Excavation and Preliminary Analysis of an Obsidian Workshop in Tula, Hidalgo, Mexico

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Previous survey of the Toltec site of Tula, Hidalgo, Mexico, revealed what is believed to have been a zone of obsidian workshops within the Early Postclassic city. Tulane University conducted excavation of part of one topographic complex within the zone, revealing a workshop complex consisting of a linear arrangement of residential compounds, peripheral refuse dumps, and open work areas, the latter tentatively identified by microscopic analysis of soil samples. Over 500,000 pieces of obsidian were recovered, revealing an exclusively core/blade industry that imported percussion macrocores from at least two different sources and produced prismatic blade cores, blades, and certain blade products. The reduction sequence and differences in the processing of obsidian from different sources are well documented. Ceramic and stratigraphic data suggest the locality was originally marginal land settled relatively early in Tula's history, possibly by immigrants from the Basin of Mexico.

Introduction

The study of prehistoric obsidian exploitation is a relatively new and multifaceted area of research covering a variety of topics that include reconstruction of regional exchange networks, reduction technology, and archaeological investigation of lithic reduction sites including both quarry and non-quarry workshops. Obsidian workshops have been identifed in many prehistoric communities largely on the basis of anomalous surface concentrations of obsidian debitage and other artifacts. Their identification has played a major role in assessing the importance of obsidian exploitation in prehistoric economic systems as well as in reconstructing such systems. Unfortunately, much of the archaeological investigation of obsidian workshops has been restricted to surface survey or limited test-pitting, despite obvious benefits of large-scale excavation for technological, functional, and chronological study, as well as for providing information about domestic, social, and other non-technological realms of workshop activity.

In Mesoamerica, it is apparent from many lines of research that control of the exploitation of various resources, including obsidian, played a key role in shaping the course of prehispanic cultural development. In Central Mexico there appears to have been a succession of powerful centers that controlled systems for the exploitation of resources that included Middle Formative Chalcatzingo,[1] possibly Late Formative Cuicuilco, and Classic period Teotihuacan. Teotihuacan is of particular interest because recent research has demonstrated that its economy was inextricably tied to obsidian exploitation.[2] The Early Postclassic period has been a notable gap in current knowledge about this pattern of succession, which has up to now been filled by speculation that Tula, the dominant center in Central Mexico during the Early Postclas-

David Grove, Kenneth Hirth, David Buge, and Ann Cyphers, "Settlement and Cultural Development at Chalcatzingo," *Science* 192 (1976) 1203–12 Kenneth Hirth, "Interregional Trade and the Formation of Prehistoric Gateway Communities," *AmAnt* 43 (1978) 35–45.

Michael Spence, "The Obsidian Industry of Teotihuacan," *AmAnt* 32 (1967) 507–5 idem, "Obsidian Production and the State at Teotihuacan," *AmAnt* 46 (1981) 769–788; Rene Millon, *Urbanization at Teotihuacan, Mexico: The Teotihuacan Map I* (University of Texas Press: Austin 1973) 45– Thomas Charlton, "Teotihuacan, Tepeapulco, and Obsidian Exploitation," *Science* 200 (1978) 1227–1236.

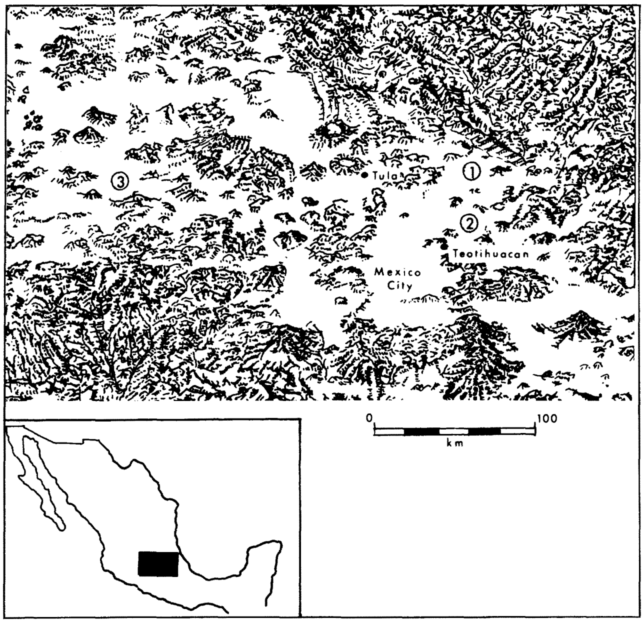

Figure 1. Landform map of Central Mexico, showing the location of Tula with respect to the Classic period site of Teotihuacan and three obsidian sources expoited by Tula: 1, Pachuca (Cruz del Milagro), Hidalgo; 2, Otumba, Mexico; 3, Zinapecuaro, Michoacan.

Table 1. Provisional chronology of the Tula region.

	PERIOD	*PHASE*
A.C. 1600	Colonial	Tesoro
1500	Late Postclassic (Second Intermediate phase 3 and Late Horizon)	Palacio
1400		
1300		Fuego
1200	Early Postclassic (Second Intermediate phase 2)	
1100		Tollan
1000		
		Terminal Corral
900	Epiclassic (Second Intermediate phase 1)	Corral
800		Prado
700		

sic, inherited the obsidian exploitation system previously controlled by Teotihuacan.[3]

This paper is a preliminary report of the excavation and analysis of an obsidian core/blade workshop located in what was probably a larger workshop zone at Tula. The excavation involved extensive exposure of a single workshop complex, and the artifact analysis is unusual in the sheer quantity of workshop debitage plus other artifacts recovered in situ. The report is preliminary in nature, since much of the analysis and interpretation is still in progress.

Background

Tula is located in SW Hidalgo about 70 km. NW of Mexico City (FIG. 1).[4] The site incorporates the alluvial bottoms and adjacent uplands of the Tula and Rosas Rivers and the modern town of Tula de Allende (FIG. 2).[5] Ethnohistorical research by W. Jiminez-Moreno[6] and extensive archaeological exploration by J. Acosta[7] have

3. Michael Spence and Jeffrey Parsons, "Prehispanic Obsidian Exploitation in Central Mexico: A Preliminary Synthesis," *MichMusAnth* 43 (1972) 29; Charlton, op. cit. (in note 2) 1235; Lee Parsons and Barbara Price, "Mesoamerican Trade and its Role in the Emergence of Civilization," *Contributions of the University of California Archaeological Research Facility (CARFC)* 11 (1971) 188; Robert Zeitlin, "Towards a More Comprehensive Model of Interregional Commodity Distribution: Political Variables and Prehistoric Obsidian Procurement in Mesoamerica," *AmAnt* 47 (1982) 270.

4. Adapted from *Landforms of Mexico, Prepared for the Geography Branch of the Office of Naval Research,* by Erwin Raisz (Cambridge 1959).

5. Sources: James Stoutamire, "Trend Surface Analysis of Archaeological Survey Data from Tula, Hidalgo, Mexico," unpublished Ph.D. dissertation, University of Missouri-Columbia (1975) figs. 5–10; Juan Yadeun Angulo, "El Estado y la Ciudad: El Caso de Tula, Hgo.," *Coleccion Cientifica* 25 (INAH 1975) figs. 17, 25–32; Alejandro Pastrana Cruz, "Produccion de Instrumentos en Obsidiana—Division del Trabajo," unpublished thesis, Escuela Nacional de Antropologia e Historia (=E.N.A.H.) (Mexico D.F. 1977); Enrique Nalda and Alejandro Pastrana, "Una Proposicion para la Investigacion de los "Talleres de Litica" en Tula, Hgo.," in "Proyecto Tula, Segunda Parte," Eduardo Matos Moctezuma, ed., *Coleccion Cientifica* 33 (INAH 1976) 75–83.

6. Wigberto Jiminez-Moreno, "Tula y los Toltecas Segun las Fuentes Historicos," *Revista Mexicana de Estudios Antropologicos* 5 (1941) 79–83.

7. Jorge Acosta, "Interpretacion de Algunos Datos Obtenidos en Tula

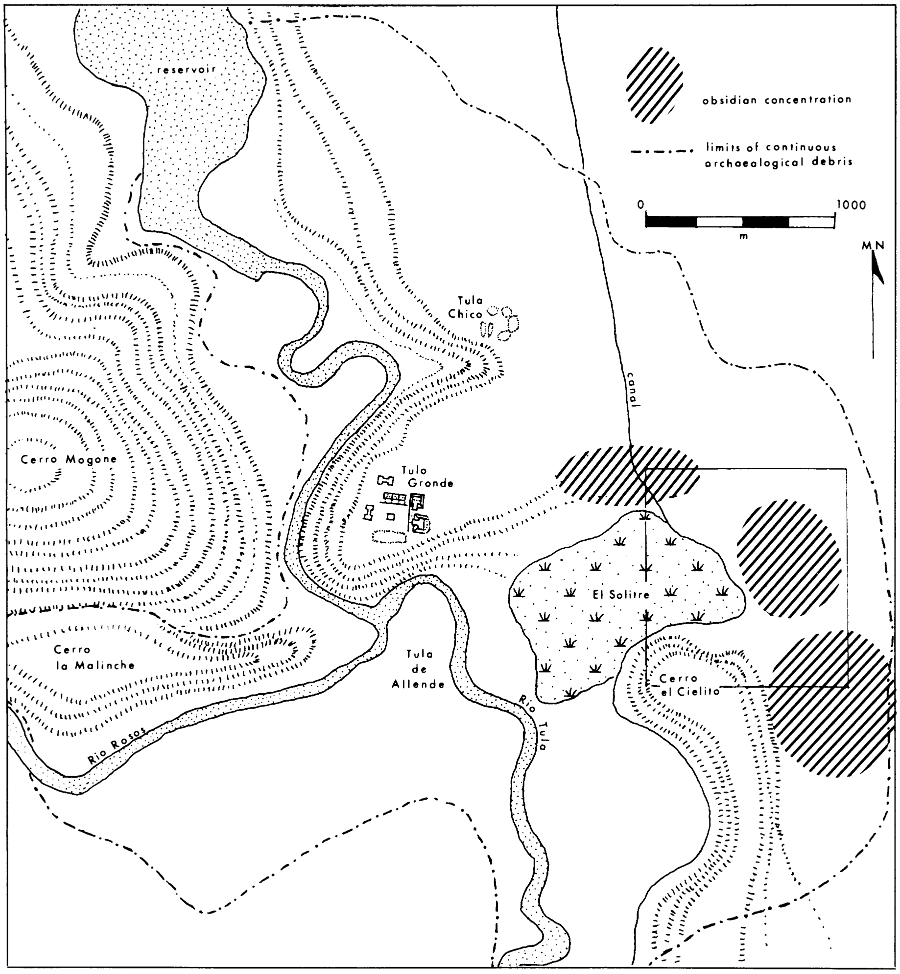

Figure 2. The archaeological zone of Tula, Hidalgo, as determined by the University of Missouri and INAH surface surveys. A more detailed map of the area east of El Salitre (box) is presented in Figure 3.

