

Environmental impacts of abandoned VMS deposits: An example case from NE Turkey

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The eastern Black Sea Region (NE Turkey) is well known for massive sulphide deposits. The abandoned mines near Espiye (Giresun, NE Turkey) are characterised by widespread slag disposed of along valleys into streams and tributaries causing serious environmental pollution. This study presents physical and chemical features of stream and spring waters and their degrees of pollution based on a sampling programme in August, 2010.

In the Ficklin diagram [1], three groups of samples collected from highly polluted mine effluent (along Acisu tributary), areas of slag disposal sites and upstream from the mine effects plot in high acid-extreme metal and high acid-high metal fields, acid-high metal field and near neutral-low metal field, respectively. The water samples from the zones near the effluent are highly polluted and contain extremely anomalous values of S, Fe, Cu, Zn, As, Cd, Pb with values as high as 1375, 1130.12, 71.37, 53.08, 2.15, 0.21, 0.1 mg/L, respectively. After about a km downstream from the effluent, these values are diluted to a great extent, especially for Pb, Fe and As. Elevated levels of other elements continue further. In contrast, the waters of tributaries draining slag piles have much lower levels of heavy metals, with some elements such as As and Fe having undetectable concentrations.

In the Acisu tributary, SO₄ is highly enriched (up to 5410 mg/L) due to microbial oxidation of sulfides. 16S rRNA analyses on water samples from this area indicates presence of *Acidithiobacillus ferrooxidans* at 98% precision.

The sediments are in compliance with this, and are enriched in As, Mo, Pb, Cu, Cd, Zn, Hg and Fe based on geoaccumulation (I_{geo}) values [2]. These values are significantly high and denote heavy contamination in stream sediments along the Acisu tributary. The sediments with the surface waters are potentially hazardous to the environment adjacent to the abandoned Karaerik mine and thus are in need of remediation.

[1] Plumlee *et al.* (1999) *Economic Geology* **6** (B) **70**, 373–407. [2] Muller (1969) *Geo. Journal* **2**, 109–118.

Prograde P-T path of a ~3.2 Ga tectonometamorphic event from Assegaai greenstone belt, SE Kaapvaal Craton

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P-T pseudosections are being used extensively in modern petrological studies not only to determine the P-T conditions of peak metamorphism but to establish how these conditions have been achieved, i.e. the tectonic scenario related to such processes [1]. In the present study we have used P-T pseudosection to determine the prograde P-T path from amphibolite facies garnet-staurolite-chlorite-albite-quartz-ilmenite-bearing pelitic schist from the Archaean Assegaai greenstone belt, SE Kaapvaal craton.

The pelitic schist forms part of a supracrustal sequence consisting of amphibolite, BIF, talc-tremolite schist, quartzite and calc-silicate. Within the metapelite, garnet and staurolite form the peak metamorphic assemblage and are replaced by chlorite. Absence of inclusions of any prograde mineral within garnet and staurolite porphyroblasts hinders application of any conventional thermobarometry to determine the prograde and peak metamorphic conditions.

Pseudosection analysis reveals that the garnet and staurolite assemblage was formed along a clockwise P-T path by breakdown of chloritoid: Fe-Chloritoid = almandine + Fe-Staurolite, a common reaction in pelitic rocks under amphibolite-facies conditions. Peak P-T conditions are estimated at ~ 8 kbar, 600–625°C. Chlorite and albite were formed during post-peak decompression and cooling by breakdown of garnet-staurolite and paragonite, respectively.

Zircon crystallisation ages (²⁰⁷Pb/²⁰⁶Pb, SHRIMP) obtained from syntectonic quartzofeldspathic veins derived from partial melting reveal that peak metamorphism occurred ~3.18 Ga. The clockwise P-T path from the metapelite indicates a collisional tectonic event similar to that reported from other greenstone belts of SE Kaapvaal craton [2, 3], that marked stabilisation of the craton at ~3.2 Ga.

[1] O' Brien, P. (2011) *GRA* **13**, 11043. [2] Saha *et al.* (2010) *Am. J. Sci.* DOI 10.2475/04.2010.00. [3] Moyen *et al.* (2006) *Nature* **443**, 559–562.