In situ X-ray diffraction study of the phase transformations, melting behaviours, and rheological properties of the earth's materials at high pressure and high temperature

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We have developed experimental techniques for in situ x-ray diffraction measurements under high pressure and high temperature using a combination of the synchrotron radiation and a large multianvil high pressure device (SPEED-1500). Such experiments are now possible at pressures up to 25 GPa and at temperatures exceeding 2000°C, and some important results were already obtained based on these newly developed techniques:

1) Postspinel phase boundary in Mg_2SiO_4

The phase boundary between spinel and postspinel phases of Mg_2SiO_4 olivine, the most important mineral in the Earth's mantle, has been precisely determined at pressures to about 24 GPa and temperatures between 1200 - 2000°C. It was found that the boundary of the phase transformation shifts toward lower pressures by more than 2 GPa as compared to the results of quench experiments and thermodynamic calculations, while the Clapeyron slope (dP/dT) of the boundary was consistent with those estimated by these earlier studies. The present results have most important implications for the constitution and composition of the Earth's mantle as well as the dynamic processes within the mantle.

2) The boundary between ilmenite and perovskite phases in $MgSiO_3$

We have made some preliminary experiments to constrain the above phase boundary in $MgSiO_3$ pyroxene, the second important mineral in the mantle. We were able to clearly see the phase transformation from ilmenite to perovskite at pressures above 20 GPa, but failed in precise determination of the phase boundary due presumably to the grain growth of the perovskite phase and hence the kinetic problem of the reaction during the high P/T runs.

3) Melting of Au under high pressure

Melting of gold at high pressure was observed by in situ x-ray diffraction method. The sign of melting was confirmed at temperatures near 2000°C, at 21 GPa, by a sudden loss of the diffraction peaks of gold with increasing temperature. This result is consistent with the melting curve of gold estimated from its electric resistance change by ourselves. The P/T regime where the Au can be used as a pressure marker is discussed on the basis of the present experimental data.