DRAFT

SRI Internal Report

Report on an Archeological Radar Experiment at Chaco Canyon, New Mexico

Conducted in conjunction with

Museum Applied Science Center for Archeology
University of Pennsylvania

and

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1. Setting

Chaco Canyon is situated in the Northwest corner of New Mexico and is the site of a number of Indian ruins dating back to A.D. 600 or so in various stages of excavation. There are some dwellings that have been excavated and then backfilled, with the result that accurate maps of the structures are available, and others which have areas of completely undisturbed overburden containing obvious extensions of buildings already exposed. The site is therefore ideal for testing new techniques in that there is considerable preknowledge of the location of the buried structures. Chaco Canyon is ideal for radar experiments from another point of view also. The soils which form the cover for the Indian ruins are extremely dry and have remarkably low microwave losses. Radar signals can therefore penetrate into the soil with little loss or dispersion. This condition is rarely found except in solid rock.

2. The Experiment

Samples from the site were analyzed at SRI and their microwave properties tabulated, as shown in Table I. The results were encouraging, and in October 1974 a field experiment was conducted at Chaco Canyon to obtain radar signatures of some of the buried ruins. The radar system used employed a center frequency of 400 MHz, with the provision for operating at other lower frequencies if necessary. The resolution of the system at this frequency was not better than 1 ft. The mode of

operation was to house the electronics and display system in a panel truck (Figure 1) and to run cables out to the antennas which were mounted on a small hand cart (Figure 2). The cables allowed a radius of operation of about 150 ft, which was sufficient for most of the sites surveyed. Data ~~was~~ were recorded on an instrumentation recorder in the truck and brought back to SRI for further processing. The only method of viewing the data on site was by means of Polaroid photographs.

Traverses were made with the radar systems at the following sites:

Pueblo Bonito (the Great Kiva, backfilled)

Pueblo Bonito (the city wall, undisturbed)

Marsha's Pit House (backfilled)

Hungo Pavie (undisturbed area close to main ruins)

Other measurements were made but not recorded in outlying areas to see if the radar could detect the depth to bedrock.

3. Results

a) Pueblo Bonito

A number of traverses were made over an area which included a vertical structure referred to as the city wall. The approximate location of the traverse is shown in Figure 3. Excavation a short distance away revealed the wall to be about 1 ft wide, 4" below the surface, oriented normal to the traverse direction, and in a good state of preservation (see Figure 4). Our radar had a dead time of 5 ns corresponding

to the first one foot of record and so the wall may not have been an entirely suitable target since it was so close to the surface. The processed data showed a large number of subsurface features which were difficult to interpret, however, one of the more conspicuous features was at the location of the wall. It appears from the radar data that there was more than one structural feature along the traverse, and in addition a great number of smaller point reflectors, probably scattered building materials, were present in the near surface. Since the map printing equipment was not present on this field trip it is difficult to verify all the targets identified by radar. In future experiments some form of mapping, however crude, must be attempted on site. A photograph of one of the traverse radar maps is given in Figure 5. The interpretation on the figures in this report is based on our knowledge of the area and our experience with radar echoes from similar targets on other sites. The vertical scale in Figure 5 is approximately 5 ft (full scale).

The plaza of Pueblo Bonito contained an area which covered a Great Kiva, previously excavated and now backfilled. Several traverses were made over the kiva in order to see if the radar could detect the perimeter walls. As in the case of the city wall, the construction materials were mostly sandstone and a form of mortar. The traverses were measured from the south wall extending over the center of the kiva and onto the far wall. The radar records show a discontinuity about 2 ft in width at 70 ft out from the south wall, and a narrow vertical structure,

probably 1 ft or less in width and 4 to 6 ft down at 90 ft out. Estimates by the archeologists at the site placed the buried wall at about 90 ft but no estimate of depth was made. We did not succeed in separating the radar echo from the near (southern) kiva wall because of the multitude of other echoes coming from structures related to the south city wall of Pueblo Bonito.

b) Hungo Pavie

The area traversed at this site was to the best of our knowledge undisturbed, and crossed a prominent mound containing an extension of the main structure. The mound was some 15 to 20 ft in width and was surmised to contain rooms as well as a portion of the city wall. The radar results for this site were the most successful that we obtained anywhere at Chaco Canyon. A portion of the radar record is shown in Figure 6. The vertical extent of this record is about 12 ft, and the horizontal extent about 20 ft. Vertical structures with interconnecting horizontal members are clearly depicted and indicate a man-made origin. From the scale it is obvious that the horizontal sections are not the floors of successive stories as was first thought, but more probably different levels of partially decayed walls. Computer processing of this record produced similar results but with less visual impact as shown in Figure 7.

