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REPORT ON DIPOLE-DIPOLE RESISTIVITY
AND TECHNOLOGY TRANSFER AT THE
AHUACHAPAN GEOTHERMAL FIELD
AHUACHAPAN, EL SALVADOR

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INTRODUCTION

The Ahuachapan Geothermal Field (AGF) is a 90 megawatt geothermal-sourced powerplant operated by the Comision Ejecutiva Hidroelectrica del Rio Lempa (CEL) of El Salvador. During the period November 1987 through May 1988 a deep resistivity survey and technology transfer was performed at the AGF at the request of Los Alamos National Laboratory (LANL) as part of a United States Agency for International Development (USAID) project. The resistivity surveying is ongoing at the time of this report under the supervision of CEL personnel. LANL and contract personnel were present at the site during performance of the initial surveying for the purpose of technology transfer. This report presents the results and interpretation of the two initial resistivity survey lines performed on site during and shortly after the technology transfer period.

OBJECTIVES

The principal objective of the resistivity program was the transfer of sufficient technology to allow CEL personnel to perform subsequent resistivity surveys in El Salvador for the purpose of geothermal development. In particular, in the Ahuachapan area, a work plan was presented with two objectives: technology transfer and the collection of sufficient data to assist in delineation and extension of the developed geothermal field. As part of the technology transfer an IBM-compatible microcomputer was supplied to the geophysics department of CEL with adequate software to perform all modeling described in this report.

The field investigation was divided into three parts, each designed to study a particular aspect of the geothermal resources of the Ahuachapan region. Those parts were:

1. defining the electrical characteristics of the known geothermal reservoir such that adjacent areas may be investigated and compared,
2. identifying and mapping the relevant physical properties related to shallow geothermal production so that the Chipilapa area to the east may be better evaluated, and
3. determining the deep electrical characteristics beneath the volcanic mountains to the south of Ahuachapan to evaluate the geothermal and recharge potential in that area.

LOCATION

The Ahuachapan Geothermal Field, as shown in Fig. 1, is located at the western end of El Salvador immediately north of a chain of volcanic mountains that run the length of El Salvador. Site coordinates are 13°55' North latitude and 89°49' West longitude. Site elevation is approximately 800 meters. The mountains to the south rise to approximately 1800 meters. None of the volcanos is active but some are young enough to have well defined craters. The geothermal field is named after the nearby town of Ahuachapan in the state of Ahuachapan.

Vegetation is of particular interest since it influenced the logistical aspects of field surveying. Privately owned coffee plantations cover much of the area and cutting lines through the plantations was not permissible. Coffee extends to the higher locations and is the prevalent vegetation. Little indigenous vegetation remains in the area.

The intensive agriculture involves extensive rural habitation which influences the safety of electrical surveying and, to a very minor degree, security of equipment left in the field overnight. Additional personnel were generally required to provide safety. Overnight security was usually obtained from the local residents. Typically, extra time for setup and teardown was allowed to remove equipment and supplies.

COMPANIES AND PERSONNEL

Personnel from CEL directly involved in the on site field operations were: Mr. Carlos Rodriguez, Mr. Manuel Ernesto Monterrosa, and various geophysical staff members. Personnel from CEL involved in supporting the field operations were: Dr. Gustavo Cuellar, Mr. David Vega, Mr. Mauricio Retana, Mr. Alejandro Quintanilla, and Mr. José Alonzo Martinez.

Personnel involved on site from LANL were: Dr. Dan J. Cash, seismologist; Mr. Michael T. Gerety, geophysicist, and Mr. Richard A. Fenster, electronics technician.

Personnel involved from Geophynque International were: Mr. James B. Fink, geophysicist.

Personnel involved from Geociencias Aplicadas were: Dr. Mauricio F. de la Fuente Duch, geophysicist; Mr. Alfonso Ochoa, geophysicist; Mr. Antonio Cano, geophysicist; and Mr. David Brito, geophysicist.

RESISTIVITY SURVEYING

The method of electrical resistivity surveying employed a dipole-dipole array with dipole spacings of 500 and 1000 meters. Forty-two line kilometers of dipole-dipole resistivity surveying

were proposed for the project. During the technology transfer phase, it was anticipated that 19 line kilometers would be run under LANL supervision and that the remaining 23 line kilometers would be run under CEL supervision. Resistivity lines 1 and 2 shown in Fig. 2 comprised the initial 19 line kilometers. Due to logistical problems, line 1 could not be run during the planned technology transfer period while US personnel were present. Consequently, line 1 was run during the months of February and March by CEL personnel. Line 2 was completed as projected in January, but the results justified extensions on both ends of the line. These extensions were performed during January and February by CEL personnel. Lines 1 and 2 are interpreted and presented in this report. Regardless of the rearrangement of field work, the technology transfer proceeded during preliminary attempts at line 1 and the initially planned portion of line 2.

In order to assure adequate shallow resistivity information, dipole spacings of 0.1, 0.5, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, and 6.0 were used to collect the 1000 meter dipole data, and the 500 meter dipole data were gathered using spacings of 0.2 and integer intervals of 1 through 14. The reduced data are presented in pseudosection format in various forms in Figures 3 through 18.

The objectives of using two dipole spacings were to enhance the lateral and near-surface resolution with the shorter dipole spacing (500m) and to allow deeper penetration with the larger spacing (1000m). Both of these objectives were achieved successfully. Indeed, the combination of field logistics and resultant data suggest that future work may be satisfactorily performed with only the 500m spacing, if adequate current is injected into the ground. In situations where adequate current is not achievable, larger dipole spacings must be used.

Previous resistivity work performed by Carlos Rodriguez, geophysicist for CEL involved Schlumberger array resistivity soundings (VES's) in a grid covering the Ahuachapan area and extending to the northeast towards Turin. The grid is indicated in Fig. 2. Qualitative and quantitative data comparisons between the dipole-dipole array work and the Schlumberger array work are quite good. The dipole-dipole data, because of instrumental design, allowed deeper penetration with no interference from electromagnetic (EM) response, whereas the Schlumberger array data, because of instrumental design limitations, suffered from EM response at the larger spacings. Although Rodriguez' interpretation allowed for the EM response, the deepest information was of concern.

EQUIPMENT

The motor-generator set, resistivity transmitter, and recording receivers were supplied to the Central American program by LANL.

Motor-generator set

The 50 kilowatt motor-generator set was built by EG&G Kirtland Operations, Albuquerque, New Mexico. The unit is diesel powered, trailer mounted, and uses a LIMA generator. The generator output to the transmitter is 480 volt, 3 phase, 60 Hz. A 120 volt, 1 phase, 60 Hz output is also available.

Resistivity transmitter

The resistivity transmitter was designed by LANL and built by EG&G Kirtland Operations, Albuquerque, New Mexico as Model ESS-3 Resistivity Transmitter. It has an output capability of 30 kilowatts on two separately programmable channels. Maximum output voltage is 800 volts and 37.5 amps. The waveform is bipolar dc with variable timing for each channel. The variable timing control of the output has significant advantages over commercially available equipment.

Variable timing

The typical operation of a resistivity system involves injecting a *pseudo-dc* current into the ground. Emphasis is on the pseudo-dc because accurate dc readings must be made for both polarities of current flow. This allows for self-potential compensation and ultra-low-frequency telluric cancellation. Therefore, a true dc (i.e. unipolar current) waveform is rarely used. Consequently, the resultant waveform is truly a low-frequency ac waveform. Ac or transient waveforms contain other information such as induced polarization and EM response that, aside from the usefulness, tend to detract from the ready acquisition of simple dc resistivity data. In particular, in areas of low resistivity, the EM response can be quite strong and drastically affect the observed dc resistivity if undetected or not avoided. The ability to readily change the timing of the waveform in the field allows these problems to be avoided quite easily.

Receivers (strip-chart recorders)

The receivers used for the work are portable (battery operated), single channel, analog, strip-chart recorders. They are "off the shelf" from Western Graphtec, Inc., Type W, Model SR 6513 Chart Recorders. They are capsulized-wet-pen recorders and use conventional 6 inch wide paper. They are not field instru-

ments and lack protective covers and ruggedization. Nevertheless, with appropriate care, they performed well.

Field pre-amplifiers

Field pre-amplifiers were built by EG&G Kirtland Operations, Albuquerque, New Mexico to amplify received signals and allow for self-potential balancing (buckout) prior to the signal reaching the recorders. These units were modified in El Salvador to include low-pass filtering.

Electrodes (potential and current)

Tinker & Rasor Model 3A copper/copper sulphate porous pots were used for the potential electrodes. Aluminum foil was used for the current electrodes. With current-electrode pit sizes of approximately 1 meter square by 1/4 meter deep, injected currents of 20 to 40 amps were common.

SURVEY PROGRAM

The original work plan included five lines, four of which were oriented due east-west, parallel to each other, and eight kilometers long. Three of these four lines (lines 2, 3, & 4) were one-half kilometer apart and located so that they would connect the known area of the Ahuachapan field to the Chipilapa area by crossing the southwestern corner of the grid of existing Schlumberger array data. This would then extend the resistivity information to the south of the grid. The fourth line (line 5), although displaced four kilometers to the south, on the south side of the volcanic mountain chain, was intended to investigate the electrical properties of a proposed surface-recharge area and was seven kilometers long. The fifth line (line 1) was oriented approximately N25°W so that it would cross the western end of the Schlumberger array grid, cross the established limits of the Ahuachapan field, and extend to the south over the mountains to cross line 5. Line 1 length was anticipated to be eleven kilometers. Total planned survey-line length was 42 kilometers.

While work was underway, line locations and orientations were rearranged so as to accomplish these same goals, but to also take advantage of improved logistics and incorporate geologic information learned on site. The locations of lines 1 and 2, which are discussed herein, are essentially unchanged from the original work plan. Locations for lines 3, 4, and 5, have changed considerably, but are not known at this time.

DIPOLE-DIPOLE RESISTIVITY

Data presentation

Dipole-dipole data are generally presented in pseudosection format. This method of data presentation displays the collected data in a manner such that the horizontal scale is linear distance and is scaled in units of dipole length (either 500 or 1000 meters per unit) and the vertical scale is in units of dipole separation and may be either linear or logarithmic. The vertical axis is positive downward. Although the appearance is that of a geologic section, it is emphasized that the location of the plotted points is not necessarily indicative of depth.

For logistical convenience, dipole-dipole data are frequently collected using only integer dipole separations. Consequently, most software available for plotting and modeling dipole-dipole data have restricted capabilities and usually cannot plot or model non-integer dipole separations. Such is the case for the software used in the modeling herein. This point is made because the topographic and geologic model pseudosections are limited to integer dipole separations.

Topographic modeling

The effects of topography on a resistivity survey are well known. These effects are due mostly to two causes: lack of collinearity of the four electrodes represented by any given data point, and compression or expansion of the equipotentials observed on the earth's surface related to the transmitting dipole.

The former problem may be solved quite easily by recalculating the data using a general four-point solution instead of the simplified dipole-dipole formulation. Errors due to this approach are usually relatively small (<10%), even for extreme topography. Consequently, this sort of recalculation is seldom done.

The latter problem is more difficult and is more computationally intensive. Hence, computer solutions are generally used. For the work herein, the method of Schwarz-Cristoffel (SC) conformal transformation was used to approximate the topographic effects. This method allows the topography along the survey line to be modeled as if it were a two-dimensional structure. Clearly, in the case of the Hoyo de Cuajuste, there are severe topographic effects and they are not two-dimensional. However, the 2-D model results offer an improvement over no corrections and, at least, give a qualitative idea of the trends and magnitudes of effects anticipated from the modeled structures.

