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# Functional analysis of water control features at Monte Alban, Oaxaca, Mexico

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Archaeological field work concerned with water management or water control in highland central Mexico has emphasized locating early examples of agricultural water control systems to demonstrate their use in the Formative period (1500 B.C.–A.D. 200), prior to the development of the first states and urban centres (Sanders 1976; Fowler 1969; Palerm 1961; Armillas, Palerm, and Wolf 1956). These research efforts were stimulated by the model of hydraulic society proposed by Wittfogel (1938, 1957) which postulates a strong relationship between large-scale agricultural water control and centralized bureaucratic political systems characteristic of a state level organization (Wolf 1976). However, while research (summarized below) has considerably broadened our understanding of early Mesoamerican agricultural water control systems, relatively little attention has been paid to non-agricultural water control systems, also discussed by Wittfogel (1957: 30), such as civic water supply for domestic use and drainage of complex structural areas in civic-residential zones. Planning and organization required by such systems may, in some cases, rival that required by coeval agricultural water control systems. This will be demonstrated through analysis of a civic drainage-water supply system found at the site of Monte Alban in the Valley of Oaxaca, Mexico. A contemporary agricultural water control system will be compared. Analysis of these water control systems is carried out by means of a functional classification of the water control features which comprise the system.

Other examples of Formative period agricultural water control devices have now been located in most of the key areas (as defined by Palerm and Wolf 1957: 29–30) of the Central and Southern Highlands. In the Central Highland, a Late Formative agricultural system has been located at Amalucan, Puebla (Fowler 1969) and Palerm (1961) has described canals visible where the lava has been cut away near the Late Formative site of Cuicuilco in the southern Basin of Mexico. Elsewhere in the Basin of Mexico, Late or Terminal Formative agricultural water control is inferred at Teotihuacan on the basis of pollen samples (Sanders 1976: 117–19) and an agricultural canal system has recently been located near Santa Clara Xalostoc which may date to the Middle Formative (Sanders and Santley 1977).

Work in the Southern Highland has defined a diversionary structure for channelling runoff to fields at Chalcatzingo, Morelos (Grove *et al.* 1976). The large Purron dam,

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which was probably begun in the Middle Formative around 700 B.C. in the Arroyo Lencho Diego of the Tehuacan Valley of south-east Puebla, impounded seasonal runoff for use in a canal system (Woodbury and Neely 1972). Two agricultural canal systems have been found in Oaxaca, one having a spring as a water source, at Hierve el Agua (Neely 1967), and one which made use of runoff impounded by a dam, on the Xoxocotlan piedmont below Monte Alban in the Valley of Oaxaca (Neely 1972; Mason *et al.* 1977), which will be further discussed below.

Research described above documents the presence of agricultural water control systems in the Formative period in highland central Mexico. Studies of later agricultural water control systems have also been made in the Basin of Mexico (Wolf and Palerm 1955; Millon 1957; Armillas 1971; Palerm 1973) and in the Tehuacan Valley (Woodbury and Neely 1972). In contrast, studies of domestic water supply systems have been few in number. Millon (1973) mentions the canalization of the Rio San Juan through Teotihuacan and the presence of reservoirs within the ancient city, but the operation of the system is not fully described. One other residential-civic water supply and drainage system known in highland central Mexico is at Monte Alban, to be described below. The two systems are of different types, since the Teotihuacan system was dependent on an outside source (the Rio San Juan), while at Monte Alban (located on a hilltop) a system was designed to recycle runoff.

Monte Alban covers 6·5 km.$^2$ on the summits and flanks of three adjacent hills in the centre of the Valley of Oaxaca (fig. 1). Blanton, who carried out a mapping and surface collection project at the site, sees Monte Alban as the administrative centre of a 'regional military alliance' which united the three arms of the valley into a single polity during the Late Formative period (500–200 B.C.) (Blanton 1978: 37). Presence of 2,006 residential terraces indicates Monte Alban was also a residential centre for 15,000 to 30,000 people at its height during the Classic period (Blanton 1978: 30).

Classification of Monte Alban as an urban centre has yet to be conclusively established, since little evidence for economic specialization has been found (Blanton 1978: 96). This may be due in part to the fact that lithic artefacts, which usually impart information on functionally specialized activities, were not systematically collected. While occupational specialization is usually considered to be one of the defining characteristics of urbanism (Sanders 1968; Schaedel 1968), Schaedel (1968) also includes water supply and drainage in his list of problems to be solved by an urban organization. In the absence of evidence for economic specialization, presence of a water supply system at Monte Alban, not described previously (Blanton 1978), provides further evidence of urbanism beyond that of a large nucleated population and the administrative functions alluded to by Blanton.

Monte Alban, as already noted, occupies the upper slopes of three hills in the centre of the Valley of Oaxaca. The nearest water source is the Atoyac River on the valley floor and even this does not flow during the dry season. In 1959 Eric R. Wolf observed that

> no source of water has been found to allow us to imagine how the inhabitants of the mountain assuaged their thirst. Perhaps they were the masters of a social system so tightly organized that they could rely on systematic deliveries of food and water from the three surrounding valleys (Wolf 1959: 97).

