Iron Oxides Chemistry from High-grade Iron Ore, Iron Quadrangle

ANA-SOPHIE HENSLER[1*], STEFFEN HAGEMANN[1], CARLOS ALBERTO ROSIERE[2], THOMAS ANGERER[1] AND SARAH GILBERT[3]

[1]Center for Exploration Targeting, University of Western Australia, hensla01@student.uwa.edu.au (*presenting author)
[2]Universidade Federal de Minas Gerais, Brazil, crosiere@gmail.com
[3]University of Tasmania, Australia, sgilbert@utas.edu.au

Abstract

Most of the high-grade iron ore deposits in the Iron Quadrangle (IQ), Brazil are hosted by itabirites of the Caue Formation, a Paleoproterozoic Lake-Superior type Banded Iron Formation. The IQ was affected by two main orogenies, the Transamazonian (2.6 – 2.0 Ga) and the Brasiliano (0.7 – 0.45 Ga) resulting in a western low-strain and an eastern high-strain domain. Iron ore bodies in the western domain are dominated by early-stage martite and granoblastic hematite, whereas ore bodies of the eastern domain contain mainly late-stage microplaty hematite and specularite.

Minor and trace element contents (Mg, Mn, Al, Cr, V, Ti, Ga, Ni, Co, Zn, As, Bi and REE) of selected iron ore deposits in the IQ, such as Aguas Claras, Pau Branco, Casa de Pedra, Bau and Conceicao were analysed using Laser Ablation ICPMS. At a deposit-scale, the minor and trace element patterns of specific iron oxide phases (e.g., martite) are consistent within an ore body, but show significant variations, when compared to another iron oxide phase of the same ore body (e.g., to microplaty hematite). A progressive depletion of elements, (most significantly Mg, Al, Cr, Ti, and Ni) is recorded when comparing paragenetically older (i.e., granoblastic hematite) with younger (i.e., microplaty hematite, specularite) oxides (Figure 1). At a scale of the IQ, chemistry of iron oxides that formed during the early Transamazonian event (i.e., martite after magnetite and granular hematite) shows consistent Mn, Al, Ti, Ga, Co, Zn, As, and Bi contents. This is distinct from late crystallised oxides (i.e., microplaty hematite, specularite), which display also consistent but different chemical patterns (e.g., Mn, Cr, Ti, Ga, and As) when compared to the “early” oxides. Therefore, different tectonometamorphic stages may have a major influence on the mineral chemistry of the iron oxide generations. The actual factors, that may control the mineral chemistry patterns of iron oxides and are currently under investigation, are the host and country rock petrology, fluid source type(s) and/or the mineral-specific preference of cation substitution.

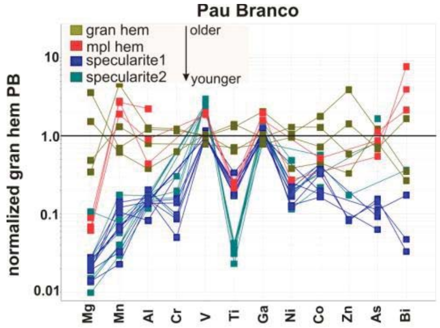

Figure 1: Chemical signature of iron oxide species from Pau Branco (PB) iron ore deposit, normalized to granoblastic hematite. Abbreviations: Gran hem = granoblastic hematite; mpl hem = microplaty hematite

---

Pilot-scale barrier system for removal of nitrate in mine drainage

ROGER HERBERT[1*] AND HARRY WINBJÖRK[2]

[1] Department of Earth Sciences, Uppsala University, Uppsala, Sweden, roger.herbert@geo.uu.se (* presenting author)
[2] LKAB, Malmberget, Sweden, harry.winbjork@lkab.com

Introduction

Undetonated ammonium nitrate - based explosives are readily soluble in water and quickly enter into the mine water and process water at a mine site. Process water is eventually discharged to a surface water body and, without treatment, can lead to eutrophication in the recipient. In order to investigate the application of nitrate removal by denitrification in the cold climate of northern Sweden, laboratory and field experiments have been conducted. Laboratory column experiments were designed to determine denitrification rates at relevant temperatures for northern Sweden. Based on the column experiments at low temperature, a hydraulic residence time of ca. 24 hours was one of the design criteria used for dimensioning a barrier system in the field. In autumn 2009, a pilot-scale barrier system was constructed of sheet metal at the Malmberget iron ore mine. The barrier (9m x 2m x 1.5m) appears as an open basin with three inner dividing walls, and is filled with a reactive mixture consisting of crushed rock, sawdust, and sewage sludge. A small fraction of the water discharging from the Malmberget clarification pond was fed by pump to the barrier at a rate of ca. 5 m^3 day^{-1}.

Results

In the pilot-scale barrier system, analytical results from 2010 indicated that nitrate (NO_3^-) removal generally lay in the range between 11 and 77% of influent nitrate concentrations. In order to achieve a higher removal rate, the barrier system needed to be supplemented with an additional carbon and energy source for denitrifying bacteria. In 2011, a sodium acetate solution as an external electron donor was continuously added to the barrier system along with the influent water. Analytical results from 2011 indicate that the barrier system in Malmberget removes >95% of the incoming nitrate during summer months (average daily temperature 14ºC for 2011) with the addition of acetate. The barrier did exhibit decreases in performance toward the end of the study period in 2011, but this is likely the result of a lower hydraulic residence time in the barrier at this time.

Nitrite (NO_2^-) concentrations in effluent waters were initially in excess of influent values, indicating the production of nitrite in the barrier. However, both nitrite and ammonium (NH_4^+) concentrations decreased to below detection limits after the addition of acetate (CH_3COO^-), suggestion the occurrence of anaerobic ammonium oxidation (anommox) in the barrier substrate. During this period, alkalinity values peaked at 500 mg HCO_3^- L^{-1} in effluent waters, indicative of organic carbon (acetate) oxidation through denitrification:

$$5CH_3COO^- + 8NO_3^- + 3H^+ \rightarrow 4N_2(g) + 10HCO_3^- + 4H_2O$$

Stable isotope analyses of $\delta^{15}N$ and $\delta^{18}O$ in nitrate demonstrate an enrichment in ^{15}N and ^{18}O along the flowpath, supporting the conclusion that denitrification is responsible for nitrate removal.