traditional view of the relationship between agriculture and population followed that proposed by Malthus in An Essay on the Principle of Population in 1798 (and many other later publications). Malthus argued that the basic problems of mankind, especially poverty and famine, rise because population grows beyond the means of society to produce sufficient food

(Grigg 1980:11-12). Populations increase geometrically while food production progresses much more slowly. He acknowledged certain checks to population growth such as moral restraint, war, famine, and disease, but the ultimate check was the rather inelastic limit set by food production (Grigg 1980:12, 21). Agricultural change, seen as innovations (invented or borrowed) in agricultural technology, raised this limit. As Boserup notes, the Malthusian assumption is that population is a variable dependent on agricultural production limits (1965:11-12).

Boserup's assumption takes the opposite view, that "population growth is here regarded as the independent variable which in its turn is a major factor determining agricultural developments" (ibid.11) or "agricultural developments are caused by population trends rather than the other way around" (ibid. 12). She believes this view can explain cultivation methods and the social structure of agricultural groups, in addition to the evolution of traditional or pre-industrial agriculture on a global scale (ibid.).

According to Boserup, population growth, with resultant "population pressure," is the cause of changes in the cycle of fallow and cultivation. Related to the process of continually decreasing fallow periods is the use of increasingly labor intensive methods, primarily devoted to fertility maintenance. In extensive systems, fertility was maintained by long fallow periods, but with shorter or no fallow periods, fertility must be replenished by techniques dependent upon human labor. Labor

productivity or labor efficiency, according to Boserup, varies inversely as systems of shorter fallow develop (ie. the Law of Diminishing Returns) (ibid. 28-41), although some of this loss of efficiency can be regained by longer and more regular working hours. She documents that the output for man-days per unit of land is much higher in long (20-25 year) fallow systems than it is in intensive systems. She concludes that farmers would not adopt more intensive agricultural systems unless population growth forced them to do so (ibid. 28) [referred to by others as the "Law of Least Effort" (Spooner 1972; Bronson 1972)]. Implicit in this hypothesis is that farmers generally are aware of more intensive agricultural tools and techniques, but will not employ them unless population increases to a certain density.

In Boserup's view, production is theoretically endlessly expandable (through shorter cropping systems, requiring labor intensification combined with new techniques and tools) but at a reduced level of efficiency.

5.2.2 Discussion of Boserup

5.2.2.1 Assumptions of Population Growth:

Both hypotheses of Malthus and Boserup assume that steady uncontrolled population growth is part of human nature (unless "checks" are applied). In Boserup's model, population growth is an independent variable, and populations always rise to and beyond the level of the local carrying capacity. Most followers

of Boserup similarly assume that if intensive forms of agriculture were practiced, then there must have been high population densities (Turner and Denevan 1985:20; Turner and Harrison 1983:255; Spooner 1972; Harrison and Turner 1978:355-361, Brookfield 1972). A few critics of the Boserup model have pointed out that population growth in agrarian societies is not an independent variable (Hassan 1981; Flannery 1986; Cowgill 1975a, 1975b; Bronson 1972; 1975; Green 1980; Grigg 1976, 1979, 1980). There are many cultural, social, economic and political aspects to population growth and population control present in the ethnographic literature that must also be considered.

5.2.2.2 Problems of an Environment-Free Model

Boserup's original model stressed that differences in local environmental conditions did not have to be considered in explaining agricultural change. Bronson (1972:206-210) points out that there are many ways in which to cultivate a unit of land more intensively. One of the most basic ways is to first select and colonize areas that have naturally rich cultivable soils that can produce continuously without fallow such as certain wetlands and riverine areas. Irrigation agriculture is commonly cited as a good example of intensive agriculture. Padoch (1985:271) has pointed out that, in the case of intensive rice cultivation, an environment-free model cannot adequately explain nor predict the continuum of cropping patterns from extensive to intensive. She demonstrates that among the Lun Dayeh of Indonesia, intensive

forms of agriculture are found without evidence of population pressure, in areas where irrigation can be easily practiced. The influence of environmental factors such as the availability of certain culturally "favored" agricultural lands suitable for intensification was neglected by the Boserup model. Pockets of naturally rich soils, high water tables, and flood-renewed soils are found throughout the world, and certainly were not ignored by early farmers seeking to intensify production.

5.2.2.3 Law of Least Effort and Labor Efficiency

Another important assumption in Boserup's model is that traditional and prehistoric farmers will invest the minimum of effort necessary for agricultural production. Farmers are assumed to be "rational" and "economic maximizers" and will maximize leisure time over production (Chisholm 1968; Chayanov 1966). In Boserup's model, more intensive systems, which she provides data to show are less labor efficient than more extensive systems (Law of Diminishing Returns), will only be adopted if the farmers are forced to use them by population pressure. This idea has been referred to as "The Law of Least Effort" (Spooner 1972).

Boserup's contention that extensive forms of agriculture such as long fallow shifting systems are necessarily less labor intensive and less labor efficient than forms of intensive agriculture has been criticized (Bronson 1972; Ho 1968; Padoch

1985; Netting 1974; Waddell 1972). Boserup's contention, that population decrease leads to the abandonment of more intensive systems and adoption of less intensive systems has been used by many researchers as confirmation of her model. Bronson shows that this "disintensification" is usually based on certain bureaucratic, economic and/or political concerns (such as development project administration) or in marginal or radically new environments (ibid. 194-196). He provides many examples of low populations with available land for expansion where farmers prefer to use intensive systems (ibid 197-198).

Intensive systems are not inherently less labor efficient than extensive systems if one defines them as I have above. Bronson argues that even if labor efficiency and land use were inversely related (as assumed by Boserup and the "Law of Least Effort"), farmers would not necessarily always use the most labor efficient system (ibid. 199).

The assumptions "that effort-minimizing tendency is strong... and the concept of 'effort' must be cross-culturally meaningful" is rejected by Bronson (ibid. 199; also see Netting 1974:39). Strong cultural factors, food likes and dislikes, religion, and use of farming system as ethnic markers, (in addition to the other factors discussed below) may better explain the adoption of agricultural systems than the Law of Least Effort (1972:200-201). He discards the concept of "effort" as meaningful, providing cases of time-consuming and labor-intensive activities that are considered "enjoyable" by primitive

farmers.

Bronson argues that alternative factors such as 1) risk minimization (choosing of systems that are better adapted to local environments), 2) markets, regional exchange, urbanism etc., 3) farmer motivation, 4) "illogical, inexplicable" factors may better explain the adoption of agricultural systems than the Law of Least Effort (1972:200-201).

The "Law of Least Effort" probably does apply in some cases to certain intensive agricultural systems as Boserup and other argue. It may be a factor, but only one of many, possibly more important cultural factors.

5.2.2.4 Measuring Population Pressure

If the Boserup model is to be tested, we must be able to document the supposed cause of agricultural change, population pressure. Population pressure is defined as the "function of the ratio of actual population size to carrying capacity" (Smith in Hassan 1981:162). Wilkenson (1973:167) states that "pressure exists only when an imbalance occurs between the number of people and the resources available to them." In practice, this becomes a very difficult concept to measure.

Several investigators have simplistically used population density as a measure of population pressure and compared this to levels of agricultural intensity, measured using various methodologies (Turner et al. 1977; Turner and Doolittle 1978; Brown and Podolefsky 1976). Most of these analyses are similar,

using the cropping frequency and fallow period to calculate land use ratios. Turner and Doolittle (1978:297-298) stress that agricultural intensity must be measured not only by the frequency of cultivation and techniques utilized, but also should include the production output. The ideal situation would be to measure production output against constants of land and time (for example tons of food or number of calories per ha per 20 years). They note that, because none of the ethnographic studies have involved long-term collection of reliable production data, thus they are forced to rely heavily on estimated labor input data. I feel that this is unacceptable for comparison of population to agricultural intensity in non-western societies. Accurate collection of labor inputs and production data over a long period is required. This data may be obtained from field data or experimentally, as we have done in the case of raised field agriculture (see Chapter 4).

I do not believe that population density can be necessarily equated to population pressure. There may not be any adequate way to measure population pressure which is always culturally defined. A number of supporters of population pressure as the explanation of agricultural change have attempted to test the association between population density (a very crude estimate of population pressure) and agricultural intensity. Studies of various non-industrialized cultures have shown a slight positive correlation between population density and agricultural intensity (Turner and Doolittle 1978; Turner et al. 1977; Brown and

Podolefsky 1976). The problem with these studies is that there is no causal relationship demonstrated by such analysis, simply the general association of intensive agriculture with dense populations and extensive agriculture with less dense populations. However, citing 44 societies within the Pacific, Brookfield (1972:36; also see Brookfield and Hart 1971) showed that there is no clear relationship between population and agricultural intensity. Brown and Podolefsky generalize the situation, stating that "the relationship between variables is positive, but complex" (1976:229), and that "the relationship between population density and agricultural intensity is interactional and that neither can be consistently antecedent to the other" (ibid.).

In addition, as Brown and Podolefsky (1976:229, also see Brown 1978:227) indicate, the simple correlations of population to agricultural intensity have no time depth, the ultimate test of any model explaining change. Despite this, many archaeologists and geographers, especially the Mayanists, still consider the above studies as evidence that population pressure causes agricultural intensification. Although population may have a causal relationship to intensification, these studies do not adequately demonstrate it.

Several investigators have successfully used historical records to document agricultural and population changes through time (Grigg 1980, Geertz 1966). Unfortunately, the methodology is not appropriate for studies of agrarian change in prehistoric

or many non-western cultures.

Archaeology should be able to provide the necessary time depth for testing the hypotheses regarding agricultural intensification and population changes. Unfortunately, it is very difficult, if not impossible, to prove "population pressure" archaeologically. Cohen (1977:71-84) has attempted to provide a methodology for the measurement of prehistoric population pressure focusing on the population and its resource base and changes in subsistence. A major problem with this is that although population size and density can be crudely measured (Hassan 1981, Hardesty 1979), the simple documentation of change in subsistence and what Cohen refers to as "stress indicators" does not prove prehistoric population pressure. Population growth is often interpreted as population pressure, but this cannot be assumed true (Hassan 1981:163). Even with improved methodologies for archaeological settlement survey, few, if any, archaeological studies are fine-grained enough to document the occurrence of "population pressure" prior to technological and agricultural changes. Others have attempted to use evidence of prehistorically degraded landscapes as an indicator of local population pressure. Many of these studies rely heavily on analyses of pollen and sediments, a very controversial data base for determining population pressure (Brookfield 1986; Spriggs 1985; Hughes 1985).

5.2.2.5 Social Production vs. Subsistence Production

Most discussions of Boserup focus on the intensification of subsistence production through increasing labor inputs. Brookfield notes that intensive agricultural practices are not necessarily found associated only with subsistence crops:

Often intensive practices were applied to only a part of the total production pattern, specifically to that part having ritual significance, or used in large-scale presentations. Among the Sepik Abalam, to cite only an extreme example, the labour input per tuber planted was fifty or sixty times greater with Dioscorea alata used in ceremonial presentations than with subsistence yams. Considerations of evidence of this sort lead to a rethinking of simplistic notions concerning agriculture and populations (1972:36-37)

Brookfield distinguishes between three forms of production. "Subsistence production" is used to meet basic subsistence needs of the society. "Social production" or "supra-subsistence production" (ibid. 37-38; also see Bronson 1972, 1975) focuses on the "satisfactions and security gained by participation in ritual and ceremonial life, access to wives, land, support, refuge, and security from reciprocity, trading links, etc." (ibid. 37). Much of this production, especially the case of yams in the Melanesia, is used for public displays of wealth and is not eaten. His third form is "trade production" which in many societies is closely related to social production. Brookfield notes that, while subsistence production follows the Boserupian scheme in many egalitarian societies, the social production is highly variable with little relationship to population density and "wildly uneconomic in terms of caloric returns" (ibid. 38). The

"pressure," instead of being caused primarily by population densities impinging on the resource base or production capacity, can be totally cultural defined.

5.2.2.6 Importance of "Landscape Capital" in Intensification

Brookfield has introduced the concept of the creation of "landscape capital" or infrastructure such as permanent improvements to land such as raised fields, irrigation systems and terraces into considerations of intensification of agriculture (1972; 1986). The labor for certain agricultural systems is invested in certain structures such as canals, terrace walls, dams, roads, raised field platforms, etc. during the process of intensification. Brookfield makes an important point regarding the long-term productivity per labor unit of intensive agriculture in contrast to the short-term productivity of extensive agriculture. (1986:179). Our experimental work in Huatta has demonstrated the long term benefits of raised field agriculture (continuous high productivity) far outweigh the initial "landscape capital" labor investments made in canal and platform construction. Important to note here is that the labor involved in raised field construction is a relatively permanent investment. Once constructed, the fields can be utilized continuously without major maintenance costs. Unfortunately, Brookfield falls back on the Boserup idea that farmers would not be motivated to invest labor in agricultural landscape capital unless forced to by population pressure and that subsequent

capital investments will always lead to decreasing production efficiency (1986:177, 179).

5.2.2.7 Technological Innovation

The economist Simon (1978; also 1977:Chapter 8) has demonstrated that one must consider both Malthus's and Boserup's hypotheses to understand agricultural intensification in non-western societies. Simon stresses the importance of technological inventions in the intensification process, something that Boserup takes for granted. He distinguishes between two types of technological "inventions," 1) inventions that increase labor efficiency and 2) inventions that do not, at that time, increase labor efficiency, but may at some future date be highly productive with a higher labor input (1978:167). The first type of invention is adopted immediately, (without population density being a factor in the adoption) and population increases as a result of the increased production potential, until the population capacity is reached (Simon's "Invention-Pull" following Malthus). The second type of invention will be adopted through necessity when population reaches a certain level (Simon's "Population-Push" following Boserup) (ibid. 168). He (ibid. 182; 185) stresses that both of these types of inventions have been important in the evolution of traditional agricultural systems throughout the world, thus the Malthus-Boserup hypotheses should not be considered conflicting, but should be considered

complementary explanations of agricultural evolution. In the case of raised field agriculture as an innovation, farmers would have seen immediate results after implementation of the technology and population would grow accordingly, corresponding to Simon's "invention-pull" model. In the case of labor intensive agricultural systems, the technology would only be adopted through necessity, even though the technology has been known for a time (Simon's Population-Push). Thus, Boserup's model may hold true only under certain conditions and for certain technologies.

5.2.2.8 Reduction of Risk

Bronson (1972; 1975) and Grigg (1979:76) argue that many early farmers would adopt labor intensive systems if agricultural risks could be substantially reduced, in spite of the "Law of Least Effort." A small farmer may be more interested in an assured harvest involving greater labor input than necessary for simple subsistence production. Wilk (1985:54) has shown that Kekchi Maya accept lower yields from intensive riverbank cultivation in return for lower risks and harvest certainty. The adoption of strategies of risk reduction is also believed to have been an important factor in the early development of agriculture (Flannery 1986).

Raised fields help to greatly reduce the risks involved in cultivating the pampa of the Lake Titicaca Basin. As demonstrated in our experiments (see Chapter 4), crop losses due

to inundation, frost, drought, and salinization are minimized. Today's indigenous farmers of the area consider these to be the primary reason for not cultivating the pampa. Even if raised fields were not efficient in terms of production vs. labor input, the technology may have been adopted to substantially reduce risks.

5.2.2.9 Opportunities and Positive Decisions

Cowgill (1975a, 1975b) argues forcefully that population pressure can explain neither cultural nor agricultural change. Cowgill stresses that intensification "may be stimulated by more effective demand and perceptions of new possibilities" (1975a: 505) rather than something forced upon farmers. He distinguishes between the concepts of "need" (basic caloric necessities to survive) and "demand" (culturally defined needs beyond basic subsistence). In this perspective, humans take a more active role in changes than that proposed by Boserup and her supporters. Cowgill stresses that changes are more likely to occur in "good times" because resources are available and individuals see opportunities. This is especially the case in urban situations, in which farmers will intensify agricultural production to meet the demands of urban populations.

I believe that the decision-making process of farmers are very critical to understanding agricultural change. Unfortunately, this is very difficult to analyze in archaeological cases. In my opinion, experimentation with

innovations is much more likely to occur during times of no population pressure, as Sauer has proposed for the initial development of agriculture (1975). As argued below, raised field agriculture was a response by sedentary fishermen and lacustrine and riverine-oriented early farmers. Opportunities were seen to increase production without substantial changes in labor input.

5.2.2.10 Alternatives to Intensification

Not considered by Boserup are possible alternative responses to intensification under conditions of population pressure. Potential alternatives include the use of higher yielding crops, agricultural expansion into previously unused areas, fragmentation of farms, diversification, specialization in non-agricultural activities, migration, acceptance of poorer diets, birth controls, migrations, group fission, and coercive measures to get food (Grigg 1976; 1979; Turner and Doolittle 1978), although these pathways are not always available to farming populations.

5.3 AN ALTERNATIVE MODEL FOR THE DEVELOPMENT OF INTENSIVE RAISED FIELD AGRICULTURE

Boserup's explanation of agricultural change, by addressing universal cases, has had an important impact on archaeology and the study of the evolution of prehistoric agricultural systems. The criticisms mentioned above show that Boserup's unilineal

model may fail to explain agricultural land use in many of archaeological and ethnographic cases. Boserup's model holds in some specific situations (e.g. Barlett 1976), especially recent historical and modern cases. In the case of raised field agriculture, the model does not adequately account for the early adoption of raised field agriculture in the Maya lowlands and the Titicaca Basin, and I believe that as more research is done, other zones where prehistoric raised field agriculture was practiced will show similar trends such as early dates and lack of presence of population pressure.

In an attempt to account for intensification, Bronson (1972:205) proposes an open-ended multilineal evolutionary model for the evolution of agricultural systems to replace the unilinear model proposed by Boserup. He notes that there are many ways to increase cropping frequency of land, all of which would have been very easy to develop. The use of fertilizers, manipulation of water with dissolved or suspended nutrients, farming on organic-rich, permanently cultivable soils, and adoption of cultivation techniques that mimic naturally stable ecosystems, such as mixed-cropping, arboriculture, and house gardens (ibid. 206-210). Bronson notes that most intensive systems are what he refers to as "hardware free," in that there are no special tools required or that the tools necessary for construction and maintenance of these systems are simple and readily available to the farmers (ibid. 202-203; 211). The simple agricultural tools used for intensive prehispanic

chinampas and modern New Guinea raised field systems are good examples, in sharp contrast the elaborate, and sometimes expensive and difficult to obtain, tools used in many shifting agricultural systems (such as the dependence upon metal tools). Many of the tools used in preparing slash and burn plots today were unavailable to prehistoric farmers. In areas such as savannas (where many raised field systems developed), farmers would have preferred to practice short or no fallow intensive systems to prevent the development of tough sods which are difficult to cultivate. The poor soils and inundation of many tropical savanna zones would be offset by the production and capture of nutrients in canals, the doubling of the depth of fertile topsoil, and the creation of a dry cultivation platform, major contributions of raised field agriculture. The crops available to early Neolithic swidden farmers would have produced much less than the fully-developed crops in later periods, so farmers wanting to increase production would have had to choose between clearing additional land each year or making the same land more productive through application of outside fertilizers (ibid.). Bronson argues that increased fertilization on cleared land (using the techniques mentioned above) would have been an easier strategy for early farmers (ibid. 213), especially those without metal forest clearing tools.

A multievolutionary model would account for the development of intensive agricultural systems in different parts of the world throughout prehistory much better than Boserup's rigid unilineal

model. Because of the reasons discussed above, the environmental conditions associated in each individual context of agricultural intensification, and the basic differences between strategies of agricultural intensification (raised fields, irrigation, terracing, etc.), the evolutionary trajectories of each system is expected to vary somewhat. Unfortunately, Bronson's model would be difficult to test because it is so open-ended with intensification occurring (or not occurring) in any situation because of a multitude of factors.

I believe that any model for the intensification of agriculture should focus on the particular environmental context and the particular agricultural technology being utilized. The model I propose will concentrate on the special environmental conditions of wetlands and the details of raised field technology. The assumption that labor intensification must be a part of agricultural intensification, the basis of Boserup's model, is questioned in regard to raised field agriculture and may not be applicable to many forms of intensive agriculture.

I believe that a multievolutionary model fits the archaeological data for many agricultural systems, in particular raised fields, much better than the confining unilineal model of Boserup and her followers. Bronson recognizes the important of environment (local environmental conditions, in particular soils and water resources) in the adoption of intensive agriculture, which I argue is a key issue. The stability of certain environments under continuous cropping would certainly have been

attractive to early farmers. Wetlands, discussed below in Chapter 7, are excellent examples of an ideal agricultural environment for the development of early prehistoric intensive agriculture. In general, wetland environments (including riverine, seasonally inundated savanna, and lacustrine), are characterized by rich, well-watered agricultural soils, on which agriculture can easily be intensified (shorter intervals or continuous cultivation with sustained high yields) using simple techniques of raising planting platforms. This intensification based on raised fields occurs early because of the high efficiency of such systems in terms of number of calories per unit of labor input. Thus, the reason the system is adopted and intensified is because it is more economically efficient, not because of population pressure. The idea to raise planting platforms to prevent flooding of fields is very basic, and because returns in the form of increased yield are seen the first year, innovation and adoption would be expected to occur early. These systems are most likely to be developed and expand in areas where year-round sedentism is possible. An established long tradition of a fishing and gathering economy supplemented by hunting within a wetland provides the necessary pre-adaptation for wetland agriculture and its intensification. Also important in this model is that any intensive agricultural systems must be considered a product of many generations of farmers who have contributed in a piece-meal fashion to the final product. Raised field systems were not constructed all at once, but are a result

of continual investment of "landscape capital," which produces a relatively stable and permanent agricultural infrastructure. Details of this model are discussed below.

Farmers are most likely to adopt labor-saving technological innovations and more productive techniques or crops soon after these become available (Simon 1977). The high productivity of raised fields with relatively low labor input would be a good example.

The concept of the Law of Least Effort, the backbone of the Boserup model, raises important issues. If the Law of Least Effort does hold in non-Western agricultural systems, is it true that all cases of intensive agriculture are necessarily "labor intensive?" Much of the literature on the subject tends to equate intensive agriculture based on cropping frequency and high productivity with labor intensive agriculture. Some forms, in particular raised field agriculture, can be shown to be as labor efficient as more extensive forms, in addition to being many times more productive (see Chapter 4). Thus, it is no wonder that early farmers adopted simple intensive agricultural systems over more extensive forms, outside of situations of population pressures.

The Boserup Model relies on population pressure putting stress on subsistence production as the "prime mover" in explanations of agricultural change. Here it is important to distinguish "social production" from "subsistence production." In many cases where intensive agriculture is practiced by

traditional societies (especially true in the New Guinea Highlands), intensification is related to the production of certain goods not related to basic subsistence needs. In many cases, intensive agricultural systems, some of which are labor intensive, are devoted to this production. Inca construction of elaborate terraces for socially prestigious maize production (Murra 1980) on the islands of the Sun and Moon, Copacabana Peninsula, and other peninsulas in Lake Titicaca, an area pushing the limits of maize cultivation, is an good example of this obsession. Social production has wide ranging effects within the system to further stabilize it such as production for rituals and ceremonies, reciprocity, trade, integration and alliances.

One very important aspect of intensification that is commonly neglected by Boserup and her followers is that intensive systems were not created all at once. They are the product of many generations of farmers contributing piecemeal to the total system, referred to by Doolittle as "agricultural change as an incremental process" (1984). He demonstrates through his analysis of the temporal irrigation systems of Sonora, Mexico, that the system is the result of continual accumulation of small-scale land improvements by individual farmers over many generations forming a rather sophisticated agroecosystem. In this case, there was no initial massive labor input to intensify, rather, the labor was spread out over a considerably long period. The creation of vast "landscape capital" (Brookfield 1972), accumulating through the process of slow accretion as described

by Doolittle (1984), such as terracing, irrigation, and raised field systems did not necessarily require any additional labor beyond what is expended in normal cultivation over a long period of time. I feel that this concept is very important in any explanation of prehistoric agricultural change and for understanding abandoned agricultural systems and evaluating their labor input and sociopolitical associations. Synchronic studies of intensive agriculture used by ethnographic groups, one-time experimental construction for obtaining labor and production figures, and archaeological studies that assume that the past agricultural system under investigated was constructed all at once will produce skewed interpretations. In the case of the Lake Titicaca raised fields, the gradual construction and improvement through a considerable period of time is demonstrated in the stratigraphic profiles of raised fields.

If this model accounts for the early evolution of raised field agriculture, the following predictions can be made:

- 1) the earliest raised field agricultural systems were located in wetland areas (riverine, lacustrine, marsh, seasonally inundated savanna, etc.) and later spread to surrounding dryland areas and smaller wetland blocks.
- 2) raised field systems were first developed by sedentary populations pre-adapted to wetland environments, probably relying on a mixed economy of fishing, hunting, and gathering of wetland resources and cultivation of house gardens.

- 3) raised field agricultural systems are likely to occur as early or earlier than many extensive agricultural systems such as swidden and dryland farming.
- 4) population pressure was not the cause of adoption of raised field agriculture.
- 5) the archaeological remains (both areal distribution and superposition) of raised fields are the result of a long process of construction by many generations of farmers, not something constructed all at once.
- 5) the motivating force behind the adoption of raised field agriculture was its high productivity and relatively low labor input, combined with climatic risk minimization and the benefits of a high biomass characteristic of wetland environments.

The following chapters apply the archaeological, experimental, ethnographic and ethnohistorical information on raised field agriculture in the Lake Titicaca Basin to test and refine this wetland-oriented model. This model not only best explains the development of raised field agriculture, but may have implications for understanding other intensive agricultural systems such as terracing and irrigation systems.

5.3.1 Archaeological Evidence for Early Raised Field Agriculture

5.3.1.1 Introduction: Current Models for Raised Field Evolution

Max Schmidt (1974 [1951]:64) was one of the first New World archaeologists to suggest that mound agriculture, a type of raised field agriculture, may have been one of the earliest forms of agriculture. He noted that, in various manifestations, mounding is widespread throughout the highlands and lowlands of South America and the Caribbean. He argued that this form of agriculture would predate shifting cultivation since it would be easier than slash and burn in the tropical forests. Other researchers note that root crops such as yams, sweet potatoes, and manioc, the earliest subsistence cultigens of the tropical forest, are generally closely associated with mounding techniques (Sauer 1975; Coursey 1976; Harris 1972a, 1972b, 1977, 1978). The early domestication of root crops and the inferred associated use of mounding would have provided an excellent context for the early development of more intensive forms of raised field agriculture.

For many decades, the predominant archaeological paradigm for Maya subsistence was the exclusive use of shifting tropical forest agriculture (Morley 1946 and others), which eventually caused the downfall of the Maya Civilization as it could not support the growing populations, particularly the urban and ceremonial centers (Meggers 1954 and others). For many years, the carrying capacity of shifting agriculture under different

following strategies was debated (Harrison and Turner 1978).

D. Puleston and O. Puleston (1970) developed a model for the lowland Maya such that intensive cropping systems in riverine and wetland environments predated swidden systems. Soon afterwards, D. Puleston's focus on riverine environments and wetlands as a context for the early Maya farming and the discovery of raised fields along the Rio Candelaria floodplain in Campeche, Mexico by Siemens (Siemens and Puleston 1972) resulted in a complete revision of the paradigm for Maya subsistence (Harrison and Turner 1978; Turner and Harrison 1983; Flannery 1982; Pohl 1985). The so-called "swidden theory" was now replaced by a model of the Maya as a "hydraulic society," much like that defined by Wittfogel (1955, 1956, 1957, 1972) for explaining the origins of "despotic societies." Still, most students of Maya agriculture supported the Boserupian ideas of evolution (Boserup 1965) from extensive (swidden practiced by the early Maya) to intensive (raised fields and terraces, developed by the "civilized" Maya) cropping schemes, with population pressure as the motivating force. This has become the most popular paradigm for the evolution of raised field agriculture in the Maya area.

Puleston's extensive archaeological research on Albion Island on the Rio Hondo in Belize seriously questioned those paradigms (1976, 1977a, 1977b; 1978). Puleston recovered a hewn wooden post excavated in secure context from a raised field canal edge which dates to $3,010 \pm 230$ years B.P. (1110 B.C. \pm 230), demonstrating that the intensive system was practiced in the

Early to Middle Preclassic and was not a late development (1977b:452; 1978:237-239). Maize pollen from 1800 B.C. contexts provide additional support for early farming. Puleston also stratigraphically documented at least two stages of raised field construction within a single context, suggesting an early origin of the system (1978:237-239). Puleston also reported a somewhat later radiocarbon date of A.D. 229 ± 50 obtained from wood fragments beneath raised fields on the Rio Candelaria, Campeche, Mexico (1977b:452). He argued that not only did raised fields appear very early in the development of Mayan agriculture, but that Maya world view, and social, economic and intellectual beliefs, appeared to revolve around a wetland inspired cosmos (1977b).

