GL01500

ZUNIL ELECTRICAL RESISTIVITY STUDIES

ZUNIL GEOTHERMAL AREA, GUATEMALA

REVIEW COMMENTS

by

Howard P. Ross

June 1, 1989

Earth Science Laboratory

University of Utah Research Institute
391 Chipeta Way, Suite C
Salt Lake City, Utah 84108
(801) 524-3422

DRAFT

ZUNIL ELECTRICAL RESISTIVITY STUDIES

ZUNIL GEOTHERMAL AREA, GUATEMALA

Review Comments

by

Howard P. Ross

June 1, 1989

DRAFT

These surveys have only a small application to the development area (~1 sq. km) and are not able to resolve the detail of flow patterns known to exist via other work.

DRAFT

ZUNIL ELECTRICAL RESISTIVITY STUDIES

Introduction

Electrical resistivity surveys completed earlier have been reviewed in support of the CyM/MKF Zunil I project. It appears that two electrical resistivity surveys have been completed in the Zunil I area, both of which employed the Schlumberger array to complete vertical electric soundings (VES). The first survey was completed by Japanese scientists (JICA) in 1976-77 and the second survey by INDE in 1977.

JICA Survey

The JICA data were obtained as a series of VES stations with centers at intervals between 150 m and 250 m along Lines 1, 2, 3 and 4. All of these station centers are located north and east of the area which includes wells ZCQ-3, -4, -5, -6 and are generally south and west of the town of Zunil (CyM/MKF, 1988). Difficult terrain conditions precluded the extension of the VES soundings to the southwest. The maximum depth probed by the JICA soundings was limited by the AB/2 distance of 750 m. The data were presented in map and block diagram form (CyM/MKF Figs. 3.3-20, 3.3-21) but individual VES plots were not available for review. The locations of JICA and INDE VES station centers are shown on Figure 1.

INDE Survey

The INDE survey (Palma A., 1977) included 17 soundings along Lines 1, 2, 3, and 4 and approximately 18 additional soundings,
probing Depth = 500 m   800 m   1,000 m
using AB separations of 1,000 m, 1,600 m, and 2,000 m. A notable result of this work was the delineation of a low resistivity zone at depths approaching 100 m in the area of wells ZCQ-1 and ZCQ-2, which extends to the southwest. The INDE data are reported in much more detail by Palma A.,(1977) who includes VES plots of

resistivity versus AB/2 as well as final interpretative results.

INDE Resistivity Interpretation

Most of the INDE VES plots indicate good data and a reasonably layered resistivity structure which is important to the correct interpretation of the VES data. INDE completed both qualitative and quantitative interpretations. The quantitative interpretation of individual soundings appears to have been completed using graphical and curve matching techniques. The interpretations appear valid and no attempt was made to verify or reinterpret these sounding plots. This could be done using the UURI Schlumberger inversion computer program if the additional effort was justified. Using the INDE resistivity-thickness solutions, resistivity cross sections were plotted for Profiles 1, 2, 3, and 4. These sections are similar to those completed by INDE (which were not readable in the copied document).

The resistivity cross sections are shown in Figures 2 and 3, with the positions of JICA stations incicated for reference. While these stations are in general agreement with the resistivity-depth diagram from the JICA data (CyM/MKF Fig 3.3-21) some differences were noted. The INDE data with the larger AB/2 respond to a resistive layer not seen by JICA on Line 1. The depth to the top of the conductive layer and it's interpreted resistivity often differ between the two surveys. On Line 1, JICA resistivities of 6.5, 5.6, and 8-14 ohm-m contrast with INDE values of 2.1, 1.5, and 3.75 ohm-m for VES 11, 10, and 9 respectively. On Line 2, JICA data show resistivity values of 5-6 ohm-m compared to 7.4 and 13.6 ohm-m interpreted by INDE. The shorter distances between stations of the JICA data provide some additional detail and therefore more indications of faulting. Without the detailed resistivity versus depth plots of the JICA soundings they cannot be evaluated in detail. The JICA VES results, are used to supplement the interpretation of the INDE data.

Figure 4 summarizes the principal results of the INDE and JICA resistivity data. Discontinuities betwen resistivity layers are interpreted as faults on Figures 2 and 3, and these have been transfered to Figure 4. Unfortunately most of this information is east of the portions of the reservoir tested by ZCQ-3, -4, -5, and -6, due to the steep topography in the area which has been drilled. Projection of the interpreted faults to the northwest is of current exploration interest however. Since the position of the discontinuity can only be estimated between adjacent VES centers, the trend and continuity of the structures must be inferred from geologic and topographic information.

