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USE OF MAGNETIC METHODS IN THE INVESTIGATION OF AN ANCIENT HAWAIIAN FISHPOND: ‘AIMAKAPĀ‘A FISHPOND, HAWAI‘I

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Use of magnetic methods in the investigation of an ancient Hawaiian fishpond: ‘Aimakapā‘a Fishpond, Hawai‘i

Abstract:

Magnetic methods were used at ‘Aimakapā‘a fishpond on the island of Hawai‘i to look for a stone seawall, or *kuapā*, that may be buried beneath a sand berm. The study was also aimed at searching for the fishpond's inlet channels, *‘auwai kai*. Magnetic methods should show the location of magnetic basaltic rocks beneath relatively non-magnetic calcareous sand. Results indicate that there is no wall under the existing sand berm. In addition, magnetic profiles verify the location of the fishpond's one visible *‘auwai*, reveal a possible second one, and suggest the possibility of other buried rock structures.

Introduction and Historical Background:

Pre-dating western contact, Hawaiian fishponds (*loko*) have been hailed as the most complex and fully developed in all of Polynesia. The Hawaiians had developed this unique method of aquaculture on all the major islands of Hawai‘i. Even though use of these ponds was already in a decline, production of fish from these ponds was about 1 million pounds per year in 1902 (Kelly, 1992). There are various types of Hawaiian fishponds: some are walled-off natural bays, some connect two points of land jutting into the ocean, and some are built upon and enclose entire reefs (fig. 1).

