Magnetic Survey at San Andres Semetabaj, adjacent to Lake Atitlan, Guatemala

Sheldon Breiner

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Magnetometers can be useful tools in the early stages of reconnaissance in archaeological zones. Magnetic anomalies arise from common artifacts and sherds of many types, particularly objects made of baked clay (pottery, tiles, terracotta) and from objects comprised of rocks, especially those from volcanic or igneous rocks. More subtle magnetic anomalies are caused by the organic action from organic material such as human, animal or plant decay; or from disturbed ground due to the effects of farming or from burial or excavation or turning over the earth. Under certain ideal conditions, it may even be possible to detect and map tombs or subsurface chambers, or ancient pathways incised into rock, detectable, for example, by the gravity-concentrated naturally-occurring magnetic mineral grains that collect from the action of water. For an explanation of the source and detection of magnetic anomalies associated with archaeological sites, see "Application Manual for Portable Magnetometers" available online at

http://www.georentals.co.uk/ampm-opt.pdf

The most valuable aspect of magnetic surveys at a site is that important features can be mapped without excavation or otherwise disturbing the ground. The mapping itself can be done quickly and easily and the data interpreted to provide a guide to an excavation plan. Successful application of magnetic mapping techniques, however, entails the use of sensitive magnetometers which are relatively expensive instruments and, like any specialized equipment or technique, requires training to glean useful information that would aid site investigation. In particular, training is required for the survey procedures and in the subsequent interpretation of the data. The skills of an experienced geophysicist or geologist, can be sought until the anthropologist or archaeologist has had sufficient experience at a specific site.

A magnetometer was used to map small representative areas of the San Andres Semetabaj site. Surveys were conducted on December 6 and 8, 2003 in profile and 2-D mapping modes, for reconnaissance and mapping purposes, respectively.

The instrument used was a Geometrics Model G-858 Cesium magnetometer loaned for this project use by its manufacturer, Geometrics, based in San Jose, California. The magnetometer has a basic sensitivity in a fixed position of 0.01 nanoTesla, abbreviated, nT. The magnetometer is comprised of a sensor at the end of 2.5-meter-long staff. The sensor is connected to a console carried on the front of the operator on a belt at waist level. The console and sensor are powered by batteries carried on a harness on the back of the operator. The console is a specially-configured personal computer with a screen display showing anomalies plotted as the operator walks and which emits an audio tone that varies with local changes in the magnetic field, so that the operator can note anomalies as one walks and observes. Profiles of each line can be displayed, if desired, to note line-to-line anomalies or other survey data important to note immediately or while still in the field. Data were uploaded to a laptop computer for archiving and preparation of 2 and 3 dimensional map preparation.

A grid is first established over a mappable unit. Inasmuch as the prime area of investigation was almost completely covered by long rows of corn whose stalks had grown to 2 or 3 meters or more. Furthermore, the stalks were very dry and, together with the deep, 15 centimeter-deep furrows, made walking on a regularly-gridded plan, exceedingly difficult.

Grids was formed by laying two parallel lines of rope on the ground along two opposite sides of a grid. A third line, parallel and in between the two bounding lines served a midpoint. Knots had been tied at intervals of 2 meters and marked at those knots by survey flagging of alternate colors , one for the 2-meter marks and another for the 5 meter points. The ropes were 50 meters long.

GPS readings were taken at corners of grids for location of the grids. To supplement these locations, an engineering compass, compensated for local magnetic declination of 3 degrees east of north, was used to obtain headings of the sides of the grids and, on occasion, to "square" the grid ropes.

The operator walked as much as possible at a constant walking speed while carrying the sensor at a constant height above the ground . The speed is important only between marks on the grid ropes because the data are interpolated linearly between these marks. These marks -- at the beginning, the midpoint and the end of each line -- are noted by depressing buttons on the magnetometer as the operator starts, reaches a midpoint and finishes each line. These marks are used by the console and post-processing computer to generate a gridded data set for display as profiles, for export to a PC, and for contouring or other anomaly analyses.

