Triple Oxygen Isotope Investigation of Granites Through Time in Comparison with Coeval Shales

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We report analyses of 69 granites, TTG, and large-volume ignimbrites from around the world that range in age from 4 Ga to modern. Most studied granites are orogenic and anatectic in origin and represent large volume remelts of metasedimentary crust, thus recording its average composition. They develop a significant progressive increase in $\delta^{18}O$ values from 6-7‰ (4-2.5 Ga) to 10-13‰ (2-1 Ga) after which $\delta^{18}O$ stay constant or even decrease. We additionally observe a moderate 0.04‰ step-wise decrease in $\Delta'^{17}O$ between 2.1 and 2.5 Ga, which is about half of the step-wise decrease observed in shales over this time interval (1). We also report new results from Phanerozoic shales that complete our Precambrian record, and consider reasons of temporal mid-Phanerozoic $\delta^{18}O$ decrease. We suggest that granites, as well as shales, record the significant advent and greater volumetric appearance of low-$\Delta'^{17}O$, high-$\delta^{18}O$ weathering products (shales) altered by meteoric waters upon rapid emergence of large land masses at ~2.4 Ga (1). These weathering products were incorporated into 2.1-1.8Ga orogens around the world, passing they isotopic signature to granites. Additionally, the earliest 3.0-4.0Ga crust and TTGs require involvement of hydrothermal products with lower-$\Delta'^{17}O$ at moderately high-$\delta^{18}O$, likely due to secondary silicification of the protoliths before partial melting.

We also investigated bulk $\Delta'^{17}O$ and $\delta^{18}O$ values during diagenetic transformation of weathering products into shales, using a 5km deep Texas coast drillholes. We found no bulk isotopic change from shallow smectite-rich unconsolidated sediments, to deep illite-rich shales. This suggests that shales inherit and preserve weathering-derived low-$\Delta'^{17}O$ and high-$\delta^{18}O$ signatures, thus reflecting surface water isotopic values and temperature of weathering. Rock cycle passes these signature from sediments to sedimentary, then metasedimentary, high-grade metamorphic to anatectic igneous rocks. Continental crust became progressively heavier in $\delta^{18}O$, lighter in $\Delta'^{17}O$ due to putative accumulation of high-$\delta^{18}O$ sediments, scrapped in accretionary wedges. Second-order trends are due to supercontinent cycles and glacial episodes.

[1]Bindeman IN et al. (2018) Nature 557: 545