Intraplate magmas as expressions of evolving convecting mantle P-T-X-f_{O2}

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The compositions of modern and ancient intraplate magmas (IPM) attest to mantle heterogeneity at all times and scales, and they provide tantalising evidence for the longevity of chemically distinct reservoirs generated during early differentiation processes (core formation, magma ocean crystallisation). Inextricably linked to evolving IPM production through time is the changing nature of the recycled component, with incompatible element-enriched oceanic crust and sediment having the greatest impact.

Some IPL form when decompressing convecting mantle crosses its solidus at depths exceeding lithosphere thickness as a function of mantle potential temperature (T_P), composition (X) and oxygen fugacity (f_{O2}), for example in thermochemically buoyant plumes. Given that the average age of heterogeneities in sublithospheric IPM sources is ca. 2 Ga - implying the recycling of much older material - the nature of the mafic component recycled in the Archaean may be inferred from rare spreading ridge-derived xenolithic and orogenic eclogites. Evidence from such eclogites (V/Sc, $Fe^{3+}/\Sigma Fe$) suggests that their protoliths were derived from more reducing mantle sources than today. This may reflect ancient redox heterogeneity related to the upward mixing of less dense oxidised mantle after disproportionation of Fe^{3+} below the depth of metal saturation. Stranded reducing and dense metal-rich domains with primordial isotopic signatures may be sampled by the hottest and most buoyant plumes.

The f_{O2} of eclogites decreases with depth (~0.5 log units/GPa), implying a shallow depth of metal saturation and limited redox contrast between ambient mantle and subducted crust, with little Fe^{3+} to drive redox melting. Low f_{O2}, elevated Archaean mantle T_p and thinner continental lithospheres with highly reducing roots may have impeded extraction of carbonate-rich melts, due to rapid dilution by silicate components. Thus, carbonated IPM, although expected to form in the convecting mantle, may in large part require lithospheric sources.