# Geoarchaeology of an Aztec Dispersed Village on the Texcoco Piedmont of Central Mexico

**Carlos E. Córdova**

*Department of Geography, University of Texas at Austin, Austin, Texas 78712*

**Jeffrey R. Parsons**

*Museum of Anthropology, University of Michigan, Ann Arbor, Michigan 48109*

Analysis of the microstratigraphy, geomorphology, and soils within an Aztec site in the piedmont of Texcoco provides information on the ecological context of the dispersed village during the Late Aztec phase (A.D. 1350–1520). Two erosional phases are identified, the first in the period between A.D. 500 and 1000, and the second in the 1600s. The two erosional events are correlated with the transition from dispersed settlements, with relatively high population density, to nucleated settlements marking a decline in population. Land reclamation by Aztec settlers is attested by the remains of the semiterracing system of *metepantli* and rock-faced terraces, which are features discussed in the context of anthropogenic soils identified within the site. © 1997 John Wiley & Sons, Inc.

## INTRODUCTION

The archaeological survey maps of the Basin of Mexico show a great number of dispersed villages for the Late Aztec phase (A.D. 1350–1520) or Late Horizon (Sanders et al., 1979), suggesting that dispersed settlement was the most common form of rural occupation, particularly on the piedmonts, which are usually slopes of low agricultural productivity, due to their thin soils, problems of erosion, and reduced availability of water for irrigation.

The dispersed village was a distinctive type of settlement in the Aztec rural landscape; the Spanish conquistador Hernan Cortes in 1519 commented on the sparse character of the communities on the piedmont between Coatepec and Texcoco (*Tercera Carta de Relacion,* 1522, in Cortes, 1985:137). Later, during the 16th and early 17th centuries, the dispersed settlement pattern began to disappear through a gradual process of nucleation which formed the modern rural communities, which are characterized by houses aligned along streets laid in a rectangular grid, and the administrative and religious premises located in the center.

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The archaeological survey of the Basin of Mexico defined the "dispersed village" as a light concentration of surface pottery with no evidence of civic, elite, or ceremonial architecture, which in turn was arbitrarily divided into two categories, large (500–1000 people) and small (100–500) (Sanders et al., 1979:56). Since there is basically no analogue in the contemporary rural landscape of the Basin, a dispersed village is difficult to envisage. Although some studies have yielded information on the social organization and productivity of Aztec rural communities (Cabrero, 1988; Evans, 1990; Williams, 1994), it still remains necessary to search for more clues as to how soils were managed within the fields of an Aztec dispersed village, as well as to comprehend the importance of the distribution of dwellings and fields with respect to the available land. This necessarily implies an examination of features to control erosion and productivity, such as terraces, whose remains are still visible in a few archaeological sites.

The main objective of this paper is to examine an Aztec dispersed village of the Texcocan piedmont from a geoarchaeological perspective, including its reconstruction at different times, as well as the evaluation of the agricultural settlement in the ecological context of erosion-prone areas.

The archaeological site of this study is Tx-A-78, surveyed in 1967 and reported by Parsons (1971:132–133). Although part of the area occupied by this settlement was referred to in some sixteenth century documents as "Olopa," the name of a remaining small Indian community, the assignation Tx-A-78 is used in this article, since no local name has been assigned to the site at present. This site has been chosen for this study, because it is one of the best examples of an Aztec dispersed village to survive extensive recent leveling by machinery for the purpose of reforestation, which in the last two decades has destroyed some 60% of the archaeological vestiges on the Texcocan piedmont (Parsons, 1989).

## GEOARCHAEOLOGICAL STRATEGY AND METHODS

The reconstruction of site Tx-A-78 required a previous understanding of the processes of development and destruction of the site. This objective required the establishment of a detailed chronology of the site attained through microstratigraphic study in the same way that Butzer (1981) and Butzer et al. (1983) have reconstructed processes of transformation in urban sites. Adapted to rural sites, this method involves, on the one hand, a thorough examination of those cultural deposits and its interrelation with soil and lithostratigraphic units, and, on the other, a search into historical documentation dealing with land use and people in the area during the Early Colonial period.

Since the landscape has been transformed by land reclamation during the years after the survey, it was necessary to examine the original aerial photographs, survey maps, site descriptions, and ceramic collections.

Using enlarged aerial photographs taken in 1956 and 1980, and revisiting the site, it was still possible to locate those features recorded through survey. On the same photographs, lithologic and soil units were traced, and their limits subsequently corroborated in the field. Distinct spatial associations between domestic structures, field patterns, terraces, and soil units were still visible in a few areas where postoccupational erosion and mechanized land leveling had not yet been implemented. In order to examine this association between cultural features and soils, the best preserved area was isolated and studied on an enlarged photograph, the "test area" within the site.

Four soil units were identified here on the basis of depositional and erosional phases, and the accumulation of artificial soil. These soil units were examined through the study of six selected soil profiles, from which samples of each horizon were analyzed in the laboratory to obtain data on texture, organic matter, bulk density, total phosphorus, and soluble salts. These parameters were used to compare soil properties among different anthropogenic horizons and some of their natural counterparts within the site, a methodology of terraced soil characterization in archaeological sites developed by Sandor (1992). Thin sections were also obtained from some horizons in order to make comparisons with properties of anthropogenic soils.

The information on surface pottery collected by Parsons in 1967, which was basically from domestic units, was complemented with the pottery obtained from each of the soil units defined during the present research. In order to have points of reference on the site's test area, it was necessary to define 13 control points which correspond to the localities of pottery collection and the localities of described soil profiles. These 13 control points within the test area were designated as datum levels to reconstruct soil cover for each period, as well as to estimate the depth of ravine incision. Four geomorphological profiles showing the Late Quaternary stratigraphy were also traced to illustrate the close association between lithologic units, topography, soil units, soil erosion, and gully incision.

Two profiles of modern semiterraced soils were described and sampled, and used to back up the interpretation of their archaeological analogues within the Aztec village.

The methodology proposed and used by Charlton (1969) to study spatial relationships of ceramics and settlement delimitation for Late Aztec sites in the Teotihuacan Valley is applied to the study of this settlement. The methodology consists in the use of several early Colonial documents to delimit settled territories and properties. Documents dealing with land grants (*Mercedes*) (AGN, 1591a, 1607) and land litigation (*Tierras*) (AGN, 1591b), spanning the last half of the 16th century and the first decade of the 17th century, provided information to reconstruct the history of settlement and to estimate the date of abandonment. Pictorial information on some sketch maps accompanying the *Tierras* documents was particularly helpful in combination with the texts.

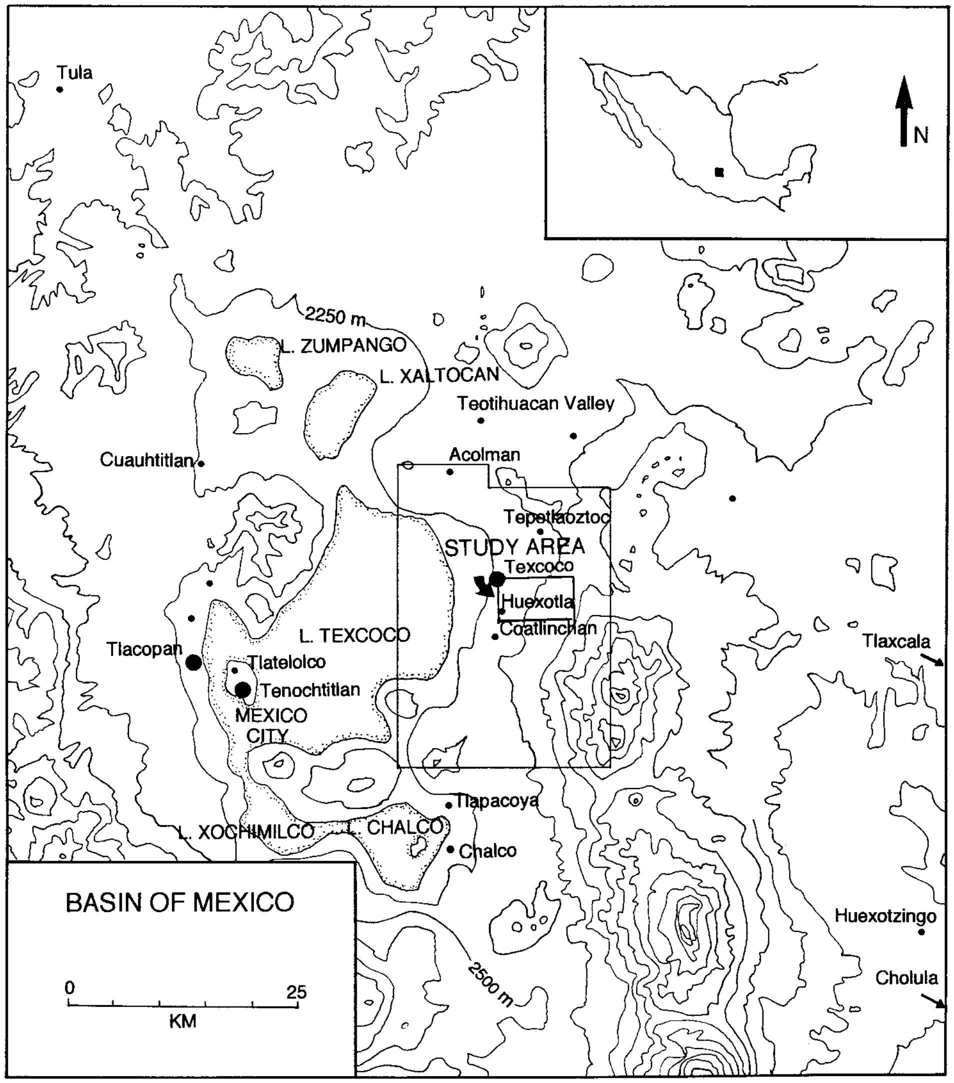



**Figure 1.** The Basin of Mexico, the Texcoco Region and the study area.

## ENVIRONMENT

The study area is located on the piedmont of the Sierra Nevada, about 30 km east of Mexico City (Figure 1). This is the heartland of the Aztec-affiliated Acolhua Kingdom, ruled by a dynasty of eight kings using Texcoco as their capital. The area chosen to analyze the regional context of settlement pattern evolution around site Tx-A-78 includes three main ecological zones: lower and

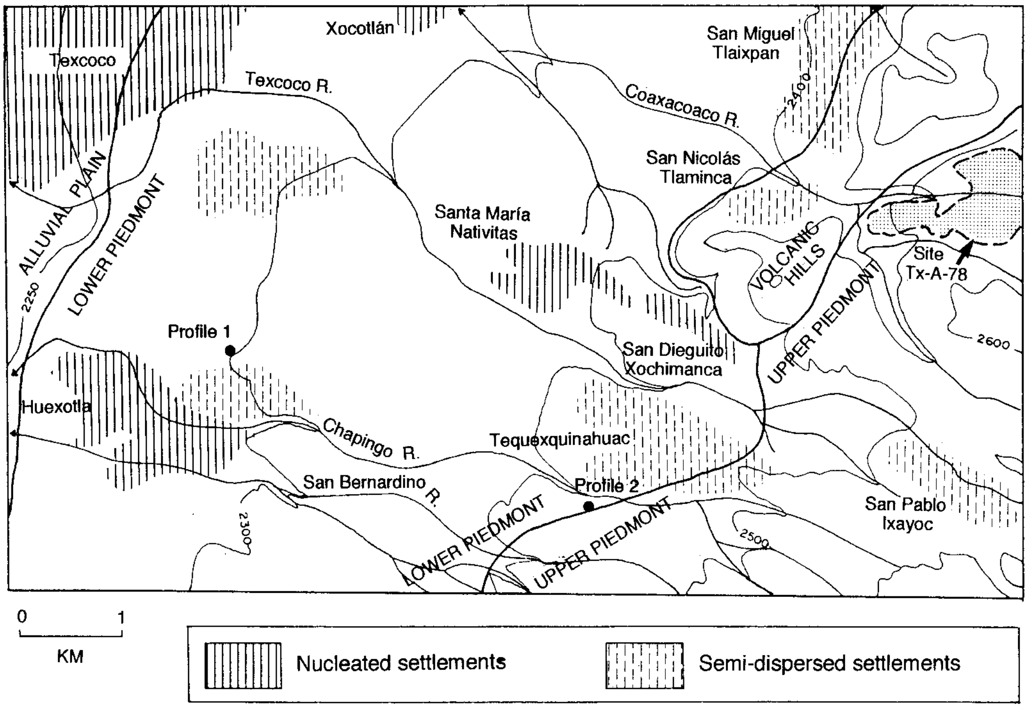



**Figure 2.** Ecological zones and modern settlements in the study area. Location of site Tx-A-78 and two metepantli soils sampled (profiles 1 and 2).

upper piedmonts, and volcanic hills; the alluvial plain covers just the western end of the study area (Figure 2).