provided persuasive evidence that the site constitutes the ruins of *Tollan,* legendary capital of the Toltec empire between the 10th and 12th centuries A.C.[8] Recently, Tula was the subject of two extensive archaeological research projects, conducted by the Instituto Nacional de Antropologia e Historia (INAH) of Mexico[9] and the University of Missouri,[10] which have greatly amplified our knowledge of Tula's history and internal structure. Cobean has recently provided a revised ceramic chronology for the Tula area (TABLE 1)[11] based upon the Missouri project's urban survey, and the residential excavations and selected test pits of the INAH project. Data from both projects indicate that Tula was originally a relatively modest settlement some 3–5 sq. km. in area that was centered around Tula Chico, a smaller version of Tula Grande, the political-religious center of the later city (FIG. 2). During the Tollan phase of the Early Postclassic period (TABLE 1), Tula underwent expansive growth, and

Relativos a la Epoca Tolteca," *Revista Mexicana de Estudios Antropologicos* 14, segunda parte (1956–1957) 75–110. Acosta also published detailed summaries of his field seasons at Tula, which are listed in the bibliography of *Supplement to the Handbook of Middle American Indians, Volume 2,* Victoria Bricker and Jeremy Sabloff, eds. (University of Texas Press: Austin 1981).

8. Pedro Armillas, "Teotihuacan, Tula, y los Toltecas," *Runa* 3 (1950) 37–70; Lawrence Feldman, "Tollan in Hidalgo: Native Accounts of the Central Mexican Tolteca," in "Studies of Ancient Tollan," Richard Diehl, ed., *University of Missouri Monographs in Anthropology* 1 (1974) 130–149; Nigel Davies, *The Toltecs Until the Fall of Tula* (Oklahoma 1977).

9. Eduardo Matos Moctezuma, ed., "Proyecto Tula, Primera Parte," *Coleccion Cientifica* 15 (INAH 1974); Matos Moctezuma, op. cit. (in note 5).

10. Diehl, ed., op. cit. (in note 8); "Tula," in Bricker and Sabloff, op. cit. (in note 7) 277–295.

11. Robert Cobean, "The Pre-Aztec Ceramics of Tula, Hidalgo," unpublished Ph.D. dissertation, Harvard University (Cambridge 1978) fig. 4. We have modified Cobean's period designations by including in parentheses an alternate scheme proposed by the 1972 Valley of Mexico Conference; cf. Eric Wolf, *The Valley of Mexico* (New Mexico 1976) fig. 16.

during its apogee encompassed an area of about 12 sq. km.[12]

The importance of obsidian to Tula is evident in the frequency with which obsidian artifacts, chiefly prismatic blade fragments,[13] are encountered among the debris that litters the site's surface. This is no less evident in in situ deposits, given that over 25,000 obsidian artifacts, again principally fragments of prismatic blades, were recovered by the Missouri project's excavation of a series of residental compounds.[14] Prismatic blade cores from Tula have a distinctive type of platform which has been ground or abraided to a flat surface with a texture like ground glass.[15] Tula lies only about 70 km. west of the Pachuca or Cruz del Milagro obsidian source (FIG. 1), an important source of obsidian for Mesoamerican core/blade industries and which was the major source exploited by Teotihuacan during the Classic period. This distinctive clear green obsidian is also the predominant source represented at Tula.[16]

A significant result of the recent research at Tula was the discovery of several areas of high surface concentration of obsidian artifact debris around a brackish marsh (El Salitre) and an adjacent elongated hill (Cerro El Cielito) in the eastern portion of the site. As shown in Figure 2,[17] there are three major concentrations: one along the north flank of El Salitre, another along its east flank, and a third immediately east of Cerro El Cielito. During the summer of 1978, Healan made an informal reconnaissance of the "east flank" concentration and discovered within it localized concentrations of obsidian, utilitarian sherds, and architectural stone frequently associated with low topographic rises indicative of collapsed structures. Thus the "east flank" concentration, and probably the others as well, seemingly represents a series of distinct workshop sites; in other words, a zone of obsidian workshops within the city wherein a number of artificers both lived and worked.

During the summer of 1980, Tulane University conducted excavations at a single locality within the "east flank" concentration (FIG. 3). The excavations were directed by Healan and sought to provide extensive exposure of one workshop complex. The excavation and subsequent analysis was intended to satisfy four goals: 1) verification of the existence of an obsidian workshop and delineation of its structure; 2) recovery of a substantial part of the workshop lithic assemblage for determination of input, output, and reduction technology; 3) recovery of data pertaining to domestic and other nontechnological realms of workshop activity; 4) diachronic study of the development of obsidian workshop production at Tula through stratigraphic excavation.

Field Methods

The locality selected for excavation is located near the center of the "east flank" concentration in a modern agricultural field (FIGS. 2, 3). The locality contains several low ridges or longitudinal mounds littered with stone typical of collapsed structures, but otherwise rather low frequencies of surface artifacts. Conversely, little building stone but very high surface concentrations of obsidian and sherds were found in the low areas between the ridges. Healan decided to expose a continuous area extending from the top of the largest ridge (ridge A) to the adjacent interridge area (FIGS. 3, 4) in order to sample the full range of topographic and surface artifact diversity.

As seen in Figure 4, we used 3-m. squares excavated in 10-cm. levels that were subdivided horizontally and/or vertically when necessary to separate different depositional contexts. We planned to expose only the first components of occupation encountered below the surface in order to maximize horizontal rather than vertical exposure. At the same time, however, a series of 1-m. square pits normally placed in the NE corner of every other square were excavated to sterile deposits in order to recover data pertaining to earlier components.

Considerable effort was made to recover soil samples from the various floors and other surfaces and depositional features encountered in excavation, in the belief

12. Stoutamire, op. cit. (in note 5).

13. Prismatic blades, also called "fine blades," are unusually regular, parallel-sided blades with a commonly trapezoidal cross section removed by pressure from equally distinctive, finely fluted cylindrical cores. For a discussion of ethnohistorical accounts of prismatic blade production as well as modern replicative experiments, Don Crabtree, "Mesoamerican Polyhedral Cores and Prismatic Blades," *AmAnt* 33 (1968) 446–478; Charles Fletcher, "Escapable Error in Employing Ethnohistory in Mesoamerica," *AmAnt* 35 (1970) 209–2 Payson Sheets and Guy Muto, "Prismatic Blades and Total Cutting Edge: An Experiment in Lithic Technology," *Science* 175 (1972) 632–6 John Clark, "Manufacture of Mesoamerican Prismatic Blades: An Alternative Technique," *AmAnt* 47 (1982) 355–376.

14. Alice Benfer, "A Preliminary Analysis of the Obsidian Artifacts from Tula, Hidalgo," in Diehl, ed., op. cit. (in note 8) 56–87.

15. At least some of these "ground" platforms are actually natural cortex surfaces.

16. Stoutamire, op. cit. (in note 5) 41–42.

17. There is disagreement among the various surveys (cf. note 5) on the nature of these surface concentrations. Stoutamire's survey defined a single, large concentration that covers virtually all of the area north, south, and east of El Salitre. The alternative definition of distinct concentrations was suggested by Nalda and Pastrana's interpretation of Yadeun's survey data and by Pastrana's resurvey of the area; the latter surveys, however, disagree on the precise number, location, and extent of these concentrations. Based on informal survey, Healan agrees that distinct concentrations rather than a continuous distribution exists in the area. The concentrations depicted in Figure 2 are approximations intended to reconcile the major differences among the latter surveys.

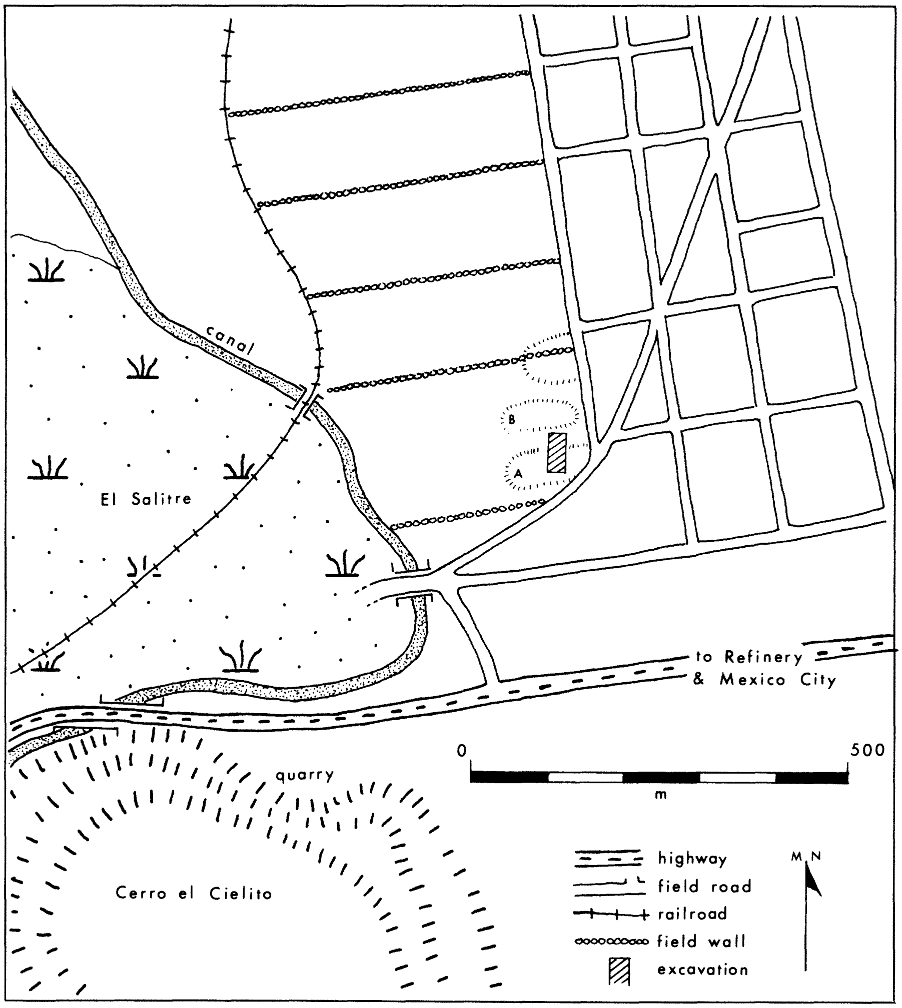

Figure 3. Map of area of high surface concentration along the east flank of El Salitre, showing the location of the workshop complex excavated by Tulane University.

