Mesozoic evolution of the Hefei basin in eastern China: Sedimentary response to deformations in the adjacent Dabieshan and along the Tanlu fault

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ABSTRACT

This paper presents a study of Jurassic–Early Cretaceous sedimentary evolution of the Hefei basin in eastern China and explores the relationship between clastic sedimentation and coeval deformation of the Dabieshan to the south and the Tanlu fault to the east. The Hefei basin experienced a two-stage evolution. The basin was initiated in the Early Jurassic and expanded in the Middle and Late Jurassic. The synsedimentary Jinzhai normal fault is considered to be a border fault of the basin because it controlled Middle to Upper Jurassic proximal alluvial deposits. Persistent N- to NE-directed paleoflows in the southern Hefei basin indicate that sediments came from the Dabieshan, and the presence of Triassic coesite-bearing detrital zircon in Lower Jurassic sediments documents exhumation of ultrahigh-pressure rocks of the Dabieshan to the surface as early as the Early Jurassic. Occurrences of eclogite clasts in an Upper Jurassic unit indicate continued denudation of the Dabieshan at that time. Thickening of Jurassic clastic units to the southern and southeast parts of the basin suggests that basin subsidence and depositional loci were under the coupled control of the Jinzhai normal fault on the south and the NE-striking left-lateral transtensional Tanlu fault on the east. Jurassic extensional subsidence of the Hefei basin is in marked contrast to the coeval development of a contractional foreland basin south of the Dabieshan, which combines to indicate contemporaneous extension and contraction on the north and south sides of the Dabieshan, respectively. Vigorous volcanism and uplift of the southern Hefei basin characterized the second stage of development of the Hefei basin in the Early Cretaceous, and this led to a synchronous shift of its main depocenter to the north. This younger depocenter is characterized by lacustrine and fluvial-deltaic sedimentation, where alluvial and fan-deltaic coarse-grained deposition mainly occurred along the eastern edge of the basin. Early Cretaceous subsidence is attributed to E-W extension across the middle segment of the Tanlu fault, and the Zhangbaling massif on the east acted as a footwall and provided a source for sediment to the northern basin. A model is accordingly advanced to account for how the Hefei basin developed in response to the tectonic exhumation of the Dabieshan and the deformation of the Tanlu fault in the Mesozoic. It illustrates that the Hefei basin initiated and evolved during Jurassic time in an extensional setting that was triggered by southerly upward extrusion of ultrahigh-pressure rocks of the Dabieshan. Early Cretaceous development of the basin was controlled by magmatism-related uplift of the Dabieshan on the south and orthogonal normal faulting of the middle segment of the Tanlu fault on the east. This study provides an independent constraint upon the exhumation processes of ultrahigh-pressure rocks of the Dabieshan.

Keywords: sedimentation, basin tectonics, Mesozoic, eastern China, Dabieshan, Hefei basin.

INTRODUCTION

Eastern China is geologically made up of the North and South China blocks, which were amalgamated diachronously from east to west along the Qinling-Dabieshan orogenic belt from the latest Late Permian to Middle Triassic (Zhao and Coe, 1987; Yin and Nie, 1993; Meng and Zhang, 1999). Late Mesozoic and Cenozoic tectonics of eastern China are considered to have been related to westward subduction of the Pacific plate (Northrup et al., 1995; Ren et al., 2002), such as widespread magmatism (Zhou and Li, 2000; Li, 2000; Wu et al., 2005) and crustal extension (Ma and Wu, 1987; Tian et al., 1992; Faure et al., 1996), but the North and South China collision must have exerted a major control on crustal deformation of eastern China in the early Mesozoic, particularly in the regions adjacent to the Qinling-Dabieshan belt (Liu et al., 2003; Meng et al., 2005). The Dabieshan has attracted much research in the past decade because it contains ultrahigh-pressure (UHP) metamorphic rocks that indicate deep subduction of continental crust of the South China block beneath the North China block (Hacker et al., 2000). Another spectacular geological feature of eastern China is the crustal-scale NE-trending Tanlu fault (Fig. 1), which is believed to have originated and developed in association with collision of the North and South China blocks and exhumation of the Dabieshan UHP rocks (Yin and Nie, 1993; Gilder et al., 1999; E. Wang et al., 2003; Hacker et al., 2004). Deep subduction

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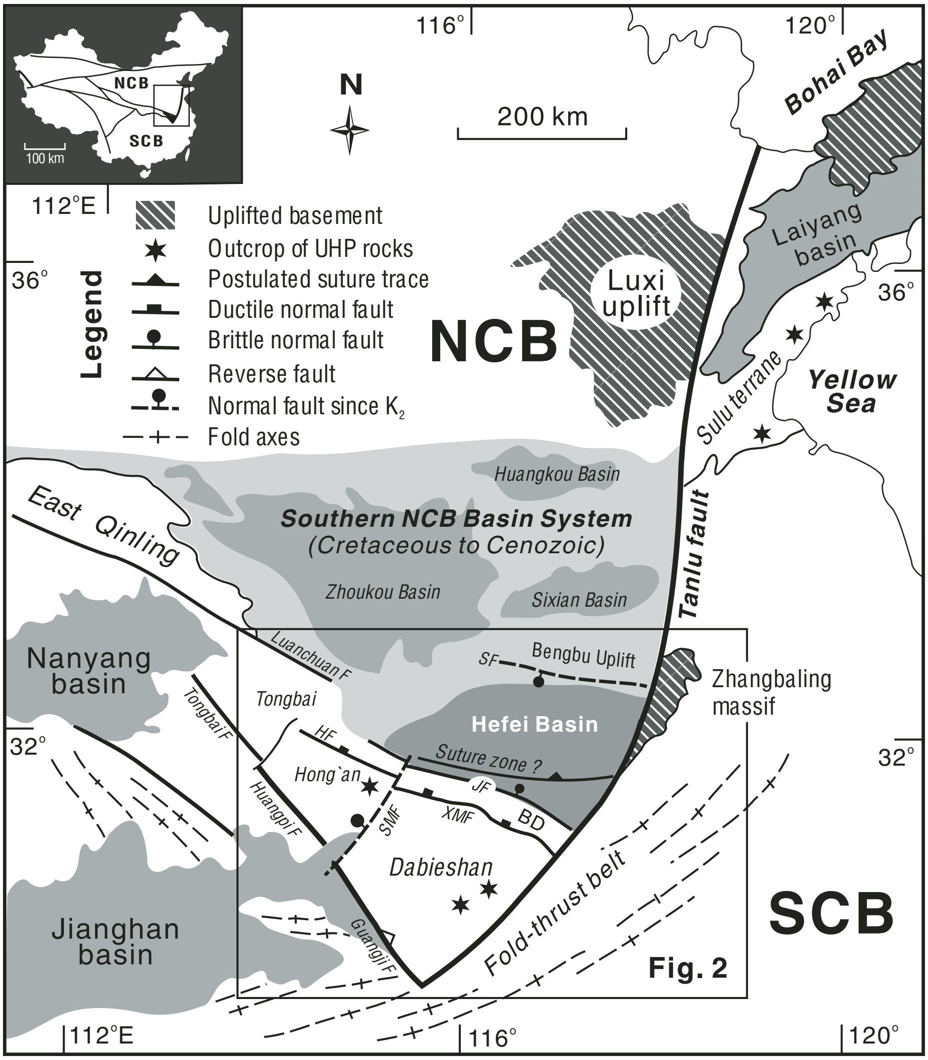

Figure 1. Sketch of the eastern North China block, showing position of the Hefei basin and its relationships with adjacent structural belts and basins. NCB—North China block; SCB—South China block; BD—Beihuaiyang domain; JF—Jinzhai fault; XMF—Xiaotian-Mozitan fault; SMF—Shangcheng-Macheng fault; HF—Huwan fault; UHP—ultrahigh-pressure; F—fault.

of the South China block continental crust and subsequent exhumation of the Dabieshan UHP metamorphosed rocks influenced a broad area of eastern China during the Mesozoic and were among the principal tectonic processes in East Asia. Therefore, the study of the evolution of Dabieshan is crucial for better understanding of Mesozoic tectonics of eastern China.

Significant advances have been made in understanding the petrology and geochronology of the UHP rocks of the Dabieshan (Li et al., 1993; Liou et al., 1996; Hacker et al., 1998), but there is no consensus about how and when the UHP rocks were brought to the surface from depths >100 km. A number of tectonic models have been proposed to explain the exhumation process on the basis of petrology, geochemistry, geochronology, and regional structural analysis (Yin and Nie, 1993; Hacker et al., 2000; Faure et al., 1999; E. Wang et al., 2003). Okay and Şengör (1992) suggested that the Dabieshan UHP rocks were exhumed by means of intracontinental thrusting and concomitant erosion, whereas other studies have indicated that exhumation of the UHP rocks is presumably attributable to synconvergence crustal extension (Webb et al., 1999; Hacker et al., 2000; Faure et al., 2003). Geochronological and geochemical investigation shows that the UHP rocks underwent two stages of rapid cooling or exhumation in the intervals of 226–219 Ma and the Early–Middle Jurassic, respectively, possibly corresponding to contractional tectonics in the first stage and crustal extension in the second stage (Li et al., 2000). A recent provenance study, however, convincingly demonstrates that the UHP rocks had already reached the surface by the Early Jurassic, and they provided a source for sediment in the adjacent Hefei basin (Li et al., 2005).

Most sedimentary basins are controlled by deformation in adjacent mountain belts (Ingersoll, 1988), and, therefore, careful study of basin tectono-sedimentary history is an effective approach to unraveling the linkage between the deformed belts and sedimentary basins. The Hefei basin, situated north of the Dabieshan and bounded on the east by the Tanlu fault (Figs. 1 and 2), should have developed under the control of deformation of the adjacent structural belts during Mesozoic time. In recent years, some efforts have been made to understand the tectonic relationship between the Dabieshan exhumation and the formation of surrounding basins (Liu et al., 2003). However, controversies have persisted about the tectonic setting for the Hefei basin. The basin was assumed to have arisen from flexural subsidence in Jurassic time as a result of northward emplacement of the Dabieshan (Li et al., 2001; Liu et al., 2003), although Jurassic thrust faults controlling Jurassic sedimentation of the Hefei basin have never been identified. Jurassic strata directly north of the Jinzhai fault are only moderately folded (Figs. 3, cross section C–C′, and 4), and the folding is considered to be the result of Early Cretaceous granitoid intrusion on the south and induced (gravity-driven) northward motion of the Beihuaiyang crystalline rocks (Jiang et al., 2003; Lin et al., 2005b). It is generally accepted that crustal extension prevailed in Early Cretaceous time in and around the Dabieshan (Zhong et al., 1999; Faure et al., 1999; Ratschbacher et al., 2000), and that the Hefei basin developed as an extensional basin (Liu et al., 2003). The objective of this paper is to present a detailed anatomy of Jurassic to Lower Cretaceous sedimentary fill of the Hefei basin and propose a model describing how the Hefei basin evolved and use our observations to constrain tectono-sedimentary linkage between the basin and coeval deformation of the bordering Dabieshan and the Tanlu fault.

TECTONIC SETTING

The Hefei basin came into existence in Early Jurassic time and developed through the late Mesozoic into the Cenozoic. The modern basin is bounded on the north by the Shouxian normal fault, and it is internally cut by several E-W–trending intrabasinal extensional faults (Fig. 2B). Based upon the interpretations of seismic-reflection profiles across the Hefei basin (Zhou et al., 1999; Xue and Jin, 2001; Y.L. Wang et al., 2002), these intrabasinal faults only exert controls on Late Cretaceous–Tertiary clastic units that were deposited in discrete small E-W–oriented extensional basins (Fig. 3). A regional unconformity separates Jurassic–Early Cretaceous sequences from the overlying units, indicating that the Hefei basin experienced two distinct phases of development from Mesozoic to Cenozoic times. This study focuses on the first-phase evolution of the basin during the period from the Jurassic to the Early Cretaceous.

The Dabieshan is connected with the East Qinling Mountains through the Hong'an and Tongbai Maintains toward the west, and they together constitute a major roughly W-NW–trending, ~1000-km-long orogenic belt in central China (Fig. 1). UHP metamorphism within the Dabieshan occurred at 244–240 Ma (Li et al., 1993; Hacker et al., 1998; Wawrzenitz et al., 2006). The UHP rocks were then rapidly exhumed to mid-crustal levels in Middle to Late Triassic times, and they had reached the surface by the Middle to Late Jurassic (Webb et al., 1999; Li et al., 2000; Grimmer et al., 2003). The Early Cretaceous was a period of strong crustal extension in association with intensive magmatism in and around the Dabieshan (Xue et al., 1997; Ratschbacher et al., 2000; Faure et al., 2003). Post-Early Cretaceous exhumation rates of UHP rocks within the Dabieshan were significantly lower (Reiners et al., 2003).

The boundary between the Dabieshan and the Hefei basin is defined by a number of normal faults, such as the Huwan fault, Jinzhai fault, and Xiaotian-Mozitan fault (Figs. 1 and 2). It is vexing, however, to identify the original suture between the North and South China blocks because of intense deformation and erosion in the wake of exhumation of the UHP rocks from depths >100 km. The Xiaotian-Mozitan fault has been considered the relict suture (Zhong et al., 1999), and the Huwan fault has been regarded as its possible western extension (Hacker et al., 2000). A recent study by Liu et al. (2004) throws doubt upon the presumption that the Huwan fault was the suture trace, inasmuch as some metamorphic units north of this fault, the Nanwan and Balifan units (Fig. 2B), exhibit affinity to the South China block. Accordingly, the suture should be located to the north of these units (Fig. 1). In addition, the Beihuaiyang domain north of the Xiaotian-Mozitan fault (Figs. 1 and 2B) has been recently shown to consist of South China block Sinian basement rocks, such as the Luzhenguan Group (Chen et al., 2003), which imply a more northward location for the suture (Faure et al., 2003). Neoproterozoic to Paleozoic lithostratigraphy in the Bengbu uplift (Fig. 1) shows an affinity to the North China block (BGMRAP, 1987), and, therefore, the suture should lie south of the Shouxian fault, as indicated on Figure 1. Middle Jurassic granitic intrusions have been recently documented in the Bengbu uplift, and they contain inherited zircons that are interpreted to have originated from partial melting of the South China block crust (Xu et al., 2005). Based on these observations, we propose that the South China block crust might have subducted beneath the North China block for a considerable distance to the north.