Recent investigations provide support for Puleston's early dates. A radiocarbon date of 2620 ± 190 years B.P. (670 B.C. possibly too recent because of material dated) was obtained from maize recovered from a raised field at San Antonio, Belize near Albion Island (Bloom et al. 1985:26; 1983). These authors also stress that this is good evidence of prehistoric wetland cultivation long before the high dense populations of the Maya Classic Period (Bloom et al. 1983:417; 1985).

Other support for Puleston's early dates for intensive agriculture comes from the site of Cerros. Freidel and Scarborough (1982:151) cite a radiocarbon date obtained from raised field canal fill of 2372 B.P. (420 B.C.).

The Early Formative through Late Classic Period site of

Cuello on the Rio Hondo in Belize also provides indirect support of Puleston's hypothesis of early Maya wetland farming. Hammond et al. (1979) defined an early sedentary Maya community of Cuello (Swasey Culture) dating to 2500-1300 B.C., and although no raised field sites are clearly associated with Cuello, Hammond believes that raised fields may supported this population. Wilk (1985:55) suggests that the lack of prehistoric axes recovered from this site is evidence that river-oriented flood farming rather than swidden, based on forest clearing, was the focus of agriculture in Cuello society.

Turner, the staunchest supporter of Boserup among the Mayanists interested in agricultural development, has debated Puleston's early dates for raised field agriculture (Turner 1983a:22; 1983b, 1985:201; also Turner and Harrison 1978:358-359; Turner and Harrison 1983:253, 255, 270; Turner and Denevan 1985:20). He calls into question Puleston's interpretation of their context, noting that since the dates were obtained from a peat zone under the fields, they possibly represent some sort of pre-raised field agriculture (Turner and Harrison 1983:269). Turner also stresses that the later project at Albion Island (Bloom et al.1983; 1985; Antoine et al.1982) refers to these fields as "channelized" instead of "raised." Since no evidence of superimposed raised fields was recovered from the Pulltrouser Swamp excavations, Turner and Harrison (1983:269) do not believe that they could have been present at Albion Island. Turner's main argument is that the data does not fit the "accepted"

Boserup scheme, since population pressure probably did not occur that early in Maya prehistory (Turner and Harrison 1983:254-255). Relatively late radiocarbon dates of A.D. 150 \pm 150 from raised fields in Pulltrouser Swamp (Turner and Harrison 1983:254; Turner 1985:201), a radiocarbon date of 2372 B.P. from Cerros (Freidel and Scarborough 1982:151) and a Late Preclassic (800 B.C.-150 B.C.) or Late Classic (A.D. 600-850) date based on ceramics from Bajo Mococoy (Gliessman et al. 1985:108) are cited as further proof that Puleston's early dates are not possible (Turner 1985:201).

Turner (1985:199-203; also see Turner and Denevan 1985:21; Turner and Harrison 1978:357-358; 1983:253, 270, 255; Denevan 1970:652-653) assumes that extensive swidden systems had to precede intensive raised field systems, but so far has not provided any archaeological evidence to support the necessity of that widely accepted idea, in fact, there is no known direct evidence of prehistoric swidden agriculture anywhere in the world. In rejecting the early dates Turner and Denevan state, "while the use of wetland raised fields in the Americas was early, it was not so early as to predate dryland agriculture" (1985:20). Turner and Harrison state that if raised field agriculture was early, "It contradicts the concept of agricultural efficiency by suggesting that the early Maya (colonists?) deliberately chose to pursue a more strenuous and less efficient form of cultivation in the floodplains than was probably necessary" (1978:359; also 1983:255).

Prehistoric pollen records are scarce for the the Maya lowlands, but the available ones have been used as indirect evidence for early swidden agriculture. Pollen cores have been analyzed for Lake Petenxil, in the Peten of Guatemala and evidence of rapid sedimentation here has been interpreted as proof of the environmental impact of swidden agriculture (Rice 1978), but these interpretations have been questioned (Sanders 1979; Turner 1985:203).

The relatively late dates from Pulltrouser Swamp is used by Turner and Harrison to support a late adoption of raised fields by the Maya. What should be pointed out is that the raised field excavations at Pulltrouser Swamp by Turner and Harrison were conducted in highly disturbed contexts (for example, Late Pre-Classic sherds were found at 30 cm BD while Late Classic sherds were recovered at 150 cm BD in the same excavation unit) (Turner 1985:198). I feel that it is very difficult to establish good chronology from such a context. The Pulltrouser Swamp raised fields may indeed be late, as supported by recent ceramic dating of raised fields at nearby Nohmul (Hammond et al. 1987:258-260). To argue that this means that all prehistoric intensive raised field systems are late based on this evidence is illogical. Because Puleston's dates do not "fit" the Turner model, they have been automatically disregarded. In addition, Turner argues that the dates obtained by Puleston and Bloom et al. were from "channelized fields," not "true raised fields." What did the Maya do with the soil removed from the "channels?"

It appears that the Maya were focusing heavily on the wetlands for subsistence, certainly during the Classic Period and if Puleston and others are correct, this began during the Early Pre-Classic or earlier. Linear patterns on aerial photographs of large areas of the central Peten and Yucatan with extensive baio features were proposed as evidence of intensive Maya agricultural and hydraulic engineering (Harrison 1978; Turner and Harrison 1978; Siemens 1977, 1982, 1983) or natural "gilgai" formations (Puleston 1978:234-237). Raised fields now have been partially confirmed for some of these areas by satellite data and aerial photographs (Adams et al. 1981) and by ground truth in some areas (Gliessman et al. 1983). Unfortunately, none of these recently discovered raised field systems have been adequately dated.

Ethnographic investigations into the potential of recessional floodwater farming, demonstrating the ease of cultivation in these zones, has provided further support for the riverine orientation of early Maya farmers in the Maya area (Wilk 1985; Gliessman et al. 1985; Siemens 1977, 1983) and for South America (Lathrap 1970, 1977; Lathrap et al. 1985; Denevan 1966, 1982). The idea that intensive floodwater farming along riverbanks and floodplains was adopted early in prehistory has been discussed in detail by Sherritt (1980) for the Old World. In the Maya zones of Tabasco, Mexico, three crops per year of maize and beans may be obtained on the seasonally flooded riverbanks (Gliessman et al. 1985:105). The Kekchi Maya, studied by Wilk (1985), practice "floodwater recessional agriculture" on the

tops and backslopes of the river levees, in addition to high backswamps, which are cultivated intensively (an average of 5.2 years, with 2.8 years of fallow, some up to 12 years continuously) (ibid. 47-50). He notes that, although the shifting systems practiced on the uplands yields higher corn production than the riverbank farming, the risk is much lower in riverbank farming, the riverbank cropping period occurs when off season agricultural labor is available during the dry season, and labor input is low. Other benefits include the ease of transportation of goods using canals and river channels, and the reduced destruction of crops by animals. Most significantly, this occurs in a context without population pressure necessitating intensive production (ibid. 54). Wilk, arguing by analogy, concludes that the Maya, using prehispanic stone hoes, would have much preferred riverbank cultivation to shifting agriculture in the forests (ibid. 54). He believes that riverbank cultivation would have easily evolved into raised field agriculture.

This proposed early intensive recessional floodwater farming (and, I would add, farming on the fringes of wetlands and lakeshores) was an important preadaptation to full-scale raised field agriculture. All of the necessary conditions for the domestication of crops and development of early cultivation systems described by Sauer (1975) and Lathrap (1970, 1977; Lathrap et al. 1985) are found here; in addition, a detailed understanding of the natural seasonal hydraulics of these

environments would facilitate the adoption of raised field agriculture.

5.3.1.2 Evidence for Early Raised Field Agriculture in South America

Early dates for raised field agriculture have also been reported for the Guayas Basin of coastal Ecuador (Parsons and Shlemon 1982; Denevan and Mathewson 1983). From a paleosol 95 cm below the surface of a canal at Caño Matanzas near Duran, Parsons and Shlemon (1982:35-36) obtained a date of 3995 \pm 95 years B.P. (2005 B.C.), and from a mollic epipedon at the base of a raised field at Ensenada Taura they obtained date of 2450 \pm 85 years B.P. (590 B.C.). These early dates must still be considered with caution, since little supporting evidence has been recovered (Denevan and Mathewson 1983) other than an indirect association with the Valdivia, Chorerra, and Milagro Quevedo Period site of Peñon del Rio (Parsons and Shlemon 1982:36). It must be pointed out that tropical forest riverine and wetland-oriented agricultural societies in the Guayas River Basin area where the raised fields are found date to 3000-4000 B.C.. (Lathrap et al. 1975, 1977).

At the site of Caño Carate in the Lower San Jorge River Valley of Colombia, much later dates of 755 B.P. \pm 80 years, 505 \pm 70, and 435 \pm 120 B.P. were obtained from deeply buried organic sediments which formed after the abandonment of the raised fields. These samples were possibly contaminated with modern

organic material, and thus these dates may be too recent (Parsons 1978:123). Raised fields of the Lower San Jorge River valley are believed to be associated with ceramics of the Painted and Modeled Tradition dating from A.D. 200-600 (Plazas and Falchetti 1981:30), possibly in use until A.D. 1100 (Plazas and Falchetti 1987:483). According to Lathrap et al. (1985:61), these ceramics should date to approximately A.D. 1 to A.D. 600, and are related to the Milagro-Quevedo complex of ceramics associated with the Guayas Basin raised fields at Peñon del Rio, possibly representing a common tradition.

Bray and colleagues (Bray et al. 1983, 1985, 1987) has defined a form of ditched fields on hillslopes and raised fields in wetlands in the Calima area of Colombia. From the cultivation platform of a ditched field of the Yotoco Period, Bray obtained a date of A.D. 790 ± 60 (1985:19, 21), and date of A.D. 750 ± 50 was obtained from the base of a wetland raised field (ibid.). Other ditched fields date to the Sonso Period, post-A.D. 1200 (ibid. 23). Dates (100-600 B.P.) obtained by thermoluminescence of sherds from raised fields also support the Sonso Phase dates (ibid. 1983:26). A date of A.D. 1465 ± 65 from the floor of a ditch, is interpreted as relating to the abandonment of the fields (ibid. 28). Much older dates of 2000 and 3500 B.P. were recovered from beneath raised fields, but these may predate the agricultural system (ibid. 26), although Bray also reports maize pollen from 4000-5000 B.C. contexts indicating prehistoric agriculture (1985:9).

If the fields of the San Jorge and Calima areas are superimposed, as in Huatta, the dates may refer only to the latest periods of use and abandonment. The excellent archaeological context demonstrated by Bray for the San Jorge and Calima raised fields is solid. The dates from the three areas in northern South America points to a long tradition of wetland and hillslope utilization through raised field agriculture.

5.3.1.3 Discussion

Are raised field systems earlier than swidden systems in the New World? The early dates presented above from lowland areas of Belize and Mexico, the Guayas Basin of Ecuador, and highland Lake Titicaca in Peru are certainly suggestive of the early use of wetlands and raised field agriculture. These early dates are certainly not related to the actual beginning of the agricultural economies in these zones, which occurred much earlier, but they are associated with the some of the earliest-documented sedentary lifestyles and pre-urban settlements in certain areas. Swidden agriculture leaves no archaeological evidence, and so, no one has yet provided substantial proof that it was even practiced prehistorically, let alone that it preceded more intensive agricultural systems. Lathrap (1970, 1977) and Harris (1972a, 1972b, 1973, 1977, 1978) have demonstrated the important role that the house garden, a form of intensive agriculture based on permanent cultivation, could have had on the origins of agricultural systems in the Tropical Forest. Systems such as

raised fields would have been a logical development from house gardens located in rich wetland areas, where hunting and gathering would have permitted a very stable sedentary existence. Sauer (1975) predicted that the earliest agriculture would be found in woodland riverine zones, where the rich biotic resources could have provided all of the resources necessary for dense permanent settlements. Sauer (ibid.) disagreed with application of the cliché "necessity is the mother of invention" to the development of agriculture, and argues that agriculture did not develop because of prehistoric population pressure, rather in a context of relative stability and rich naturally-concentrated resources, necessary for experimentation and the domestication of crops (also see Lathrap 1977). This same context would have been ideal for experimenting with raised field agriculture, which possibly originated as a combination of flood recessional farming and small scale house gardening (Lathrap 1977).

Lathrap argues that shifting agriculture was "a secondary, derived, and late phenomenon within the Amazon Basin" which followed the intensive use of the floodplains adjacent to the major rivers (Lathrap et al. 1985:54; also see Lathrap 1970). The key to this "de-evolution" of agricultural intensity was the relatively late introduction of productive races of maize (Zea mays), and advanced techniques to process and store the maize into Amazonia. This made swidden efficient enough to be adopted as an agricultural strategy by lowland farmers and as a result permitted the spread of farming communities throughout the

uplands and interfluvial areas. Before this introduction, intensive tropical forest agriculture was fully entrenched in the riverine areas, and a myriad of cultigens and cultivation techniques were used on river banks, edges of oxbows, and levees. Lathrap (1970:160-161) also argues that raised field agriculture developed in these same riverine contexts. In regard to the raised fields of the Llanos de Mojos of eastern Bolivia, he states:

The form of the longer drained fields and their relation to one another suggests the configuration of the parallel point-bar formations in the flood plains off the major rivers. As noted earlier, it is the tops of these natural ridges that were intensively farmed by the Tropical Forest Groups. It appears that the linear drained fields of the Llanos were a conscious and deliberate attempt to expand the ecological conditions present in the limited areas of riverine flood plains (Lathrap 1970:160-161).

Certain intensive systems of agriculture such as raised fields do not necessarily have to have been preceded by extensive systems such as swidden, with change from extensive to intensive propelled by population pressure. Eoserup's hypothesis has been a significant explanatory tool in the past, but because of its unilineal character, it simply does not account for the evolution of all forms of intensive agriculture, in particular raised field agriculture. I argue above that Bronson's (1972) multilinear model for the evolution of agricultural systems best fits the data for raised field agriculture. Once one accepts that certain intensive agricultural systems, such as raised fields, can possibly precede swidden systems, the early dates for raised

field agriculture in other parts of the Americas do not seem so controversial. In the following section, I will present data to support the early development of intensive agriculture in the Lake Titicaca Basin in a context of a sedentary lacustrine, wetland-oriented subsistence pattern similar to that proposed by Lathrap for the Central Amazon.

5.3.2 Population and Agriculture in the Lake Titicaca Basin

We have demonstrated, based on the TL dates obtained through excavations in raised fields (Chapter 3) and radiocarbon dates from occupation sites associated with raised fields (Erickson 1988) that the raised fields of the Lake Titicaca Basin were developed early, at a much earlier period than proposed by other investigators (Kolata 1986, 1987; Kolata et al. 1987; Smith et al. 1968; Browman 1978a). If one follows the Boserup model and the Law of Least Effort, farmers would not have adopted intensive raised field agriculture unless forced to do so by population pressure. Previous investigators have argued that dense prehistoric populations in an area of raised field remains imply prehistoric population pressure. I believe this inference is sometimes erroneous. There is no evidence that population pressure was the cause of raised field agriculture in the Lake Titicaca Basin, even though populations grew to large densities during the climax of raised field use.

Archaeological surface survey of mounds within the raised field complexes of the Lake Titicaca region can be very

deceptive. In surface collections from the occupation mounds in the Huatta area, diagnostic sherds from the more recent periods of prehistory (Late Intermediate Period and Late Horizon) were most frequent. This does not indicate that populations were necessarily more dense or had greatly increased in the later periods, since the mounds have not been deeply disturbed. Deeply buried early cultural material has not been brought to the surface of these mounds, so any early occupations are only scantily, if at all represented. Excavation in the mounds of Pancha and Kaminaga verified this phenomenon (Erickson 1988).

There is no evidence of population pressure in the Lake Titicaca Basin for the period of the first dated raised fields, around 1000 B.C.. Sites are numerous and dense in the pampa around the lake margin, but this appears to have occurred at the same time as (and not before) the development of raised fields. Our survey and excavations indicate that many of these occupation mounds were probably established by 800 B.C., and nearly continually occupied through the Late Horizon, with abandonment of mound sites and contraction of raised field complexes occurring twice, during the Middle and Late Horizons. We have demonstrated in Chapter 4 that once the raised fields, in addition to andenes and gochas, were established, there probably was no practical limit to the population that these agricultural systems could support. I calculate that if 100% of the raised fields were in use, some 1.5 million people could have been supported by this form of agriculture (see Chapter 4). During

the Late Horizon, a population of only 190,000 has been calculated for Chucuito, the most densely populated zone in the Lake Titicaca Basin, based on analysis of demographic data from the Chucuito visita (Smith in Cook 1981:48). This is far below the potential carrying capacity of the prehistoric Lake Titicaca agricultural systems.

5.3.3 Raised Fields as Intensive Agriculture

Raised fields are an intensive form of agriculture because long-term continuous cropping is possible if the field is properly maintained. I believe that the fallow period, if any, were never longer than the periods of cultivation and that long fallow was probably not desired because of the reasons discussed above (Chapter 4).

Are raised fields necessarily "labor intensive?" As discussed in Chapter 4, experimental raised fields demonstrate that they are not labor intensive if considered in the long term. The initial labor investment in construction is relatively high, but when the benefits of continuous cultivation with sustained high yields are considered, this initial "labor intensive" system becomes one with minimal labor input. Most discussion of intensive agriculture neglect this very important fact. Raised fields, at least those of the Lake Titicaca region, are a classic case of what Bronson (1972) would consider highly efficient in terms of labor in his comparison of intensive to extensive agricultural systems. Even the initially high labor costs should

be reconsidered. My estimate of $5.0 \text{ m}^3/\text{day}$ of earth moved under normal conditions demonstrates that raised field construction is not necessarily as arduous as presented by other investigators

As Bronson (1972) noted, one means of obtaining high soil fertility for intensive cropping is to select areas that have extremely high natural fertility. This allows the farmer to continuously cultivate without the labor and resources necessary for major fertilization. Raised field farmers did just that. They exploited the nutrient-rich soils of the lake shallows and shore, and expanded this system inland across the pampa. But since well-managed raised field cultivation encourages the continuous production and recycling of nutrients in the canals, soils can be even further improved.

Considering these factors, especially those of high production and low overall labor input, it is easy to understand why raised field agriculture would have been attractive to the early farmers of the Lake Titicaca Basin. Even according to the Law of Least Effort, these farmers probably would have preferred the raised fields to alternative forms of agriculture.

As discussed in Chapters 3 and 4, the raised fields were not constructed all at one time. Raised fields were gradually constructed, probably in piecemeal fashion, by many generations of farmers, which spread out construction costs over a long period of time. The importance of incremental evolution in large-scale agricultural systems has been discussed by Doolittle (1984). He studied the development of moisture control checkdams

and extensive irrigation systems (temporales) in the Sonora Desert of Mexico, demonstrating that through slow incremental growth, impressive complex agricultural systems can be developed by small local groups without major labor investments. In the Lake Titicaca Basin, 5000 farmers working 5-hour days continuously could construct the entire 82,000 ha of recorded raised fields in only 32 years. Of course, it is unlikely that this was the case. Over the 2000 years of use of raised fields in this region have been documented and if 500 years were necessary for the construction of the bulk of the raised fields, then 1000 farmers could have worked only 117 days of each year (approximate length of the agricultural offseason) to complete the job.

CHAPTER 6

THE SOCIAL ORGANIZATION OF RAISED FIELD AGRICULTURE

6.1 EARLY PERSPECTIVES ON THE SOCIAL ORGANIZATION OF INTENSIVE AGRICULTURE

6.1.1 The Wittfogel Hypothesis

Wittfogel, in his Oriental Despotism: A Comparative Study of Total Power published in 1957, and in numerous other works (1955; 1956; 1972), was the first to adequately present a model of the relationship between agricultural systems based on irrigation and social organization. Wittfogel's intention was to explain the origin of the pre-industrial despotic state. Influenced by Marx's treatise, regarding the "Asiatic Mode of Production," Wittfogel focused on the importance of the despotic bureaucracy, stating that "under the conditions of the Asiatic mode of production the agromanagerial bureaucracy constituted the ruling class" (1957:6). In his model, Wittfogel discusses what he refers to as "hydraulic agriculture," or large-scale, government-directed, agriculture and argues that the problems associated with controlling large quantities of water, the mobilization and coordination of the mass labor and capital necessary to construct, maintain and operate such systems, and the reduction and adjudication of conflicts over water and land resources give rise to the opportunity (but "not the necessity")

for "despotic patterns of government and society" (ibid. 12) which he calls "agromanerial despotism" (ibid. 414). He specified that this creation of powerful ruling bureaucracies (full time specialists) with a monopoly on power will occur only if there is no alternative to irrigation agriculture (ibid.). An important characteristic of these societies is the recurrent use of corvee, forced coercive labor.

Wittfogel also made an important distinction between hydroagriculture, where farmers use small-scale irrigation, and hydraulic agriculture, which involves large-scale government-managed irrigation and flood control. Hydroagriculture does not have the effect on social organization that occurs with hydraulic agriculture.

Wittfogel's model has received considerable attention over the past several decades, mostly critical (Downing and Gibson 1974; Gibson 1974; Price 1971; Steward 1955; Hunt and Hunt 1974; Millon 1962; Mitchell 1976). Critics have pointed out that there are many historical and ethnographic cases where irrigation systems are not associated with despotic governments, but rather informal means of cooperation and dispute resolution. Another major defect is the problem of causality and the basic unilineality of the model, whether irrigation "causes" complex society (as Wittfogel claims) or vice versa (Price 1971:43-46). Others point to diachronic evidence of cases where complex social organization occurred long before complex irrigation projects were implemented (Moseley 1974; Adams 1974; but see Price

1971:44). Wittfogel also neglected to deal with the the problem of comparing irrigation systems on vastly different scales (e.g. simple Hopi irrigation vs. large Chinese multi-valley systems) or functions (e.g. canal irrigation vs. ponding, or inundation farming vs. flood control) (Downing and Gibson 1974; Hunt and Hunt 1974:130-131; Price 1971:39-43).

Wittfogel's focus on the association of irrigation systems with despotic governments has recently been replaced with a focus on the tendency towards centralization in societies which rely on irrigation. Societies using irrigation tend towards cooperative, rather than individual, efforts, no matter what the scale of the system (Price 1971:40). Hunt and Hunt (1974:132) insist this centralization is variable and must be examined in terms of the degree of "embeddedness" of the power roles of individuals and/or institutions making irrigation decisions at different levels of a hierarchically, centrally organized political system. As Downing and Gibson indicate, "The key to this centralization may well be scarcity...however, the scarcity may not be merely one of water" (1974:x). They suggest stress on local resources and increasingly limited access to resources, population pressures, declines in population limiting labor availability, and a lack of necessary capital at the local level, as "triggers" to centralization. Related to this is the degree of cooperation necessary to keep the system functioning, which is a better measure than the physical scale of the system (Spooner 1974:46). Spooner divides irrigation systems into "complex," those that "require

engineering and maintenance beyond the ability of individuals or groups involved in the actual cultivation, in contrast to 'simple systems' run by individuals" (ibid. 48). When systems become complex, centralization becomes more critical, but does not always develop. Spooner points out that it is difficult to find cases where the process of centralization has developed along with the evolution of irrigation from simple to complex and that "most centralized systems were able to initiate and maintain complex irrigation systems because of the ability to organize investment on a large scale" (ibid.). Others see no relationship between centralization and irrigation systems (Millon 1962, but see Hunt and Hunt 1974:131 and Price 1971).

6.1.2 Centralization of Authority and Raised Field Agriculture

Because raised fields are an intensive form of agriculture, it is common to find them discussed in the archaeological literature in relation to complex social organization. Much of the debate that followed Wittfogel's model of irrigation agriculture is beginning to be readdressed in discussions of the raised field agriculture. Wittfogel actually used the Maya as an example of what he called "marginal agromanerial societies" (1957:184-188). He considers the Maya, although they did not utilize classic irrigation per se, as "hydraulic" because of the importance of the management of water resources, primarily for drinking (the construction and maintenance of cenotes, chultunes,

and aguadas). Because of "influences" from the Central Mexican Highlands where intensive irrigation systems were well established, Wittfogel called Maya a "derived" hydraulic society.

It is assumed in the majority of the literature that raised field agriculture, because of its large scale, the large amounts of labor necessary for construction and maintenance, and the need for cooperation and coordination of activities, is necessarily associated with complex social organization and centralization (Kolata 1986, 1987; Denevan 1970:653; Wilkerson 1983:64; Matheny 1978:209). This has especially been the case with the Mayan raised fields. Because water control features, both agricultural and non-agricultural, are now being defined in great numbers for the Maya, they are considered by some to have been a "hydraulic society," (Matheny 1978:206-210), which Wittfogel predicted in 1957. This classification is primarily based on assumptions about labor necessary for the construction and maintenance of raised field systems, supposedly very high and onerous for the participants. It is commonly believed that people would not participate in raised field agriculture unless forced to by a despotic or coercive government. In addition, the engineering and coordination of raised field agriculture is assumed by many to be at a high level, far beyond the capabilities of the average prehispanic farmer; corps of state engineers "must" have been responsible for the planning and execution of these projects. Also, such labor intensive projects, if constructed all at once, would have required a huge

capital base (logistical support, tools, food and housing for laborers, materials, etc.) only possible through centralized structures.

Only a few voices were heard denouncing the idea that centralization was essential to Maya raised field agriculture, often those of "outsiders" (Bronson 1978:294-298; Harris 1978:310-318; also see Turner and Harrison 1978b:361-368). Denevan (1970:653, 1982), in his early survey of raised fields in the Americas, concluded that prehistoric farmers and contemporary peoples using raised fields span a wide range of socio-cultural complexity, from semi-nomadic to state level societies. He notes that they could have been managed and constructed "through small-scale family and community cooperation" (ibid.), although he basically agrees with Carniero (1967) that there appears to be a relationship between "degree of intensification, population size, and complexity of social organization" (Denevan 1970:653).

Another important point is that raised field agriculture is very different from complex irrigation agriculture (and other labor intensive forms of agriculture) with its centralization and Wittfogel's despotic hydraulic society. As Price has pointed out, irrigation and terraces, in contrast to raised fields, commonly involve a level of labor and cooperation beyond the individual farmer.

Terraces, like irrigation canals, require continuous upkeep to maintain them in good repair. While chinampas also require such attention, a single farmer's eroded chinampa menaces the security of no one but himself. A single disintegrating terrace, however, can threaten the productivity of all the holdings located below it. Thus

like small irrigation systems operating at the single community level, community-level cooperation is generally advantageous in terrace cultivation (1971:40-41).

In irrigation agriculture, a single integrated systems can spread both linearly and radially over a long distance from source of water to its final destination. The social organization necessary for the operation of larger systems has been the main focus of the Wittfogel debate, but most authors now agree that there must be some form of cooperation amongst the users of such a system, be it complex or low level (Mitchell 1973, 1976; Hunt and Hunt 1974; Seligmann and Bunker 1986; Gelles 1986; Sanders and Price 1968). Water shortage, channelling of water over long distances from one area to another, fair distribution, and enforcement of regulations are not problems in raised field agriculture. In the Lake Titicaca Basin and most wetland locations, there is more than enough water for all participating farmers and an high water table insures that even during short term droughts, there is sufficient moisture for cultivation.

Raised field agriculture should not be included with the classic hydraulic societies based on irrigation described by Wittfogel. Raised field agriculture differs from large scale irrigation in that there is no necessarily inherent need for large-scale cooperation, in the construction, use, nor maintenance of the system. Water is a very scarce resource or difficult to control in the cases which best fit Wittfogel's model and show a high degree of centralization (Downing and Gibson 1974).

6.2 ANDEAN ORGANIZATION OF AGRICULTURAL LABOR

There are several kinds of traditional symmetrical reciprocal and asymmetrical labor exchanges practiced prehispanically and today in Andean communities such as Huatta. These operate at different levels, from the the individual household to the ayllu to the Inca state. Concepts of reciprocity are found at all levels of Andean society. During the Incaic period, redistribution at the kuraka or (local lord) level was couched symbolically in terms of reciprocity (Alberti and Mayer 1974; Wachtel 1977).

The modes of labor organization practiced in Huatta today have been discussed in Chapter 4. I also discussed how this organization effectively provided the necessary labor force for construction of experimental raised fields in Huatta. The following is a presentation of the various basic Andean forms of labor organization for agricultural activities.

