

## Third International Symposium on Water-Rock Interaction

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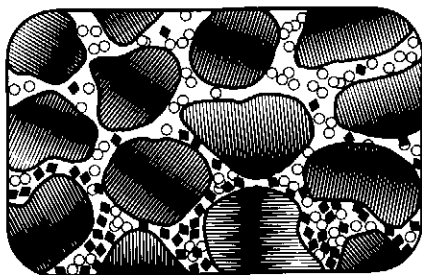
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# Conference Reports



## Third International Symposium on Water-Rock Interaction

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Over 150 scientists from about 20 countries gathered at the University of Alberta in Edmonton, July 16 to 20, 1980, to attend the Third International Symposium on Water-Rock Interaction. Pre-session and post-session field excursions included visits to oil sands deposits, the Columbia Icefields, and hot-springs at Banff.

For many of the researchers, involvement with chemical and mineralogical aspects of water-rock interaction has been precipitated by the devil's trinity of petroleum panic, water worries and nuclear necessities. Man's capability to efficiently produce needed petroleum and water resources and to safely dispose of unwanted nuclear wastes is influenced strongly by the chemistry of the water-rock interface, particularly in those cases where the interaction is artificially induced (e.g., steam stimulation of oil sands). The geochemistry of water-rock interaction has thus become as important to man as the mechanical processes by which mountains move to the sea. Sedimentologists, move over!

The more than 70 research papers presented at the meeting can be grouped into seven broad categories: 1) studies of formation waters; 2) mineral stability in the presence of water; 3) rates of water-rock

interaction; 4) the application of water-rock interaction studies to ore deposits; 5) active geothermal systems; 6) environmental and engineering aspects of water-rock interaction; and 7) water-rock experiments.

Numerous investigators demonstrated the potency of stable isotope techniques in addressing problems concerning water-rock activity. In a paper of special significance to hydrogeologists, F.W. Schwartz and K. Muehlenbachs reported  $\delta D$  and  $\delta^{18}O$  ratios for formation waters from successive geological units within the western Canada sedimentary basin. Significant variations in the isotopic (and chemical) data were used to outline the complex manner in which such fluids circulate. An intriguing paper by R.W. Raiswell concerned the formation of framboidal and euhedral pyrite in concretions. Sulphur isotope and Fe solubility measurements indicate that framboidal pyrite forms from rapid, open system sulphate reduction with Fe derived from *in situ* sources. In contrast, the euhedral pyrite apparently grows during slower, closed system sulphate reduction, Fe being incorporated from external sources. Such guidelines will be most useful to many workers engaged in studies of diagenesis.

Since nuclear waste disposal in igneous rocks was first contemplated, information concerning the effects of deeply circulating groundwaters upon potential repositories has been required. Knowledge of rates of mineral dissolution, in particular, is critical. P.C. Fung and G.G. Sanipelli showed experimentally that microcline very rapidly (<10 minutes) undergoes ion exchange during leaching to form a monolayer shell of H-feldspar. This reaction occurs regardless of pH or solution composition. A second, slower stage (2 to 24 hours) involves dissolution of the H-shell and concomitant liberation of Al and Si until the leaching solution becomes saturated. At this stage existing fresh surfaces on the microcline form a H-shell and all reaction between the rock and fluid effectively ceases.

The weathering rate of silicate rocks is an extremely important variable in the modelling of many geochemical systems. Not surpris-

ingly, this subject received much attention during the symposium. Of particular interest were discussions concerning the validity of parabolic rate laws as applied to the dissolution of mineral grains. A.F. White and H.C. Claassen presented data for the low temperature weathering of glassy volcanic rocks that favours release of Na and K into solution according to a parabolic rate law. R.A. Berner, E.L. Sjöberg and J. Schott studied the dissolution kinetics of enstatite, diopside and tremolite by X-ray photoelectron spectroscopy. They found linear, rather than parabolic kinetics for the release of silica. A logistically appealing study of olivine from Hawaiian beach sands by D.E. Grandstaff showed that olivine's rate of dissolution and cation release is constant (e.g. linear), and pH dependent. Grandstaff noted that freshly crushed mineral grains show parabolic behaviour, but that constant linear rate patterns are probably more characteristic of geological conditions. In their paper, Berner *et al.* suggest that the parabolic rate laws reported by others for enstatite and bronzite are artifacts of selective dissolution of submicron particles formed during sample comminution. Continued discussion between the 'linearists' and the 'parabolicists' is eagerly awaited.

Zeolite buffs appreciated a paper by R.N. Guillemette, J.G. Liou and F.W. Dickson. They showed how the formation of zoned zeolite assemblages is influenced by parent material grain size and crystallinity. Experiments comparing the behaviour of andesite glass and holocrystalline andesite, each in reaction with a NaCl solution at 300°C and 500 bars, produced quite different results. Zeolites crystallized during the glass experiments, but were not found in the products from the holocrystalline runs. Further, the sequence of secondary minerals formed during the glass experiments correspond quite closely to naturally occurring zoned zeolite assemblages.

