

Changes in the global P cycle in the Neoproterozoic recorded by the compositions of arc lavas

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The primitive lavas erupted at active subduction zones have higher P/Nd ratios than the bulk continental crust. This difference has been explained by the delamination of apatite-rich lower crust, which transfers P from the crust to the mantle at subduction zones. Here we compile geochemical data from basaltic (5.5-6.5 wt.% MgO) lavas from arcs that have formed in the last 2 billion years and show that Proterozoic arcs erupted basaltic lavas with lower average P_6/Nd_6 ratios than those of Phanerozoic and active arcs. This transition in P_6/Nd_6 ratios occurred between 800 and 600 Ma, coincident with an increase in P contents of siliciclastic marine sediments, and the Late Proterozoic oxygenation event. The P_6/Nd_6 ratios of basalts from active arcs are negatively correlated with Th_6/La_6 and positively correlated with $^{143}Nd/^{144}Nd$, U_6/Nb_6 and Ba_6/Th_6 , indicating that high P_6/Nd_6 ratios in arc lavas are inherited from dehydration of altered oceanic crust, rather than subduction of P-rich sediments. Altered oceanic crust has higher P/Nd ratios (up to 97) than the upper mantle, and metalliferous sediments deposited close to active spreading ridges have high P (up to 13,100 ppm) concentrations and P/Nd ratios (127-1,456) due to coprecipitation of P together with Fe oxyhydroxides formed when reducing hydrothermal vent fluids mix with oxygenated deep ocean water. We propose that the rise in atmospheric O_2 levels between 800 and 400 Ma caused changes in the redox state of the deep oceans, leading to an increase in the P/Nd ratios of subducting material at the end of the Proterozoic. Our results show that changes in the global P cycle in the Neoproterozoic are recorded by the compositions of arc lavas, and that P/Nd ratios of modern arc lavas are therefore not typical of those that erupted over most of Earth history. Secular changes in arc lava composition must be taken into account when using active subduction zones to investigate the growth of the continental crust.