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AEROMAGNETIC SURVEY AND INTERPRETATION, ASCENSION ISLAND, SOUTH ATLANTIC OCEAN

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Abstract—A detailed aeromagnetic survey of Ascension Island, which was completed in February and March of 1983 as part of an evaluation of the geothermal potential of the island, is described. The aeromagnetic map represents a basic data set useful for the interpretation of subsurface geology. An *in situ* magnetic susceptibility survey was also carried out to assist in understanding the magnetic properties of Ascension rocks and to aid in the interpretation of the aeromagnetic data. The aeromagnetic survey was interpreted using a three-dimensional numerical modeling program that computes the net magnetic field of a large number of vertically sided prisms. Multiple source bodies of complex geometry were modeled and modified until a general agreement was achieved between the observed data and the computed results. The interpretation indicates northeast- and east-trending elongate bodies of much higher apparent susceptibility than adjacent rocks. The relationship to mapped geologic features such as volcanic vents, dikes and faults suggests that these magnetic sources are zones of increased dike density and of other mafic intrusives emplaced along structures that fed the many volcanic centers. A large magnetic source on the northeastern portion of the island may be the intrusive equivalent of trachyte lavas present at the surface. A low-magnetization area, mainly north and west of Green Mountain, appears to be the most likely area for the presence of a geothermal system at moderate (1–3 km) depth. *Copyright* © 1996 *CNR. Published by Elsevier Science Ltd.*

Key words: Ascension Island, aeromagnetic survey, geothermal exploration, Atlantic Ocean.

INTRODUCTION

The geothermal energy potential of Ascension Island was evaluated to determine the feasibility of a low-cost, renewable energy alternative for United States facilities at Ascension Auxiliary Airfield (Ascension AAF). Geologic mapping and interpretation for this resource evaluation was completed in a Phase I study by Nielson and Sibbett (1982, 1996). They concluded that the young age of Ascension Island volcanic activity, the presence of geologic structures to provide permeability, and the probability of fluids to transport thermal energy, demonstrated a very high potential for the discovery of a geothermal resource. Nielson and Sibbett (1982) recommended a Phase II program of more detailed exploration activities. The aeromagnetic and magnetic susceptibility surveys reported here were a part of that geophysical exploration effort.

GEOLOGY

Ascension Island is located about 100 km west of the Mid-Atlantic Ridge median valley and 50 km south of the Ascension fracture zone (van Andel *et al.*, 1973). Composed almost entirely of volcanic rocks (Nielson and Sibbett, 1996), the island represents the top of a volcanic mountain that rises almost 4 km above the sea floor to 850 m above sea level, and is perhaps 50 km in diameter at its base (Brozena, 1986). Nielson and Sibbett (1996) present a detailed geologic map of Ascension Island, describe the units and structures, and discuss the geologic history of the island. The geophysical surveys were conducted to help define the subsurface geology, and to search for physical properties indicating a geothermal system at depth. A brief review of the geology is useful as a prelude to discussing the aeromagnetic and magnetic susceptibility surveys.

Mafic flows dominate the surface of Ascension Island, with the youngest flows emanating from the Sisters Peak and South Gannett Hill areas. These rocks are classified as basalt–hawaiite–mugearite–benmoreite (Weaver *et al.*, 1996); however they will be referred to as mafic flows in this paper. Nielson and Sibbett (1996) suggest that the youngest flows are probably only several hundred years old based on the lack of weathering and erosion. These flows cap older flows that occur throughout the island. Trachyte lava flows, pyroclastic deposits, domes and intrusions dominate the central and eastern portions of the island. Potassium–argon (K–Ar) age dating reported by Nielson and Sibbett (1996) suggests that the trachyte at Bears Back was emplaced at approximately 0.61 Ma. The Middleton Ridge rhyolite flow, exposed at the base of the Green Mountain stratigraphic sequence, was dated at approximately 0.94 Ma, which corresponds to the early part of the Matuyama magnetic field reversal. Prominent cinder cones and cinder aprons occur throughout the island.

GEOPHYSICS

Geophysical surveys

No significant geophysical data base had been published for Ascension Island prior to the present geothermal studies, although Dash and Milson (1973) do comment on the gravity field of the island. Nielson and Sibbett (1982) recommended aeromagnetic and resistivity surveys and thermal gradient drilling as part of a geothermal exploration program. Electrical resistivity surveys were completed in June 1983 and September 1984 and are discussed by Ross *et al.* (1996). The results of the thermal gradient study are reported by Nielson *et al.* (1996).

In 1979 and 1980, the U.S. Naval Research Laboratory conducted low level (200 m) aeromagnetic studies of the Mid-Atlantic Ridge (MAR) between the Ascension and St. Helena fracture zones in the South Atlantic Ocean (Brozena, 1986). The survey, which extended east and west to magnetic anomaly 5B (20 Ma age), covered an area of almost 700,000 km^2 with profiles having an average separation of 18 km. Brozena (1986) provides a thoughtful interpretation of plate spreading rate and direction, and fragmentation and rotation of ridge segments between fracture zones. He postulates that Ascension Island and several seamounts were produced some distance away from the "hotspot" location, now about 225 km southeast of Ascension Island, as a result of channeled subaxial magma flow beneath the spreading center. Brozena's data provide a useful regional context for the detailed magnetic survey reported here.

Description of the aeromagnetic survey

The remote location of Ascension Island is such that a conventional aeromagnetic survey using a permanently instrumented, fixed-wing aircraft would be very costly even if an aircraft with sufficient range could be contracted. The presence of a British helicopter unit, the 845th Squadron Detachment, Royal Navy, on Ascension Island provided the opportunity to conduct a survey using a "button-on" or portable aeromagnetic survey system. The British base commander agreed with the U.S. AAF base commander to provide helicopter support for the survey when flight operations schedules permitted. The authors mobilized a button-on magnetic survey system to Ascension Island in February 1983.

The data acquisition system included a GeoMetrics (TM) Model G803 Airborne Proton Magnetometer and sensor mounted in a 0.7 m long housing commonly referred to as the "bird". The magnetometer console was installed in a Wessex helicopter and connected to the sensor by a 30-m long electrical cable with an exterior nylon sleeve strength member. A Mark-lOX Bonzer radar altimeter was mounted on the helicopter skid to record the height of the aircraft above the ground surface. Magnetometer and altimeter outputs were recorded on a Hewlett Packard 7130 thermal printer that simultaneously records two channels of information in addition to the magnetometer-driven counting (fiducial) marker. The flight path corresponding to the magnetic observations was simultaneously observed by a downward-looking camera system and recorded on a Sony video recorder (model AV-3600). The magnetometer was operated at a sensitivity of 1.0 nT (1 nanotesla = 1 gamma) corresponding to a sampling rate of 0.5 seconds (GeoMetrics, 1973), or a distance of 20–30 m on the ground depending on true ground speed.