The Tanlu fault is considered to have experienced left-lateral displacement from ~300 to ~500 km in Mesozoic (Xu et al., 1987), and it

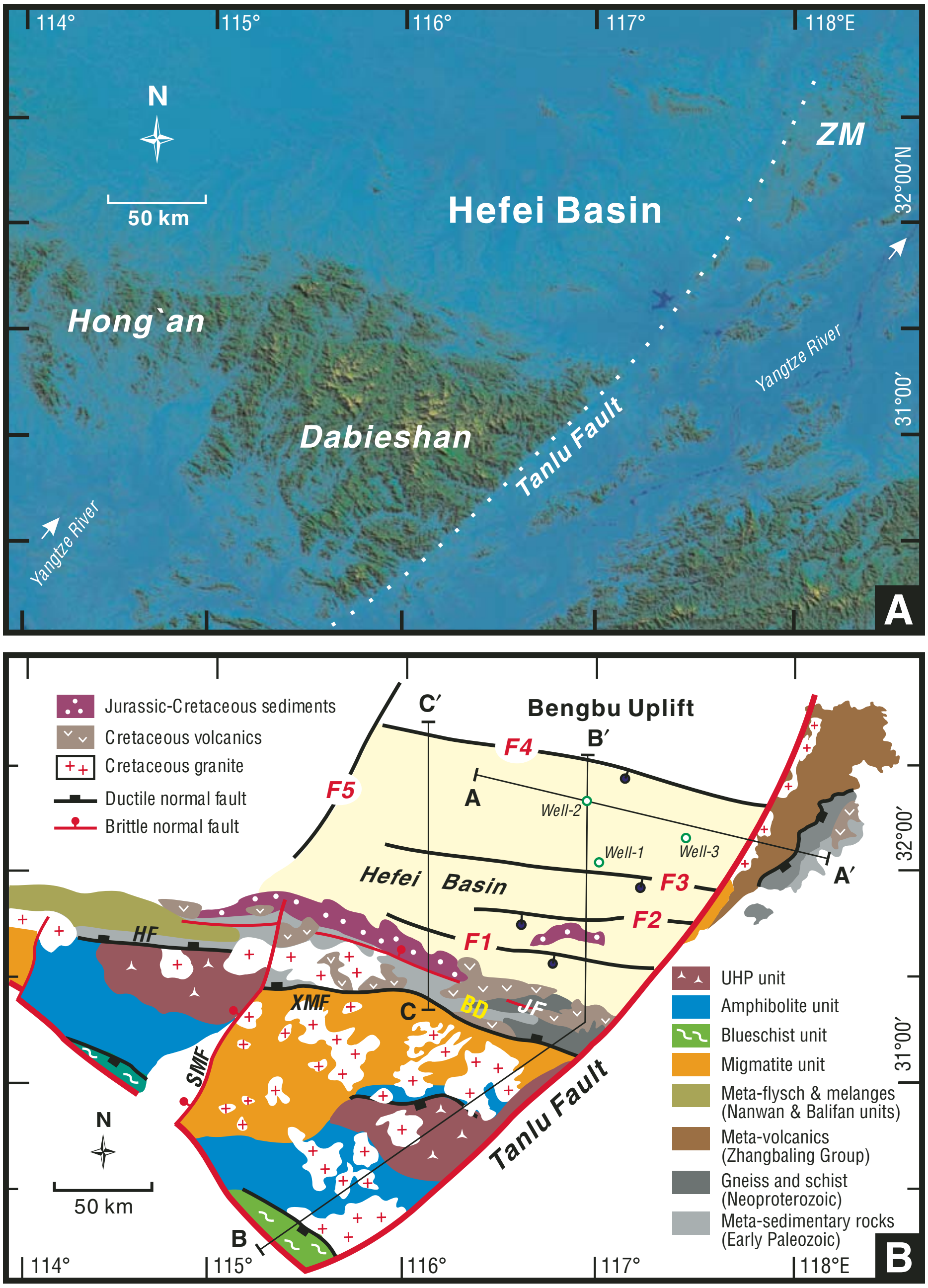

Figure 2. (A) A digital elevation model (DEM) image showing topography of the Hefei basin, Dabieshan, and Tanlu fault. (B) Simplified tectonic map of the Hefei basin, Dabieshan, and Zhangbaling massif, based on Ratschbacher et al. (2000), Faure et al. (2003), P. Li et al. (2003), and Lin et al. (2005a). ZM—Zhangbaling massif; F1—Liu'an fault; F2—Shushan fault; F3—Feizhong fault; F4—Shouxian fault; F5—Fuyang fault. Note that F1–F5 were not active until the Late Cretaceous. Refer to Figure 1 for meanings of other abbreviations.

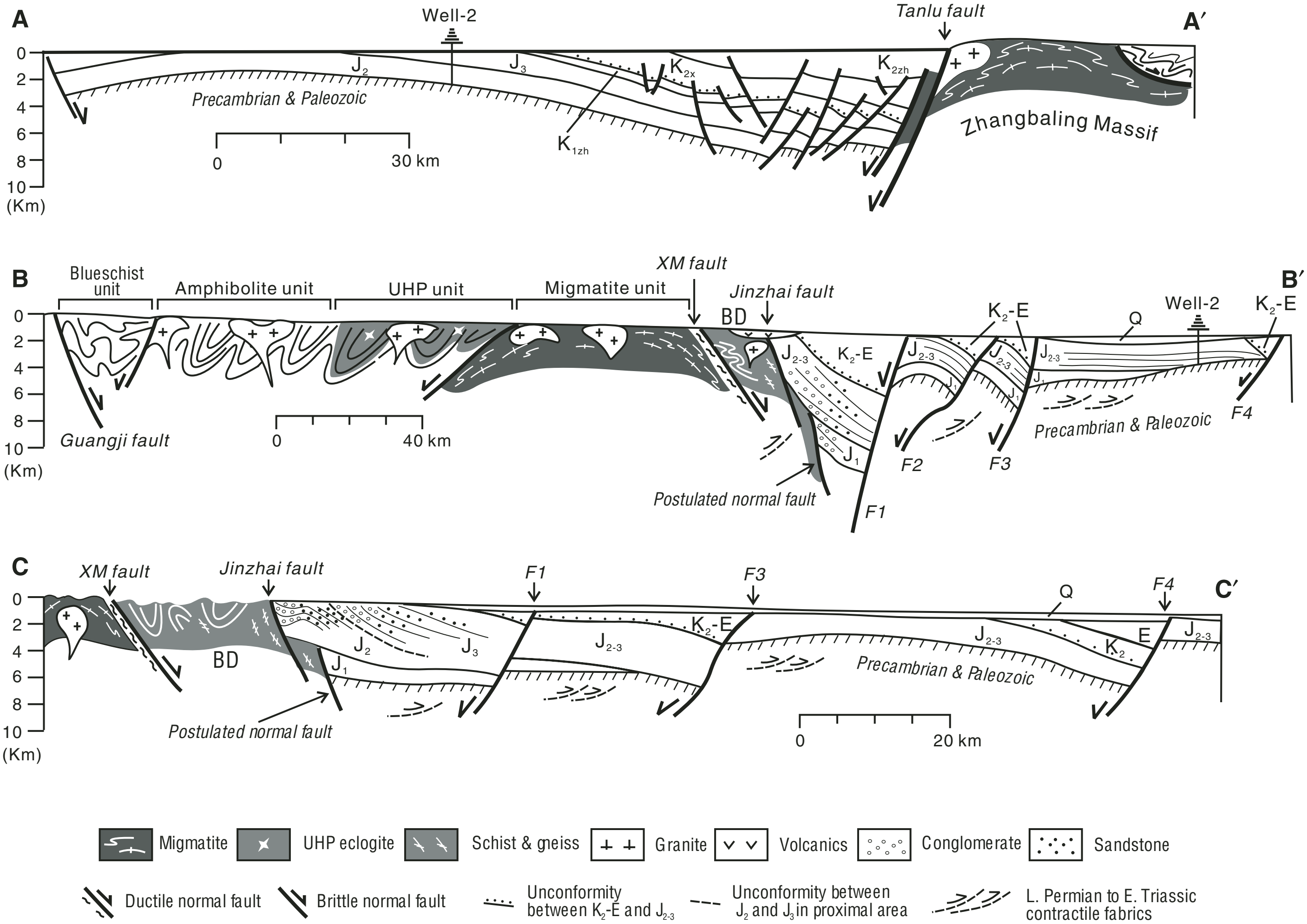

Figure 3. Geological cross sections showing internal structure and stratigraphy of the Hefei basin and its relationship with the adjacent Dabieshan and Zhangbaling massif. Positions of the three sections are shown in Figure 2B. Sections across the Hefei basin are based on geological interpretation of seismic lines (Zhou et al., 1999; P. Li et al., 2003; Xue and Jin, 2001); structures and tectonic subdivisions of the Dabieshan are mainly based on Webb et al. (1999), Ratschbacher et al. (2000), and Faure et al. (2003). Structure of the Zhangbaling massif is mainly from Lin et al. (2005a). Abbreviations: J_1—Lower Jurassic; J_2—Middle Jurassic; J_3—Upper Jurassic; K_{1zh}—Lower Cretaceous Zhuxiang Formation; K_{2x}—Upper Cretaceous Xiangdaopu Formation; K_{2zh}—Upper Cretaceous Zhangqiao Formation; E—Paleogene; Q—Quaternary; XM fault—Xiaotian-Mozitan fault; BD—Beihuaiyang domain.

likely displaced the Sulu UHP metamorphic terrane to the N-NE (Yin and Nie, 1993). Timing of motion on the Tanlu fault is constrained by recent $^{40}Ar/^{39}Ar$ dating of associated mylonites exposed east of the southern Hefei basin. The mylonites yield two clusters of ages, 143–130 Ma and 193–189 Ma (Zhu et al., 2004, 2005). It is possible that the Tanlu fault changed its sense of movement from left-lateral to right-lateral to normal slip during the Jurassic to Cretaceous, and displayed diverse activities in different segments (Grimmer et al., 2002; Zhang et al., 2003). The central segment of the Tanlu fault experienced dextral transtension and then orthogonal extension in the Early Cretaceous (Zhang et al., 2003).

Magmatism began in the latest Late Jurassic and culminated in Early Cretaceous time in and around the Dabieshan. Granitic intrusions yield both single-zircon and cooling ages from ca. 140 to 120 Ma by SHRIMP (sensitive high-resolution ion microprobe), TIMS (thermal ionization mass spectrometry), and $^{40}Ar/^{39}Ar$ methods (Xue et al., 1997; Hacker et al., 1998). Andesitic volcanism occurred simultaneously with the plutonism, as evidenced by TIMS zircon U-Pb ages of 133 ± 3 Ma and 130 ± 2 Ma for basalts and andesites in the Xiaotian area (Fig. 4) (Xia et al., 2003). It is noteworthy that the plutonic and volcanic rocks share identical geochemical features, as manifested by rare earth element (REE) distribution patterns and similar Sr-Nd-Pb isotopic signatures (Zhang et al., 2002). These facts indicate that Early Cretaceous plutonic and volcanic assemblages originated from same source.

BASIN STRATIGRAPHY

Mesozoic strata of the Hefei basin consist of Jurassic and Cretaceous continental facies associations and volcanogenic rocks that unconformably rest on either deformed Paleozoic units or Precambrian complexes (Fig. 5). Triassic strata are absent throughout the basin (Han, 1996; P. Li et al., 2003). A higher regional unconformity separates Upper Cretaceous–Cenozoic strata from underlying

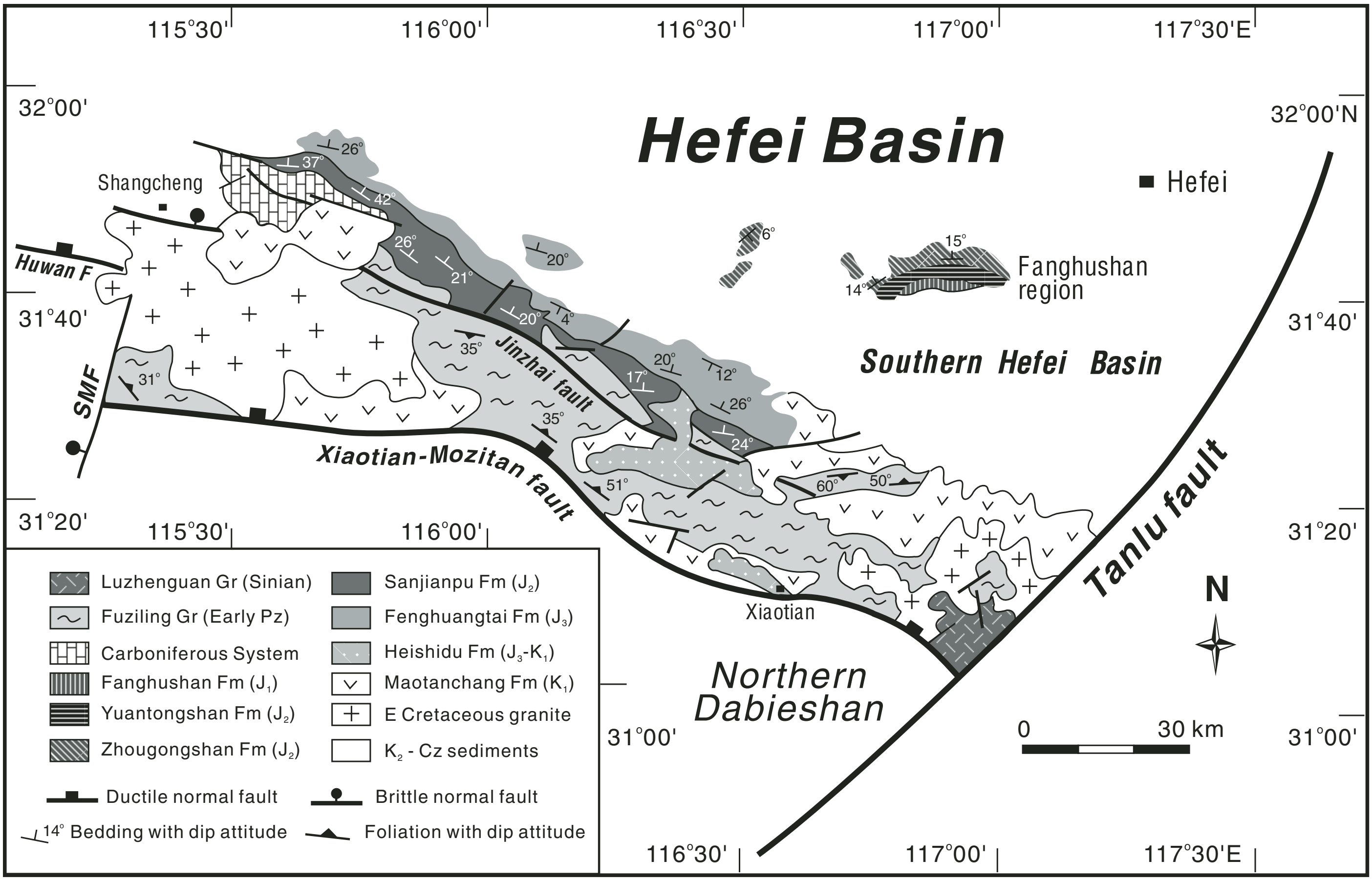

Figure 4. Simplified geologic map of the southern margin of the Hefei basin. Note that Jurassic strata occur exclusively to the north of the Jinzhai fault. Cz—Cenozoic; Pz—Paleozoic; Gr—Group. Refer to Figure 3 for meanings of other abbreviations.

units. Uncertainty exists about the ages of some stratigraphic units, inasmuch as they consist mostly of continental red beds devoid of determinative fossils. Ages of some units are inferred or extrapolated on the basis of well-constrained overlying and underlying units.

The Lower Jurassic Fanghushan Formation crops out in few areas (Fig. 4), and its age assignment is based on plant fossils (Fig. 5). The Middle Jurassic Sanjianpu and Upper Jurassic Fenghuangtai Formations are well exposed at the southern edge of the basin, where they rest unconformably on Lower Paleozoic metamorphosed rocks such as the Fuziling Group (Fig. 4). Recent $^{40}Ar/^{39}Ar$ dating of diagenetic illite from the Sanjianpu Formation has yielded a late Middle Jurassic plateau and isochron $^{40}Ar/^{39}Ar$ ages, ranging from 159 ± 0.5 Ma to 157 ± 0.3 Ma (D. Wang et al., 2000). The overlying Fenghuangtai Formation is considered to be of Late Jurassic age because it lies below andesite, trachyte, and agglomerate of the Maotanchang Formation that have been dated at 148–138 Ma by whole-rock K-Ar method (Y.J. Wang et al., 2002). Although dominated by volcanic and volcaniclastic rocks, the Maotanchang Formation also contains fine-grained siliciclastic interlayers with abundant Early Cretaceous fossils (Fig. 5) (Wu et al., 2002). Therefore, the Maotanchang Formation was developed in the Early Cretaceous, and the underlying Fenghuangtai Formation is likely Late Jurassic in age.

