Earth and Planetary Science Letters 277 (2009) 345–354

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

Age and nature of eclogites in the Huwan shear zone, and the multi-stage evolution of the Qinling-Dabie-Sulu orogen, central China

Yuan-Bao Wu [a,b,c,*], John M. Hanchar [b], Shan Gao [a,c], Paul J. Sylvester [b], Mike Tubrett [b], Hua-Ning Qiu [d], Jan R. Wijbrans [e], Fraukje M. Brouwer [f], Sai-Hong Yang [a], Qi-Jun Yang [d], Yong-Sheng Liu [a], Hong-lin Yuan [c]

[a] State Key Laboratory of Geological Processes and Mineral Resources, Faculty of Earth Sciences, China University of Geosciences, Wuhan 430074, China
[b] Department of Earth Sciences, Memorial University of Newfoundland St. John's, NL A1B 3X5, Canada
[c] State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University, Xi'an 710069, China
[d] Key Laboratory of Isotope Geochronology and Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, 510640 Guangzhou, China
[e] Department of Isotope Geochemistry, VU University Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, Netherlands
[f] Department of Petrology, VU University Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, Netherlands

ARTICLE INFO

Article history:
Received 11 June 2008
Received in revised form 27 October 2008
Accepted 27 October 2008
Available online 20 December 2008

Editor: R.W. Carlson

Keywords:
Qinling-Dabie orogen
zircon U-Pb ages
Hf isotopes
Huwan shear zone
Paleotethyan oceanic crust

ABSTRACT

In situ LA-ICPMS U-Pb, trace element, and Hf isotope data in zircon demonstrate a Carboniferous age for eclogite-facies metamorphism in Siluro-Devonian protoliths in the Huwan shear zone, Dabie Mountains, Central China. This age contrasts with the more prevailing Triassic age for high- to ultrahigh pressure (HP to UHP) metamorphism in the Qinling-Dabie-Sulu orogen. Metamorphic zircon in two eclogite samples from Sujiahe is characterized by low Th/U ratios, small negative Eu anomalies, flat HREE patterns, and low $^{176}Lu/^{177}Hf$ ratios. These geochemical signatures suggest that the zircon crystallized in the presence of garnet and in the absence of plagioclase feldspar. Furthermore, temperatures of ~655 and ~638 °C, calculated using the Ti content of zircon, are consistent with their formation during eclogite-facies metamorphism. The weighted mean $^{206}Pb/^{238}U$ age of 309±4 Ma (2δ) for this zircon improves previous age estimates for eclogite-facies metamorphism in the Huwan shear zone, ranging from 420 to 220 Ma. Metamorphic zircon from one eclogite sample from Hujiawan, most likely formed during prograde metamorphism, yields an equivalent age estimate of 312±11 Ma. Magmatic zircon cores in the three samples yield ages for the magmatic protoliths of the eclogites ranging from 420±7 to 406±5 Ma, and post-dating the middle Paleozoic collision of the North China and the Qinling terrain. The zircon crystals in the three eclogite samples display a large variation of $\varepsilon_{Hf}(t)$ values of −4.9 to 21.3. The metamorphic zircon overgrowths show the same range of $\varepsilon_{Hf}(t)$ values as those of the inherited magmatic crystal interiors. This suggests that the metamorphic zircon overgrowths may have formed by dissolution-reprecipitation of pre-existing magmatic zircon thereby preserving their original Hf isotopic composition. The high $\varepsilon_{Hf}(t)$ values suggest that the protoliths were derived from depleted mantle sources, most likely Paleotethyan oceanic crust; while the low $\varepsilon_{Hf}(t)$ values are attributed to crustal contamination. Some eclogites in the Huwan shear zone have a distinctive signature of continental crust most probably derived from the Yangtze Craton. The coexistence of Paleozoic oceanic crust and Neoproterozoic continental crust with similar metamorphic ages in the Huwan shear zone implies that Paleozoic Paleotethyan oceanic crust was produced within a marginal basin of the northern Yangtze Craton. The opening of the Paleo-Tethyan ocean was slightly younger than the collision of the North China Craton and the Qinling terrain during the Late Paleozoic in the Qinling-Dabie-Sulu orogen. Subduction of the Paleo-Tethyan oceanic crust and associated continental basement resulted in the 309±2 Ma (2σ) eclogite-facies metamorphism in the Huwan shear zone. The subsequent Triassic continent-continent collision led to the final coalescence of the Yangtze and Sino-Korean cratons. Amalgamation of the Yangtze and North China cratons was, therefore, a multistage process extending over at least 200 Ma.

