Using Geophysical Magnetic Surveying Methods in Locating the Buried Wall of the Hawaiian Fishpond, Pa'aiea

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INTRODUCTION

In this project, geophysical surveying methods were used to delineate the location of a buried wall belonging to the fishpond, Pa'aiea. According to strong legendary, topographic, and archeological evidence Pa'aiea is thought to occupy an area of 3.5 mi. by 0.5 mi. between Mahai'ula and Keahole Point.

Fishpond legends begin in the times of heroes and gods. Fishponds are documented in legends from the fourteenth century through the nineteenth century. There is evidence for their existence as early as 1200 CE. By the late tenth century Polynesians had created large permanent settlements on all the major Hawaiian islands. These settlements dictated a focus on marine exploitation. Ancient fishponds have been found on all the major islands. The majority of ponds are particularly extensive on Kaua'i, O'ahu, Molokai'i, and Hawai'i (Wyban, 1992). An estimated 449 fishponds were constructed prior to 1830. Native materials are used in the assembly of fishponds. The structure of the walls include stone (either a'a or pahoehoe basalts), lithified sand, coral, alluvium, timber, and vegetable material (Apple, 1975).

A number of important coastal Hawaiian fishponds have been buried beneath recent lava flows. The ancient Hawaiian fishpond, Pa'aiea, is located north of Kona on the Big Island of Hawaii. Pa'aiea was a coastal pond that was buried by the 1801 Hu'ehu'e flow from the Hualalai volcano. Hawaiian pahoehoe lava flows are thin and usually flow around walls, not destroying them. However, inflation often occurs as molten lava flowing underneath the original top crust raises the lava to the level of the fishpond wall. Later flows can then flow over the wall covering it completely. Present-day topography suggests the existence of a bay where the fishpond Pa'aiea is buried. Given sea level at the time of inundation, as well as legendary accounts, the Pa'aiea fishpond walls are considered to be about 8 meters to 10 meters below the surface of the 1801 Hu'ehu'e flow (Jim Kauahikaua, personal communication).

METHODS

Field work. The lines of this grid were set according to the supposed strike of the fishpond wall, topographic constraints, and man-made features. The grid consists of nine lines running semi-parallel to one another. The lines extend from the west to the east. The lines of this survey are extensions of a previous survey headed by Jim Kauahikaua of the Hawaiian Volcanological Observatory.

The shape of the wall is likely to be slightly curved forming a large convex arc bowing toward the sea. The length of the wall is thought to run approximately 3.5 miles north to south, with a width of about 8 meters to 10 meters. The grid was set with the dimensions of the wall in mind. The wall should run perpendicular to the lines of the grid (Figure 1).

Measurements of the magnetic field were taken at every 2 meters along each line that make up this grid. The staff height of the magnetometer was 2.44 meters.

Laboratory Work. A sample was collected in the field and cored in the lab using a Hoffman 2.54 cm diameter drill bit. Paleomagnetic expriments were performed on these cores in order to obtain data on the magnetic properties of the basaltic material surrounding the buried fishpond wall. Magnetic susceptibility, remanent magnetization, and inclination and declination were measured.

Equipment and Software. The instrument used for measuring magnetics in this survey was a proton-precession Geometrics G-816 magnetometer. The surveying instrument (which was also loaned by the HVO at HVNP) was the PTS-V Total Station Survey Instrument by Pentex. A dual frequency Bartington Instruments MS2 Magnetic Susceptibility Meter was used for susceptibility measurements and a Molspin Spinner Magnetometer and an alternating field demagnetizer were used in the paleomagnetic experiments.

The programs used for this the project were: MacGridzo (data contouring), Microsoft Excel (graphing and data manipulation) and Kaleidagraph (graphing). The programs used in modeling were MagModel, as well as programs from the USGS Digital Data Series DDS-9 (CD-ROM publication of this series) and the USGS Potential-Field geophysical software, version 2.0. Other programs used from the Digital Data Series and Potential-Field software were ASCII2SF, Magpoly, and ProfilePlot.

