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A Uniform Orogen-parallel Extension System of the Shear Zones in the Tongbai-Dabie Orogenic Belt, Central China

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Abstract: Large-scale magmatism affected the Tongbai-Dabie orogenic belt during post-collisional lateral tectonic extension in the Cretaceous, which was suggested to account for the widespread deformation and migmatization in the Tongbai-Dabie complexes. However, it cannot explain the most deformations in the shear zones. The northwest-southeast shear zones are developed around or wrapped the Tongbai-Dabie complexes. They play an important role for the interpretation of the tectonic evolution of the Tongbai-Dabie orogenic belt. By a systematically observation and description of the geometry and kinematics of these shear zones, we found that the shear zones to the north dip NE and have a uniform sinistral shear sense, the shear zone to the south dips SW and has a uniform dextral shear sense, and the shear zones at the core are sub-horizontal and have a uniform top-to-NW sense of shear. Combining with the comparison of previous and our geochronological studies, we interpret these associations as indicating that these shear zones were originally a single, more flat-lying and sub-horizontal shear zone with a uniform top-to-NW shear sense before the folding-doming of the Tongbai-Dabie complexes and suggest that the Tongbai-Dabie orogenic belt experienced a uniform top-to-NW orogen-parallel extension in the ductile lithosphere before the widespread magmatism in the Cretaceous.

Key words: Tongbai-Dabie orogenic belt, shear zone, Tongbai complex, Dabie complex, orogen-parallel extension

1 Introduction

Shear zones and faults are common structures in the Tongbai-Dabie orogenic belt (Figs. 1, 2). Understanding their geometry and kinematic history is important for the interpretation of the tectonic evolution of the orogenic belt (Qu Chunyan et al., 2017). These shear zones and faults occur mainly in two orientations, northwest-southeast and southwest-northeast (Fig. 2). Both of them are common in the orogen. Of these, the southwest-northeast-trending ones are mostly brittle faults, whereas the northwest-southeast-trending ones are ductile shear zones. The ductile shear zones develop symmetrically at the south and north sides of the orogen and are a defining feature of the orogenic belt.

It is generally believed that large-scale extension and magmatism affected the Tongbai-Dabie orogenic belt during post-collisional lateral tectonic extrusion in the Cretaceous (Fig. 3), which led to the development of the Tongbai-Dabie complexes (Tongbai complex and Dabie complex, Niu Baogui et al., 1994; Chen Jiangfeng et al., 1995; Ames et al., 1996; Wang et al., 1998; Faure et al., 1999, 2003; Zhong et al., 1999, 2001; Hacker et al., 2000; Ratschbacher et al., 2000; Suo et al., 2001, 2005; Lin et al., 2007, 2009; Liu et al., 2010; Wang et al., 2011; Hou et al., 2012; Cui et al., 2012; Lin et al., 2015). Many of the existing tectonic models for the Tongbai-Dabie complexes were proposed based on the study of these northwest-southeast-trending shear zones (e.g., Liu et al., 2010; Wang et al., 2011; Hou et al., 2012; many reference therein). However, many of them are based on a single shear zone or a local area (mostly in the Dabie orogen), or based on the chronological and geochemical data in the orogen. A comprehensive study of the structural relationships among these northwest-southeast-trending shear zones is lacking.

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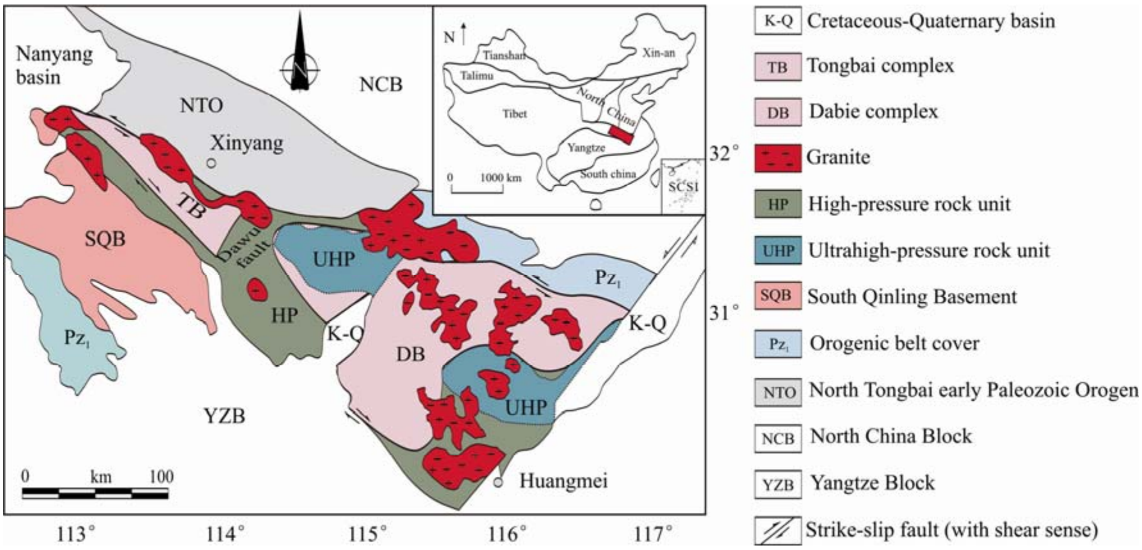

Fig. 1. Simplified geological map of the Tongbai-Dabie orogenic belt.

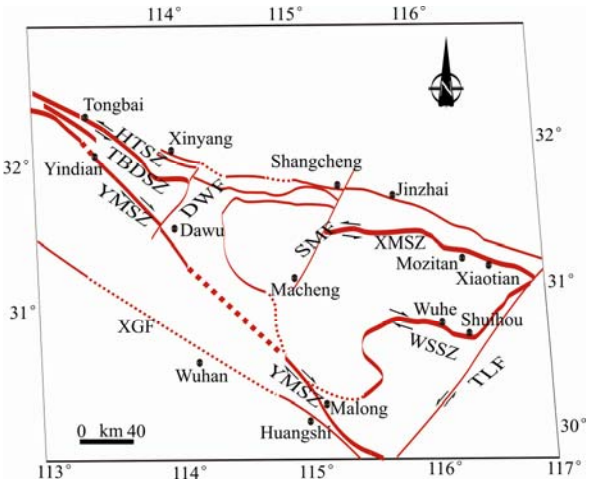

Fig. 2. The shear zones and faults that developed in the Tongbai-Dabie orogenic belt.
HTSZ: Hongyihe-Tongbai shear zone. XMSZ: Xiaotian-Mozitan shear zone. WSSZ: Wuhe-Shuihou shear zone. TLF: Tancheng-Lujiang fault. YMSZ: Yindian-Malong shear zone. XGF: Xiangfan-Guangji fault. TBDSZ: Taibaiding shear zone.

