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THE ADOBES OF HUACA DEL SOL AND HUACA DE LA LUNA

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Mud bricks in Huaca del Sol and Huaca de la Luna differ in soil composition, dimensions, mold marks, and makers' marks. The differences reflect conditions of brick production and use, and some variables are chronologically significant. This paper discusses the archaeological significance of adobes in these platform mounds, located on the south side of the Moche Valley. Four brick variables–soil, dimensions, mold, and makers' marks–are examined in terms of patterns of associations.

UNITS OF ASSOCIATION

The construction of the two huacas was characterized by periods of building followed by periods of summit use and then renewed building. We use construction stages and their subdivisions to establish units of association. Information on building stages, as well as bricks, comes largely from examination of excavations left by looters. Therefore, our sample of both building events and bricks is small, and much information is either not exposed to view or has been destroyed.

Huaca del Sol

Measuring at least 342 m by more than 159 m, Huaca del Sol was the largest brick structure in South America. It was probably cross-shaped in plan and had four sections numbered 1 through 4 from north to south (Fig. 1). Colonial period looters used the Moche river to wash away at least two thirds of the mound. In Section 2 this produced a profile 28 m high, in which eight construction stages are visible. These are number I through VIII from bottom to top. Stage V produced a burial with Moche Phase III ceramics, and Stage VII had a tomb with Phase IV ceramics (Moseley et al. 1973).

Section 1 was built after Section 2 and is treated as a unit of associated bricks. The south side of Section 4 was covered with a facade of bricks about 4 m thick, and this forms another adobe assemblage.

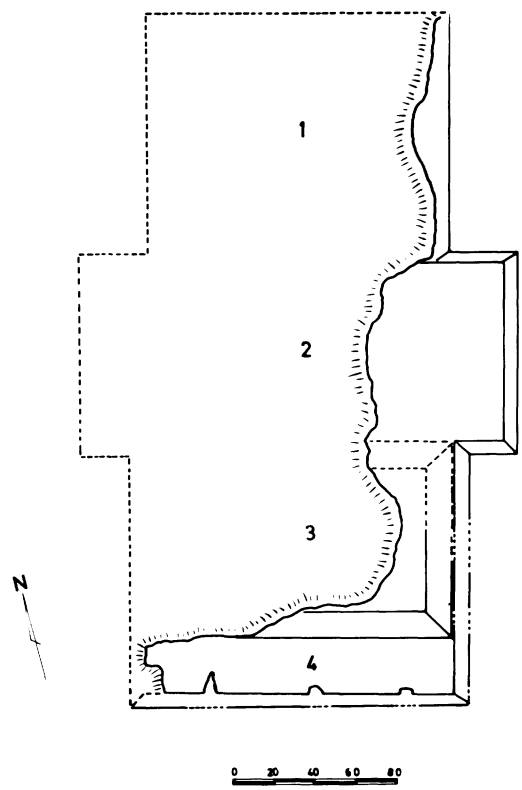

Fig. 1. Plan of Huaca del Sol. The dashed line indicates the projected original dimensions prior to Colonial destruction. Sections are numbered 1-4 for reference in the text.

Huaca de la Luna

The Luna complex is formed by three mounds connected by courts (Fig. 2). Section 1 is the largest platform and was built in at least three stages. Stage I was a mound about 95 m long by 85 m wide and 20 m high. On its summit were a flag-stone paving, rooms, and other walled structures. Construction Stage II raised the summit 3-4 m. New rooms and summit structures were built, one of which was decorated by murals dating to the end of ceramic Phase IV or the opening of Phase V (Mackey 1973). Stage III filled in the rooms and further elevated the top of the platform.

