The global oxidation state of the upper oceanic crust

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Abstract

The oxidation state of the oceanic crust is an important component of the Earth system. The widespread oxidation of the crust is a major contributor to the redox state of the mantle due to the subduction of hydrothermally altered oceanic crust, which supplies 10 - 25 % of the net ferric iron flux to the global mantle Fe3 /FeTOT budget (Lécuyer and Ricard, 1999). Secondly, the degree of oxidation of the upper oceanic crust provides a measure of the biomass of microbial life sub-basement (Bach and Edwards, 2003). Thirdly, oxidation state analyses of oceanic basalt give information on the environment and relative timings of local hydrothermal alteration events. To date comprehensive measurements of Fe3 /FeTOT for the oceanic crust are lacking. Post crystallisation oxidation processes, occurring predominantly in the upper basaltic layers of the crust, elevate ratios of ferric to total iron (Fe3 /FeTOT) from mantle levels of 0.16 ± 0.01 (Cottrell and Kelley, 2011). Ferrous (Fe2 /) iron is oxidised to ferric (Fe3 /) iron during reaction with oxidised seawater, which circulates through oceanic crust for tens of millions of years following crustal formation. This study integrates published data with new analyses from six ocean crustal boreholes to categorise the global oxidation state of the upper crust. Samples range from <1 to 129 Ma, and represent basalt from medium to superfast spreading centres, depths between <100 - 2000 mbsf, and at a variety of sedimentary cover rates and thicknesses. Results show that by 1 Ma, the Fe3 /FeTOT ratio of the bulk crust is already raised to an average of 0.28 ± 0.07, implying that the oxidation state is established very early in the lifetime of the

ocean crust. Post 1 Ma, Fe3 /FeTOT ratios are more variable, reflecting the effects of prolonged exposure to circulating seawater, but are on average ~0.35.

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