Unfortunately, the cane in the field lying at all directions and in thick, dry stalks made it exceedingly difficult to walk through on a straight line. Even more of an obstacle to covering the grids were the furrows dug at highly variable angles and spacing and at, an obtuse angle to the intended grid lines and up to 20 centimeters peak-to-peak.

In a mobile mode, the effective sensitivity is generally 1 nT (nanoTesla), limited by local disturbances in the magnetic field because of nearby rocks, man-made objects, daily solar disturbances and by position uncertainties of the sensor. The earth's magnetic field intensity is approximately 38,000 nT in this area.   Of greatest concern to this survey, however, were the underlying geology, including the soil which was derived from volcanic ash from the local cinder cone volcanoes). Among some of the target objects of possible interest were certain rock fragments, kiln-baked pottery and the subtle aspects of concentrations of the common magnetic mineral, magnetite.

Sand, water, soil, rock, air and other materials do not diminish the magnetic effects of an object as observed with a magnetometer. Distance from an object does decrease the magnitude of an anomaly more-or-less with the cube of the distance between the sensor and the object (see Applications Manual)

Magnetite is heavy (specific gravity 5) compared to all other minerals in the sand and very resistant to weathering, both mechanical and chemical, which can form local placer concentrations or adhere to material such as wood and serve as a means of detection with the magnetometer. A clean magnet was inserted into the local soil and withdrawn, having attracted a small amount of magnetite grains, perhaps 0.1 to 0.01mm in diameter.

The field values were recorded in the magnetometer and downloaded into a laptop PC. The data were then contoured using software programs in the PC. The results were then plotted and printed to produce magnetic field contour maps presented as shaded-relief, contour maps. No regional gradients were removed.

A high magnetic field gradient was evident from the pronounced apparent magnetic effects of the soil comprising the furrows in the corn field and the underlying volcanic geology, exacerbated by the effects of the change in the elevation of the sensor as one walked the survey lines of the rough terrain of the furrows in the cornfield.

Samples of soil were obtained, packed in bags and placed at a point 25 cm above and to the magnetic south of a fixed magnetometer sensor and rotated in all directions (to avoid any non-isotropic effects), and then it was removed. Readings were noted before, during and after the specimens were in the vicinity of the sensor. The magnetic susceptibilities thus measured for two soil samples were 0.29 and 0.42 X 10-3 cgs units.
The vertical magnetic field gradient was also measured at the point N 14'º 44.897 x W91'º 08.173' on the access road near the SW corner of Mound 15, magnetic field reading were taken at various elevations above a locally flat ground surface.

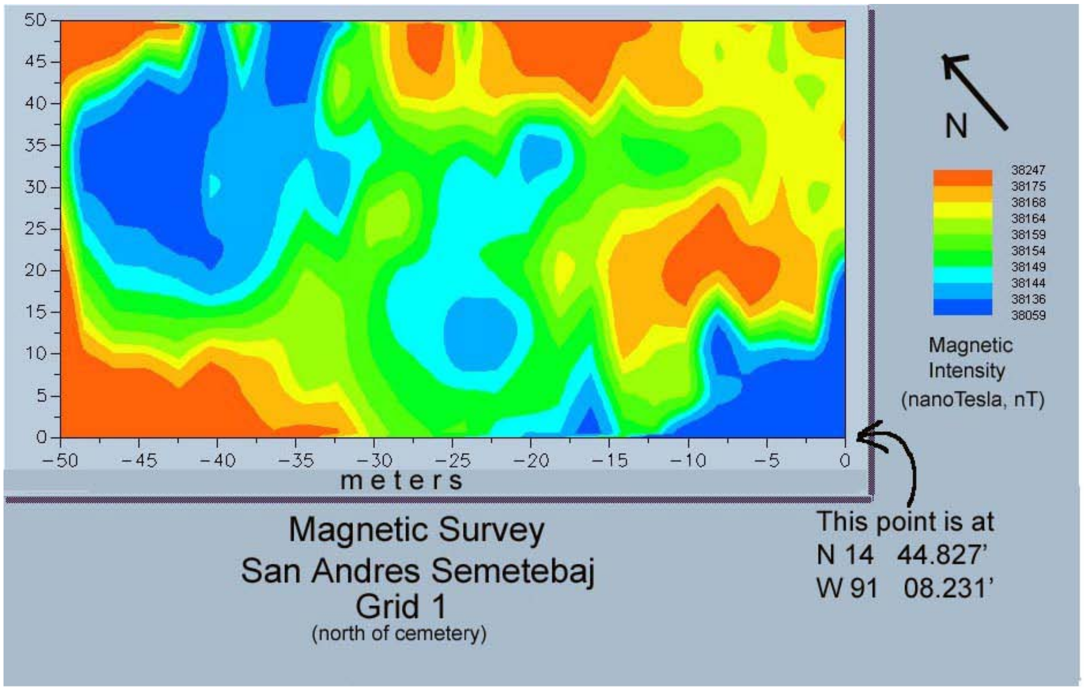
surface + 0.5 m	110 nT
surface + 1.0 m	143
surface + 2.0 m	160