The lower piedmont is gently dissected by a wide network of parallel gullies known locally as *barrancas.* Most of the modern population living in this zone is concentrated in nucleated and semidispersed towns, some of which are of Aztec origin (Parsons, 1971; Hodge and Minc, 1990). The upper piedmont, by contrast, is an area of variable slope, densely dissected by deep barrancas. Its most salient characteristic is an erosional, "badland" topography where much of the original soil has been stripped off. The areas lost to erosion are now barren surfaces of *tepetate,* an indurated crust of volcanic ash cemented mostly by silica, although in some parts also with calcium carbonate (Nimlos and Ortız-Solorio, 1987; Dubreucq et al., 1989). However, a recent micromorphological study of tepetates in Central Mexico focusing on the Texcocan piedmonts shows that the process of induration consists of calcitic accretion independent from clay illuviation and pedogenic silica, and that the presence of silica is due to abundant volcanic glass shards and phytoliths (Fedoroff et al., 1994:471). This study also shows that calcitic accretion not only contributes to induration of tepetates by cementation, but to the formation of a laminar crust which gives the tepetates their impermeability.

In the last 25 years, a state-sponsored reclamation program has broken the tepetate, leveled the terrain, and reforested most of the area. Previously, the area was so desolate that Palerm and Wolf (1954) labeled it an "arid zone." One of the modern settlements in the upper piedmonts is San Pablo Ixayoc, a semidispersed community that lies on the eastern edge of this unit in contact with the pine forest of the Sierra Nevada (Figure 2). The volcanic hills are the remains of an igneous structure described as an old caldera rim of Tertiary age exposing andesitic lava and breccia (Mooser, 1975). This structure has been shaped by erosion into a semicircular hill, resembling an amphitheater. The concave area is currently occupied by a semidispersed pattern of houses and terraced plot fields on which fruit trees and flowers are cultivated.

At San Miguel Tlaixpan, mean annual temperature is 14.2°C, and mean annual precipitation is 621 mm, concentrated between May and October (García, 1981). Frosts occur between October and April, with a higher frequency between November and February, more common and damaging in the plains and lower piedmont than in the upper piedmont and volcanic hills, due to the effect of topography in breaking the layer of cold air.

There are four main streams in the area: the Coaxacuaco, Texcoco, Chapingo, and San Bernardino Rivers, which in the piedmont flow inside the barrancas. They are intermittent streams, except for the Coaxacuaco and the Chapingo Rivers, which are fed by springs on the mountain slopes. However, the amount of water carried during the rainy season is so small that is lost through seepage or is tapped for irrigation.

## SOIL EROSION AND TERRACING

Severe erosion on the tepetate areas of the upper piedmont is a complicated process that has occurred in different phases during the last millennia. A study on sediment yield in several subbasins within the Texcoco River basin shows that erosion is an ongoing process in the area of bare tepetate where the estimated sediment loss is 16 tons/ha/yr, a figure that contrasts with those areas of soil remnants where sediment yield values range between 1 and 3 tons/ha/yr (Figueroa-Sandoval, 1975). Studies on accelerated erosion on slopes in similar environments in Central Mexico have modeled the processes involved in soil stripping and incision in areas of indurated substrates such as ignimbrite or several types of indurated ash, which are also known as tepetates. These studies include the analysis of the evolution of soil surface features such as scarplets, soil depressions, and gullies which have been meticulously observed to explain a complicated process of soil erosion, combined with shallow mass movements produced by nonconcentrated throughflow

(Bocco, 1993). Similar features that favor soil stripping are present in the upper piedmont of Texcoco, where slope degradation begins with microsliding of the upper horizons, and the creation of scarps that retreat to uncover tepetate, leading eventually to a concentrated flow that produces deep incision. The high erodibility that characterizes these soils is due to the impermeability of the tepetate and the argillic B horizons, both operating as internal base level for subsurface flows, stimulating saturation in the horizons above them, and causing sliding that triggers subsequent gully formation (Bocco, 1993:498).

Terrace construction is a soil conservation procedure practiced in this region to control soil erosion on the hill slopes and the piedmont east of Texcoco since Pre-Conquest times. Most of the modern and abandoned terraces are associated with Aztec sites, or contain abundant artifacts of this period. At present, two basic types of terracing coexist in the area of study: stone-walled contour terraces, and *metepantli* semiterracing, both systems very common in the area since pre-Hispanic times (West, 1970; Donkin, 1979, Evans, 1990).

Stone-walled terraces occur on the slopes of the old volcanic structures in the Tetzcutzingo area where they have been irrigated since Late Aztec times. In fact, some of them were part of the royal gardens created by King Nezahualcoyotl (who ruled from 1428 to 1472) in which irrigation was implemented through a series of canals that carried water from the mountains across the upper piedmont, crossing depressions on a series of aqueducts (Wolf and Palerm, 1955; Parsons, 1971; Doolittle, 1990). Parallel to the Aztec water-conduit network, some Post-Conquest canals tap water from permanent streams at different reaches in the upper piedmont. Stone-walled terraces are basically confined to the volcanic hills because faced stones are available from the abundant deposits of brecciated lava, as is the common case in other volcanic areas in the Basin of Mexico (Cordova and Vazquez, 1991).

A type of semi-terracing, known as *metepantli* (from the Nahuatl: *metl,* maguey, and *pantli,* line or row), is widespread on the Texcocan piedmonts. Metepantli is a soil conservation method in which rows of maguey (*Agave* spp.) are laid out parallel to the slope in order to retain soil; they are common in the Mexican Highlands (West, 1970). Although the basic element used in the retaining walls is maguey, in the area of Texcoco, the rows may also be formed by earth and rock. The purpose of the rooting system of maguey is to reinforce the mass of soil particles and the few stones within the bump created along the row. Metepantlis protect thin soils from erosion and increase soil thickness by catching sediments removed from up slope by overland flow or in general by colluviation, although artificial soil buildup is also practiced behind the rows. Thus, the use of metepantli is a technique implemented to solve primarily the problem of erosion, although it seems to have been used to solve other concerns of prehispanic farmers such as the maintaining of soil texture, soil fertility and soil depth (Sanders et al., 1979).

In the study area, metepantlis are widely spread on the lower piedmont, but they are also present on soil remnants of the upper piedmont, usually within Aztec sites, presently cultivated or abandoned. Since most of them have been reclaimed or been in use continuously, it is hard to find and demonstrate the age of archaeological metepantlis, although they are common in the Basin of Mexico (Sanders et al., 1979:249). Current metepantlis are commonly associated with dry farming plots, except in some few areas within the semidispersed town of Tequexquinahuac, where fields are irrigated.

Two soil profiles in current metepantli fields (Figure 3) were studied in order to evaluate their typical structure and properties and make comparisons with archaeological metepantli soils. Soil 1 represents a long term process of reclamation of a sterile surface indurated by calcium carbonate in the form of a pedogenic calcrete. The Ap horizons present a low value of bulk density, probably because of the relatively high content of organic matter within a proportional mix of sand, silt, and clay. In general, there are no significant changes across the three superimposed Ap horizons of this profile; the uppermost horizon (1Ap) is currently plowed, the middle horizon (2Ap) shows a relatively higher value of bulk density, and low value of total phosphorus, probably the result of intensive use; the lowermost horizon (3Ap) shows the result of the first reclamation, with similar parameters as 1Ap. Aztec potsherds are present in all three horizons. It is possible that reclamation started in the Aztec period, since this profile is located in the outskirts of the site of Aztec Huexotla.

Soil 2 represents the reclamation of a soil from which a former A horizon was truncated by erosion. Metepantli were constructed on the surface of the 2ABt horizon, so that the 1Ap horizon basically is an artificial deposit of sandy material, mixed with some clay and silt brought in by overland flow. The organic content in this horizon is moderate to high, compared with other soils in the area. A large number of Aztec sherds record its continuous use during that period, which implies nearby dwellings, confirmed by the large number of Aztec mounds in the area. Thin section study of this 1Ap horizon reveals a well-sorted deposit of sand, with interstitial clay binding the sand particles together (Paul Goldberg, personal communication, 1994). Compaction and high density is probably due to this binding of particles, although it may also be due to intense use which is also reflected in a low content of phosphorus (Figure 3).

In summary, metepantli soils show a very distinctive Ap horizon built upon underlying horizons or substrate. Their particle size distributions show good sorting and are mostly sandy, with finer fractions introduced by overland flow. They also contain abundant pottery, which in the case of Aztec sites is indicative of the proximity of houses.

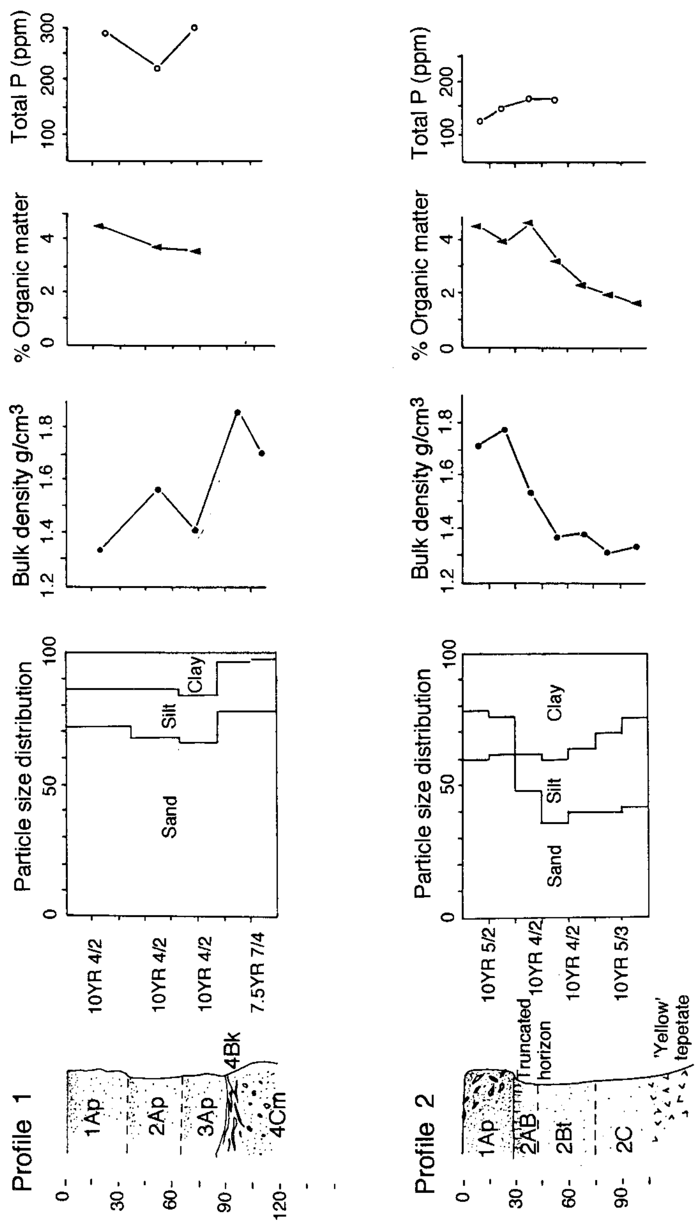



**Figure 3.** Typical profiles of Metepantli soils. See Figure 4 for location.

## SETTLEMENT HISTORY

Archaeological sites in Texcoco, as mapped and classified during Parsons' survey (Parsons, 1971), show an interesting dynamic of settlement change across the archaeological phases preceding the Aztec period. In the course of time, sites seem to expand, shrink and disappear, as well as change in settlement pattern, so that nucleation predominates in some phases and dispersion in others. An analysis of these changing patterns from the Classic to the Early Colonial period is relevant to understand the ecological background of the Aztec settlement as well as the course of soil erosion.