The Baidafan and Heishidu Formations are of Early Cretaceous in age; the first consists of volcanic and volcaniclastic series, and the second is composed mostly of tuffaceous sediments. Volcanic rocks are dominantly alkaline basalt and trachyte dated at 130 ± 2 Ma and 132 ± 2 Ma by the whole-rock K-Ar method (Y.J. Wang et al., 2002) and 130 ± 2 Ma by single-zircon U-Pb method (Xia et al., 2003). Abundant fossils are present in the Heishidu Formation (Fig. 5), all of which are the common species of Lower Cretaceous strata in China (Hao et al., 1986). The two formations are considered roughly synchronous and unconformably overlie Lower Paleozoic and Neoproterozoic units or the Maotanchang Formation.

SEDIMENTOLOGY

Southern Hefei Basin

Fanghushan Formation

The Lower Jurassic Fanghushan Formation, which rests unconformably on the Sinian Luzhenguan Group, represents the oldest unit within the Hefei basin. This Lower Jurassic unit crops out only in a few places, and the following description is mainly based on our measured section in the Fanghushan region (Fig. 4). It consists dominantly of coarse-grained sandstone and pebbly-cobbly conglomerate as well as fine-grained sandstone and siltstone layers in the uppermost portion of the sequence (Fig. 6A). Massive conglomerate is both matrix- and clast-supported and exhibits nonerosive contacts with underlying units. Thick- and medium-bedded gravelly sandstone is usually associated with massive conglomerate. Some parallel-stratified gravelly sandstones internally display gravel-sand couplets 10–40 cm thick. The two lithofacies primarily occur in the lower and middle parts of the

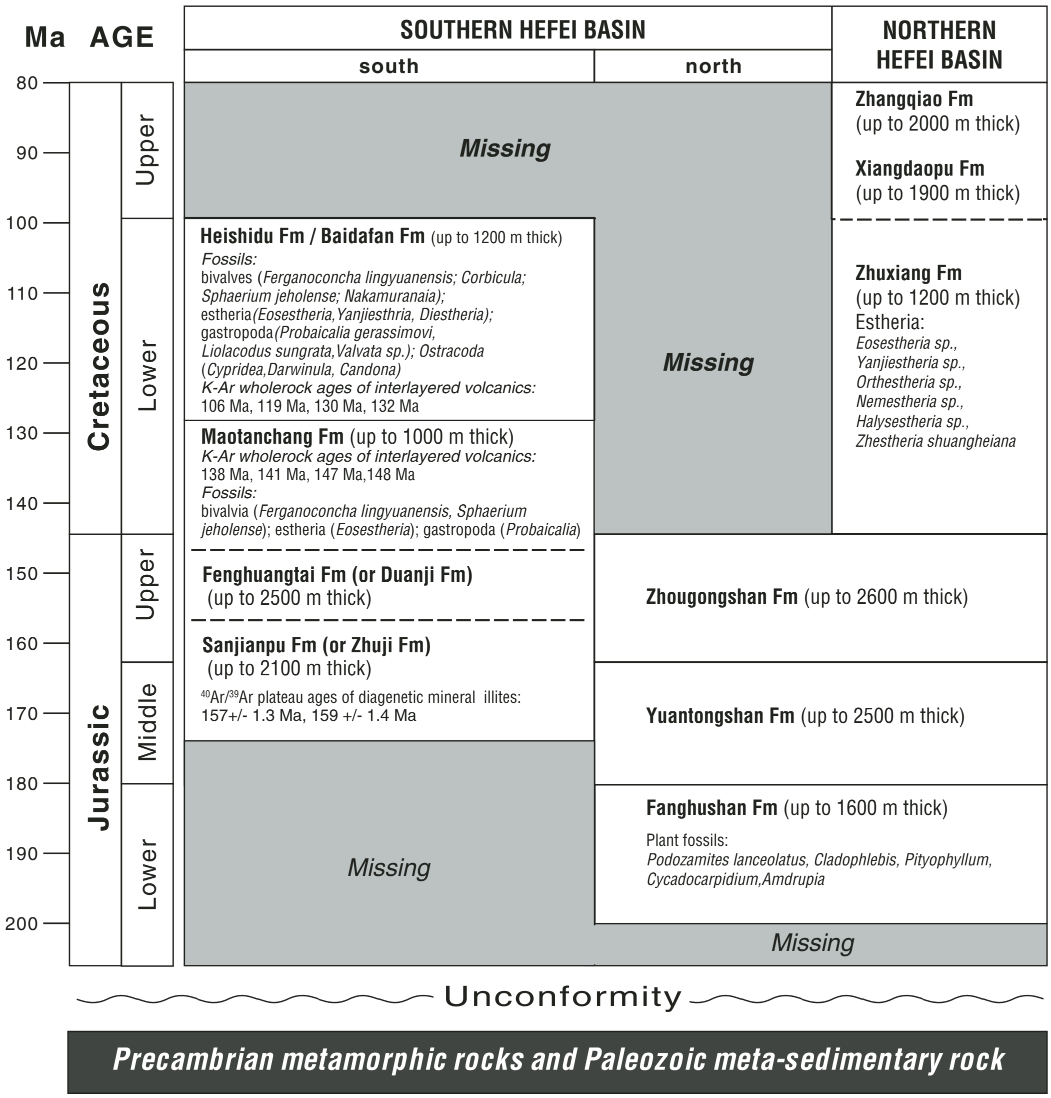

Figure 5. Mesozoic stratigraphy of the Hefei basin, compiled from Li and Jiang (1997), D. Wang et al. (2000), Y.J. Wang et al. (2002), and Wu et al. (2002). Dashed and wavy lines indicate erosional and angular unconformities, respectively.

measured section. Coarse- and medium-grained cross-stratified sandstone and conglomeratic beds dominate the upper portion of the sequence but are also present in the lower portion. Sandstone units are thick- and medium-bedded and have prominent channeled bases. Conglomerate units exhibit various-scale lens-shaped geometry and cut into the underlying units. Thin-bedded fine-grained sandstone and siltstone in the upper portion are rich in Early Jurassic fossils.

Massive matrix-supported conglomerate facies with nonerosive basal contacts are interpreted as debris-flow products, whereas gravelly coarse-grained sandstone facies with parallel bedding and gravel-sand couplets are thought to have resulted from sheet floods (Blair and McPherson, 1994). The association of the two lithofacies therefore constrains alluvial deposition in the lower and middle portions of the Fanghushan Formation. Cross-stratified and planar-laminated sandstone and lens-shaped conglomerate comprise another distinct lithofacies association, which is interpreted to have formed in a sandy fluvial system in consideration of its minor proportion of conglomerate. The conglomeratic facies are interpreted as either lag or gravel-bar deposits, whereas the sandstone, which usually overlies the conglomeratic facies, is ascribed to migration of bedforms (Miall, 1996). This facies association is organized into several upward-fining sub-sequences of various thicknesses, probably resulting from channel migration and filling processes (Maill, 1996). In general, the Fanghushan Formation is formed mainly of alluvial and fluvial lithofacies associations.

Sanjianpu and Yuantongshan Formation

The Sanjianpu Formation crops out widely along the southern margin of the Hefei basin (Fig. 7), and its base usually consists of massive matrix-supported conglomerates (Figs. 8 and 9A). Its basal conglomeratic units vary in thickness from tens to hundreds of meters in different localities, and it unconformably overlies the Lower Paleozoic Fuziling Group. Conglomeratic facies dominate the lower half of the Sanjianpu Formation and are up to 860 m thick in the measured section (Fig. 8). Horizontal-bedded gravelly sandstone is closely associated with the massive conglomerate. Other types of lithofacies comprise the upper part of the formation, such as cross- and planar-bedded sandstone (Fig. 9B), although some crude low-angle cross-stratified conglomerate units may also appear as interbeds of varying thickness and lateral extent. Cropping out ~50 km north of the basin edge, the Yuantongshan Formation (equivalent to the Sanjianpu Formation) is composed mostly of finer-grained facies associations (Fig. 6B), contrasting with the coarse-grained facies of the

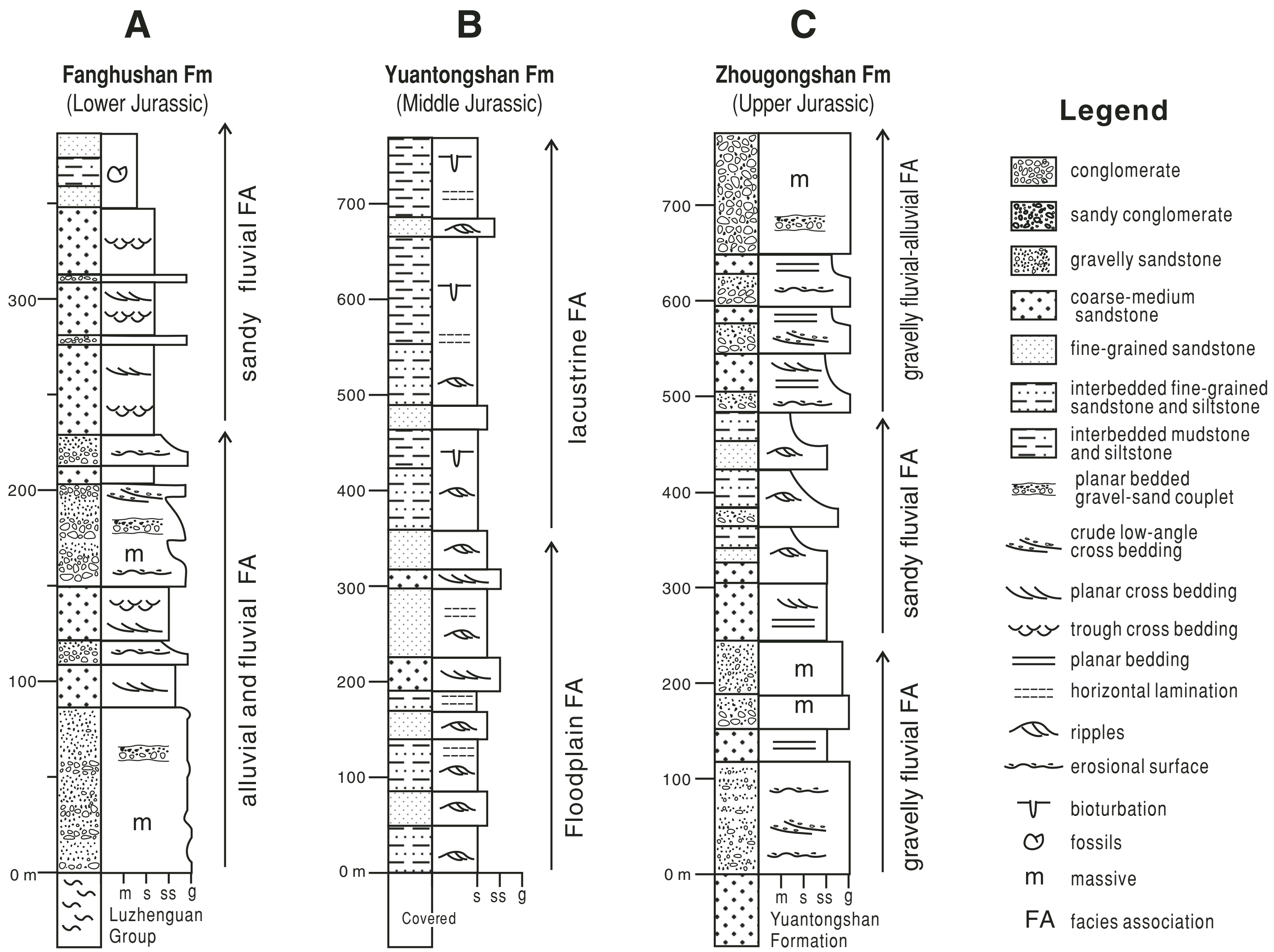

Figure 6. Representative measured sections of Jurassic strata in the Fanghushan region of the southern Hefei basin and interpretations of sedimentary environments. Section A starts at 31°41′58.9″N latitude, 116°54′10.6″E longitude, and sections B and C are continuous, starting at 31°42′31.3″N latitude, 116°54′18.8″E longitude.

Sanjianpu Formation. The dominant lithofacies include thin- to medium-bedded fine-grained sandstone, rippled siltstone, and laminated mudstone (Fig. 9C). Some lens-shaped cross-bedded sandstone bodies are sandwiched in the fines. Bioturbation is common.

The facies characteristics of conglomerate within the lower portion of the Sanjianpu Formation, such as matrix-supported, disorganized texture, absence of stratification, and nonerosive base, are all indicative of a debris-flow origin for conglomerate in the lower portion of the Sanjianpu Formation. The associated horizontal-bedded sandy conglomerate can be readily attributed to sheet-flood deposition (Blair and McPherson, 1994) or hyperconcentrated flood flows (Smith, 1986). We propose that these two lithofacies formed in alluvial environments. Cross-bedded sandstone and conglomerate are attributed to normal stream flows in channels, whereas the finer rippled and horizontal-laminated lithofacies are regarded as floodplain deposits in interalluvial regions. On the whole, the Sanjianpu Formation is made up of three distinct facies associations formed in alluvial, sandy-gravelly fluvial, and floodplain environments, although the relative dominance of individual lithofacies associations varies spatially. The finer facies of the Yuantongshan Formation are interpreted as floodplain and lacustrine deposits, which are distal counterparts to the proximal alluvial fan system represented by the Sanjianpu Formation.

Fenghuangtai and Zhougongshan Formation

The Fenghuangtai Formation also widely crops out along the southern edge of the Hefei basin (Fig. 7), and is composed primarily of variably clast- and matrix-supported conglomerate beds (Figs. 8 and 9D). Crude inverse grading is developed in basal portions of some conglomeratic beds or throughout others. Cross-bedded gravelly sandstone or coarse-grained sandstone appears in the uppermost parts of conglomeratic beds. Clast-supported, granular and pebbly conglomerate becomes pronounced in upper portions of the sequences and is interbedded with planar- and cross-bedded sandstone. Fine lithofacies characterize upper portions of some sequences but are regionally minor in proportion when compared to the coarser lithofacies.