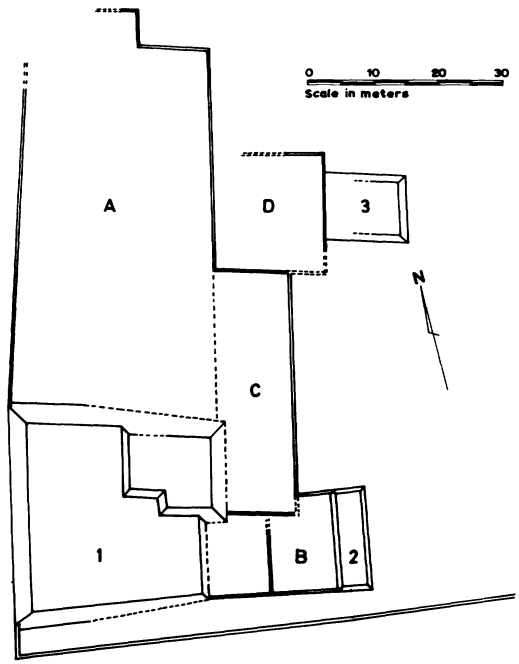

Fig. 2. Plan of the Huaca de la Luna complex. The platforms are numbered as Sections 1-3; Section 4 is the Luna courts, lettered A-D.

The smallest Luna platform is Section 2, and we think it was built as a single undertaking. The other mound, Section 3, is heavily looted. An old structural core, Stage I, is encased by subsequent expansions of the mound, but we have not been able to order these into coherent stages.

The courts of Luna comprise Section 4. Court A ties to Section 1 and Court B to Section 2, but A and B cannot be dated relative to one another. Court C intrudes into both enclosures and was built later. Associated with Section 3, Court D extends out from the north wall of Court C and was a later feature. Thus, A and B are the earliest courts and were followed successively by Courts C and D.

Segmentation

Huacas del Sol and de la Luna are characterized by "segmented" construction. This entails the division of an otherwise homogeneous construction into discrete, repetitive units. Adobes were laid up in long "skins" 0.4-2.0 m wide and as high as the construction stage. Adjacent skins were unbonded. They are usually subdivided into smaller unbonded segments that look like tall rectangular columns of adobes.

Given this phenomenon, bricks have degrees of association. They may belong to the same structure, the same construction stage, the same skin, and if the skin is partitioned, to the same skin segment.

THE ADOBES

The construction of Huaca del Sol required more than 143 million adobes, and we estimate that the Luna platforms needed more than 50 million adobes. All bricks were made in four-sided rectangular molds open at the top and bottom. Although mold-made, the adobes vary in composition, size, and mold and makers' marks.

Soil Types

The most commonly used soil was a brown water-laid silt found in the vicinity of the huacas. Less frequent are adobes of granular yellow sediments from desert soils beyond the zone of cultivation. Some adobes are gray and a product of soil containing organic matter, such as occurs in sumps within the valley. Between extremes of brown, yellow, and gray are many gradations in color.

In general, adobe composition varies independently of other brick characteristics. The one level where brick composition shows a patterned distribution is in skins and segments. With rare exceptions the adobes of a construction segment have uniform soil color and composition.

Dimensions

The only dimensional trait common to all Moche adobes is that they are wider than they are high. Bricks in the same construction segment generally measure within 2 cm of one another. The facade of Sol Section 4 has bricks of similar size, reflecting an attempt to give the huaca a uniform facing. Otherwise, there is substantial variation between the dimensions of bricks found in adjacent skins and segments. Deviation was particularly great in Luna Section 3 where bricks of 40 X 27 X 16 cm occur in the same stage that a few meters away utilized bricks averaging 23 X 17 X 12 cm.

Through time, thin bricks were replaced by thick bricks. In the Sol Section 2 profile Stage I and II adobes are 8-11 cm thick. In the overlying stages, brick thickness falls between 12 and 18 cm. The same trend is evident in Luna Section 1 where Stage I adobes are about 9 cm thick and Stages II and III have bricks averaging 13 cm. Luna Courts A and B were built primarily of thin adobes, whereas the later C and D courts have thicker bricks.

