Solid-Earth oxygen cycling revealed by enriched mantle domains

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The cycling of material through the Earth's deep interior and surface environment couples mantle oxidation state to the evolution of the oceans and atmosphere. A major uncertainty in this exchange is the flux of oxidised material from the Earth's surface back into the mantle. We present measurements of $Fe^{3+}/\sum Fe$ on a suite of 64 mid-ocean ridge basalt glasses sampling long- and short-wavelength heterogeneity in the Iceland plume. These basalts exhibit positive correlations between $Fe^{3+}/\sum Fe$ and isotopic tracers of ancient crustal recycling, indicating that subducted oceanic crust locally oxidises the mantle. The Fe_2O_3 concentration inferred for the enriched Icelandic source is consistent with the recycled material having experienced seafloor-hydrosphere interaction, oxidising the crust and generating a return flux of oxygen into the mantle.

Oxidation of the seafloor during hydrothermal circulation has probably only been efficient since global surface oxygenation generated appreciable sulfate concentrations in the oceans. Estimates of the age of the enriched component in the Icelandic source place it at older than 400 Ma, consistent with the requirement for oxic conditions to have been present in the deep ocean at the time of the source's formation. The present-day eruption of oxidised basalts from the Iceland plume may therefore represent closure of the global oxygen cycle, as oxygen sequestered into the solid Earth by subduction is returned to the surface environment.