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Terrigenous Sediment Contribution to Granitoid Magmatism: Evidence from Garnet-Bearing Diorites, Central Qilian Belt, China

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Significant amounts of compositionally diverse sediments are subducted into the mantle, yet identifying the geochemical fingerprints of recycled terrigenous material and tracking their fate is key to deciphering the evolution of the silicate earth. Here, we examine Early Paleozoic garnet-bearing diorites from the western Central Qilian Belt, China, integrating geochronological, geochemical, and isotopic data to constrain magma evolution and assess the contribution of subducted sediments. U-Pb zircon dating constrains emplacement of the garnet-bearing diorite to ~508 Ma. Petrographic observations and mineral compositional analyses indicate that the garnet in the diorite is of magmatic origin. Geochemically, the diorite shows a metaluminous character, with A/CNK values of 0.6–1.1. It is characterized by relatively low SiO_2 contents (46.2–61.7 wt.%, averaging 53 wt.%), moderate total alkalis ($Na_2O + K_2O$ = 3.8–6.6 wt.%), and comparatively high MgO (2.5–8 wt.%) and FeOT (6.5–11.7 wt.%) contents. The initial Sr ratios (ISr) range from 0.7047 to 0.7049, while εNd(t) and εHf(t) values vary from +1.7 to +4.2 and +11 to +15, respectively. These characteristics, together with Rhyolite-MELTS modeling, indicate that the diorite formed through hydrous fractional crystallization of mantle-derived magma, accompanied by the incorporation of slab-derived sediment melts. Trace element and isotopic modeling, coupled with high Th/Yb and La/Sm ratios and comparatively low Nd/Hf ratios, indicate the involvement of terrigenous sediment components, suggesting that about 1–2% sediment-derived material was added to the mantle source. Collectively, these findings indicate that the studied rocks experienced subduction-related metasomatism driven by terrigenous sediment melts, followed by partial melting and subsequent differentiation of juvenile magma.