The Middle Formative (850–550 B.C.), Late Formative (550–250 B.C.) and Terminal Formative (250–150 B.C.) were characterized by a gradual increase in number of sites that were occupying the different ecological zones, started by the first sedentary peoples. In the area of study, the Terminal Formative, in particular, was characterized by a maximum of population that was never experienced in any later phase, until the Late Aztec phase. Although a large number of communities were evenly distributed in the area, there were no sites of the upper part of the hierarchy, reflecting the rural character of the area during this period.

At the beginning of the Classic period (A.D. 150–750)* the number of sites began to decrease, a process that continued gradually into the next phase. While remains of few small hamlets were found in the lower piedmont, almost no evidence of Classic occupation is reported for the volcanic hills and upper piedmont in this area of the Texcocan region. This decrease in the number of communities was probably the result of the depopulation experienced in several parts of the Basin in response to the urban growth of Teotihuacan that is believed to have absorbed settlers from rural areas (Sanders et al., 1979). Yet, population levels in the Late Classic were still moderate in relation to the next period: Depopulation reached its nadir during the Early Toltec (A.D. 750–950), a situation common in the central part of the Texcoco Region. However, there were sizable settlements in the north, in the area of Tepetlaoztoc, and in the south, near Coatepec (Figure 1). Parsons (1971) interpreted this gap in the central area of Texcoco as a no-man's land created between two powerful states, Tula in the north and Cholula (in the neighboring Valley of Puebla) in the south (see Figure 1 for reference).

Population levels began to recover during the Late Toltec (A.D. 950–1150) when a few hamlets appeared around the volcanic hills and areas of the lower piedmont, next to the alluvial plains. The number and size of settlements increased considerably during the Early Aztec (A.D. 1150–1350), a process over which there has been much discussion, since it is represented in the Codex Xolotl as the intrusion of Chichimec groups from the north (Parsons,

* At the time of the survey, it was considered that this period comprised two phases: Early Classic (A.D. 150–500) and Late Classic (A.D. 500–750), and so is presented in the chronological table of Figure 11. The recent trend is to join these phases together simply as Classic.

1970, 1971; Calnek, 1973; Dibble, 1980). At this time Huexotla (Fig. 4) appeared as a nucleated center that played an important role as a city state, according to ethnohistoric sources and confirmed by archaeological assemblages in the Basin (Brumfiel, 1976; Hodge and Minc, 1990). The dramatic rise of population continued throughout this period to reach a maximum at the end of the Late Aztec phase (A.D. 1350–1520), when a great number of dispersed villages occupied most of the area of the upper and lower piedmonts, and two important political nucleated centers grew on the lower piedmont, at the fringes of the alluvial plain. Occupation of the volcanic hills now was substantial, although characterized by segregated elite districts (Parsons, 1971). The increase in population during Late Aztec times has been interpreted as an influx of immigrants from several parts of the Basin, and from remote areas as far as Oaxaca, in southern Mexico, a process enabled by the policy of immigration favored by the Texcocan kings, particularly Techotlalatzin (1359–1402) and Nezahualcoyotl (1428–1472) (Alva Ixtilxochitl, 1975:361; Offner, 1979).

Late Aztec demographic growth appears to be reflected in the archaeological record by the presence of two basic ceramic styles. The increase of population during the Early Aztec phase is represented by the emergence of new sites bearing the Aztec II style, and the rapid rise of population experienced with the expansion of sites, or the appearance of new ones during the Late Aztec phase, are represented by the ever increasing abundant quantities of Aztec III ceramics, a style that developed during the 1400s (Sanders et al., 1979:467; Minc, 1994).

The Early Colonial period showed notable changes in size, number, and patterning of settlements, a transformation that took place in less than a century following the Spanish conquest in 1520. This process of depopulation started with a disastrous demographic decline that eventually affected all of Mesoamerica, in response to the introduction of Old World diseases. In the Basin of Mexico, Indian population declined to a third of its former numbers by 1580, and to a fourth or less by 1600 (Sanders et al., 1979:243). Depopulation of the rural realm was accomplished by the implementation of *congregaciones* or *reducciones,* namely, the removal and concentration of dispersed and shrinking settlements into nucleated towns to facilitate conversion and taxation. By 1610 most of the dispersed villages on the piedmont had disappeared, only a few of them survived as semidispersed villages. Tequexquinahuac and San Pablo Ixayoc represent settlements of this type, although we are not sure if they were actual Aztec communities, or an agglomeration created in the Early Colonial period, when they functioned as barrios (districts) dependent on larger towns formerly Aztec.

The transformation and disappearance of Aztec communities during the Early Colonial period is also visible in the ceramic styles. The Aztec IV is a ceramic tradition that apparently began at about the time of the Conquest and continued over subsequent decades (Sanders et al., 1979; Minc, 1994).

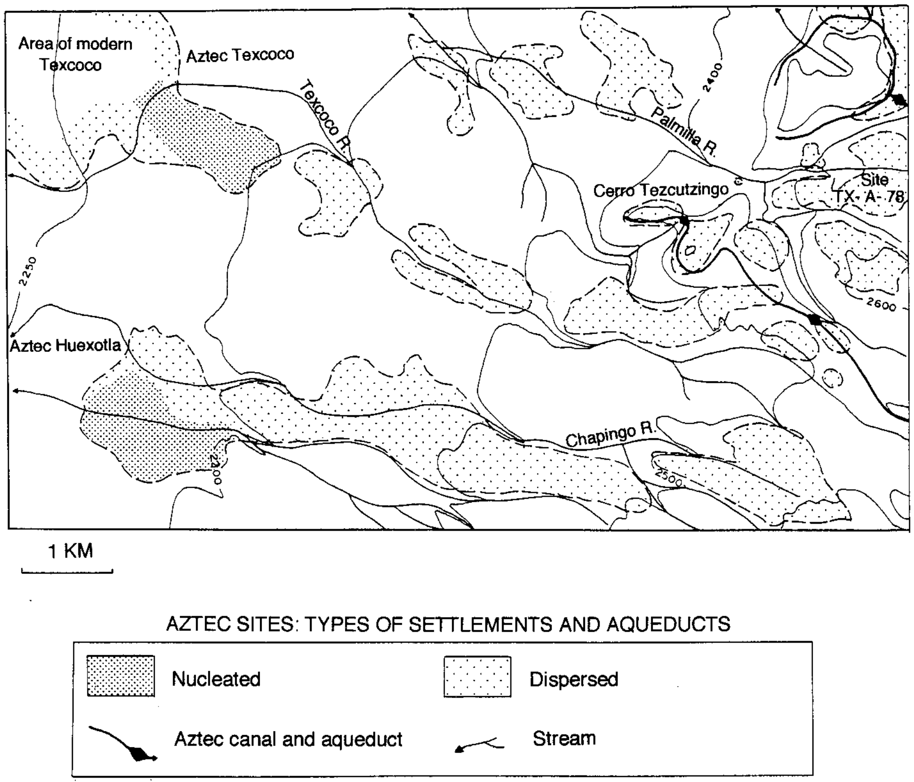



**Figure 4.** Scatters of Aztec material, canals and aqueducts. After Parsons (1971).

Charlton and Nichols (1992) have found that Aztec IV increased notably at the nucleated sites together with other imported styles. At the same time, on the periphery, especially in dispersed villages and hamlets, these styles are only found in very low quantities or are virtually absent, suggesting a shift of population towards the nucleated centers (Charlton, 1969; Charlton and Nichols, 1992). In the dispersed settlements of the upper piedmont of Texcoco, Aztec IV and imported colonial styles are rare, if not totally absent, a situation that bespeaks the decline of population in the rural settlements of the piedmont.

## SITE TX-A-78

### General Description of the Site

Tx-A-78 extends east–west over an area of elongated hills demarcated by streams. The site has been divided into three sectors by barrancas and gaps created by zones of intense erosion. The eastern sector extends towards the mountains and merges with the modern settlement of Santa Catarina del Monte. The central sector is divided from the eastern one by a system of barrancas, and from the western section by a gap resulted from obliteration of the site created by a combination of postoccupational erosion and recent artificial leveling. The western and central sectors extend over a surface of gentle slope dipping north, into a stream with permanent flow; to the south the slope falls off abruptly into a deep barranca of an intermittent stream. Erosion is marked on this slope, except for a substantial zone where former Aztec terraces have been repaired by combining metepantlis and stone-wall terraces; they contain fields that are currently cultivated.

The general aspect of the site is a surface of chaotic topography, due to a dissected tepetate surface interrupted by flat-topped mounds of soil remnants or pedestals. On the largest soil remnants, there are traces of mounds that correspond to domestic structures (triangles in Figure 5). The bulk of the ceramics collected from these mounds is Late Aztec, although Early Aztec is not uncommon (Parsons, 1971).

The main activity of this village seems to have been rain-fed agriculture, for there is no evidence that irrigation was practiced in the site using the water of the canals, except for the use of local springs fed by water seepage, as in the case of a check dam described below. There is indeed no evidence that large scale irrigation was practiced in Aztec times among the dispersed villages of the piedmont, although at some point water for irrigation was requested from King Nezahualcoyotl by villagers elsewhere in the piedmont (McAfee and Barlow, 1946). Canal irrigation apparently was not implemented in this type of community; around Texcoco, canals and aqueducts were instead constructed to conduct water to royal gardens or to built-up areas for utilitarian purposes (Parsons, 1971; Offner, 1981; Doolittle,1990). Even during the late 1500s, documentary sources mention that the canals crossing the area carried water to the city of Texcoco, to the gristmills downstream, and to the area of Tezcutzingo, where water was used to irrigate lots owned by the surviving Texcocan aristocracy (AGN,† 1591b: *Tierras,* Vol. 2726, Exp. 8). Water is tapped for irrigation at different reaches of the northern stream and conducted by canals to the area of Tlaixpan.

Activities other than farming around the site probably included the exploitation of maguey, fiber for textiles and the sap for preparing substances of nutritional value (*aguamiel, pulque,* and cooked flesh) (Parsons and Parsons, 1990). Maguey textile processing may have been present in the village, judging by a few spindle whorls recovered. However, this activity was primarily practiced in the towns of the piedmont, where a much larger concentration of spindle whorls is reported (Parsons, 1971; Brumfiel, 1976).

† Archivo General de la Nación, Mexico City.

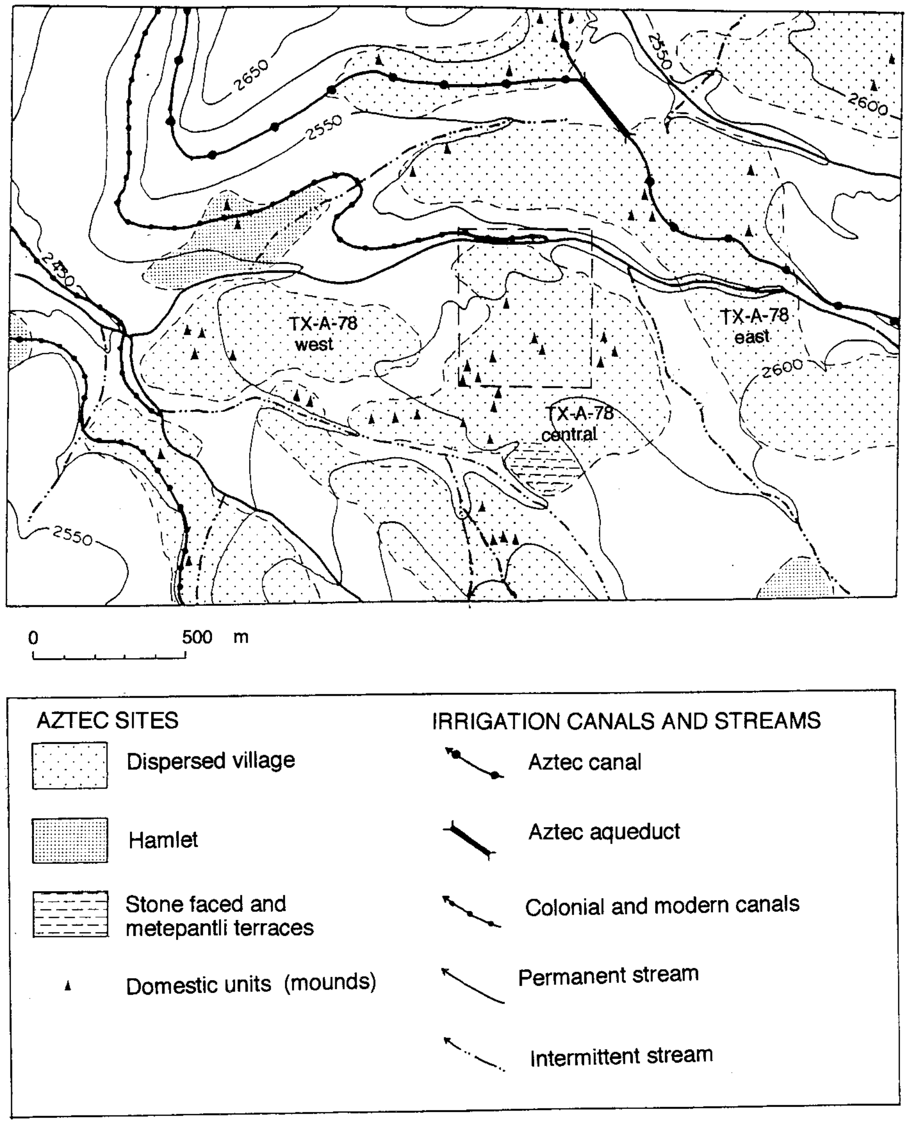



**Figure 5.** Site Tx-A-78 in the context of the Aztec settlement and irrigation network. Box in the central sector indicates the test area.

