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Authigenic magnetite in soils: pollution tracer in a former tungsten mine?

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Abstract

As part of the project "SHS: Soil health surrounding former mining areas: characterization, risk analysis, and intervention", one of the targets is the Regoufe mine whose exploitation stopped in the fifties of 20th century. In this area occurred several tungsten-tin deposits associated to the Regoufe granite. Regoufe granite is a variscan muscovite-albite porphyritic granite, whose composition changes from a medium-grained muscovite-albite granite (at the northern and eastern parts of the intrusion) to a tourmaline-bearing porphyritic two-mica granite (particularly in the western sector). According to Ishihara classification, Regoufe granite belongs to the ilmenite-type-series. The mineralized veins show wolframite, cassiterite, arsenopyrite and, also pyrite, sphalerite, apatite and beryl. These veins have been exploited in galleries that are still accessed.
In this study, magnetic methods are used to identify ferromagnetic (s.l.) minerals in soils sampled in the surrounding area of Regoufe mine, which serve as tracer for anthropogenic pollutants.

Representative soil samples were prepared and the mass magnetic susceptibility (X), isothermal remanent magnetization (IRM) curves and saturation isothermal remanent magnetization (SIRM) were analyzed on the < 2 mm fraction of dried, disaggregated, and sieved soil. The frequency-dependent susceptibility (KfD%= kfd = ((Klf − Khf)/ Klf) × 100%) which reflects the concentration of superparamagnetic (SP) grains, and particularly those close to the threshold SP – single domain (0.015–0.025 μm for magnetite) was also evaluated. The unmix of the magnetic mineral components was examined using two statistical methods that decompose the magnetization curves: Cumulative Log-Gaussian (CLG) function with the software developed by Kruiver [1] and MAX UnMix statistical unmixing [2].

Our results show that X is comprised between 2.82 and 477.20 × 10-8 m3/kg which indicates that besides diamagnetic and paramagnetic, ferromagnetic minerals are present in variable concentrations. All IRM curves were fitted by using a single component with mean coercivity (B1/2) of 53.7-61.7 mT and dispersion parameter (DP) of 0.27-.029, typical of fine-grained magnetite. SIRM values are comprised between 1.69 and 14.71 × 10-2 Am2/kg, suggesting that the large variability observed in the values of magnetic susceptibility results from a heterogeneous distribution of magnetite among the studied samples. The S-ratio (IRM300mt/SIRM) varies between 0.989 and 0.992, indicating that magnetite is the main magnetic carrier of the studied samples. The mean coercivity (B1/2~60mT) of this magnetite population is significantly higher than the typical mean coercivity of pedogenic or detrital magnetite [3]. DP of 0-27-0.28 are also lower than the DP values for pedogenic or detrital magnetite (typically ~0.34-0.36) pointing to the presence of authigenic magnetite in the soil.

An authigenic magnetite formation can be related to the deterioration of the metallic parts of the remain washing plant that still exists in the area. More investigation is required to evaluate the extent of the polluted areas and their impacts on the environment.