VI. PROBLEMS IN THE FUNCTIONAL INTERPRETATION OF ARTIFACTS: SCRAPER PLANES FROM MITLA AND YAGUL, OAXACA*

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We have recently studied a series of unifacial stone artifacts from the Post-Classic sites of Mitla and Yagul in the Valley of Oaxaca, Mexico.[1] These specimens are of a distinctive form, termed "scraper planes" or "push planes", found in various parts of the New World, particularly in arid regions of Mexico and the western United States. They occur in abundance at both Mitla and Yagul and have been reported from other parts of the Valley of Oaxaca (Lorenzo and Messmacher 1966). At Mitla, the specimens often occur in the earth and rubble hearting of the stone faced walls. The wall fill was presumably obtained from nearby superficial midden deposits of approximately the same age as the ruins, and thus we believe that the stone artifacts described here probably date from the Post-Classic. Examples of the Mitla specimens were first described by Holmes (1897), who called them cores, although he noted (p. 286) that flakes derived from them had not been modified or used as tools. A more recent discussion of Mitla "scraper planes" was published by Williams and Heizer (1965:46, Pl.7). During a visit to these two sites in the winter of 1970, we were able to examine a number of the artifacts and decided to analyze a series of them in an attempt to learn more of their manufacture and use.

THE SAMPLE

Eighty-one specimens were studied; 54 are from Mitla and 27 are from Yagul (Figs. 2,3). The series from both sites are quite similar, although those from Yagul are more crudely made and show less evidence of use.

Most are plano-convex in cross section, ovate in outline, and unifacially chipped. The majority have been formed by the splitting of a cobble, with the resultant fracture surface used as a striking platform to remove flakes, by percussion, from the convex face. Six specimens (4 from Mitla,

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2 from Yagul) are made on thick flakes, the ventral surfaces of which served as platforms for the removal of flakes from the dorsal side. For a discussion of the manufacturing techniques of similar tools from Lake Mohave, see Barbieri (1937: 101-102).

The dorsal surface is usually dome-shaped and is referred to in this paper as the "dome" (see Fig. 1 for descriptive terminology). The ventral surface or base is termed the "planar surface"; use-wear is often found around the edge ("planar edge") of this surface. The planar surface is generally flat, consisting of a single large flake scar (i.e., a single facet). Four specimens (all from Yagul) have two or more facets on the planar surface. In seven instances, specimens have two opposing (or sometimes adjacent) planar surfaces. These are similar to the "multifacted scraper planes" reported by MacNeish et al. (1967) from the Tehuacan Valley of Mexico. Two specimens (both from Mitla) have wedge-shaped domes and markedly convex planar surfaces.

The flake scars on the dome are often large and extend to near the crest; cortex remnants are usually present. On many pieces, there is step flaking along the planar edge (see Fig. 1). Some of the tiny step flakes are attributable to use-wear. Such use-flaking has been referred to as "nibbling" by Hole, Flannery and Neely (1969) and Hester (1970). Larger step flakes (those exceeding 5-7 mm. in length) may result from either resharpening activities or the shaping and trimming of the planar edge. On four examples, flakes have been detached from the ventral or planar surface (using the planar edge as a striking platform), probably part of a resharpening technique (cf. Shafer 1970: Fig. 1,c). Burins on scraper planes such as observed on specimens from coastal California (Heizer and Kelley 1961) are absent from the Oaxaca examples studied by us.

