The making of a brine pool – An integrated modeling approach

C. SCHARDT

Institute of Mineralogy and Economic Geology, RWTH Aachen University, Wüllnerstrasse 2, 52062 Aachen, Germany (schardt@iml.rwth-aachen.de)

Finite-element numerical computer simulations of the Atlantis II Deep/Red Sea rift are used to 1) investigate the nature of hydrothermal fluids feeding a brine pool, 2) research free mixing of discharging hydrothermal fluids and seawater in a submarine depression and 3) study chemical and physical chances of involved fluids and rocks. Modeling parameters reflect seafloor conditions and enable saline fluid circulation within faults, clastics and basalt and mixing in brine pool. (Fig. 1). Evaporites supply constant salinity; other units contain seawater salinity. A 30 ky limit is imposed.

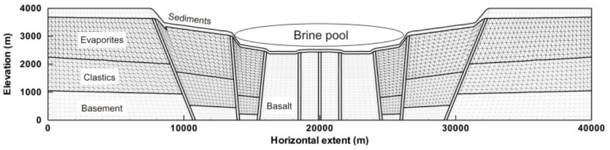

Figure 1 Rock units and fault distribution of the Red Sea rift model. Heat flux ranges from 300 – 2000 mW/m^2.

Fluid convection patterns show fluid recharge on flanks, main fluid convection within basalt and major fluid discharge at the central fault. Discharge fluid characteristics (T: 150°C-290°C, V: up to 1 m/h, S: up to 150 ‰) are within the range of previous data but lower than highest salinites recorded [1]. Higher rock permeabilites, increased heat flux or other processes can account for the difference. The development of a brine pool may include I) simple mixing of discharging hydrothermal fluids with seawater, II) processes such as boiling in addition to mixing and/or III) addition of other high-saline fluids, e.g. magmatic fluids.

Initial results of free mixing of discharging hydrothermal fluids with seawater indicate that fluid property differences, discharge location and shape of exit orifice influence plume shape, buoyancy reversal and ponding behavior. The development of a salinity stratification is a non-steady process and probably requires additional conditions, e.g. pool drainage pattern.

The future addition of fluid and rock chemistry will enable the study of fluid evolution, brine pool development and mineral precipitation in the Atlantis II Deep.

[1] Anschutz & Blanc (1996) *EPSL* **142**, 147–159.

Mass-independent fractionation processes in heavy elements

E.A. SCHAUBLE

Department of Earth and Space Sciences, UCLA, Los Angeles CA 90095, USA (schauble@ucla.edu)

Advances in instrumentation and analytical technique have recently led to several discoveries of mass-independent isotope signatures in heavy elements ($Z > 16$). The most intensively studied effects in natural terrestrial samples are found in mercury [1], but evidence of MIF also extends to thallium [2] and uranium [3]. Isotope variations in molydenum, ruthenium, and some other elements show MIF-like patterns in samples from refractory inclusions in meteorites [4]. Possible mechanisms causing these MIF signatures will be examined.

It appears that truly mass-independent nucleus-electron interactions play an important role in causing heavy-element MIF signatures. The nuclear volume effect, resulting from weakened Coulomb attraction between *s*-electrons and isotopes with diffuse nuclear charges, is an example[5]. Nuclear volume fractionations typically display odd/even staggering, because nuclei with odd numbers of neutrons tend to be more compact. MIFs caused by this effect can be estimated with quantum mechanical methods. Nuclear volume effects appear to explain oceanic thallium isotope signatures, in particular the large (2-3‰) $^{205}Tl/^{203}Tl$ fractionations observed in seawater, altered oceanic crust and sediments. This signature is inferred to reflect an equilibrium between Tl^{3+} (no *6s* electrons → high $^{205}Tl/^{203}Tl$) and Tl^{+} (two *6s* electrons → low $^{205}Tl/^{203}Tl$). For uranium, the otherwise paradoxical pattern of high $^{238}U/^{235}U$ in reducing, U^{4+}-bearing sediments, relative to seawater and oxidizing, U^{6+}-bearing sediments is also consistent with nuclear volume fractionation. A similar pattern of $^{238}U/^{235}U$ depletion in U^{6+}-species, along with odd/even deviations from mass dependence, led to the original discovery of nuclear volume isotopic fractionation [5].

Natural mercury isotope fractionation is more complicated. Nuclear volume effects can explain the heavy-isotope enrichment (~0.2‰/amu) and odd-isotope depletion (~0.1‰ relative to a mass-dependent law) in liquid Hg equilibrated with vapor [6], but not the much larger ^{199}Hg and ^{201}Hg anomalies found in biological samples. These are most likely caused by effects of nuclear spin on electron reorganization in spin-forbidden reactions. However, this mechanism is difficult to forward model, and thus pinpoint as a key mechanism in natural mercury cycling.

[1] Bergquist & Blum, (2007) *Science* **318**, 417. [2] Schauble, (2007) *GCA* **71**, 2170. [3] Weyer *et al.* (2008) *GCA* **72**, 345. [4] Fujii *et al.* (2006) *ApJ* **647**, 1506. [5] Bigeleisen, (1996) *JACS* **118**, 3676. [6] Estrade *et al.* (2009) *GCA* **73**, 2693.