THE AGRICULTURAL FOUNDATIONS OF THE TIWANAKU STATE: A VIEW FROM THE HEARTLAND

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In this essay I explore the nature, role, and significance of intensive agriculture in the ancient state of Tiwanaku, which was centered in the high plateau of southern Peru and northwestern Bolivia. Significant primary evidence that the state of Tiwanaku systematically reclaimed immense tracts of now abandoned agricultural land around the borders of Lake Titicaca is adduced and evaluated.

I conclude that Tiwanaku was a dynamic, expansive state based squarely on an effective, surplus-producing system of intensive agriculture, that the intensification agricultural production through large scale reclamation of flat, seasonally inundated land along the margins of Lake Titicaca was a prime economic strategy of the Tiwanaku state, and that this strategy was devised and managed by a hierarchically organized, central government.

At issue in this essay are the nature, role, and significance of intensive agriculture in the ancient state of Tiwanaku, which was centered in the *altiplano,* or high plateau of southern Peru and northwestern Bolivia (Figure 1). For nearly a millennium (ca. A.D. 100–1000), Tiwanaku was the paramount city of the Lake Titicaca basin, which, in turn, was one of the great demographic centers of native Andean civilization. Despite Tiwanaku's fundamental position in the cultural history of the Andes, we know very little concerning its economic history, and virtually nothing about its important agrarian heritage. This essay is a prolegomenon to an ongoing, comprehensive exploration of vital aspects of the nature, organization, and impact of large-scale agricultural production in the Tiwanaku state.

Preliminary field research in Bolivia undertaken from 1979–1982 indicated that the state of Tiwanaku supported its sprawling capital by systematically reclaiming immense tracts of now abandoned agricultural land around the borders of Lake Titicaca (Kolata 1982, 1983). The results of this preliminary research form the foundation for my central hypothesis that Tiwanaku, like some of its counterparts in Peru, was a dynamic, expansive state based squarely on an effective, surplus-producing system of intensive agriculture (Ponce 1979, 1980, 1981).

RESEARCH SETTING

The economic foundations of ancient Tiwanaku were conditioned, in great part, by landscape and environment. The city evolved on the Andean high plateau, situated between two great mountain chains: the *Cordillera Occidental* in Peru, and, to the east in Bolivia, the towering *Cordillera Real.*

The *altiplano* is a cold, windswept environment subject to a marked alternation between dry (April-October) and wet (November-March) seasons. The high plateau ranges in elevation from 3,500 to over 4,000 m and exhibits substantial diurnal variation in temperature. During the growing season, frosts and sporadic hailstorms can cause extensive crop damage (Unzueta 1975). Today, erosion of the landscape is extensive and cultivated soils are poor in basic nutrients such as nitrogen and phosphorous (Ministerio de Asuntos Campesinos y Agropecuarios [MACA] 1974).

The topography, elevation, and attendant cold climate of the *altiplano* severely constrain the agricultural inventory of the Titicaca basin: only hardy tubers such as potato, oca, ulluco, and mashwa, and the unique high-altitude adapted chenopod grains, quinoa and cañiwa, can be readily

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Figure 1. Map of Bolivia with the area of interest around the southern shores of Lake Titicaca emphasized.

cultivated in this dour environment. Despite these environmental and botanical constraints on the agricultural regime, the Bolivian *altiplano,* particularly its northerly region around Lake Titicaca, has traditionally been the country's major center of population and agriculture (MACA 1974:Volume 1).

The research conducted to date is set within this region that holds such critical importance for Andean cultural geography, both past and present. In the broadest sense, the study area encompasses the ancient city of Tiwanaku and its immediate rural hinterland on the southern shores of Lake Titicaca (Figure 2). The fieldwork, consisting of survey and test excavations, was concentrated in an approximately 70 km^2 area near the base of the Taraco Peninsula some 10 km north of Tiwanaku. Specifically, the zone of interest, referred to locally as the *Pampa Koani,* lies between 16°30′–16°20′S latitude and 68°45′–68°30′W longitude (Figures 3, 4).

RESULTS OF THE REGIONAL SURVEY

The greater Pampa Koani zone was chosen for investigation after an initial inspection of aerial photographs of the region at 1:40,000 and 1:10,000 scale revealed massive and well-preserved

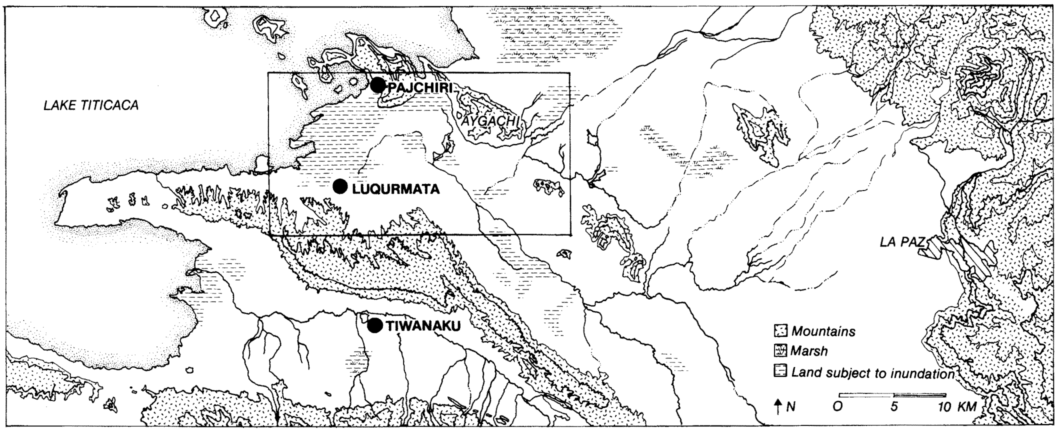


Figure 2. Tiwanaku and its rural hinterland. Superimposed box represents area illustrated in Figure 3.

archaeological features. Important elements of the archaeological landscape first observed on these photographs of the Koani zone included: (1) extensive, continuous tracts of now abandoned raised agricultural fields that run from the edge of Lake Titicaca to nearly 15 km inland; (2) an intersecting set of linear features crosscutting field segments that subsequent study suggests was a formal network of causeways; (3) large, quadrangular and L-shaped mounds set within the raised field system, located near, or at the terminal points of the presumed causeways; (4) a series of massive agricultural terraces cut into hill slopes bordering the northern edge of Pampa Koani; and (5) an artificial canalization of the Rio Catari that bisects the Pampa Koani. These features may be seen clearly on the maps compiled from the aerial photographs (Figures 3, 4).