The Zhougongshan Formation, equivalent to the Fenghuangtai Formation, is dominated by conglomerate and coarse-grained sandstone, in contrast to the underlying finer lithofacies of the

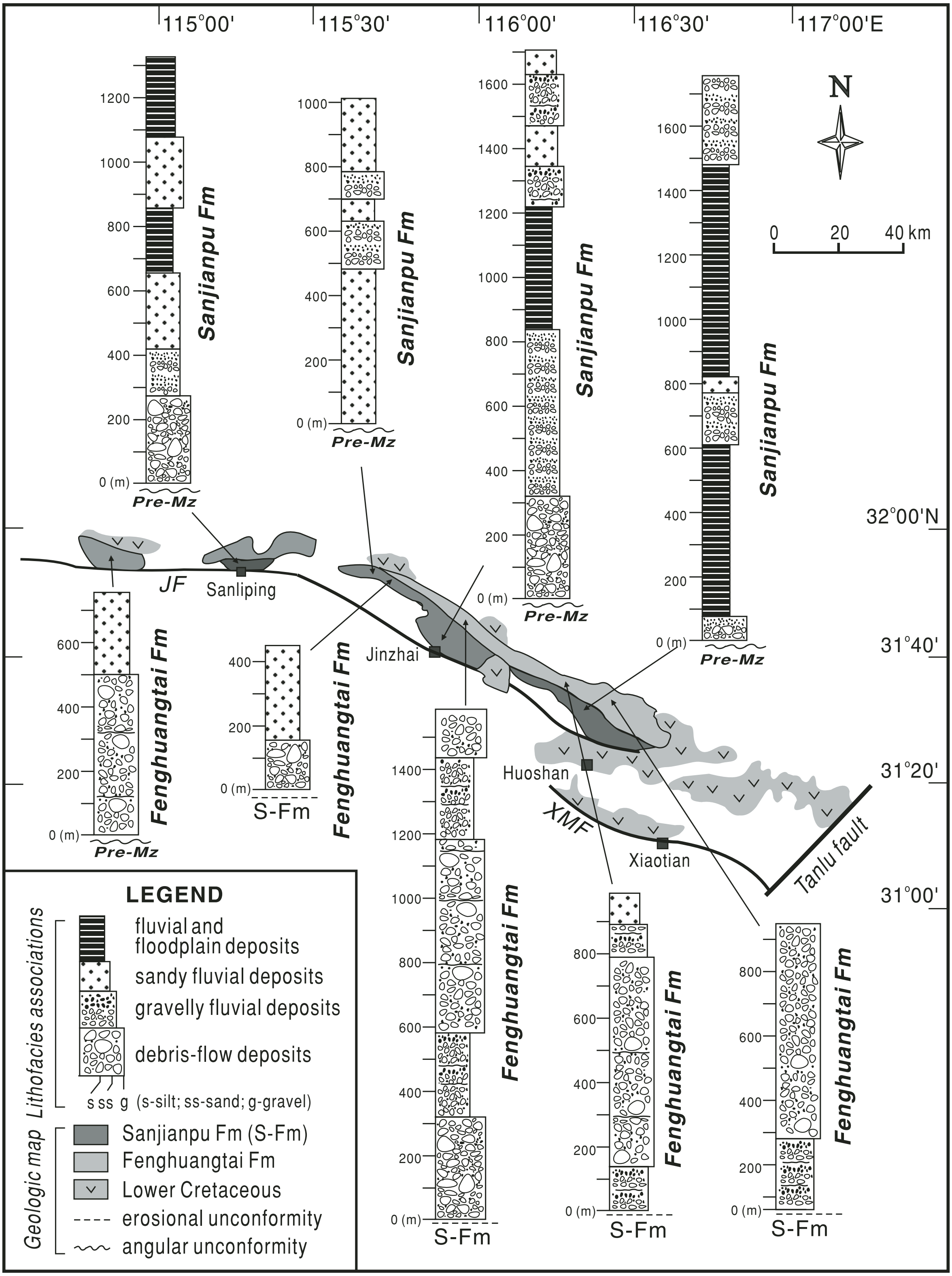

Figure 7. Spatial and temporal variations of depositional sequences of the Middle Jurassic Sanjianpu Fm (Formation) and the Upper Jurassic Fenghuangtai Formation in the southern Hefei basin. Note that alluvial-fan deposits dominate lower parts of the Sanjianpu Formation in certain places and that their counterparts in intervening areas are mainly fluvial and floodplain facies. Fluvial and floodplain facies also characterize the middle and upper parts of the formation. The Fenghuangtai Formation consists primarily of alluvial and gravelly fluvial deposits, with sandy fluvial facies dominating the upper parts. JF—Jinzhai fault; XMF—Xiaotian-Mozitan fault.

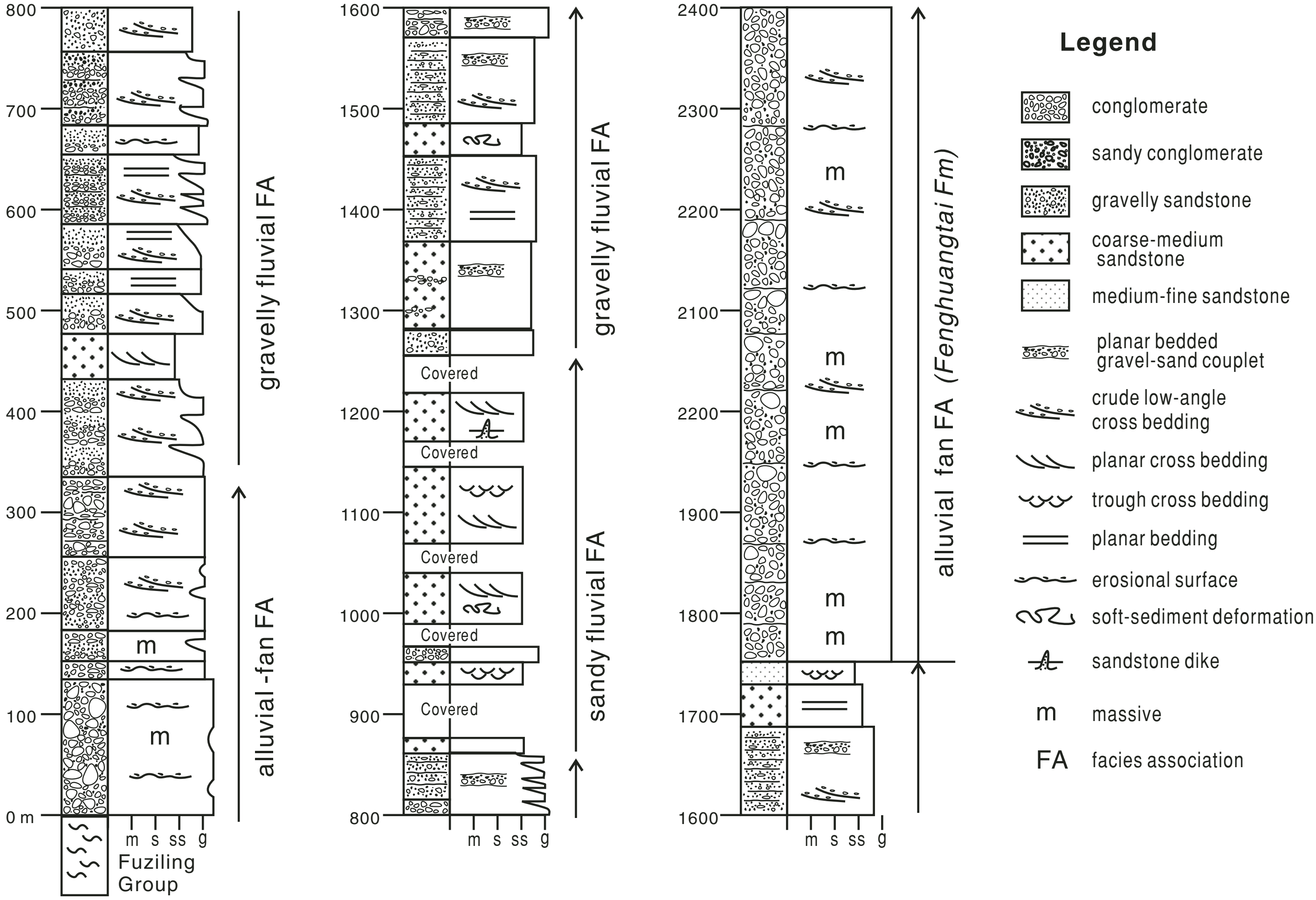

Figure 8. A measured section from the Middle Jurassic Sanjianpu Formation to Upper Jurassic Fenghuangtai Formation in the southern Hefei basin and interpretations of sedimentary environments. Section starts at 31°41′29.6″N latitude, 115°53′11.3″E longitude.

Yuantongshan Formation (Fig. 6C). The upper portion is formed mainly of massive conglomerate and parallel-stratified gravelly sandstone. The lower portion is dominated by variably clast- to matrix-supported conglomerate in association with planar-bedded coarse-grained sandstone. Clast-supported conglomerate beds are mostly channeled, and clasts are imbricated (Fig. 9E). Medium-grained, planar-laminated or cross-bedded sandstone constitutes the bulk of the middle portion of the measured section. Also present are gravelly sandstone and sandy conglomerate bodies that incise the underlying unit (Fig. 9F).

Matrix-supported conglomerate of the Fenghuangtai Formation is quite similar to conglomerate of lower portions of the Sanjianpu Formation, and, therefore, it is ascribed to debris-flow sedimentation. Both clast-supported conglomerate and cross-bedded gravelly sandstone are thought to be the products of normal stream flows, and their close association represents stacked channel deposits of gravelly braided rivers because the resulting facies sub-sequences are devoid of finer-grained facies and full of erosive surfaces (Miall, 1996). Localized thick sequences of finer lithofacies may represent floodplain deposition between adjacent alluvial and braided-river systems. The Fenghuangtai Formation north of Jinzhai County is dominated by alluvial facies, as shown by the measured section (Fig. 8). As for the Zhougongshan Formation (Fig. 6C), the clast-supported conglomerate and cross-bedded sandstone, which are predominant in the lower portion, are obviously the result of stream flows. Fining-upward sequences of differing thickness, which are made up of cross-bedded sandstone and rippled siltstone in the middle portion, indicate that this facies association formed in sandy fluvial systems. The massive conglomerate in the upper portion is interpreted as debris-flow deposits, and the associated parallel-stratified gravelly sandstone is assumed to result from sheet flooding.

Maotanchang Formation

The Maotanchang Formation is composed of volcanics and volcanogenic sedimentary rocks (Fig. 10), which contrast with underlying continental siliciclastic rocks. The volcanic rocks are mostly andesite and trachyandesite, accompanied by subordinate trachyte, basalt, and rhyolite. Pyroclastic deposits include lapillistone, tuff, and volcanic breccia (Fig. 11A). The pyroclastics can make up successions more than 200 m thick and usually appear massive. Sedimentary structures like cross-bedding and lamination exist in some relatively well-sorted pyroclastic rocks below or atop thick ignimbrite. Coarser pyroclastic deposits occur only in certain areas, although accompanying tuffs appear relatively extensive. Both are associated with interlayers of fine-grained epiclastics and tuffaceous sandstone, siltstone, and mudstone.

Our reconnaissance of the volcaniclastic rocks suggests that pyroclastic flows were

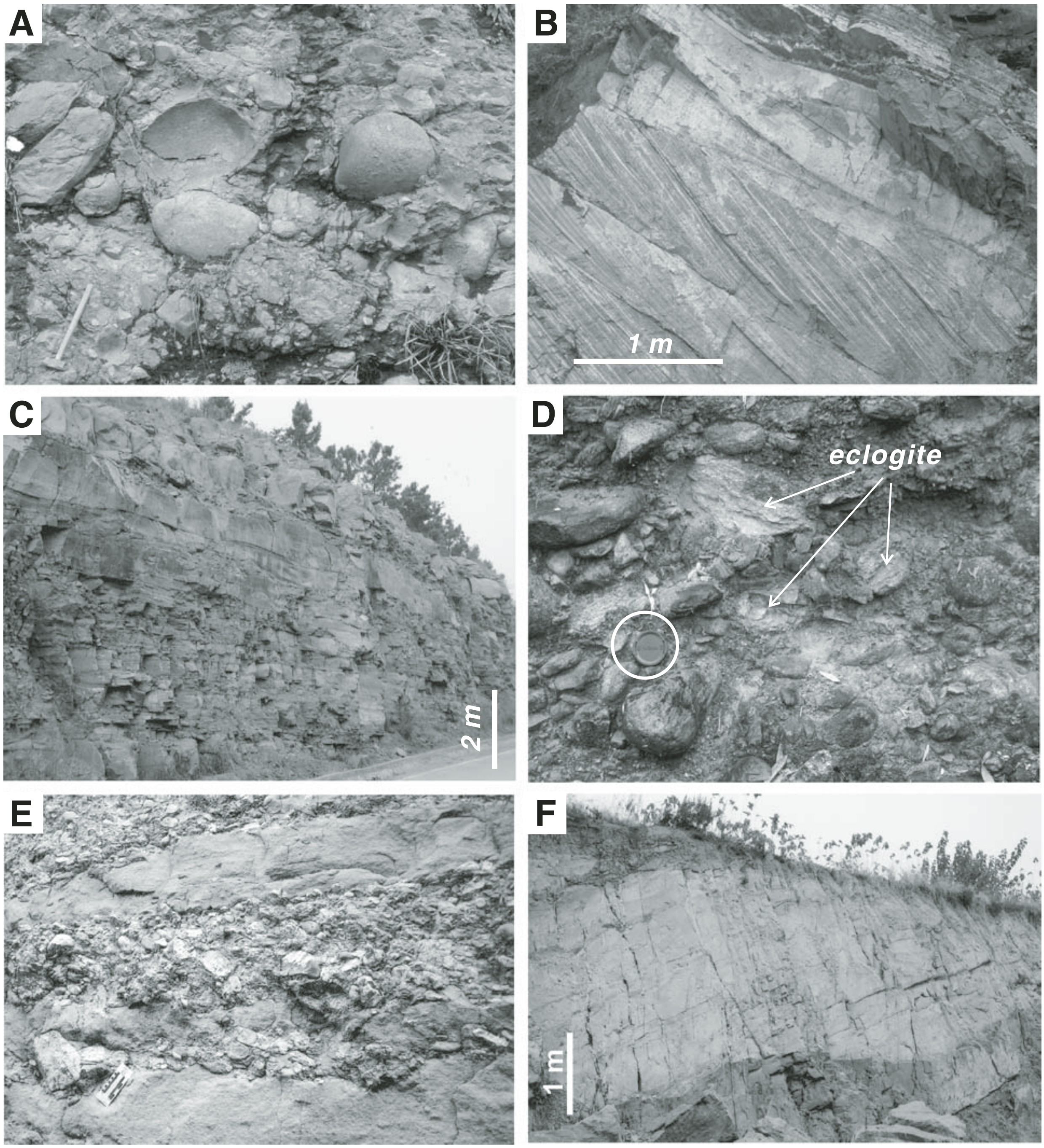

Figure 9. Field photos of Middle and Upper Jurassic sedimentary facies. (A) Matrix-supported conglomerate in the lower part of the Sanjianpu Formation. Hammer (40 cm long) for scale. (B) Large-scale planar cross-bedded sandstone in the Sanjianpu Formation. The view is ~4.5 m wide. (C) Thin- to medium-bedded fine-grained sandstone, siltstone, and mudstone in the Yuantongshan Formation. The view is ~6 m high. (D) Eclogite gravels in conglomerate in the Fenghuangtai Formation. Camera cap (55 mm in diameter) for scale. (E) Interbedded gravelly sandstone and clast-supported conglomerates with striking imbrications and channeled base in the Zhougongshan Formation. The photo scale is 16.5 cm long. (F) Channel fills in the Zhougongshan Formation. The view is ~6 m high.

