Fluid-flow controls of low δ^{57}Fe hydrothermal iron mineralization

A. MATTHEWS[1]*, Y. EREL[1], D. STERN[1], U.RYB[1]
AND Y. AVNI[2]

[1]Institute of Earth Sciences, Hebrew University of Jerusalem, Israel (*correspondence: alan@vms.huji.ac.il)
[2]Geological Survey of Israel, Jerusalem 95501, Israel

Low δ^{57}Fe values are characteristic of iron isotope fractionation during bacterial and abiogenic reduction. However, experiments on the Fe isotopic fractionation during sorption-desorption of aqueous Fe on quartz [1, 2] indicate alternative mechanisms for generating isotopically light iron.

We investigate the controls of Fe-isotopic fractionation during low temperature hydrothermal iron mineralization along a 70 km section of a fault (Paran Fault) adjacent to the Dead Sea Transform (DST), which separates the Arabian plate from the Sinai Sub-plate. The MVT type mineralization comprises iron oxide lenses in the fault zone and iron oxide-bearing dolomites in the adjacent Cretaceous host rock limestone. The Mg-Fe rich brines were sourced in evaporite-bearing sandstones (Nubian) underlying the limestone.

Fe isotopic compositions from two 10 km long segments in the west (Haspas) and East (Menuha) parts of the fault show uniformly negative values: Menuha: δ^{57}Fe (Fe-ox) = -1.08±0.4‰ (n=23); (Fe-dol) = -0.87±0.26‰ (n=15); Haspas δ^{57}Fe (Fe-ox) = -0.86±0.26‰ (n=17); (Fe-dol) = -0.61±0.21‰ (n=13). These values represent isotopically light source solutions formed by the dissolution of clastic iron minerals in the sandstone with δ^{57}Fe = 0.34±0.19‰. (n=8).

Both bacterial and abiotic reduction of the clastic iron oxides could have provided isotopically light Fe (II) solutions. However, the highly saline conditions of the sandstone fluids do not necesssarily favour bacterial intervention. An alternative fluid flow model is examined whereby the isotopically light Fe compositions are generated by sorption on sandstone grain surfaces. The uniformity of the Fe isotope composition suggests that fluid flow was generally orthogonal to the E-W trending fault. Northward fluid flow is consistent with the topographic recharge being to the south (present-day Suez Rift) at the Oligocene time of the major pulse of mineralization. Slightly lighter δ^{57}Fe values ($\leq$ -1.0 ‰) in dolomites closer to the DST possibly represent Miocene reactivation related to creation of the transform [3].

[1] Matthews *et al.* (2008) *GCA* **72**, 5908–5919. [2] Mikutta *et al.* (2009) *GCA* **73**, 1795–1812. [3] Erel *et al.* (2006) *GCA* **70**, 5552–5570.

Using atomic force microscopy to probe pore surfaces of oil-bearing sandstone

J. MATTHIESEN*, T. HASSENKAM,
N. BOVET AND S.L.S. STIPP

Nano-Science Center, Department of Chemistry, University of Copenhagen, Denmark
(*correspondence: jmatth@nano.ku.dk, tue@nano.ku.dk)

Pore surface properties of oil-bearing sandstone control the oil recovery from sandstone reservoirs. The wettabillity of the pore surface, i.e. the tendency of the surface to cover itself with a fluid, plays a key role in recovery. Pore surface wetting behavior for chalk reservoirs has previously been shown to be inhomogeneous over scales of 10's of nanometers [1]. Here we investigate whether the same applies for sandstone.

Using atomic force microscopy/spectroscopy (AFM/AFS), we have probed the surface wetting properties at the nanoscale of natural oil-bearing sandstones. A self-assembled monolayer of alkane-thiols is formed on the AFM tip surface, creating a hydrophobic layer. Force curves measuring the adhesion between the hydrophobic tip and the sandstone surface were acquired in a 50x50 grid over a 5x5 μm area thereby forming a map of adhesion. Properties such as topography and elasticity were also extracted from these measurements.

We observe that sandstone wettability varies on a sub-micrometer scale. In some areas, the degree of adhesion of the hydrophobic tip decreases with number of scans over the area and the force curves indicate that material is pulled off the surface. Using X-ray photoelectron spectroscopy (XPS) measurements, we saw that the initial surfaces were covered with several layers of carbon containing material. The wetting behavior of the pore surface is thus controlled by adsorbed organic material and not by the actual surface of the mineral. This improved understanding about the wetting behavior of reservoir minerals will hopefully provide clues for increasing oil recovery.

[1] Hassenkam *et al.* (2009) *PNAS* **106**, 6071–6076.