Rare earth elements: Indicators of redox conditions and surface water-groundwater mixing in an estuarine wetland

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This study was conducted on the Tinchi Tamba Wetlands (TTW) of Moreton Bay, southeast Queensland, as part of a project aimed at characterizing the wetlands' water fluxes. The TTW aquifer is a bowl-shaped aquifer of a semi-confined type, sitting on top of an impermeable clayey layer, with a maximum depth no greater than 20m. The aquifer material comprises high percentage of clay and some medium to coarse sand and gravel. In most cases, coarse grains usually occur as lenses and interbeds. Groundwater flow paths and the extent of mixing of surface and groundwater in the wetlands are difficult to quantify because of the complexity of the geological substrate. In this study we combined field hydrogeological and geochemical data to trace the spatial and temporal evolution of rare earth elements (REEs) distribution in TTW and the adjacent watershed.

Groundwater, ponds, and estuarine waters were sampled monthly over a ten-month period, with additional samples collected during a major storm event that caused significant flooding. Results indicate that a) meteoric water infiltration and evaporation heavily influence the aquifer's geochemistry (electrical conductivity ranging from 3 to 48 ms/cm), b) different sources contribute to the surface water budget, c) REE patterns respond rapidly to changes in redox conditions in the aquifer (redox ranging from -80 to 450mV), d) in areas dominated by low-permeability units, REE patterns are fractionated and exhibited Ce, Pr, Nd, Sm, and Eu depletions, e) the spatio-temporal pattern of REEs indicates mixing of different water sources. In conclusion, the results show that REEs can be used to accurately characterize the surface water and groundwater sources from different reservoirs, as well as the extent of mixing between recharged surface water and groundwater in an estuarine environment.

2-D thermodynamic and trace element models of subduction zones

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Fluids derived from dehydration reactions in subducting slabs display major carriers of trace elements tranferred into the mantle wedge. During ascent the fluids interact with the wall rock within the subducted plate, thus it is necessary to quantify element distribution during this fluid-rock interaction in order to get information about the amount and composition of fluids entering the mantle wedge. Complexities in modeling trace element compositions of subduction zone fluids arise from the fact that migrating fluids interact with rocks of different major and trace element compositions undergoing continuous metamorpic transformation within a complex pressure-temperature framework. Based on modeled isotherm patterns of different subduction zone settings we calculate phase relations in the entire subducted slab, considering upward migration of liberated fluids during subduction utilising incremental Gibbs energy minimisation models. The modeled phase relations and fluid amounts are then used to calculate mass balanced trace element distribution among the stable phases at every increment within the slab. Trace element transport occurs within the migrating fluid that equilibrates with the wall rock during ascent, which controls trace element depletion and/or enrichment of fluid and wall rock. With these models we can constrain the absolute amount and the resulting trace element composition of the fluid at the slab surface after fluid-rock interaction within the subducted plate. Preliminary results show that the fluid flux on top of the slab is strongly dicontinuous and shows distinct maxima between 35 and 60 as well as 70 and 80 km slab depth, depending on slab temperature. Potentially fluid-mobile trace elements, such as Li, Be and B show a significant intra-slab fluid rock interaction. Trace element concentration trends of these elements are similar to those observed in arc volcanics, such that Li, Be and B are continuously depleted during subduction and B/Be is significantly decreasing with increasing slab depth. However, in our models the transfer of fluid mobile elements into the mantle wedge already occurs at fore-arc depths, which indicates that mantle dynamics play an important role for element transfer to the sites of melt production beneath the volcanic arc.