that microscopic material, particularly obsidian microdebitage, would be useful in identifying the actual obsidian work sites and other activity areas. A preliminary microscopic examination of soil samples was undertaken in the field using a Wild M–5 stereomicroscope with magnification of up to 50x. Further study is planned using better techniques of sample preparation and examination.

Unfortunately, much of the area around El Salitre has been under intensive tractor cultivation for over a decade, and there has been considerably greater damage to the archaeological deposits than expected; much of the damage was found to be the result of very recent chisel plowing. In 1979 Healan learned that a government-sponsored program was introducing chisel plows in the Tula area to break up subsurface deposits of *caliche,* and the field season was planned with this eventuality in mind. Chisel plowing in this area, however, occurred far ahead of schedule (ironically, only about *three weeks* prior to the start of our excavation!). Chisel scars covered the entire field in a crisscross pattern, spaced at roughly 1-m. intervals (FIG. 5), and penetrated almost a *full meter* below the surface! Despite the obviously extensive damage to the subsurface deposits, we decided to continue excavation for two reasons: fortunately, the archaeological deposits were sufficiently thick that at least part had escaped the chisel plow, and below the tractor plow zone the chisel scars were easily detected and cleaned out to avoid stratigraphic contamination of the lower levels. Hence we were able to overcome some of the major problems posed by the chisel plowing, but at considerable cost in time and resources, since it required excavating much deeper than planned in some areas (cf. FIG. 8). It appears that none of the "east flank" concentration escaped the chisel plow, and it is not likely that the other concentrations did either. We regret not having been able to excavate at least one season earlier.

Delineation of the Workshop Complex

General Comments

The artifacts and features encountered confirm that the

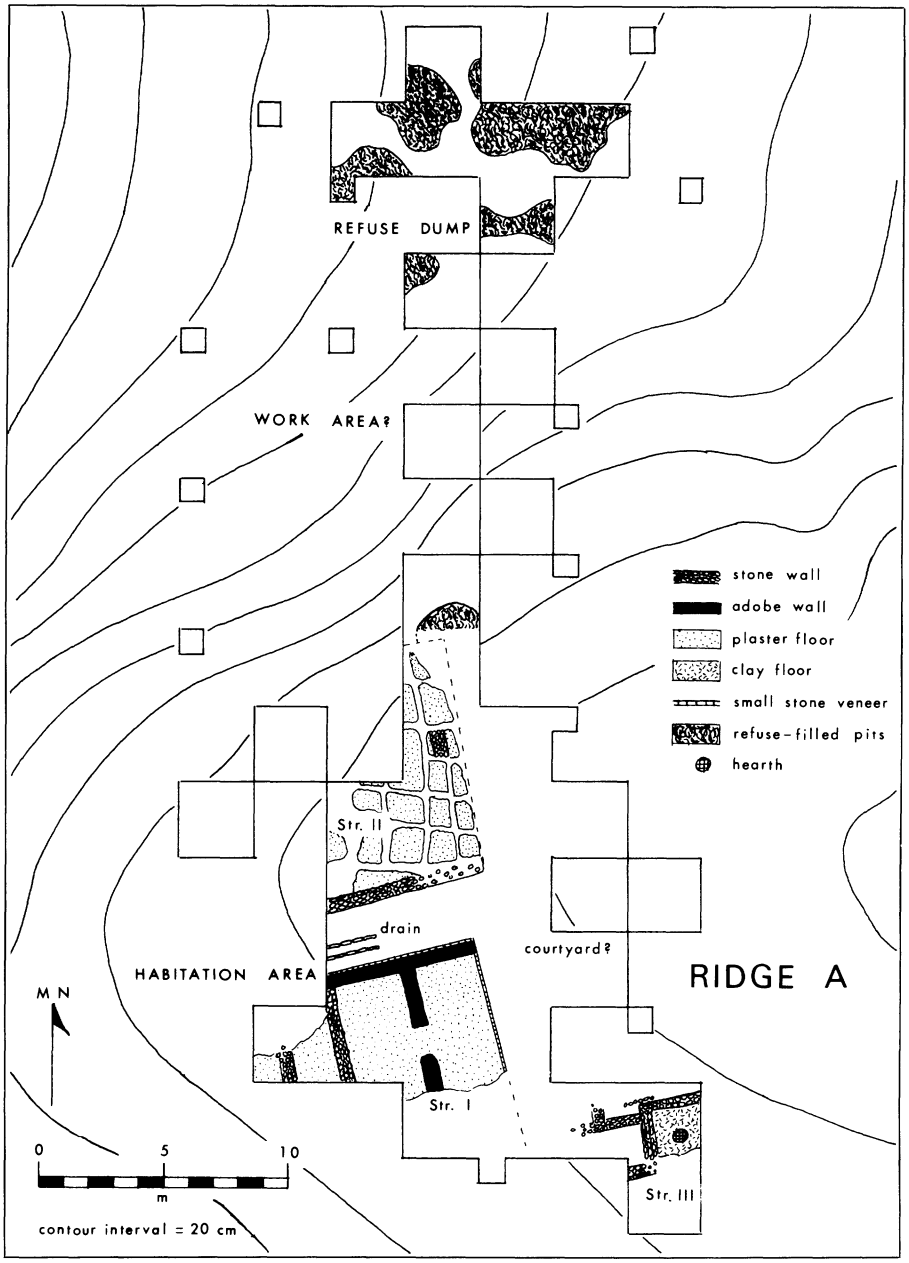

Figure 4. Plan of the obsidian workshop complex excavated by Tulane University.

locality had been an obsidian workshop. The necessity of deeper excavation restricted the degree of lateral exposure that had been planned; nevertheless, there was sufficient exposure to sample a large part of one ridge and interridge system and parts of adjacent areas. The complex was a rather dispersed affair, containing distinct habitation, obsidian-working, and refuse-dumping areas (FIG. 4), each of which is described below.

Underlying the entire excavation was a horizon of tan, sterile clay (FIG. 5), which apparently comprised the surface of the locality at the time of initial occupation. The surface of this clay was scarred by erosional channels and other features of weathering (FIG. 6) that indicate the clay horizon had lain exposed before the locality was occupied. This is also indicated by the fact that artifact-rich refuse soils and structural remains lay directly on and were partially embedded in the clay surface.

Habitation Area

Ridge A was an entirely artificial accumulation of superposed structures and fill (FIG. 5). The ridge was apparently an accretional feature, which is to say it was not a purposeful terrace or platform, but rather the ac-

