

Characterising geochemical processes using the $\delta^{34}\text{S}$ and $\delta^{18}\text{O}$ of sulfate in groundwater

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Introduction

Developing predictive numerical models of hydrogeochemical systems requires an understanding of the physical and chemical processes affecting the composition of the water. Physical processes like mixing and evaporation can be reasonably well defined using the chemical data, but redox sensitive chemical processes are more difficult to quantify. Applying the isotope chemistry of dissolved sulfate to characterise and even quantify these redox processes enhances the capabilities of numerical modelling, in particular those associated with acid mine drainage, acid sulfate soils and sulfide mineral exploration. This work describes how the stable isotopes of sulfur and oxygen in sulfate can be used to characterise geochemical processes and thereby improve reactive transport models.

Discussion

Groundwater, pore water and surface water from a number of areas in Australia have been used to determine the sources of sulfur in acid sulfate susceptible systems. Sulfate reduction, and sulfide oxidation commonly dominate the chemical processes controlling sulfur in a groundwater system. Bacterial sulfate reduction (BSR) can be recognised by the effect on the $\delta^{34}\text{S}$ and $\delta^{18}\text{O}$ of sulfate. Both ratios increase as the lighter isotope is removed through dissimilatory bacterial reduction. Oxidation of sulfides occurs through two processes, one involving molecular oxygen (O_2) and the other involving oxidised iron (Fe^{3+}). The different pathways result in considerable differences in the oxygen isotopic composition of the produced sulfate. Surface water and some groundwater from the Loveday basin in SA show evidence of evaporation and BSR, while the near surface pore waters, although similarly evaporated, contain sulfate that predominantly originates from sulfide oxidation. Sulfate in groundwater from several other regions has isotopic compositions that indicate sulfide oxidation involving either the O_2 or the Fe^{3+} pathways. The implications are that the sulfate history can be understood through isotopic analysis and that this can be used in geochemical models to trace chemical processes.