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RESISTIVITY IMAGING AS A TOOL FOR GROUNDWATER STUDIES AT SANTO DOMINGO, CENTRAL NICARAGUA

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INTRODUCTION

Electrical resistivity imaging has become a widely used technique for engineering and environmental investigations. The object of this work was to use the resistivity method to delimit weathered and quartz veins areas of the Tertiary terrain in central Nicaragua, Central America. The investigations were carried out within the framework of a multi disciplinary research and training programme funded by Sida/SAREC, with the aim of mapping groundwater systems in an area contaminated by mining activities.

Continuous Vertical Electrical Soundings (CVES) were performed crossing a quartz veins area, called San Sebastián (Figure 1). These quartz veins have a predominant direction East - West along the upper part of a hill with approximately 15º slope.

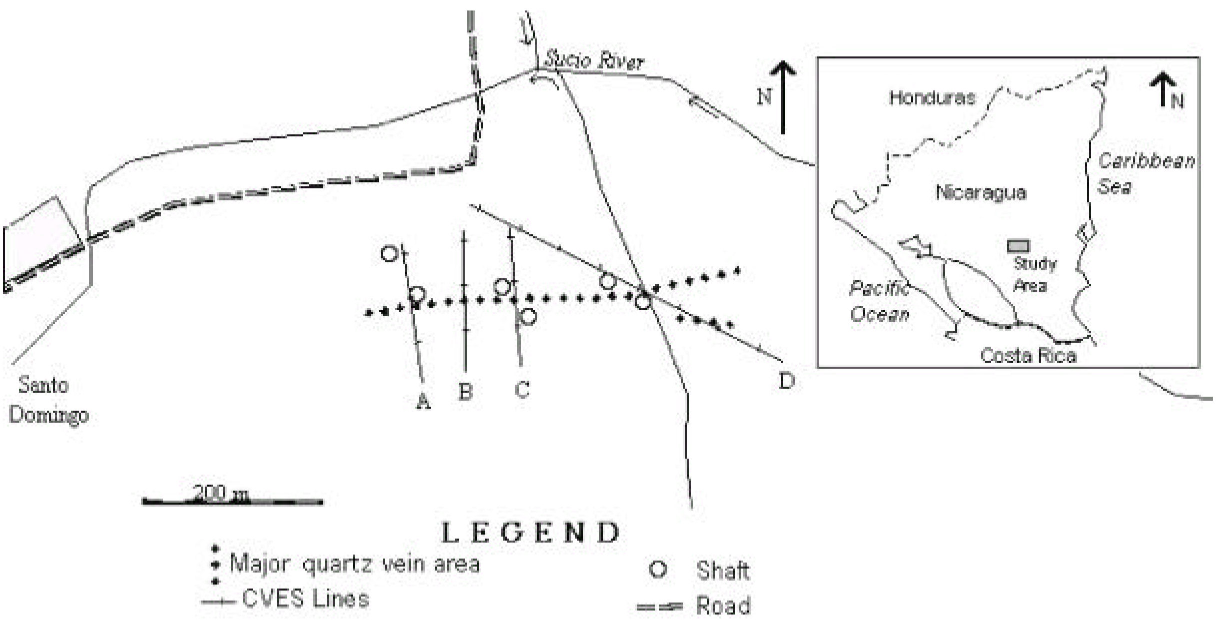

Figure 1. San Sebastián area, near the village of Santo Domingo, in central Nicaragua.

GEOLOGY AND HYDROGEOLOGY

The San Sebastian area is located in the gold mining district of La Libertad – Santo Domingo, central part of Nicaragua, approximately 177km east of Managua. Geologically, this site consists of volcanic rock, mainly well weathered and hydrothermally altered basaltic andesite flows (Hodgson, 1972). The quartz filled fractures have a preferential strike in East - West and dip 70°N. These veins are often from 0.01m to 3.50m wide. However, the largest quartz vein in this area is the San Sebastián vein which is 1.5m to 10m wide and approximately 500m long.

Several shafts excavated by small-scale mining workers show zones of strong weathering down to 15m depth. Under this level the rock gradually becomes less affected by alteration. Fractures and breccias surrounding the quartz veins facilitate the weathering process through leaching water resulting in increased porosity. The regional tectonic development and thereby associated fracturing, hydrothermal processes and secondary alteration of veins and breccias are believed to control groundwater infiltration, occurrence and flow in the area. The hydrogeological implications will be further studied in the project.

METHOD

The multi electrode resistivity data acquisition system used was the ABEM Lund Imaging System (Dahlin, 1996). Three of the CVES lines had 2m electrode spacing and one had 5m electrode spacing. Both the Wenner and Wenner-Schlumberger arrays were used.

The true resistivity structures were estimated using smoothness constrained 2D inversion with L1-norm, which attempts to minimise the absolute changes in the resistivity values (Loke, 1998). To accommodate the topography a distorted finite element grid was applied in the inversion process.

RESULTS AND INTERPRETATION

The inversion results are shown in Figure 2. Lines A, B and C cross the quartz vein area more or less perpendicularly, in direction North- South. Line D crosses a stream valley diagonally and attempts to examine the weathering patterns on the hillsides.

Three more or less horizontal layers and a vertical structure can be distinguished in the resistivity models in Figs. 2(A), 2(B), and 2(C). Based on observations from the surface geology and mining shafts, the first layer belongs to a very weathered zone, which is affected also by removal of material from mining activities (890Ωm - 1400Ωm). The second layer is composed by weathered and altered rock (160Ωm - 890Ωm). The third layer coincides with the saturated zone, and is easily distinguished in Line D (130Ωm - 160Ωm). The vertical high resistive body is the San Sebastian vein.