Topographic effects are determined by the severity of the

topography relative to the dipole size. At Ahuachapan, topographic effects were maximum where the line crossed the highest elevation and the Cuajuste crater. Ridges produce an enhancement of the observed apparent resistivities, in this case with 1000m dipoles, up to fifty percent greater than a flat surface. Valleys, or flanks of ridges, produce an attenuation of the observed apparent resistivities, approximately twenty-five percent less using 1000m dipoles. In spite of the large topographic effects present, the general patterns present in the uncorrected apparent resistivity pseudosection were still present after removing the topographic effects. This suggests two possibilities: either the topographic corrections were inadequate, or lithologic changes occurred sympathetically with the topography. Usually, 2-D topographic corrections are numerically insufficient because most topographic situations are three-dimensional. However, the high cost of digitizing topography precludes the application of 3-D topographic corrections. The lack of 3-D topographic corrections is not a major drawback because most topographic features are caused by lithologic changes.

Prior to geologic modeling, the modeled 2-D topographic effects were subtracted from the observed field data. The computer program used for the topographic modeling has been supplied to CEL.

Geologic modeling

Modeling of apparent resistivity due to complex earth structures is more computationally intensive than the topographic modeling. For the work discussed in this report, 2-D geologic models using orthogonal blocks and a finite-element algorithm were used to approximate the observed data. The finite-element program used is a microcomputer version of a program available from the University of Utah Research Institute. This program and two others that perform similar geologic modeling have been supplied to CEL.

Once again, it is already known that the geology is three-dimensional, especially in the area of the Ahuachapan field. Nevertheless, 2-D approximations are the most readily available and should suffice to guide the interpretation of the observed data. It is understood that performing a least-squares fitting of a 2-D model to 3-D field data is not a productive path to follow. The statistical significance of a "good" fit has limited value. The general trends and approximate quantitative values are most important for determining general geologic characteristics.

Physical property assignments for the computer-geologic model were based on reported laboratory-measured physical-proper-

ties and estimated physical properties based on short-dipole-spacing field data. The laboratory resistivity measurements were made for a frequency range of 5 to 10,000 Hz and three pressures of 100, 500, and 1000 psi. The laboratory results show reservoir rocks (andesite and breccia) to have true resistivities in the range of 5 to 50 ohm-meters, whereas the overlying tuffs and lavas range from 10 to 1000 ohm-meters. Although there appears to be a preference for the tuffs and lavas to be of higher true resistivity, hydrothermal alteration of any of the lithologies present will produce low resistivities. Consequently, although the laboratory results indicate very general trends and approximate resistivities for the relevant lithologies, the bulk-in-situ range of resistivities for the geothermal reservoir can only be correctly determined by cross-hole resistivity logging. Nevertheless, the observed values of resistivity are adequate to use for modeling purposes. The reported trends of increasing resistivity with decreasing frequency are acknowledged, but extrapolation to dc is not prudent as IP effects are inferred to be present in the laboratory data. The inverse relationship of resistivity with pressure at the lower frequencies is also acknowledged. This would only tend to decrease the observed apparent resistivities in the field data.

RESISTIVITY DATA INTERPRETATION

LINE 1 ($a = 1000\text{m}$)

Observed apparent resistivities ranged from 2.3 to 4500+ ohm-meters. In general, the apparent resistivities fall into two groups, low (2 to 20 ohm-meters) and moderate (20 to 200 ohm-meters). The low-apparent resistivities correlate with the surface expression of hydrothermally-altered lithologies and with deeper stratified lithologies, most likely those of the andesites and saturated agglomerates in the lower Quaternary San Salvador Formation. There is no evidence in the resistivity data that older lithologies such as the Pliocene Balsamo Formation were detected. The moderate-apparent resistivities correlate with the shallower tuffs and lavas where they appear to form cap-rock and in the high-topographic-relief area where the survey line crosses the mountains. The highest observed apparent resistivity occurred at the extreme southern end of line 1. Being a singular value, at the very end of the line, and representing very shallow material (for $n = 0.1$), it is regarded as irrelevant to the purposes of the survey and has been deleted from the data plots.

Line 1 ($a=1000\text{m}$) data are shown in logarithmic pseudosection in Figs. 3, 4, and 5. Increased data density was desired in the immediate vicinity of the geothermal field, so the received data

were collected with half-dipole moves for the transmitter. That is, between stations 1 and 5 the data are double density. The portion of the geothermal field crossed by the line is between stations 2 and 3. Blank spaces occurring beneath dipoles 4-5 and 6-7 indicate unreliable or unreadable data.

Fig. 3 shows the numerical values of apparent resistivity in ohm-meters. Fig. 4 shows the logarithmically contoured pseudosection without the data values. Fig. 5 shows the combined numerical values and contours for reference. Fig. 6 shows numeric results normalized to 100% for the topographic model in percent change from a flat surface overlying a homogeneous, isotropic earth. Fig. 7 shows the contoured pseudosection for the topographic model contoured in ten percent intervals. Fig. 7 shows contoured apparent resistivities corrected for topographic effects and contains the data used for the geologic modeling.

A qualitative investigation of the data in Figs. 3-5 indicates considerable variation in the near-surface apparent resistivities. The lowest observed apparent resistivity (3.8 ohm-meters) for the shallowest data occurs at station 5 which was located at the soccer-field fumaroles. Low apparent resistivity values also occur at the geothermal field (5.5 ohm-meters) and next to Cerro Blanco at station 6 (4.0 ohm-meters). In the high-density portion of the pseudosection these low apparent resistivities are flanked by slightly higher values ranging from 5 to 17 ohm-meters.

Moderate-valued near-surface apparent resistivities occur to the extreme northern and southern ends of the line and midway between stations 3 and 4. The northern end of the line is in a cultivated area. Generally, shallow data are artificially low due to the increased soil moisture content typical of cultivated areas. Consequently, the slightly-higher-valued shallow data seen in this area demonstrate that the lower-valued shallow data seen elsewhere are not due solely to surface moisture. The moderate-valued apparent resistivities occurring in the southern end of the line are in the area of outcrop and high topographic relief. Therefore, they would be expected to be higher-valued than data in lower, cultivated areas. The significance of the very low values mentioned previously is that they occur where extensive hydrothermal alteration is quite evident at surface. With increasing depth (pressure), saturation, and temperature, the true resistivities should decrease considerably. Therefore it is expected that lower apparent resistivities should appear for larger dipole separations, especially in the vicinity of the geothermal field where extensive hydrothermal alteration has taken place.

Of particular interest is the moderately-valued (55 ohm-

meters) data point between stations 3 and 4. This data point is flanked by data points of lower values. Therefore, this local, moderately resistive area probably represents a near-surface, relatively unaltered lithologic block that may be representative of caprock material. The block is likely 100 to 200 meters thick and perhaps up to a kilometer wide in the direction of the survey line and is restricted to the area between stations 3 and 4.

The lowest observed apparent resistivity values occur immediately beneath this localized, near-surface, moderately-resistive block. Model data show that the low closure for the 3 ohm-meter contour is a constructive interference phenomenon and that more representative true resistivities would be around 5 to 10 ohm-meters. The interference phenomenon results from the lower near-surface resistivities which modeling suggests to be around 5 ohm-meters or less.

With increasing dipole spacing the apparent resistivities appear to increase (for example, between stations 4 and 5) perhaps suggesting a deep, resistive medium. The presence of a deep resistive body or layer is unresolvable due to the fact that surface resistivities also increase to the south which, as already indicated, will produce constructive interference for the larger spacings.

The gradient indicated in the contoured data between stations 6 and 7 suggests a lithologic change occurring on the north slope of the mountains. The constancy of the shallower apparent resistivities to the south of the gradient suggests that the lithology remains the same within the detectable distance of the survey line. This gradient location coincides with the contact between the Laguna Verde volcanics and the central graben pyroclastics. The moderately resistive material likely represents the unaltered Laguna Verde mountain-building volcanics.

Geologic model

A geologic model for Line 1 is presented in Fig. 8. This model is based on the 1000 meter dipole data. Four media of different true resistivities were used to generate the model: medium 1 (100 ohm-meters); medium 2 (10 ohm-meters); medium 3 (500 ohm-meters); and medium 4 (5 ohm-meters). In the immediate vicinity of the geothermal field only media 1, 2, and 4 are relevant for the purpose of defining reservoir characteristics.

Model medium 1

Medium 1 is intended to represent the unaltered (or only partially altered) surface pyroclastics and lavas of younger San Salvador age. The moderate resistivity of 100 ohm-meters suggests

limited hydraulic permeability and good potential for caprock formation. Medium 1 is vertically limited to the upper 600 meters. Laterally, medium 1 is modeled at the north end of the line, between stations 5 and 9, and in the previously-discussed isolated block between stations 3 and 4. In general, the base of medium 1 corresponds to the contact between reservoir lithologies and overlying lithologies. The depth to this contact in AH-12 is reported at 550 meters, whereas in AH-1 and AH-20 the depth is 450 to 500 meters. In an area of variable lithology this would be considered good agreement.

Model medium 2

Medium 2 represents lower resistivity material occurring from 300 meters to depth (greater than 1000 meters) and forming a vertical "plume" between stations 3 to 5. This plume-like vertical extension of lower resistivities corresponds very well with the shallow depths to high temperatures between stations 3 and 4. The northern extent or contact of the plume-like low resistivities occurs at station 3 and is coincident with a vertical fault. To the south, the plume-like feature contacts lower resistivity material (medium 4) at station 5 beneath the soccer-field fumaroles. Two lesser blocks of medium 2 are modeled at surface near station 7 to the south and between stations 1 and 2 to the north. These lesser blocks are regarded as being transitional material, probably less altered, between media 4 and 1. The thickness of these blocks is 100 meters, which corresponds well with the known alluvial thickness.

Model medium 3

Medium 3 represents a high resistivity medium occurring to the south of station 7 and corresponding to the aforementioned Laguna Verde volcanics of the high plateau in the vicinity of Apaneca. Enough data are available in that area to suggest that the Laguna Verde volcanics overlie more conductive lithologies represented by medium 2. Although medium 2 shows continuity from the known geothermal field to approximately station 9, there is nothing else in the electrical data to support continuity for the thermal characteristics. Nevertheless, this area should not be disregarded for future geothermal potential.

Model medium 4

Medium 4 should be representative of extensive hydrothermal alteration regardless of lithology. The close association of the low apparent resistivities with the fumarolic activity and surface alteration suggest that these low resistivities are likely a

result of high porosity and high clay content. Hydraulic permeability is probably higher than the less altered lithologies in spite of the increase in clay content. Although no medium 4 is present in the model below 600 meters, a simple trade-off exists from the modeling standpoint.

Consider the large, irregular block of medium 4 beneath stations 2 to 3. By removing some of that block of medium 4 and placing it below 600 meters in the same general area would produce similar model results. This exemplifies the inherent non-uniqueness of any modeling procedure. The choice of not modeling medium 4 beneath 600 meters was made to determine the resolvability of a conductive deep body with this particular data set. *In this instance, a deep body of only moderate resistivity contrast with the overlying material is very difficult to detect, because of the complexity of the overlying geology.* On the other hand however, this indicates that in an area of less surface complexity such as extensive caprock and minimal surface alteration, a deep conductive body should be readily mappable.

LINE 1 (a = 500m)

Figures 9, 10, and 11 show the numeric, contoured, and combined data for Line 1 (a = 500m), respectively. As might be expected from the 1000 meter dipole data, the observed resistivities ranged from 1.8 to 5600 ohm-meters. To be as compatible as possible, data were collected for dipole separations ranging from 0.2 to 14. Within the accuracy of the method, the 1000 meter and 500 meter pseudosections are very similar. The same pattern exists for the two sections and consequently the same interpretation would apply. The differences that are observed are not significant enough to warrant minor modeling changes.

This similarity of results illustrates two important points. First, there is probably no need to collect data at both 1000 and 500 meter dipole spacings as long as; 1. shallow data are collected for the larger dipole spacings, or 2. deeper data are collected for the shorter dipole spacings. The original work plan was oriented towards using the 1000 meter dipole data for deep investigation and the 500 meter dipole data for shallower control. The field work performed at Ahuachapan shows that both situations may be satisfied with a single dipole spacing, if appropriate dipole separations are used.