Subsequent ground survey confirmed the artificial nature of each of these five elements of the cultural landscape, and further revealed the presence of several smaller habitation mounds dispersed throughout the zone that are directly associated with the raised field system. These smaller mounds, as well as the other archaeological features of more massive scale, are frequently better preserved near the lake shore. Here, contemporary agricultural activity, which is the primary source of site destruction, is precluded by perennially waterlogged soils and seasonal inundation of the landscape.

In the initial regional survey, we divided the Pampa Koani into quadrants with the intention of producing a controlled surface collection of ceramics for typological and chronological purposes. However, it became apparent that only the small habitation mounds and the larger platform mounds produced significant quantities of cultural materials (ceramics, bone, metal, stone, and shell artifacts). The field surfaces were essentially devoid of such archaeological materials, and, as later excavation proved, such material was rare in subsurface levels of the fields as well.

The exceptionally rich surface collections from the two classes of mounds did provide an important chronological overview of Prehispanic human occupation on the Pampa Koani. Table 1 compiles the nature, size, and cultural/temporal affiliations of 23 mound structures that were located in the survey. Figure 5 places the sites in their proper chronological context (Ponce 1970, 1976, 1981).

In general terms, as this table indicates, the Pampa Koani zone was occupied as early as 1000 B.C. by Chiripa peoples who may have been exploiting the marshy area along the lake edge for its substantial lacustrine resources. Of course, the intriguing possibility that even in Chiripa times the Koani zone was being transformed into an artificial agricultural landscape remains a viable proposition, but one whose confirmation awaits further testing in the field.

The heaviest and most extensive human activity on Pampa Koani occurred during Tiwanaku IV and V times (ca. A.D. 400–1100): the bulk of the extant agricultural fields was constructed during this period. As demonstrated below (Figure 6), Tiwanaku IV habitation mounds can be structurally