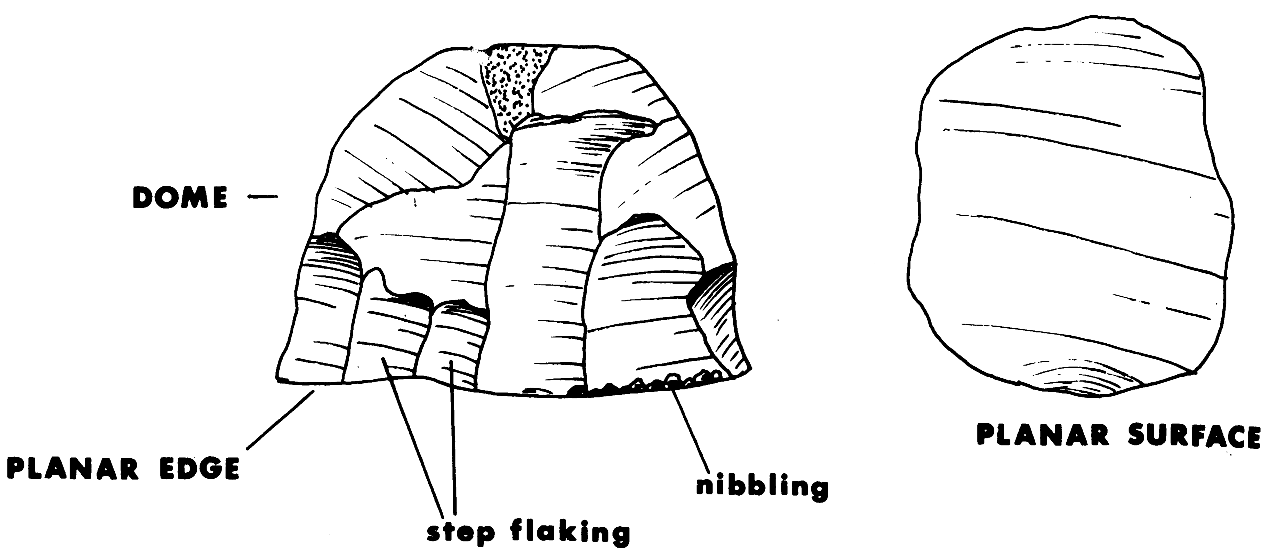

Fig. 1. Descriptive Terminology for Scraper Planes.

The raw materials used in the manufacture of these artifacts at Mitla include silicified tufaceous sediment (dominant), rhyolitic ignimbrite, and silicified sediments derived from ignimbrite. At Yagul, several specimens are made of gray-black andesite, several of banded rhyolitic lava, and others of silicified ignimbrite, impure limestone and rhyolitic ignimbrite.[2]

Dimensions and weights of the study series are given in Tables 1 and 2.

WEAR PATTERN ANALYSIS

The planar edges of all specimens were examined under high magnification (30X to 75X), using a binocular microscope with an independent light source. Dulling of various kinds was observed on almost every specimen. Much of the dulling is light and scattered, although in certain instances it extends along one-half of the circumference of the planar edge. In all cases, light dulling had to be detected microscopically. Twenty-nine specimens (14 from Mitla and 15 from Yagul) show heavy dulling, observable on the macroscopic level. Such dulling appears as a broad band of attrition (seen as a rounded or slightly beveled planar edge) usually restricted to one-half or less of the circumference. Under magnification, 13 specimens exhibit deep striations or grooving (perpendicular to the planar edge; see Fig. 3,b) in association with heavy dulling.

Other forms of use-wear include nibbling (4 specimens, all from Mitla) crushing or battering of the planar edge (Mitla, 3; Yagul, 4) and polishing of the edge (1 example, from Mitla). In one instance, a specimen from Mitla is abraded over much of the dome. The domes of four other specimens (all from Mitla) exhibit light to heavy battering.

EDGE ANGLE ANALYSIS

Semenov (1964) and Wilmsen (1968a) have suggested a direct correlation between the angle of the tool working edge and the function of the tool. In order to supplement our wear pattern data, we measured the edge angles of all specimens. Results are given in Tables 1 and 2. Initially, we used a polar coordinate graph to measure the angles (cf. Wilmsen 1968b), but we later found that these measurements could be more easily determined with equal accuracy with a goniometer.[3]

Edge angle values for the Mitla series (those specimens with a single planar surface) ranged from 50° to 125°. Sixty-seven percent of these values were between 60°-80°. Yagul edge angles show a similar wide range, from 55° to 100°, although 56% were between 65°-80°. In the samples from both sites, numerous specimens have edge angles in excess of 90°. These steep edges were created primarily by pronounced recession of the planar edge caused by nibbling and by the removal of larger step flakes (i.e., resharpening and trimming flakes). Edge angle values for specimens with two planar surfaces are indicated in Tables 1 and 2.

DISCUSSION AND INTERPRETATION

In our attempt to ascertain the function of these artifacts, we had several types of data with which to work. First of all, Holmes (1897) had pointed out that flakes removed in the manufacture of these objects apparently had not been used in any manner; thus they do not seem to be cores or exhausted nuclei in the usual sense. In addition to the presence of use-wear, which suggests that they are tools, they appear to be made according to a predetermined form or mental template (cf. Rogers 1929:459). They are reminiscent of the "hoof core" planing tools of Great Britain described a century ago by Gillespie (1877), a form which has also been noted among aboriginal groups in Australia (Mitchell 1949: Fig. 16; Gould 1968:171).