Topographic effects for the shorter dipole spacing are considerably larger and more complex. Fig. 12 shows the modeled topographic effects in the vicinity of the Cuajuste crater. In this case the ridge effects may increase the apparent resistivities by up to 100% whereas the valley effects decrease

apparent resistivities by approximately 50%. These extremes in topographic corrections suggest that the logistical advantage of shorter dipole sizes may be offset by more complex topographic effects in the resultant data.

LINE 2 ($a = 1000\text{m}$)

Line 2 is oriented approximately east-west and crosses Line 1 roughly 250 meters north of station 4. The point of intersection on Line 2 is approximately 250 meters west of station 6 (see Fig. 2). The lines cross at an angle of 55° . Apparent resistivities ranged from 3.4 to 105 ohm-meters. With only a few exceptions, the entire pseudosection shows resistivities less than 20 ohm-meters, however, the general pattern of low-to-high apparent resistivities is surprisingly similar to that of Line 1. The similarity of pattern would be desirable for two-dimensional modeling if the features appeared parallel. They do not appear parallel and do demonstrate the three-dimensionality of the area.

The apparent resistivity data are presented in Figures 13, 14, and 15, in numeric, contoured, and combined formats, respectively. The lowest near-surface resistivities occur at station 4 near the Agua Shuca fumaroles. The low apparent resistivities appear to extend to station 5, located just east of the Río Los Ausoles. Higher resistivities are encountered at station 7 and are suggestive of the localized moderate resistivity block occurring on Line 1 between stations 3 and 4. There does not appear to be a direct connection between these two localized resistive blocks. At surface, another low resistivity area occurs to the east around station 10 which is reasonably close to the Cuyanausul fumaroles. These near-surface, apparent resistivity lows further support the previous observation that they are associated with extremely altered lithologies.

Topographic corrections were not determined for Line 2. Only the eastern end of the line encountered sufficient topographic relief to consider corrections due to the shallow angle at which the Line encountered the northern part of the mountains. However, the lack of severe relief and the non-orthogonal two-dimensionality of the topography encountered minimized the necessity and usefulness of topographic corrections.

The most salient feature of the pseudosection is the presence of an apparent resistivity low beneath stations 4 to 6. It is most likely that this feature is related to the aforementioned hydrothermally-altered lithologies. This feature is quite similar to the apparent resistivity low occurring on Line 1 beneath stations 2 to 4 in the immediate vicinity of the main geothermal field. Interestingly, both drillholes AH-8 and

AH-9 (which bracket Line 2 between stations 4 and 5) are non-productive. The geologic logs indicate that the more permeable agglomerates are missing in these two holes but the temperature logs indicate that relatively high temperatures are still present. A drillhole location between these two might be considered if there are no contrary indications.

A second noteworthy feature is the area between stations 7 to 11. The consistent values of 10 to 15 ohm-meters is suggestive of an elevated thermal environment. The lack of shallow, more resistive material that could serve as caprock is somewhat of a deterrent, but not so much that the area should be disregarded. This area lies between the Chipilapa and Cuyanausul surface expressions.

The deeper appearing localized highs and lows in the apparent resistivities are likely the result of interference effects from surface features.

LINE 2 (a = 500m)

Figures 16, 17, and 18 show the Line 2 (a = 500m) numeric, contoured, and combined apparent resistivities, respectively. As before, the shorter dipole data display a pattern quite similar to that of the larger dipoles. Apparent resistivities ranged from 3.3 to 127 ohm-meters. Differences in the observed apparent resistivities do not justify any change in interpretation of the larger dipole pseudosection. The similarity of the 500 and 1000 meter dipole data on both lines indicates that sufficient information is available with only one dipole spacing if the appropriate dipole separations are used.

SUMMARY

The apparent resistivity data collected for Lines 1 and 2 display a three-dimensional complex geologic picture. Two-dimensional modeling demonstrates that known lithologies may be identified (where unaltered) by a general range of resistivities. Reservoir rocks have interpreted true resistivities of less than 10 ohm-meters. Younger overlying rocks range from 20 to 200+ ohm-meters. Both of these lithologies may be hydrothermally altered to have resistivities below 5 ohm-meters.

The known geothermal reservoir at Ahuachapan does not appear to have a sufficiently diagnostic electrical signature to stand out relative to the interference effects of the near-surface altered lithologies and possible cultural effects. It is not unusual for a fracture-flow hydraulic regime to show little or no electrical resistivity contrast with the country rock. Nevertheless, the resistivity anomaly observed in the immediate vicinity

of the geothermal field justifies further work, as is being done presently.

One of the results of a magnetotelluric survey performed previously indicated that the reservoir was a high resistivity body relative to the country rock. These relatively high resistivity characteristics are not seen in either the Schlumberger array or dipole-dipole dc data.

The severe topography encountered on Line 1 does not pose an interpretational problem with 1000 meter dipole data as long as it is taken into account. The 500 meter dipole data suffer more from the topography but should not be left out of consideration for future work because the shorter dipoles have other logistical advantages.

The technology transfer aspect of the project has been very successful as demonstrated by the high quality data produced by CEL field operations. The computer facilities (hardware and software) established at CEL under this project have been used successfully and should enable CEL geophysicists to perform sophisticated modeling for several other geophysical methods, as well as dc resistivity.

Long term decisions and final conclusions should be withheld pending the outcome of the ongoing field work.

FIGURES 1 - 18

DC RESISTIVITY - LINES 1 AND 2

AHUACHAPAN GEOTHERMAL FIELD

AHUACHAPAN, EL SALVADOR

Fig. 1. Location map of the Ahuachapan Geothermal Field, El Salvador.

Fig. 2. Location map of lines 1 and 2 for the dipole-dipole dc resistivity program of 1987-1988.

Fig. 3. Logarithmic pseudosection of line 1 showing the numeric values of apparent resistivity in ohm-meters for the data points obtained for $n = 0.1, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 4.5, 5.0, 5.5,$ and 6.0 , for $a = 1000$ meters.

Seudoseccion Linea 1 ($a=1000m$) Ahuachapan, El Salvador

Fig. 4. Logarithmic pseudosection of line 1 showing the contoured apparent resistivities using logarithmic contour intervals in ohm-meters.

Pseudoseccion Linea 1 ($a=1000m$) Ahuachapan, El Salvador

Fig. 5. Logarithmic pseudosection of line 1 showing both the numeric and contoured apparent resistivity data.

Figure 1 is a contour map illustrating the spatial distribution of the first principal component (PC1) scores for 11 sampling stations. The map is plotted on a grid with the x-axis ranging from 0 to 11 and the y-axis ranging from 0 to 1.1. The contour lines represent PC1 scores, with values ranging from 0.71 to 1.48. The distribution shows a general trend of increasing PC1 scores from left to right, with a notable peak around station 10.

Fig. 6. Logarithmic pseudosection of line 1 showing topographic effects due to the mountains south of the site for integer dipole spacings of $n = 1, 2, 3, 4, 5$, and 6 , for $a = 1000$ meters.

Fig. 7. Logarithmic pseudosection of line 1 showing the observed apparent resistivities corrected for topographic effects.

2-D geo-electric model for Line 1, Ahuachapan, El Salvador

Fig. 8. Two-dimensional geo-electric model for line 1 based on topographically corrected apparent resistivity data using a finite-element program.

Seudoseccion Linea 1 ($a=500m$) Ahuachapan, El Salvador

Fig. 9. Logarithmic pseudosection of line 1 showing the numeric values of apparent resistivity in ohm-meters for the data points obtained for $n = 0.2, 1.0, 1.2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,$ and $14,$ for $a = 500$ meters.

Seudoseccion Linea 1 ($a=500m$) Ahuachapan, El Salvador

Fig. 10. Logarithmic pseudosection of line 1 showing the contoured apparent resistivities using logarithmic contour intervals in ohm-meters.

Fig. 11. Logarithmic pseudosection of line 1 showing both the numeric and contoured apparent resistivity data.

Topographic effects Line 1 ($a=500m$) Ahuachapan, El Salvador

Fig. 12. Logarithmic pseudosection of line 1 showing topographic effects due to the mountains south of the site for integer dipole spacings of $n = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15$, for $a = 500$ meters.

Fig. 13. Logarithmic pseudosection of line 2 showing the numeric values of apparent resistivity in ohm-meters for the data points obtained for $n = 0.1, 0.5, 1.0, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5,$ and 6.0 , for $a = 1000$ meters.

Seudoseccion Linea 2 ($\alpha=1000m$) Ahuachapan, El Salvador

Fig. 14. Logarithmic pseudosection of line 2 showing the contoured apparent resistivities using logarithmic contour intervals in ohm-meters.

Seudoseccion Linea 2 ($a=1000m$) Ahuachapan, El Salvador

Fig. 15. Logarithmic pseudosection of line 2 showing both the numeric and contoured apparent resistivity data.

Pseudoseccion Linea 2 ($a=500m$) Ahuachapan, El Salvador

Fig. 16. Logarithmic pseudosection of line 2 showing the numeric values of apparent resistivity in ohm-meters for the data points obtained for $n = 0.2, 1.0, 1.2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13$, and 14 , for $a = 500$ meters.

Seudoseccion Linea 2 ($\alpha=500m$) Ahuachapan, El Salvador

Fig. 17. Logarithmic pseudosection of line 2 showing the contoured apparent resistivities using logarithmic contour intervals in ohm-meters.