Several soundings indicate very low resistivities (1-6 ohm-m) in the conductive layer. These include VES 11, 10, and 9 on Line 1; the area between VES 6 and 4 on Line 2; west of VES 12 on Line 3, from JICA stations 21 and 31; and JICA station 81 on the west end of Line 4. These areas are important because the low resistivities may indicate hot, relatively undiluted reservoir fluids circulating near faults, and/or increased clay alteration resulting from geothermal fluids. These areas are shown on Figure 4.

Summary

Experience in geothermal areas throughout the world indicates that electrical resistivity surveys will not delineate all faults and fractures which may be of interest. The detection of these structures requires a significant physical property contrast, perhaps in the form of a vertical offset along a fault. The survey type and resolution are also important factors. Discontinuities which are interpreted as faults are often major structures important as structural controls to the geothermal system, or as fluid conduits. Discontinuities interpreted as faults are often several structures which cannot be resolved by the observed data.

This review has not yielded new data or interpretative results, but does provide familiarity with and confidence in the JICA and INDE work completed several years ago. The resistivity data suggest that the least-diluted thermal fluids are transmitted along structures near the western limit of the survey area, near the ZCQ wells. The locations of faults inferred from the data should be integrated with other information to improve the understanding of faulting and permeability in the area.

It is possible that additional electrical resistivity work would aid in better delineation of fractures in the area of the ZCQ wells. Two or three dipole-dipole lines which trend roughly northeast parallel to Line 1, using an electrode separation of 200 m, would map resistivity structure to depths of 400-500 m and would probably detect major fault offsets and zones of upwelling thermal fluids. The dipole-dipole array would be compatible with the terrain northeast of ZCQ-6 and most topographic effects could be accounted for in the numerical model interpretation of the data.

References

CyM/MKF, 1988, Summary of Zunil exploration data and results (title unknown), CyM/MKF Tech. rept. to INDE.

Palma Ayala, J. C., 1977, Proyecto Zunil estudio de factibilidad preliminar - informe geoelectrico, Septiembre, 39 p.