## The History and Abandonment of the Site

The archaeological evidence and historical documents allow an approximate delineation of site history from its foundation to its abandonment; in the different documents the community is always referred to as Olopa. Although there are minor occupation traces from Early Aztec times, the community was probably not established until the early 17th century, so that in the historical events that led Nezahualcoyotl to power in 1428, Olopa is recognized by Alva Ixtilxochitl (1977:69) as "puesto," namely, a small hamlet. The site grew in size and numbers as the century progressed and reaching their maximum at the beginning of the 17th century, based on the abundant Aztec III sherds transitional to Aztec IV. In the years that followed the Spanish Conquest, the community underwent a gradual decline. Probably, the community experienced a dramatic decimation of settlers in between 1576 and 1580 when the epidemics reduced population to one third (Pomar, 1986:99).

In 1591, a document dealing with a land conflict, reports that a community by the name of San Juan Olopa had only nine houses (AGN, 1591: *Tierras* 2726, Exp. 8), probably located on the western end of the site, as shown on an accompanying map not included in the figures. By the descriptions given in this document it is implied that their ancestors represented the class of free commoners or *macehual* (Nahuatl, pl. *macehualtin*), as Hicks (1982) has shown for some communities of this type around Texcoco.

The settlement of Olopa was completely deserted by about 1603 (AGN, 1607: *Mercedes* 25, f. 435; AGN, 1603: *Congregaciones,* Vol. 1, f. 25–26), although the decline of the community was gradual during the second half of the 16th century. In 1607, shortly after its abandonment, the area was requested by a Spaniard, who asserted that the site was empty as a result of *congregacion,* and that there were no claimants (AGN, 1607: *Mercedes,* vol. 25, f. 435). The document specifies that the area of the site was half a *caballeria de tierra,* that is, 21.4 ha (Butzer and Butzer, 1993); the fact that the documents specifies *tierra* (arable land) indicates that the site was not fully devastated by erosion as it appears today.

## TX-A-78 TEST AREA

### Stratigraphy and Geomorphology

The geologic stratigraphy of the test area (Figure 6) shows a series of Late Pleistocene and Early Holocene pyroclastic deposits originating in the volcanoes of the Sierra Nevada that have been diagenetically and pedogenically indurated to tepetate. These pyroclastic deposits overlie an andesitic flow and breccias of Plio-Pleistocene age (map in Mooser, 1975).

The lavas and breccias are the oldest deposits exposed by incision in the northern creek (Figure 7, section A–A′), covering only a minimal surface of the test area. The tepetates, however, are exposed in most of the eroded areas. Three consecutive horizons of tepetates have been reported in the piedmont and classified according to their overall color impression: the yellow, and white tepetates of Pacheco (1979). In the test area of site Tx-A-78, four tepetate units have been identified, including the three tepetates reported here. Overlying the breccias and lavas is the "red" tepetate (7.5YR 4/6,

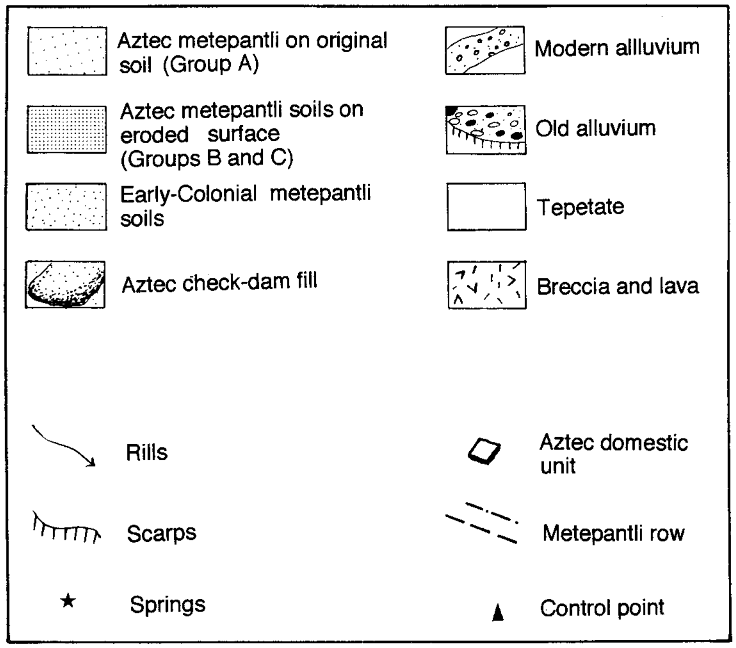



**Figure 6.** Test area in the central sector of Tx-A-78.

brown, to 10YR 5/6, yellowish brown) which has a palaeosol developed on top, at the contact with the "yellow" tepetate (10YR 5/4, yellowish brown) (Figure 7, section B–B′). The yellow tepetate grades into a softer deposit here normally designated as the "light brown" tepetate (10YR 5/3, brown), which in a very few places shows a palaeosol. Overlying this palaeosol, is the "white" tepetate (10YR 6–7/3, pale brown), a uniform deposit of volcanic ash preserved in pedestals. In the area of Tepetlaoztoc, this mid-Holocene ash has been dated 5313 ± 51 B.P. (Tx-7781); the ash was altered by a soil that has either been eroded or buried by a series of colluvial soils. The sequence of tepetates and soils is most complete at the pedestal of section C–C′ (Figure 7) and in soil profile 3 (Figure 8).

One erosional unconformity in the sequence of tepetates, ash, and soil horizons records a period of instability and erosion during the Holocene. The aforementioned light brown tepetate is a C horizon that appears extensively in the site, and is an erosional remnant of a soil that was preserved in few places before the ashfall event, indicating severe erosion in Early to Middle Holocene times. This palaeosol was visible in a section exposed recently by a bulldozer near control point 7 (Figure 6).

The development of at least two soil horizons on colluvium overlying the ash (white tepetate) suggests a long period of stability eventually interrupted

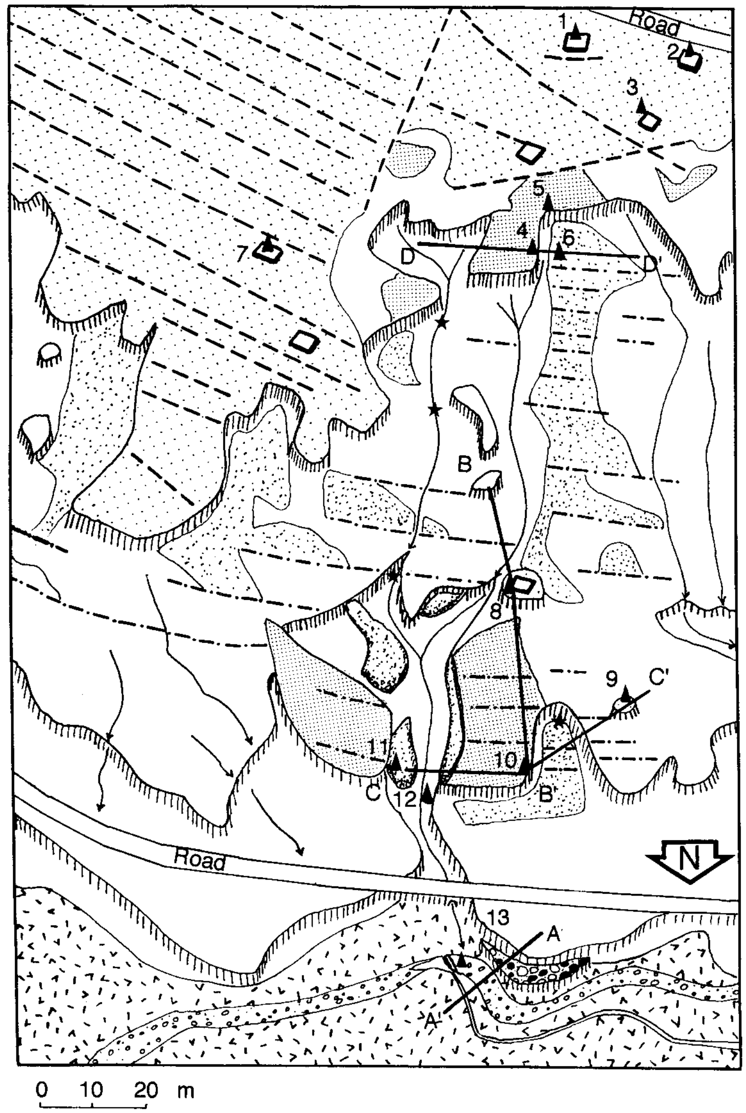



**Figure 6**—*Continued*

by the first phase of erosion concomitant with human presence. These two soil horizons are visible in soil remnants (pesestal) such as that of profile 3 (Figure 9). The sequence of this soil is here referred to the "original colluvial soil," in contrast with other soils that have anthropogenic horizons.