In this paper, we summarize the geometry and kinematics of the northwest-southeast-trending shear zones in the Tongbai-Dabie orogenic belt. We focus on the structural relationship and correlation among these shear zones and discuss the implications for the evolution of the Tongbai-Dabie complexes and the orogenic belt.

2 Geological Setting

The Tongbai-Dabie orogenic belt is located in the central part of the Qinling-Tongbai-Dabie-Sulu orogenic belt (also called the Central Orogenic Belt in China; Fig. 1). It resulted from collision between the Yangtze Block (YZB) and North China Block (NCB) in the Paleozoic.

The Tongbai orogenic belt as a whole has an antiformal geometry (Figs. 4a, 4b), with the Tongbai complex in its core (Fig. 4b). The Tongbai complex includes strongly deformed and mylonitized felsic rocks, residuals of metamorphic rocks (felsic gneisses and amphibolites) and undeformed Cretaceous granite intrusions. Two high-pressure eclogite belts occur symmetrically to the north and south of the complex (e.g., Liu et al., 2005, 2008, 2010, 2013).

The Dabie orogenic belt as a whole has a dome shape with the Dabie complex inits core (Figs. 4a, 4c). The Dabie complex is mainly composed of deformed gneiss, migmatite and undeformed Cretaceous granite intrusions. High-pressure and ultrahigh-pressure rocks are fragmentarily preserved around the margin of the complex (Figs. 1, 4d).

The high-pressure and ultrahigh-pressure rocks in both the Tongbai and Dabie orogens are spatially associated with mica schist, gneiss and marble. Geochronological studies of these rocks indicate that the Tongbai-Dabie orogenic belt experienced subduction-exhumation from 255 Ma to 180 Ma (e.g., Zheng et al., 2003, 2007; Liu et al., 2008, 2010, 2013; Cui Jianjun et al., 2009; Lin Wei et al., 2013; Liu Xiaochun et al., 2011, 2013; many references therein). The Tongbai-Dabie complexes are pervasively deformed in the Early Cretaceous and are intruded by Early Cretaceous syntectonic granite intrusions that are believed to have formed by partial melting of the Yangtze Block basement (e.g., Liu et al., 2017). The shear zones bounding or wrapping the Tongbai -Dabie complex overprints the rocks in complexes. Therefore, the structures described below, including the bounding shear zones and deformation in complexes,

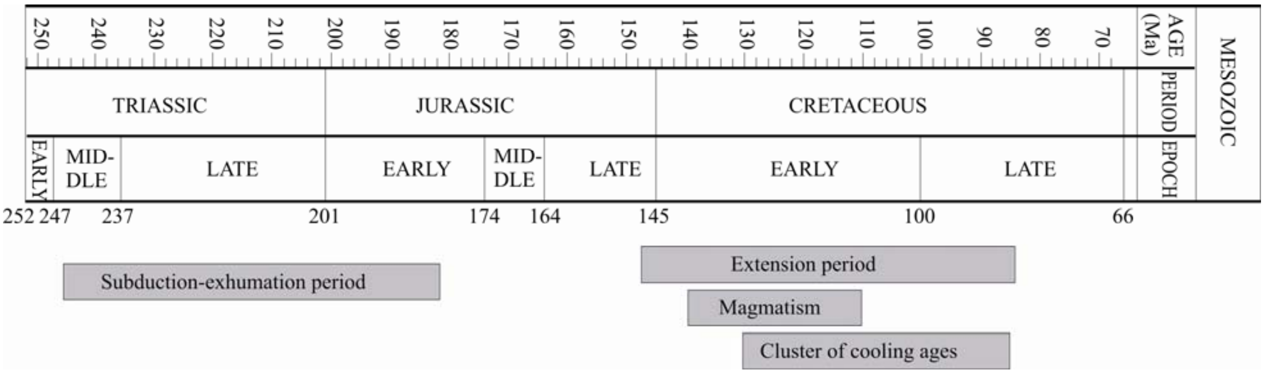

Fig. 3. Overview of important events in the Tongbai-Dabie orogenic belt during Mesozoic.
Simplified Geologic Time Scale is referred to Cohen et al. (2012) and Gradstein et al. (2012).

formed in the Cretaceous, after the subduction-exhumation event.

3 Ductile Shear Zone System in the Tongbai-Dabie Orogenic Belt

In this section we describe the most important shear zones wrapping or bounding the Tongbai-Dabie complexes. Firstly, we reconstruct the names of the northwest-southeast shear zones based on a higher frequency of use by previous researchers as seen in Fig. 2, which are the Hongyihe-Tongbai shear zone (HTSZ) and Xiaotian-Mozitan shear zone (XMSZ) to the north, Taibaiding shear zone (TBDSZ) and Wuhe-Shuihou shear zone (WSSZ) at the core (or top), and Yindian-Malong shear zone (YMSZ; west segment in Tongbai and east segment in Dabie) to the south. Then we detailed characterize the uniform orogen-parallel shear zone system within the surrounding Tongbai complex zone from our unpublished observations (the HTSZ, the TBDSD and the west segment of YMSZ). In the Dabie orogenic belt, some geological data of two important shear zone (XMSZ and WSSZ) is taken from the literature where is indicated, and compilation from the east segment of the Yindian-Malong shear zone (YMSZ) is taken from our pre-existing data. All shear zone described below played an important role during the extension process in the Tongbai-Dabie orogenic belt.

3.1 Yindian-Malong shear zone in the Tongbai orogenic belt (west segment of YMSZ)

The west segment of Yindian-Malong shear zone (YMSZ) is considered as a boundary within the Tongbai orogenic belt (e.g., Cheng et al., 2012; Liu Huan et al., 2015). It strikes NW-SE as a whole (Fig. 1) and extends for about 120 km in the Tongbai orogenic belt. It is covered by the Nanyang basin to the west and locally covered by the Early Cretaceous volcanic rocks. To the east, it is crosscut by the Dawu fault (DWF). Along the west segment of YMSZ, the exposed zone of protomylonites, mylonites and ultramylonites is 250 to 3200 m wide. These mylonitic rocks are mainly quartz-feldspathic, with well-developed foliation and lineation. The foliation is defined by mineral alignment and transposed bedding. The lineation is defined by the long axis of elongate quartz and feldspar. Mylonitic foliation dips mostly at 30º–60º SW (Fig. 5). Mineral stretching lineations are consistently subhorizontal trending SE and or plunge very shallowly to the NW (Fig. 5). Shear sense indicators are best developed, such as shear bands (Fig. 6a) and δ-type feldspar porphyroclasts, indicate a dextral strike-slip movement (e.g., Wang et al., 2003; Liu et al., 2010; Cui et al., 2012; Cheng et al., 2012; Liu H et al., 2015, 2016).