6.2.1 The Andean Household

The extended family or household is generally considered the fundamental unit of production and consumption in Andean society (Bolton and Mayer 1977; Tschopik 1963:542; Orlove and Custred 1980:32; Mayer 1977; Orlove and Guillet 1985; Brush and Guillet 1985). The households "allocate land, labor, and capital" and self-sufficiency in food production is the goal (Brush and Guillet 1985:20; 25). They are the locus of decision-making and

are relatively autonomous (Orlove and Custred 1980:33). Extended family networks often form "loose and ad hoc neighbourhoods" (ibid.). Households interact with other households to form larger networks and corporate groups for agricultural production and other activities (Orlove and Custred 1980:32).

Division of labor within households is based on sex and age (Orlove and Custred 1980:33). Because of the labor requirements of the household, large extended families with several adults and subadults tend to be the norm for labor activities in Huatta. The basic unit of agricultural labor at the family level is the three-person chakitaqlla team (masa) for field preparation and the two-person team for planting, usually a man digging the holes or furrows and a woman placing the seed. Other activities such as weeding, banking tubers and harvesting can be done singly, but few farmers like to work alone, even if individual labor would suffice. In the Huatta area, a family maintains numerous houses scattered among the different environmental zones of hill, lake and pampa, which helps maximize the labor efficiency of the small nuclear family group.

6.2.1.1 Ayni

Labor needs often go beyond what is available within the household, especially during peak periods of agricultural activities such as ground preparation, planting, weeding, and harvesting, so that self-sufficiency is rarely obtained (Orlove

and Custred 1980). In addition, tight scheduling of these agricultural activities, because of limited irrigation water, short growing seasons, and/or climatic conditions, requires that work often be completed within a short time span. Labor in Andean communities is limited, and the periods of peak labor need affect all of the farmers at the same time (Guillet 1980:156). In response, Andean peoples have worked out complex schedules for agricultural activities to maximize production (Golte 1980).

The most basic form of labor organization in Huatta is the concept of ayni, delayed symmetrical labor reciprocity between individuals which are equals (Alberti and Mayer 1974; B. Isbell 1978:167-177; Mishkin 1963:419; Tschopik 1963:543; Mayer 1974:45; Bourricaud 1967:114; LaBarre 1948:146). The labor or service performed by one person for another will be repaid at a later time in exactly equal kind and amount. This is most commonly practiced within an extended family, kin groups, between close neighbors, friends, or compadres (ritual kin). The individuals participating in ayni expect to receive food, coca, chicha (corn beer) and cane alcohol during the work day. A less formal kind of ayni is yanapi (or ayuda), where the labor or services offered between close kin or friends is not expected to be "paid back" (Mayer 1974:47).

6.2.1.2 Minka

Andean farmers generally prefer to work in groups larger than the immediate family. This was especially the case when

land was communally controlled by the ayllu, discussed below. The best work situations became festive occasions, especially those organized by minka. Agricultural labor is commonly organized in teams of three, a masa. The masa generally consisted of two men using chakitaqlla and a woman. Commonly, a farmer attempts to obtain several masa through avni or minka for agricultural labor.

Minka involves a special asymmetrical exchange of goods for labor or services (B. Isbell 1978; Alberti and Mayer 1974; Orlove and Custred 1980:41; Mayer 1974:46-47; Fonseca 1974; Guillet 1980). It involves a formal request for short-term labor or services, and may occur between equals or, more commonly, unequals. Usually, the request is sent to numerous people for assistance in the completion of a large project such as housebuilding, or the preparing, planting and harvesting large fields, or help in sponsoring a community festive event. "Payment" for the labor or services is in goods such as elaborate meals throughout the day (especially in the case of festive minka), part of the harvest, coca, alcohol, music and/or "rights" (often in cash today) provided by the sponsor or host. If equals, participants can ask the host to participate in their own minka at a later date. As B. Isbell (1978:168) notes, minka is not always economically efficient, since it can be quite expensive for the host, more than hiring the same number of persons on a cash basis.

6.2.2 The Supra-Household

The supra-household "refers to the collective sphere of resource management with specific behavioral norms, management principles, and time orientation" (Brush and Guillet 1985:20, 26). In the prehispanic period, and also in many traditional communities today, communal land is managed by the supra-household ayllu, parcialidad, or comunidad. This level of social organization is responsible for the equal distribution of communally controlled land and the maintenance of sectorial crop fallow systems on these lands (ibid., Orlove and Godoy 1986). Prehistorically, all ayllu land was communal and thus, this level of social organization was even more important. Today, supra-household labor commonly involves large scale community projects such as maintenance of irrigation system, terrace construction, and road building, (Brush and Guillet 1985:26).

6.2.2.1 The Ayllu

The ayllu is generally considered the most important element of Andean social organization and production (Bourricaud 1967:86-92; Harman 1986; B. Isbell 1978:105, 249; LaBarre 1948:141-154; Mishkin 1963:441-442; Silverblatt 1987:217-222; Tschopik 1963:539-542; Zuidema 1964, 1977a:256-261). It has also been one of the most elusive concepts to define because it is used in many different contexts. The ayllu generally is considered to be kin related (at least several extended families), with members claiming descent from a common (possibly mythical) ancestor,

tends to be endogamous, and sometimes has its own leader(s) (kuraka (Quechua) or hilicata (Aymara)). As a localized territorial unit, the ayllu has distinct boundaries which are often defended, Ayllus can be of different scale and at times are hierarchical. It may also serve both a political and geneological role (B. Isbell 1978:105; Zuidema 1977). Because of historical (pre-Inca vs. post-Inca, pre-Spanish vs. post-conquest) and possibly ethnic factors, there are many exceptions to the above definition (Silverblatt 1987:217-225; B. Isbell 1978:105; Zuidema 1964:26-27, 1977; Harman 1986).

An important agricultural function of the traditional ayllu was the control and organization of communal land, periodic redistribution of land among its members, and the maintenance of systematic crop rotation cycles on blocks of land (called secciones, suertes, suyus, and/or anogas). Each married couple received a topo of land, enough to support themselves, with portions of additional topos assigned for dependent children.

The Inca state, and presumably Tiwanaku and Pukara States, utilized the traditional structure of the ayllu for administrative purposes. Today, the ayllu is commonly the comunidad (community) if rural, or a subgroup (sector) of the community if urban or densely populated (Mishkin 1963:441; Tschopik 1963:539; Orlove and Custred 1980:44-45). Many lands which were previously managed communally, are now privately owned, although sectorial crop rotational cycles established by the ayllu are still maintained in some communities (Orlove and

Godoy 1986).

Minka, discussed above is also used at the level of the supra-community for public works. Another form of minka is the faena or collective work group (B. Isbell 1978; Mayer 1974:55-56; Candler and Erickson 1987; Erickson and Candler 1988). In Huatta, this is obligatory labor commonly mobilized for large public projects such as road building, school construction, maintenance of the town plaza or church, communal field preparation, planting and harvest, and canal digging and maintenance. As in minka, if there is a sponsor of the event, he must "pay" the participants in goods, primarily food for the day. In some cases, the participants must bring their own meals. Failure to show up or send a replacement usually results in a fine or expulsion from the group.

In Huatta today, many communal projects organized by faena and minka are divided up into tareas ("tasks") whereby each community member participant or family must complete an equal portion of the work at their own pace. This appears to have been an old Andean pattern (discussed below).

6.2.2.2 Local Agriculture under the Inca State

Tribute obligations during the Inca Period were in the form of labor, not goods (Cobo [1653] 1979:208-238; Wachtel 1977; Murra 1980). The land of each community was divided into portions for the Inca, the State religion, and the community. An adapted form of minka was used by the Inca and local kurakas

to farm the lands of the State (Inca and local lords) and Inca State religion. These were considered festive occasions where food and drink were provided in return of the required/obligatory labor. This system is certainly pre-Incaic and was practiced by local level kurakas, ayllu headmen, or ethnic lords for their own revenue and also to support of the local huacas before and during the Inca Period.

Of special interest to raised field agriculture, Cobo refers to a tarea system practiced on the lands controlled by Inca religion and local huacas.

These Indians divided the work they had to do by lines, and each task or section of work was called a suyu, and, after the division, each man put into his section his children and wives and all the people of his house to help him. In this way, the man who had the most workers finished his part, or suyu, first, and among them he was considered a rich man; and the poor man was he who had no one to help him finish his work, so he spent a longer time working ([1653] 1979:212)

Polo also refers to the tarea system:

when a job is to be done, they never begin without figuring out and measuring what each share would be...each family's part is known as a suyu...Once this is completed, they set out (Polo in Murra 1980:91).

This form of labor organization was also found in our experiments in Huatta, and appears to be the the most efficient mode for raised field construction, as well as for terrace construction (see Chapter 4).

6.2.2.3 Mit'a

A higher level of labor organization is that which was practiced by local ayllu heads, regional kurakas, and the Inca

State, also later adopted in a distorted form by colonial government, called "mit'a" (Rowe 1963:265-267; Murra 1980; Wachtel 1977). Mit'a is obligatory labor or services determined by rotating "turns" for certain projects where large and/or steady labor mobilization was necessary, such as military service, personal service for nobles, government mines and public works. Mit'a labor was always asymmetrical in nature, with labor and services repaid with food and alcohol during the the work, often with the redistribution of exotic or symbolic goods from other environmental zones (e.g. coca, aji, cotton, and salt) and indirectly with the enforcement of regional peace, economic security, and state sponsored religious functions. It has been demonstrated that mit'a labor was involved in agricultural projects for the pre-Inca Moche State (Hastings and Moseley 1975) and the Chimu State (Kus 1980).

During the period of the Incaic conquest of most of the Andes, intensive agricultural projects were undertaken by the state with mit'a labor. State-built terrace complexes and associated irrigation systems are found in many parts of the Andes, along with roads, bridges, administrative centers, and storehouse complexes. Where efficient intensive agricultural works operated under local organization, the Inca found it more productive not to meddle with them. Despite Incaic political social, and economic control implemented through an elaborate bureaucractic structure, the day-to-day operation of irrigation systems was the responsibility of the local ayllus (Guillet 1987;

Sherbondy 1982:18-22). Even at the local ayllu level, rigid centralization is rarely found. Mitchell (1976, 1977, 1980) has demonstrated that in the community of Quinoa, a complex and extensive irrigation system is operated on very low levels of social organization, with higher-level community officials only participating at certain times of the year. The Quinoa system, according to Mitchell, even lacks sanctions for individual farmers who steal water. A similar case of coordination at the cooperative group level is presented for Huanquite (Seligmann and Bunker 1986) and San Pedro de Casta (Gelles 1986). In contrast to most cases of Andean irrigation systems, that practiced in San Pedro de Casta does document a high degree of centralization (with norms and specialists for water distribution and maintenance of the system), probably because agriculture there is based exclusively on irrigation (Gelles 1986:128-129). It may also be related to the interference of the Peruvian government in the system since 1969.

Netherly's (1984) ethnohistoric investigation of late prehispanic irrigation on the North Coast of Peru also demonstrates that, despite the existence of large-scale irrigation systems, the construction, water distribution, maintenance, and associated ritual tend to be decentralized and related to small localized corporate or ethnic groups. The only State-run irrigation systems were in the larger intervalley canals.

In addition to irrigation systems, the expansion of

agricultural frontier through terracing appears to have been a Inca agricultural policy (Donkin 1979:33, 133). There is considerable evidence that the Inca State designed, constructed, and managed certain blocks of terrace systems in the Colca Valley (Denevan 1986 pers. com., Treacy 1987 pers. com), in addition to the well documented massive landscape alteration for agriculture of the Urubamba Valley (Farrington 1983).

Because of the apparent complex engineering behind much of the prehistoric terracing, combined with irrigation in the southern Andes, there has been a tendency in the literature to give the Inca State credit for much of the slope management projects. Terracing has been of major importance for thousands of years in this area, most of which was apparently the result many generation of farmers and low level social organization, undertaken outside of state influence. As Donkin notes:

The agricultural terraces of the aboriginal New World represent an enormous investment of time, energy, skill, and imagination. Individually, however, they are mostly small and irregular in plan and distribution. They were undoubtedly constructed piecemeal by single families or small groups of families, and, unlike irrigation, their maintenance involved cooperation at a level no higher than that of the village community. The one important exception is the terracing organized by the Incas as part of a systematic and nationwide policy of land improvement and colonization (1979:33).

There is little indication of planned development of entire slopes, but rather a gradual extension by families and small communities (ibid. 120).

Thus, I argue that most terrace systems were developed over long periods of time by local level social organization. These are non-centralized, non-despotic organizations which correspond to

Wittfogel's concept of hydroagriculture, in contrast to hydraulic agriculture constructed by corvee labor directed by a highly centralized, despotic state bureaucracy. Critical to the evaluation of these arguments is the need to more accurately date the construction period of terrace and irrigation systems and define the social groups responsible for their construction and maintenance. Unfortunately, few prehistoric terrace and irrigation systems have been investigated in as much depth as the raised fields of Lake Titicaca.

6.3 SOCIAL ORGANIZATION OF RAISED FIELD AGRICULTURE IN THE LAKE TITICACA BASIN

Of major importance to this dissertation is the ascertainment of the level of labor organization necessary for the construction and maintenance of the raised field systems in the Lake Titicaca Basin. As discussed above, raised fields are a form of intensive agriculture and so have been assumed to be associated with complex social organization. This belief is based on the notion that because the Lake Titicaca Basin was the center for a number of important civilizations or complex states (Pukara, Tiwanaku, and the Aymara Kingdoms) and an important resource zone for the later Inca, these polities must have been responsible for the intensive agricultural systems of the Basin. I argue that the construction, use and maintenance of prehistoric

raised field agricultural systems in the Lake Titicaca Basin were organized at the local levels, primarily the family and ayllu. I will demonstrate that there is no need to invoke larger levels of centralized organization to explain the phenomena of raised field agriculture.

6.3.1 Previous Research

Smith et al. (1968) first proposed that the raised fields of the Lake Titicaca Basin, although an intensive form of agriculture, did not appear to have been centrally organized or centrally planned. They based their interpretation on the irregularity of the patterns of field blocks. Regarding the "open checkerboard" form, they state:

It may be hazarded that the construction of each block of strips may have been done by individual farmers cooperating to reclaim new pieces of land in marshy areas to supplement land on the slopes or better drained terrain elsewhere. The irregularity of the dimensions of the ridges and of the number of strips suggests that reclamation could not have been highly organized or stringently planned. Similarly, the absence of well-defined major canals suggest that there was greater concern to build up ridges or patches of cultivated land rather than to effect any kind of integrated drainage or irrigation system (ibid. 357).

and in discussing the "irregular embanked pattern"

The existence of embankments around groups of ridges does suggest some attempt at water control. However, the absence of irrigation ditches or drainage canals in the Juliaca plain is surprising if embanking represented an attempt at coordinated water control. It may therefore be that embanking was sometimes a simple means of resisting occasional or seasonal inundation, and an effort made by the individual farmer against personal disaster, for there is no trace of long, continuous earthworks to provide protection for a large area, and bundles of unbanked ridges often lie adjacent to embanked ridges (ibid. 357-359).

They clearly suggest that small groups or individuals were responsible for the "loose" organization of the raised fields.

Lennon (1982) disagrees with Smith et al. in regard to the level of hydraulic organization, but provides little discussion of the social organization presumably responsible for this agricultural system. He argues that the raised fields show impressive order and understanding of hydraulic concepts, and documents his case with statistical analysis of aerial photographic data, but does not conclude that the fields were built and maintained under centralized control. Lennon suggests that the embankments around raised field blocks may demarcate individual landholdings (ibid 189); and that while the raised fields at the lake edge show the most coordinated effort of water control, indicating to him some form of core organization behind the planning, it is also possible that they could have been created through individual action (ibid. 227).

Kolata, in a number of recent articles (1982, 1986, 1987), addresses the issue of social organization of labor and level of control of the raised fields in Koani Pampa, Bolivia. Kolata interprets the mounds within the pampa to be intentionally built with construction fill, not the result of gradual accumulation of midden and house leveling as we argue for Huatta occupation sites. He argues that mounds PK-5 and PK-6 have the form of truncated pyramids, and possibly sunken courtyards, indicating that they are of "paramount ritual and administrative importance, subordinant only to the two regional centers of Luqurmata and

Pajchiri" (1986:755) and "housed corps of administrators and their household retainers charged with organizing the seasonal cycle of agricultural activities and accounting for the staggering quantity of produced that flowed from the state fields of Pampa Koani" (ibid. 757-8). He also suggests (ibid 756-7) that differences in cultural debris from the mounds indicates a clear class division between the low level occupants of the small house mounds and the high-status occupants of the "pyramid" mounds. He argues that the four-level hierarchy in site size, from the large regional centers such as Lukurmata and Pajchiri to the small house mounds within the raised field complexes, represents a state-level settlement pattern, and thus, state controlled social organization of agricultural production. He states:

Tiwanaku was a dynamic, expansive state based squarely on an efficient-producing system of intensive agriculture, raised fields, a prime economic strategy of the Tiwanaku State, and that this strategy was devised and managed by a hierarchically organized, central government (1986:748).

and

that the excavations provide ... substantial evidence, both direct and inferential, that the construction, maintenance, and production of these fields were managed by a centralized political authority that systematically coopted land and labor for the benefit of non-local populations (ibid. 760).

He cites the following as proof of this state control of the agricultural system: 1) the highly organized labor force needed to construct and maintain raised fields, 2) the differences in status of the mound occupants, and 3) the hierarchically-

arranged, four-level settlement pattern (ibid. 760). In addition, he points out that the fields appear to have been abandoned after the collapse of Tiwanaku state, and concludes that the fields must have been directed by a Tiwanaku bureaucracy (ibid. 753) and Tiwanaku "agrarian engineers" (1987:39, 41).

6.3.2 Discussion

Lennon has demonstrated that the raised field water control system is complex and internally organized. Kolata implies that this system must have been planned, implemented and controlled by a high level of social organization, at least in the case of the Koani raised field systems. For the northern Lake Titicaca Basin raised fields, we have shown in the experimental raised field investigations that small groups or individuals would have been capable of doing this work, given a sufficiently long period of time (Chapter 4). The vast agricultural knowledge of individual Andean farmers is well documented in the literature (Morlon et al. 1982; Brush 1977; de la Torre and Burga 1986; Gade 1975), and raised field technology would not have been beyond the capabilities of small groups.

Kolata's argument for state control of the raised fields based on the archaeological evidence from Koani Pampa is convincing for the Middle Horizon, but the origins of the raised field systems can be found much earlier in the Early Horizon. The indirect dating of raised fields through association with the occupation mounds is not necessarily reliable; as I have argued

for Huatta, this association does not necessarily mean contemporaneity. Nor does the structural merging of mounds with field systems (1986:750-751, 755) accurately date the fields when the mounds are multicomponent, as Kolata states they are. Further, the mound merged with raised fields was apparently only surface collected, which poses more problems for dating the mound occupations (see Chapter 3). During the excavation, Kolata (1986:753) notes that the fill of the excavated mounds was considerably mixed or highly disturbed; Tiwanaku IV and V were found in the same context and Chiripa material was found superimposed over Tiwanaku IV material indicating that precise dating of raised fields cannot be obtained through association with occupation mounds. New unpublished reports on excavations at Lukurmata document in situ associations of Tiwanaku IV and V ceramics with raised fields (Kolata and Graffam 1987).

Apart from problems of dating the fields, the scheme used to classify occupation mounds into a hierarchy possibly exaggerates the significance many of the mounds. The "massiveness" of the larger mounds does not seem as impressive when the dimensions are considered. I would not consider the mounds presented in Table I to be of "enormous proportions" (1982:23) requiring "large scale corporate construction" when compared to occupation mounds in the Huatta pampa. The largest, 120 x 75 x 3.75 meters, could easily be a very small hamlet of several ordinary house compounds or a single family house compound as are found in the Huatta and Koani pampas today. A mound of these proportions would be considered

of small to medium size in the Huatta area. Small groups of farmers occupying these sites over several hundred years could have easily accumulated the bulk of the fill through the construction and leveling of various house structures. It is difficult to compare the small mounds to the larger mounds without excavating adequate samples of each class.

In another part of his argument, Kolata provides evidence that the raised fields of Koani were active during the Middle Horizon while Tiwanaku Culture was at its peak, but this does not necessarily imply that the Tiwanaku state controlled and directed their construction and operation. The presence of Chiripa ceramics dating to the Early Horizon or Early Intermediate Period within the mound fill indicates that the origins of the raised field system at Koani Pampa may be much older than the Middle Horizon. Midden and fill material recovered from cultural levels of the mounds below the present-day surface of the pampa at Koani (Kolata 1986:755) indicate the likelihood that there is a series of superimposed raised fields, similar to the sequences found in Huatta and Illpa. Superimposed raised fields have recently been documented for the site of Lukurmata (Kolata and Graffam 1987).

One feature of the Koani Pampa raised field system that may have been organized at a higher level was the re-routing and channelization of the Rio Koani to the northeast edge of the pampa (Kolata 1982, 1986). Whether this was truly functional to improve raised field hydrology or merely "cosmetic" as in the

case of Inca channelization projects in the Rio Urubamba in the Sacred Valley (Farrington 1983) is not clear. Tampering with river channel hydraulics by artificially constructing levees to prevent flooding can actually be detrimental to raised field agriculture as in the case of the Rio Illpa and the adjacent raised fields (see Erickson and Candler 1988). And, of course, it does not necessarily imply that the state controlled the agricultural fields.

6.3.3 Huatta: Archaeological Evidence of Social Organization

6.3.3.1 Raised Field Morphology

The raised fields themselves can be examined for evidence of social organization in planning, construction, labor and maintenance as Smith et al. (1968, 1981) and Lennon (1982; 1983) have suggested. I agree with the analysis of Smith et al. that the raised field patterns suggest the work of individuals or small local groups rather than state-level organization. Smith et al.'s typology of raised field forms and the distribution of these forms throughout the Huatta area indicate a piece-meal or incremental construction, almost haphazard at times. Blocks of fields are not uniform in size or form, but instead, highly variable, as Lennon documents. The average area of the blocks is sufficient to support an average family unit for a year (see Chapter 4). This is also be the area that a small communal group

could easily construct in one season (see Chapter 4). This is not to deny that the raised fields of the Huatta and Illpa pampas are an effectively organized hydraulic system; their hydrology is indeed complex, but would not have been beyond the engineering capacities of small groups of cooperating farmers. And because the raised fields were not constructed all at once but over a period of many generations of farmers (see Chapters 3 and 4), they were continually modified, with canals dug deeper, platforms enlarged, secondary canals added, or filled in, etc.. This continual modification would have gradually increased the efficiency of the system over time, as hundreds of generations of farmers accumulated knowledge about lake level fluctuations, water tables, river flooding, and soils.

One uniform characteristic of the Lake Titicaca Basin raised field systems is the orientation of field and canal axes to the cardinal directions. I have argued that this is to maximize the solar energy capture and for micro-climate modification (Erickson 1986, 1988), but it could also be that this reflects cosmological or other ideological principles. However, the use of cardinal directions in the orientation of raised field patterns does not imply state organization of the fields. The use of sacred or "official" state orientations has been argued for the Maya raised fields (Siemans 1977, 1983), the Teotihuacan chinampa system (Coe 1964; Armillas 1971), and for Chimu state irrigation systems (Kus 1980). This does not appear to be the case for the Lake Titicaca raised fields.

Why are the blocks of the raised fields of the Lake Titicaca Basin, especially those with the open checkerboard pattern, oriented at right angles to each other? It would have been much simpler to have oriented all the fields in the same direction, as long continuous linear fields such as the "linear pattern" (discussed in Chapter 1). I believe that the checkerboard pattern was created to clearly define the boundaries between raised field blocks without embankments or special moats. Even the linear pattern is not continuous, but the long fields are broken periodically by gaps to form blocks of parallel fields. This suggests that there was some form of individual or small group "ownership" of the raised field blocks. (Other functional reasons for alternating orientations would be to disperse and circulate water among fields, slow the flow of water, and maximize microclimate modification). In the New Guinea highlands, individual blocks of raised fields are set apart from others by encircling drainage ditches (and presumably a dike constructed from the soil of the ditches) in the Kuk case (Gorecki 1982), and differences in block orientation in the case of the Dani (photographs in Heider 1970; Gardner and Heider 1968). Also, individual blocks make up the area that could easily be constructed by a typical work group in a single season.

Uniformity and order in the pattern of raised fields are not necessarily the best criteria to use for determining the level of social organization, as shown by the cases from New Guinea presented above. New Guinea field patterns, especially the

square "gridiron" fields used for sweet potatoes, are remarkably uniform over wide areas, and between valley systems and widely dispersed ethnic groups. In the Mount Hagen area, long vines and stakes are used to lay out grid systems for raised fields (Williams 1937:95). The rigid order of the sweet potato gridiron fields distributed over huge expanses of valley bottom land visible in aerial photographs (Gorecki 1982; Brass 1941; Heider 1970) could be easily misinterpreted as having been planned and operated by some centralized state-level organization, when in reality, these systems are associated with the family and household level.

6.3.3.2 Major Canal Systems and Social Organization: Ceques

Some aspects of the major canal systems discussed in Chapter 1 do not appear to be directly related to drainage functions. One of the most striking characteristics of a completely artificial canal is that it is almost perfectly straight for very long distances. One extremely well-preserved canal begins in Huanina (at the south end of the hill of Huatta) and extends approximately 5 kilometers across the pampa before finally disappearing into the lake (Figure 54). As with other examples of this type of canal system, other canals similarly radiate from the end-point on Huanina. Surprisingly, the courses of these long straight canals cross old river meander channels and seasonal streams. Their extension beyond the natural water courses (even abandoned channels carry substantial amounts of

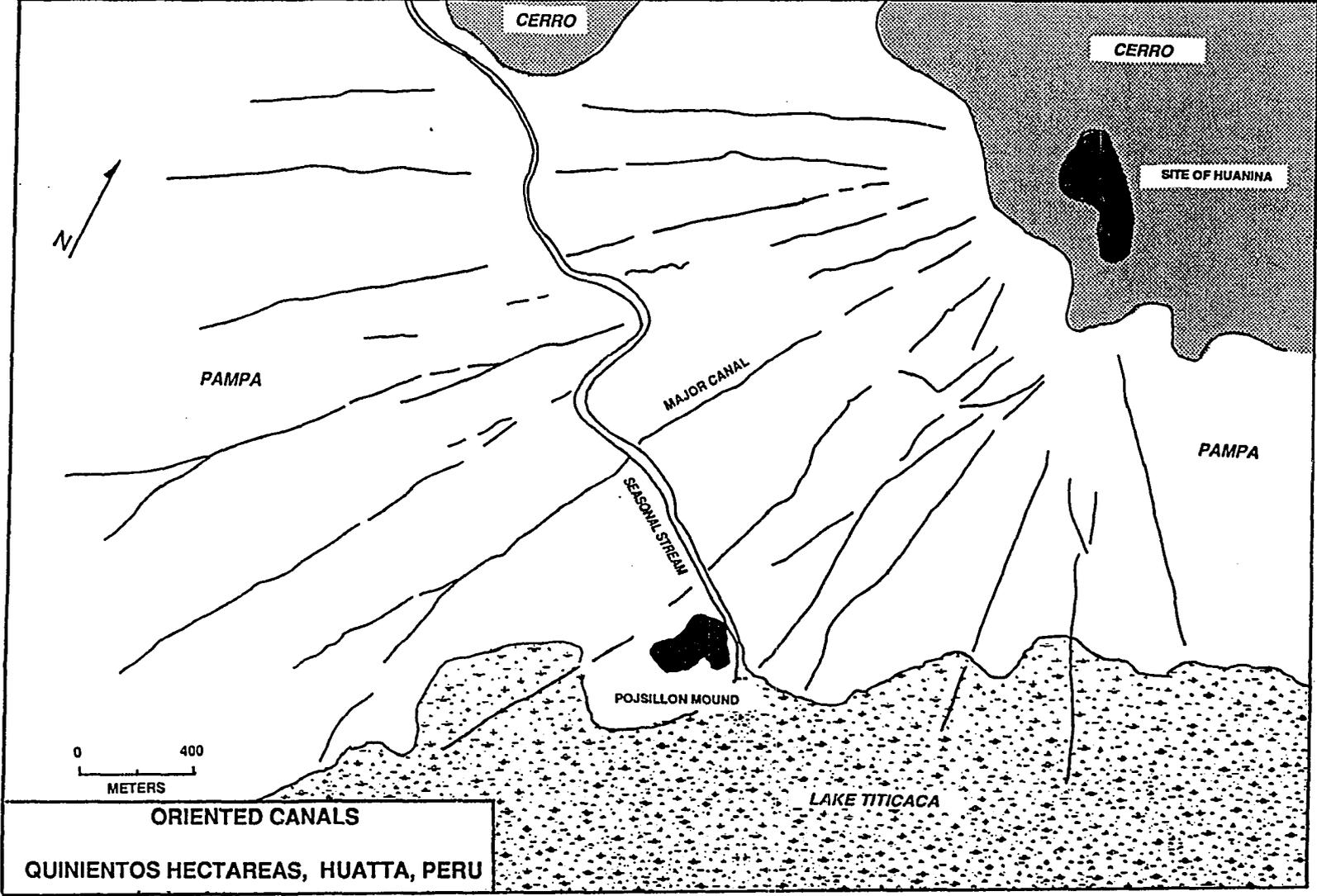


Figure 54: The ceque canal system of Quinientos Hectareas, Huatta.

water in the rainy season) suggest a purpose other than hydrological. In addition, their precise straightness over such long distances is elaborated beyond that necessary for practical efficiency. Neither lengths nor the orientations of these canals can be considered to have an efficient hydraulic function.

