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Transitional time of oceanic to continental subduction in the Dabie orogen: Constraints from U–Pb, Lu–Hf, Sm–Nd and Ar–Ar multichronometric dating

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ABSTRACT

We investigated the oceanic-type Xiongdian high-pressure eclogites in the western part of the Dabie orogen with combined U–Pb, Lu–Hf, Sm–Nd and Ar–Ar geochronology. Three groups of weighted-mean $^{206}Pb/^{238}U$ ages at 315 ± 5, 373 ± 4 and 422 ± 7 Ma are largely consistent with previous dates. In contrast, Lu–Hf and Sm–Nd isochron dates yield identical ages of 268.9 ± 6.9 and 271.3 ± 5.3 Ma. Phengite and amphibole Ar–Ar total fusion analyses give Neoproterozoic apparent ages, which are geologically meaningless due to the presence of excess ^{40}Ar. Plagioclase inclusions in zircon cores suggest that the Silurian ages likely represent protolith ages, whereas the Carboniferous ages correspond to prograde metamorphism, based on the compositions of garnet inclusions. Despite weakly-preserved prograde major- and trace element zoning in garnet, a combined textural and compositional study reveals that the consistent Lu–Hf and Sm–Nd ages of ca. 270 Ma record a later event of garnet growth and thus mark the termination of high-pressure eclogite–facies metamorphism. The new U–Pb, Lu–Hf and Sm–Nd ages suggest a model of continuous processes from oceanic to continental subduction, pointing to the onset of prograde metamorphism prior to ca. 315 Ma for the subduction of oceanic crust, while the peak eclogite–facies metamorphic episode is constrained to between ca. 315 and 270 Ma. Thus, the initiation of continental subduction is not earlier than ca. 270 Ma.

1. Introduction

Subduction zones are essential to the dynamic evolution of the earth's surface due to plate tectonics. Subduction of oceanic and continental crust eventually leads to closure of backarc basins and arc-continent and continent-continent collisions (O'Brien, 2001; Ernst, 2005; Zheng et al., 2008), forming various types of high-pressure (HP) and ultrahigh-pressure (UHP) metamorphic rocks. Subduction of oceanic lithosphere causes a complex continuum of diagenetic and metamorphic reactions; many kilometres of oceanic lithosphere are ultimately consumed prior to the subsequent continental slab subduction and collision. Subducted continental slabs that detach from the oceanic lithosphere that was dragging them into the mantle are expected to rapidly rise to Moho depths because of their positive buoyancy. Thus, studying subducted oceanic crust in subduction zones can provide clues to the incorporation rate of supercrustal material into the mantle and can shed light on the initiation of successive continental subduction. Determining a geochronological framework for determining the sequence and duration of oceanic to continental subduction and HP and UHP metamorphism plays an essential role in this respect.

Zircon has long been recognized as a promising geochronometer of the U–Pb decay system because of its refractory nature, commonly preserved growth zones and mineral inclusions within a single grain. Recent developments in analytical techniques allow us to unravel a wealth of information contained in zircons with respect to their growth history and thus the prograde and retrograde metamorphic evolution of the host rock (Gebauer, 1996; Wu et al., 2006; Zheng et al., 2007). The Lu–Hf garnet technique has been applied to constrain the prograde and high-temperature histories of metamorphic belts (e.g., Duchêne et al., 1997; Blichert-Toft and Frei, 2001; Anczkiewicz et al., 2004, 2007; Lagos et al., 2007; Kylander-Clark et al., 2007; Cheng et al., 2008a) because of its high closure temperature (Dodson, 1973; Scherer et al., 2000) and the fact that garnet strongly partitions Lu over Hf, resulting in a high parent/daughter ratio (Otamendi et al., 2002). Combined with Sm–Nd age determination, the Lu–Hf garnet geochronometer can potentially be used to estimate the duration of

