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Application of electrical resistivity tomography to the environmental characterization of abandoned massive sulphide mine ponds (Iberian Pyrite Belt, SW Spain)

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ABSTRACT

Mining activity in the Iberian Pyrite Belt, on the south-west of the Iberian Peninsula, has generated a great amount of mine tailing ponds, which once the extractive activity is finished, are abandoned and become a serious environmental problem. Here we present the results of applying the electrical resistivity tomography (ERT) technique to characterize the abandoned mine ponds in two sites: Monte Romero and Mina Concepción. ERT has allowed us to determine both the general geometry of the pond's base and the maximum thickness of the mine tailings. In all cases, the resistivity contrast between the infilling and the bedrock is high enough to clearly define the bottom pond boundary. The low-resistivity values (lower than 5 Ωm) obtained for the infilling are explained by the high concentration of pyrite in the tailings and the occurrence of acid waters. Whereas the Monte Romero mine pond is almost completely saturated with water, in Mina Concepción it has been possible to identify the presence of inner acid water flows, the outlet of which through the damaged dyke originates a spilling of acid waters to the Odiel River. No low-resistivity water flows through the base of the ponds into the bedrock have been observed, indicating a good isolation of the base of the studied mine ponds.

INTRODUCTION

The mining of copper from sulphide ores, in addition to metal production, generates large amounts of mine tailings that are deposited in mine ponds. Furthermore, due to natural leaching from these reactive materials, contamination of the environment close to the deposits often occurs. The main problems are related to possible mobilizations of heavy metals and formation of acid mine drainages from the oxidation of sulphides. For this reason, the study of the pond geometry, the thickness of the mine tailings accumulated in it, as well as the presence or absence of inner water flows and the location of acid drainage leaks are all essential for a conclusive assessment of the environmental risk.

In the SW of the Iberian Peninsula, there are a large number of mine ponds related to the mining of the massive sulphide ores of the Iberian Pyrite Belt (IPB) (IGME 1986; Fig. 1). The 250 km-long Iberian Pyrite Belt is located in the South-Portuguese Zone, the southernmost terrane of the Variscan Belt of Iberia. Among other geological units, the belt includes the so-called volcanic sedimentary complex, Upper Devonian-Carboniferous in age, where massive sulphide bodies frequently occur. These are hosted by a complex felsic-mafic volcanic sequence interbedded with mudstone and several chemical sediments and are related to Variscan tectonics and hydrothermalism (Lunar *et al.* 2002; Almodóvar and Sáez 2004; Tornos 2006; and references cited therein).

The IPB hosts 82 inactive or working mines, as well as more than 38 ore showings of massive sulphides or stockworks, with a very high total tonnage/surface ratio of about 15 000–20 000 tonnes of massive sulphides per hectare of outcropping volcanic sedimentary complex. Despite their large size, most are pyrite-rich and only 11 deposits show important Cu–Zn–Pb contents (Tornos 2006). Many of the major ore deposits consist of several (two to six) individual massive sulphide lenses clustered in a small area of just a few square km, as occurs in the giant deposits of Neves Corvo, Aljustrel, Tharsis, Sotiel–Migollas, Rio Tinto and Aznalcóllar–Los Frailes. The intense mining activity in the district has produced a large number of mining waste deposits, most of them nowadays abandoned, which constitute an important environmental problem (Blanco *et al.* 2003; López *et al.* 2007; Pérez-López *et al.* 2007). In the case of mine ponds, they

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