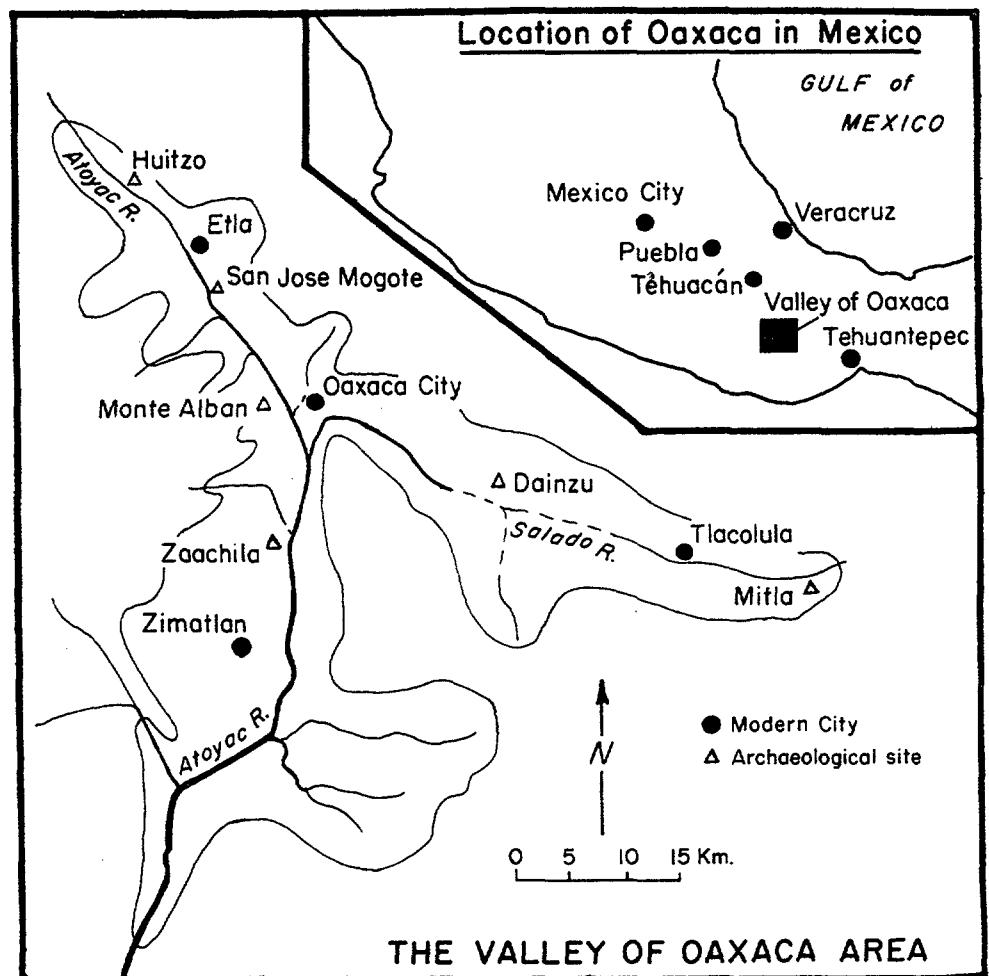


Climate and Man in Formative Oaxaca

By KENT V. FLANNERY AND JAMES SCHOENWETTER



In 1928, archaeologist Herbert Spinden advanced the theory that all the great "high cultures" of Mesoamerica had grown out of a common underlying ancestral tradition which he called the "Archaic culture." Then, many of his colleagues laughed; today, those smiles have in general faded away. For almost anywhere archaeologists have searched in Mesoamerica they have come across remnants of an earlier horizon which does show an amazing superficial similarity. Now called the "Early Formative" rather than the "Archaic," this horizon is almost everywhere distinguished by globular neckless jars and flat-based bowls with vertical or slightly outleaned walls; decoration by incising, excising, or rocker-stamping, often in zones; lavish use of specular hematite pigment; and differential firing or smudging used to produce vessels which are part white and part black.

This does not mean, nor did Spinden intend it to mean, that "one people" or "one culture" was responsible for the Early Formative. Once past the "superficial similarity," it is clear that the archaeologist is dealing with a multiplicity of diverse regional cultures and that each Formative culture must be understood in its own terms. What is striking, and presumably accounts for their superficial similarity, is the extent to which all these cultures were in contact. Probably this interconnection was vital to the growth of Mesoamerican civilization. By the time civilization arose, interaction between regions was so strong that, in the words of Gordon Willey and Philip Phillips, "all drew on a common fund of great depth and richness."