c) Marsha's Pit House

This area was a backfilled site covering an adobe pit house. The

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dimensions and exact location of the walls were unknown at the time, and it is hoped that some correlation of our results with notes taken by the University of Pennsylvania at the time will be possible at a later date. Figure 8 shows one complete traverse from the pit house site. It is quickly seen that there are no striking features like those in the records from Hungo Pavie, but nevertheless some evidence of a buried wall is present at 78 ft, and shallow echoes are present at 47-50 ft, 66-68 ft. We did not expect too much success at this site since the dielectric contrast between adobe and the fill material is minimal.

Conclusions

The simple radar system that was used at Chaco Canyon produced some very promising results, and more importantly pointed out a number of improvements in design that would greatly enhance the performance of a radar system designed expressly for archeological work. It should not be forgotten that the Chaco Canyon area was not typical of conditions encountered throughout the USA in that the soils were extremely dry and non-conductive. In wetter areas the radar would stand no chance at all of producing high resolution results, and one would be forced to resort to methods more close to resistivity surveys in their frequency content, and suffer the attendant loss of resolution.

The use of radar techniques in archeology should certainly be pursued further, with more field tests over undisturbed areas and subsequent follow-up to determine the actual position of structures located

by the radar system. Further, more extensive work at Chaco Canyon is an attractive possibility. With the knowledge gained during our first expedition a more definitive experiment could be designed and conducted.