This topographic map depicts the region around San Salvador, El Salvador. The map features a grid system with horizontal coordinates labeled 2 through 12 and vertical coordinates labeled 1 through 12. Contour lines are drawn to represent elevation, with labels such as 138, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000, 1010, 1020, 1030, 1040, 1050, 1060, 1070, 1080, 1090, 1100, 1110, 1120, 1130, 1140, 1150, 1160, 1170, 1180, 1190, 1200, 1210, 1220, 1230, 1240, 1250, 1260, 1270, 1280, 1290, 1300, 1310, 1320, 1330, 1340, 1350, 1360, 1370, 1380, 1390, 1400, 1410, 1420, 1430, 1440, 1450, 1460, 1470, 1480, 1490, 1500, 1510, 1520, 1530, 1540, 1550, 1560, 1570, 1580, 1590, 1600, 1610, 1620, 1630, 1640, 1650, 1660, 1670, 1680, 1690, 1700, 1710, 1720, 1730, 1740, 1750, 1760, 1770, 1780, 1790, 1800, 1810, 1820, 1830, 1840, 1850, 1860, 1870, 1880, 1890, 1900, 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020, 2030, 2040, 2050, 2060, 2070, 2080, 2090, 2100, 2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190, 2200, 2210, 2220, 2230, 2240, 2250, 2260, 2270, 2280, 2290, 2300, 2310, 2320, 2330, 2340, 2350, 2360, 2370, 2380, 2390, 2400, 2410, 2420, 2430, 2440, 2450, 2460, 2470, 2480, 2490, 2500, 2510, 2520, 2530, 2540, 2550, 2560, 2570, 2580, 2590, 2600, 2610, 2620, 2630, 2640, 2650, 2660, 2670, 2680, 2690, 2700, 2710, 2720, 2730, 2740, 2750, 2760, 2770, 2780, 2790, 2800, 2810, 2820, 2830, 2840, 2850, 2860, 2870, 2880, 2890, 2900, 2910, 2920, 2930, 2940, 2950, 2960, 2970, 2980, 2990, 3000, 3010, 3020, 3030, 3040, 3050, 3060, 3070, 3080, 3090, 3100, 3110, 3120, 3130, 3140, 3150, 3160, 3170, 3180, 3190, 3200, 3210, 3220, 3230, 3240, 3250, 3260, 3270, 3280, 3290, 3300, 3310, 3320, 3330, 3340, 3350, 3360, 3370, 3380, 3390, 3400, 3410, 3420, 3430, 3440, 3450, 3460, 3470, 3480, 3490, 3500, 3510, 3520, 3530, 3540, 3550, 3560, 3570, 3580, 3590, 3600, 3610, 3620, 3630, 3640, 3650, 3660, 3670, 3680, 3690, 3700, 3710, 3720, 3730, 3740, 3750, 3760, 3770, 3780, 3790, 3800, 3810, 3820, 3830, 3840, 3850, 3860, 3870, 3880, 3890, 3900, 3910, 3920, 3930, 3940, 3950, 3960, 3970, 3980, 3990, 4000, 4010, 4020, 4030, 4040, 4050, 4060, 4070, 4080, 4090, 4100, 4110, 4120, 4130, 4140, 4150, 4160, 4170, 4180, 4190, 4200, 4210, 4220, 4230, 4240, 4250, 4260, 4270, 4280, 4290, 4300, 4310, 4320, 4330, 4340, 4350, 4360, 4370, 4380, 4390, 4400, 4410, 4420, 4430, 4440, 4450, 4460, 4470, 4480, 4490, 4500, 4510, 4520, 4530, 4540, 4550, 4560, 4570, 4580, 4590, 4600, 4610, 4620, 4630, 4640, 4650, 4660, 4670, 4680, 4690, 4700, 4710, 4720, 4730, 4740, 4750, 4760, 4770, 4780, 4790, 4800, 4810, 4820, 4830, 4840, 4850, 4860, 4870, 4880, 4890, 4900, 4910, 4920, 4930, 4940, 4950, 4960, 4970, 4980, 4990, 5000, 5010, 5020, 5030, 5040, 5050, 5060, 5070, 5080, 5090, 5100, 5110, 5120, 5130, 5140, 5150, 5160, 5170, 5180, 5190, 5200, 5210, 5220, 5230, 5240, 5250, 5260, 5270, 5280, 5290, 5300, 5310, 5320, 5330, 5340, 5350, 5360, 5370, 5380, 5390, 5400, 5410, 5420, 5430, 5440, 5450, 5460, 5470, 5480, 5490, 5500, 5510, 5520, 5530, 5540, 5550, 5560, 5570, 5580, 5590, 5600, 5610, 5620, 5630, 5640, 5650, 5660, 5670, 5680, 5690, 5700, 5710, 5720, 5730, 5740, 5750, 5760, 5770, 5780, 5790, 5800, 5810, 5820, 5830, 5840, 5850, 5860, 5870, 5880, 5890, 5900, 5910, 5920, 5930, 5940, 5950, 5960, 5970, 5980, 5990, 6000, 6010, 6020, 6030, 6040, 6050, 6060, 6070, 6080, 6090, 6100, 6110, 6120, 6130, 6140, 6150, 6160, 6170, 6180, 6190, 6200, 6210, 6220, 6230, 6240, 6250, 6260, 6270, 6280, 6290, 6300, 6310, 6320, 6330, 6340, 6350, 6360, 6370, 6380, 6390, 6400, 6410, 6420, 6430, 6440, 6450, 6460, 6470, 6480, 6490, 6500, 6510, 6520, 6530, 6540, 6550, 6560, 6570, 6580, 6590, 6600, 6610, 6620, 6630, 6640, 6650, 6660, 6670, 6680, 6690, 6700, 6710, 6720, 6730, 6740, 6750, 6760, 6770, 6780, 6790, 6800, 6810, 6820, 6830, 6840, 6850, 6860, 6870, 6880, 6890, 6900, 6910, 6920, 6930, 6940, 6950, 6960

Fig. 18. Logarithmic pseudosection of line 2 showing both the numeric and contoured apparent resistivity data.

TABULAR DATA LISTINGS
DC RESISTIVITY - LINES 1 AND 2
AHUACHAPAN GEOTHERMAL FIELD
AHUACHAPAN, EL SALVADOR

DIPOLE-DIPOLE RESISTIVITY DATA

AHUACHAPAN GEOTHERMAL FIELD, EL SALVADOR, C.A.

LINE 1 (a = 1000 meters) - Page 1 of 4

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V/I	Rho-a (Ω-m)	(V/I)c	(Rho-a)c (Ω-m)	% ERR
0	1000	1100	2000	0.1	116.814	84.773	116.814	84.773	0.000
0	1000	1500	2500	0.5	32.869	193.617			
0	1000	2000	3000	1.0	0.187	3.528	0.185	3.483	1.277
0	1000	2500	3500	1.5	0.119	4.886			
0	1000	3000	4000	2.0	0.101	7.586	0.101	7.613	-0.355
0	1000	3500	4500	2.5	0.062	7.715			
0	1000	4000	5000	3.0	0.042	7.842	0.042	8.002	-2.041
0	1000	4500	5500	3.5	0.038	10.399			
0	1000	5000	6000	4.0	0.032	12.141	0.030	11.479	5.453
0	1000	5500	6500	4.5	0.027	13.532			
0	1000	6000	7000	5.0	0.023	14.924	0.022	14.651	1.829
0	1000	6500	7500	5.5	0.014	11.941			
0	1000	7000	8000	6.0	0.024	24.996	0.025	25.925	-3.716
500	1500	1600	2500	0.1	19.169	13.911	19.462	14.123	-1.525
500	1500	2000	3000	0.5	0.459	2.702			
500	1500	2500	3500	1.0	0.192	3.613	0.192	3.618	-0.135
500	1500	3000	4000	1.5	0.141	5.827			
500	1500	3500	4500	2.0	0.079	5.968	0.080	6.065	-1.638
500	1500	4000	5000	2.5	0.047	5.795			
500	1500	4500	5500	3.0	0.041	7.677	0.040	7.561	1.506
500	1500	5000	6000	3.5	0.035	9.561			
500	1500	5500	6500	4.0	0.031	11.778	0.031	11.827	-0.415
500	1500	6000	7000	4.5	0.025	12.795			
500	1500	6500	7500	5.0	0.011	7.540	0.011	7.540	-0.000
500	1500	7000	8000	5.5	0.022	18.373			
500	1500	7500	8500	6.0	0.032	33.690	0.031	32.771	2.729
1000	2000	2100	3000	0.1	17.683	12.833	17.637	12.799	0.259
1000	2000	2500	3500	0.5	0.391	2.302			
1000	2000	3000	4000	1.0	0.199	3.753	0.201	3.783	-0.794
1000	2000	3500	4500	1.5	0.097	3.985			
1000	2000	4000	5000	2.0	0.048	3.654	0.048	3.647	0.189
1000	2000	4500	5500	2.5	0.039	4.842			
1000	2000	5000	6000	3.0	0.032	6.126	0.033	6.180	-0.880
1000	2000	5500	6500	3.5	0.027	7.424			
1000	2000	6000	7000	4.0	0.022	8.473	0.023	8.533	-0.707
1000	2000	6500	7500	4.5	0.016	8.013			
1000	2000	7000	8000	5.0	0.018	12.133	0.019	12.533	-3.300
1000	2000	7500	8500	5.5	0.021	17.793			
1000	2000	8000	9000	6.0	0.012	12.659	0.013	13.511	-6.726

LINE 1 (a = 1000 meters) - Page 2 of 4

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V/I	Rho-a (Ω -m)	(V/I)c	(Rho-a)c (Ω -m)	% ERR
1500	2500	2600	3500	0.1	7.632	5.538	7.630	5.537	0.020
1500	2500	3000	4000	0.5	0.565	3.326			
1500	2500	3500	4500	1.0	0.158	2.973	0.161	3.030	-1.911
1500	2500	4000	5000	1.5	0.055	2.251			
1500	2500	4500	5500	2.0	0.039	2.963	0.039	2.959	0.131
1500	2500	5000	6000	2.5	0.030	3.748			
1500	2500	5500	6500	3.0	0.024	4.458	0.024	4.442	0.346
1500	2500	6000	8000	3.5	0.020	5.511			
1500	2500	7500	8500	5.0	0.014	9.296	0.014	9.527	-2.481
1500	2500	8000	9000	5.5	0.009	7.393			
1500	2500	8500	9500	6.0	0.006	6.756	0.007	6.896	-2.083
2000	3000	3100	4000	0.1	22.838	16.574	24.271	17.613	-6.272
2000	3000	3500	4500	0.5	2.105	12.397			
2000	3000	4000	5000	1.0	0.141	2.662	0.140	2.639	0.846
2000	3000	4500	5500	1.5	0.061	2.531			
2000	3000	5000	6000	2.0	0.045	3.394	0.045	3.357	1.116
2000	3000	5500	6500	2.5	0.033	4.107			
2000	3000	6000	7000	3.0	0.025	4.672	0.024	4.510	3.465
2000	3000	6500	7500	3.5	0.020	5.540			
2000	3000	7000	8000	4.0	0.026	9.817	0.028	10.384	-5.772
2000	3000	7500	8500	4.5	0.024	11.996			
2000	3000	8000	9000	5.0	0.011	7.461	0.011	7.452	0.119
2000	3000	8500	9500	5.5	0.007	5.834			
2000	3000	9000	10000	6.0	0.006	5.902	0.006	5.916	-0.237
2500	3500	3600	4500	0.1	75.551	54.828	75.541	54.820	0.013
2500	3500	4000	5000	0.5	2.380	14.022			
2500	3500	4500	5500	1.0	0.275	5.190	0.273	5.137	1.010
2500	3500	5000	6000	1.5	0.158	6.504			
2500	3500	5500	6500	2.0	0.098	7.364	0.098	7.406	-0.576
2500	3500	6000	7000	2.5	0.062	7.611			
2500	3500	6500	7500	3.0	0.049	9.234	0.049	9.262	-0.303
2500	3500	7000	8000	3.5	0.125	34.138			
2500	3500	7500	8500	4.0	0.118	44.553	0.120	45.108	-1.245
2500	3500	8000	9000	4.5	0.031	15.764			
2500	3500	8500	9500	5.0	0.014	9.294	0.015	9.690	-4.262
3000	4000	4100	5000	0.1	12.500	9.071	12.336	8.953	1.310
3000	4000	4500	5500	0.5	1.007	5.933			
3000	4000	5000	6000	1.0	0.416	7.832	0.418	7.880	-0.614
3000	4000	5500	6500	1.5	0.222	9.158			
3000	4000	6000	7000	2.0	0.139	10.513	0.134	10.079	4.133
3000	4000	6500	7500	2.5	0.080	9.868			
3000	4000	7000	8000	3.0	0.083	15.599	0.082	15.463	0.868