While there is little evidence bearing on Monte Alban's relations with its hinterland, it

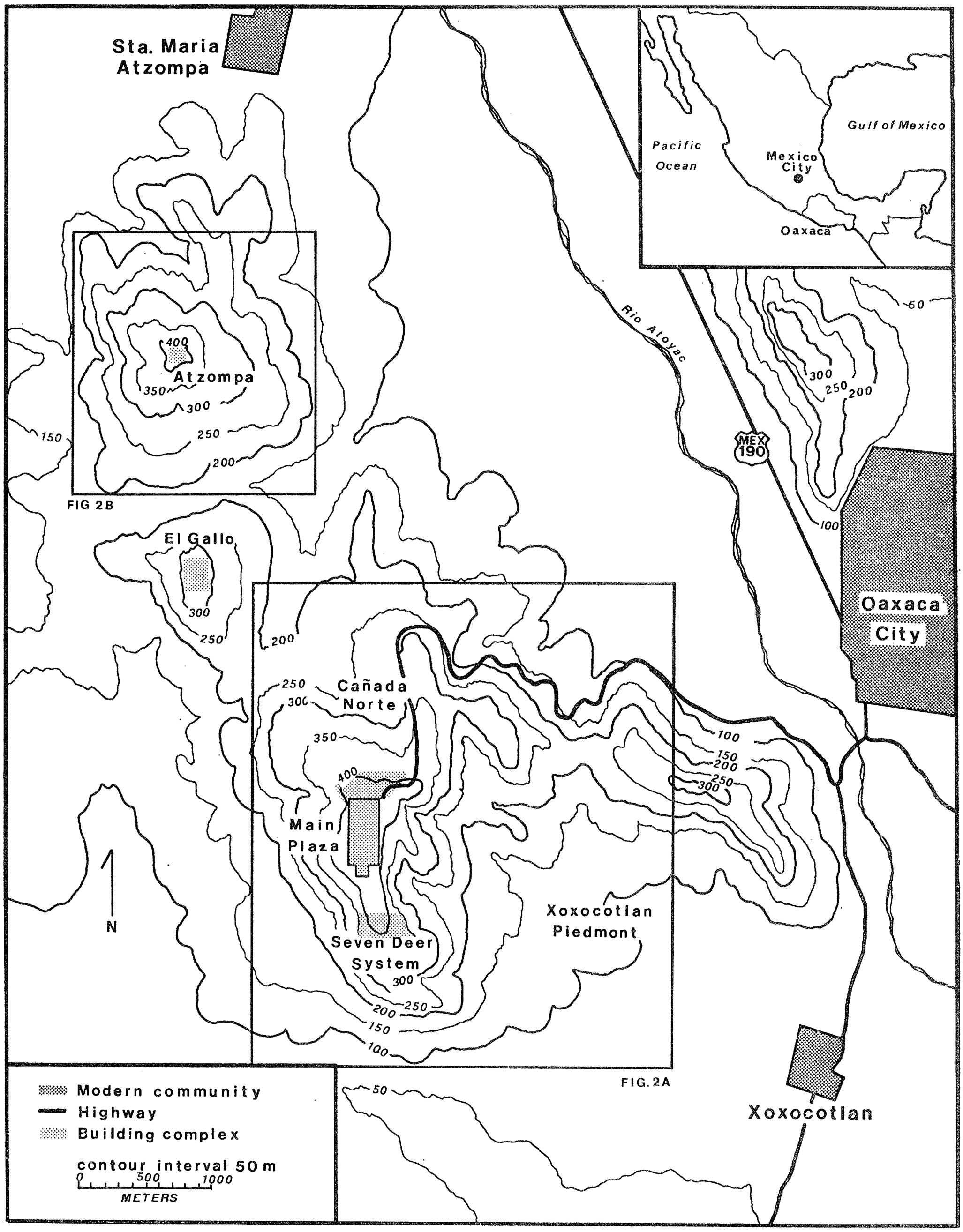


*Figure 1* Location of Monte Alban in the Valley of Oaxaca

now appears that at least Monte Alban was 'tightly' enough organized to construct a complex internal water supply system.

The following discussion makes an initial distinction between civic-residential and agricultural water control systems based on function of features and final use of water. In general, functional terms, civic systems drain and channel excess water from residential and civic-ceremonial areas and often store this water for consumption by the resident population. Conversely, primary functions of agricultural systems are storage and transport of water to agricultural fields. Following Vivian's (1972: 102–3) functional classification of water control systems in the American Southwest, a further distinction is made between conservation structures and diversion structures, the former employing water in place and the latter transporting water to another location for final use. Within each functional system, individual structures are defined based on construction technique and specific function. The end product is a hybrid taxonomy (Dunnell 1971: 142), with the first level differentiating between civic and agricultural systems, the second between conservation and diversion functions, and the third between specific functional structures.

## Civic water control features

One way to organize civic water control features at Monte Alban is by taking into account the sequential operation of diversion and conservation functions as water moves from higher to lower elevations. Diversion structures, such as drains, diversion walls, or channellized barrancas, serve to transport water along the entire length of the systems. Since drains comprise the uppermost components of civic water systems, they will be discussed first.