The flight crew included five people: the pilot, navigator, helicopter crewman and cargo observer, magnetometer operator, and videosystem operator. The survey was completed in four flights beginning 28 February and concluding on 4 March. Constant cloud cover over Green Mountain during the survey period resulted in a 2 km by 3 km data gap centered on this area.

Aeromagnetic surveys are generally flown with the primary flight direction perpendicular to geologic structure so that the higher data sampling frequency corresponds to the direction of greater change in geologic features. Geologic mapping by Nielson and Sibbett (1996) indicated both NW and ENE structural trends on Ascension Island. The primary flight-line directions were oriented S65°E directly into (or out of) the strong (20 knot) southeast trade winds to minimize drift off the intended flight path. Twenty-nine flight lines were completed at an average separation of 380 m. Eight tie lines were flown in a NNE direction, roughly perpendicular to the primary flight direction, at varying intervals across the entire island. The helicopter was flown on a smoothly draped flight path with a mean terrain clearance of 230 m as monitored by the aircraft radar altimeter. The magnetometer sensor hung approximately 25 m vertically below the aircraft, at the end of the 30 m cable. The total magnetic intensity data thus pertain to a mean terrain clearance of approximately 205 m.

Magnetic survey compilation

The flight path recovery was completed by playback of video tapes, identifying the surface features on the video monitor with respect to aerial photography and the 1:25,000 topographic map of the island. Total magnetic intensity strip chart recordings were manually digitized at all maximum and minimum points, at supplemental intervals depending on the magnetic gradient and noise levels, and at all intersections between flight and tie lines. Thus, magnetic field values were digitized at intervals of less than 400 m (ground distance) and most typically at less than 200 m. Diurnal variations during a given two-hour flight were found to be less than 10 nT, and were not specifically corrected. Magnetic field variations as measured between different flights were adjusted by minimizing the residuals at flight-line and tie-line intersections using the method of least squares (Yarger *et al.*, 1978). All data values were therefore adjusted to the second survey flight, which occurred between 0930 and 1200 hours, 2 March, 1983. Contouring of the data points was assisted by reference to an independent compilation of maxima and minima positions and magnetic gradient notations compiled directly from the analog records. The overall accuracy of the data compilation, reflecting errors in position, diurnal variation, altitude variation and leveling, is judged to be +/- 20 nT. This was considered sufficient for the exploration effort and justified a 20-nT contour interval for the compiled map. A constant value of 27,000 nT was subtracted from all observed data values for the presentation of data on Fig. 1. The total magnetic intensity field strength, for a fairly uniform area near the center of the island (approximately 1 km south of Two Boats Village), was approximately 27,800 nT at 200 m above the ground surface.

MAGNETIC SURVEY INTERPRETATION

The interpretation of aeromagnetic survey data for resource exploration has two main components: the delineation of magnetization contrasts and physical property parameters, and the interpretation of these parameters in geologic terms. Physical property measurements on outcropping rocks can often improve the geologic portion of the interpretation.

Magnetic susceptibility survey

The induced component of magnetization of an anomalous feature in the earth's magnetic field is proportional to the body's magnetic susceptibility. Magnetic susceptibility, defined as a ratio, is a dimensionless unit, and magnitudes of this parameter are expressed here in SI (Système International) units. The magnetic susceptibility of natural rocks is generally a function of the amount of the mineral magnetite ($Fe_2O_3 \cdot FeO$) present. Several empirical studies indicate that one volume percent of pure magnetite will result in a magnetic susceptibility of approximately 0.031–0.038 SI, although this is highly variable. Other iron minerals have magnetic susceptibility, but these are generally less important and probably of little significance on Ascension Island.

Magnetic susceptibility measurements were made with a Bison Instruments magnetic susceptibility system, Model 3103, equipped with a Bison 3120 *in situ* coil (Bison Instruments, 1969). The flat, 15 cm diameter sample coil was held against a smooth, planar rock surface to obtain the uncorrected susceptibility value. The observed value was multiplied by a correction factor to account for the average surface roughness, which prevented a perfect contact between the rock surface and the sample coil. This correction varied between 1.00 for no offset from the surface, to 1.21 for an average offset of 0.8 cm. A single susceptibility measurement represents a volume of approximately 1000 cm^3.

Susceptibility determinations were completed at 29 sample sites on Ascension Island (Fig. 2). Many locations represented two or three sample stations 30–100 m apart, or traverses of up to 300 m length. Three to 13 different measurements were made at each sample area, for a total of 289 readings. Table 1 summarizes the rock type and location, number of samples (n), sample mean (x) and standard deviation (s) for 17 rock-type groupings from all 29 sites. Mafic flows, which dominate the surface of the island, show the highest and most variable susceptibility, with individual readings varying from 0.003 to 0.0359 SI. The range of station averages for mafic flows lies between 0.0041 and 0.0278 SI. In general, the more vesicular the sample (i.e. higher porosity), the lower the susceptibility, though no attempt was made to quantify this relationship. A most typical susceptibility for mafic flows would be approximately 0.019 SI. Very high susceptibility flows (> 0.025 SI) occur north of Sisters Peak, along the coast, and at Dark Slope Crater. One mafic dike (sta. 22) also showed a very high (0.0317 SI) average susceptibility. Since the average susceptibilities for mafic flows are less than 0.03 SI, it would appear that the mafic flows typically contain less than one volume percent of pure magnetite. If substantial amounts of titanium are present in the magnetite lattice, several volume percent of magnetite could be present in the mafic flows, since titanium substitution in the magnetite lattice decreases magnetic susceptibility. Chemical analyses reported by Nielson and Sibbett (1996) do indicate that substantial amounts of titanium oxides are present, probably as titanomagnetite.

Table 1 shows that the other principal rock types present on Ascension (i.e. rhyolite, trachyte, mafic cinders and pumice or pumiceous sediments), all exhibit magnetic susceptibilities that are lower by a factor of 5–10 than those of the mafic flows. Other rock types may be present at depth that have higher (or lower) magnetic susceptibilities. A geothermal reservoir area within the mafic flows could be expected to exhibit lower susceptibilities than adjacent flows as a result of hydrothermal alteration processes.

