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Site report

MAGNETOMETER SURVEY

AT SAN LORENZO, MEXICO

Winter, 1969

by

Elizabeth K. Ralph

The Olmec site of San Lorenzo Tenochtitlan in the state of Veracrux, Mexico is a suitable one for the detection of ancient monuments with magnetometers because of the fortuituous fact that the Olmecs imported massive basaltic rocks from 80 km away for their construction. Also, this basaltic rock does not occur naturally at the site. Samples of the rocks and earth were first collected by Dr. Froelich Rainey (Director of the University Museum, University of Pennsylvania, Philadelphia) in 1967. These were tested for their magnetic susceptibilities and it was found that the basaltic rocks were extremely magnetic and that the natural earth contained negligible magnetism. These measurements indicated that it should be quite possible to detect all of the ancient monuments with magnetometers.

In collaboration with Dr. Ignacio Bernal (Director of the Instituto Nacional de Antropologia, Mexico), initial trials at the site were conducted in March 1968 on behalf of the Museum Applied Science Center for Archaeology (MASCA) of the University Museum by Dr. Sheldon Breiner and Marvin Harris of Varian Associates (Palo Alto, California). These were extremely successful and in a few weeks of field work 40 anomalies were detected and 4 were confirmed by excavation.

The site of San Lorenzo is not new to archaeologists and has been excavated extensively by Mathew Sterling, Philip Drucker, Michael D. Coe, Richard E. Diehl, Paula Krotser,

Ramond Krotser and Francisco Beverido. However, it was decided that a comprehensive systematic magnetometer survey should be conducted over the entire site to locate all of the remaining monuments. Therefore, the mutual collaboration between the Instituto Nacional and the University Museum was continued in February and March, 1969. The field surveys were conducted by Elizabeth K. Ralph (Associate Director of MASCA) and John Parker (Varian Associates). The Campamento de San Lorenzo was organized and the test excavations were supervised by Francisco Beverido (Instituto de Antropologia de Veracruz and INAH) and assisted by Roberto Gallegos (Ins. Nacl. A.H.).

Two types of cesium magnetometers, (both manufactured by Varian Associates) were used. The basic components of each are a readout and a cesium sensor and both are powered by 30 volt batteries (see Figs. 1 & 2). The designs of the two readouts are quite different. The larger and more sensitive readout is the Model 49-116 which was designed especially for MASCA and was first used in the search for Sybaris in southern Italy (Rainey and Lerici, 1967). With a single sensor, its maximum sensitivity is 0.1 gamma (10^{-6} oersted). It also contains a difference circuit so that two sensors can be used and it is possible to read only the difference between the two. The second sensor, if placed in a fixed position or in a gradiometer arrangement, serves to cancel out external (or diurnal) magnetic changes so that the full sensitivity of the instrument can be utilized. The features and operation of this magnetometer have been described by Ralph, Morrison,

and O'Brien (1968). The difference mode of operation was tried in grids #4 & 5, but it was found that the anomalies at San Lorenzo were sufficiently large so that maximum sensitivity was not required and that the diurnal changes could be ignored. For more practical reasons, its use here was slower because the brush and trees caused difficulties with the long cable leading to the second sensor in a fixed position in the center of the grid. Also, in the midst of grid #5, the second sensor ceased to function. Therefore, subsequent grids made with the Model 49-116 (labeled MASCA Cs on the grids) were with a single sensor and readings appeared in digital form directly in gammas.

The second type of readout (labeled Audio Cs on the grids) is smaller and is not calibrated directly in gammas. It contains a variable oscillator with a scale of 1000 units attached to the variable control knob. In use, the frequency of this oscillator is varied to match the Larmor precession frequency from the cesium sensor. The match is made by obtaining an audio null, or zero beat frequency, and then the dial is read. Each unit on the dial is roughly equivalent to $1\frac{1}{2}$ gammas. This readout is the more suitable of the two for rapid exploration and for pin-pointing the centers of anomalies when it is not necessary to take readings. For doing precise grids, however, the MASCA Cs readout is more rapid to use because there is no need to adjust a dial to take a reading. An experimental dual audio readout system was provided by Varian Associates for trials at this site, but for various reasons, this system did not work. Therefore,

except for grid #4 and part of #5, all grids were made with single sensors.

The procedure in the field was to measure out the base lines of each grid with tape measures and to place stakes at 10-meter intervals. (Where possible, the grids measured 100 by 100 meters.) Then for each grid a 100-meter rope, marked at 2-meter intervals, was strung between the first stakes of the base lines. The man carrying the sensor then moved along the rope, pausing at each 2-meter marker while a reading was taken by a second operator carrying a readout and batteries. Then successive parallel lines were made at two-meter intervals. It was possible for the sensor-man to see the rope markers from a distance of 4 meters so that the rope could be advanced at intervals of 10 meters instead of for every line. Each reading was recorded in a notebook orientated in the same direction as the grid was traversed. At completion, the pages of the notebook were pasted together to form the whole grid.

The locations of the magnetometer grids are shown in Figure 3. When this figure is overlain on the excellent map of the site made by G. R. Krotser (Fig. 4) the relationship between the grids and the features of the site can be seen. The grids in Fig. 3 have been located approximately, but the significant anomalies, more precisely by triangulation. Unfortunately, our main baseline running south from benchmark M3 went askew as we passed over mound 1 before a surveyor's transit was available. Therefore, there is some uncertainty about the locations and exact shapes of grid numbers 10, 11,

13, 15, and 16.

The results of this magnetometer survey are summarized in Table 1, and some of the grids are illustrated in Figs. 5 to 13. In these grids, the line numbers referred to in Table 1 are labelled at the bottom of each. The anomalies are regions of closely spaced contours of equal magnetic intensity. In most cases, contours have been drawn at intervals of 10 gammas (or units). Grid #22 (Fig. 5) is an example of one with no anomalies. It contains a few wiggly contours which represent only natural subsurface or possibly small diurnal changes. The base reading in this and other grids made with the MASCA Cs readout was 43100 gamma, but to save time and space, only the last two digits were recorded. A contour labelled 70, for example, is actually 43170 gamma. Grid #19 (Fig. 6) shows an example of a small doubtful anomaly centered on line 10. It has an intensity of 100 gamma above the base reading, but only in one reading. To the right of this (north in this case) there is a small anti-magnetic reaction represented by a few contours of lower than normal magnetic intensity. Pronounced diurnal changes are also illustrated in this grid by the long, mostly straight vertical east-west contours. These could be eliminated and corrected for by reference readings taken regularly at a fixed position, but since there is no confusion between these long vertical lines and the true anomalies, this extra work is not necessary. Six anomalies were tested by excavation. The anomaly of Grid No. 5 (Fig. 7), excavation No. 1-69 is similar to that of Grid No. 19 and it was a true anomaly in that it represented basaltic

rocks, but only a jumble of small ones. The first exciting find was a large Olmec head, 2.55 meters long (see photo, Fig. 8). This anomaly was detected in Grid No. 9 (Fig. 9). The anomaly is again small in area due to the shallow depth (46 cm) of the monument, but it does contain one very magnetic reading (over 120 units) and two anti-magnetic. In this same grid, the doubtful anomaly in line 2 was excavated (No.3-69) and nothing was found. Presumably then other similar doubtful anomalies of less than 50 gammas can be ignored. The anomaly of Grid No. 13 (Fig. 10) which continues in the adjoining Grid #11 seemed to be more extensive and had a maximum intensity of over 150 gamma, but in a large test excavation (No. 4-69), no basaltic rocks were found. Some reddish and possibly magnetic earth was removed which may account for the anomaly. We are quite sure that the feature could not have been deeper or missed laterly because after the excavation, the anomaly disappeared.

In Grid No. 14 (Fig. 11) many anomalies were, at last, detected. The most pronounced one centered on line 0 was so intense that it was not possible to draw all of the contours at 10 gamma intervals at the grid scale of 1:200. These have, therefore, been drawn at intervals of 50 gamma at a scale of 1:100 as shown in the insert (Fig. 11). Excavation No. 5-69 indicates that these anomalies represent the area of an Olmec workshop.

In Grid No. 16 it was not really necessary to use a magnetometer to find a relatively small torso lying on the surface, but it did produce a magnetic anomaly. Grid No. 17 (Fig. 12) contains two anomalies. Excavation No. 6-69

revealed that the more intense one (lines 48 and 50) was caused by a massive column, probably more than two meters long, lying on its side at a depth of 50 cm. (See photo, Fig. 13).

Summary

In six weeks, over 200,000 square meters were covered in 31 complete grids with readings taken at every 2 meters. It is possible that small monuments at depths of less than 1 meter were missed in the regions covered by grids, but unlikely that large ones have been. In addition, fringe areas and some steep slopes were covered with the Audio Cs (as designated by the hatched areas in Fig. 3) without laying out grids and recording readings. Thirteen grids contained no anomalies. In others 12 doubtful anomalies were detected and 13 good ones. From the test excavations, completed as of March 29, 1969, there were three significant finds - the head, the column, and the workshop.

When on compares these results with the many monuments found in the past as shown on Krotser's map (Fig. 4), one wonders why more were not found with the magnetometers. The most logical explanation seems to be that the site has been excavated so extensively both by archaeologists and by the local population of nearby San Lorenzo Tenochtitlan, that little reamins to be found. Many of the large excavations are still in evidence and in addition, as one walks over the ground all day taking magnetometer readings, one encounters the many small pits made by the "clandestinos."

(Continue to next page for Postscript)

Postscript

A letter from Francisco Beverido Pereau dated April 9, 1969 has just been received from San Lorenzo, and he reports on subsequent excavations as follows:

1) The second anomaly in Grid No. 17, (the grid with the column, excavation 6-69) produced nothing.

2) The anomaly in Grid No. 31 near the Trough Stones represented a stela of green stone harder than serpentine. It is 5.35 m long and 60 cm in diameter and has a light relief that is typically Olmec.

3) The anomalies of Grid No. 18 are both significant. The easternmost one (near the edge of the grid) represented a column of basalt 1.8 m long by 80 cm in diameter, located vertically and associated with two other artifacts of stone in the manner of chairs. The anomaly in the western part of the grid produced a beautiful rectangular plaque, 1 m long and 80 cm wide and 25 cm thick with a low relief similar to the stela found by Michael Coe two years ago in the same location.

This good news from San Lorenzo now brings the total of finds to six, some of which are extremely interesting.

REFERENCES

F. G. Rainey and C. M. Lerici, 1967, The Search for Sybaris, 1960-1965, Lerici Editori, Rome.

E. K. Ralph, F. Morrison, and D. P. O'Brien, 1968, Archaeological Surveying Utilizing a High Sensitivity Difference Magnetometer. Geoexploration, Vol. 6, pp. 109-122.

Table 1. Summary of Magnetometer Survey, Winter 1969

Grid No.	Magnetic Anomalies	Results of Excavation or Interpretation
1	1 doubtful (line 20)	
2	none	
3	none	
4	none	
5	1 good (line 34)	No. 1-69. Consisted of approximately 20 basaltic rocks averaging 2-3 kg. each and found at a depth of about 45 cm.
	1 doubtful (line 60)	
6	none	
7	none	
8	small anomalies in southwest corner	Area of anomalies was recovered in G#14.
9	1 good (lines 8 & 10)	No. 2-69. Large Olmec head, approximately 2.55 m long, lying on its back side, at depth of 46 cm.
	1 doubtful (line 2)	No. 3-69. Nothing found in excavation.
10	1 doubtful (line 34)	
11	1 good (SW corner)	Anomaly at border of G11 & G13, but more pronounced in G13.
12	none	
13	1 good (SE corner)	No. 4-69. No basaltic rock found, but there was reddish earth which was probably magnetic
14	1 large & intense and many smaller ones surrounding it	No. 5-69. Appears to be the site of an Olmec workshop and contains many basaltic rocks.
15	1 large & intense (lines 20 to 30)	Anomaly previously detected by S. Breiner in 1968. Excavation revealed massive stone slab.
	1 doubtful (line 38)	
16	1 small (line 84)	Small torso found on surface of the ground.

Table 1. Continued

Grid No.	Magnetic Anomalies	Results of Excavation or Interpretation
17	1 very intense (lines 48 & 50)	No. 6-69. Large column, at least 2 m long, lying on side at depth of 50 cm.
	1 less intense (near old excavation pit)	
18	1 very intense (east end line 36)	
	1 less intense (west on lines 36 & 38)	
	1 intense but small (line 22)	Large stone, excavated previously.
	Several additional doubtful ones	One visible rock. No anomaly from visible section of drain.
19	1 doubtful (line 10)	Example of unusually large diurnal changes.
20	1 small (line 36)	Two meters away from large slab excavated previously.
21	none	
22	none	Example of negligible diurnal changes.
23	none	
24	none	
25	none	
26	none	Very small reaction of small excavated monument.
27	1 doubtful (line 18 W)	
28	none	
29	1 doubtful (line 10)	
30	none	
31	1 good	

FIGURE CAPTIONS

Fig. 1. MASCA cesium magnetometer in use at San Lorenzo.

Fig. 2. Varian Associates audio cesium magnetometer in use at San Lorenzo.

Figs. 3. & 4.

Fig. 3. Map of locations of magnetometer surveys overlain on

Fig. 4. Map of San Lorenzo site made by G.R. Krotser, 1967 edition.

Notes: Outlines and numbers of magnetometer grids are shown. Hatched regions are areas which were covered with the audio cesium magnetometer without laying out grids.

The two maps were related by the benchmarks as designated by M, N, X symbols.

Fig. 5. Magnetometer Grid #22.

Fig. 6. Magnetometer Grid #19.

Fig. 7. Magnetometer Grid #5.

Fig. 8. Olmec head, Excavation 2-69, Grid No. 9.

Fig. 9. Magnetometer Grid #9.

Fig. 10. Magnetometer Grid #13.

Fig. 11. Magnetometer Grid #14.

Fig. 12. Magnetometer Grid #17.

Fig. 13. Column, Excavation 6-69, Grid #17.

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Remote Sensing and Interpretation

Magnetic Survey and Excavation Results
San Lorenzo Tenochtitlan
February-March, 1970
Marvin Harris/Sheldon Breiner

The San Lorenzo Survey of 1970 started 19 February. On Friday, 20 February, we went out looking for some of the anomalies that we knew were there from the results of the preceding two years.

1. The first one we found was on the south central ridge and it turned out to be somewhat insignificant. The location was at the isthmus; the anomaly turned out to be due to a stone about 6 inches across which was a metati stone, volcanic but with more magnetic effects than most of the other stones from which the monuments were made. It gave us large readings but it was very small itself, a depth of one-half meter.

2. A few minutes later we ran across another one that was further south on the same ridge, south of the isthmus and which was also a metati stone, also about 6 inches across.

3. Then we searched the area more thoroughly and at a point 20 meters northeast of monument 18, we got another reading - much broader - indicating it was deeper and a weaker reading. Although after we dug it, we found that it was a bench approximately 1 meter long and about on-half meter high, with legs, and made in an "L" shape. No markings of any kind appeared on the bench. It was on the edge of the flat, a little south-southeast of the isthmus, on the south central ridge.

4. The next monument that gave large readings was what we call monument 60 located approximately 80 meters southeast of the big altar discovered in 1968. This monument, however, turned out to be a small altar or at least that is what we called it. It was a large rock about 1-1/3 meters high, probably 1 meter in diameter, and buried 3.8 meters to its bottom. It was a square, large rock that had been rounded at the corners. No carvings were obvious, but there was a small notch or square-cut with 90^{o} angles cut in one side of the rounded top.