Civic drainage features can be subdivided into primary units which drain residential patios, and secondary units, which connect several building complexes. A number of small, primary collection drains are evident both in residential complexes at Monte Alban proper (fig. 1; fig. 2a) and at outlying Atzompa (fig. 1; fig. 2b). These occur in open patios and enclosed rooms and consist of 8 cm. to 10 cm. square openings, connected diagonally or vertically to secondary drains serving several residential structures.

Larger collecting channels, termed here secondary drainage features, carry water from two or more residential complexes and have also been defined at Monte Alban. This system of secondary drainage features is located on the north-east corner of the Main Plaza (fig. 1; fig. 2a), channelling water from various parts of the North Platform towards the Cañada Norte. Drains are constructed of well fitted, cut limestone blocks ranging in size from 25 cm. to 40 cm. on a side. Large, flat limestone slabs constitute floors and roofs of channels. Drainage channels are 40 cm. to 50 cm. square, and run horizontally, usually 1 m. below the present ground surface. At terrace edges, drain channels change from a relatively horizontal plane to a 45° orientation to accommodate drop in elevation. When a lower terrace is reached, channels resume a nearly level, horizontal plane.

Three of these civic drainage systems have been delineated, the largest of which occurs on Terrace 25 (Blanton 1978: 152), where 170 linear metres of drainage channel was mapped (fig. 2a: 4). The main channel of this system originates in Monticulo X, a large civic-ceremonial complex, and flows under a large, cut-stone terrace wall. It continues downhill, where feeder channels enter at right angles from other terraces and residential areas. Vertical shafts spaced every 30 m. along the main and feeder channels facilitated cleaning silt and debris from the system.

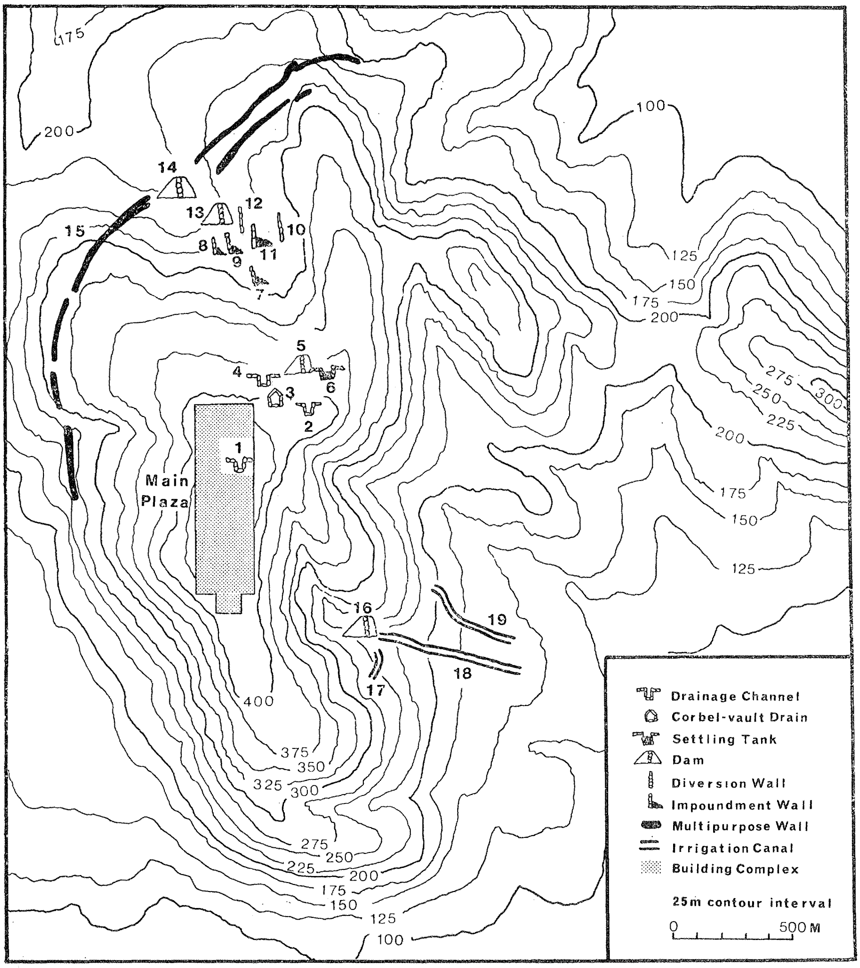


*Figure 2a* Inset of Monte Alban Proper showing location of water control features

