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Settlement, Farming Technology, and Environment in the Nochixtlan Valley

A valley of Oaxaca provided the geographical base for development of Mixtec culture: 700 B.C. to A.D. 1600.

Ronald Spores

Six decades of intensive research have produced numerous studies on the rise of civilization in Mesoamerica. Conventional archeological and ethnohistorical investigations of the prehistoric developments in central Mexico and in the Maya area have been augmented in recent years by several more rigorously defined problem-oriented studies. Multidimensional research on the cultural ecology of the valleys of Mexico, Tehuacan, and Oaxaca has yielded substantial knowledge of cultural evolution in Mesoamerica and at the same time has served to refine the theoretical framework for observing and explaining developmental processes that were operative in the rise of civilization here and elsewhere (*1*, *2*).

During the past 3 years these studies have been extended into still another area, the Mixteca Alta of northwestern Oaxaca (Fig. 1). Abundant archeological and documentary resources and the existence in the area of the modern descendants of ancient peoples afford an exceptional opportunity to employ what Strong called the "direct historical approach" for studying the long-range cultural change from prehistoric and protohistoric times to the historic period (*3*). Starting with living peoples and the early historic accounts of people who had lived in the area, we pushed our inquiry farther back into the prehistoric past to search for cultural origins, for patterns of development and change, and for explanations of these developments within a specific microgeographical context—the Nochixtlan Valley of northwest Oaxaca.

This article examines the relationship of population growth, local adaptation, and cultural development in the Nochixtlan Valley. Our particular orientation has been set forth to some extent by Cook and Fletcher who briefly treated relationships between population and cultural development in the Valley of Mexico during ancient, historic, and modern times (*4*). Fletcher states that "the Valley of Mexico has a long history of overpopulation. . . . One way of relieving population pressure was by maintenance of systems of trade and tribute which allowed nonagricultural specialists to be fed from the agricultural production of other areas." Another response to these pressures, in both ancient and modern times, has been temporary or permanent emigration. These related factors have been of particular sociopolitical and economic significance in determining the course and direction of cultural development, not only in central Mexico but throughout Middle America.

In addition to the importance of migration, trade, and tribute in allowing the maintenance of populations too large to be supported by local agricultural production, I believe that there are two additional alternative responses: territorial expansion by political means (possibly, but not necessarily, related to tributary expansion) and technological innovation. These five alternatives have been available to expanding civilizations in both hemispheres since farming, village life, the accumulation of exploitable surpluses, and higher levels of social and political integration became possible in Neolithic and Formative times. While all variables are worthy of consideration, we will be concerned with only one—technological innovation and its relationship to population growth. Archeological, historical, and ethnological studies in the Nochixtlan Valley suggest that there is a causal relationship between demographic pressure and certain technological innovations that have taken place in the Valley during ancient, protohistoric, and historic times.

The Mixteca and the Mixtecs

The Mixteca is the geographically diversified area which comprises the western third of the modern state of Oaxaca. Parts of the region are high, cool, and moderately moist (the Alta); other areas are low, hot, and semiarid (the Baja); and still other areas are low, hot, and humid (the Costa and portions of the Baja). These three major zones were occupied by closely related Mixtec-speaking peoples at the time of the Spanish conquest, and more than 250,000 of their descendants continue to reside in the area (*5*). Their most notable cultural achievements, however, were centered in the Mixteca Alta (Fig. 2).

When the Spaniards arrived in the 1520's, the Mixtec people were organized into many small kingdoms which were governed by powerful ruling lineages that controlled the most productive lands in the Nochixtlan Valley and elsewhere in the Mixteca. In return for political, social, and ceremonial leader-

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Fig. 1. Map of Mexico, indicating the location of Oaxaca and the three subareas of the Mixteca.

ship, economic security, and protection which were provided by the ruling elites, the citizens of a kingdom were required to pay tribute, to provide labor for the fields and houses of the rulers, to support the religious cult, and to serve in war. The institution of the Mixtec regional or community kingdom (termed "cacicazgo" by the Spaniards) was firmly established long before the Europeans colonized the area, and continued in gradually altered form for many decades after the Spanish conquest. Much is known of the Mixtec community and the cacicazgo because of the existence of abundant documentation as a result of litigation over royal lands and titles in the 16th century and because of the preservation of pictographic historical documents, several of them dating to pre-Hispanic times. This corpus, still only partially utilized, serves as the basis for direct historical inferences about the ancient culture of the Nochixtlan Valley (*6*).

Fig. 2. Map of central and western Oaxaca, indicating locations of the three Mixtecas, the valleys of Nochixtlan and Oaxaca, and several of the principal towns in the area.

The Nochixtlan Valley, about 450 kilometers southeast of Mexico City on the Pan American Highway, is the largest area of relatively open and level land between the Valley of Oaxaca 100 kilometers to the south and the Nexapa Valley at Izucar and the Tehuacan Valley, more than 200 kilometers to the north. It was probably the single most important area in the Mixteca throughout its occupational history and continues to be the most fertile, productive, and intensively settled of the several valleys of the region (Fig. 3).

The Valley is composed of four major sectors: Yanhuitlan in the northwest, Yucuita in the north, Nochixtlan in the east, and the Jaltepec sector in the southeast below the confluence of rivers flowing from the other three sectors. From the northern and northwestern extremities to the southeast margin, the Valley measures approximately 25 kilometers. It varies from 5 to 10 kilometers across and consists of a series of narrow valleys situated between and among high mountain ranges and is punctuated by numerous hills, buttes, and piedmont spurs. Level lands are found only in the central portions of the large and small valleys and in areas where artificial terracing has altered the natural contours of the land.

Preliminary geomorphological investigations conducted by Michael and Anne Kirkby during the summer of 1968 indicate that the basic understratum of the Valley is a fairly resistant rock formation composed of some deposits of Jurassic and Cretaceous age, others of Cenozoic volcanics; with gneiss outcrops appearing particularly in the southeastern end of the Valley. Interbedded with and overlying these formations were the buff to deep red clays of the Yanhuitlan-Huajuapan series of deposits. The well-developed soils which have formed on the Yanhuitlan beds consist of up to 60 centi-

meters of dark gray to gray-brown clay soil, overlying a 50- to 250-centimeter pale gray to whitish lime accumulation layer, which itself usually overlies little-weathered Yanhuitlan beds containing some lime nodules. The lime accumulation layer has a tough claylike consistency in the soil, but hardens on exposure to a tough caliche material (locally termed "endeque") which has been used in the Valley as a building stone since Formative times. Probably this caliche cover extended over most of the Valley in presettlement times; it certainly predates the extensive visible erosion in the area and must have formed under conditions which did not encourage gullying; this suggests a healthy vegetation cover, probably a natural oak and pine forest appropriate to the 2100- to 2500-meter elevation of the Valley. When analyzed, pollen samples taken from stratigraphic tests will help greatly in establishing the nature of environmental conditions during Formative and later times.

Formative Stage: The Cruz Phase

Although remains of fossilized mammoth were discovered during the site survey of the Valley, no evidence of contemporaneous human life could be found in excavations carried out at the point of discovery (*7*). At the site of Yuzanuu near Yanhuitlan, Lorenzo recovered a very crude assemblage of chipped stone tools from deep alluvium in association with a hearth that dated to approximately 2000 B.C. (*8*). Surveys of 130 sites failed to produce another preceramic site. In fact, no site could definitely be said to predate the Late Formative, set at around 700 B.C. This contrasts markedly with the situation in the valleys of Oaxaca and Tehuacan, in Chiapas, and on the coast of Guatemala where sedentary villages are found in Early Formative times (*9*). Present indications are that the Nochixtlan Valley was peripheral to earliest developments in agriculture and settled village life, and that it became an important occupational zone after this pattern was well established in other regions.