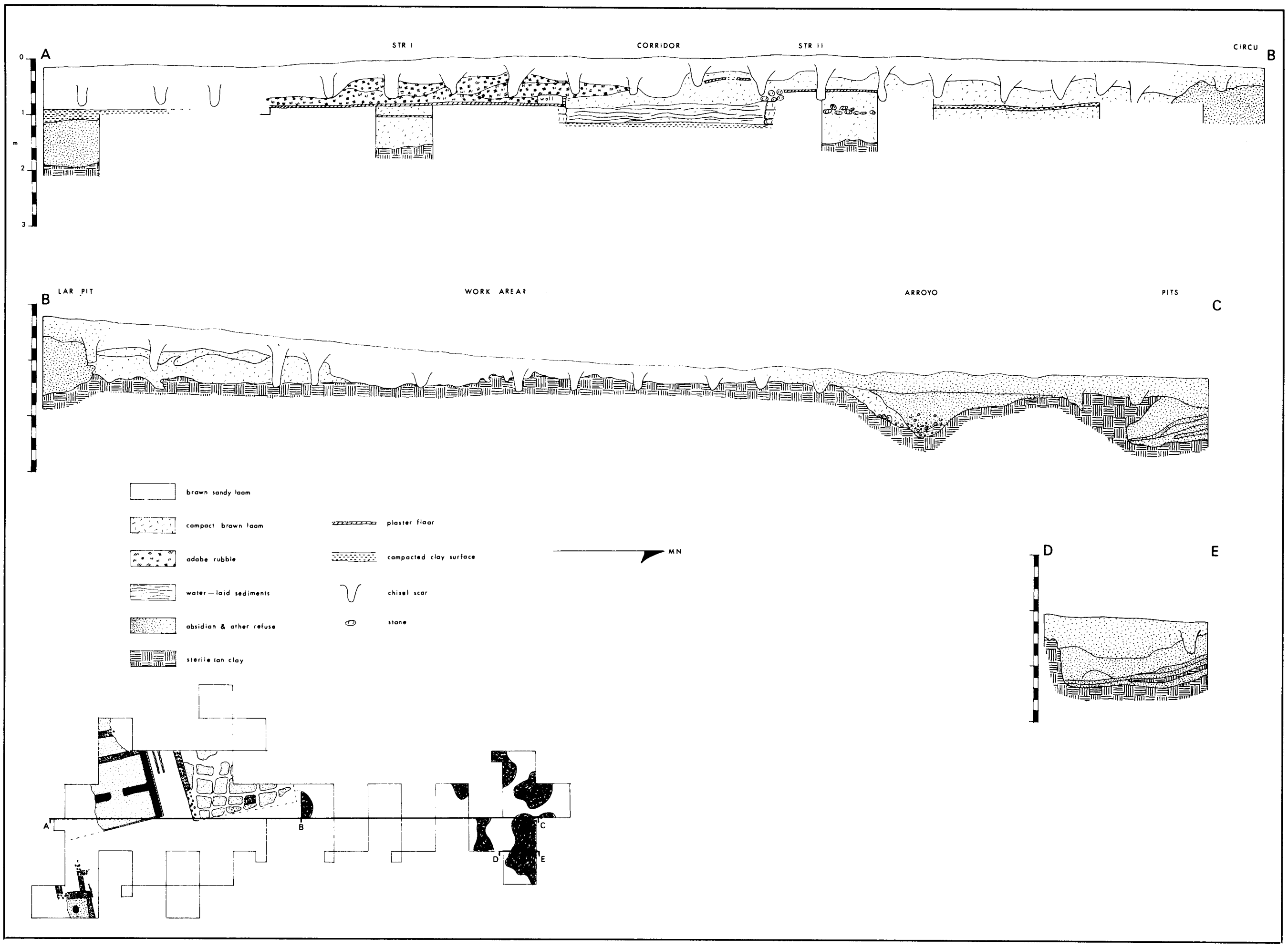

Figure 5. Simplified stratigraphic transect of the workshop complex seen in Figure 4.

Figure 6. The tan clay horizon, exposed immediately north of Structure II, looking south. The extremely eroded nature of the clay surface is seen in foreground; half of an apparently circular refuse pit is seen at top.

cumulation of localized structural renovation and collapse. The earliest structures were erected on the clay surface, over which artifact-rich fill, predominantly workshop and domestic refuse, was placed as a base for later structures. As many as three distinct, superposed structures were noted in some profiles. Invariably, only traces of the uppermost structures remained; we elected, therefore, to expose earlier structural remains which we hoped had escaped much of the destruction of plowing (FIG. 7). Excavation to lower levels produced remains of three structures (FIGS. 4, 8) designated I–III.

Both Structures I and II underlay traces of later structures, and Structure III underlay a cobblestone surface that may have been a paved thoroughfare. Because of limitations of time and resources, all three of these structures were only partially exposed.

Structures I and II form part of a single complex comparable to residential compounds excavated by the Mis-

Figure 7. Habitation area along ridge A, looking NE. The front (east end) of Structure I faced with small-stone veneer is seen in foreground. The workers are digging through the badly damaged remains of a later structure (note *metate* on floor) to expose the earlier, better-preserved Structure I.

souri project[18] at the Canal locality. Both are rectangular, multiple-room structures erected over low platforms, and they compare favorably to the most elegant structures of the Canal locality by virtue of their plaster floors and walls, their apparent spaciousness, and use of tabular small-stone veneer as decorative facing or lath for plaster. Unfortunately, both had sustained considerable damage, Structure II from chisel plowing (FIG. 4) and Structure I from later building activity that destroyed its southern margin. The two structures were separated by a narrow, open corridor with a prepared clay floor that contained an open-trough drain. The clay floor extended beneath both structures and into an open area to the east that probably comprised an open courtyard for the compound. Structure III is of less elegant construction, consisting of stone-and-mud walls enclosing a compacted earth floor without an underlying platform. It probably predates Structures I and II, given its lower elevation and stratigraphic context (it was built directly on the underlying clay horizon), but was probably part of an earlier complex that included previous versions of Structures I and II, remains of which were found beneath them.

As yet no study has been made of the artifacts recovered from the floors of these three structures or the remains of those that overlay them, but they were clearly domestic in function, given the occurrence of whole and fragmentary utilitarian vessels, *metates,* and hearths in one or more of them. Despite rather large quantities of obsidian debitage recovered from fill incorporated into these structures, only nominal amounts of obsidian, mostly fragments of prismatic blades and cores, were recovered from floors. In a superficial microscopic examination of floor samples from the structures and open areas, Healan did not detect any concentrations of microdebitage that should have existed had obsidian been worked there with any regularity. Hence there is no evidence for obsidian working in the habitation area, though the debitage recovered from structural fill must have come from nearby.

18. Dan M. Healan, "Architectural Implications of Daily Life in Ancient Tollan, Hidalgo, Mexico," *WA* 9 (1977) 140–156.

Refuse Dump

In the area between ridges A and B (FIGS. 3, 4), high concentrations of obsidian and other artifacts were found that extended throughout the soil to the underlying clay horizon (FIG. 5). Since very little loose building stone and no architectural remains were encountered, we conclude that this had been an open area; this circumstance is fortunate, since any structural remains in the relatively thin soil here would have been destroyed. The clay surface was scarred by chisel plowing, but was otherwise well preserved. Its surface displayed numerous small, irregular channels and rills, including a localized arroyo (FIG. 5), dating from when the clay horizon had lain exposed. In addition to these obvious erosional features, several large pits, the largest over 6 m. in diameter, were encountered (FIGS. 4, 5). These were filled with the same dark, artifact-rich soil that overlay them. Throughout this soil, the densities of artifacts, particularly obsidian, were extremely high, in some cases averaging 60 pieces of obsidian per liter of earth removed. The majority of the artifacts recovered in our excavation came from these pits. Because of the artifact density here, we screened levels from selected pits and squares, using quarter-inch screen, and, as elsewhere in the excavation, soil samples were also taken for microscopic study.

The pits were U-shaped or somewhat bell-shaped in cross section (FIG. 5), and measured a meter or more in depth. Their internal stratification was a complex pattern of localized bands, lenses, and amorphous pockets of artifact-rich soil and yellow clay. Artifact concentrations were highest in the lenses and pockets, which probably comprise individual loads of refuse. This consisted predominantly of obsidian, chiefly debitage from core/blade reduction (see below), but also large quantities of utilitarian sherds, animal bone, and other domestic refuse. It is important to note that workshop and domestic refuse occurred mixed in the same deposits, and while densities of obsidian were high, there were no pure layers of obsidian comparable to waste piles seen at quarry or biface workshops.

The regularity of the pits suggests they were artificial, perhaps source pits for clay used in construction which

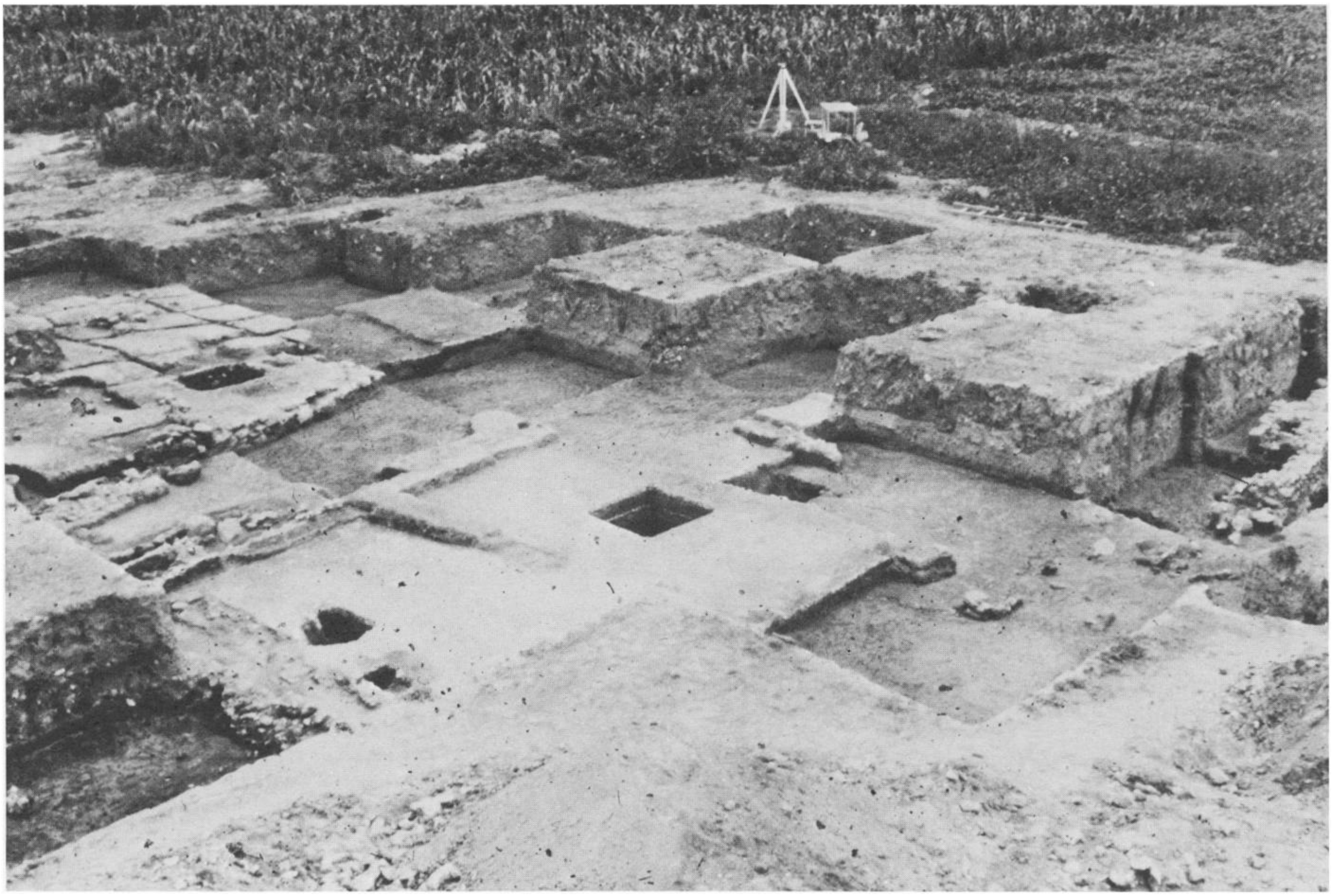

Figure 8. Panorama of the habitation area along ridge A, looking NE. Structure II is seen in left background (note chisel scars); Structure I is in foreground, and Structure III is at the extreme right. Chisel scars can be seen in many of the profiles.

were later used to discard refuse. It seems unlikely that obsidian was worked at these dumps, though some of the banded deposits may represent localized work surfaces. More likely, the work areas were located elsewhere, probably near the habitations, given the fact that domestic and workshop refuse occur mixed in the same strata. During preliminary stratigraphic analysis, Healan noted that some of the deposits had been disturbed (other than by chisel plowing), and may represent attempts to retrieve waste obsidian for re-use.