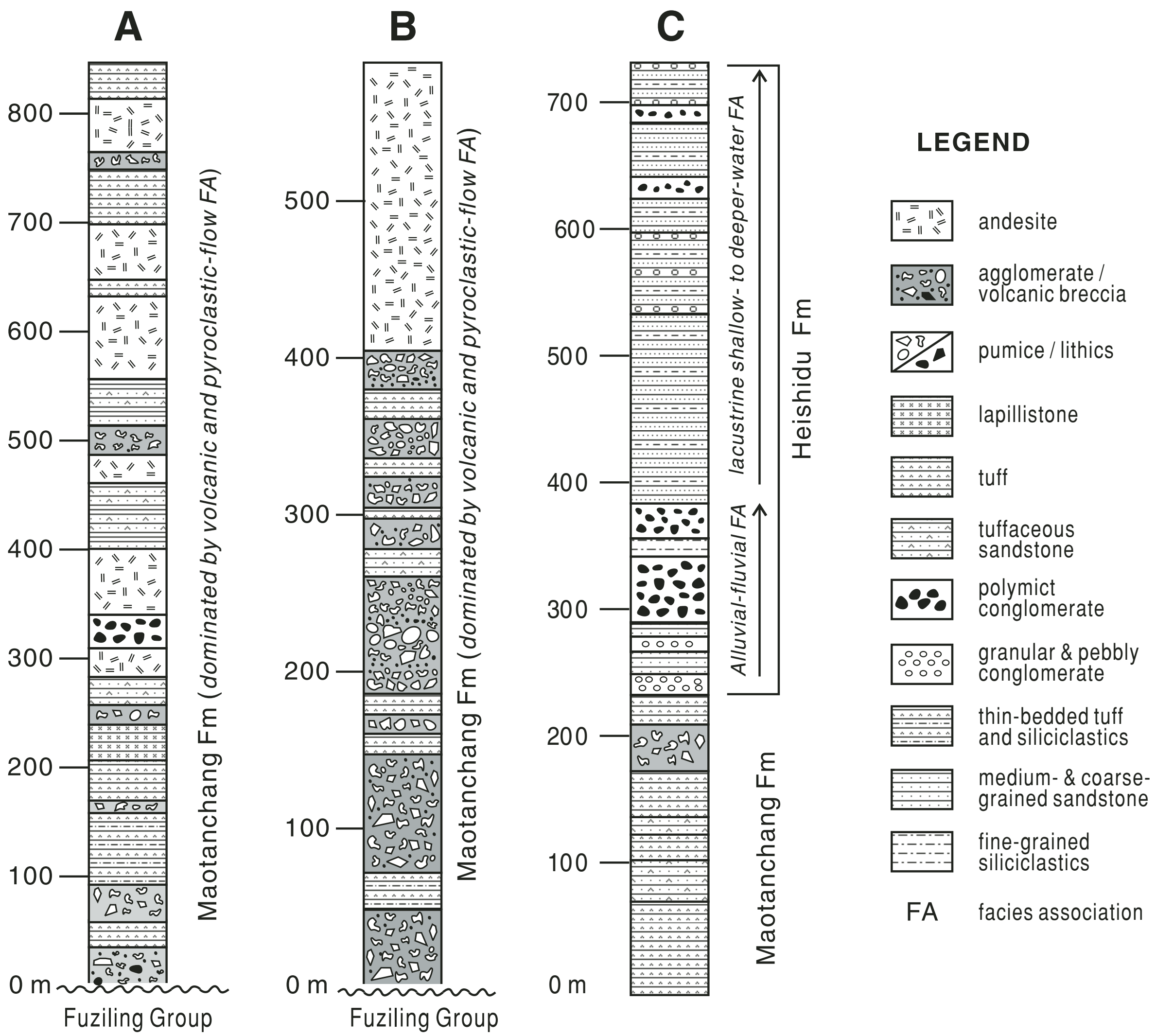

Figure 10. Measured sections of Lower Cretaceous Maotanchang and Heishidu Formations and facies interpretations. Note that the Maotanchang Formation is composed primarily of volcanic and pyroclastic rocks, while the Heishidu Formation consists mostly of volcaniclastic–siliciclastic associations. Section A starts at 30°09′16.7″N latitude, 116°31′50.3″E longitude; section B is at 31°22′31.1″N latitude, 116°33′28.4″E longitude; and section C is at 31°10′0.6″N latitude, 116°34′20.9″E longitude.

responsible for the formation of massive ignimbrite, but the cross-bedded and well-sorted units owe their origin to pyroclastic surges (cf. Branney and Kokelaar, 2002). Volcanic breccias are interpreted as the consequence of block-and-ash flows because the blocks are composed dominantly of nonvesicular andesitic rocks instead of pumices (Cas and Wright, 1987). It is considered that the collapse of eruption columns might have been responsible for generation of these volcaniclastic rocks, whereas the fine-grained sedimentary interlayers were deposited during interim periods of volcanic quiescence. The spatial restriction of pyroclastic-flow deposits implies that they were topographically confined to valleys or that they were simply deposited near the vent, in contrast to the extensive tuffs, which were fallout in origin.

Heishidu Formation

The Heishidu Formation consists largely of epiclastic rocks, including siltstone, sandstone, and polymict conglomerate. Massive conglomerates with abundant volcanic clasts exhibit nonerosive bases. Granular conglomerate and gravelly sandstone are parallel bedded. Thin- and medium-bedded, laterally continuous finer lithofacies (Fig. 11B), however, dominate Lower Cretaceous successions. They are internally characterized by horizontal lamination, soft-sediment deformation, and normal grading in some interlayered sandstone beds. Massive conglomerate either occurs as bodies sandwiched within finer facies or makes up the bulk of the sequences in places where it is closely associated with horizontal-bedded gravelly sandstone.

The coarser conglomerates are interpreted as debris-flow products, as implied by their massive fabrics and nonerosive bases, whereas we interpret the finer conglomerate and gravelly sandstone to have formed through fluvial processes because of the presence of planar- and cross-bedding. Subaqueous environments are assigned to the formation of horizontal laminated fine- and medium-grained sandstone and siltstone, inasmuch as they contain abundant freshwater fossils such as gastropod, estheria, bivalves, and fish (Wu et al., 2002). The upper

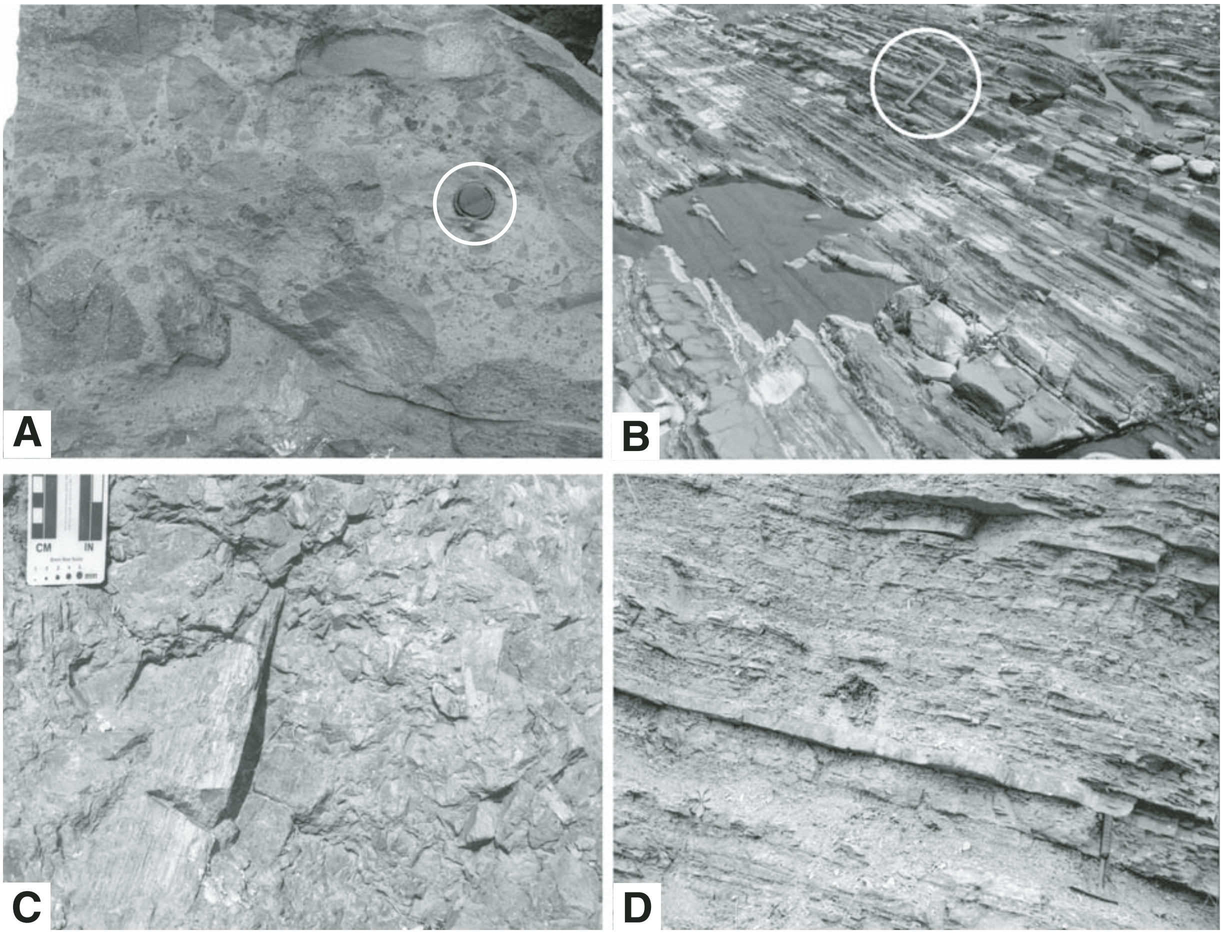

Figure 11. Field photos of Lower Cretaceous sedimentary facies. (A) Volcanic breccia in the Maotanchang Formation. Camera cap (55 mm in diameter) for scale. (B) Interlayered tuffaceous fine-grained sandstone and siltstone/mudstone of the Heishidu Formation. Hammer (50 cm long) for scale. (C) Breccia in the Zhuxiang Formation containing quartz-schist clasts from the Zhangbaling Group. (D) Dark-colored, thin-bedded, fine-grained sandstone and siltstone/mudstone in the Zhuxiang Formation. Hammer (35 cm long) for scale.

portion might have formed in a deeper-water environment because complete and incomplete Bouma sequences are developed in some sandstone layers. Fining-upward successions of the Heishidu Formation thus represent a temporary transition from alluvial/fluvial to lacustrine sedimentation. Given its limited distribution and spatial variations of facies sequences, we infer that the Heishidu Formation might represent fan-delta deposition in crater lakes.

Northern Hefei Basin

The northern Hefei basin is almost entirely covered with Cenozoic sediments, with a few exposures of Lower Cretaceous strata within and on the eastern edge of the basin. The depositional systems of the basin are, therefore, deduced mainly from well logs, cores, and seismic-reflection data (Xue and Jin, 2001; P. Li et al., 2003), combined with mapping and section measuring of the exposed Lower Cretaceous units. Lower Jurassic strata in the northern Hefei basin are composed mainly of dark-colored horizontal-laminated muddy siltstone and mudstone (Fig. 12A), and their seismic reflections display typical high amplitude and high lateral continuity. Lower Jurassic strata are, therefore, interpreted as lacustrine deposits on account of their uniform lateral extent, fine grain size, and horizontal laminations. Middle Jurassic strata consist primarily of interlayered grayish fine-grained sandstone, siltstone, and mudstone (Figs. 12Aand 12B), containing cross-stratifications and wavy laminations. Their seismic configuration is typified by low to medium amplitude and continuity. We infer that Middle Jurassic deposition occurred in lacustrine and deltaic settings. Upper Jurassic strata consist of medium-grained sandstone (mostly arkosic and lithic arenites), and purple muddy siltstone and mudstone. These two facies are made up of several fining-upward sub-sequences of varying thickness (P. Li et al., 2003). Seismic reflections show variable amplitude and low continuity. Late Jurassic sedimentation is considered to have occurred in fluvial environments as a whole (Figs. 12A and 12B).

The Lower Cretaceous Zhuxiang Formation is mostly gray fine-grained sandstone and siltstone (Fig. 12C), with coarse-grained lithofacies only developed along the eastern edge of the basin. The facies distribution and interpretation in the basin interior are mainly based on cores and seismic facies (P. Li et al., 2003) and are substantiated by our observations at some outcrops. Lower Cretaceous units at the eastern basin margin are composed of thick-bedded, poorly sorted, angular conglomerates (Fig. 11C) and parallel-stratified gravelly sandstone. Clasts of the conglomerate are mostly metavolcanics and pyroclastics. The finer-grained facies dominate in most of the basin, and they display horizontal

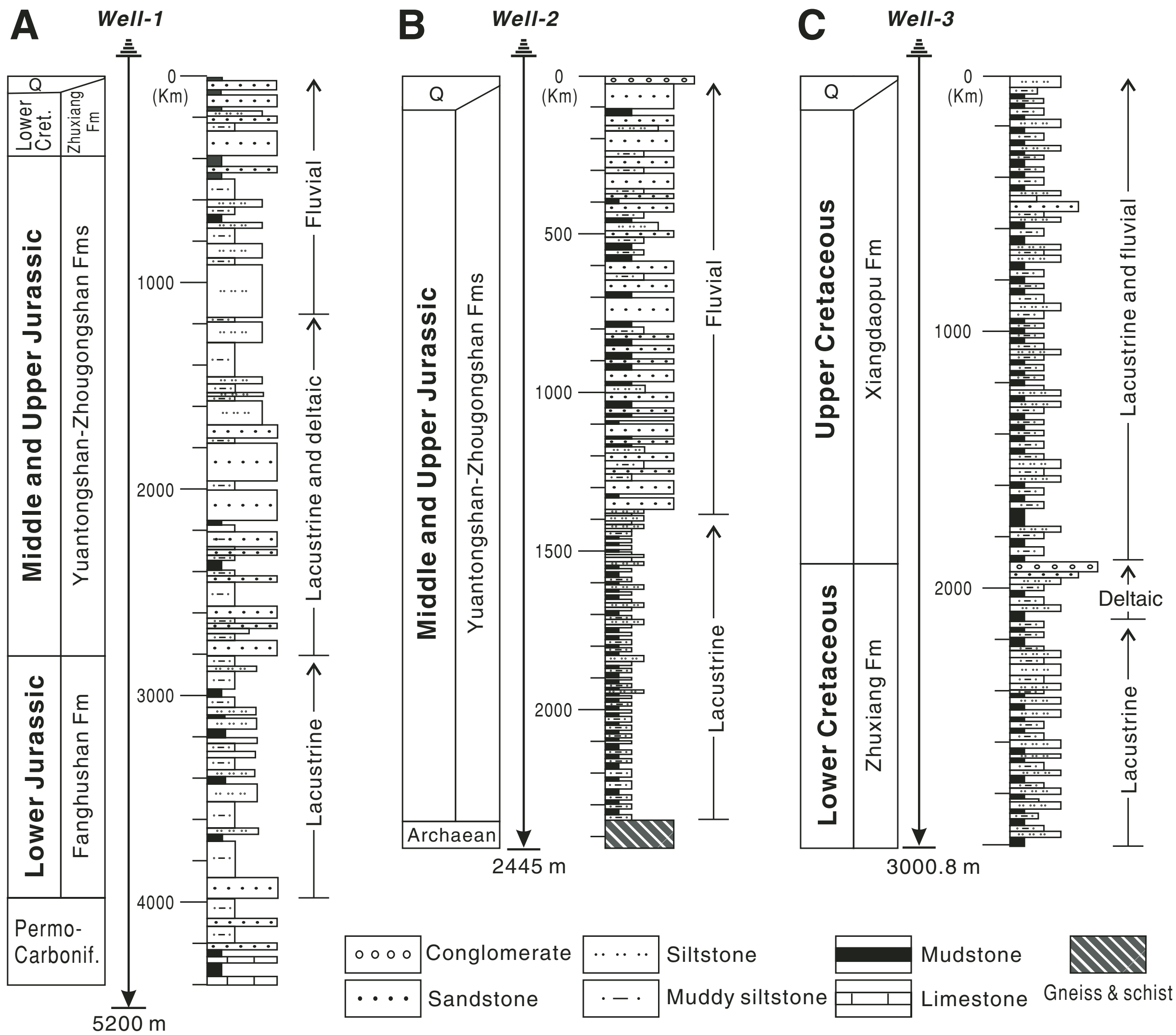

Figure 12. Representative well logs within the Hefei basin, showing the stratigraphy, lithology, and interpretations of depositional environments. Well hole localities are indicated in Figure 2B. Data are from Xue and Jin (2001), Xu et al. (2002), and P. Li et al. (2003).

lamination and ripple cross-stratifications in thin-bedded fine-grained sandstone and siltstone (Figs. 11D and 12C). Thick-bedded and even massive sandstones are observed in some quarries, which internally contain dewatering structures and intrabasinal mud clasts. The coarse lithofacies at the eastern edge of the basin are interpreted as alluvial fan and proximal fan-delta deposits. The thin-bedded fines represent lacustrine sediments, and the thick sandstone beds probably developed in delta fronts. Lower Cretaceous strata thicken eastward (Fig. 3, section A–A′) and pinch out to the north, west, and south. In general, the northern Hefei basin was dominated by lacustrine deposition in the Early Cretaceous, although rimmed by alluvial, fluvial, and deltaic systems at the basin's margins.