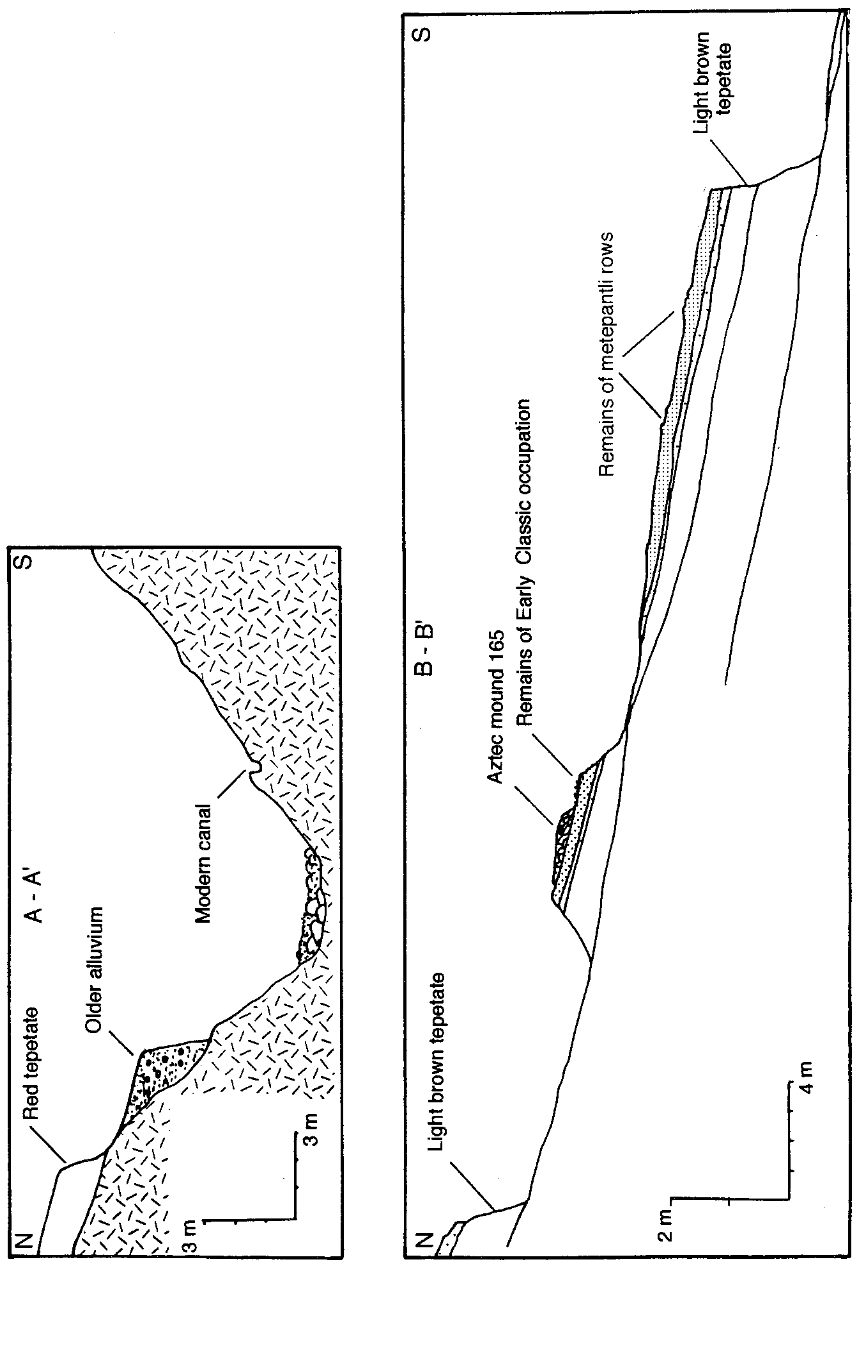



**Figure 7.** Geomorphological sections. For locations see Figure 6.

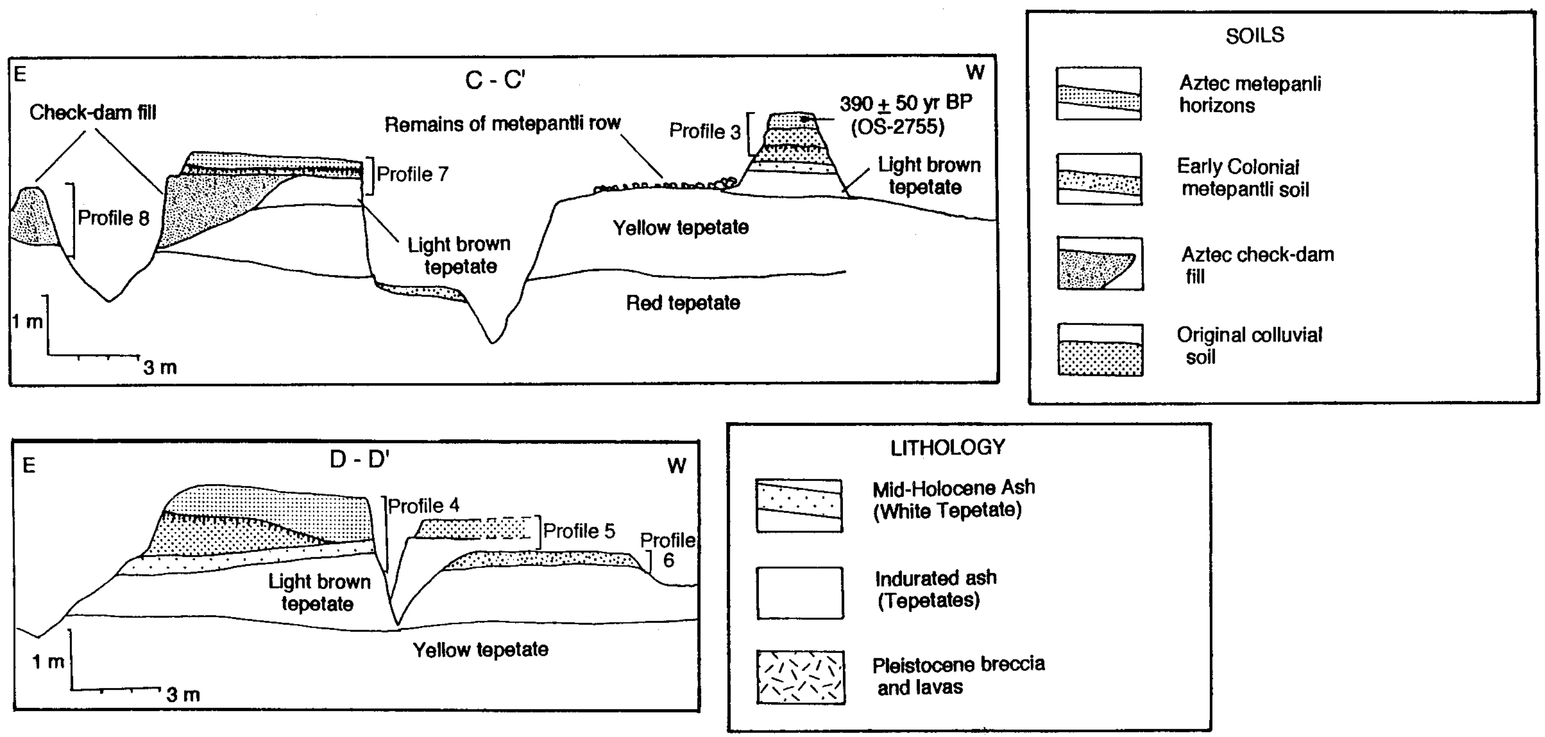



**Figure 7**—*Continued*

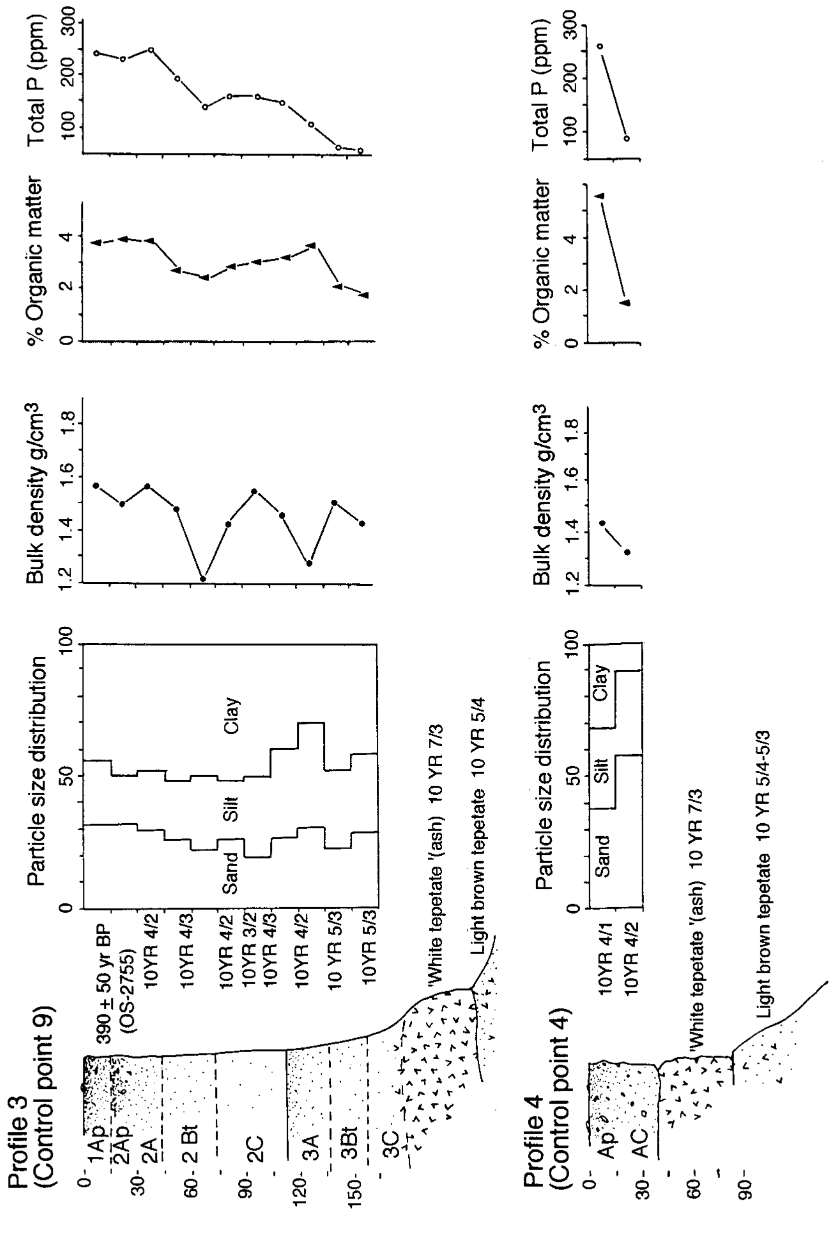



**Figure 8.** Soil profiles 3 and 4, located at control points 9 and 4, respectively.

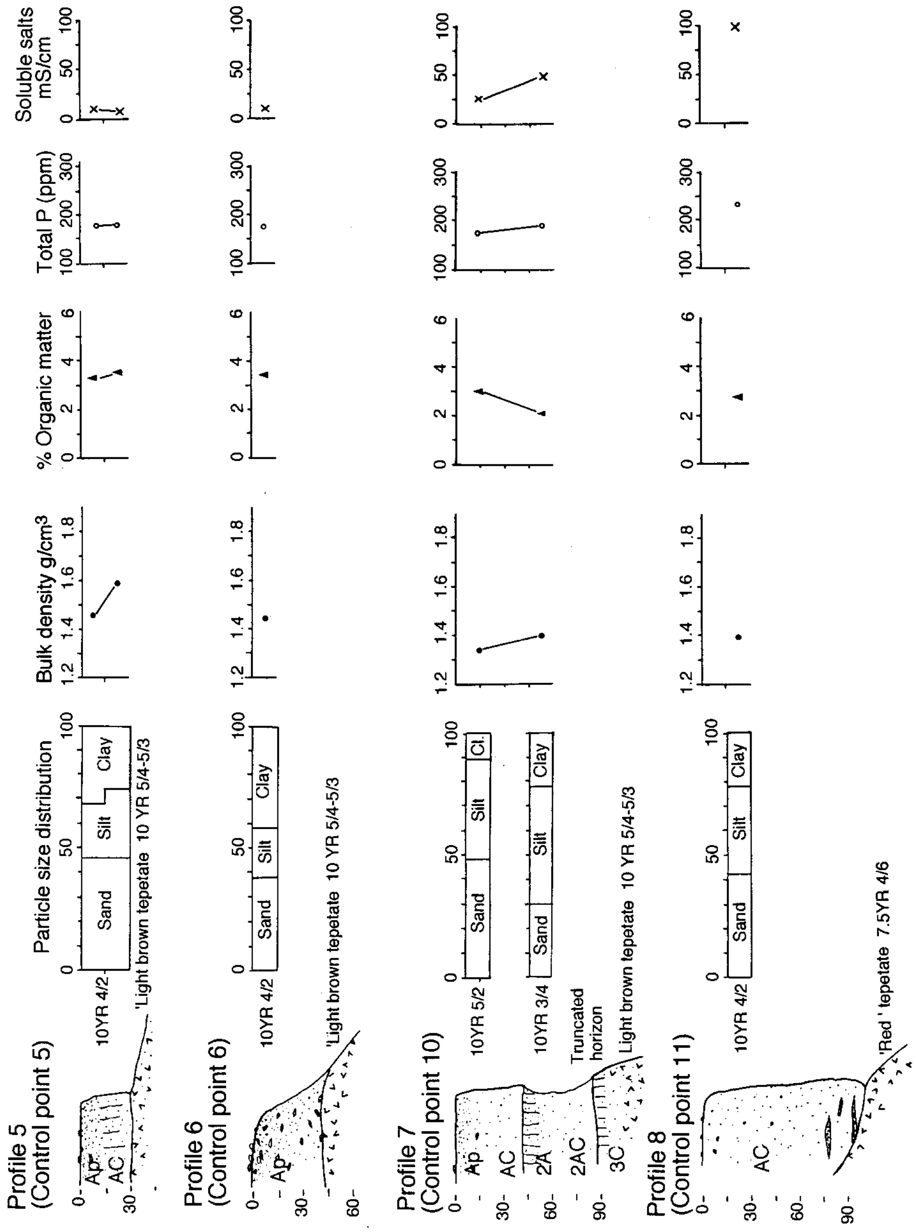



**Figure 9.** Soil profiles 5, 6, 7, and 8, located at control points 5, 6, 10, and 12, respectively.

## Metepantli Soils

Arable soils account for only the 27% of the test area, including three soil units associated with metepantli semiterracing, and one unit with the fill behind a check dam (Figure 6). Metepantli soils are associated with rock and earth alignments that imply ancient metepantli rows of different ages (Figure 9). According to the orientation of these rows and their associated edaphic horizons, these soils are divided into three groups:

### *Group A. Metepantli on Original Colluvial Soil*

This soil unit covers most of the southern area of the site along the water divide, and is also found in erosional remnants or pedestals. It represents at least two different soils, one developed on the white ash and the other with a colluvial substrate converted to an anthropogenic A horizon by means of metepantli management (Figure 8, profile 3). These two soils have a Bt horizon which indicates a long period of stability, perhaps under wet conditions, subsequent to deposition of the ash. The relatively high content of clay and the darker tone of its horizons make this soil similar to the *tierra negra* (black soil) of the folk taxonomy in the area reported by Williams and Ortız-Solorio (1981).