3.2 Taibaiding shear zone (TBDSZ)

The Taibaiding shear zone (TBDSZ) is located at the top of the Tongbai complex. A large amount of L-S or L>S tectonite (protomylonite) occur in the shear zone and its protolith is a quartz-feldspathic granitic gneiss. Mylonitic foliation in the shear zone is sub-horizontal, dipping at 3°–10° SW (Fig. 5). Stretching lineations in the shear zone trend NW-SE and are sub-horizontal. Shear sense indicators, such as δ-type feldspar porphyroclasts and S-C fabrics (Fig. 6b), indicate a top-to-NW shear sense (Xu and Wang, 2010; Liu et al., 2017).

3.3 Hongyihe-Tongbai shear zone (HTSZ)

The Hongyihe-Tongbai shear zone (HTSZ) was previously recognized as one of the exhumation boundaries between the Yangtze Block (YZB) and the North China Block (NCB; Okay et al., 1992; Hacker et al., 2000; Faure et al., 1999; Jiang et al., 1999; Ratschbacher et al., 2000; Suo Shutian et al., 2001; Wang et al., 2003; Lin et al., 2005). It extends for about 100 km between the Nanyang basin and the Dawu fault in the Tongbai orogenic belt (Figs. 1, 2) and continues much further east. An Early Cretaceous granite intruded the shear zone. The

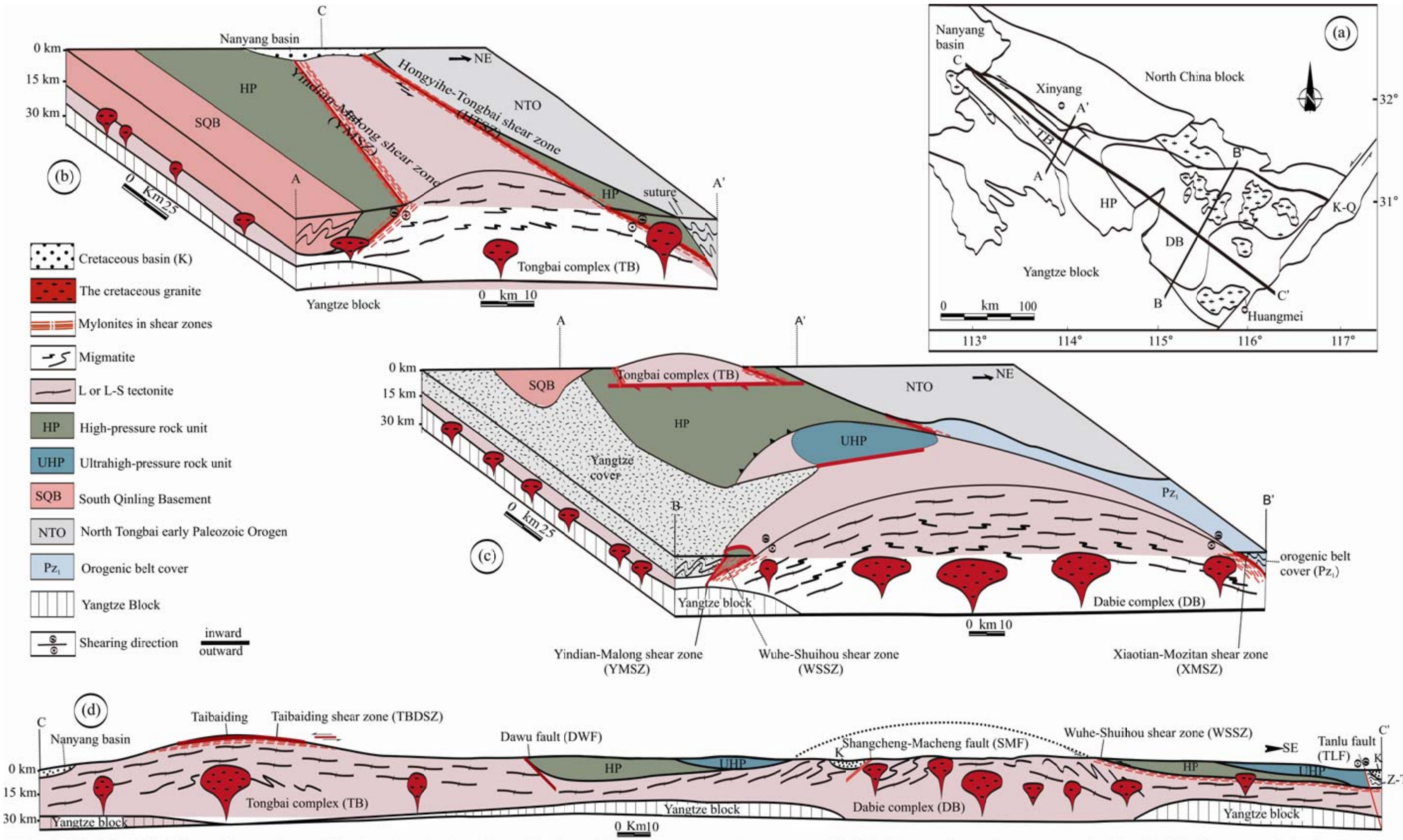

Fig. 4. (a), Simplified from figure. 1., mainly showing the locations of schematic sections across the orogen. (b) -(d), Schematic sections across the Tongbai-Dabie orogenic betl, note the ductile shear zones.

