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Magmatism During the Exhumation in the Northern Qinghai-Tibet Plateau: Evidence from Granitoids and Enclaves in Dulan area

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The North Qaidam terrane, known as an ultra-high pressure (UHP) metamorphic belt located at the northern margin of Qinghai-Tibet plateau, is a collisional orogen recording the early Paleozoic oceanic subduction and continental collision between the Qaidam and Qilian blocks. Abundant exhumation-related magmatism, with mantle material participation or contamination in different degrees, has been observed in North Qaidam. However, none of any post-collisional exhumation-related mantle-derived magmatism has been reported. In this study, whole-rock major-trace elements and Sr-Nd isotopes and zircon U-Pb ages are reported for the granodiorites and its mafic microgranular enclaves (MMEs) from the Dulan area, East segment of North Qaidam. The emplacement age of the granodioritic pluton has been constrained by zircon U-Pb age of 405 ± 2 Ma, which is consistent with the exhumation age of UHP metamorphism and closed to the age of post-collisional magmatism and extensional molasses in this area. The enclosed MMEs present a coeval U-Pb age of 402 ± 3 Ma. Combined with the previous researches, we propose that the main period of the plate exhumation started at the age of ca. 400 Ma, and ceased at ca. 382 Ma. The granodiorites present mainly calc-alkaline and metaluminous with A/CNK of 0.97-1.03 and 0.78-0.96, respectively. The granodiorites are characterized by enrichment in LREE and nearly flat in HREE ($(La/Yb)_N = 15.19-23.41$), with relatively enriched large ion lithophile elements (LILE) on chondrite- and primitive mantle-normalized diagrams. These characteristics, which are consistent with post-collisional magmatism geochemical signatures and the counterparts of their neighboring gneiss, indicating that the granodiorites either share analogical source region with the neighboring gneiss or formed by partial melting of the gneiss. Whole-rock $\epsilon_{Nd(t)}$ values of -1.21 to -0.97 and two

stage Nd model ages of 1.23-1.25 Ga indicate the granodiorites are derived from a Meso-proterozoic lower continental crust. In addition, the MMEs present fine-grained igneous textures with disequilibrium textures and contain acicular apatite. The MMEs are also enriched in LILE and LREE but flat HREE with lower $(La/Yb)_N$ of 3.55 to 14.26. Whereas whole-rock $\epsilon_{Nd(t)}$ values of MMEs range from -0.72 to 1.79 with two stage Nd model ages of 1.00-1.21 Ga. We infer that the MMEs are derived from a Neo-proterozoic mantle source which has been contaminated with the granodioritic melt. The geochemical characteristics of the MMEs documents 400 Ma $\pm$ mafic magmatism existing in this area, which may have some evolutionary relationship with the synchronous granitic magmatism.

Key words: exhumation, mafic microgranular enclaves, North Qaidam, U-Pb zircon age, isotope geochemistry

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