CHAPTER 4

Gradiometric Survey, PACH, 2004 Season

David Monsees

Survey Area

The geophysical survey area is located in Chocolá, Suchitepéquez, Guatemala. The archaeological site lies under and around the small village of Chocolá, presently inhabited by some 8,000 people. Both the archaeological site and the village, of Maya speakers, are found in the narrow region of the northern portion of the Suchitepéquez department and between the rivers Chocolá and Chichoy, at the immediate foot of the mountain range that houses active volcanoes to the north and wide plains that descend towards the Pacific Ocean. Everyday, the fumaroles of the volcanoes of the northeast and southwest are visible. Most of the land in the region is occupied by small plots of coffee plantations as a part of the collective efforts of the Associative Peasant Enterprise *(Empresa Campesina Asociativa)* ECA Chocolá, an entity that congregates these individual efforts for the commercialization of the product. Other plots are planted with corn and several different crops that are grown for local or domestic consume only. This characteristic of the property, divided in small plots, restricts the mapping efforts. To this date, the archaeological site has been mapped in an area of 2 x 5.5 km (see Chapter 3), and it seems to represent ancient occupations from the Middle and Late Preclassic periods to the Postclassic period (B.C. 900 to A.C. 1500). The remote sensing probes attempted to confirm the success of gradiometry in the geological setting of Chocolá, to identify interest points for excavation, and to map through the survey the traits and structures found in several parts of the ancient city.

Conditions of the field

The soil of the area consists in a very productive layer, rich in volcanic ash and igneous stones, as well as layers with varied proportions of iron (the *taxcal*, a paste of decomposed muds of an impermeable nature was used here by ancient inhabitants to build underground, stone-faced water conduits. Naturally, it is found in the subsoil and the hues range from yellow, red and orange and then turn to gray, blue tones).

During the survey works we had moderate to heavy rains, typically in the afternoon, but in the morning, the water from the previous day was almost entirely drained, in a way that the gradiometric survey could be carried out from 7 am to 2 pm. Due to the magnetic nature of the subsoil at Chocolá, we had to build a 1.60 m platform or elevated chair made of fastened bamboos and planks to lift the machine and separate it from the ground during calibration [Fig. 4-1].

Fig. 4-1. Machine being calibrated.

Most of the fields were sowed, making it necessary to use the swaths of coffee trees or corn as grids for transects [Fig. 4-2]. Coffee trees are planted at a distance of around two meters from one another. The distance for corn is of about one meter. The width varies between the different swaths and the orientation of the cultivated fields change frequently, making it difficult to locate the anomalies and forcing us to use the spaces between the swaths as a grid. Even though the fields free of crops were cleared with *machetes*, among the coffee plants we would regularly find shadow trees, an impediment that represented an added difficulty to our attempt of reducing data defects.

Fig. 4-2. Transects.

Survey methodology

The magnetic survey took place during the first three weeks of June, 2004. The size of the grids varied depending on the area to be studied. Four areas were surveyed: 1) the initial grid *(retícula inicial),* (RI) in Mound 15, a 20 x 20 m grid established by total station in an old coffee plantation and in the adjacent *milpas* at the north and west of the Mound; 2) in "Area 35"[1], fully covered with corn, and a relatively young adjacent coffee plantation, easy to explore; 3) in Mound 5, a mature coffee plantation where we had to clear or kill many plants. The orientation of the traverses –from north to south approximately and then from east to west approximately- was forced by the orientation of the swaths. The branches of the coffee trees forced us to survey at a distance of two meters between them instead of only one meter, which is the desirable distance. All readings were collected at regular intervals, with eight readings per each meter traveled. In the grid of Mound 15 and also in other cases where there was space enough to walk on a straight line, tapes with marks placed each half meter were used to control the position and thus facilitate the data capture at regular intervals. The device used was a Geoscan FM fluxgate gradiometer operated at a sensitivity level of 0.1 nT (nanoTeslas). The distance traversed in the three areas represented approximately 70.000 data points collected.