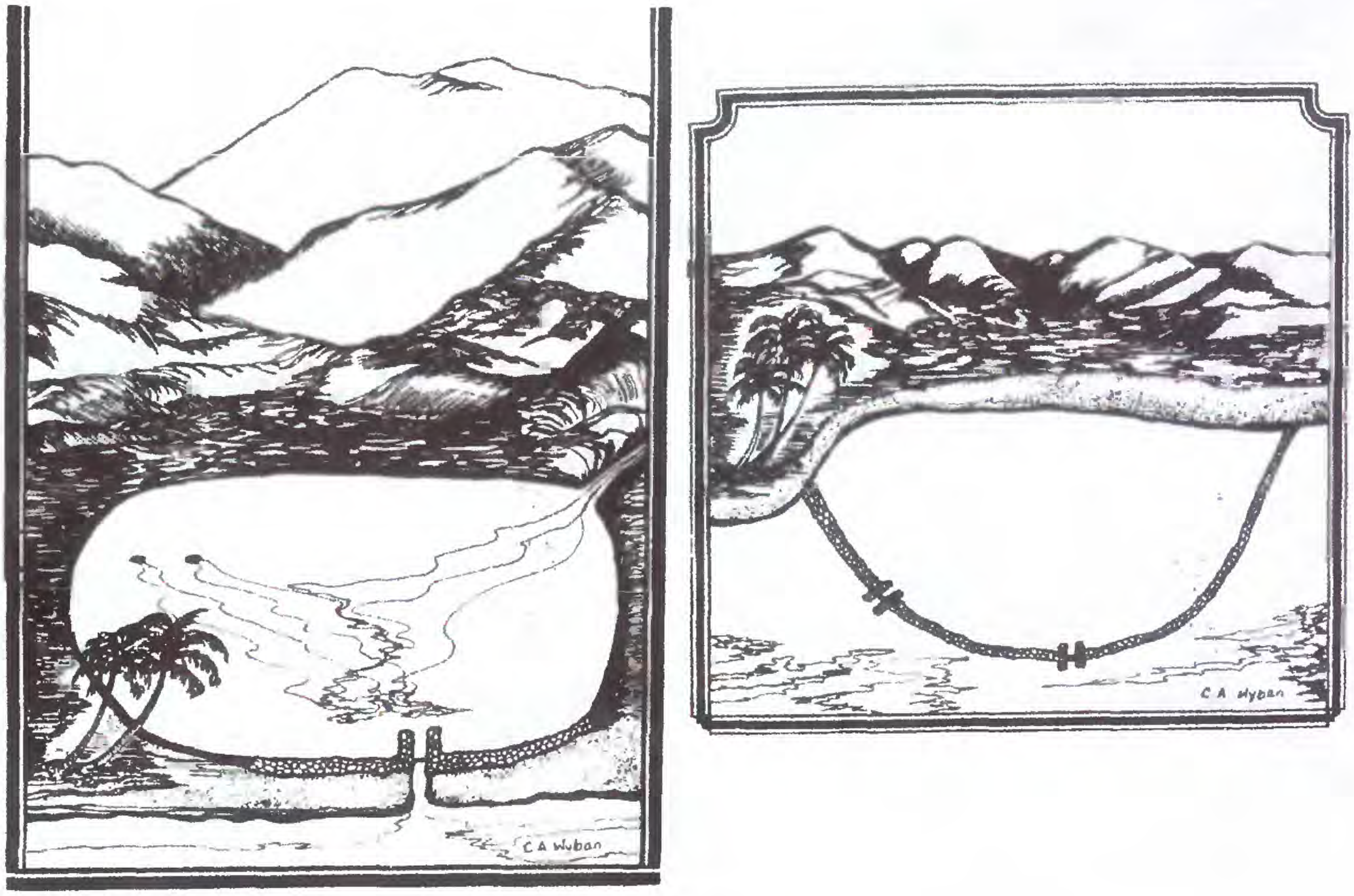


Figure 1: Loko pu'uone (left) and Loko kuapā (right) from Wyban (1992).