FIGURE 1 RADAR SYSTEM MOUNTED IN PANEL TRUCK

FIGURE 2 CHACO CANYON ANTENNAS ON HAND CART

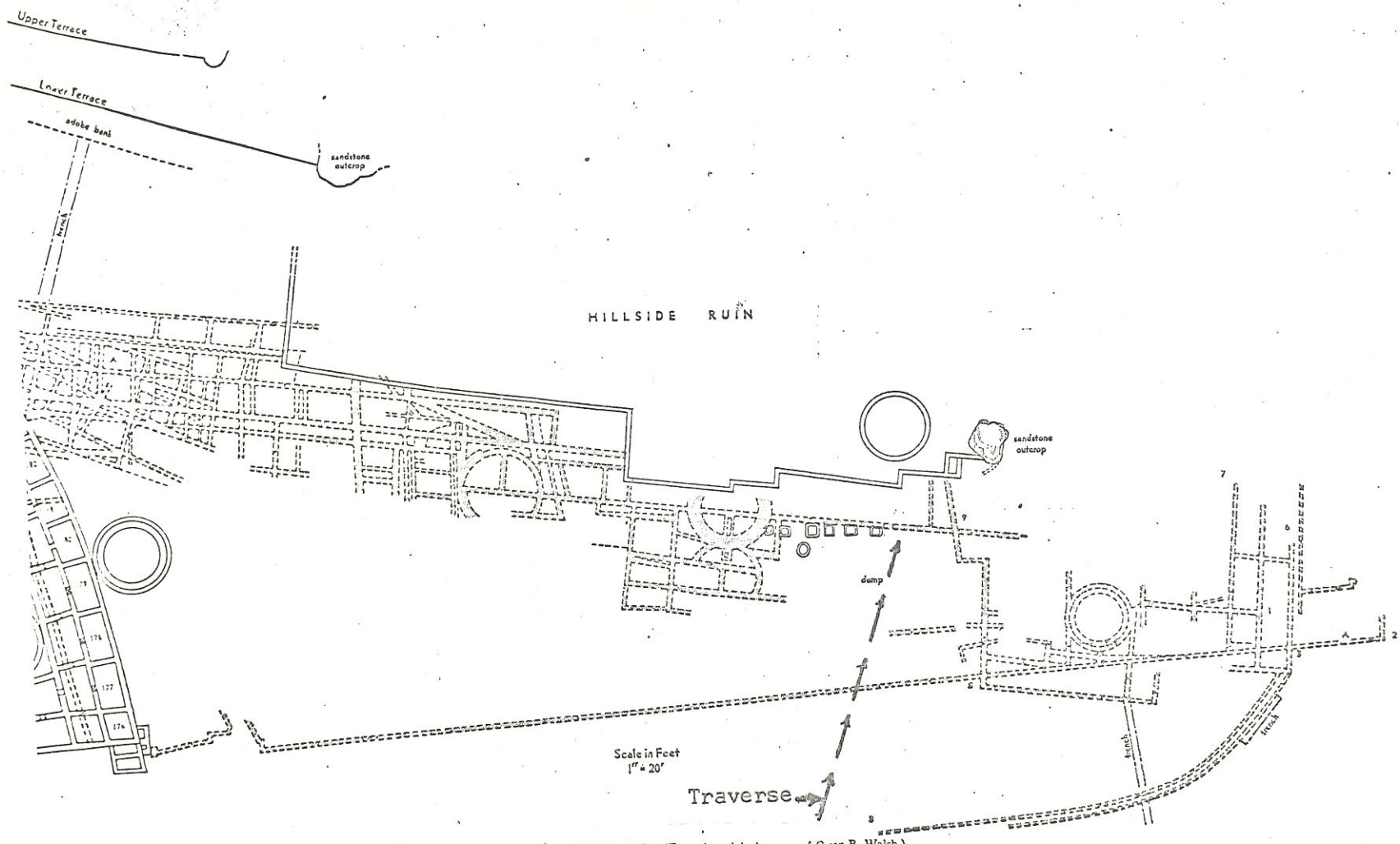

Fig. 11.—Exposed portion of the Northeast Foundation Complex in relation to Pueblo Bonito and Hillside Ruin. (From the original survey of Oscar B. Walsh.)