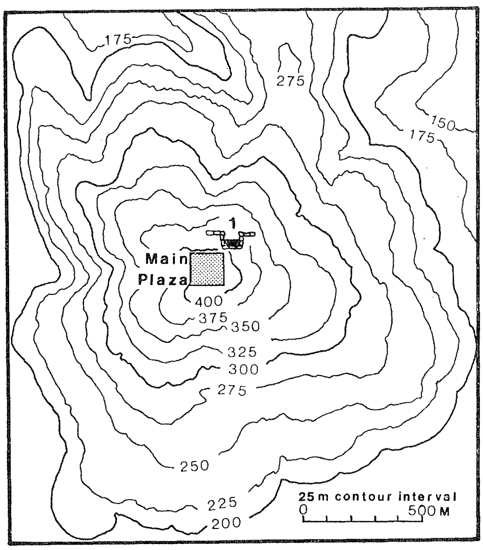


*Figure 2b* Inset of Atzompa showing location of water control features

Another drainage system is found in the north-east corner of the North Platform, Terrace 21 (Blanton 1978: 151) presumably to collect water from primary drains in rooms and patios on the Platform (fig. 2a: 3). The upper end of the drain has been eroded leaving only diagonal and horizontal downslope sections. The sloped portion is 1 m. wide, 1·5 m. high, and is corbel-vaulted. Steps cut into bedrock run the length of the 45° sloped section, with horizontal side drains entering the channel at various points along the diagonal section. The sloped section of drain levels off into a 1 m. by 1 m. passage emptying into the upper end of the Cañada Norte.

A final drainage system is located on the east side of the Main Plaza (fig. 2a: 1). The main drainage channel runs in a north–south direction underneath the Plaza with primary drains entering from the civic-ceremonial buildings along the east side of the Plaza. This drainage/sewage system proceeds under the North Platform but cannot be traced further due to roof fall and rubble.

Other important elements of civic drainage work are limestone block walls along open, downsloping drainage channels. One such feature is located behind an erosion control dam in the Cañada Norte, and consists of a 50 m. long cut limestone block wall constructed in the west bank of the barranca drainage channel (fig. 2a: 12). Limestone blocks up to 60 cm. square were laid two courses high to retard lateral barranca erosion and concentrate flow through the main barranca channel.

Another important example is Blanton's (1978: 52) large, multifunctional defensive wall (fig. 2a: 15). In addition to boundary definition, defensive, and impoundment roles, long portions of the wall could have served to channel slope runoff into barrancas impounded where the wall crosses them. One instance of this occurs where the wall crosses the Cañada Norte, creating a large reservoir (fig. 2a: 14).

Location of conservation features, the second important civic functional class, is conditioned by functional necessity and cost efficiency. Perhaps one of the most interesting and unique classes of civic conservation structure is that of collection/settling tanks. Examples of these were found near the Main Plaza at Monte Alban proper (fig. 2a: 6) and at the outlying building complex of Atzompa (fig. 2b: 1). Both are situated by functional necessity: the need to remove silt and provide a water supply near major building complexes.

The Monte Alban construction is located on the east slope of the Cañada Norte, immediately downslope from the North Plaza (fig. 2a), on Terrace 40 (Blanton 1978: 153). The 15 m. wide, 18 m. long rectangular structure probably functioned as a settling pond for water channelled through drainage systems from the Plaza. Three interior compartments are formed by diagonally oriented walls (fig. 3a) of varying heights below the outer structure walls, with the two downslope diagonals at a lower elevation than the upslope one. Land beneath the structure is unmodified, so supporting exterior walls conform to changes in bedrock, with the downslope wall 4 m. high and the upslope wall 2 m. high. An adjacent dam functioned in conjunction with the settling structure (discussed below) by forcing water into the system. Siltation in the structure was assured by constructing the upslope wall 1·8 m. lower than the downslope wall, impounding water behind the downslope wall. Once the sediment load was dropped, drainage downslope was facilitated by the relatively small elevation difference between the upper and lower interior walls and depth of settlement compartments.

Importance of this structure must be assessed in the context of the entire northern drainage-impoundment complex. A settling pond provided an efficient, easily maintained device to extend the functional life of the large impoundment structure at the base of the

