

Processes of Persistent Heavy Metal Contamination in the Río Tinto, South West Spain

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The Iberian Pyrite Belt comprises one of the most extensive metallogenic sulphide deposits in the world. A highly significant historical mining area within this province, is the Riotinto region in south western Spain. The Río Tinto, with its low pH (1.86 - 3.79), red-brown colour and high dissolved metal contents, (Schell, et al., 2000), meanders through floodplains of historic and present mining waste, draining an area approximately 1,676km². The Río Tinto, with its source in the Sierra Aracena, flows over a distance of 70-80km southwards before entering the Huelva Estuary and emptying into the Gulf of Cádiz.

Historical evidence suggests (Pinedo, 1963; Strauss, et al., 1977) mining first began in the region around 3,000 B.C principally for Cu, Au, Ag and pyrite. Both opencast and underground mining methods have been used since then and approximately 115 million tonnes of ore have been extracted to the present day. As a result of past and present mining activities, the Río Tinto has consequently been subjected to high concentrations of heavy metals, as sediment and water samples collected within the source and mining region indicate this (figure 1). Initial results using ICP-OES and ICP-MS show high dissolved levels of Al (2,016ppm), As (9ppm), Cu (50ppm), Fe (7,220ppm), Mg (1,149ppm), Sb (4ppm) and Pb (2ppm) from the headwaters of the Río Tinto combined with low pH values (2-3). Anion concentrations show exceedingly high values of sulphates (>19,600ppm). The Eh and pH relationship along the river illustrates a classic example of sulphide oxidation. It is thought that microbial activity plays an important role in these elevated concentrations and low pH values but it is still not clear as to why this unusual chemistry persists along the entire 80km length of the river.

Preliminary interpretation of these data suggests an increase in contamination once the Río Tinto enters the mining region approximately 8km downstream from the headwaters. Aqueous contamination remains elevated for a further ~ 20km, in particular, Mg, Al, Cu, Fe, and S. Beyond the mining region dissolved metal concentrations decrease steadily, with levels of Fe and S in water samples measured at 269ppm and 413ppm, respectively, 60km downstream. There are positive correlations between elements such as Fe, S, Al and Cu and also between Mg, Ca and Mn indicating inter-element dependence. In addition, precipitate minerals carpet the Río Tinto's floodplains during the summer months including copiapite [$\text{Fe}^{2+}\text{Fe}_4^{3+}(\text{SO}_4)_6(\text{OH})_2 \cdot 20\text{H}_2\text{O}$] and coquimbite [$\text{Fe}_2^{3+}(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$], and point to transient storage of metals.

It is intended that this study will provide an appreciation of chemical and microbiological processes within the Río Tinto system and will, therefore, be a major step forward in our understanding of how such processes operate within a unique environment.

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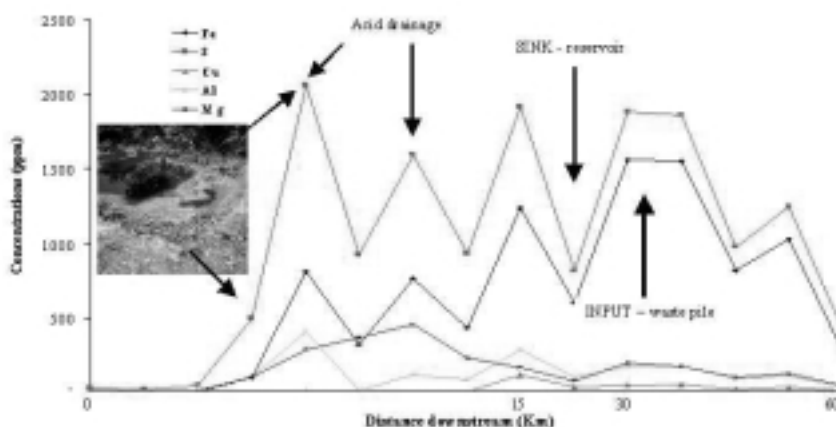


Figure 1:- Water samples (pH 1.86 - 3.79) from the Río Tinto source to 60 km downstream