

Hydrochemical patterns in a structurally controlled geothermal system

M. BREHME¹, C. HAASE², S. REGENSPURG¹, I. MOECK¹, F. DEON¹, B. WIEGAND³, Y. KAMAH⁴, G. ZIMMERMANN¹ AND M. SAUTER³

¹Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, International Centre for Geothermal Research, Telegrafenberg, 14473 Potsdam, Germany

²Institute for Geosciences, Kiel University, Ludewig-Meyn-Strasse 10, 24118 Kiel, Germany

³University of Göttingen, Applied Geology, Goldschmidtstr. 3, 37077 Göttingen, Germany

⁴Pertamina Geothermal Energy, Jl.M.H. Thamrin No.9, Jakarta 10340, Indonesia

In this study, we investigate a magmatic structurally controlled geothermal reservoir in North Sulawesi-Indonesia focusing on structural geology and hydrochemistry. A combination of a thermal-hydraulic model with hydrochemical modelling is the goal of this study. The running geothermal system is located above a subduction zone surrounded by a complex network of faults and repetitive volcanic eruptions.

Analyses of the samples collected from wells, hot springs, rivers and lakes show typically two types of water. Acid high saline waters were found in the northern reservoir area (pH: 2.7-3.2, electrical conductivity: 4620-9700 $\mu\text{S}/\text{cm}$). A similar water type rises above this reservoir through several hot springs (pH: 1.8-2.7) and a lake (pH: 2.5) located above the reservoir. A second type of reservoir water was observed in the South where wells show a pH range of 4.2 to 6.5 and conductivities from 400 to 1729 $\mu\text{S}/\text{cm}$. Neutral hot springs occur in the surrounding area with pH values ranging of 5.8 to 7.0. While the northern and southern reservoirs are only 2km away from each other we observe strong difference between the water types. This is assumed to be due to laterally low permeability in the fault network. All the data analysed in this study converges to a consistent hydrotectonic model, which shows different reservoir compartments controlled by complex fault systems.

In addition to the conceptual model a hydrochemical model was set up in PHREEQC and suggests scaling from both water types such as Fe- and Si-bearing minerals. In this context, a cycle including hot water production, surface mixing and several reinjection scenarios was simulated. Modelled precipitations will eventually be compared with XRD-analyses of cores, precipitation-, alteration- and rock-samples in order to calibrate the hydrochemical model.

$\delta^{97/95}\text{Mo}$ in molybdenites from the Azegour skarn (Morocco)

BREILLAT NOEMIE^{1,2}, GUERROT CATHERINE¹, NEGREL PHILIPPE¹ AND MARCOUX ERIC²

¹BRGM, ISTO, UMR 7327, BP 36009, 45060 Orléans, France (n.breillat@brgm.fr)

²Univ d'Orléans, ISTO, UMR 7327, 45071 Orléans, France

Molybdenum (Mo) isotopes are frequently used to investigate ocean and lake (paleo-)redox conditions. In the frame of mineral resources, only few studies have been performed regarding Mo-Re-Os isotopes. The aim of this study is to understand the source, processes and mobility of metals concentrations using Mo isotopes on molybdenites in different ore deposits. The present study focuses on the Azegour skarn (Morocco). Located in the High-Atlas, the Azegour site is one of the rare Mo-W-Cu exploited skarns (three historic mines). It is formed by a granitic intrusion (271 \pm 3Ma) in cambrian volcano-sedimentary serie composed by schists, volcanic complex (andesites, pyroclastites) and carbonate formations (calcareous and dolomites). The skarn takes place in the carbonate formations where pyroxenites and grenatites occurred. The grenatites being the Mo-bearing minerals in the form of molybdenites.

Molybdenites sampling has been performed in the main mine (Azegour) and in the Tizgui mine (1km north of the Azegour mine). The Mo isotopic composition has been determined on molybdenites using a MC-ICP-MS Neptune after aquaregia dissolution and adjustment to [Mo] = 1 $\mu\text{g}\cdot\text{g}^{-1}$. The $\delta^{97/95}\text{Mo}$ ratios have been normalized to NBS3134 and a reproducibility of 0.07‰ (2 σ) is reached.

Presently, we have analysed 12 molybdenites from Azegour and 2 from Tizgui and 14 others are in progress. Regarding the first 14 samples, the $\delta^{97/95}\text{Mo}_{\text{NBS}}$ ratios vary between -0.40 and 0.32‰ for Azegour and between 0.08 and 0.30‰ for Tizgui. It is worth noting that variations can occur either at the whole site (difference of about 0.72‰) but also at the cm scale in the same sample (here the largest observed difference is up to 0.40‰).

Regarding the Azegour skarn, there is no direct relationship for explaining the Mo fractionation in molybdenites between the facies or the two sites of sampling. Different processes will be discussed to explain the observed variability (redox conditions prevailing during the molybdenites deposits, late metamorphism phase...). Further investigations using Pb and S isotopic compositions will help deciphering the oxidation state and the origin of molybdenites regarding the possible different fluids.