

Lead and lead isotopes in the Atlantic and Indian Ocean: GEOTRACES data

E. BOYLE¹, Y. ECHEGOYEN-SANZ¹, K. FORNACE¹, J.-M. LEE¹, T. GAMO², H. OBATA² AND K. NORISUYE³

¹Massachusetts Institute of Technology, Earth, Atm. & Planet. Sci., (eaboyle@mit.edu)

²University of Tokyo, Atm. & Ocean Research Institute, (gamo@aori.u-tokyo.ac.jp, obata@aori.u-tokyo.ac.jp)

³Kyoto University, Institute for Chemical Research, (knorisue@inter3.kuicr.kyoto-u.ac.jp)

We will present data on the evolving anthropogenic Pb penetration into the Atlantic and Indian Oceans. In the North Atlantic Ocean, a few sites have multidecadal (Bermuda) and decadal data that show lead decreasing in the upper ocean in response to the phaseout of leaded gasoline; the decrease at depth depends on the ventilation time as shown by anthropogenic transient tracers (although Pb has been entering the deep Atlantic for at least the past 2 centuries, much longer than bomb nuclides and fluoro-compounds). The Atlantic Pb isotopic composition evolves as U.S. dominance is displaced by European Pb gas dominance; the southern Atlantic shows a distinct surface isotope composition. We will show a 10-station section in the Atlantic western boundary from 32degN to 25degS that shows N. Hemisphere Pb penetrating the S. Hemisphere dominantly with the Labrador Sea Water with some from the lower NADW. We will also show the Pb isotopic composition of these waters, including for the first time data on the scarce isotope Pb-204. We will also show a section of 8 stations from Lisbon to the Cape Verde Islands collected on the first US GEOTRACES North Atlantic Transect (2010). In the subtropics, the temporal Pb decrease due to Pb gas phaseout is reflected in this new data as compared to data from 1989 and 1999. In the tropical North Atlantic, thermocline Pb is low (<35 pmol/kg) reflecting the limited ventilation of this “shadow zone”, but shows a maximum at about 700m depth. We have data from 11 stations from the Japanese Indian Ocean GEOTRACES cruise, from the Bay of Bengal and Arabian Sea into the Antarctic (18degN to 65degS). In response to later industrialization and a two-decade lag of Pb gas phaseout (and limited convection), anthropogenic Pb is higher in the surface waters of the Indian Ocean (40-80 pmol/kg) than in the present-day North Atlantic and North Pacific (20-30 pmol/kg), although Pb has not penetrated as deeply in the Indian Ocean (with little occurring below about 2000m, and some of the deep waters having extremely low Pb (~3 pmol/kg).

Modelling of hydrogeochemical processes in groundwaters of the North German Basin (NGB)

ELKE BOZAU AND WOLFGANG VAN BERK

TU Clausthal, Hydrogeologie, Leibnizstraße 10, D-38678 Clausthal-Zellerfeld (elke.bozau@tu-clausthal.de)

Modelling and forecasting quantitative hydrogeochemical changes in highly mineralised groundwaters is still a challenge. The extraction of deep groundwater for geothermal energy production from the NGB is affected by the precipitation of certain minerals, e.g. sulphates (Ba, Ca, Sr), carbonates (Ca, Fe), and silicate phases (SiO₂). These scalings often disturb the continuous production of geothermal energy and should be avoided in the technical systems.

Groundwaters in deep aquifers of the NGB are dominated by Na⁺ and Cl⁻, or Na⁺, Ca²⁺, and Cl⁻. The amount of total dissolved solids ranges from 100 to 300 g/l and increases with depth and temperature. Compared to surface groundwaters the deep groundwaters are enriched in a broad range of elements, including trace elements such as Ba, Pb, Sr, and Zn, and contain high amounts of dissolved gases (N₂, CO₂, H₂S, and CH₄).

An extended hydrogeochemical thermodynamic database for the well known and commonly used software PHREEQC has been developed to predict possible mineral precipitations during the use of highly mineralised groundwaters for geothermal energy production. Temperature (up to 200°C) and pressure (up to 500 bar) adaptations of the equilibrium constants were necessary. Pitzer parameters for the calculation of activity coefficients in waters of high ionic strength and solubility equilibria among gaseous and aqueous species of N₂, CH₄, and H₂S had to be implemented into the database.

In order to validate the implemented parameters the modelled mineral solubilities have been compared to experimental data gathered from the literature. First modelling results confirm the experimental data for the solubility of the minerals quartz, barite, anhydrite and calcite. However, there are problems with the solubility of several minerals at higher temperatures. Hence, evaluation and improvement of the thermodynamic database will be an ongoing process.

Acknowledgements. The presented data are results of the project “gebo” (Geothermal energy and high performance drilling research) financed by the Ministry of Science and Culture of the State of Lower Saxony and the company Baker Hughes.