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The Ba isotopic composition of Fagradalsfjall Fires reveals fluid-modified lithospheric mantle beneath the mid-Atlantic ridge

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The asthenosphere, which is the source of mid-ocean ridge basalts (MORB), has been demonstrated to be highly heterogeneous based on geochemical studies of abyssal peridotites, ophiolites and ultra-slow spreading MORBs. However, the origin of this heterogeneity remains controversial. Here we investigate upper mantle chemical heterogeneity beneath the Reykjanes Peninsula (Iceland), a subaerial segment of the mid-Atlantic ridge, by analyzing combined Ba-Sr-Nd isotopic compositions of basaltic lavas from the 2021-2022 Fagradalsfjall fires eruptions. Our findings imply that magmatic rocks erupted from the mid-Atlantic ridge (including those from the Azores, Iceland and Atlantic MORBs) are best explained by ternary mixing between distinct mantle endmembers. Besides depleted MORB mantle (DMM) and mantle plume components, a third component is necessary to account for the heavy Ba isotope values along with moderate enriched Sr-Nd isotopes and K_2O/TiO_2, La/Sm, Zr/Y, and Th/Yb ratios. This third endmember is compositionally best represented by the fluid-modified lithospheric mantle that foundered into the asthenosphere during the opening of the Atlantic Ocean. Our results suggest that fluid-modified mantle components may be widespread and are responsible for upper mantle chemical heterogeneity under Reykjanes and potentially elsewhere too.