There are numerous publications which have described similar artifacts in the New World and many of these papers have proposed functional identifications of these tools. The rubric "scraper plane" has been most often used, and has been applied to specimens in California (Rogers 1929, 1939, 1966; Amsden 1937; Barbieri 1937; Heizer and Lemert 1947; Treganza and Malamud 1950; Treganza and Bierman 1958; Heizer and Kelley 1961; Creutz and Moriarty 1963; Kowta 1969), Baja California (Arnold 1957), Arizona (Hayden 1954), Chiapas, Mexico (MacNeish and Peterson 1962) and the Tehuacan Valley of Mexico (MacNeish et al, 1967). Additional distributional data are given by MacNeish et al (1967:39).

A number of these publications provide opinions for their functional interpretations. For example, Arnold (1957: 253) believes that Baja California scraper planes were "...designed primarily for use...against some relatively soft materials (wood?) and that they were also employed in a variety of other ways". His specimens were "smoothed" along the planar edges.

In their discussion of scraper planes from the Topanga lithic assemblage, Treganza and Bierman (1958:56) note: "The nature of the wear indicated hard usage, such as would result from repeated contact on an unyielding surface". Amsden (1937:61) observes that the Lake Mohave scraper planes "...meet the requirements of a fleshing tool, in addition to having a fore edge sufficiently well sharpened and thinned to serve as a skinning knife". The scraper planes found by Rogers (1939) in the Playa complex were attributed to use as "fleshing planes in dressing hides" (p. 29). However, Rogers (1939:50) also presented ethnographic data which suggested the use of scraper planes for processing *Agave* leaves. This latter interpretation is accepted by Kowta (1969:52), although he suggests that these tools might have had other uses in the exploitation of *Agave*, such as the shaping of chisel-ended digging sticks (Ibid.,p.54).

While it is probable that scraper planes served a wide variety of functions in different environmental situations, our major interest is determining their use at the sites of Mitla and Yagul. Our sample shows a wide range of use-wear, such as light and heavy dulling, crushing, battering and nibbling, none of which by itself can be linked to a specific function. However, 36% of the specimens have heavy dulling (often as a band of attrition along the planar edge) and associated striations. Such a wear pattern, according to Witthoft (1955:20), can be caused when a stone tool comes into sustained contact with another stone. We postulated two tasks which might involve these conditions: (1), the tools were used to shape and/or trim the building blocks found in the structures at Yagul and Mitla; or (2), the tools were used to process some type of thin, pliable material which had been placed on a stone backing or anvil and that during the course of such work, the tool edge repeatedly rubbed against the resistant backing. We feel that if their function had involved the first task (i.e., shaping of building stones) much more evidence of rough use, such as massive crushing and battering of the edge and more extensive planar surface wear, would be observed on the tools. When considering the second possible task, we reviewed some of the functional interpretations found in the literature. We were particularly interested in the hypothesis that this tool form was employed in _Agave_ exploitation, particularly the shredding and de-pulping of the leaves. Since the fibers of this plant (which occurs in abundance in the Oaxaca Valley) could be used in making cordage and rope, the proliferation of these tools at Mitla and Yagul might be related to the local manufacture of rope, perhaps to aid in the construction activities (such as dragging building blocks, tying poles used in scaffolding, etc.). This has been previously suggested by Williams and Heizer (1965:46).

Rogers (1939:50) recorded the use of scraper planes in the working of _Agave_ leaves in southern California:

> "A Southern Diegueno informant has described them as being used in the preparation of fiber for cordage. The green leaves of various species of agave were placed on flat rocks or the backs of metates and the pulp pushed out with these heavy planes, which were manipulated exactly as a carpenter's plane".

MacNeish et al (1967:36) have reported two scraper planes recovered from dry caves in the Tehuacan Valley which had plant fibers adhering to the planar edges. Unfortunately, these fibers cannot be specifically identified (R. S. MacNeish, personal communication).

To test the proposition that these tools were used in the working of _Agave_, we conducted an experiment. Leaves of an _Agave_ (an unidentified species from Mexico) were secured from the Botanical Garden of the University of California, Berkeley. Tools used in the experiment were taken from the Mitla series; those selected had earlier been examined microscopically and bore no evidence of use. In addition, two modern scraper planes of obsidian were made for the experiment.