The susceptibility measurements reported here have many similarities to the susceptibility of basalt flows and dikes of the Reydarfjordur, Iceland area. Bleil *et al.* (1982) reported on the magnetic susceptibility and remanent magnetization properties of a 3 km vertical section of Icelandic crust in conjunction with the drilling of the Iceland Research Drilling Project (IRDP) hole. They observed magnetic susceptibilities of 1000–5000 × 10^{-6}cgs (0.0126–0.0628 SI), generally increasing with depth in the upper 1.5 km of crust accessible through surface exposure. Schonharting and Hall (1982) completed a very detailed susceptibility log of the 1919 m deep IRDP drill hole, and noted that the susceptibility of flows increased to depths of approximately 1 km, then decreased systematically to the bottom of the hole. The susceptibility of dikes varied much less both within a given dike, and with the depth of dike occurrence in general. They noted that iron–titanium composition, grain size and abundance controlled the initial susceptibility of the basaltic rocks. Weathering and oxidation, dike density, and hydrothermal alteration were important factors governing the net susceptibility of the IRDP section.

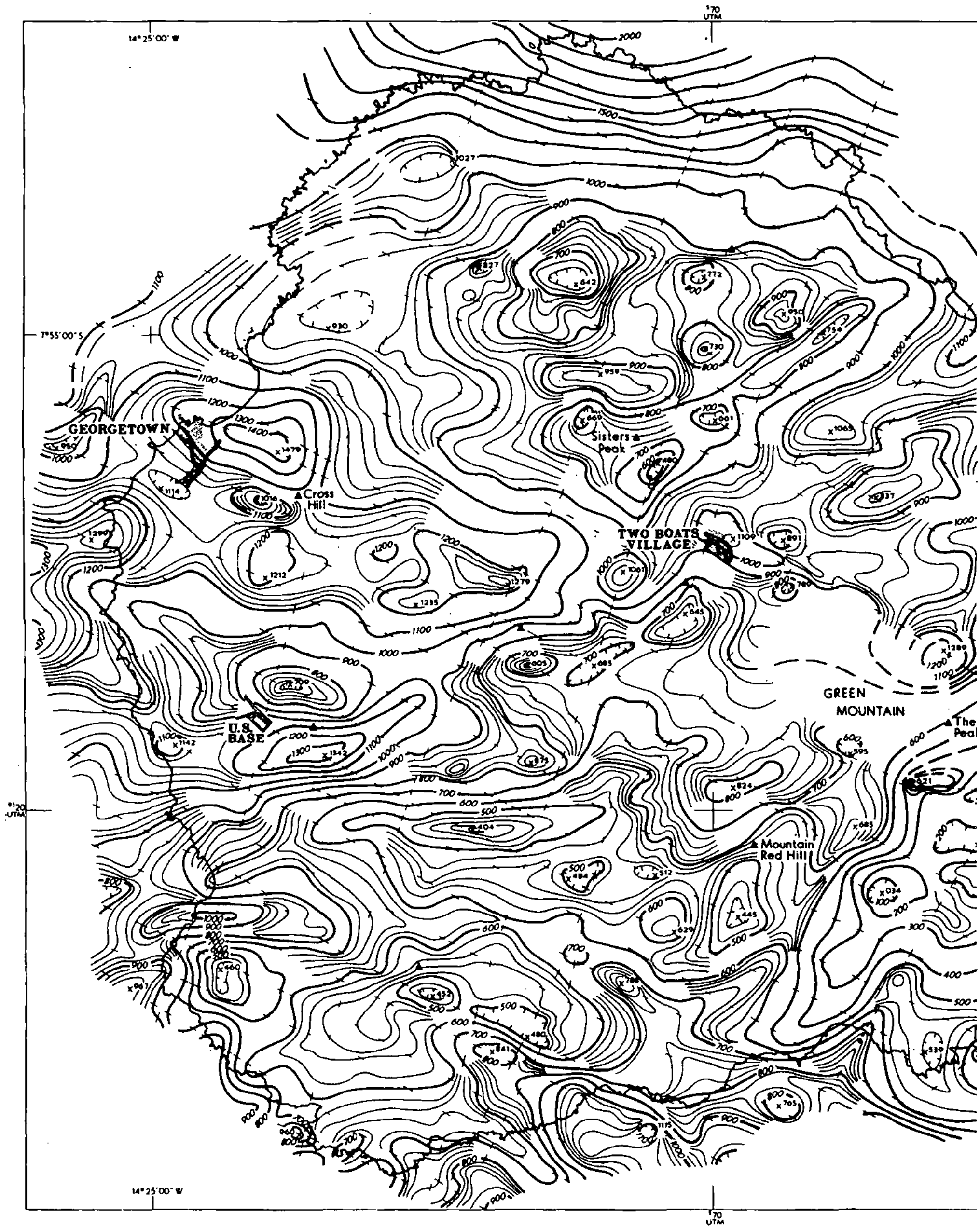
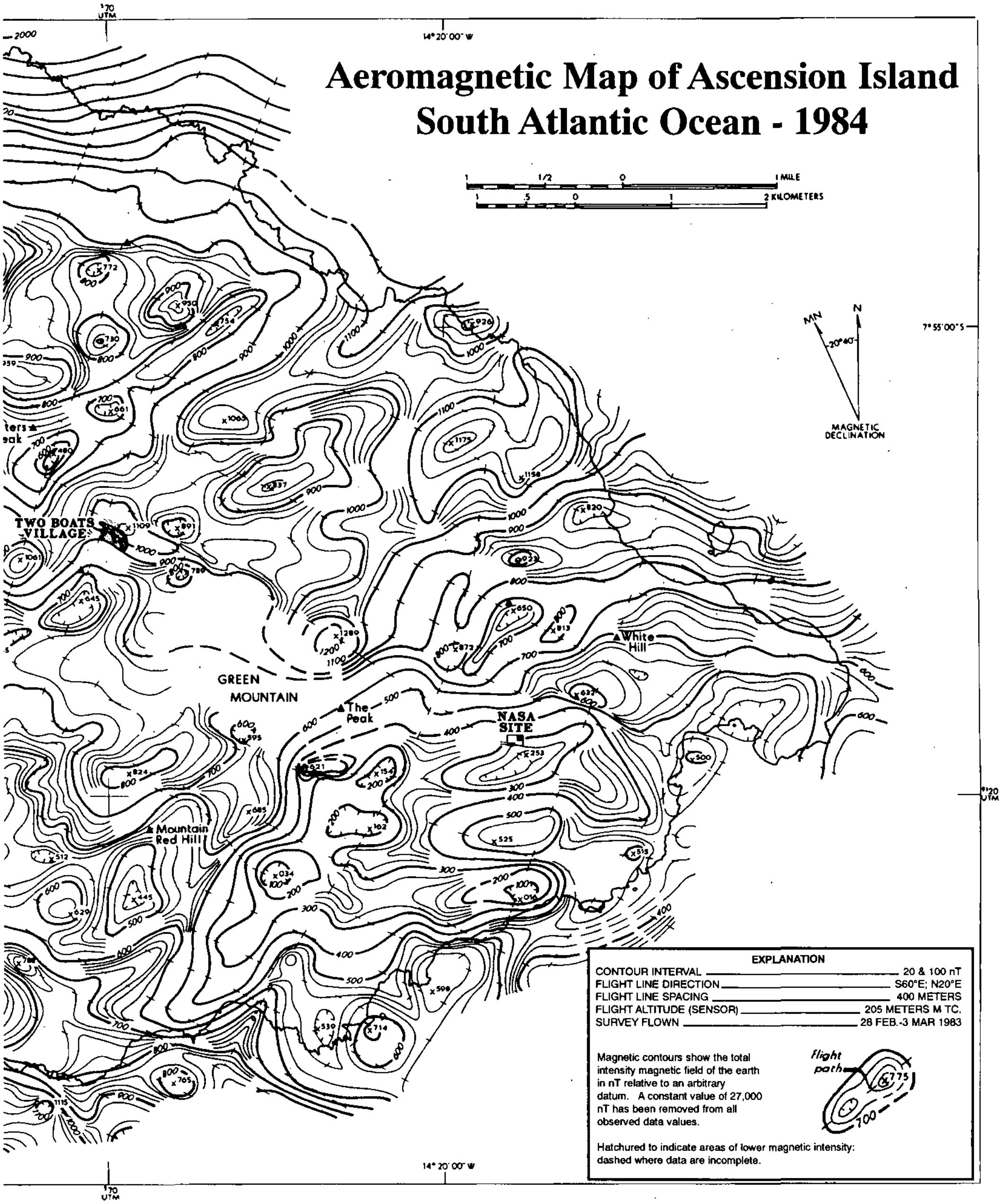