BASIN ANALYSIS

Paleocurrents

We use cross-stratification and clast imbrication to restore paleoflow directions in the Hefei basin. Jurassic paleocurrents in the southern Hefei basin were mostly toward the north and northeast (Fig. 13), implying that clastic influx was from the Dabieshan. The dominant Middle to Late Jurassic N- and NE-directed paleoflows might also imply that the main depocenter was located in the eastern portion of the southern Hefei basin. This inference is supported by isopach patterns of Middle–Upper Jurassic units (Fig. 14D). The SE-directed paleoflows in the region east of Jinzhai County (Fig. 13A) are an exception that might indicate that this location was in the eastern flank of the inferred Jinzhai alluvial fan in the Middle Jurassic. In addition, the relative consistency of NE-directed paleoflows at both the southern margin and in the interior of the southern Hefei basin (the Fanghushan region) suggests that sediments were dispersed through transverse rivers draining the Dabieshan. Lower Cretaceous strata in the southern margin of the Hefei basin are dominantly volcanic rocks, pyroclastic rocks, and associated crater-lake deposits, which represent in situ lava flow and volcanogenic sedimentation. In the northern Hefei basin, Early Cretaceous paleoflows were mainly to the west and southwest along the eastern edge, indicating that sediments were derived from the Zhangbaling

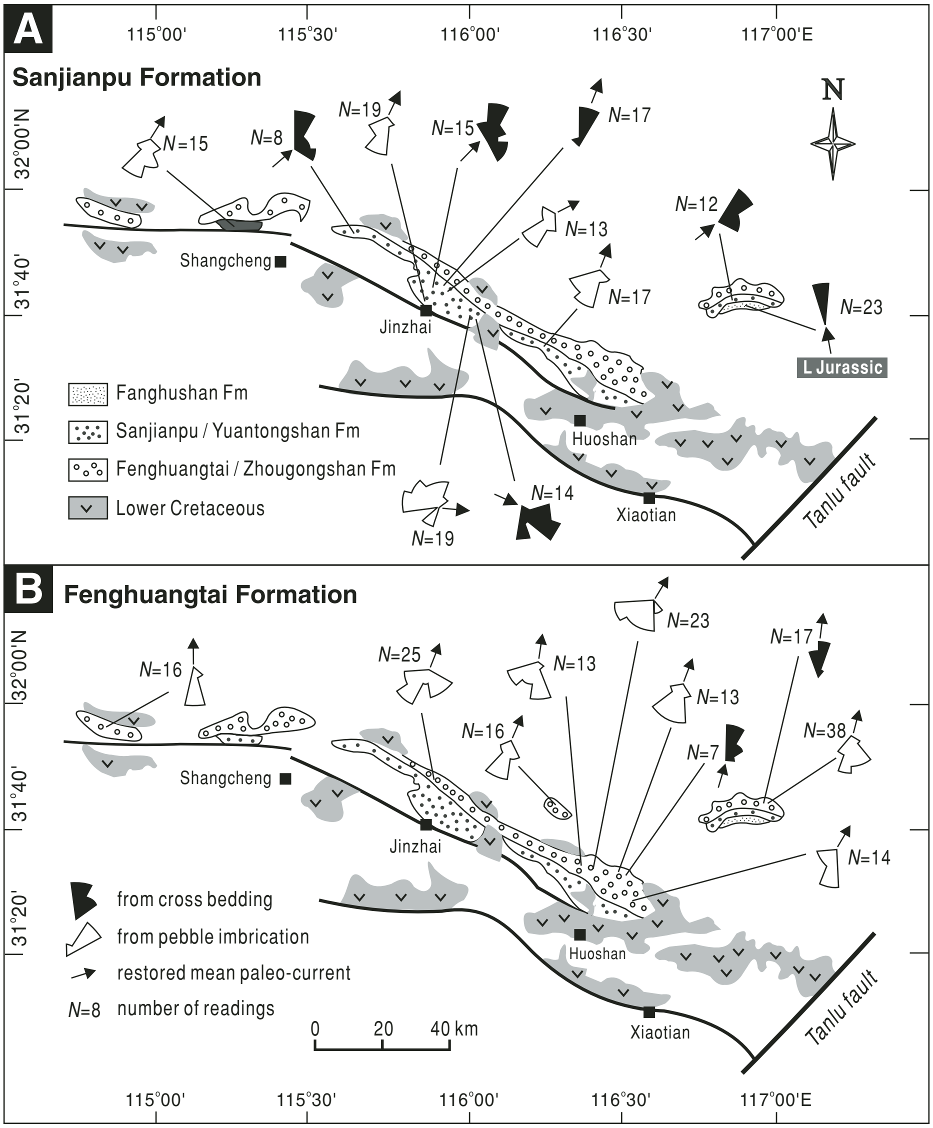

Figure 13. Restoration of Jurassic paleoflows in the southern Hefei basin. (A) Early–Middle Jurassic paleoflows were mainly to the north and northeast. Note SE-directed paleoflows that denote the eastern margin of the Jinzhai alluvial fan. (B) Late Jurassic paleoflows were also mostly to the northeast. Paleocurrent restoration is made from cross-stratifications and pebble imbrications.

massif, and to the north and northeast at the southern margin (Fig. 14E).

Provenance

Although source areas of the basin can be inferred in part from paleocurrent analysis, understanding of their nature and evolution requires the study of petrology, geochemistry, and geochronology of basin sediments. As an ideal proxy for the original rocks of source areas, gravels in conglomerates were analyzed in an attempt to define their provenance. There exists a variety of gravels in Jurassic–Cretaceous successions in the southern margin of the Hefei basin, such as gneiss, schist, marble, amphibolite, granite, and quartzite (Q. Wang et al., 2003). Gravels in the lower portion of the Sanjianpu Formation are dominantly schist, quartzite, granite, and marble. These clasts match the lithology of the Carboniferous strata and Lower Paleozoic Fuziling Group in the Beihuaiyang domain (BGMRAP, 1987). Conglomerates in the Fenghuangtai and Maotanchang Formations are composed primarily of gneiss, schist, and granite clasts. Considering that the Luzhenguan Group and the Dabieshan are mostly composed of these sorts of rocks (BGMRAP, 1987), they presumably served as the main provenance of the Fenghuangtai and Maotanchang Formations. A significant discovery was eclogite clasts in the Fenghuangtai and Maotanchang Formations that are identical to eclogite within the Dabieshan in both petrology and geochemistry (Li et al., 2002; Q. Wang et al., 2003). Vertical variations of the clast types suggest an unroofing process of the highlands south of the Hefei basin, and the appearance of eclogite clasts clearly indicates that UHP metamorphic rocks had been exposed at the surface by Late Jurassic time.

Sandstone compositions in Mesozoic basins around the Dabieshan have also been investigated to constrain their provenance and unroofing processes. Liu et al. (2003) carried out an analysis of lithic grains of sandstones in a Jurassic succession north of Jinzhai County (Fig. 8) and recognized a gradual variation in lithic composition from the Sanjianpu to Fenghuangtai Formations. Sandstones in the lower portion of the Sanjianpu Formation are abundant in grains of reworked sedimentary rocks, whereas grains of high-grade metamorphic rocks increase in the upper portion. Lithic types become more diverse in the lower part of the Fenghuangtai Formation, indicating input of various source rocks. Apparently, the variation in lithic composition of sandstones also records an unroofing process from cover to core rocks of the highland south of the Hefei basin.

Detrital minerals are utilized not only to study provenance of Jurassic–Cretaceous sediments of the Hefei basin, but to put constraints on the timing of UHP rock exposure as well. Grimmer et al. (2003) investigated detrital white micas from Triassic and Jurassic sediments in the basins east and south of the Dabieshan. Their results show that there are detrital white micas with intermediate to high Si contents (3.0–3.6 atoms pfu [per formula unit]) in Middle Jurassic strata, suggesting that they originated from the Dabieshan and that initial exposure of HP and UHP rocks was in the Middle Jurassic. Detrital white micas were also studied from the Sanjianpu and Fenghuangtai Formations in the southern Hefei basin (R. Li et al., 2003). Many of those white micas are actually high-Si phengites with $^{40}Ar/^{39}Ar$ plateau ages of 216.5 ± 0.6 Ma and 217.4 ± 1.3 Ma. The occurrence of high-Si phengites in the Sanjianpu Formation indicates that the Dabieshan HP-UHP rocks must have been exposed and eroded in the Middle Jurassic, similar to the conclusion of Grimmer et al. (2003). Our recent research on detrital zircons from the Lower Jurassic Fanghushan Formation in the Hefei basin discovered a coesite inclusion within a zircon grain dated at 220 Ma (Li et al., 2005). This finding requires that exposure

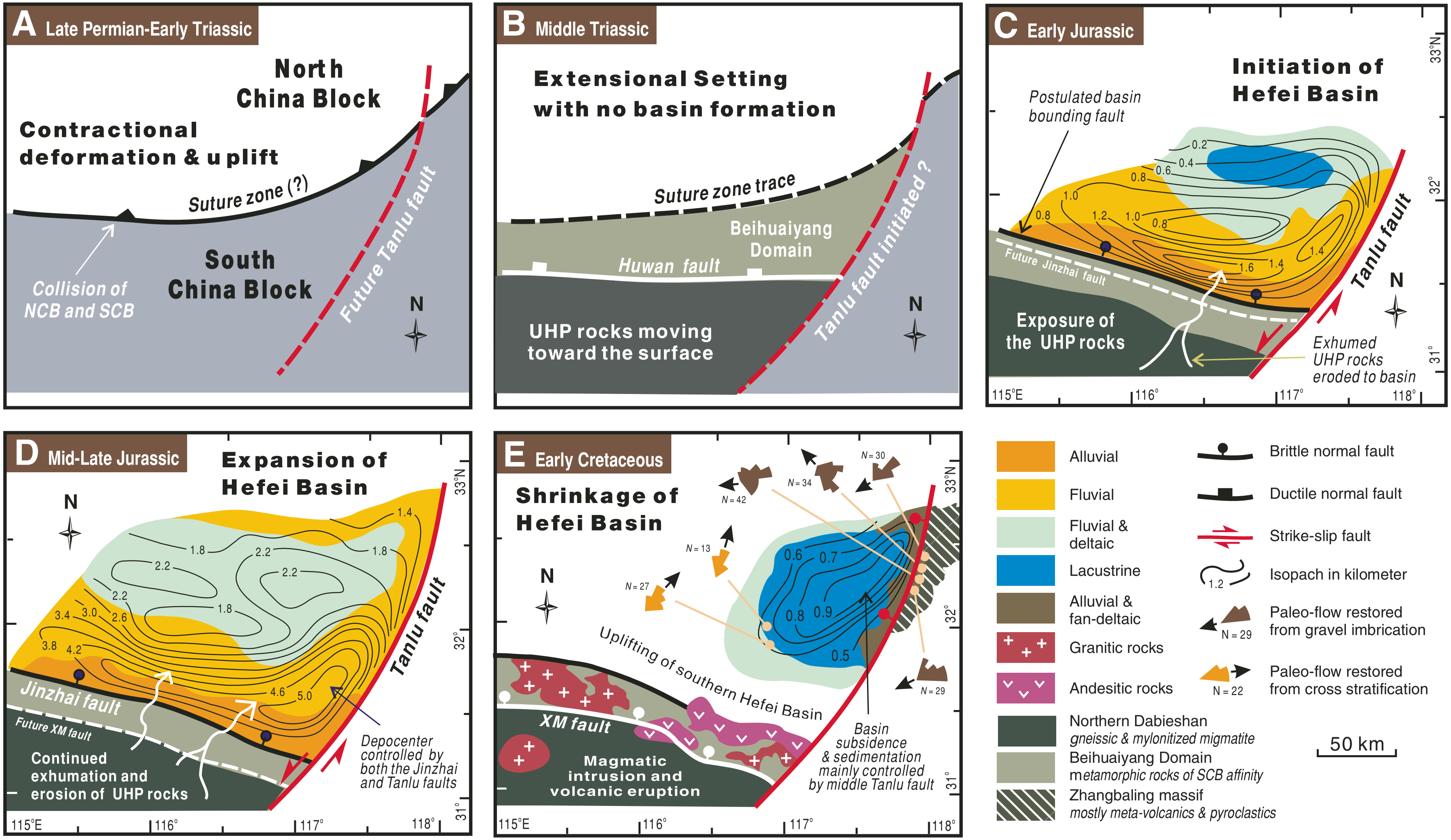

Figure 14. Sequential reconstruction of tectono-depositional paleoenvironments of the Hefei basin and adjacent regions. (A) The North and South China blocks collided in the late Permian–Early Triassic along a suture zone, the precise trace of which is still uncertain, and the southern North China block experienced contractional deformation and uplift. (B) Ultrahigh-pressure (UHP) rocks began moving upward, and the Huwan fault formed south of the suture zone, accommodating southerly upward extrusion of the UHP rocks. (C) The Hefei basin was initiated in the Early Jurassic, bounded on the south by a postulated N-dipping normal fault and on the east by the Tanlu fault, which together controlled the Early Jurassic depocenter of the Hefei basin. The UHP rocks were brought to the surface and eroded into the basin. (D) With continued exhumation of UHP rocks in the Middle and Late Jurassic, the Hefei basin expanded significantly, and the depocenter was still under the control of the combined effect of the Jinzhai and Tanlu faults. (E) Magmatism prevailed in both the Dabieshan and Beihuaiyang domain during the Early Cretaceous, resulting in uplift of the southern Hefei basin. The deposition area withdrew to the northern Hefei basin and was primarily controlled by E-W extension of the middle Tanlu fault. The Zhangbaling massif served as main provenance of basin fills. Refer to text for detailed discussion. Lower Jurassic and Middle to Upper Jurassic isopach is from Jia et al. (2001), whereas the Lower Cretaceous isopach is from Lu et al. (2002). XM—Xiaotian-Mozitan fault.

of some UHP rocks in the Dabieshan occurred as early as the Early Jurassic. In addition, there is a spatial variation in composition of detrital micas in Jurassic sediments from west to east in the southern Hefei basin (Li et al., 2005); more high-Si phengites are present in the eastern portion of the southern Hefei basin. This phenomenon might imply that UHP rocks were more exhumed and denudated in the east than in the west of the Dabieshan or the Hong'an.

Gravels of conglomerates and breccias of the Lower Cretaceous Zhuxiang Formation are mostly metavolcanic and pyroclastic rocks, identical to the components of the Zhangbaling Group, which makes up the main part of the Zhangbaling massif east of the middle Tanlu fault (Fig. 2B). Therefore, the Zhangbaling massif should have served as the main source area of the northern Hefei basin in Early Cretaceous time.