The magnetic data were transferred to a laptop using a Geoplot 3 software program. The data processing included: 1) the clipping to three standard deviations to diminish the distortion of high frequency spikes in the data, and to intensify the archaeological traits that were weaker for whatever the reason; 2) a "zero mean grid" control was applied to eliminate the discontinuities at the edge of the grid; 3) "high pass" filters were used to eliminate the large scale tendencies and to preserve the slow scale spatial details; 4) interpolation to a uniform number of data points on the X and Y axis (four per meter) to facilitate visual interpretation. Besides, other techniques of filtering and analysis were applied, including "zero mean traverse", "low pass filtering", "relief mapping", "absolute function", "median filtering", and the "clipping" of data to improve the understanding of the magnetic anomalies. Once processed, the data were exported to the Surfer 8 software program to print the maps and other graphics.

Results and interpretations

The four north-south surveyed areas are described. The area to the north possibly consisted in elite residences, while the central area served an administrative function, and the southern area housed common people dwellings, workshops, and intensive agriculture. Mound 15 and the *milpa* adjacent to the north are located in the northern area, "Area 35" is located south of the administrative area, and Mound 5 is located at the southern edge of the latter.

[1] Name of the area with small and low mounds identified as 32-35, rich in surface artifacts.

1. Area at the north of Mound 15

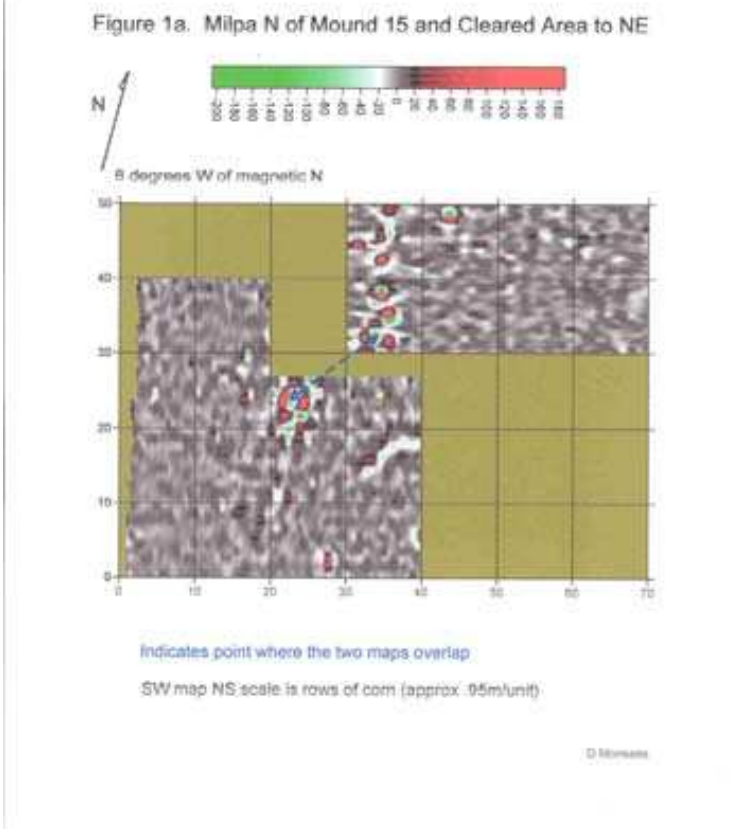

Fig. 4-3a. The milpa, north of Mound 15-1 and the cleared area to the northeast.