There is a negative correlation between thin adobes and makers' marks. The relationship of size to mold marks is variable. Thin bricks may or may not have a high frequency of cane mold marks, while thick adobes were infrequently made in cane molds.

Mold Marking

Adobes were made in two types of molds. One was constructed of smooth slats and produced bricks with flat sides. The other mold type was of narrow canes, probably *Cana brava*. The reeds were placed horizontally one above the other and left parallel impressions up to 0.5 cm deep in the sides of the adobes. Deep cane marks are found in some bricks of the preceding Gallinazo phase. Marks of the Moche phase are often shallow, faint, and difficult to distinguish. We consider bricks cane marked only if definite, though not necessarily deep, reed impressions are present on at least two sides.

There was no standardization about the types of molds used to make bricks for individual skins and segments. Some construction units within the same stage have more marked bricks than others, and frequencies in adjacent skin segments may differ by as much as 25%. Very rarely does the incidence of this trait exceed 50% of the adobes in a skin segment.

Cane marking exhibits chronological variation. In Sol Section 2, 27% of the Stage I bricks were marked, while in Stage II the frequency fell to 13%. In Stage III and above, marking is present but rare. Similarly, Luna Section 1 Stage I has a 10% frequency of marks, and in the overlying assemblages the frequency falls below 5%.

Makers' Marks

Some Moche phase adobes had symbols impressed on their top surfaces before the mud bricks dried. Because they can only have been applied during production, they are called makers' marks. The symbols are segment specific. Some exceptions occur where reused bricks were employed and in a few cases where only new bricks were in evidence. Yet, of all segments examined we estimate that 85-95% had but one mark each.

There was a time when makers' marks were not employed, evidenced at Luna by Section 1 Stage I, Section 2, and Courts A and B, and at Sol by Stages I through III of Section 2. Marks in Sol Section 2 first appear in Stage IV on 75% of the adobes examined. In overlying Stages V through VIII the incidence of marks remains high, and the number of different symbols increases. Comparably high frequencies were found only in Luna Section 3. The emergence of marking in the construction sequence of Luna Section 1 is less clear than at Sol because Stage II is poorly sampled and revealed only a few marked bricks. Stage III above and the facade of Sol Section 4 are relatively late brick assemblages with a low incidence of marks. Moche Phase V monumental architecture at the nearby site of Galindo produced but three symbols, and makers' marks have not been found on later adobes.

Most of the 101 marks we found are composed of dots, lines, or combinations thereof drawn with the finger tips, and represent separate symbols. Inversions, such as finger prints of the left versus right hand, or left to right versus right to left diagonals, may or may not represent distinct symbols. Sol produced 93 marks (Fig. 3), of which six (A-1, E-1, E-3, G-3, H-3, and K-4) were very common, 24 (A-3, A-4, A-7, B-2, B-7, B-8, C-1, C-3, D-1, D-6, E-4, F-1, F-3, G-5, G-6, H-5, I-4, J-1, J-2, J-5, K-1, K-2,

