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Subduction initiation of the SE Paleo-Asian Ocean: Evidence from a well preserved intra-oceanic forearc ophiolite fragment in central Inner Mongolia, North China

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Subduction of oceanic lithosphere is the primary driver of plate tectonics on Earth. However, one of the least understood aspects of plate tectonics is how subduction zones initiate, due to the lack of recognition of subduction initiation records in many ophiolites. Here we report a newly recognized complete magmatic record including Early Carboniferous fore-arc basalts (FABs), transitional lavas and boninites in the Diyanmiao ophiolite zone in central Inner Mongolia, North China. The stratigraphy and chemo-temporal relations of the suite are identical to those of the Izu–Bonin–Mariana (IBM) forearc as well as the ophiolite suites associated with subduction initiation. In Diyanmiao, the FABs overlying gabbroic rocks of the ophiolite, and underlain by transitional lavas and boninites from bottom to top. Zircon U–Pb geochronology of the FABs shows a mean age of 335.6±2.6 Ma. The boninites (~328 Ma) are strongly porphyritic with skeletal olivine crystal, clinopyroxene and orthopyroxene phenocrysts. The major and trace element and Sr–Nd isotopic characteristics of FABs, transitional lavas and boninites in the Diyanmiao ophiolite are comparable to those of corresponding rocks in the IBM forearc. The FABs display compositions similar to those of the most depleted mid-ocean ridge basalts (MORB), but with lower Ti/V ratios, suggesting slightly higher concentrations of fluid-soluble elements than MORB. The Diyanmiao transitional lavas have transitional compositions between FABs and boninites, and have higher large ion lithophile elements (LILEs) and lower high fifield strength elements (HFSEs) than FABs. The boninites are characterized by significant depletion of Ti, heavy rare earth element (HREE), and HFSE and are more LILE-enriched. This volcanic sequence is akin to that in the Mariana forearc, suggesting that the Diyanmiao FABs might record initial volcanism associated with subduction initiation in the southeastern Paleo-Asian Ocean during Early Carboniferous (~335.6 Ma). We infer that the primary magmas of the Diyanmiao FABs were generated by partial melting of upwelling mantle associated with decompression during forearc spreading with little or no slab input. Progressive subduction of the Paleo-Asian oceanic slab (ca. 328 Ma), and flushing by slabderived hydrous fluids resulted in melting of the more depleted, residual mantle at (probably) shallower levels generating the boninites.