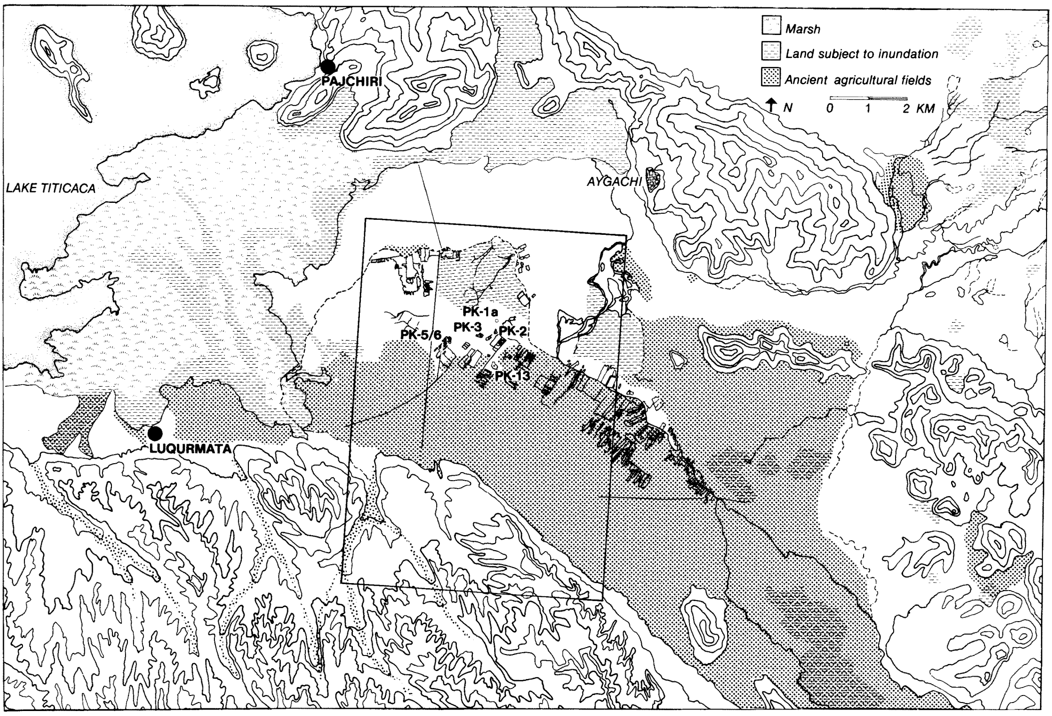


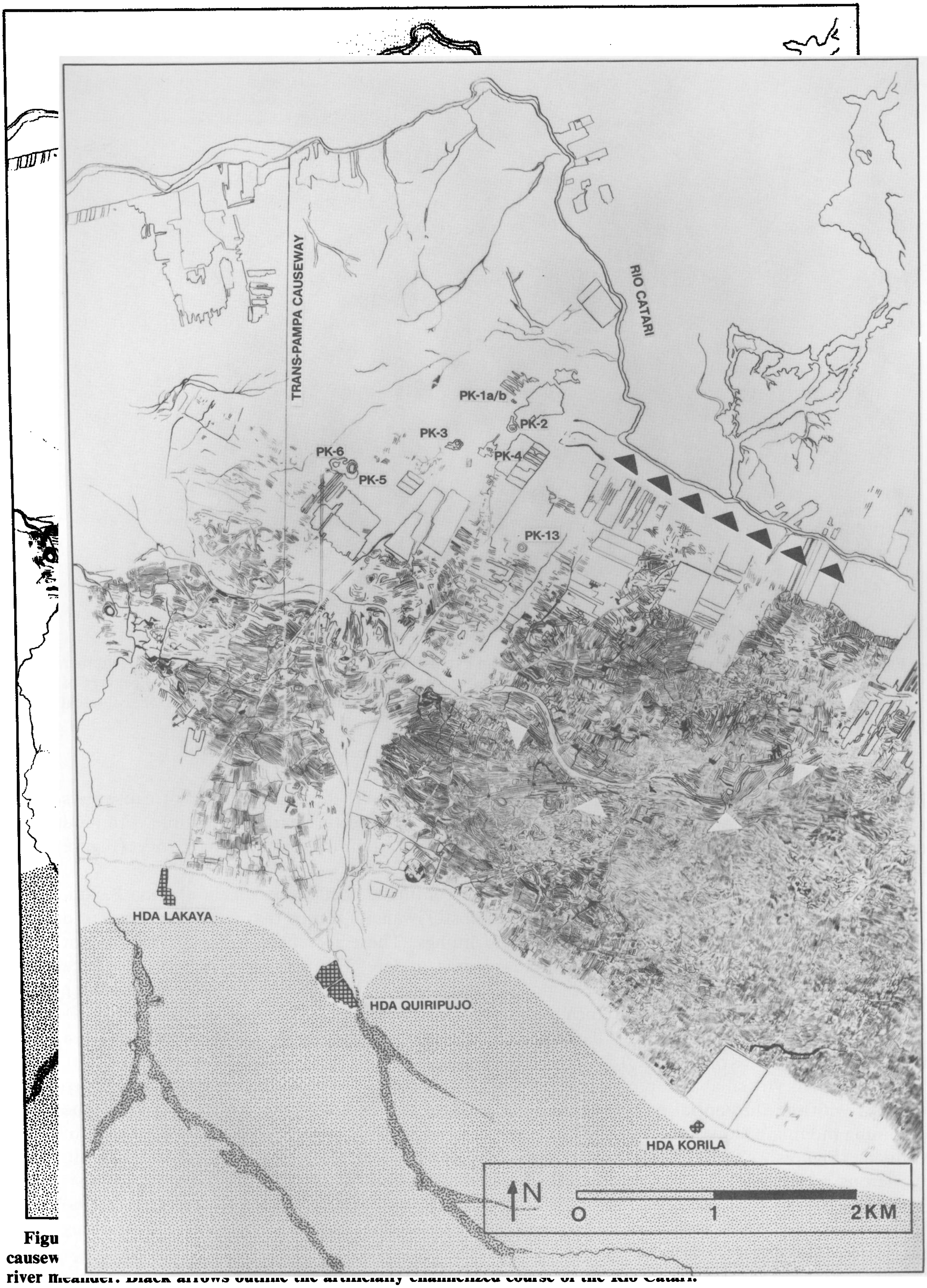
Figure 3. Pampa Koani and vicinity. Shown here is an extensive zone of ancient agricultural fields, together with a system of causeways that linked local administrative sites with the regional administrative centers of Luqurmata and Pajchiri. Superimposed box represents the detailed area of fields, causeways, and archaeological sites mapped in Figure 4.

linked with the construction of raised field segments. Moreover, the configuration of causeways linking the larger platform mounds dated to Tiwanaku IV–V times is clearly compatible with, and designed around the spatial and hydraulic requirements of the adjoining raised field networks (Figure 4).

After Tiwanaku V, there is very little evidence for continued occupation on the Pampa Koani. The larger platform mounds do contain intrusive, post-Tiwanaku tombs that were excavated into the old mound surfaces and furnished with slab linings. These rectangular cist tombs are not associated with any areas of local habitation discovered to date. The tangible evidence of an Inca presence is even more scarce than that of the indigenous post-Tiwanaku materials. This evidence is limited strictly to a few diagnostic Inca sherds recovered from the surface of sites PK-2 and PK-3, and a beautiful cut spondylus shell llama figurine of probable Inca origin discovered eroding from the surface of PK-3 (Kolata 1982:15).

The apparent virtual abandonment of the Pampa Koani after Tiwanaku V times stands in sharp contrast with the substantial post-Tiwanaku occupations and agricultural constructions along the adjoining mountain slopes north of the modern village of Aygachi, and on the nearby peninsula of Cumana (Figures 2, 3). In contradistinction to the Pampa Koani, these dissected hillsides contain numerous rectangular *chullpas,* multi-story burial towers built of field stone that date to post-Tiwanaku times within the period ca. A.D. 1100–1500, as well as several Inca sites clearly defined by field-stone structures with trapezoidal niches and by abundant jars and shallow bowls imitating the Cuzco-Inca style (Cordero 1971).

This distinctive patterning of human settlement along temporal lines was a surprising discovery



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river meander. Black arrows outline the artificially channelized course of the Rio Catari.

given the intensity of Inca occupation on the nearby islands of Titicaca and Koati (Bandelier 1910; Bennett 1936; Posnansky 1945) and along the rocky terraces that enclose the Pampa Koani at its northern extremity. Two explanations for this unexpected feature of the region's patterns of settlement and agricultural production immediately come to mind: (1) the evident decline in human activity on the Pampa Koani after Tiwanaku V times was related to the disintegration of the Tiwanaku state, with the collapse of strong central authority inducing disruption of the formidable seasonal maintenance requirements of the field systems; and (2) a physical change in the lake edge environment, specifically a significant rise in the level of Lake Titicaca, induced perennial inundation or waterlogging of a substantial portion of the agricultural soils on the Pampa Koani, rendering them useless for farming. Either of these explanations is plausible alone, or they may describe an interrelated cause-and-effect relationship.