The major part of the experiment centered on the use of one tool (Cat. No. 3-24143; see Table 1 and Fig. 4), which was used to work a single large Agave leaf (length of leaf, 3.5 feet; basal width, 7 inches). The leaf was placed flat on the macadam surface on the west side of Kroeber Hall. The operator held the implement at a slight angle to the leaf (see Fig. 4,b), although it sometimes rested flat against the leaf, and pushed the tool in a forward motion (i.e., away from the operator). Using this technique, it was found that the tool was extremely effective in peeling away the tough epidermis of the leaf, and thereby exposing the underlying fibers. At the same time the epidermis was being shredded (Fig. 4,a) the tool also pushed out much of the pulp contained in the leaf (note the dark stains caused by the pulp expulsion on the macadam surface; Fig. 4,c). We also discovered that some of the pulp could be expelled by pounding the exposed fibers with the dome of the tool (this, incidentally, caused light battering marks such as those found on four specimens collected at Mitla). As the shredding of the leaf proceeded, the exposed fibers began to spread, causing the planar edge to occasionally come into contact with the road surface. This was particularly true as the process neared completion and the long, white fibers became increasingly free of pulp and even more separated (see Fig. 4,c,d). The working of this large leaf consumed almost 45 minutes. No doubt with more practice less time would be needed. Afterwards, the tool was examined, and it was apparent that the edge had become heavily dulled. This was confirmed by microscopic examination. A slight beveling of the planar edge was also noted. During the leaf-working process, the dulling of the planar edge was felt as the tool became much less efficient, requiring frequent stops to clear the edge of accumulated fibrous material. We have no doubt that the dulling was caused by the occasional contact of the working edge of the tool against the backing (road surface). The wear observed as a result of the experiment closely duplicates the heavy dulling noted on the archaeological specimens. We attempted to use one of the freshly-made obsidian scraper planes to work a leaf. However, the planar edge was much too sharp, and it cut deeply into the leaf, with the result that the fibers were severed and the tool "jammed" in the leaf.

Thus, our experiment showed that tools such as those from Mitla and Yagul can be effectively used in a push-plane motion to decorticate and express the pulp from Agave leaves. The close correspondence of the use-wear on the tool used in the experiment ,and those with ancient wear patterns provides the best indications of the function of the tools at Mitla and Yagul. However, we should not rule out the possibility that they could have been put to other tasks, as the types of minor wear (nibbling, crushing, etc.) were not replicated in our experiment.

Wilmsen (,968a:157) has suggested a variety of functions for tools with edge angles of 60°-75°. As we discussed earlier, the majority of our samples from both sites have edge angles roughly in this range. The uses listed by Wilmsen are the working of wood, bone, and skin, and heavy shredding. We can state that our experimental tool (with an edge angle of 75° worked quite well in the latter task. We did not experiment with working wood, bone or skin with these tools.

We should also point out that there are other methods and other implements, which can be used to process Agave (cf. Castetter, Grove and Bell 1938). An excellent example is provided by Michels (1971:265). He used an obsidian "scraper rasp" (a steeply beveled end scraper) to separate the pulp from the fiber of maguey leaves. Osborne (1965:48) has carried out a similar experiment, in which she used a claystone side scraper to process a yucca leaf; apparently, the scraper became dull and had to be resharpened during the work. Osborne also experimented with tools made from deer and mountain sheep humeri. An account by Lothrop (1929) records the use of a handled wooden scraper for the purposes of fiber extraction in a Guatemalan hennequen industry. Morris and Burgh (1954:61) used a notched deer rib to pulp yucca leaves, and cite an account of the Pima using a deer scapula to scrape the pulp from roasted maguey leaves.

It was earlier suggested (Williams and Heizer 1965:46) that the large numbers of scraper planes which occur generally in the zone of the Mitla ruins, and which constitute a conspicuous cultural element (along with potsherds) in the earth-fieldstone wall heartings of the Mitla buildings, might be taken as an indication that in prehistoric times there was an extensive local manufacture of maguey cordage and rope which served as aids in the construction activities at Mitla. This suggestion rested on no solid basis and was merely an inference. We have looked for evidencein Conquest and early colonial period documents for a substantial production of Agave cordage in the Oaxaca valley but have not found any. We cannot say whether this lack of early documentation signifies absence of such an industry or mere neglect to note a prosaic local activity in which the conquistadors and ecomenderos saw little of economic interest for themselves.

But the archaeological fact remains that scraper planes are present in very considerable numbers at Mitla, and we are inclined to believe on the basis of our technological examination of a number of these, together with our single successful experiment in extracting fibers from an Agave leaf, that the scraper planes were anciently used to extract cordage fibers. But in stating our hypothesis we are no further forward as regards actual evidence of what the scraper planes were used for in pre-Conquest times. We can offer a possible means of reaching a fairly firm conclusion to the question.

