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SHRIMP zircon U–Pb ages and REE partition for high-grade metamorphic rocks in the North Dabie complex: Insight into crustal evolution with respect to Triassic UHP metamorphism in east-central China

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ABSTRACT

We present SHRIMP U–Pb ages and REE data for zircon of two granulites, a garnet pyroxenite and a clinopyroxene amphibolite from the North Dabie complex. The North Dabie complex is a major fault-bounded petrotectonic unit in the Dabie continental collisional orogen between the South and North China Blocks. Zircon REE data are applied to link ages to specific petrological processes. In addition to SHRIMP zircon U–Pb dating, measurements were made on monazites from a HP–UHT metapsammitic granulite. Metamorphic zircon grains and coeval overgrowths on detrital cores from one granulite yielded a weighted mean $^{207}Pb/^{206}Pb$ age of 2042 ± 7 Ma, corresponding to peak HP/UHT metamorphism. The zircon cores have well-preserved oscillatory, magmatic growth zoning and generated a range of $^{207}Pb/^{206}Pb$ ages from 2766 ± 8 Ma to 3089 ± 3 Ma, representing the detrital source. Concordant analyses of monazites from the same granulite sample yielded a weighted mean $^{207}Pb/^{206}Pb$ age of 2001 ± 6 Ma, which we interpret as the time of exhumation to the middle crustal level. A magnetite–orthopyroxene–garnet quartzite associated with a banded iron formation has a metamorphic zircon age of 2293 ± 7 Ma (granulite-facies) with a detrital core age of 2435 ± 28 Ma. These results are interpreted to indicate a composite affinity to the South China and North China Blocks for the ancient Archean–Paleoproterozoic crust in the North Dabie metamorphic rocks. The garnet pyroxenite, known as a typical HP–UHP granulite, contains a multiple, latest Permian to Triassic metamorphic zircon population with $^{206}Pb/^{238}U$ ages of ca. 254–253, ca. 242–226, ca. 210, and ca. 203 Ma. Along with published zircon and titanite U–Pb age data and mineralogical evidence, we suggest that the HP–UHP granulite evolved broadly synchronously with UHP eclogites during continental collision in the latest Permian to Triassic. In the garnet pyroxenite, there is also zircon inheritance of variable ages (ca. 291–2477 Ma), indicative of a probable sedimentary origin of the protolith; there also occur young, mid-Jurassic to Cretaceous zircons ranging in age between 165 and 112 Ma, signifying considerable crustal reworking in mid-Jurassic and Cretaceous times. Zircons from the clinopyroxene amphibolite have a weighted mean $^{206}Pb/^{238}U$ age of 780 ± 6 Ma representing the minimum time of protolith emplacement, and 133 ± 2 Ma for an anatectic event in the post-collisional stage. The age data of this amphibolite are similar to those of granitic gneisses/migmatites in the North Dabie complex. The new U–Pb zircon ages for the North Dabie rocks provide constraints on the affinity of collided crustal blocks, the metamorphic history of HP–UHP granulites, and post-collisional crustal reworking.

1. Introduction

Zircon geochronology of high-grade metamorphic rocks commonly aims to constrain the time scale of pressure–temperature (PT) evolution (e.g., Schmitz and Bowring, 2003) via dating crucial metamorphic zircon-forming reactions (Pan, 1997; Roberts and Finger, 1997; Degeling et al., 2001; Bingen et al., 2001; see also Harley et al., 2007 for an overview) as well as the protolith age of meta-igneous rocks (Kelly and Harley, 2005) and the provenance of detrital grains in metasediments (e.g., Hoskin and Ireland, 2000). In practice, the first-order task is to separate metamorphic zircons or metamorphic domains from inherited components, i.e. primary and variably recrystallized/metamorphosed, precursor zircons or zircon domains. To do this, significant progress has been made towards characterizing the internal texture and external morphology of metamorphic (Vavra et al., 1996, 1999; Kröner et al., 2000), magmatic (Hanchar and Miller, 1993; Corfu et al., 2003) and solidusly or subsolidusly recrystallized (Pidgeon, 1992; Pidgeon et al., 1998; Hoskin and Black, 2000) zircon. A metamorphic zircon or domain has a