The first explanation accords well with the general archaeological evidence bearing on the history of the Tiwanaku state, but does not cast light on why the Koani fields were never reutilized in post-Tiwanaku times. The second explanation finds a measure of support from excavations in one of the Pampa Koani mounds (PK-1a) in which two inundation caps appear prominently in the stratigraphic profile. However, if it is to be truly compelling, this hypothesis of environmental degradation will require more substantive backing through additional paleohydrological research (Hill 1959). In either case, there are broad avenues of research yet to be traversed before we arrive at a definitive explanation of the post-Tiwanaku abandonment of the Pampa Koani.

EXCAVATIONS ON THE LOWER PAMPA KOANI

During the pilot program, test excavations were undertaken in three contexts: platform mounds, small habitation mounds, and fields. A total of twelve 2 × 2 m test pits were excavated in the two types of mounds (PK-1a, PK-2, PK-3, PK-5, PK-6, PK-13, PK-15; see Table 1 for mound typology), while three long, shallow trenches were cut across separate elevated field surfaces and intervening swales.

Our initial set of test pits was sunk into the larger platform mounds strung along the center of the lower Pampa Koani just south of the Rio Catari. The results of these excavations, conducted in sites PK-2, PK-3, PK 5/6, and PK-13, are generally comparable and provide some tentative, but nonetheless revealing insights into the nature of human occupation on the Pampa Koani.

The structures themselves consist of multiple, stratified clay, packed earth, or adobe floors, and melted adobe wall rubble interdigitated with natural deposits of aeolian, fluvial, or lacustrine origin. Deposits of artificial origin between floors within the mound structures were either laid down purposefully as a part of construction processes, or result from agricultural activities in the surrounding pampa. In addition, excavations in PK-3 revealed a set of multiple post holes excavated into the clay surface of a floor, suggesting that some form of wooden superstructure was a characteristic feature of these mounds.

The artificial fill in these mounds consists almost entirely of highly disturbed, temporally mixed deposits, with frequent examples of presumptive inverted stratigraphy: in PK-2 and PK-3, samples of early Chiripa fiber-tempered ceramics were found in fill overlying floors securely associated with Tiwanaku IV ceramics. A plausible explanation for recurrent mixed deposits is that in the process of mound construction and periodic remodelling, the earth used as the primary material for the clay floors and adobe walls was scraped up from areas adjacent to the intended structure, or from portions of previous construction phases and subsequently reincorporated into the new structure.

Test pits in two of the largest platform mounds were excavated to sterile deposits that consisted of clean, fine-grained white sand (PK-5), or a red, loamy sand (PK-13). The sterile basal deposits of these two mounds, which may represent original lake beach (PK-5) or riverine (PK-13) facies, were initially encountered between 90 to 110 cm beneath the present surface of the pampa. Test pits in PK-1a, PK-2, and PK-3, each reaching depths of nearly 3 m, also penetrated up to 90 cm beneath the present surface of the surrounding pampa, but without encountering unequivocal sterile deposits. These excavations reached the phreatic boundary and subsequent seepage of water forced termination of further operations.

In PK-1a, PK-2, PK-3, and PK-13 there are substantial clay floors, hearths, human and llama

Table 1. General Characteristics and Tentative Dating of Selected Sites on the Pampa Koani, Department of La Paz, Bolivia.

Site	Location	Type	Approximate Dimensions (L × W × H)	Phase Date(s)
PK-1[a]	See map, Figure 4	Small habitation mound: oval	28 m × 20 m × 1.50 m	Chiripa, Tiwanaku I, Tiwanaku III–V
PK-1[b]	Adjacent to PK-1[a]	Small habitation mound: oval	27 m × 20 m × 1.50 m	Chiripa, Tiwanaku III–V
PK-2	See map, Figure 4	Large platform mound: L-shaped	73 m × 65 m × 2.10 m[a] 67 m × 19 m × 1.50 m	Chiripa, Tiwanaku III–V
PK-3	See map, Figure 4	Large platform mound: L-shaped	75 m × 60 m × 2.35 m[b] 40 m × 30 m × 1.75 m	Chiripa, Tiwanaku III–V, Inca
PK-4	See map, Figure 4	Small habitation mound: quadrangular	16 m × 14 m × 1.10 m	Tiwanaku III(?)–IV
PK-5	See map, Figure 4	Large terraced platform mound: quadrangular with possible sunken court and gateway	120 m × 75 m × 3.75 m	Chiripa, Tiwanaku III–V
PK-6	See map, Figure 4	Large terraced platform mound: quadrangular paired with PK-5	110 m × 67 m × 3.10 m	Tiwanaku III–V
PK-7[a]	Approximately 750 m SE of PK-2	Small habitation mound: oval	27 m × 21 m × 2.20 m	Tiwanaku IV–V
PK-7[b]	Adjacent to PK-7[a]	Small habitation mound: oval	24 m × 18 m × 1.50 m	Tiwanaku IV–V
PK-8	Approximately 1 km SE of PK-2	Small habitation mound: oval	32 m × 28 m × 1.45 m	Tiwanaku IV–V
PK-9	Adjacent to PK-8	Small habitation mound: oval	28 m × 25 m × 1.25 m	Tiwanaku IV–V
PK-10	Approximately 2 km SE of PK-5	Small habitation mound: quadrangular	34 m × 30 m × .90 m	Tiwanaku IV–V
PK-11	Approximately 2 km SE of PK-5	Small habitation mound: oval	24 m × 27 m × 1.30 m	Tiwanaku IV–V
PK-12[a]	Approximately 2.5 km SE of PK-5	Small habitation mound: oval	26 m × 18 m × 1.24 m	Tiwanaku IV–V
PK-12[b]	Adjacent to PK-12[a]	Small habitation mound: oval	12 m × 16 m × .90 m	Tiwanaku IV–V
PK-13	See map, Figure 4	Large terraced platform mound: quadrangular	60 m × 57 m × 3.30 m	Tiwanaku IV–V
PK-14	Approximately 1.5 km due north of Hda. Lakaya, Figure 4	Small habitation mound: oval	23 m × 22 m × 1.35 m	Tiwanaku IV–V
PK-15	Approximately 1.5 km due north of Hda. Lakaya, Figure 4	Small habitation mound: oval	20 m × 13 m × .90 m	Tiwanaku IV–V
PK-16	Approximately 1.5 km due north of Hda. Lakaya, Figure 4	Small habitation mound: oval	13 m × 17 m × .80 m	Tiwanaku IV–V
PK-17	Approximately 1.5 km due north of Hda. Lakaya, Figure 4	Small habitation mound: oval	27 m × 22 m × 1.72 m	Tiwanaku IV–V