Fig. 1. Aeromagnetic map of Ascension Island—1984.



Aeromagnetic Map of Ascension Island
South Atlantic Ocean - 1984

EXPLANATION

CONTOUR INTERVAL	20 & 100 nT
FLIGHT LINE DIRECTION	S60°E; N20°E
FLIGHT LINE SPACING	400 METERS
FLIGHT ALTITUDE (SENSOR)	205 METERS M TC.
SURVEY FLOWN	28 FEB.-3 MAR 1983

Magnetic contours show the total intensity magnetic field of the earth in nT relative to an arbitrary datum. A constant value of 27,000 nT has been removed from all observed data values.

Hatchured to indicate areas of lower magnetic intensity: dashed where data are incomplete.

Fig. 1. *Continued*

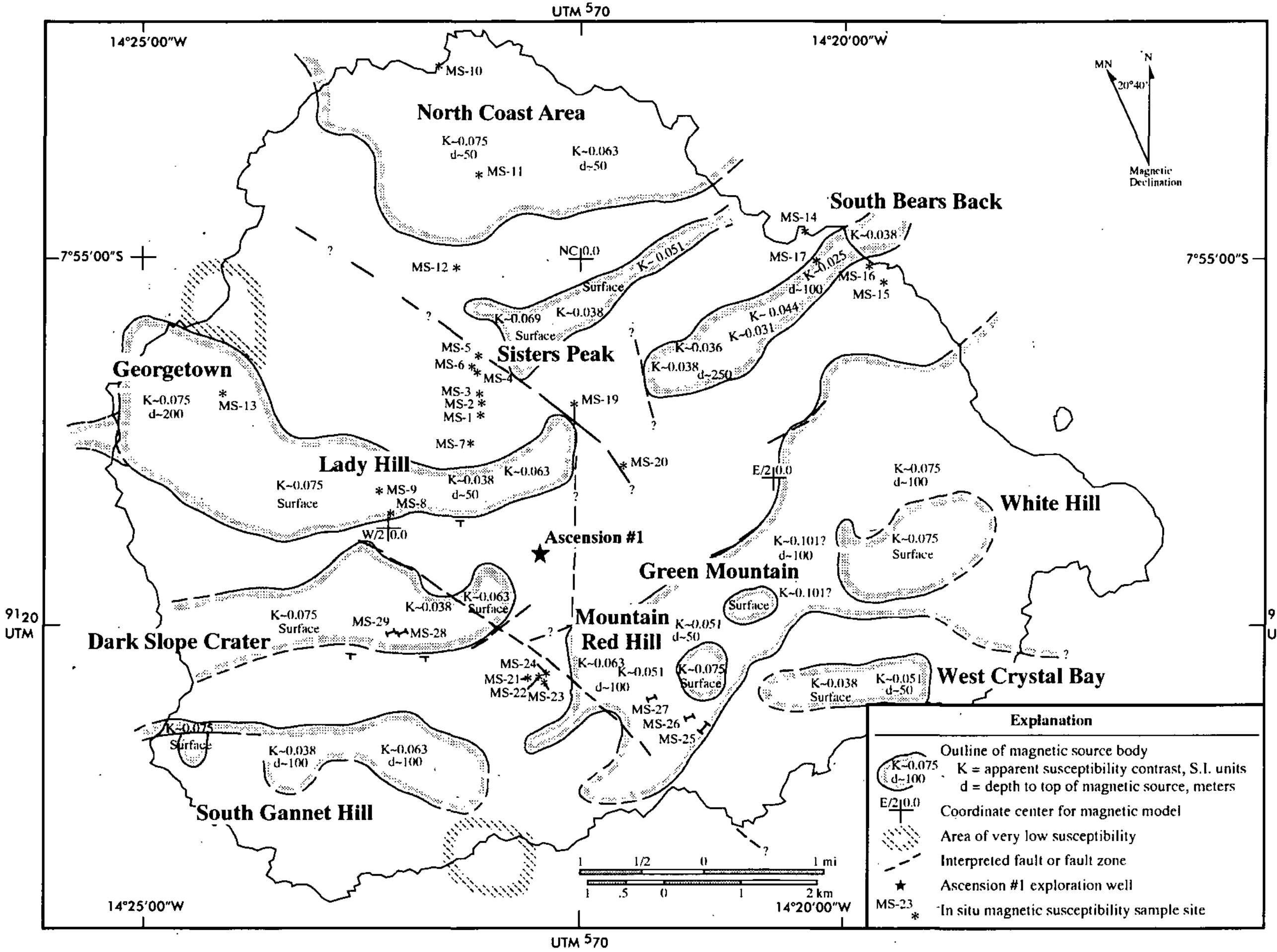


Fig. 2. Integrated magnetic interpretation and magnetic susceptibility survey, Ascension Island.

