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Fluid properties and equilibria in the upper mantle

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The EoS [1,2] treats the thermodynamic properties for a large number of neutral species and their mixtures for P - T conditions occurring within the upper mantle. Because at these conditions experimental P - V - T properties are rare, the calculated properties using the EoS are verified with the help of experimentally derived phase equilibria which consist of results for mineral reactions and fluid unmixing. In addition the results are compared to other EoS.

For the thermodynamic treatment of metamorphic phase equilibria at conditions occurring within the crust pure fluids or their mixtures are usually considered but dissolved solids are usually neglected. At mantle conditions at least H_2O -rich fluids are heavily loaded by dissolved material. As a first approximation it can be assumed that at these conditions SiO_2 and Al_2O_3 are the predominant dissolved components. Assuming further the occurrence of solely neutral species the EoS [1,2] has been extended using available experimental results for solubilities of SiO_2 , Al_2SiO_5 and Al_2O_3 and now incorporates the species like $Si(OH)_4$, $Si_2O(OH)_6$ and $Al(OH)_3$. Therefore the calculations of equilibria involving simple solutions are now possible at mantle conditions.

To demonstrate the capabilities of the EoS phase equilibria for various systems like C-O-H, Ca-Al-Si-O-H are calculated without and with dissolved species at conditions occurring in subducting plates, mantle wedges and plumes.

References

- [1] Churakov S.V., Gottschalk M. (2003) *GCA* **67**, 2397-2414.
- [2] Churakov S.V., Gottschalk M. (2003) *GCA* **67**, 2415-2424.

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Viscosity of fluids in subduction zones

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The technical difficulty of measuring viscosities of low-viscosity liquids at high pressures and temperatures was overcome by performing falling-sphere experiments in the hydrothermal diamond anvil cell (HDAC). With this technique, viscosities of aqueous fluids containing 10-80 wt% dissolved silicates could be measured at 600-950°C and 10-20 kbar [1]. Pieces of albite, leucite or pectolite ($Ca_2NaSi_3O_8OH$) were filled together with distilled water and spheres of platinum or glassy carbon into the cell, which was heated horizontally until complete homo-genization between water and silicate was attained, and subsequently was tilted together with the microscope into vertical position. The composition of the above-mentioned silicates is similar to that of low-degree partial melts generated during fluid-present melting of subducted oceanic crust. A video camera attached to the microscope allowed the events in the sample chamber to be recorded at a rate of 25 pictures per second. Viscosities were calculated from the speed of falling spheres, using Stoke's law and corrections to account for the effect of nearby walls.

The results demonstrate that the viscosity of silicate-bearing fluids increases only slowly with increasing silicate content. The viscosity of a fluid with 20 wt% silicates at 800°C, for example, is similar to that of pure water at room temperature (1.0×10^{-3} Pa s), and that of fluid with 50 wt% silicate at the same conditions is comparable to olive oil at room temperature (0.8×10^{-1} Pa s). The low viscosity of such silicate-rich fluids, together with their favorable wetting angle compared with silicate-poor fluids, allows them to migrate out of the subducting slab even at low volume fractions. Silicate-poor fluids, on the other hand, remain trapped in the slab because of their high wetting angle. The position of the volcanic front 70-150 km above the subducting plate may therefore mark the depth at which aqueous fluids and silicate melts become completely miscible. Our results also suggest that the flux of silicate components from the slab could be much higher than previously assumed.

References

- [1] Audétat A. und Keppler H. (2004) *Science* **303**, 513-516.