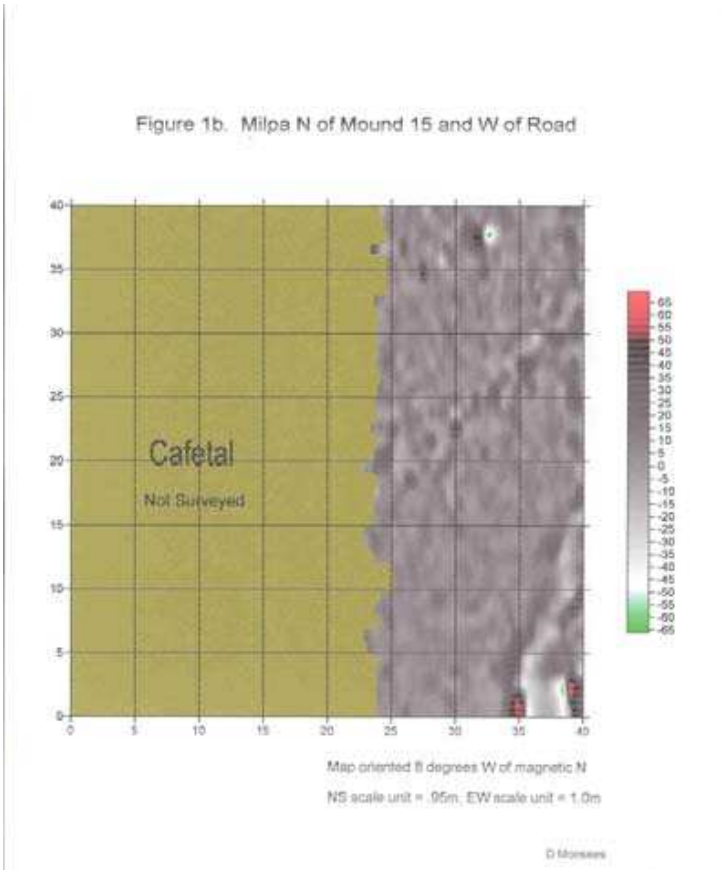

Fig. 4-3b. The milpa, north of Mound 15-1, west of the road.

Figure 4-3a shows the results of the magnetic survey accomplished in the area at the east of the road. Figure 4-3b shows the results obtained in the area at the west of the road. The east-west traverses shown in these two figures were restricted because of the corn swaths, and correspond to the southwest section of figure 4-3a and the entire figure 4-3b. The average width between the corn swaths was of 0.95 m. Once the obstructions were cleared in the northeastern area shown in figure 4-3a, the area was crossed in traverses oriented to the north and separated by a distance of one meter. In the maps of figures 4-3a and b, around 21.700 data points are represented. Figure 4-3c repeats figure 4-3a, but with drawn-up lines as a part of the analysis.

The magnetic field data represent the deviations of a given full body. The areas with archaeological or geological anomalies are deviated from the hypothetical gentle uniformity of the field. Objects with no magnetism yield negative signals and are shown with lighter colors in the maps. The objects with a magnetic susceptibility or a remnant magnetism yield positive signals, and are manifested with dark tones. Magnetic susceptibility is caused by the concentrations of ferruginous molecules. Remnant magnetism is caused by the heating of different materials at a temperature that exceeds the Curie point and their subsequent cooling within a magnetic field –such as that of planet Earth-. This process aligns the ferruginous molecules in the material and yields a permanent magnetic field after the cooling.

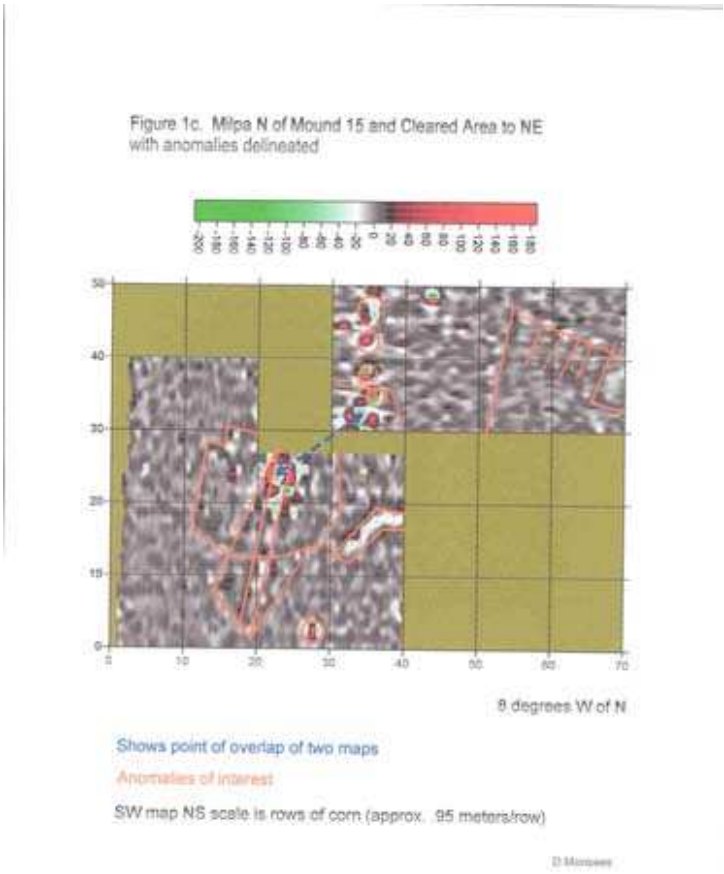

Fig. 4-3c. The milpa north of Mound 15-1 and the northeastern area with its delineated anomalies.