The earliest substantial occupation in the Nochixtlan Valley is assigned by ceramic crossties with the Valley of Oaxaca and by relative stratigraphic placement to a period extending from around 700 B.C. to about 200 B.C. (*10*). Ceramic indicators of the Late Formative Cruz phase are present in 21 of the 130 sites surveyed, but only 8 of these sites were intensively occupied or utilized (*2*). Most sites were located on low-lying piedmont spurs that projected into the valley from hills, buttes, and peripheral mountain ranges. The choice of location for settlement, just above but adjacent to fertile and level bottomlands, conforms to a pattern observed in contemporaneous and earlier manifestations in the Valley of Oaxaca (*11*).

The Cruz phase was encountered stratigraphically in excavations at Yucuita, but at present very little is known of the total material culture or architecture of these early valley farmers. Some of the structures found in test trenches were built of cut or roughly shaped stone and formed into straight-sided masonry walls which intersected to form contiguous apartment-like cells of indeterminate use. Associated shallow pits were dug for cooking, rubbish disposal, or for other purposes and were found to contain animal bones, ash, pottery griddles, large pottery fragments, manos, and metates. Very few chipped stone implements have been encountered in Cruz phase contexts.

Large Tan jars, usually painted on the sides and rims with red or dark orange paint, were produced and utilized by the thousands. These are associated with several decorated Gray and Red-and-White wares and distinctive figurines which serve to link the Nochixtlan Valley with Oaxaca, Tehuacan, and Chiapas during the Late Formative period.

Settlements were located on the projecting spurs of land which are invariably areas of dark brown soils overlying red clay soils. While two types of land were available to the first farm-

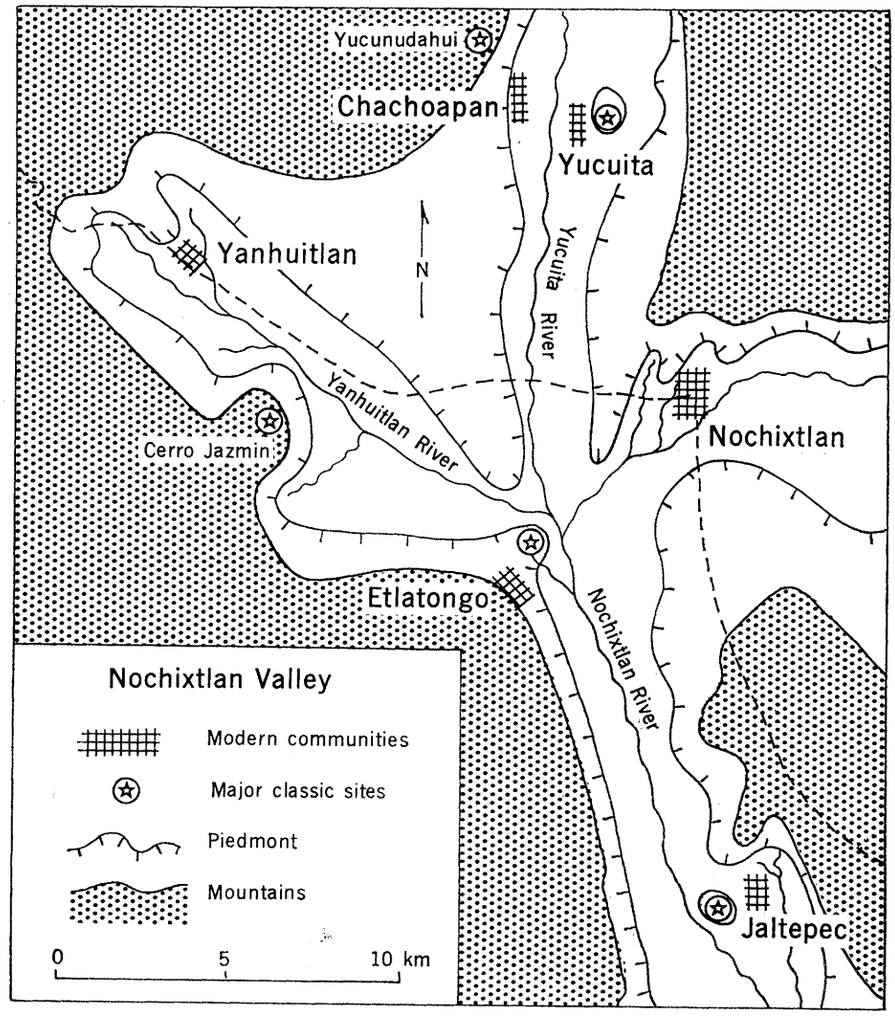

Fig. 3. Map of the Nochixtlan Valley, indicating the four major geographic and survey sectors of Yanhuitlan, Yucuita, Nochixtlan, and Jaltepec; six important Valley towns; and the location of five of the largest and most important Classic Period (Las Flores phase) sites.

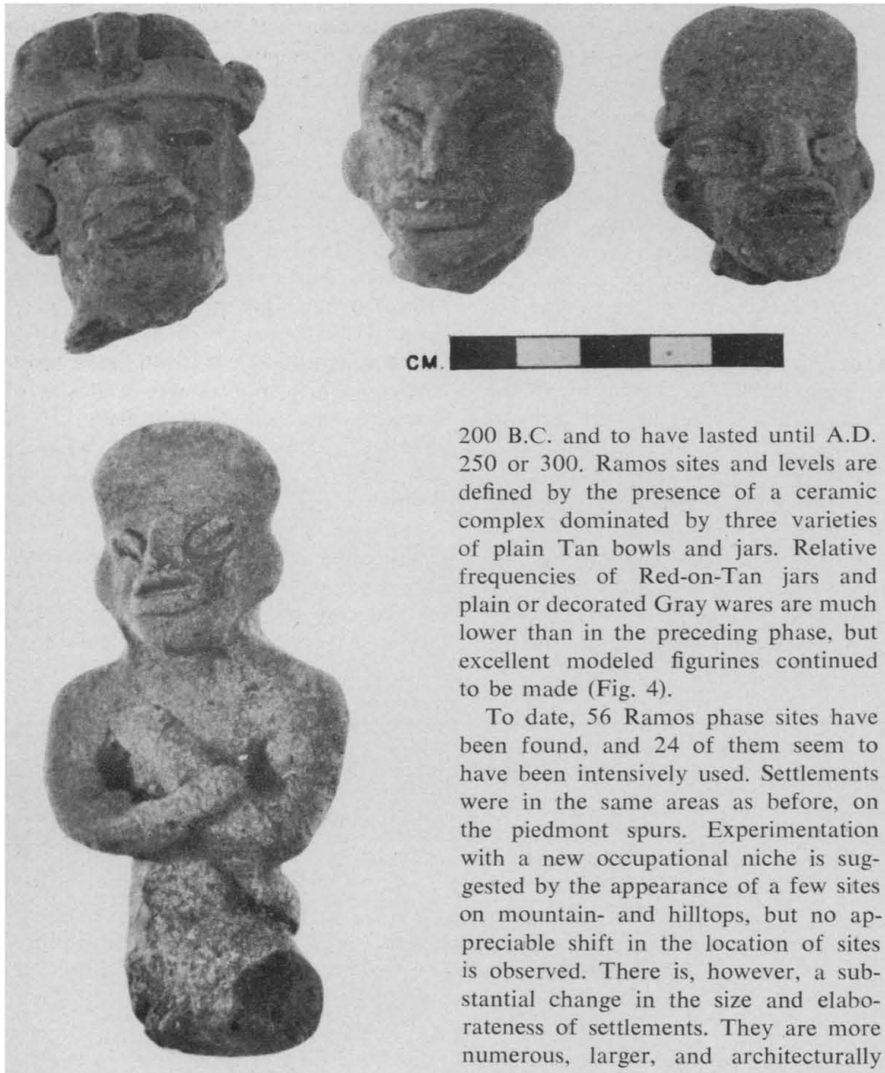

Fig. 4. Four Ramos phase figurine fragments from Yucuita.

ers—valley bottom and hillside—the level, generally more fertile, black soils of the valley floor and margins would have been preferred. At that time, prior to the massive alluviation of the valley floor, seasonal flooding and relatively easy diversion of stream waters would have rendered the valley floor and its peripheries more fertile and productive than the irregular contours of the oak-covered slopes and mountaintops. With so few sites being intensively occupied in the valley, vast areas of flat, low, fertile, and easily tillable land would have been available with little or no pressure on land resources.