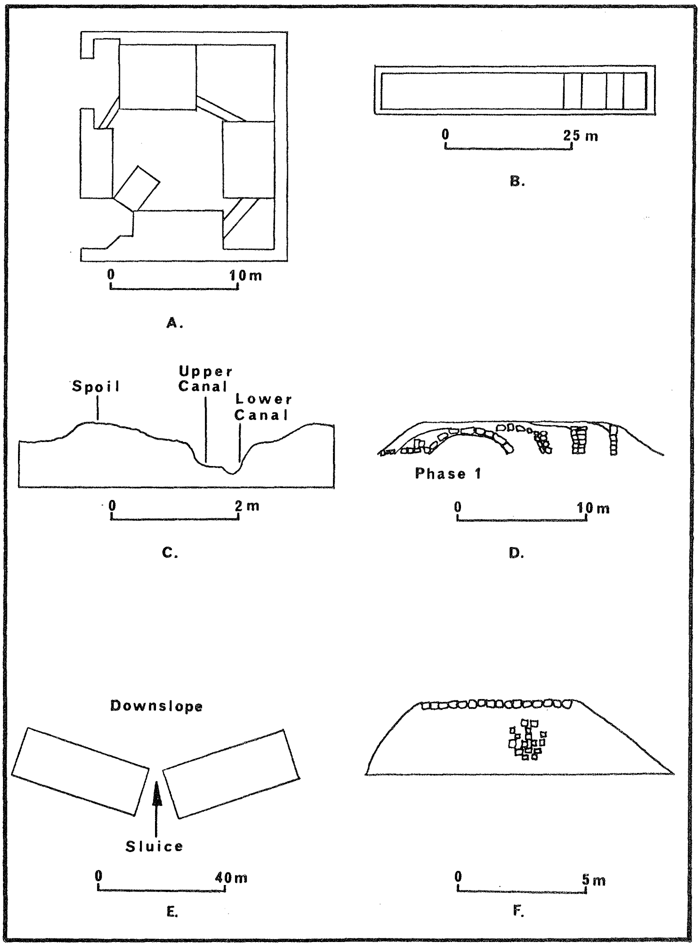


*Figure 3* Schematic diagrams of water control features: (a) Cañada Norte settling tank; (b) Atzompa settling tank; (c) Main Xoxocotlan canal; (d) Cañada Norte dam; (e) Xoxocotlandam; (f) Xoxocotlan dam

Cañada Norte (see discussion below). Studies of prehispanic and modern dam systems indicate longevity of such systems is determined by deposition of water-borne silt within reservoirs.

A second collection/settling structure is located at Atzompa, north-east and downslope from the Main Plaza (fig. 2b). A 55 m. by 15 m. pit, excavated into the downslope edge of an artificial terrace (Terrace 3), is divided into three compartments and lined to a maximum depth of 3 m. with limestone blocks (fig. 3b). Two compartments, formed by two 3 m. wide walls, measure 15 m. long and 5 m. wide, while the third, largest compartment is 15 m. wide and 39 m. long. Walls forming smaller compartments provided access to all parts of the settling pond for silt removal and also served to limit evaporation. Surface area of the entire tank is 825 m.², which would be subject to high evaporation during dry season, low water periods. The smaller two compartments appear to not only create deep pools for easy retrieval of water but serve to contain water in a structure with less surface area, thus reducing moisture loss through evaporation. Conservation impoundment structures are usually located where sufficient water volume justifies intensive labour investment.

A number of civic impoundment dam structures are located on the lower reaches of the Monte Alban mountain. Chief among these is the large, complex, multifunction wall surrounding the entire west side (Blanton 1978: 52–4), which bifurcates as it reaches the north side of the mountain. At one time, both walls crossed the Cañada Norte, the largest arroyo on the mountain, but heavy erosion has cut into and bisected the walls (fig. 2a: 15). The wall at the higher elevation, built upslope from the lower wall, was probably constructed first, forming a large reservoir behind it. Water pressure and erosion breached this structure, requiring construction of a second wall/dam downslope (fig. 2a: 14). Estimated storage volume of the reservoir created by the second structure is 67,500 m.³, based on the height of the remaining wall and the slope of the hill.

A remnant portion of the second dam was sectioned and shown to be constructed by 'cell blocks' similar to those in the Purron Dam in the Tehuacan Valley (Woodbury and Neely 1972: figs. 8, 10). Such a technique utilizes rows of flat limestone slabs laid parallel to the long axis of the dam, stacked as high as the structure to form cells, and filled with dirt, rock, and gravel (fig. 3d). Cross-sections show the dam was constructed in two stages, with initial construction of an undifferentiated grey fill core capped with small cobbles and some large stones, with a height of 1·6 m. and a width of 7 m. Water-lain clays and gravels on the reservoir side of the structure indicate that the dam remained this size through several seasons. A second construction stage consisted of truncating upslope sediments and strengthening the structure with large cut-limestone blocks. Dirt was placed on the slabs on the reservoir side to form a tapered slope, with the toe of the slope stabilized by a low row of limestone blocks. On the downslope face, loads of brown clay were faced with a double row of angular limestone blocks, and capped by a single course of flat stones. More clay was added and strengthened by a 2 m. wide stack of flat, uncut limestone slabs. This latter construction was repeated to form a structure 20 m. wide and 2·8 m. high (fig. 3d).

Another dam forms one element of a complex of drainage, filtration, and impoundment features at the head of the Cañada Norte (fig. 2a: 5). This 3 m. wide, 20 m. long dam abuts the west end of a settling pond and spans the barranca to create a small reservoir with an estimated surface area of 1,500 m.²

One-half kilometer downslope in the Cañada Norte, a small dam functions in conjunction with a limestone outcrop, which causes an abrupt 4 m. drop in the floor of the barranca. Since the outcrop extends only partially across the barranca, causing downcutting and soil erosion adjacent to it, an 8 m.-long retaining wall of cut limestone blocks was constructed across the erosional channel preventing lateral erosion into nearby agricultural terraces (fig. 2a: 13). Previous downcutting had scoured a deep area around the outcrop forming a reservoir after construction of the dam/retaining wall, with the damming effect backing water up the barranca where some was diverted into diked fields (see below).

## Agricultural water control features

Agricultural water control features at Monte Alban comprise a range of diversion and conservation functions, from diversion walls and canals to conservation impoundment.

One of the most ubiquitous agricultural diversion classes consists of dry-laid limestone rock walls located throughout the lower elevations of Monte Alban, apparently diverting runoff water into agricultural terraces. These features either parallel barrancas or are located along hillside contours. An example is situated on the east side of the Cañada Norte, which consists of a single course of limestone boulders and dirt paralleling a small barranca (fig. 2a: 10). This device channelled water away from the barranca into an agricultural terrace.