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distinct internal texture and, by definition, is a newly crystallized grain, or an overgrowth on an inherited core. It precipitates from aqueous fluids or hydrous melts without inherited signature from the precursor (Vavra et al., 1996, 1999; Williams et al., 1996; Rubatto, 2002; Geisler et al., 2003, 2007; Zheng et al., 2006; Rubatto et al., 2008; Xia et al., 2009, 2010; Chen et al., 2010, 2011). However, notably subsolidus, fluid-assisted recrystallization of zircon was often confused with new metamorphic growth (e.g., Hoskin and Black, 2000). A solidusly or subsolidusly recrystallized zircon or domain inherently retains more or less the protolithic age memory dependent largely on the local physical and chemical environment (Pidgeon, 1992; Pidgeon et al., 1998) and hence is metamorphosed with partially reset components (e.g., solid-state and replacement recrystallization). In the extreme case, a coupled dissolution–reprecipitation process is involved at suprasolidus conditions during high-grade metamorphism, resulting in dissolution recrystallization of magmatic zircon with inheritance of some geochemical signatures from the precursor (Xia et al., 2009, 2010; Chen et al., 2011). Complementary to the textural distinction between metamorphic and metamorphosed zircons, diagnostic REE (Rare Earth Element) patterns have been documented for metamorphic (Schaltegger et al., 1999; Rubatto, 2002; Whitehouse and Platt, 2003), magmatic (Hinton and Upton, 1991; Belousova et al., 2002; Hanchar and van Westrenen, 2007) and recrystallized zircons (Xia et al., 2009, 2010; Chen et al., 2010, 2011). The most important mineral phase controlling the REE chemistry of metamorphic zircon is cogenetic garnet (Schaltegger et al., 1999; Rubatto, 2002; Whitehouse and Platt, 2003), a major rock-forming mineral in many granulites given the importance of net transfer reactions (Ellis and Green, 1985; Vielzeuf and Montel, 1994) and thermobarometric modeling (e.g., Kelsey et al., 2008).

The general geology of the Dabie continental collision zone of east-central China between the North and South China Blocks (Fig. 1) is described in detail in the literature (e.g., Wang et al., 1992; Li et al., 1993; Zhang et al., 1996, 2009; Hacker et al., 1998; Xu et al., 2000, 2001; Fu et al., 2003; Zheng et al., 2005). The North Dabie complex represents the northern unit in this orogen and is situated north to the Central Dabie UHP (ultrahigh-pressure), coesite- (Wang et al., 1992) and diamond-bearing (Xu et al., 1992) eclogite-dominant metamorphic zone (Fig. 1). Numerous geochronological studies on the Dabie eclogites and associated meta-felsic and meta-ultramafic rocks by Sm–Nd (e.g., Li et al., 1993; Li et al., 2000; Jahn et al., 2003), Lu–Hf (Schmidt et al., 2008) and U–Pb zircon (SHRIMP and LA-ICPMS) (e.g., Hacker et al., 1998; Liu et al., 2006; Wu et al., 2006, 2008; Gao et al., 2011) methods have constrained that the UHP (coesite- to diamond-stable) metamorphism occurred in the Triassic, with the exact timing of metamorphism at 242–227 Ma (Liu et al., 2006; Wu et al., 2006) or 240–225 Ma in the coesite–diamond stability field (Zheng et al., 2009; Liu and Liou, 2011). Traditionally, the North Dabie complex has been distinguished from the adjacent UHP zones by a lack of classic eclogites (garnet + omphacite) (e.g., Wang et al., 1992; Zhang et al., 1996, 2009). This view is now challenged because Triassic HP–UHP rocks, namely garnet pyroxenite (clinopyroxene + orthopyroxene) (e.g., Su et al., 2000; Tsai and Liou, 2000; Zhang et al., 2000; Malaspina et al., 2006), granulitized "eclogite" (e.g., Fu et al., 2003; Liu et al., 2007a, 2011a,b), retrogressed (e.g., Wei et al., 1998; Xu et al., 2000, 2001) or relict diamondiferous "eclogite" (Xu et al., 2005) and garnet peridotite (Zhang et al., 1995; Xu et al., 2001) are widespread as volumetrically minor components (mostly lenses) in the North Dabie complex. Although these North Dabie