RESULTS

Table 1 show statistics associated with the magnetic measurements along each line. The average range per line for all of the measurements is 1181 nT. In this table the mean represents the average measurment along each of the lines. The maximum and minimum columns show the highest and the lowest measurement along each of the lines. The range and the standard deviation values show another aspect of variablity in the magnetic measurements alnog each of the eight grid lines.

Table 1: Line Statistics: Calculations for each line showing the variablility of measurements

line	mean (nT)	max (nT)	min (nT)	std.dev (nT)	range (nT)
1.0	34957.2	35943	34458	266.6	1485
1.5	35005.2	35837	34230	295.6	1607
2.0	34910.0	35512	34195	264.3	1317
2.5	34898.4	35777	34375	224.3	1402
3.0	34790.8	35168	34381	176.8	787
3.5	34846.4	35237	34545	146.0	692
4.0	34866.9	35210	34257	209.3	953
4.5	34822.1	35379	34173	235.5	1206

Figure 2 shows the magnetic measurement of a specific line as a function of distance along the line. All eight lines are represented in this figure. These graphs are positioned to show how the grid lines are hypothetically represented in the field. The measurements for each line are plotted as a function of an original base distance. This base distance for each line serves to create a regular spacing interval about which each measurements can be compared. The original base distance starts at -100 meters in the west and extends to 400 meters to the east. Lines that do not span this area are positioned on this base line according to their relative position in the field.

INTREPRETATION

A significant trend of anomalies can be seen in the easternmost 200 meters of the grid sight. These anomalies lie between 250 meters and 350 meters from the zero point on the base grid system. This linear anomaly can be seen in the contours of the data, as well as in the profile plots for each individual line.

A model for the anomaly given by the wall was generated using the program Magpoly. The dimensions for the wall that were used in the program estimate the width of the wall at 5 meters to 10 meters. These values correspond to the widths of present-day fishpond walls of a similar sized fishpond and historical accounts of old fishponds similar to Pa'aiea (Wyban, 1992). The value used for the length of the fishpond was the length of the grid from north to south. Since the grid was 175 meters from north to south the wall was assumed to extend along the length of the grid. Different models were used where the depth to the anomaly was between 5 meters to 25 meters below the surface. These values were used because it is assumed that the fishpond wall, before the time of inundation, rested at sea level. The height of the field area is 20 meters above sea level, so the wall must lie between present-day sea level and the present-day elevation of the land. The input values for declination and inclination were the same as that of the present-day field. Since this Hualalai flow is relatively young, it can be assumed that direction of the remanent magnetization is very similar to the present-day field.

The susceptibility input value was determined by the paleomagnetic experiments. The primary value used in the modeling was 305.59 (SI, volume specific). In other modeling attempts, the maximum susceptibility value was 1400. These are essentially the "effective" susceptibility values that were derived from the magnitude of the remanent magnetization (J_r). This value is justified given the that the magnitude of the remanent magnetization is greater than the magnitude if the induced magnitization (J_i).

The results of the modeling experiments do not directly reflect what is seen in the data (figures 2 and 3). Although the wavelength in the model anomaly is similar to that seen in the data, the amplitudes are dissimilar. The amplitudes for the modeled anomaly range from approximatel 30nT to 200nT, while the amplitude for the correlated anomalies range to 1000nT.

In a previous experiment, where models were generated using data collected from a partially buried wall at Lae Apuki, Hawai'i (Kauahikaua, 1994), the amplitude and wavelength of the anomaly produced were very similar to data found in this study. Given this evidence, the model generated in this study may not sufficiently represent the true anomaly seen in the field. In conclusion, a significant linear anomaly is present in the specific area in which the fishpond, Pa'aiea, once rested.