LINE 1 (a = 1000 meters) - Page 3 of 4

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V/I	Rho-a (Ω -m)	(V/I)c	(Rho-a)c (Ω -m)	% ERR
3000	4000	7500	8500	3.5	0.082	22.370			
3000	4000	8000	9000	4.0	0.047	17.734	0.046	17.363	2.096
3000	4000	8500	9500	4.5	0.031	15.592			
3000	4000	9000	10000	5.0	0.023	14.924	0.022	14.696	1.524
3000	4000	9500	10500	5.5	0.018	14.981			
3000	4000	10000	11000	6.0	0.014	14.705	0.014	14.522	1.245
3500	4500	4600	5500	0.1	8.587	6.232	8.779	6.371	-2.240
3500	4500	5000	6000	0.5	1.311	7.720			
3500	4500	5500	6500	1.0	0.513	9.674	0.509	9.589	0.876
3500	4500	6000	7000	1.5	0.267	11.007			
3500	4500	6500	7500	2.0	0.241	18.184	0.242	18.221	-0.207
3500	4500	7000	8000	2.5	0.182	22.512			
3500	4500	7500	8500	3.0	0.078	14.734	0.073	13.797	6.358
3500	4500	8000	9000	3.5	0.067	18.115			
3500	4500	8500	9500	4.0	0.052	19.500	0.049	18.557	4.833
3500	4500	9000	10000	4.5	0.039	19.797			
3500	4500	9500	10500	5.0	0.028	18.797	0.027	18.133	3.536
4000	5000	5100	6000	0.1	5.174	3.755	5.137	3.728	0.723
4000	5000	5500	6500	0.5	1.404	8.269			
4000	5000	6000	7000	1.0	0.558	10.511	0.571	10.765	-2.419
4000	5000	6500	7500	1.5	0.300	12.355			
4000	5000	7000	8000	2.0	0.228	17.167	0.224	16.900	1.553
4000	5000	7500	8500	2.5	0.170	21.029			
4000	5000	8000	9000	3.0	0.117	22.140	0.118	22.284	-0.649
4000	5000	8500	9500	3.5	0.077	20.887			
4000	5000	9000	10000	4.0	0.058	21.824	0.057	21.464	1.647
4000	5000	9500	10500	4.5	0.042	21.117			
4000	5000	10000	11000	5.0	0.031	20.620	0.031	20.646	-0.130
5000	6000	6100	7000	0.1	5.513	4.001	5.567	4.040	-0.983
5000	6000	6500	7500	0.5	1.042	6.141			
5000	6000	7000	8000	1.0	0.548	10.332	0.548	10.332	0.002
5000	6000	7500	8500	1.5	0.321	13.231			
5000	6000	8000	9000	2.0	0.239	18.032	0.238	17.931	0.561
5000	6000	8500	9500	2.5	0.148	18.366			
5000	6000	9000	10000	3.0	0.105	19.716	0.106	19.958	-1.227
5000	6000	9500	10500	3.5	0.077	20.944			
5000	6000	10000	11000	4.0	0.056	20.971	0.055	20.898	0.347
6000	7000	7100	8000	0.1	103.333	74.990	104.583	75.897	-1.210
6000	7000	7500	8500	0.5	12.295	72.421			
6000	7000	8000	9000	1.0	3.169	59.734	3.162	59.602	0.222
6000	7000	8500	9500	1.5	0.666	27.475			
6000	7000	9000	10000	2.0	0.347	26.177	0.346	26.081	0.365
6000	7000	9500	10500	2.5	0.207	25.579			
6000	7000	10000	11000	3.0	0.135	25.384	0.133	25.070	1.238

TX 1	TX 2	RC 1	RC 2	n	V/I	Rho-a	(V/I)C	(Rho-a)C	ERR
(meters)	(meters)					(Ω-m)		(Ω-m)	
5000	8100	9000	0.1	206.746	150.038	206.746	150.038	0.000	0.000
3000	8500	9500	0.5	39.921	235.152				
3000	9000	10000	1.0	5.032	94.846	5.032	94.846	0.000	0.000
3000	9500	10500	1.5	1.696	69.924				
7000	8000	10000	2.0	0.733	55.229	0.727	54.852	0.683	
8000	9100	10000	0.1	220.588	160.083	233.775	169.653	-5.978	
8000	9500	10500	0.5	43.215	254.555				
9000	10000	11000	1.0	7.971	150.242	8.100	152.686	-1.627	

DIPOLE-DIPOLE RESISTIVITY DATA

AHUACHAPAN GEOTHERMAL FIELD, EL SALVADOR, C.A.

LINE 1 (a = 500 meters) - Page 1 of 5

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
0	500	1100	1500	1.2	36.500	12.000	3.042	40.363
0	500	1500	2000	2.0	5.280	12.000	0.440	16.588
0	500	2000	2500	3.0	0.479	11.800	0.041	3.826
0	500	2500	3000	4.0	0.241	11.800	0.020	3.850
0	500	3000	3500	5.0	0.313	11.200	0.028	9.219
0	500	3500	4000	6.0	0.219	11.200	0.020	10.320
0	500	4000	4500	7.0	0.121	12.000	0.010	7.983
0	500	4500	5000	8.0	0.121	12.000	0.010	11.404
0	500	5000	5500	9.0	0.099	13.500	0.007	11.404
0	500	5500	6000	10.0	0.083	13.600	0.006	12.654
0	500	6000	6500	11.0	0.097	16.500	0.006	15.846
0	500	6500	7000	12.0	0.063	13.700	0.005	15.776
0	500	7500	8000	14.0	0.096	13.300	0.007	38.096
500	1000	1100	1500	0.2	1075.000	34.200	31.433	26.070
500	1000	1500	2000	1.0	94.000	34.000	2.765	26.057
500	1000	2000	2500	2.0	2.995	34.500	0.087	3.273
500	1000	2500	3000	3.0	1.300	34.600	0.038	3.541
500	1000	3000	3500	4.0	1.022	31.200	0.033	6.174
500	1000	3500	4000	5.0	0.629	29.300	0.021	7.081
500	1000	4000	4500	6.0	0.329	30.100	0.011	5.769
500	1000	4500	5000	7.0	0.310	30.200	0.010	8.127
500	1000	5000	5500	8.0	0.269	30.800	0.009	9.878
500	1000	5500	6000	9.0	0.207	32.300	0.006	9.966
500	1000	6000	6500	10.0	0.213	30.100	0.007	14.673
500	1000	6500	7000	11.0	0.127	29.900	0.004	11.449
500	1000	7000	7500	12.0	0.098	31.100	0.003	10.810
500	1000	7500	8000	13.0	0.285	31.200	0.009	39.172
1000	1500	2100	2500	1.2	2.188	16.400	0.133	1.770
1000	1500	2500	3000	2.0	1.250	18.900	0.066	2.493
1000	1500	3000	3500	3.0	2.250	33.000	0.068	6.426
1000	1500	3500	4000	4.0	1.063	33.000	0.032	6.072
1000	1500	4000	4500	5.0	0.450	33.200	0.014	4.471
1000	1500	4500	5000	6.0	0.375	33.300	0.011	5.944
1000	1500	5000	5500	7.0	0.213	21.000	0.010	8.030
1000	1500	5500	6000	8.0	0.165	21.000	0.008	8.886
1000	1500	6000	6500	9.0	0.221	28.700	0.008	11.975
1000	1500	6500	7000	10.0	0.153	28.800	0.005	11.015
1000	1500	7500	8000	12.0	0.295	33.100	0.009	30.575
1000	1500	8000	8500	13.0	0.154	33.800	0.005	19.538
1000	1500	8500	9000	14.0	0.115	33.800	0.003	17.957

LINE 1 (a = 500 meters) - Page 2 of 5

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
1500	2000	2100	2500	0.2	300.000	17.500	17.143	14.218
1500	2000	2500	3000	1.0	3.375	17.500	0.193	1.818
1500	2000	3000	3500	2.0	2.550	33.200	0.077	2.896
1500	2000	3500	4000	3.0	1.240	33.200	0.037	3.520
1500	2000	4000	4500	4.0	0.263	21.200	0.012	2.338
1500	2000	4500	5000	5.0	0.200	21.100	0.009	3.127
1500	2000	5000	5500	6.0	0.175	23.100	0.008	3.998
1500	2000	5500	6000	7.0	0.148	23.200	0.006	5.050
1500	2000	6000	6500	8.0	0.150	28.100	0.005	6.037
1500	2000	6500	7000	9.0	0.116	28.200	0.004	6.397
1500	2000	7000	7500	10.0	0.121	21.900	0.006	11.456
1500	2000	7500	8000	11.0	0.110	21.900	0.005	13.539
1500	2000	8000	8500	12.0	0.116	34.800	0.003	11.435
1500	2000	8500	9000	13.0	0.054	28.100	0.002	8.241
2000	2500	3100	3500	1.2	5.910	27.700	0.213	2.831
2000	2500	3500	4000	2.0	2.500	28.700	0.087	3.284
2000	2500	4000	4500	3.0	0.550	27.100	0.020	1.913
2000	2500	4500	5000	4.0	0.300	27.100	0.011	2.087
2000	2500	5000	5500	5.0	0.250	27.400	0.009	3.010
2000	2500	5500	6000	6.0	0.183	26.800	0.007	3.604
2000	2500	6000	6500	7.0	0.184	32.200	0.006	4.524
2000	2500	6500	7000	8.0	0.123	32.500	0.004	4.280
2000	2500	7000	7500	9.0	0.172	28.300	0.006	9.451
2000	2500	7500	8000	10.0	0.174	28.200	0.006	12.794
2000	2500	8000	8500	11.0	0.060	26.900	0.002	6.012
2000	2500	8500	9000	12.0	0.054	26.800	0.002	6.912
2000	2500	9000	9500	13.0	0.032	32.500	0.001	4.222
2000	2500	9500	10000	14.0	0.038	31.500	0.001	6.367
2500	3000	3100	3500	0.2	470.000	21.000	22.381	18.562
2500	3000	3500	4000	1.0	39.500	20.600	1.917	18.072
2500	3000	4000	4500	2.0	1.875	22.400	0.084	3.156
2500	3000	4500	5000	3.0	0.557	22.300	0.025	2.354
2500	3000	5000	5500	4.0	0.415	23.800	0.017	3.287
2500	3000	5500	6000	5.0	0.315	26.800	0.012	3.877
2500	3000	6000	6500	6.0	0.250	27.300	0.009	4.833
2500	3000	6500	7000	7.0	0.143	27.000	0.005	4.193
2500	3000	7000	7500	8.0	0.231	21.100	0.011	12.382
2500	3000	7500	8000	9.0	0.227	20.900	0.011	16.890
2500	3000	8000	8500	10.0	0.124	26.900	0.005	9.558
2500	3000	8500	9000	11.0	0.066	27.000	0.002	6.589
2500	3000	9000	9500	12.0	0.054	29.700	0.002	6.237
2500	3000	9500	10000	13.0	0.047	29.800	0.002	6.763
3000	3500	4100	4500	1.2	26.000	31.000	0.839	11.130
3000	3500	4500	5000	2.0	4.800	31.200	0.154	5.800
3000	3500	5000	5500	3.0	2.219	28.100	0.079	7.443
3000	3500	5500	6000	4.0	1.275	28.300	0.045	8.492

LINE 1 (a = 500 meters) - Page 3 of 5

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
3000	3500	6500	7000	6.0	0.431	28.600	0.015	7.954
3000	3500	7000	7500	7.0	0.853	29.650	0.029	22.776
3000	3500	7500	8000	8.0	1.114	29.650	0.038	42.493
3000	3500	8000	8500	9.0	0.319	28.500	0.011	17.406
3000	3500	8500	9000	10.0	0.176	28.300	0.006	12.895
3000	3500	9000	9500	11.0	0.128	26.900	0.005	12.826
3000	3500	9500	10000	12.0	0.099	26.900	0.004	12.626
3000	3500	10000	10500	13.0	0.100	31.300	0.003	13.701
3000	3500	10500	11000	14.0	0.072	31.000	0.002	12.258
3500	4000	4100	4500	0.2	162.500	15.000	10.833	8.985
3500	4000	4500	5000	1.0	9.050	15.900	0.569	5.364
3500	4000	5000	5500	2.0	2.969	15.100	0.197	7.412
3500	4000	5500	6000	3.0	1.405	15.100	0.093	8.769
3500	4000	6000	6500	4.0	0.783	14.300	0.055	10.321
3500	4000	6500	7000	5.0	0.508	14.300	0.036	11.718
3500	4000	7000	7500	6.0	1.410	15.800	0.089	47.100
3500	4000	7500	8000	7.0	0.674	15.800	0.043	33.772
3500	4000	8000	8500	8.0	0.178	14.300	0.012	14.078
3500	4000	8500	9000	9.0	0.138	14.300	0.010	15.007
3500	4000	9000	9500	10.0	0.103	14.800	0.007	14.430
3500	4000	9500	10000	11.0	0.090	14.800	0.006	16.391
3500	4000	10000	10500	12.0	0.073	15.900	0.005	15.751
3500	4000	10500	11000	13.0	0.051	15.900	0.003	13.755
4000	4500	5100	5500	1.2	7.500	13.500	0.556	7.372
4000	4500	5500	6000	2.0	3.450	13.400	0.257	9.706
4000	4500	6000	6500	3.0	1.660	13.300	0.125	11.763
4000	4500	6500	7000	4.0	0.800	13.300	0.060	11.338
4000	4500	7000	7500	5.0	0.931	14.700	0.063	20.892
4000	4500	7500	8000	6.0	0.359	14.700	0.024	12.889
4000	4500	8000	8500	7.0	0.317	13.400	0.024	18.729
4000	4500	8500	9000	8.0	0.228	13.500	0.017	19.101
4000	4500	9000	9500	9.0	0.160	12.900	0.012	19.288
4000	4500	9500	10000	10.0	0.127	13.300	0.010	19.799
4000	4500	10000	10500	11.0	0.096	13.900	0.007	18.616
4000	4500	10500	11000	12.0	0.085	14.700	0.006	19.837
4500	5000	5100	5500	0.2	63.500	17.600	3.608	2.992
4500	5000	5500	6000	1.0	13.250	17.600	0.753	7.095
4500	5000	6000	6500	2.0	4.840	18.500	0.262	9.863
4500	5000	6500	7000	3.0	2.000	18.600	0.108	10.134
4500	5000	7000	7500	4.0	1.375	21.300	0.065	12.168
4500	5000	7500	8000	5.0	1.563	21.200	0.074	24.320
4500	5000	8000	8500	6.0	0.794	17.600	0.045	23.810
4500	5000	8500	9000	7.0	0.464	17.600	0.026	20.872
4500	5000	9000	9500	8.0	0.359	18.700	0.019	21.712
4500	5000	9500	10000	9.0	0.266	18.800	0.014	22.003