Obsidian Work Areas

Where were the actual obsidian work areas located? On the basis of preliminary microscopic examination of soil samples, Healan believes that they were located in the area between the habitations and the refuse dump. This area was only partially exposed by alternate 3 m. × 3 m. squares (FIG. 4), but it was clearly an open area devoid of architecture. The underlying clay horizon displayed the same small erosional features noted elsewhere, but lacked large refuse pits, with one exception: a shallow, apparently circular pit, filled with obsidian and other artifact refuse, was found protruding from beneath the north side of Structure II (FIGS. 4–6) along the south edge of this area. Aside from this pit, only moderate quantities of macroscopic obsidian debris were recovered from this area; Healan, however, noted significant amounts of obsidian microdebitage in soil samples from the top of the clay horizon and the overlying soil in this area. The existence of the refuse pits discussed above indicates that the work areas were regularly cleaned of debitage accumulations, so that an area with moderate visible debitage and disproportionately large amounts of microdebitage would very likely represent the actual work area. Confirmation of this hypothesis awaits more systematic examination of all of the floor and soil samples recovered from the excavation.

Discussion

All three of these general activity areas maintained functional integrity throughout the prehispanic occupation. No structural remains were found outside the habitation area, and continuous occupation in one area contributed to the ridge buildup. Refuse dumping was confined to the interridge refuse dump, except for use as structural fill, and once the pits were filled, continued dumping covered the interridge area with the artifact-rich soil seen today. Neither the habitation area nor the refuse dump encroached upon the intervening area we have tentatively identified as the obsidian work area. The integrity and continuity of activities in these areas indicate a relatively formal organization that was followed throughout the prehispanic occupation.

The presence of residential structures and the mixed workshop and domestic refuse deposits demonstrate that obsidian working took place in a domestic setting, as is probably typical of preindustrial societies. We noted above that the structures partially exposed along ridge A are similar in layout to those excavated at the Canal locality by the Missouri project, and in fact the degree of similarity is striking. The structures of the Canal locality comprised three residential compounds, including a small temple platform, arranged side by side and connected by a public street as well as a closed system of passageways and alleys.[19] It is interesting to note that these collapsed compounds formed a low ridge similar to ridge A, though lower, and like ridge A, remains of earlier structures were found beneath the excavated compounds, which contributed to the ridge effect. Healan is certain that ridge A constitutes a similar linear arrangement of residential compounds, for several reasons: scattered architectural remains were encountered in two test pits near the east end of the ridge, and we know that a prominent mound, probably a temple platform, existed near the west end of ridge A before it was destroyed about a decade ago. Given the length of ridge A, at least two juxtaposed compounds plus the temple platform had probably existed, and the paved surface that overlay Structure III may have been part of a thoroughfare that connected them.

We are also certain that ridge B, located immediately north of ridge A (FIG. 3), was comparable in form, since architectural remains erected over artifact-rich structural fill were encountered in two pits placed along this ridge, and its surface was likewise littered with architectural stone.

19. Ibid. fig. 3.

Obsidian Analysis

General Comments

With most of the tabulation complete, we can report that we recovered over 650 kg. of obsidian numbering over 500,000 pieces, including over 375,000 macroscopic pieces. Kerley is conducting a two-stage technological analysis of the obsidian recovered from our excavations. The first stage, now near completion, has involved a sorting of the entire collection into a series of technological categories (TABLE 2);[20] the second stage will involve more detailed study through attribute analysis of a sample of each category. The categories were derived from previous studies of Mesoamerican core/blade technology,[21] plus data obtained during Healan's preliminary surface reconnaissance of the locality in 1979. Inevitably, new categories were created and some existing ones subdivided or modified in the course of the preliminary sorting,[22] the results of which provide the following generalizations.

20. It should be noted that Table 2 is a tentative tabulation, since about 10% of the obsidian from our excavations has not been sorted. We do not, however, expect the relative frequencies of the categories in Table 2 to change significantly once the entire collection has been analyzed. We estimate that the total collection will comprise over 700 kg. of obsidian numbering over 560,000 pieces. Some of the categories listed in Table 2 have been modified from those used in the actual sorting.

21. Thomas Hester, Robert Jack, and Robert Heizer, "The Obsidian of Tres Zapotes, Vera Cruz, Mexico," *CARFC* 13 (1971) 65–131; Payson Sheets, "Behavioral Analysis and the Structure of a Prehistoric Industry," *CA* 16 (1975) 369–378; idem, "Part 1: Artifacts," in *The Prehisotry of Chalchuapa, El Salvador, Volume 2,* Payson Sheets and Bruce Dahlin, eds. (Pennsylvania 1978) 2–131; Thomas Hester, "The Obsidian Industry of Beleh (Chinautla Viejo), Guatemala," *Actas del XLI Congreso Internacional de Americanistas, Volumen I* (Mexico D.F. 1975) 473–488; Jay Johnson, "Chippped Stone Artifacts from the Western Maya Periphery," unpublished Ph.D. dissertation, Southern Illinois University (Carbondale 1976).

22. Both Healan and Kerley have had experience in flintknapping, but we would not be overly modest in characterizing ourselves as sophisticated novices. Nevertheless, our understanding of the workshop reduction technology has been greatly enhanced by our own replicative experiments in blade/core reduction, which are continuing. It is important to note that this work has involved the fabrication of prismatic blade cores "from scratch"; that is, forming percussion cores from raw obsidian nodules, which are then further reduced by pressure to become prismatic blade cores. Much of the previous replicative experimentation concerning prismatic blade core reduction has involved the use of sawn blocks of obsidian rather than percussion cores for pressure reduction (cf. Crabtree, op. cit. [in note 13] and Sheets and Muto, op. cit. [in note 8]), which does not yield the kinds of debitage typical of our workshop assemblage. John Clark first demonstrated to us the techniques of fabricating prismatic blade cores from scratch, and we gratefully acknowledge the advice and formal instruction in reducing percussion macrocores by pressure given us by J. Jeffrey Flenniken, director of the Washington State University Flintknapping Field School, and Gene Titmus.

Table 2. Preliminary tabulation of obsidian artifacts from the workshop complex. Percentages refer only to the macroscopic artifact categories (A-W).

A. Macroblades—35 (0.01%)	K. Prismatic Blade Cores—3,102 (0.83%)
B. Platform Faceting Flakes—56,988 (15.19%)	1. whole—473
C. Percussion Blades—11,990 (3.19%)	2. frag.—2,629
1. whole—1,192	a. proximal—947
2. frag.—10,798	b. medial—765
D. Irregular Pressure Blades—203,647 (54.26%)	c. distal—917
1. primary decortication—17	L. Miscellaneous Core Fragments—2,770 (0.74%)
2. secondary decortication—6,661	1. rim fragments—312
3. first series—10,401	2. distal flakes—974
a. whole—1,972	3. tablets—318
b. frag.—8,425	4. miscl. fragments—1,166
4. general—186,568	M. Percussion Cores—177 (0.05%)
a. whole—2,824	1. whole—1
b. frag.—183,744	2. frag.—176
E. Prismatic Blades—45,701 (12.18%)	N. Bifaces—35 (0.01%)
1. whole—128	1. whole—3
2. frag.—45,573	2. frag.—32
F. Prismatic Blade Errors—1,204 (0.32%)	O. Unifaces on Large Blades or Flakes—134 (0.04%)
1. plunging blades—983	P. Alternate Flakes—40 (0.01%)
2. bending fractures—190	Q. Thinning Flakes—3,272 (0.87%)
3. miscl.—31	R. Primary Decortication Flakes—47 (0.01%)
G. Primary Crested Blades—1,155 (0.31%)	S. Secondary Decortication Flakes—2,493 (0.66%)
H. Secondary Crested Blades—515 (0.14%)	T. Eraillure Flakes—374 (0.10%)
I. Blade Products—522 (0.14%)	U. Unclassified Flakes with Platforms—34,628 (9.23%)
1. trilobal eccentrics—446	V. Macroflakes—14 (0.01%)
a. whole—109	W. Chunks—840 (0.22%)
b. frag.—337	
2. unifacial retouched blades ("endscrapers")—18	TOTAL MACROSCOPIC SPECIMENS—375,288 (100%)
3. miscl.—58	
J. Blade Product Debitage—5,605 (1.49%)	
1. unilateral notched blade segments—5,363	X. Shatter—125,746
2. bilateral notched blade segments—133	
3. lateral flaked blade segments—109	TOTAL SPECIMENS—501,034

Source

About 83% of the collection is green in color and undoubtedly comes from the Cruz del Milagro (Pachuca) source, given its proximity (FIG. 1) and its prior identification at Tula.[23] The remainder is predominantly grey and probably comes from a number of sources, including Zinapecuaro, Michoacan (a major source of the grey obsidian recovered by the Missouri project), and Otumba, Mexico (FIG. 1).[24] Trace-element analysis will be undertaken in the near future. Kerley performed separate tabulations of green and non-green obsidian in order to determine if obsidian from Pachuca versus other sources was handled differently in the workshop, about which more is said below.