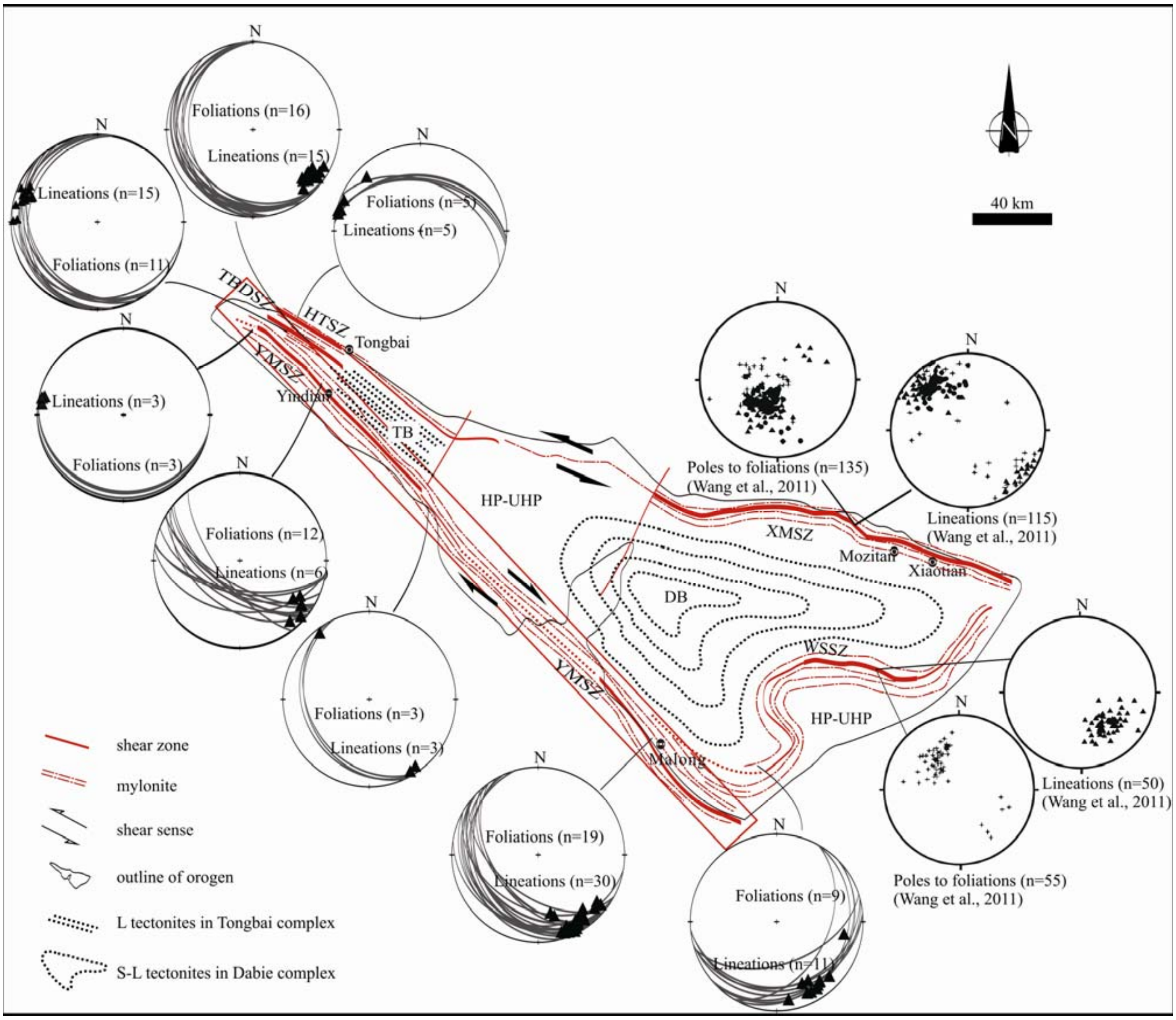

Fig. 5. The geometry of the shear zones in the Tongbai-Dabie orogenic belt.
All the lineations and foliations in the HTSZ, the TBDSZ and the YMSZ are taken from our measured data and projected in the equal-area lower hemisphere projections, the geometric data in the XMSZ and the WSSZ are taken from Wang et al. (2011). TB: Tongbai complex, DB: Dabie complex; L tectonites: rock with strong development of lineations but no foliations; S-L tectonics: rock with both strong foliations and lineations.

shear zone strikes NW-SE and the mylonitic foliation in the zone mostly dips at 30º–60° NE (Fig. 5). The shear zone comprises quartz-feldspathic protomylonites, mylonites and ultramylonites and has an exposed width of 1–2 km. Stretching lineations in the mylonites dominantly plunge at ~10° SE (Fig. 5). Shear sense indicators, such as mica-fish (Fig. 6c), indicate a sinistral strike-slip movement (e.g., Wang et al., 2003; Liu et al., 2010; Cui et al., 2012; Liu H et al., 2015, 2016).

3.4 Yindian-Malong shear zone in the Dabie orogenic belt (east segment of YMSZ)

The east segment of YMSZ strikes NW-SE and extends for about 100 km in the Dabie orogenic belt. It is covered by the Cretaceous-Quaternary basin to the west. To the east, it is crosscut by the Tanlu fault (TLF). Along the east segment of YMSZ, the exposed zone of protomylonites, mylonites and ultramylonites is 500 to 3000 m wide. These mylonitic rocks are mainly quartz-feldspathic. Some undeformed granitic dikes intrude the ductile shear zone. Mylonitic foliation in the YMSZ dips mostly at 30º–60º SW (Fig. 5). Mineral stretching lineations are well developed (Fig. 6d). They trend SE and plunge shallowly to the SE. Shear sense indicators, such as asymmetric deformed dyke in the shear zone (Fig. 6e), indicate a dextral strike-slip movement, consistent with that in the west segment of shear zone (e.g., Cheng et al., 2012; Liu Huan et al., 2015, 2016; Liu Huan, 2016).

