Applying fluid inclusion stratigraphy analyses to geothermal systems

DAVID I NORMAN[1], LORIE DILLEY[1], KRISTIE MCLIN[2], AND JOSEPH N. MOORE[2]

[1] New Mexico Tech, Earth and Env. Sci. Dept., Socorro, NM 87801, USA; dnorman@nmt.edu
[2] EGI, University of Utah, Salt lake City, UT 84108, USA; jmoore@egi.utah.edu

We are developing methods of interpreting fluid inclusion gas analyses performed systemtically on geothermal borehole cuttings. This type of analysis is offered commercially for oil and gas well cuttings, and yields a fluid inclusion stratigraphy (FIS). Hydrocarbon reservoir inclusions occur in cements deposited in the geologic past. In contrast, we are interested in Recent geothermal fluids. Studies of cuttings from three geothermal fields show that FIS analyses can identify different fluid types, seals, fractures, and zones of high permeability. Fence diagrams show the geothermal system structure. An unanswered question is the contribution to geothermal FIS analyses from past hydrothermal events. Our working hypothesis is that active geothermal systems occur in highly strained rock, and that fluid inclusions are destroyed and new inclusions formed continually as the rock fractures and refractures.

We are able to test this hypothesis by analysis of chips from an injection well (Coso 68-20) that was redrilled (Coso 68-20RD) because of porosity decrease. Fluid Inclusion Technologies performed the FIS analyses on drill cuttings collected at 20 ft intervals from the original and redrilled well. Chips are crushed in vacuum and the volatiles released analyzed by quadrupole mass spectrometry. Injection waters are ~110 C fluids from a flash plant and devoid of condensable gas. The time between drilling and redrilling is 7 years. Wall rock temperatures were about 180 C at 878 m and 222C at 1710 m. Analyses plotted on mud-log diagrams show that redrill fluid inclusion gas/water ratios decreased by about 60% whereas the amount of inclusion water was about the same for both suites of chips. The largest change in gas/water ratios occur at depths of fluid injection identified by FIS analyses and petrography study of redrill cuttings that show abundant secondary minerals.

The analyses show that fluid inclusion contents are different in the redrill chips. Differences between the two sets of analyses require the opening and loss of gaseous species from over 50% of the wallrock fluid inclusions. Our data show that geothermal fluid inclusions assemblages can change chemical compositions in a few years and that the changes in inclusion contents are most pronounced in areas of high fluid flux. Thus it is possible for bulk fluid inclusion gas analyses on drill cuttings to show the chemistry of Recent fluids. An implication is that all types of geothermal-system bulk-geochemical analyses will be biased towards the most recent event.