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Tectonic Environments of the Yan-Liao Rift during Earth's Middle Age (1.7~0.75 Ga): Evidence from Mafic Dyke Swarms in Eastern Hebei, North China

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During the past decade, generations of Precambrian mafic dykes/sills have been investigated and revealed in the North China Craton (NCC). Researchers identified more than 20 episodes of Precambrian dyke swarms, which have significantly improved our understanding of the tectonic evolution of the NCC (Peng, 2015 and references therein). Three-stage Proterozoic mafic dyke swarms are identified in the periphery of the Yan-Liao rift in eastern Hebei Province, all of which are diabase and intruded the Archean basement with clearly chilled margins. Precise U-Pb SIMS analysis yields ²⁰⁷Pb/²⁰⁶Pb weighted average ages of 1677±12 Ma (baddeleyite), 1236±7 Ma (baddeleyite), and 775±5 Ma (zircon) for three representative dykes, which are interpreted as their crystallization ages. These dykes are referred to as the Tujiagou (~1680 Ma; NW trending, >20 m wide for each), Maojiagou (~1230 Ma; 0°–10° trending, ~40 m wide), and Dingjiagou (~775 Ma; ~70° trending, 12–20 m wide) dyke swarms, respectively.

All these dykes show typical ophitic texture and their mineral assemblages are mainly composed of plagioclase and clinopyroxene, with various degrees of epidotization, chloritization, and uraltization. Based on whole-rock chemistry of these dykes, little crustal contamination was supposed to be involved during their emplacement. They are tholeiitic (for the 1680 Ma and 775 Ma dykes) and alkaline (for the 1230 Ma dykes) in compositions. The Tujiagou dykes (1680 Ma) have low Mg# (44–46) and have experienced clinopyroxene- and plagioclase-dominated fractional crystallization. They have (La/Yb)_N of 5.3–7.7 and are depleted in some HFSEs, such as Zr and Hf, with the ε_{Nd}(t) value of -1.9. The Maojiagou dykes (1230 Ma) show relatively higher Mg# (51–57) and have experienced plagioclase-dominated fractional crystallization with the crystallization of Fe-Ti oxides

resisted. The dykes exhibit light REE enrichment ((La/Yb)_N = 6.48–12.8) and slight or no depletion in HFSEs. Both the 1680 Ma and 1230 Ma dykes exhibit similar ε_{Nd}(t) values (-1.9 to 1.3). All these features indicate similar depleted mantle sources for both swarms. The Dingjiagou dykes (775 Ma) have Mg# of 47–60 and have experienced plagioclase-dominated fractionation. They also present significantly negative Ce- anomalies and show medium light REE enrichment ((La/Yb)_N = 2.3–4.12) and deplete in HFSEs (such as Nb, Ta, Zr, etc.) with ε_{Nd}(t) values of -7.2 to -5.1. We suggest that they could be originated from the metasomatized sub-continental lithospheric mantle.

The 1680 Ma Tujiagou dykes are coeval and chemically similar to and could be equivalents of the Laiwu dykes in Luxi area (west Shandong province) (Li et al., 2015). The 1230 Ma Maojiagou dykes are similar to some other 1240–1210 Ma mafic dykes/intrusions in several regions of the NCC. The 775 Ma Dingjiagou dykes are newly reported. These dyke swarms occurred in the adjacent areas of the Yan-Liao rift, and could represent a long-living (from ~1730 Ma to ~775 Ma) and stepwise opening rift in the northern parts of the craton. These dyke swarms could be potential geological records that were dismembered during the breakup of supercontinents in the Middle Age (1700–700 Ma) and the markers for paleogeographic reconstruction. Specifically, the 1230 Ma dykes and the synchronous Sudbury dykes in Laurentia (Shellnutt and MacRae, 2011) could be parts of a large igneous province, and the NCC was neighboring the Laurentia till ~775 Ma. However, this hypothesis awaits more data, especially paleomagnetic study.

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