Since 1966 we have been struggling to understand just one of those Formative cultures in its own terms. Our region is the Valley of Oaxaca in the southern highlands of Mexico, 500 km. south of Mexico City, and the time involved is the period from 1500 B.C. to A.D. 1. So far we have barely gone beyond what seemed to be our essential first task: finding out how the Formative people earned their living. Still ahead of us is the more difficult task of determining how they gave rise to the "Classic" civilization of the Valley of Oaxaca, which appeared between A.D. 1 and 300 and reached its peak between A.D. 300 and 900.

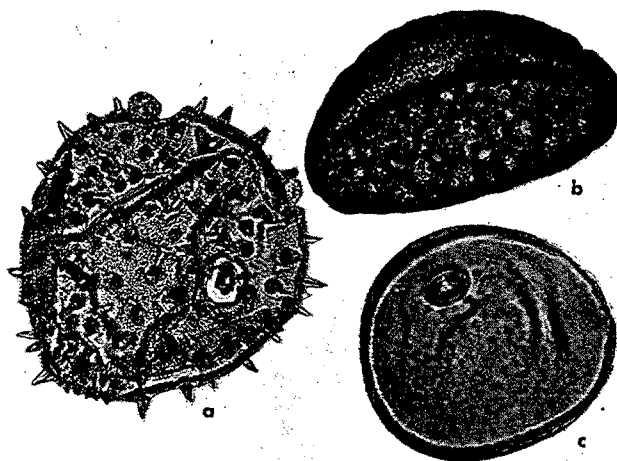
THE VALLEY OF OAXACA is semitropical, with an average elevation of 1550 meters above sea level, and semiarid (with an annual rainfall of about 500-700 mm.). The natural vegetation of the valley floor, now largely destroyed by more than five thousand years of agriculture, appears to have been a brushland of mesquite, prickly pear and thorny legumes, with forests of alder, willow and fig along watercourses. The surrounding hills have a cover of cactus and oak, which thickens to pine-oak forest at the summit.

Striking differences can be seen in the agricultural potential of the region, which is seventy kilometers long (north-south) and forty kilometers wide (east-west). The northwest or Etla arm of the valley is most productive; the drier southeast or Tlacolula arm includes some of the poorest land; and the southwest or Zimatlán arm is highly fertile in some places but prohibitively swampy in others. The present-day Zapotec Indians, who occupy the valley, know the peculiarities of all these sub-regions and make the most of them. To find out precisely how this is done, our colleagues Michael and Anne Kirkby spent 1966 through 1968 studying Zapotec farming.

We were sure that the Kirkby's findings would shed light on the land-use patterns of Formative farmers as well—assuming the environment of that period was similar to today's. It was Schoenwetter's job to find out, using pollen analysis, just how different the prehistoric environment of the valley had been. Finally, once the Formative environment had been determined, it became the task of Flannery and his archaeologist colleagues to find out how the Indians had adapted to it.

Schoenwetter began by taking a series of thirty samples from the present-day surface of the valley, in all plant communities, from nearly pure pine forest on the mountain tops to open grassland on the drier parts of the valley floor. This initial series has since been augmented by one hundred fifty additional surface samples taken by his assistant, Suzanne Kitchen. These surface samples served as a guide to the present-day pollen rain over the valley as a whole, and they constituted a standard against which samples of prehistoric pollen could be compared.

"Environment" is a term of many meanings, incorporating many distinct and segregable ecological variables. Insofar as the Formative period was concerned, the kind of environmental variables we thought it most profitable to concentrate on were those more directly influencing the agricultural base of society. Given the semi-arid nature of the Valley of Oaxaca,



