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Magmatic evolution biases records of mantle chemistry towards recycled sources

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The chemistry of erupted magmas provides our main window into the composition of Earth's convecting mantle. However, magmatic differentiation in the crust can impose significant biases on the picture of mantle chemistry reconstructed from the erupted products of volcanoes. Here we investigate how basalts derived from different mantle sources, and so with differing major and volatile element compositions, are variably disposed to survive crustal processing and be sampled at the surface. We performed internally heated pressure vessel experiments on analogues of primitive Icelandic melts from the Reykjanes Peninsula that are known to be derived from lithologically distinct sources. At realistic magma storage conditions (300 MPa, 1140–1260 °C), we show that enriched melts from recycled and potentially pyroxenitic sources retain higher melt fractions during cooling than depleted melts from lherzolitic sources. In ocean island settings, variations in magmatic water (H_2O) content may also impart biases: hydrous magmas are more likely to survive than their anhydrous equivalents. Hence, the melts most likely to survive differentiation and contribute to erupted magma mixtures are low-degree melts of enriched and hydrous mantle sources. This result can explain two enigmatic features of the basalt record: 1) The anomalous over-enrichments of incompatible elements during differentiation of mid-ocean ridge basalts; 2) The frequently documented cargoes of highly anorthitic plagioclase crystals in liquids too evolved and too enriched to be in equilibrium with them. These crystals can now be understood as the remnants of depleted, lherzolite-derived melts that have been mixed into melts from more enriched sources.