Table 1. Continued.

Site	Location	Type	Approximate Dimensions (L × W × H)	Phase Date(s)
PK-18	Approximately 1.5 km northwest of Hda. Lakaya	Small habitation mound: oval	24 m × 19 m × 1.10 m	Tiwanaku IV–V
PK-19	Approximately 1.5 km northwest of Hda. Lakaya	Small habitation mound: oval	20 m × 14 m × .90 m	Tiwanaku IV–V
PK-20	Approximately 1.5 km northwest of Hda. Lakaya	Small habitation mound: oval	23 m × 21 m × 1.10 m	Tiwanaku IV–V

[a,b] Both PK-2 and PK-3 are "L-shaped" mounds and the two sets of figures given reflect this configuration. The first set of figures refers to the main quadrangular portion of each mound; the second set refers to the narrow terrace that projects from the main portion (see Figure 4).

bones, and other domestic debris in primary contexts well below the present surface of the pampa on which the agricultural fields illustrated in Figure 4 were constructed. These relatively deep, sub-pampa cultural deposits raise the possibility that there are now buried fields associated with the initial phases of mound construction. However, direct evidence for such fields has yet to be uncovered.

Each of the platform mounds exhibit a measure of careful architectural treatment. Intact floors in PK-2, PK-3, and PK-13 were carefully plastered with a dense, clay solution that dried to a hard surface with a bone white finish. The largest structure on the Pampa Koani, mound PK-5, at one time may have been furnished with a formal gateway: a plain, roughly cut rectangular stone pillar was recovered on the southeast façade of the structure. This pillar may have formed the lintel of a gateway that gave access to the summit of the mound. There are strong surface indications that the summit of PK-5 itself was spatially organized around a sunken rectangular court with an elevated platform attached to the northern end. But, pending further excavations, this conclusion must remain tentative.

Unlike the other platform mounds, PK-5 was not a single isolated structure: it, along with PK-6, forms part of an architectural ensemble I refer to as the "dual pyramid complex." As indicated in Table 1, this complex is distinguished by the disproportionate size of the two constituent monuments. The sheer size and massiveness of the dual mounds, along with the possible gateway and sunken court configuration, argue for a special status for this complex. It is reasonable to conclude that in the hierarchy of sites in the Koani agricultural zone these two structures were of paramount ritual and administrative importance, subordinate only to the two regional centers of Luqurmata and Pajchiri.

Apparent class stratification during Tiwanaku IV–V times is substantiated by a sharp dichotomy in residential patterns, in architectural treatment of functionally distinct structures, and in material culture. The larger platform mounds were distributed in a kind of ersatz metropolitan cluster, while the smaller habitation mounds were simple living surfaces associated with field segments dispersed widely throughout the agrarian zone. Figure 6 illustrates a direct structural association between such "house mounds" and elevated field surfaces that is recurrent in the Koani zone. The smaller habitation mounds tested to date show little evidence of internal structure, and consist primarily of low platforms of packed earth, rather than the more elaborate adobe walls and plastered floors of the large platform mounds.

The two classes of mound structures share similar kinds of faunal remains indicative of a widespread consumption of fish, and, to a lesser extent, camelid meat. Substantial quantities of fish bones and scales were recovered from every mound tested, while smaller numbers of disarticulated and frequently charred camelid bones were extracted from hearths, most often within the large platform

YEARS AD/BC	RELATIVE CHRONOLOGY		ARCHAEOLOGICAL SITES
1500	LATE HORIZON(INCA)		Iñak-uyu, Pilko-kaina
1200	LATE INTERMEDIATE PERIOD (AYMARA KINGDOMS)		Hatuncolla, Chucuito
900	TIWANAKU V		
600			
300	TIWANAKU IV		Luqurmata, Pajchiri PK-1a/b, PK-2, PK-3 PK-4, PK-5, PK-6, PK-13
	TIWANAKU III		
AD -- 0 BC	TIWANAKU II	TIWANAKU	
300	TIWANAKU I		
600	LATE CHIRIPA		PK-1a
900		CHIRIPA	PK-1a, PK-2, PK-3, PK-5
1200			
	EARLY CHIRIPA		
1500			

Figure 5. Chronological chart placing the Pampa Koani's archaeological sites in their temporal context.

mounds. The artifactual correlates of hunting (grooved bola stones, projectile points), fishing (stone net weights), and butchering of game (stone cleavers and scrapers) likewise appear distributed across the two classes of mound structures. However, the finest chipped and ground stone tools were recovered from the large platform mounds.