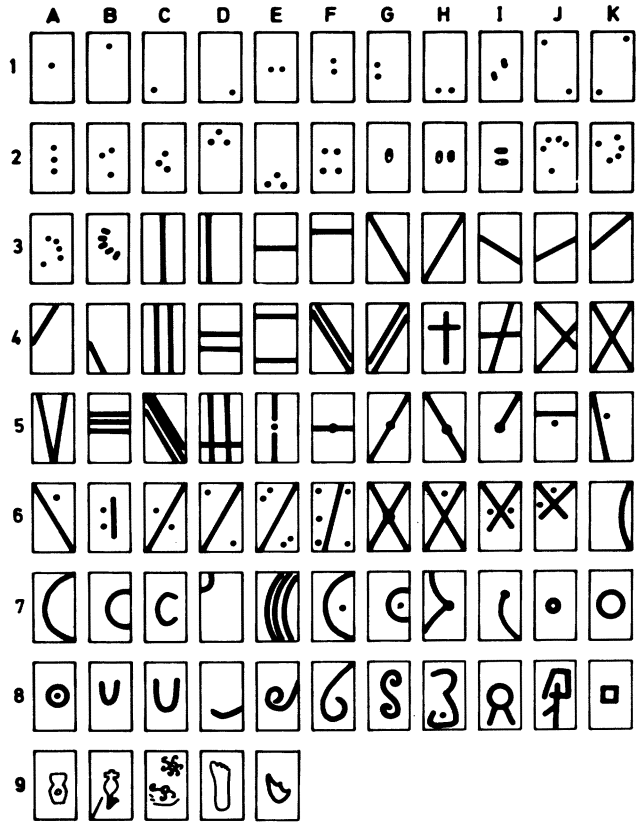

Fig. 3. Index of all makers' marks recorded at Huaca del Sol, regardless of their exact provenience. Columns and rows are lettered and numbered, respectively, for reference.

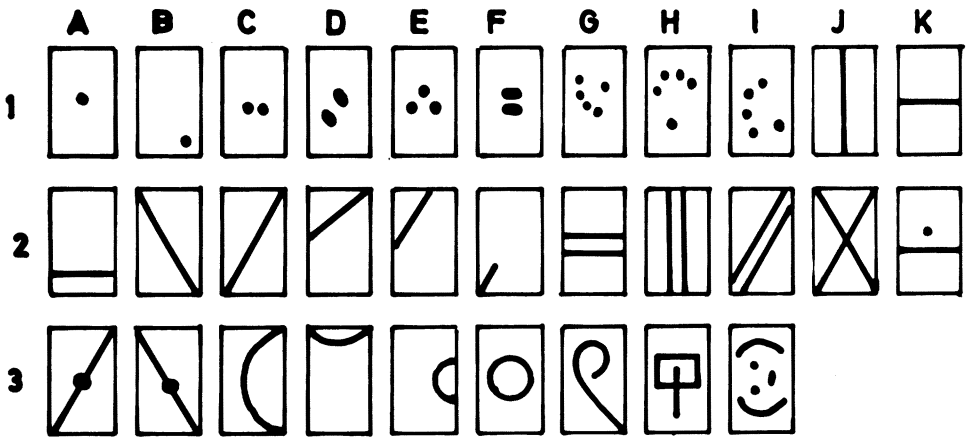

Fig. 4. Index of all makers' marks recorded in Section 3 of Huaca de la Luna, regardless of their exact provenience. Columns and rows are lettered and numbered, respectively, for reference.

K-3, and K-7) were common, and 63 were rare. Luna Section 3 produced 31 marks (Fig. 4), and Section 1 had 10 symbols (Fig. 6). As at Sol, the simpler designs were the more common.

Information on the temporal relationships of individual marks in the Sol Section 2 construction stages is graphically summarized in Fig. 5. The few symbols found in Luna Section 1 Stages II and III are similarly illustrated in Fig.

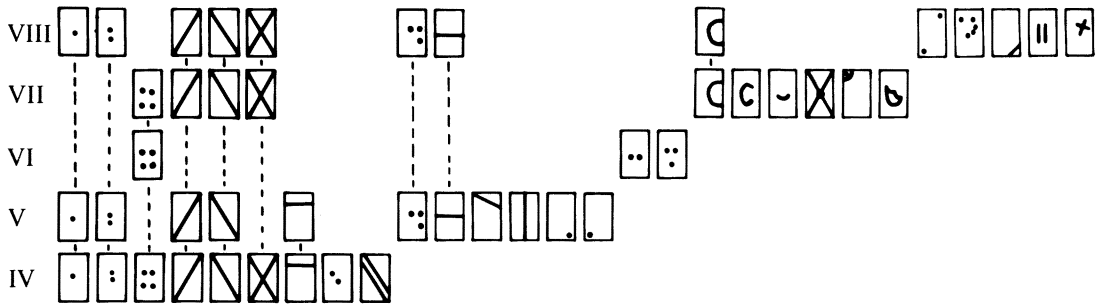

Fig. 5. Makers' mark chronology for Section 2 of Huaca del Sol. Marks found on *in situ* adobes are entered by construction stage.