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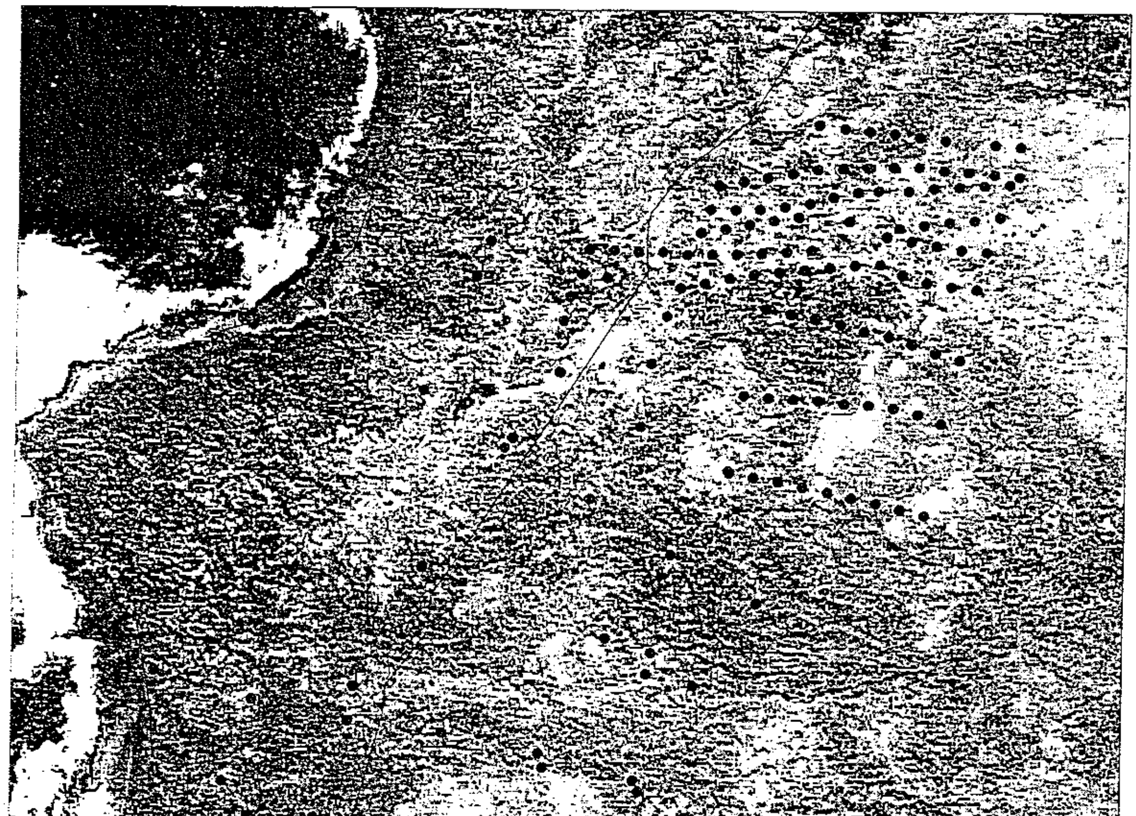

Figure 1
Scale 1:50,000
Plan view map of field area survey points superimposed. The lines used in the study are the northernmost eight lines.