The stronger the presence or absence of magnetism, the darker or lighter the hues in the map will be. Modern iron and steel produce, as a consequence of magnetic susceptibility, a very strong bipolar field with positive and negative poles that distorts the field and darken all the surrounding readings. The concentrations of organic material from middens, postholes, or water wells, reflect the concentration of ferrous molecules (magnetic susceptibility) as a positive anomaly. Remnant magnetism may produce a very strong bipolar field with an aspect similar to iron, particularly in the case of objects or traits that were subjected to high temperatures, such as igneous stones, hearths, or burnt structures. Soils that have undergone change by the action of fire, ceramic sherds and bricks, will all exhibit remnant magnetism.

In figure 4-3a the interesting anomalies are indicated with orange, while in fig. 4-3c the blue arrows show where the milpa (southwest map) and the cleared area (northeast map) overlapped and joined together. Differences may be noted in the traits due to the interpolation used in both maps, and the greatest density of data is centered in the lines of the southwest map and the columns of the northeast map. The stained aspect of the maps derives from highs and lows of less than +/- 25 nT; this is probably the result of cutting trees and sowing in the past, emphasized by the type of filter used in the procedure, and maybe, of the geology of the area. The anomalies that are very probably cultural are located at 13-15 m NS and 7-8 m EW, in a cluster of extreme bipolar anomalies that extend along a northern direction up to the edge of the map, and begin in E20-26/N18, to continue north. We must point out that the northeast map is displaced 10 m to the east. Possibly there is an indication of a structure surrounded by a platform marked by a positive ring of orange color. Flagstones or possible monuments are also indicated. In the eastern portion of the northeast map, the almost parallel lines that run along a north-south direction and end up north with a row of east-to-west negative points (light in color), may possibly represent a trail to the Chocolá River, though we should not leave aside the possibility that they were possibly a consequence of plowing, because when the German rural establishment was there, these lands were used as sugar cane plantations. The nature of these traits must be verified to define the meaning of the anomalies. The curved anomaly with an extreme bipolarity that extends from E32/N13 to E40/N18 may probably be indicating a dam built with igneous stones. We come to this conclusion because the anomaly is consistently positive at the north and negative at the south –we feel that should this structure be a cultural trait, the stones with remnant magnetism would be randomly oriented, as was confirmed in the case of Mound 15's structure. The anomaly showing magnetic extremes in E28/N2 may probably represent a common stone, modern metal, or a monument.

Fig. 4-3b does not seem to show anomalies of a cultural nature. The anomalies observed in the lower right corner probably indicate surface materials deposited during the construction of the road immediately east of the milpa. The more or less lineal anomalies that extend across the map along a southwest-northeast direction, beginning approximately in N15/E25 and ending approximately in N35/E40 could be cultural traits, though more probably they were caused by the erosion of the terrain.

2. Mound 15

Fig. 4-4a shows the full prospection of Mound 15. Prior to beginning, most of the area comprised in E20-40/N30-50 was entirely cleared, mapped with a total station, and staked at 2 m intervals. The areas at west and east were cleared preserving the

coffee plantations and the grid was established using a compass and a metric tape. All traverses were 1 m apart and run along a south-north direction. Figure 4-4a shows more than 10.000 data points. The initial grid *(retícula inicial)* (RI) of 20 x 20 m was mapped twice, to guarantee precision in the methodology.

