Mineralogical characterization of Mn ores of shallow marine origin in northeast Vietnam

DUY ANH DAO AND RETO GIERÉ

Mineralogisch-Geochemisches Institut, Albert-Ludwigs-Universität, Freiburg (anh.dao@jupiter.uni-freiburg.de)

Geological and mineralogical properties

Important Mn deposits occur in the Halang basin, located in the Cao Bang Province in the northeastern part of Vietnam. The Mn ore in this region is of neritic origin, representing a chemical sediment, and was described as consisting of primarily pyrolusite and "psilomelane" (Le, 1988). The Mn ore seams are hosted by grey recrystallized limestone of Devonian age. The Mn deposits are distributed mainly at the margin of Devonian synclines or at their juncture. The productive Mn-bearing seam varies in thickness from 0.2 to 2 m, and is overlain by black siliceous rocks. The average chemical composition of the deposits is as follows: Mn = 30 wt%; Fe = 6.38 wt%; SiO_2 = 22.79 wt%; P = 0.224 wt%. The reserves have been estimated at more than one million tons.

The banded Mn deposits were strongly affected by various geological processes, which postdate ore formation. Folding and faulting led to a complicated distribution pattern of the ore seams. Weathering in the humid subtropical climate has resulted in supergene enrichment in Mn as well in the formation of various secondary minerals, thus producing a mineralogically complex ore. Layers of secondary calcite and quartz are intercalated with the Mn-rich seams.

X-ray diffractometry, EMPA analysis and mineral formula calculations based on the procedure of Saini-Eidukat (1993) revealed that the following minerals are present as major Mn hosts [average composition in brackets]: pyrolusite [MnO_2]; hausmannite [$Mn^{2+}_{1.01}Mn^{3+}_{1.91}O_4$]; manganite [$Mn^{3+}_{0.94}O(OH)$]; jacobsite[$(Mn^{2+},Fe^{2+})_{1.07}(Mn^{3+},Fe^{3+})_{1.78}O_4$]; hollandite [$(Ca_{0.1}K_{0.44}Ba_{0.02}\square_{0.34})(Mn^{2+}_{0.43},Mn^{4+}_{7.43})O_{16}\cdot H_2O$] and possibly birnessite. In addition, the ores contain hematite, Mn-rich hematite [$(Fe^{3+}_{1.26},Mn^{3+}_{0.68})O_3$], bixbyite [$Mn^{3+}_{1.17}$, $Fe^{3+}_{0.83})O_3$], goethite, ferrihydrite, quartz, and apatite. The Mn minerals are often intimately intergrown, on a µm-scale, with other minerals.

Discussion of results

The results indicate that not all the Mn minerals are of sedimentary origin but rather, that some of the Mn phases were formed during subsequent alteration. Based on these results we can establish an effective processing technology to improve the ore grade.

References

Le T. Xinh, (1988). Geology and mineral resources of Vietnam. **Vol. 1**, 108-112.

Saini-Eidukat B. (1993) *Appl. Geochem*. **8**, 37-49.

The application of chrome-spinel in the tectonic discrimination of mafic-ultramafic rocks: New developments from the analysis of gallium

S.A.S. DARE[1], J.A. PEARCE[1], I. MCDONALD[1] AND M.T.S. STYLES[2]

[1]School of Earth, Ocean and Planetary Sciences, Cardiff University, Cardiff, CF10 3YE, U.K. (DareSA@cf.ac.uk)

[2]British Geological Survey, Keyworth, Nottingham, NG12 5GG, U.K.

Chrome-spinel, [(Mg,Fe)(Al,Cr)2O4], is well-established as a useful, alteration-resistant petrogenetic and tectonic setting indicator for mafic-ultramafic rocks (e.g. Dick and Bullen, 1984; Barnes and Roeder, 2001). Among its many applications, chrome-spinel geochemistry provides a means of interpreting ophiolites and serpentinites emplaced along continental suture zones, and of interpreting mafic-ultramafic intrusions in the deep crust.

The most effective fingerprints are based on occupancy of the Y (Cr,Al) site of the chrome-spinel with covariations between Cr# [Cr/(Cr + Al], Fe^{3+}# [Fe^{3+} / (Fe^{3+} + Cr + Al)], V and Ti providing sensitive indicators of degree of melting, oxygen fugacity and melt-rock interaction. This work extends this suite of elements by including gallium, analysed by LA-ICP-MS using a 213nm UV laser and well-characterised chrome-spinel standards. Ga values for a suite of peridotite samples from modern-day tectonic settings range from 70 ppm to just above the L.O.D. of 5 ppm.

Of particular significance is the covariation of Ga and Fe^{3+}. These elements have similar ionic radii but only Fe^{3+} is redox-dependent. Thus, melting and fractionation trends retain a near-constant Fe^{3+}#/Ga ratio, but spinels from supra-subduction zone dunites have higher Fe^{3+}#/Ga ratios than those from non-subduction dunites. This Fe^{3+}#/Ga fingerprint has been tested on crustal and mantle dunites from the northernmost blocks of the Oman ophiolite, where it confirms lava and dyke evidence for an evolution from a mid-ocean ridge to a supra-subduction zone setting.

References

Dick, H. J. and Bullen, T. (1984), *Contrib. Mineral. Petrol.* **86** 54 – 76

Barnes, S. J. and Roeder, P. L. (2001), *Journal. Petrol.* **42** 2279 - 2302