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Evolution of the Xiaotian-Mozitan fault and its implications for exhumation of Dabie HP–UHP rocks

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Abstract

The Xiaotian-Mozitan fault (XMF) located north of the Dabie orogenic belt separates the North Dabie complex to the south from the Beihuaiyang low-grade metamorphic rocks to the north. It comprises several NW-striking ductile shear zones and brittle faults. The brittle faults obviously overprinted on the ductile shear zones and promoted the development of the volcanic basins in early Cretaceous to the north, which suggests that the brittle faults were normal faults formed in early Cretaceous during doming of the Dabie orogenic belt. The ductile shear zone superposed on the north Dabie gray gneiss, and it is an important channel where the Dabie HP–UHP rocks exhumed. For obtaining new structural constraint on exhumation of the HP–UHP rocks, we present here experimental results on the microstructure, quartz C-axis fabrics and the microprobe analyses of phengite. The ductile shear zone was determined to be formed at a temperature of 600–650 °C and pressure of 1.1 GPa by the mineral deformation, microprobe analyses and geobarometry of Si-in-phengite of the mylonite, the results suggest that the mylonite now exposed on the surface experienced an upper amphibolite-facies metamorphism in the lower crust. The mineral stretching lineation varies from horizontal in the east segment to sub-dip in the west. Shear sense indicators from outcrop and thin sections of orientated specimen and quartz C-axis fabrics suggest that the XMF is a sinistral normal fault. The kinematics analysis of the ductile shear zone indicates that the exhumation of Dabie HP–UHP rocks is the results of a SE-directed extrusion and an anticlockwise rotation around its eastern pivot simultaneously.

Keywords: Xiaotian-Mozitan fault zone; Exhumation boundary; Ductile shear zone; Brittle normal fault

1. Introduction

The formation and exhumation of high-pressure (HP)–ultrahigh-pressure (UHP) rocks in the Dabie orogenic belt has attracted much attention since the discovery of diamond, coesite and its pseudomorphs in UHP rocks [1]. Recently, much progress has been made based on the studies of geochronology [2–4], geochemistry [5] and petrology [6] on the Dabie HP–UHP rocks, which gave us better understanding of the development of the HP–UHP rocks. However, limited work has been done in terms of the structural analyses on the exhumation of the HP–UHP rocks in Dabie orogenic belt. It is widely accepted that the HP–UHP rocks were metamorphosed at Indosinian (240–210 Myr) [2–4] when South China Block collided with the North China Block. But how these metamorphic rocks were exhumated to the middle–upper curst is still under debate. Chemenda et al. [7,8] modeled successfully the dynamics of the exhumation of the subducted slab in a compressive environment. Faure et al. [9,10] applied this model to explain exhumation of UHP rocks and structural evolution of the Dabie orogenic belt. They came to a conclusion that the Xiaotian-Mozitan fault (XMF) is a normal fault, which is coincident with that of Lin et al.

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[11–13]. Li et al. [14] proposed a lithospheric-wedging model which favored that the XMF is a normal fault. A rotation-and-extrusion model proposed by Hacker et al. [15] also supported that the XMF is a sinistral normal fault. Although, kinematics of the XMF was considered in these models [9–16], there was no detailed study on the XMF. As a crucial exhumation boundary of HP–UHP rocks in Dabie orogenic belt, the XMF records abundant information about the exhumation process, therefore we conducted a detailed study on the microstructure, quartz C-axis fabrics and the microprobe analyses of phengite to constrain the tectonic models about the exhumation process in this belt.

2. Geological background

The Dabie orogenic belt is located between South China Block and North China Block (Fig. 1), and it is sinistrally offsetted from the Sulu orogenic belt by the Tan-Lu fault [17]. The Dabie orogenic belt is divided into two segments by Shangcheng-Macheng fault (SMF). Its east segment is composed of Susong complex unit, South Dabie HP–UHP metamorphic unit, North Dabie complex unit and the Beihuaiyang low-grade metamorphic unit from south to north. The Dabie orogenic belt is bounded by the Xiangfan-Guangji fault (XGF) to the south and the Xinyang-Shucheng fault (XSF) to the north which separates it from the Hefei Basin.