1. Introduction

The Qinling-Dabie-Sulu orogen marks the suture zone between the North China and Yangtze cratons in Central China (Fig. 1). Despite intensive study for more than 20 years, controversies still exist about the location and number of sutures and the timing of collision. Researchers working in the western part of the orogen, i.e. the Qinling

* Corresponding author. State Key Laboratory of Geological Processes and Mineral Resources, Faculty of Earth Sciences, China University of Geosciences, Wuhan 430074, China.
E-mail addresses: cugybwu@yahoo.com, yuanbaowu@cug.edu.cn (Y.-B. Wu).

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doi:10.1016/j.epsl.2008.10.031

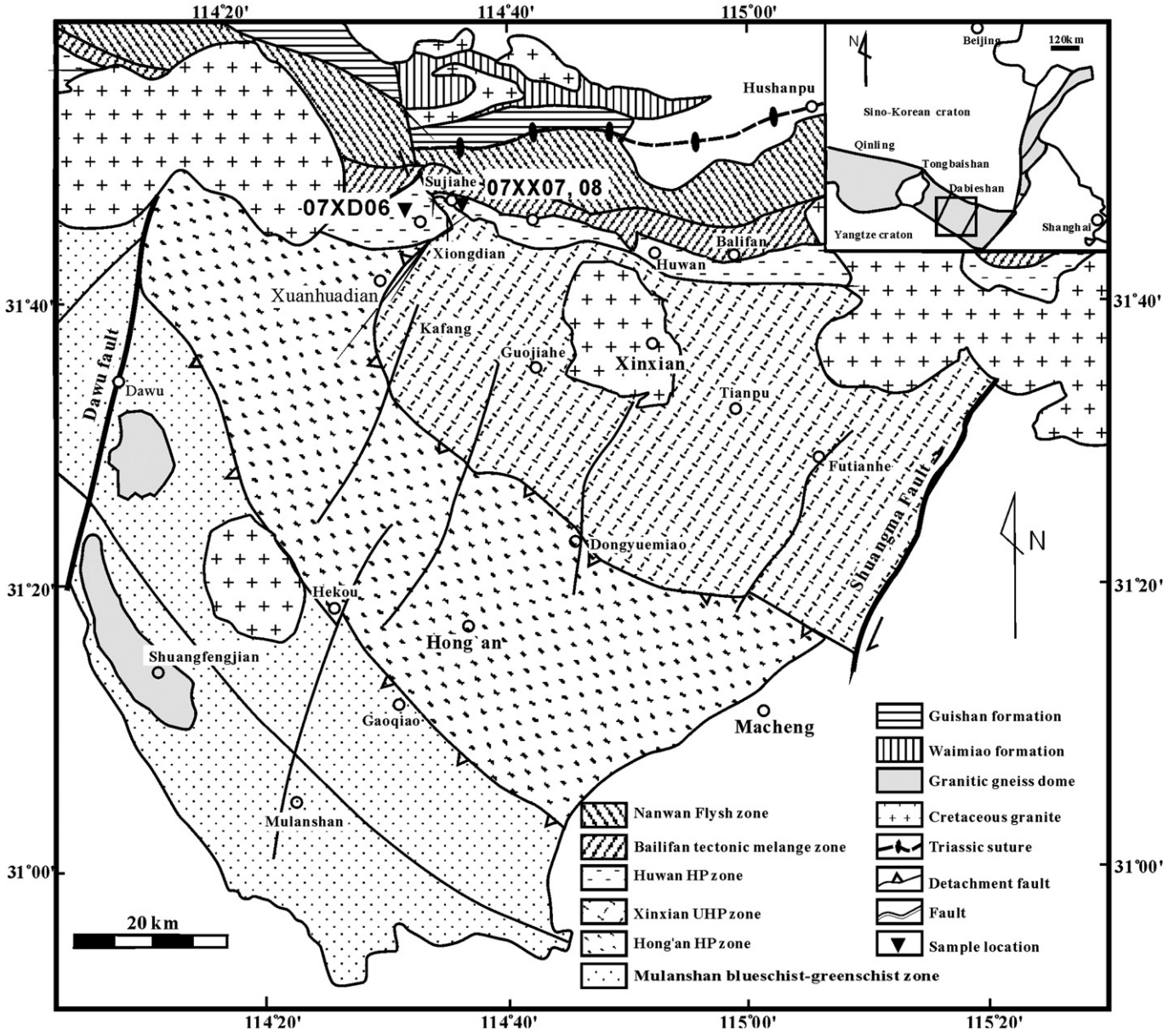

Fig. 1. Sketch geological map of the Huwan shear zone in the Qinling-Dabie-Sulu orogen and sample locations (Modified after Liu et al., 2004b).

and Tongbai mountains, have argued for a Paleozoic amalgamation (Kröner et al., 1993; Yang et al., 2005) or a Paleozoic collision overprinted by Mesozoic intracontinental shortening (Mattauer et al., 1985; Zhai et al., 1998). In contrast, investigations in the eastern part of the orogenic belt, i.e. in the Dabie-Sulu terrane, suggest Triassic subduction (Ames et al., 1996; Hacker et al., 1998; Li et al., 2000; Ayers et al., 2002; Zheng et al., 2003, 2004; Hacker et al., 2006). Multi-stage subduction, and extension and rifting, in relation to the opening of the Paleotethyan ocean floor have been proposed as a model to reconcile these controversies (Meng and Zhang, 1999, 2000; Ratschbacher et al., 2003, 2006). This model, however, has been debated because of the scarcity of precise ages (Sun et al., 2002; Liu et al., 2004a; Jahn et al., 2005; Qiu and Wijbrans, 2006).

