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Origin of basaltic magmas from the Neoarchean Qingyuan greenstone belt in the Eastern Block, North China Craton: Implications for geodynamic evolution

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Archean granite–greenstone terranes are composed in large part of granites and grey gneisses (tonalite–trondhjemite–granodiorite gneisses, TTG), and supracrustal remnants comprise the remainder. Supracrustal remnants, generally referred to as greenstone belt, are composed dominantly of mafic volcanic rocks engulfed in a sea of Archean granitic rocks. A well understanding of the origin of the granite–greenstone terranes is not only critical to deciphering the Archean geodynamic evolution, but also has important implications for the processes by which continental crust has grown. Without exception, Neoarchean granitic rocks occupy volumetrically at least 70% of the exposed Precambrian crystalline basement of the North China Craton. Furthermore, recent investigations laid great emphasis on the geochemistry, geochronology, isotope and metamorphism of the grey gneisses, and proposed two major tectonic models including a magmatic arc environment and a mantle plume model. However, it should be noted that these granitic magmas are produced by partial melting of crustal materials, and may give ambiguous tectonic implications, so these models need to be augmented with other petrological and geochemical data.

The Neoarchean basaltic rocks are well exposed in the Qingyuan greenstone belt, the northeastern part of the North China Craton. These rocks provide important insights into the mantle process and geodynamic setting of the NCC in the Neoarchean. However, few geochemical, geochronological or isotope researches have been done on them, particularly lack of a combination of these approaches. In this contribution, we present systematic whole-rock geochemical, Sm–Nd isotope, and zircon U–Pb geochronological studies on the Neoarchean basalts in the Qingyuan greenstone belt. The Qingyuan greenstone belt consists of three rock units, with (i) a komatiite–tholeiite sequence in the lower part (Shipengzi Formation), (ii) a calc–alkaline sequence in the middle (Hongtoushan Formation), and (iii) a volcanic–sedimentary sequence in the upper part (Nantianmen Formation), similar to the well preserved and exposed Barberton greenstone belt in the eastern part of the Kaapvaal Craton. Zircons from the basaltic rocks are equant to stubby prismatic and range from 50 to 130 μm in size, classified as the magmatic and metamorphic ones. (a) Most grains exhibit obscure internal textures in CL images and high Th/U ratios (>0.1), indicative of mafic magmatic rocks. The eruption age of the protoliths of the meta-basalts could be fixed at ca. 2.51 Ga, which are comparable to those of the Archean granitic rocks, thus suggesting a synchronism for the two rock units. (b) Our new U–Pb age data of the metamorphic zircons place a good constraint on the timing of the regional metamorphism. Zircon grains from the meta-basalts show relatively dark CL images, with patchy zoning or irregular structures and low Th/U ratios (<0.1). These features suggest that they should be formed during a process of fluid-present metamorphism, and their U–Pb ages of 2.46 Ga represent the metamorphic age. The metamorphic volcanic rocks in the Qingyuan greenstone belt formed at ca. 2.51 Ga, which was coeval with the emplacement of the Archean granitic rocks. These rocks were subsequently deformed and metamorphosed at ca. 2.46 Ga, followed by the emplacement of post-tectonic potassium granites. The basaltic rocks belong to high-Fe tholeiite. Two kinds can be recognized: the enriched one with relatively high La/Yb and Zr/Nb, and the depleted with low La/Yb and Zr/Nb. The basaltic rocks experienced significant fractional crystallization and minor crustal contamination during magma evolution. The

enriched basaltic rocks are supposed to represent partial melts from a fertile cratonic sub-continental lithospheric mantle source and the depleted to mainly derive from deep mantle source (OIP source) with minor contributions from the lithospheric mantle source. The large volume of ca. 2.5 Ga mafic rocks over the whole Eastern Block (e.g., in the Qingyuan greenstone belt) suggests that ca. 2.5 Ga is another major crustal growth event except for the ca. 2.7 Ga crustal growth event. In the present state of knowledge, the mantle plume model appears as the most likely geodynamic interpretation of the Qingyuan greenstone belt.

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