Input, Reduction Technology, Output

About 75% of the tabulated obsidian, or 375,288 pieces, consists of macroscopic pieces that constitute categories A–W in Table 2; the remainder comprise a single category designated *shatter,* which consists of small flakes and fragments that were mostly recovered from screened levels. We intend to examine the shatter category in more detail during the second stage of the analysis. In the following discussion, categories A–W will be collectively referred to as the *macroscopic collection,* to which most of our remarks will be directed. Because only a small and nonrandom part of the excavation was screened, we have omitted the shatter category from the percentage calculations.

23. Thomas Hester, Robert Jack, and Alice Benfer, "Trace Element Analysis of Obsidian from Michoacan, Mexico," *CARFC* 18 (1973) 167–176.

24. Ibid.

Approximately 89% of the macroscopic collection belongs to categories that are clearly derived from core/blade reduction (A–M, TABLE 2). Though the remainder include some flake categories that could have derived from biface manufacture, not a single unfinished biface reject was recovered; the few whole and fragmentary bifaces found were all finished products. Hence we are almost certainly dealing with an exclusively core/blade workshop.

The virtual absence of macrodebitage associated with "roughing out" cores from raw obsidian indicates that some type of prefabricated core or preform constituted the workshop input. Our data indicate that these were percussion *macrocores* (M, TABLE 2),[25] or large polyhedral cores, usually with a conical or pyramidal shape, bearing percussion blade scars on their face.

A distinctive core preparation activity at the workshop involved percussion flaking of the macrocore to produce a multifaceted platform. The resulting *platform faceting flakes* (B, TABLE 2) constitute about 15% of the macroscopic collection. These flakes are easily distinguishable by their perpendicular platform representing a remnant blade scar on the macrocore face; their flat, thin cross section; and the radial pattern of remnant flake scars on their dorsal surface. Their high frequency in the collection is surprising, considering that cores and blades with multifaceted platforms are extremely rare at Tula. Healan and Kerley believe that platform faceting was a preliminary step in producing the ground platform that typifies the prismatic core/blade industry at Tula. Faceting and subsequent grinding of the macrocore platform must have constituted the first steps of the workshop reduction sequence, since little core-derived debitage with other than ground platforms was recovered.

Aside from platform faceting flakes, percussion debitage is in strikingly low frequency[26] in the macroscopic collection, which implies that virtually all subsequent core reduction involved the use of pressure rather than percussion. This is not to say, however, that prismatic blade removal followed immediately. Of the 249,348 pressure blades so far tabulated in the collection, only about 18% possess the distinctive parallel margins and dorsal ridges characteristic of typical prismatic blades (E, TABLE 2). The remainder, which comprise about 54% of the macroscopic collection, are collectively called *irregular pressure blades* (D, TABLE 2). Besides their irregular form, remnant percussion blade scars are frequently seen over all or part of their dorsal surface. Our own experience in blade-core replication indicates that most of these comprise the first removals of pressure blades from a macrocore. During this process the macrocore is transformed from a generally conical form with wide, irregular blade scars or flutes to a commonly bullet-shaped form with narrow, parallel flutes that ensure subsequent removal of typical prismatic blades. Given their predominance in the collection, irregular pressure blades must have been considered waste and not utilized, though the latter assumption awaits confirmation through wear analysis. Within this category is a distinctive subcategory, *first series pressure blades* (D3, TABLE 2), which represent the very first blade removals by pressure from percussion macrocores. While Healan had suspected the existence of such a subcategory on the basis of fragmentary surface material examined during preliminary surface reconnaissance of the locality in 1979, it was first defined and named by John E. Clark of the New World Archaeological Foundation using data from replicative experiments and analysis of core/blade debitage from Chiapas. Clark, who generously made his data available to us during visits to our laboratory in 1980, defined this subcategory on the basis of distinctive attributes of length, shape, dorsal scars, and mode of termination. Similar blades have been produced in our own replicative work. The first pressure blades do not run the full length of the core, hence percussion blade scars will remain on the distal portion of the core until later rinds of pressure blades are removed. These later pressure blades, therefore, possess remnant percussion blade scars at their distal end, providing a means of further subdividing the irregular pressure blade category according to order of removal.

A large number of whole and fragmentary prismatic blade cores were recovered (K, TABLE 2). Most were exhausted or in an advanced stage of reduction, and closer examination will probably reveal the reasons for discarding the unexhausted cores. We also identified several categories of core fragments which probably include pieces derived from error recovery or core rejuvenation (L, TABLE 2). It is likely that the category for irregular pressure blades also contains specimens of error recovery.

Counting whole and proximal (platform) fragments, a minimum of 1,420 individual prismatic blade cores are represented. Undoubtedly, additional cores are represented by the core fragments in category L of Table 2, perhaps as many as 300 or more. Hence we estimate that as many as 1,720, but not less than 1,420, prismatic

25. Thomas Hester, "Notes on Large Blade Cores and Core/Blade Technology in Mesoamerica," *CARFC* 13 (1972) 95–105; John Clark, "A Macrocore in the Regional Museum in Tuxtla Guiterrez, Chiapas, Mexico," *LT* 6 (1977) 30–32; Robin Torrence, "Macrocore Production at the Melos Obsidian Quarries," *LT* 8 (1979) 51–60.

26. The majority of the percussion blades in category C of Table 2 are from levels examined at the very beginning of the sorting operation. Kerley now believes that many of these so-called "percussion blades" are in fact misidentified irregular pressure blades, and these levels will be re-examined to determine whether or not they are.

blade cores are represented in that part of the collection that has been analyzed to date.

About 2% of the macroscopic collection pertains to the manufacture of products from prismatic blades (I, J, TABLE 2). Only two kinds of blade products and associated debitage occur with sufficient frequency to indicate they were regularly manufactured at the workshop: *trilobal eccentrics* and *unifacially retouched blades,* or "endscrapers on blades". Trilobal eccentrics are small, "3"-shaped forms common at Tula and Teotihuacan;[27] the trilobal element is a common motif in Mesoamerican iconography believed to be part of *Tlaloc* symbolism representing drops of water, blood, or other fluid, but the function of these obsidian facsimilies is not known. We recovered a sufficient number of rejects to permit a tentative reconstruction of the manufacturing sequence, which essentially involves pressure flaking of notched prismatic blade segments. It should be noted that the blade product debitage categories consist entirely of rejects, which would account for only a small proportion of debitage from the production of blades; undoubtedly, the majority consists of very small pressure flakes that would escape recovery even in screened levels (though some might be identified during microdebitage analysis of soil samples). It is likely, therefore, that the magnitude of the manufacture of blades in the workshop is far greater than the macroscopic collection would suggest.

In Table 3 we have attempted to estimate the total number of individual blades represented by the whole and fragmentary specimens.[28] These estimates were then divided by the estimated number of prismatic blade cores in the collection (1,720) to derive a blade:core ratio for each category. Assuming the collection is a representative sample of the workshop assemblage, if the workshop were consuming all of its own output (a null hypothesis), we would expect the blade:core ratio for each blade category to be consistent with ratios obtained during core reduction. The extremely low blade:core ratios for decortication blades probably reflect the degree of refinement of macrocores entering the workshop (but see the discussion of source differences below). The equally low ratio for first series pressure blades probably reflects an

Table 3. Estimated number of individual pressure blades in the collection and associated blade:core ratios.

Category	*Estimated minimum and maximum number of individual blades:*	*Estimated minimum and maximum number of blades per core:*
D. Irregular Pressure Blades		
1. primary decortication	5–9	1
2. secondary decortication	1903–3331	1–2
3. first series	4379–6185	2–4
4. general	55322–94696	32–55
TOTAL	61609–104212	35–61
E. Prismatic Blades	13149–22915	7–13

inability systematically to distinguish these blades from general irregular pressure blades. Taken as a whole, the estimate of 35–61 irregular pressure blades per core seems to fall within the expected range based upon our own experience, though Healan believes that the lower end of this range is more appropriate for a skilled blade maker. On the other hand, a striking discrepancy exists in the extremely low ratio of prismatic blades to cores of 13:1 at most; even if the more conservative estimation of 1,420 cores were used, this ratio would only increase to 16 blades per core at most. Our own experience and that of others indicates that an average prismatic blade core can produce 100 or more prismatic blades; hence *at least* 85% of the expected prismatic blade yield of these discarded cores is missing, and presumably left the workshop as unmodified blades or blade products.

We noted above that about 83% of the obsidian in the collection is green, presumably from Pachuca, and in fact green obsidian was predominant in all but one of the categories listed in Table 2. There is considerable variation, however, in the proportion of green obsidian across the categories which ranges from 93% to 47% (TABLE 4); furthermore as Table 4 demonstrates, this variation is clearly patterned. Categories with the highest proportions of green obsidian are those that derive from the final stages of the reduction sequence in the workshop—the production of prismatic blades and blade products—and cluster around 90%. On the other hand, the lowest proportions of green obsidian are those categories that derive from the initial stages of the reduction sequence—macrocore trimming and platform preparation. What, then, is the true proportion of green obsidian processed at the workshop, and why is there such vari-

27. Terrance Stocker and Michael Spence, "Trilobal Eccentrics at Teotihuacan and Tula," *AmAnt* 38 (1973) 195–199.

28. Two different methods were used to estimate the number of individual blades represented by the fragmentary specimens. In Table 3 the maximum estimates were obtained simply by assuming that at the least, two blade fragments equal one whole blade; this is almost certainly too liberal an estimate, since many blades probably broke into more than two macroscopic pieces. The second method, which produced the minimum estimates in Table 3, involved calculating the average weight of whole blades for each category and dividing the total weight of the fragmentary specimens by that figure; this worked out to about 3.5 fragments per whole blade.

Table 4. Percentage of green obsidian among the artifact categories in Table 2, ranked from highest to lowest. Asterisk indicates categories in which whole and fragmentary specimens have been merged.