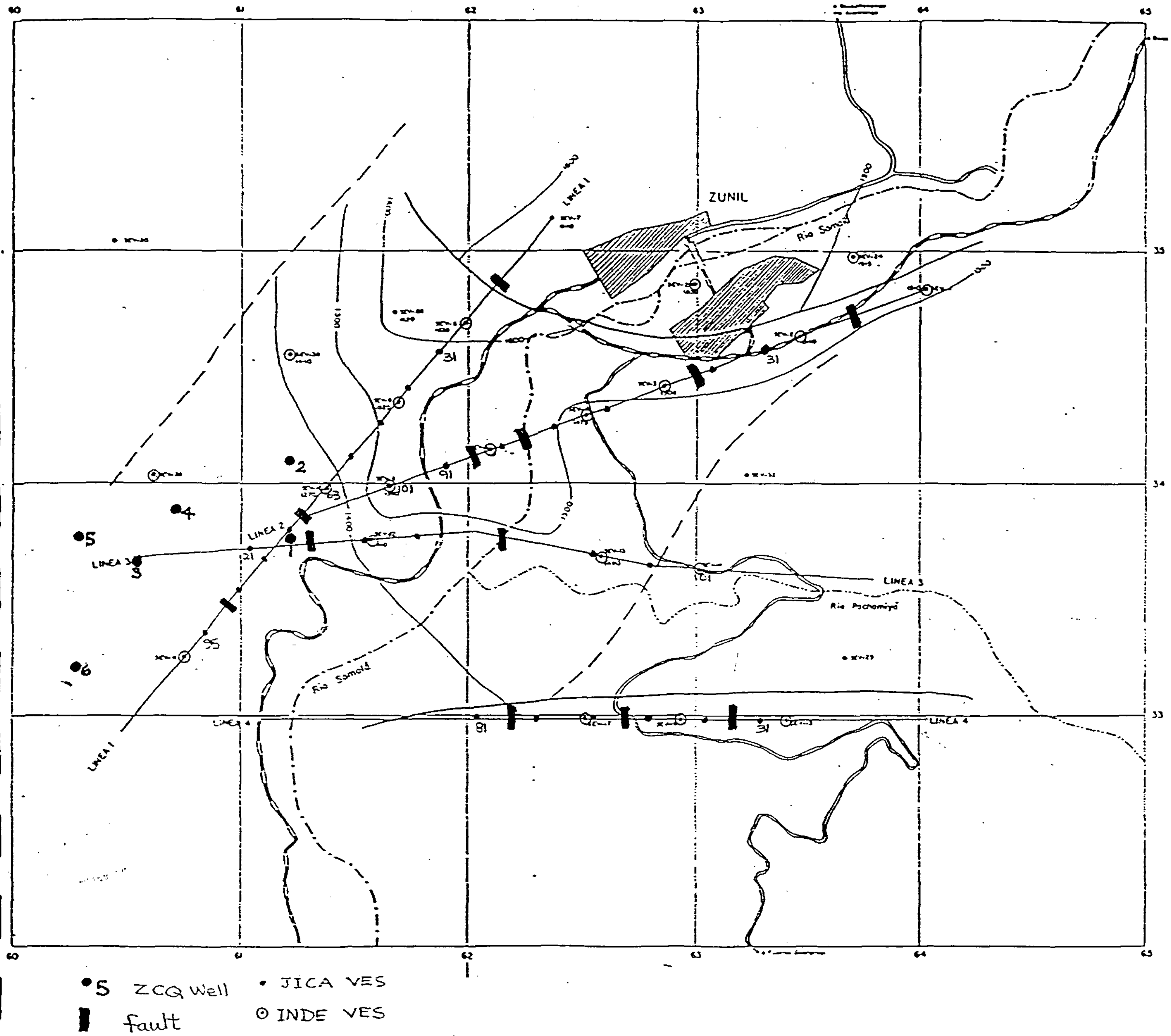

Figure 1. Location of JICA and INDE Schlumberger vertical electric soundings (VES).