The Ap horizon (tilled soil) has more organic matter, and total phosphorus than other metepantli soils in the site, probably due to a larger influx and translocation of organic matter as well as the dumping of organic trash, as it is the example of profile 3 (Figure 8). The addition of domestic trash to soils has been reported by the 16th century sources as a method of fertilizing soils in fields near houses (Rojas-Rabiela, 1988); trash evidently included both organic and inorganic waste as evidenced by the presence of broken sherds, *tezontle* (volcanic scoria), and obsidian flakes. The large number of sherds is mainly Late Aztec, covering the surface in a homogeneous way, except for large concentrations that represent mounds or remains of dwellings. Other origins for the accumulations of inorganic material include the practice of cultivating surfaces previously occupied by a house; such deposits were considered fertile soil, and were known in the Aztec soil classification as *callali* (Nahuatl: house soil) (Dibble and Anderson, 1963; Williams, 1985).

### *Group B. Metepantli Soils on Eroded Surfaces*

These soils are the result of land reclamation or attempts to check soil particles by setting up metepantli rows on a barren surface of tepetate; in this group there are two soil units, distinguished by age. One of the soil units represents Aztec attempts to recover areas for cultivation, probably when the village was founded or expanded; typical examples of this unit are profiles 4 and 5 (Figures 8 and 9, respectively). The other unit is younger and represents lower levels, after erosion had lowered the terrain (Figure 7, section D–D′). This suggests a struggle to contain soil erosion, either shortly before the abandonment of the village or later by the new landowner. The typical horizonation of this type of soil is shown in profile 6 (Figure 9).

No additional horizons have been developed in these soils since they are relatively younger, probably younger than 600 years. By their overall characteristics mentioned above, this type of metepantli soil is similar to what has been described in the area as *tierra amarilla* (yellow soil) by Williams and Ortız-Solorio (1981). In general, organic matter and nutrients in soils of this group tend to be lower than metepantlis created on original soils. Organic matter and total phosphorus contents are relatively high in profile 2, and low in profiles 5, 6, and 7. This variability reflects uneven concentration of organic waste; concentrations of broken sherds in an irregular pattern, suggesting that the farmers were dumping soil and trash brought from elsewhere; this incoming material was in turn mixed with particles carried by overland flow created by rain. The Aztec soils of this group are less variable in terms of waste concentration, possibly suggesting that this management lasted longer and required more careful work than their Early Colonial counterpart.

Sherds in these soils show a mixture of Early and Late Aztec sherds, including a few Early colonial pieces in the oldest unit, whereas the original metepantli soils presents a uniform cover of mainly Late Aztec sherds.

### *Group C. Metepantli Soil on Older Anthropogenic Horizons*

This type of soil represents the attempt to trap sediment so as to build up a new horizon on a preexisting soil, either to improve its quality or level the terrain. The result is an older Ap horizon buried by younger sediment, turned into a new Ap through plowing and cultivation. There is no clue as to the age of the younger horizon; its elevation and associated artifactual debris indicate it may be Late Aztec, although its associated metepantli rows parallel the Early Colonial ones (Figure 6). The oldest soil (2Ap) is probably associated with the Late Aztec check dam (Figure 7, section C–C′). Soil properties of these two Ap horizons are similar and comparable with soils of Group B.

Although metepantlis were the instrument used to produce the soils of this group, the strategy was different for each group. In the case of Group A, metepantlis were set up as a preventive measure against erosion, whereas in the cases of Groups B and C they were implemented for constructive purposes. The two modern analogues from the lower piedmont, profiles 1 and 2, presented previously, do not have a precise equivalent with profile 3 in group A, except for the horizons developed on the indurated layer of volcanic ash, but the profiles of Groups B and C show similar anthropogenic horizons.

Thin sections also reveal differences in the nature of the A horizons. Those Ap horizons in group B corresponding to Aztec metepantlis show better sorting than those of Group A, derived from colluvial soils. This difference may be due to the fact that sorting in anthropogenic horizons results from the homogenization of the anthropogenic parent material, a very characteristic property created by dumping and favored by cultivation and fertilization of a former sterile material (Courty et al., 1989: 131).

The technique of breaking tepetate to make tepetlalli soils is described by Sahagun in the Florentino Codex and discussed by Williams (1972), but its application to these soils is uncertain. Fragments of white tepetate within the matrix of the Aztec soils of group B, specifically profile 2, may be of such origin. Foreign particles like tezontle, pumice, basalt, and andesite, brought in by means of human agency, are also abundant, suggesting that fragments of tepetate may have been introduced in the same way.

### Check Dam Deposit

Land reclamation during Late Aztec times included the barranca fill trapped behind the dam, perhaps in combination with trash dumped in it. The dam or retaining wall of this check dam has been removed by erosion, but rubble remains are preserved at control point 11 (Figure 6). The topsoil of this deposit, which may have been topographically equivalent to profile 7, has been lost to erosion (Figure 7, section C–C′). Only the underlying sediment remains, which was sampled for comparison with the metepantli soils (Figure 9, profile 6). It is a loamy mass of sediment without structure, except at the bottom, where it has lenses of sand and gravel; it has a very low density and moderate values of organic matter and relatively high values of total phosphorus. There is a high content of soluble salts, compared with the metepantli soils 5, 6, and 7, suggesting that soils behind this check dam may have been irrigated. However, there is no evidence of canals, and if they existed, such canals would have been easily removed by erosion. It is likely that this field benefited naturally from water seepage, so that water from the local springs that still exist at the head of the barranca may have been managed to provide moisture to the check-dam soil (Figure 6).

## EROSIONAL ADVANCE AND BARRANCA INCISION

The control points established within the test area served, on the one hand, to enable an association between pottery collections and soil units (Table I), and on the other, to estimate the extent of land lost to erosion, the extent of soil reclaimed, and the depth of incision of the barranca in the center of the area at different periods (Table II), for which control point 9 was the datum to measure depth. Two phases of soil erosion and two attempts at land reclamation can be identified in the test area.

### First Phase of Soil Erosion (Pre-Aztec)

Erosion started before the Aztec occupation, based on the reclamation of lands that resulted in the building of soil in profiles 4 and 5. No exact span of time has been established, although the existence of Early Classic to Early

**Table I.** Control points and associated soil and archaeological features.

| Control Point | Top Soil Surface | Cultural Features | Surface Ceramics and Mound Number[a] |
|---|---|---|---|
| 1 | Metepantli on original colluvial soil | Domestic unit | Late Aztec mound 159 |
| 2 | Metepantli on original colluvial soil | Domestic unit | Mostly Late Aztec; some Early Aztec mound 160 |
| 3 | Metepantli on original colluvial soil | Domestic unit | Mostly late Aztec; some Early Aztec mound 163 |
| 4 | Metepantli soil on eroded tepetate surface; profile 4 | None | Late Aztec |
| 5 | Metepantli soil on eroded surface; profile 5 | None | Mostly Late Aztec; some Early Aztec |
| 6 | Metepantli soil on eroded surface (Post-Aztec); profile 6 | Trash mounds | Mostly Late Aztec; some Early Aztec |
| 7 | Metepantli on original colluvial soil | Domestic unit | Late Aztec mound 164 |
| 8 | Metepantli on original colluvial soil | | Mostly Late Aztec; some Early Aztec are present; mount 165; Late Classic around the mound |
| 9 | Metepantli on original colluvial soil; pedestal profile 3 | None | Late Aztec and low amount of Early Aztec; mound 167 |
| 10 | Metepantli soil on older anthropogenic soil | None | Late Aztec |
| 11 | Check dam soil resting on red tepetate | Check dam fill | Late Aztec |
| 12 | None; red tepetate | Remains of check dam wall | None |
| 13 | None; modern alluvium | Modern weir and irrigation canal | None |

[a] Mound number and description in Parsons (1971). Early and Late Aztec designations are basically Aztec II and Aztec III, respectively.

Toltec material in a pedestal at point 5 suggests that there was a Classic settlement that was destroyed by erosion. The Early Aztec occupation of this site postdates this interval of soil erosion, since its vestiges are confined to higher and lower areas; this association allowed us to date the intervening erosion between roughly A.D. 500 and 1000 for certain, with the possibility that it extended to ca. A.D. 1250, when the Early Aztec occupation started. Since a decline in population is established for the region during the Late Classic and Early Toltec phases, the area presumably was deserted for a long period until settled again in the Early Aztec phase. Perhaps erosion set in as the land was abandoned, so that rains affected compacted tilled soils that increased surface runoff. The effects of abundant and intense rains on soil

**Table II.** Values indicating erosional advance and stream incision within test area in Tx-A-78.[a]

| Period | Tepetate Surfaces (%) | Arable Land Surfaces (%) | Total Arable Land in Site Tx-A-78 West and Central (ha) | Depth of Barranca Incision (m) (Reference datum, Control Point 9) | Incision of Northern Creek |
|---|---|---|---|---|---|
| Early Classic occupation | 20 | 79 | n.e.[b] | <2 | n.e.[b] |
| Early Aztec prior to land reclamation | 52 | 48 | n.e. | 2.20[c] | 6 |
| Late Aztec | 24 | 76 | 20[c] | 0.50[d] | n.e.[b] |
| Early Colonial to present | 73.5[d] | 27.5[d] | 14.8[d] | 3.10[d] | 1–2 |

[a] Figures and percentages are based on estimations unless otherwise indicated.
[b] n.e. = not estimated.
[c] Estimated according to land grant information.
[d] Values measured in the field and on aerial photographs.

erosion is difficult to evaluate, since there are no proxy data to rely on. However, ongoing research in the lower valleys of the San Juan Teotihuacan, Papalotla, and Coatepec Rivers indicates that floods were frequent during the Classic and Early Toltec phases (Cordova, 1996). Evidence for high lake levels during the Early Toltec phase in Chalco (Hodge et al., in press), are probably due to copious rains, so that the onset of a period of abundant precipitation may have contributed to river flooding in the basin, but more proxy data are needed to prove it.

Surprisingly, barranca incision in the site was less important than the formation of a great number of rills that carried away soil and subsequently the underlying white ash. The original extent of soil cover and barranca depth at the end of the Classic is unknown, but a rough estimate of 1.25 ha would imply that 79% of the area was covered with arable soil before site abandonment and subsequent erosion. At the end of this phase, pedestals of soils were isolated by small barrancas and areas of barren tepetate as the reconstruction of the test area suggests (Figure 10).

