Pb, Zn and Cd dynamics in mining areas under Mediterranean climate and carbonated geologic context: northern Tunisia example

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Maghreb countries, particularly Tunisia contain large amounts of mining wastes richs in metals such as Pb, Cd and Zn. Wastes are located in active or abandoned mining sites. Metals can diffuse to all environment compartments: water, air and soil.

In wastes, due to carbonated geology, calcite is dominant and metals are mainly associated with carbonates (cerussite, smithsonite and hydrozincite), in addition to silicates (hemimorphite and willemite) and sulphides (galena and sphalerite). Cd substitutes Zn in zinc-carbonates, silicates and sphalerite where it can reach 0.98wt%.

In this carbonated context, drainage water display a basic pH and metals are fixed by precipitation of stable minerals under oxidizing conditions (cerussite, hydrozincite, smithsonite and hemimorphite). Equilibrium between water and secondary minerals in mining drainage controls concentrations of metals at low values.

Ore treatment wastes are fine grained (silt and clay). Their cohesion is variable (15 and 124 kPa) and their permeability is low (10^{-6}-10^{-9} m/s) and limits infiltration process. These features, under Mediterranean climate, promote mechanical erosion of wastes during brief and intense rainfall events. However, the low density of water runoff makes the impact of particulate transport often limited, but highly concentrated, in soils around the waste dumps. Thus, maximum concentrations in soils have been measured up 2% Pb, 3% Zn and 200 $mg.kg^{-1}$ Cd.

This climate, also characterized by a long dry season, allows contaminated dust emissions from dumps especially in summer. Maximum emission flux of dust was estimated to 88.2 g/s of PM10. Resulting concentrations of airborne Pb and Cd exceeded WHO guidelines for air quality, up to 1km from the source in the dominant wind direction (Ghorbel, 2012).

Remediation is intended to support natural processes using phytostabilisation of wastes by covering them with native metal-resistant plants.

[1] Ghorbel, M (2012). Contamination métallique issue des déchets de l'ancien site minier de Jebel Ressas : modélisation des mécanismes de transfert et conception de cartes d'aléa post-mine dans un contexte carbonaté et sous un climat semi-aride. Evaluation du risque pour la santé humaine. PhD thesis of Toulouse and Tunis El Manar Universities. 231p.

Structure and thermal property of dense silicate glasses under high-pressure

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The current structure of Earth's interior is believed to have formed through dynamic differentiation from a global magma ocean in the early Earth. Elucidation of the structural changes and heat transport properties of silicate melts in the deep Earth is fundamental to understanding the evolution and structure of Earth's interior. The possible presence of dense, gravitationally stable, silicate melts at the bottom of the current mantle as a remnant of a deep magma ocean has been proposed to explain observations of anomalously low seismic velocities above the core-mantle boundary. However, the nature of silicate melts under such extreme pressures is poorly understood. Direct measurements of structural changes or thermal properties on silicate melts under ultrahigh-pressure conditions remain a great challenge and are currently beyond experimental capabilities. Silicate glasses have alternatively been extensively studied as analogues for quenched silicate melts, to simulate the high-pressure behavior of silicate melts. Previous experimental works on silicate glasses have, however, been still limited to lower pressure condition, which is far below the pressure condition of the bottom of the mantle.

To address this issue, we have conducted several series of ultrahigh-pressure experiments on silicate glasses with chemical compositions ranging from pure silica to more complex system up to ~200 GPa using combined spectroscopic techniques including Brillouin scattering, optical absorption (from visible to near-infrared) and synchrotron Mössbauer measurements in the energy domain. The results based on sound velocity data reveal the possible densification mechanism of silicate glasses above ~100 GPa that is likely associated with the onset of a change in Si-O coordination number to higher than sixfold. Optical and synchrotron Mössbauer data show a significant change in the absorption coefficients of the iron-bearing silicate glasses with pressure, most likely due to their gradual electronic structural changes. Based on the present results, we will discuss the possible implications for the densification mechanisms and heat transport property of the silicate melts at the base of the mantle.

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