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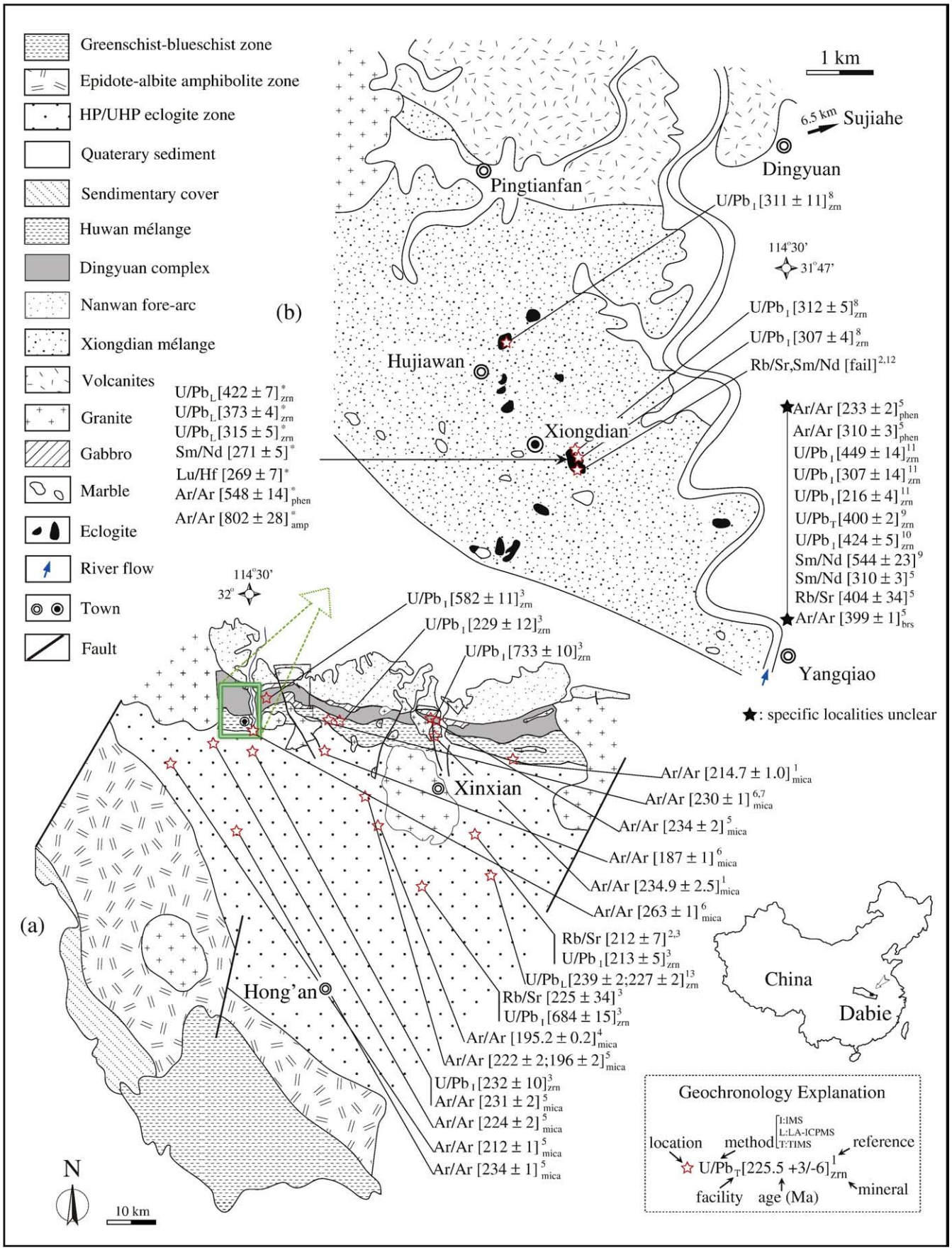

Fig. 1. Simplified geologic map of the Huwan mélange area (b) in southern Dabie orogen (a), modified after Ye et al. (1993) and Liu et al. (2004b), showing the sample localities for the Xiongdian eclogite. References: asterisk, this study; [1], Ratschbacher et al. (2006); [2], Jahn et al. (2005); [3], Liu et al. (2004a); [4], Eide et al. (1994); [5], Webb et al. (1999); [6], Xu et al. (2000); [7], Ye et al. (1993); [8], Sun et al. (2002); [9], Jian et al. (1997); [10], Jian et al. (2000); [11], Gao et al. (2002); [12], Li et al. (2001); [13], Wu et al. (2008). amp — amphibole; brs — barroisite; phen — phengite; zrn — zircon.