FIGURE 3 LOCATION OF TRAVERSE IN PUEBLO BONITO

FIGURE 4 CITY WALL OUTSIDE PUEBLO BONITO

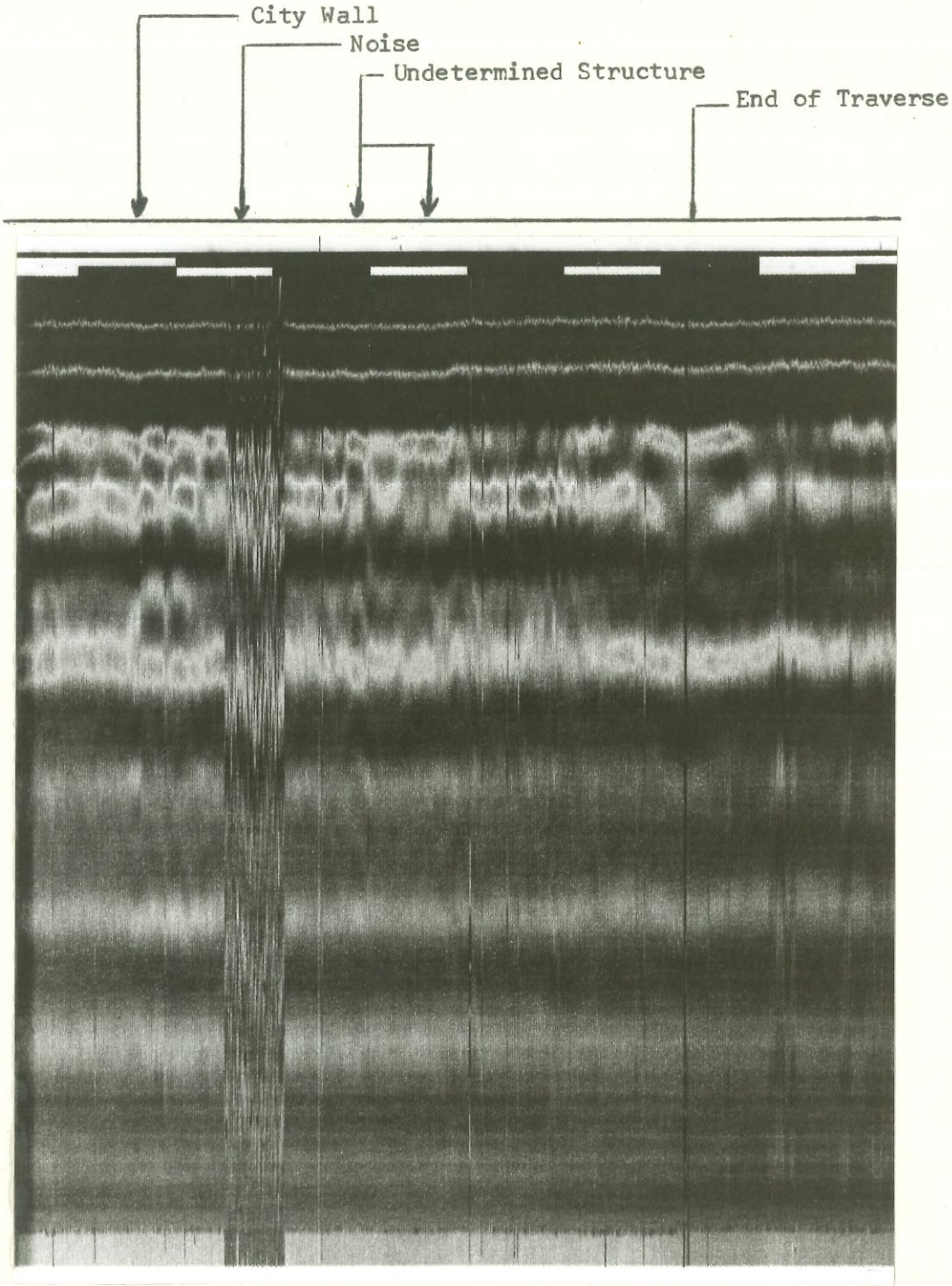

FIGURE 5 RADAR DATA FROM PUEBLO BONITO (over city wall)