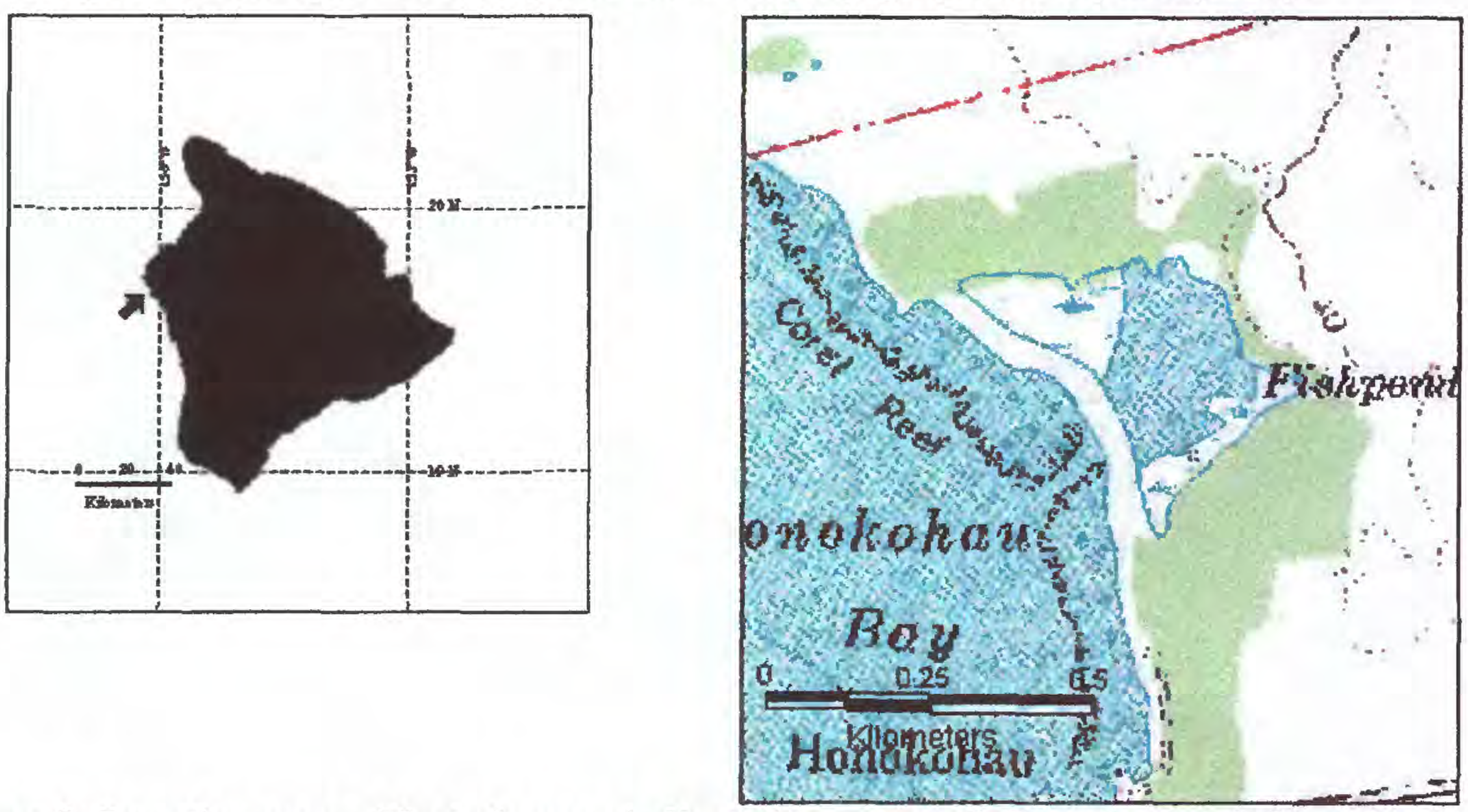


Figure 2: Location map with study area indicated by arrow (left) and a detail from the Keahole Point 7.5' USGS topographic quadrangle showing 'Aimakapā'a fishpond.

'Aimakapā'a (or 'Aimakapā) fishpond is one of several coastal ponds in Kaloko-

Honokōhau National Historical Park on the island of Hawai'i (fig. 2). The pond is bordered by 2,200 - 10,000 year old lava flows on three sides (Moore and Clague, 1991) and by a sand berm on the ocean side. Though much of the pond has been overgrown by vegetation, it still has an open water area of about 60,700 m^2 (15 acres). It is rather shallow, about 1.5 m deep in most places. 'Aimakapā'a was maintained and in use from antiquity until about the 1940s (Laura Schuster, 1997, oral communication). Today, it is primarily considered a valuable refuge for native Hawaiian waterfowl. In addition, the sand berm serves as a beautiful white sand beach.

The only visible evidence of a seawall, *kuapā*, or of pond inlet channels, *'auwai*, is a partially uncovered *'auwai* on the northern tip of the pond (see fig. 2). Also visible are several walled compartments within the pond itself. There are now no open channels leading into the pond, and therefore no way for new fish to enter. However, mixed seawater and freshwater continuously enters the pond via the underground basal lens.

Since almost all known fishponds have at least two *'auwai,* usually at opposite ends, and 'Aimakapā'a has one exposed *'auwai*, this study began with the assumption that at least one more *'auwai* exists but needed to be located and documented.

As for the *kuapā*, its existence has been a longstanding question. Many people, local residents and scholars alike, have assumed that a wall once enclosed the pond and that the sand built up to the beach and covered the wall. However, one known type of Hawaiian fishpond, *loko pu'u one* (literally: sandhill pond), consists of an inland pond separated from the ocean by a relatively small wall and adjacent large sand berm. If this is the case with 'Aimakapā'a, then the sand berm has probably been there since the pond was first constructed and there is no wall under the beach.

This project used magnetic measurements to detect the presence (or non-existence) of magnetic stone structures, namely the *kuapā* and *'auwai*, under the relatively non-magnetic calcareous sand berm, thereby answering the pertinent archeological questions.

To summarize, this 'Aimakapā'a study has three primary aims:

1. Locate any buried rock structures, such as fishpond *'auwai,*
2. Confirm or rule out the existence of a *kuapā* buried beneath the beach, and
3. Evaluate the usefulness of magnetic methods in this type of archeological investigations.

Methods:

Survey Configuration: Data were obtained along 95 profiles, which were 5 m apart, and oriented perpendicular to the shoreline (approximately east-west). The profiles were located along the whole length of the pond's seaward edge. The lines begin at the water's edge and extend as far as possible inland across the berm. Along each profile, the magnetic field intensity was measured at 2-m intervals, which should provide sufficient resolution of most variations in the magnetic field. Unfortunately, much of the berm is capped by thick brush, and a complete line across the sand is not possible in all places. However, the brush-free areas allow us to construct good magnetic profiles in our search for the wall. The *'auwai* are expected to be oriented perpendicular to the berm, so that profiles need not extend entirely across the berm.