In other regards, the material culture of the small house mounds associated with field segments versus that of the large platform mounds is palpably distinct. The house mounds contained only coarse reddish-brown or black utilitarian ceramics consisting predominantly of simple bowls and jars. The large platform mounds, on the other hand, yielded substantial quantities of both domestic wares and the superb, polychrome ceramics emblematic of the Tiwanaku IV style. The exquisite, highly burnished, and carefully painted pottery from the Pampa Koani platform mounds is indistinguishable from superior vessels excavated at Tiwanaku itself, and displays all of the characteristic vessel forms of the finest quality Tiwanaku wares: *keros,* modeled, puma-headed *incensarios, challadors* (ritual drinking cups with a wide flaring body and a circular base of small diameter), bowls, and jars.

This structured distribution of utilitarian versus high-quality ceramic wares presents a strong argument for drawing both status and functional distinctions between the two classes of mounds.

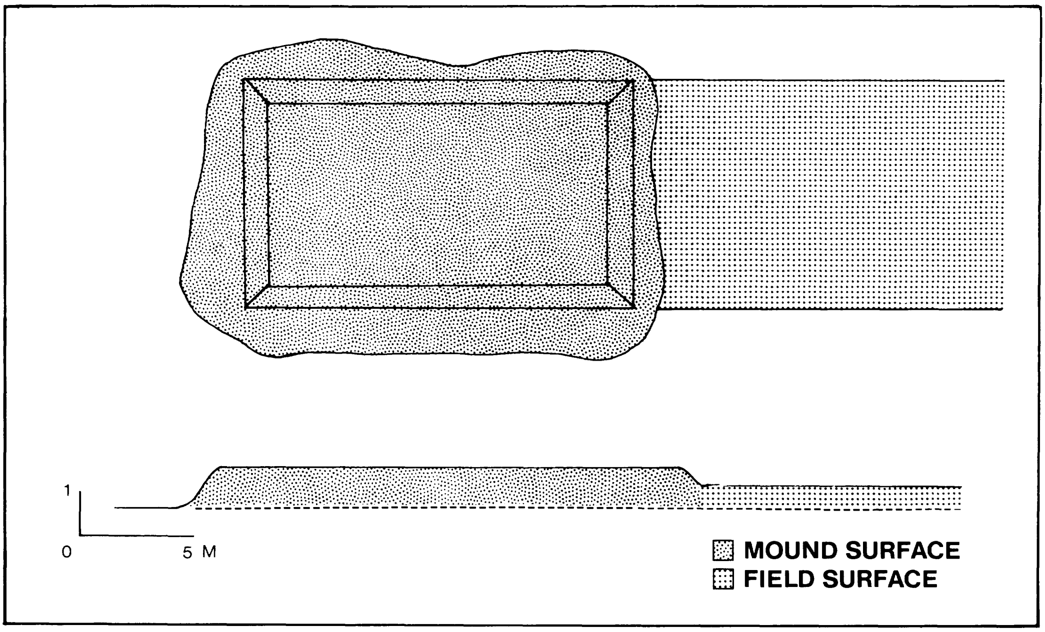

Figure 6. Sketch map of site PK-15, a small Tiwanaku IV-V habitation mound in the Lakaya region of the Pampa Koani. This plan illustrates the manner in which raised field segments were frequently merged structurally with the mounds themselves permitting a direct means of dating the fields.

Such distinctions are further enhanced by the distribution of metal artifacts: whole copper plaques, copper *topo* pins, and fragments of silver and bronze were recovered exclusively from the platform mounds. Most often these metal objects were found in association with seated, flexed human burials accompanied by other luxury items such as turquoise or sodalite beads and highly polished ceramics. Slag found on the surface of PK-2 and PK-3 may indicate that these structures were the focus of some kind of small-scale metal working industry. At present, this presumptive smelting activity cannot be securely dated to the primary Tiwanaku IV occupation.

The patterns that emerge from the distinctive nature, distribution, and elaboration of sites and their associated material culture suggest the following interpretation of settlement function and hierarchy on the Pampa Koani. The small house mounds physically associated or structurally merged

Table 2. Two Labor and Population Density Estimates for the Pampa Koani Fields.

Total surface area		7,000 ha	
Surface area of fields		3,500 ha	
Total earth moved		3,500,000 m^3	
Total labor days	1,346,000[a]		714,285[b]
Population supported per hectare	5.7		15.85
Total population supported	19,950		55,475

Both estimates assume 100% utilization of the fields.

[a] Estimate based on assumptions stated in Denevan (1982:190–191). Total labor days calculated on the basis of 2.6 m^3 of earth excavated per person per 5 hour day. Population supported per hectare based on an average potato yield of 3,050 kg/ha/year, an average of 1,000 calories/kg, and an average daily consumption of 1,460 calories per capita.

[b] Estimate based on assumptions stated in Erickson (1984). Total labor days calculated on the basis of 4.9 m^3 of earth excavated per person per 5 hour day derived from construction of an experimental raised field in Huatta, Peru. Population supported per hectare based on an extrapolated average potato yield of 8,440 kg/ha/year, 1,000 calories/kg, and 1,460 calories daily intake per capita.