It is a known fact that many, perhaps most, plants have a particular affinity for certain trace elements which they extract from the soil and concentrate in their structure. We assume that Agave behaves in the same manner, but we do not know which trace elements are selectively favored in this plant. If in the past great quantities of Agave were processed, the pulp and liquid residues would presumably have become part of the occupation soil zone and would be associated with rejected scraper planes. Since the wall heartings at Mitla are apparently midden soils, in this case we might expect to find in this earth a very high level of those particular trace elements for which Agave has an affinity. Such a demonstration still would not offer absolute and final proof that the Agave was manipulated with scraper planes, but it would strengthen the case for the association of Agave and this particular tool.

There is nothing very original in this approach except for its proposed application to illuminate the Mitla question. One of us (Heizer 1960: 99-100) proposed over ten years ago this kind of "chemical archaeology" as a possible way to show that maize may have been grown and eaten even though no palpable remains of the plant had survived. It has also been suggested that this approach might tell us the antiquity in Central California of dependence upon the acorn as a primary food resource. So far as we know, nothing has ever been done in the way of testing these propositions, but it could be done easily by applying the well developed methods used in geochemical prospecting (e.g. Chikisev 1965; Malyuga 1964; cf. Stiles 1951).

We intend to try the geochemical test for Agave identification at Mitla if and when the opportunity permits. In the meanwhile, we would encourage others to make this test if they wish, because we are equally as interested in exploring the potentials of the method as in any particular results which might be obtained.

Notes

1. Specimens studied for this paper are in the collections of the Lowie Museum of Anthropology, University of California, Berkeley.

2. We thank Dr. Howel Williams (Professor Emeritus, Department of Geology and Geophysics, University of California, Berkeley) for making the petrographic identification of the specimens.

3. Crosby (1967:102-103) reports some problems encountered in using a goniometer to measure tool edge angles, especially the accurate measurement of low angles. She suggests the use of a carpenter's template former.

Cat. #	Height	Max. Diam.	Min. Diam.	Weight	Edge Angle
3-24160	88	107	97	1014	100
3-24149	65	81	75	520	75
3-24176	86	82	62	639	75
3-24175	66	133	108	786	60
3-24141	94	83	83	851	105/85
3-24159	90	100	87	869	105
3-24171	72	98	78	752	100
3-24174	74	79	62	447	85
3-24162	65	75	72	470	80
3-22680	36	78	71	194	70
3-22868	46	61	48	181	60
3-24167	46	74	54	208	70
3-24173	42	82	58	261	85
3-24151	42	93	70	349	75
3-24165	72	76	66	424	90/75
3-24145	49	62	40	190	70
3-24147	50	78	60	259	80
3-24170	48	84	57	315	80
3-24149	64	79	75	520	60
3-24156	57	71	52	320	70
3-24146	43	66	57	195	80
3-24143	44	74	66	266	75
3-24142	41	78	67	244	70
3-24169	64	78	73	418	100
3-24144	51	90	61	353	90
3-24164	48	79	62	263	95
3-24152*	23	80	76	141	50
3-24161	26	68	57	98	60
3-24153	51	58	53	179	75
3-24158	59	80	47	266	125
3-24150	48	73	53	216	80
3-24166*	22	75	64	124	50
3-24163	54	72	53	235	60
3-24154	55	frag.	frag.	frag.	60
3-24168	58	75	45	169	60
3-24148	61	53	46	159	80/65
3-24172	44	82	57	242	80/75
3-24155	70	78	65	419	100/80
3-24157	53	71	58	283	65/100
3-22862	49	64	58	193	65
3-22860	53	78	64	220	70
3-22865	47	62	52	209	80
3-22863	62	81	69	323	75
3-22858	47	93	64	362	70
3-22861	50	63	60	260	70
3-22867	41	61	48	171	95
3-22681	25	63	51	109	70
3-22864	68	81	78	459	70
3-22866	49	63	50	182	90
3-22857	27	55	52	88	70
3-22859*	26	61	59	97	80
3-22854	30	76	59	139	60
3-22679*	36	75	70	154	70
3-22853	31	71	63	147	75
Mean	54.0	79.4	62.9	319.8	75.8

Table 1. Dimensions, Weights and Edge Angles of Scraper Planes from Mitla. Dimensions are in millimeters and weight in grams. Asterisk (*) denotes specimens made on flakes. The mean edge angle indicated here was calculated for 48 specimens (specimens with 2 planes excluded).