5. The most significant find was the next monument we found, number 61, another large head, with an estimated weight of approximately 10 tons or more. It was at a depth of 4 meters and was found lying on its left side with the front of the face pointing southwest. The head was much more beautiful than the other heads, primarily because it was not very weathered. It was not defaced with marks like the other heads were, either. It also looked like more effort went into the carving of such features as the lips, the nose, and all features of the face were more pronounced. It appeared to be a larger head, I think, than monument 17 located near the isthmus. It was located approximately 30 meters southeast of the lagoon where the horses watered, that is, immediately east of the drains and the rain god found in 1968.

6. In the lagoon to the northwest of the head we began digging over readings which indicated a deep anomaly. However, we ceased the digging because of the water problem in the lagoon at very shallow depths.

7. Another monument that we found was a large disk, monument 64, almost directly south of the large head at a distance of perhaps 150 meters. It was a disk approximately 2 meters in diameter and 1/3 meter thick with a fairly flat surface. It had several major cracks through the entire disk. The markings consisted of two straight parallel lines, like cords, symmetric about a diameter which enclosed about half the area of the circle. Around one circumference at one end of the cord-enclosed area, there were several depressions somewhat equally spaced which could either be a design or defacing marks. At the other circumference of this cord-enclosed area were zig-zag lines which appeared to be some sort of design. The disk was buried approximately 1/3 meter deep to the top of its surface on the eastern slope of the southwest ridge down the side of the ridge approximately 20 meters.

8. Another monument which we found but which did not appear to be very significant, we called monument number 62. It was next to the big head directly to the southeast and was another stone that appeared to have been worked by man. It was flat on the bottom, slightly rounded, but we did not dig the stone clear to see what it actually was. We could see no carving, it was fairly small, with the edge of the stone perhaps one meter from the edge of the big head but buried at a high level such that the bottom of the stone was approximately the same elevation as the top of the head.

9. On the south central ridge we found another stone, monument 63, almost round and more or less egg-shaped, approximately 1-1/3 meters in its longest dimension. It was in grid number 27 in the western part of the south central ridge, a little north of the central part of the ridge and on the west side.

10. In grid number 14, there appeared to be rocks of many types with numerous magnetic anomalies as they appear on the grid number 14. It was as if the inhabitants used that area for dumping their chips and their rocks that they used for cutting other monuments or remnants of other monuments. This littered area includes all of northern grid 14, the southwest portion of grid 8, and the northwest corner of grid 10, all of which is heavily covered with anomalies. Digging out some of these which were near the surface turned out to be rocks which ranged between 10 and 50 centimeters across with no definite shapes, as if they were just broken fragments. I found 25 different variations of the rocks consisting mostly of volcanics, quartzite and perhaps a few igneous rocks. Approximately half of them were magnetic which we checked by moving the samples near the magnetometer. Most of the magnetic rocks were very strongly magnetic, the same as the metati stone. We took samples from all of the monuments and made magnetic checks on these rocks to note that there was quite a difference between the magnetic properties of the different monuments.

11. I found another anomaly on Group D ridge on the west end of the south edge of the ridge. This anomaly might be worth digging - perhaps 1 meter deep and 1 meter across in size.

12. We went to the end of the southeastern ridge and walked back. There seemed to be a lot of metal trash on the trail, pieces of wire, etc., but I did observe a large anomaly in about the center of that area where the ridge is very narrow, east of grid 28 and near where the isthmus appears across the arroyo.

The head that was discovered last year, monument 53 at the north end of grid 9, was a head that was very badly defaced and full of holes that was found less than 1 meter from the surface. Also last year, a hole was dug in the northwest ridge to find a large monument which turned out to be a large rock with no carvings.

I have photographs of all the monuments uncovered this year and have noted their locations approximately on one of the published topographic maps of the area. Getting around and getting permission to explore in many of the areas on the mesa is very difficult because the land has been sub-divided

and given to the villagers. Many of them have refused to allow archaeologists on the property, others have planted corn, in other areas the jungle is very thick and new fences appear everywhere. The south central ridge is planted in corn, the southwest ridge is still jungle.

The instruments required repair on many occasions with only one sensor surviving in operable condition after parts from the other sensor were utilized. The only way the remaining cesium magnetometer could operate was by removing the heater card from the sensor electronics. The ambient temperature and the lamp temperature was sufficient to keep it operating. The audio reading magnetometer was the only model utilized in this year's work and proved very useful.

A Dr. Winnie attempted to reach me by telephone from Chapala, Jalisco. He wanted to know if I could come to Guadalajara for some work, however, he did not make contact with me to arrange for such a test. I returned 16 March.

Report by Marvin Harris, Written by Sor

cc: Dr. Froelich Rainey
Dr. Michael Coe

Sent by:
Howard Wyant
316 Gerard Ave.
Elkins Park, Pa.
19117
(shaky handwriting)

Reports

Olmec Civilization, Veracruz, Mexico: Dating of the San Lorenzo Phase

Abstract. *Archeological excavations at San Lorenzo Tenochtitlan, Veracruz, show that the Olmec sculptures of this zone are associated with the San Lorenzo phase, which can be placed in the Early Formative period (1500–800 B.C.) on the basis of ceramic comparisons. Five of six radiocarbon dates for the San Lorenzo phase fall within the 1200–900 B.C. span. The San Lorenzo phase therefore marks the beginning of Olmec civilization, and the sites forming the San Lorenzo Tenochtitlan group represent the oldest civilized communities known in Mexico or Central America.*

The Olmec civilization of Mexico was discovered by Stirling, who excavated several sites in southern Veracruz and Tabasco between 1939 and 1946. The size of great Olmec ceremonial centers like La Venta, the gigantic proportions of some Olmec sculpture, and the sophistication and delicacy of the art style have convinced some scholars, mainly Mayanists, that this civilization could not be older than that of the Maya. On the other hand, Stirling and certain Mexican archeologists—principally Caso and Covarrubias—have claimed the Olmec civilization to be the oldest in all of Mesoamerica (*1*). This claim was substantiated by the excavations carried out at La Venta in 1955 by the University of California; a number of radiocarbon dates from that ancient center showed that La Venta was constructed and occupied from about 800 B.C. through 400 B.C., roughly contemporary with what has been called the Middle Formative period. It predates the earliest Maya civilization by several centuries (*2*).

The first of three seasons of field work at the Olmec sites collectively known as San Lorenzo Tenochtitlan (Fig. 1), in southern Veracruz, was begun in January 1966. The aims of this project are (i) to discover the origin and nature of Olmec civilization in this zone, (ii) to provide a means of dating the Olmec monuments, and (iii) to throw light on ancient human ecology and agricultural practices in the humid tropics.

We know of only three major archeological sites in the zone. Tenochtitlan is the largest and is located just to the south of the bank of the Río Chiquito, an arm of the Río Coatzacoalcos; the site has long mounds arranged in linear fashion like La Venta. San Lorenzo is much smaller, with fewer and lower mounds, and is placed on a much dissected plateau about 2.5 km south of Tenochtitlan. The third, Potrero Nuevo, is the smallest and lies some 3 km south-southeast of San Lorenzo. All three were explored by Stirling and Drucker in 1946 (*3*); the collections from these excavations are only now being studied at Yale (*4*). Most importantly, they brought to light a large number of fine Olmec sculptures, including the largest colossal heads yet discovered—enormous, freestanding, basalt sculptures believed to be portraits of Olmec lords. San Lorenzo alone produced 15 monuments, most of which were found in, or on the slopes of, ravines which cut into the plateau.

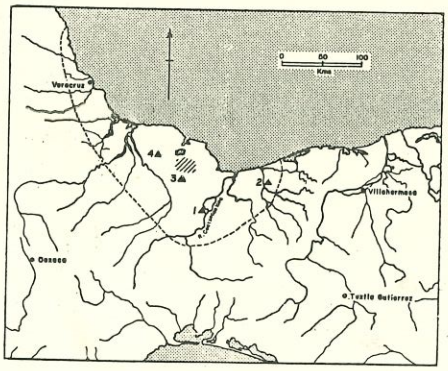

Fig. 1. Important Olmec sites of southern Veracruz and Tabasco. *1*, San Lorenzo Tenochtitlan; *2*, La Venta; *3*, Laguna de los Cerros; *4*, Tres Zapotes. The broken line encloses the Olmec "heartland" in which large-scale stone monuments are found. The source of the basalt used in the San Lorenzo Tenochtitlan sculptures is indicated by hatching.

Several additional monuments were found in the intervening years. In 1966 we excavated three more at San Lorenzo in an attempt to establish the stratigraphic record, that is, to associate the sculptures with a cultural phase which could be dated by normal methods, such as cultural comparison and radiocarbon analysis. Monument 19 was deeply buried on the edge of a precipitous ravine on the southeast side of San Lorenzo, and proved to be a badly damaged head. Monument 20, sunk deep into the ground on the northwest edge of the site, is a large "altar," with a figure sitting in a niche and holding a were-jaguar baby. The monument was definitely correlated with strata and pits rich in potsherds and figurines. Monument 21 was discovered with one of its corners protruding from the surface at the head of a small ravine. On excavation, it proved to be a rectangular block of stone with the back hollowed out; the obverse shows a relief of a running animal, perhaps a jaguar or coyote. It had been placed facedown over an offering of seven stone celts and blanks for celts, all of serpentine, along with large fragments of pottery vessels and charcoal. The "destruction" of the San Lorenzo monuments was not a haphazard affair but was carefully planned, with a good deal of ritual activity. When was this carried out and by whom? We have at least a partial answer to the first of these questions.

Stratigraphic cuts were also made in the riverbank at Tenochtitlan, where the present-day Río Chiquito has cut through a deeply stratified succession of village materials, which reach down to almost 6 m below ground level. It was here that Drucker in 1946 found two great stone columns at the deepest level excavated.

All of the pottery and other artifacts from the 1966 season have now been studied. There are only two archeological phases or cultures detectable in the San Lorenzo Tenochtitlan group; they are separated from each other by a very long period of abandonment. The later phase, which we are

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See "Sources of stones used in prehistoric mesoamerican sites" #1 Sept 65.

Table 1. Dating of samples of wood charcoal from stratified hearths of the San Lorenzo phase, taken from the riverbank cut at Tenochtitlan, Veracruz, Mexico. B.P., before present.

Sample	Source (hearths)			Date
	No.	Level	Cut	
Y-1797	3	10	1	3010 ± 80 B.P. (1060 B.C. ± 80)
Y-1798	1	12	1	3100 ± 140 B.P. (1150 B.C. ± 140)
Y-1799	4	14	1	4100 ± 80 B.P. (2150 B.C. ± 80)
Y-1800	4	18	1	3050 ± 100 B.P. (1100 B.C. ± 100)
Y-1801	1	H	4	3090 ± 80 B.P. (1140 B.C. ± 80)
Y-1802	From hearth series associated with deposits of whole and broken pottery vessels of the San Lorenzo phase			2870 ± 140 B.P. (920 B.C. ± 140)

calling Villa Alta, falls at the very end of the Late Classic period (about A.D. 800–900) and is similar in many ways to the coeval occupation of Tres Zapotes (*5*). Both contain much fine orange-paste ware and hollow, mold-made figurines of Mayoid appearance. It seems probable that much of the mound construction at Tenochtitlan (but not at San Lorenzo) dates to the Villa Alta phase.

But it is the earlier occupation with which we are most concerned, for this is purely Olmec. We have named it the San Lorenzo phase, since that site seems to have been occupied mainly at that time. With the exception of the uppermost meter (belonging to the Villa Alta phase), the village materials exposed in the riverbank below Tenochtitlan were also laid down in San Lorenzo phase. Briefly, the pottery of San Lorenzo is extraordinarily similar to that of the Cuadros phase on the Pacific coast of Guatemala, which has been dated by the radiocarbon method to 1000–850 B.C. (*6*), and to the Chiapa I or Cotorra phase of Chiapas which has a radiocarbon age of 3010 ± 100 years (GRO-774) (*7*). These cultures share such specific features as a preponderance of tecomates (neckless jars), the use of interior finger-punching or dimpling on the walls of these tecomates, plain rocker-stamping, zoned red decoration, and deep bowls with exteriorly bolstered rims. These traits strongly suggest that the Olmec occupation at San Lorenzo Tenochtitlan is concomitant with the Early Formative period (1500–800 B.C.), and probably falls within the latter half of that period.

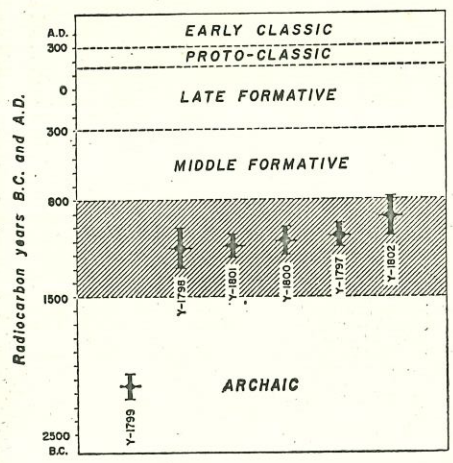


Fig. 2. Radiocarbon dates from the San Lorenzo phase, with 1-sigma deviations. The hatched area indicates the span covered by the Early Formative period.

The Olmec nature of the San Lorenzo phase is revealed by the presence of hollow, baby-faced, pottery figurines (some of which are identical with the large examples from Las Bocas, Puebla) (*8*), and by the deep excising of the typically Olmec jaguar-paw-wing motif on pottery vessels (*9*). But, apart from this, the monuments which we excavated at the San Lorenzo site are all unquestionably associated with offerings and debris of the San Lorenzo phase alone. Stone monuments cannot be directly dated by the radiocarbon method, but the associated culture can be. Six wood charcoal samples from stratified hearths of the San Lorenzo phase, all from the riverbank cut at Tenochtitlan, have now been analyzed at the Yale Radiocarbon Laboratory (Table 1). These dates show a high degree of internal consistency, with the exception of Y-1799 which may well be contaminated with pieces of asphalt (of which lumps appeared in every one of our excavations) and should thus be disregarded (*10*). Converting these figures into radiocarbon years of our calendar (by subtracting them from A.D. 1950), there is a high degree of probability that the radiocarbon date of the San Lorenzo phase—and the famous Olmec monuments of the zone—lies between 1200 and 900 B.C. (Fig. 2); this date confirms our pottery analysis which suggested an Early Formative placement. Of course, if one is to consider the "true" age for the San Lorenzo phase (which must be done when comparing the C^{14} dates with time scales based upon other methods), then a correction must be made for the estimated fluctuations of the C^{14} activity of atmospheric CO_2 with time (*11*). In this case, the "true" sample age of Y-1801 might be on the order of about 3300 years B.P. (1350 B.C.).

Therefore, the Olmec monumental style of the San Lorenzo Tenochtitlan group cannot be later than 900 or 800 B.C. This date reverses the usual scheme and puts San Lorenzo at the beginning, not the end, of the Olmec development. We have, therefore, found the oldest civilized communities thus far known in Mesoamerica. Nonetheless, by pushing back the earliest Olmec civilization to such an early date—to a time when there was little else but simple village cultures in the rest of Mexico and Central America—the lack of antecedents is an embarrassing problem. We now have no idea where the Olmec came from who built the mounds and carved the sculptures of San Lorenzo. Whoever they were, these pioneers must have been unusually gifted in engineering as well as art, for it has now been shown that the basalt from which these great monoliths were fashioned came from the slopes of the Cerro Cintepec in the Tuxtla Mountains, far to the northwest of San Lorenzo Tenochtitlan (*12*). They must have been floated on rafts down to the Gulf of Mexico and along the coast to the mouth of the Río Coatzacoalcos, and dragged from the river up to the San Lorenzo plateau with ropes (*13*).