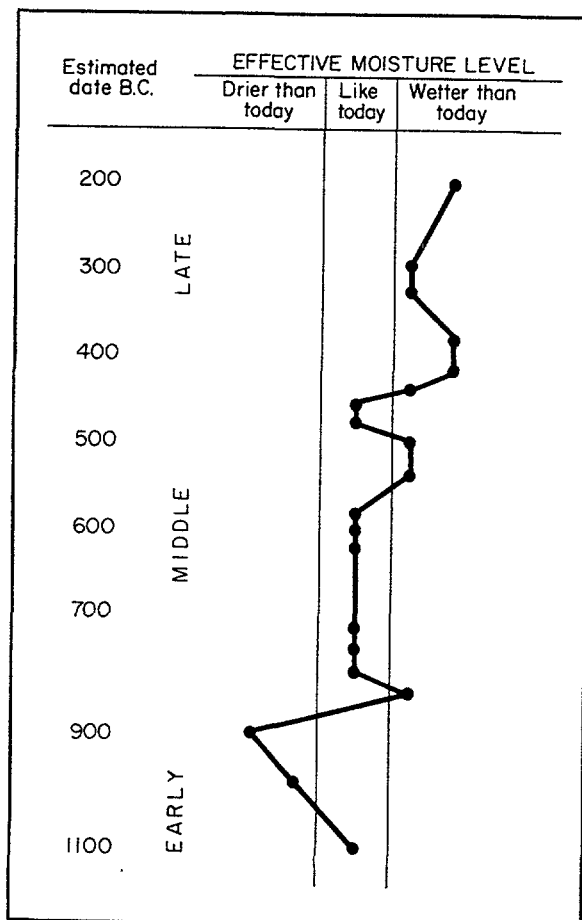
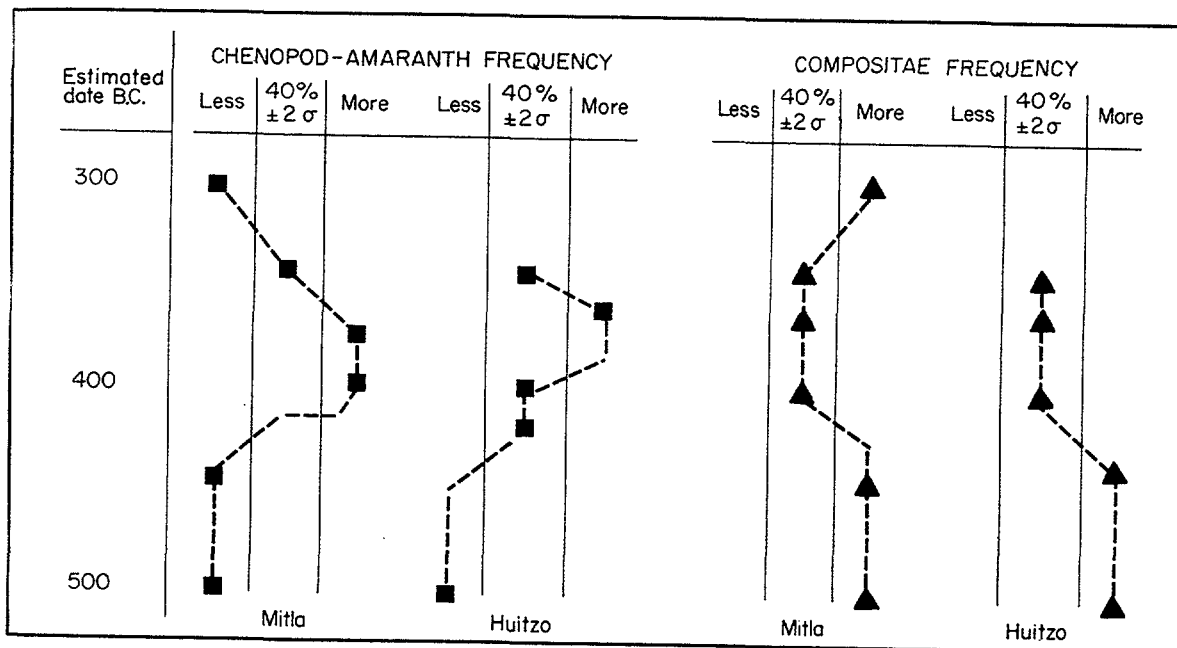
Formative sites in Oaxaca also produced pollen from economically useful plants: (a) squash; (b) *Agave*, the maguey or century-plant, used for food and fiber; (c) maize. Pollen identification is made by analysis of the characteristics of apertures and surface sculpturing. The squash pollen type has many pores (some with operculate caps) and is spiny; the maize type has one pore and is smooth surfaced; the *Agave* type has a single furrow and a network (reticulum) sculpture pattern. (These photographs are not to scale; squash and maize pollen are about twice the size of *Agave* pollen.)

the most critical variable might be called *effective moisture*: the amount of water available to plants, from any source. Effective moisture is a useful concept for several reasons. First, changes in effective moisture are such that they will often be reflected in a 100-grain sample of pollen, which is rather small by palynological standards. Second, the concept does not force us to be explicit about the source of moisture, which may be due to a variety of factors. One of our jobs, therefore, was to determine what kinds of fluctuations in effective moisture had taken place during the Formative period, and by comparing them with today's moisture levels, decide whether they had been of sufficient magnitude to affect maize-bean-squash agriculture.

Under today's environmental conditions, an "average" 100-grain count of pollen from the floor of the Valley of Oaxaca would show ten percent grass pollen and forty percent pollen of the *Compositae* (a group of plants including sunflower, dandelion, golden rod and their relatives), with the remaining grains made up of pine, oak and miscellaneous species. As effective moisture goes up, so does the frequency of *Compositae*; the wetter zones of the valley floor today yield samples which are sixty-four percent *Compositae* and only seven percent grass. These are the prime agricultural areas of the valley, the floodplains of the main Atoyac River, where water is always within three meters (or less) of the surface. The drier zones of the valley floor today have a pollen spectrum which is forty-eight percent grass and twenty percent *Compositae*; these areas are agriculturally very risky unless some kind of irrigation is practiced.

