

Hydrogeochemistry around an epithermal system hosting gold mineralisation

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Introduction

Planning a mining activity requires an *a priori*, careful investigation of the environment in the area. The knowledge of processes related to the water-rock interaction of the mineralised body and host-rock is essential to prevent water pollution. Therefore, a hydrogeochemical study was undertaken in southern Sardinia, where an openpit gold mine is expected to be open in the near future.

Geological and hydrological features

The study area covers about 15 km² between the villages of Serrenti and Furtei. Outcropping lithologies belong mostly to the Oligo-Miocene calc-alkaline volcanics, with marked lineaments trending NWSE. The area has been mined for kaolin minerals (Rossetti, 1963; Marini *et al.*, 1992). Recently, gold mineralisation was found in relation with advanced argillic alteration in the volcanics (Garbarino *et al.*, 1990): the oreassemblage is characterised by native gold and associated sulphide minerals (e.g. pyrite, sphalerite, covellite, enargite, luzonite and chalcopyrite). Sulphate minerals, including gypsum and alunitejarosite (Garbarino *et al.*, 1990), and alum, pisanite, boothite, chalcalthite, epsomite, and melanterite (Rossetti and Sitzia, 1958) are associated with both kaolinised and silicified rocks. Fluid inclusion data indicate an epithermal system for the ore-forming fluid (Lattanzi *et al.*, 1991). At the margins of the area, Miocene marine sediments and Plio-Pleistocene terrigenous sediments outcrop (Pecorini, 1966).

Hydrogeology is controlled by the altered volcanic rocks characterised by high porosity. Water circulation is relatively close to the surface (about 20 m below ground level), and only rarely goes deep in correspondence to regional structures. Drainage of the water table takes place by intermittent streamlets, with flow rates strongly decreasing during dry periods, usually extending from May to October. In the area, the mean

temperature is 17°C, with high evapotranspiration, and mean rainfall of 550 mm, and therefore, the availability of both surface water and groundwater is scanty.

Hydrogeochemistry

Stream, spring, well and borehole water samples were filtered *in situ* through a 0.4 µm pore-size membrane filter, using an all-plastic filtration assembly, and collected into pre-cleaned polyethylene bottles. Sample stabilisation, for the analysis of a wide range of metals (by AAS, GFAAS and ICP-OES), was carried out *in situ* upon filtration. Temperature, pH, Eh, conductivity, alkalinity and flow were measured at the sampling site.

Water samples showed a large variability in chemical composition, resulting from the interaction of waters with the different rocks of the area. Waters interacting with the fresh volcanics show a neutral pH, low content of total dissolved solids (TDS 200 mg l⁻¹), with a CaHCO₃ and NaCl balanced chemical composition, low SO₄ (30 mg l⁻¹) concentration, and trace amounts (usually 10 g l⁻¹) of most metals.

When waters interact with the intensely altered volcanics, the salinity increases up to 7500 mg l⁻¹, pH raises at 7.8, and higher (at least, one order of magnitude compared with the low-salinity waters) concentrations of F, B, Li, Sr and Al are observed. The chemical composition of the high-salinity waters is dominated by abundant sulphate (up to 2500 mg l⁻¹), whilst Eh values (about 400 mV) are similar to those observed in the low-salinity waters. Water-rock interaction processes evolve when the high-salinity waters come into contact with the mineral deposit: high concentrations of iron (33 mg l⁻¹), manganese (3 mg l⁻¹), and arsenic (400 µg l⁻¹) in solution, pH slightly acidic (6.6) and lower Eh (250 mV) are observed; these waters can be clearly distinguished in the field due to the precipitation of brownish deposits of iron-oxi-hydroxides ('ferruginous' waters), close to their emergence. The results of interaction

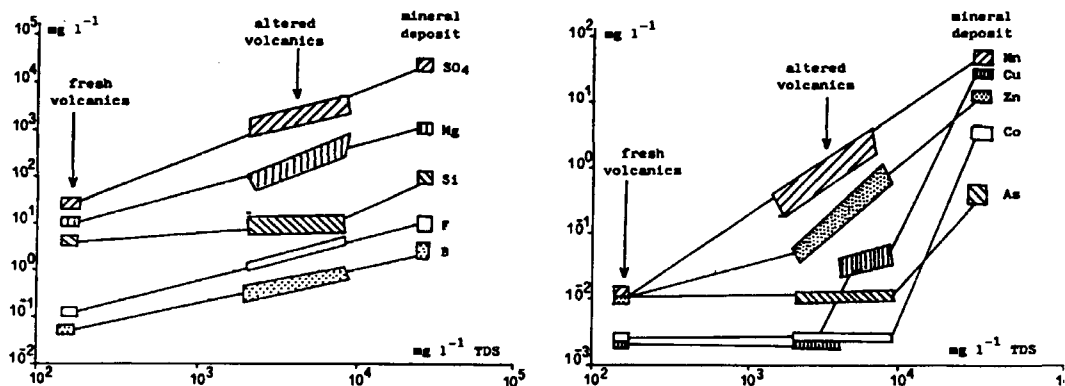


FIG. 1. Hydrochemical patterns in waters from the Serrenti-Furtei area.

processes are highlighted in the oxidation zone of the mineral deposit, where the porosity increases and abundant sulphate minerals are present. In this case, the ferruginous waters evolve to a pH value down to 2.2, Eh of 800 mV, and salinity up to 26000 mg l⁻¹, with a sulphate concentration up to 22000 mg l⁻¹, and concentration of metals in solution extremely high (in mg l⁻¹): Fe 2000, Al 1600, Mn 43, Cu 30, Zn 12, Ni 5, Co 3, Cr 0.8, As 0.4 and Cd 0.2 (Fig. 1).

Conclusions

The results of this study show the evolution of waters interacting with altered volcanics hosting an epithermal gold mineralisation. Acid drainage and high amounts of metals in solution are expected for the waters leaching the oxidation zone of the mineral deposit.

References

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