3.5 Wuhe-Shuihou shear zone (WSSZ)

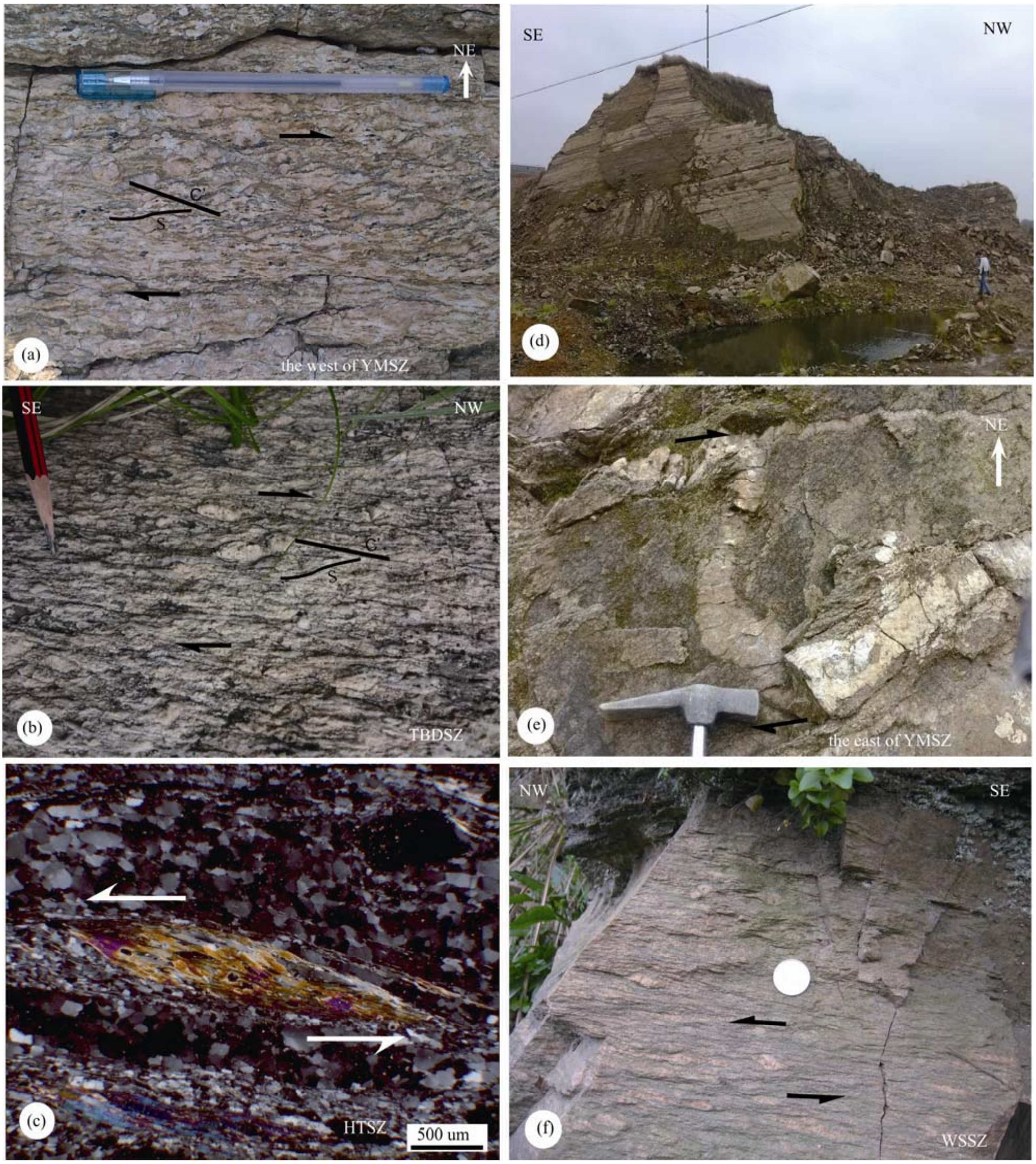

Fig. 6. Field photos and micrograph show the kinematics of the shear zones in the Tongbai-Dabie orogenic belt.
(a), Shear bands and S-C fabric indicating dextral shearing in the west segment of the Yindian-Malong shear zone (YMSZ). Note that photographed surface is sub-horizontal. Pen is about 15 cm. (b), shear bands indicating top-to-NW shearing in the Taibaiding shear zone (TBDSZ). Note that photographed surface is vertical. Pencil is about 12 cm. (c), mica fish indicating a sinistral shearing in the Hongyihe-Tongbai shear zone (HTSZ). (d), note the strong stretching lineations developed on mylonitic foliation surface in the east segment of YMSZ. (e), asymmetric deformed dyke indicating a dextral shearing in the east segment of YMSZ. (f), asymmetric boudins indicating a top-to-NW shearing in the Wuhe-Shuihou shear zone (WSSZ). Note that photographed surface is vertical. Coin is about 3 cm in diameter.

The WSSZ is curved and overlain by the high-pressure and ultrahigh-pressure rock unit to the southeast (Ratschbacher et al., 2000; Lin et al., 2007; Wang et al., 2011; Hou et al., 2012). The west segment of the shear zone overlaps with the east segment of YMSZ and curves from northwest to northeast. The exposed zone of protomylonites, mylonites and ultramylonites in this segment is 1000 to 2000 m in wide. Our observation show that this segment dominantly dips SE at 30º–50º even though it has variable strikes (Fig. 5). Stretching lineations in the mylonites dominantly plunge at ~15° SE (Fig. 5). Shear sense indicators, such as δ-type feldspar porphyroclasts (Fig. 6f), indicate a dextral top-to-NW shearing movement.

Detailed researchwas also done on the well-exposed east segmentof WSSZ by Wang et al. (2011). They found that the east segment of the shear zone are composed of protomylonites, mylonites and locally ultramylonites, overprinting the Dabie complex. The mylonitic foliation in this segment strikes from northeast to northwest but dominantly dips at SE (Fig. 5). Stretching lineations dominantly plunge SE. Shear sense indicators indicate a top-to-NW or WNW shear sense. These structures in the east segment are consistent with our observation in the west segment of WSSZ.

3.6 Xiaotian-Mozitan shear zone (XMSZ)

The domain of the XMSZ is developed between the Shang-Ma fault (SMF) and the Tan-Lu fault (TLF; Figs. 1, 2). It was generally recognized as one of the HP-UHP rock unit exhumation boundaries between the Yangtze Block (YZB) and the North China Block (NCB; Okay et al., 1992; Hacker et al., 2000; Faure et al., 1999; Jiang et al., 1999; Ratschbacher et al., 2000; Suo Shutian et al., 2001; Wang et al., 2003; Lin et al., 2005). It dominantly strikes NW to SE and partly intruded by the Cretaceous volcanic rocks. Along the XMSZ, the exposed zone of protomylonites, mylonites and ultramylonites is 1000 to 2000 m in wide. Mylonitic foliation in the zone mostly dips NE at about 40º and stretching lineations dominantly plunge NW or shallowly to the SE (Wang et al., 2011; Fig. 5). Structure associations indicate that this shear zone is a sinistral with normal component shear zone as Wang et al. (2011) reported.

4 Discussion

4.1 The structural relationship between the northwest-southeast shear zones.

In the Tongbai-Dabie orogenic belt, all the shear zones described above are developed between the Tongbai-Dabie complexes and the (ultrahigh)-high pressure rock unit. The shear zones to the north (the HTSZ and the XMSZ) have a sinistral sense of shear, and the shear zone to the south (the YMSZ) has a dextral sense of shear. The summarized geochronology data indicates that they deformed contemporaneity in the early Cretaceous, and all of these shear zones show a similar deformed conditions in the Middle-Lower crust (Fig. 7, Table 1; Chen Jiangfeng et al., 1993; Hacker et al., 1995, 1998; Webb et al., 1999; Ma Changqian et al., 2004; Cui Jianjun et al., 2009, 2012; Wang et al., 2011; Cheng et al., 2012; Hou et al., 2012; Lin et al., 2015; Liu et al., 2017). Therefore, it has long been recognized that the Tongbai-Dabie complexes commonly experienced a lateral extrusion in the early cretaceous (e.g., Liu et al., 2010; Xu Guang and Wang Erqi, 2010). However, the Tongbai complex is folded and the Dabie complex is domed, and based on some local NE-plunging, SE (or SW) -plunging stretching lineations around (in) the Dabie complex, it is also generally believed that the Tongbai-Dabie orogen experienced a vertical (or oblique) extrusion in the early cretaceous, and both of the folded Tongbai complex and the domed Dabie complex are due to the vertical extrusion