In addition, a final profile was constructed along the whole length of the berm. It was set on the crest of the berm and run parallel to the shoreline. Points along this profile are also at 2-m intervals. This profile's primary purpose is to act as a check on the other lines.

Points were surveyed with a Pentax total station survey instrument. Though only relative positions are important for this study, the total station data were tied in with GPS and superimposed upon a map. The reflector staff was set upon a piece of wood to prevent it from sinking into the sand and significantly affecting the results. Semi-permanent markers were installed as the survey progressed, and two or more of them were surveyed at least twice a day for measures of survey repeatability. This allowed for proper translation and rotation of all lines into the final, complete grid. Accuracy is expected to be less than 10 cm.

Magnetic Measurements: All magnetic measurements were made with a GeoMetrics G 816 Magnetometer. The sensor was placed 1.5 m above ground level. A reference location for the magnetometer was chosen each day and re-read after every second profile. Time of reading was recorded for benchmarks and almost all points along the profiles. A total of over 1,150 magnetic values were obtained. The average standard deviation for the survey was 14.86 nT.

Modeling: Magnetic modeling was done to evaluate the possibility of a buried seawall. A magnetic wall was constructed using computer program SAKI (Webring, 1985), and the computed magnetic anomaly compared to the observed profiles across the sand berm. Specific values for the variables used in the model are presented below.

Results and Discussion:

Overall Magnetic Plot: Figure 3 is a map showing the locations of all the magnetic measurements. The colors are scaled to specific ranges of magnetic intensity. A 100 nT interval between color-coded contours was determined to give the best resolution of features. At larger intervals the smaller anomalies disappear, and at smaller intervals the patterns become too complex.

