

Arsenic transport from former mine sites: an empirical modeling approach

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As a result of extensive gold and silver mining in California, elevated levels of naturally-occurring arsenic and other trace metals are exposed in mine wastes located in semi-arid regions (e.g. the western Mojave Desert). With extended periods of weathering and erosion, these potentially toxic elements can become mobilized and contaminate surrounding communities. Concerns over the health of individuals living in and visiting these communities have increased due to the greater awareness of this issue [1, 2]. In the past, other studies on this topic have focused on the chemical characteristics of wash sediments [3], the spatial distribution around mine sites [4], and the sources of the heavy metals [5]. While there has been some work in other semi-arid environments examining wash sediments [6], an empirical model used to reconstruct the concentration patterns observed in mining regions has not been developed.

This study sought to examine the role infrequent rain events have on the transport of mine tailings down washes and conduct a quantitative analysis of the empirical observations at multiple mine sites. Soil and sediment samples were collected from multiple mine sites in the Mojave Desert and analyzed for a suite of 49 elements. Distances between points were calculated and plotted against arsenic concentration. An empirical model was then developed and fitted to the data to explain the fluvial migration of mine wastes down washes.

The field data indicated that arsenic concentrations are highest closest to the main waste pile. Generally, as the distance from the pile increases, the arsenic concentration decreases. However, due to the complex patterns of each wash resulting from multiple source inputs and episodic movements of mine wastes, multiple power law trends were used to model the variations, and apparent pulses, of arsenic concentration. These pulses can be representative of infrequent, but intense, rainfall events occurring in the past that are characteristic to semi-arid environments. This has implications for future modeling efforts in similar environments as a potentially predictive tool for the nature of mine waste fate and transport.

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Strontium-, Magnesium-, Sulfur- and Bromine-isotopes as indicators for brine origin and migration

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Introduction

Causes and extents of subsidence processes following potash mining activities are still under debate for the city of Stassfurt, Germany. In our study, we investigate the role of groundwater in this context, and examined a set of environmental tracers to identify the water's origin from different aquifers (Quaternary, Triassic, caprock and the saline Zechstein formation (including flooded former mining shafts)). Groundwater flow in strata covering the salt dome is well constrained: Stadler et al. [1] showed that the sampled groundwater could be related to multi-component mixing processes having occurred under three time scales: young groundwater ages were locally found (0-50 a), an old (< 40 ka) component was identified by radiocarbon data, and contact between meteoric water and Zechstein salts (naturally or anthropogenically induced) could be identified by the presence or absence of Permian crystallization water from the dissolution of e.g. Carnallite and/or Kieserite. Interactions between these components could be identified for the studied site. However, the origin and fate of highly saline water sampled from both the salt dome and the mining shafts remained unclear. A non-traditional isotope ($^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{26}\text{Mg}$, $\delta^{81}\text{Br}$, $\delta^{34}\text{S}\text{-SO}_4$ and $\delta^{18}\text{O}\text{-SO}_4$) study was initiated to gain insight into the brine history.

Results and Conclusion

$^{87}\text{Sr}/^{86}\text{Sr}$ of saline water samples range 0.70713 to 0.71014 with Sr concentrations varying between 0.2 and 52.3 mg/L. $\delta^{81}\text{Br}_{\text{SMOB}}$ values were found to range between 0.16‰ and 1.01‰ with Br concentrations of 6 to 3336 mg/L. $\delta^{34}\text{S}_{\text{VCDT}}$ and $\delta^{18}\text{O}_{\text{VSMOW}}$ (of SO_4) range from 0.5‰ to 15.4‰ and from 4.5‰ to 11.7‰, respectively, with SO_4 concentrations varying between 0.2 and 33 g/L. $\delta^{26}\text{Mg}_{\text{DSM3}}$ values range from -0.794‰ to 0.291‰ with Mg concentrations up to 84 g/L. Rocks from the various aquifers were also examined. Combining the isotopic results with geochemical data indicate that saline water samples from the Zechstein formation are largely unmodified residual brines formed during evaporation. The brines could be identified according to their origin (potash salt z(K2) or anhydrite z(A3) (and in few cases Leine salt residuals z(Na3))). For instance, potash salts and related brines could be linked by in part highly radiogenic $^{87}\text{Sr}/^{86}\text{Sr}$. $\delta^{26}\text{Mg}$ could not differentiate between z(K2) and z(A3). Both sets of isotopes can however, clearly identify evaporitic components in fluids of cover layers.

[1] Stadler, S., Sültenfuß, J., Holländer, H., Bohn, C. Jahnke, C., Suckow, A. (2012): Isotopic and geochemical indicators for groundwater flow and multi-component mixing near disturbed salt anticlines. *Chemical Geology* 294-295: 226-242.