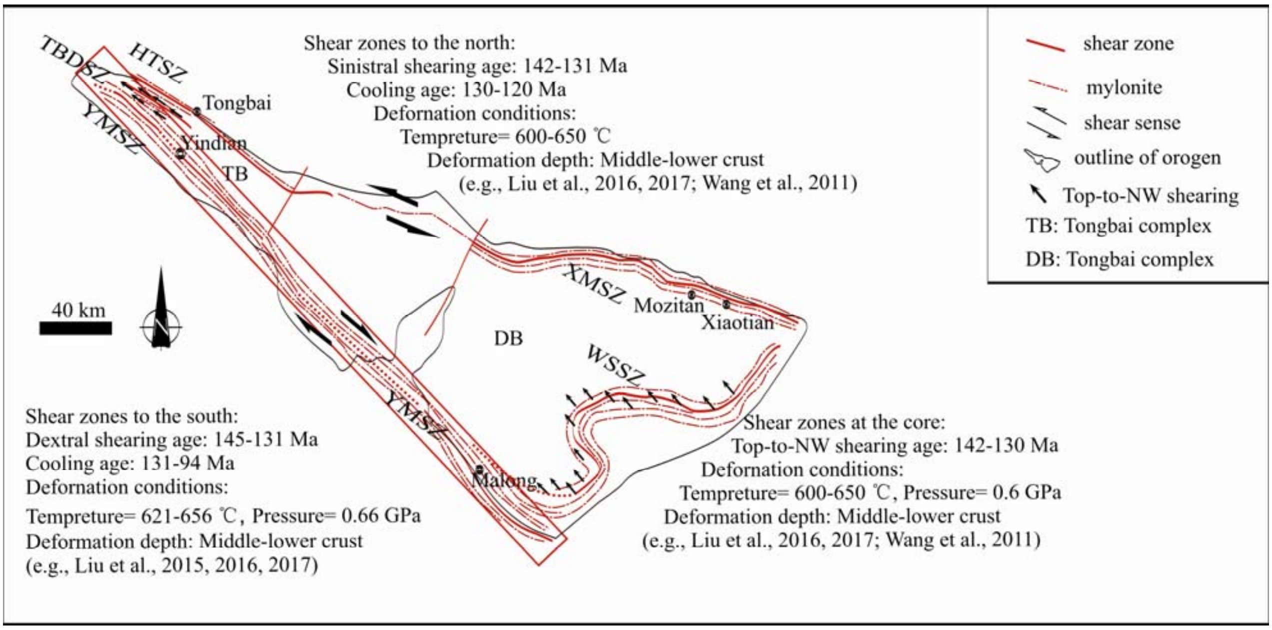

Fig. 7. The summarization of deformation ages and conditions in the shear zones of the Tongbai-Dabie orogenic belt.

Tabel 1 The collection of the ages obtained in the shear zones in the Tongbai-Dabie orogenic belt

Tectonic unit	Age (Ma)	Dating target	Methord	reference	Interpretation
YMSZ (Yindian-Malong shear zone)	94	Mylonite	Ar/Ar	Cui et al., 2012	131–94 Ma cooling time and uplifting period
	99	Biotite schist	Ar/Ar	Cui et al., 2012	
	116	Biotite	Ar/Ar	Hacker et al., 1998	
	119	Mylonitic granite	Ar/Ar	Webb et al., 1999	
	123	K-feldspar	Ar/Ar	Hacker et al., 1998	
	124	Mylonitic granite	Ar/Ar	Webb et al., 1999	
	125	Biotite	Ar/Ar	Hou et al., 2007, 2012	
	126	Mylonitic gneiss	Ar/Ar	Lin et al., 2015	
	128	Biotite	Ar/Ar	Hou et al., 2007, 2012	
	131	Muscovite	Ar/Ar	Hacker et al., 1998	
	131	Undeformed veins	U-Pb	Cui et al., 2009	145–131 Ma dextral shearing
	135	Mylonite	Ar/Ar	Cui et al., 2012	
	136	Undefromed felsic veins	U-Pb	Cheng et al., 2012	
	138	Undefromed felsic veins	U-Pb	Cheng et al., 2012	
	144	Syntectonic graniticic bands	U-Pb	Cheng et al., 2012	
	145*	Mylonite	U-Pb	Liu et al., 2017	
WSSZ (Wuhe-Shuihou shear zone)	130	Biotite	Ar/Ar	Chen et al., 1993	139–130 Ma top-to-NW shearing
	134	Mylonite	U-Pb	Hacker et al., 1998	
	135	Mylonite	U-Pb	Hacker et al., 1998	
	139	Hornblende	Ar/Ar	Ma et al., 2004	
TBDSZ (Taibaiding shear zone)	142*	Protomylonite	U-Pb	Liu et al., 2017	~142 Ma~ top-to-NW shearing
XMSZ (Xiaotian-Mozitan shear zone)	121	Biotite	Ar/Ar	Hacker et al., 1998	130–120 Ma cooling time and uplifting period
	121	Hornblende	Ar/Ar	Hacker et al., 1998	
	121	Hornblende	Ar/Ar	Wang et al., 2011	
	123	Biotite	Ar/Ar	Wang et al., 2011	
	124	Biotite	Ar/Ar	Hou et al., 2007, 2012	
	127	Biotite	Ar/Ar	Hou et al., 2007, 2012	
	127	Biotite	Ar/Ar	Wang et al., 2011	
	127	Hornblende	Ar/Ar	Wang et al., 2011	
	128	K-feldspar	Ar/Ar	Hacker et al., 1998	
	128	Hornblende	Ar/Ar	Wang et al., 2011	
	129	Biotite	Ar/Ar	Wang et al., 2011	
	130	Biotite	Ar/Ar	Wang et al., 2011	
	120	Granite dike	U-Pb	Wang et al., 2011	
	121	Granite dike	U-Pb	Wang et al., 2011	
	125	Granite dike	U-Pb	Hacker et al., 1998	
	129	Granite dike	U-Pb	Wang et al., 2011	
	130	Granite dike	U-Pb	Wang et al., 2011	
	131	Biotite	Ar/Ar	Wang et al., 2011	142–131 Ma sinistral shearing
	132	Hornblende	Ar/Ar	Wang et al., 2011	
	133	Hornblende	Ar/Ar	Wang et al., 2011	
	133	Hornblende	Ar/Ar	Hacker et al., 1995	
	134	Hornblende	Ar/Ar	Wang et al., 2011	
	137	Hornblende	Ar/Ar	Wang et al., 2011	
	142	Hornblende	Ar/Ar	Wang et al., 2011	
HTSZ (Hongyihe-Tongbai shear zone)	132*	Mylonite	U-Pb	Liu et al., 2017	~132 Ma~ sinistral shearing

by doming related to the widespread magmatism in the early cretaceous (e.g., Xu Bei et al., 2000, 2007; Huang Shaoying et al., 2006; Hou et al., 2012).