Cat. #	Height	Max. Diam.	Min. Diam.	Weight	Edge Angle
3-24118	45	67	58	203	70
3-24139	44	78	68	220	80
3-24117	30	66	61	170	65
3-24136	64	78	61	526	75
3-24131	38	78	60	196	60/65
3-24116	47	93	70	290	60
3-24124	54	66	51	261	85
3-24129	50	83	65	369	75
3-24135	53	106	96	522	65
3-24114	46	108	76	380	65
3-24138	70	84	77	601	75
3-24119	65	75	60	315	80
3-22862	52	77	74	317	80
3-22855	37	71	60	196	55
3-24127	84	86	74	655	95
3-24120	51	76	75	291	75
3-24123	35	81	71	260	70
3-24122	35	68	66	154	85
3-23137	72	122	100	895	90
3-24133	92	100	90	855	85
3-24115	75	97	88	803	90
3-24130	86	97	77	793	100
3-24128	84	94	81	783	95
3-24126	74	75	63	510	90
3-24125	77	90	90	671	70
3-24134	65	86	75	470	80
3-24132	23	80	76	230	75
Mean:	57.3	84.5	77.7	442.1	78.5

Table 2. Dimensions, Weights and Edge Angles of Scraper-Planes from Yagul. Dimensions are in millimeters and weights in grams. The mean edge angle indicated here has been calculated for 26 specimens (the specimen with 2 planes was excluded).