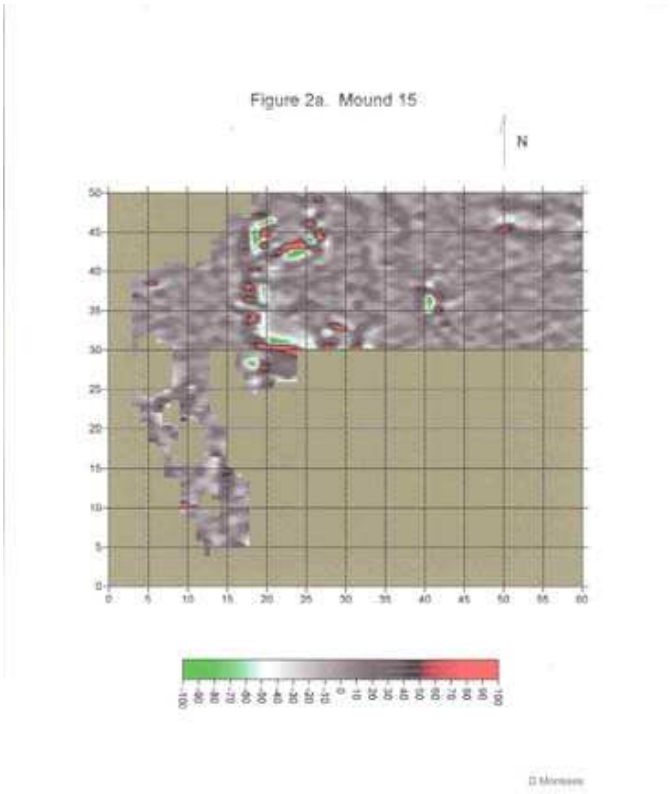

Fig. 4-4a. Mound 15.

The excavation immediately after the mapping produced information for the interpretation of anomalies in this and other areas of the ancient site. Figure 4-4b outlines the interesting anomalies in the map of Mound 15. Maps display a clear code of intercrossed lines that run along a west-southwest-east-northeast and northwest-southwest direction, which by means of the excavation, proved to be old plow marks scattered in positive areas, probably indicating contemporary plantations.

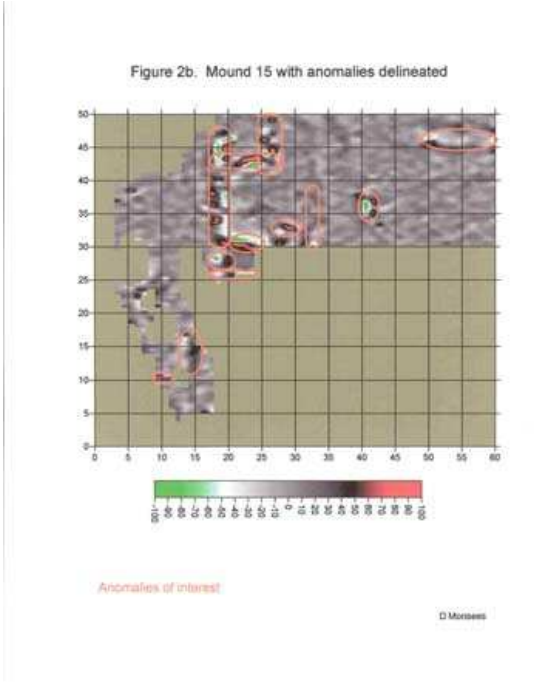

Fig. 4-4b. Mound 15 and delineated anomalies.

The area at the northwest of the initial grid (RI) of 20 x 20 m shows extreme positive and negative signs. At the beginning we thought that the great ellipsoidal anomaly observed in E21-27/N40-44 could have been caused by a lightning. However, during the excavation we observed that the anomaly represented the stone foundations of the south wall of Structure 15-1. It is possible that the anomaly was caused by the ancient use of igneous stone in the wall, as well as by the remnant magnetism of a lightning, as storms with lightning are frequent in this area. It was found that the anomaly in E18-20/N40-47 represented a stone alignment in the shape of a *talud* or sloping wall, and that it belonged to the west wall of Structure 15-1. The anomaly seems to continue south down to N30, where it turns to continue east to E28. At the eastern edge of the wall and proceeding towards north, we located the anomalies E25-27/N48-50, which proved to be three walls of Structure 15-1. After the excavation, the anomaly in E27-30/N33 proved to be a stretch of a water canal (see chapters 5 and 6). A well preserved canal that runs across the entire grid from E31.5/N30 to E30.5/N50 was located during the excavation. However, apart from the south portion of this canal, no other cultural trait was anticipated through gradiometry.

Precisely at the east of the initial grid (RI) of 20 x 20 m, a complex anomaly was observed, however, the excavation of four pits, each one a meter and a half deep, proved to be in grounds with no architectural traits. (The additional excavation of these pits to reach deeper levels is recommended to identify the cause of this anomaly). Given the extreme bipolar values, it is extremely surprising that the origin of the anomaly could not be found. Finally, in E50-60/N45-47 extreme values were found in the west edge, with a long, moderate negative area, flanked at each side by moderate positive signals. They may be of a geological nature, as they are located in a slope that descends to the river where the erosion has exposed a concentration of volcanic stones. It would be advisable to dig a deep pit to make sure that this is not a cultural trait.