NEXT CAME THE COLLECTION of prehistoric pollen samples. These were samples of earth, averaging one hundred fifty cubic centimeters each, from the archaeological sites themselves. Samples had to be taken from archaeological contexts so that they could be dated in relative terms (by the associated prehistoric pottery) and absolute terms (by radiocarbon dating). Since the pollen program was one of the most crucial parts of the project, we did not limit our excavations to the kind of artifact-rich sites which archaeologists like to dig. In fact, we dug four sites just because they offered good pollen stratigraphy and could be tied into the local arroyo system, with its geological history of alluviation and deposition. In all, when the pollen program is completed, we will have analyzed about five hundred prehistoric samples.

For a variety of reasons, few such archaeological pollen programs have been attempted. Pollen deposited in terrestrial (as contrasted with aquatic and sub-aquatic) environments is far more difficult to identify and recover in quantities sufficient for meaningful analysis. Beyond this, when the pollen is collected from a sediment which was formed within an area of human habitation, it is reasonable to expect that the actions of man would "skew" the frequencies of one kind of pollen to another. Man brings economically useful plants (like corn, squash and others) into his villages, sets fires, kicks dust around and engages in many activities which may destroy certain kinds of pollen or may cause certain pollen types to be more commonly preserved than others. We were aware of these problems and tested for them by sampling all kinds of archaeological contexts: house floors, storage pits, post holes, middens, courtyards and even arroyos on the margins of the site. We reasoned that, due to skewing, samples of identical age from different settings within a village, or from two different villages, might not produce statistically equivalent data. To our surprise, this turned out not to be the case. Over



One of the surprises of the Oaxaca study was the close correspondence of archaeological pollen samples from the same period, regardless of context. These graphs compare fluctuations through time in the percentage of pollen of the Chenopod-Amaranth group (pigweed, goosefoot and their relatives) and the Compositae (goldenrod-dandelion family) at two archaeological sites 65 kilometers apart. Black squares or triangles indicate their actual frequencies in 100-grain counts from archaeological samples, dated by the associated pottery; dashed lines connecting them are theoretical reconstructions of the frequency trend through time.

Fluctuations in effective moisture during the Early, Middle and Late Formative periods in the Valley of Oaxaca, based on a synthesis of all presently available archaeological pollen data. Solid dots indicate actual points in time for which pollen counts are available, dated by associated pottery and radiocarbon; the line connecting them is a theoretical reconstruction. Today's effective moisture level was determined by analysis of samples from the present land surface.

eighty percent of the samples of equivalent age, from whatever context, show the same pollen record, and what is more, they closely match samples taken from the valley today! We could only conclude that skewing due to human activity was so minor that it usually would not be reflected in a 100-grain count.

What did the prehistoric pollen show? It showed that there *were* fluctuations in effective moisture dur-

OAXACA continued

ing the Formative period, but that they stayed roughly within the parameters of today's environment. The Early Formative (1200-900 B.C.) was generally drier than today, yet the "driest" archaeological sample (from a site near the Atoyac River) has twenty-nine percent Compositae and thirty-five percent grass pollen, which is less extreme than the driest areas of the valley floor today. The Middle Formative (900-400 B.C.) was characterized by moisture values like today's. Finally, the Late Formative (400 B.C.-A.D. 1) was somewhat wetter than today, but the "wettest" sample from that period shows seventy-one percent Compositae and ten percent grass, which is not significantly moister than the wettest parts of the valley floor at present. In other words, conditions for agriculture became increasingly favorable throughout the Formative, but taken alone they are not sufficient to account for the explosive population increase and political development of the Valley of Oaxaca. Moreover, the changes in effective moisture are such that it would probably be best to regard them as local phenomena, rather than indicators of the climate of Mesoamerica as a whole.

THESE PRELIMINARY RESULTS of the pollen program convinced us that the Kirkby's data on Zapotec farming was indeed relevant to an interpretation of Formative agriculture. This, coupled with data produced by our archaeological excavations and surveys, suggest the following tentative reconstruction of cultural events in the Valley of Oaxaca.