Table 1. Magnetic susceptibility summary, Ascension Island

Rock type, locality and stations ( )	n	x	s	Range
Mafic flows				
Two Boats Flow (1,2,3)	15	2.144	0.496	1.487–3.563
South Sisters Peak—vs.m.f.#1 (4,5,6)	13	1.719	0.759	0.630–3.189
North Sisters Peak—vs.m.f.#1 (10,11)	16	2.442	0.570	1.395–3.461
Donkey Flat—vs.m.f. (7,8)	12	0.950	0.313	0.513–1.425
Bears Back—vs.m.f. (18)	7	0.407	0.111	0.315–0.618
Spoon Crater—vs.m.f.#2 (21)	9	0.880	0.249	0.638–1.487
Older mafic flow—SE, NASA Road (26,27)	24	1.720	0.515	0.842–2.667
Older mafic flow—NE Bay Club (14)	12	1.661	0.695	1.407–3.157
Pillow basalt—Blow Hole Road (16,17b)	7	0.654	0.111	0.480–0.829
Older mafic flows—Dark Slope Crater (28,29a,29b)	18	2.776	0.421	2.197–3.592
Mafic intrusives				
Massive (22)	9	3.168	0.412	2.491–3.780
Lower dike (23)	8	0.956	0.314	0.494–1.357
Upper dike (24a, 24b)	19	1.172	0.373	0.395–1.690
Other rock types				
Trachyte and rhyolite (12a,13,15,17a,19a,20)	68	0.288	0.226	0.014–1.257
Trachyte—Ragged Hill (25a,25b)	18	0.196	0.111	0.070–0.413
Mafic cinders (9a,9b,9c,12b,19c,20b)	31	0.204	0.122	0.028–0.462
Pumiceous sediments, pumice (24c)	3	0.496	0.086	0.398–0.553

n = number of samples; x = sample mean; s = standard deviation; magnetic susceptibilities in SI units × 10^2; vs.m.f. = vesicular mafic flow.

Qualitative interpretation

Ascension Island lies south of the magnetic equator near the minimum of the earth's field, which occurs east of Brazil. The magnetic field has an inclination of 27°S (similar to parts of Africa, South America, and Indonesia) and a declination of approximately 21° west of geographic north (Nelson *et al.*, 1962). The total field intensity was observed to be approximately 27,800 nT. Thus, the magnetic field anomaly is substantially different for a magnetic body on Ascension than for the same source body located in northern magnetic latitudes, for which the majority of literature has been published.

Figure 3 illustrates the computed magnetic anomalies for three simple vertical prism models using the magnetic field characteristics of Ascension Island. These models have an upper surface 305 m below the data plane and a lower surface 915 m below that plane (to simulate finite depth-extent bodies at shallow depths), and an assumed susceptibility of 0.0251 SI, close to the measured average for Ascension mafic flows and intrusives. The amplitudes of these computed anomalies are much smaller than those of the observed anomalies (Fig. 1), suggesting that the net magnetization of several sources is three to five times as large as would be expected from a susceptibility of 0.0251 SI. This could indicate substantial (normal) remanent magnetization. The anomaly minima occur within the southern margin of the sources and positive maxima occur north of the northern edge of the bodies, somewhat west of center. First approximations of magnetic source positions and shapes were determined from the aeromagnetic map by reference to models such as