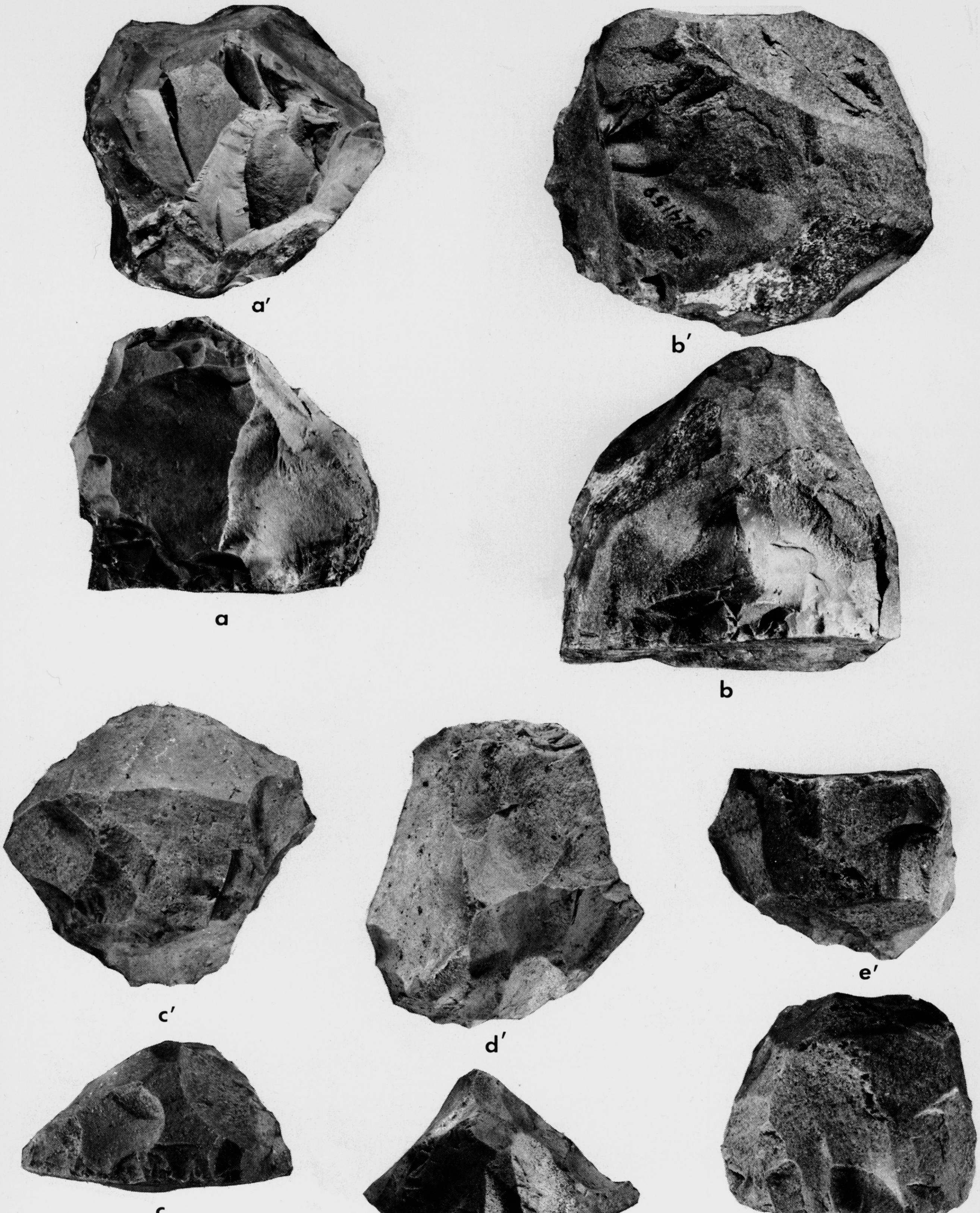

Fig. 2. Scraper Planes from the Valley of Oaxaca. a-e, frontal views, showing working edge; a'-e', corresponding dome views. a,a' (Cat. No. 3-22864); b,b' (3-24159); c,c' (3-22680); d,d' (3-22679); e,e' (3-24145).

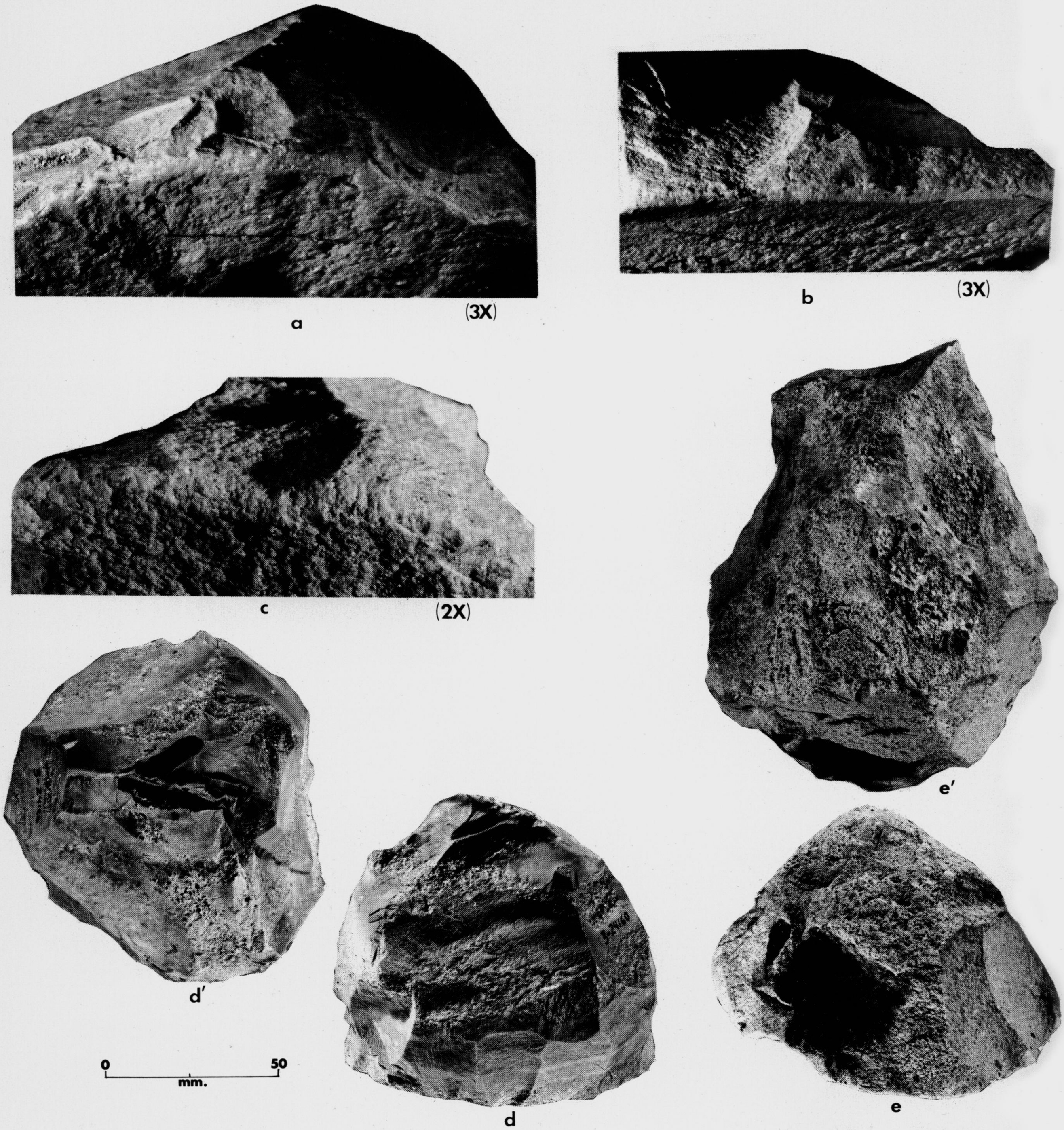

Fig. 3. Scraper Planes from the Valley of Oaxaca. a-c, low power photomicrographs of wear patterns on working edge of three scraper planes (linear magnifications are indicated); a, 3-22680 (dulled edge); b, 3-22679 (dulling and associated striations); c, 3-24175 (dulling and associated deep striations); d, d', frontal and dome views of 3-24160; e, e', frontal and dome views of 3-24175.