During the Early Formative, when effective moisture levels were lower than the present average, many parts of the valley would have been difficult or impossible to farm without irrigation. In fact, no Early Formative settlements are known from those areas. All the villages of this period—at least eight have been located so far—lie adjacent to the main Atoyac River or the lower course of its tributary the Río Salado. At least half the population lived in the Etla arm of the valley, which is the smallest and narrowest, but which has the greatest agricultural potential. Apparently, irrigation systems were not advanced at this time, and the strategy used was to restrict agriculture to the permanently humid bottom land of the major rivers, where soil moisture is so high that the maize can survive despite periods of erratic rainfall. The piedmont and mountain zones, which would have been relatively unproductive farmland under lower effective moisture conditions, were left as a vast reserve of wild products such as acorns, prickly pear fruit, mesquite, deer, peccary and rabbit. The Early Formative villagers also raised dogs for food and collected mud turtles from the river. Evidence

for all these practices could be found in the abundant animal bones, pollen grains and carbonized maize kernels and other seeds obtained from the middens between houses.

The southern half of the Etla arm of the valley, with its strategic access to humid bottomland, wooded mountains and the wild resources of the upper piedmont, seems to have been the focal point of social, ceremonial and economic activity. One Early Formative site, San José Mogote, covered at least forty-five acres at this time. Within this area, surface remains suggest three different kinds of residential zones, possibly indicative of (1) low-status families, (2) high-status families and (3) part-time craftsmen. It is in the "high-status" residence area that we recover the pottery showing most of the "pan-Mesoamerican" characteristics already described at the start of this article. While the bulk of the population shows little evidence of ties beyond the limits of its village, there appears to have been one segment of society which participated in a network of relationships extending far beyond the Valley of Oaxaca. It was evidently at this "chiefly" level that Mesoamerica was linked, valley by valley, into the widespread interaction sphere that Spinden had visualized.

THE EARLY FORMATIVE villagers participated in substantial exchanges of trade goods with other regions of Mesoamerica. From the Pacific Coast—most likely in the Tehuantepec region—they obtained pearl oyster, *Spondylus* shell, marsh clams, estuary snails and a variety of sea shells, all of which were then converted into ornaments by Oaxacan craftsmen. The artisans at San José Mogote also worked black and white mica and ground small mirrors out of magnetite and ilmenite, two locally available iron ores. Some of these materials were presumably traded out of the Valley of Oaxaca into other regions of Mesoamerica. From the peculiar distribution of all these materials in the archaeological sites, we were led to believe that the entrepreneurs who directed and controlled this trade resided in the "high-status" areas.

Among primitive agriculturalists, such trade is more than a luxury: it is often closely linked to the subsistence economy and thus indirectly related to the agricultural adaptation. Given the erratic rainfall of semi-arid regions like Oaxaca, unusually good years—and hence maize surpluses—are unpredictable. One way of "banking" unpredictable maize surpluses (as an alternative to storage) is to convert them into imperishable trade goods which can be used either (1) as "wealth" in times of shortage, or (2) as part of a ritual exchange system, used to establish reciprocal obligations between neighboring peoples. Such ex-

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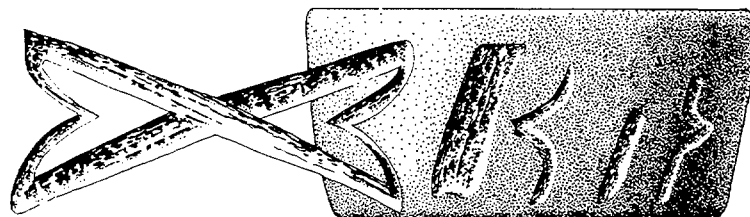
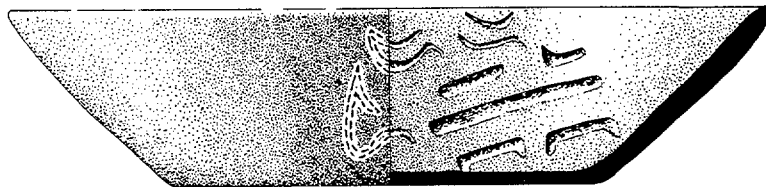
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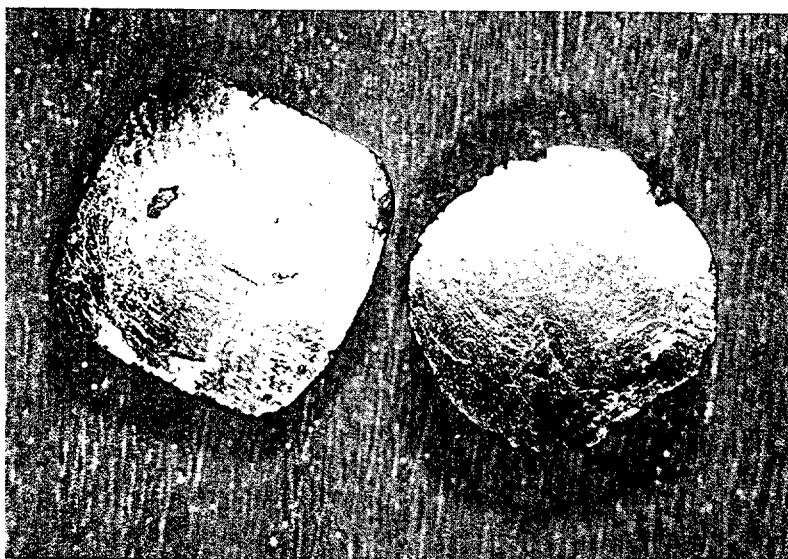