Border Faults

A number of normal faults define the southern margin of the Hefei basin (Fig. 2). The Huwan fault was formed between ca. 237 and 230 Ma as a N-dipping normal detachment, and it was reactivated during 198–187 Ma (Webb et al., 1999; Xu et al., 2000), synchronous with activities of other normal ductile faults within the Dabieshan (Niu et al., 1993; Chen et al., 1995). Implicitly, Early Jurassic reactivation of the Huwan normal detachment might have contributed to the initiation of the Hefei basin.

Lower Jurassic strata rarely crop out in the southern Hefei basin, but they apparently thicken to the south, as shown by the isopach (Fig. 14C). Given that the northern edge of the Dabieshan was in an extensional setting in the Early Jurassic (Webb et al., 1999; Lin et al., 2005b), it is postulated that Early Jurassic subsidence and sedimentation were controlled by a normal fault on the south (Figs. 3B and 3C). It is, unfortunately, hard to specify the postulated normal fault because of the extremely poor quality of seismic profiles available.

It has been proposed that the Jinzhai fault came into being as a left-lateral strike-slip fault in the Cenozoic (Ratschbacher et al., 2000). In consideration of the facts that the Middle Jurassic Sanjianpu Formation is exclusively distributed north of the Jinzhai fault and is characterized by proximal alluvial-fan systems, we believe that the Jinzhai fault acted as a synsedimentary border fault in the Middle Jurassic. The Jinzhai fault now manifests itself as a relatively high-angle fault that is segmented by both Early Cretaceous volcanics along its strike and is offset by the Late Cretaceous Shangcheng-Macheng normal fault (Fig. 2B). Middle–Upper Jurassic strata proximal to the Jinzhai fault moderately dip to the north and northeast and are gently folded in some places (Figs. 3C and 4). We propose that the Jinzhai fault must have been modified later due to contraction, presumably induced partly by large-scale granite intrusion in the Beihuaiyang domain and partly by gravity-driven northward displacement of supracrustal materials as a result of thermal doming of the Dabieshan on the south in the Early Cretaceous.

The Xiaotian-Mozitan fault has been considered to have first been a N-dipping thrust fault, which then became a prominent top-to-north normal detachment in the Early Cretaceous (Faure et al., 2003). Ratschbacher et al. (2000), in a detailed structural analysis of this fault, concluded that it formed synchronously with Early Cretaceous granitic emplacement in the Dabieshan and experienced left-lateral transtension from 140 to 120 Ma. Right-lateral motion formed later from ca. 110 to 90 Ma. Mylonites within the Xiaotian-Mozitan fault have been dated, and they yield $^{40}Ar/^{39}Ar$ ages of 127 ± 0.3 Ma and 124 ± 0.3 Ma on biotites (Hou et al., 2003) and 127 ± 1 Ma on muscovite (Lin et al., 2005a). Very few $^{40}Ar/^{39}Ar$ thermochronological studies have recorded the pre-Cretaceous history of the fault, presumably due to the resetting of the $^{40}Ar/^{39}Ar$ chronometer by Early Cretaceous magmatism.

The Tanlu fault has been extensively studied, but there is still much unknown about its origin, timing, and kinematics. Regional geologic and paleomagnetic studies have shown that a left-lateral Tanlu fault was active during the Late Triassic and Jurassic (Gilder et al., 1999; X. Wang et al., 2000). Recent $^{40}Ar/^{39}Ar$ dating of mylonites has also demonstrated that sinistral-slip motion of the Tanlu fault took place in the Jurassic and latest Early Cretaceous (Zhu et al., 2004, 2005). Zhang et al. (2003) demonstrated that dextral transtension and perpendicular extension were dominant in the middle Tanlu fault during the Early Cretaceous, although Grimmer et al. (2002) concluded that the southern Tanlu fault, the portion bounding the Dabieshan, was probably inactive at that time. The Mesozoic geologic relationships between the Tanlu fault and the southern border faults of the Hefei basin remain uncertain, although a variety of models have been advanced to accommodate their kinematics (cf. Ratschbacher et al., 2000; E. Wang et al., 2003).

Evolution of Depositional Systems

The spatial pattern of Lower Jurassic sedimentary facies indicates the existence of proximal alluvial and braided-river deposits in the southern Hefei basin (Fig. 6A) that graded northward into lacustrine facies (Fig. 12A). Lower Jurassic units die out southward, as shown by observations of Middle–Upper Jurassic units directly overlying southern basement rocks (Fig. 4). Accordingly, the principal border fault of the basin in the Early Jurassic should lie south of the Fanghushan region, but north of the Jinzhai fault (Fig. 14C), although it cannot be precisely defined. The Hefei basin expanded southward during the Middle and Late Jurassic to the Jinzhai fault and northward at least to the Shouxian (Figs. 3B and 3C). In a manner similar to the Lower Jurassic isopach pattern (Fig. 14C), the Middle–Upper Jurassic units thicken to the south and southeast and thin to the north and northwest (Fig. 14D). The northwestward pinch-out of Middle–Upper Jurassic strata can be perceived by the absence of coeval deposits in the Zhoukou basin on the northwest (Fig. 1) (Li et al., 1996). At least two alluvial fans can be defined in the Middle Jurassic, with fan apexes located just to the north of Jinzhai County and Sanliping village, respectively (Fig. 7). Alluvial-fan deposits consist primarily of debris-flow and sheet-flood deposits, and contemporaneous deposits in the intervening areas of the fans are sandy fluvial and floodplain facies associations. The Middle Jurassic alluvial facies then evolved into fluvial systems throughout the southern margin of the Hefei basin, as represented by the middle and upper sections of the Sanjianpu Formation (Fig. 7). The proximal alluvial and gravelly fluvial depositional systems also graded into sandy fluvial and lacustrine systems basinward, as evidenced by their equivalent deposits of the Yuantongshan Formation of the Fanghushan region (Fig. 6B) and in the northern Hefei Basin (Figs. 12A and 12B). Seismic facies interpretations show that the northern Hefei basin is mainly composed of lacustrine, meandering fluvial, and deltaic facies (P. Li et al., 2003).

Dramatic changes took place in basin sedimentation during the Late Jurassic. Alluvial and gravelly fluvial sedimentation not only reoccurred at the basin margin, as represented by the Fenghuangtai Formation, but also migrated toward the basin interior, as recorded by gravelly fluvial and alluvial deposits of the Zhougongshan Formation in the Fanghushan region (Fig. 6C). Middle Jurassic lacustrine facies associations also evolved into sandy fluvial systems in the northern Hefei basin during Late Jurassic time (Figs. 12A and 12B). The implications of the facies changes are that denudation/erosion became more pronounced in the source area, and transverse fluvial systems probably became vigorous, allowing coarser sediments to enter distal areas. Occurrences of eclogite clasts in the Fenghuangtai Formation also imply that the

UHP rocks of the Dabieshan were continuously denudated in Late Jurassic time.

The Early Cretaceous saw another period of remarkable change in the sedimentation of the Hefei basin. Volcanic eruptions and pyroclastic-flow deposition were prevalent in the southern margin of the basin, accompanied by synchronous uplift of the southern Hefei basin where Lower Cretaceous strata are missing (Fig. 14E). Early Cretaceous sedimentation withdrew to the northern Hefei basin and was dominated by lacustrine and sandy fluvial finer-grained facies, with alluvial, fan-deltaic, and fluvial-deltaic systems developing along the basin margins (Figs. 12C and 14E).

BASIN EVOLUTION

A vast area north of the Dabieshan must have experienced uplift and denudation prior to the inception of the Hefei basin in the Early Jurassic, as indicated by the existence of a regional unconformity between Jurassic strata and underlying Permian–Carboniferous and older units. The basement uplift can be attributed to the collision of the North and South China blocks during the period from Permian to Early Triassic times (Fig. 14A). Initiation of the Hefei basin has previously been postulated to be the result of flexural subsidence due to northward advance of a hinterland thrust system bounding the northern edge of the Dabieshan (Li et al., 2001; Liu et al., 2003). However, previous workers have shown that the northern side of the Dabieshan was in an extensional tectonic setting from Middle Triassic to Jurassic times (Figs. 14B and 14C), as manifested by development of N-dipping normal faults (Webb et al., 1999; Xu et al., 2000; Hacker et al., 2000; Lin et al., 2005b). We thus suggest that the Hefei basin was initiated as an extensional basin in the Early Jurassic, rather than in relation to postulated thrust emplacement of the Dabieshan. Considering that the Lower Jurassic strata thicken to the south and southeast, we postulate that the Early Jurassic Hefei basin was bounded on the south by a N-dipping normal fault (Fig. 14C), and possibly the Tanlu fault might also have exerted a control on basin subsidence.

The Hefei basin expanded in Middle to Late Jurassic times, when its depositional area extended southward to the Jinzhai fault and northward beyond the Shouxian fault (Fig. 3C). Synsedimentary activity of the Jinzhai fault can be inferred from its obvious control on Middle Jurassic proximal alluvial deposits of the basin. Alluvial and gravelly fluvial deposits also characterize Upper Jurassic strata, coincident with extensional deformation documented in both the Dabieshan and Beihuaiyang domains (Lin et al., 2005b). Depositional environments also change from lacustrine/deltaic to fluvial systems in the basin interior from Middle to Late Jurassic times (Figs. 6B, 6C, 12A, and 12B), indicating a long-distance basinward progradation of coarser sediments. This phenomenon implies not only pronounced denudation and erosion of source areas but also an excess of sediment supply over basin accommodation space in the Late Jurassic. It is particularly notable that Middle to Upper Jurassic units thicken to the southeast of the Hefei basin (Fig. 14D), implying a combined effect on basin subsidence by the Tanlu fault and the southern border faults.

The Tanlu fault is generally believed to have achieved its large-magnitude sinistral displacement from the Jurassic to earliest Early Cretaceous (X. Wang et al., 2000; Zhu et al., 2005), and thus its left-lateral slip should have been simultaneous with extension at the northern edge of the Dabieshan, which has been assumed to be responsible for the initiation and development of the southern Hefei basin. Superficially, the normal faulting in the northern margin of the Dabieshan is kinematically inconsistent with coeval left-lateral slip on the Tanlu fault, but in practice, the fault kinematics are compatible if the Tanlu fault was generated by the southerly upward extrusion of the UHP rocks. As proposed by a number of studies (Hacker et al., 2000; E. Wang et al., 2003), the Dabieshan UHP rocks were exhumed to the surface as a channel flow, where the flow channel base was a S-directed thrust system consistent with the sinistral motion of the Tanlu fault. The roof fault of the flow channel, in contrast, acted as a N-dipping normal fault (detachment) to accommodate S-directed upward extrusion of the UHP rocks (Figs. 15A, 15B, and 15C).

The Early Cretaceous depositional area of the Hefei basin was reduced considerably, and it migrated northward, with vigorous volcanism and granitic plutonism occurring in both the Beihuaiyang domain and within the Dabieshan (Fig. 14E). The granitic intrusions were probably responsible for the uplift of the southern Hefei basin and thus the northward shift of deposition. The middle Tanlu fault appears to have played a significant role in the Early Cretaceous basin subsidence. Our reconstruction of the Early Cretaceous depositional system shows that proximal alluvial and fan-deltaic systems developed near the Tanlu fault, and that sediments were evidently shed into the basin from the Zhangbaling massif, as evidenced by the paleocurrent restoration (Fig. 14E). Considering that metavolcanic clasts of the Zhuxiang Formation in the northeast portion of the Hefei basin originate directly from the adjacent Zhangbaling massif, we suggest that subsidence of the Hefei basin resulted primarily from perpendicular extension across the middle Tanlu fault in the Early Cretaceous, as suggested by Zhang et al. (2003), and no large-scale strike-slip motion was involved. Prevalence of E-W extension along the Tanlu fault in the Early Cretaceous is presumably attributable to backarc extension as a result of westward subduction of the Pacific plate, which is also thought to be the trigger of vigorous and widespread magmatism in both the Dabieshan and the whole of eastern China (Ratschbacher et al., 2000; Wu et al., 2005). Uplift of the Hefei basin toward the end of the Early Cretaceous is indicated by a basinwide unconformity between Lower and Upper Cretaceous strata. Extension and sedimentation resumed in the Hefei basin in the Late Cretaceous to early Tertiary (Fig. 3), probably due to dextral transtension of the Tanlu fault (Grimmer et al., 2002).

It is interesting to note that a foreland basin was formed to the south of the Dabieshan as early as the Early Triassic, and it continued to develop in the Jurassic (Liu et al., 2003). Although S-directed thrust faults are hardly identified at the outcrops (Faure et al., 2003; Hacker et al., 2004), recent seismic-reflection profiling clearly displays several S-vergent crustal-scale thrust faults in the Dabieshan foreland (Dong et al., 2004). Thus, the extensional Hefei basin was evolving simultaneously with the formation of a foreland basin south of the Dabieshan in the Jurassic. This situation is quite similar to the Miocene tectonic processes in the Himalayan region, where crustal compression in front of the Higher Himalayan gneisses, as represented by the Main Central thrust and Main Boundary thrust, was accompanied by crustal extension in the rear, as evidenced by the south Tibetan detachment (Hodges et al., 2001). Coeval occurrence of contraction and extension on two sides of an orogen has been well explained by models of lateral upward extrusion of lower-crustal materials (Chemenda et al., 1995). A similar thin-slab exhumation model has also been applied to the Dabieshan (Ernst, 2001). E. Wang et al. (2003) proposed another upward exhumation model, considering that the southward extrusion of the UHP rocks from depth may have been coupled with clockwise rotation. One merit of the model of E. Wang et al. (2003) is that it incorporates the sinistral-slip displacement of the Tanlu fault into the extrusion process of the Dabieshan UHP rock, and accommodates seemingly contradictable kinematics, such as concurrent occurrence of extension at the northern edge of the Dabieshan and left-lateral displacement on the Tanlu fault. The southerly upward extrusion of the UHP rocks could also lead to the stretching of the upper crust above it, as numerically modeled