We do not yet know why the San Lorenzo Tenochtitlan group was abandoned near the close of the San Lorenzo phase. We now speculate (i) that there was a transfer of some monuments (the rest being ceremonially abandoned) and presumably leaders to La Venta, which at about 800 B.C. became the new Olmec supreme center; (ii) that there was a simultaneous movement of Olmec groups to the Mexican highlands, particularly to Puebla and Morelos, and across to the Pacific coast of southeastern Mesoamerica; (iii) that La Venta was in turn destroyed or abandoned after 400 B.C.; and (iv) that in the Late Formative period there was the final flicker of a civilization which could now barely be called Olmec at the site of Tres Zapotes.

MICHAEL D. COE
Department of Anthropology, Yale University, New Haven, Connecticut
RICHARD A. DIEHL
Department of Anthropology, Pennsylvania State University, University Park
MINZE STUIVER
Radiocarbon Laboratory, Yale University

Table I. Continued

— = computer plot

Increase

Grid No.	Magnetic Anomalies	Results of Excavation or Interpretation
17	1 very intense (lines 48 No. 6-69. & 50)	Same lying on side at depth of 50 cm.
→	1 less intense (near old excavation pit)	same Excavated - nothing nothing
18	1 very intense (east end line 36)	Column 1.8m x 80 cm, vertical same
	1 less intense (west on lines 36 & 38)	same Rectangular plaque, 1m. x 80cm x 25 cm
	1 intense but small (line 22)	same Large stone, excavated previously.
	Several additional doubtful ones (=)	2 doubtful One visible rock. No anomaly from visible section of drain.
19	1 doubtful (line 10)	2 doubtful Example of unusually large diurnal changes. 1 d
20	1 small (line 36)	same Two meters away from large slab excavated previously.
21	none	none
22	none	none Example of negligible diurnal changes.
23	none	2 small (on edges) 2 d
24	none	none
25	none	1 doubtful 1 d
26	none	same Very small reaction of small excavated monument.
27	1 doubtful (line 18 W)	same
28	none	none
29	1 doubtful (line 10)	same
30	none	none
31	1 good	Stela of green stone

g d

IIII IIII I

Totals - Hand Plot

good 30

doubtful 15

Grids with None 14

Computer plot increase Total → 11 doubtf

1 good

— = computer plot

E K Ralph

Table 1. Summary of Magnetometer Survey, Winter 1969

Computer plot

Grid No.	Magnetic Anomalies	Results of Excavation or Interpretation
1	1 doubtful (line 20) 2 very small	1 similar, 2 very small
2	none	none
3	none	none
4	none	1, 1 doubtful
5	1 good (line 34)	1 No. 1-69. Consisted of approximately 20 basaltic rocks averaging 2-3 kg. each and found at a depth of about 45 cm.
	1 doubtful (line 60)	1 doubtful
6	none	none
7	none	none
8	small anomalies in southwest corner	Area of anomalies was recovered in G#14. same, more pronounced
9	1 good (lines 8 & 10)	1 No. 2-69. Large Olmec head, approximately 2.55 m long, lying on its back side, at depth of 46 cm.
→	1 doubtful (line 2)	← 1 - looks more promising, but nothing there No. 3-69. Nothing found in excavation.
10	1 doubtful (line 34)	4 small but clear anomalies - marginal
11	1 good (SW corner)	1 good 1 smaller Anomaly at border of G11 & G13, but more pronounced in G13.
12	none	none
→ 13	1 good (SE corner)	1 good 2 small No. 4-69. No basaltic rock found, but there was reddish earth which was probably magnetic
14	1 large & intense and many smaller ones surrounding it	No. 5-69. Appears to be the site of an Olmec workshop and contains many basaltic rocks. same number but clearer possibly 20 anomalies
15	1 large & intense (lines 20 to 30)	same Anomaly previously detected by S. Breiner in 1968. Excavation revealed massive stone slab.
	1 doubtful (line 38)	1 small (illegible)
16	1 small (line 84)	same Small torso found on surface of the ground.

1 incense

1 g 1 d

3 d

1 d

2 d

TTH NN III

+20

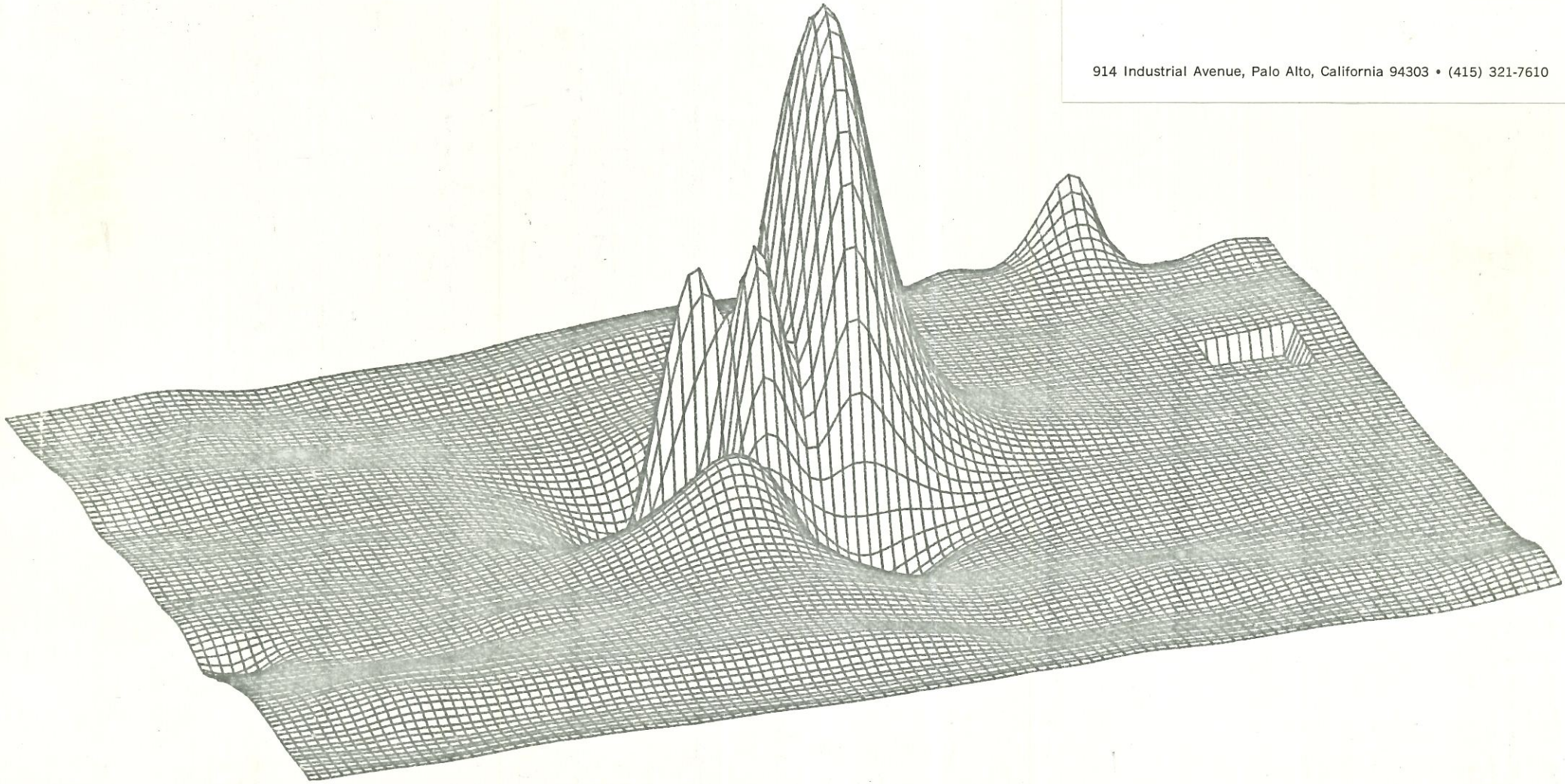
Anomaly from altar at San Lorenzo

geoMetrics

SHELDON BREINER
President

Remote Sensing and
Interpretation

914 Industrial Avenue, Palo Alto, California 94303 • (415) 321-7610



Beta for your file

CESIUM MAGNETOMETER PROBLEMS ENCOUNTERED IN MEXICO, February to March, 1969 by Elizabeth K. Ralph.

University of P nnsylvania Precision Portable Cesium Magnetometer Model 4920

1 Readout no. 49-116-90 o.k.

1 Readout no. 49-116-93
Three Shelly lights (which form the numbers) don't work and the difference circuit may be unstable.

1 Cesium Sensor No. 49-544-93 o.k.

1 Cesium Sensor No. 49-544-90
Sensor became inoperable in hot weather and then ceased to function even at 70° F. ambient temperature. Suspect thermistor and associated temperature control circuits are bad or out of adjustment.
This sensor was repaired by Varian Associates, order date 1/2/69, Order No. 31-51071K, U of Pa No. 80877.

30-volt battery pack -- purchased from Varian Associates about September 1, 1968. Batteries were found to be old and used up.

Varian Associates Experimental and Rental Equipment

Supplied:
2 V-4971 portable search magnetometers, serial nos. 130 and 198 which included 2 sensors, 2 audio readouts, 3-1/3 battery packs and 2 battery chargers
2 transistor radio receivers
1 prototype coupler mixer
various spare parts

Cost to U of Pa:

Salary for John Parker (not a regular Varian technician nor any training for fieldwork, but a good worker)	$2400
2 months lease of above equipment	3000
Travel and expenses of technician	600
Total:	$6000

/contd...

Results:

Experimental Differential System

This idea was good, but both the planning and construction were incomplete. Also, hardly any of the components operated in warm temperatures, even 80°F. To be practical in the field, an additional set of transmitter and receiver were required to direct the movable sensor carrier. The equipment supplied had been thrown together in great haste and was not rugged enough for field use. Also, the numerous components in small boxes were awkward to carry. The heat affected the signal receivers, the mixer operated erratically, and the base sensor drifted at first, then ceased to function.

Single Sensor model V-4971

The only components which functioned with out drift or complete breakdown were the unmodified audio readout and one of the sensors (the small one). Fortunately, these comprised a single sensor magnetometer assembly. However, there were difficulties with these.

Audio readout:

Required daily tuning and the control of the tuning capacitor is difficult to reach without removing the case--no external control knobs provided. The circuit cards were mounted too far into the chassis causing short circuits and broken connections.

Sensor

Heater did not shut off when sensor reached operating temperature. Therefore, it was necessary to open the case of the sensor electronics and remove the heater card every day after initial warm-up. Sensor ceased completely when temperature was above 95° F. Sensor head was hotpwater proofed and had to be disassembled and dried every time it rained.

University of Pennsylvania Requirements from Varian Associates for field work, spring and summer, 1969

Repair of Cesium Sensor No. 49-544-90 (now at Varian)

Possible repair of Readout No. 49-116-93 (now at U. of Pa.) if it does not operate stably after replacement of Shelly lights.

Return of U. of Pa. demountable sensor staff and housing which has been lost at Varian Associates for more than six months.

Loan or gift of one complete V-4971 search magnetometer (now at Varian) including:

1 audio readout, checked for stability in heat.
1 cesium sensor with demountable staff, also checked for stability in heat
1 battery charger with provision for fast and slow charging.

varian
611 hansen way/palo alto/california
REPRESENTATIVE

REFER TO: ☐ RECORDER DIV. ☐ INSTRUMENT DIV. ☐ QUANTUM ELECTRONICS DIV. ☐ ANALYTICAL INSTRUMENT DIV.
AND THIS NUMBER ON ALL CORRESPONDENCE

SHIP AND/OR CHARGE TO
University of Pennsylvania, Museum
33rd & Spruce Streets
Attn: Miss Ralph
Philadelphia, Pa. 19104

CHARGE TO (IF DIFFERENT THAN SHIP TO)
University of Pennsylvania
Purchasing Department
Philadelphia, Pa. 19104

ORDER NO. 31-51071K
ORDER DATE 1/2/69
TERMS NET 30 DAYS

CUSTOMER PURCHASE ORDER NO.	GOVERNMENT CONTRACT NO.	PRIORITY	INV.	F O B	SHIP VIA
80877			2R	PALO ALTO	Air Express Prepaid

CUSTOMER CODE	TERRITORY CODE	TPR	CLASS	SHIP BY	SHIPMENT DATE	INVOICE NO.
102940	52-3	1	99-371	1/2/69		

ITEM	PRODUCT CODE	Quantity Ordered	CATALOG NO. AND DESCRIPTION	SERIAL OR PART NUMBERS	UNIT PRICE	Balance on Order	Quantity Shipped	AMOUNT
1	370-99950 (20)	1	Order to cover services of Varian Associates service engineer for 10 hours at $15.00 per hour. Non Warranty Repair 49-544 Ser. 490 Cesium Oscillator.		$150.00			

PACKING LIST

BOX OR PACKAGE QTY	BOX OR PACKAGE SIZE	WEIGHT GROSS LBS	WEIGHT GROSS KILOS	WEIGHT LEGAL LBS	WEIGHT LEGAL KILOS	WEIGHT NET LBS	WEIGHT NET KILOS	ITEM NOS	CUBE FT.

SALES TAX
TRANS.
INVOICE TOTAL $

SPECIAL INTERNAL INSTRUCTIONS ONLY

Code: 200 INS
RMR# 18653

☐ CHANGED
☐ CANCELLED

rh

346-9-3 REV. 6/67

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LEGEND

CONTOUR INTERVAL 2 FEET
SITE MERIDIAN —·—·—
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REFERENCE POINT ⊙
RECENT DISTURBANCE -------

