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Universal behavior in pressure-induced melt-polymerization in primordial magmatic reservoirs

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Pressure-induced changes in melt-composition, viscosity, entropy, and solubility of elements in silicate melts in magma oceans provided a unique situation in which significant chemical differentiation of the silicate earth could have occurred and formed unrecycled partial by forming a hidden reservoir in Earth's mantle. Although the structures of silicate melts have been linked to these key properties, the melt structures at high pressure remained largely unknown. Even more challenging is to unveil the structure of natural silicate magmas in the Earth's mantle because any experimental effort to reveal the complex structure tends to be hampered by inhomogeneous broadening in experimental data associated with such complexity. Therefore, chemical constraints such as the non-bridging oxygen (NBO) content at 1 atm, rather than the real structural parameters for melt polymerization at high pressure, are commonly used to account for pressure-induced changes in the melt properties in Earth's interior. Here, we show that the pressure-induced NBO fraction in diverse silicate melts show a universal behavior where all the reported experimental NBO fractions at high pressure can be simplified into a single decaying function, regardless of melt composition. This simplicity in the pressure-induced changes in melt polymerization enables us to account for the non-linear variations in thermodynamic and the transport properties of multi-component and thus natural silicate melts at high pressure. The current results with universality in melt polymerization thus provide atomistic insights into the density crossover between melts and crystals and a formation of hidden reservoir with distinct chemical composition.

Keywords: silicate melts, high pressure, melt polymerization, mantle reservoirs