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The nature and history of the Qilian Block in the context of the development of the Greater Tibetan Plateau

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The Greater Tibetan Plateau is a geological amalgamation formed by several continental collision events from northeast in the Early Palaeozoic towards southwest in the Cenozoic. Compared to the youngest India-Asia collision event ($\sim$ 55 Ma), the earlier events to the north are not well understood, especially the earliest Qilian-Qaidam system at the northern margin. Understanding the petrogenesis of the Paleozoic granitoids in the Qilian Block (QB) helps understand the nature and history of the block, while also offering new perspectives on its sutures to the north (the North Qilian Orogenic Belt) and to the South (the North Qaidam Ultra-High Pressure Metamorphic Belt).

Granitoids in the QB were sampled from several intrusions in two areas: Huangyuan (HY) and Gangcha (GC). All the samples are calc-alkaline varying from mafic-diorite to granite. Most of the HY samples are peraluminous containing Al-rich phases. The GC samples can be divided into two groups (fine-grained group with amphibole and coarse-grained without amphibole). Most HY samples are enriched in LREEs with flat HREE patterns (Group A). A garnet-bearing HY sample has elevated HREEs. Another three adakitic samples are depleted in HREEs with negative εHf(t) (-12$\sim$-11), indicating a deep crustal origin. The coarse-grained GC samples have similar REE patterns to HY group A while fine-grained samples have flat REE patterns with a stronger negative Eu anomaly.

Zircons in all these samples are of magmatic origin but age data scatter along the Concordia and do not give “well-constrained” crystallization ages within a single sample. We adopt the histogram and identify the crystallization age with a peak at $\sim$450 Ma. The ages of inherited zircons range from $\sim$ 500 Ma to $\sim$ 2600 Ma. The more peraluminous samples tend to have older inherited zircons, pointing to the greater old crust contribution. The older Proterozoic and Archean ages recorded in inherited zircons reveal the complex histories of the QB, which is likely a micro-continent or fragment of an ancient continent probably drifted from the Yangtze Craton.

The initial whole-rock Sr-Nd-Pb-Hf isotopes of these samples vary significantly, e.g., εHf(t) (-15$\sim$+3), εNd(t)(-14.6$\sim$+2.6), radiogenic Pb_i($^{206}Pb/^{204}Pb_i$: 18.20$\sim$20.63) and I_{Sr} (0.7051$\sim$0.7606). εHf(t) is negatively correlate with A/CNK indicating more peraluminous samples have more crustal contributions. Taken all the data together, we conclude that these granitoids are genetically associated with continental collision with varying amount of mantle input and contributions of heterogeneous basement rocks of the QB. Furthermore, the significantly correlated εHf(t) - εNd(t) variation is consistent with these granitoids being formed as the result of melting-induced mixing process. The crustal melting is most likely accomplished through heating by mantle derived basaltic melts, which in this context may be associated with seafloor subduction. Varying extents of melting of the crustal rocks with varying age/isotopic composition will give the observed compositional variability of the granitoids and the εHf(t) - εNd(t) correlation also reflects the mantle melt contributions as well as the different crustal lithologies of varying histories.

As discussed above, the QB has the affinity of the Yangtze Craton and underwent $\sim$450 Ma magmatism in a subduction/collision environment.