Geochemical processes underlying a sharp contrast in groundwater arsenic concentrations in a village on the Red River delta, Vietnam

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Abstract: The spatial variability of As concentrations in aquifers of the Red River Delta, Vietnam, was studied in the vicinity of Hanoi. Two sites, only 700 m apart but with very different As concentrations in groundwater (site L: <10 ?g/L vs. site H: 170-600 ?g/L) in the 20-50 m depth range, were characterized with respect to sediment geochemistry and mineralogy as well as hydrochemistry. Sequential extractions of the sediment were carried out in order to understand why As is released to groundwater at one site and not the other. No major differences were observed in the bulk mineralogy and geochemistry of the sediment, with the exception of the redox state of Fe oxyhydroxides inferred from sediment colour and diffuse spectral reflectance. At site H most of the As in the sediment was adsorbed to grey sands of mixed Fe(II/III) valence whereas at site L As was more strongly bound to orange-brown Fe(III) oxides. Higher dissolved Fe and low dissolved S concentrations in groundwater at site H (?14 mg Fe/L, <0.3 mg S/L) suggest more strongly reducing conditions compared to site L (1-2 mg Fe/L, <3.8 mg S/L). High concentrations of NH_4^+ (?10 mg/L), HCO_3^- (500 mg/L) and dissolved P (600 mg/L), in addition to elevated As at site H are consistent with a release coupled to microbially induced reductive dissolution of Fe oxyhydroxides. Other processes such as precipitation of siderite and vivianite, which are strongly supersaturated at site H, or the formation of amorphous Fe(II)/As(III) phases and Fe sulfides, may also influence the partitioning of As between groundwater and aquifer sands. The origin of the redox contrast between the two sites is presently unclear. Peat was observed at site L, but it was embedded within a thick clayey silt layer. At site H, instead, organic rich layers were only separated from the underlying aquifer by thin silt layers. Leaching of organic matter from this source could cause reducing conditions and therefore potentially be related to particularly high concentrations of dissolved NH_4^+, HCO_3^-, P and DOC in the portion of the aquifer where groundwater As concentrations are also elevated.

Index Keywords: Aquifers; Arsenic; Calcite; Chemistry; Crystallography; Dissolution; Earth sciences; Geochemistry; Groundwater; Groundwater geochemistry; Hydrogeology; Iron compounds; Iron ores; Leaching; Lithology; Magnesium printing plates; Mineralogy; Minerals; Ore deposit geology; Organic compounds; Phosphate minerals; Sedimentation; Sedimentology; Silt; Sulfide minerals; Underground reservoirs; Amorphous; Arsenic concentrations; Consistent; Depth ranges; Geochemical processes; High concentrations; Hydrochemistry; Organic; Organic matters; Oxyhydroxides; Red river deltas; Redox states; Reducing conditions; Reductive dissolutions; Sequential extractions; Sharp contrasts; Spatial variabilities;

Spectral reflectances; Vietnam; Groundwater resources; aquifer; arsenic; comparative study; dissolved organic carbon; extraction method; hydrogeochemistry; iron; leaching; peat; sand; siderite; spatial variation; spectral reflectance; village; vivianite; Asia; Eurasia; Red River Delta; Southeast Asia; Viet Nam

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