Petrogenesis of the Ulungur Intrusive Complex, NW China, and Implications for Crustal Generation and Reworking in Accretionary Orogens

Gong-Jian Tang\textsuperscript{1,2}, Qiang Wang\textsuperscript{1,2}, Derek Wyman\textsuperscript{3}, Wei Dan\textsuperscript{1,2}, Lin Ma\textsuperscript{1}, Hai-Xiang Zhang\textsuperscript{1}, and Zhen-Hua Zhao\textsuperscript{4}

\textsuperscript{1}State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
\textsuperscript{2}CAS Center for Excellence in Tibetan Plateau Earth Science, Beijing 100101, China
\textsuperscript{3}School of Geosciences, The University of Sydney, NSW 2006, Australia
\textsuperscript{4}Key Laboratory of Mineralogy and Metallogeny, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

Accretionary orogens are characterized by voluminous juvenile components (recently derived from the mantle) and knowing the origin(s) of such components is vital for understanding crustal generation. Here we present field and petrological observations, along with mineral chemistry, zircon U–Pb age and Hf-O isotope data, and whole rock geochemical and Sr-Nd isotopic data for the c. 320 Ma Ulungur intrusive complex from the Central Asian Orogenic Belt. The complex consists of two different magmatic series: one is characterized by medium-K to high-K calc-alkaline gabbro to monzogranite; the other is defined by peralkaline aegirine-arfvedsonite granitoids. The calc-alkaline and peralkaline series granitoids have similar depleted mantle-like Sr-Nd-Hf isotopic compositions, but they have different zircon $\delta^{18}$O values: the calc-alkaline series have mantle-like $\delta^{18}$O values with mean compositions ranging from 5.2 ± 0.5‰ to 6.0 ± 0.9‰ (2SD), and the peralkaline granitoids have low $\delta^{18}$O values ranging from 3.3 ± 0.5‰ to 3.9 ± 0.4‰ (2SD). The calc-alkaline series were derived from a hydrous sub-arc mantle wedge, based on the isotope and geochemical compositions, under garnet peridotite facies conditions. This study suggests that the magmas underwent substantial differentiation, ranging from high pressure crystallization of ultramafic cumulates in the lower crust to lower pressure crystallization dominated by amphibole, plagioclase and minor biotite in the upper crust. The peralkaline series rocks are characterized by $\delta^{18}$O values lower than the mantle and enrichment of high field strength elements (HFSEs) and heavy rare earth elements (HREEs). They likely originated from melting of preexisting hydrothermally altered residual oceanic crust in the lower crust of the Junggar intra-oceanic arc. Early crystallization of clinopyroxene and amphibole was inhibited owing to their low melting temperature, leading to HFSEs and HREEs enrichment in residual peralkaline melts during crystallization of a feldspar-dominated mineral assemblage. Thus, the calc-alkaline and peralkaline series represent episodes of crust generation and reworking, respectively, demonstrating that the juvenile isotopic signature in accretionary orogens can be derived from diverse source rocks. Our results show that reworking of residual oceanic crust also plays an important role in continental
crust formation for accretionary orogens, which has not previously been widely recognized.