It is obvious that these models are still of considerable debate and the structure relationship between these shear zones are neglected as we emphasized before. In the traditional lateral extrusion models (Fig. 8a), the northern and southern shear zones are taken as two unrelated shear zones, being two individual boundaries with a synchronous movement constraining the lateral extrusion of the Tongbai-Dabie complexes in the early Cretaceous, but down played the significance of the sub-horizontal top -to-NW shear zones (the TBDSZ and the WSSZ); On the other hand, it cannot explain the folding of the Tongbai complex (TB) and the doming of the Dabie complex (DB).In the vertical or oblique extrusion models (Figs. 8b, 8c), the shear zones around the Tongbai-Dabie complexes should act as normal faults, which are not consistent with the wide spread strike-slip shear zones in this area; What is more, it cannot explain the horizontal (sub-horizontal) lineations that widely developed in the Taibaiding shear zone.

Here, a potential explanation is suggested that these shear zones were originally a single shear zone before the folding of the Tongbai complex and doming of the Dabie complex (see below).

It should be noted that thegeometry and kinematics described above support the interpretation that these shear zones are most likely parts of a single shear zone with a uniform top-to-NW shear sense. We name this single

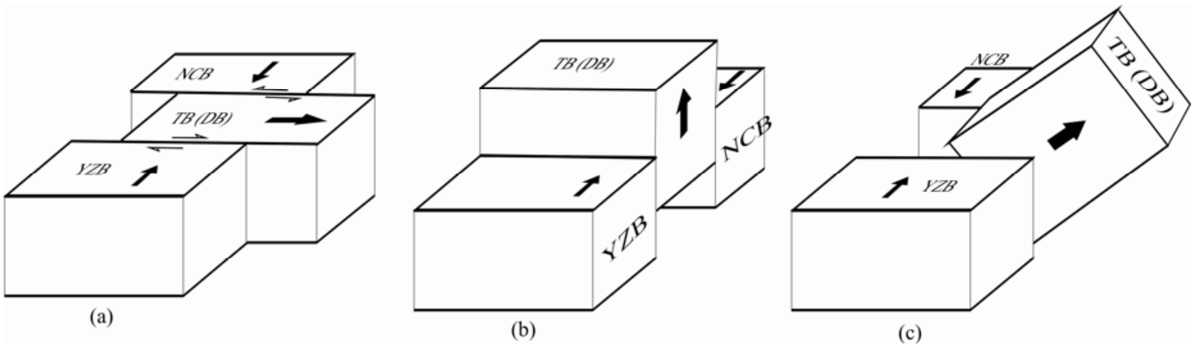

Fig. 8. Schematic diagram showing the general evolution models in the Tongbai-Dabie oregenic belt.
(a), Lateral extrusion. (b), vertical extrusion. (c), oblique extrusion.

shear zone the Tongbai-Dabie shear zone. For the convenience of description, we divided the uniform top-to-NW shear zone into the Tongbai shear zone and Dabie shear zone in the Tongbai and Dabie orogenic belt respectively (Fig. 9).

In the Tongbai orogenic belt, field observations and kinematics show that the west segment of YMSZ and the HTSZ have opposite shear senses, which are dextral and sinistral respectively. The TBDSZ is recognized to have a top-to-NW shear sense and overly the L tectonites in the interior Tongbai complex (TB). Removing the folding effect by the Tongbai complex in vertical, it is natural that the HTSZ and the west segment of YMSZ could merge into a single zone through the connection by the TBDSZ, namely the Tongbai shear zone.

In the Dabie orogenic belt, the east segment of YMSZ and the XMSZ are dextral and sinistral respectively. The curved WSSZ has a uniform top-to-NW sense of shear. Removing the doming effect by the interior Dabie complex (Wang et al., 2011), these three shear zone could be also merge into a single shear zone, namely the Dabie shear zone.

On the whole, it is most likely that the northwest-southeast shear zones, composed of the HTSZ, the XMSZ, the TBDSZ, the WSSZ and the YMSZ, were originally a single, more flat-lying sub-horizontal shear zone, Tongbai-Dabie shear zone, with a top-to-NW shear sense before the folding and doming of the Tongbai complex and the Dabie complex, respectively.

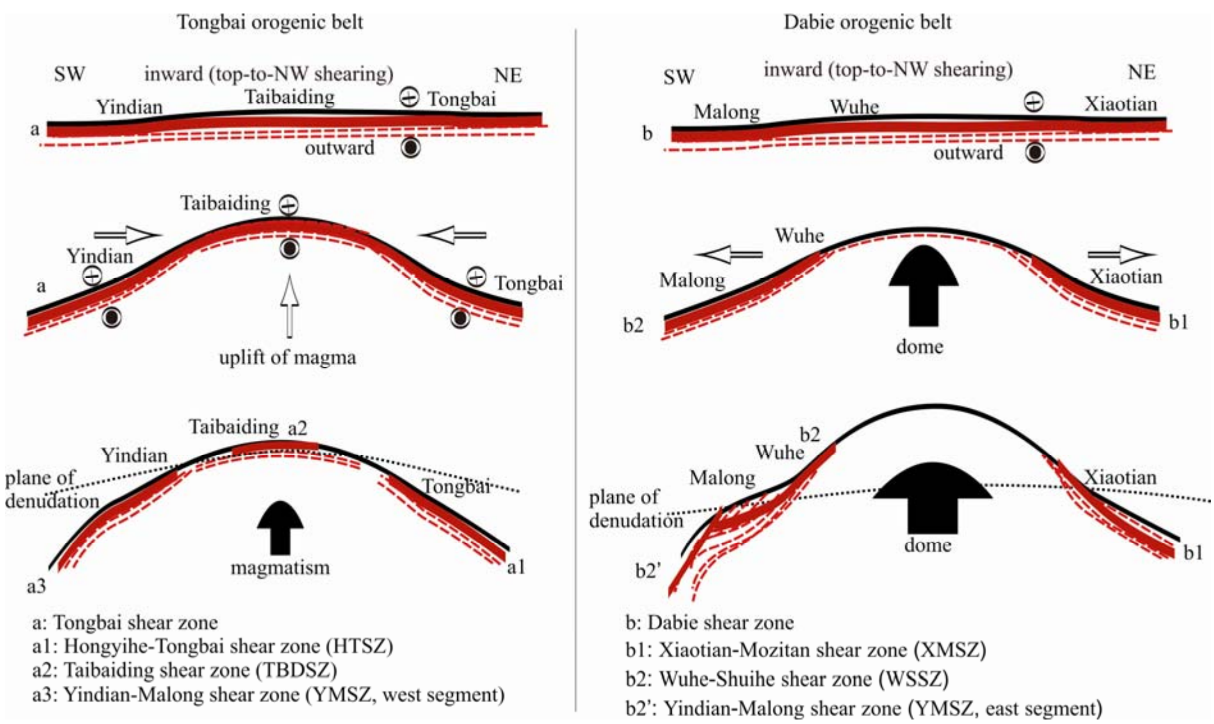

Fig. 9. Schematic diagram showing the formation of shear-zone system in the Tongbai-Dabie orogenic belt.
Note the original Tongbai/Dabie shear zone. Detailed explanation see the paper.

