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Frontiers in mineral physics relevant to geodynamics issues

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Mineral physics plays a critical role in understanding geodynamics for two reasons. First, properties of mineral play an important role in mass and energy transport in Earth's interior. Particularly important are the rheological properties that control the nature of mantle convection. Key issues in this area are the rheological properties of deep mantle and those of the lithosphere. Second, mineral physics knowledge is critical in interpreting various geophysical observations in terms of geodynamics. Interpretation of geophysical observations such as anomalies in seismic wave velocities, seismic anisotropy and electrical conductivity is not straightforward, and requires understanding of subtle details such as the role of minor element, hydrogen.

In this talk, I will present a review of some of the recent advances in these areas focusing on the results obtained in my group. Understanding of rheological properties under the deep mantle conditions is challenging because of technical difficulties. We have developed a new deformation apparatus (RDA: rotational Drickamer apparatus) to study rheological properties under deep mantle conditions. This apparatus has been operated to P$\sim$25 GPa and T$\sim$2200 K. Even the study of rheological properties under the lithospheric conditions requires some technical development because orthopyroxene that is stable only above $\sim$1 GPa plays a key role (commonly used gas apparatus cannot be used under these conditions). I will review some new results using these new techniques including the first quantitative results on the rheological properties of a perovskite + (Mg,Fe)O mixture and the strain weakening of a model peridotite under the lithospheric conditions.

These new results provide some hints as to plausible models of dynamics and evolution of Earth's interior. However, Earth is complex and geodynamic studies must also be constrained by observations. Seismological observations including seismic discontinuities, lateral variation in velocities and seismic anisotropy are the key to the understanding of the dynamics of Earth's interior. Although the resolution is less, observations on electrical conductivity are also important particularly in inferring the distribution of hydrogen (water). Current status of these studies will be reviewed and key issues that require further studies will be discussed.