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Genesis of strongly peraluminous granites facilitates nitrogen retention in the crust

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Sediments/sedimentary rocks are a major sink of atmospheric N_2, which can be fixed into diazotrophic biomass and recycled into other organic matters or diagenetically transferred (in the form of NH_4^+) into the crystal structures of phyllosilicate minerals in sediments. Driven by tectonic activities, sedimentary rocks may experience various degrees of metamorphism with some eventually being melted to form S-type granitoids. The destiny of sedimentary N during these processes, i.e., retained in the crust or returned to the atmosphere, determines the long-term N evolution in the crust and the atmosphere, which profoundly impacts not only volatile properties in the lithosphere but also the surface climatic and environmental conditions. Previous studies have reported various extents of N loss (from very subtle to up to 70%) from regional meta-sedimentary rocks. However, detailed studies on the N-losing mechanism during crustal anatexis and S-type granitoid formation are rare. Here, we examined the Permian–Triassic strongly peraluminous granites (SPGs) in the Diancangshan-Ailaoshan area in SW China, which were formed by extensional decompression melting of the Precambrian pelitic sediments in a back-arc basin. The results show that the SPGs have relatively high N contents with a narrow range of 26–58 ppm, with $\delta^{15}N$ mostly falling into a small range from 0.0‰ to +3.1‰ (mean = +2.3 ± 1.8‰; 1σ; n = 20). Compared with the Precambrian sedimentary rocks, these SPGs contain statistically at least an order of magnitude less N. Data modeling suggests that magmatic N_2 degassing preponderates metamorphic N devolatilization for the major N loss, consistent with the observation on sediment-derived PGs in subduction-zone settings. Interestingly, further compilation of the N contents of global granitoids show that SPGs contain 2–4 times higher N than non-SPGs, suggesting higher N retention capability of SPGs. This can be attributed to the crystallization of hydrous peraluminous minerals (micas in particular, which have higher N-hosting capacities) in the H_2O-rich strongly peraluminous melts. We further estimated the N inventory in SPGs as $0.9^{\pm 0.5} \times 10^{17}$ kg N, which accounts for 4–9% of the N budget in the upper continental crust.