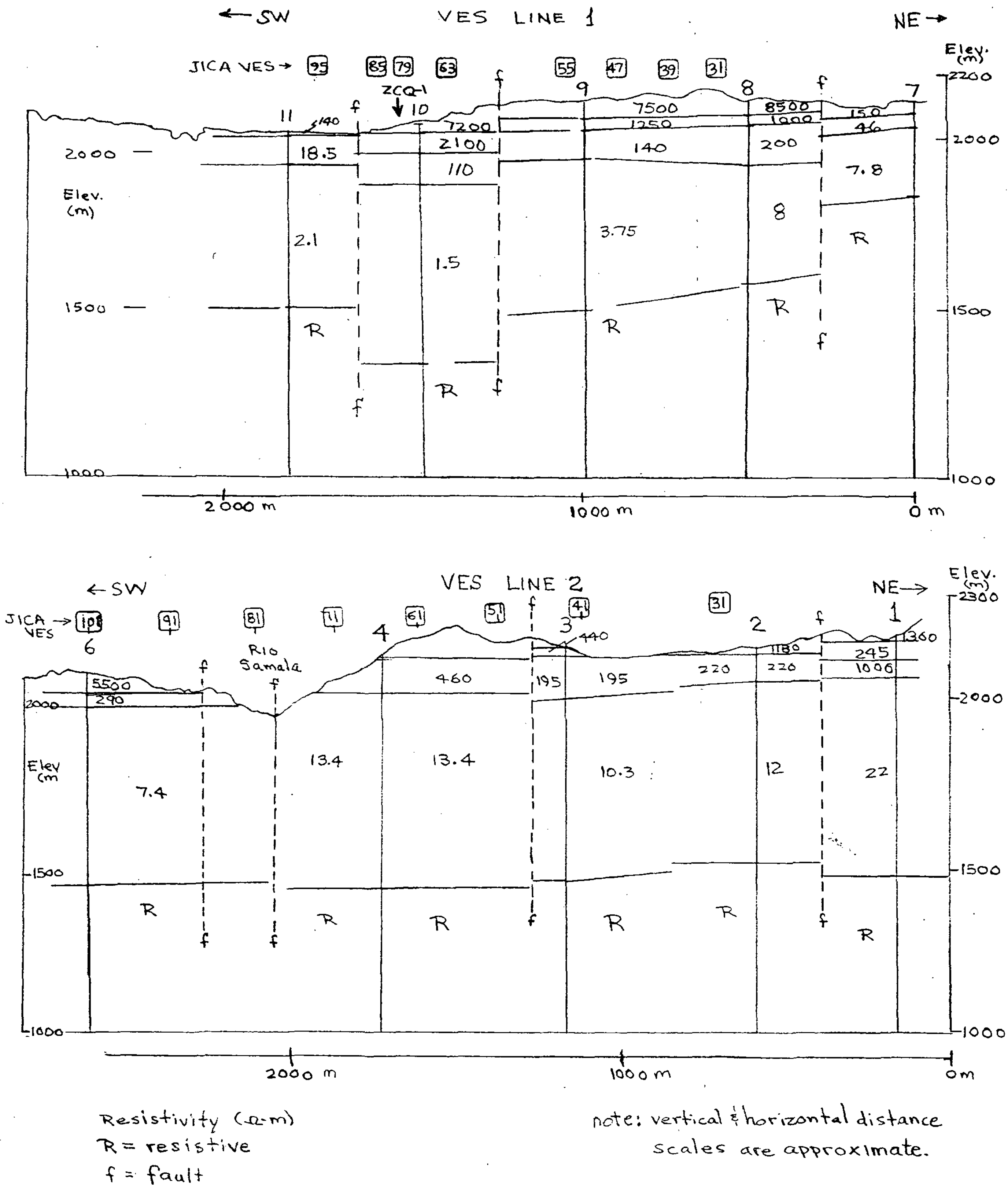

Figure 2. Electrical resistivity cross sections for INDE VES Lines 1 and 2. Corresponding JICA VES sounding locations are indicated.

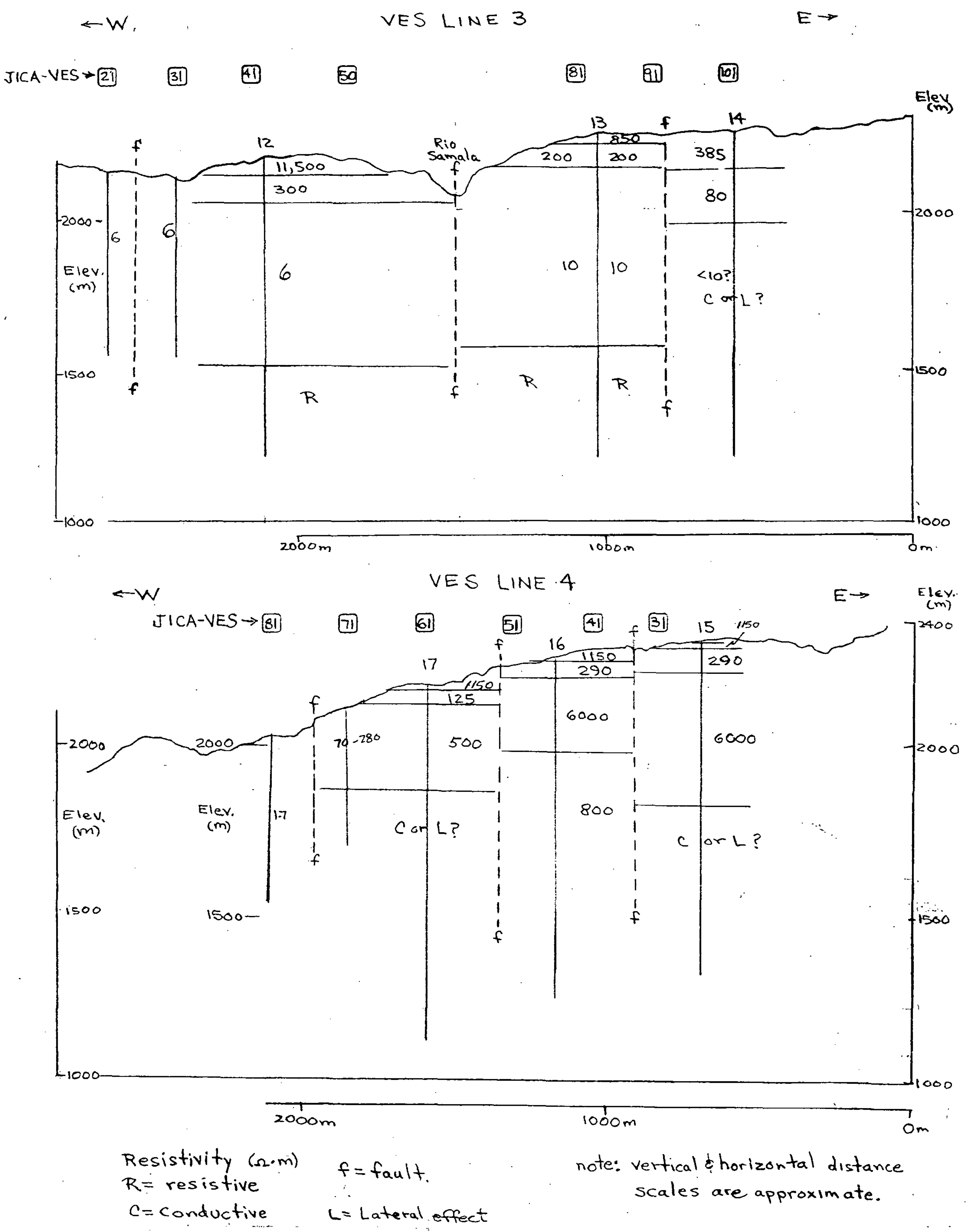

Figure 3. Electrical resistivity cross sections for INDE VES Lines 3 and 4. Corresponding JICA VES sounding locations are indicated.