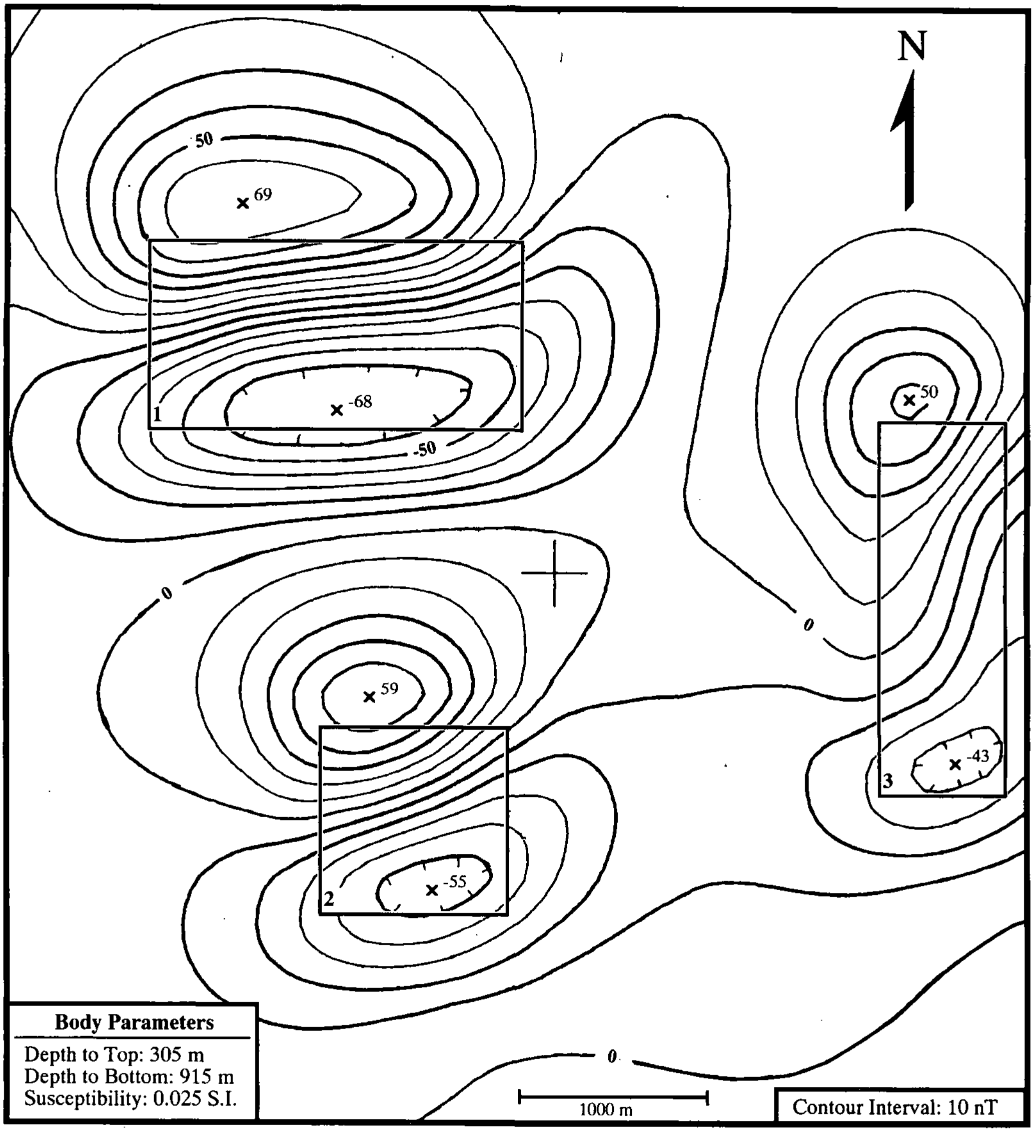


Fig. 3. Magnetic anomalies for simple prism models for Ascension Island magnetic field vector.

those in Fig. 3, and initial depth estimates were determined from the steep linear gradients across the center of the anomalies.

The island itself generates a strong anomaly on the earth's magnetic field, as it is the upper portion of a magnetic rock mass rising several kilometers above the sea floor. Figure 4 illustrates to a first approximation the anomaly pattern caused by the island itself, assuming a uniform susceptibility of 0.0754 SI and a moderate (15°–20°) slope to the sea floor away from the island. The positive gradient observed north of the island (Fig. 1) and a weak high-to-low trend across the island are due in part to the overall island mass, rather than an indication of geologic structure or lithologic changes within the land mass. Closed magnetic lows occur along the southern coastline in the observed data (Fig. 1) and in the simple model of Fig. 4.

A qualitative interpretation of the observed survey data was completed making reference to precomputed simple models (Fig. 3), rule of thumb depth estimates, and a cross correlation between magnetic intensity, topography and geologic maps. Several high amplitude anomalies with steep linear gradients of short horizontal extent are present on Fig. 1. These occur near Sisters Peak, Lady Hill, Red Hill, South West Bay, Green Mountain and several other areas. The short linear gradients suggest instrument ground clearances that are perhaps as low as 150 m in several places. The reduced ground clearance over a magnetic ground surface (topographic effects) helps explain the unusually high amplitude of several anomalies noted above.

Elongate, NE-trending magnetic sources are indicated near Sisters Peak, Bears Back and Green Mountain (Fig. 2). West- to NW-trending magnetic bodies are present on the western portion of the island. The central and northeastern parts of the island appear, in general, to be less magnetic than the rest of the island. These are the areas of outcropping trachyte flows, domes, and intrusions whereas the more magnetic areas are generally mafic flows and cinder deposits.

Quantitative model interpretation

Numerical modeling was used to refine the location, size and magnetization of various magnetic bodies identified in the qualitative interpretation. Program GM3D (Maurer and Atwood, 1980) was used to calculate the net magnetic field anomaly resulting from many (<40) right-rectangular prisms. Several prisms may be used to comprise a single complex magnetic source, and the complex anomaly resulting from multiple sources can be approximated by several groups of prisms. Two complex models were computed and modified, one for the eastern half of the island (E/2 ASCN) and one for the western half (W/2 ASCN). A third model (North Coast) was computed to verify the increased magnetization of the North Coast area (Ross *et al.*, 1984). The models and computed magnetic contour patterns are too complex for presentation at small scales. Table 2 summarizes model characteristics and anomaly amplitudes for all numerical models.

The models achieved a good match to the mid- to long-wavelength (1–6 km) observed anomalies, and in many cases to the 'sharp' or short-wavelength anomalies that result from varying terrain clearance and near-surface features. The emphasis was placed on approximating the deeper (mid- to long-wavelength) information, which could relate to buried geological structures and intrusive bodies not evident at the surface. Four model iterations for the west half, and five for the east half, resulted in good agreement with the anomaly maxima and minima positions and contour trends present in the observed data (Fig. 1).