Early Classic Stage: The Ramos Phase

A marked increase in the number of sites is noted for the Ramos phase which is believed to have begun around 200 B.C. and to have lasted until A.D. 250 or 300. Ramos sites and levels are defined by the presence of a ceramic complex dominated by three varieties of plain Tan bowls and jars. Relative frequencies of Red-on-Tan jars and plain or decorated Gray wares are much lower than in the preceding phase, but excellent modeled figurines continued to be made (Fig. 4).

To date, 56 Ramos phase sites have been found, and 24 of them seem to have been intensively used. Settlements were in the same areas as before, on the piedmont spurs. Experimentation with a new occupational niche is suggested by the appearance of a few sites on mountain- and hilltops, but no appreciable shift in the location of sites is observed. There is, however, a substantial change in the size and elaborateness of settlements. They are more numerous, larger, and architecturally much more complex than Cruz phase settlements. One cluster of mounds, plazas, and buildings at Yucuita is linked by an extensive system of subterranean tunnels and covers more than a square kilometer (Fig. 5). It is of sufficient dimension to suggest that there had been a concentration of economic resources and political power sufficient to command the creative participation of a large number of people. Ceremonialism is clearly important and this is reflected in the massive architecture and evidence of ritual (including cannibalism) in and around Ramos phase structures.

Population was at least double that of earlier times, and it can be assumed that increased pressure was being exerted against the productive potential of the Valley. Farming strategy, nevertheless, did not vary greatly from the preceding phase. There is no indication of appreciable alluviation at this time, nor is there any significant disconformity between Cruz and Ramos deposits that would suggest substantial alteration in settlement-environmental relationships. There is no indication of hillside erosion, steep slopes apparently not being utilized for agriculture at this time. Settlements continued to hug the spurs and low-lying ridges, and valley lands were farmed as before.

Later Classic: The Las Flores Phase

No less than five major ceremonial and civic centers were developed during the period which began around A.D. 300 and gradually phased out sometime between 900 and 1100. Yucuita remained extremely important, as evidenced by massive extensions and relocations which took place during this phase. Of equal, or perhaps even greater, importance was Yucuñudahui which sits astride a high, steep-sided mountain ridge just northwest of the modern town of Chachoapan (Fig. 6) and directly across the Yucuita arm of the Valley from Yucuita (*12*). Similar civic-religious centers were developed at Cerro Jasmín near Yanhuitlan, at Etlatongo in the central region of the Valley, and at Jaltepec in the far southeastern extremity of the Valley. These sites were either clustered on and around high buttes rising from the valley floor, on high ridges, or on mountaintops. Dozens of smaller sites are found in analogous locations in all parts of the Valley, but most notably in the Nochixtlan sector. These lesser sites consisted of from one to three central mounds, a plaza area that was paved or plastered, usually several stone alignments of undetermined function, stepped terraces, stelae, and sometimes one or two subsidiary plaza-mound complexes.

The ceramic inventory associated with Las Flores sites is simple, relatively drab, and undistinguished. Plain Gray wares reemerge, and together with a fine tempered variety of orange painted Orange or Tan-Cream ware, a medium to coarse tempered Orange-Rust ware, and coarse Brown jars, dominate the ceramic complex (*13*).

Ninety-two sites were occupied, and this, coupled with the fact that unusually heavy and extensive deposits of Las Flores ceramics are found on 36 of these sites, would indicate an upsurge in population (*14*). Not only are more sites being occupied but there is also a new emphasis on larger centers, probably increased clustering of population, and a shift from earlier times in the choice of site location. The val-

ley floor continued to be intensively farmed, but many settlements were moved above the low-lying ridges and spurs onto higher elevations. The desire to open additional farmland along the formerly occupied lomas and piedmont may well have furnished the impetus for the shift in settlement. The number and size of sites and the heavy concentrations of ceramics suggest at least a doubling of population since Ramos times. The inferred intensity of occupation and the number of large quasi-urban centers (five covering at least 1 square kilometer) indicate that a 150 percent increase in population would not be out of reason.

Examination of alluvial deposits reveals the existence of a medium layer of black soil which contained Las Flores and earlier materials that were deposited during Las Flores times. The black layer can still be found in undisturbed areas on the mountaintops and on certain steep slopes. The existence of a black stratum in the valley alluvium is proof that the mountains and slopes were being intensively utilized in response to increasing demographic pressure. Hillside terraces, many of which are presumed to be agricultural, are found adjacent to major Las Flores centers.

External ties, as reflected by ceramic inventories, architecture, and location of sites, are very strong with the north, manifestations being found in the Tamazulapan Valley in the Mixteca Alta, at Huajuapan and Tequixtepec in the heart of the Mixteca Baja, and possibly as far away as Xochicalco and Teotihuacan. There are certain affiliations with Monte Alban III A-B sites in the Valley of Oaxaca, but these have not yet been clearly defined (*15*).

Postclassic Stage: The Natividad Phase

From around A.D. 1000 to the Spanish conquest, the number and size of sites greatly increased. At least 111 of the 130 sites show definite signs of occupation, and 78 of them were in-

Fig. 5. The ancient archeological site and modern community center of Yucuita, shown in the lower portion of the photograph. Remains from all major phases of cultural development—Cruz, Ramos, Las Flores, Natividad, Convento, and Modern—are represented in the site which measures more than 2 kilometers north to south and 1 kilometer east to west. Across the river from Yucuita, to the west, is the ancient site of La Peña, and to the northwest, in the upper right, is the modern town of Chachoapan. [Mexicana Aereofoto]

tensively used. Many mountain top settlements of the Las Flores phase, including several large centers, were abandoned or only partially utilized, reflecting the pronounced tendency for settlements to once again cluster along the piedmont, piedmont spurs, and low-lying ridges (*16*). The surviving Natividad architecture pales beside the impressive Las Flores structural complexes, but the very extensive accumulations of pottery and scattered stone make it apparent that a massive expansion did occur. Distributions of sherds are frequently found to extend continuously from 1 to 3 square kilometers, and persisting nucleation of settlement is quite evident. The northern end of the Valley around Yanhuitlan seems to have been filled to near capacity, with 52 of 58 sites in the sector showing signs of moderate to heavy occupation. A descending ridge system running from Yanhuitlan to Sayultepec and Etlatongo, some 1 to 2 kilometers wide and 10 kilometers long, shows an almost continuous concentration of Natividad phase ceramics. Even a few of the alluvial lands, so valuable for agriculture, reveal limited occupation; this is particularly noticeable in the Yanhuitlan sector and in the vicinity of Nochixtlan.

A number of new cultural features appear in the Nochixtlan Valley. The most prominent feature of this emerging pattern is the Mixtec ceramic complex which we know to have been carried by the Mixtec-speaking people of the Valley in 1520 and later. Although positive dating on the initial appearance of the various components of the complex is lacking, it preceded the Spanish conquest by several hundred years and continued to be a feature of the culture long after.