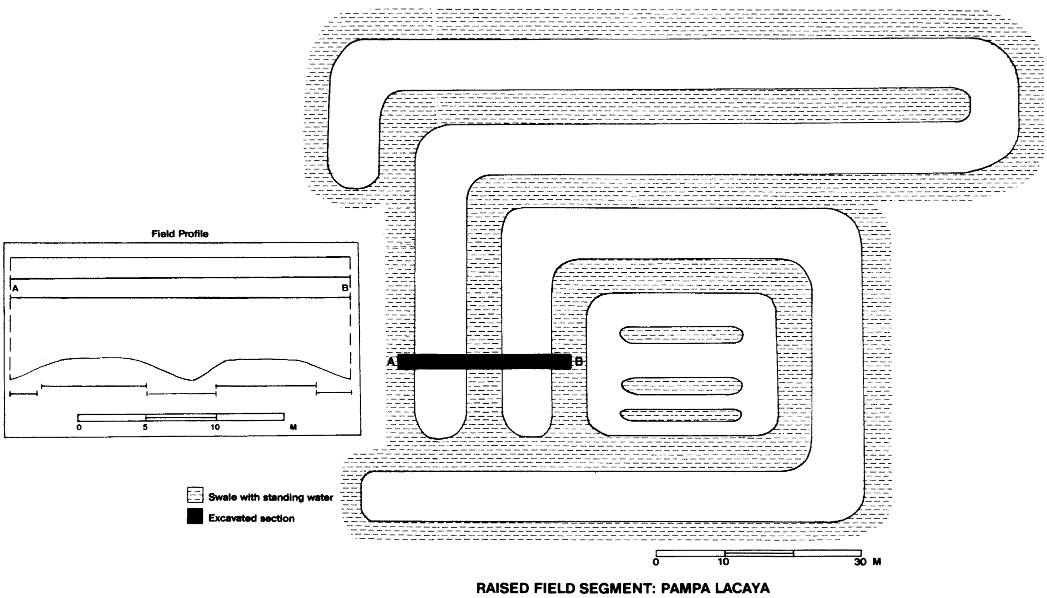

Figure 7. Map of self-contained raised field segment from the Lakaya region of the Pampa Koani. This field segment was associated with sites PK-14, PK-15, and PK-17; see Table 1.

with raised field segments were the residences of peasant families engaged in primary agricultural production. (However, a more ephemeral or seasonal function for some of the smaller mounds, such as the base of huts used in guarding crops, cannot be entirely discounted.) The large platform mounds, on the other hand, housed a corps of administrators and their household retainers charged with organizing the seasonal cycle of agricultural activities, and accounting for the staggering quantity of produce that flowed from the state fields of the Pampa Koani (see Table 2 for some quantitative estimates).

The monumental dual pyramid complex of PK-5 and PK-6 represents the ritual and administrative apex of settlement hierarchy on the Pampa Koani, distinguished in status from both the small habitation mounds and the other platform mounds. The entire settlement system of the Pampa Koani during Tiwanaku IV–V times revolved around the requirements of intensive agricultural production, and reflects the truly vital purpose of human activity on that plain: the construction and maintenance of a stable agricultural landscape.

THE AGRICULTURAL FIELDS

The fossil raised field system of the Pampa Koani is a representative portion of a vast network of similar abandoned fields that encompasses nearly the entire circumference of Lake Titicaca. This imposing landscape of once reclaimed fields has only recently received systematic archaeological attention (Denevan 1970, 1980; Erickson 1984; Kolata 1982, 1983; Lennon 1982; Smith et al. 1968). This preliminary work revealed that these fields are not uniform in size or shape, although all performed a similar *primary* function: draining planting surfaces to permit cultivation. Various other specific functions of the raised fields in the context of this high altitude environment have been suggested. Most prominent among them is the hypothesis that the surface contours of the raised fields served to minimize the damage from severe frosts endemic to this region (see Erickson [1984] for an assessment of this hypothesis).

The raised fields themselves were formed by excavating earth from either side of the projected field and mounding it in the center. The resulting agricultural construction was an elevated planting surface ranging from 5 to 10 m wide and up to 200 m long. Ground survey coupled with the analysis

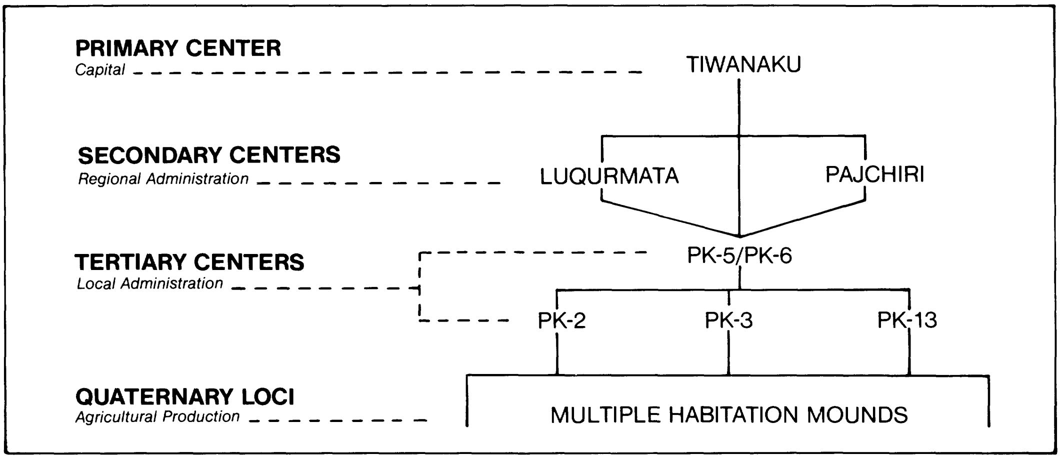

Figure 8. Schematic representation of Tiwanaku's hierarchical settlement network.

of aerial photographs indicated that at least 70 km^2 of near lake land within the research zone was reclaimed in Pre-Hispanic times by constructing these massive, elevated planting surfaces. Figure 3 illustrates the core area of reclaimed fields that are preserved and visible on the surface today. An undetermined area of fossil fields has been destroyed by modern agricultural encroachment.