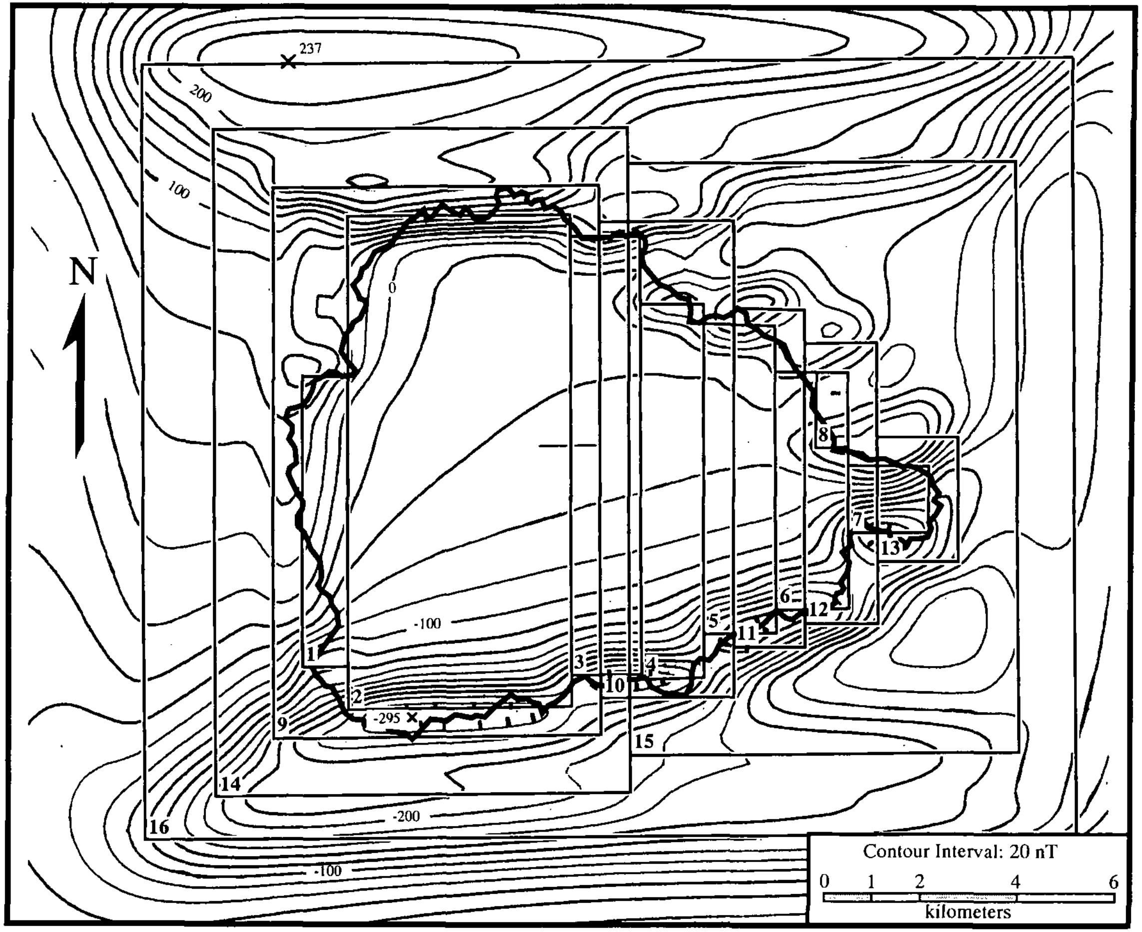


Fig. 4. Magnetic expression due to a uniformly magnetized island as modeled by vertical-sided prisms. (Prisms shown as rectangular bodies identified by number in southwest corner.)

Table 2. Characteristics of numerical models used for magnetic interpretation, Ascension Island

Model	No. prisms	Scale	Grid points (E × N)	Grid space (m)	Magnetic susceptibility (SI)	Computed field (nT)	
						Max	Min
Island	16	1:100,000	41x35	1000	0.0754	237	−295
W/2 ASCN	25	1:25,000	27x24	300	0.0377–0.0754	313	−329
E/2 ASCN	27	1:25,000	27x24	300	0.0251–0.1005	354	−485
North Coast	15	1:25,000	27x23	300	0.0377–0.1005	655	−414

The anomaly amplitudes and gradients have been matched to a lesser degree, reflecting uncertainties in instrument terrain clearance, depth to the top of the magnetization source, and probable nonvertical dips, which are not easily modeled with program GM3D.

Most magnetic sources appear to occur within a few hundred meters of the surface, as inferred from a comparison of the steepest linear gradients of numerical models and observed data. The interference of many different sources often precluded an accurate interpretation of the depth extent of the sources, and these have generally been arbitrarily assigned to 600–800 m. The magnetic susceptibilities required to approximate the observed amplitudes typically vary from 0.037 to 0.074 SI. This is a factor of 1.5–3 times as large as the higher average susceptibilities determined in the *in situ* susceptibility study. There are several probable explanations for this difference. Most of the basaltic rocks probably contain viscous remanent or thermoremanent magnetization, roughly directed along the present field direction, that may be 0.3–10 times the induced magnetization. In addition, the magnetic sources may have a greater depth extent than modeled. The susceptibility and/or remanent magnetization may increase with depth, as observed by Bleil *et al.* (1982) and Schonharting and Hall (1982) in the IRDP study.

Figure 2 summarizes the integrated magnetic interpretation using geologic maps (Nielson and Sibbett, 1996) and topographic maps. It indicates dips and geometric changes from the final numerical models that simulated the observed data. In the simplest sense, Fig. 2 separates the magnetic and relatively non-magnetic portions of the island's geology, primarily from the surface to depths of 1000 m. Most of the magnetic areas are elongate with relatively straight or gently curving margins, suggesting structural borders that may separate less mafic intrusions and flow sequences from more mafic feeder zones, such as dike swarms and basaltic lava sequences. The correspondence between source borders (and terminations) and geologic structures mapped by Nielson and Sibbett (1996) is reasonable, especially north of Green Mountain, south of Sisters Peak, and near Devil's Riding School. A brief description of the principal magnetic sources follows.

Sisters Peak source. The Sisters Peak magnetic source is an elongate body that occurs at or near the surface at Sisters Peak and extends 3.5 km to the coast in a N60°E direction. The equivalent (apparent) susceptibility contrast with adjacent rocks is approximately 0.0377–0.06283 SI. The body is 1 km wide near the volcanic cone and narrows to about 0.2 km near the coast. Cinder cones and older mafic flows correlate well with the source position, and the numerical modeling suggests a depth extent of 500 m or more. The magnetic source is probably a composite feature consisting of mafic cinders and flows, and

NE-trending dikes or plugs related to the eruptive features. The dikes intruded NE-trending fractures. The source may be terminated west of Sisters Peak by a NW-trending fault that is not identified at the surface but is mapped to the southeast near Green Mountain.

South Bears Back. This elongate magnetic source also trends N60°E from south of Bears Back to North East Point. The elongation is normal to structures mapped by Nielson and Sibbett (1996) but related structures may terminate the source southwest of Bears Back. The source does not correlate well with the surface geology and arises from shallow (25–100 m) depths. The numerical model suggests a depth extent of 500 m or more, and apparent susceptibility contrasts of 0.0251–0.0503 SI. A dike swarm or intrusive is the probable source, located along structures that served as magma conduits for Upper Valley Crater and Lower Valley Crater.

Mountain Red Hill – White Hill source. This is a large composite magnetic source that includes more than 10 km^2 of the eastern portion of the island (Fig. 2). The northern edge of the source is relatively well defined and corresponds in part to a series of NE-trending faults mapped by Nielson and Sibbett (1996). Very sharp anomalies with short horizontal gradients, indicating reduced terrain clearance (topographic effects), contribute to anomaly amplitudes in several places, such as near South East Crater, Green Mountain, and Cricket Valley. Trachyte flows, domes, and intrusions occur throughout much of the source area and an underlying (mafic?) intrusive may represent the magnetic source at depth. This magnetic source has a higher apparent susceptibility contrast with adjacent rocks (0.0503–0.1006 SI) than other bodies discussed previously. Cinders, flows and probably mafic intrusives, which fed Mountain Red Hill and The Peak, comprise the source on the west. The numerical model for the eastern half of the island (E/2 ASCN) suggests an abrupt N-trending termination of the source at its western limit along Grazing Valley.

