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Geochemical and geochronological studies on two bimodal magmatism in the eastern Tianshan Belt, Northwest China and implications for the Later Paleozoic tectonic evolution

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The Early Carboniferous to Permian marks an important phase of terrane amalgamation through accretion–collision in the Central Asian Orogenic Belt (CAOB). In the Bogda–Harlik area, we identified two episodes of Late Paleozoic bimodal suites formed during Early Carboniferous and Early Permian. We present the petrological, geochronological, geochemical and whole rock Sr–Nd isotopic compositions of the Late Paleozoic bimodal volcanic rocks in an attempt to trace the possible mechanisms for the generation of the bimodal volcanic suites.

The Hongshankou suites (Early Carboniferous) yield crystallization ages of 347.1±3.9 Ma whereas those from the rhyolites are dated as 344.4±1.9 and 345.0±2.5 Ma. The major and trace element signatures of basalts suggest high alumina basalt (HAB) as the source magma which was generated from metasomatised asthenosphere mantle. Both the mafic and felsic rocks are enriched in light rare earth elements (LREE) and large ion lithophile elements (LILE), and are depleted in high field strength elements (HFSE). Broadly homogenous Rb–Sr and Sm–Nd isotopic compositions of mafic and felsic rocks are also characteristic. The basalts display a distinct enrichment in incompatible elements and positive εNd (345 Ma) (from +5.87 to +8.25). We envisage a subduction related origin to account for the LILE enrichment with arc-like melts (enriched in Th and LREE and depleted in Nb,with εNd(345 Ma)>+6) produced through the partial melting of a depleted-mantle source, and the involvement of minor crustal component. The rhyolites also display high εNd (345 Ma) (from +6.35 to +8.53). Consequently, we suggest a mixing process between a source similar to mid-ocean ridge basalt (depleted end-member mantle) and arc-like magmas for the petrogenesis of the mafic rocks, whereas the rhyolites are best interpreted to have formed by fractional crystallization from the parental magma of the basalts. Several lines of evidence from elemental and isotopic geochemistry suggest a close genetic relationship between the mafic and felsic rocks in the Hongshankou bimodal suites. We propose that the essentially bimodal character of this complex reflects the features of back-arc extensional magmatism, induced by Junggar plate subduction during the Late Paleozoic.

The post-collisional event (Early Permian) generated an E–W trending bimodal volcanic zone that extends for ca. 500 km from the southern Bogda Mt. to the easternmost Tianshan Belt. Here we report the petrology, geochemistry and geochronology of the bimodal volcanic rocks to characterize the post-collisional tectonic evolution in Late Paleozoic. The major element chemistry of the basalt and rhyolite samples indicates a bimodal high-K calcalkaline affinity. The basalts are characterized by high abundance in TiO2, Th, U and Pb and depletion in Nb, Ta and P, together with slight enrichment in LREE contents and low HFSE/LREE ratios. The rhyolites show a close affinity to aluminous A-type granites, with enrichment in K+Na, Zr, Ce, Y, and depletion in P, Nb, Ta and Ti. They also exhibit fractionated REE

patterns with prominent negative Eu anomalies. The petrographic and geochemical data suggest that this bimodal rock series was generated in a post-collisional setting. The mafic rocks are likely derived from a metasomatized lithospheric mantle. Assimilation of different crustal components played a minor role in the genesis of these basaltic rocks. The LA-ICP-MS analysis on zircons from four rhyolites and two basalts yielded similar ages ranging from 295.8±2.8 to 293.3±1.7 Ma, suggesting an Early Permian event. Zircons from the basalts show a wide εHf(t) range from −0.49 to +13, whereas those from the rhyolites show two groups of εHf(t) values: from −5 to 3 and from 6 to 12, suggesting a mixing of crust–mantle material. The magmatic zircons from the bimodal volcanic rocks yielded two peaks of TDM2 between 600–820 Ma and 1160–1360 Ma, probably representing two significant episodes of continental crust growth. The bimodal volcanic rocks are correlated with the early stage of post-collision.