Susong complex unit mainly comprises meta-sedimentary rocks, such as mica schist, quartzite and marble, and Proterozoic meta-volcanic rocks, as well as gneiss with unknown protolith. The meta-volcanic rocks have the same geochronological characteristic with the Yangtze Block, and it is believed to be the basement of Yangtze plate [18].

South Dabie HP–UHP metamorphic unit comprises granitic gneiss surrounding rock with patches of eclogite, quartzite and marble. The gneiss metamorphosed under UHP condition [19,20] during subduction with peak metamorphism took place at Indosinian, which ia supported by the geochronology study [19,20] and the presence of the diamond and coesite in zircon from the gneiss [21,22]. The primary age of the gneiss is 800–700 Myr [2,19,23].

The North Dabie complex is mainly composed of gray gneisses and amphibolites, including some granulite and meta-mafic/ultramafic rocks, characterized by widespread migmatization. The gray gneisses experienced a tectono-thermal event in early Cretaceous [24]. The discovery of eclogite [25] and isotopic dating [26] demonstrate that, except for some granitic gneisses formed in the Yanshannian episode, the wall rocks of most gray gneisses and amphibolites formed in Neo-Proterozoic of 700–800 Myr, and underwent Indosinian metamorphism.

Beihuaiyang unit is mainly composed of Foziling group and Luzhengguan group. The Foziling group consists of argillaceous slate, low-grade meta-sandstone, phyllite and mica schist. Luzhengguan group experienced a relatively higher metamorphism, composed of granitic gneiss, amphibole and mica schist. Zheng et al. [27,28] believed that the low-grade metamorphic unit is scratched from the South China Block when it was subducting beneath the North China Block. However, different views have been proposed by others [10,11,29,30].

Yanshannian igneous rock has been widely exposed in the North Dabie unit (NDU) the and Beihuaiyang low-grade metamorphic unit. Intrusive rocks dominate in both North Dabie and Beihuaiyang, but volcanic rocks are only present in the Beihuaiyang unit. These volcanic rocks are dominated by the Maotanchang group, composed of trachyandesite, latite, trachyte, with minor basalt and rhyolite distributed at Maotanchang and Xiaotian areas. Geochronological study shows that these igneous rocks at the northern Dabie orogenic belt emplaced at 140–110 Myr [24,31], which coincides with the Early Cretaceous doming in the Dabie orogenic belt [32].

3. Characteristics of the fault zone

Xiaotian-Mozitan fault zone (Fig. 1a) is about 1-km-wide ductile shear zone with widely exposed mylonite and ultramylonite (Fig. 2a–c). This ductile shear zone is characterized by mylonite and ultramylonite in the center (Table 1) overprinted on the North Dabie gray gneisses (Fig. 1c). The mineral assemblage of the mylonites is the same with that of its wall rocks. Porphyroclasts of the mylonite are feldspar and hornblende, and matrixes are recrystallized quartz, feldspar, hornblende, and mica. The mylonite changes to protomylonite from the shear zone center toward the south. Based on the cross-section observation, the ductile shear zone is bounded with low-grade Foziling metamorphic unit by normal faults to the north and a transition from gneisses to the south occurs (Fig. 1c). It is noticeable that the move direction of the ductile shear and that of the normal brittle fault are nearly perpendicular (see detailed explanation in the following text). It suggests that the ductile shear and the brittle normal fault are not the expression of the same tectonic event in different depths, but the expression of two different tectonic events.

According to the attitude of the mineral lineation and mylonite foliation, the ductile shear zone can be divided into three segments. At east of Mozitan, ductile fault is characterized by mylonite foliation of a 40–60°-trending, a 30–50°-dipping and horizontal lineation or sub-horizontal lineation with 10° plunge. From Mozitan to Qingshan, the ductile shear zone is characterized by mylonite foliation of NNE40°–NNW350° -trending, 20–40°-dipping and lineation varies from horizontal in the east to 15–25° plunges toward the west locally. At west of Qingshan, the foliation varies between NE40° and north, and the lineation plunge is 40–60° NW. Generally speaking, the foliation varies along its strike, and the dominate foliation strikes NNE. The plunge of the lineation increases from east to west.

Another characteristic of the XMF is that the brittle normal faults overprinted on the ductile shear zone. The brittle normal faults cut cross the ductile shear zone in a small angle with mylonite foliation (Fig. 2b). Cataclasites