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A new mode of mantle heterogeneity simulated by stochastic melting

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Understanding and determining the composition and evolution of the upper mantle is valuable to unravel Earth's evolutionary geodynamics. Oceanic basalts are inevitably biased by the preferential melting of fusible mantle components and subsequent homogenization. Ophiolites, abyssal peridotites, and orogenic massifs are our only large-scale exposures of the mantle. We present whole rock and mineral chemistry as well as Re-Os isotopic systematics from the Table Mountain ophiolitic mantle massif of Newfoundland, as well as thermodynamic melting models and Monte Carlo simulation of time-integrated Re-Os-Al_2O_3 mantle evolution during a stochastic process of convection-induced partial melting through Earth history. Here we show that, at Table Mountain, harzburgite residual to sub-arc fluid-fluxed melting is interleaved with lherzolite residual to shallow adiabatic melting on metre- to kilometre-scale in outcrop. Monte Carlo models demonstrate that the development of mantle heterogeneity can be simulated by a stochastic process of partial melting at random time and to random degrees, and that the slope and intercept of an apparent, regressed $^{188}Os/^{187}Os$ vs Al_2O_3 aluminachron can be used to discern the time when the mantle began to experience and preserve an Os-isotopic record of partial melting. This study provides new insights into the development of mantle heterogeneity and offers new constraints on when a parcel of mantle previously homogenized by convective stirring and diffusion starts to preserve a record of partial melting and heterogeneity.