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Coevolution of the sedimentary and granite phosphorus records

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Phosphorus plays a critical role in both surface biological cycles as an essential nutrient and in magmatic systems as the backbone for trace element-rich phosphate minerals. Phosphorus cycling between sedimentary and igneous systems throughout Earth history has had potentially profound effects on biogeochemical cycles [1,2]. Here we present a literature compilation of phosphorus concentrations in strongly peraluminous granites (SPGs) from the past 3.5 billion years, which have been previously interpreted as the products of partial melting of sedimentary rocks. Phosphorus contents of SPGs with source regions of latest Neoproterozoic (<~720 Ma) to Phanerozoic age are on average higher than that of those with older sources, mirroring a previously documented increase in the phosphorus contents of marine siliciclastic sediments [3]. After consideration of the effects of metamorphic, partial melting, and igneous differentiation processes on SPG phosphorus contents, we conclude that low phosphorus contents in SPGs with >720 Ma source rocks are most parsimoniously explained as resulting from low phosphorus contents in their source rocks. Our SPG compilation both confirms observations from the marine sedimentary record and provides an alternative archive in that SPGs integrate large volumes of continental shelf to slope sedimentary rocks. We document a clear shift in the crustal phosphorus cycle with the initiation of enhanced recycling of sedimentary phosphorus into the igneous crust, where it can be again weathered and returned to the ocean to fuel further photosynthesis. Further, through new trace element analyses of zircon from Archean and Proterozoic SPGs, we demonstrate that the phosphorus content of zircon should be used cautiously to identify zircon that crystallized from peraluminous versus metaluminous melts. Melt phosphorus contents exert an important control, but as shown here, vary temporally in SPGs. Our results highlight how changes in biogeochemical cycling can be imprinted on the igneous rock record, and in turn, fundamentally influence our interpretation of it.

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