I believe that these straight large canals marked the boundaries between social groupings of farmers, similar to the ceque lines of Inca Cuzco (Zuidema 1964, 1977b), through on a much smaller scale or the urco (also referred to as suyus, chuta, or chapa systems described for various ethnographic and ethnohistorical cases in southern Peru and Bolivia (Wachtel 1982; Urton 1984; Zuidema 1988). These cultural patterns of the social division of agricultural land and public space suggest certain aspects of the social organization of raised field agriculture.

Zuidema (1964; 1977b) demonstrates that ceque lines, in this case 41 imaginary sight lines to 328 huacas (sacred places), were used to divide the Inca capital of Cuzco and the surrounding Inca territory into hierarchical organizational units for social, ritual, economic and political-administrative purposes. The ceque system also served as a basis for the Inca calendar, in which the sight lines were used for determining lunar and solar astronomical events.

It has also been argued that the Nazca lines and ground drawings are related to a form of ceque system (W. Isbell 1978; Aveni 1985). Here, straight narrow sight lines created by removing the weathered upper surface project outward from

"radiating centers," slightly higher ground on the Pampa Colorado or from low hills on the edges of the pampa.

In the Lake Titicaca Basin, the canal-ceque systems are a visible, permanent part of the physical landscape. The system of Huanina (described in Chapter 2) with eleven radiating major canals, is the most elaborate example in the northern Lake Titicaca Basin. The central point of the system is located near the center of the largest and most densely-inhabited prehistoric occupation site, Pancha, located on the cerro of Huatta. The dense midden and remains of structures cover over several hectares of occupation terraces on the slopes of Huanina. The site is multicomponent, but the majority of the surface artifacts suggests an important Pukara and Pre-Pukara occupation.

I argue that the radiating ceque lines of canals within the raised field systems possibly were used to divide up blocks of raised fields of social groups responsible for their construction, use and maintenance. These may be ayllu or sub-ayllu organizations, each carefully spatially delineated from other social and political groups. The rectilinear raised field blocks (bordered by encircling canals or changes of cardinal direction of the fields making up the block) within these delimiting boundaries formed by the radiating canals may be analogous to the urco, chuta, or chapa systems mentioned above. In the ethnographic and ethnohistorical cases presented for Pacariqtambo, San Sebastian, and the Cochabamba Valley, these divisions are long parallel blocks or narrow strips of

agricultural land or public space (church yards, plazas, roads, etc.) associated with ayllus groups that communally farm them or communally construct and/or maintain them. Both Zuidema (1988) and Urton (1984) indicate that these are an relatively informal, dynamic, subgrouping within the formalized, static, ceque, saya, and Suyu systems. The clearest example of this concept as applied to raised fields is found in the "ladder" form reported for the Pomata pampa (Smith et al. 1968). In addition, aerial photographs demonstrate that the long linear raised fields found near rivers or meander scars tend to be oriented perpendicular to the watercourse. Linear raised fields near hillslopes also tend to be oriented perpendicular to hill-pampa interface. This is found for the land divisions in the Cochabamba and San Sebastian case.

The conceptual pattern of spatial divisions combining both radiating lines from central places and rectilinear blocks within these lines apparently was successfully used in both Inca Cuzco and in pre-Inca agricultural landscape organization. An analysis of the unity of this conceptual model has been presented by Zuidema (1973).

6.3.3.3 Major Canals and Social Organization:

Sectorial Fallow Systems

I also argue that these lines also delineate a prehistoric sectorial fallow system, commonly practiced today in the Lake

Titicaca Basin, as well as other parts of Peru. They are variously referred to as laymi, suyu, turno, manta, and avnoqa (Guillet 1980:144, Orlove and Godoy 1986) and these are well-organized coordinated systems of crop rotation on the cultivated land within the control of a community, parcialidad or avllu. The system maintains permits sustained long term cropping on relatively poor agricultural land by cycles of rotating crops and fallow through the various sectors of the system. The agricultural landscape is commonly divided into pie-shaped wedges, radiating from a central point in the community.

With canals as lines of demarcation for sectorial fallow, the cycles of fallow and crops on raised fields would easily be controlled and maintained. Although the raised fields have better soil fertility than most altiplano fields cultivated under sectorial fallow, frequent systematic rotation of a variety of crops would have been an efficient means of conserving natural soil fertility, and would deter the establishment of crop pests and undesirable weeds in the fields. As discussed in Chapter 4, this problem imposes certain limits on the variability of raised field agriculture in the zone. In the large experimental raised field plot at Illpa, the fields were divided into 6 major areas using canals which separated major blocks of raised fields. Each of these was planted in different crops, to be annually rotated. These divisions aided in the organization of crop rotation.

The only other similar radiating canals systems reported for the altiplano are those from the system of gochas near Pucara

(Flores and Paz 1983; Rosas 1986). Here, the qocha depressions are connected by straight shallow canals. On the aerial photographs, the radiating network of qocha canal systems (ONERN-CORPUNO 1965) bear a striking similarity to the major canal systems in the Huatta pampa.

6.3.3.4 Archeological Site Survey and Social Organization:

A broad hierarchy of sites can be constructed based on size for the Huatta pampa (see Erickson 1988). The distribution of sites throughout the pampa is very regular and dense, especially near the lakeshores and river mouths.

The majority of the sites are small, less than 100 meters in diameter; always found on elevated area, they are generally less than 1 meter tall above the surrounding pampa. They would have been small dispersed farmsteads and seasonally inhabited temporary camps for caretakers of the fields. Site of medium size are 100-200 meters diameter. These would have been small agglutinated settlements of several farmsteads, with probably no more than 10-20 structures at any one time. Large agglutinated settlements, sites 200-400 meters in diameter such as Coata, Pancha, Almosanchis, Poqsin Karata, and Yasin could have had 20-50 structures at any one time and are villages. Most of these medium and large sites are today the foci of population on the pampa.

There is no evidence for specialized site functions, with the exception of Pancha and Isla Karata. All sites appear to be

occupation sites for the farmers who constructed and maintained the raised field system. Some sites have late period burials (Late Horizon and Late Intermediate Period) near the surface, possibly interred after the site was abandoned for occupation. The burials are in small circular limestone cist tombs similar to those on the hill crests of Huatta.

Pancha is unique among the sites on the pampa. It is the largest site in the Huatta pampa and has a kalasasaya structure (50 meters each side, predating Pukara culture) constructed of large limestone blocks quarried from the surrounding hill of Huatta or Illpa. The ceramics associated with this structure are similar to those excavated from the occupation site at Kaminaga as well as the ceramics recovered from the surface at other sites. Pancha was probably the major occupation center of the raised field agriculturalists, since it lies in the center of the largest block of raised fields in the Lake Titicaca Basin. The thousands of hoe flakes, hoe fragments, and utilitarian wares are evidence that farmers occupied the site. The stone-lined kalasasaya may have been a ceremonial structure (huaca), or it may have been part of a local kurakas residence. Apart from this one, relatively late, structure, there is no evidence of administrative or bureaucratic functioning at the site. There is good evidence the site was heavily occupied for several hundred years before the construction of the stone structure and the bulk of the mound fill and midden is earlier. The structure apparently is not in use during the Pukara occupation, since a

deep midden of garbage from this period covers the wall.

I believe that the data indicates that the site Pancha was similar to other occupation mounds associated with early raised field use, but because of its central location in the pampa, became a local center (possibly ceremonial) by the Early Intermediate Period. This occurred long after the raised fields had already been constructed.

The surface debris from the site at Isla Karata is similar to that of the small to medium occupation sites with the exceptional addition of several eroded Formative period (Early Horizon-Early Intermediate Period) monoliths on the surface with considerable Inca material. This indicates a possible special purpose ceremonial or ritual function of the site after considerable use as a fishing and agricultural community. The monoliths may have been brought here from elsewhere and reutilized during later periods, possibly during the Early Horizon.

Isolated limestone blocks were found erected vertically on some other sites (Pojsillon, Yasin, and Uchuymoro). Because these sites are in or near the lake, transportation of large stone blocks by balsa during periods of high water would not have been particularly difficult (c.f. Chavez 1975).

The sites on the hill of Huatta appear to be ordinary occupation sites associated with the raised field farmers. The quantity of Pukara and pre-Pukara refuse at Viscachani and Huanina point to the importance of these sites as habitation

centers. The occupational terraces of these sites yielded cultural material similar to that from the occupation mounds in the pampa.

The only site that was clearly an administrative center is the Inca occupation in the present town of Huatta. The spatial organization of the older structures in the town, visible in aerial photographs, conforms to canons for an Inca administrative center (Julien 1979:205-211, Gasparini and Margolies 1980). This may have been the site of "Huaca" (Julien pers. com. 1983) and may have functioned as a subordinate administrative center to Incaic Hatuncolla.

6.3.3.5 Discussion

The spatial distribution of prehistoric settlements throughout the pampa and cerro is very similar to that of the present settlement patterns of Quechua farmers. The major difference is that both zones were much more densely occupied in the past, and there was more of an emphasis on settlements on the lakeshore and in the lake during the prehistoric period. I believe that modern settlement patterns mirror that of the past. The social organization of the prehistoric farmers occupying the habitation mounds and hillslopes probably was very similar to that of today's occupants. The small mounds in the the lake and pampa zones of Huatta are occupied by nuclear and extended families, often closely related to households living on nearby mounds. In addition to blood and marriage ties, compadrazco,

cross-cuts and reinforces the relationships. Members of both formal (parcialidad and minka/faena) and informal (ayni) cooperative work groups tend to reside in localized clusters. These multifamily clusters are commonly referred to as sectores, which can be spread over the pampa on various mounds or nucleated on the larger mounds, especially those near the lake. As is the case today, families probably owned several houses in different zones, which they temporarily occupied according to the annual schedule of economic activities.

In summary, there is no clear evidence in the Huatta pampa for a complex socio-political hierarchy of sites that Kolata has attempted to document in the Koani pampa. Nor is there clear evidence of state or high-level bureaucratic control of the raised fields in the Huatta pampa. Rather, the evidence supports the hypothesis that the raised fields were constructed and cultivated by families, multiple families, and communal or ayllu groups. This is not to say that raised field surplus production, which must have been considerable, was never used to support state and ceremonial hierarchies, such as those associated with Pukara and Tiwanaku. Complex social organization in the Lake Titicaca Basin extends back into the Formative Period, as evidenced by remains from Chiripa, Tiwanaku, and Pukara. These polities reached the level of state/civilization by the later part of the Early Intermediate Period and were further elaborated in the Middle Horizon and the Late Intermediate Period. The surplus or "social production" (Brookfield 1972) generated by

raised fields would have been an important stimulus for the evolution of the polities that became Pukara, Tiwanaku, and the Late Intermediate Period "Aymara Kingdoms," but this does not necessarily mean that the means of production were directly controlled by the state. We know that in the case of the Inca, local-level, kin-based (ayllu) organizations were responsible for the construction and maintenance of [state] irrigation systems (Sherbondy 1982). What is commonly confused in discussions of social organization and raised field agriculture is the social organization necessary for the construction and operation of a raised field system and the social organization present while a raised field system was functioning. In the Lake Titicaca Basin, the raised fields were associated with relatively small cooperative groups, while the dominant political organization in the basin was at the level of a state. It is unlikely that this highly productive system which functioned efficiently under local management would have been tampered with by the state.

The experimental raised fields in Huatta and Coata have demonstrated that raised field construction and maintenance is well within the means of low level, local organizations (Chapter 4). Labor organized at the individual family level is sufficient for most small scale raised field agriculture and is certainly the origin of this form of agriculture. We found that the optimal level of organization for efficient construction work and maintenance of larger blocks of fields was that of multifamily groups or communal groups. Because archaeological and

experimental data indicate that the raised fields were constructed in portions or incrementally over a very long period of time, there is no need to assume that the state had to organize what seems, in total, a massive engineering project. Finally, the experimental labor and production figures demonstrate that raised field agriculture is a very efficient productive technology which would have been adopted by individual farmers and small groups without coercion from a bureaucracy.

6.3.4 Conclusions

The first raised fields were probably scattered blocks built by innovators. An experimental success, they would have been expanded in following years, and the technique adopted by other local families and groups. Each new field would serve as the core in a continually expanding network of cultivation on the pampa. As the pampa was covered by the raised fields, the boundaries of fields belonging to different social units become clearer through contrasts in morphology.

For the construction and maintenance of raised fields, traditional andean forms of labor and organization would have been sufficient. Minka and ayni were probably the relationships commonly used for raised field construction. Later, when the area was dominated by other polities, local level kurakas may also have used mit'a labor for their personal fields, and supervised the payment of labor tribute.

This scenario contrasts sharply with the widely-accepted view of Maya raised field agriculture, often based on models inspired by Wittfogel and Boserup, but more closely follows the ethnographic patterns of experimental raised fields in Huatta, terrace and irrigation systems in other parts of the Andes, and raised field use in New Guinea. It also conforms with the archaeological evidence of the system's evolution, and ethnohistoric examples of pre-hispanic political control.

Butzer (1977:109-111) has documented a similar case for ancient Egypt. Local level organizations, centered around the nomes or smaller groupings, were responsible for constructing and maintaining the complex irrigation systems which provided the bulk of subsistence and surplus for the Egyptian state. These systems were so resilient, and independent, that they continued for thousands of years, despite the rise and fall of state level kingdoms. As discussed below for the raised fields of Huatta, the rise and fall of the regional states did apparently have an effect on the local level production.

CHAPTER 7

A CULTURE HISTORY OF THE LAKE TITICACA BASIN

7.1 THE INITIAL PERIOD (1800-1200 B.C.) AND EARLY HORIZON (1200 -200 B.C.)

The oldest known ceramic-using cultures in the Lake Titicaca Basin are Qaluyu at ca. 1400 B.C. (Mohr-Chavez 1982-1983) and Chiripa at ca. 1350 B.C. (Browman 1980), both dating to the later part of the Initial Period. The three other poorly-defined Early Horizon Cultures of the Lake Titicaca region are Tiwanaku, Cusipata, and Wankarani.

7.1.1 Qaluyu

Qaluyu Culture is named after the type site of Qaluyu, which lies 110 km north of Lake Titicaca and a few kilometers north of Pukara (Mohr-Chavez 1982-1983:320). It appears to have been an agglutinated village by at least 1000 B.C.; the settlement on the large low mound continued during the Early Intermediate Period as a minor Pukara village (Mohr-Chavez 1982-1983). The quantity of midden indicates that occupation was dense and continuous, certainly large villages (Mujica 1987:22) and perhaps urban (Rowe 1967). The site's location indicates an economy based on river floodplain potato and quinoa agriculture and camelid pastoralism, probably combined with long distance trade or other contacts with

the Marcavalle culture of the Cuzco Valley (Mohr-Chavez 1982-1983). Although not adequate as evidence of early use, the site's location within the gocha remains throughout the plains surrounding the Rio Azangaro suggests they may have been constructed at this time, although some believe these are associated with later Pukara culture (Flores and Paz 1983). No monumental architecture has been found in direct association with Qaluyu, although many of the early stoneworking styles throughout the basin are related to Qaluyu (Chavez and Mohr-Chavez 1975; Browman 1978a).

Qaluyu ceramics date to between 1400 B.C. and 500 B.C. (Mujica 1987:22; Mohr-Chavez 1982-1983 [1400-1100 B.C.]). Although poorly defined, primarily on the basis of several small surface collections and sherds eroding from roadcuts, these ceramics are characterized by vertical walled, burnished brown plainware open bowls and plates. Decoration is rare; it consists of broad geometric or curvilinear/spiral incision and brown, black and/or red painting on cream slip, usually a checkerboard design (Mohr-Chavez 1982-1983; Lumbreras and Amat 1968; Lumbreras 1974a, 1974b). There are some similarities between the ceramics from Qaluyu and those from the Cuzco area sites such as Marcavalle and Pikicallepata (Mohr-Chavez 1978, 1982-1983). Mujica (1987:28) hypothesizes that Qaluyu was introduced to the Titicaca Basin from the Marcavalle/Pikicallepata area only after the local style found at Pukara (discussed below) was well established. Mohr-Chavez

(1982-1983) believes otherwise, that Qaluyu may have influenced the Cuzco Valley because of its temporal priority over Marcavalle. The stone carving style referred to as "Yaya-Mama" relates to Qaluyu and other contemporary cultures of this time, and appears to be pan-Lake Titicaca Basin (Chavez and Mohr-Chavez 1975, also see Browman 1978a).

Qaluyu ceramics have been found at numerous sites throughout the northern basin (Mohr-Chavez 1969, 1982-1983), but these, in addition to those at the type site, have never been adequately described, making it difficult to define Qaluyu culture.

A later Fukara occupation has been defined, based on the occurrence of ceramics and stone monoliths, at the site of Qaluyu (Rowe 1967), but no clear transition between Qaluyu and Fukara has been found (see Mujica 1987 and below for discussion of transition style).

7.1.2 Chiripa

Chiripa is the earliest occupation site and ceramic style documented in the southern Lake Titicaca Basin. The site is located on the Taraco Peninsula in Lago Pequeño, the small southern extension of Lake Titicaca. The later semi-subterranean temple constructed here may be the earliest in the basin (Bennett 1936; Ponce 1970, 1980; Kidder 1963; Mohr-Chavez 1966; Browman 1978b, 1980). During the earliest occupation ("pre-mound") at the site, dating between 1350 B.C. and 850 B.C., a

deep midden was formed from material accumulated from a small nucleated settlement (Bennett 1936; Browman 1978b; 1980, 1981). An occupation mound was gradually formed as midden and adobes from house structures accumulated. A later occupation dating between 850-600 B.C. ("lower houses") consisted of a ring of semi-subterranean houses around a small central courtyard or patio. Between 600 B.C. and 200 B.C., 16 houses ("upper houses") were constructed around a sunken courtyard with walls lined with cut and rough field stones. The houses from this period have double walls, apparently for the storage of agricultural produce. The mound itself was surrounded by a 2-3 meter tall fieldstone wall, forming a kalasasaya structure. Much later (A.D. 200), a Tiwanaku III semi-subterranean temple was constructed in the midden and fill that had accumulated over the earlier ring of houses and Chiripa semi-subterranean temple, and this structure may also have been surrounded by houses (Browman 1980, 1981).

In his seriation of the ceramics, Browman (1980; 1978b; 1981) divides them into 4 major phases: Condori Phase (1300-850 B.C.), characterized by dark brown ware ollas and jars with "pebble/spatula polish," and plain or red-slipped round-based bowls; Llusco Phase (or "Early Chiripa" 850-600 B.C.) with brown wares (majority) and red wares (minority) with fiber and sand temper and black on red, black and cream on red, and cream on red painting and Mamani Phase A and Phase B (600-200 B.C.) which includes the "Classic Chiripa" fiber-tempered ceramics including flat-bottomed bowls, jars, and ollas, and bichrome (cream on red)

and polychrome (red, cream/yellow, and black) painting, with or without incision. Modeled human figures and animals are common throughout the sequence. Also characteristic of Chiripa and other Early Horizon and Early Intermediate Period styles of the basin are the incised ceramic "trumpets" (Mohr-Chavez 1966; Bennett 1936). Early evidence of copper smelting and goldsmithing is also found at the site of Chiripa (Browman 1978b, 1980, 1981; Ponce 1980:14).

Chiripa sites have been reported in other areas of the region (Browman 1978a, 1978b; Bennett 1936, 1948; Ponce 1970; Kolata 1986; Erickson 1976; Hyslop 1976; Oswaldo Rivera Sundt pers. com.), but these have not been well-documented or described in any detail. Many of these reports seem to be based on a misidentification of other Early Horizon ceramics (Qaluyu, Wankarani, etc.) as Chiripa style.

The distribution of known Chiripa sites is completely lacustrine (Ponce 1970), while Chiripa economy is fully agricultural. The remains of domesticated potatoes (and possibly other tubers), and chenopods (quinua and cañihua) have been recovered from the site, in addition to other non-agricultural economic plants (Erickson 1976, Erickson and Horn 1977). Stone hoe blades, both whole and fragmentary, were common in the excavation, in addition to ground stone grinders (Erickson 1976). Complementing the cultivation of Andean crops were camelid pastoralism, raising guinea pigs, and hunting deer, aquatic birds and other game (Kent 1982, Erickson and Horn 1977). There is a

clear indication in both the floral and faunal remains from the site that the economic orientation of Chiripa society was lacustrine or wetland-based (Erickson and Horn 1977, Erickson 1976). The discovery of Chiripa communities on islands in the lake and documented use of watercraft (Bennett 1936) is further indirect evidence of a wetland or lacustrine orientation. Recently, raised fields remains have been discovered near the site of Chiripa, but the dating of the fields has not yet been determined (Gray Graffam, pers. com. 1988).

7.1.3 Wankarani

Wankarani Culture is named after the type site of Wankarani located on the altiplano between La Paz and Oruro at an elevation of 3600-3800 m a.s.l. (Walter 1966; Wason 1967; Ibarra-Grasso 1973; Ponce 1970, 1980). The earliest dates from this site and the associated Sokotina site place the beginning of Wankarani culture around 1200 B.C. (Ponce 1970). The majority of the Wankarani sites are small, although several large mounds (tumuli) have been located. So far, no ceremonial architecture has been found associated with this culture. These sites probably were villages of 15-780 circular houses in a circular plan, suggesting an estimated 75-3900 persons/village (Ponce 1980:14). Some of these sites may have been surrounded by adobe or stone walls. Continuous dense occupation of these sites is indicated by the large quantity of midden and house debris, which forms large mound structures. Exotic materials such as obsidian,

copper, basalt, and non-local lithic material indicate the culture's integration into a network of long distance exchange. The earliest evidence of copper metallurgy in the Andes occurs at Wankarani and other associated sites in levels dating to ca. 1200-800 B.C.. Caches of carved sandstone effigy heads, primarily of camelids, have also been found at some Wankarani sites (Ponce 1970).

Wankarani ceramics are primarily brown wares with spatula polishing/burnishing; plain wares with mica temper appear in the early levels, and red wares are found in later levels (Ponce 1970; Browman 1980). Fiber temper appear at approximately 800 B.C. (Wasson 1967; Browman 1980). Vessel forms are poorly known except for a few complete or reconstructable vessels from the excavations of Walter (1966). Several vessel forms and decorative treatments, especially coffee-bean eyed figurines (Ponce 1970, Walter 1966), show clear Amazonian ties.

Agriculture, probably based on the cultivation of potatoes and quinoa, and combined with camelid pastoralism, appears to have been the mainstay of Wankarani Culture. Numerous hoe fragments, very similar to those found at Chiripa and Huatta, have also been recovered from these mound sites. Unfortunately, no flotation has been done at these early sites. Hunting activity is evidenced by small triangular projectile points, similar to those found at the contemporaneous site of Chiripa (Ponce 1970).

It has been suggested that Wankarani culture was related to

early cultures in the Cochabamba Region, such as Chullpa Pampa and Chullpapata (Ryden 1952, 1961; Ibarra Grasso 1973; Walter 1966, Byrne de Caballero 1965; Browman 1980:114), and to sites in Northern Chile (Browman 1980:113), but these relationships have not been sufficiently documented. The ceramic vessel forms are different in the two Cochabamba styles and the dates for the Cochabamba sites are much later (450 B.C. - A.D. 400) (Walter 1966; Byrne de Caballero 1965).

The distribution of Wankarani sites presented by Ponce (1970), with the exception of the type site, clearly corresponds to wetland environments, including lacustrine, marsh, and riverine. This distribution is similar to that of other Formative cultures of the Lake Titicaca Basin (discussed below).

7.1.4 Tiwanaku I and II at the Site of Tiwanaku

Ponce's (1971, 1972) description of the earliest occupation at the site of Tiwanaku is based on lots from offerings or tombs, and within occupation midden and possibly fill found deep within the Kalasasaya structure. The remains are primarily closed-mouth vessels (jars and brewing/serving vessels), with decorations consisting of geometric incision and polychrome painting, primarily red on buff, sometimes with modeled animals (ibid.). Spatula polishing is common on the utilitarian wares (Ponce 1980:15). Browman (1980:114) points out that later disturbances of these contexts have resulting in a series of unlikely dates for these ceramics, some of which are historic.

One published date of 1580 B.C. \pm 120 (Ponce 1971) was not taken from a good context. Of these 36 vessels which Ponce (1971) has illustrated from the Tiwanaku I period, 24 were found in one lot directly associated with a date of A.D. 297 \pm 61 (Browman 1980:114). Browman (ibid) places Tiwanaku I and II relatively late in the Early Horizon or early in the Early Intermediate Period, between 300 B.C. and A.D. 300. Ponce (1979:15) claims that Tiwanaku began as early as 1580 B.C. (his argument is apparently based on a single radiocarbon date), at which time the site was a village with rectangular house structures and "beehive-shaped" additions. Associated with this period are exotic precious metals (gold, silver, and copper) and turquoise and sodalite (Ponce 1972; 1979:15) indicating that trade networks were well established (Browman 1980:115). According to Ponce (1970, 1971), the "average" date for Tiwanaku I is 237 B.C. and average date for Tiwanaku II is A.D. 43 (Ponce 1972). Unfortunately, the ceramics (and their contexts) used to define the Tiwanaku II period have never been adequately discussed in the literature.

7.1.5 Pre-Pukara Occupations at Pukara

The Cusipata Style was originally defined by Kidder (1948:89) on the basis of ceramics from the lower levels of the site of Pukara which were also later studied by Franquemont (1967). Recent excavations in the earlier lower levels of the Kalasaya at the site have produced ceramics contemporaneous with the other Early Horizon ceramics of the altiplano. Mujica (1987)

reports on the new evidence for the Cusipata style. These ceramics date to approximately 800-600 B.C. and differ from the ceramics from Qaluyu. The style is characterized by open bowls, jars, and ollas with beveled rims. Mujica defines four vessel treatments: cream on brown (older), cream on black (more recent), incised, and red slipped. No information on the context of these early ceramics is given. They were apparently recovered from levels of midden and eroded adobe house walls, possibly associated with a large village.

Mujica (1987:25) suggests that Cusipata was an intermediary phase between Qaluyu and Pukara, although Qaluyu style remains are found throughout the Cusipata strata. He argues that Cusipata represents a break from Qaluyu (ibid. 26), and that Qaluyu was a non-local ceramic style that was introduced in Pukara relatively late in the site's sequence. He also discusses an earlier ceramic complex that dates to ca. 1300 B.C., pre-dating the introduction of Qaluyu ceramics to the site, but also contemporaneous with Qaluyu in later levels (Mujica 1987:28).

Other reports mention early ceramics recovered from levels beneath the best-preserved Pukara period semi-subterranean temple (Lynch 1981), but these ceramics have not been described in any detail. They are reported to have yellow, white and red paint and bear little resemblance to the later Pukara style (Mujica 1978:301). They may be associated with the early ceramic complex defined by Mujica.

7.1.6 Huatta

Radiocarbon dates from our excavations indicate that the the Huatta pampa was occupied by large farming communities by at least ca. 850 B.C.. A TL date of 1320 B.C. (although admittedly with a very large standard deviation) from a raised field context indicates that the raised field farming began very early. The radiocarbon dates come from the lower through middle levels of the mounds at Pancha and Kaminaga. The most intensive occupation of these mounds appears to have been between 800 B.C. and 600 B.C. and surface collections from other mounds and sites on the Huatta cerro tend to support this claim (Almosanchis, Umanchiri, Viscachani, and Huanina). In the deeper excavations, this early settlement is represented by numerous clay occupation floors which alternate with thin bands of sediments, ash and garbage midden. A few housewall foundations and adobe brick fragments could also be attributed to this time period, as well as several pits filled with garbage. The large structure (Structure 1 at Pancha), probably a rustic form of kalasasaya, appears to date to the end of this period.