In the area below N32 and west of E15 there are two anomalies that probably represent water conduits. Completing this traverse was difficult because this area is located under a post that carries electric wires with two poles of ferrous rods. The three white areas at the north within the map reflect the extripation of the extreme signals of the wires, aimed at preserving the machine's sensitivity for the artifacts in the subsoil. The more southern white area reflects a large trunk (inhabited by the most vicious ants). The anomalies in the area between N25 and N30 must be investigated. Very possibly, we could detect cultural traits such as water canals associated with the extensive ruin of Structure 15-1 and other traits that were excavated within the initial 20 x 20 m grid.

3. Area 35

Initially, 40 m of the north portion of Area 35 were mapped within a coffee plantation using parallel north-south traverses, with a 2 m separation [Fig. 4-5a]. The low data density is evidenced in the faded sections of this map. The mapped part consisted of milpas surrounded by unmapped coffee plantations. The swaths of the milpa were traversed along a west-east direction. The swaths had variable widths, and besides, at times they had to be side-stepped, particularly in the 40 m long section. Probably these variations resulted in a distortion of the possible traits; the extent of the distortion will be discussed below, in the description of Mound 5. As it may be understood by fig. 4-5b, Area 35 shows an intense magnetic activity. The probability that said activity is marking cultural traits holds up, due to the surface finding of many ceramic artifacts, obsidian blades, carved stones, and several big spike stones, probably (plain?) stelae. The sowing and piling up of stones by the peasants has disturbed the context for magnetic reading not only in the surface but also deep down in the subsoil. The abundance of artifacts, particularly those broken or worn out, has led us to believe that this is an area of workshops for some king of production. The large groups of interest are discussed below, as it is not possible to elaborate on all the anomalies. All the areas marking extreme magnetic values probably contain stones of cultural interest and must be researched through excavation. Figure 4-5b shows more than 28.100 data points.

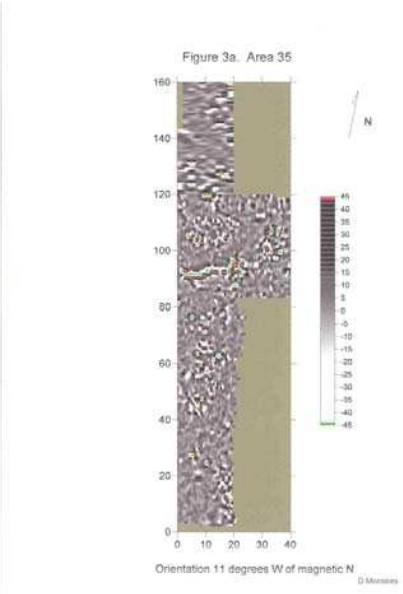

Fig. 4-5a. "Area 35".

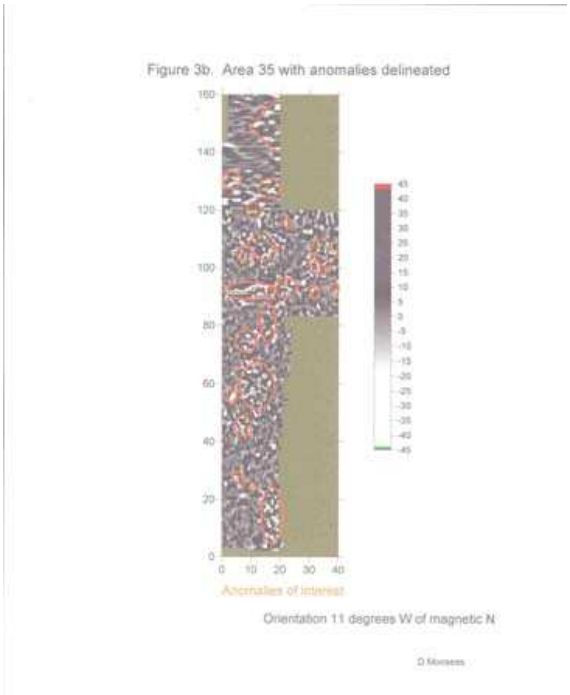

Fig. 4-5b. "Area 35" and delineated anomalies.

In the area north of the coffee plantation there is one interesting anomaly located at the east end, however, it may be indicating a natural outcrop near the creek, so that the marks could be caused by geology. The cause may only be determined through the excavation of this trait. Also, this area shows less surface artifacts, therefore, if we are in front of cultural traits, it is more probable that this is representing an ancient context less disturbed. In the areas to the south there are two clusters of anomalies shown between N98 and N112, which could very probably be cultural structures. Close to N90 there is what could probably be a dam of igneous stone, or the wall of a structure to the east. We have also observed groups with extreme values in N50-68 and N5-14.