LINE 1 (a = 500 meters) - Page 4 of 5

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω-m)
4500	5000	10000	10500	10.0	0.209	19.600	0.011	22.110
4500	5000	10500	11000	11.0	0.167	19.700	0.008	22.850
5000	5500	6100	6500	1.2	2.650	5.900	0.449	5.960
5000	5500	6500	7000	2.0	1.150	5.900	0.195	7.348
5000	5500	7000	7500	3.0	0.568	6.000	0.095	8.922
5000	5500	7500	8000	4.0	0.675	6.000	0.113	21.206
5000	5500	8000	8500	5.0	0.395	6.000	0.056	21.716
5000	5500	8500	9000	6.0	0.220	6.000	0.037	19.352
5000	5500	9000	9500	7.0	0.154	5.900	0.026	20.664
5000	5500	9500	10000	8.0	0.118	5.900	0.020	22.619
5000	5500	10000	10500	9.0	0.083	5.800	0.014	22.254
5000	5500	10500	11000	10.0	0.062	5.800	0.011	22.164
5500	6000	6100	6500	0.2	18.000	4.500	4.000	3.318
5500	6000	6500	7000	1.0	2.050	4.600	0.446	4.200
5500	6000	7000	7500	2.0	1.271	4.700	0.270	10.195
5500	6000	7500	8000	3.0	0.267	4.700	0.057	5.354
5500	6000	8000	8500	4.0	0.384	4.600	0.083	15.735
5500	6000	8500	9000	5.0	0.211	4.600	0.046	15.131
5500	6000	9000	9500	6.0	0.147	4.500	0.033	17.241
5500	6000	9500	10000	7.0	0.114	4.500	0.025	20.056
5500	6000	10000	10500	8.0	0.067	4.600	0.015	16.473
5500	6000	10500	11000	9.0	0.053	4.600	0.012	17.917
6000	6500	7100	7500	1.2	26.250	11.500	2.283	30.290
6000	6500	7500	8000	2.0	5.830	11.500	0.507	19.112
6000	6500	8000	8500	3.0	3.785	13.400	0.282	26.621
6000	6500	8500	9000	4.0	1.525	13.300	0.115	21.613
6000	6500	9000	9500	5.0	0.988	13.300	0.074	24.504
6000	6500	9500	10000	6.0	0.653	13.400	0.049	25.720
6000	6500	10000	10500	7.0	0.362	11.500	0.031	24.921
6000	6500	10500	11000	8.0	0.270	11.600	0.023	26.324
6500	7000	7100	7500	0.2	580.000	8.500	68.235	56.593
6500	7000	7500	8000	1.0	127.500	8.500	15.000	141.372
6500	7000	8000	8500	2.0	21.500	8.900	2.416	91.071
6500	7000	8500	9000	3.0	2.950	8.900	0.331	31.239
6500	7000	9000	9500	4.0	1.238	8.900	0.139	26.220
6500	7000	9500	10000	5.0	0.706	8.900	0.079	26.167
6500	7000	10000	10500	6.0	0.390	8.500	0.046	24.216
6500	7000	10500	11000	7.0	0.272	8.500	0.032	25.334
7000	7500	8100	8500	1.2	112.500	3.400	33.088	439.084
7000	7500	8500	9000	2.0	10.750	3.400	3.162	119.196
7000	7500	9000	9500	3.0	2.100	3.400	0.618	58.212
7000	7500	9500	10000	4.0	0.890	3.500	0.254	47.932
7000	7500	10000	10500	5.0	0.477	3.900	0.122	40.345
7000	7500	10500	11000	6.0	0.286	4.000	0.072	37.737

LINE 1 (a = 500 meters) - Page 5 of 5

Tr 1 (meters)	Tr 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
7500	8000	8100	8500	0.2	1000.000	3.200	312.500	259.182
7500	8000	8500	9000	1.0	108.750	3.200	33.984	320.295
7500	8000	9000	9500	2.0	10.250	3.200	3.203	120.755
7500	8000	9500	10000	3.0	3.093	3.200	0.967	91.096
7500	8000	10000	10500	4.0	1.334	3.800	0.351	66.172
7500	8000	10500	11000	5.0	0.700	3.800	0.184	60.765
8000	8500	9100	9500	1.2	70.500	6.800	10.368	137.580
8000	8500	9500	10000	2.0	25.250	6.800	3.713	139.986
8000	8500	10000	10500	3.0	6.500	6.800	0.956	90.090
8000	8500	10500	11000	4.0	2.650	6.800	0.390	73.458
8500	9000	9100	9500	0.2	730.000	3.500	208.571	172.986
8500	9000	9500	10000	1.0	127.500	3.500	36.429	343.331
8500	9000	10000	10500	2.0	18.500	3.500	5.286	199.267
8500	9000	10500	11000	3.0	4.563	3.500	1.304	122.872
9000	9500	10100	10500	1.2	128.000	3.400	37.647	499.580
9000	9500	10500	11000	2.0	26.750	3.400	7.868	296.603
9500	10000	10100	10500	0.2	20250.000	3.000	6750.000	5598.340

DIPOLE-DIPOLE RESISTIVITY DATA

AHUACHAPAN GEOTHERMAL FIELD, EL SALVADOR, C.A.

LINE 2 (a = 1000 meters) - Page 1 of 3

Ex 1 (meters)	Ex 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V/I	Rho-a (Ω-m)	(V/I)c	(Rho-a)c (Ω-m)	% ERR
3000	4000	0	1000	2.0	0.115	8.645	0.114	8.566	0.905
3000	4000	500	1500	1.5	0.380	15.652			
3000	4000	1000	2000	1.0	1.415	26.674	1.401	26.409	0.995
3000	4000	1500	2500	0.5	8.172	48.134			
3000	4000	2000	2900	0.1	175.241	127.174	175.884	127.640	-0.367
3000	4000	4100	5000	0.1	5.300	3.846	5.300	3.846	0.000
3000	4000	4500	5500	0.5	0.658	3.879			
3000	4000	5000	6000	1.0	0.242	4.560	0.232	4.382	3.913
3000	4000	5500	6500	1.5	0.100	4.144			
3000	4000	6000	7000	2.0	0.052	3.947	0.052	3.898	1.260
3000	4000	6500	7500	2.5	0.046	5.660			
3000	4000	7000	8000	3.0	0.031	5.911	0.032	6.015	-1.760
3000	4000	7500	8000	3.5	0.025	6.906			
3000	4000	7500	8500	3.5	0.030	8.164	0.028	7.552	7.500
3000	4000	8000	8500	4.0	0.025	9.486			
3000	4000	8000	9000	4.0	0.020	7.540	0.019	7.287	3.352
3000	4000	8500	9500	4.5	0.016	8.137			
3000	4000	9000	10000	5.0	0.013	9.285	0.013	8.658	-4.492
3000	4000	9500	10500	5.5	0.010	8.626			
3000	4000	10000	11000	6.0	0.011	11.400	0.011	11.445	-0.389
4000	5000	0	1000	3.0	0.022	4.159	0.023	4.243	-2.033
4000	5000	500	1500	2.5	0.032	4.018			
4000	5000	1000	2000	2.0	0.052	3.896	0.050	3.799	2.481
4000	5000	1500	2500	1.5	0.119	4.906			
4000	5000	2000	3000	1.0	0.257	4.843	0.261	4.928	-1.745
4000	5000	5100	6000	0.1	11.692	8.485	11.587	8.409	0.893
4000	5000	5500	6500	0.5	0.818	4.816			
4000	5000	6000	7000	1.0	0.185	3.487	0.188	3.544	-1.622
4000	5000	6500	7500	1.5	0.109	4.486			
4000	5000	7000	8000	2.0	0.066	5.000	0.064	4.818	3.648
4000	5000	7500	8500	2.5	0.039	4.873			
4000	5000	8000	9000	3.0	0.031	5.832	0.031	5.750	1.416
4000	5000	8500	9500	3.5	0.024	6.481			
4000	5000	9000	10000	4.0	0.019	7.314	0.018	6.773	7.393
4000	5000	9500	10500	4.5	0.014	7.260			
4000	5000	10000	11000	5.0	0.014	9.170	0.013	8.610	6.115
4000	5000	10500	11500	5.5	0.008	6.473			
4000	5000	11000	12000	6.0	0.004	4.307	0.004	4.464	-3.658

LINE 2 (a = 1000 meters) - Page 2 of 3

5000	6000	0	1000	4.0	0.019	7.065	0.018	6.966	1.413
5000	6000	500	1500	3.5	0.023	6.304			
5000	6000	1000	2000	3.0	0.035	6.582	0.034	6.373	3.172
5000	6000	1500	2500	2.5	0.065	3.084			
5000	6000	2000	3000	2.0	0.129	9.694	0.129	9.757	-0.648
5000	6000	2100	3000	0.1	35.185	25.534	35.244	25.577	-0.166
5000	6000	6500	7500	0.5	1.041	6.134			
5000	6000	7000	7500	1.0	0.365	6.883	0.368	6.945	-0.901
5000	6000	7500	8500	1.5	0.173	7.148			
5000	6000	8000	9000	2.0	0.106	7.983	0.111	8.387	-5.054
5000	6000	8500	9500	2.5	0.066	8.121			
5000	6000	9000	10000	3.0	0.047	8.923	0.047	8.788	1.509
5000	6000	9500	10500	3.5	0.034	9.177			
5000	6000	10000	11000	4.0	0.029	11.111	0.029	11.074	0.335
5000	6000	10500	11500	4.5	0.018	8.887			
5000	6000	11000	12000	5.0	0.009	6.254	0.009	5.983	4.328
5000	6000	11500	12500	5.5	0.011	9.342			
5000	6000	12000	13000	6.0	0.013	13.340	0.013	13.607	-2.001
6000	7000	0	1000	5.0	0.010	6.707	0.010	6.707	0.000
6000	7000	500	1500	4.5	0.040	20.268			
6000	7000	1000	2000	4.0	0.059	22.419	0.058	21.877	2.415
6000	7000	1500	2500	3.5	0.046	12.514			
6000	7000	2000	3000	3.0	0.059	11.205	0.054	10.095	9.907
6000	7000	7100	8000	0.1	145.000	105.227	144.823	105.099	0.122
6000	7000	7500	8500	0.5	7.857	46.282			
6000	7000	8000	9000	1.0	0.699	13.185	0.692	13.042	1.086
6000	7000	8500	9500	1.5	0.263	10.862			
6000	7000	9000	10000	2.0	0.146	10.996	0.150	11.302	-2.790
6000	7000	9500	10500	2.5	0.083	10.261			
6000	7000	10000	11000	3.0	0.069	12.928	0.074	13.902	-7.529
6000	7000	10500	11500	3.5	0.044	12.055			
6000	7000	11000	12000	4.0	0.019	7.194	0.018	6.901	4.068
6000	7000	11500	12500	4.5	0.021	10.448			
6000	7000	12000	13000	5.0	0.021	13.797	0.021	14.055	-1.869
6000	7000	12500	13500	5.5	0.016	13.686			
6000	7000	13000	14000	6.0	0.010	10.945	0.010	10.996	-0.463
7000	8000	0	1000	6.0	0.010	10.101	0.010	10.131	-0.298
7000	8000	500	1500	5.5	0.017	14.091			
7000	8000	1000	2000	5.0	0.016	10.441	0.016	10.441	0.000
7000	8000	1500	2500	4.5	0.021	10.556			
7000	8000	2000	3000	4.0	0.040	14.910	0.041	15.560	-4.364
7000	8000	8100	9000	0.1	25.000	18.143	24.475	17.762	2.100
7000	8000	8500	9500	0.5	1.710	10.072			
7000	8000	9000	10000	1.0	0.667	12.566	0.651	12.262	2.424
7000	8000	9500	10500	1.5	0.291	11.987			
7000	8000	10000	11000	2.0	0.223	16.846	0.221	16.675	1.014
7000	8000	10500	11500	2.5	0.109	13.465			