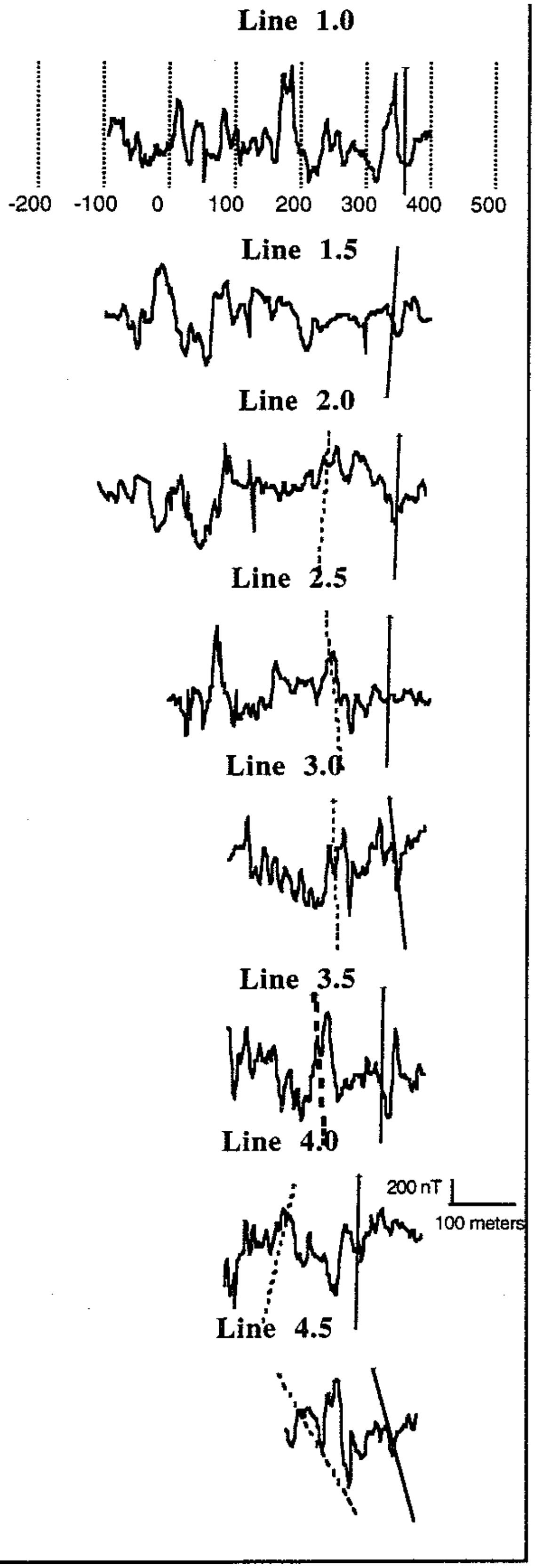

Figure 2: Profiles which correspond to distance along the line. Dashed and solid lines represent possible strikes for anomalies.

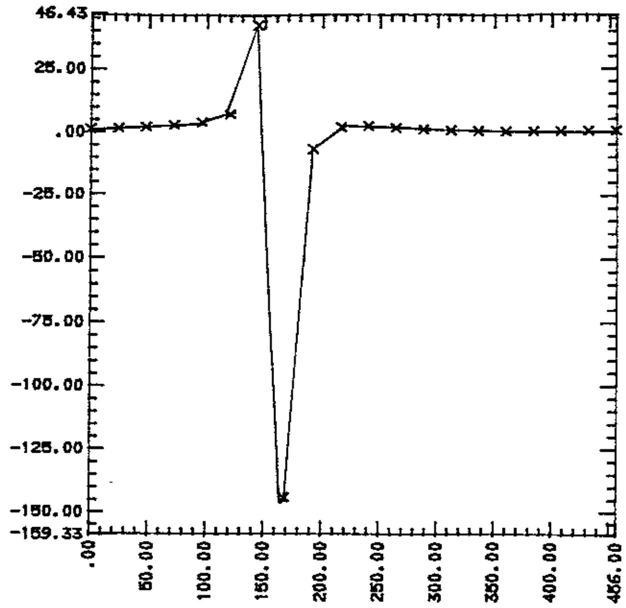

Figure 3
This figure is a model for the anomaly where the wall is 5 meters to 10 meters below the surface.

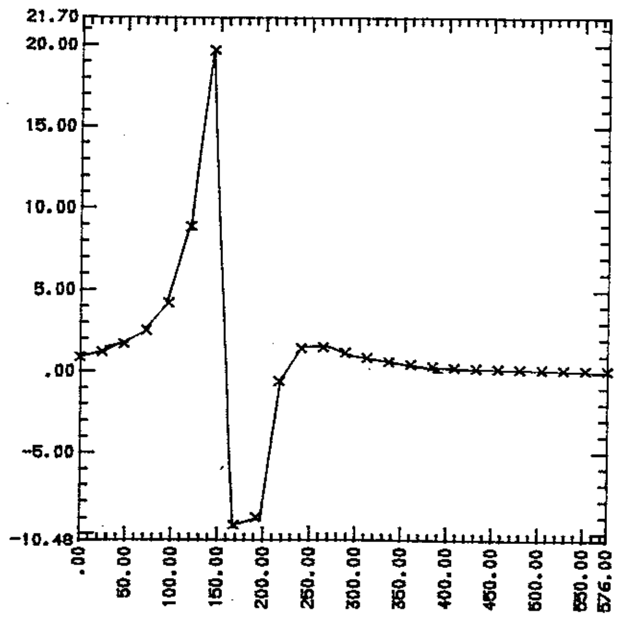

Figure 4
This figure is a model for the anomaly where the wall is 20 meters to 25 meters below the surface.