The Hong'an Block, that forms part of the western Dabie Mountains, is one area critical to decipher the tectonic evolution of the Qinling-Dabie-Sulu orogenic belt (Fig. 1), as it is located at the junction between the western and eastern sections of the orogenic belt, and forms the transition between zones exposing low-pressure and ultra-high pressure rocks. The east-west trending 5–10 km wide Huwan shear zone defines the tectonic contact between the more inboard Qinling belt to the northwest and the outboard Dabie-Sulu belt in the southeast (Fig. 1). The timing of eclogite-facies metamorphism and protolith formation of the Huwan shear zone is important for testing multi-stage subduction, and extension and rifting models. However, published $^{40}Ar/^{39}Ar$, U/Pb, Rb/Sr, and Sm/Nd ages interpreted to date the eclogite-facies metamorphism from the Huwan shear zone span from ca. 420–220 Ma (Ratschbacher et al., 2006, and references therein). The age and origin of the protoliths of eclogites in this zone have not yet been well documented. In this paper, we present an integrated study of in situ U-Pb, trace element, and Lu-Hf analysis, for zircon crystals from three eclogite samples from the Huwan shear zone. These results not only unravel the eclogite-facies and protolith ages and origin of these eclogites, but also shed light on the multi-stage tectonic evolution of the Qinling-Dabie-Sulu orogen.

2. Geological setting and previous geochronology

The Hong'an Block forms the central section of the Qinling-Dabie-Sulu orogen and is bounded by the Shangma Fault in the east and the Dawu Fault in the west (Fig. 1). The Huwan shear zone is the