One of the pan-Mesoamerican artifacts characteristics of the Early Formative period was a globular neckless jar decorated with rocker-stamping in zones, often separated by bands of red hematite pigment. These fragments are from San José Mogote in the Valley of Oaxaca (scale in centimeters).



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Centimeters

Pottery used by important individuals in the Early Formative period was often decorated with elaborate, stereotyped glyphs. These examples from San José Mogote in the Valley of Oaxaca are nearly identical to specimens found near Mexico City, southwestern Puebla and the Gulf Coast of Veracruz.



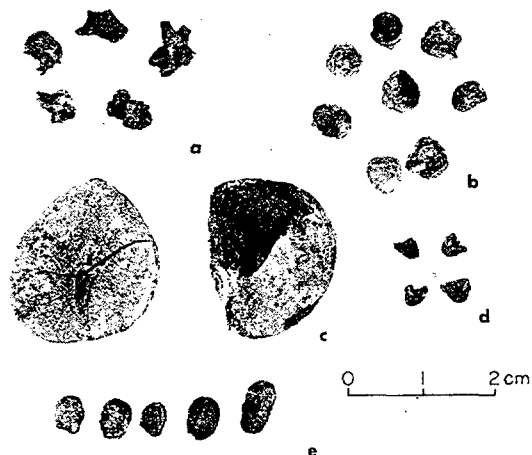
Small mirrors of magnetite and ilmenite, two native iron ores, were manufactured by Early Formative craftsmen in the Valley of Oaxaca, possibly for export to other regions; width, ca. 1.4 cms.



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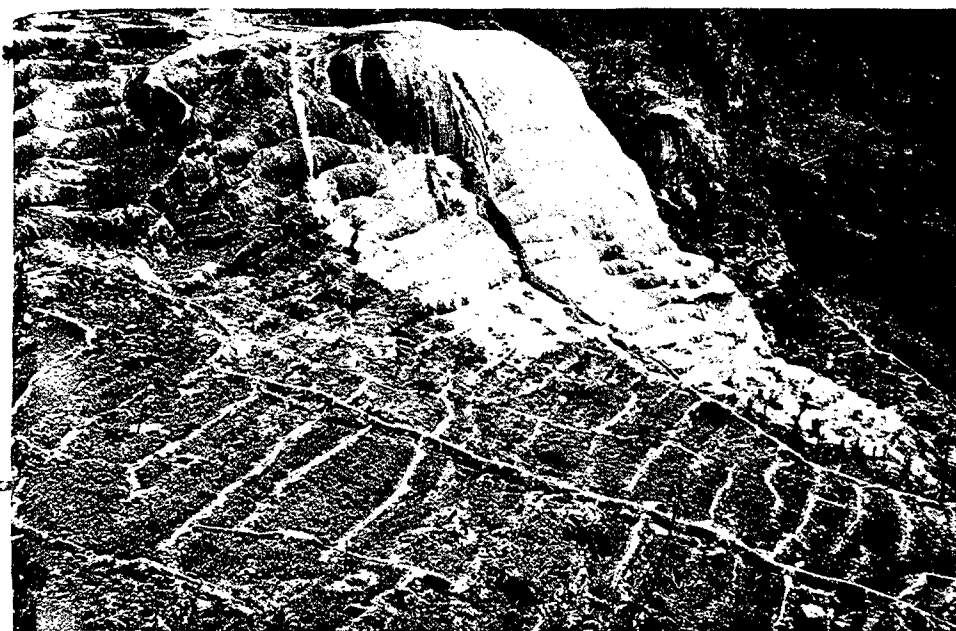
change systems help to "even out" the differences between good and bad years by circulating foodstuffs and trade goods between regions with different crop cycles. They also serve to augment the prestige of the entrepreneurs.

Population in the Valley of Oaxaca increased during Middle Formative times. More than a dozen sites are known from that period, which was characterized by effective moisture levels like those of the present. Villages were still restricted to the immediate floodplain of the Atoyac and Salado rivers, but they were spaced closer together and at least one of them covered ninety acres. Two archaeological sites of this period have produced wells, of the size and shape used today for bucket irrigation. According to the Kirkbys' land-use data, such wells are used to irrigate vegetables like



Carbonized plant remains of the Middle Formative period were floated from ashy middens at Huitzo by Kathryn Vaughn and Jane Wheeler of the Oaxaca Project: (a) cupule-bearing fragments from shattered maize cobs; (b) maize kernels; (c) two cotyledons of domesticated avocado seed; (d) seeds from prickly pear fruit; (e) cotyledons of domestic bean.