LA VENTA

TABASCO, MEXICO

AN OLMEC CEREMONIAL CENTER

COMPLEX C

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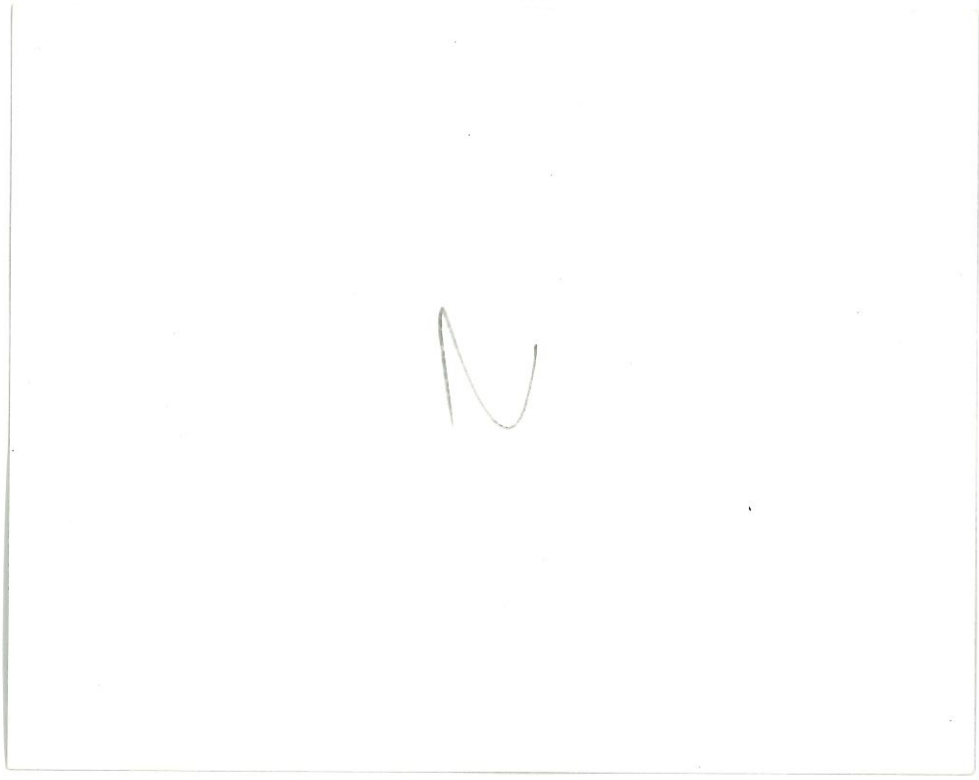
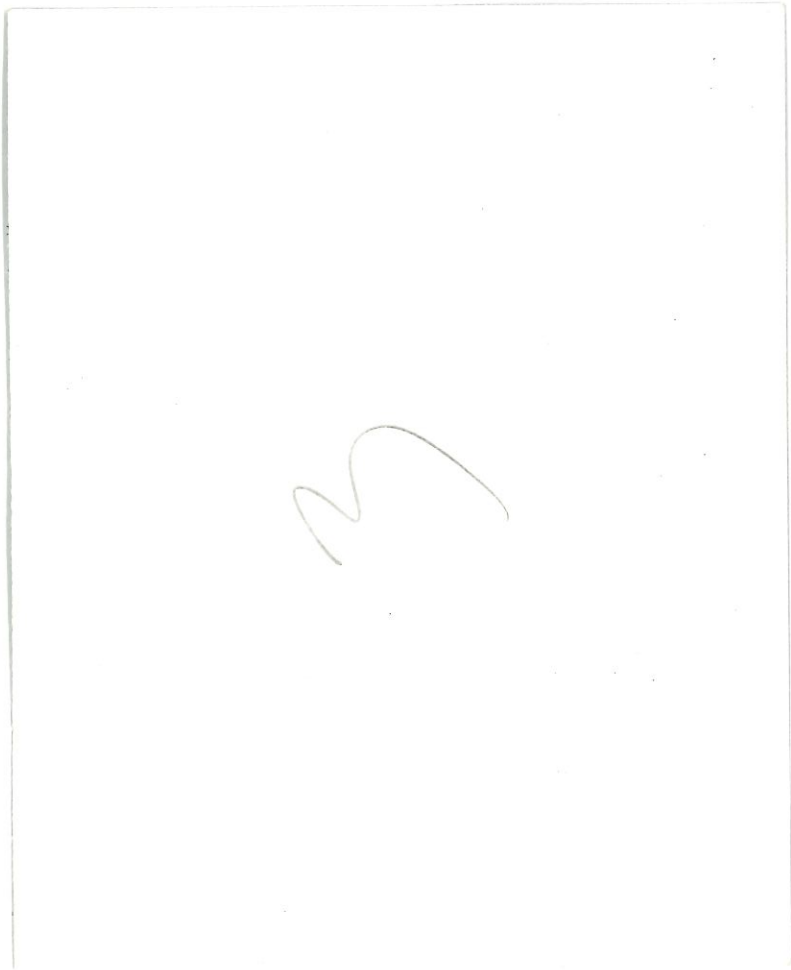
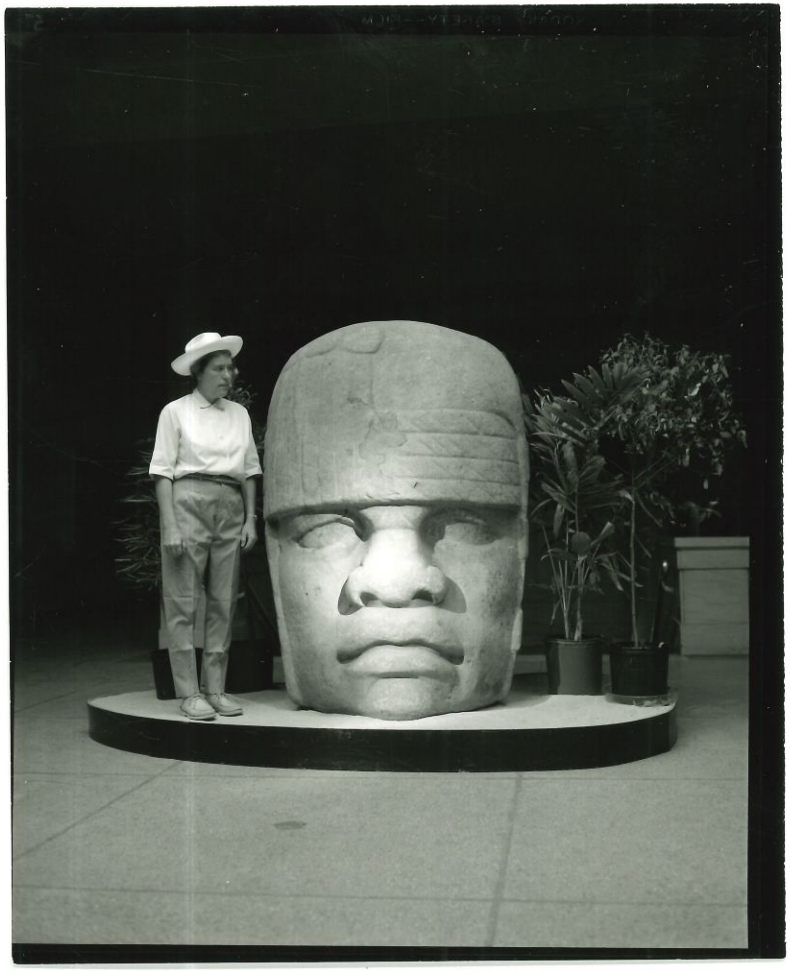
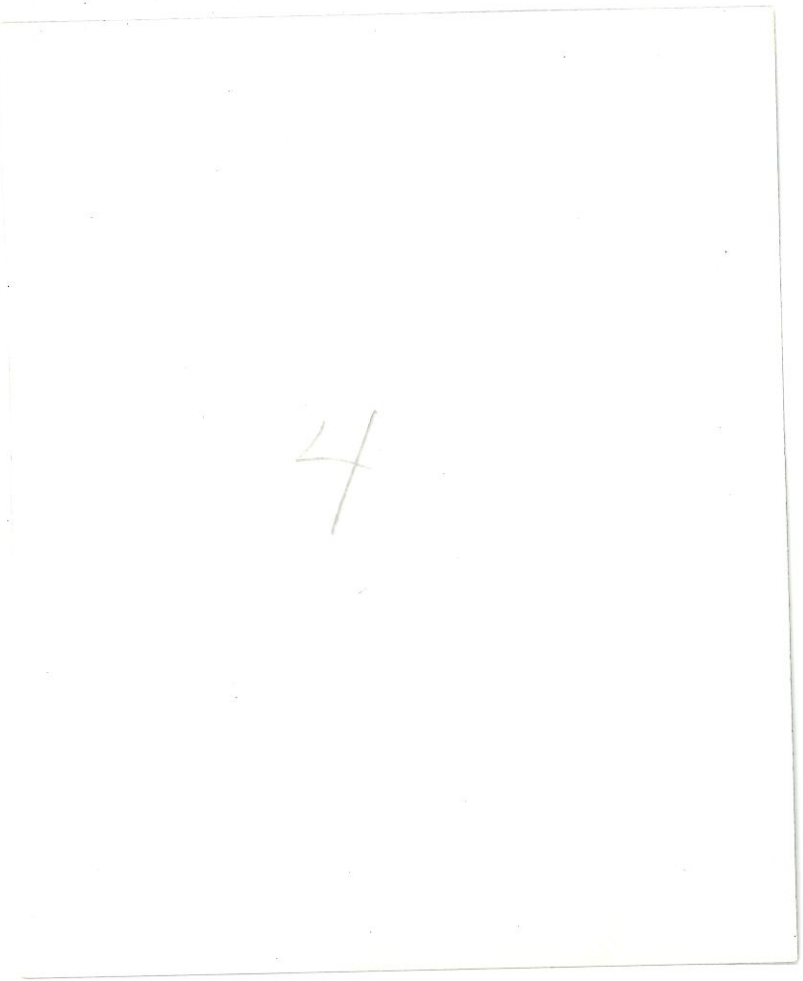
SAN LORENZO

OLMEC 1971
HEAD
+ RALPH





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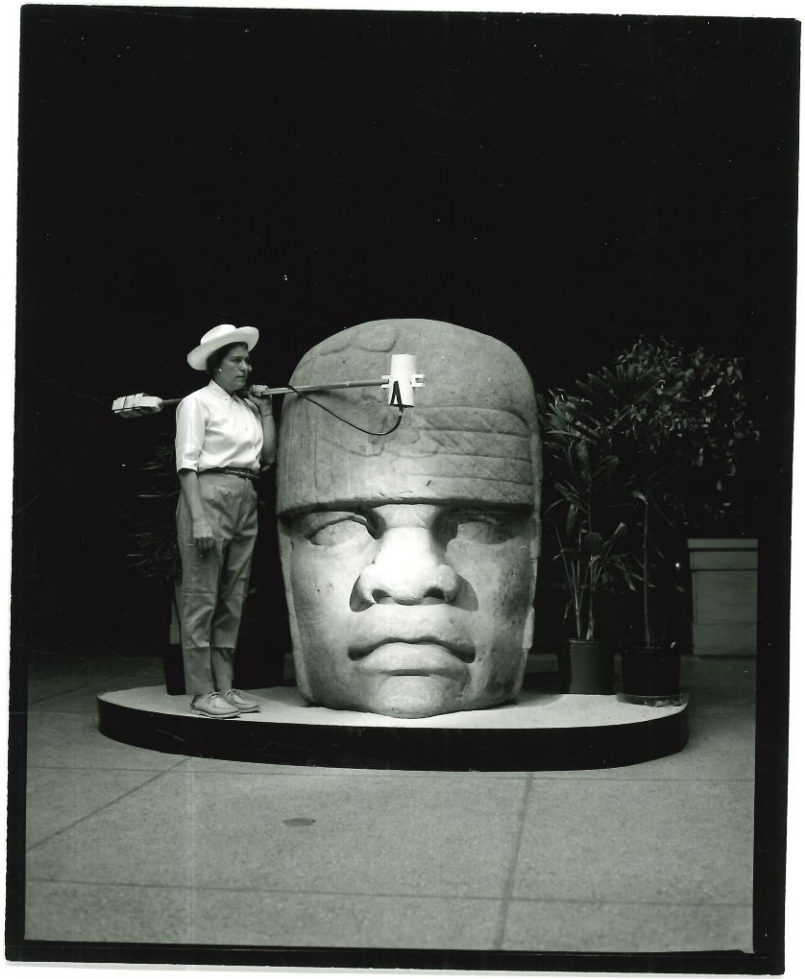

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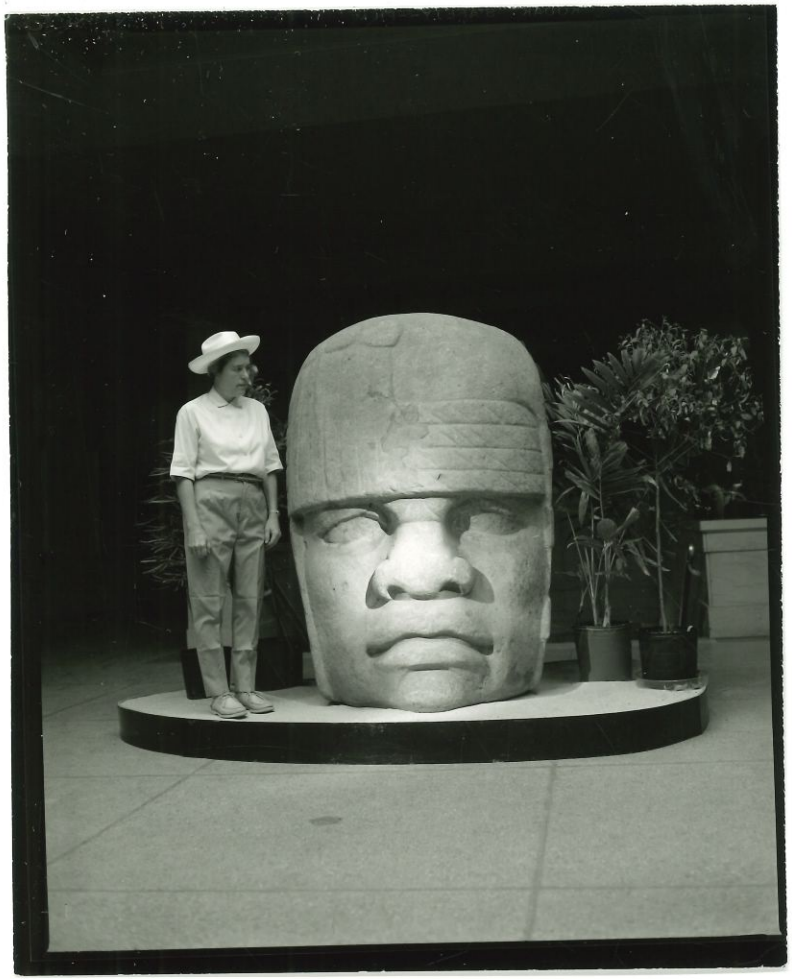

