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Geochemistry and zircon U-Pb ages and Hf isotopes of TTG gneisses from the Huai'an Complex, Trans-North China Orogen and their implications

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Major advancements in understanding the formation and evolution of the North China Craton (NCC) have been made following recognition of the Trans-North China Orogen (TNCO), a Himalayan-type continent-continent collisional belt, along which the Eastern and Western blocks amalgamated to form the basement of the craton. In the past decade, researchers have carried out extensive geological investigations on the TNCO and produced large amounts of data and interpretations. Now there is a broad outline regarding the timing and processes that were operative during the amalgamation of the Eastern and Western blocks. However, it still remains unknown or controversial about the pre-collisional tectonic setting and detailed architectures of the TNCO. For example, whether or not did the TNCO develop from a magmatic arc? If yes, when did the subduction start to form the arc and what kind of magmatic arc it was, a continental marginal arc or an intra-oceanic arc? To resolve these issues, it is essential to carry out petrological, geochemical and geochronological studies on major lithologies in the TNCO, especially on the TTG gneisses that are widely exposed in the TNCO. It is the case with the Huai'an complex in which TTG gneisses are dominant lithologies, which forms the justification for this study in which we carried out extensive field-based geochemical studies and zircon U-Pb dating and Hf isotopic investigations on TTG gneisses in the Tianzhen-Xinpingbu area of the Huai'an Complex, which is situated in the northern part of the TNCO. Whole-rock geochemical analyses show that the protoliths of TTG gneisses from the studied area are analogous to the typical subducted oceanic crust-derived adakites, although in terms of SiO_2 composition, they have highly depleted HREE (heavy rare earth element). Positive or no anomalies of Eu, negative Nb, Ta, Ti anomalies and moderately positive Pb anomalies are consistent with their origin related to the partial melting of a basalt source dominated by amphibolite or eclogite. Their high Mg numbers indicate the involvement of mantle materials. Based on U–Pb zircon dating data, the igneous protoliths of TTG gneisses crystallized at 2512-2407 Ma, while the time of metamorphic zircon growth is 1869-1808 Ma. In addition, the TTG samples have positive epsilon Hf values of +0.6 to +4.4, close to values of the depleted mantle, indicating that magmatic protoliths were derived from the juvenile crust. Taken together, it can be inferred that the partial melting of subducted oceanic crust slab yielded the magmas of TTGs, which subsequently interacted with overlying mantle wedge during the ascent, suggesting a subduction environment for the TNCO where the igneous protoliths of TTG gneisses were emplaced during Late Neoarchean time through a subduction process that led to the final closure of an ancient ocean between the Eastern and Western blocks.

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