The decorated ceramics characteristic of this period are burnished dark brown, red and blackwares, with polish and red slip occurring infrequently. Common vessel forms are neckless ollas (some with slightly common-shaped rims), small to large flat-bottomed open bowls with vertical or slightly divergent walls, and necked ollas. Decorations is infrequent, and consists primarily of geometric fields of black, brown, gray, cream/white

paint outlined by incisions varying from fine to medium in thickness on burnished or polished red slip surfaces. A rarer form decorative pattern is a lattice of thick brown or black paint applied over a cream paint which covers a red slip on the upper half of open bowls. The paste and temper is highly variable, but sand and fine grit appear to be the most common tempers in a medium- to well-fired paste. No fiber tempers have been found. Fragments of incised ceramic "trumpets," made from clay rolled around bundles of ichu grass are also associated with these ceramics; the trumpets are usually incised and often carry modelled adornments. Later in the sequence, open bowls with wide reinforced rims become more common.

The ceramics from these early levels at Huatta are similar at a generic level, to contemporaneous ceramic complexes in the Lake Titicaca Basin (Wankarani, Chiripa, Qaluyu, Tiwanaku I and II). The flatbottomed open bowl form, burnishing (referred to by others as "spatulate polishing"), ceramic trumpets, decorated and undecorated ollas, geometric incision defining fields of polychrome paint on red slip are common traits. The neckless olla form is also found in the pre-Cusipata ceramic complex at Pukara (Mujica 1987). The rare lattice decoration appears to be somewhat similar to descriptions of Qaluyu ceramics. Despite general similarities to forms and decorative techniques of contemporaneous traditions, Huatta ceramics appear to form a distinct early complex. The ceramic material from from unpublished excavations at the site of Taraco to the north on the

Rio Ramis (Sergio Chavez and Karen Mohr-Chavez 1984: pers. com.) seems to be stylistically closest to the Huatta complex.

An agricultural economy is indicated by numerous basalt hoe blade fragments, several nearly complete hoes, and thousands of small flakes which resulted from the manufacture and resharpening of these tools. The ubiquitous seeds of Chenopodium and fragments of tubers recovered from these levels probably represent cultigens.

Although agricultural, these early Huatta sites are found in lacustrine and pampa wetland environments. The settlement pattern cannot be absolutely determined because the occupation strata with evidence of this time period are deeply buried, and associated remains are not often found on the surface. I predict that a majority, if not all, of the lower levels of the occupation mounds in the Huatta pampa date to this period.

7.1.7 The Lacustrine Cultures

The very general similarities between the Early Horizon ceramics of the Lake Titicaca Basin and the traditions of the Cuzco area (Marcavalle and Pikicallepata) and Cochabamba (Chullpa Pampa and Chullpa Pata), are more likely to stem from a shared ancestral tradition, rather than from interaction or influence. By the Early Horizon, each of these traditions represents a small regional polity, consisting of small to medium sized farming communities, some centered around small ceremonial complexes. Each of the polities in the Lake Titicaca Basin was probably involved in raised field agriculture by this time, in

addition to camelid pastoralism in the puna. Trade or environmental complementarity within and between regions appears to have been well established by the Early Horizon (Browman 1978, 1980; Mujica 1978, 1985). The early stoneworking techniques, iconography, and related religious beliefs, expressed in the Yaya-Mama style, also appears to have been shared by all of the Formative cultures of the Lake Titicaca region.

In the Huatta and Illpa pampa, raised field agriculture was well-established during the Early Horizon. As presented in Chapter 3, the Phase I raised fields relate to this period. These are deeply buried raised fields with 2-5 meter wavelengths, although some may have been much wider (Unit M Pancha, Unit A Jucchatta). Kolata (1986, 1987) reports Chiripa ceramics in the lowest levels of the excavated occupation mounds in Koani Pampa, but it is not clear whether these relate to raised field agriculture. The early Phase I fields in Koani Pampa are probably deeply buried beneath the later Tiwanaku IV and V period raised fields. Early Horizon Chiripa and Wankarani sites are distributed throughout the wetland zones near the lakes and rivers south of Lake Titicaca. Although the agricultural systems of Qaluyu have not yet been defined, the type site is located in the extensive zone of gochas north of Lake Titicaca, and near the northern extension of the main block of raised fields. With more research in the Lake Titicaca Basin, I predict that raised field agriculture will be documented for all of the Early Horizon cultures of the region.

7.2 THE EARLY INTERMEDIATE PERIOD (200 B.C.-A.D. 550)

7.2.1 Pukara

Pukara was the principal site in the Lake Titicaca Basin during the early part of the Early Intermediate Period (Kidder 1943; Mujica 1979, 1985; Franco Inojosa 1940; Valcárcel 1925, 1931, 1935; Franquemont 1967; Lumbreras 1974a, 1974b). The site is located 100 km north of the lake shore, at the base of a large rock outcrop. Dense occupation debris covers approximately 4² km², and the site definitely supported an urban population (Mujica 1978). The main ceremonial complex of the site is located at the foot of the rock outcrop, and is a series of huge artificial terraces and stairways constructed of large cut stones, artificial fill and debris from earlier occupations. Three large semi-subterranean temple structures, each surrounded by outlying stone structures, are located on the flat surface of the upper terrace.

Pukara reached its peak between 200 B.C. and A.D. 200, during the Early Intermediate Period (Kidder 1948; Lumbreras 1974a, 1974b; although Mujica argues that it may have lasted until A.D. 400, 1985:123). Two ceramic phases have been proposed by Mujica (1987), Early and Late ("Classic") Pukara.

The ceramics of Pukara have been described in detail in numerous publications (Kidder 1943, 1948; Bennett 1950; Rowe and Brandel 1976; Lumbreras and Amat 1968; Lumbreras 1974a, 1974b; Mujica 1978; 1987; Franquemont 1967; and others). They are characterized by fine wares with polychrome pre-fire painting

(red, black, brown, orange, cream, and white) defined by fine-line incision on highly polished red slip bases. The most common designs are geometric, typically step designs and curvilinear patterns, and there are some representations of human heads in profile, deities, trophy heads, and mythical winged animals, particularly, felines. The most common vessel forms are short keros, pedestal annular-base bowls, flat-bottomed open bowls of various sizes, jars, and ollas. Modeling is common, especially low relief combined with incision on vessels, and on elaborate "trumpet" forms.

The stone working clearly evolved out of the earlier local traditions (Yaya-Mama and others) and much of the iconography on Pukara textiles and ceramics also have their origin in the lithic style. Most common are depictions of human-god figures, felines, fish, serpents, lizards, and humans with trophy heads prominently displayed, both in the round and as flat relief. Some traits of Pukara style, especially visible in the stonework, are similar to the earlier Chavin style in the northern highlands of Peru (Rowe 1971). Lathrap (pers. com.) suggests that tradition was introduced by a group of Chavin elites after the collapse of the Northern highland center at Chavin de Huantar.

Easy access to the relatively rich Lake Titicaca resources, fertile valleys to the north, and pastoral land in the puna, gave Pukara a strategic advantage over other polities; the center was able to control trade raw materials and redistribution of finished goods, especially textiles (Mujica 1985:125). The

population appears to have grown considerably during this period, and for the first time a single polity had control over a large part of the southern highlands. The settlement pattern was clearly hierarchical, with the major urban ceremonial center of Pukara, smaller towns, and numerous village sites (Mujica 1985:126).

During the Early Intermediate Period, Pukara influence in textiles and ceramics appears to have extended to Northern Chile at Alto Ramirez and other sites (Browman 1980; Mujica 1985). The exact nature of this influence is not yet clear, but Mujica (1985:112) argues that the Chilean sites were not necessarily Pukara colonies, but rather parts of an extensive exchange network based on complementarity of resources.

7.2.2 Qeva or Tiwanaku III

Tiwanaku as an urban ceremonial center and important Andean polity had its origin during the Tiwanaku III period, in the later part of the Early Intermediate Period. Between A.D. 100-375, the large construction projects (Akapana, Semi-subterranean Temple, Kalasasaya, and other major structures) began (Ponce 1964, 1979; Browman 1978; 1981). At this time, Tiwanaku probably dominated the southern lake basin, and near the end of this period, after the collapse of Pukara, it gained control of the northern basin. By Tiwanaku III (A.D. 100-A.D. 375), the ceremonial center of Tiwanaku has reached urban proportions (Ponce 1972).

Early Tiahuanaco was first defined by Bennett (1934, 1936) as the predecessor of Classic Tiahuanaco. This style has also been referred to as "Qeya" (Wallace 1957) and "Tiwanaku III" (Ponce 1970, 1976). These ceramics have been described in detail (Wallace 1956; Bennett 1934, 1948, 1950; Posnansky 1945, 1957; Ponce 1972). There is much debate about the relationship between Tiwanaku (especially Tiwanaku III) and Pukara (Wallace 1956; Lumbreras 1974a, 1974b, Mujica 1978; Ponce 1972, 1980). The classic Tiwanaku feline figures, running human figures, staff-god figure, and trophy heads appear earlier in Pukara style. There is some evidence that Tiwanaku III ceramics were contemporaneous with Pukara-like ceramics at the site of Kallamarka in Bolivia (Mujica 1978; Lumbreras and Mujica 1982; Portugal and Portugal 1975-1976). Even if the poorly-defined Tiwanaku I and II ceramics were contemporaneous with those of Pukara, the Pukara style was much more advanced in elaborating the traits that were later adopted during Tiwanaku IV. The stone carving style Yava-Mama, which precedes both Pukara and Tiwanaku, shows many characteristics common to both styles and was found throughout the lake basin. Ponce (1972) argues that the Tiwanaku III phase should date between A.D. 100-375, putting it much later than Pukara.

Mujica (1985:123) argues that Qeya (Ponce's Tiwanaku III and Bennett's Early Tiahuanaco) and late Pukara were contemporaneous if Pukara lasted until A.D. 400. He argues that the spatial distribution of sites relating to these two cultures indicates

they were two distinct political or ethnic groupings. In Mujica's opinion, "true Tiwanaku" did not begin until A.D. 500, the Tiwanaku IV period; and it lasted through Tiwanaku V (A.D. 1200).

7.2.3 Huatta

A few classic Pukara community sites are found in Huatta pampa and cerro locations. These sites range from a large occupation mound with what was probably a ceremonial structure (Pancha) and large farming villages (Kaminaqa, Viscachani, Coata, Pojsin Karata, Huanina) to small isolated house mounds and hamlets.

In my excavations in the Huatta area, Early Intermediate Period occupations were found near the surface at Pancha and in the middle levels of the site of Kaminaqa. Pukara ceramics were associated with the midden along the wall of Structure 1, the Early Horizon structure at the site of Pancha. They were probably deposited after the structure had lost importance and had been abandoned. Structure 2 at the site of Pancha, an intact rectangular house foundation, also probably dates to the Early Intermediate Period. The ceramics from these sites do not have classic Pukara iconography (such as modeled and incised felines or humans/gods), or characteristic vessel forms, but the geometric incision, surface treatments and high-quality firing is definitely Pukara. This may indicate that Huatta sites represent a rural Pukara community with less elaborate ceramics than those which define the tradition at the ceremonial center of Pukara.

The ceramics of the classic Pukara style found in surface collections of sites in the Huatta area may represent a few special ceremonial pieces. The Cusipata ceramic style, which Franquemont (1967) and Mujica (1987) argue was transitional between the Early Horizon ceramics and Pukara, is not found in the Huatta area.

Several exotic sherds of incensarios with wide grooved designs, probably contemporaneous with the Qeya or Tiwanaku III period, were collected from the surface of a few Huatta sites. Incensarios are found throughout the lake basin and the Cuzco area, and were probably important ritual items in regional trade networks (Mohr-Chavez 1984).

During the Early Intermediate Period, raised fields continued to be an important agricultural technology in the Huatta area. Hydraulic agriculture may also have been practiced at the site of Pukara. Qochas technology appears to be associated with the Pukara site, although no direct evidence has been found to confirm this. Terrace agriculture may also have been practiced by Pukara farmers. Although not agricultural, the massive stone-faced platforms constructed at the type site as level foundations for the ceremonial structures were in fact terraces.

At the end of the Early Intermediate Period, the construction and use of Phase I raised fields in the Huatta area declined. This may represent a period of complete abandonment of raised field agriculture, although it is also possible that the technology remained in limited use (see below).

7.3 THE MIDDLE HORIZON (A.D. 550-1000)

7.3.1 Tiwanaku

The urban ceremonial center of Tiwanaku has been described in detail in the literature (Browman 1978a, 1980, 1981; Ponce 1972, 1980; Bennett 1936; Posnansky 1945, 1957; Ryden 1947; Kolata 1981, 1983). Although settlement at Tiwanaku began several centuries before the Middle Horizon, it was not until then that the site reached the peak of its importance and power in the southern Andes.

During Tiwanaku IV, some changes were made in the temples and pyramids constructed during the (Early Intermediate) Tiwanaku III period. Several stone carvings, such as the Gateway of the Sun, also date to Tiwanaku IV (Lumbreras 1974a:139). Parsons (1968) estimates the urban core was approximately 2.4 km², with a population between 5,200 and 10,500 people; Ponce (1972) has revised these figures to over 4 km² with estimates between 20,000-40,000 people during the peak occupation of the site. Bronze metallurgy was common during this period, in addition to the previously-developed copper and gold technology (ibid. 145).

Around A.D. 400, the Tiwanaku ceremonial center seems to have usurped the power and prestige of the Pukara center. The axis mundi of the south central Andes was moved southward. As Chavez (1975) has demonstrated, the important monoliths from smaller ceremonial centers such as Taraco were transported to the

rising new center at Tiwanaku. Lathrap (pers. com.) suggests that much of the confusion in seriating the early monoliths from Tiwanaku and nearby sites (Browman 1978a; Chavez and Mohr-Chavez 1975) is the result of the Tiwanaku practice of "capturing" and "holding hostage" the axis mundi of the various ethnic groups dominated by the ceremonial center of Tiwanaku, so that several different contemporaneous traditions, rather than various chronological phases, are represented.

After A.D. 400, during the Tiwanaku IV period (A.D. 375-725), Tiwanaku gained prominence throughout the Lake Titicaca Basin, extending into most of the altiplano of Peru and Bolivia, the coast of southern Peru and northern Chile and the montaña zone to the east of Lake Titicaca. This dominance was apparently based on militarism, the establishment of Tiwanaku controlled colonies, and/or trade networks (Browman 1978a, 1980, 1981; Kolata 1983; Ponce 1972, 1979, 1980; Mujica 1985). Tiwanaku's influence extended to the Wari empire, far to the north. The finest works of Tiwanaku stone and ceramic art were mostly produced during Tiwanaku IV. Tiwanaku V (A.D. 725-1250) is characterized as , the period of maximum expansion of the Tiwanaku sphere of influence.

The exact nature of the Tiwanaku phenomenon has not been well-defined because of an overemphasis on the archaeology of the ceremonial center without sufficient research in the rural hinterlands, secondary centers, and trade colonies. The site has been traditionally considered a vacant ceremonial center or

pilgrimage center (Bennett and Bird 1960:185). Ponce (1972) and Kolata (1982, 1983, 1986, 1987) argue that Tiwanaku was a major urban center and expansionist empire. An alternative view is proposed by Browman (1978a, 1980, 1981), who argues that Tiwanaku was a loose federation, tied together by long-distance trade and markets, with its focus at the ceremonial center. All agree that during Tiwanaku IV, the trade network and sphere of influence was most extensive, connecting NW Argentina, the Atacama, coastal Chile, southern Coastal Peru, the eastern montaña region, and north of the lake basin, and possibly extending to the area under Wari control (Browman 1980). After the collapse of the Wari Empire, most of Tiwanaku's trade network also apparently collapsed. As a result, Browman argues, Tiwanaku-controlled vertical archipelagos were established to meet the demand for raw and exotic materials during the Tiwanaku V Period (ibid. 109, 117; also see Mujica 1985:112-114).

The language spoken by Tiwanaku peoples is not known, but several languages have been proposed. Browman (1980:117, 1984) argues that Tiwanaku peoples spoke Aymara, and this is supported by the distribution of Aymara toponyms which roughly follows the distribution of Tiwanaku influence (also see Browman et al. 1988). Hardman (1985; also see Torero 1980, 1987) proposes that the Tiwanaku religious elite spoke Pukina, while Aymara was used as a commercial trade language and for the administration of zones under Tiwanaku influence. There appear to be strong ties between the Larecaja region and Tiwanaku during the Middle

Horizon and Late Intermediate Period; the famous Callahuaya curers, who still speak a form of Pukina (Stark 1972a), are from this region, and a medicine man's mummy and toolkit with Tiwanaku affiliation were discovered there (Wassen 1972). I will argue that the Early Horizon and Early Intermediate Period cultures of the immediate lake area were Uru-Chipaya and/or Pukina speakers, and these groups were responsible for the raised fields (See Chapter 7). This probably continued into the Middle Horizon. Even if Aymara was the language of domination during the Middle Horizon, the groups practicing raised field agriculture in Koani Pampa were probably ethnically Uru-Chipaya-Pukina speakers.

During Tiwanaku during Tiwanaku III, the site of Tiwanaku was probably a strong rival to the site of Pukara. Tiwanaku III is definitely the basis of what would later become Classic Tiwanaku. The iconography on Tiwanaku IV ceramics, stonework, and textiles clearly has its roots in the earlier Pukara traditions, which in turn originated in the Early Horizon cultures of the lake basin. Common elements include the modeled feline heads, the kero cup form, a preoccupation with trophy heads, running figures, staff god, and stylistic organization of these elements. Certain Chavinoid features appear suddenly in Pukara without local precursors, such as the staff god figure, notched stone pillars, certain feline depictions, and winged human figures or "eagle men" (Rowe 1971; see Lathrap above). All of this coalesces first in Pukara, then slightly later at Tiwanaku, during Tiwanaku III, and more completely in Tiwanaku IV.

7.3.2 First Abandonment of Raised Field Agriculture

Our archaeological evidence strongly suggests that the raised fields were not abandoned once, but at least twice, in the Huatta area (see Chapter 3). As I pointed out in Chapter 3, "abandonment" does not necessarily imply a sudden "collapse" of the raised field systems, but is more likely a period of contraction of the area under cultivation. We do not have evidence of complete abandonment of the raised field systems until after the Spanish conquest.

The first hiatus of raised field construction and maintenance occurred at the end of the Early Intermediate Period or beginning of the Middle Horizon, and the second at the beginning of or during the Late Horizon. Both periods of abandonment correspond to periods of socio-political change, not environmental change. There is no clear evidence that climate change (including flooding and droughts) caused either the depopulation of the region or the collapse of agricultural systems (Erickson 1988).

Abandonment events coincide precisely with important socio-political changes occurring in the Lake Titicaca Basin. The first major raised field construction and use period, Phase I, was initiated by the Pre-Pukara (Early Horizon) cultures of the northern lake basin, and continued throughout the Pukara Period during the Early Intermediate Period. The emphasis on raised field agriculture appears to have shifted to the southern lake basin as Tiwanaku gained importance as a ceremonial center during

the Middle Horizon or later part of the Early Intermediate Period (ca. A.D. 300-400). A second period of raised field construction in the northern lake basin, Phase II, occurred after the collapse of Tiwanaku in the Late Intermediate Period, and lasted until the Inca conquest of the Lake Titicaca Basin.

Excavations at the type site of Pukara have not revealed very much about the collapse of Pukara influence in the lake basin. It is clear, however that Tiwanaku, during the Tiwanaku III period, was a strong competitor for control of the region. By A.D. 300-400, Tiwanaku had gained control over most of the southern lake basin, and possibly part of the northern basin. The rapid growth of influence of the southern ceremonial center was apparently responsible for the collapse of Pukara as the pre-eminent regional ceremonial center. Competition between major ceremonial centers has recurred throughout Andean prehistory, and this is a clear case of one center usurping the power of another.

The nature of Tiwanaku influence over the northern basin after the collapse of the Pukara center has not been illuminated by archaeological investigation. Some small regional Tiwanaku centers were established relatively late (during Tiwanaku V) on Isla Esteves in the Bay of Puno (Nuñez and Paredes 1978). Some Tiwanaku IV and V kero fragments were collected from the surface of some larger Huatta sites, but only on the cerro. None of the sites in the Huatta area appear to have been important ceremonial or administrative centers during the Middle Horizon, which indicates that the state did not control agricultural production

in the northern Basin at this time. Most significantly, the occupation sites directly associated with raised field agriculture in the Huatta area did not yield evidence of occupation by Tiwanaku peoples. It is likely that local ceramic traditions continued during the Middle Horizon. The few diagnostic Tiwanaku ceramics were probably high status or ceremonial trade pieces brought into the area from the south. The raised fields were abandoned and the pampa sites appear to have been largely unoccupied during the Middle Horizon as indicated by the lack of diagnostic ceramics dating to this time period. This may indicate that the area was relatively depopulated during this time, possibly through migration to the southern lake basin drawn by the growing ceremonial center of Tiwanaku. As long as Tiwanaku remained important, the raised fields were not fully maintained in the northern lake basin.

Tiwanaku control over the Northern Basin may not have been peaceful. The relocation of the large stone monoliths, some weighing tons, from the Pukara ceremonial center and other regional centers such as Taraco (Chavez 1975), to the Tiwanaku ceremonial-urban center suggests considerable upheaval in the northern Lake Titicaca Basin.

If Tiwanaku was controlled by Aymara elite, the low-status Uru-Chipaya or Pukina farmers who constructed and used raised field agriculture may have been marginalized to the point that the agricultural system collapsed. Their response to domination during the Late Horizon (see discussion below) and the Colonial

period was to retreat to the totora marshes, subsisting by intensive fishing, hunting, and gathering of lacustrine resources, and this may have also occurred when Tiwanaku gained power in the region.

Tiwanaku's rise in power and prestige in the southern lake basin corresponds to the introduction of large scale raised field agriculture in Koani Pampa, and probably in the Rio Desaguadero plains, while at the same time, Pukara and the Pukara raised fields were contracting or collapsing. According to Kolata (1982, 1983, 1986, 1987), the Tiwanaku state directly controlled the planning, construction, and scheduling of raised fields in Koani Pampa and other areas (see my critique in Chapter 6).

7.4 THE LATE INTERMEDIATE PERIOD (A.D. 1000/1200-1475)

7.4.1 The Aymara Kingdoms

Between A.D. 1000 and A.D. 1200, Tiwanaku lost its control of the southern Andes and the Lake Titicaca Basin. The collapse of the urban-ceremonial center precipitated conflict among the regional Aymara states, probably previous tributaries of Tiwanaku, all vying for the position of supremacy. Certain characteristics of Tiwanaku style (such as the kero form and other vessel forms, geometric designs, and red slips) were carried over into the Late Intermediate Period in the lake region (Collao, Sillustani), and also in the zones to the East (Mollo), West and South (Chiribaya, Churajón).

The Late Intermediate Period of the Lake Titicaca Basin is characterized by the "Aymara kingdoms" (Señorios). These groups, the Lupaca, Qolla, and Pacajes are best known through ethnohistoric documents, such as the visita and testimonies recorded by Diez de San Miguel ([1567] 1964; Murra 1968) and other ethnohistorical sources although this data was recorded long after the Inca conquest of these polities. Other Aymara-speaking polities at this time included the Cana and Canchi to the south of Cuzco, and the Collagua in Arequipa, which may have been as powerful as the lake polities (Lumbreras 1974a:201). The Lake Titicaca groups were apparently ruled by hereditary dynasties, the rulers called "kurakas" (Quechua: local leaders) or "señores" (Spanish: lords). The principle language of these kingdoms was Aymara, although other languages such as Uruquilla (Uru-Chipaya) and Pukina were also common. The kingdoms were multiethnic, with the Aymara ethnic group as the dominant class. There were 4 lords of the region; the most powerful appears to have been Zapana of the Qolla, with his capital at Hatuncolla.

The areas influenced by these altiplano polities was extensive, and seems to have covered the Lake Titicaca Basin and extended as far as the coast between Arequipa and Arica to the west, Sicuani to the north, south to Oruro, into the eastern Andean jungle slopes and to Cochabamba. there are some indications that the influence also penetrated the Humahuaca region of NW Argentina (Lumbreras 1974a:200). The nature of this influence seems to have been colonization and establishment of

vertical archipelagos, rather than military domination (Murra 1968, 1975; Lumbreras 1974a:200-1); warfare seems to have been directed towards establishing priority among the competing altiplano polities more than conquering distant lands.

Because of the nearly-constant state of conflict, densely populated communities were established in fortified positions near the puna edge, along militarily defensible spurs (Hyslop 1977a, 1977b, 1979). Hyslop's settlement survey identified several fortified villages (Tanka-Tanka, Anquicollo, Siriya B, Nuñamarca, and Cutimbo) associated with the Lake Intermediate Period, which he considers the typical Aymara settlements of this period. The Lupaca, the best-studied altiplano señorio of the Late Intermediate Period, maintained colonies or vertical archipelagos in various zones of the coast, highland puna and montaña slopes (Murra 1968, 1975). Señorio economies were apparently oriented towards developing llama and alpaca pastoralism in the puna and corn production in lower altitudes, but potatoes and other altiplano crops probably supported the expanding states (Julien 1982, 1983; Murra 1968, 1975; Hyslop 1979; Pease 1982; Lumbreras 1974a, 1974b; Lumbreras and Amat 1968; Bouysse-Cassagne 1986)

These groups were powerful enough to be considered a threat to rising Inca hegemony in the Cuzco area (Julien 1982; 1983; Pease 1982). The Qolla lord, Zapana, was considered to be very powerful. During the Late Horizon, that indigenous Hatuncolla lord, with Inca support, controlled all of the Lake Titicaca

region except the Pacajes area, although details of how this control was exerted are not known (Julien 1983:41-42).

Very little archaeological work has been done on the Late Intermediate Period. Brief, unsystematic surveys have been conducted around the Lake Basin (Vazquez 1940; Franco and Gonzalez 1936; Hyslop 1976, 1979; M. Tschopik 1946), but these tell us little about the Aymara Kingdoms' settlement patterns (with the exception of Hyslop 1976, 1979). Most of the work has focused on the chullpa burial sites (Hyslop 1977a, 1977b, Lumbreras 1974a, 1974b; M. Tschopik 1946; Neira 1967). Some of the non-lacustrine and frontier areas of the Aymara zone of influence have been examined, including the southern basin (Ryden 1947; Cordero 1971; Bennett 1934, 1936), the Mollo area (Ponce 1957; Arellano 1975), and Moquegua (Stanish 1985).

The only good published description of Late Intermediate Period ceramics is the work of M. Tschopik (1946), where she describes the Allita Amaya style apparently related to the Lupaca and Collao styles. The Churajón and Chuquibamba of Arequipa, Mollo of the eastern Bolivian slopes, and Chiribaya of the southern Peruvian Coast and lower Moquegua Valley appear similar to the Allita Amaya style, while the Collao style is only related to the Sillustani style, and, more distantly, to ceramics from Tacna and Arica (Lumbreras 1974a:205). The establishment of Aymara vertical archipelago colonies in these zones seems to have been responsible for this distribution of ceramic similarities (Lumbreras 1974a:207).

Colonial records and early Aymara dictionaries show that there appear to have been two major conceptual spatial divisions of the Lake Titicaca Basin, the Aymara Urcosuyu located in the high puna areas above 4100 meters, and Umasuyu, of primarily Uruquilla and Pukina speakers, located in the Lake Titicaca plain and valleys east of the basin (Bouysse-Cassagne 1986). Communities were multiethnic, consisting of people with Aymara, Uru, and Pukina affiliations (Murra 1968, 1975; Julien 1982, 1983; Bouysse-Cassagne 1986).

Although not mentioned in the literature, there is evidence that intensive agriculture was practiced by these Late Intermediate Period polities. The raised fields in Huatta were re-established during the Late Intermediate Period, and probably reached their peak use during this period (see Chapter 3). That terrace systems were also probably cultivated intensively during this period is suggested by the numerous Late Intermediate Period tombs and occupation sites located on or near terraces. These systems may have been constructed and operated by the previous raised field farmers, the Uru-Chipaya and/or Pukina.

If the Huatta archaeological survey data is typical for the Qolla region, the population was dense, with new settlement patterns appearing in the basin. The Late Intermediate Period communities around the lake were not all located in defensible positions, as argued by Hyslop (1976) for the high-altitude puna areas west of the lake. This may have been a distinction between the Lupaca and Qolla settlements, or perhaps Hyslop's data base

may be biased towards the hilltop settlements. Documentary evidence supports the idea that some Late Intermediate Period communities were located on the lake plains (Julien 1982:133). In the Huatta area, Late Intermediate Period sites are located both on the cerro of Huatta and on nearly all of the moqos in the pampa. I believe that these lake area communities were occupied by Uru-Chipaya and/or Fukina peoples, an ethnically-defined class within the Aymara Kingdoms, who constructed and maintained raised fields.

7.4.2 Raised Field Agriculture during the Late Intermediate Period

After the Tiwanaku V Period and the beginning of the Late Intermediate Period, the Tiwanaku raised fields of Koani Pampa appear to have been completely abandoned in the southern Basin. Kolata (1986:763) believes that the collapse of the centralized Tiwanaku state authority disrupted the maintenance activities of raised fields and thereby led to the abandonment of the fields. He also postulates that a climatic catastrophe, such as a drought or flood may have also been a factor (Kolata 1987:41).