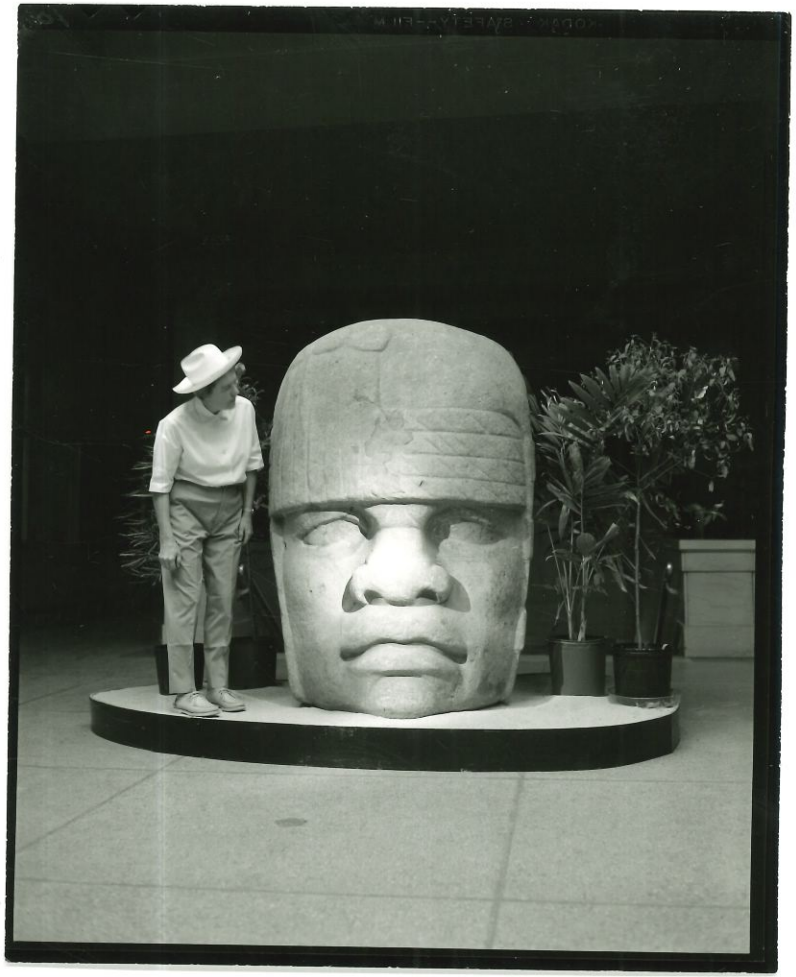

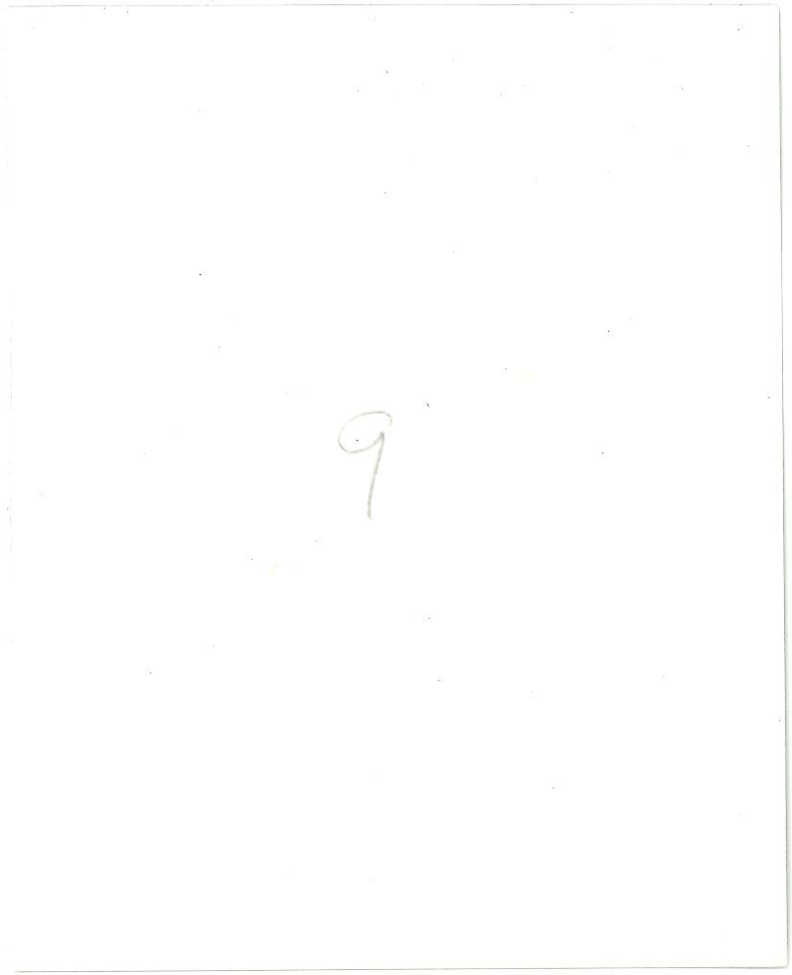
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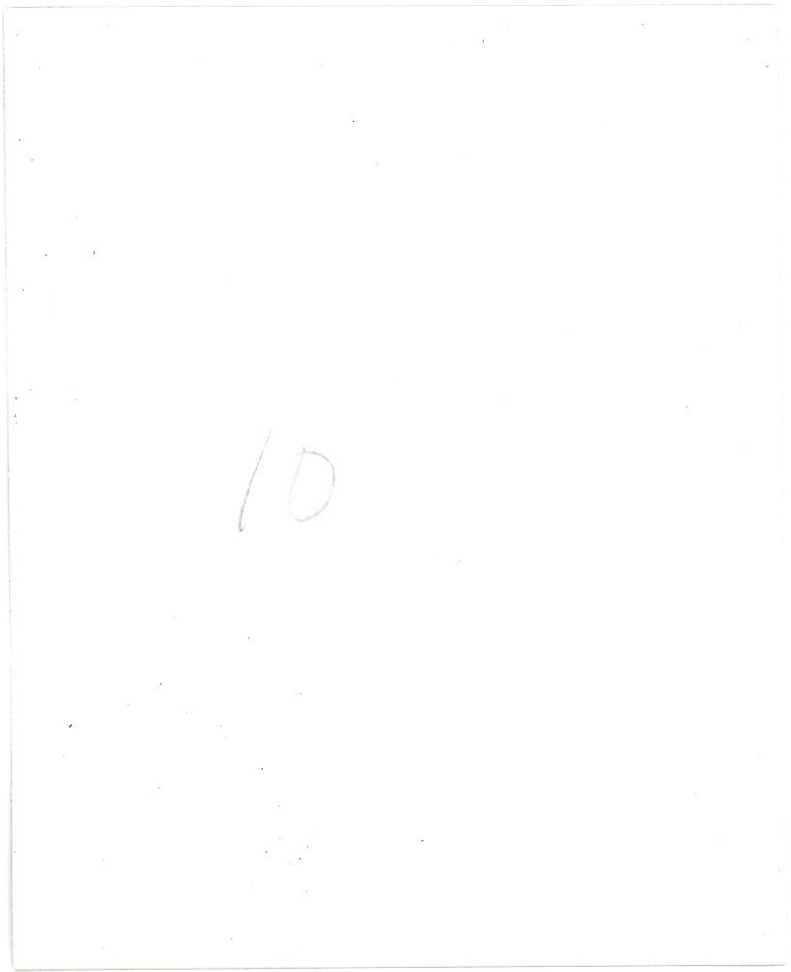
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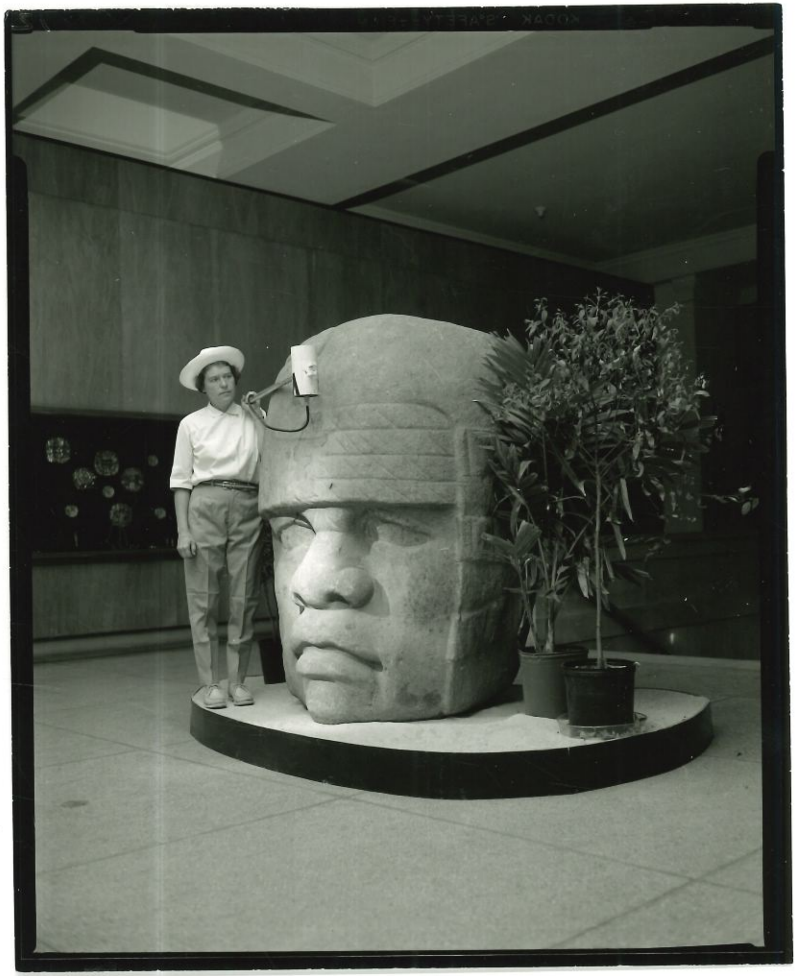


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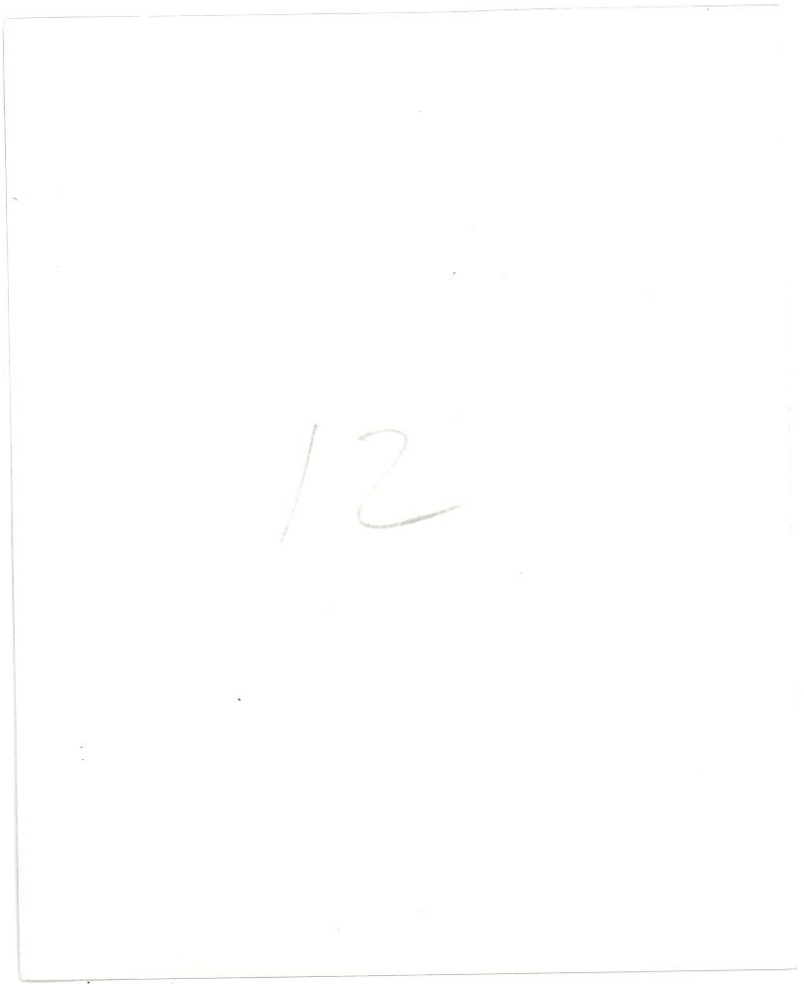
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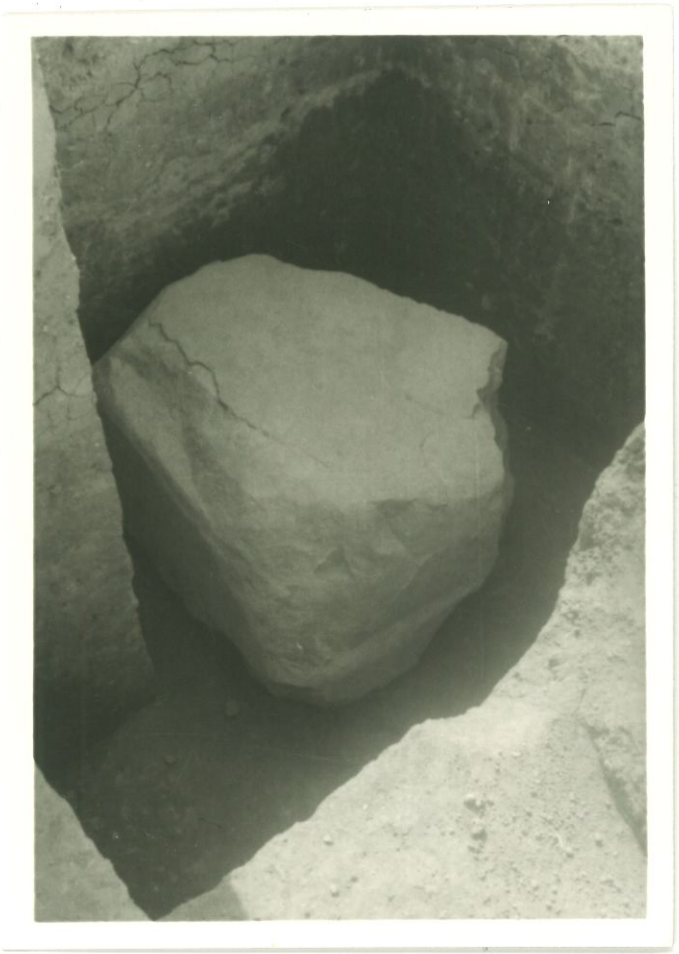
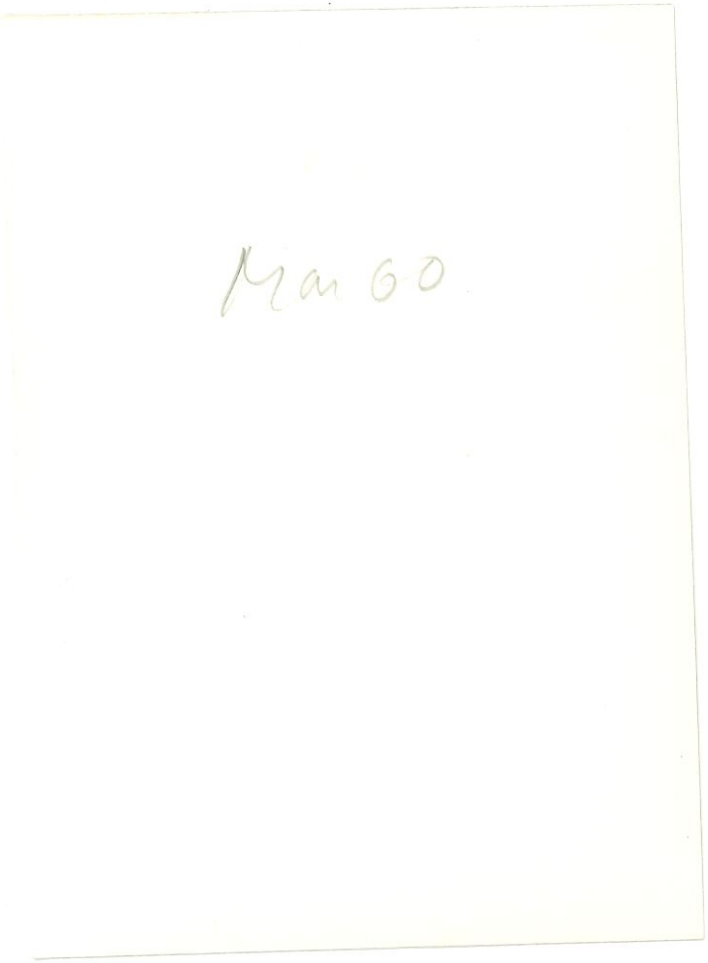
Dr. Rainey

San Lorenzo "heads"

March 1970

(pulled Gram
attached envelope)
July 15 '82
EMH

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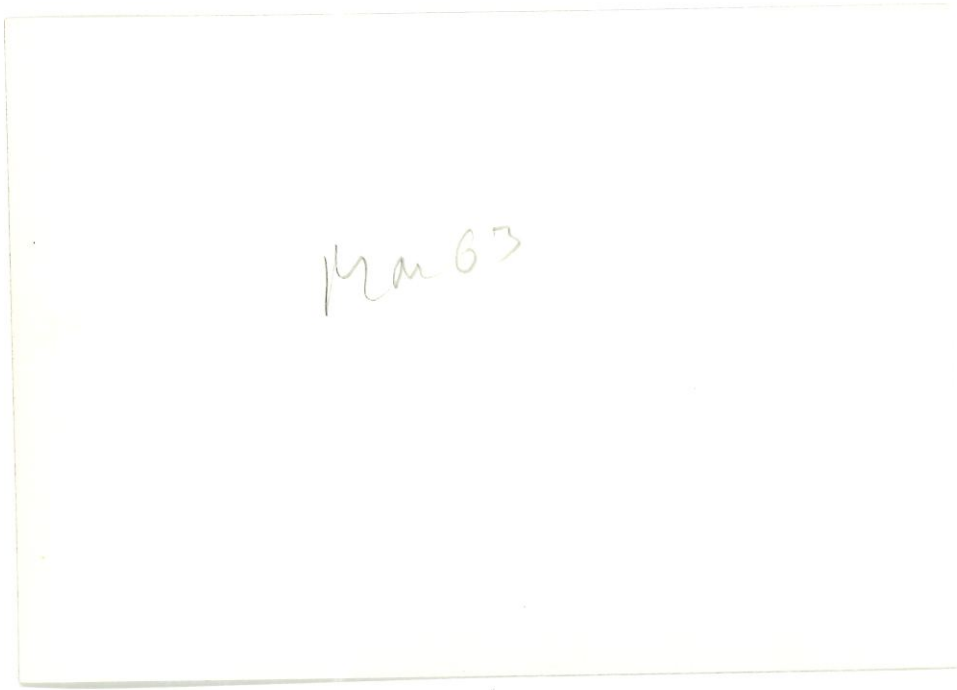
Man 63