## Aztec Land Reclamation

Notable changes date from the Aztec period: the area was resettled, metepantlis were constructed, soil was built and cultivated, and incision of the barranca and smaller gullies were controlled by means of check dams. The wide distribution of pedestals containing Late Aztec reclaimed metepantli soils illustrates the extent of artificial soil accretion in a manner that the site can be reconstructed for the end of the Aztec period (early 1500s) (Figure 10). Arable land is estimated at 1.2 ha, accounting for 76% of the test area. Most

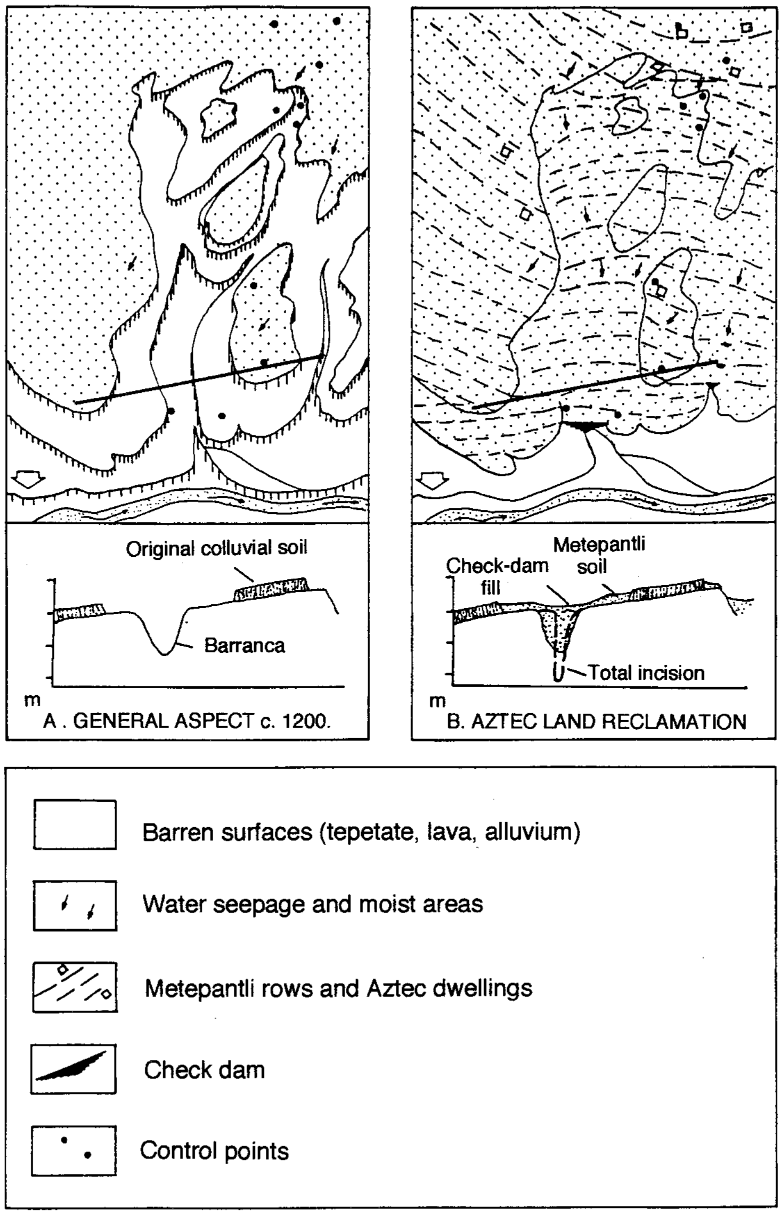



**Figure 10.** Reconstruction of the test area for (a) the Early Aztec period prior to land reclamation, and (b) the end of the Late Aztec period.

of the land reclamation was probably carried out in Late Aztec times, since most of the dwellings recorded by survey, within and without the test area, have abundant Aztec III pottery. A recent analysis of the pottery collected, based on a more elaborate seriation by Minc (1994), shows that the variants of this pottery bespeak the rapid development of this dispersed settlement in the second half of the 1400s. As for the 1500s, Aztec IV and Early Colonial imported pottery are very scanty, perhaps reflecting the gradual reduction of population. A radiocarbon assay from a piece of charcoal from the Ap horizon, collected at 15 cm below the surface of the pedestal at control point 8, yielded an age of 390 ± 50 yr B.P. (OS-2755) (A.D. 1485 ± 73), indicating that the soil surface of this pedestal, now only 1.5 sq m in size, once was larger, and may still have been cultivated in the 16th century.

### Second Phase of Erosion (Post-Aztec)

As site population declined, erosional processes may have gradually set in; once the site was completely deserted in the early 1600s, the land began to erode more rapidly. Evidence for attempts at land reclamation is given by some metepantli soils, generally dating to the colonial period, after erosion had already devastated most of the site area. Even thereafter, erosion eventually exposed a total of 1.17 ha, in contrast with the 0.38 ha during the early 1500s. The check-dam now broke up and was no longer rebuilt, and incision totaled 3.10 m (Figure 10). This final phase of erosion shaped the site into its present configuration.

The causes of post-Aztec erosion are several and can be discussed in the light of historical documents. The most evident cause of these erosional events was the desertion of the village, which in turn led to abandonment of structures constructed to control erosion, such as metepantlis and check dams that were destroyed by runoff. The first three decades of the 17th century are known for extensive and continuous floods, produced by copious rains in the Basin of Mexico (Gibson, 1964; Boyer, 1973). In the plains of the Texcoco region, we have identified several alluvial deposits datable to this period. These catastrophic events probably took their toll on the abandoned semi-terraced lands and check dams of the piedmont. A possible modern analog is suggested at Meztitlan, Hidalgo, where a sequence of erosional and landslide events took place during the years after abundant rains produced by hurricane Gilbert in 1988 (Lugo et al., 1993).

The introduction of sheep to the study area, mentioned in the land grand documents (*Mercedes*), is another factor to consider as to triggering post-Aztec soil erosion, since overgrazing may have impacted susceptible soils in the Mexican highlands (Melville, 1994). But very few sheep estancias were granted in the upper piedmont in the period 1580 to 1630 (Colın, 1967). The closest *estancia de ganado menor* (sheep place) was requested in 1591 (AGN, 1591a: *Mercedes,* Vol. 17, f. 30), just north of the site, but was refused after a long conflict with the local people, according to a document written in 1592 (AGN, 1591: *Tierras,* Vol. 2726, Exp. 8). However, this document does note that the farmers in the area had "all kind of livestock." Whether or not overgrazing was one of the main causes of soil erosion, soils in tepetate areas of Texcoco are highly susceptible to erosion even without livestock impacts, as the pre-Aztec erosional phase demonstrates.

During this last phase of erosion, the site area lost approximately 5 ha of soil cover. This figure is based on 20 ha of arable land at the site ca. 1600, compared with the 14.5 ha today, ignoring land recently reclaimed. The original 20 ha is an estimation of arable land for the site of San Juan Olopa, which covers most of the western and central sectors of the site, as based on the half *caballeria de tierra* (approximately 21.4 ha) requested in 1607 (AGN, 1607: *Mercedes,* Vol. 25, f. 435).

Early Colonial attempt of tepetate reclamation included metepantli construction, just as in Aztec times; the soils of Group C represent this phase.

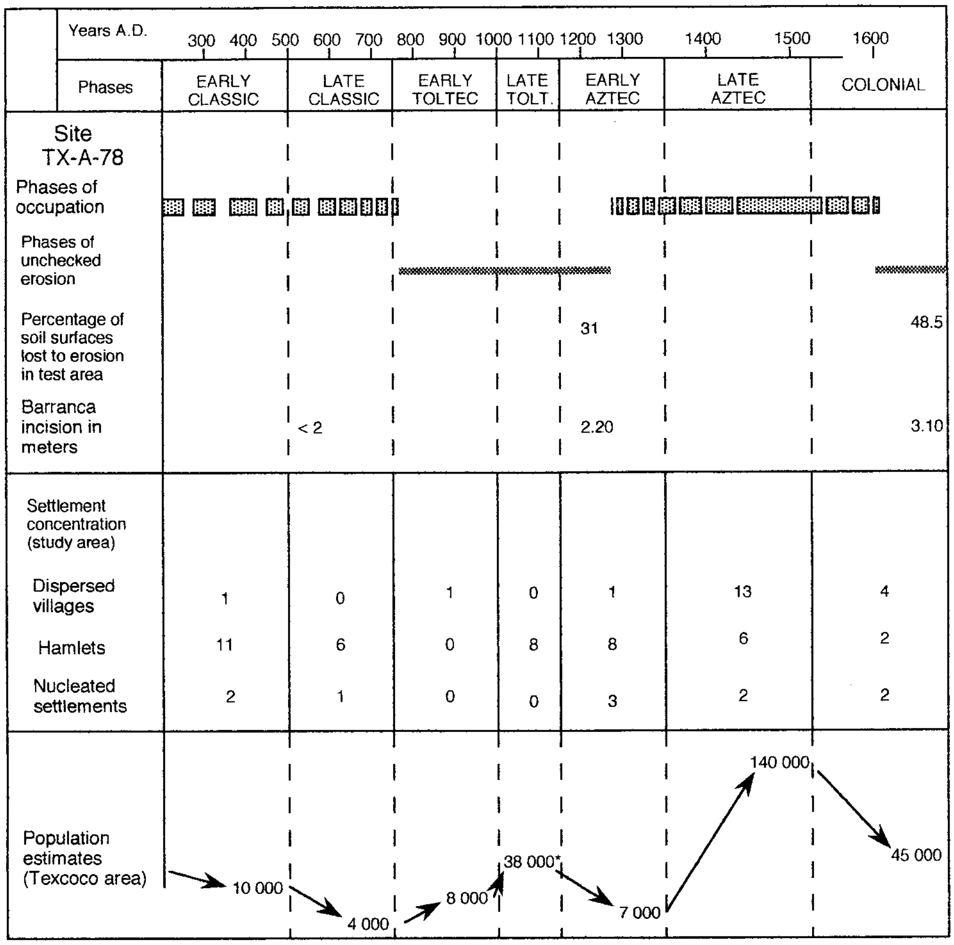
## EROSION AT TX-A-78 IN THE CONTEXT OF SETTLEMENT EVOLUTION IN THE PIEDMONT

It is probable that the eroded areas around other Aztec dispersed villages tell a similar story. There is a close relationship between the two periods of erosion recorded at site Tx-A-78 and the settlement history of this part of the piedmont (Figure 11). As the geoarchaeological reconstruction demonstrates, the most important factor stimulating soil erosion in this local perspective was abandonment. In a regional perspective, the progression of erosion across the piedmont was more complex and concomitant with the declining number of sites and the shift from dispersed to nucleated settlement. The pre-Aztec erosional period coincides with a falling population, and the disappearance of scattered hamlets. The second phase of post-Aztec erosion, again was a time of population decline, with a reduction of site numbers and increased nucleation. The period between the two erosional phases occurred in a regional increase in numbers of sites in a dispersed pattern.

## CONCLUSIONS

This geoarchaeological examination of the remains of a dispersed Aztec village provides a fairly detailed picture of the history of settlement, land use and erosion at site Tx-A-78, which is only a small sample of the 21 sites classified as dispersed villages on upper piedmont of Texcoco. However, most of the sites across the piedmont show similar arrangements of dwellings, soils, metepantlis, and check dams structures of the Aztec period, all of which are located in geomorphological context similar to Tx-A-78.

Archaeological features and soils show that one of the main elements of soil management in the Aztec village was the metepantli, a successful device in land conservation for marginal lands with thin soils and dry farming. Anthro-



* Late Toltec settlements are concentrated to the north and south, outside of the study area.

**Figure 11.** Chronology of events in site Tx-A-78 and their correlation with demographic facts in the Texcoco region.

pogenic horizons in the metepantli profiles reveal some practices for soil management used at the time of the Spanish Conquest as depicted by ethnohistoric accounts such as the Florentine Codex. The breaking up of tepetate substrates reported by the same codex may also have been practiced, but no clear evidence is preserved in the existing profiles.

Dispersed villages may have been a solution devised by the Texcocan kings to settle incoming populations, rehabilitate eroded areas, and maintain structures such as terraces and check dams that protect the soil over extensive, highly erodible surfaces of the piedmont in the context of rapid population growth. Free commoners (*macehualtin*) were given such lands for subsistence in exchange for work services.

The Holocene micro-stratigraphy identifies a period of soil erosion at the site probably before the onset of agricultural communities. The soil that formed on the mid-Holocene white ash and a series of overlying colluvial soils were eroded during the last two millennia in concomitance with occupational changes in the region. In general, soil erosion episodes are due to changes in land-use intensification and settlement pattern; the role of climatic changes is only proved by the occurrence of short periods of intense rains that act as a catalyst in the triggering of soil erosion. In the particular case of the Aztec village of this study the causes of the severe erosional events during the Early Colonial period were the abandonment of the village which in turn implied the lack of maintenance of terraces and check dams, which are devices that protect soils from erosion. The clear impact of climate on the onset of this erosional phase is testified by short periods of intense rains that followed the abandonment of the village in the early 1600s. The effect of climatic fluctuations on the pre-Aztec erosional phase is difficult to evaluate since there are no reports, but they are likely to have occurred also in the forms of short periods of intense rain following the depopulation of the area during the Classic and Early Toltec phases.