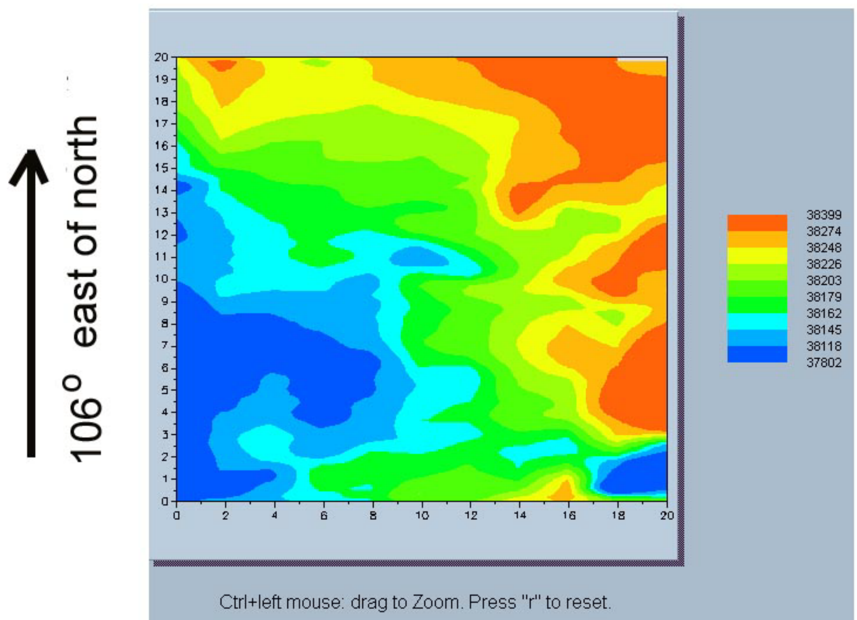
Thus, the average gradient at 0.75 meters = 66 nT/m and at 1.5 meters = 17 nT/m
illustrates that the soil developed from local volcanic ash does indeed have a high magnetic susceptibility.

On the basis of these measurements, it was decided to conduct the remaining surveys holding the sensor at an elevation above the ground of 2 meters. In this fashion, the effects of unavoidable varying ground clearance of the sensor is sharply diminished while the distance from underlying artifacts and possible magnetic structures is only minimally diminished. The result was then a more noise-free survey for more meaningful interpretation. (see grids over pea-field and grid near Mound 15.)