4. Mound 5

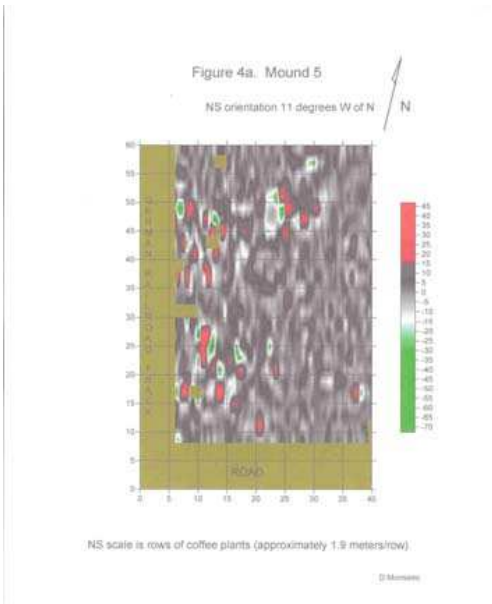

Fig. 4-6a. Mound 5.

This area, covered by a coffee plantation, required the clearing of branches before accomplishing the traverses with the gradiometer, and that procedure resulted in the variation of directions: instead of moving from west to east, we moved from west-south-west to east-north-east. As seen in figure 4-6a, to the south there is an access road to the coffee plantation. To the west lie the remains of a clean area that in the past was used by the railway that functioned during the first half of the XX century. When the railroads were removed, large nails and other ferrous debris accumulated in the area. Those residues were removed from the surface before the survey was initiated, to avoid false signals and to lessen the distortion of the anomalies. At times, the swaths of plants changed their orientation in the middle of the traverse, and some others, the distance between the swaths varied, and what began as one swath, turned into two. The distortion caused may be observed in figure 4-6b, where the blue frame marks the position of a 20 x 20 m grid with an ordinal orientation. This distortion complicates the interpretation of anomalies, but it was not possible to provide any other solution. The figure represents more than 7.000 data points.

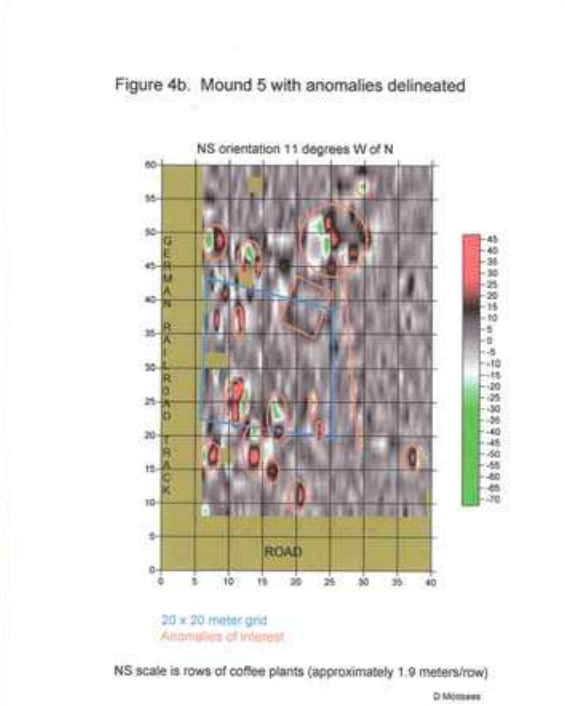

Fig. 4-6b. The mound and the delineated anomalies.

The anomalies with extreme values (and usually bipolar) we see dispersed in figures 4-6a and 4-6b, may represent igneous stones (native or either belonging to structures) or modern iron objects. The smaller bipolar spikes may not be determined without an excavation. Anomalies and unipolar anomalies probably do not reflect modern traits. However, the context is disturbed by plowing activities. The moderate positive and negative lines that run along a southeast-northwest direction are probably reflecting plowing. One may observe that some of the major anomalies are aligned with these marks, possibly a number of stones that were aligned by the plow. In figure 4-6b, the frame in E16-26/N35-44 is a positive anomaly that may reflect some cultural trait and that must be tested through excavation. The large circle in this figure with its center in E26/N49 is an area with signals above the average, particularly at west, it may reflect geology, and it must be tested. Proceeding from this circle to the south, there is a line with periodical negative values; this may be of a cultural nature, particularly if negative values are the result of sedimentary stone.

