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Metamorphism of the Northern Liaoning Domain: Implications for the Tectonic Evolution of the Archean Basement Rocks of the Eastern Block, North China Craton

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As one of the areas where typical Early Precambrian continental crust is exposed, the Northern Laioning Domain located in the North China Craton principally comprises pretectonic tonalitic-trondhjemitic- granodioritic gneisses, syntectonic granitoids and supracrustal rocks. The supracrustal rocks are named the Qingyuan Group and consist of interbedded plagioclase amphibolite, hornblende granulite, biotite granulite and BIF. However, the formation of the Archean basement rocks of the Northern Liaoning Domain is still controversial. One school of thought suggests that the metamorphism of the basement rocks was caused by a typical arc-continent collision and thus the Northern Liaoning Domain is part of a huge orogenic belt of the Late Archean in the east of North China Craton (NCC), while the others propose that the tectonic mechanism should be related to the intrusion and underplating of huge amounts of mantle-derived magmas occurring in the Eastern Block of the North China Craton in the Late Archean.

In order to place more constraints on the tectonic setting and history of the Eastern Block of the North China Craton, this study discusses its tectonic evolution in the Late Archean with the petrological data, geochemical data and an inferred P-T path of the plagioclase amphibolites from the Northern Liaoning Domain. The petrological evidence from the plagioclase amphibolites define three metamorphic mineral assemblages (M1 to M3). The early prograde assemblage (M1) is preserved as mineral inclusions, represented by hornblende + plagioclase + quartz + actinotite + epidote, within garnet poikiloblasts. The peak assemblage (M2) is indicated by assemblages of garnet + clinopyroxene + plagioclase + quartz. The post-peak assemblage (M3) is characterized by garnet + quartz symplectite surrounding clinopyroxene. Different from the previous research in the metamorphic history of the Northern Liaoning Domain, a more precise method, pseudosection modeling by using a computer software THERMOCALC, was used for calculating the P-T conditions of a representative sample from the plagioclase amphibolites in the Na_2O-Cao-FeO-MgO-Al_2O_3-SiO_2-H_2O-TiO_2-O (NCFMASHTO) system. By using X-Ray Fluorescence (XRF) analysis, the bulk composition (in mole basic) used for the construction is SiO_2: Al_2O_3: CaO: MgO: FeO: Na_2O: TiO_2: O = 56.5: 10.2: 13.2: 7.7: 8.2: 2.5: 1.0: 0.6, assuming that H_2O and quartz are in excess.

As a result, an anti-clockwise P-T path involving isobaric cooling is inferred for the three metamorphic mineral assemblages and their P-T conditions. This P-T path suggests that its origin should be related to the intrusion and underplating of huge amounts of mantle-derived magmas. Hence, by considering all the lithologic, structural, metamorphic, geochemical and geochronologic data, the tectonic history can be explained by a mantel plume (hotspot) model, i.e. initial heating the crust by the cooler plume head (M1), continuous heating by the upwelling of hot plume “tail” (M1) and final cease of the plume activity (M3). This tectonothermal event is accordant with the anti-clockwise P-T paths from the other Archean basement rocks in the Eastern Block of the North China Craton.