

The geochemical evolution of groundwater in local to regional scale aquifer systems using reaction path and reactive transport modelling.

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Groundwater is a critical resource in most areas of the world and understanding the vulnerability of that resource to anthropogenic and natural forcings is a vital aspect of its management. Numerical reactive transport modelling is a valuable tool capable of capturing the evolution of water quality to assess impacts of natural and anthropogenic forcings and determine the effectiveness of remedial strategies. In this study, groundwater chemistry along with aquifer and aquitard physical and chemical characterization are used to generate geochemical reaction path and reactive transport models to determine the dominant controls on water quality in a shallow groundwater system. The study area is in the northeast of British Columbia Canada, a region with significant hydrocarbon exploration and production activity. Extensive drilling (30+ wells) and groundwater sampling (~350) programs were undertaken to provide the basis for understanding the groundwater chemistry. There are two main aquifer systems in the region, one occurring in the Quaternary sediments and the other in the underlying Cretaceous marine bedrock. The groundwater chemistry is distinct between the two systems. The Quaternary hosts primarily Ca-Mg-HCO₃ to Ca-Mg-HCO₃-SO₄ type waters and the bedrock ranges from Na-HCO₃ to Na-HCO₃-SO₄ type waters. Aquifer mineralogy, cation exchange capacity and exchangeable cation composition and adsorption site content and adsorbed ion content were used to populate reaction path and reactive transport models to simulate the chemical evolution of the groundwater in the different aquifer systems. The models indicate that carbonate mineral dissolution and, in some cases, carbonate mineral as well as gypsum dissolution dominate in the Quaternary sediments. The bedrock appears to have groundwater chemistry that is evolved from the Quaternary through extensive cation exchange coupled with carbonate mineral dissolution and variable amounts of gypsum dissolution. The chemical evolution of both systems is not possible without a flux of CO₂ and CH₄. The CO₂ drives continued mineral dissolution reactions while the CH₄ is oxidized to CO₂ largely through Fe-oxide/oxyhydroxide reduction. Iron mineral reduction commonly leads to carbonate mineral precipitation but limited trace element mobilization.