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## REFERENCES

Alva Ixtilxochitl, F. (1975). *Obras Historicas,* edited by E. O'Gorman. Vol 1. Mexico City: Universidad Nacional Autonoma de Mexico.

Alva Ixtilxochitl, F. (1977). *Obras Historicas,* edited by E. O'Gorman. Vol 2. Mexico City: Universidad Nacional Autonoma de Mexico.

Archivo General de la Nacion (AGN) (1603). *Congregaciones,* Vol. 1, f. 25–26. Unpublished archival document. Mexico City.

Archivo General de la Nacion (AGN) (1591a). *Mercedes,* Vol. 17, f. 130. Unpublished archival document. Mexico City.

Archivo General de la Nacion (AGN) (1607). *Mercedes,* Vol. 25, f. 435. Unpublished archival document. Mexico City.

Archivo General de la Nacion (AGN) (1591b). *Tierras,* Vol. 2726, Exp. 8. Unpublished archival document. Mexico City.

Bocco, G. (1993). Gully Initiation in Quaternary Volcanic Environments Under Temperate Subhumid Seasonal Climates. *Catena* **20,** 495–513.

Boyer, R.E. (1973). *La Gran Inundacion: Vida y Sociedad en la Ciudad de Mexico, 1629–1638.* Translation by A. Sanchez Mejorada. Mexico City: Sep Setentas.

Brumfiel, E.M. (1976). Specialization and Exchange at the Late Postclassic (Aztec) Community of Huexotla, Mexico. Ph.D. dissertation, University of Michigan, Ann Arbor.

Butzer, K.W. (1981). Rise and Fall of Axum, Ethiopia: A Geoarchaeological Interpretation. *American Antiquity* **46,** 471–495.

Butzer, K., and Butzer, E. (1993). The Sixteenth Century Environment of the Central Mexican Bajio: Archival Reconstruction from Colonial Land Grants and the Question of Spanish Ecological Impact. *In* K. Mathewson, Ed., *Culture Place and Form.* Geoscience and Man **32,** 89–124. Baton Rouge: Louisiana State University.

Butzer, K.W., Miralles, I., and Mateu, J.F. (1983). Urban Geo-Archaeology in Medieval Alzira (Prov. Valencia, Spain). *Journal of Field Archaeology* **10,** 333–349.

Cabrero, M,T. (1988). *Entre Chinampas y Bosques: Estudio Arqueologico de Topilejo D.F.* Serie Arqueologica 33. Mexico City: Instituto de Investigaciones Antropologicas–Universidad Nacional Autonoma de Mexico.

Calnek, E.E. (1973). The Historical Validity of the Codex Xolotl. *American Antiquity* **38,** 423–427.

Charlton, T.H. (1969). Ethnohistory and archaeology: Post-Conquest Aztec sites. *American Antiquity* **34,** 286–294.

Charlton, T.H.M., and Nichols, D.L. (1992). Late Postclassic and Colonial Period Elites at Otumba, Mexico: The Archaeological Dimensions. *In* D.Z. Chase and A.F. Chase, Eds., *Mesoamerican Elites: An Archaeological Assessment,* pp. 242–258. Norman: University of Oklahoma Press.

Colın, M. (1967). *Indice de Documentos Relativos a los Pueblos del Estado de Mexico. Ramo de Mercedes del Archivo General de la Nacion.* Mexico City: Biblioteca Enciclopedica del Estado de Mexico.

Cordova, C. (1996). Soil Erosion and Flooding in Response to Settlement Pattern Change. *The Association of American Geographers 92nd Annual Meeting,* Abstracts, p. 54. Charlotte, NC: Association of American Geographers.

Cordova, C., and Vazquez, A. (1991). Tipologıa para Terrazas de Cultivo en el Contexto de los Sistemas Agrıcolas Tradicionales de Mesoamerica. *In Topicos de Investigacion y Posgrado,* Vol. 2, pp. 13–24. Mexico City: Universidad Nacional Autonoma de Mexico.

Cortes, H. (1985). *Cartas de Relacion.* Mexico City: Editores Mexicanos Unidos.

Courty, M.A., Goldberg, P., and Macphail, R.I. (1989). *Soils, Micromorphology and Archaeology.* Cambridge: Cambridge University Press.

Dibble, C. (1980). *El Codice Xolotl.* Text and Plates. Mexico City: Universidad Nacional Autonoma de Mexico.

Dibble, C., and Anderson, A. (transl.) (1963). *Florentine Codex: General History of the Things of New Spain, by Fray Bernardino de Sahagun. Book 11, Earthly Things.* Santa Fe: School of American Research and the Museum of New Mexico.

Donkin, R.A. (1979). *Agricultural Terracing in the Aboriginal New World.* Publications in Anthropology 56. New York: Viking Fund.

Doolittle, W.E. (1990). *Canal Irrigation in Prehistoric Mexico.* Austin: University of Texas Press.

Dubroeucq, D., Quantin, P., and Zebrowski, C. (1989). Los Tepetates de Origen Volcanico en Mexico. Esquema Preliminar de Clasificacion. *In Terra,* Vol. 7, pp. 3–12. Chapingo, Mexico: Sociedad Mexicana de la Ciencia del Suelo.

Evans, S. (1990). The Productivity of Maguey Terrace Agriculture in Central Mexico during the Aztec Period. *Latin American Antiquity* **1,** 117–132.

Fedoroff, N., Courty, M.A., Lacroix, E., and Oleschko, K. (1994). Calcitic Accretion on Indurated Volcanic Materials (Example of Tepetates, Altiplano, Mexico). *In* International Society of Soil Science, Ed., *Transactions of the 15th Congress of Soil Science,* Vol. 6A, pp. 460–473. Acapulco, Mexico: International Society of Soil Science.

Figueroa-Sandoval, B. (1975). Perdidas de Suelo y Nutrimentos y Su Relacion con el Uso del Suelo en la Cuenca del Rıo Tezcoco. Thesis, Universidad Autonoma de Chapingo, Mexico City.

García, E. (1981). Modificaciones al Sistema de Clasificación Climática de Koeppen (para Adaptarlo a las Condiciones de la Republica Mexicana). Mexico City: Author.

Gibson, C. (1964). *The Aztecs under Spanish Rule: A History of the Indians of the Valley of Mexico 1519–1810.* Stanford, California: Stanford University Press.

Hicks, F. (1982). Tetzcoco in the Early 16th Century: The State, the City, and the Calpolli. *American Ethnologist* **9,** 230–249.

Hodge, M.G., and Mic, L.D. (1990). The Spatial Patterning of Aztec Ceramics: Implications for Prehispanic Exchange Systems in the Valley of Mexico. *Journal of Field Archaeology* **17,** 415–437.

Hodge, M.G., Cordova, C.E., and Frederick, C.E. (in press). Los Asentamientos prehispánicos y el Medio Cambiante del Sureste de la Cuenca de Mexico. *In* A. Tortolero-Villasenor, Ed., *Medio Ambiente, Agricultura e Industria en la Cuenca de Mexico; Varios Siglos de Transformaciones.* Mexico City: Siglo XXI.

Lugo, J., Zamorano, J.J., and Gallegos, G. (1993). Deslizamiento de Tierras Activo en Meztitlán, Hidalgo. *Geofisica Internacional* **32,** 153–166.

McAfee, B., and Barlow, R. (1946). The Titles of Tezcotzingo. *Tlalocan* **2,** 110–127.

Melville, E.G.K. (1994). *A Plague of Sheep. Environmental Consequences of the Conquest of Mexico.* Cambridge: Cambridge University Press.

Minc, L. (1994). Political Economy and Market Economy under Aztec Rule: Original Perspective Based on Decorated Ceramics, Production and Distribution Systems in the Valley of Mexico. Ph.D. Thesis, University of Michigan, Ann Arbor.

Mooser, F. (1975). Mapa Geologico de la Cuenca de Mexico y Zonas Colindantes. *In Memoria de las Obras del Sistema de Drenaje Profundo del Distrito Federal,* Vol. IV. Mexico City: Secretaria de Obras y Servicios.

Nimlos, T.M., and Ortiz-Solorio, C. (1987). Tepetate and Soil Erosion in the Valley of Mexico. *Journal of Soil and Water Conservation* **42,** 83–86.

Offner, J. (1979). A Reassessment of the Extent and Structuring of the Empire of Techotlalatzin, Fourteenth Century Ruler of Texcoco. *Ethnohistory* **26,** 231–241.

Offner, J. (1981). On the Inapplicability of "Oriental Despotism" and the "Asiatic Mode of Production" to the Aztecs of Texcoco. *American Antiquity* **46,** 43–60.

Pacheco, M. del C., (1979). Cartografia y Caracterización Mineralogica de los Tepetates del Oriente del Valle de Mexico. Thesis, Universidad Autonoma de Chapingo, Mexico City.

Palerm, A., and Wolf, E. (1954). El Desarrollo del Area Clave del Imperio Texcocano. *Revista Mexicana de Estudios Antropologicos* **14,** 337–350.

Parsons, J.R. (1970). An Archaeological Evaluation of the Codice Xolotl. *American Antiquity* **35,** 431–430.

Parsons, J.R. (1971). *Prehispanic Settlement Patterns in the Texcoco Region, Mexico.* Memoirs of the Museum of Anthropology 3. Ann Arbor: University of Michigan.

Parsons, J.R. (1989). Arqueologia Regional en la Cuenca de Mexico: Una Estrategia para la Investigacion Futura. *Anales de Antropologia* **26,** 157–257.

Parsons, J.R., and Parsons, M. (1990). Maguey Utilization in Highland Central Mexico: An Archaeological Ethnography. Anthropological Paper 81. Ann Arbor: Museum of Anthropology, University of Michigan.

Pomar, J.B. (1986). Relacion de la Ciudad y Provincia de Tezcoco. *In* R. Acuña, Ed., *Relaciones Geograficas del Siglo XVI: Mexico, 3.* Mexico City: Universidad Nacional Autonoma de Mexico.

Rojas-Rabiela, T. (1988). *Las Siembras de Ayer: La Agricultura Indigena del Siglo XVI.* Mexico City: Secretaria de Educacion Publica.

Sanders, W.T., Parsons, J.R., and Santley, R.S. (1979). *The Basin of Mexico: Ecological Processes in the Evolution of a Civilization.* New York: Academic Press.

Sandor, J.A. (1992). Long-term effects of Prehistoric Agriculture on Soils: Examples from New Mexico and Peru. *In* V.T. Holliday, Ed., *Soils in Archaeology,* pp. 217–245. Washington, D.C.: Smithsonian Institution Press.

West, R. (1970). Population Densities and Agricultural Practices in Pre-Columbian Mexico, with Emphasis on Semi-terracing. *Verhandlungen des XXXVIII Internationalen Amerikanistenkongresses,* Vol. 2. Munich: International Congress of Americanists.

Williams, B. (1972). Tepetate in the Valley of Mexico. *Annals of the Association of American Geographers* **62,** 618–626.

Williams, B. (1985). Clasificación Nahua de los Suelos. *In* T. Rojas-Rabiela and W.T. Sanders, Eds., *Historia de la Agricultura. Época Prehispanica–Siglo XVI,* Vol. 1, pp. 233–236. Mexico City: Instituto Nacional de Antropología e Historia.

Williams, B. (1994). The Archaeological Signature of Local Level Polities in Tepetlaoztoc. *In* M.G. Hodge and M.E. Smith, Eds., *Economies and Polities in the Aztec Realm,* pp. 73–87. Studies on Culture and Society 6. Albany: Institure for Mesoamerican Studies–State University of New York at Albany.

Williams, B., and Ortíz-Solorio, C.A. (1981). Middle American Folk Soil Taxonomy. *Annals of the Association of American Geographers* **71,** 335–358.

Wolf, E., and Palerm, A. (1955). Irrigation in the Old Acolhua Domain, Mexico. *Southwestern Journal of Anthropology* **11,** 265–281.

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