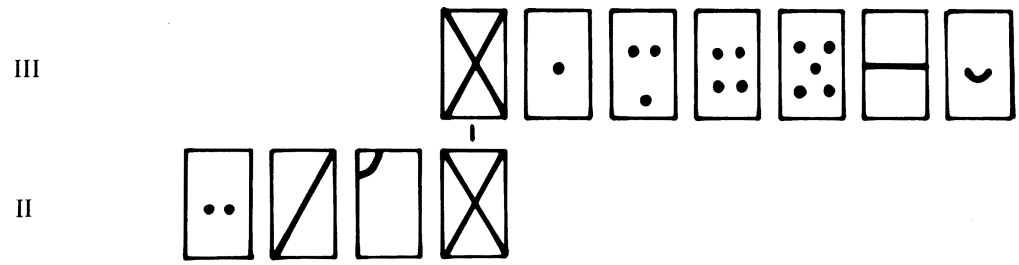

Fig. 6. Makers' mark chronology for Section 1 of Huaca de la Luna. Marks on *in situ* adobes are entered by construction stage. These include all the marks found in this section.

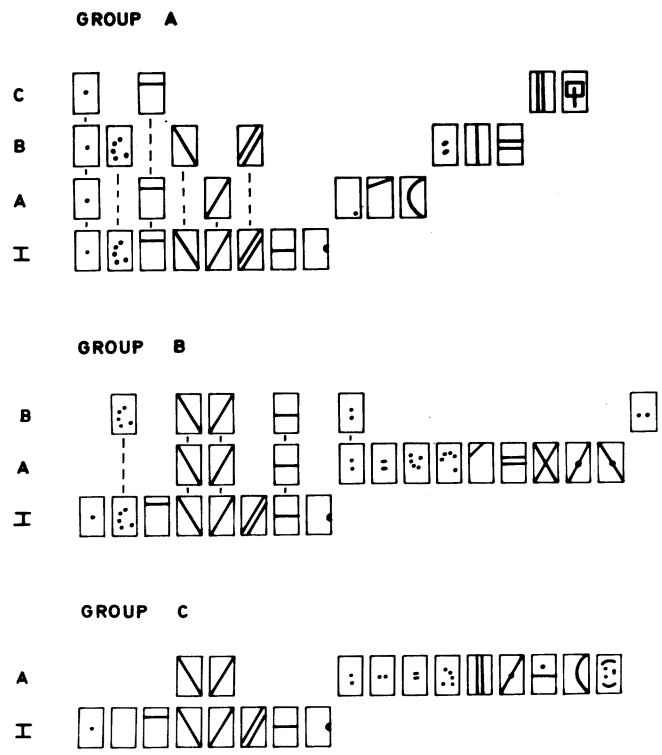

Fig. 7. Makers' mark chronologies for *in situ* adobes in Section 3 of Huaca de la Luna. Each chronology begins with the marks of Stage I, the core. Group A shows marks found in subsequent stages of expansion on the north side; Group B includes the marks used in the expansion of the huaca to the south and then west; Group C indicates the marks used in an expansion stage on the west side.

Table 1. Chronologically significant adobe traits of all sampled assemblages in Sol and Luna huacas.