Impoundment structures, a subset of agricultural conservation features, represent a broad range in size and complexity, and location. On the southern flank of Monte Alban proper, a large dam spans a moderately wide barranca that cuts through a portion of high piedmont above the modern town of Xoxocotlan (fig. 2a: 16). A V-shaped structure with the 'V' pointing upstream, the dam is composed of two 40 m. long spans of unmodified boulder fill consolidated by a limestone mix acting as cement (fig. 3e, f). Tightly fitted cut limestone blocks form the top metre. In spite of erosion through the centre of the dam, one original face is composed of small, neatly fitted limestone blocks. This face, and the eroded opposite wall, would have supported a sluice gate which has since been eroded away.

On the opposite side of Monte Alban, a 1·5 m. high by 45 m. wall of large (40–60 cm.) cut limestone blocks forms a dike along the east side of the Cañada Norte (fig. 2a: 11). This structure parallels the eastern edge of the barranca and is situated well above the entrenched part of the stream channel. A large, flat, triangular field, Terrace 643 (Blanton 1978: 157), is located behind the dike at an elevation approximately 1 m. lower than the top. Since the ends of the structure abut steep slopes, an ideal situation is created to flood the field during periods of high runoff. Substantiating evidence is available in the one metre gap in the dike which held a control gate when the system was in use. Both Terrace 643 and the dike are located immediately upstream from an erosion control dam (fig. 2a: 13) which would have impounded additional water to flood the terrace during periods of lower runoff.

Numerous small erosion control dams are situated throughout barrancas leading from the higher portions of Monte Alban. Perhaps the largest concentration of check dams is located in small side barrancas draining into the Cañada Norte (fig. 2a: 7–9). Such features probably also served as small scale impoundment structures, collecting water for diversion to agricultural terraces via canals. Constructed of unconsolidated rubble and dirt, 3 m. to 4 m. wide, 1 m. high, and ranging in length from 6 m. to 15 m., small check dams are usually placed at outfalls of small barrancas where the land slope is moderate to slight and streamflow low.

An agricultural diversion canal is functionally related to the Xoxocotlan dam, one of three canal systems located on the Xoxocotlan piedmont south-east of Monte Alban (fig. 2a: 17–19). Water from the Xoxocotlan dam was channelled into the main canal system (fig. 2a: 18) flowing to an agricultural community downslope (O'Brien *et al.* 1979; Mason *et al.* 1977). Field reconnaissance traced the system for over 2 km. until severe erosion prohibited further identification. Structure of the channel was defined by four cross-sections spaced along the course. Data indicate the canal was constructed in two levels, with a small channel excavated into the base and along one edge of a larger channel (fig. 3c). Actual functioning channels comprise only a small portion of total evidence for the canal, such as spoil banks paralleling its edge. The larger, upper channel averages 80 cm. in width and 25 cm. in depth, while the smaller, lower channel averages 30 cm. in width and 12 cm. in depth. The larger channel, which apparently included the lower channel when functioning, had a flow volume 6·5 times that of the small canal. Canal fill strongly suggests both canals were in contemporaneous use, providing an efficient means by which two different, relatively predictable flows could be distributed through the same system. Different flow rates could have resulted from water allocation practices of prehispanic agriculturalists, but more likely were conditioned by seasonal availability of water supplies. Use of a small channel within a larger canal represents an efficient means of conserving water during moisture deficient months by reducing surface evaporation and subsurface seepage.

A second canal system in the Xoxocotlan piedmont consists of a series of small canals following contours of the mountain on which the Seven Deer System is located (fig. 2a: 17). Located near the base of a steep hill directly above agricultural terraces, the system served a dual purpose of diverting runoff water into the main Xoxocotlan canal system and preventing damage to crops in upper agricultural terraces by stopping excess runoff.

North of the main Xoxocotlan piedmont canal system, a third, smaller canal system (fig. 2a: 19) collected and distributed runoff to downslope agricultural terraces. The mid-section, measuring 1 km. long, was mapped, but both upper and lower ends of the system have been eroded.

## Conclusions

As Wittfogel (1957: 43) has noted, water control features are frequently overlooked in favour of aesthetically more appealing temples, palaces, and tombs. At Monte Alban, studies of temples, palaces, and tombs occupied Caso and his associates for decades (Caso 1933; Caso and Bernal 1952; Caso, Bernal and Acosta 1967) and the trend has been continued by Flannery and Marcus (1976). Blanton (1978: 62–3) has discussed the organizational implications of the structures on the North Platform and other structures around the Main Plaza but does not discuss the implications of the presence of an integrated system of drainage and water supply.

The series of civic water control features connecting the North Platform area with the North Barranca reservoir constitutes such an integrated system. The functions of drainage, collection, filtration, transport, and impoundment of water for domestic use are performed by specialized water control features. Independent construction of these specialized features is not likely since they are of little use when not operating as part of the complete system. This indicates a certain amount of central planning on the part of the Monte Alban elite.