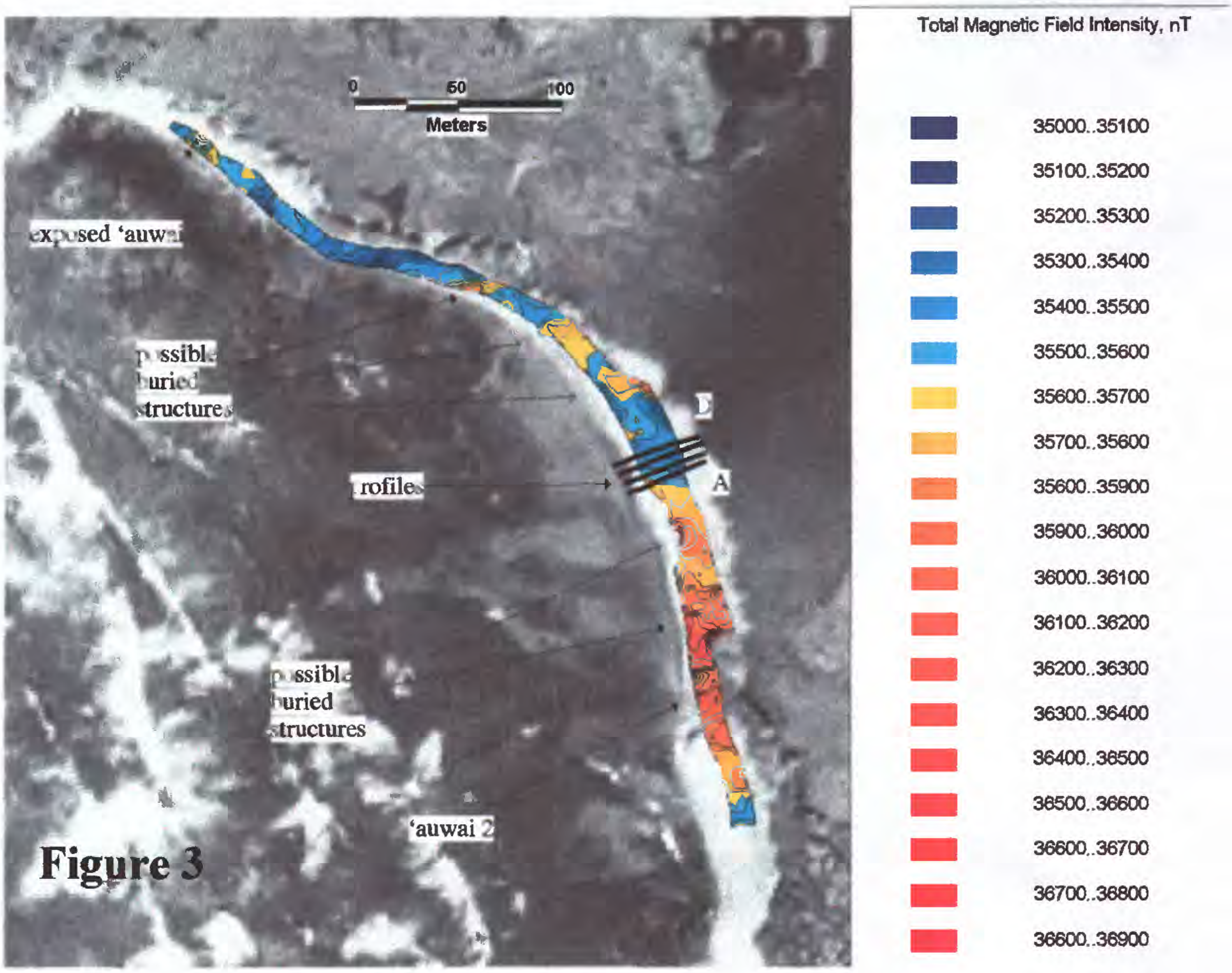
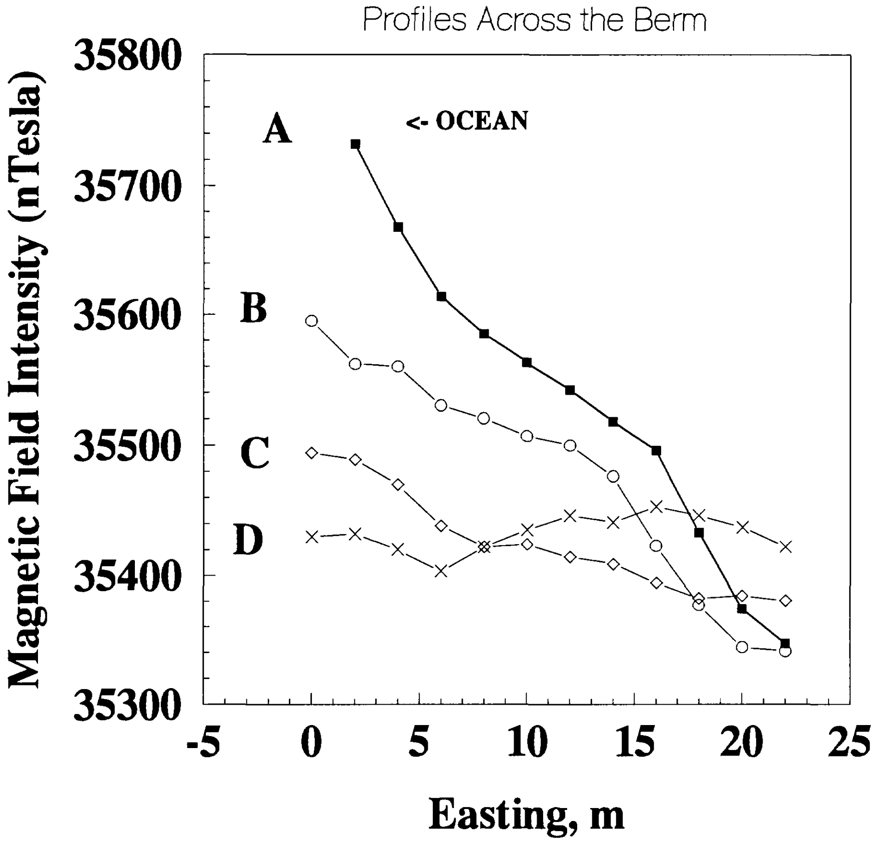