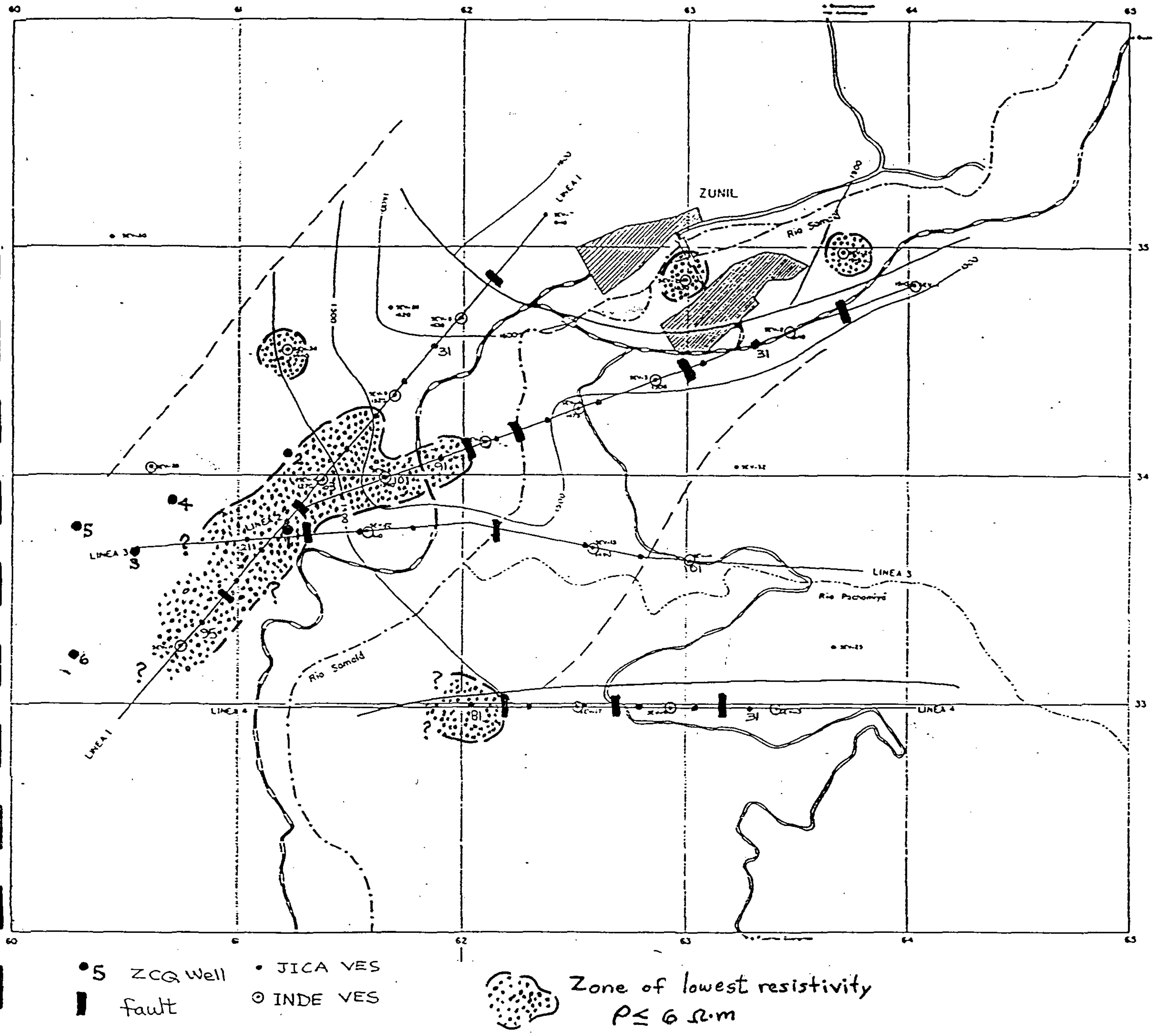

Figure 4. Summary of INDE and JICA electrical resistivity results, Zunil area.

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108
(801) 524-3422