4.2 The division of the Tongbai-Dabie shear zone.

In the Tongbai orogenic belt, the sub-horizontal Tongbai shear zone was folded by the uplifting of the Tongbai complex due to the widespread Cretaceous magma. Then the cambered shear zone is divided into three shear zones by uneven denudation as we observe today. These three shear zones are the HTSZ at the north, the west segment of YMSZ at the south, and the TBDSZ at the top as a residual part of the Tongbai shear zone (Fig. 9).

In the Dabie orogenic belt, the sub-horizontal Dabie shear zone with top-to-NW sense of shear transferred into a detachment zone in the doming process of Dabie complex. The doming of the Dabie complex and the uneven denudation forced the development of the XMSZ at the north, the east segment of YMSZ at the south, and the curved WSSZ at the southeast (Fig .9).

4.3 The significance of the uniform shear zone system.

Structurally, the Tongbai-Dabie complexes are overlain by the Tongbai-Dabie shear zone that has a uniform top-to -NW movement in the early Cretaceous (Fig .10a). These uniform shear zone system suggest that the Tongbai-Dabie orogenic belt suffered an orogen-parallel extension in the ductile lithosphere. Such orogen-parallel ductile flow is common in many orogenic belts (e.g. Liu et al., 2001; Rey et al., 2001; Vanderhaeghe et al., 2001; Klepeis et al., 2004; Wang et al., 2011; Lin et al., 2015;Yang Wencai and Sun Yanyun, 2016). Though the widespread magmatism affected the Tongbai-Dabie complexes and led to the folding of Tongabi complex and doming of Dabie complex (Figs. 10b, 10c), the principal orogen-parallel structures are reserved in the uniform shear zone system around the Tongbai-Dabie complexes in the orogen.

5 Conclusions

(1) The Hongyihe-Tongbai shear zone (HTSZ), the Xiaotian-Mozitan shear zone (XMSZ), the Taibaiding shear zone (TBDSZ), the Wuhe-Shuihou shear zone (WSSZ), and the Yindian-Malong shear zone (YMSZ) are originally a single shear zone with a uniform top-to-NW shear sense before the folding of the Tongbai complex and the doming of the Dabie complex in the Tongbai-Dabie

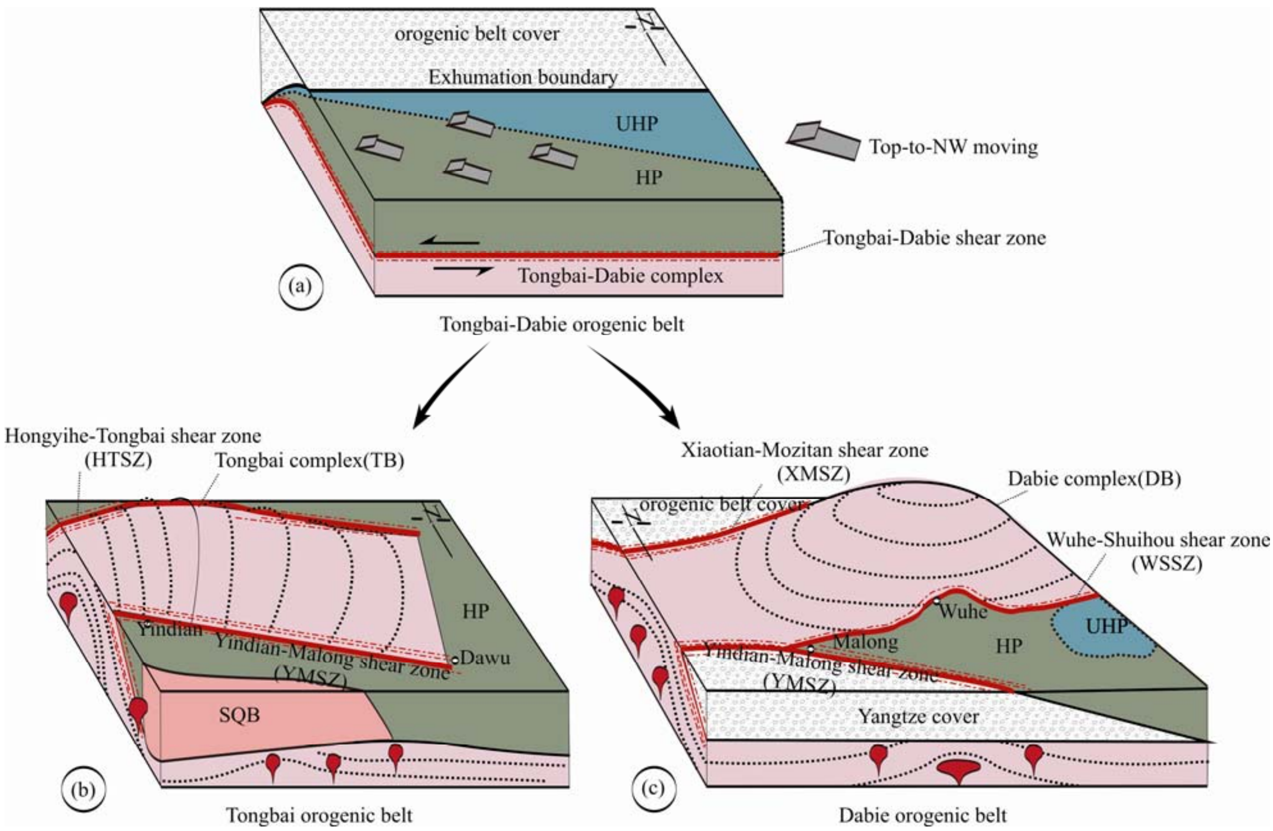

Fig. 10. Schematic 3D diagrams showing the different evolution path between the Tongbai and Dabie orogenic belt, but with a uniform extension boundary composed of shear zones.

(a), A uniform top-to-NW shearing in the ductile lower lithosphere of the Tongbai-Dabie complex, note the integration of the shear zones, named the Tongbai-Dabie shear zone. (b), domain of orogen-parallel extension with a slight uplift of magma in the Tongbai orogenic belt, formed the HTSZ, the TBDSZ at the top and the west part of the YMSZ. (c), doming of the Dabie complex in the Dabie orogenic belt, led to the development of the XMSZ, the WSSZ and the east part of the YMSZ.

orogenic belt. We name this uniform shear zone system the Tongbai-Dabie shear zone.

(2) The geometry and kinematics in the Tongbai-Dabie shear zone suggest that the Tongbai-Dabie orogenic belt experienced a uniform top-to-NW orogen-parallel extension in the ductile lithosphere before the widespread uplifting of the magma in the Cretaceous.

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