Modern Geophysical Advances in Perú

by José R. Arce

Introduction

South American geophysics started in the early twentieth century with resistivity and self-potential surveys. Apart from petroleum exploration, which has been significant in Venezuela and throughout most of the Amazon jungle countries, most geophysical applications have been oriented toward mining exploration in the Andean countries (Perú, Chile, Bolivia, Argentina, Ecuador, Colombia and Venezuela). During the 1960s most geophysical work in Perú was for groundwater exploration with the large agricultural industries. In the 1970s and 1980s there was a significant increase in mining exploration with geophysical techniques. Mining operations started using geophysical techniques for environmental applications in the 1990s, to comply with new government regulations.

As an indication of the distribution of methods an applications in Latin America, I provide a summary of work conducted by our company. We completed 608 geophysical surveys between 1960 and 2004. This includes 226 for mineral deposit characterization, 93 of them of the porphyry-type, 100 investigations of groundwater aquifers, 133 engineering geophysics projects, and 2 archaeological investigations. Most of these surveys have been conducted in Perú, but they span to Chile, Bolivia, Ecuador, Brasil, Colombia, Guatemala and El Salvador.

A broad range of geophysical methods are currently in use, and including seismic refraction, resistivity, IP, well-logging, EM, magnetics, gravity and self-potential. There are numerous professional associations related to the earth sciences in Latin America. Some of these are the Asociación Geológica Argentina, Sociedad Venezolana de Geólogos, Sociedad Geológica de Chile, Sociedade Brasileira de Geología, Sociedad Cubana de Geología, Centro de Investigaciones Geológicas (Argentina), Instituto de Geofísica (Universidad Autónoma de México), Instituto Geofísico del Perú, Instituto Geofísico-Universidad San Agustín (Perú) and the Grupo de Investigaciones en Geofísica (Universidad Nacional de Colombia). In Perú we have the Sociedad Geológica del Perú, which has been active since 1924 and houses numerous geoscientists. This organization organizes the Peruvian Geological Congress every two years, where large numbers of local and foreign papers are presented.

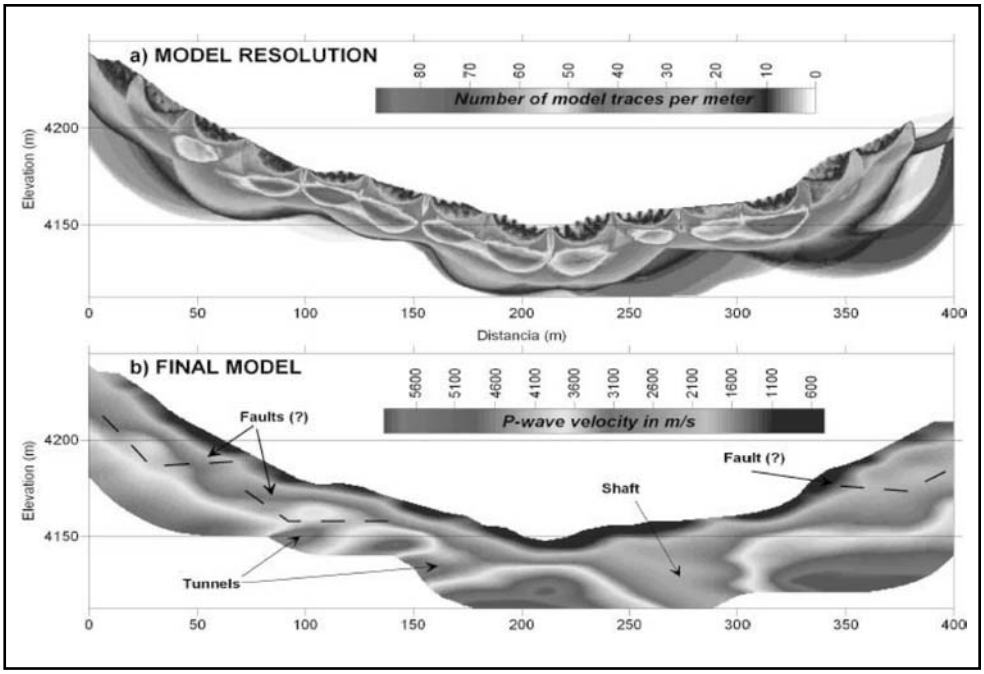

Figure 1. Wavepath Eikonal Tomography (WET) technical application applied to Refraction Seismics Data.