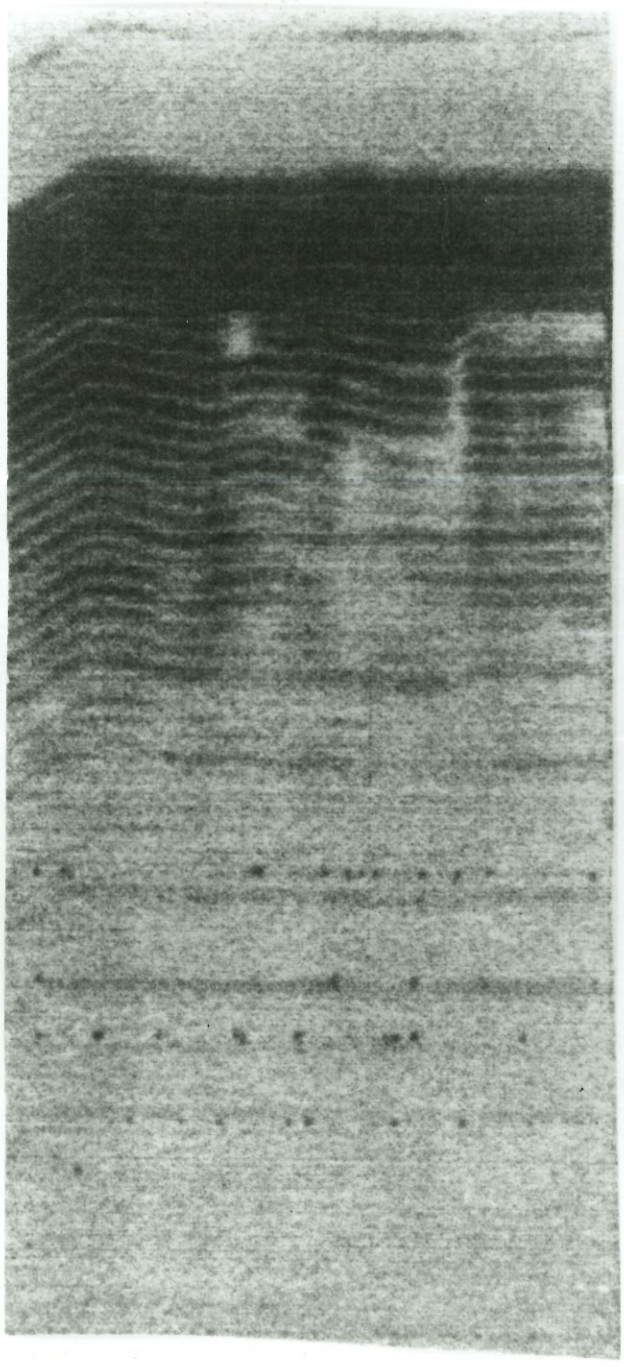

FIGURE 6 UNPROCESSED DATA FROM TRAVERSE AT HUNGO PAVIE

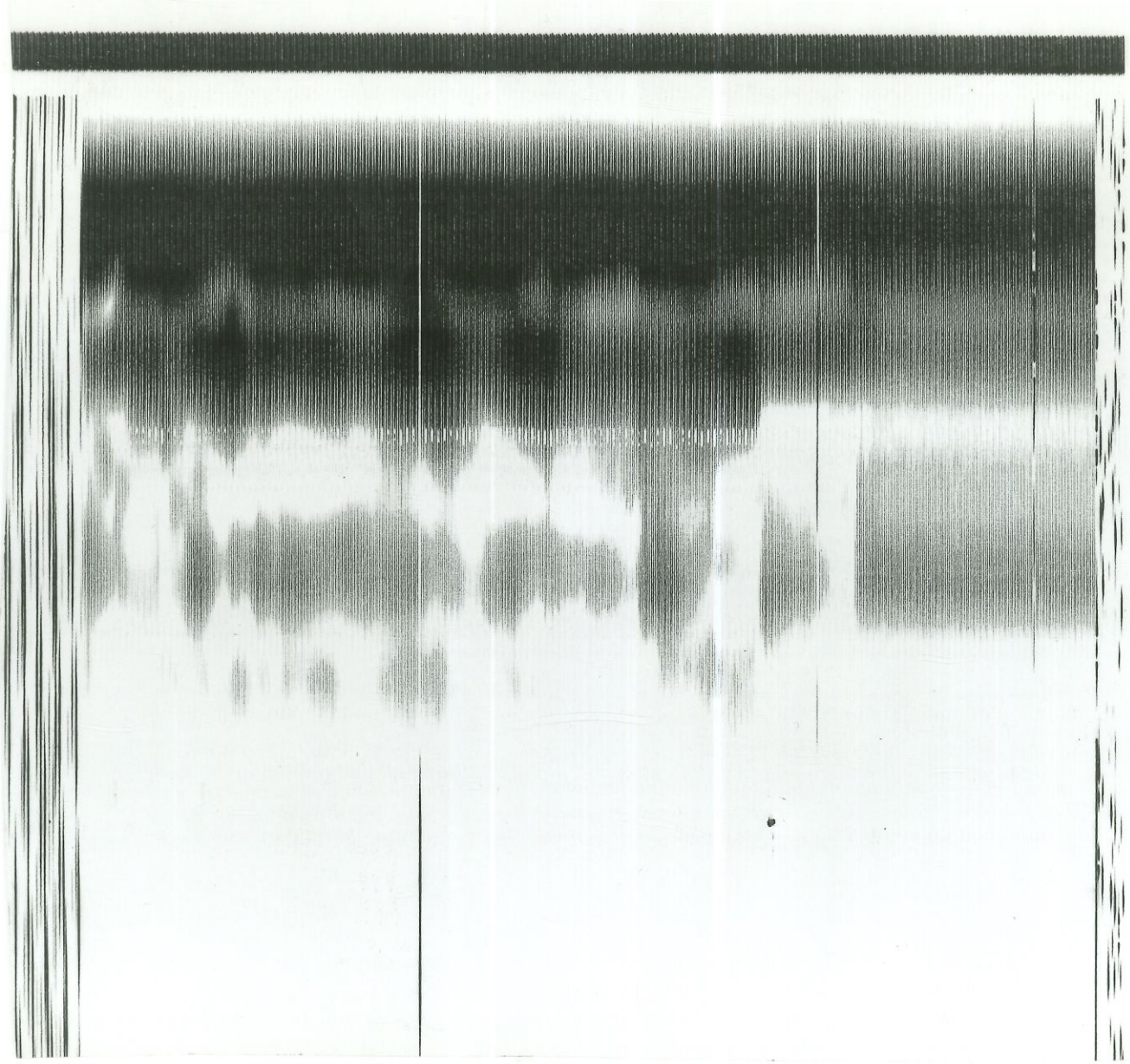

FIGURE 7 PROCESSED DATA FROM TRAVERSE AT HUNGO PAVIE

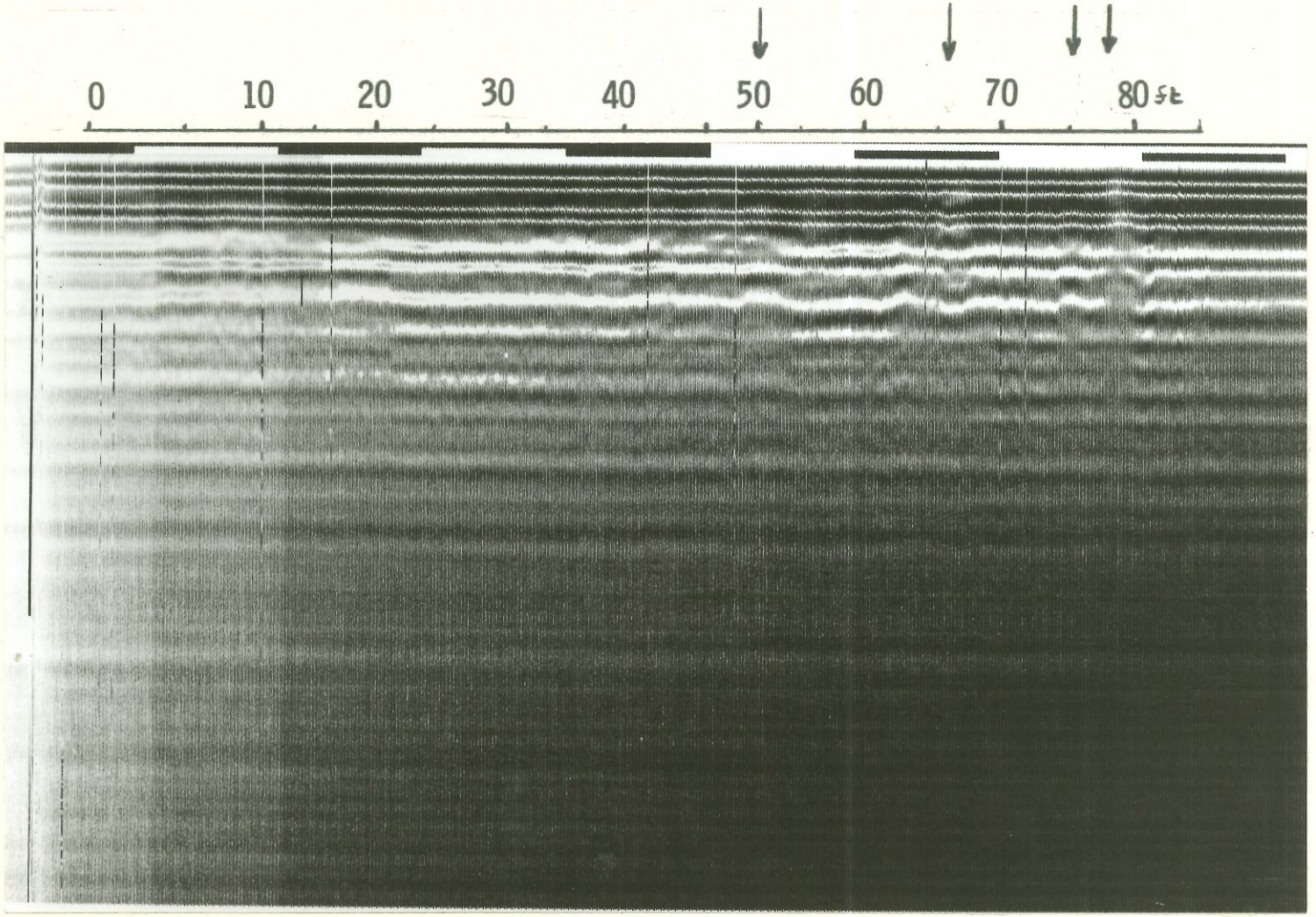

FIGURE 8 DATA FROM TRAVERSE OVER MARSHA'S PIT HOUSE

Table 1

RADIO FREQUENCY ATTENUATION FACTOR FOR SAMPLES I THROUGH IV*

Frequency (MHz)	Attenuation, in Decibels per Meter (dB/m)			
	α_1 †	α_2	α_3	α_4
10	0.24	0.20	-	0.33
20	.45	.45	-	.64
30	.60	.66	-	.90
40	.83	.82	-	1.2
50	1.0	1.0	-	1.4
60	1.3	1.2	11.7	1.4
70	1.4	1.4	14.2	1.7
80	1.5	1.5	16.2	1.9
90	1.8	1.7	19.6	2.0
100	2.0	1.8	22.0	2.1
120	2.6	2.2	24.3	2.5
140	3.2	2.8	30.1	2.9
160	4.1	3.2	36.1	3.4
180	4.4	3.4	43	3.8
200	5.8	3.5	55	4.2
220	7.4	3.8	69	5.2
240	-	5.1	86	6.2
250	-	5.7	-	7.5

*Sample I: Construction sandstone, Pueblo Alto, average dielectric constant, ϵ_r = 4.9 to 6

Sample II: Alluvial sand, Pithouse E, ϵ_r = 1.7 to 2.1

Sample III: Alluvial clay, Chaco Wash, ϵ_r = 7.0 to 12

Sample IV: Alluvial loam below trash dump, ϵ_r = 1.6 to 2.4.

†