	Adobe Thickness	Frequency of Cane Marking	Frequency of Makers' Marks
H. del Sol			
Section 1	12-18 cm	8% ?	more than 50%
Section 2			
Stage I	8-11 cm	27%	absent
Stage II	8-11 cm	13%	absent
Stage III	12-18 cm	less than 5%	absent
Stage IV	12-18 cm	less than 5%	more than 50%
Stage V	12-18 cm	less than 5%	more than 50%
Stage VI	12-18 cm	less than 5%	more than 50%
Stage VII	12-18 cm	less than 5%	more than 50%
Stage VIII	12-18 cm	less than 5%	more than 50%
Section 4			
Facade	12-18 cm	less than 5%	20%
H. de la Luna			
Section 1			
Stage I	8-11 cm	10%	absent
Stage II	12-18 cm	less than 5%	5%
Stage III	12-18 cm	less than 5%	30%
Section 2	8-11 cm	less than 5%	absent
Section 3	12-18 cm	less than 5%	more than 50%
Section 4			
Court A	8-11 cm	less than 5% ?	absent
Court B	8-11 cm	less than 5%	absent
Court C	12-18 cm	less than 5%	40%
Court D	12-18 cm	less than 5%	more than 50%

6. Three successions of marks in Luna Section 3 appear in Fig. 7. Each of these three shares Stage I, the platform core, followed by expansion stages on different sides of the core that cannot be integrated into a single construction sequence. The groups must overlap, but looting has obscured their structural ties.

In our limited sample the first construction stages with makers' marks contain only four different symbols in Luna Section 1, eight in Section 3, and nine in Sol. Dots, diagonals, and parallel lines are the most common early marks and were employed in different combinations and relationships for later designs. The earlier

Table 2. Types of adobes most commonly grouped together in the Sol and Luna huacas. "Thin" = 8 to 11 cm; "thick" = 12 to 18 cm; "low" = 10 to 30%; and "negligible" means less than 10%.

	Adobe Thickness	Frequency of Cane Marking	Frequency of Makers' Marks
Group 1	thin	low	absent
Group 2	thin	negligible	absent
Group 3	thick	negligible	absent
Group 4	thick	negligible	present

marks tend to be simpler, longer lasting, and more common. Broad, open, curved lines are late, and dot-and-line combination symbols are also absent from the early assemblages.

CHRONOLOGICAL IMPLICATIONS

The distribution of brick characteristics by architectural context is summarized in Table 1. There are four relatively distinct adobe classes: thin cane-marked bricks; thin plain bricks; thick plain bricks; and thick bricks with makers' marks (Table 2). The last class is further subdivided by the absence or presence of open, curved makers' marks.

We believe these brick classes and subclasses represent chronologically distinct phases within the Moche tradition of adobe manufacture. The only class not represented in stratigraphic position in the Sol Section 2 building sequence is thin plain bricks. This adobe class dates relatively early because it was used in Luna Court B, which architecturally predates Court C with its thick bricks and makers' marks. We think thin plain bricks were produced after Sol Section 2 Stage II was completed and while the summit surface was in use, but before the onset of Stage III construction.

The sequence can be correlated, in part, with the Moche style ceramic sequence. The Phase III burial in Sol Section 2 Stage V and the Phase IV burial in Stage VII partly delineate the temporal span of makers' marks. The use of marked bricks started no later than Phase III and was prevalent during Phase IV. The practice had all but died out when the Phase V monumental architecture was built at Galindo.

The utility of the adobe sequence is that it provides chronological ordering for past building activities which cannot be dated by ceramic associations or other traditional approaches. Table 3 summarizes the relative dating of the adobe assemblages we studied at Huacas del Sol and de la Luna.

BRICK PRODUCTION AND USE

Moche adobes lack standardized dimensions. This may relate to the hypothesis that the Sol and Luna huacas were built with a *mit'a*-like labor tax and organizational system. In theory, a community met its tax obligations by sending a work party to build a particular section of construction designated by the governing body of authority. The party made its own bricks, marked them, transported the adobes to the

Table 3. Constructional history of Sol and Luna Huacas. Most of the adobes made during each of the numbered phases are those of the corresponding groups in Table 2. Phase 4 is divided into subphases a and b on the basis of the absence or presence of curved lines in the makers' marks.