The basic Natividad wares reflect the same kind of slow persistent change that had characterized the total material culture of the Valley for many centuries. Continuities in vessel forms, paste texture, and modeling techniques are, however, associated with the appearance of several additional forms and some impressive new decorative techniques. Instead of having an overall coating of thin orange paint as in earlier times, the dominant Cream or Orange bowls were decorated with variable combinations of well-executed portraits, lines, dots, and geometric forms applied with red or brown paint (Fig. 7). Identical design elements were also combined to decorate a beautiful new polychrome ware ("Mixtec Polychrome") which appears in the area for the first time, although not frequently. Three varieties of incense burners, trough-handled ladles, pottery graters, mold-made figurines, fine Gray vessels with effigy tripod legs, and some distinctive incised and punctuated minia-

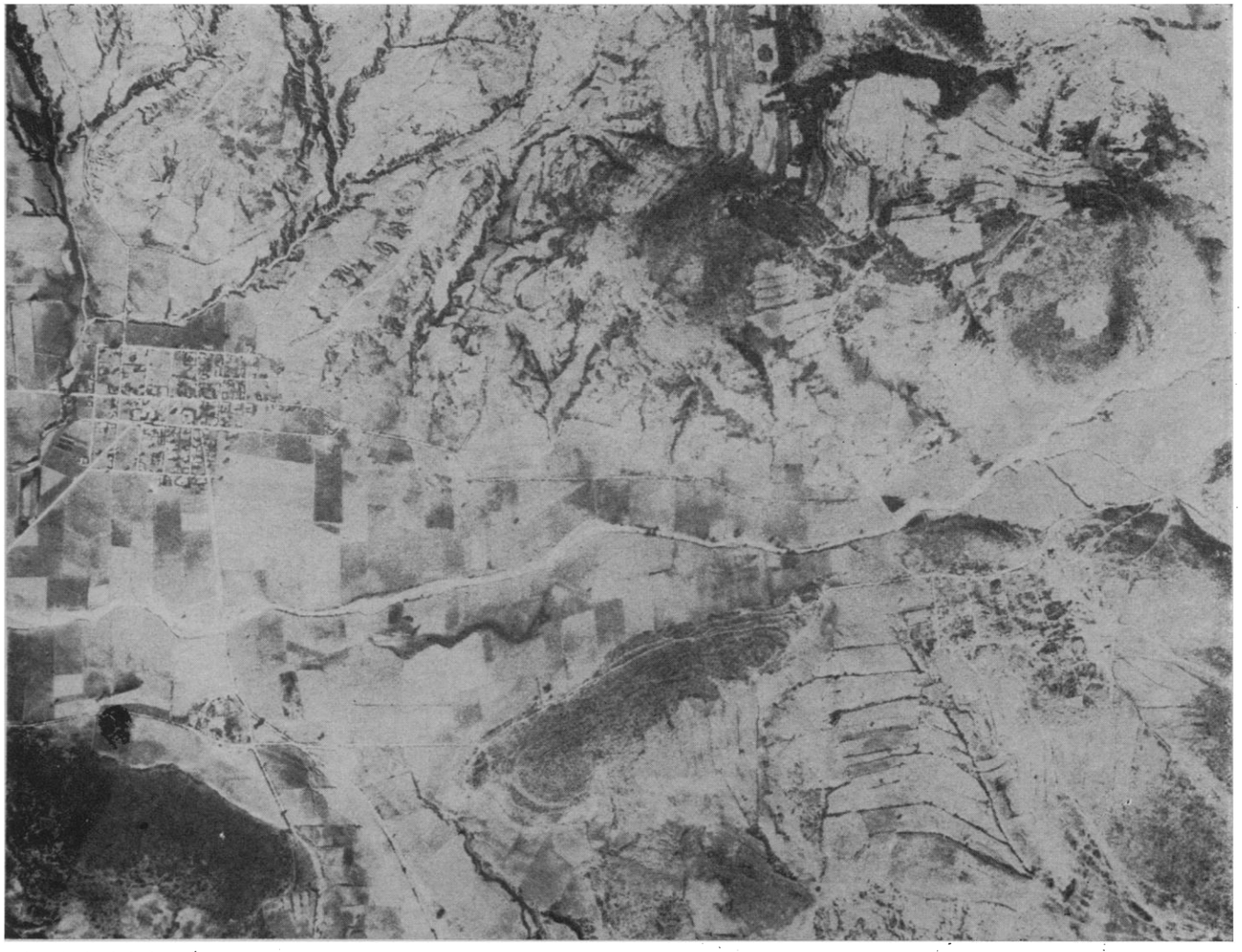

Fig. 6. At left is the modern community of Chachoapan. At center right, northeast of Chachoapan, is the community of Coyotepec. The ancient Classic (Las Flores phase) site of Yucuñudahui extends along the summit and upper slopes of the mountains northwest of Chachoapan and can be seen in the upper-right corner of the photograph. [Mexicana Aereofoto]

ture vessels, called "ollitas," are commonly found together (*17*). Many of the symbols used in decorating pottery were also found in picture manuscripts, in murals, and in stone, bone, and wood carvings.

Few traces of intact architecture have survived more than 400 years of stone robbing and reuse, but massive accumulations of sherds, bone, scattered building stones, and stone tools make it clear that unprecedented pressure had been exerted on the productive resources of the Valley. It is probable that normal population growth was augmented by movements of other Mixtec-speaking groups into the area from the north, that there was more or less continuous social and economic contact and interaction with the Puebla-Tehuacan areas, and that these contacts and migrations were responsible for many of the cultural modifications in the Nochixtlan Valley during the Postclassic period (*18*). It is also likely, of course, that customs, techniques, and goods evolving in the Valley were "fed back" to the north, and that this cultural interchange existed for many centuries before and after the Spanish conquest. Many of the specific design elements found on materials pertaining to the Cholula phase at Cholula and to the Venta Salada phase in the Tehuacan Valley are repeated in Nochixtlan, but, with the exception of Polychrome and rather distinctive Gray tripod vessels, these tend to be absent in areas farther to the south.

Unusual demographic pressures in the Nochixtlan Valley made it necessary to use all available bottomland that was not occupied. However, even this appears to have been inadequate to meet the needs of a rapidly expanding population. But without substantial improvement in an agricultural technology based on hand labor, the use of the digging stick, and apparently almost total dependency on rainfall and some diversion irrigation, no substantial increase in productivity could be expected.

Fig. 7. A "Red-on-Cream" vessel of the Natividad phase from the Nochixtlan Valley. [Courtesy C. Moser]

Purposive Erosion

The Mixtecs of the Valley responded to these needs by constructing stone and rubble dikes designed to trap water and eroding soils as they descended the natural drainage channels that extended from the mountain to the valley floor during the period of heavy summer runoff. These dikes, built of coursed stone and rubble, were 1 to 4 meters high and from 10 to 200 meters long. Modern farmers, who continue to construct these terrace systems, find that in 2 to 3 years sufficient soil (*lama*) can be accumulated in a new terrace (*terraza, trinchera,* or *bordo*) to form level and quite fertile farm plots, and they produce excellent yields of corn, grain, and vegetables. The plots, which range from a few hundred square feet to 10 hectares, can be worked for as long as the system is maintained, and many terraces have been worked since antiquity (*19*) (Fig. 8).

Farming strategy in Natividad times was (i) to continue to work the valley lands, (ii) to till limited areas on mountain- and hilltops where the old dark soil overlying the caliche could be retained on more or less level plots, (iii) to trap the black top soil or underlying red soils in small V-shaped valleys and at the heads of larger valleys. The new strategy devised in response to increasing need led to appreciable expansion of arable land and productive potential.

The Kirkbys' preliminary geomorphological investigations indicated that, once the black soils from the slopes had been removed by a combination of use and erosion, it was necessary, if the *lama-bordo* system was to be maintained, to intentionally cut down through the caliche layer at the edge of the valley and expose the underlying soils of the Yanhuitlan beds. Once an initial experiment or accident of this sort had occurred, the predictable sequence must have been clear to every farmer in the Valley. Gullying cut back the red Yanhuitlan beds, progressively undercutting the caliche layer upslope. Below the gullied area, farmers could trap and farm the red soil which was washing down and create new farmland (Figs. 9 and 10). Level and well-watered farm plots could thereby be produced in areas that had previously been considered unsuitable for agriculture, and local productivity was substantially increased.

The conclusion which must be drawn is that the disastrous erosion so apparent in the Nochixtlan Valley today was not simply the result of deforestation, intemperate grazing, or agriculture that followed the Spanish conquest, but that it was in large part intentionally induced and encouraged by pre-Hispanic

Mixtec farmers who wanted to expand and improve the *lama-bordo* terrace system (*20*). It is significant that this effective but not always farsighted manipulation of the environment continues in 1969.

The Spanish Conquest:

The Convento Phase

Clear archeological indications of the European culture that began to penetrate the Nochixtlan Valley in the 1520's are relatively rare, being found in trace amounts on 44 sites but intensively on only 7 sites. Natividad phase (continuing Postclassic Mixtec) material persisted in unadulterated form in many areas known through documentation to have been occupied both before and after Spanish contact. In fact, it has not been possible to detect any change in the cultural remains of many sites that are known to have been occupied during the early Spanish period. It is only in the important civic centers or around the churches, chapels, and monastery built by the Dominicans that European architectural innovations and ceramics are well represented. Other sites reveal strongly persistent Natividad technology, material culture, and settlement patterns, a fact that coincides quite well with a documented persistence of native art, technology, and social and political institutions for many decades after the Spanish conquest (*21*).

