ROUND TABLE - HIGH PRESSURE IN GEOPHYSICS AND PLANETOLOGY

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The main goal of the discussion was to identify general problems that are of current importance in planetary physics (including geophysics), and which could be addressed by the high-pressure physics and chemistry community. The topics covered were by no means exhaustive, but they do illustrate some of the major issues in high-pressure geophysics.

I. A fundamental understanding of melting.
This is needed because melting is thought to be one of the most significant processes in the early formation, and subsequent chemical and thermal evolution of terrestrial (rocky) planets. Often there is little constraint on the composition, temperature and pressure that is of relevance so we need a general understanding of the physical and chemical conditions that lead to melting. Thus, laboratory or detailed theoretical (ab initio solid + liquid modelling) studies on specific systems can only represent trial-and-error attempts to characterize melting of a given compound within a planet at a given time. Rather, a more global understanding of the trends involved would be useful. For example, what are the roles of changes in liquid or solid structures? Can one generally predict which chemical species will affect melting temperatures more than others (e.g. if present as impurities)? Is there a fundamental connection between melting and other processes such as diffusion or creep in the solid state? This leads to the next topic:

2. Rheology - A microscopic theory that is general.
Engineers have empirically correlated creep deformation (and diffusion) to the melting process (e.g. through the T/Tm homologous temperature concept). Is there any fundamental basis to this? Can one go beyond the present state of affairs in which constitutive relations and creep-deformation maps can only be derived from experiment? (In other words, we have no fundamental understanding of creep in solids).

This topic is important for understanding the nature of convection within, and hence the thermal evolution of terrestrial planets. Contrary to the situation with melting, we can never hope to carry out truly appropriate experiments because of the long time scales involved in geological processes (\( \sim 10^6 \) to \( 10^9 \) yrs.) compared to laboratory experiments. That is, the strain rates have to be extrapolated 9 to 10 orders of magnitude from experimental conditions. As we have no microscopic theory of the deformation mechanisms in any general sense this is nothing more than a blind extrapolation - especially at high pressures (above 20 GPa where no data exist even at the high strain rates).

3. Some specific topics (in the order given, not necessarily the order of importance). The preceding topics made up most of the discussion but for the sake of completeness, and especially to include the nonterrestrial (gasy or giant) planets some further, specific topics were brought up.

   i) Melting of alkali halides at high pressures:
   An area of current interest in any case, this might serve as a paradigm for the structurally more complex (more or less polymerized) silicate melts. What is the effect of pressure and how does liquid structure change?
ii) Basic (ab initio) modelling of mixtures of H and any other cosmically significant constituent. This has a direct bearing on modelling of the interiors of giant planets.

iii) If there is one system to try to understand fully, it was suggested that \( \text{H}_2\text{O} \) might be good. \( \text{H}_2\text{O} \) is ubiquitous and is of great chemical interest because of its unusual properties—especially under pressure.

iii) A more complete theoretical understanding of the bonding in minerals (particularly the Si-O bond) as a function of pressure and structure.

One reason for suggesting these particular topics is that they can all be addressed at the present. More futuristic or speculative proposals are not mentioned here.