	Category	*Non-green*	*Green*	*Percent green*
F3.	Miscl. prismatic blade errors	2	29	93.5
I3.	Miscl. blade products	4	54	93.1
I1.	Trilobal eccentrics*	34	412	92.4
L2.	Distal core flakes	78	896	92.0
K1.	Whole prismatic blade cores	40	433	91.5
K2c.	Distal prismatic blade core frags.	78	839	91.5
J1.	Unilateral notched blade segments	487	4876	90.9
F2.	Prismatic blade bending fractures	18	172	90.5
J2.	Bilateral notched blade segments	13	120	90.2
E.	Prismatic blades*	4507	41194	90.1
K2b.	Medial prismatic blade core frags.	80	685	89.5
L4.	Miscl. core frags.	122	1044	89.5
K2a.	Proximal prismatic blade core frags.	100	847	89.4
F1.	Plunging prismatic blades	105	878	89.3
J3.	Lateral flaked blade segments	12	97	89.0
I2.	Unifacial retouched blades	2	16	88.9
A.	Macroblades	4	31	88.6
L3.	Core tablets	41	277	87.1
C.	Percussion blades*	1604	10386	86.6
O.	Unifaces on large blades or flakes	20	114	85.1
D4.	General irregular pressure blades*	28942	157626	84.5
X.	Shatter	21055	104691	83.3
M2.	Percussion core frags.	30	146	83.0
P.	Alternate flakes	7	33	82.5
G.	Primary crested blades	205	949	82.2
U.	Unclassified flakes w/platforms	6719	27909	80.6
H.	Secondary crested blades	101	414	80.4
D3.	First series pressure blades*	2076	8325	80.0
T.	Eraillure flakes	80	294	78.6
V.	Macroflakes	3	11	78.6
Q.	Thinning flakes	730	2542	77.7
W.	Chunks	198	642	76.4
L1.	Core rim frags.	78	234	75.0
N.	Bifaces*	9	26	74.3
B.	Platform faceting flakes	14695	42293	74.2
S.	Secondary decortication flakes	683	1810	72.6
D2.	Secondary decortication blades	1912	4749	71.3
R.	Primary decortication flakes	15	32	68.1
D1.	Primary decortication blades	9	8	47.1

ation in this proportion between categories? Given the coherent pattern of variation indicated and the size of our collection, it is unlikely that this variation is due simply to chance.

In Table 5, the frequencies of green and non-green obsidian for each category listed in Table 4 have been divided by our minimal estimation of the number of green and non-green prismatic blade cores represented in the collection (140 and 1,280 cores, respectively) to derive a count of the number of pieces of debitage per core by color for each category. This is not intended to represent an estimation of number of individuals per core for each category, as was done for pressure blades in Table 3, simply because we are at present unable to estimate number of individuals for many of the fragmentary non-blade categories. Rather, these counts of debitage per core are intended to provide a means of comparing the amount of debitage generated by green versus non-green core

Table 5. Number of pieces per core of green and non-green obsidian among the core/blade artifact categories of Table 4, ranked by per-core predominance of non-green obsidian from least to most.

Category	Number of pieces per prismatic blade core: Non-green	Green	Similarity ratio (non-green:green)
F3. Miscl. prismatic blade errors	0.01	0.02	0.6:1
I3. Miscl. blade products	0.03	0.04	0.7:1
I1. Trilobal eccentrics	0.24	0.32	0.8:1
L2. Distal core flakes	0.56	0.70	0.8:1
J1. Unilateral notched blade segments	3.48	3.81	0.9:1
F2. Prismatic blade bending fractures	0.13	0.13	1.0:1
J2. Bilateral notched blade segments	0.09	0.09	1.0:1
E. Prismatic blades	32.19	32.18	1.0:1
L4. Miscl. core frags.	0.87	0.82	1.1:1
F1. Plunging prismatic blades	0.75	0.69	1.1:1
J3. Lateral flaked blade segments	0.09	0.08	1.1:1
I2. Unifacial retouched blades	0.01	0.01	1.1:1
A. Macroblades	0.03	0.02	1.2:1
L3. Core tablets	0.29	0.22	1.4:1
C. Percussion blades	11.46	8.11	1.4:1
D4. General irregular pressure blades	206.73	123.14	1.7:1
X. Shatter	150.39	81.79	1.8:1
M2. Percussion core frags.	0.21	0.11	1.9:1
P. Alternate flakes	0.05	0.03	1.9:1
G. Primary crested blades	1.46	0.74	2.0:1
U. Unclassified flakes w/platforms	47.99	21.80	2.2:1
H. Secondary crested blades	0.72	0.32	2.2:1
D3. First series pressure blades	14.83	6.50	2.3:1
T. Eraillure flakes	0.57	0.23	2.5:1
V. Macroflakes	0.02	0.01	2.5:1
Q. Thinning flakes	5.21	1.99	2.6:1
W. Chunks	1.41	0.50	2.8:1
L1. Core rim frags.	0.56	0.18	3.0:1
B. Platform faceting flakes	104.96	33.04	3.2:1
S. Secondary decortication flakes	4.88	1.41	3.4:1
D2. Secondary decortication blades	13.66	3.71	3.7:1
R. Primary decortication flakes	0.11	0.02	4.3:1
D1. Primary decortication blades	0.06	0.01	10.3:1

reduction for each category, on the assumption that the relative proportions of discarded green and non-green prismatic blade cores in the collection approximate the true proportions of green and non-green cores that were reduced at the workshop. We stress that these are meaningless quantities, except for comparison of green and non-green debitage counts per core within the same category. This comparison is aided in Table 5 by the calculation of a ratio expressing the degree of similarity between the counts.[29]

What is immediately apparent in Table 5 is that the variation in the proportion of green obsidian is in fact caused by a disproportionately greater amount of non-green obsidian in all debitage categories except those that pertain to the final stages of the workshop reduction sequence. For most of these categories of ''final stages'', the quantity of debitage per core for non-green and green

29. Our estimations of 140 non-green and 1,280 green prismatic blade cores were obtained by counting the number of whole and proximal fragments of prismatic blade cores of each color in Table 4; this is, of course, our minimal estimation of 1,420 cores. Given that it is not the absolute values of the piece per core counts themselves, but rather the degree of similarity between the green and non-green counts for each category that is of interest here, in fact, any one or combination of the core categories (K and L) in Table 4, except for L1, could have been used as the denominator and would have produced counts having the same similarity ratios as those in Table 5. This is because all of these categories have about the same proportion of green obsidian (roughly 90%), as noted in Table 4.

obsidian is *nearly identical,* and in fact is perfectly so in the case of prismatic blades. This would suggest, perhaps not surprisingly, that the average green and non-green cores produce the same number of prismatic blades. On the other hand, for the earlier stages of the workshop reduction sequence, particularly the earliest stages, there is a considerably greater quantity of non-green obsidian per core than green obsidian. This circumstance suggests that macrocores arriving from sources other than Pachuca required more preparatory reduction to become "ready" prismatic blade cores. If so, the quantities could reflect differences in the inherent workability of different types of obsidian, or perhaps lax production standards at quarry workshops other than Pachuca; Healan suggests it could as well reflect differences in the geological occurrence of obsidian at these sources, perhaps the fabrication of macrocores from nodules instead of blocky flow fragments, the latter typical of raw material seen at the Pachuca quarries today. In general, we believe that the proportion of green obsidian in the "final stages" categories, roughly 90%,[30] represents the true proportion of green obsidian entering the workshop, and that the disproportionately greater amount of initial preparation of non-green macrocores accounts for the lower overall proportion of green obsidian in the collection.

We noted that at least 1,420 prismatic blade cores and concomitant blades and blade products were produced at the workshop. This is obviously nowhere near the total output, since only part of the workshop was excavated, but we are not prepared to estimate total output at this time. It is important to note that only a small portion of a single complex was exposed; indeed, approximately 55% of the 375,288 pieces that constitute the macroscopic collection came out of only *five* 3-m. squares and two 1-m. pits in the refuse dump! Given that this figure constitutes a very small proportion of a refuse dump that spans the entire length of the area between ridges A and B, total workshop output would undoubtedly number in the tens of thousands for prismatic blade cores alone. A problem in defining the output of one workshop lies in distinguishing the debitage boundaries of one workshop, since only the habitation compounds would define discrete entities, and the refuse dump may have been used by workshops along both ridges.

A number of as yet unstudied implements of bone, antler, and stone were recovered, some of which were almost certainly used in obsidian working. We recovered numerous antler tines, for example, several of which have minute flakes of obsidian embedded in them. Some of the bone implements, including fragments of rods and points, are slightly burned and polished, perhaps a hardening technique. Some of these points may have been used in the removal of blades by pressure, but this is at present only speculation. Stone implements include small hammerstones and abraiders, but it is not yet certain that any of these were used to work obsidian. We hope that microscopic examination for wear and residue will be of value in making this determination.

30. This agrees with Spence's figures for Teotihuacan, as he notes that the frequency of green obsidian in core/blade workshops there was "rarely less than 90%"; cf. Spence, op. cit. (in note 5) 777.

Ceramic Chronology

Bey has recently completed a typological classification of the pottery from the excavations that provides a general chronological framework, pending submission of radiocarbon and obsidian hydration specimens for dating in the near future. Though tabulation is not complete, over 133,000 sherds were recovered from our excavations. Bey's classification is based upon Cobean's extensive study[31] of the pre-Aztec pottery of Tula that was based upon the Missouri project's residential excavations and the urban survey, and selected test pits of the INAH project from near Tula Chico (FIG. 2).

Bey's classification places the entire workshop occupation within the Tollan phase (TABLE 1): less than 200 Aztec sherds and less than 50 sherds of the Corral and earlier phases have so far been tabulated. During the classification process, however, Bey noted a rather high frequency of Mazapa Red on Brown or "Wavy Line Mazapan", a type previously found only rarely at Tula[32] and assigned by Cobean to the preceding Terminal Corral phase (TABLE 1). In a trial seriation of pottery from selected levels of our excavation, Bey noted that Mazapa sherds tend to occur in greatest frequency in lower stratigraphic levels, but always as an integral part of an otherwise essentially Tollan phase assemblage. In comparing these atypical levels with those having a more typical Tollan phase assemblage, Bey noted two other differences: 1) the "atypical" levels had unusually low frequencies of the most common and diagnostic Tollan phase type, Jarra Polished Orange or "Naranja a Brochazos"; 2) subtle but consistent modal differences occurred between sherds of the same type from "atypical" and "typical" levels, most notably differences in surface finish of certain cream-slipped wares.