In their pioneering work, Smith et al. (1968:362) recognized five distinct patterns of raised fields in the Titicaca basin: (1) "open checkerboard," (2) "irregular embanked," (3) "step ladder," (4) "riverine," and (5) "linear" or "curvilinear." Virtually all of the fields in the Koani zone conform to the latter two varieties, with the bulk of the fields falling in the curvilinear category. A detailed map of a portion of the Pampa Koani, compiled from a 1:10,000 aerial photograph enlargement, graphically illustrates the sweeping, curved platforms of earth characteristic of these fields (Figure 4). The actual form and profile of an individual, self-contained field segment is illustrated in Figure 7. Approximately 50% of the area of a field segment is given over to the planting surface itself. The remaining half of the surface area is occupied by the intervening swales.

Working with distributional data from the entire Titicaca basin, Denevan (1982) and Erickson (1984) have each attempted to estimate the amount of labor invested in the construction of the raised fields, as well as the potential population density that may have been supported on a sustained yield basis. Table 2 offers two potential labor investment and population density estimates for the Pampa Koani field system calculated on the basis of assumptions employed by Denevan and Erickson, respectively.

Although these two estimates differ radically because of markedly different assumptions concerning labor and crop production, they do provide a preliminary set of boundary conditions within which more precise quantitative studies of population and labor investment can profitably proceed. It should be noted that both Denevan and Erickson assume 100% utilization of the fields in making their estimates, and, as both acknowledge, given potential effects of localized crop loss, temporal differences in field construction, and other such variables, this expectation is not entirely realistic. However, the probable contemporaneity of the fields on the surface of the Pampa Koani enhances the viability of crop production and population estimates based on the assumption of 100% utilization of the fields in this zone.

Despite their differences, both of these estimates strongly imply that a substantial amount of labor was invested in reclaiming the lake edge land of Pampa Koani, and that a significant population could have been supported on a permanent basis by the agricultural products of these fields. These conclusions are further substantiated by the artificial canalization of the Rio Catari, which was designed to permit reclamation of land to the south of the river, and by the establishment of a causeway network across the Pampa Koani (Figure 4).

Other than the dispersed set of small house mounds associated with field segments, and the five larger platform mounds, no evidence for large, numerous, or dense rural occupations on the Pampa Koani during Tiwanaku IV times has been uncovered to date. This implies that if the Koani zone was producing approximately between 11 and 30 million kg of potatoes per year as calculated from the estimates in Table 2, or enough to support between 20,000 and 56,000 people annually, then a substantial portion of this agricultural product was not being consumed locally, but was intended for export to more numerous non-local populations. The causeway network would have facilitated the transportation of bulk agricultural commodities from the immediate zone of the raised fields, probably through the vehicle of llama pack trains.

The most likely consumers for the surplus production of the Koani fields were the populations residing around the regional administrative and ritual centers of Luqurmata and Pajchiri, and, more importantly, those residing in the capital of Tiwanaku itself where over 4 km^2 of domestic refuse argues for a substantial urban residential zone (Parsons 1968; Ponce 1980:30). Current projections of peak urban population at Tiwanaku range from 20,000 to 40,000 (Browman 1978:328; Parsons 1968). If these projections are reasonably accurate, then the requisite annual food supply for the city of Tiwanaku could have been satisfied by the production of the Pampa Koani fields alone.

CONCLUSIONS

Until recently, our understanding of Tiwanaku as a pivotal nation in the geopolitical landscape of the ancient Andean world has been severely constrained by a lack of primary data on its system of intensive agricultural production. We now have the means, preliminary as these may be, to provide a truly compelling explanation for the monumental scale, architectural elaboration, and artistic sophistication that distinguishes Tiwanaku and its satellite cities.

For the first time we have unequivocal evidence that a large rural hinterland transformed into an artificial agricultural landscape was directly associated with the city of Tiwanaku. Plausible crop-yield estimates suggest that a substantial population, ranging from 20,000 to 56,000 could have been sustained on a continuous basis by the fields in this immediate hinterland.

There is significant evidence, both direct and inferential, that the construction, maintenance, and production of these fields were managed by a centralized political authority that systematically co-opted land and labor for the benefit of non-local populations. The presence and apparent power of this centralized authority is reflected in the archaeological record by: (1) massive public reclamation and construction projects, such as the artificial canalization of the Rio Catari, which required a large and coordinated labor force; (2) a consistent distinction between an elite, luxury-oriented material culture and a subsistence-oriented proletarian material culture implying some form of class stratification; and (3) a contemporaneous hierarchical settlement network marked by unambiguous distinctions in size, status, and function. This settlement hierarchy implies, minimally, a nested, quadrapartite division of administrative and primary production responsibilities (Figure 8). Such a hierarchical settlement system is a distinguishing characteristic of an integrated preindustrial state (Isbell and Schreiber 1978; Wright and Johnson 1975), and implies that the Tiwanaku state maintained a high degree of administrative efficiency and centralization of agricultural production.

From the evidence presented here, I conclude that the fields on the Pampa Koani were the proprietary agricultural estate of Tiwanaku, that the intensification of agricultural production through large-scale reclamation of flat land along the margins of Lake Titicaca was a prime economic strategy of the Tiwanaku state, and that this strategy was successfully devised and managed by a centralized arm of government. Furthermore, I would suggest that this portrait of the key agrarian sector of Tiwanaku's economy is not limited to the capital city's immediate hinterland. A similar pattern of strategically located, state-built administrative centers near zones of potentially arable land can be documented for the entire circum-Titicaca region during Tiwanaku phases III–V (Nuñez and Paredes 1978; Tapia 1976). This distinctive settlement pattern, when assessed against our new knowledge of the Pampa Koani rural zone, strongly suggests a regional political unification of the Titicaca basin imposed by Tiwanaku directed toward expanding that state's agricultural production.

However one wishes to interpret the growing body of data from the Pampa Koani and its counterparts around Lake Titicaca, any subsequent analysis of Tiwanaku's political and economic organization must take into account the fundamental role of that ancient state's rich, but long-forgotten agrarian heritage.

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