Deep water in the Upper Rhine Rift Valley, central Europe

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Section 9f: Innovative geochemical approaches to understanding geothermal systems

Hydrochemical data from deep wells in the Upper Rhine Graben area in France and Germany were collected und examined. Primary targets were the potential geothermal reservoirs: Hauptrogenstein (Dogger). Upper Muschelkalk (middle Triassic) and Buntsandstein (lower Triasic). The data (table) were used to characterize the fluids found in the hydrogeothermal reservoirs [1. 2]. Waters at < 500 m depth are weakly mineralized. Water composition is controled by the rock. With increasing depth also TDS increases and the distinct waters of the three different aquifers all evolve to Na-Cl brines independent of the reservoir rock. Water from 3000 m depth is of very similar composition. All waters are saturated with respect to calcite and some other minerals. When thermal water is pumped to the surface and cooled, they become oversaturated with respect to a series of predictable solids including calcite, barite, celestite and others.

Table: Selected hydrochemical analyses (mg/kg):

Well	depth (m)	Na	Ca	Cl	HCO_3	SO_4
Buntsandstein						
GB1 Bruchsal	2537.	35840.	7415.	82220.	520.	384.
TB Zähringen II	843.	1115.	621.	330.	680.	3114.
Eschau 1	1619.	28307.	400.	44375.	180.	125.
GB Cronenbourg	3220.	32560.	4680.	61550.	305.	220.
Meistratzheim 2	1437.	8500.	600.	12800.	671.	2240.
Mutzenheim 1	1857.	23500.	912.	35720.	1415.	4640.
Muschelkalk						
Langenbrücken	607.	12240.	1660.	21130.	500.	1850.
Bad Schönborn	636.	9760.	1367.	16770.	571.	1942.
Bad Krozingen	591.	554.	707.	348.	1519.	1960.
TB Freiburg 1	858.	390.	632.	113.	918.	2240.
Bad Bellingen III	1194.	308.	2525.	3454.	2227.	1585.
GB 1 Riehen	1547.	4900.	805.	7270.	1012.	2550.
Eschau 1	1407.	28307.	400.	44375.	180.	125.
Staffelfelden 9	2529.	19710.	800.	30530.	950.	1900.
GB Helios	1146.	6712.	1979.	13783.	326.	960.
Hauptrogenstein						
TB 3 Freiburg	483.	59.	67.	31.	386.	98.
Georg-Quelle	487.	928.	462.	1758.	961.	291.
Blodelsheim I	1891.	7431.	1200.	13490.	1870.	1300.

Within the underlain Variscan crystalline basement the fracture porosity is filled with saline thermal water[3]. Its composition forms a continuum with the waters from the deep sedimentary aquifers. The crystalline basement in the Upper Rhine Graben is used for enhanced geothermal systems (EGS). TDS at 5000 m depth is about 100 g/kg.

[1] HE. K. & STOBER. I. & BUCHER. K. (1999): Chemical Evolution of Thermal Waters from Limestone Aquifers of the Southern Upper Rhine Valley. - Applied Geochemistry. 14. 223 – 235. Exeter/UK.
[2] STOBER. I. & JODOCY. M. (2011): Hydrochemie der Tiefenwässer im Oberrheingraben - eine Basisinformation für geothermische Nutzungssysteme. – Z. geol. Wiss.. 39. 1. S. 39 - 57.
[3] STOBER. I. & RICHTER. A. & BROST. E. & BUCHER. K. (1999): The Ohlsbach Plume: Natural release of Deep Saline Water from the Crystalline Basement of the Black Forest.- Hydrogeology Journal. vol 7 (3). pp. 273-283. Springer. Berlin/Heidelberg.

Magnetite (U-Th)/He dating–Attractive Dates in Mafic and Ultramafic Rocks

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Magnetite is a common mineral phase in felsic, mafic, hydrated ultramafic igneous and metamorphic rocks. Magnetite (U-Th)/He (MHe) dating has been shown to be a reliable and powerful alternative method for obtaining absolute age constraints from mafic volcanic rocks in light of inherent difficulties in $^{40}Ar/^{39}Ar$ dating due to excess ^{40}Ar and/or recoil, susceptibility to alteration, or lack of datable mineral phases [1]. More recently, we have explored MHe as a novel and exciting geo- and thermochronometric technique for constraining the formation and thermal processes related to serpentinization and exhumation of sub-lithospheric mantle during continental break-up. While ultramafic rocks (e.g., sub-lithospheric mantle) do not commonly contain mineral phases that are datable by traditionally for geo- and thermochronometric, magnetite occurs ubiquitously as an alteration phase in serpentinized peridotites as a result of olivine breakdown. MHe Tc of ~250°C [1] can be exploited to elucidate the thermal history of exhumed mantle and formation of serpentinites. Application of MHe ages should provide critical temporal insights into continental rifting and serpentinization during break-up along magma-poor continental margins. As attractive and powerful as MHe dating is, not all magnetite samples are suitable for MHe dating due to its texture, grain size, and [U] making it prone to matrix He implantation. Detailed petrographic characterization of basaltic and ultramafic magnetite is required to determine the suitability of magnetite size and textures for MHe dating. The biggest hurdles in reliable magnetite dating, however, are grain morphology and He implantation, as matrix [U] commonly is one order of magnitude greater than magnetite (~100 ppb). While air-abrasion tends to alleviate this in large magnetite [1], irregular and complexly intergrown magnetite require careful pre-analysis screening. We have the developed the routine use of non-destructive microCT scanning for imaging of magnetite, identification of suitable magnetite, and monitoring of air-abrasion progress and high-U matrix removal. Understanding petrologic context and screening prior and during analysis are critical for deriving reliable and meaningful MHe dates.

[1] Blackburn et al. (2007) EPSL, vol. 259, p. 360–371.