Figure 3

The most obvious features in figure 3 are the two areas having the highest magnetic intensity separated by an area with lower magnetic field intensity toward the southeast (lower right) corner of the map. This is exactly the anomaly pattern expected from an '*auwai* consisting of two approximately east-west stonewalls separated by a strip of sand. Over the one exposed '*auwai*, in the northwest corner, a small magnetic high quickly tapers off to lower values. There are other high spots toward the middle of the plot, but no clear indications of any additional '*auwai*. However, it is important to note that the southern half of the sand berm is thickest, a few meters. The thickness of the berm tapers off through the northern half of the berm, and the uneven, rocky reef is less than a meter below the berm crest. It is probably for this reason that the exposed '*auwai* does not show up well on the plot. The many large rocks embedded in the sand, and the undulating nature of the underlying basalt shelf, may be masking the '*auwai* signal.

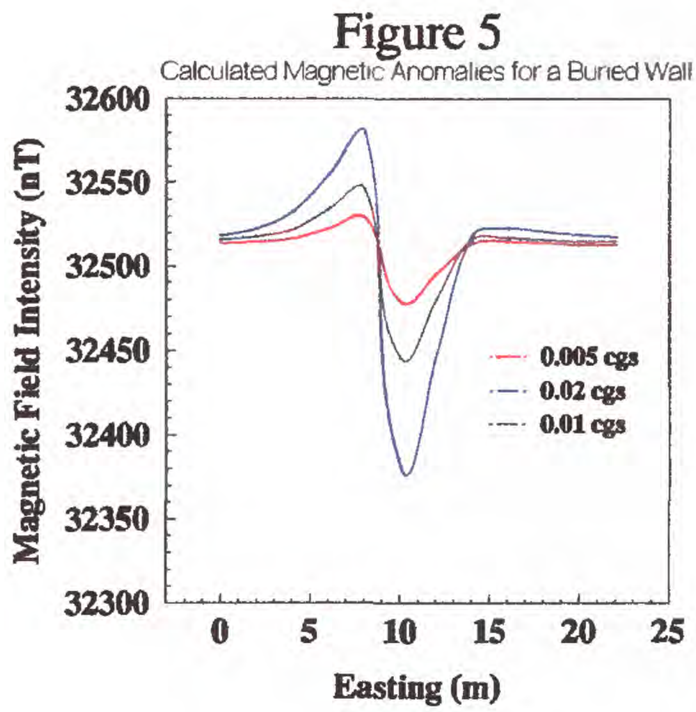
Figure 4



No evidence for the buried seawall:A glance at fig. 3 reveals no obvious indication of an intact *kuapā*, or stonewall, running parallel to the coastline. However, to better analyze the possibility of a buried intact wall, data profiles that extend completely across the berm (and across the possible wall) were plotted. The four profiles in fig. 4 were taken from the widest section of beach and are representative of the types of magnetic signals generated. The four profiles are parallel and approximately 20 m apart. The trend toward decreasing magnetic field to the east is present in varying amounts in all profiles. This trend varies on a much larger spatial distance than that expected for a stone wall, so we should really be evaluating magnetic field changes over shorter distances.

Next, a model was created to compare with these profiles. Location and elevations in the model were taken from one of the actual magnetic profiles (line D in fig. 4, location shown in fig. 3). Figure 5 shows typical magnetic anomalies calculated over the same 1 m-wide buried-wall model (fig. 6) for three different susceptibility values. The buried wall is modeled as having no remnant magnetization and only induced magnetization. The wall would be built with randomly oriented stones, each of which has remnant magnetization; however, their random orientation should allow their magnetizations to cancel, leaving only induced magnetization. The relevant values used in the model are shown below:

wall height and width = 1m x 1m magnetic field = 35,000 nT
susceptibility = 0.005, 0.01, and 0.02 cgs
remnant magnetization = 0 profile azimuth = N35E
inclination = 35 degrees declination = N11E



