

Letter Report

TITLE: Review of: Origin of saline groundwaters in the Carnmenellis granite (Cornwall, England): natural processes and reaction during hot dry rock reservoir circulation, Chemical Geology 49, 287-301, 1985, by W. M. Edmunds, R. L. F. Kay, and R. A. McCartney.

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The subject report is a synthesis of several, more detailed studies, undertaken in an attempt to understand the origin of highly saline (up to 19,002 mg/l TDS) fluids in the Carnmenellis granite. The authors propose a model which includes groundwater movement, convective heat transport, water/rock interactions, secondary mineral formation, and fluid inclusion formation and stability to explain the genesis of the observed saline fluids. Groundwaters were sampled from several locales in the granite batholith, including tin mines at depths up to 800 m, shallow groundwaters at depths up to 41 meters, and from the drill hole for the hot dry rock experiment at depths up to 4032 m. Based on SiO₂ and Na/K geothermometry the maximum temperatures of these solutions appears to be 54°C, and based on their isotopic values they appear to be derived from meteoric waters, without a seawater component.

The source of the saline water appears to be primarily the hydrolysis of biotite, which provides a source of Cl, Li, Fe, Mg, F, K, and minor Na, and the hydrolysis of plagioclase which provides the major source of Na and Ca. Both of these reactions lead to the formation of kaolinite and also add additional SiO₂ to solution. Several experiments reported in the subject document are pertinent to the formation of these saline waters. In one set of experiments the authors react biotite with water at 80°C, and the resulting composition of the water, although more dilute than that sampled in the field, maintains many of the same molar ratios. This confirms that the biotites can provide much of the needed chlorinity, and other ions found in the saline waters. The second major set of experiments relates to the drilling of an ~4000 m deep hot dry rock couplet into which water was pumped for a period of 4000 hours (166 days), and the volume and the composition of the effluent measured. An increase in Na,

Cl, Li, Si, and B was found in the effluent compared to the input waters and the concentrations of Na, Li and Si reached steady-state concentrations at about 1000 hours. These results suggest two important conclusions: first, that the process occurring in the drill hole is not merely a displacement of highly saline pore waters, or the concentrations should continue to drop with time due to dilution, and second that water/rock reactions are occurring on a very short time scale (~2 months) at a relatively low temperature (<54°C) and the waters are apparently reaching a steady-state with the rocks. Since the inferred hydrolysis reactions, which were confirmed experimentally, produce SiO₂ and the solutions appear to be supersaturated with respect to chalcedony, fluid inclusions in quartz can also be eliminated as a source of the saline fluids. Rather, as SiO₂ phases should be precipitating, not dissolving, fluid inclusions should be forming.

In summary this study has shown that saline groundwaters in granite can be generated via water/rock reactions with minerals such as biotite and that no seawater or evaporite input is necessary. A more general, and perhaps more important result, is the fast (<2 month in this study) time scale in which the fluids come to equilibrium or reach steady state with the rocks at low temperature. Also important to note is that fluid inclusions should not be dissolving but rather forming due to the high concentrations of SiO₂. As the levels of SiO₂ are often fairly high in groundwaters it is important to consider, when invoking fluid inclusions as a source of salinity, whether it is reasonable to expect the dissolution of quartz to be occurring.