At this same time there appears to have been a resurgence in raised field construction and occupation of the pampa sites in the northern Lake Titicaca Basin, at least in the Huatta and Illpa area. Phase II of raised field construction and use, probably initiated at this time, corresponds roughly to the Late Intermediate Period (see Chapter 3). The Phase II raised fields have much larger platforms (10 meter wavelengths or larger are

common) than the raised fields associated with the Early Horizon and Early Intermediate Period.

The excavated sites of Pancha and Kaminaqa both have thick strata representing Late Intermediate Period occupations. The area under terrace agriculture was also enlarged considerably during the Late Intermediate Period in the Colca (Malpass 1987, Malpass and de la Vera Cruz 1987) and Moquegua Valleys of Peru (Stanish 1985) and the Mollo area of Bolivia (Ponce 1957; Arellano 1975). Presumably, this florescence of terrace construction also occurred in the Lake Titicaca Basin.

The collapse of the Tiwanaku raised field system at the same time as the start of intensive raised field construction by the Aymara Kingdoms in the northern basin echoes the shift in the locus of both power and raised field agriculture that occurred at the end of the Early Intermediate Period and beginning of the Middle Horizon. Again, the change in political dominance clearly had dramatic effects on agricultural techniques. These coincidences of shifts in political and ceremonial power and raised field agriculture are too obvious to be ignored.

7.5 THE LATE HORIZON

(CIRCA A.D. 1438-1532)

7.5.1 The Inca Conquest of the Lake Titicaca Basin

Very little is known archaeologically about the Late Horizon and the Inca conquest of the Lake Titicaca region. Excavations

at the sites of Hatuncolla (Julien 1983) and Chucuito (M. Tschopik 1946), in addition to regional survey (Hyslop 1976), have provided some critical information on this important period in Lake Titicaca prehistory, but many important details are missing. Because of this lack of archaeological documentation, many archaeologists and historians have relied heavily on the chronicles and visitas for reconstructing events of the Lake Horizon. Zuidema (1964:12-17) has warned against using information provided by the chroniclers to reconstruct a literal Inca history. Much of what was written by the chroniclers on the Inca conquest and administration of the Lake Titicaca region may be based on myth, but certain information may be useful in the formation of hypotheses that could be tested against the archaeological data. I will briefly present certain data based on written documents regarding the Inca and the Lake Titicaca peoples during the Late Horizon and discuss their relevance to the abandonment of raised field agriculture in the region.

After the Incas gained control of the Lake Titicaca Basin, two major rebellions were waged by the Qolla of the northern lake basin (Julien 1983:246, 257). The Aymara Kingdoms and the Inca had been rivals before the Inca conquest of the zone (Murra 1982:254), and apparently the Qolla rebellions were primarily attempts to usurp Incaic power, as the Qolla had imperial ambitions of their own (Julien 1983:7-8).

Certain aspects of Inca policy towards the indigenous

polities in the Lake Titicaca region can be understood from census data (Diez de San Miguel [1567] 1964; Toledo 1975) and the Spanish chronicles. Various interpretations of this data have been presented generally following either the Cuzco-centric view of the chroniclers or the local ethnic groups' perspective recorded in the *visitas*. Pease (1982) and Murra (1975; 1968; 1982) argue that the local polities, especially those in the Lake Titicaca Basin, continued relatively unchanged under Inca rule, and that the minimal changes and reorganization that did occur have been overemphasized in the literature. They argue, using the Lupaca as an example, that the negative effects of Inca rule were slight, and the local polities were allowed a certain degree of autonomy and permitted to maintain their archipelago colonies in other environmental zones (Pease 1982:185). On the other hand, it is believed that the Lupaca were forced by the Inca to leave their hilltop defensive communities and live in the lakeshore cabeceras (Hyslop 1976, 1979:57-59), a change which could hardly be considered "slight." Large Inca towns, such as Hatuncolla, were established in new sites (Julien 1983), and Rowe (1982) and Julien (1982, 1983) argue that Inca rule had considerable impact on local polities. Rowe (1982) maintains that the Inca policies of educating the children of Aymara lords in Cuzco, mitma colonization (both moving loyal groups in and moving Aymara communities out of the basin), selecting local yanacona to be directly answerable to the Inca, and the establishing camayoc crafts specialists tended to culturally

homogenize local areas while making Inca rule easier to impose upon the Aymara. Julien (1982, 1983) argues that the Inca state had considerable influence on local elites in the basin, especially in terms of labor expropriation under the decimal system (also see Pease 1982). Julien (1982) has presented a convincing case that the Inca used local kurakas for administrative purposes, but also limited their power by reassigning their tributaries to permanent Inca state services and appointing local provincial Inca governors.

Julien (1983:7) claims that Late Horizon ceramic style and architecture, in particular the incorporation of Inca architectural canons in the construction of chullpa burial towers throughout the basin are evidence of the process of "Incanization" of the local Colla culture. The ceramic sequence from Hatuncolla shows a gradual adoption over time of the imperial Cuzco-Inca style and the chullpas of nearby Sillustani demonstrate the influence of Inca stonemasonry on what was previously a local tradition. Julien states:

Written sources document several attempts by the people of the Qolla dynasty to seek their independence from Inca rule. Before the Inca conquest, the Qolla dynasty appears to have had imperial ambitions of their own, and when a rebellion against the Inca government was declared, the rebels did not challenge the authority of the Inca emperor, but rather tried to usurp it. The strong identity of these same people with the material symbols of Inca authority, principally seen in ceramic remains and stonework, may not have been so much an expression of solidarity with Inca imperial goals as a reflection of local imperial ambitions (Julien 1983:7-8).

There appears to have been a considerable difference between

the Lupaca and Qolla in their relationship with Inca administration and rule. The Lupaca made peace alliances with the Inca even before the Inca entered the area, and the Inca apparently allowed them to continue with little interference. This may explain why the 1567 census data of Diez de San Miguel indicates that the Lupaca maintained indigenous, non-Inca, traits. The Lupaca did not participate in the Qolla rebellions against the Inca or resist the initial Inca incursion into the region (Hyslop 1979:55). Most of the bloody battles fought during the rebellions during the rule of Pachacuti Inca were fought in Qolla territory at the north end of the lake, and were led by the lords of Hatuncolla, Humalla, and Azangaro (Julien 1983:81). During one of these rebellions, the Inca governor of Qollasuyu and his Cuzco nobles were killed; the Inca retaliated by setting up military garrisons, and uprooting and moving communities around the lake area, relocating local populations from the hilltops to the lake plain, and importing foreign colonists to the Lake Titicaca Basin. Groups from the Chinchasuyu quarter of the empire were moved to Hatuncolla and Juli and Inca ayllus were settled here after one of the rebellions (Julien 1983:82-85). According to Julien (1983:88), all native peoples of the Copacabana Peninsula were moved out and replaced by Inca groups, who maintained state shrines there. Retaliation in Ayaviri was particularly severe, and the local population was completely wiped out by the Inca. The relatively high population of the Lupaca at the time of Spanish contact

(Hyslop 1979, Murra 1968, 1975; Diez de Miguel 1567) may reflect the fact that they faced less Inca military retaliation than the Qolla peoples. Many of the rebellious Qollas may have been forcibly moved out the area as mitmaq colonists, killed during the wars, or forced to serve with the Inca armies in the conquest of the northern Andean region.

7.5.2 The Final Abandonment:

The Incas and Raised Field Agriculture

The Inca do not appear to have had an interest in maintaining the raised field systems. There are some traces of short-term Inca period occupation on the mounds in the pampa of Huatta and Illpa, but these are far less extensive than the previous Late Intermediate Period occupations. Inca occupation in the pampa may be overemphasized because Inca ceramics are highly diagnostic and are identified easier than ceramics of other time periods. and also, being later, are in the uppermost layers or on the surface of sites. Some major regional Inca administrative centers were located near large blocks of raised fields, such as at Hatuncolla (Julien 1979, 1983) and possibly the site of Huatta (located in the present town of Huatta), but there is no evidence that these sites were associated with functioning raised field systems. In the southern basin, Kolata (1986:763) recovered few Inca remains from the occupation mounds in Koani pampa, and concludes that the raised fields were completely abandoned after Tiwanaku collapse during the Middle Horizon and not reutilized by the Inca.

Why didn't the Inca State maintain the highly raised field systems of the Lake Titicaca Basin after their conquest of the zone? The answer to this is not yet known, but the following hypothesis is suggested. According to Inca history reported by the Spanish chroniclers, the Inca faced considerable difficulties in conquering and maintaining control over Qollasuyu, especially the Qolla Kingdom at the north end of the lake. In pre-Inca times, the Urqosuyu peoples (Aymara speakers of the western side of the lake and puna) of Qollasuyu lived in fortified towns in defensive positions at the puna edge (Bouysse-Cassagne 1986:205-6, Hyslop 1979). After the Inca conquest of the zone, the Aymara provided the best loyal troops in the Inca military, who were given credit for much of the expansion of the empire to the north (Bouysse-Cassagne 1986:206); meanwhile, their conscription may have depleted the available labor force for agriculture in their homeland. The rebellions of the Lake Titicaca peoples against the Inca apparently lasted for many years. If the historical documentation is true, the repeated pattern of conflict and retaliation would certainly have disrupted agriculture during this time. Cook (1981:25-26) presents data from the 1567 Visita which indicates the effects Andean warfare that approximately one quarter of the male population died in local wars. With the Incas' final pacification of the area, sometime after the middle of the 14th Century A.D., came the implementation of their policy of drastic settlement changes. These included moving the centers of population from defensive positions on the puna edge to the

lake shore and the establishment of mitmaq colonies whereby certain local groups were moved out of the area to faraway places such as Cochabamba (Wachtel 1982) and replacing them with loyal ethnic groups from other part of the empire (Pease 1982; Julien 1982, 1983) such as Quechuas colonists from Cuzco and the Chimu groups from the North Coast of Peru settled in the Community of Ichu and Chimu near Puno. This policy of major reorganization may have also caused a major disruption in the local agricultural production.

I believe that Huatta was a low-level Inca administrative center. The town's street and wall pattern is typical of the structure of Inca sites (Julien 1979:205-211, Gasparini and Margolis 1980). Occupation midden, both on the surface and in deep excavated disturbances, is predominantly Inca. Few intact stone walls are found, and these may be pre-Inca terrace constructions, since they do not show typical Inca stonework. I also suggest that the local pre-Inca indigenous populations may have been moved out after the rebellions, and that both the town and pampa were settled by mitmaq colonists from Quechua-speaking areas, possibly Inca colonists. The occurrence of diagnostic Inca ceramics on the surfaces of occupation mounds in the pampa and occupation and burial sites on the hill of Huatta support this contention.

If the Inca were trying to suppress the power of the local Qolla lords to prevent bloody and costly rebellion, the best means would have been to limit the major source of local

production, which was the raised field system. By removing the local population of raised field farmers, the major source of revenue for local power would have been disrupted. The replacement of these raised field farmers with outside foreigners may have succeeded in suppressing rebellions, but these foreigners did not know how to manage raised field agriculture and the technology was abandoned and lost over time. The pampa raised fields eventually reverted to pastureland. The raised field farming population of Coata and Capachica, both predominantly made up of Pukina speakers and ethnically Uru may have remained intact throughout the Inca period, but probably reverted to an economy focusing on fishing and gathering of lake resources. Coata remained an important relatively independent Uru center through the early Colonial Period (Wachtel 1986; Julien 1983). The major occupation mounds in the Coata area, the site of Coata, Pojsin Karata, Isla Karata, and Almosanchis, all have Inca occupation debris and Inca tombs. The Inca sites of Hatuncolla and Huatta could have easily controlled the large areas where raised field agricultural remains are found.

Areas less affected by Inca rule, such as the Lupaca zone do not have large areas of raised field remains, and so there was not chance that the technology was preserved in an area under less oppressive rule. The Inca material on occupation mounds and nearby hillslopes Koani Pampa, in the only other studied raised field area for which we have any data, may indicate a similar reorganization of local populations during the Late Horizon.

Even if all of the local farmers were not removed, the establishment of mitmaq colonies in the Huatta area would have increased tensions to the point of disrupting the agricultural system, especially as the local Uru-Chipaya and Pukina groups would have retreated into the lake shallows.

The Inca administrators, military, and loyal Inca mitmaq colonists came from a very different environmental zone, the Valley of the Urubamba/Vilcanota in Cuzco (Gade 1975). This zone has no extensive areas of seasonally flooded pampa or wetlands except for parts of the pampa of Anta and it is unlikely that they were familiar with raised field agriculture. Inca State agricultural production seems to have focussed on (almost to an obsession) terrace construction and irrigation systems (Donkin 1979; Farrington 1983; Sherbondy 1982). In the Lake Titicaca Basin there appears to have been an Inca emphasis on developing production on the islands (Amantani, Taquile, Isla del Sol, Isla de la Luna) and large protected peninsulas (Copacabana, and Capachica) by constructing and/or expanding the terrace systems. It seems their interest lay primarily in expanding the production of altiplano maize varieties for the support of the state ceremonial and administrative centers.

The Spanish first explored the Lake Titicaca region in 1533. The first Spanish influence in the area occurred much later in 1538 (Julien 1983). Inca control probably collapsed soon after the capture of Cuzco. According to Pease (1982:179), Inca mitmaq colonists returned to their homelands soon after the

Spanish conquest. This, in addition to epidemics, conscripted mine labor, and civil wars, would have quickly depopulated the Huatta area, thus eliminating the labor force necessary for raised field agriculture, even if knowledge of the technology was still alive.

In summary, the second abandonment of raised fields may have been partially a result of the social, economic and political disruption caused by the Inca conquest. Inca policies in Qollasuyu and the lake area may not have included raised field construction or may have simply de-emphasized it. Once the raised field technology was forgotten, the fields were abandoned and never reused. I have argued for a socio-political cause of raised field abandonment. It is possible that a natural event, such as a long term drought or inundation, contributed to the demise of a system already stressed to its limits. However, even if this was the case, we must understand the socio-political context of this event in order to explain the agricultural change that resulted.

The final abandonment of the raised fields probably occurred after the Spanish arrival in the Lake Titicaca Basin. Depopulation because of epidemics, warfare, and mine labor exploitation, man-made environmental degradation, and the introduction of new economies, especially sheep and cattle pastoralism in the pampas surrounding the lake, disrupted the infrastructure necessary for raised field agriculture and lessened the need for such highly productive systems.

7.6 THE URU, CHIPAYA, AND PUKINA:
THE PREHISTORIC RAISED FIELD AGRICULTURALISTS

I argue that the Uru, Chipaya, and/or Pukina or groups practicing a similar wetland subsistence economy were the first to develop and utilize raised field agriculture in the Lake Titicaca Basin. These Formative cultures in the Lake Titicaca Basin during the Early Horizon and early part of the Early Intermediate Period expanded this highly productive subsistence strategy to support a much denser population and more complex social organization than previously existed in the Lake Titicaca Basin. This, in turn, provided much of the stable agricultural base for larger polities such as Pukara, Tiwanaku and the later Aymara Kingdoms.

The Uru have been considered, from their first recorded mention until the present, to be the most "primitive" and "barbaric" of altiplano peoples (LaBarre 1941, 1963, Wachtel 1986; Julien 1982; Vellard 1954, 1963). "Uru" is an Aymara word meaning "worm," a despective term which was certainly never used by the people to describe themselves. This term probably was used by the dominant Aymara, Inca, and later Spanish to lump all of the non-Aymara speakers including the Uru (Uruquilla), Chipaya and Pukina, and never referred to a single language group. The Aymara refer to the Uru as uma haque ("water people" Aymara) (Bouysse-Cassagne 1986:207), while the Lake Titicaca Uru refer to themselves as Kot'suns ("people of the lake") and the

Chipaya consider themselves Jas-shoni ("water people") (Wachtel 1986:284). The following discussion focuses primarily on the historically known Uru of the wetlands, rather than the Chipaya, who presently occupy pockets of the central and southern altiplano of Bolivia and practice an economy based primarily on pastoralism.

7.6.1 The Uru, Chipaya, and Pukina

as Linguistic Groups and Their Distributions

The term "Uru" has been used in many different contexts throughout recorded history. In the chronicles, archival, and visita documents, the term has been used to refer to a language, language group, ethnic group, status classification, a grouping for tax and tribute purposes, an economic lifestyle, and as a derogatory epithet (LaBarre 1963, 1941; Torero 1987; Julien 1982, 1983; Horn 1984; Bouysse-Cassagne 1986; Wachtel 1982, 1986). The confusion in the literature reflects the complex and sometimes contradictory social classifications imposed in the area over hundreds of years of domination of the Uru and related groups by the prehistoric Aymara, later the Inca and Spanish, and the present-day Quechua, Aymara, and non-indigenous peoples of the altiplano.

It has been commonly speculated that the Uru represent some "leftover of a very early, pre-Aymara population" who were pushed into less desirable ecozones" (Wachtel 1986:283). Linguists and ethnographers have debated the issue of Uru (or Uruquilla) language relationships for many years, some

suggesting ties to the Pukina, another altiplano language that was important at Spanish contact, which is believed by some to be related to Arawak, but this is still unconfirmed (Wachtel 1986:284; LaBarre 1941:496-500).

The native non-Aymara languages of the Lake Titicaca Basin, Uru, Chipaya, and Pukina, were spoken by large groups of people at the time of the Spanish conquest. It is generally believed that Uru and Chipaya are closely related (Wachtel 1986; Julien 1983, LaBarre 1941) and that the Uru-Chipaya spoken today is the same language that was referred to in early documents as Uruquilla (Julien 1983:62). Most agree that Uru-Chipaya and Pukina are separate languages (LaBarre 1941:496-499; Torero 1987; Chamberlain 1910) and this is supported by the archival data (Julien 1983:62). Although separate languages, I believe that speakers of these these language groups were commonly lumped as "Uru" by both the Spanish and the Aymara. Because the distribution of these groups maps the distribution of wetlands (although Pukina has a wider distribution), I also argue that these groups traditionally had similar, if not identical, lacustrine and riverine-oriented economies.

The origins and relations to the Uru, Chipaya, and Pukina languages have been debated for years (LaBarre 1941, 1963; Wachtel 1986). These languages were not studied or recorded in detail by linguists and they are not commonly spoken today; thus, interpretations are based on limited vocabulary lists. Once, Uru-Chipaya was thought to be related to Arawak and believed to

be a highland branch of the Proto-Arawak (Noble 1965; Greenberg 1960), but this is not now generally believed to be the case (LaBarre 1963; Stark 1968, 1972b; Wachtel 1986; Olsen 1964, 1965; but see Wachtel 1986:308 footnote 3). Through comparative linguistic analysis, Olsen (1964, 1965) argues that Chipaya is genetically related to Mayan. Stark (1968, 1972b), expanding on this idea, demonstrated that the Uru-Chipaya language was related to Yunga, which is now extinct, but which played an important role as a prehistoric lingua franca among coastal cultures. Yunga was clearly related to proto-Mayan (ibid.). Lathrap (1977:743) argues for a proto-Mayan hearth within the northern Andes, possibly associated with Monzu ceramics dating to approximately 3,000-4,000 B.C.. Lathrap (1970; 1977) has proposed a demographic and ecological model based on archaeological data to account for these distributions. Lathrap suggests that Aymara may have been the language spoken by the pastoralists and hunters within the puna environmental zone during the Formative Period of the southern Andes, a language possibly associated with this zone as far back as Ayampitin occupations at 5000 B.C.. The ancestral Uru-Chipaya, according to this hypothesis, migrated into the wetland zones, believed to have been an unutilized or underutilized niche before 1500 B.C. (Donald Lathrap: pers. comm. 1988). This division between two distinct economies developed into the sharply divided ethnic, later becoming associated with social status and tax rankings. I will argue below that a primitive form of "Uru" wetland economy, possibly associated

with Uru-Chipaya speakers, must have been present much earlier than 1500 B.C., because the wetland zones around Lake Titicaca were much too rich to have been ignored by early hunters, fishermen, and gatherers.

Pukina may have been the language of Tiwanaku during the Early Intermediate Period and Middle Horizon (Torero 1980:151 1987; Hardman 1985:627), although others suggest that the language of Tiwanaku was Aymara (Browman 1978a; Browman 1984; Browman et al. 1988).

Language distribution can be traced through historical documents from the early colonial years, and extrapolated back into the Late Intermediate Period and Late Horizon of the prehistoric period. The geographic lists of languages compiled by the church for the priests working in the Lake Titicaca Basin indicate that the major languages were Aymara, Pukina, Uruquilla, and Quechua (Julien 1983; Torero 1987). It is important to note that the modern distribution of these languages is not the same as their prehistoric distribution (Julien 1983:45-51). Aymara was clearly the most important language of the basin during the Late Intermediate Period, stretching from 30 miles south of Cuzco far into southern Bolivia. Uru or Uruquilla-speakers (certainly including Chipaya) were concentrated in the far south around Lake Poopo and within the islands in the Rio Desaguadero. Pukina language was spoken throughout the area of distribution of Aymara, but was most common in Paucarcolla, Coata, and Capachica and other areas near the lake and inland to the north and east,

traditionally considered the Umasuyu area (ibid.). Quechua speakers apparently lived in enclaves throughout the basin, most likely a result of the Inca mitma policies of the Late Horizon (ibid. 51).

At one time Pukina was much more extensive, and old documents even refer to Lake Titicaca as "Lake of Pukina" (Bouysse-Cassagne 1986:207). Most Pukina speakers were found in the areas near the lake or immediately adjacent, a distribution similar to that of the historic and present day Uru (both social and linguistic classification). The language is now extinct except for a variation spoken by the Callahuaya curers of Charassani, Bolivia, where a Pukina lexicon is combined with a Quechua grammar (Stark 1972a:199-201). There is general agreement that Pukina is distinct from the language family which includes Uru-Chipaya language (LaBarre 1941; Torero 1980, 1987; Chamberlain 1910), although Julien demonstrates that they were clearly separate as ethnic and tax groups during the early colonial period (ibid. 57; 62). The Pukina and Uru often lived together near the lake (Julien 1983:57). I would argue that in the eyes of the Aymara and Inca, the Pukina vs. Uru-Chipaya distinction was vague in terms of class status and economic lifestyle, and these groups became generically referred to as "Uru."

In the early colonial period, the Uru (including the Chipaya and Pukina) lived primarily in or near wetlands in a widely including the Rio Azangaro, Lake Titicaca, the Rio Desaguadero,

Lake Poopo, the Rio Lacajahuira, and Lake Coipasa (Wachtel 1986:283). Most settlements today are located in what are considered "marginal" areas, particularly for western agriculture, and possibly for the Incas and Aymaras of the Lake Basin. The number of Uru-Chipaya speakers has continually declined in the past several centuries, and today the language is spoken only in a few small enclaves.

7.6.2 Ethnicity, Class, and Tax Status in the Lake Titicaca Basin

Most of the confusion regarding the distribution of various language groups in the Lake Basin during the late prehistoric and colonial periods is due to the inconsistent use of the terms to refer to linguistic communities, ethnic groupings, economic occupation, and status or class groupings (Julien 1982:134, 1983; Wachtel 1986). In the Toledo document (1975) from 1570-1573, the terms "Aymara" and "Uru" were used as tax and tribute classifications by the Inca, the Spanish, and the Aymara kurakas or malkus, and was divorced from linguistic affiliations. People of the Uru classification paid half the amount paid by people classified as "Aymara" (Julien 1982; Wachtel 1986). These classes did not necessarily correspond to language groups because "rich" Uru-Chipaya speakers could be classified as "Aymara." The Aymara classification was considered much more prestigious than the Uru, which always had a perjorative connotation. The Uru class paid taxes in weavings, thus they

must have been competent in this technology and have had access to raw wool and fibers. Chufío was also a tax item required of the Uru during the Inca period, implying production of potatoes and/or access to a locale away from the lake that was suitable for freeze-drying.

The most well-to-do Uru-Chipaya populations, and the majority of the Pukina speakers, appear to have been located in the northern lake Basin. The Inca quipu census from Chucuito indicates that there were also large Uru populations in the towns of Chucuito, Acora, and Ilave, which are all good fishing and wetland resource areas, and are presently the areas of densest rural populations in southern Peru. The remains of raised fields are concentrated in these areas.

7.6.3 The Uru Economy

Historically-known and present-day Uru settlements are generally located at the edges of totora swamps or within them. House sites are commonly found on old levee formations, prehistoric occupation mounds, and artificial floating islands of totora reed. Very little is known about the social organization of the Uru, but divisions into ayllus and moieties, similar to those of Aymara communities, have been documented (LaBarre 1941:513-519).

Uru subsistence economy is based on fishing, hunting of wild game (in particular water birds), and gathering of lake resources. The ideal zones for Uru settlement are within the dense totora reed swamps in the lake shallows, where fishing and

bird hunting are optimal (LaBarre 1941:495). Fish are the main food of the Uru. Weirs made of bundled totora and nets are used in rivers and shallows surrounding the lake, and nets with large circular wooden frames, drag nets, and wooden fishing spears are used in more open water (LaBarre 1941:510-511). Hunting is almost as important as fishing to the Uru (ibid. 512). Waterhens, ducks, geese, loons, herons, diving birds and gulls are the favored prey. Individuals hunt these by hand from blinds, with slingshots, and with bolas; and communal groups hunt with nets (ibid. 513). Bird eggs are also regularly collected for food.

Totora reeds are of major importance in the Uru economy. Roots and stalks are eaten, and they serve as raw material for "fish weirs, supports for bird-nests, root-mats, floor- and sitting-mats, rafters, doors, balsa-boats and their sails; and the few cattle they have browse upon the roots of totora as well" (LaBarre 1941:513).

Today, Uru agriculture is limited. The main crops are quinoa and cañihua and bitter potatoes for making chuño during the dry season (LaBarre 1941:510). Most agricultural products are obtained through barter with neighboring farmers. This apparently was not the case, at least for the "rich" Urus during the Late Intermediate Period and Late Horizon who controlled extensive tracts of agricultural land in certain areas throughout the basin.

The Uru also practice animal husbandry (pigs, donkeys,

sheep, cows, chickens), but less so than their Quechua and Aymara neighbors. They have developed specialized techniques because of the lack of grazing land available to them. Most Uru in the 1930's and 1940's owned animals that were fed on aquatic lake vegetation (totora, llachu, algae). Grazing animals can wade into the water up to a certain point, but most of the forage must be cut daily and brought on balsa boats to the islands. The Chipaya of Lake Coipasa have evolved an elaborate system of rotational irrigation to produce edible roots and grasses for raising pigs (Wachtel 1976).

The Chipaya have a much more mixed economy successfully combining pastoralism with potato and quinoa agriculture (Vellard 1954, 1963; Metraux 1934a, 1934b, 1935a, 1935b, 1935c 1936a; Wachtel 1986). I argue that the Chipaya have been somewhat marginalized from their original environment, the wetlands of the Rio Desaguadero and the Lake Poopo marshes. The economy of the Chipaya of the Lake Coipasa region in southern Bolivia probably reflects more accurately the past situation. Unfortunately, we know virtually nothing about the economy of the Pukina other than that many of them in the Lake Titicaca region also had a wetland orientation, in addition to practicing pastoralism and hillslope farming.

7.6.4 The Uru Today

Despite the present low numbers of Uru-Chipaya-speakers (most Uru now speak Aymara or Quechua), an Uru-like wetland economy thrives in both Aymara and Quechua communities in and

around the lake shallows, especially centered in areas where prehistoric raised field remains are located. The present-day Uru of the Bay of Puno speak Aymara and Quechua. These Uru rely heavily on fishing and the sale and trade of roofing material and mats made of totora reeds, in addition to a small income from tourists visiting the floating islands. Many believe that these lake people have nothing to do with the original Uru inhabitants of the lake, who were driven out of the Bay of Puno by the long extended droughts of the 1940's and 1950's when the totora reed they relied upon disappeared (Nuñez 1984; Monheim 1963; Vellard 1963). Whether or not these groups are linguistically or ethnically Uru does not concern me. These groups do practice an Uru economy based on lacustrine resources which I believe is analogous to that of original Uru of Lake Titicaca and Lake Poopo. The Quechua of Huatta and Coata still rely heavily on the lake for their subsistence, and combine this Uru-like economy effectively with farming (see Chapter 2). The present-day Morato Uru of Lake Poopo have been discussed by Horn (1984) and the Uru-Chipaya of Lake Coipasa have been discussed by Wachtel (1976, 1986).