The 400m profile in Line D shows how the low resistive layer interpreted as weathered rock becomes thicker close the stream in the valley. A segment of the San Sebastián quartz vein is visible at 80m.

DISCUSSION

In San Sebastián, the alteration is characterised by an irregular occurrence of altered rocks that were pervasively penetrated by silica rich hydrothermal fluids (Carranza, 1991). The high quartz content and the lack of clayey weathering products causes the high resistivity values in the zone corresponding to the quartz vein in the inverted models. When there are open fractures, widened by leaching, they act as points of infiltration and flow of groundwater.

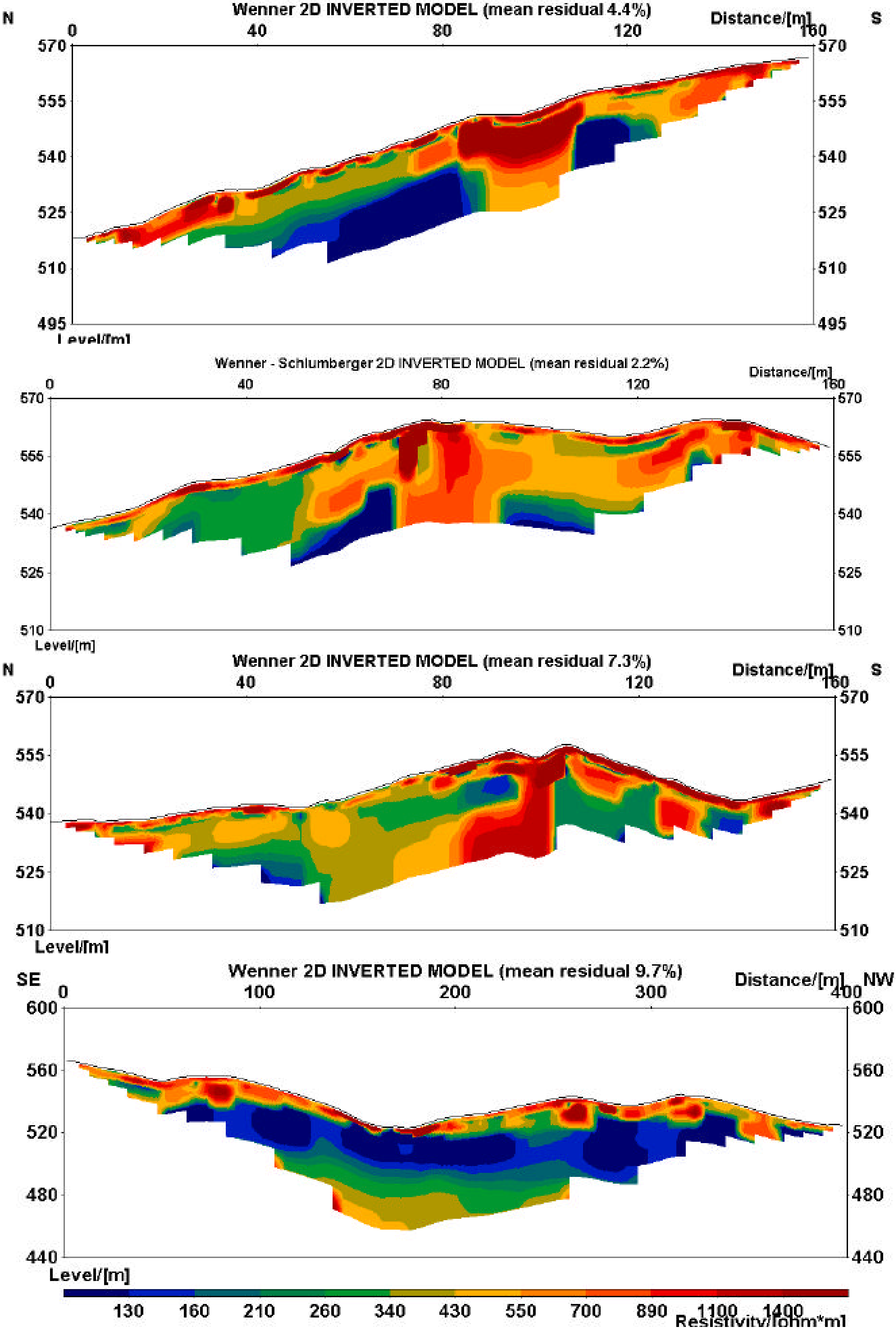

Figure 2. Inverted models from Lines A, B, C and D.

The Wenner array demonstrates capability to detect lateral weathering areas, while the vertical structures related to San Sebastián quartz vein are better detected by the combined Wenner – Schlumberger array.

The significant topographic variation causes a distortion of the current lines and therefore of the measured potential field, which if not accounted for gives rise to a terrain anomaly (Tsourlos et al, 1999). In this case the topography along the investigated lines is modelled through the distorted finite element grid, however it may be that the relatively high mean model residuals for Line C and Line D are caused by 3D effects from the steep hillsides adjacent to the investigated lines.

CONCLUSIONS

The resistivity imaging supports the conceptual model of quartz veins and tectonic zones, with associated fracturing and weathering, being the major controlling factors for the groundwater occurrence in the investigated area in central Nicaragua. The San Sebastián quartz vein is a typical example of such a feature, where the quartz vein stands out as a high resistive zone from the clay weathered surrounding rock. A high secondary porosity is expected to be associated with the quartz veins, which can thus act as conduits for infiltration and transport of groundwater. The resistivity imaging results will be used as a basis for the continued investigations.

The investigation examined here demonstrates that continuous vertical electrical soundings (CVES) are suitable to delimit weathering and quartz veins areas in central Nicaragua. The combined Wenner and Schlumberger arrays appear to provide a good combination of both lateral and vertical resolution.

ACKNOWLEDGEMENTS

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