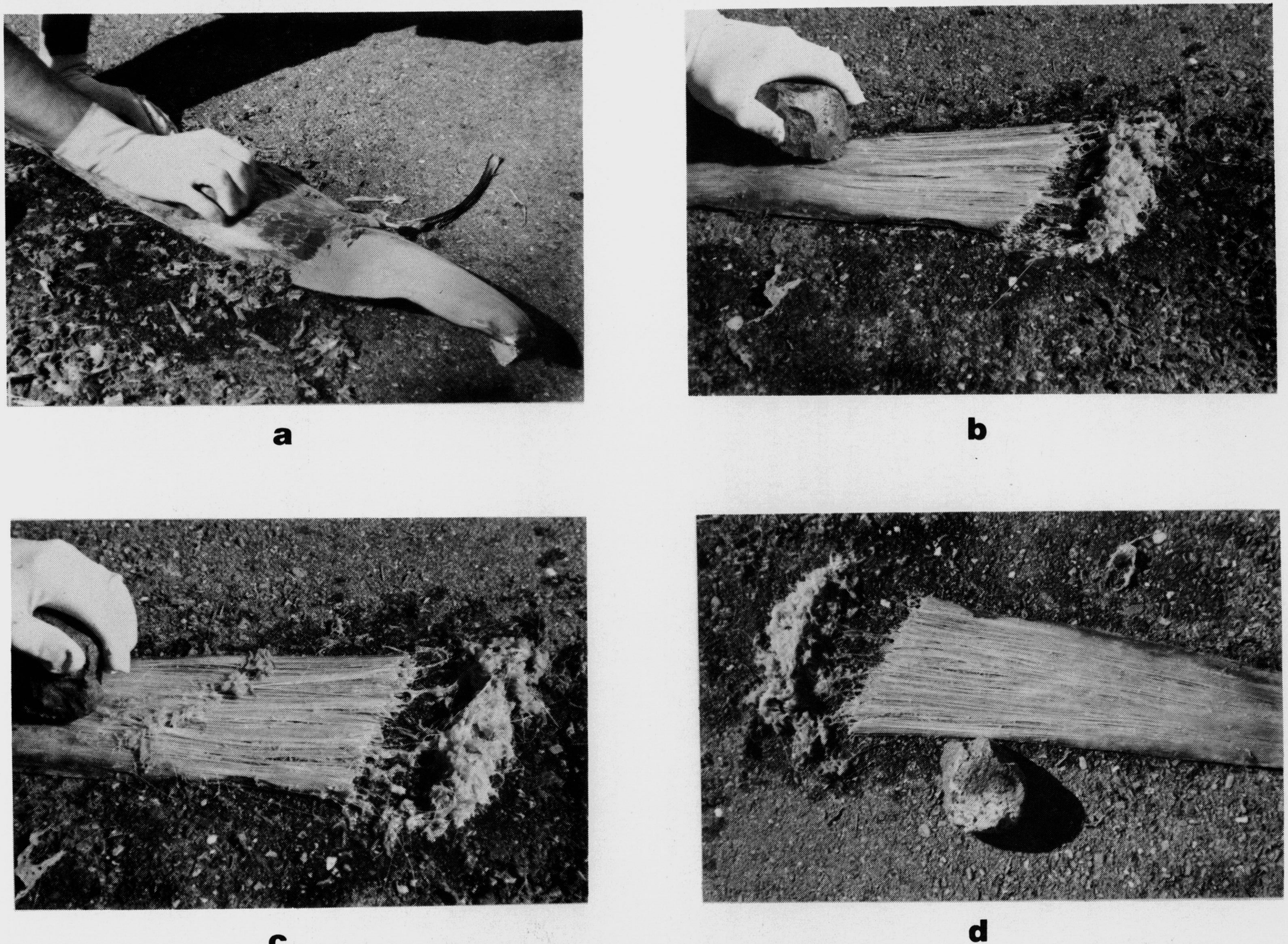

Fig. 4. Experimental Use of Scraper Plane. a, decortication of Agave leaf; b,c, expressing the pulp from the leaf; d, leaf end after completion of experiment.

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