

Environmental Geochemistry of some Ore Deposits in the “Sierra Gorda” nature preserve, east-central Mexico

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General Geology and Mineralization

Sierra Gorda nature reserve is the central part of the East Sierra Madre (Mother Range) of east Mexico. The Sierra Gorda is mostly composed by a highly deformed sequence of Mesozoic Carbonate sedimentary rocks. The Zuluaga Jurrassic formation host various hydrothermal deposits, which include Sn mantos, polymetallic sulfide veins and other irregular bodies [1]. There have been recognized some Eocene to Oligocene igneous intrusive bodies (granitoides stocks), crosscutting all the sedimentary sequence and developing mineralized metamorphic halos and hydrothermal veins, mantos, and skarn bodies (stibine, cinabar, realgar, chalcopryite, galena, sphalerite, Ag minerals with some Au and As) [2]. Exploitation of these mineralized bodies have left behind millions of tons of mine waste materials scattered in the nature preserve. These waste materials have released to the environment (soil and water) heavy metals (Cd, Cr, Co, Cu, Ni, Pb, Hg and Zn), and metalloids (As and Sb).

Environmental Geochemistry

We select three mining zones in the Sierra Gorda nature preserve for chemical analysis on the mine waste material, sediments, soil, water and some plants to assess the mobility, dispersion and geochemical controls of heavy metals and metalloids in the environment. Preliminary results show that mine tailings have up to 7 gr/Kg of As, 1 gr/Kg of Cu, 5 gr/Kg of Zn and 3 gr/Kg of Pb. River sediments concentrations of As and metals (maximum) are as follow: As = 2.5 gr/kg, Cu = 0.146 g/Kg, Zn = 1 g/Kg, and Pb = 0.117 g/Kg. For agricultural soils (small patches of land along river terraces) the As and metals concentrations are: As = 0.117 g/kg, Cu = 0.022 g/kg, Zn = 0.087 g/kg, and Pb = 0.037 g/kg. For surface water (seasonal mountain creeks) the As and metals concentrations are: As = 0.05 mg/l; Cu = 0.01 mg/l; Pb < 0.017 mg/l, and Zn = 0.01 mg/l. We are processing different vegetation to determine bioaccumulation of As and metals in different parts of the plants and in different zones of the mining area (affected by mine tailings, and no-affected by mine tailings). The ultimate goal is to understand the geochemical controls of As and heavy metals in this environment.

[1] Mascuñano et al., (2011) *Simple Sb Deposits in Mexico, in Barra, F. et al. (eds.) Proceedings, SGA Meeting, Chile Sept, 2011.*

[2] Vassallo, L.F., et al., (2001) *Mineralogy, age and control setting of La Negra and Zimapan skarn ore deposits, central part of Mexico. GEOS, Unión Geofísica Mexicana, Volume 21, No. 3, p. 192.*

Uranium concentration processes in Archaean batholiths, sources of the oldest uranium deposits

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The oldest economic uranium deposits on Earth are the quartz pebble conglomerate containing detrital uraninite from the Dominion Group (3074 ± 6 Ma) and the Witwatersrand Supergroup (2970 to 2714 Ma) on the Kaapvaal craton in South Africa. A reducing atmosphere before 2.2 Ga allowed uraninite to be stable on Earth's surface. We investigate the magmatic source of the uraninite; the ubiquitous Archaean TTG suite (trondhjemite-totalite-granodiorite) having uranium concentrations (about 2 ppm) insufficient to permit uraninite crystallization, the only possible source is ca. 3.1 Ga, incompatible elements-enriched, granitic batholiths such as the Mpuluzi and Heerenveen batholiths located to the South of the Barberton Greenstone Belt of South Africa

The Heerenveen and Mpuluzi batholith belong to the 3105 Ma granodiorite-monzogranite-syenogranite GMS suite intruding paleoarchaean TTG plutons. These two batholiths are made of different facies belonging to different phases of emplacement. Early sheeted leucogranites are followed by the intrusion of a large core of porphyritic granite, then by the intrusion of diverse facies in the border shear zones of both batholiths.

Although the average U composition of either batholiths is low (3 and 6 ppm for Heerenveen and Mpuluzi resp.), late phases emplacing in shear zones are significantly richer. However, they show a similar U/Th ratio than the bulk of the intrusions. On the other hand, a few samples show uranium concentrations up to 25 ppm, with Th/U ratios below 1, compatible with uraninite crystallization. Radiometric maps and analysis show that all these samples are located inside the shear zones; however in details the distribution of these spots is independent of lithologies. The size of these high uranium concentration zones is about 100 meters and can be located in later phases of intrusion as well as in earlier phases. This suggests that redistribution of incompatible elements and fractionation of U relative to Th occurred after emplacement of the granitoids and independently of it.

Microscopic studies confirm that the primary uranium-bearing minerals such as monazite, xenotime and thorite are partially or totally altered, uranium-rich phases being secondary minerals such as brannerite and uraninite. Primary monazite have been altered by calcic fluids, and replaced by apatite and thorite; REE from the monazite form allanite and residual thorite, while uranium is partially incorporated into secondary thorite and partially liberated into the fluid. In ilmenite, uranium is concentrated in altered crystals (up to 6% wt UO₂), showing that ilmenite was altered by uranium-enriched fluids.

Conclusion

Two different processes seem to explain the uranium concentrations: (1) a magmatic process which concentrate uranium and thorium in the later intrusion phases and (2) a second process, calcic fluids associated to the shear-zones which alter primary accessory minerals and preferentially concentrate uranium in small zones independent of the different intrusion lithologies.