The continuing needs of a large population, coupled with increasing demands for goods and services by the Encomenderos, the Spanish crown, the clergy, and the privileged native nobility, placed additional strain on the resources of the Valley. Although the Spaniards introduced several new crops to the area, they fostered no substantial technological innovation in farming methods, and it was probably necessary to expand the *lama-bordo* system to an unprecedented level. It seems likely that local farmers continued the practice of cutting into the Yanhuitlan deposits through most of the 16th century. During the last quarter of the century, however, depopulation and a corresponding reduction in demands for tribute led to decreasing pressure on land resources and probably to abandonment of much of the terrace system. Grazing and intentional removal of plant cover served only to exacerbate the destruction of the slopes that had been caused by the creation as well as the abandonment of the ter-

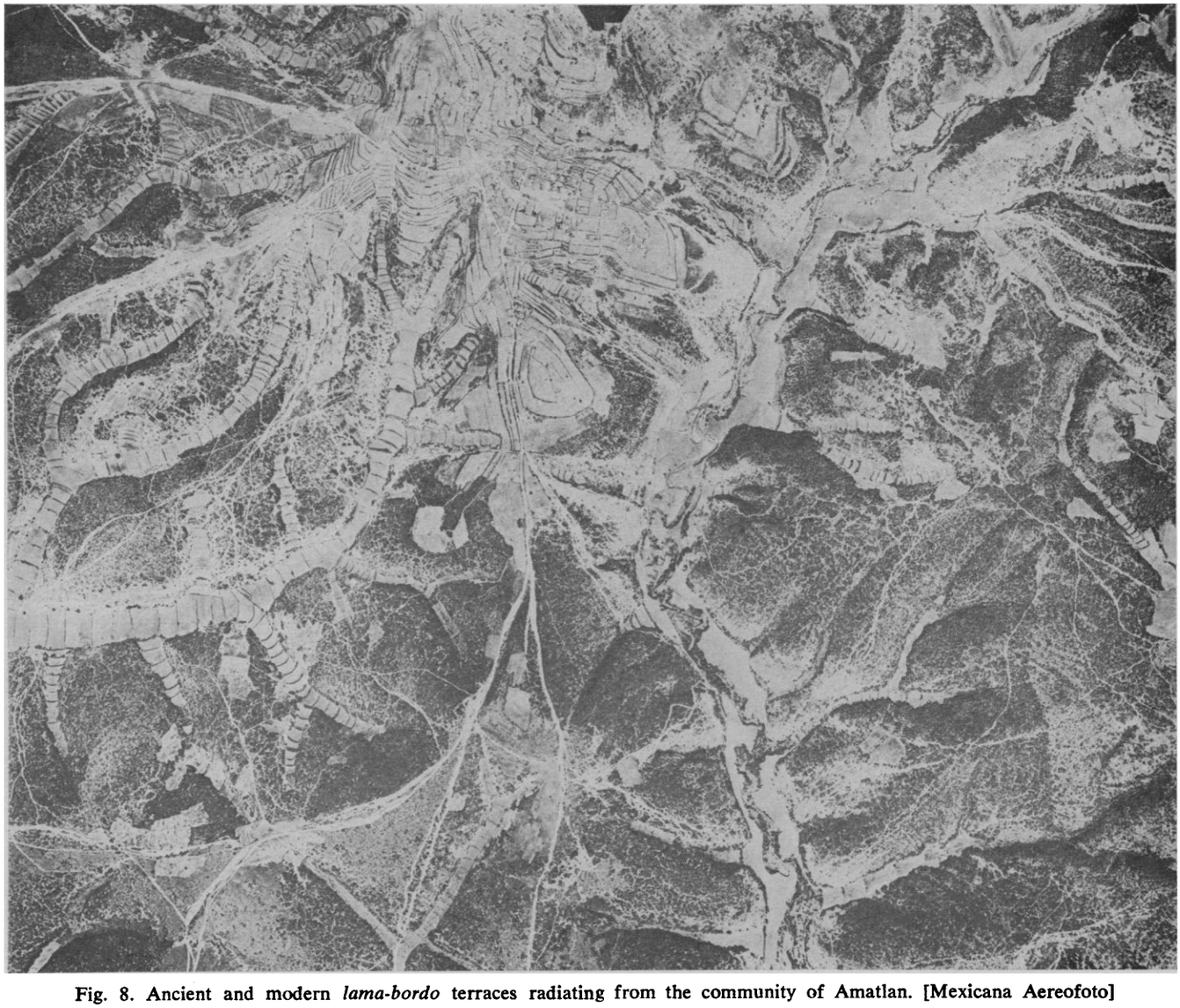

Fig. 8. Ancient and modern *lama-bordo* terraces radiating from the community of Amatlan. [Mexicana Aereofoto]

Fig. 9. Modern *lama-bordo* terraces at Yanhuitlan. Terraces are formed by accumulation of soil behind dikes of posts, brush, maguey plants, rubble, and stone. The structures are frequently reinforced with coursed masonry walls.

Table 1. Pre-Hispanic and postconquest cultural periods, indicating the number of sites (out of 130 surveyed) occupied during ancient times and the estimated population at intervals from Late Formative times to the present.

Period	Estimated population	Native sites occupied
Present population (1969)	35,000	
Late Colonial (1745)	8,000	
Early Colonial (1600)	32,000	
Spanish conquest (1520)	50,000	
Postclassic (Natividad phase) (A.D. 1000–1520)	50,000	111 (78 intensive)
Later Classic (Las Flores phase) (A.D. 300)	25,000	92 (36 intensive)
Early Classic (Ramos phase) (200 B.C.)	10,000	56 (24 intensive)
Late Formative (Cruz phase) (700 B.C.)	4,000	21 (8 intensive)

races. Thick alluvial deposits containing Natividad sherds are found in all areas of intensive occupation, and occasional Convento phase materials found among and above these remains suggest that there was no decrease in alluviation during the Convento phase.

Settlements continued to be found along the hilly flanks of the Valley, on piedmont spurs, and on low-lying ridges. The Spaniards succeeded in relocating and realigning the centers of several larger communities, namely Chachoapan, Nochixtlan, and probably Yanhuitlan, but in other localities there was little alteration of community patterns that had existed in pre-Hispanic times. Many of the modern communities occupy precisely the same land that they did in Natividad times and earlier. These persistent themes in settlement, as in other aspects of the culture, serve to make us aware that Spanish culture had only slight effect on many native patterns.

Demographic Inferences: 700 B.C. to A.D. 1600

The population of the Nochixtlan Valley today is approximately 35,000 (*22*). Our ethnographic researches reveal that emigration to Mexico City, Oaxaca City, Puebla City, the United States, and elsewhere has drained off between 25 and 35 percent of the population that would otherwise reside in the Valley (*23*). Although this has impeded expansion of population, it has also relieved pressure on available farmlands which are either abandoned, sold, put out on shares, or taken over by remaining relatives or others. With the exception of small communal holdings for church and school support and a small ejido at the community of Chindua, lands under cultivation are held privately. Individual family holdings vary from 4 or 5 hectares up to more than 200 hectares. Average holdings range from 15 to 25 hectares per family, which is considerably higher than for other parts of the Mixteca. Many old terraced lands have been abandoned and destroyed by erosion (Fig. 11); others have been maintained, some probably since antiquity; others have been built anew through *lama-bordo* technique or by machine. Almost all flat or gently irregular bottomlands are under cultivation.