Important Middle Formative families in the Valley of Oaxaca lived in large houses on white-washed earthen platforms, with stairways leading down to patios. Here workmen under the direction of Mark C. Winter of the Oaxaca Project expose such a platform at Huitzo. Part of the structure had been destroyed by local adobe brick-makers, but several postholes from the house had survived and were excavated (foreground).



At Hierve el Agua, east of the Valley of Oaxaca, prehistoric irrigation canals begun in the Late Formative have been literally "fossilized" by the deposition of travertine, which is carried in solution by the water from a mineral spring. In the foreground can be seen the main canals running downhill (from left to right), and the feeder canals branching off them at right angles to run along the top of dry-laid stone terraces. The "waterfall" in the background is actually solid travertine. (Photograph by Chris L. Moser.)

tomatoes and chile peppers near the village, while maize and beans are grown on the backslope of the river levee. They also make it possible for a second, "cash" crop to be grown during the winter dry season.

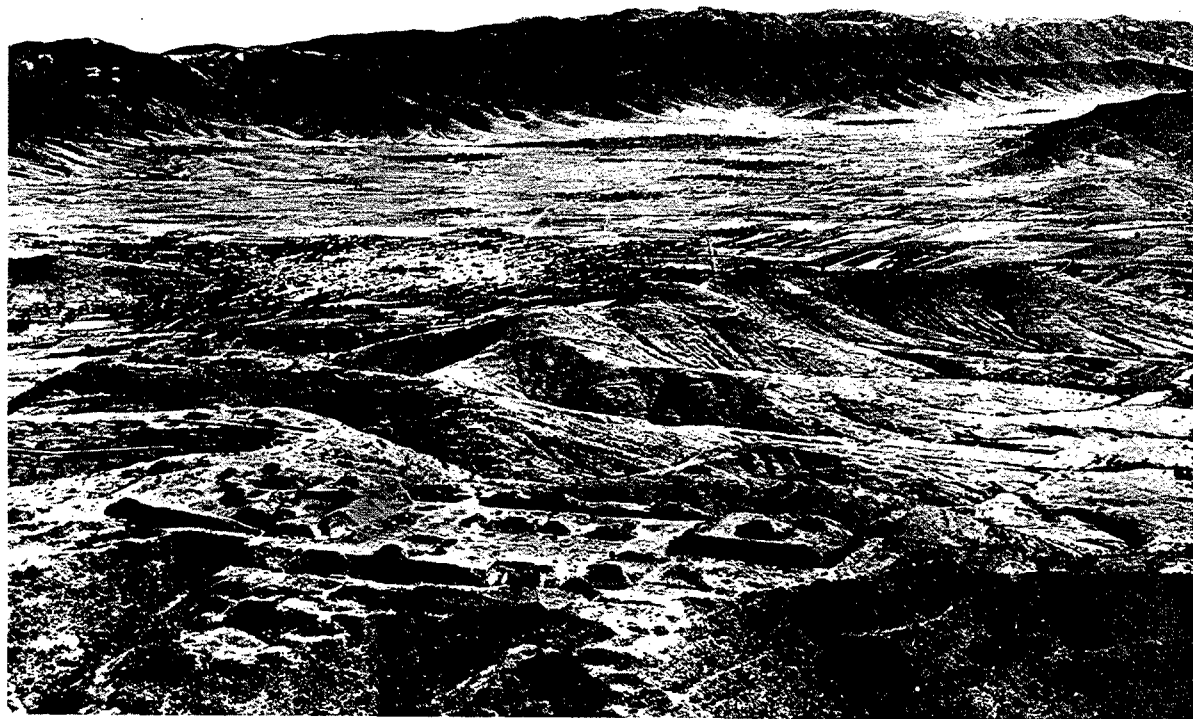
Social differentiation was still more pronounced in Middle Formative villages. Some families lived in houses raised on platforms twelve meters wide, built of earth and adobe brick, with plastered stairways leading down to courtyards shared by other elite residences. Their trade relationships brought them conch shells, marsh clams, sting-ray spines and shark teeth from the coast and small basalt mortars from the northwest. The ordinary villagers lived in houses half that size, constructed of river canes and plastered with mud, but without platforms. Between the houses were open areas where domestic refuse had accumulated. Using water and fine screens, we "floated" masses of carbonized seeds out of these refuse layers. Maize kernels, beans, cultivated avocados, pumpkins, chile peppers, prickly pear fruit and a variety of wild plants emerged. One peculiar type of fragment puzzled our project botanist, C. Earle Smith, until suddenly he recognized it: hundreds of cupules with stiff, indurated glumes broken loose from cobs of maize which had been crossed with corn's nearest relative, *teosinte*.