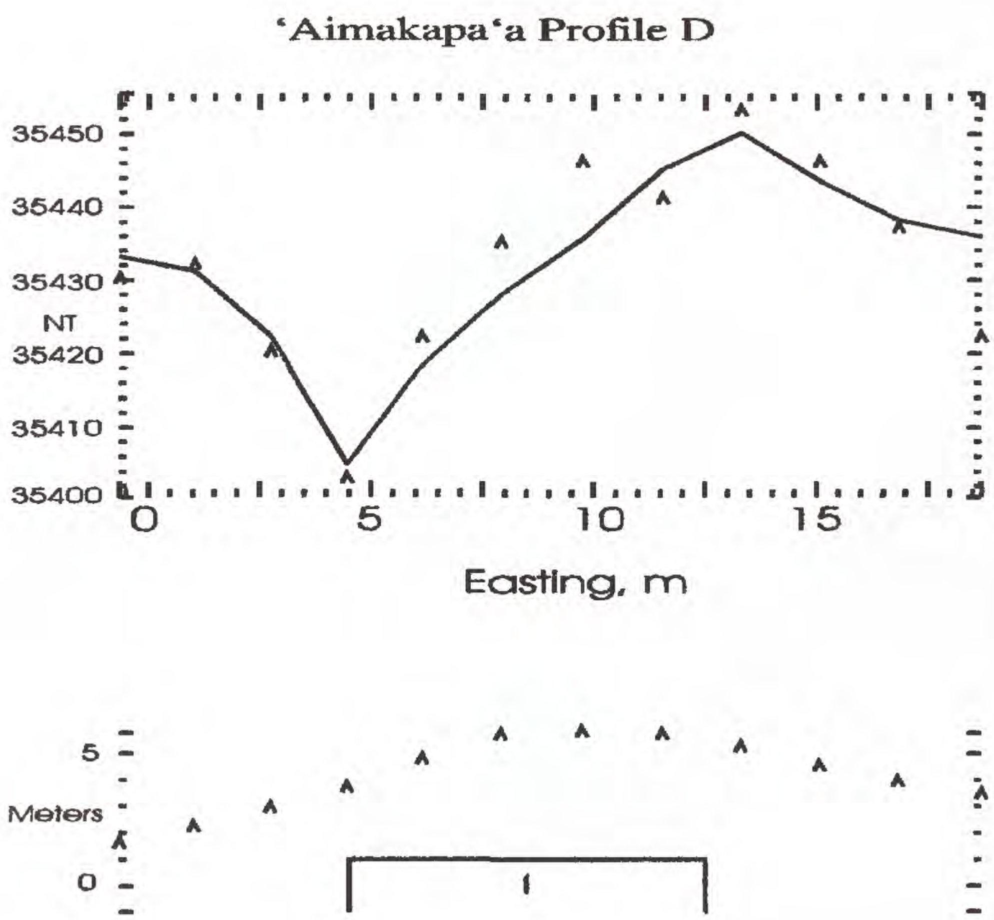
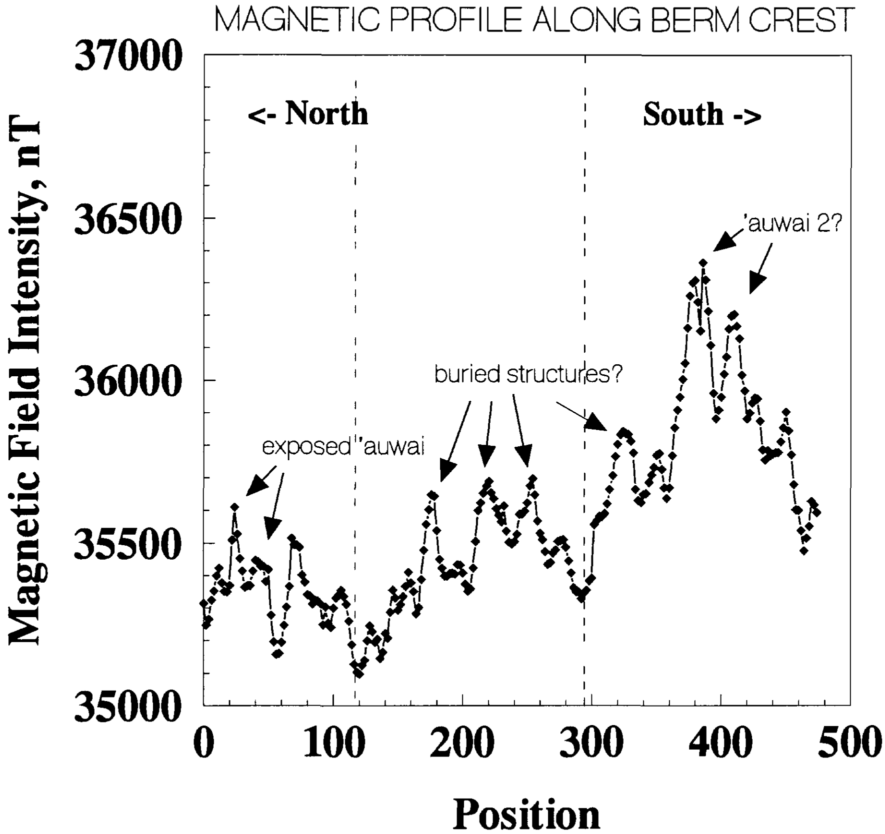


