Modelling sulphide weathering and the link to biologically-derived nitrate in groundwater of the northeast Yilgarn Craton, Western Australia

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Groundwater chemistry is inextricably linked to the surrounding rocks, soils and biological communities. This relationship is evident in the ancient landscapes of the northeast Yilgarn Craton. Here, we have investigated the weathering and oxidation of sulphide orebodies in Archean rocks at depths >100 m to show the influence on groundwater chemistry in the weathered zone.

In groundwaters close to the weathering front, SO_4 and NO_3 but not O_2 are important for major oxidation reactions. Sulphate is actually consumed and relatively depleted in deep, reduced groundwaters, but enriched in near surface, oxidised groundwaters. Nitrate is strongly depleted in the shallow groundwater zone above a sulphide body, but not depleted in groundwater 500 m away from the orebody. The NO_3, sourced from leakage of N-fixing bacteria associated with the roots of the dominant *Acacia aneura* vegetation, is the dominant oxidant in the shallow groundwater system. Modelling groundwater interactions with sulphidic rocks using Geochemists Workbench®, for both NiS and FeS systems, demonstrated additional weathering effects. Deeper groundwaters are controlled by alteration of pentlandite/pyrrhotite to violarite/pyrite/hematite, resulting in high pH, depletion of dissolved SO_4 and very low concentrations of dissolved Ni. Iron, Ni, and Cu dominated sulphides produced similar results (Zn and Pb sulphides did not alter), making distinguishing barren (Fe-rich) and mineralized (Ni, Cu-rich) sulphides difficult using target metals alone. In contrast, near surface groundwaters contacting sulphides may have Fe, other metals (Ni, Cu, Zn etc) and SO_4 enrichment due to violarite oxidation and dissolution, with strong potential to distinguish NiS from FeS.

Spatially, the variation of major anions in this environment, along with other related metal signatures, enables targeting of sulphide orebodies at multiple scales. Results will be presented from a local case study and a regional mapping project, with samples spaced approximately 50 m and 5000 m apart, respectively.

Arsenic not attenuated during downstream transport in Gibbon and Firehole Rivers, Yellowstone National Park

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Synoptic sampling with discharge measurements were obtained under low-flow conditions for the Gibbon River (September, 2006), and for the Firehole River (September, 2007). The Gibbon River (about 30 km) varies in discharge from about 2 to 16 m^3/s and receives thermal inflows from Norris and Gibbon Geyser Basins, Chocolate Pots, and Terrace Spring. The Firehole River (about 40 km) varyies in discharge from about 6 to 23 m^3/s, and receives thermal inflows from Upper, Midway, and Lower Geyser Basins. Mass fluxes (loads) were calculated to determine if any elements were being attenuated during downstream transport. Little mass was attenuated for either major solutes or trace elements. Some silica was lost during mixing and transport, maintaining very constant concentrations that correlated with temperature in the rivers. Silica solubility between amorphous silica and beta-cristobalite was maintained. Silica has cemented bed sediment in the Firehole River for several kilometers downstream and probably coats most sediment in both rivers. Only small amounts of arsenic are lost during downstream transport, about 7% of the total flux for the Gibbon River and less for the Firehole River. Hence, high concentrations of dissolved arsenic occur in these rivers: up to 0.45 mg/L for the Firehole and up to 0.2 mg/L for the Gibbon. The arsenic mass fluxes are 30 kg/d for the Gibbon and 230 kg/d for the Firehole. Our hypothesis for the lack of arsenic attenuation is the poor sorption properties of silica-rich surfaces along with long-term flow that would also saturate surfaces. Such a phenomenon would explain why rivers like the Rio Loa in Chile, which receive thermal waters from the El Tatio hot springs, have high concentrations of arsenic and pose health risks to residents drinking water from this river.