With the Late Formative, effective moisture rose to a point higher than today's levels. Geological studies suggest that during this period many local streams were flowing high and building broad alluvial flood plains in areas which today have only meager, deeply-entrenched arroyos. One effect must have been a considerable expansion of those zones of the valley where high-water-table farming could be practiced. The number of villages in the valley increased to

twenty, then to forty by the end of the Late Formative; several sites reached two hundred acres in size.

BUT ARCHAEOLOGICAL DATA indicate that a simple population increase, explainable through favorable climatic conditions, is too simplified a picture. At least three settlement processes were at work. One was an increase in sites along the major rivers, which continued until a rather even spacing of villages had been reached. Once this spacing was attained—for example, when there was a village every three kilometers along the Atoyac in the Etla arm of the valley—no further settlement took place in that niche. From that point on, most "new" settlements were founded in the upper piedmont zone, on permanent tributary streams which could be used for canal irrigation. The impressive stone architecture of these sites suggests that this second settlement process was not solely the work of pioneer farmers, looking for unoccupied land, but a systematic development of the piedmont streams, in which the elite were also involved.

The third settlement process seen in the Late Formative was the construction of administrative or "ceremonial-civic" centers on hilltops or promontories. Some were situated so as to overlook (and presumably control) long stretches of the major river floodplains; some are on steep hills in the piedmont where perennial streams emerge from the mountains. Still others overlook both the piedmont and the valley center, including the lower courses of streams shared by two or more villages. Today and in Colonial times, as far back as written records go, this land has been the subject of hotly-contested disputes, litigations, and even shooting wars between villages. It is not unlikely that such competition for land and water was a factor in



The mountaintop elite center of Monte Albán overlooks the present city of Oaxaca from 500 meters above the valley floor. Originally founded at the end of the Middle Formative period, it reached its maximum size between A.D. 600 and 900 (Photograph by Compañía Mexicana Aerofoto.)

the Late Formative, although it has not been archaeologically demonstrated.

Recently, William T. Sanders and Barbara Price have suggested that three variables—population pressure, competition and cooperation—were prime movers in the formation of centralized government and urban civilization in the valley of Mexico. Probably these variables operated in Oaxaca as well, but they were complicated by many of the factors we have suggested above: the spread and diversification of irrigation systems, fluctuations in effective moisture, manipulation of trade networks, exchange and conversion of crop surpluses and the rise of a hereditary elite with preferential access to strategic resources.

In Oaxaca, the rise of civilization is physically expressed most clearly by the site of Monte Albán, which in Late Formative times was one of the hilltop ceremonial-civic centers. Monte Albán, architecturally fitted to a mountain top five hundred meters above the valley floor, near the point of intersection of all three arms of the valley, grew faster than any of the other centers. By A.D. 700 it comprised many square kilometers of temple platforms, open plazas, palaces with rich associated tombs and terraced slopes. In the anthropomorphic pottery sculptures and bas-relief stone carvings of the site there are represented nearly forty aboriginal deities known to have been worshipped by the Zapotec at the time of Spanish Con-

quest, numerous glyphs for Zapotec calendrical day-signs, and even what appear to be glyphs representing conquered neighboring peoples. Seemingly, Zapotec civilization developed *in situ* in the Valley of Oaxaca, out of the simpler Formative cultures we have been investigating. How climate and man interacted to accomplish this is an interesting question. Full answers still elude us, but we are not about to give up the chase.

Kent V. Flannery and James Schoenwetter were undergraduate classmates at the University of Chicago in the 1950's. Their careers diverged when Flannery elected to do graduate work in zoology and animal ecology, while Schoenwetter went into botany and plant ecology, then studied pollen analysis at the University of Arizona. They converged again in the 1960's when both transferred into Anthropology and wrote doctoral dissertations concerned with human ecology. Flannery received his Ph.D. from the University of Chicago in 1964, served as Associate Curator at the Smithsonian Institution from 1964-1966, and joined the University of Michigan in 1966, where he is presently an Associate Professor in the Department of Anthropology and Curator of Archaeology in the Museum of Anthropology. Schoenwetter received his Ph.D. from Southern Illinois University in 1967; from 1963 to 1967 he served as Curator of the Palynology Laboratory at the Museum of New Mexico, and is presently Assistant Professor of Anthropology and Director of the Anthropological Palynology Laboratory at Arizona State University.