

extremely limited. The symposium was therefore not a summary of achievements in a well-established and well-researched field. Rather it was a delineation of our areas of ignorance and a discussion of various methods of tackling the problems.

Take the best known fluid, water, as an example. S.D. Hamann (CSIRO, Melbourne) noted that our present knowledge of the PVT (pressure-volume-temperature) behaviour of water is known quite accurately up to 100 °C and 1 kbar, less accurately to 1,000 °C and 10 kbar, and progressively more uncertainly above these limits. The highest temperature reached by conventional techniques is 1,200 °C (at 4 kbar) and the highest pressure is 34 kbar (at 175 °C). Shock-wave PVT data, which are less reliable, have been obtained up to 400 kbar and 3,100 °C but are very uncertain above 30 kbar. The actual nature of water under these extended conditions is not well known. E.U. Franck (Karlsruhe University) suggested that treating it as $\text{H}_3\text{O.OH}$ was a good approximation; that is, as hydronium hydroxide, very similar to fused sodium hydroxide.

The data are even more limited for systems which contain other components in addition to water. The best-known system, $\text{H}_2\text{O-NaCl}$, has only been extended this year to 400 °C, 4 kbar and 25 weight percent salt. The few other systems that have been studied are known over a much more limited range of conditions.

Apart from the mechanical problem of confining solutions at high pressures and temperatures within a limited space, the solutions of interest are often highly corrosive. H.L. Barnes (Pennsylvania State University) pointed out that a major problem concerning geochemical experimentation was the relatively long reaction times often needed to reach equilibrium. Materials have to withstand temperatures of several hundred degrees and pressures in the kilobar range for up to one month. It is not without reason that these experimental systems are called bombs.

Materials in themselves are not the only problems facing the experimentalists at high temperatures and pressures. Experimental apparatus must be constructed so that measurements can actually be made. That is, it is not only necessary to confine the reactants but also to have access to them. Particular interest was engendered by spectroscopic methods of measurements of the chemical properties of solutions up to 5 kbar and 500 °C by M. Buback (Karlsruhe University). These techniques involve constructing a bomb with a window of a transparent, chemically resistant material, such as sapphire. Spectra of the reactant solution may be examined. Infrared adsorption spectra are commonly observed, but Buback also

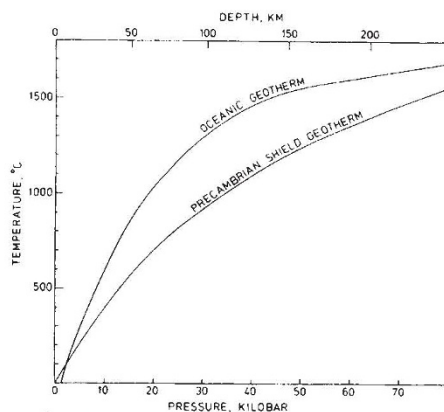


Fig. 1 Typical temperature and pressure variations with depth (geotherms) in the Earth for an oceanic and ancient Precambrian situation (from Wickman & Rickard, Chemistry and geochemistry of solutions at high temperature and pressure: an introduction to the symposium).

described the advantages and potential of laser Raman spectroscopy for these types of systems.

Even if experiments could be performed simply and quickly, the variety of solution compositions occurring in nature is so great that centuries of labour would be required to complete the work. Furthermore, it is not, at least at present, possible to examine experimentally the chemical properties of many systems under the extreme conditions that occur in the Earth. It is obvious that a major goal of high PT research is the construction of reliable methods for the theoretical prediction of the chemistry of solutions under extended conditions.

H.C. Helgeson and K.S. Pitzer, both from the University of California, Berkeley, presented alternative approaches to this problem. Helgeson discussed the 'ion association' approach, which provides specifically for ions combining together as a function of pressure and temperature. He argued that we know that solutions at high temperatures and low pressures contain a large proportion of combined or associated ions and that therefore the ion association model is more realistic.

The 'virial coefficient' approach used by Pitzer treats the solutions as though they contained only separate ions, and divergences from this ideal behaviour are accounted for in the coefficients of a single equation. Pitzer argued that the concentration of associated ions is not always unambiguously determinable and that there is essentially a continuous distribution of populations of ions at varying distances from one another.

However, these different approaches should not be regarded as competitive, but rather as complementary. For example, H. Eugster (Johns Hopkins University) showed, in a contribution to the discussion of Pitzer's paper, that use of the virial coefficient approach had solved for the first time a long-standing problem in physical chemistry — the theoretical prediction of salt precipitation during the

evaporation of seawater. No other approach had resolved this problem which has been known since van't Hoff's work at the beginning of this century. In comparison, application of the ion association model has already given much information about the nature of geological processes under extreme physical conditions — information which is not available experimentally at present nor is likely to be for some time to come.

The application of theoretical and experimental high PT solution chemistry to geological and technological problems was a recurrent theme of the symposium. On the geological side delegates discussed the formation of igneous rocks, the origin of ore deposits and the response of rocks to solutions at high temperatures and pressures. Geothermal energy was a topic of some considerable interest and various aspects were reviewed from source to power station chemistry. T. Seward (DSIR, Petone, New Zealand) combined several themes in his poignant tale of drilling for hot water and finding a source that deposited gold in large quantities. His chemical studies were able to show how the gold was transported in these hot solutions, combined with sulphur-containing ions.

One of the prime purposes of the 48th Nobel Symposium was to initiate a dialogue between chemists and geologists working in the same field, often unaware of each other's contributions. In this the meeting succeeded and several firm suggestions were made for future cooperation and for future meetings on this theme. Berzelius would have been happy! □

Erratum

In the article 'Dissecting the red cell membrane skeleton' (*News and Views* 281, 426; 1979) the sentence beginning on page 427, third column, four lines from the bottom, should read "... This suggests that the lower molecular weight forms are degradation products of the parent band 2.1 molecule." On page 429, first column, the two lines following line 13 were inadvertently omitted. The complete sentence should read "This is probably the end of the molecule where actin and band 4.1 bind since interactions between actin and crude spectrin preparations are phosphorylation sensitive (*Pinder et al. Nature* 270, 752; 1977). Unfortunately, so far at least, it has not been possible to recapture the phosphorylation dependence in more purified systems (*Brenner & Korn op. cit.*; *Cohen & Branton op. cit.*). On page 429, line 9 of the second column is incorrect: the complete sentence should read "This implies that spectrin has evolutionarily critical functions and, since its only known functions relate to the membrane skeleton, that the skeleton is an evolutionarily critical structure".