Mar 64

Mar 65

"Bach"

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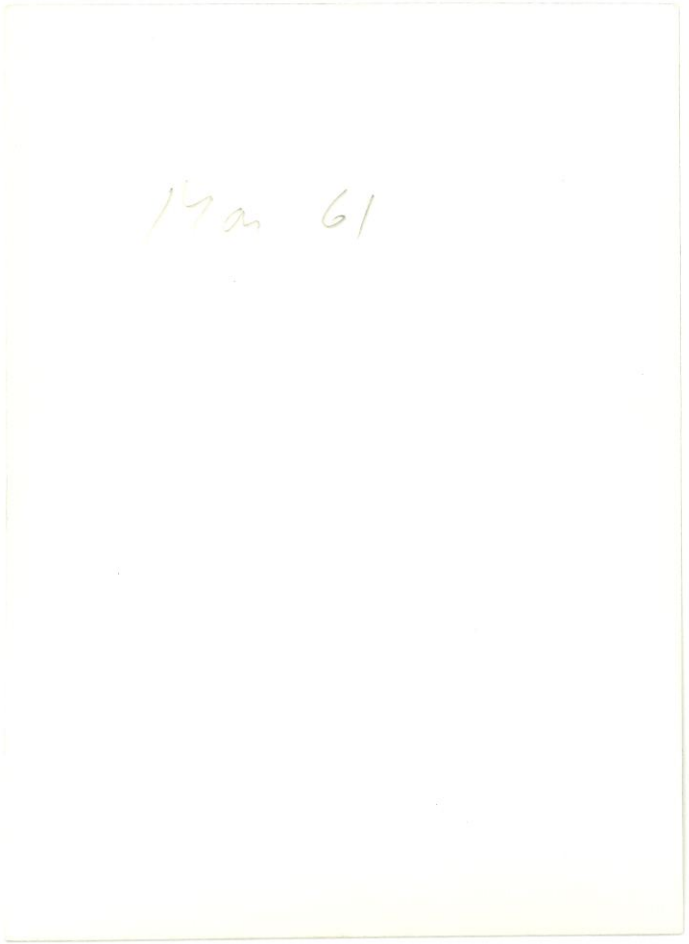
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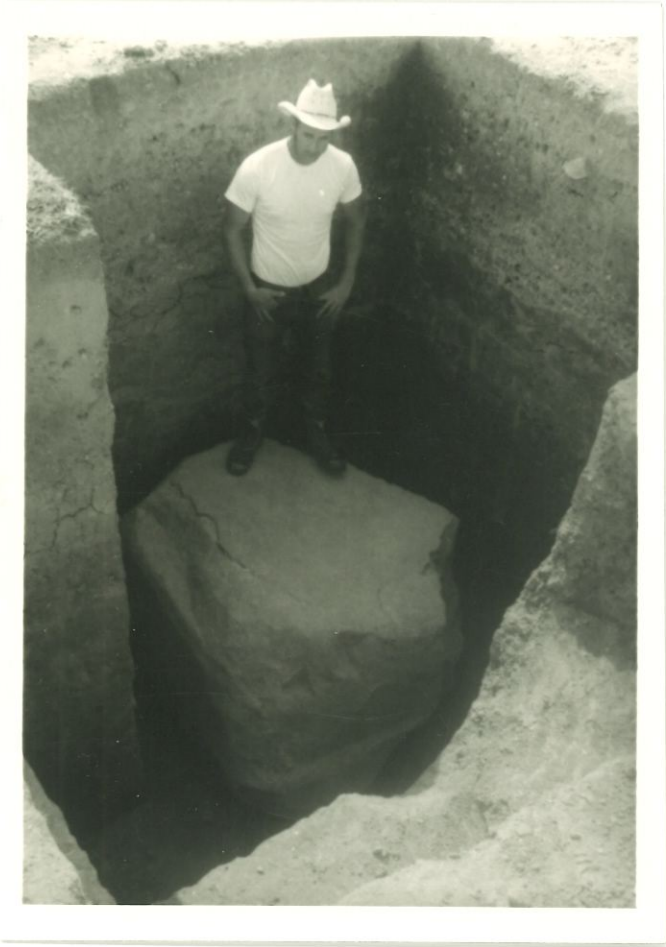

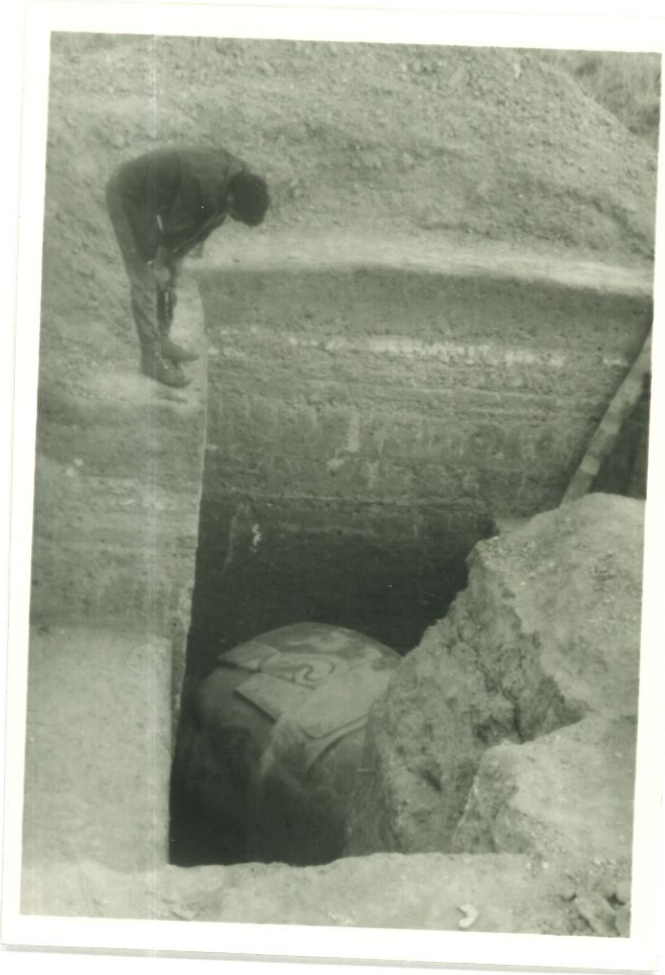

Man 60

Man 61

LV 8° N

M28,29

M56

COMPLEX B

A2

M49 LONG MOUND

A3

STIRLING GROUP

A5

STIRLING "PLAZA"

A4

M50

M51

STIRLING "ACROPOLIS"

D3 M57 D4

M55 D2

M46

D5

M45

M39,40,41,44

COLUMNS

D1

M42,43

GREAT PLATFORM

M59 M36A M36B

M58 M37

M35

S2 M1

M47

A7

A1

M48

M61

(AIRFIELD)

COMPLEX C

A3 M25

A2 M26

M27

M38

A-5

A-3

A-4

A-2

COMPLEX A

LEGEND

MOUND ○ ALTAR(A) STELA(S)

MONUMENT □ DRAIN(D)

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LA VENTA

TABASCO, MEXICO

AN OLMEC CEREMONIAL CENTER

SITE PLAN

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SAN LORENZO

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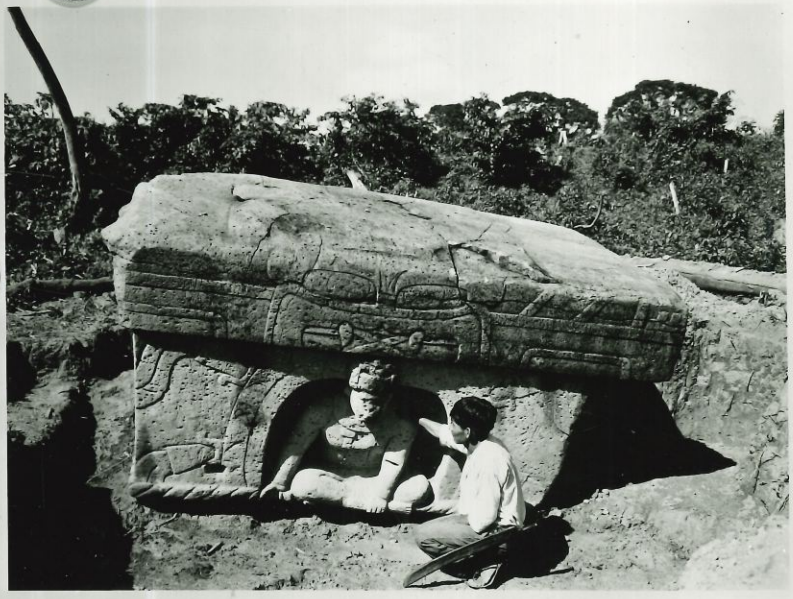
1969



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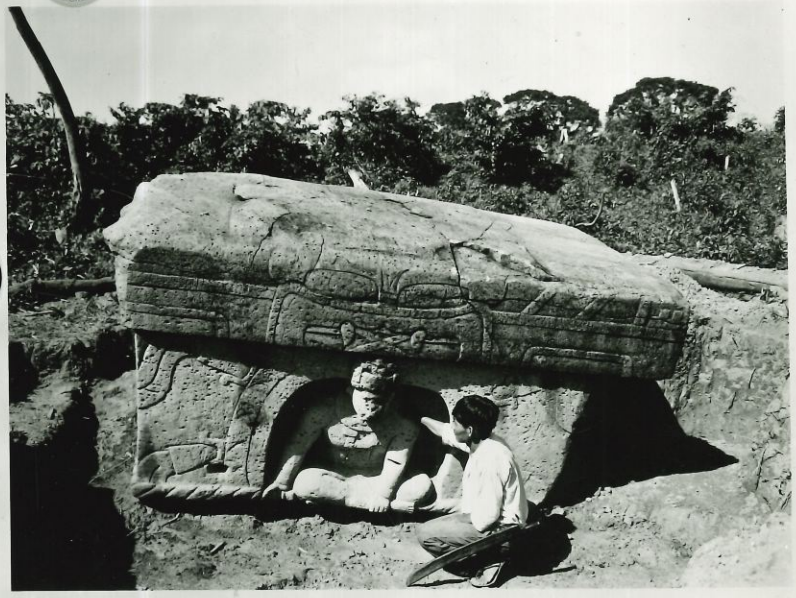

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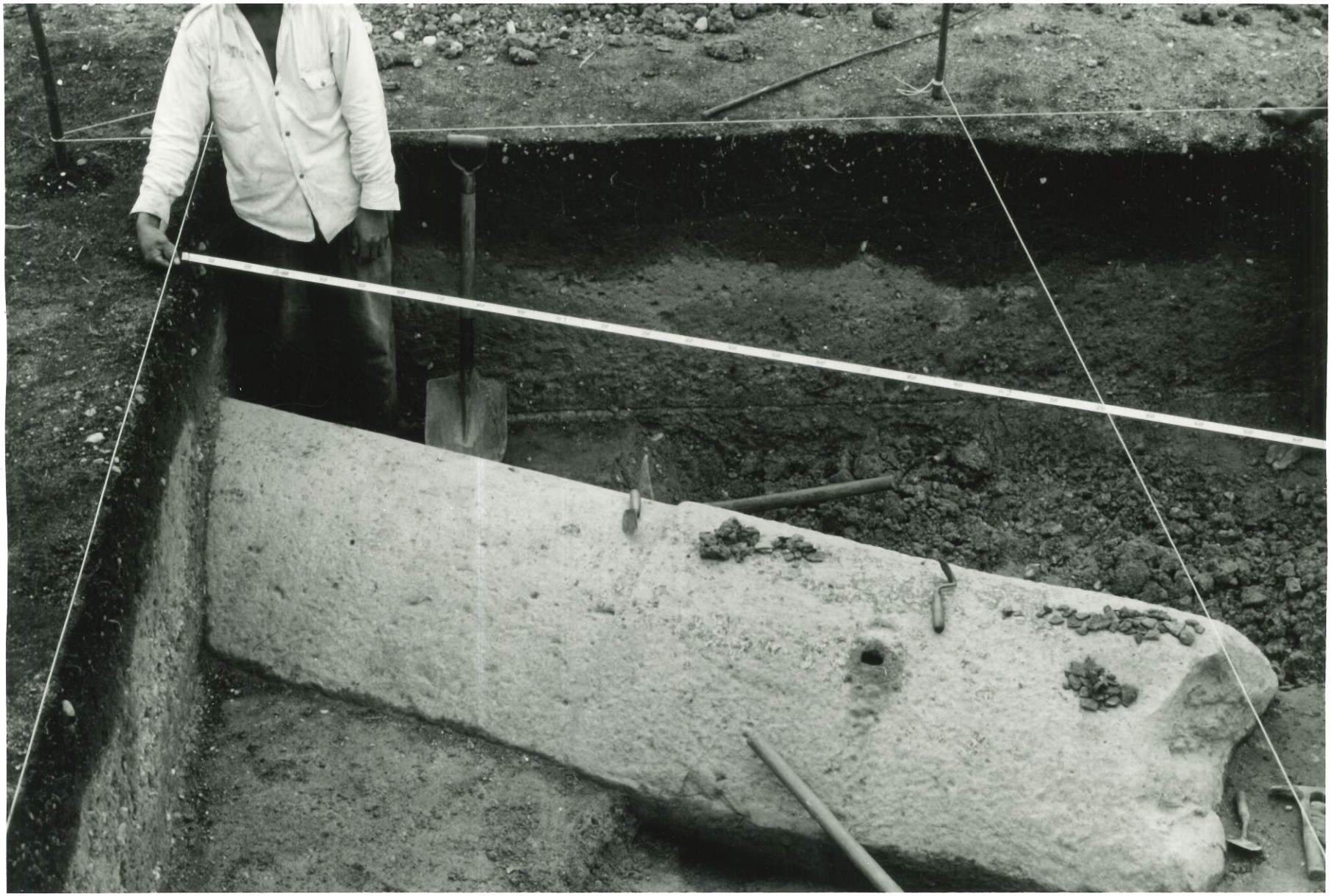
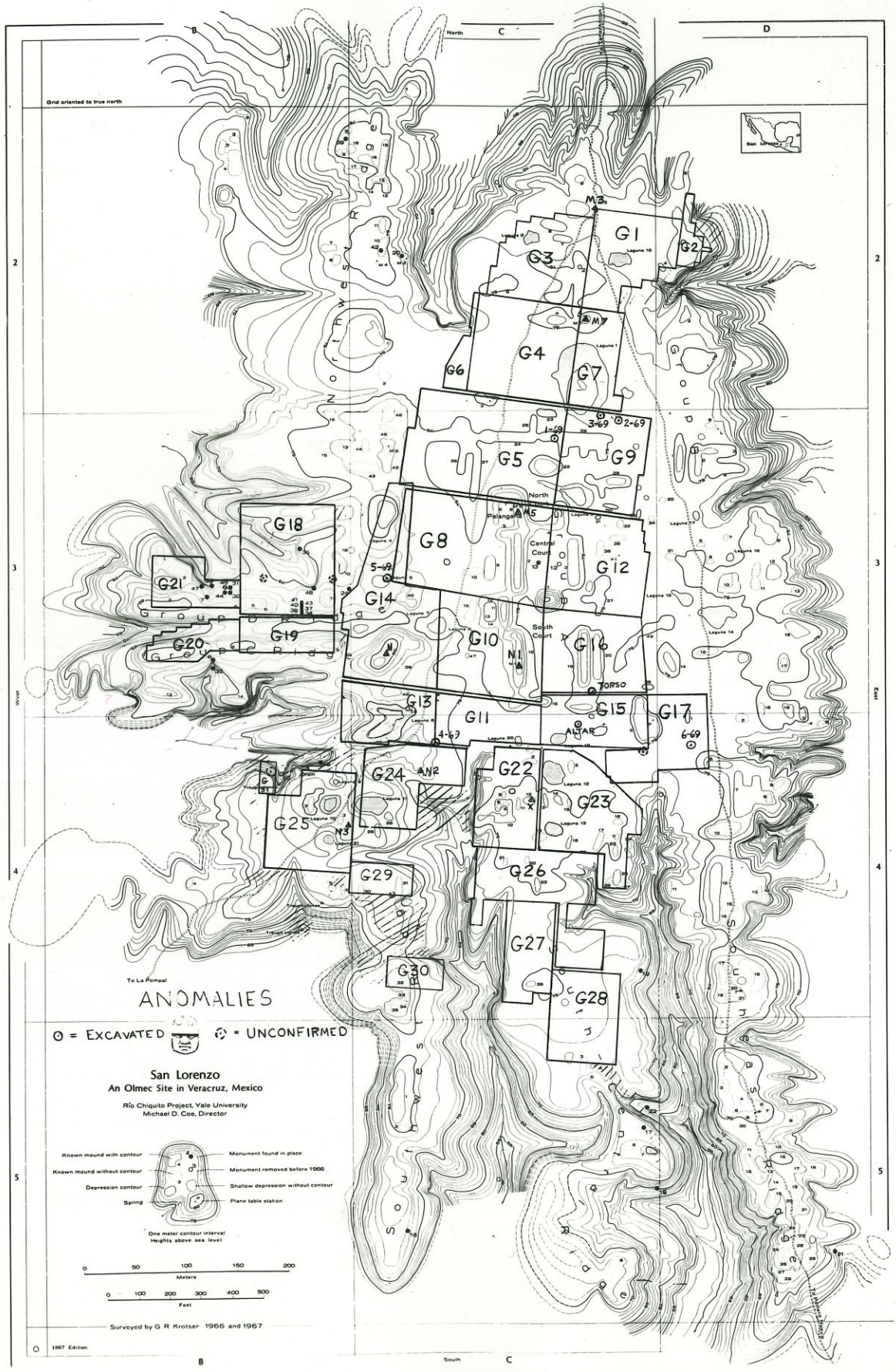