Careful examination of 16th-century Spanish tribute records indicates that the population of the Valley was about 50,000 in 1520. After several fluctuations as a result of disease, population was reduced to 32,000 by 1600. This is the first time in the observable develop-

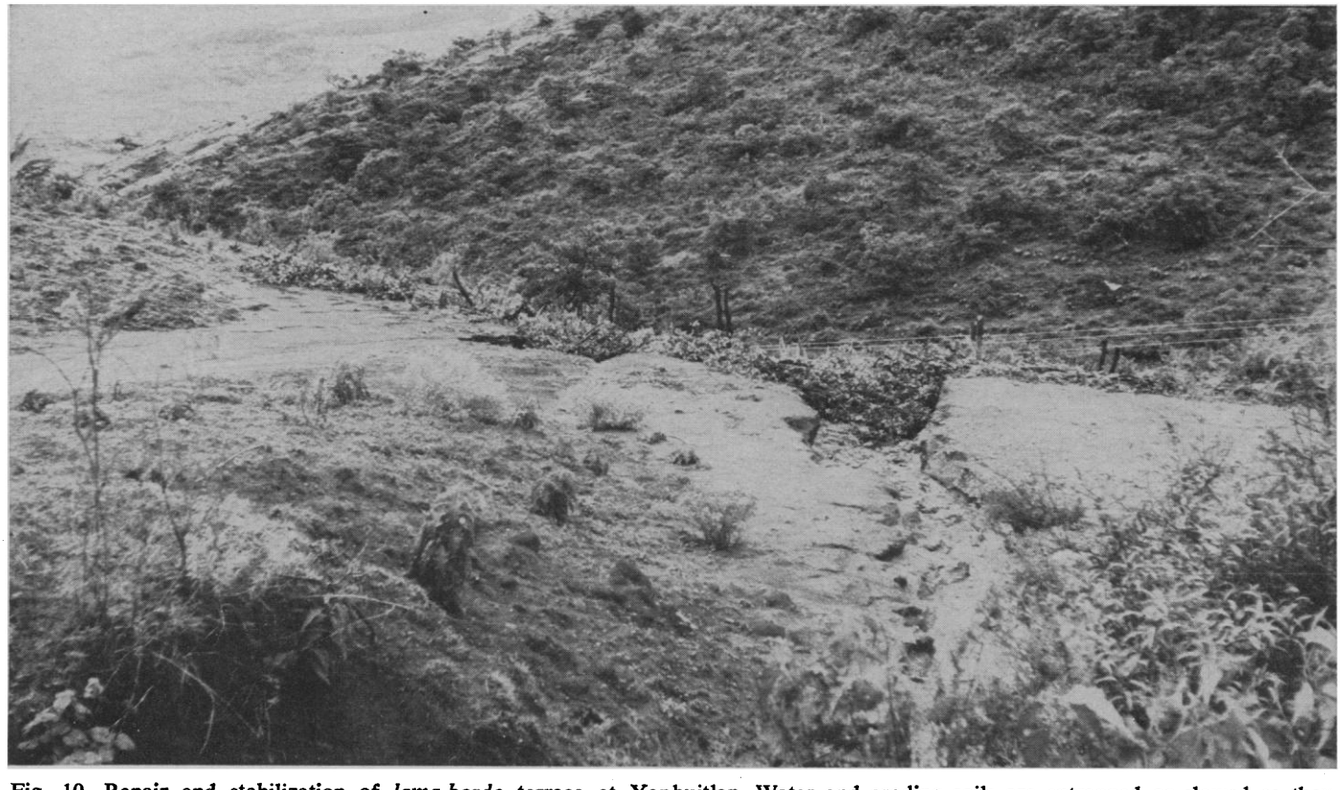

Fig. 10. Repair and stabilization of *lama-bordo* terrace at Yanhuitlan. Water and eroding soils are entrapped or slowed as they descend the natural drainage channels.

ment of the area that there was a decline in population, and it amounts to around 35 percent in 80 years (*24*). Moreover, it is clear that there was no substantial population recovery here or elsewhere in Mexico until well into the present century, most notably since 1930 (*25*). Available data, in fact, suggest that the population may have dropped to a low of 8000 around 1745!

With the 16th century as a demographic base line, and proceeding from there to a consideration of the relative number and intensity of occupation of sites, it is possible to infer a tentative population profile for the Nochixtlan Valley (Table 1). During the Cruz phase, when population was at its lowest level, there was more than sufficient bottomland to support the farming activities needed for the subsistence of the estimated population of 4000. This sufficiency continued into Early Classic times, but in Late Classic and Postclassic times, expanding population and probably increased tributary demands by a native nobility, eager to amass and concentrate wealth, resulted in growing pressure on the available level fields favored by Mixtec farmers. This led first to the development of hillside terracing in Las Flores times and later, in the Natividad phase, to the discovery and development of the *lama-bordo* technique. The erosion of higher elevations was induced during Natividad times in order to fabricate fertile terraces in the lower drainage channels. Then, as population declined after the conquest and Spaniards were forced to reduce tribute assessments, many terraced lands were abandoned and lower slopes were allowed to erode.

Since the 16th century nearly one third of the productive land has been removed from the slopes and redeposited over already fertile bottomlands. The destruction of the land was directly correlated with a sharp decline in population, abandonment of terraces and settlements on slopes and lomas, a breakdown of native polity which had served as the coordinating and directing force in the Valley, and a rapid economic decline which began in the late 16th century with no significant recovery until the mid-20th century.

Renewed demands for farm lands, particularly during the 1930's, 40's, and 50's led to renewed attempts to check erosion for the purpose of recreating usable terrace fields along the hills and arroyos. In many cases, however, the erosional process has outstripped the ability of modern farmers to respond effectively with ancient techniques, placing fertile bottomlands and reclaimable slope lands at a premium. Competition for these lands during the last four decades frequently led to violent interfamily feuding, factional splits, and intercommunity warfare. Fortunately, the escape valve of emigration has opened in recent years and, as a result, a substantial proportion of the population has been siphoned off by the industrialized urban centers and effectively removed from the explosive competition for land. Machinery, fertilizers, and more judicious use of available lands have made it possible for farmers who remain in the area to make better use of the productive resources of the Valley. Thus, an increase in technology during the last decade has made it possible for the Valley to support a sizable population but on considerably less arable land than was available before the Spanish conquest.