LINE 2 (a = 1000 meters) - Page 3 of 3

7000	8000	11000	12000	3.0	0.024	4.515	0.024	1.520	0.365
7000	8000	11500	12500	3.5	0.039	10.504			
7000	8000	12000	13000	4.0	0.050	18.942	0.051	19.135	-0.752
7000	8000	12500	13500	4.5	0.037	18.799			
7000	8000	13000	14000	5.0	0.018	11.995	0.019	12.395	-3.333
8000	9000	2000	3000	5.0	0.028	18.353	0.026	17.453	4.902
8000	9000	9100	10000	0.1	29.121	21.133	29.446	21.369	-1.117
8000	9000	9500	10500	0.5	1.890	11.133			
8000	9000	10000	11000	1.0	0.755	14.230	0.741	13.961	1.892
8000	9000	10500	11500	1.5	0.342	14.086			
8000	9000	11000	12000	2.0	0.115	8.693	0.115	8.656	0.434
8000	9000	11500	12500	2.5	0.102	12.562			
8000	9000	12000	13000	3.0	0.100	18.850	0.100	18.795	0.298
8000	9000	12500	13500	3.5	0.070	18.916			
8000	9000	13000	14000	4.0	0.032	11.875	0.033	12.511	-5.352
9000	10000	2000	3000	6.0	0.021	22.060	0.018	19.273	12.634
9000	10000	10100	11000	0.1	9.444	6.854	9.501	6.895	-0.600
9000	10000	10500	11500	0.5	2.140	12.604			
9000	10000	11000	12000	1.0	0.419	7.906	0.418	7.886	0.251
9000	10000	11500	12500	1.5	0.253	10.435			
9000	10000	12000	13000	2.0	0.202	15.203	0.215	16.207	-6.604
9000	10000	12500	13500	2.5	0.135	16.694			
9000	10000	13000	14000	3.0	0.058	10.987	0.058	10.851	1.242
10000	11000	11100	12000	0.1	57.703	41.876	57.703	41.876	0.000
10000	11000	11500	12500	0.5	3.885	22.883			
10000	11000	12000	13000	1.0	1.434	27.030	1.427	26.892	0.513
10000	11000	12500	13500	1.5	0.609	25.117			

DIPOLE-DIPOLE RESISTIVITY DATA

AHUACHAPAN GEOTHERMAL FIELD, EL SALVADOR, C.A.

LINE 2 (a = 500 meters) - Page 1 of 6

Tx 1 (meters)	Tx 2 (meters)	Rx 1 (meters)	Rx 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω-m)
3000	3500	0	500	5.0	0.517	20.000	0.026	8.527
3000	3500	500	1000	4.0	1.204	20.000	0.060	11.347
3000	3500	1000	1500	3.0	5.300	20.000	0.265	24.976
3000	3500	1500	2000	2.0	20.000	19.900	1.005	37.889
3000	3500	2000	2500	1.0	147.500	22.200	6.644	62.620
3000	3500	2500	2900	0.2	3700.000	22.200	166.667	138.230
3000	3500	4100	4500	1.2	6.200	20.000	0.310	4.114
3000	3500	4500	5000	2.0	2.650	19.200	0.138	5.203
3000	3500	5000	5500	3.0	1.580	25.500	0.062	5.840
3000	3500	5500	6000	4.0	0.720	25.400	0.028	5.343
3000	3500	6000	6500	5.0	0.280	25.000	0.011	3.695
3000	3500	6500	7000	6.0	0.280	25.000	0.011	5.911
3000	3500	7000	7500	7.0	0.220	25.000	0.009	6.967
3000	3500	7500	8000	8.0	0.130	24.800	0.005	5.928
3000	3500	8000	8500	9.0	0.125	20.200	0.006	9.623
3000	3500	8500	9000	10.0	0.100	24.000	0.004	8.639
3000	3500	9000	9500	11.0	0.092	25.000	0.004	9.887
3000	3500	9500	10000	12.0	0.068	25.000	0.003	9.331
3000	3500	10000	10500	13.0	0.076	26.300	0.003	12.392
3000	3500	10500	11000	14.0	0.067	35.000	0.002	10.103
3500	4000	0	500	6.0	0.168	22.050	0.008	4.021
3500	4000	500	1000	5.0	0.277	22.050	0.013	4.144
3500	4000	1000	1500	4.0	0.935	22.600	0.041	7.798
3500	4000	1500	2000	3.0	2.625	22.500	0.117	10.996
3500	4000	2000	2500	2.0	9.938	22.550	0.441	16.614
3500	4000	2500	2900	1.2	37.750	22.550	1.674	22.215
3500	4000	4100	4500	0.2	90.000	20.000	4.500	3.732
3500	4000	4500	5000	1.0	7.200	20.000	0.360	3.393
3500	4000	5000	5500	2.0	2.550	26.000	0.098	3.697
3500	4000	5500	6000	3.0	1.140	26.000	0.044	4.132
3500	4000	6000	6500	4.0	0.380	27.000	0.014	2.653
3500	4000	6500	7000	5.0	0.350	27.000	0.013	4.276
3500	4000	7000	7500	6.0	0.280	26.000	0.011	5.684
3500	4000	7500	8000	7.0	0.130	26.000	0.005	3.958
3500	4000	8000	8500	8.0	0.160	28.000	0.006	6.463
3500	4000	8500	9000	9.0	0.110	26.200	0.004	6.529
3500	4000	9000	9500	10.0	0.114	26.000	0.004	9.091
3500	4000	9500	10000	11.0	0.073	26.000	0.003	7.547
3500	4000	10000	10500	12.0	0.068	25.300	0.003	9.221
3500	4000	10500	11000	13.0	0.083	25.300	0.003	14.068

LINE 2 (a = 500 meters) - Page 2 of 6

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
4000	4500	0	500	7.0	0.129	32.200	0.004	3.172
4000	4500	500	1000	6.0	0.266	34.400	0.008	4.081
4000	4500	1000	1500	5.0	0.322	32.100	0.010	3.309
4000	4500	1500	2000	4.0	0.581	32.300	0.018	3.391
4000	4500	2000	2500	3.0	1.340	34.500	0.053	5.027
4000	4500	2500	3000	2.0	4.000	34.500	0.116	4.371
4000	4500	3100	3500	1.2	6.700	33.400	0.201	2.662
4000	4500	3500	4000	2.0	3.300	39.200	0.097	3.655
4000	4500	4000	4500	3.0	0.860	33.800	0.025	2.398
4000	4500	4500	5000	4.0	0.590	33.750	0.017	3.295
4000	4500	5000	5500	5.0	0.450	33.850	0.013	4.385
4000	4500	5500	6000	6.0	0.210	33.500	0.006	3.309
4000	4500	6000	6500	7.0	0.200	33.800	0.006	4.685
4000	4500	6500	7000	8.0	0.144	33.300	0.004	4.891
4000	4500	7000	7500	9.0	0.131	33.000	0.004	6.173
4000	4500	7500	8000	10.0	0.087	33.300	0.003	5.417
4000	4500	8000	8500	11.0	0.075	33.800	0.002	5.981
4000	4500	8500	9000	12.0	0.084	34.000	0.002	8.476
4000	4500	9000	9500	13.0	0.027	35.300	0.001	3.280
4000	4500	9500	10000	14.0	0.023	35.000	0.001	3.468
4500	5000	0	500	8.0	0.092	23.600	0.004	4.409
4500	5000	500	1000	7.0	0.126	23.600	0.005	4.227
4500	5000	1000	1500	6.0	0.210	23.600	0.009	4.696
4500	5000	1500	2000	5.0	0.341	23.400	0.015	4.807
4500	5000	2000	2500	4.0	0.808	24.000	0.034	6.346
4500	5000	2500	3000	3.0	1.250	24.100	0.052	4.888
4500	5000	3100	3500	0.2	215.500	20.200	10.668	8.848
4500	5000	3500	4000	1.0	12.130	20.200	0.600	5.660
4500	5000	4000	4500	2.0	1.900	20.000	0.095	3.581
4500	5000	4500	5000	3.0	0.980	20.000	0.049	4.618
4500	5000	5000	5500	4.0	0.650	20.200	0.032	6.065
4500	5000	5500	6000	5.0	0.270	21.200	0.013	4.201
4500	5000	6000	6500	6.0	0.238	20.100	0.012	6.249
4500	5000	6500	7000	7.0	0.148	20.100	0.007	5.829
4500	5000	7000	7500	8.0	0.147	20.800	0.007	7.993
4500	5000	7500	8000	9.0	0.098	20.800	0.005	7.327
4500	5000	8000	8500	10.0	0.089	20.000	0.004	9.227
4500	5000	8500	9000	11.0	0.107	20.000	0.005	14.421
4500	5000	9000	9500	12.0	0.046	30.500	0.002	5.174
4500	5000	9500	10000	13.0	0.029	25.000	0.001	4.974
5000	5500	0	500	9.0	0.075	17.900	0.004	6.516
5000	5500	500	1000	8.0	0.096	18.000	0.005	6.032
5000	5500	1000	1500	7.0	0.142	18.700	0.008	6.012
5000	5500	1500	2000	6.0	0.221	18.700	0.012	6.237
5000	5500	2000	2500	5.0	0.471	17.900	0.026	8.680
5000	5500	2500	3000	4.0	0.702	17.900	0.039	7.392
5000	5500	3100	3500	1.2	15.250	19.000	0.803	10.651