West of Crystal Bay. Numerical model results (E/2 ASCN; Table 2) insist on the presence of a 2 km long E-trending source body north and west of Crystal Bay. The anomaly may include components from the interference pattern of sources to the north and west, and the southern edge of the island itself. Model E/2 ASCN, however, achieved a good fit to the observed data by incorporating this distinct source. The geologic nature of the source is unknown, but the trend is similar to sources on the western portion of the island.

Georgetown – Lady Hill. This 6 km long magnetic source has a predominant E–W elongation and includes the Travelers Hill, Lady Hill, and Cross Hill vent areas, and in part corresponds with the outcrop pattern of the young mafic flows of Nielson and Sibbett (1996). The numerical model (W/2 ASCN) suggests considerable depth extent (600–800 m) and a high apparent susceptibility contrast (0.0754 SI) for the source. These parameters, coupled with the geologic setting, suggest that mafic feeder dikes and/or a great thickness of magnetic flows filling a structural depression, are the probable magnetic source.

Dark Slope Crater. This 4.5 km long, E-trending magnetic source includes the Command Hill and Dark Slope Crater mafic cinder cones and flows. Disagreement between observed and computed magnetic anomalies indicates that the source dips or thins to the south. The eastern side of the source may terminate against a fault (Fig. 2).

South Gannet Hill. Another E-trending magnetic source, including Cross, South Gannet, and Booby hills. The source cuts across several different flows. The observed data can be approximated by bodies 300 m thick and apparent susceptibility contrasts of 0.0377–0.06283 SI. Mafic dikes and flows are thought to be the source.

North Coast area. A S–N magnetic gradient of 1000 nT in a distance of 1.5 km occurs along the north coast near English Bay. Numerical modeling (Fig. 4, North Coast) suggests that 200–300 nT of this anomalous gradient may be due to island mass–ocean contrast, but that a large increase in net magnetization is required to explain the full magnitude of the gradient. The 300 nT closed low occurs just north of the southern border of the magnetic body. Young mafic flows derived from the Sisters Peak area form the surface rocks that cover the magnetic source. The geometry and depth extent of the source suggest that the source is a large intrusive body.

Areas of low magnetization. Two specific areas have been identified where anomaly character and amplitude suggest apparent magnetizations below the less magnetic zones within the interior of the island. These areas would have magnetic susceptibilities near zero or, alternatively, remanent magnetization that is directly opposite to the present field direction. The Clarence Bay–Long Beach area includes sediment infill, beach sands and trachyte intrusives in the near surface and, with increased terrain clearance north of Cross Hill, could explain the first area of low apparent magnetization. The second area of low apparent magnetization lies along the southern edge of Wideawake Flats, primarily over water adjacent to the coastline. Sea floor topography (a low) or southward projection of the central low-magnetization zone seems the most likely explanation.

An irregular area of approximately 7 km^2 within the center of the island, primarily north and west of Green Mountain, is an area of low magnetic relief (<200 nT) and near background field intensity (700 nT). The Middleton Ridge rhyolite flow (reversely magnetized) outcrops in 2 km^2 within this area. No well-defined anomaly is associated with the Middleton Ridge outcrop area, and the net magnetization of this unit appears to be very low. Mapping by Nielson and Sibbett (1996) shows the surface to be relatively devoid of mafic lava flows. Various trachyte flows and intrusions, mafic ash and trachyte pyroclastics are present, and these are cut by NE-, NW- and N-trending structures, some of which can be inferred from the magnetic data.

All of the apparent magnetic susceptibility contrasts modeled are 2–4 times as large as the highest average susceptibilities actually measured *in situ*. In addition, there is little correlation between the location of high-susceptibility sample sites and the interpreted position of magnetic source bodies. This lack of spatial correlation is not surprising in view of the intent to characterize rock types with reasonable access rather than to obtain a uniform susceptibility coverage of the island. Magnetization studies of the Iceland volcanic crust (IRDP; Bleil *et al.*, 1982) indicate substantial thermoremanent magnetization and an unknown amount of viscous remanent magnetization, as well as higher susceptibilities at depth. Similar rock magnetization variations are probably present on Ascension.

The geometric and geologic relationships presented on Fig. 2 suggest that an older, elevated core of the island is situated at the intersection of major geologic structures. The younger mafic cinder cones and vents are peripheral to this core area. The density of structural intersections may be favorable for fracture zones with high permeability at depth.

SUMMARY

A detailed aeromagnetic survey of Ascension Island was carried out in February and March 1983 as part of a program to evaluate geothermal resource potential. Interpretation of these data, supported by numerical modeling, presents a picture of E- and NE-trending magnetic sources peripheral to the central core of the island. The magnetic sources are interpreted as zones of increased dike density and intrusives, which now occupy the feeder zones for recent cinder cones and basalt flows. A large magnetic source, which includes much of the eastern portion of the island, could be the intrusive equivalent (syenite?) of the trachytic domes, intrusives, and flows seen at the surface.

The central 7 km^2 of the island is weakly magnetic and is cut by NE-, NW- and N-trending structures. The combination of complex structural intersections and low magnetization suggests the possibility of rock alteration, resulting in magnetite destruction or more acidic intrusive rocks at moderate depths (200–1000 m) in this central part of the island. A low-magnetization area, mainly north and west of Green Mountain, appears (from magnetic data) to be the most likely area for the presence of a geothermal system at moderate (1–3 km) depth. Temperature gradient studies (Nielson *et al.*, 1996) and deep drilling data from Ascension #1 (Nielson and Stiger, 1996) confirm the presence of a high-temperature geothermal system at depth within this area. More extensive studies (including additional drilling) would be required to quantify the net magnetic expression resulting from the hydrothermal system.

A comparison between electrical resistivity survey results (Ross *et al.*, 1996) and the magnetic interpretation of Fig. 2 is also revealing. With few exceptions, low resistivity areas indicated by both reconnaissance and dipole–dipole resistivity data correspond to areas of low apparent susceptibility. Several interpreted structures and magnetic source borders are indicated as resistivity changes on the interpreted models for resistivity lines 1, 2 and 3 (Ross *et al.*, 1996). The strong agreement gives substantial confidence in the geometric interpretations for both geophysical methods, although the geologic explanations may still be subject to some ambiguity.

The detailed magnetic survey provides a useful continuous data set that adds significance to the more limited and discrete electrical resistivity and temperature gradient data. Uncertainties and ambiguities in magnetic interpretation may preclude a more refined interpretation of these data. Electrical resistivity and deep thermal gradient tests were completed before drilling a deep geothermal test well, Ascension #1 (Nielson and Stiger, 1996), which proved the presence of the geothermal system.

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