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Insights into nitrogen dynamics during partial melting: case studies from the Anatectic Complex of Toledo, Tormes Dome, and Adamello Pluton migmatites.

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The behavior of nitrogen (N) during partial melting remains largely unknown, with few studies yielding contrasting results [1,2,3]. Furthermore, little research has been conducted on migmatites, particularly at the leucosome-restite level where N partitioning and isotopic fractionation between mineral-melt-fluid interactions can be elucidated. In this study, we examined leucosome-melanosome pairs of metapelitic and metagranitic rocks from Spain and Italy that experienced partial melting under low- to high-temperature and low-pressure conditions (0.3–0.6 GPa; 690–800 °C; [4,5]) with the goal of assessing N behavior during partial melting. These samples provide insight into N fractionation related to differing melting mechanisms, including extensional anatexis (incomplete biotite dehydration melting) in the Anatectic complex of Toledo [4], isothermal exhumation (muscovite dehydration melting) in the Tormes Dome anatectic region [4], and contact metamorphism (fluid-fluxed partial melting) in the Adamello pluton contact aureole [5]. $\delta^{15}N$ is shifted between restite and leucosome (0.7-5.3‰) regardless of the melting mechanism. Isotopic shifts were more pronounced in the low-pressure, low-temperature metapelitic samples (3.2-5.3‰) compared to the low-pressure, high-temperature metagranites (0.7-1.2‰), consistent with $\delta^{7}Li$ and $\delta^{11}B$ systematics [4]. Leucosomes consistently contain less N than restites or host-rocks (related in part to mineralogy), but the directions of the isotopic shifts vary. Nitrogen preferentially partitioned into the restite phase or migrated into fluid rather than being incorporated into the melt, consistent with mineralogy and previous findings [6]. The $\delta^{15}N$ isotopic shift and direction observed in the Adamello pluton (fluid-mediated melting) agrees in magnitude and direction with those reported for the Ivrea zone, NW Italy, where infiltration by low-N fluids was proposed [3]. These results largely indicate N isotope disequilibrium during partial melting between melts and restite/protoliths, likely influenced by varying oxygen fugacity conditions. Moreover, they bear important implications for understanding the distribution and mobility of N within the continental crust.

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