LINE 2 (a = 500 meters) - Page 3 of 6

Tr 1 (meters)	Tr 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V _a (	Rho-a (Ω-m)
5000	5500	6500	7000	2.0	3.400	19.000	0.179	6.746
5000	5500	7000	7500	3.0	1.750	20.000	0.087	8.247
5000	5500	7500	8000	4.0	0.750	20.000	0.038	7.069
5000	5500	8000	8500	5.0	0.590	19.300	0.031	10.084
5000	5500	8500	9000	6.0	0.280	19.300	0.015	7.657
5000	5500	9000	9500	7.0	0.309	19.300	0.016	12.675
5000	5500	9500	10000	8.0	0.129	19.300	0.007	7.559
5000	5500	10000	10500	9.0	0.132	19.100	0.007	10.747
5000	5500	10500	11000	10.0	0.139	20.100	0.007	14.339
5000	5500	11000	11500	11.0	0.215	23.100	0.009	25.088
5000	5500	12000	12500	13.0	0.085	23.000	0.004	15.848
5000	5500	12500	13000	14.0	0.086	23.100	0.004	19.649
5500	6000	0	500	10.0	0.079	20.900	0.004	7.837
5500	6000	500	1000	9.0	0.101	20.900	0.005	7.515
5500	6000	1000	1500	8.0	0.140	20.500	0.007	7.724
5500	6000	1500	2000	7.0	0.198	20.000	0.010	7.838
5500	6000	2000	2500	6.0	0.323	20.900	0.015	8.157
5500	6000	2500	3000	5.0	0.747	20.900	0.036	11.790
5500	6000	3100	6500	0.2	675.000	20.000	33.750	27.992
5500	6000	6500	7000	1.0	11.750	20.000	0.587	5.537
5500	6000	7000	7500	2.0	3.200	18.100	0.177	6.665
5500	6000	7500	8000	3.0	1.140	18.000	0.063	5.969
5500	6000	8000	8500	4.0	0.790	19.100	0.041	7.796
5500	6000	8500	9000	5.0	0.390	19.100	0.020	6.736
5500	6000	9000	9500	6.0	0.323	19.100	0.017	8.925
5500	6000	9500	10000	7.0	0.234	19.000	0.012	9.750
5500	6000	10000	10500	8.0	0.150	18.100	0.008	9.373
5500	6000	10500	11000	9.0	0.155	18.000	0.009	13.391
5500	6000	11000	11500	10.0	0.059	24.100	0.002	5.076
5500	6000	11500	12000	11.0	0.063	24.100	0.003	7.046
5500	6000	12000	12500	12.0	0.078	23.800	0.003	11.243
5500	6000	12500	13000	13.0	0.092	23.800	0.004	16.577
6000	6500	0	500	11.0	0.043	23.100	0.002	5.018
6000	6500	500	1000	10.0	0.104	22.600	0.005	9.542
6000	6500	1000	1500	9.0	0.100	23.100	0.004	6.732
6000	6500	1500	2000	8.0	0.113	23.100	0.005	5.532
6000	6500	2000	2500	7.0	0.235	23.100	0.010	8.054
6000	6500	2500	3000	6.0	0.330	23.000	0.014	7.573
6000	6500	3100	7500	1.2	12.500	20.900	0.598	7.937
6000	6500	7500	8000	2.0	4.950	27.200	0.182	6.861
6000	6500	8000	8500	3.0	2.200	25.600	0.086	8.099
6000	6500	8500	9000	4.0	0.950	25.600	0.037	6.995
6000	6500	9000	9500	5.0	0.683	26.200	0.026	8.599
6000	6500	9500	10000	6.0	0.303	26.300	0.012	6.081
6000	6500	10000	10500	7.0	0.296	23.100	0.013	10.144
6000	6500	10500	11000	8.0	0.311	24.550	0.013	14.327
6000	6500	11000	11500	9.0	0.129	24.800	0.005	8.089

LINE 2 (a = 500 meters) - Page 4 of 6

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
6000	6500	11500	12000	10.0	0.027	24.000	0.001	2.333
6000	6500	12000	12500	11.0	0.113	24.300	0.005	12.535
6000	6500	12500	13000	12.0	0.086	26.900	0.003	10.968
6000	6500	13000	13500	13.0	0.053	27.900	0.002	8.146
6500	7000	0	500	12.0	0.156	27.800	0.006	19.251
6500	7000	500	1000	11.0	0.080	27.700	0.003	7.785
6500	7000	1000	1500	10.0	0.136	27.700	0.005	10.180
6500	7000	1500	2000	9.0	0.127	27.800	0.005	7.104
6500	7000	2000	2500	8.0	0.340	27.800	0.012	13.832
6500	7000	2500	3000	7.0	0.482	27.800	0.017	13.726
6500	7000	7100	7500	0.2	3050.000	22.000	138.636	114.982
6500	7000	7500	8000	1.0	157.500	22.100	7.127	67.167
6500	7000	8000	8500	2.0	12.750	28.000	0.455	17.167
6500	7000	8500	9000	3.0	3.400	28.100	0.121	11.404
6500	7000	9000	9500	4.0	2.025	28.100	0.072	13.584
6500	7000	9500	10000	5.0	0.908	28.200	0.032	10.621
6500	7000	10000	10500	6.0	0.608	27.200	0.022	11.798
6500	7000	10500	11000	7.0	0.508	25.500	0.020	15.772
6500	7000	11000	11500	8.0	0.188	28.350	0.007	7.500
6500	7000	11500	12000	9.0	0.175	28.350	0.006	9.599
6500	7000	12000	12500	10.0	0.208	28.600	0.007	15.080
6500	7000	12500	13000	11.0	0.181	28.800	0.006	16.940
6500	7000	13000	13500	12.0	0.133	32.500	0.004	14.039
7000	7500	0	500	13.0	0.071	31.000	0.002	9.822
7000	7500	500	1000	12.0	0.097	32.400	0.003	10.271
7000	7500	1000	1500	11.0	0.141	32.500	0.004	11.694
7000	7500	1500	2000	10.0	0.194	32.400	0.006	12.415
7000	7500	2000	2500	9.0	0.288	30.900	0.009	14.494
7000	7500	2500	3000	8.0	0.497	31.000	0.016	18.132
7000	7500	8100	8500	1.2	62.500	33.000	1.894	25.133
7000	7500	8500	9000	2.0	15.000	33.200	0.452	17.033
7000	7500	9000	9500	3.0	6.750	33.000	0.205	19.278
7000	7500	9500	10000	4.0	2.600	33.100	0.079	14.806
7000	7500	10000	10500	5.0	1.968	32.900	0.060	19.732
7000	7500	10500	11000	6.0	1.575	32.900	0.048	25.266
7000	7500	11000	11500	7.0	0.449	36.000	0.012	9.874
7000	7500	11500	12000	8.0	0.425	36.000	0.012	13.352
7000	7500	12000	12500	9.0	0.497	35.700	0.014	21.649
7000	7500	12500	13000	10.0	0.440	35.700	0.012	25.555
7000	7500	13000	13500	11.0	0.250	35.600	0.007	18.929
7000	7500	13500	14000	12.0	0.103	35.600	0.003	9.926
7500	8000	2000	2500	10.0	0.086	13.700	0.006	13.016
7500	8000	2500	3000	9.0	0.141	13.700	0.010	16.005
7500	8000	8100	8500	0.2	255.000	12.000	21.250	17.624
7500	8000	8500	9000	1.0	12.900	12.000	1.075	10.132
7500	8000	9000	9500	2.0	3.330	12.100	0.275	10.375

LINE 2 (a = 500 meters) - Page 5 of 6

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
7500	8000	9500	10000	3.0	1.080	12.000	0.090	8.482
7500	8000	10000	10500	4.0	0.803	12.000	0.067	12.613
7500	8000	10500	11000	5.0	0.584	12.000	0.049	16.054
7500	8000	11000	11500	6.0	0.169	37.500	0.005	2.379
7500	8000	11500	12000	7.0	0.140	37.500	0.004	2.956
7500	8000	12000	12500	8.0	0.193	15.400	0.013	14.174
7500	8000	12500	13000	9.0	0.175	16.400	0.011	16.594
7500	8000	13000	13500	10.0	0.097	15.400	0.006	13.060
7500	8000	13500	14000	11.0	0.084	15.400	0.005	14.703
8000	8500	2000	2500	11.0	0.100	14.100	0.007	19.117
8000	8500	2500	3000	10.0	0.175	14.100	0.012	25.734
8000	8500	9100	9500	1.2	11.100	12.100	0.917	12.173
8000	8500	9500	10000	2.0	3.650	12.100	0.302	11.372
8000	8500	10000	10500	3.0	2.135	12.100	0.176	16.630
8000	8500	10500	11000	4.0	1.415	12.100	0.117	22.043
8000	8500	11000	11500	5.0	0.418	14.200	0.029	9.710
8000	8500	11500	12000	6.0	0.314	14.200	0.022	11.671
8000	8500	12000	12500	7.0	0.338	15.000	0.023	17.839
8000	8500	12500	13000	8.0	0.347	15.000	0.023	26.163
8000	8500	13000	13500	9.0	0.175	15.000	0.012	18.143
8000	8500	13500	14000	10.0	0.077	15.000	0.005	10.644
8500	9000	2000	2500	12.0	0.128	32.000	0.004	13.722
8500	9000	2500	3000	11.0	0.195	32.200	0.006	16.324
8500	9000	9100	9500	0.2	500.000	18.300	27.322	22.661
8500	9000	9500	10000	1.0	20.250	18.100	1.119	10.544
8500	9000	10000	10500	2.0	5.310	18.100	0.293	11.060
8500	9000	10500	11000	3.0	3.000	18.300	0.164	15.450
8500	9000	11000	11500	4.0	0.924	23.800	0.039	7.318
8500	9000	11500	12000	5.0	0.614	23.800	0.026	8.510
8500	9000	12000	12500	6.0	0.366	26.100	0.014	7.401
8500	9000	12500	13000	7.0	0.266	26.100	0.010	8.068
8500	9000	13000	13500	8.0	0.298	25.400	0.012	13.269
8500	9000	13500	14000	9.0	0.111	25.400	0.004	6.796
9000	9500	2000	2500	13.0	0.108	23.700	0.005	19.541
9000	9500	2500	3000	12.0	0.159	23.700	0.007	23.016
9000	9500	10100	10500	1.2	12.750	15.400	0.828	10.987
9000	9500	10500	11000	2.0	8.000	15.200	0.526	19.842
9000	9500	11000	11500	3.0	2.100	20.800	0.101	9.515
9000	9500	11500	12000	4.0	1.172	20.800	0.056	10.621
9000	9500	12000	12500	5.0	1.266	22.100	0.057	18.896
9000	9500	12500	13000	6.0	0.963	22.100	0.044	22.998
9000	9500	13000	13500	7.0	0.452	20.800	0.022	17.204
9000	9500	13500	14000	8.0	0.167	20.800	0.008	9.080
9500	10000	2000	2500	14.0	0.093	20.600	0.005	23.827
9500	10000	2500	3000	13.0	0.085	20.600	0.004	17.694

LINE 2 (a = 500 meters) - Page 6 of 6

Tx 1 (meters)	Tx 2 (meters)	Rc 1 (meters)	Rc 2 (meters)	n	V (volts)	I (amps)	V/I	Rho-a (Ω -m)
9500	10000	10100	10500	0.2	135.000	19.600	6.888	5.713
9500	10000	10500	11000	1.0	26.000	19.600	1.327	12.502
9500	10000	11000	11500	2.0	3.305	17.300	0.191	7.202
9500	10000	11500	12000	3.0	1.222	17.300	0.071	6.657
9500	10000	12000	12500	4.0	1.320	20.300	0.065	12.257
9500	10000	12500	13000	5.0	0.919	20.300	0.045	14.933
9500	10000	13000	13500	6.0	0.376	17.300	0.022	11.471
9500	10000	13500	14000	7.0	0.130	17.300	0.008	5.949
10000	10500	11100	11500	1.2	29.500	17.200	1.715	22.760
10000	10500	11500	12000	2.0	4.150	17.200	0.241	9.096
10000	10500	12000	12500	3.0	2.572	15.100	0.170	16.053
10000	10500	12500	13000	4.0	1.490	15.100	0.099	18.600
10000	10500	13000	13500	5.0	0.613	15.100	0.041	13.391
10000	10500	13500	14000	6.0	0.188	15.100	0.012	6.571
10500	11000	11100	11500	0.2	960.250	22.800	42.116	34.931
10500	11000	11500	12000	1.0	61.000	22.800	2.675	25.215
10500	11000	12000	12500	2.0	17.000	20.900	0.813	30.664
10500	11000	12500	13000	3.0	7.364	20.900	0.352	33.208
10500	11000	13000	13500	4.0	1.344	22.800	0.059	11.111