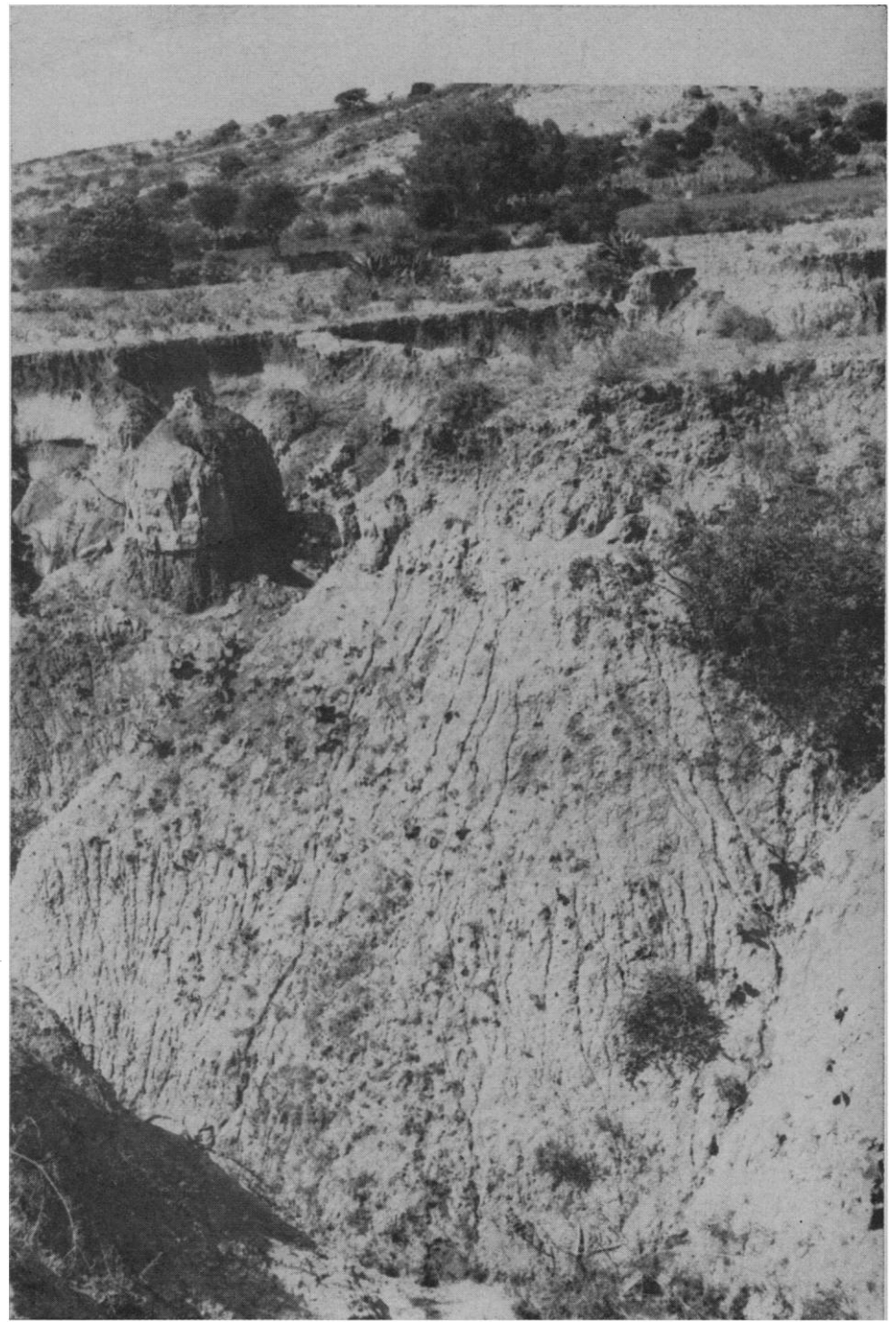

Fig. 11. Unchecked erosion, such as here at Nochixtlan, has removed up to one third of the land formerly under cultivation in the Valley.

Conclusion: Nochixtlan and the "Nuclear Hypothesis"

These investigations suggest a steady evolution of culture and growth of population in the Nochixtlan Valley from Formative times to the Spanish conquest. There has been a long and continuous occupation by Mixtec-speaking people who came into the Valley in Formative times and continued to come and settle there until late Postclassic times. Contact with groups outside the Valley was always maintained, but these affiliations seem to have been strongest during the Formative Cruz phase, then much later in Natividad times. Experimentation during the Formative was followed by a period of internal stability and consolidation during the Classic and then by a time of primarily externally induced elaboration of the material culture during the Postclassic.

Conquest-level Mixtec culture emerged during the Postclassic, probably as a result of the mixing of local traditions with dramatic new influences from the Cholula-Puebla area. The Nochixtlan Valley did not, however, attain the level of influence and urban complexity enjoyed by Cholula and in this respect seems to have lagged behind other key areas throughout its history. The Mixteca Alta has been included with the valleys of Oaxaca, Puebla, Mexico, and Guatemala City in Wolf and Palerm's group of five Mesoamerican "nuclear areas," which were hypothesized to have "maintained their key importance from Archaic times right up to the time of the Spanish Conquest" (*2, 26*). Flannery and associates have demonstrated the continuing "nuclearity" of the Valley of Oaxaca throughout the Formative, Classic, and Postclassic periods, and there seems little doubt about the sustained importance of the other regions. But it must be concluded that the Nochixtlan Valley—and by extension, the Mixteca Alta—did not maintain "nuclearity" throughout the three major periods, but only during the Postclassic period, and even this must be qualified. The importance of the area in Postclassic times is not denied, but it is inappropriate to speak of it as an area of "*massed* economic and demographic power" relative to contemporaneous developments in Puebla, the Valley of Mexico, and in the Valley of Oaxaca. When we compare the level of internal development and probable degree of social, political, and economic influence attained by the other nuclear areas, it must be concluded that the Nochixtlan Valley occupied a decidedly inferior position of power, possibly even during the Postclassic period.

Examination of the long record of cultural development in the Nochixtlan Valley has produced no convincing evidence of massive displacement of population, large-scale warfare, radical political reorientations, depletion of wild plant and animal resources, significant climatic shift, or any comparable cataclysm that would account for the changes in settlement and use of land which have been observed. Immigration, emigration, trade, tribute, and territorial expansion through political means (warfare, alliance, or royal marriage) played roles of varying importance in allowing adjustments to the needs of a growing population (*27*). Clearly, technological innovation has played a highly significant role in the development of Mixtec culture. It is believed that investigations currently under way will serve not only to further illustrate the connection between demographic pressure and technological innovation but also that all other variables can be placed in their proper functional contexts as related to the development of culture in the Nochixtlan Valley. These demonstrations will lead to a greater understanding of the processes of cultural development in the Valley and in all areas where similar variables can be shown to be operative.

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5. Based on the Mexican National Census of 1960.
6. J. Paddock, in *Ancient Oaxaca*, J. Paddock, Ed. (Stanford Univ. Press, Stanford, Calif., 1966); I. Bernal, in *ibid.*; ———, in *Handbook of Middle American Indians*, vol. 3, *Archaeology of Southern Mesoamerica*, G. R. Willey, Ed. (Univ. of Texas Press, Austin, 1965); A. Caso, in *ibid.*; ———, I. Bernal, J. Acosta, *La Cerámica de Monte Albán* (Instituto Nacional de Antropología e Historia, Mexico City, 1967). Historical and pictographic manuscripts have served as the basis for several ethnohistorical studies, including the following: A. Caso, *Interpretación del Códice Bodley (2858)* (Sociedad Mexicana de Antropología, Mexico City, 1960); M. E. Smith, *Tlalocan* **4**, 276 (1963); B. Dahlgren, *La Mixteca: Su Cultura e Historia Prehispánicas* (Universidad Nacional de México, Mexico City, 1954); R. Spores, *The Mixtec Kings and Their People* (Univ. of Oklahoma Press, Norman, 1967).
7. In 1966 a mammoth mandible in loose association with lithic implements was found embedded in an arroyo bank under 6 to 7 meters of alluvium. Careful excavation of the site by archeologists from the Instituto Nacional de Antropología e Historia (under the direction of J. L. Lorenzo) found that the mandible and associated materials were the result of redeposition. The contemporaneity of man and mammoth in the Valley remains in doubt.
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10. Two runs on radiocarbon samples from Cruz phase context (Geochron Laboratories) are inconclusive. Ceramic ties between the Cruz phase and the late Guadalupe and Monte Alban I phases of the Valley of Oaxaca are so clear, however, that virtually no doubt exists as to the proper temporal placement of the Cruz phase in the last half of the Formative period.
11. Intensity of occupation at each site has been estimated by rating localities where ceramics were noted on the surface on a scale from 1 (light concentration) to 5 (heavy concentration). Localities rated 3 (medium), 4 (medium-heavy), or 5 (heavy) are considered for present purposes to have been intensively occupied.
12. A. Caso, *Inst. Panamericana Geograf. Hist. Pub. 34* (1938); ———, in *Actas del 27° Congreso Internacional de Americanistas* (Mexico City, 1947).
13. Plain Gray does in fact reemerge, but detailed study of paste composition and form suggests that the Gray wares of the Las Flores phase are probably derived from the Tan wares so common in Ramos times. Color differences are attributed to changes in firing techniques. In addition, the large Brown jars seem to evolve from the large Red-on-Tan jars of the preceding phase, and the Orange wares represent a further refinement of the earlier Ramos Tan wares.
14. There are nearly twice as many Las Flores sites as Ramos sites, but the former phase seems to have endured perhaps 200 years longer than the latter. The size and intensity of occupation of the Las Flores sites, however, are much greater than for Ramos sites, and I feel secure in inferring a doubling of population between the end of Ramos and the end of Las Flores.
15. J. Paddock, Ed., "Excavations in the Mixteca Alta," vol. 4 of *Mesoamerican Notes* (1953); I. Bernal, in *Ancient Oaxaca*, J. Paddock, Ed. (Stanford Univ. Press, Stanford, Calif., 1966); J. Paddock, in *ibid.*
16. Extensive survey of the large Las Flores phase site of Yucuñudahui brought to light only one very small area in the entire site that showed signs of utilization during Natividad phase times. It is clear from historical documents, however, that hilltop sites were employed for ceremonial purposes in Colonial and Natividad times.
17. Caso's 1937 excavation at Iglesia Vieja, Chachoapan, produced an estimated 10,000 Mixtec Polychrome sherds (never thoroughly studied and now lost) from a refuse pit. My excavations at this site in 1967 produced less than 100 examples of Polychrome out of a total of more than 7000 Natividad phase sherds. The frequency with which sherds of this ware are found on, but not beneath, the surface (with the exception of Caso's test pit, which also contained part of a Spanish sword) leads to agreement with Bernal that Mixtec Polychrome, although an important component of the Mixtec complex, was a relatively late introduction to the area. In many cases the ware upon which Polychrome designs are applied does not seem to arise from local Tan, Cream, Gray, or Brown traditions, and we are tempted to derive most Mixtec Polychrome from some point totally outside the Nochixtlan Valley, probably Puebla.
18. Design elements found on Polychrome and