The planning of this system may have taken place as early as Late Monte Alban I (400–150 B.C.) since the North Platform was well underway by this time and a test excavation made by Kuttruff and Autry (1978) into the base of the diversionary-defensive wall which forms the reservoir in the North Barranca indicates a Late Monte Alban I construction date. Beginning of the system may be traced to the Early Monte Alban I phase (500–400 B.C.) since Caso, Bernal, and Acosta (1967: 96) report an Early Monte Alban I platform with a drain carved into bedrock in their North Platform excavations.

While the degree of centralization needed to construct and maintain the system is unknown, the presence of a functionally complex water supply system, combined with the monumental architecture of the Main Plaza, indicate a centralized authority able to plan, mobilize, and coordinate labour on a large scale. Thus, the civic water supply system adds another dimension which must be considered in discussions about the classification of Monte Alban as urban or the centre of a military confederacy.

Agricultural water control features are also present at Monte Alban. The most complex agricultural water control system is the dam and canal system which irrigated approximately 50 h. of the Xoxocotlan piedmont east of Monte Alban. This system was in use during Early and Late Monte Alban I (550–150 B.C.) and was abandoned at the beginning of Monte Alban II. The agricultural system is smaller and less complex than the civic system and probably could have been managed and maintained by the population which lived along the canal. It has been estimated that the Xoxocotlan piedmont agricultural system could have fed, at most, 250 people (O'Brien, *et al.* 1979; Mason, *et al.* 1977). The civic water control system, however, probably supplied water to a substantial percentage of the population of Monte Alban, estimated by Blanton (1978: 30) to have been over 15,000 during the Classic period. The agricultural system was abandoned relatively early in the history of Monte Alban while the civic system was being developed. The civic system was probably in use during much of the Classic period. The relative importance of the two systems to the population of Monte Alban is thus heavily weighted in favour of the civic water control system.

The complexity of the civic water control system at Monte Alban has implications for the study of other large complex sites in highland central Mexico. It is probable that some sort of civic water control system existed at such sites as Cholula, Tula, and Xochicalco. Xochicalco, especially, deserves attention because of its similar location on a hilltop where impoundment of runoff would obviate constant trips to the canyon of the Rio Tembembe. Reservoirs are known to exist at Teotihuacan and the Rio San Juan is canalized (Millon 1973), but the functioning of the system has not been described. Tenochtitlan was supplied with water by an aqueduct from the Chapultepec springs but distribution of the water was probably effected by canoe (Lombardo de Ruiz 1973: 193–5). The systems at Tenochtitlan and probably Teotihuacan had outside water sources while that at Monte Alban (and the hypothesized system at Xochicalco) depended on the processing of internal runoff requiring drainage, collection, diversion, filtration and impoundment. Studies of civic water control systems employing outside water sources should be made to determine the relative functional complexity of the two types of system.

Whatever one's position may be concerning the utility of the hydraulic model in explanations of the development of more centralized forms of political organization, it has been demonstrated that water control systems, especially civic water control systems, are indicators of the degree of centralization which has been achieved, when taken in conjunction with other indicators, such as monumental architecture, size and density of population, and evidence of occupational specialization. Civic water control systems may well be more complex than agricultural systems in much of highland Central Mexico since, except for the lakes in the Basin of Mexico (which were not employed for agricultural water control until the Late Postclassic period), the region lacks large water sources located in agriculturally productive areas.

Summary of water control systems at Monte Alban suggests that civic water control features occur in greater numbers, operate in functionally more complex systems, and represent more intensive initial and maintenance labour than the agricultural water control features. While agricultural water control systems are useful to discuss carrying capacity and population potential at Monte Alban (although civic conservation reservoirs would also have to be weighed in this argument), civic water control systems appear to represent the most important kinds of water control features, with consequences relating to labour control for planning, construction, and maintenance of the systems. This has important implications for Monte Alban as well as evaluating the role of water control features in other contexts in Mesoamerica.

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## References

Armillas, Pedro. 1971. Gardens on swamps. *Science*. 174:653–61.

Armillas, Pedro, Palerm, Angel, and Wolf, Eric R. 1956. A small irrigation system in the Valley of Teotihuacan. *American Antiquity*. 21:396–9.

Blanton, Richard E. 1978. *Monte Alban: Settlement Patterns at the Ancient Zapotec Capital.* New York: Academic Press.

Caso, Alfonso. 1933. Las tumbas de Monte Alban. *Anales del Museo Nacional.* 8:578–82. Mexico, D.F.

Caso, Alfonso and Bernal, Ignacio. 1952. Urnas de Oaxaca. *Memorias* 2. Mexico, D.F.: Instituto Nacional de Antropologia e Historia.

Caso, Alfonso, Bernal, Ignacio and Acosta, Jorge R. 1967. La ceramica de Monte Alban. *Memorias* 13. Mexico, D.F.: Instituto Nacional de Antropologia e Historia.

Dunnell, Robert C. 1971. *Systematics in Prehistory.* Glencoe: The Free Press.

Flannery, Kent V. and Marcus, Joyce. 1976. Evolution of the public building in Formative Oaxaca. In *Cultural Change and Continuity* (Charles B. Cleland, ed.), pp. 205–21. New York: Academic Press.