7.6.5 The Uru during the Inca and Colonial Periods

Today, the Uru only number some 2000, but at the time of Spanish contact, they made up approximately a quarter of the Lake Titicaca and Lake Poopo population (Wachtel 1986:283; 307). The early documents on the Lake Titicaca region show that a large

part of the total indigenous population during colonial times were classified as "Uru" and "Pukina," and in some districts, the Uru population outnumbered the Aymara (Julien 1982; Hyslop 1976, Wachtel 1986). Pukina was also considered to be one of the leguas generales of Peru (Julien 1982; Torero 1987).

Wachtel has recently analyzed archival and census data on the Uru, and describes the complex situation wherein the term Uru "partakes of ethnicity, lakeside specialization, and social stratification" (ibid. 284; also see Julien 1983). Wachtel points out that, according to Toledo's "general inspection" of 1573-1575, the Uru comprised 16,950 (and the Aymara 52,623) of the 69,664 households owing tribute; from this Wachtel extrapolates a total population of 80,000 Uru (ibid. 285). The population varied within the districts surveyed, but the Uru populations were generally highest near the lake, and lower in the wetland areas away from it. Coata's population was 100% Uru. The censuses of Toledo and Garcí Diez ([1567] 1964) in Chucuito both place the Uru as a low-status class, but also refer to them as ayllus, and as an ethnic group (also see Julien 1982). Wachtel indicates that Uru were considered to be of yana, servants of local kuraka lords, in some communities. Commonly stated in the literature is that the Uru paid no tribute to the Inca. Wachtel argues that this was part of their yana status (1986:285-292). Because of their lacustrine economy, the Uru could easily provide goods from the lake to their Aymara lords, and they also provided agricultural labor (ibid. 291-2).

According to the Garci Diez document, not all Uru were at the low end of the social stratification; the Uru of Coata did not have an Aymara kuraka, but their own leader, and presumably their own agricultural fields (ibid.). Some of the Uru were considered as "Aymara" because they owned large tracts of land and maintained large herds (Wachtel 1982:204). The Uru of Paria (Lake Poopo) controlled a large area of prime agricultural land in the Cochabamba Valley, which Wachtel argues was a true Uru vertical archipelago or this archipelago may have been established under the Inca rule of Huayna Capac as a state archipelago (ibid.; 1986:295-296).

During the Colonial Period, the Uru were generally taxed at a much lower rate than the Aymara because of their poverty and lack of land. Wachtel (1986) indicates that there were exceptions to this generalization. The Uru of Yunguyo and Zepita were taxed the same as the Aymara, since they controlled productive agricultural fields and lake resources. They were considered "rich," and to increase their prestige, they offered to pay more tribute than their Aymara neighbors (ibid. 293-295).

The Uru were not considered by most chroniclers to be agriculturalists, although we now know that many were cultivators. In addition to planting the extensive agricultural lands they controlled in the Coata area, Urus cultivated crops on floating islands within the swamps. Balthesar Ramirez reports in 1597 that:

Los indios Vros es gente que bibe en las lagunas,
como en la laguna de Chuquito y en la de Paria y en

otras partes. Estos hazen sus casas en el agua sobre vnas balsas de heno o enea, que el el Pirú se llama totora, y en la Nueva España, tule; estas balsas con el tiempo crian por lo baxo sus raizes. y se entrapan y texen de manera que se convierten en céspedes. y así echándoles alguna tierra encima. siembran en ellas algunas cosillas que comen (Balthesar Ramirez in Maurtua [1597] 1906:295-296, emphasis added).

Early floating island gardens similar to these may have been the prototype for raised field agriculture (Figure 55). In addition to cultivation on the floating islands, the Uru practiced animal husbandry. In 1632-1633 during a Uru pacification campaign, the Spanish and Aymara captured seven hundred pigs and thirty llamas on floating island sanctuaries in the Zepita swamps (Wachtel 1986:303). These, along with the Uru archipelago in Cochabamba mentioned above, indicate that at least some Uru groups were successful farmers of both the pampas/lake edge and the valleys during the Late Intermediate Period, Late Horizon, and into the Colonial period.

Wachtel documents that the Uru were also well-organized and successful fighters who terrorized the Aymara and Spanish for many centuries by attacking and looting settlements, only to return to the safety of their swampy hideouts (ibid. 302-304). Various battles and campaigns were fought to pacify these Urus.

In summary, Wachtel has demonstrated that the Uru "primitivity" and "backwardness" are "the end product of a long process of domination and rejection" (ibid. 306-307). The archival material demonstrates that the term "Uru" combines ethnic, linguistic, social, and economic connotations. Many Uru were obviously highly-successful farmers living in large



Figure 55: Uru farming on floating islands of totora reeds, Los Urus, Bay of Puno. The potatoes here are growing in rich organic mucks which have been dredged up from the shallow lake bottom. This may be the prototype from which raised fields evolved.

independent Uru communities, while others were the major labor force and suppliers of lake products to Aymara lords, and some were independent and rebellious fishermen. This history of domination and rejection is also useful in understanding the prehistory of the lake basin. The process of domination and rejection probably began with the spread of Aymara influence during the Middle Horizon, and culminated with the establishment of the Aymara Kingdoms in the Late Intermediate Period, when the Uru were considered a low status, inferior ethnic class. Different degrees of assimilation, domination and conflict of different Uru groups made simple classification according to linguistic, or social status inappropriate. As a result, the term "Uru" was applied inconsistently in heterogeneous contexts during the Colonial Period, as the people who had been Urus (linguistically, ethnically, and economically) diversified.

7.6.6 Prehistory of the Uru, Chipaya, and Pukina

Although originally an important political and economic force, the Uru, Chipaya, and Pukina lost power and were marginalized as political power became concentrated in the urban religious center of Tiwanaku. In the following discussion of prehistory, I will use the term "Uru" for the people who practiced a specific economy or lifestyle, the wetland orientation which led to the development of raised field farming, rather than a specific ethnic or linguistic affiliation, although originally this orientation was shared by speakers of distinct

languages (Uru, Chipaya, and Pukina) and ethnic identities. The later connotation of low status probably was applied to all of the groups with a wetland orientation, although some were undoubtedly relatively wealthy.

If Uru populations were so dense and numerous in certain locations in the Lake Titicaca Basin during the Late Horizon and early Colonial Period, where is the archaeological evidence? In his site survey of the Lupaca Zone, Hyslop (1977:194-199) was unable to distinguish between Uru and Aymara remains. He suggests that Uru remains will be found in Tiwanaku IV sites, commonly located near the lakeshore, or perhaps the sites have been destroyed by lake level changes or wave erosion, such as in Pilcuyu on the Ilave Peninsula.

The Uru settlements are not archaeologically invisible. I believe that most, if not all, of the occupation mounds around the lakeshore and within the lake were once Uru settlements. Since the Uru were also lake edge agriculturalists (as argued above) in addition to fishermen and hunter-gatherers specializing in lake resources, it would be difficult to distinguish them from other farming groups. Horn (1984) has discussed the problems of archaeological Uru visibility, based on ethnographic analogy with the Morato Uru of the Lake Poopo area. Although ethnic markers would be difficult to determine archaeologically, evidence of Uru ecology and economy can be recovered from archaeological sites. The large amounts of fish and bird bone, bola stones, net weights and other hunting equipment found at

sites such as Chiripa (Erickson 1976; Erickson and Horn 1977; Horn 1984), Pancha and Kaminaga (Erickson 1988) provides a strong argument for an Uru presence. The use of aquatic plants for animal forage is evident from the presence of aquatic gastropods which are associated with these plants in flotation samples from middens. The spatial concentrations of the hundreds, perhaps thousands of occupation mounds, both large and small, within the wetland zones around the lake reflects the same distribution of Uru settlements during the Inca period, the Colonial and Republican periods, and today. Not surprisingly, these are also the areas where remains of prehistoric raised fields are concentrated.

I suggest that a common ceramic form, the neckless olla, in addition to the flat bottomed, reinforced-rimmed bowls found in the pre-Pukara strata of Pancha and Kaminaga and in surface collections on other sites in the Huatta area, are related to the Uru (Erickson 1988). Lathrap (1977:740-744) has argued that the "pumpkin tecomate" and the "neckless olla" form found throughout Nuclear America is associated with Proto-Mayan speakers, possibly from a hearth in lowland Colombia. The neckless olla form in the Lake Titicaca Basin may be a much later Uru derivative of this tradition.

Throughout recorded history there has been a constant dialectic between the Uru and Aymara of the Lake Titicaca Basin. The Uru have been considered a low status ethnic groups, almost status class, under the ruling Aymara kurakas during the early

colonial period, under the Inca administration, and under the regional Aymara lords of the Late Horizon. Apparently this stratification also applied during the Late Intermediate Period Aymara Kingdoms. During the Middle Horizon, this relationship is not so clear. If Tiwanaku was an Aymara phenomena (Browman et al. 1988; Browman 1984; Ponce 1972), the Uru probably held the low status they held in later periods. But, if Tiwanaku peoples or the Tiwanaku elites were Uru, Chipaya or Pukina speakers (Torero 1980:151, 1987; Hardman 1985; Lathrap 1976 pers. com.), the Uru may have been in control of an empire until it collapsed. Certainly, the roots of Tiwanaku and Pukara are in Formative lacustrine-oriented economies of the Early Horizon and Early Intermediate Period such as Chiripa, Qaluyu, Pukara, and presumably the early phases (Tiwanaku I-II) at the site of Tiwanaku. A strong argument can be made that these cultures had a wetland Uru economic base, and most probably were Uru-Chipaya-Pukina speakers.

The relationship of Uru to Pukara during the Early Intermediate Period is not clear. I argue above that the Early Horizon cultures such as Chiripa, Qaluyu, and Wankarani (of the Oruru wetlands) practiced an Uru economy, and possibly speaking Uru, Chipaya, or Pukina. The ceremonial-urban center of Pukara is located at the edge, not the center of a wetland area. Many regional rural Pukara sites are located near the lakeshore and within areas where raised fields are found. The type site appears to have been located in the optimal location for equal

access to the puna highland grazing regions and the highly productive lakeshore plains, and also provided access to the major trade routes between the Lake Titicaca Basin and the Cuzco Region, the Arequipa valleys, and the coastal valleys of southern Peru and northern Chile (Mujica 1985; Lumbreras 1974a, 1974b, 1981). Lumbreras argues that the basis of Pukara economy was alpaca pastoralism, which is generally associated with the Aymara, although the alpaca is more readily adapted to lowlands and wetland environments than other camelids. Associated with the site of Pukara are thousands of hectares of gocha agricultural remains, unfortunately undated, which suggests that the farmers of the Pukara urban center were directly involved in hydraulic wetland agriculture. This is certainly the case for the rural Pukara farmers in Huatta, where extensive raised field complexes were constructed and maintained during the Early Intermediate Period.

The Uru vs. Aymara dichotomy is a long-standing distinction based on different ecological and economic adaptations. Lathrap (pers. com. 1977) has argued that the Ayampitin Culture (5000 B.C.) of southern Peru and Bolivia were Aymara-speaking hunters who domesticated llamas and alpacas, began potato and quinoa agriculture, and adopted an economy focusing primarily on camelid pastoralism. This is expressed in the Wankarani Culture during the Initial Period and Early Horizon of the altiplano. On the other hand, the Uru culture evolved out of a wetland focus, represented by Qaluyu and Chiripa during the Early Horizon and

Early Intermediate period and possibly later Pukara culture during the Early Intermediate Period. The contrast between the non-wetland environment and economy of the Pukara ceremonial-urban center north of the lake basin and the rural lakeshore Pukara communities practicing raised field agriculture may demonstrate that the distinction between Uru wetland farmers and local elites extends back to the Early Intermediate Period. The marginalization of raised field farmers became extreme during the Tiwanaku Empire of the Middle Horizon, the Aymara Kingdoms of the Late Intermediate Period, and the Inca Empire of the Late Horizon.

The economic adaptation distinction between Urus and Aymaras is expressed cogently in concepts of Aymara space. In indigenous Aymara cosmology, there is a sharp distinction between Umasuyu and Urcosuyu (Bouysse-Cassagne 1986; also see Julien 1983). The Umasuyu zone is characterized conceptually by wetlands and well-watered valleys, and extends from the lakeshore to the eastern slopes northeast and east of the Lake Titicaca Basin, an area now populated by both maize and potato agriculturalists. The Urcosuyu zone is characterized conceptually as the highland puna areas, and lies south of Lake Titicaca, a zone commonly associated with pastoralism. The Aymara word "uma" is the term for water, and is conceptually and spatially related to wetlands and lowlands (Bouysse-Cassagne 1986:206-209, 223; Bertonio [1612] 1984). Many of the communities listed for Umasuyu (Wachtel 1986; Julien 1983; Bouysse-Cassagne 1986) are areas where extensive

raised field remains are located. although the main block surrounding Huatta is within Urcosuyu.

Even while under Aymara domination, the Uru still may have been constructing and maintaining the raised field systems. The surplus produced by this form of agriculture is considerable, and such an efficient farming system would have been encouraged by the Aymara elite as a source of revenue. The large Uru populations within most of the wetland raised field areas during the late prehistoric period is evidence of the continuation of raised field use, although it may have been very limited.

7.7 WETLAND RESOURCES AVAILABLE TO PAST RAISED FIELD FARMERS

The wetlands of Lake Titicaca provide not only a rich resource base for hunting, fishing, and gathering cultures of the past and present, but also would have been very important for the early agriculturalists, both as a context for early development of cultivation systems and intensification of these systems. As I have argued in Chapter 3, the practice of raised field agriculture would have expanded the desired wetland environmental zone artificially far into the pampa through construction of canal networks, reservoirs and other water distribution and conservation engineering features. Discussed below are some of the advantages of the wetlands based on environmental studies and ethnographic investigation of wetland economies in the Lake Titicaca Basin with a focus on the Huatta pampa.

7.7.1 Soils

The soils of the fluctuating lake edge near Huatta belong to the Limnos Series of the Limnos Association (ONERN-CORPUNO 1965 vol. 3 Chapter V:12-15). These soils are intrazonal, developed in association with a high water table and processes of gleization. They are of Holocene and Pleistocene lacustrine sedimentary origin. These soils are seasonally inundated, have low relief, and are very poorly drained. They have extremely high organic matter content due to the continuous accumulation of aquatic vegetation. The O1/O2 Horizon characteristically contains 27% organic matter, the A11 Horizon contains 15%, and the A12 Horizon with 5% (ibid). Some 25-30 cm of the upper profile is mineralized silty loam; under this lies a gleyed, poorly-developed B Horizon 25-50 cm thick. The pH of these soils is high, ranging between 8.4 and 8.8. Phosphorus is found in medium low levels, and potassium is medium to high. The ONERN-CORPUNO study notes that, despite the relatively high fertility of these soils, they are not suitable for agriculture because of poor drainage, and they are recommended only for temporary pasture or for wildlife use (ONERN-CORPUNO 1965).

7.7.2 Aquatic Vegetation

The vegetation of the lakeshore and lake shallows is very diverse. In the ONERN-CORPUNO classification, the vegetation of this zone belongs to the Scripetum and Junchetum Associations. The predominate species in the Junchetum Association are Juncus imbricatres and J. dombevanus, with Calamagrostis rigescens, C.

heterophylla, Luzula sp., and Hypochaeris sp., Carex sp., and Cyperus sp. in the drier areas. The Scripetum Association ("totoraes") is characterized by the predominance of Schoenoplectus totora, with aquatic communities of Rupia maritima, Helodea sp., Potamogetum sp., Myriophyllum sp., and Chara sp. (locally known as "llachu"). Collot (1980:46; 95) calculates the total biomass (dry weight) of the shallows of the Bahia de Puno is 585,200 tons; of this, 202,000 tons are totora alone. Although only a small portion of the total area, the littoral zone produces 30% of the primary production of the lake (Hanek 1982). The littoral zone is very important in the economy of the lakeshore dwellers, and nearly all Huatteenos have access to its resources. The residents of Yasin, and most of Faon, live permanently on the edge of this zone or within it.

The totora is the most highly-valued littoral plant. The spongy, slightly sweet, lower inner stalk (chullu) is considered by Huatteenos a special treat, and is especially favored by women and children. The roots (sipe) rich in concentrated starch nutrients and the stalk (gaku) and leaves provide forage for cows, pigs, sheep, burros and horses. During periods of prolonged drought, the roots are eaten by humans, and informants say that totora sustained many Huatteenos during the droughts of the 1940's and 1950's (also see Nuñez 1984:17).

The totora plant is also a valuable construction material. it is used for thatching houses and although metal roofs are more prestigious, every compound has at least one structure roofed

with totora. The stalks are tied into bundles or mats, placed on the roof, and covered with a layer of ichhu. Mats made from totora are used as mattresses, and to build temporary shelters and storage facilities for harvested crops. Bundles of totora are also used to construct the famous balsa boats of Lake Titicaca, and few Huatteenos have wooden boats. The Urus living in the Bay of Puno use totora to form floating platforms for their living structures. These massive beds of interwoven mats form a spongy, but relatively dry and stable living surface.

Nuñez (1984:7-13; 16-17) has demonstrated that the traditional exploitation of totora is carefully controlled by the lake shore communities. Each community or parcialidad carefully delineates its totorales from those of other communities and jealously protects them against use by others. In some communities, careful scheduling of harvest is enforced. Today, many of the totorales are individually controlled, and through a process similar to the development of minifundia on agricultural and pasture land, they are being divided into smaller and smaller holdings (ibid).

In Huatta, totorales are both privately and communally owned. Ownership of lake edge property permits access to the adjacent llachu, totora and fishing resources. Networks of kinship, marriage and compadrazco allow most Huatteenos direct access to the lake and lakeshore resources. Large totorales located from several hundred meters to a kilometer from shore are considered a communal resource, available to all members of the

community. Disputes occur when Coata farmers and fishermen begin to cut the totorales claimed by Huatta, sometimes resulting in legal suits. The Reserva Nacional del Bahía de Puno, established in 1978, has attempted to establish norms for totora exploitation and to protect community rights in delimited sectors, but it has been largely inefficient. The government agency has aided only the Urus, who were able to gain control over large areas of totora (Nuñez 1984:10-13).

Despite traditional controls against overexploitation, the increasing commercial use of totora has not allowed stands to regenerate in many areas. Because of this overexploitation, the farmers and fishermen must go into deeper areas to harvest it, a time-consuming and dangerous task. Recently, totora has been cultivated to a limited extent by some Huattekños and Coateños. Near Pojsin Karata in Coata, and Isla Karata and Yasin in Huatta, where the totorales had begun to disappear, stands have been regenerated by planting the roots in the shallow lake bottom. This form of cultivation, in addition to the planting of seed, has been reported for other areas in the Lake Titicaca Basin, the Central Andes and the coast of Peru (Erickson 1976, Nuñez 1984).

Llachu, the general name for non-totora aquatic vegetation, is the second most important vegetable in Lake Titicaca, the Rio Coata and Rio Illpa, and the shallow seasonal lakes of the pampa. The major species of aquatic macrophytes of the Bahía of Puno and Huatta area of Lake Titicaca are Myriophyllum, Elodea,

Potamogetum, Chara, Nitella, Schoenoplectus tatora, and Sciaromium (Collot 1980:24-29).

These aquatic species are a major source of forage for the domestic animals of Huatta and Coata. Cattle are driven into the shallows of the lake to graze on the floating and submerged vegetation. In areas where the llachu has been overexploited, or when the lake suddenly rises, campesinos cut the underwater weeds with blades attached to long poles and mound the harvest on large specialized balsas. Great quantities of llachu are brought to ashore, and the small littoral occupation mounds of Pojsin Karata, Lluco, of Coata and Yasin, Uchuymoro, and Isla Karata (Huatta) have essentially become feedlots for domestic animals. ONERN-CORPUNO reports that llachu is more nutritious for cattle than alfalfa (ONERN-CORPUNO 1965:Chapter VI vol. 4:18). Collot's analysis of the nutrients in different species of llachu and totora indicates that most are very rich in nutrients and minerals (1980:67, also annexe III),

In Collot's classification (1980:30-37) of the major aquatic plant associations for altiplano lakes (particularly Lake Titicaca), depth appears to be the most significant factor effecting aquatic vegetation distribution. This produces wide band zonation of the different aquatic plant communities along the edges of the lake.

Dense communities of llachu act as silt traps for the sediments borne by rivers and seasonal streams. These vegetation communities are also the habitats of several species of wildlife,

especially aquatic birds and fish. The spongy mats of dense floating vegetation provide foundations for bird nests and protection of small fry. The heat storage capacity of the shallows is increased by the aquatic vegetation, and the higher temperature produces faster rates of photosynthesis, organic decomposition, and mineralization of nutrients. We found that the water temperature in the shallow littoral zone was much higher (over 5°C) than that of the open lake. Monheim (1963:146) reports that water temperatures within the aquatic vegetation littoral zone are normally 4.5°C higher than in the other areas and in dense vegetation, up to 25°C higher. The bays and shallows around the Lake Titicaca are known to have lower levels of dissolved salts than the main lake (Serruya and Pollinger 1963:90).

These aquatic plant associations, especially as they respond to water depth, are an important element in raised field agriculture. The most important aquatic plant (wetland) communities for raised field agriculture are those that produce well between 0 and 2 meters depth of water, the Shore and the Myriophyllum-Elodea Associations. The maximum depth of the raised field canals was probably 2 meters, although canals with permanent water would have provided stable environments for these vegetation associations, many species can become established within a single growing season. In effect, the construction of raised fields created an extension of the littoral zone of the lake far into the pampa. Colonization of aquatic flora in the

canals brings the production of nutrients (used as green manure or left to decompose to a rich organic muck) directly into the raised field system. In addition, raised field system would expand the littoral habitat for economic fish and birds.

Lake level fluctuations drastically change the distribution of these plant communities, which are, of course, important as green manure in raised field canals. During the flooding of 1985-6, the floating vegetation moved inland with the rising water, and shallow water communities became established within several weeks; the colonization of previously shallow areas by deeper species was somewhat slower. Huatteenos report that after such a flood, the fertility of the pampa soils is greatly improved.

7.7.3 Fauna

7.7.3.1 Fish

The fish population is densest in the littoral zone of the lake (shallower than 10 meters) (Hanek 1982:10-24). Some 80% of the fish production in Lake Titicaca is in the littoral zone. The most common species in the littoral zone [see page 10] are Orestias agassii (white carachi), O. luteus (yellow carachi, a benthic feeder) and occasionally Trichomycterus rivulatus (suche), with mean weights of 147 grams, 130 grams and 469 grams respectively. Orestias sp. (ispi) is found in deeper pelagic waters such as the river channels of the Coata and Illpa rivers within the littoral zone, and the open lake. The most commonly

caught fish in the Huatta area is the yellow carachi, which appears to be the most numerous fish in the lake shallows. All species of carachi are important in both the local and regional markets. The carachi and other lake fish probably provide most of the protein in the diet of indigenous highland populations of the Lake Titicaca Basin. Huge quantities of carachis are shipped each week to the Puno market and sometimes sent as far away as Arequipa and Cuzco.

7.7.3.2 Birds

Some 84 species of birds have been reported (Smith in Hanek 1982:6) from the Lake Titicaca area, 10 of which are common in the littoral zone: Andean gull, coot, moorhen, cormorant wader, duck, tyrant-bird, hummingbirds, flamingo, and flightless grebe (Serruya and Pollingher 1983:95-6). In the shallows of Isla Moro and the SAIS Buenavista near Huatta, dense populations of both migratory and native birds are found. Birds, especially ducks, are regularly hunted by fishermen and lake-edge farmers. Today the main weapon is a crude blackpowder musket or slingshot. Traditionally, nets and bolas were used in the Huatta area. Bird egg collecting is also an important activity by Huatteños and these are in large enough supply to be an important market item.

7.8 THE ORIGIN AND EVOLUTION OF THE RAISED FIELDS OF THE LAKE TITICACA BASIN: A RECONSTRUCTION

7.8.1 Evidence of Early Agriculture in the Lake Titicaca Basin

It is difficult to investigate the evolution of intensive agricultural systems of the Lake Titicaca Basin without data on the pre-agricultural archaic hunting and gathering cultures and the domestication of the crops which would later become basic to these systems. Little archaeological plant material relating to agriculture has been recovered from prehistoric sites in the altiplano and Lake Titicaca Basin. This is primarily because of the poor preservation of botanical remains in the open sites of the altiplano, where most archaeology has been focused. There has been a general lack of research interest in prehistoric agriculture among archaeologists working in this area and few investigations have employed flotation techniques for the recovery of carbonized plant macro-remains.

Many botanists interested in the origins of agriculture have suggested that the Lake Titicaca Basin was an important center of domestication (Vavilov 1926; Cutler 1968). Vavilov was one of the first to document the vast genetic diversity of cultigens within the basin, and to suggest that this was the primary hearth of domestication. Harlan (1970) considers highland South America to be a large "non-center" covering a broad area of potential origin where domesticated Andean crops potentially originated. Of the important high altitude Andean crops, the potato (Ugent

1970), oca, ollucu, isañu, tarwi, quinua and cañihua may have been domesticated in the distant past (Cutler 1964). This general zone is also the likely hearth of camelid domestication and the development of pastoral economies (Lumbreras 1981; Kent 1982).

The only site with abundant reported botanical remains in the Lake Titicaca region is that of Chiripa (Browman 1978a; 1978b; 1980, 1981; Kent 1982; Erickson and Horn 1977; Erickson 1976, Towle 1961; Bennett 1936; Ponce 1970; Kidder 1963; Mohr-Chavez 1966). Bennett during excavations at Chiripa in the 1930's of double walled house floors, reports that "two kinds of grain were found, the common quinua and the small-grained variety" (1936:424). During excavation in 1955, Kidder (1963; Towle 1961) recovered a cache of carbonized plant material from the storage bins of double-walled houses. This material was identified as "quinua," and twelve examples of two or more varieties of "tubers," possibly representing both processed (chuffo or tunta) and non-processed (Towle 1961). These botanical remains probably date to ca. 400 B.C. to A.D. 50 (Browman; pers. com. 1976).

During the most recent excavations at Chiripa in 1974-1975, additional plant material was recovered and analyzed (Erickson 1976; 1977, Erickson and Horn 1977). Large quantities of Chenopodium were recovered from all early levels in the site, in addition to tuber fragments, Amaranthus, totora (Scirpus), reed (Juncus), cactus (Opuntia), grasses (Stipa and Festuca), and Malvaceae. The Chenopodium was probably domesticated quinua

and/or cañihua, and the tubers were probably potatoes (Solanum tuberosum) or other domesticated andean tubers, although identification as definite domesticated species, based on morphology and size, is still tentative. These remains have been securely dated to between 1250 B.C. and A.D. 50, or the late Initial Period through the Early Intermediate Period. The presence of domesticated camelids has also been demonstrated for the site of Chiripa for this time period (Kent 1982).

In addition to the use of terrestrial species of native wild vegetation and andean crops, the importance of wetlands in the Chiripa economy is supported by the flotation analysis. Scirpus and Juncus were found in the flotation remains, representing major species in the aquatic realm of the lake shallows. A notable component of the Chiripa flotation remains was the remains of numerous small gastropods. These gastropods are found on the lake vegetation, primarily llachu, growing in shallow waters of the lake. Today, llachu is used as cattle fodder; the cattle either enter the water to graze, or it is cut and brought to the cattle on shore. The gastropods must have been brought to the site clinging to the llachu used as forage for domestic camelids (Horn 1984; Erickson and Horn 1977; Erickson 1976).

Despite the lack of agricultural crop remains, there is little doubt that Chiripa, Qaluyu, Pukara, and Tiwanaku were well-developed agricultural societies, possibly practicing intensive agriculture. Research focus in the altiplano has not been directed towards the recovery of crop plant remains and

thus, we have little direct evidence of the crops cultivated during these important time periods and the agricultural practices utilized.

7.8.2 A Model for Early Agriculture in the Lake Titicaca Basin

Many models have been suggested for the origins of agriculture and the domestication of plants (Reed 1977; Flannery 1973, 1986; Harlan 1970; Lathrap 1977; Cohen 1977; Rindos 1984; Sauer 1975; Harris 1972a 1972b, 1973, 1977; Bronson 1972, 1975; and others). Several of these models, in particular Sauer (1975), Bronson (1972, 1975), and Lathrap (1977) emphasize the importance of sedentism and wetlands environments as a context for domestication and agriculture. I argue that these models best explain the possible origins and development of early raised field agriculture in the Lake Titicaca Basin and other wetland areas where intensive raised field agriculture was practiced.

Sauer, in his Agricultural Origins and Dispersals presented the first coherent model for the origins of agriculture based on sedentism and wetland environments (1975 [1952]:20-24). Sauer presents various basic premises that he considers important in considering agricultural origins. He predicted that agriculture did not develop during periods of scarcity of food or population pressure, but rather in a context of relative stability. Early domestication would have occurred in areas with a high diversity of potential plant and animal domesticates. The most likely environment to meet these conditions would be wooded areas near

rivers that were not affected by major flooding, where a sedentary way of life could be maintained. A hunting, gathering, and most importantly, a fishing lifestyle of early settlers in these areas would "predispose" these peoples to experimentation with crops and a sedentary agricultural existence.