Cream wares in the Nochixtlan Valley appear in both painted and incised form in the Cholula phase at Cholula and in the Venta Salada phase in the Tehuacan Valley and probably begin earlier here than in Nochixtlan. E. Noguera, *La Cerámica de Cholula* (Editorial Guarania, Mexico City, 1954); R. MacNeish and R. Chadwick, in *The Prehistory of the Tehuacan Valley*, D. Byers, Ed. (Univ. of Texas Press, Austin, 1968), vol. 1. There are also strong parallels with the Coyotlatelco tradition of the Valley of Mexico that require further investigation. E. Rattray in *Mesoamerican Notes* **6** (1967). Historical documentation [for example, *Relación de Cholula* (1580)] also suggests strong ties between the ruling families of the Mixtec communities and the city of Cholula.

19. Brief comment on the economic importance of the Nochixtlan terrace system is provided by M. T. De la Peña, *Memorias del Instituto Nacional Indigenista*, **2** (No. 1), 39 (1950). Strikingly similar terrace structures of ancient date are reported for the Chihuahua-Sonora area of northern Mexico, and modern terraces much like those in the Nochixtlan Valley are found in the Valley of Mexico. L. C. Herold, *Univ. of Denver Dept. of Geography Technical Paper 65-1* (1967); C. S. Fletcher, *Teotihuacan to Tierra Caliente* (mimeographed paper, 1967).
20. Present findings strongly support Cook's view that much of the erosion of the Valley was an accomplished fact *before* the Spanish conquest; S. F. Cook, *Ibero-Americana* **34**, 14 (1949).
21. R. Spores, *Southwestern J. Anthropology* **20**, 15 (1964).
22. Based on figures derived from the Mexican National Census of 1960 with an increment of 10 percent for growth between 1960 and 1969.
23. Our own census of an average-sized (1041) town (Yucuita) in 1968 revealed that 284 (27 percent) townsfolk still maintaining social ties with the community and considered "family" by town residents actually lived *outside* the physical community, in such places as Oaxaca City, Puebla City, Mexico City, and in various locations in the United States. Inquiries and observations made in Yanhuitlan, Sinaxtla, Tecomatlan, Tillo, Chachoapan, and Nochixtlan would suggest that the Yucuita figures are roughly typical for both large and small towns in the Valley, but that, in some of the smaller towns (Tecomatlan and Tillo), the incidence of emigration would be even higher.
24. Derivation of reliable demographic information for Colonial and modern Mexico is a highly complex procedure, the difficulties of which cannot be discussed in the present article. Our estimates are based on consultation of numerous primary sources from the Archivo General de la Nación (Mexico City); the *Papeles de Nueva España* (Est. Tipográfico "Sucesores de Rivadeneyra," Madrid, 1905–06); *Epistolario de Nueva España* (Porrua Robredo, Mexico City, 1939–42); *Tasaciones de la Nueva España* (Archivo General de la Nación, Mexico City, 1952); *Relación de los Obispados de Tlaxcala, Michoacán, Oaxaca y otros lugares en el siglo XVI*, L. García Pimentel, Ed. (published by the author, Mexico, 1904); *Theatro Americano* (Editora Nacional, Mexico City, 1952); and from the recent demographic studies of M. T. De la Peña, W. Borah, S. F. Cook, G. Simpson, and G. Kubler. It is essential to state that the interpretations of the last mentioned writers might well be at variance with mine, and I do not pretend to speak for them. For example, I believe that Cook's estimate—based on general population trends in Mexico—of 100,000 for the Valley at the time of the Spanish conquest is far out of reason and not supported by our town-by-town assessment [S. F. Cook, *Ibero-Americana* **34**, 15 (1949)].
25. W. Borah, *Revista Mexicana de Estudios Antropológicos* **16**, 159 (1960).
26. A. Palerm and E. R. Wolf, "Ecological potential and cultural development in Mesoamerica," *Pan American Union Soc. Sci. Monograph* No. 3 (1957).
27. There is considerable documentary and archeological evidence to suggest a Mixtec expansion into the Valley of Oaxaca in Postclassic times [J. Paddock, in *Ancient Oaxaca*, J. Paddock, Ed. (Stanford Univ. Press, Stanford, Calif., 1966); I. Bernal, in *ibid.*] See R. Spores [*The Mixtec Kings and Their People* (Univ. of Oklahoma Press, Norman, 1967)] on trade, tribute, and territorial expansion in the Mixteca Alta in Postclassic and early Colonial times.
28. This research supported by Vanderbilt University Center for Latin American Studies, the Ford Foundation, and the Vanderbilt University Research Council. Geomorphological studies were conducted by M. Kirkby and A. Kirkby of Bristol University. J. Broster, C. White, E. McIntire, R. McIntire, S. Moore, and W. LaFevor, students at Vanderbilt University, and M. Winter, graduate student at the University of Arizona, have participated as members of the project field staff. K. Flannery, J. Paddock, D. Butterworth, J. Wheeler, A. W. Williams, C. E. Smith, M. E. Smith, T. Charlton, C. Moser, and F. V. Scholes have contributed direct advice and assistance. I. Bernal, J. L. Lorenzo, and L. Gamio substantially aided research through their offices with the Instituto Nacional de Antropología e Historia.

Delayed Radiation Effects in Atomic-Bomb Survivors

Major observations by the Atomic Bomb Casualty Commission are evaluated.

Robert W. Miller

The pace at which radiation effects in the Japanese survivors of the atomic bombs are being reported has recently quickened. In this article I seek to put into perspective the major findings of the Atomic Bomb Casualty Commission (ABCC).

Immediately after World War II, a joint commission of the U.S. Army and Navy made observations concerning the immediate effects of exposure to the atomic bombs in Hiroshima and Nagasaki. Upon completion of its work, the joint commission recommended that the National Academy of Sciences–National Research Council conduct a study of the long-range biomedical effects of the exposures. The Council convened an advisory group, whose study of the situation in Japan led to a Presidential directive authorizing the National Research Council (NRC) to establish an organization to evaluate the delayed effects of exposure to the bombs. Thus the Atomic Bomb Casualty Commission came into existence (*1*). Its large-scale study, begun in 1948, is a cooperative venture between the NRC, representing the United States, and the Japanese National Institute of Health. The Commission's present staff of 725 Japanese and 36 foreign nationals, including 18 U.S. professionals, is collecting and analyzing data from periodic comprehensive medical examinations, from postmortem findings, and from a review of vital certificates as they are generated.

Genetic Effects

It is commonly thought that congenital anomalies are the only measure of genetic effects among children conceived after one or both of the parents have been exposed to ionizing radiation. The studies conducted at the ABCC, however, concerned six indicators of genetic damage in the F_1 generation.

Pregnancies were ingeniously ascertained (*1*). In postwar Japan, when food was in short supply, pregnant women were allowed an extra ration of rice, beginning in the fifth month of pregnancy. When such women registered for this supplement in Hiroshima or Nagasaki, they were entered in the ABCC

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