Figure 6. Upper graph compares Profile D data (symbols) with calculated model (line). Lower graph shows cross-section of model with surface of berm (symbols) and model rectangle.

Finally, the calculated magnetic values from the buried wall model are compared in figure 6 with the observed values from Line D. Of the four data profiles plotted in fig. 4, Line D is the most similar to the model. There is good correspondence between the two in amplitude and in distance between the data maximum and minimum. The best-fitting model is a 1-m-high by 5-m-wide rectangle of magnetic susceptibility –0.00133. The best way to interpret a negative susceptibility is by the absence of magnetic material. That is, we may have modeled a 1-m-deep hole in the pāhoehoe normally under the sand berm. This simple modeling effort seems to rule out the existence of the buried wall in this area.

Possibility of a third *'auwai*: Though fig. 3 was the primary tool used in searching for the buried *'auwai* and *kuapā*, the profile constructed along the whole length of the berm reveals the intriguing possibility of a third *'auwai* located approximately in the middle of the beach. Magnetic values from the profile are shown below (fig. 7). The values from this profile match well when superimposed upon fig. 3, as is expected. Locations of the one visible *'auwai* and the southern *'auwai* are marked on the graph as "exposed 'auwai" and "'auwai 2?", respectively.

Figure 7



Note the similarity of the three sections separated by dashed lines. The first two maxima in the north section correspond to the '*auwai* walls visible on the surface, and the two highest two maxima in the south section are possible *'auwai* walls. Though the middle section indicates a third structure, it is not readily apparent which two of the maxima could represent two *'auwai* walls.

A natural channel (fig. 1), runs into the beach at about position 300 on the profile in figure 7. If one assumes that the Hawaiians would build walls on either side of this natural *'auwai*, then the pair of maxima to either side of position 300 could indicate another *'auwai*. Any of the maxima could result from buried basaltic rocks or stonework.

Summary and conclusions:

The project's results are encouraging. Magnetic mapping seems to be a useable technique for this type of investigation, although final evaluation will have to wait for confirming excavation. Provided a reasonable thickness of sand, the magnetic contrast between sand and rock is enough to yield sizable magnetic anomalies. Indeed, magnetic intensities near the southern possible *'auwai* change over 500 nT in a distance of only about 15 m.

Given the trends revealed, simple inspection combined with magnetic modeling rules out the existence of a buried intact *kuapā,* or stone wall. Lack of such an intact wall suggests that 'Aimakapā'a may be a *loko pu'u one* or that the wall has been destroyed all along its length. We may find a relatively small wall on the inside edge of the sand berm, as suggested in historical references. Some sand and vegetation probably cover it, but it may be revealed after minor excavation.

Though we found the possible additional *'auwai* as hoped, the question of a third *'auwai* or other buried structure was raised. One could conduct another magnetic survey in that area with smaller grid spacing, perhaps a 2 m interval between profiles. Another option is to excavate the area, an unattractive solution given the beach's beauty. Additional magnetic data should be obtained before any excavation and/or restoration is begun.

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