31. Cobean, op. cit. (in note 11).

32. Ironically, Mazapa Red on Brown is commonly thought to be the diagnostic pottery type of the Early Postclassic period at Tula, hence the frequent reference to Toltec Tula as "Mazapan" or a "Mazapan" period or phase at Tula. Cobean *notes that this pottery is indeed* common in Early Postclassic and Terminal Classic sites in the Basin of Mexico, but at Tula, the dominant Early Postclassic pottery consists of orange and cream, rather than red on brown, wares. Cf. Cobean, op. cit. (in note 11) 396–399.

Bey hypothesized that these quantitative and qualitative differences are diachronic, and provide a means to subdivide the Tollan phase into early and late subphases. The ceramics of the "typical" levels represent the late or fully developed Tollan-phase ceramic assemblage that dominates the archaeological record at the site and represents Tula's apogee and period of maximum expansion. Conversely, the ceramics of the "atypical" levels represent an early subphase marked by the initial appearance of the Tollan-phase ceramic assemblage alongside a continuation of the ceramic tradition of the preceding Terminal Corral phase. Given the rarity of Mazapa sherds at Tula, the Early Tollan subphase must predate Tula's urban expansion. Bey has found supporting evidence for an early/late subdivision of the Tollan phase in a study of ceramics from nine rural sites of the Tollan phase in the Tula region, one of which displays a ceramic assemblage comparable to the "atypical" levels of our excavation; i.e., the presence of significant numbers of types of the Terminal Corral phase in an otherwise Tollan-phase assemblage in which Jarra Polished Orange is significantly low in frequency.

The subdivision of the 250-year-long Tollan phase is an exciting prospect, for it would provide finer chronological control over the most spectacular period of Tula's history. This would have important ramifications for our workshop site, since it would therefore have been settled at the beginning of the Tollan phase prior to the city's expansion, and was probably continuously occupied for the remainder of the life of the Toltec city. It is important to note that the ceramic sequence at the workshop so far shows continuous rather than discontinuous change from the early to late subphases, which is also suggested by the stratigraphic data discussed above. The presence of Mazapa Red on Brown in significant quantities may have further ramifications, as discussed below.

Preliminary Assessment

We must stress the tentative nature of our findings, based as they are upon incomplete analysis. A number of significant points have been raised, however, that have important ramifications for other research. In conclusion, we want to discuss the implications of our preliminary findings for the study of Mesoamerican core/blade technology and the study of obsidian workshops at Tula and elsewhere.

The exclusively core/blade industry at our workshop is in part a reflection of the dominance of prismatic blades and blade products among obsidian artifact assemblages in Mesoamerica, but is also a function of the relatively specialized item or workshop input, percussion macrocores, rather than raw obsidian. Workshops that imported raw obsidian obviously had considerable latitude in their reduction strategies; even in core/blade reduction, some of the macrodebitage derived from initial stages of core formation make suitable blanks for bifacial reduction.[33] Much of the debitage from initial core formation, however, is waste: decortication, irregularities, flaws, and the like, and the transportation of raw obsidian over long distances, as in the case of Tula, would be less efficient than performing these initial reduction steps at the quarries.

The workshop was involved in the full range of core/blade reduction activities except for the initial stages of core formation, and their absence has helped clarify subsequent stages of core preparation prior to prismatic blade removal. Aside from platform preparation, virtually all core reduction at our workshop involved the use of pressure, not percussion, but this should not be taken to mean that the imported macrocores were virtually ready for prismatic blade removal. In our own experience with making prismatic blade cores from scratch, percussion was necessary to shape the raw material, which normally includes establishing a platform, establishing the first blade scars or flutes on the core face, and removing troublesome irregularities or anomalies from the core face. Beyond this point, further percussion trimming accomplishes little except the waste of potential prismatic blades; the shift, therefore, from percussion to pressure should occur as early as possible to maximize prismatic blade yield. Percussion is *not* used to establish the straight, parallel ridges on the core face that make prismatic blade removal possible; this is done entirely by pressure, as evidenced by the predominance of irregular pressure blades in our collection that are derived from this process. We believe that the significance of irregular pressure blades as defining a stage of core/blade reduction (rather than simply representing "duds" or substandard blades produced during prismatic blade removal) has not previously been appreciated, and we caution that the absence of percussion blades at a workshop site does not necessarily mean that "ready" prismatic blade cores were being imported.

John Clark[34] has argued that the study of Mesoamerican obsidian technology must consider source differences as an agent of technological variability, and our data support this. Our data demonstrate that considerably more preparation of non-green than green cores was necessary, which included decortication, platform faceting, and preliminary (irregular) blade removal by pressure.

33. Sheets, 1975 op. cit. (in note 21) fig. 3.

34. John Clark, "A Specialized Obsidian Quarry at Otumba, Mexico: Implications for the Study of Mesoamerican Technology and Trade," *LT* 8 (1979) 46–49.

We have not yet established whether this was because of differences in the source material or in activities of quarry workshops at the different sources.

We stress that our appraisal of the workshop industry is based upon a preliminary categorization, and that more detailed attribute analysis of these categories is now underway. We anticipate that the result of this second analysis will greatly expand our knowledge of various parts of the reduction sequence, including platform grinding, error recovery, and the manufacture of various blade products.

The area sampled by excavation has been interpreted as a linear arrangement of residential compounds comprising two low ridges (FIG. 3, A, B) which flank a (common?) refuse dumping area; if the results of Healan's preliminary microscopic examination of soil samples are accurate, the actual places of manufacture were in the open area between the habitation compound and the refuse dump. Each compound probably housed a series of related nuclear families that were probably related to those of adjacent compounds as well. It is likely that such a configuration represents a corporate residential entity or barrio, one which was heavily engaged in obsidian working. The presence of a ceremonial structure at the end of ridge A, presumably a neighborhood temple, also suggests a relatively self-contained residential entity. We anticipate that further study of the domestic artifacts, including utilitarian pottery, figurines, and faunal remains, will shed further light upon the domestic realm of the workshop.

How far beyond the immediate excavation area can this pattern be extended? Based upon informal surface survey, a similar configuration almost certainly exists in the next field to the north, where at least three ridges and artifact-rich, interridge areas are evident. Further north, surface obsidian diminishes in density, forming the northern limits of the "east flank" concentration. South of the excavation area, the terrain has been considerably disturbed by the construction of roads, irrigation ditches, pipelines, a quarry, and a new highway, and it is possible that the concentration east of Cerro El Cielito is a continuation of the "east flank" concentration beyond the disturbed zone (FIG. 2). East of the excavation area, the high surface concentration of obsidian continues for at least half a kilometer, and includes associated topographic features indicative of collapsed structures; in fact, we had considered an alternative excavation site in this area that consisted of an obsidian concentration alongside a mound that had been cut by a ditch, revealing superposed floors and structural walls. In summary, our informal surface survey suggests that the "east flank" concentration comprises an area at least 0.5 km. in diameter, within which is found a consistent pattern of topographic rises and high surface concentrations of obsidian and other artifacts that probably define a continuous zone of workshop complexes like that which we partially exposed. Survey data from the Missouri and INAH projects revealed three other characteristics common to the "east flank" concentration, all of which were observed in our excavation: 1) a predominance of core/blade debitage; 2) a predominance of green obsidian (a higher proportion than observed in the other concentrations); 3) relatively large quantities of Mazapa Red on Brown, a pottery type that is rare throughout much of the urban zone.

Finally, we would like to consider what the available data indicate about the occupation history of the locality and perhaps the entire "east flank" concentration. Our ceramic data suggest that the locality was settled around the beginning of the Tollan phase, prior to Tula's major expansion. Stratigraphic data indicate that at the time of initial occupation, the locality was marginal land, a barren, eroded terrain. Perhaps its marginal character was an inducement to locating obsidian workshops there, since it would have had little or no agricultural value.[35] Given the present estimation of Tula's extent before expansion,[36] the east flank of El Salitre lay outside the early community, though it was incorporated into the later city, as seen in Figure 2.

We noted that the basis of the early Tollan-phase dating of the initial settlement of our workshop is the presence of large amounts of Mazapa Red on Brown, a pottery type that is rare throughout all except the southeastern extreme of the urban site;[37] no other pottery type has this distribution. Cobean has noted that Mazapa Red on Brown is most common in Terminal Classic and Early Postclassic sites in the Basin of Mexico, particularly the Teotihuacan Valley,[38] and suggested that "it is at least possible that the sections of Tula's urban zone with the highest amounts of Mazapa Red on Brown were inhabited by a different social or ethnic group from the rest of the urban zone, or that these sections had some different economic function."[39] It is tempting to speculate that the workshop zone may have been settled by newcomers from the Basin of Mexico and the Teotihuacan Valley, which would

35. Ironically, today this is one of the most agriculturally productive areas in Tula, in large part because of the thick, organically rich refuse and construction fill that resulted from the prehispanic occupation.

36. Stoutamire, op. cit. (in note 5) fig. 12; Diehl, op. cit. 1981 (in note 10) 282.

37. Stoutamire, op. cit. (in note 5) 68–69, fig. 13.

38. Cobean, op. cit. (in note 11) 393. This type was named for San Francisco Mazapa, a locality within the site of Teotihuacan, where it was first reported.

39. Cobean, op. cit. (in note 11) 391–392.

indicate a continuity with the earlier Teotihuacan obsidian exploitation system far more direct than previously imagined. The fact that this pottery occurred alongside, and gradually gave way to, more common types of the Tollan phase suggests an eventual absorption of these peoples into Tula's cultural mainstream. At present this is speculation, but it poses a fascinating question that merits further exploration, if the origin and development of Tula's obsidian industry is to be placed in its proper regional and historical perspective.[40]

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