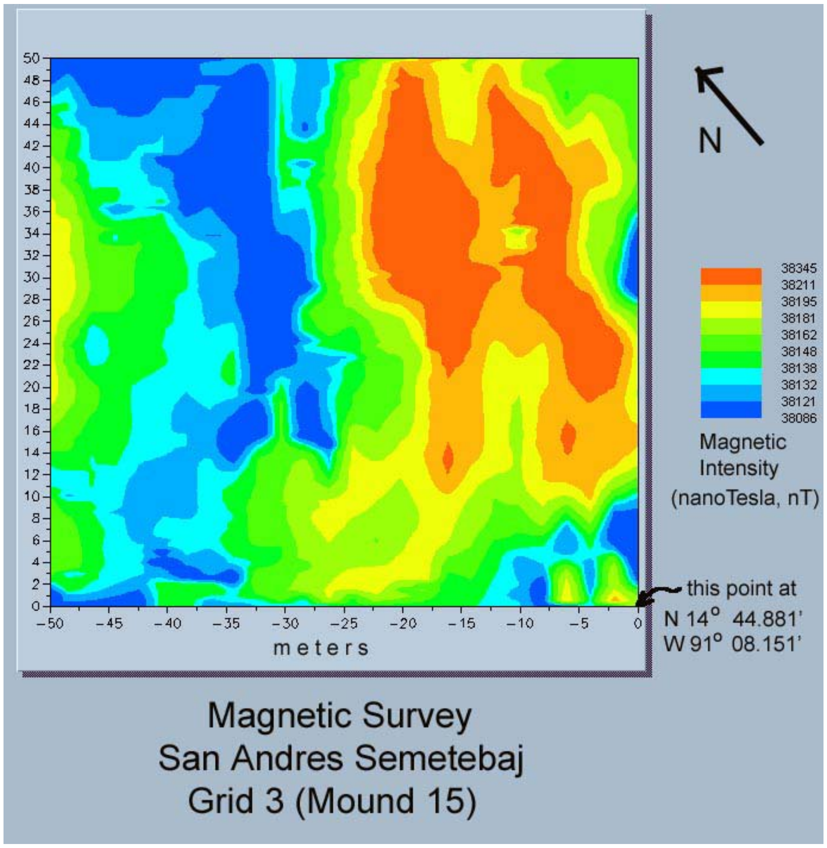
Four grids are included in this report:

1. Grid 1, just north of the cemetery
2. Grid 2 just south of the cemetery and adjacent to the excavated tomb
3. Grid 3 in the southwest portion of Mound 15
4 Grid (two combined) in the pea field approximately 0.5 km north of the site.

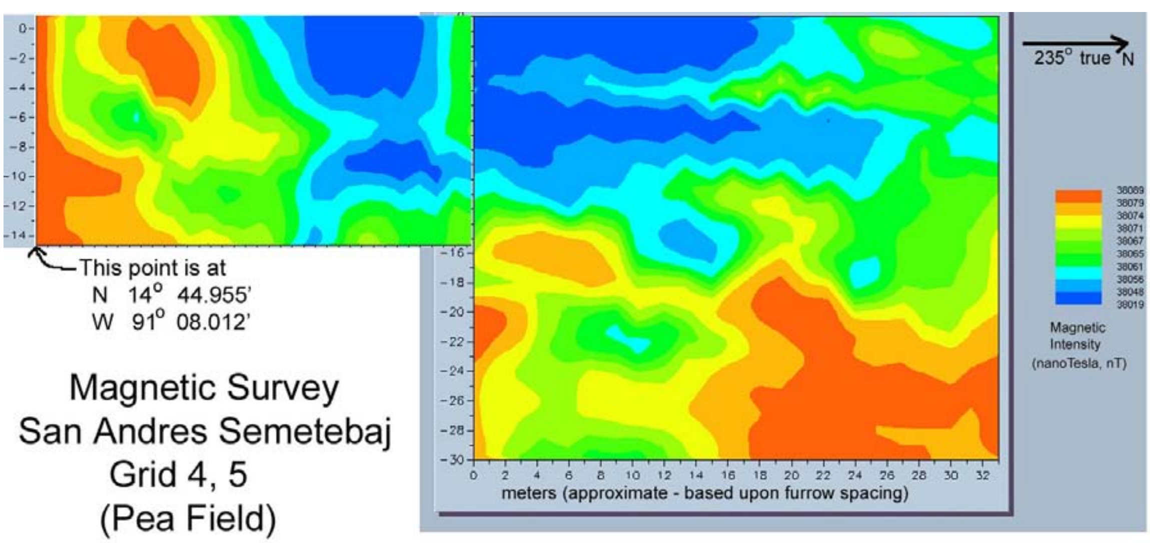




(0,0) at N14° 44.790' X W91° 08.285'
Magnetic Survey San Andres Semetebaj
(nanoTeslas, meters)



Magnetic Survey
San Andres Semetebaj
Grid 3 (Mound 15)



Magnetic Survey
San Andres Semetebaj
Grid 4, 5
(Pea Field)