Sound velocities of Earth's deep materials

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Average composition and structure of the Earth's deep interior can be approached by comparing observed seismic velocities to appropriate laboratory data collected for candidate materials under relevant conditions. Precise knowledge of the elastic properties of Earth's deep materials under high-pressure condition is crucial for constructing the accurate mineralogical model of the Earth's deep interior. However, only few experimental acoustic measurements exist under relevant high-pressure conditions. Recent technical advances in high-pressure Brillouin spectroscopic measurements combined with diamond anvil cell apparatus extended significantly the upper pressure limit for acoustic measurements [1, 2] and also enable us to explore the sound velocities under high-pressure and high-temperature conditions using infrared laser heating technique [3]. Here we present the recent progress of elastic wave velocity measurements on Earth's deep materials by Brillouin spectroscopy in a diamond anvil cell (DAC) in conjunction with synchrotron X-ray diffraction technique under ultrahigh-pressures. Based on the results we have recently obtained on mantle minerals [4] and glass materials [5] (Fig. 1), the mineralogy of deep mantle and the structure of the silicate melt in the deep magma ocean will be discussed.

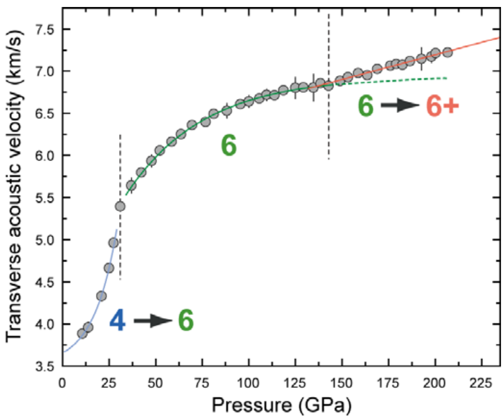

Figure 1: Transverse acoustic wave velocities of SiO_2 glass as a function of pressure up to 207 GPa [5].

[1] Murakami *et al*. (2007) *Earth Planet. Sci. Lett.* **256**, 47–54. [2] Murakami *et al*. (2007) *Earth Planet. Sci. Lett.* **259**, 18–23. [3] Murakami *et al*. (2009) *Phys. Earth Planet. Inter.* **174**, 282–291. [4] Murakami *et al*. (2009) *Earth Planet. Sci. Lett.* **277**, 123–129. [5] Murakami & Bass (2010) *Phys. Rev. Lett.* **282**, 124–128.

Weathering under low O_2 conditions: Interpretation of Paleoproterozoic paleosols

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Although the timing of the Great Oxidation Event has been constrained by the disappearance of mass independent fractionation in sulfur isotopes, the precise nature of quantitative evolution of atmospheric oxygen during the Paleoproterozoic has remained elusive. Paleosols (fossil soils) can be a powerful tool to determine a quantitative pattern of oxygen evolution because thery formed at the Earth's surface, in direct contact with the atmosphere at the time of their formation and redox sensitive elements such as Fe retained in weathering profiles should reflect the atmospheric oxygen levels. Nevertheless, our knowledge is insufficient to evaluate weathering under low O_2 conditions quantitatively. We here report the characteristics of weathering under low O_2 conditions based on analysis of paleosol compositions and mineral dissolution experiments under low O_2 conditions.

Two important parameters we used were (1) retention fraction of a metal (M_R), a mass ratio of paleosol to parent rock on equal volume basis, and (2) ψ, directly related to PO_2 and defined as a ratio of Fe^{2+} flowing out of the weathering profile that escaped oxidation to dissolved Fe^{2+} from primary Fe^{2+}-bearing minerals. The Si_R values of Precambrian paleosols were found to be linearly related to compaction factors, the fractions of original thicknesses. Because Si dissolution is representative of that of silicate minerals, it is proportional to the intensity of mineral dissolution. Therefore, Si_R will be a good indicator of the intensity of paleoweathering. Our theoretical calculations revealed that Fe_R is affected by both the intensity of weathering and PO_2 when ψ is >0.3 while it is not affected significantly by the intensity of weathering when ψ is <0.3. The mineral dissolution experiments under different PO_2 conditions in an open system indicated that PO_2 controls the fractionation of Fe between within and out of the system. That is, we can estimate PO_2 values from ψ values. The present work on evaluation of weathering under low PO_2 conditions will be useful to interprete Paleoproterozoic paleosols, and therefore, to estimate atmospheric oxygen levels during the Paleoproterozoic.