Fig. 13

Fig. 1

Fig. 2


Grid oriented to true north
North
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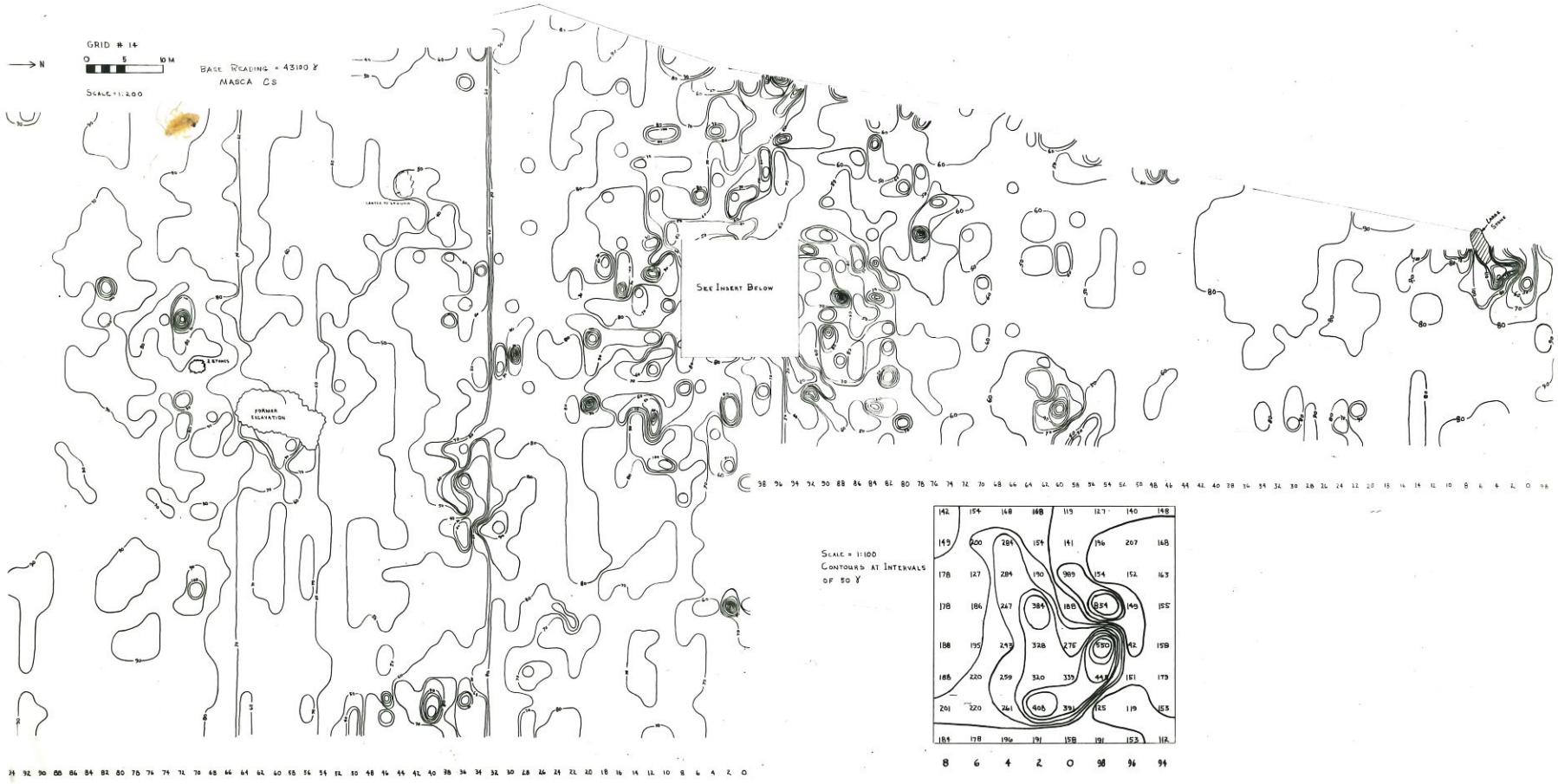
5-69
6-69
North Palangana
Central Court
South Court
TORSO
ALTAR
Group D
To La Pompal
ANOMALIES
⊙ = EXCAVATED
⊙ = UNCONFIRMED
San Lorenzo
An Olmec Site in Veracruz, Mexico
Río Chiquito Project, Yale University
Michael D. Coe, Director
Known mound with contour
Known mound without contour
Depression contour
Spring
Monument found in place
Monument removed before 1966
Shallow depression without contour
Plane table station
One meter contour interval
Heights above sea level
0 50 100 150 200
Meters
0 100 200 300 400 500
Feet
Surveyed by G R Krotser 1966 and 1967
1967 Edition

Fig. 3.4

SAN
LORENZO
1969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N
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SCALE 1:200
BASE READING = 43100 Y
MASCA CS
See Insert Below
FORMER EXCAVATION
SCALE = 1:100
CONTOURS AT INTERVALS OF 50 Y

SAN LORENZO 1969

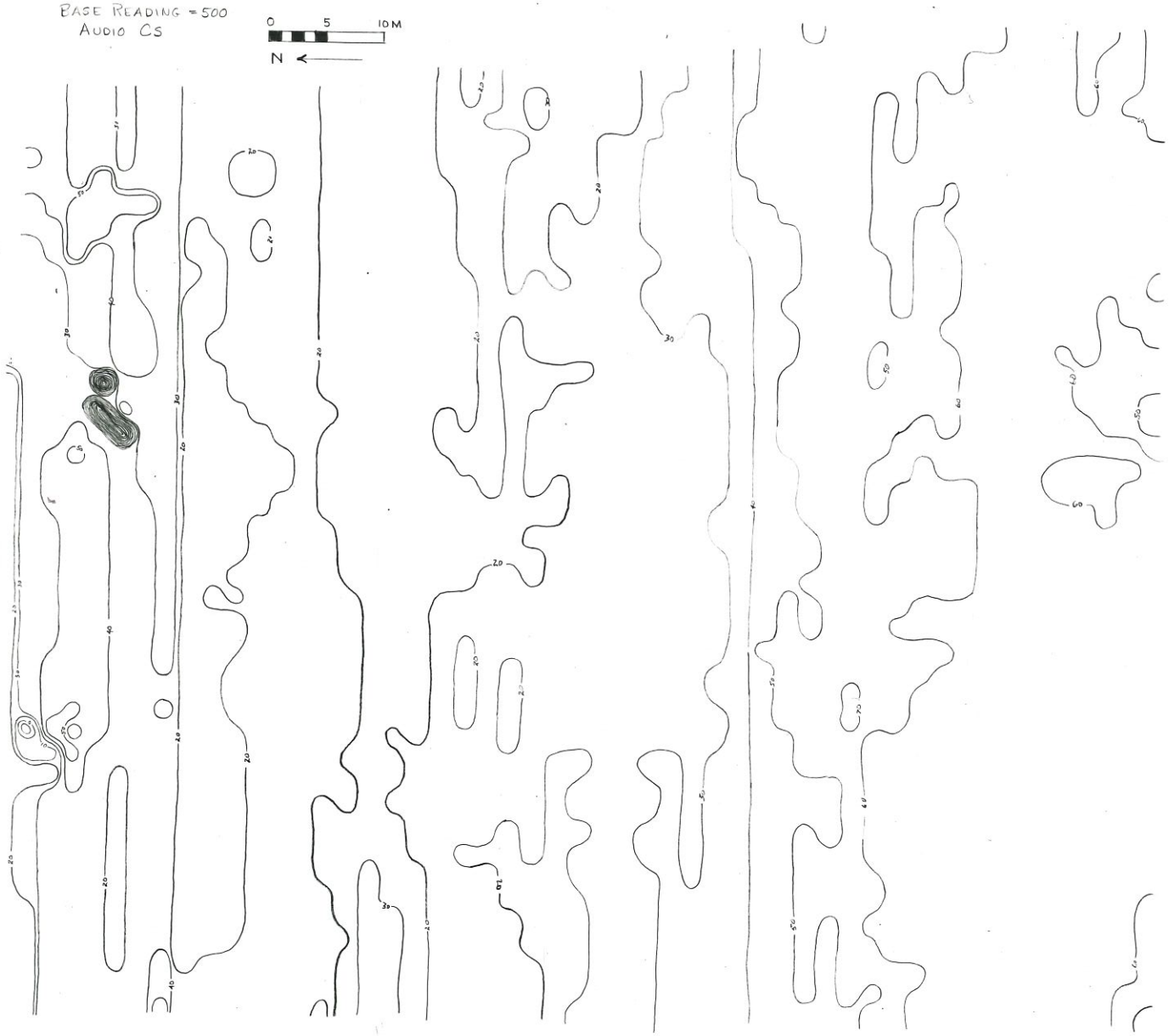
Fig. 11

GRID # 9

BASE READING = 500
AUDIO CS

0 5 10M

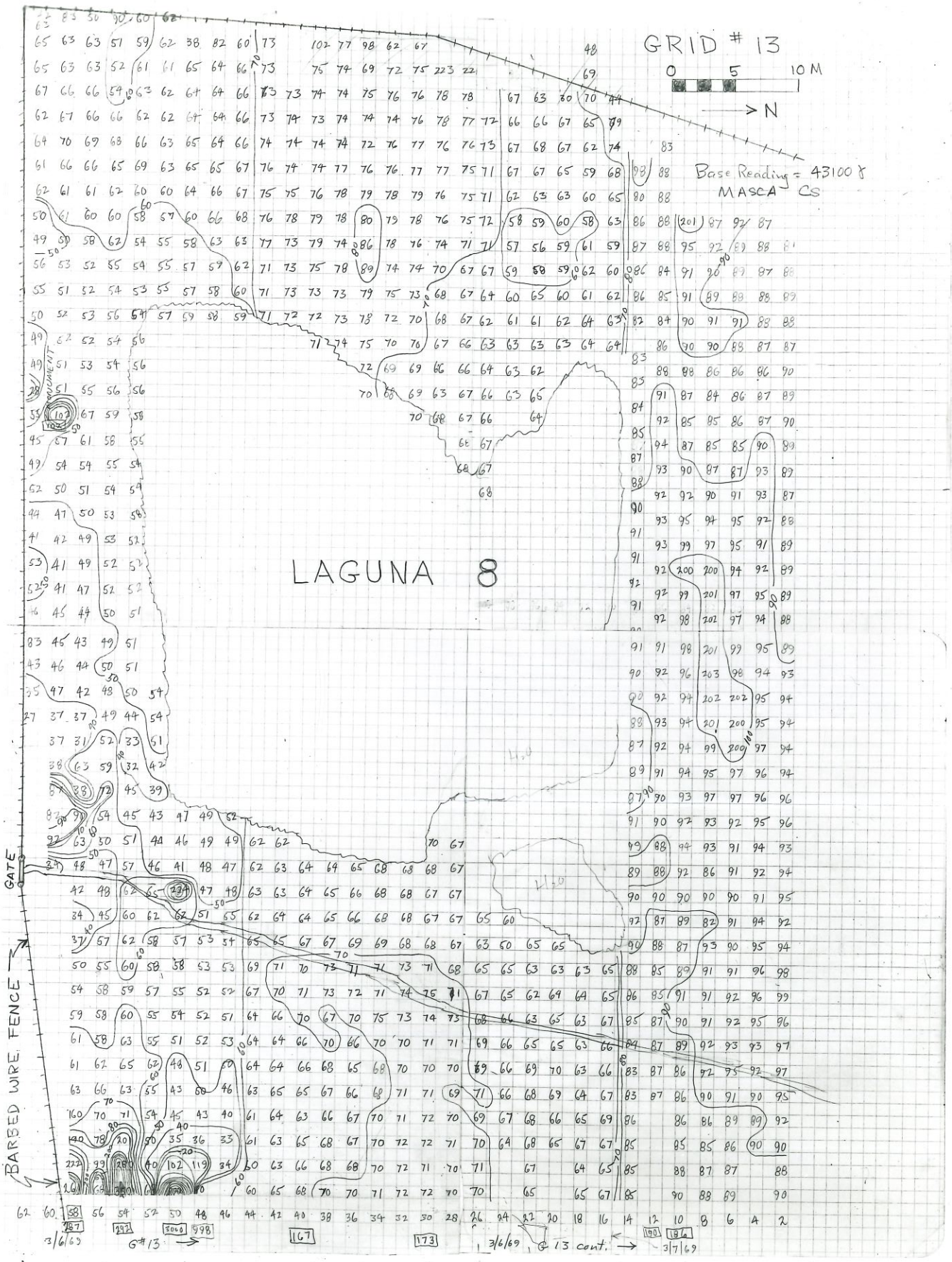
N



0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100

SAN LORENZO
1969

fig. 9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N
Base Reading = 43100 γ
MASCA CS
LAGUNA 8
GATE
BARBED WIRE FENCE
3/6/69
G#13
3/6/69 G 13 cont.
3/7/69

