Structure of carbonate-silicate melts at high P-T conditions using in situ X-ray diffuse scattering

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Carbonatites are an important class of mantle-derived magmas that may play a fundamental role in mantle metasomatism and carbon cycling. To examine compositional dependence of melt structure in the $CaO-MgO-CO_2-SiO_2$ system, we performed *in situ* X-ray scattering experiments in the Paris-Edinburgh press at HPCAT (Advanced Photon Source) using compositions along the $CaCO_3-CaSiO_3$ (Cc-Wo) and $CaCO_3-Mg_2SiO_4$ (Cc-Fo) joins. Both systems exhibit simple eutectic melting over a wide pressure range, with no subsolidus decarbonation reactions [1,2]. Charges were loaded using the setup of Yamada *et al* [3], and held at ~1800 ºC and ~40 kbar while energy dispersive X-ray scattering spectra were recorded at each of eleven scattering angles to achieve reciprocal space coverage up to q=32 $Å^{-1}$.

The presence of both Cc and Wo in quenched charges confirms the retention of CO_2. Pair distribution functions (PDF) reveal local atomic structure of the liquid and, when normalized to the calcite-liquid PDF, provide a measure of silica polymerization. Results suggest that $CaCO_3$ forms an ionic liquid with intact CO_3^{2-} ions, in agreement with previous results [4,5]. Silicate melts show a clear signal at 1.6 Å, corresponding to Si-O in SiO_4^{4-} tetrahedra. Both Wo-bearing and Fo-bearing compositions also show a strong signal at 3.3 Å, corresponding to Si-Si in polymerized silica. Thus, in the presence of carbonate, even liquid orthosilicates contain silica polymers. The extent of polymerization moderately increases with carbonate content along both joins, suggesting that carbonate has a significant influence over the chemistry of molten silicates at mantle conditions.

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Three styles of delamination found beneath the western United States

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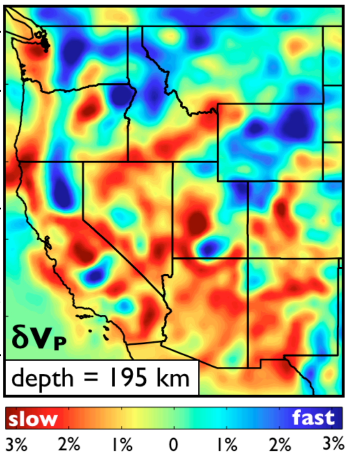
Strong seismic heterogeneity imaged across the western U.S. upper mantle implies the occurrence of segmented subduction, active upwelling associated with Yellowstone, and small-scale convection across most of the area. When put in geologic context, we recognize three types of small-scale convective downwelling. (1) Most of the fast structures are thought to be fragments of Farallon lithosphere emplaced at the base of North America during Laramide-age flat-slab subduction. Their tabular form suggests a delamination style of detachment from North America. Associated magmas probably involves melting of ascending asthenosphere, hydrated basal North America, and Farallon ocean crust. (2) Another type of downwelling is most reasonably explained as a delamiation-style detachment of North American lithosphere. An association with volcanism suggests basalt infiltration and eclogite loading of the delaminated lithosphere, i.e., thermo-chemical convection. (3) A third delamination type is inferred from the young uplift of granitic batholiths that have a geochemical signature for garnet-rich restites.



Examples include delaminations related to the Columbia River Basalt eruptions (involving delamination types 1 and 3, in conjunction with arrival of the Yellowstone plume) and the ignimbrite flareup (type 1), and uplift of the southern Sierra Nevada (3 and maybe 1), Colorado Plateau margin (2) and the Transverse Ranges (1). In many cases, magmatism appeerently is an integral part of delamination; it both enables mechanical detachment through the emplacement of lower crustal sills, and caused asthenosphere return flow. A general consequence of these delaminations is a remaking continent by driving mass exchange between continent and underlying mantle, and internal segregation of the continent.

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