Sauer argued that the earliest populations to practice agriculture would have been fishing peoples in Southeast Asia. Their riverine environment was important as a means of communication of ideas, a rich resource for wildlife, and the plants associated with fishing technology were the first domesticates (ibid. 23-24).

Sauer's model is useful as a model for the development of raised field agriculture. I prefer to replace Sauer's emphasis on river environment with the more general concept of a wetland, which would include river, bottomland, levee, swamp, and marsh. Sauer correctly pointed out that the rich ecosystem of wetlands could provide a sedentary base for rather dense populations of hunters and gathers relying heavily on fishing, in addition to hunting and gathering. Plants used in fishing technology, such as fish poisons, cordage, detergents and bark cloth, (and according to Lathrap [1977], gourd floats, cotton, drugs) would be carefully tended in intensive house gardens near the settlements. The seasonal rise and fall of the rivers and surrounding wetland backwater swamps and lakes would have provided the optimal conditions for experimentation with cultivation and domestication of food plants without high risk or

substantial labor input.

Anderson (1952) proposed a similar theory for the domestication of plants. According to Anderson, most major domesticates were weedy species. Anderson argues that the earliest tampering with plant genetics was associated with "camp followers," plants that grow well in disturbed habitats, be it a seasonally-exposed river bank or early sedentary village or camp. These "weedy" camp followers would flourish in the organic-rich middens surrounding early settlements, and could be easily selected and tended.

Lathrap (1970, 1977, Lathrap et al. 1985) and Harris (see above citations) have elaborated on many of these ideas, focusing primarily on the importance of the tropical forest house garden in the development of early agriculture. The house garden is important in traditional agricultural societies today, and still provides an excellent experimentation plot for the cultivation and selection of desired plants. Lathrap (1977; Lathrap et al. 1985) stresses that the early domesticated and semi-domesticated plants would not have been very high producers, so the early domesticators would have had to rely on fishing for basic subsistence until the crops were sufficiently productive. Flannery (1986) has also come to similar conclusions.

These models stress the importance of the environmental and social contexts of domestication and early agriculture where humans are directly involved in decision-making and the selection of desired crop characteristics. Alternative models proposed by

Rindos (1984) and Cohen (1977) take the control of the domestication process away from humans and explain domestication as a non-cultural phenomenon.

I believe that the first agriculturalists in the Lake Titicaca Basin developed out of wetland-oriented fishing cultures, much like the Uru (see above discussion). The major and minor rivers flowing into lake Titicaca, the lake shallows, river deltas, and the islands and peninsulas in the lake would have provided an optimal context for experimenting with agriculture and potential cultigens. Although the origin of highland Andean domesticated crops is not the focus of this dissertation, I am convinced that the wetland enclaves were the environment where domestication occurred. I also believe that the context of early domestication is also the context of early intensive agriculture. The resources of the lake shallows and river mouths in the Lake Titicaca Basin have been discussed in detail in Chapter 2. This would have been an excellent zone for the exploitation of fishing, hunting, and gathering resources. The Uru lacustrine-oriented economy and settlement pattern are probably a remnant of this early lifestyle. I argue that this wetland economy provided a stable, reliable, highly productive subsistence base for the lake dwellers, enabling permanent settlements to become established relatively early, after the Pleistocene stabilization of lake level. The potential carrying capacity of these areas is very high (even without agriculture) and not only would have provided a relatively stable sedentary

life, but also encouraged rather dense populations in close proximity to the lake

7.8.3 Preadaptation to Raised Field Agriculture

From what we know about the early prehistoric agricultural settled village populations of the altiplano during the Early Horizon and Early Intermediate Period, nearly all appear to be lacustrine or riverine oriented. The material culture and plant remains from the site of Chiripa indicates a strong lacustrine component in the economy of this Formative period culture (Erickson 1976, Erickson and Horn 1977). Known sites of Chiripa culture are located only in lacustrine zones and on islands around the southern Lake Titicaca Basin (Ponce 1970; Bennett 1936; Browman 1981; Kolata 1982). The sites associated with the poorly-defined Tiwanaku I culture also have a lacustrine distribution in the southern lake basin (Ponce 1970). Wankarani Culture, originally described by Ponce as non-lacustrine, based on the type site of Wankarani (1970, 1980), is actually almost completely lacustrine and riverine oriented. The type site is located some 30 km from the nearest wetlands, but I consider this to be atypical of the culture defined by Ponce. The majority of the Wankarani sites (for example Kelkana, La Joya, Kella-Kollu, Pukara de Belem, Toluma, Uspa-Kollu, Machacmarca, Jikilla, Sokotifia, Wilake and Takawa) are located on the shores of Lago Poopo, in the swamps and marshes of the mouth of the Rio Desaguadero, or within a few kilometers of these zones.

The present-day Uru of the Rio Desaguadero still use

Formative Period occupation mounds as village sites. The town of Iru Itu, very important as a focus of Uru life in the past (Vellard 1954; 1963; LaBarre 1941) and still a major Uru population center, is built on a predominantly Chiripa Period and Tiwanaku III site overlooking the vast swamps of the Rio Desaguadero plain. The farmers and fishermen of Coata, Karata, Pojsin Karata, Yasin and Uchuymoro on the north end of the Lake Basin have a lacustrine oriented Uru-like economy (see Chapter 6) which is combined with agriculture practiced in drier areas. These populations all live on mounds heavily occupied during the Formative Period.

Few early agricultural sites have been found away from the lakeshore except that of the type site of Wankarani (which Ponce (1970) considers "backwards" and not evolving). One Formative period site, Pizacoma, reported by Máximo Neira (pers. com. 1983) in the upland Puna region above Juli is only a pallid reflection of contemporaneous cultural development in the immediate lake area, and may represent a pastoral extension of the wetland groups.

The lake shore, lake shallows, river banks, levees and river deltas provide excellent disturbed habitats for weedy potential domesticates. The rich organic soils of the lake shallows and lake shore, plus the occupation sites of the fishing and gathering communities fit Anderson's and Sauer's models for the context of the origins of agriculture. With improved microclimate near the Lake Titicaca, plants introduced

from more temperate zones or lower altitudes could flourish. Farther from the lake, house compound walls would have provided protection for house gardens for experimentation and selection of plants, and the soil of these enclosures was enriched by organic material accumulated in occupation midden and animal pens.

This is not to say that the puna region was not used by early agriculturalists and later Formative Period cultures. There appears to have been a clear division between high puna hunters who later developed pastoralism and the early lacustrine and valley dwelling agriculturalists at lower altitudes (Donald Lathrap pers. com.; Browman 1970 ; Rick 1980). It probably was not until both pastoralism and agriculture were well established that the two economies were combined by some groups. The occurrence of camelid bone (domestic and possibly wild) and deer from the Puna in Chiripa and Huatta sites during the Early Horizon support the idea of a long tradition combining agriculture near the lake with herding and hunting in the Puna (Erickson and Horn 1977; Kent 1982).

Lathrap (pers. com. 1978) argues that the highland Aymara camelid-potato-chenopod complex developed as a single interacting system, independent of the Quechua corn-based tradition in lower valleys and slopes. He argues that camelid domestication preceded the domestication of highland crops. The enclosed environment of rotated or abandoned camelid corrals, with high walls providing protection against the harsh elements and

nitrogen/organic rich soils from animal dung, would have been the perfect context for experimentation and selection of domesticated plants. There are ethnographic cases of potato and cañihua cultivation in camelid corrals in the Chipaya region of the agriculturally marginal southern altiplano. The only agriculture that can be practiced at altitudes around 4200 meters a.s.l. is within the protective microclimate created by corrals or house kanchas (Morlon et al. 1982; Monheim 1963).

I propose that high altitude Andean agriculture would not have first developed in remote pastoral contexts when other, more favorable, microclimates were available in the wetlands near altiplano lakes and rivers.

In later periods, the Lake Titicaca Basin farmers became more diversified in their economies. In Chiripa and Wankarani, there is good evidence that pastoralism was practiced along with agriculture near the lake, in addition to long distance trade (Kent 1982; Browman 1980; Ponce 1970). By Tiwanaku times, there were well-established vertical archipelagos in coastal west slope and Amazonian east slope valleys (Browman 1978a, 1980, 1981, 1984; Mujica 1978, 1985; Lathrap 1970; Kolata 1983), a process which probably began as early as Pukara Period (Mujica 1985).

7.8.4 Raised Field Origins

The first settlers in the Lake Titicaca Basin may have been hunting and gathering groups similar to those responsible for the remains at the site of Viscachani on the Bolivian altiplano

(Ibarra Grasso 1973). The first settlers would have been attracted to the abundant resources of the lake, lakeshore, peninsulas, and islands. These hunters and gatherers could have established early, relatively permanent, settlements within the marshes and swamps around the lake edge. The ideal locations for these settlements would be the river levees and deltas, and levees on abandoned river courses. These slightly elevated areas would have provided protection from annual flooding during the wet season. These locations are also the best sites for fishing, and the microclimate of these areas is much more favorable than areas away from the lake. Shelter would have been provided by simple structures of totora reed mats, and possibly sod houses, known today as pituku. Simple boats would have been invented early to exploit the rich resources of the lake. The ideal locations for fishing, hunting and collecting would be areas in the shallows of the lake. Other settlements would have been built on floating masses of totora reed, which eventually become anchored to the lake bottom, similar to those used today by the Uru. Perhaps these were originally only temporary fishing, hunting and gathering camps, but as population grew, their occupation became permanent, and more and more floating islands would have been constructed to alleviate pressure on the limited levee sites.

Early domesticated plants, whether local or introduced, would have thrived on the levees and floating island gardens. The abundant moisture, rich soils, organic matter, and a better

crop climate would have made this the best location for experimenting with domesticates. Permanent occupation of these sites would have enabled close supervision of the plants. These levee gardens would have been the original model for the raised fields which expanded cultivation into the pampa.

As agriculture became more important, this economy expanded within the desired lacustrine ecozone. Since dry areas protected from annual flooding and waterlogging are limited, a choice would have to be made whether to cultivate the poorer soils and less desirable areas further inland or on the hillslopes, or to expand the elevated areas for gardens within the lake shallows and seasonally flooded areas. The simple expansion of arable land within the wetland environments already under cultivation would have created the first raised fields. Artificially expanded garden space on raised fields would have allowed the farmers to live near their fields, with easy access by balsa boats. The first raised fields were probably constructed by individual families or small cooperative groups. These early raised fields were probably haphazardly organized around existing levees and occupation mounds. To delineate individual raised field blocks, encircling dikes and ditches would have been constructed. As additional fields were gradually constructed, the system became more organized. As the occupation mounds and levees were utilized by many generations of farmers and fishermen, they increased in size, providing more area for settlements and increased security against flooding.

We do not know when raised field cultivation began, but certainly before 1000 B.C.. Proto-raised field agriculture on levees, periodically exposed lake bottom, and possibly floating gardens would have been the earliest forms, possibly beginning by 3,000 B.C.. Between 1000 B.C. and A.D. 200, much of the pampa, in addition to the lakeshore and shallows, had small wavelength (1-2 meters) raised fields, as documented by the Phase I fields of the excavations (see Chapter 3).

Around 1500 B.C., ceramics entered the altiplano. This, in addition to pastoralism, long distance and regional trade, larger sedentary villages, and population increases, rapidly changed the character of the sedentary population around the lakeshore. Small temples were established at important occupation sites such as Pancha (ca. 600 B.C.) and Chiripa (ca. 400 B.C.). Agriculture had already spread into the upland areas away from the lake edge, such as around the site of Wankarani.

Construction of raised fields in the Huatta pampa reached a peak between 800 B.C. and 600 B.C.. Numerous sites associated with the raised fields were scattered over the pampa and hill of Huatta. At the large site of Pancha, a small rustic kallasasaya "temple" structure was made.

Since Chiripa, Wankarani, and Tiwanaku I cultures are not the beginnings of ceramics technology, agriculture, and sedentary life in the Lake Titicaca Basin, there must have been earlier Formative cultures here. I believe that the Preceramic agricultural economies from which these later cultures evolved

were well established by 5000 B.C. in the Lake Titicaca Basin to have provided enough time for the development of relatively sophisticated agriculture by 1000 B.C..

Why do we have no archaeological data on the early lacustrine hunters and gatherers of the preceramic, and the agriculturalists who predate the Early Horizon in the Lake Titicaca Basin? I believe that this is because no one has systematically searched for these early sites. Most, if not all, of these sites would be buried in sediments near or within the lake shallows, or at the base strata of the occupation mounds found within the pampa and lake. Since many Phase I raised fields dating to between 1000 B.C. and A.D. 300 are found more than 1 meter below the surface, it is likely that much earlier sites (5000 to 1000 B.C.) are, indeed, very deeply buried, possibly several meters below the current surface. The best sites for hunting, collecting and fishing are the mouths of the larger rivers entering the lake and the nearby lakeshores. These are the most geomorphologically active areas in the Lake Titicaca Basin, annually receiving large quantities of sediments. In addition, the lake level probably was rather unstable (as it is today) during and soon after the Pleistocene, which would tend to hide the evidence of these sites. Many of these sites probably lie below the present-day water table of the pampa and lake shore. It is also probable that the material culture of these early pre-ceramic lake dwellers was considerably different from that of the puna hunters. Durable projectile points and other

lithic technology was undoubtedly less important to the lacustrine-oriented peoples, who had ready access only to more perishable materials for their nets, bolas, and balsas.

The few early preceramic sites documented for the altiplano appear to be oriented towards a puna hunting economy. None of the information on early sites located in the Northern Lake Titicaca Basin has been adequately published. There are cave paintings and petroglyphs in caves and rockshelters in the puna above Puno which may be preceramic, but these have not been adequately dated. One large pre-ceramic site has been reported in the Illpa Pampa (Oscar Ayca pers. com. 1983) near complexes of raised fields. An preceramic projectile point, similar to those found at the abovementioned pampa site was recovered from the lower excavation levels at Kaminaga. This apparently was curated by later cultures, although its presence in this level might result from the disturbance of earlier pre-ceramic middens for obtaining adobe or fill material for the mound.

I predict that early pre-ceramic sites associated with the origins of raised field agriculture will be found deeply buried beneath later ceramic period occupations. Many of these sites may be out in the lake itself or buried under fluvial and lacustrine deposits near the mouths of rivers. These may be difficult to identify because of perishable material goods and lack of permanent structures. The raised fields associated with these early occupations will also be deeply buried and possibly reworked by later raised field construction. We do know that by

1000 B.C., the raised fields were well established and probably supporting large and dense populations by 800 B.C..

CHAPTER 8

CONCLUSIONS AND IMPLICATIONS OF THIS INVESTIGATION

8.1 SUMMARY OF THE RESULTS

This investigation has addressed social, technological, evolutionary, and ecological issues regarding past intensive agricultural systems. This dissertation addresses 1) the process of intensification of agriculture and agricultural change and 2) the relationship between social organization and intensive agricultural systems. Many students of agriculture follow the idea proposed by Ester Boserup the agricultural systems change along a continuum from extensive (long fallow) to intensive (short or no fallow). It is assumed that the more intensive systems, although more productive, are less labor efficient and thus, according to the "Law of Least Effort," would not be adopted unless the farmers were forced to under population pressure. Another common viewpoint is that intensive agricultural systems, because they are often more complex, require a certain degree of centralization for the planning, construction, and maintenance. Archaeological investigation can address these issues by providing detailed information regarding the trajectory of agricultural systems over long periods of time and the human populations associated with them. Agricultural experimentation, based on the reconstruction of the agricultural

system using data obtained through archaeological excavation, can provide insights into the crops cultivated, labor investments, field productivity, and potential carrying capacity of the system. I have presented data from archaeological investigations of prehispanic raised fields and agricultural experiments to address these issues.

Excavations in raised fields demonstrate that the internal structure of raised fields is complex. Various construction and rebuilding stages were defined. Thermoluminescence dates from these fields shows that raised field agriculture is an early phenomenon beginning as early as the Early Horizon, associated with some of the earliest documented settled agricultural villages in this zone. The raised field system has a long evolution, beginning sometime before 1000 B.C. and lasting until approximately A.D. 1450 as demonstrated by direct dating and comparative ceramic dating of pottery within raised field contexts, in addition to the indirect dating through excavations within occupation mounds associated with the raised field complexes. Two major phases of raised field construction are defined by these excavations. Phase I begins sometime before 1000 B.C. and lasts until A.D. 300, associated with the early farming settlements in the Basin and the later Pukara Culture. Phase II begins sometime ca. A.D. 1000 and lasts until ca. A.D. 1450, associated with the Late Intermediate Period Aymara "Kingdoms" of the Lake Titicaca Basin.

Two distinct periods of abandonment have also been

documented in the raised field excavations. These two periods of abandonment, I have argued, are related to socio-political changes occurring within the Lake Titicaca Basin through time. In the Huatta area, raised fields appear to have been abandoned for the first time after the collapse of Pukara culture in the northern basin and the shift of power and influence to Tiwanaku in the southern Basin. During this period, raised field construction reached a peak near Tiwanaku (Koani Pampa). A second period of raised field abandonment in both the southern and northern Lake Titicaca Basin apparently occurred during the Inca control of the region.

The experimental raised fields proved fruitful in providing detailed data regarding raised field function and technological details, crop production, labor organization and labor costs. Labor for raised field construction and maintenance was nowhere near as high as expected or predicted by others derived from analogy to other intensive forms of traditional agriculture. From numerous raised field locations during several years of experimentation, an average figure of 5 cubic meters of earth/person/day was obtained. Since raised fields can be continuously cropped for several consecutive years and since maintenance costs are very low, any initial labor investment is made insignificant over a period of several years of cultivation. Production figures for potatoes from 3 years of raised field experimentation demonstrate that over 10,000 kg/ha (10 metric tons/ha) can be produced in a growing season and this figure has

been sustained over three years. From these figures, a return of 36 kilograms of potatoes per day of labor is calculated. The potential surplus produced by raised field agriculture is impressive and certainly was responsible for the supporting the dense populations of the raised field zone, in addition to populations outside the immediate vicinity. I suggest that these surpluses also served as a base for supporting the ceremonial complex of Pukara and the Late Intermediate Period Aymara "Kingdoms."

The experimental raised fields have also provided insights regarding the level of social organization necessary to construct, maintain and operate intensive agricultural systems. Contrary to Wittfogel's ideas of the development of despotic states from the management of water resources or the Neo-Wittfogelian notion of the necessity of centralization in intensive agricultural systems, the experimental raised fields suggest that low level organization is sufficient for raised field agriculture. Although raised fields constitute a sophisticated and highly productive complex agricultural system, they can be constructed and maintained by individual farmers, extended families, small low level corporate groups of kin and/or neighbors, or local territorial groups such as the Andean ayllu.

I have argued that the best model for the origin of raised field agriculture in the Lake Titicaca Basin would be a group practicing a wetland-oriented economy such as that of the ethnohistoric and modern Uru. Groups such as these may have been

responsible for the domestication of the highland Andean crop complex, in addition to the cultivation practices that characterize the Lake Titicaca Basin. The large area of wetland environment of the Lake Titicaca region would have provided a rich base for the sustaining sedentary and growing populations, a context where early domestication, early agriculture, and later intensification most likely developed. I would also go so far as to suggest that ancestors of the Uru-Chipaya [and possibly Pukina] speakers distributed historically and ethnographically in wetland zones around the lakes and rivers of the Altiplano were responsible for the archaeological raised field remains and the majority of associated occupation mounds.

I believe the ethnographic, ecological, and archaeological data suggests that the wetlands have priority as a zone of early intensive agricultural systems, possibly predating many more extensive systems practiced on "drylands." I believe the model presented here could be applied to other areas where raised field remains have been located, especially the Maya lowland raised fields. Similar models have already been developed for explaining the early intensification of wetlands in highland New Guinea.

8.2 WIDER IMPLICATIONS OF THIS RESEARCH

The archaeological investigation of raised field agriculture in the Lake Titicaca Basin has wide implications for other fields of study. Disciplines such as agro-ecology, farming systems,

geography, rural sociology and development, and traditional agriculture could greatly benefit from archaeological perspectives on prehistoric agriculture. It is crucial to consider the time depth of traditional agricultural systems. Most contemporary studies of agricultural systems are static, synchronic descriptions of only a few years' time depth. Long term prehistoric data on agriculture are vital, but rare in the case of the New World and most areas of the world. Sufficient time depth for describing and explaining system trajectories for most of these areas can be obtained only through archaeology and experimental agriculture.

In specific cases such as the raised fields of the Lake Titicaca Basin, there are no local modern analogies to prehistoric wetland farming any scale resembling the original prehistoric practices. In this case, archaeology is the only means of understanding the now abandoned prehispanic system.

8.3 CONTRIBUTIONS TO METHODOLOGY

Because the study of prehistoric intensive agricultural systems is relatively new to archaeology, there is no well established methodology for investigation of these systems. Geographers, in the forefront of studies of this sort, generally focus on describing the spatial distribution and morphology of the system, relying heavily on the use of aerial photographs and soils mapping.

This dissertation presents a methodology that has proven successful for study of one intensive prehistoric agricultural system, the Lake Titicaca raised fields. The methodology used in this study is multidisciplinary (agronomy, cultural anthropology, microclimatology, agricultural communications, soils science, etc.), with archaeology as its core. This study combined a combination of excavation of raised field remains, experimentation using raised fields based on the prehistoric models defined by excavations, and excavation of prehistoric communities associated with raised field agriculture. The controlled excavation of stratigraphic trenches within raised fields permitted determination of original raised field form, superposition of fields, and construction, rebuilding and erosion/abandonment sequences. The recovery of soil and pollen samples in situ provided details on soil fertility, origins of construction fill, environmental reconstruction and crops potentially cultivated prehispanically. The use of thermoluminescence dating permitted accurate assessment of chronological age of the system and documentation of changes through time. Extensive long term experimentation based on prehistoric models provided detailed data on the following defining characteristics: the labor involved in construction and maintenance of large raised field blocks, the potential crop cultivated and their potential production using indigenous Andean cultigens which could be used for reconstructing carrying capacity, and determination of the level of social organization

and labor mobilization necessary for a construction and maintenance of the raised field system.

Andean archaeological studies, particularly those undertaken in the Lake Titicaca Basin, have been preoccupied by the large scale centers of the Inca, Tiwanaku, and Pukara, traditionally focusing on chronological issues, architecture, long distance trade and colonization, and burials. These studies have generally neglected the farming communities from which these larger scale polities developed and upon which they depended. This dissertation has addressed this agricultural base and redirects focus to the lower levels of the regional social hierarchy.

8.4 THE APPLIED ASPECTS OF THE INVESTIGATION

Many have argued that potential use of traditional agriculture and prehispanic agriculture as a viable alternative to introduced Western agriculture for rural development (Denevan 1982; de la Torre and Burga 1986; Gomez-Pompa 1978; Gomez-Pompa et al. 1982; Portocarrero 1986; Treacy 1987; Altieri 1983), in particular, the raised fields of the Lake Titicaca Region (Erickson 1985, 1986; Erickson et al. 1985; Candler and Erickson 1987; Erickson and Candler 1988; Garaycochea 1986a, Brinkmeier 1985). The issues of labor intensity and centralization addressed in this dissertation are directly applicable to efforts to use raised field technology as a form of appropriate

technology. I have shown that population densities do not have to be high in areas where raised fields are constructed, nor are such systems particularly labor intensive. The relatively low labor and capital input of the fields in relation to the production output is contrary to the commonly accepted view that this form of agriculture will only be adopted if forced upon farmers by pressures (the Boserup model). In relation to the issue of centralization, I have shown that a "bottom-up" approach can be used for implementing this raised field technology because small groups are perfectly capable of constructing and maintaining relatively large blocks of raised fields.

Why were the raised fields never rebuilt after the final abandonment? Why don't today's Quechua and Aymara farmers automatically put raised field agriculture back into use on their own if this system is so efficient and beneficial? The following historical factors were all responsible: the breakup of the Andean ayllu system, the breakdown of communal landholdings and sectorial fallow systems, the establishment of haciendas and encomiendas (many of which were located on remains of ancient raised fields), the introduction of European sheep and cattle agriculture into a niche previously used for raised field farming, the civil wars and exploitation of the local populations by the Spanish, and disruption and reorganization caused by the Inca conquest of the zone before the arrival of the Spanish. All of these factors, in addition to the loss from memory of the

complexities of the technology, help explain this devolution.

When presented with raised field technology through participation in experimental raised fields or through observation of existing fields, farmers of the pampas around Lake Titicaca have begun to adopt the technology, both at the level of the community (where communal structure and lands have survived) and at the family level. Between 1985-86, some 10 hectares of raised fields had been put back into use in the Department of Puno. By 1987, some 30 hectares of new fields had been reconstructed by a government program. The enthusiasm for this "new" technology is impressive. As new pampa and wetlands become available to indigenous communities, such as through the recent breakup of the SAIS Buenavista Cooperative, we see a resurgence of communal organization and control of communal lands which has paralleled the adoption of raised field agriculture by these communities. Once again, raised field technology may make the wetland zones of Lake Titicaca one of the major breadbaskets of the Andean world.

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REPORTS AND PUBLICATIONS:

ip Raised Field Agriculture in the Lake Titicaca Basin: Putting Ancient Andean Agriculture Back to Work. Expedition, volume edited by Karen Mohr Chavez on the Prehistory of the Lake Titicaca Region, The University Museum, University of Pennsylvania, Philadelphia.

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- 1977 (with Mark Druss and Ann Ottesen). Archaeological investigations at Beaver Dam National Battlefield Park Unpublished ms. National Park Service, Richmond, Virginia.
- 1977 (with Darwin Horn). Domestication and Subsistence Implications of Plant and Animal Utilization of the Lake Titicaca Basin. Unpublished ms., Department of Anthropology, Washington University, St. Louis, Missouri.

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PAPERS PRESENTED:

- 1988 (with Kay L. Candler) Labor and Production in Raised Field Agriculture: Results of Experiments in the Lake Titicaca Basin of Peru. Paper presented in the symposium "Fragile Lands of Latin America: The Search for Sustainable Uses" at the XIV Congress of the Latin American Studies Association, March 17-19, New Orleans.
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- 1987 Prehistoric Raised Field Agriculture and Indigenous Communities in the Lake Titicaca Basin of Peru. Conference on Traditional Wet Field Agriculture in the American and Asian Tropics. University of California Pacific Rim Program and UNESCO Man and the Biosphere Programme, Riverside, CA, October 22-23.
- 1987 (with Kay L. Candler). Raised Fields in the Lake Titicaca Basin: The Indigenous Community and Agricultural Expansion. Paper presented in the symposium "Indigenous Responses to Economic Development" at the Annual Meetings of the Society for Applied Anthropology, Oaxaca, April 8-12.
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- 1984 Investigation of Prehistoric Andean Agriculture: The Raised Fields of the Lake Titicaca Basin, Peru. Paper presented at the 49th annual meeting of the Society for American Archaeology, May, Portland, Oregon.
- 1984 Raised Field Agriculture in the Lake Titicaca Basin of Peru: Recent Archaeological Investigation. Paper presented at the 12th Annual Midwest Conference on Andean and Amazonian Archaeology and Ethnohistory, February 24-25, Champaign-Urbana.
- 1983 La investigación de campos elevados en la cuenca del lago Titicaca. Paper presented in the Tercera Reunión Internacional de las Jornadas de Arqueología, Antropología, y Historia Peruano-Boliviana, June 26-June 1, 1983, Puno, Peru.
- 1981 Nuevas investigaciones en el estudio de campos elevados: el uso de LANDSAT. Paper presented in the Segunda Reunión Internacional de las Jornadas de Arqueología, Antropología, y Historia Boliviano-Peruana, August 24-27, 1981, Copacabana, Bolivia.
- 1980 Recent Investigations of Raised Field Agriculture in the Llanos de Mojos of Bolivia. Paper presented at the 8th Annual Conference on Andean and Amazonian Archaeology and Ethnohistory, St. Louis, Missouri.
- 1978 (with Juan Faldin). Informe preliminar sobre un reconocimiento arqueológico en los Llanos de Mojos: San Ignacio a San Borja. Paper presented at the Segunda Reunión Internacional de las Jornadas Peruano-Bolivianas de Estudios Científicos del Altiplano Boliviano y el Sur de Peru. La Paz, Bolivia,

1977 Subsistence Implications and Botanical Analysis at Chiripa. Paper presented in the symposium "Comodity Flow and Political Developments in the Andes" at the 42nd Annual Meeting of the Society for American Archaeology, New Orleans, Louisiana.

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- 1982 National Science Foundation Dissertation Improvement Grant.
- 1980 Social Science Research Council, Fellowship for Dissertation Research.
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