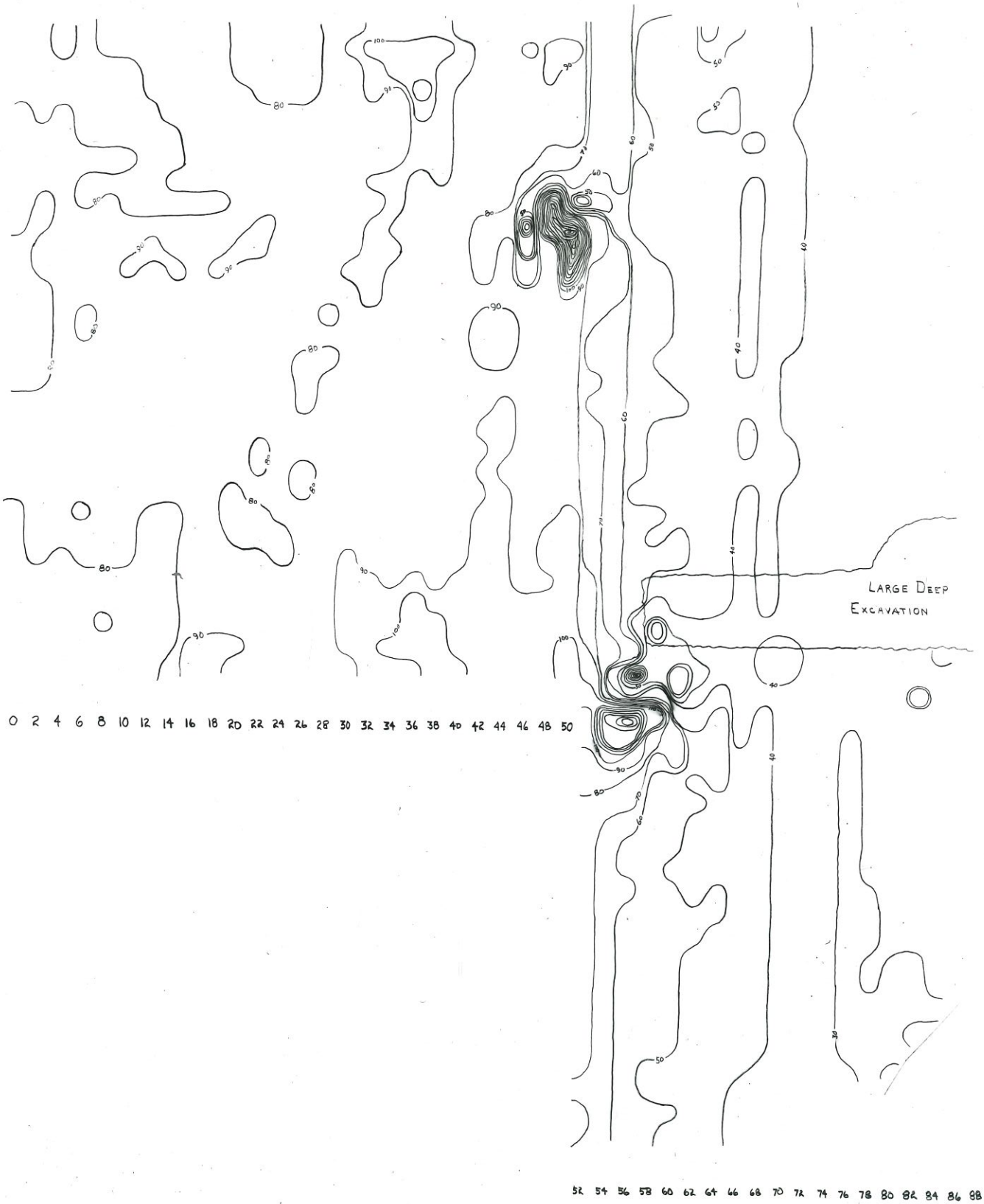
SAN LAZARO, 1969

Fig. 10

GRID #17

BASE READING = 43100 γ
MASCA CS

0 5 10 M
N



STAS LAKANZO
1969

Fig. 12

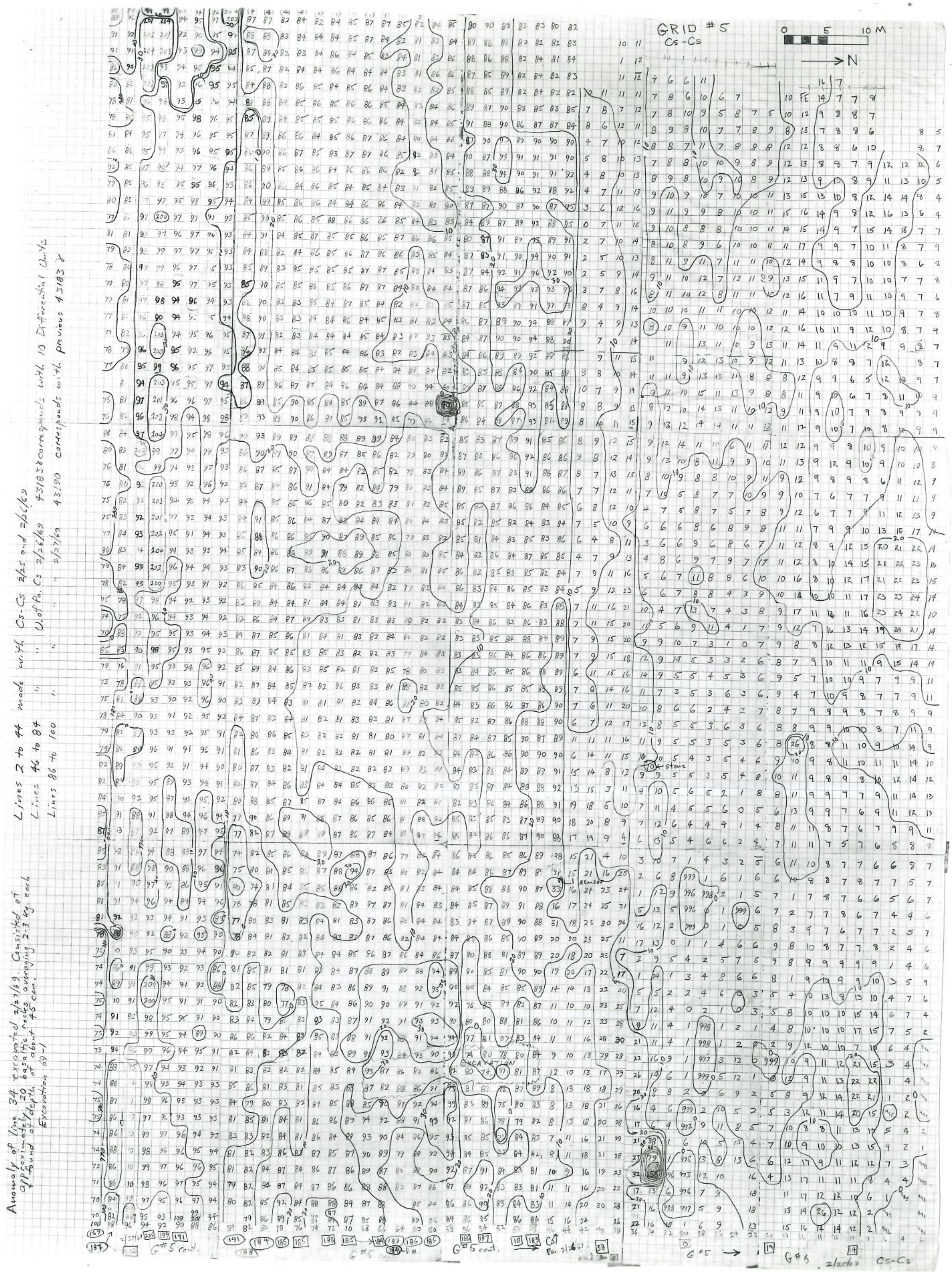

GRID #5
Cs-Cs
0 5 10 M
N
Lines 2 to 44 made with Cs-Cs 2/25 and 2/26/69
Lines 46 to 84 " U. of Pa. Cs 2/26/69 43183 corresponds with 10 Differential Units
Lines 86 to 100 " 2/27/69 43190 corresponds with previous 43183
Anomaly of line 34 excavated 2/27/69. Consisted of approximately 20 basaltic rocks averaging 2-3 kg. each found at depth of about 45 cm.
Excavation 69-1
stove
sensor
EXCAVATION
G#5 cont.
G#5
G#3 2/25/69 Cs-Cs

Fig. 7

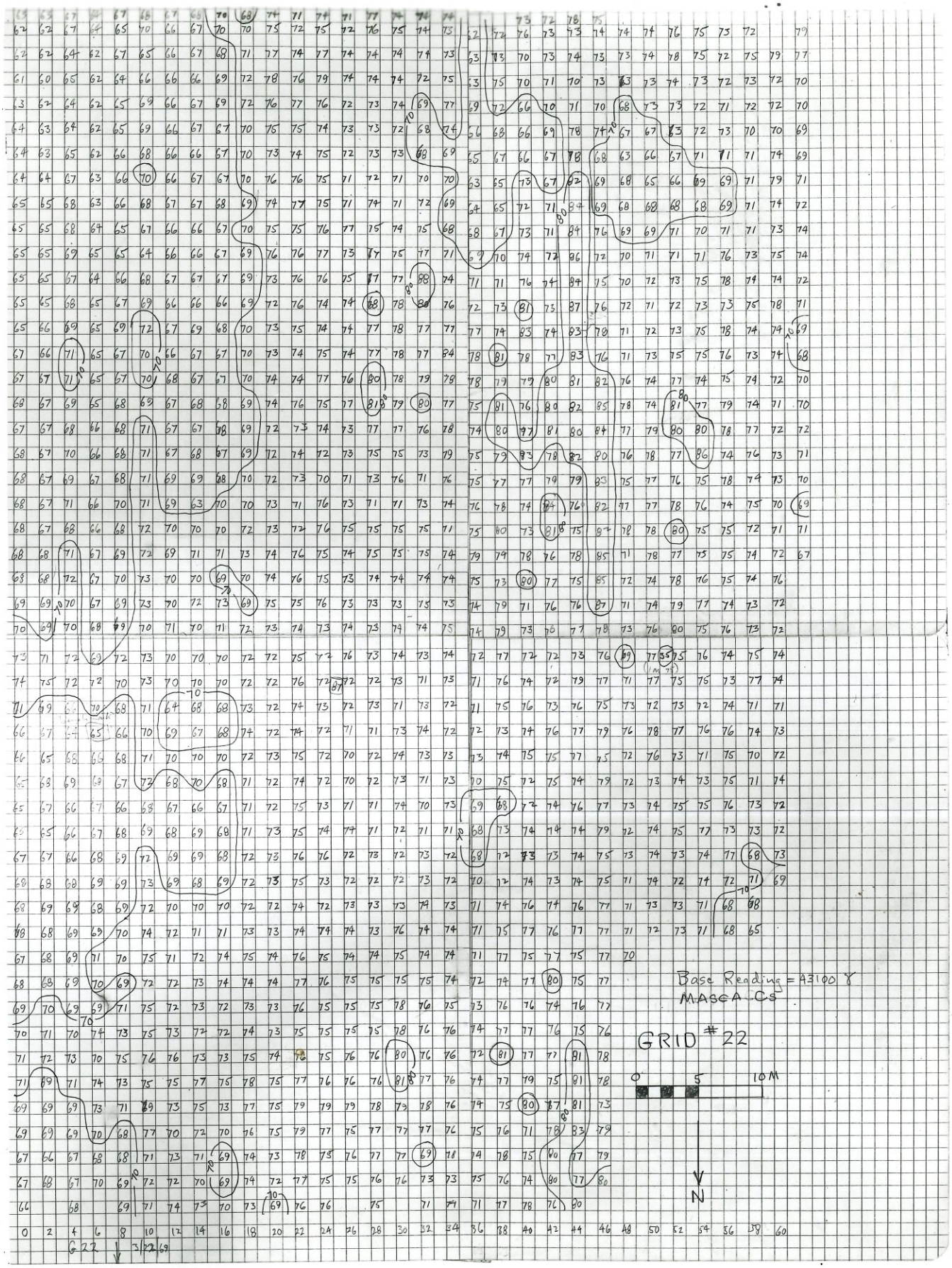

Base Reading = 43100 ?
MASEA Cs
GRID # 22
0
5
10M
N

Fig. 5

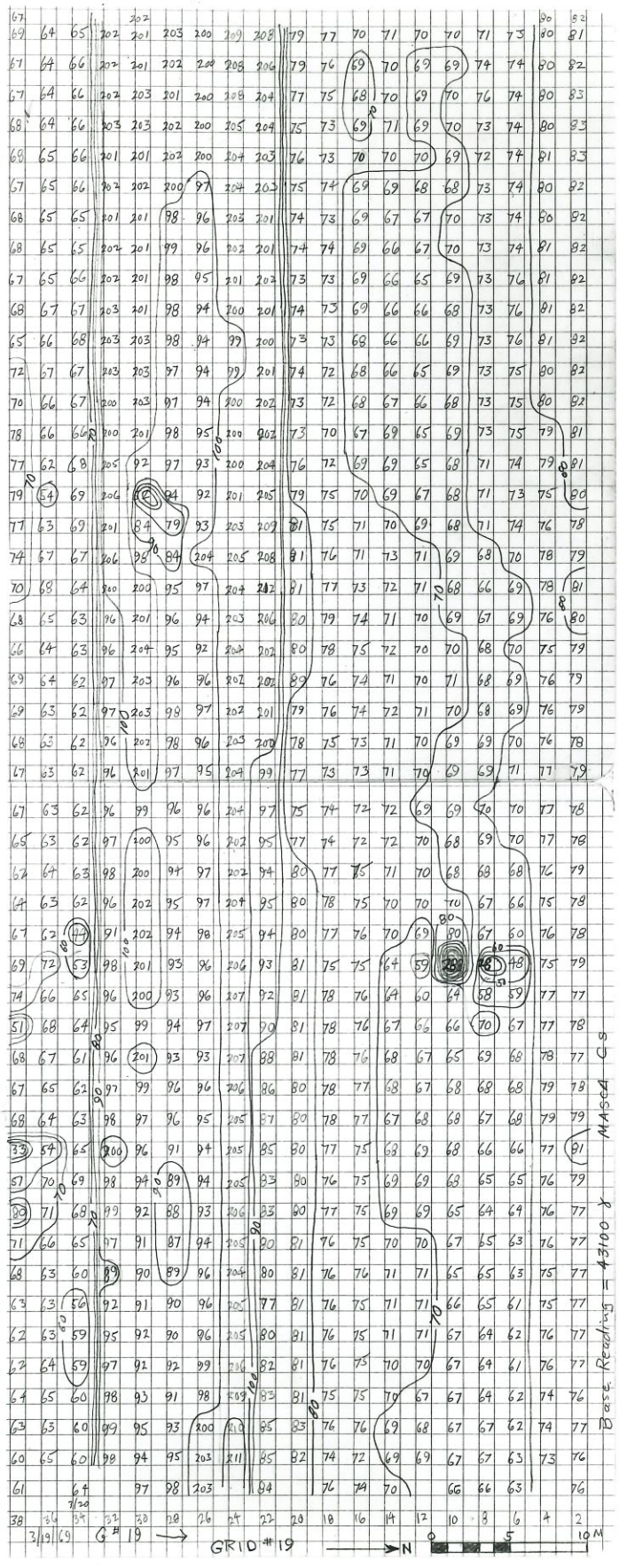

GRID #19
N
0
5
10M
Base Reading = 43100 γ
MAGd CS

Fig. 6