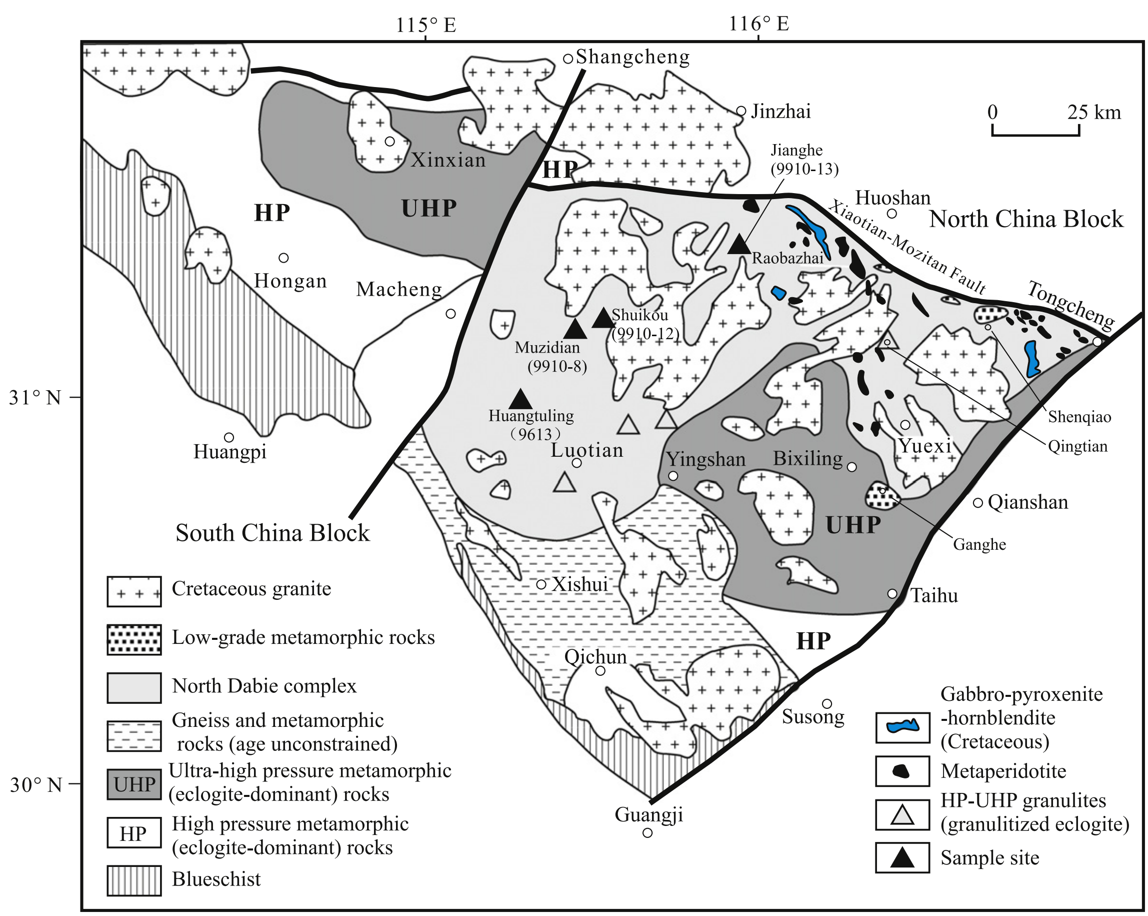

Fig. 1. Geological sketch map of the Dabie orogen (after Zhang et al., 1996; Jahn et al., 1999; Xu et al., 2000, 2001, 2005; Zheng et al., 2005; Liu et al., 2006, 2007a,b, 2011a,b). Light gray—North Dabie complex. Dark gray—UHP eclogite-dominant complex. Sample localities are marked.