Review of large low shear velocity provinces in the lower mantle

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The CMB is one of the most significant boundaries in the Earth which is forced to maintain uniform temperature. This means that the two LLSVP's in the mid-Pacific and Africa with apparent heavy distinct chemistry play particularly important roles since they are forced to convect by overheating. Meta-stable dynamic models have been proposed to solve this issue by internal circulation with cold material returning to the CMB to reheat. Here we review detailed 2D seismic sections through these two structures to investigate their differences and compatibility with the meta-stable models.

The African LLSVP is better known since part of the anomaly is beneath land where a large array is available. Our best model here from waveform modeling has a superdome shape, 1000 km high with sloping walls (roughly 70°). The average shear velocity reduction is 3%. There is a ULVZ at the edge and a narrow plume-like feature emitting from the top, in excellent agreement with the meta-stable model. The mid-Pacific LLSVP is more difficult to study because of obvious data coverage. We can overcome some of this by refining a Trans-Pacific corridor of upper mantle structure so that multiple ScS bounces can be used effectively to validate and modify existing tomographic models. We find that an enhanced lower mantle model (SQ20RT, *Ritsema*) does quite well, with a -3% slow structure but about half as high as the African structure. It again has relatively sharp edges with a ULVZ along its western edge. Thus, the meta-stable dynamic model is quite compatible with our preliminary results. However, a more complete collaboration with other disciplines involving mineral physics and geochemistry is needed in resolving the fundamental issues, especially with respect to the mixture of minerals and melts, perovskite to post-perovskite, etc.

Clay interaction with organic ligands and siderophores in a CO_2 atmosphere

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Understanding the reactivity of common clays is central to the study of weathering and is of vital importance for many environmental engineering and contaminant containment strategies. Organic ligands and siderophores have been shown to enhance rates of clay dissolution and alteration through acidic dissolution, as well as ionic complexation at the mineral surface. Complexation of ions decreases ionic activity, promoting further dissolution. The purpose of our study was to investigate clay interaction in a CO_2 atmosphere, to determine how dissolution proceeds in the presence of organic ligands and siderophores.

Closed system experiments were performed with pure samples of the common clays, Ca-montmorillonite, Na-montmorillonite and kaolinite, in a 99-100% CO_2 atmosphere (log pCO_2 = 0). Unbuffered and TRIS buffered (0.1 M) experiments were performed with solutions containing oxalic acid (0.01 M) or the siderophore, deferroxamine mesylate (DFOM) (0.05 M). Control experiments contained only TRIS buffer or water. The initial pH of the TRIS buffered experiments was 7 ± 0.5, while unbuffered experiments were titrated to pH 7 ± 0.5 with NaOH after equilibration with the CO_2 atmosphere.

The rate of clay dissolution was determined from the temporal variation in clay reaction products (Al, Si, Ca, Mg, Na and Fe). Clay surface composition before and after was determined by X-ray photoelectron spectroscopy (XPS) and end products were identified using X-ray diffraction (XRD). Atomic force microscopy (AFM) offered nano-scale observation of surface modification, allowing monitoring of very small changes, after only a few days. Oxalate and DFOM enhanced the release of mainly Al and Fe ions from the clay compared to controls experiments. XRD showed that the clay structure has collapsed and stabilized again with a lower distance between layers. The difference is 2.8 Å in the case of Ca-montmorillonite. A second phase, whewellite, has formed in all cases except for kaolinite. XPS revealed distinct changes in the Al:Si and Na:Al rations at the clay surfaces. AFM showed clear modification of the surface after 4 days.