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Dating of subduction and differential exhumation of UHP rocks from the Central Dabie Complex (E-China): Constraints from microfabrics, Rb–Sr and U–Pb isotope systems

Nicole Wawrzenitz [a,b,*], Rolf L. Romer [a], Roland Oberhänsli [b], Shuwen Dong [c]

[a] GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany
[b] Institut für Geowissenschaften, Universität Potsdam, D-14476 Potsdam, Germany
[c] Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing 100081, China

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Abstract

The correlation of deformation fabrics and metamorphic reactions with geochronologic data of UHP metamorphic rocks demonstrate that the multistage subduction and exhumation history of the Central Dabie Complex requires rapid subduction and rapid initial exhumation. Moreover, these data show that volume diffusion is not the major resetting mechanism of radiogenic isotope systems. Thus, our age data do not simply reflect a thermal/cooling history. In the investigated section, the maximum age for UHP is given by the 244 ± 3 Ma (2σ) U–Pb age of a pre-UHP titanite phenocryst that survived UHP metamorphism and subsequent tectonometamorphic events. A minimum age for UHP is set by the 238 ± 1 Ma (2σ) ^{238}U–^{206}Pb mineral isochron age of titanite and cogenetic epidote. These minerals formed from local partial melts during ascent and their age suggests fast exhumation and emplacement in the middle crust. In the period of ca. 238–218 Ma, the UHP terrain records HT metamorphism, local partial melting, and extensive pervasive strain below the eclogite (jd + grt) stability field. Exhumation was polyphase with a first phase of fast exhumation, succeeded by episodes of HT metamorphism and concomitant deformation at deep/mid crustal level between 238 and 218 Ma. Slow exhumation related to the final emplacement of tectonic units along greenschist facies shear zones did not cease before ca. 209–204 Ma. The resetting and homogenization of radiogenic isotope systems were aided by dissolution precipitation creep, which was the dominant deformation mechanism in quartz–feldspar rocks, in combination with fluid influx.

Keywords: UHP metamorphism; Exhumation; Deformation; U–Pb Rb–Sr Sm–Nd isotope dating; Titanite; Dabie Shan

1. Introduction and scope of work

During UHP metamorphism, crustal rocks are brought to extreme conditions. Large density contrasts to the surrounding mantle material result in large buoyancy forces and rapid exhumation of UHP terranes, which facilitate the conservation of UHP mineral assemblages and microfabrics from several stages of the subduction and exhumation history. Probably, partial melting of subducted material plays an important role for its mechanical behaviour during ascent, in accordance with very rapid initial exhumation pulses (Wallis et al., 2005).

For the precise dating of distinct metamorphic stages of the *PTt*d path of a UHP terrain, it is fundamental to understand how changing deformation mechanisms and

* Corresponding author. GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany. Tel.: +49 331 9678370.
E-mail address: nicole_wawr@gmx.de (N. Wawrzenitz).

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metamorphic reactions over such a large *PT* interval, as well as fluid infiltration at successive stages during subduction and ascent, affect the geochronological record of UHP rocks. To model mass transfer along convergent plate boundaries, it is necessary to know the duration of subduction, the time of exposure to the UHP conditions, the exhumation rates, and the shape of the *PT*-paths of UHP terrains, especially whether exhumation of UHP rocks was the result of one or several stages.

The aim of this paper is to combine geochronological and microtectonic investigations to constrain the subduction and exhumation history of polymetamorphic UHP rocks from the Qinling–Dabie–Sulu metamorphic belt (Eastern China). We selected the Central Dabie Complex as study area, because (i) UHP relics are abundantly preserved and peak *P–T* conditions have been established by numerous petrological investigations (e.g., Okay et al., 1989; Wang and Liou, 1991; Okay, 1993; Carswell et al., 2000; Xiao et al., 2000; Schmid et al., 2000, 2003), (ii) the Central Dabie Complex preserves relics of different prograde and retrograde stages of the metamorphic and tectonic history. Such relics are predominantly preserved in high viscosity domains. During decompression and exhumation large strain within the Central Dabie Complex transposed the former sedimentary layering at low angle to the foliation. This implies high translation magnitudes.