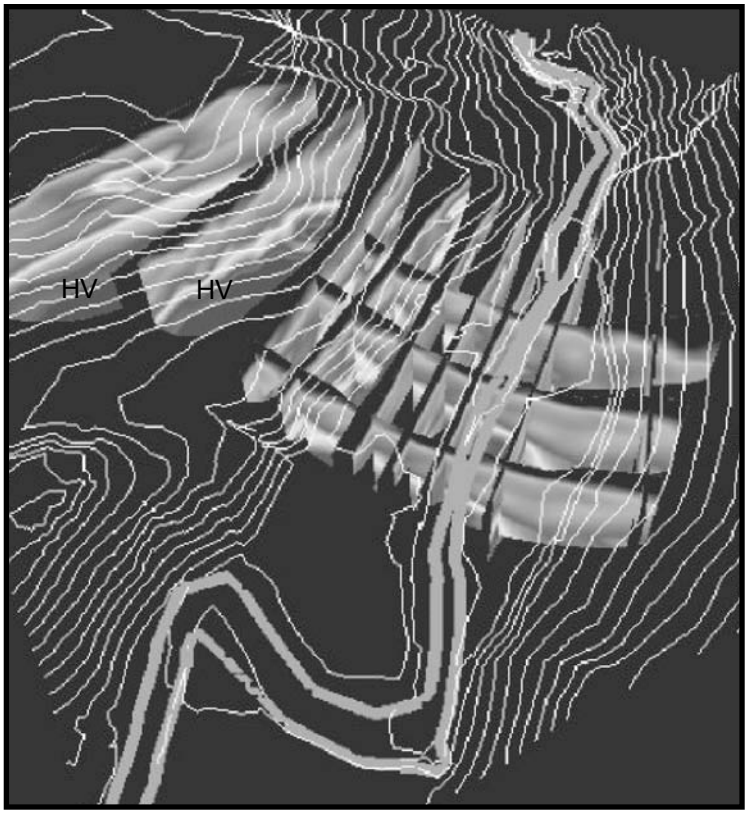

Figure 2. Seismic tomography over a sedimentation dam project, northern Perú. Geophone spacing was 5m, and approximate maximum depth was 40m.

Two-dimensional Seismic Tomography

In 2001, we started processing our engineering seismic surveys with the Wavepath Eikonal Tomography (WET) technique. This modern approach has greatly increased lateral and vertical resolution in refraction seismics, as it also partially compensates for lateral inhomegeneities and anisotropy. The results are presented as tomographic images with non-discrete contacts. Figure 1 shows an example of this technique over an old underground mine. The purpose of this survey was to detect possible shafts and depleted workings which were not previously mapped, as the company was planning to create a tailings deposit over this area. Geophone spacing was 5m, and final depth reached around 40m. Individual profiles were processed with Rayfract WET tomography processing and modeling software. All possible fracture zones and shafts were mapped with seismics for immediate follow-up drilling.

In figure 2 we show the result of a seismic survey carried out at a sedimentation dam in Northern Perú. Lines across the valley were 180m in length and the image is looking North. The engineers in charge of this particular case were concerned about preliminary drilling results, which confirmed compact andesite bedrock on the left margin of the valley (with velocities above 3000 m/s, HV), but no compact bedrock was found on the right margin. Geophysics confirmed this problem, as high velocities are not seen at depth at the right margin of the project.

2D Resistivity and Induced Polarization

2D Resistivity is an important tool for Peruvian engineering surveys. Modern modeling techniques yield high-resolution sections, which are easier to correlate with available geological information than the pseudo-sections used in the past. The example shown in Figure 3 was obtained on a tailings dam in Southern Perú, where possible fracturing within the structure was suspected. The resistivity image can clearly discriminate between the saturated dam (B) and low-porosity bedrock (P). There are chargeable responses on the saturated dam because it was built with material extracted from the mine containing sulfides. Electrode spacing was 10m, with 7 penetrations on the Pole-Pole array. EF

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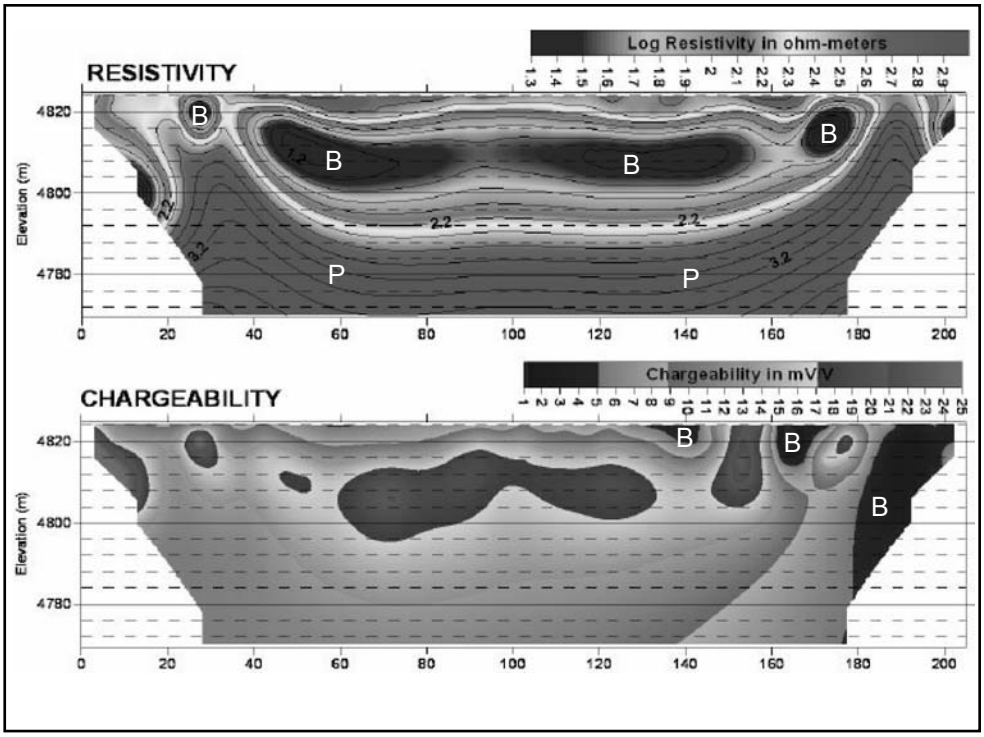

Figure 3. 2D resistivity and chargeability models for pole-pole data over a tailings dam structure.