

Early Paleoproterozoic oceanic subduction in the southern margin of North China Craton: Constraints from zircon U–Pb geochronology, geochemistry and Sr-Nd-Hf isotopes of ca. 2.3 Ga mafic intrusions

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The magmatic shutdown (2.45–2.20 Ga) is a special era of the Paleoproterozoic, during which there are few reports of magmatic activity, leading to great controversy on the tectonic evolution of North China Craton (NCC). The Jingwan diorites intruded the Songshan Group and yield a concordant ²⁰⁷Pb/²⁰⁶Pb age of 2301 ± 16 Ma, which is the only ~2.3 Ga mafic intrusion found in the southern margin of North China Craton (S-NCC) by far. These rocks belong to low-K tholeiitic series with relatively low contents of K₂O (0.1–0.7 wt.%) and total alkalis (Na₂O + K₂O) from 2.4 to 4.7 wt.%. They show low SiO₂ contents (44.8–54.1 wt.%), slight variable Fe₂O₃^T (10.1–14.4 wt.%), Al₂O₃ (14.8–17.0 wt.%), CaO (5.5–10.6 wt.%), and medium to high contents of MgO (6.1–10.8 wt.%) with Mg# values of 58–65. The mafic intrusions display slight LREE enrichment ((La/Yb)_N = 3.02–3.58) without obvious Eu anomaly (Eu/Eu* = 0.87–1.18). All samples are characterized by obvious depletion in Nb, Zr and Ti and enrichment of Ba with features of island arc magma. The order in which different crystals start to fractionate is clinopyroxene then orthopyroxene followed by plagioclase. They also exhibit variable εNd values range from –0.2 to +0.8 and zircon εHf(t) values from –3.0 to +6.6. These features suggest the mafic intrusions are formed by ~10%–30% partial melting of a garnet-spinel lherzolite and derived from an enriched lithospheric mantle source metasomatized by slab-derived fluids at shallow depth levels. Combined with previous regional geological data, we propose an arc-related environment for the formation of the mafic intrusions from S-NCC, possibly related to the subduction of ocean floor between the Western Block and Eastern Block of NCC, and that the subduction lasted continuous likely from ~2.5 Ga to ~2.3 Ga, with at least 200 Ma.