Chemistry of a Swedish groundwater affected by oxidising alum shale

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Background

Alum shale (black shale) is a rock rich in sulphides as well as in many trace elements. The shale is readily weathered when exposed to air and water and since many of its elements have toxic properties such weathering can constitute a contamination source for soils and waters, a process analouge to metal leaching from acid sulphate soils and acid mine drainage. This study aims at assessing the mobilisation of a number of elements to the groundwater phase in an old mining area with outcropping alum shale and deposits of burnt shale. The chemistry of the local groundwater, both originating from the mining deposits and the natural bedrock, was monitored for a period of eight months.

Results

The variations existing in groundwater chemistry between nearby sampling points were large, while the temporal variations generally were marginal. At some sampling points the groundwater was acidic (pH 4), while at others it was circumneutral (pH 6-8) All the groundwater samples were, however, clearly affected by the shale material, as shown by elevated metal concentrations.

The acidic groundwater was found in an area covered by extensive deposits of burnt shale where the conditions for sulphide oxidation were especially favourable, and the water was strongly elevated in the metals Al, Cd, Co, Cu, Ni, U and Zn. Uranium and Cd were, however, also abundant in many of the circumnetral water samples only affected by the natural bedrock. Another metal that was enriched in the circumneutral waters was Mo, which appears to be particularly easy mobilised from this type of shale.

Conclusion

The mobilisation of metals from the alum shale in the investigated area has clearly been enhanced by the historical mining activities, but also weathering of the natural alum shale bedrock is a considerable source for groundwater metal contamination.

Ra and Rn enrichment in the water column of the Gulf of Aqaba (Northern Red Sea)

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The Gulf of Aqaba is a pull-apart basin along the Dead-Sea-Red-Sea Transform (RST). It is about 180 km long, 20 km wide and on the average 800 m deep (maximum depth reaches ~1800 m). The gulf is bordered by active faults on which numerous earthquakes (magnitude up to 7.4) occur. The gulf is connected to the main Red Sea via the narrow Straits of Tiran. Due to large excess of evaporation, its average salinity is high (40.7 ‰) and larger than that of the northern Red Sea. Residence time of water in the gulf is about 1.5 y. The water column fluctuates seasonally between deep mixing in the winter and intensive summer stratification.

The activities of ^{226}Ra and ^{222}Rn were measured in several transects, a depth profile and a well dug on the beach.

The gulf's water column contains exceptionally high levels of ^{226}Ra (up to 60 dpm·100 L^{-1}) and unsupported ^{222}Rn (up to 700 dpm·100 L^{-1}). The temporal fluctuations of both nuclides are very high even in the center of this deep-water gulf. The activity of the long lived ^{226}Ra in the gulf is about twice as high as that in the northern Red Sea. Considering the short residence time of water in the gulf, this indicates an intra-gulf source of the Ra, which supplies Ra (and Rn) rather rapidly. The depth profiles show that the high values are near the bottom (flux from the sediments) and in the upper 200 m (Fig. 1).

We propose that both the temporal and spatial variability of Ra and Rn in the gulf are related to their release from the major faults that border the RST, especially during and following earthquakes. For example, after the Nov. 19, 1998 earthquake (Mag. 4.4) we observed a sharp peak in both Ra and Rn in the open water column.

Figure 1: Depth profiles of ^{222}Rn and ^{226}Ra (dpm·100 L^{-1}) at stations A1 (ca. 4 km off shore), R2 (ca. 1.5 km), R3 (ca. 0.7 km) and R4 (ca. 0.2 km).