Fowler, Melvin. 1969. A preclassic water distribution system in Amalucan, Mexico. *Archaeology.* 22:208–15.

Grove, David, Hirth, Kenneth G., Buge, David E. and Cyphers, Ann M. 1976. Settlement and cultural development at Chalcatzingo. *Science.* 192:1203–10.

Kuttruff, L. Carl and Autry, William O., Jr. 1978. Test excavations at Terrace 1227. In *Monte Alban: Settlement Patterns at the Ancient Zapotec Capital* (Richard E Blanton, ed.), pp. 403–16. New York: Academic Press.

Lombardo de Ruiz, Sonia. 1973. *Desarollo urbano de Mexico-Tenochtitlan segun las fuentes historicas.* Mexico, D.F.: Instituto Nacional de Antropologia e Historia.

Mason, Roger D., Lewarch, Dennis E., O'Brien, Michael J. and Neely, James A. 1977. An archaeological survey of the Xoxocotlan piedmont, Oaxaca, Mexico. *American Antiquity.* 42:567–75.

Millon, Rene. 1957. Irrigation systems in the Valley of Teotihuacan. *American Antiquity.* 23:160–6.

Millon, Rene. 1973. *The Teotihuacan Map. Urbanization at Teotihuacan, Mexico,* vol. 1. Austin: University of Texas Press.

Neely, James A. 1967. Organizacion hidraulica y sistemas de irrigacion prehistoricos en el Valle de Oaxaca. *Boletin.* 27:15–17. Mexico, D.F.: Instituto Nacional de Antropologia e Historia.

Neely, James A. 1972. *Prehistoric domestic water supplies and irrigation systems at Monte Alban, Oaxaca, Mexico.* Paper presented at the 37th annual meeting of the Society for American Archaeology, Miami.

O'Brien, Michael J., Mason, Roger D., Lewarch, Dennis E. and Neely, James A. 1979. *A Late Formative Irrigation Settlement below Monte Alban: Survey and Excavation on the Xoxocotlan Piedmont, Oaxaca, Mexico.* Institute of Latin American Studies, The University of Texas, Austin, Monograph Series. In press.

Palerm, Angel. 1961. Sistemas de regadio en Teotihuacan y en el Pedregal. *Revista Interamericana de Ciencias Sociales.* 1:297–302.

Palerm, Angel and Wolf, Eric R. 1957. Ecological potential and cultural development in Mesoamerica. *Studies in Human Ecology*, pp. 1–37. Social Science Monograph 3. Washington, D.C.: Anthropological Society of Washington and Pan American Union.

Sanders, William T. 1968. A profile of urban evolution in the Teotihuacan Valley. *Proceedings of the 37th International Congress of Americanists.* 1:95–104.

Sanders, William T. 1976. Agricultural history of the Valley of Mexico. In *The Valley of Mexico: Studies in pre-Hispanic Ecology and Society* (Eric R. Wolf, ed.), pp. 101–59. Albuquerque: University of New Mexico Press.

Sanders, William T. and Santley, Robert S. 1977. A prehispanic irrigation system near Santa Clara Xalostoc in the Basin of Mexico. *American Antiquity*. 42:582–8.

Schaedel, Richard P. 1968. On the definition of civilization, urban, city, and town in prehistoric America. *Proceedings of the 37th International Congress of Americanists*. 1:5–14.

Vivian, R. Gwinn. 1974. Conservation and diversion: water-control systems in the Anasazi Southwest. In *Irrigation's Impact on Society* (Theodore E. Downing and McGuire Gibson, eds), pp. 95–112. Anthropological Papers of the University of Arizona 25. Tucson: The University of Arizona Press.

Wittfogel, Karl A. 1938. *New Light on Chinese Society*. New York: Institute of Pacific Relations.

Wittfogel, Karl A. 1957. *Oriental Despotism*. New Haven: Yale University Press.

Wolf, Eric R. 1959. *Sons of the Shaking Earth*. Chicago: University of Chicago Press.

Wolf, Eric R. 1976. Introduction. In *The Valley of Mexico; Studies in pre-Hispanic Ecology and Society* (Eric R. Wolf, ed.), pp. 1–10. Albuquerque: University of New Mexico Press.

Wolf, Eric R. and Palerm, Angel. 1955. Irrigation in the old Acolhua domain, Mexico. *Southwestern Journal of Anthropology*. 11:265–81.

Woodbury, Richard B. and Neely, James A. 1972. Water control systems of the Tehuacan Valley. In *Chronology and Irrigation* (Frederick Johnson, ed.), pp. 81–153. *Prehistory of the Tehuacan Valley* 4. Austin: University of Texas Press.

## Abstract

*O'Brien, M. J., Lewarch, D. E., Mason, R. D. and Neely, J. A.*

### Functional analysis of water control features at Monte Alban, Oaxaca, Mexico

Agricultural water distribution systems in the Highlands of Mexico have received considerable attention. Functional analysis of water control features at Monte Alban, Oaxaca demonstrates the potential of a classification system which treats both agricultural and residential-civic public works, such as drains, filters, catchment structures, and reservoirs.