

Ancient subduction recorded in the isotope characteristics of ~1.8 Ga Fennoscandian carbonatites

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The Svecofennian ~1.8 Ga post-collisional magmatism in the Fennoscandian Shield gave rise to a suite of high-Ba-Sr granites and shoshonitic lamprophyres interpreted to originate from a metasomatically enriched lithospheric mantle (Eklund *et al.*, 1998, Andersson *et al.*, 2006). In southern Finland the bimodal suite is accompanied by rare occurrences of intrusive carbonatites showing distinctively low $\delta^{13}\text{C}$ values relative to that of average mantle carbon at around -5 ‰ (PDB). Carbonate samples from a carbonatite dike at Halpanen show $\delta^{13}\text{C}$ values varying from -12.2 to -12.4 ‰ (n=7) while those from a carbonatite dike swarm at Panjavaara display an even stronger depletion in ^{13}C , with values ranging from -15.3 to -16.5 ‰ (n=50).

The Halpanen carbonatite is a 10 m wide and up to 1.5 km long alvikite dike located in southeastern Finland some 200 km NE of Helsinki. The chemical composition of the dike is characterized by high contents of SrO, BaO, and REE (up to 3.63, 0.63 and 0.65 %, respectively). The Panjavaara carbonatite dike swarm is located some 180 km NE of Halpanen and comprises >50 carbonatite dikes and vein-dikes measuring 2 – 60 cm in width and from meters to tens of meters in length. The carbonatites of the Panjavaara dike swarm are also highly enriched in SrO, BaO and REE, with concentrations reaching 2.3, 3.9 and 10.0 %, respectively. Conventional U-Pb dating on monazite suggests an emplacement age of ~1.8 Ga for both the Halpanen and Panjavaara carbonatites. The Sr and Nd isotope data indicate enriched sources for Sr and near chondritic sources for Nd in these rocks.

The chemical characteristics of the studied ~1.8 Ga Fennoscandian carbonatites suggest a metasomatically enriched mantle source for these rocks. The depletion in ^{13}C relative to the average mantle value could be related to subduction of organic-rich crustal material. In comparison to other carbonatites, the Halpanen and Panjavaara are notably depleted in ^{13}C . Equally low $\delta^{13}\text{C}$ values have been, however, reported for many eclogitic diamonds (e.g., Shirey *et al.*, 2002).

References

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Anaerobic nitrate-dependent oxidation of pyrite mediated by *Thiobacillus denitrificans*

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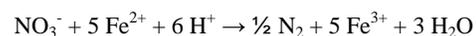
Introduction

NO_3^- reduction in nitrate-polluted groundwater may result from oxidation of organic matter and/or pyrite present in the aquifer rock. Although no direct laboratory proof exists that nitrate can serve as a pyrite oxidant under abiotic conditions, several field studies have provided indirect evidence for pyrite oxidation by NO_3^- mediated by autotrophic denitrifying bacteria. The present laboratory experiments are directed towards studying the mechanism and kinetics of water denitrification and pyrite oxidation, being mediated by *Thiobacillus denitrificans*.

Results and discussion

Anaerobic, nitrate-dependent dissolution of pyrite mediated by *Thiobacillus denitrificans* was studied by means of percolation-columns filled with pyrite powder and pyrite cubes run for 8 weeks. Input solution (thiosulfate-free specific medium for *T. denitrificans* growth) was supplied to the columns at a flow rate of 1 mL day⁻¹ and the leachate was sampled once a week. Reacted samples after 1, 2, 4 and 8 weeks were examined by SEM-EDX and ex situ AFM.

Pyrite dissolution was confirmed by sulfate release to solution and nitrate reduction. Release of sulfate and iron to the solution was lower than that stoichiometrically predicted by the overall reactions:



After 8 weeks precipitation of secondary minerals (ones rich in Fe(III), S and K and others rich in P and Ca) over the pyritic surfaces was detected by EDX analyses. SEM and AFM images revealed that bacteria cells were attached to surface of pyrite fragments and grains, sparsely distributed, and that the surface roughness increased throughout the experiments. Secondary minerals and organic matter coating the surface did not prevent bacterial metabolism and consequent nitrate reduction.

Although *T. denitrificans* is capable of catalyzing complete reduction of nitrate to nitrogen gas, over most of the entire experimental run nitrate mostly reduced to nitrite and production of gaseous compounds were not evident.