In this paper, we present titanite U–Pb ages and white mica Rb–Sr ages from microstructurally different domains from the Central Dabie Complex. Titanite had grown during different prograde and retrograde stages of the *PTt*d paths. The microfabrics of the titanite bearing rocks reflect strain-induced diffusion-controlled processes such as dynamic recrystallization, recovery, and dissolution precipitation creep (diffusion creep, e.g., Passchier and Trouw, 1996), which enhance cation mobility on the grain scale and, thus, facilitate the homogenization of isotope systems. In contrast, material transport by dislocation creep would be restricted to the grain scale. Minerals from such domains could preserve an older U–Pb system.

Provided their U–Pb system remained closed, dating of titanite and cogenetic minerals may delineate successive metamorphic and deformational episodes (cf. Heaman and Parrish, 1991; Getty and Gromet, 1992; Freeman et al., 1997; Wawrzenitz and Krohe, 1998; Essex and Gromet, 2000; Romer, 2001). Hence, combined microtectonic, petrological, and geochronological studies of these rocks set constraints on the time interval between subduction to mantle depths and emplacement in the upper crust, as well as on the duration of UHP conditions and exhumation processes. Moreover, they potentially reveal the effect of deformation mechanisms and strain rate on radiogenic isotope systems (Krohe and Wawrzenitz, 2000).

2. Geological setting

The Qinling–Dabie–Sulu metamorphic belt (Eastern China) is the result of Triassic subduction and collision between the Yangtze craton (South China block) in the south and the Sino-Korean craton (North China block) in the north (Mattauer et al., 1985). The Dabie metamorphic belt consists of tectonic slivers characterized by a wide range of *P–T* conditions (Fig. 1). In the north, the low grade Foziling and Luzhenguan Complexes, also summarized as Beihuaiyang low-grade metamorphic zone, are interpreted by Zheng et al. (2005) as a passive-margin accretionary wedge deformed during continent subduction. Hacker et al. (2000) interpreted these complexes as a part of the overriding Sino-Korean craton. They are separated from the Yangtze UHP and HP units (Yangtze craton) to the south by the Xiaotian–Mozitan fault (being a normal detachment zone, e.g., Faure et al., 1999, 2003). These Yangtze units include: (i) the North Dabie Complex (formerly termed Northern Orthogneiss Unit), characterized by amphibolite facies gneisses, that locally contain UHP relics, such as microdiamonds in eclogite (Xu et al., 2003), as well as granulitic relics (Wang et al., 1998; Faure et al., 2003; Bryant et al., 2004), (ii) the Central Dabie Complex, in the literature commonly also termed Dabie ultrahigh-pressure (UHP; coesite–eclogite bearing) Complex, (iii) the South Dabie Complex, containing amphibolitized HP rocks, possibly also with UHP relics (Li et al., 2004), (iv) the Susong Blueschist Complex, and (v) the Yangtze fold-and-thrust belt. We use the neutral subdivision North, Central, and South Dabie, because UHP occurrences have been found in each unit (see below) and, therefore, the subdivision based on metamorphic grade and tectonic position has become ambiguous.

In the Central Dabie Complex, the occurrence of microdiamond constrains minimum *P* of ca. 30 kbar (Xu et al., 1992, 2003). Phase petrology in the UHP rocks indicates *PT* conditions of 42 kbar at 750 °C (Schmid et al., 2003), which implies exhumation from more than ca. 120 km depth. In the North Dabie Complex, minimum pressures attained in eclogitic lenses also allowed coesite and microdiamond formation (e.g., Xu et al., 2003; Xie et al., 2004). Early Cretaceous granitoids (ca. 130 Ma, U–Pb zircon data, Xue et