Exploration geochemists perked up during a paper by J. Boulegue on the geochemistry of a presently forming roll-type uranium deposit. He related the geochemistry of waters flowing through the sandstone host to the formation and dissolution of

secondary minerals. Variations in pH were explained in terms of reactions involving pyrite. Of particular interest were Boulegue's observations that thiosulphate, hydrogen sulphide and iron analyses of waters in sandstone aquifers can be used to predict favourable conditions for the formation of roll-type uranium deposits.

Tar sands and heavy oils were not neglected at this symposium. Successful *in-situ* production of petroleum from such deposits partly depends upon the nature of mineral reactions induced in the host sands by steam-stimulation. J. Boon showed that pH and temperature most strongly control mineral reactivity in the Alberta tar sands. The major reactions involve dissolution of kaolinite and dolomite, and the formation of analcime, calcite, chlorite and montmorillonite. In a related paper, T. Hamilton reported on experiments designed to elucidate the less than satisfactory recovery of heavy oil at a pilot plant that uses the steam stimulation technique. The steam injection appears to be responsible for changes in the grain-size distribution and mineralogy of the petroleum host rock, as well as causing the production of extraneous gases (CO<sub>2</sub>, H<sub>2</sub>S, H<sub>2</sub>, etc.). Permeability reduction in fine-grained samples is severe. During mineral reactions, dolomite, siderite, calcic plagioclase and anhydrous ferromagnesian minerals generally disappear; calcite, quartz, albite, montmorillonite, chlorite, magnetite, analcime and other zeolites are formed. The full implications of this type of artificial diagenesis upon the petroleum potential of Western Canada is not yet clear. These difficulties, however, are of concern to all of us. This I emphasize for the benefit of certain energy policy pachyderms who naively believe that the existence of the Albertan tar sands and heavy oils obviates the need for realistic pricing of conventional petroleum resources.

Applied aspects of seawater-rock interaction were the topics of some very interesting papers. Y. Seki reported on the geochemistry of seepage waters from the Seikan undersea tunnel, presently under construction in Japan. He showed that K and Cl contents of the seepage waters can be used to predict areas of flooding hazard during tunnel construction. Low K contents are typical of slowly migrating waters, which exchange K almost completely with Ca-rich host rocks. Waters that move through the host rock very quickly (e.g., through joints and fractures) are less able to exchange cations and thus retain high K contents. Cl analyses act as a monitor of the meteoric to seawater ratio in the seepage fluid. Advance sampling is facilitated by long horizontal holes drilled in advance of the pilot tunnel.

Plans to dispose of stabilized coal wastes by their incorporation into artificial marine reefs received at least an initial setback from

R.J. Wilke and R. Dayal. They reported that a significant component of these wastes dissolves quite quickly in seawater. W.E. Seyfried, E. Thornton and D.R. Janecky reported results for seawater-sediment interaction experiments conducted at 300°C and 500 bars, conditions expected near high-level radioactive waste canisters placed in illite- and (or) smectite-rich deep ocean sediments. The results indicate that the hot chemical environment near the canisters will be acid and extremely oxidizing, conditions undoubtedly deleterious to canister integrity.

Active geothermal systems received their share of attention at the meeting. J. Tómasson, for example, reported that the chlorine content of geothermal waters is an effective monitor of cold groundwater influx, at least for the Selfoss geothermal field, Iceland. In this manner, temperature reduction can be anticipated long before actual changes occur. Trace element dispersion patterns (As, Li, Hg) of the Roosevelt Hot Springs thermal area were related by O.D. Christensen to the thermal and convective history of the area. Christensen suggests that such trace element studies will aid delineation of less well-known thermal systems. In a particularly exciting paper, S. Arnorsson and J. Benjaminsson reported on

the chemistry and origin of Icelandic carbon dioxide waters. The carbon dioxide content of some of the waters is higher than expected for their underground temperatures. They suggested that at least some of the CO<sub>2</sub> is of deep-seated origin. Oxygen and hydrogen isotope ratios indicate a meteoric origin for the carbon dioxide waters, but carbon isotope data point to a mantle origin for the CO<sub>2</sub>. The waters do occur close to faults in an area noted for mantle-derived alkaline volcanism. Do we at last have a true sample of mantle CO<sub>2</sub>? Connoisseurs of such concepts will wish to study this paper more fully.

Copies of the Symposium Proceedings are available from Dr. B. Hitchon, Alberta Research Council, 11315 - 87 Avenue, Edmonton, Alberta, T6G 2C2. This volume contains two to three page summaries of all papers presented at the symposium. The symposium was jointly sponsored by the International Association of Geochemistry and Cosmochemistry (IAGC), and the Alberta Research Council. The meeting was organized by staff from the Alberta Research Council and the Department of Geology, University of Alberta.

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