Adobe Sequence	Sol Sec. 2	Sol other	Luna Sec. 1	Luna Sec. 2	Luna Sec. 3	Luna Sec. 4	*Ceramic Sequence*
	St. I						
Phase 1:			St. I				?
	St. II						
						Ct. A?	
Phase 2:				all			
						Ct. B	?
Phase 3:	St. III						?
	St. IV						
a:	St. V				St. I		Phase III
	St. VI						
Phase 4:							
	St. VII	Sec. 1	St. II?			Ct. C	
b:					other		Phase IV
	St. VIII	Facade	St. III			Ct. D	

building site, and then laid the bricks up in the assigned skin or construction segment. Presumably, skins and segments were the units by which the tax was measured. The central authority was interested in these finished products and not in the constituent bricks. This left the size and characteristics of the bricks to vary according to predilections of the different groups meeting their tax obligations.

Finally, makers' marks represent the rise and fall of an interesting mnemonic device that correlates both functionally and chronologically with the building of Huaca del Sol. The use of marks arose early in the construction of the platform and remained in common usage during the subsequent building stages. Huaca del Sol was finally completed in Phase IV and makers' marks drop from use in Phase V.

Acknowledgments. Our research was supported by grants from the National Geographic Society and the National Science Foundation. C. B. Donnan first called attention to the potential significance of the Sol and Luna adobes. We have drawn on information collected by Robert Feldman and Theresa Lange Topic, as well as other staff members of the Chan Chan-Moche Valley Project. The assistance of these institutions and individuals is gratefully acknowledged.

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MISCELLANEOUS STUDIES IN HARD-HAMMER PERCUSSION FLAKING: THE EFFECTS OF OBLIQUE IMPACT

JOHN D. SPETH

Steel balls were dropped on to massive glass prisms at an impact angle of 45° in order to determine the effects of oblique impact on several attributes of flake size and flake shape. The results indicate that a flake produced by oblique impact is shorter, but not significantly thinner (except in the immediate area of the cone), than a flake of comparable platform thickness produced by vertical impact.

In two previous papers I presented a model, known as spalling, to account for the major events involved in the production of a flake by hard-hammer percussion (Speth 1972, 1974). A series of simple experiments was undertaken to investigate the relationships between several impact parameters and various attributes of flake size and flake shape, and also to test some of the principal expectations of the spalling model (Speth 1974). In these experiments, steel balls were dropped from an electromagnet on to massive triangular glass prisms. Only the ball size, the drop height, and the distance from the edge of the prism to the point of impact were varied; the support conditions, as well as the mechanical properties and geometry of the prism, were held constant. In all cases, impacts were normal to the largest face of the prism.

This paper reports briefly the results of an additional experiment, using identical glass prisms, to investigate the effects of oblique impact on the same attributes of flake size and flake shape (in particular, the overall form of the flake, the flake length, the platform thickness and the maximum thickness of the flake). The prisms, obtained from World War II surplus tank periscopes, were triangular in cross section (45°-45°-90°); each measures 5.75 in (14.605 cm) in length by 2.188 in (5.56 cm) in width (the hypotenuse of the triangle in section) by 1.094 in (2.778 cm) in height (the height perpendicular to the hypotenuse of the triangle in section). The edges of the prisms are slightly rounded. These bevels had no detectable influence on the experimental results, but they did prevent impacts very close to the edges. All impacts were made on the largest face of the prism at an impact angle of 45°. The percussor was a 5/8 in (1.5875 cm) diameter steel ball dropped by an electromagnet from a height of 19.685 in (50 cm).

Each prism was clamped in a heavy, box-like wooden frame with the largest face or striking platform facing up. Oblique impact was achieved by tilting the support frame. The frame was positioned so that the specimen was situated directly beneath the electromagnet. The ends of the prism fit snugly into triangular