Among the other anomalies noted in figure 4-6b –the ones located in E17/N15, E15/N23, E13/N26, and E8/N48 (denoted by its central points to facilitate the description) have been tested through excavation and are stone wall alignments of 4- x 45 m, part of a structure denominated 5-1. It should be noted that a good portion of the wall is not shown in the gradiometric map. The conclusion we may make is that many of the stones used are of a sedimentary and not of an igneous origin, and therefore are not recorded in the gradiometer traverses. One important procedure to carry out, now that we are familiar with the precise location of the platform's walls, is the investigation through excavation of the extreme values inside the walls.

Conclusions

Gradiometry has proved to be of a substantial utility in the identification and localization of archaeological traits in the volcanic area of Chocolá. The strong signals caused by the igneous stone tended to render the details obscure, which would have been evident in a locality with lesser magnetic activity in general. The traverses, set 1 m apart, tended to provide the upper details to make excavation decisions, in contrast with those of two meters. However, considering the circumstances of the researchers involved, there was no other option. The distortion in the mapping caused for the need to work between the swaths is evident. However, the utility of the survey maps is undeniable, in terms of defining the precise location of the more interesting anomalies, and to show the way for subsequent excavations. These maps enhance the significance of the data obtained through surface collection, and reaffirm the conceptualization of the Chocolá areas as forming an urban entity.

The interpretations present in this chapter must be considered as preliminary, excepting when they have been confirmed through excavation in the investigated places (Mounds 5 and 15). This is the first experience of the geophysicist surveyor with this type of volcanic soil, and with archaeological sites of the Maya area, however, the identification and interpretation of the anomalies were significantly improved with the simultaneous excavations. We not only learned whether the signals indicated true traits or not, but also, this helped the surveyor to refine the methods and to interpret the signals in two dimensions: 1) the surveyor conceptualized the features or aspects of the unique characteristics of the soil and how these were reflected by gradiometry; 2) it enabled the Project to gain time in making decisions, by providing good degrees of certainty in the identification of anomalous concentrations representing unique cultural traits of the ancient remains of the city.

Recommendations

It is obvious that only with the test excavations accomplished during the remote sensing survey has it been possible to provide feedback for the correct functioning of the gradiometer. The local conditions of magnetism vary greatly from site to site, and it has been only through such tests that we have gained this experience. With precaution, it is possible to extrapolate the knowledge and determinations of one part of the site to other parts, emphasizing that test excavations must be considered a priority.

In view of what we have stated so far, we recommend posing the following questions:

- In the excavations completed, some ideas regarding the interpretation of the identified anomalies changed; then, is it or is it not correct to make a preliminary interpretation of the anomalies not yet tested through excavation?
- Which is the physical composition of the stone traits? Are all the stones used of an igneous nature?
- Could the cultural context of traits be better identified? Do the structures date to the Preclassic period? Are the areas, for instance “Area 35” truly workshop areas? Can we define the functions of the other structures? Obviously, these questions are of a general interest to the project, but they are as well of interest specifically for the gradiometric investigations.
- Could the identifications of the more ambiguous and smaller anomalies be improved, for example to define whether they are of an archaeological or a geological nature?

In areas where it would be too costly to investigate through intensive excavation, maybe a permission of the owners could be obtained to conduct shovel tests, and to investigate the anomaly plus the immediately adjacent area, to clearly assert the dimensions and the character of the anomaly. In general, shovel tests must be placed on top of the anomaly and should extend approximately three times the diameter of the anomaly to the north, south, east and west. In the case of linear anomalies, such as the wall of a building, the excavation should be perpendicular to the anomaly and extend approximately three times the width of the anomaly at each side. The depth of the excavation cannot be specified because the image is a function of, or depends on, the size of the object or trait buried, plus the magnetic contrast between the trait and the surrounding matrix. The distortion of the extreme signals due to the remnant magnetism of the igneous stones used in the ancient construction further complicates this issue. When following these recommendations, it must be understood that most anomalies with “interest circles” are really reflecting clusters of anomalies. Besides, it may be necessary to conduct an excavation between the swaths, or there where milpas are present, during a period of rest of the crops.