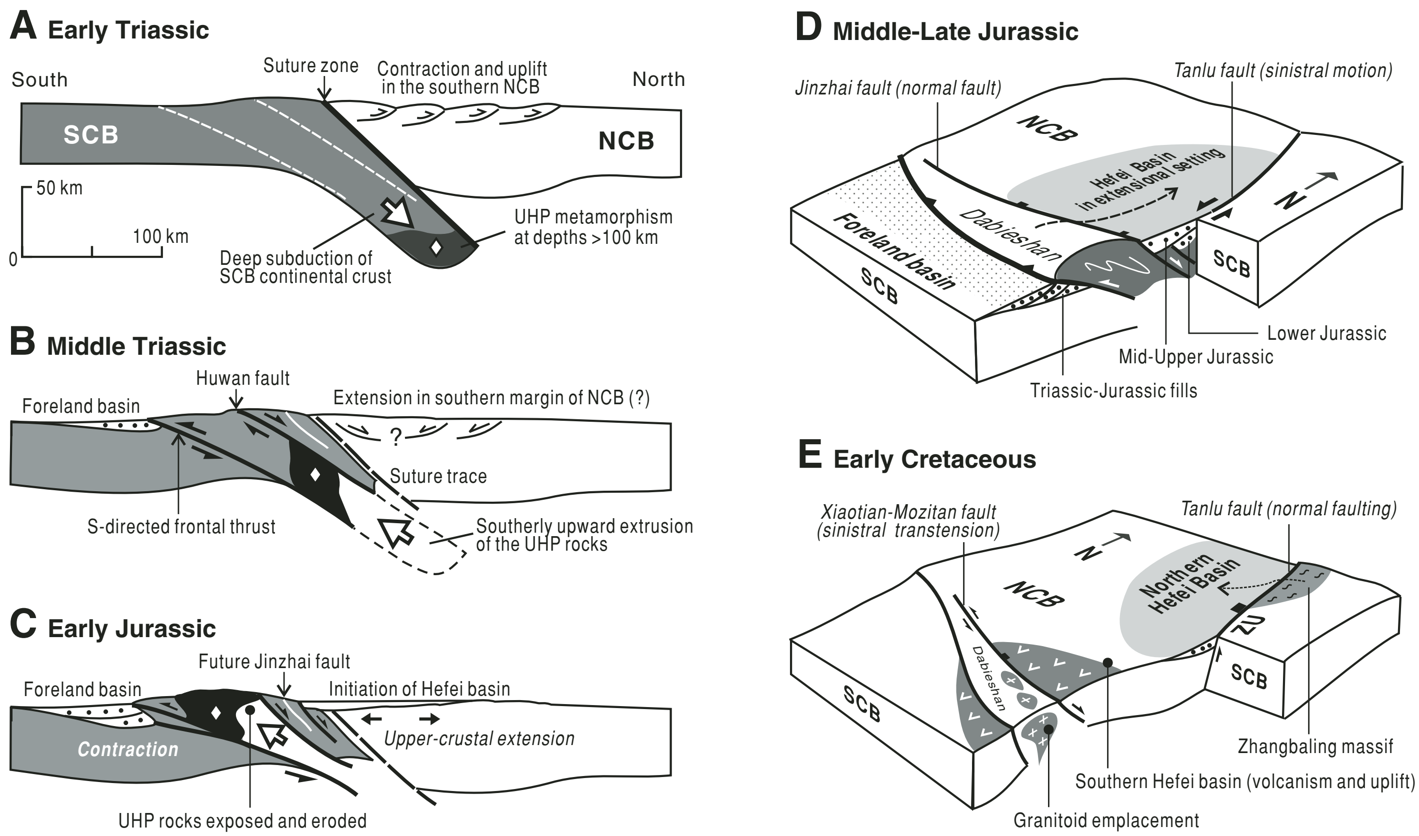

Figure 15. Cartoons illustrating evolution of the Hefei basin and its possible response to deformation in adjacent structural belts. (A) The South China block (SCB) continental crust underthrusted northward to depths >100 km and underwent ultrahigh-pressure (UHP) metamorphism in Early Triassic time. (B) The UHP rocks began extruding upward in the Middle Triassic, confined by a basal (frontal) thrust (Guangji fault?) and a roof (rear) normal detachment (Huwan fault). (C) UHP rocks were exhumed to the surface in the Early Jurassic. The Hefei basin began subsiding as a result of extension in the northern edge of the Dabieshan, presumably controlled on the south by a N-dipping normal fault. Extensional tectonics north of the Dabieshan were simultaneous with foreland basin formation south of the Dabieshan. (D) The Hefei basin continued developing in an extensional regime during the Middle to Late Jurassic with ongoing exhumation of the UHP rocks. The southern bounding fault (Jinzhai fault) of the basin stepped southward and controlled the depocenter in conjunction with the Tanlu fault on the east. (E) Intensive magmatism and uplift took place in the southern Hefei basin in the Early Cretaceous, and the Xiaotian-Mozitan fault was generated due to upward granitoid intrusion within the Dabieshan. The depositional area migrated to the north, and basin subsidence is assumed to have resulted from E-W extension across the Tanlu fault, where the Zhangbaling massif served as the footwall and a source region. Refer to the text for a detailed discussion. NCB—North China block; SCB—South China block; ZU—Zhangbaling uplift.

by Beaumont et al. (2004) for the Miocene tectonics of the Himalayan–Tibetan orogen, and thus Jurassic subsidence and expansion of the Hefei basin are thought to partially result from the upper-crustal extension. Figure 15 presents a model that illustrates generation and evolution of the Hefei basin in Jurassic and Early Cretaceous times.

CONCLUSIONS

The Hefei basin experienced a two-stage evolution from the Jurassic to Early Cretaceous, and its growth was closely related to coeval deformations of the Dabieshan on the south and the Tanlu fault on the east. The first stage was featured by extensional subsidence of the basin. The basin commenced in the Early Jurassic and expanded significantly by both the southward shifting of normal faults and the N- and W-directed widening of the depositional area during the Middle and Late Jurassic. Sediments came from the Dabieshan, as evidenced by persistent northerly and northeasterly paleoflows and the occurrence of eclogite clasts in proximal reaches of the basin. The thickening of Middle to Late Jurassic units to the south and southeast indicates that the subsidence and depocenter of the Hefei basin were governed by the combined effects of the southern extensional border faults and the Tanlu fault. The second stage of basin development was characterized by intensive volcanism and basement uplift in the southern Hefei basin and by the northward migration of deposition in the Early Cretaceous. Basin subsidence in the second stage is ascribed mainly to extension across the middle Tanlu fault, with the Zhangbaling massif on the east serving as the sediment source area. Simultaneous development of extensional and contractional basins on the north and south of the Dabieshan, respectively, carries an important implication that Jurassic exhumation of the Dabieshan UHP rocks might have been achieved through southerly upward extrusion processes.

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REFERENCES CITED

Beaumont, C., Jamieson, R., Ngbecca, M.H., and Medvedev, S., 2004, Crustal channel flows: 1. Numerical models with applications to the tectonics of the Himalayan-Tibetan orogen: Journal of Geophysical Research, v. 109, p. B06406, doi: 10.1029/2003JB002809.

BGMRAP (Bureau of Geology and Mineral Resources of Anhui Province), 1987, Regional Geology of Anhui Province: Beijing, Geological Publishing House, 721 p. [in Chinese].

Blair, T.C., and McPherson, J.G., 1994, Alluvial fans and their natural distribution from rivers based on morphology, hydraulic processes, sedimentary processes, and facies assemblages: Journal of Sedimentary Research, v. A64, p. 450–489.

Branney, M.J., and Kokelaar, P., 2002, Pyroclastic density currents and the sedimentation of ignimbrites: Geological Society of London Memoir 27, 130 p.

Cas, R.A.F., and Wright, J.V., 1987, Volcanic Successions: Modern and Ancient: London, Allen & Unwin, 528 p.

Chemenda, A.I., Mattauer, M., Malavieille, J., and Bokun, A.N., 1995, A mechanism for syn-collisional rock exhumation and associated normal faulting: Results from physical modeling: Earth and Planetary Science Letters, v. 132, p. 225–232.

Chen, F., Guo, J., Jiang, L., Siebel, W., Cong, B., and Satir, M., 2003, Provenance of the Beihuaiyang lower-grade metamorphic zone of the Dabie ultrahigh-pressure collisional orogen, China: Evidence from zircon ages: Journal of Asian Earth Sciences, v. 22, p. 343–352, doi: 10.1016/S1367-9120(03)00068-3.

Chen, J., Xie, Z., Li, X., and Foland, K., 1995, ^{40}Ar/^{39}Ar cooling age and fission track dating from Dabie orogen: Science in China, series B, Chemistry, Life Sciences & Earth Sciences, v. 25, p. 1086–1092.

Dong, S., Gao, R., Cong, B., Zhao, Z., Liu, X., Li, S., Li, Q., and Huang, D., 2004, Crustal structure of the southern Dabie ultrahigh-pressure orogen and Yangtze foreland from deep seismic reflection profiling: Terra Nova, v. 16, p. 319–324, doi: 10.1111/j.1365-3121.2004.00568.x.

Ernst, W.G., 2001, Subduction, ultrahigh-pressure metamorphism, and regurgitation of buoyant crustal slices—Implications for arc and continental growth: Physics of the Earth and Planetary Interiors, v. 127, p. 253–275, doi: 10.1016/S0031-9201(01)00231-X.

Faure, M., Sun, Y., Shu, L., Monie, P., and Charvet, J., 1996, Extensional tectonics within a subduction-type orogen: The case study of the Wugongshan dome (Jiangxi Province, southeastern China): Tectonophysics, v. 263, p. 77–106, doi: 10.1016/S0040-1951(97)81487-4.

Faure, M., Lin, W., Shu, L., Sun, Y., and Schärer, U., 1999, Tectonics of the Dabieshan (eastern China) and possible exhumation mechanism of ultra-high pressure rocks: Terra Nova, v. 11, p. 251–258, doi: 10.1046/j.1365-3121.1999.00257.x.

Faure, M., Lin, W., Schärer, U., Shu, L., Sun, Y., and Arnaud, A., 2003, Continental subduction and exhumation of UHP rocks: Structural and geochronological insights from the Dabieshan (E. China): Lithos, v. 70, p. 213–241, doi: 10.1016/S0024-4937(03)00100-2.

Gilder, S.A., Leloup, P.H., Courtillot, V., Chen, Y., Coe, R., Zhao, X., Wang, W., Halim, N., Cogne, J.P., and Zhu, R., 1999, Tectonic evolution of the Tancheng–Lujiang (Tan-Lu) fault via Middle Triassic to Early Cenozoic paleomagnetic data: Journal of Geophysical Research, v. 104, p. 15,365–15,390, doi: 10.1029/1999JB900123.

Grimmer, J.C., Jonckheere, R., Enkelmann, E., Ratschbacher, L., Hacker, B.R., Blythe, A.E., Wagner, G.A., Wu, Q., Liu, S., and Dong, S., 2002, Cretaceous–Cenozoic history of the southern Tan-Lu fault zone: Apatite fission-track and structural constraints from the Dabie Shan (eastern China): Tectonophysics, v. 359, p. 225–253, doi: 10.1016/S0040-1951(02)00513-9.

Grimmer, J.C., Ratschbacher, L., McWilliams, M., Franz, L., Gaitzsch, I., Tichomirowa, M., Hacker, B.R., and Zhang, Y., 2003, When did the ultrahigh-pressure rocks reach the surface? A ^{207}Pb/^{206}Pb zircon, ^{40}Ar/^{39}Ar white mica, Si-in-white mica, single-grain provenance study of Dabieshan synorogenic foreland sediments: Chemical Geology, v. 197, p. 87–110, doi: 10.1016/S0009-2541(02)00321-2.

Hacker, B.R., Ratschbacher, L., Webb, L., Ireland, T., Walker, D., and Dong, S., 1998, U/Pb zircon ages constrain the architecture of the ultrahigh-pressure Qinling–Dabie orogen, China: Earth and Planetary Science Letters, v. 161, p. 215–230, doi: 10.1016/S0012-821X(98)00152-6.

Hacker, B.R., Ratschbacher, L., Webb, L., Ireland, T., Calvert, A., Dong, S., Wenk, H.R., and Chateigner, D., 2000, Exhumation of the ultrahigh-pressure continental crust in east–central China: Late Triassic–Early Jurassic unroofing: Journal of Geophysical Research, v. 105, p. 13,339–13,364, doi: 10.1029/2000JB900039.

Hacker, B.R., Ratschbacher, L., and Liou, J.G., 2004, Subduction, collision, and exhumation in the ultrahigh-pressure Qinling–Dabie orogen, *in* Malpas, J., Fletcher, C.J.R., and Aitchison, J.C., eds., Aspects of the Tectonic Evolution of China: Geological Society of London Special Publication 226, p. 157–175.

Han, S., 1996, Analysis of Mesozoic and Cenozoic Sedimentary Basins in North Anhui: Beijing, Geological Publishing House, 141 p. [in Chinese].

Hao, Y., Su, D., Yu, J., Li, P., Li, Y., Wang, N., Qi, H., Guan, S., Hu, H., Liu, X., Yang, W., Ye, L., Shou, Z., and Zhang, Q., 1986, The Cretaceous System of China: Stratigraphy of China No. 12: Beijing, Geological Publishing House, 301 p. [in Chinese].

Hodges, K.V., Hurtado, J.M., and Whipple, K.X., 2001, Southward extrusion of Tibetan crust and its effect on Himalayan tectonics: Tectonics, v. 20, p. 799–809, doi: 10.1029/2001TC001281.

Hou, Q., Li, J., Zhang, H., and Liu, Q., 2003, Timing and structures of late Mesozoic extensional detachments in the Dabie Shan: Hefei, Abstracts of Symposium on Geodynamics of Continental Subduction and Exhumation, p. 54–57 [in Chinese].

Ingersoll, R.V., 1988, Tectonics of sedimentary basins: Geological Society of America Bulletin, v. 100, p. 1704–1719, doi: 10.1130/0016-7606(1988)100<1704:TOSB>2.3.CO;2.

Jia, H., Liu, G., Zhang, Y., and Zhang, R., 2001, Formation mechanism of the Hefei basin and oil–gas exploration prospect: Geology of Anhui, v. 11, p. 9–18.

Jiang, L., Wu, W., Chu, D., Liu, Y., and Zhang, Y., 2003, Post-collisional extensional– contractional structures in the north of the Dabieshan: Chinese Science Bulletin, v. 48, p. 1557–1563.

Li, P., Li, X., Song, M., Song, G., Xu, C., and Huang, K., 2003, Petroleum Geology and Geophysical Prospecting and Advance in Hefei Basin: Beijing, Geological Publishing House, 205 p. [in Chinese].

Li, R., Sang, H., and Zhang, R., 2003, Geochronological study of high-pressure and ultrahigh-pressure metamorphic minerals in Jurassic successions of the Hefei basin: Chinese Science Bulletin, v. 48, p. 480–485.

Li, R., Wan, Y., Chen, Z., Zhou, J., Li, S., Jin, F., Meng, Q., Li, Z., and Jiang, M., 2005, Provenance of Jurassic sediments in the Hefei basin, east-central China and the contribution of high-pressure and ultrahigh-pressure metamorphic rocks from the Dabie Shan: Earth and Planetary Science Letters, v. 231, p. 279–294, doi: 10.1016/j.epsl.2004.12.021.

Li, S., Xiao, Y., Liou, D., Chen, Y., Ge, N., Zhang, Z., Sun, S., Cong, B., Zhang, R., Hart, S., and Wang, S., 1993, Collision of North China and Yangtze blocks and formation of coesite-bearing eclogites: Timing and processes: Chemical Geology, v. 109, p. 89–111, doi: 10.1016/0009-2541(93)90063-O.

Li, S., Jagoutz, E., Chen, Y., and Li, Q., 2000, Sm–Nd and Rb–Sr isotopic chronology and cooling history of ultrahigh pressure metamorphic rocks and their country rocks at Shuanghe in the Dabie mountains, central China: Geochimica et Cosmochimica Acta, v. 64, p. 1077–1093, doi: 10.1016/S0016-7037(99)00319-1.

Li, Sh., Yue, S., Wang, D., Liu, Y., Wang, Q., Li, R., Meng, Q., and Jin, F., 2002, Stratigraphic evidence of the exhumation of ultrahigh-pressure metamorphic rocks in the Dabieshan orogenic belt: Enlightenment from eclogite gravels in the Maotanchang Formation: Geological Review, v. 48, p. 346–352.

Li, W., Chen, J., and Shao, L., 1996, Early Cretaceous sedimentary facies and depositional framework of the Zhoukou basin: Facies and Paleo-environments, v. 16, p. 44–50.

Li, X.H., 2000, Cretaceous magmatism and lithospheric extension in southeast China: Journal of Asian Earth Sciences, v. 18, p. 293–305, doi: 10.1016/S1367-9120(99)00060-7.

Li, Y., and Jiang, L., 1997, Lithostratigraphy of Anhui Province: Wuhan, Press of China Geological University, 587 p. [in Chinese].

Li, Z., Sun, S., Li, R., and Zhang, R., 2001, Mesozoic filling sequences in Hefei basin: Implication for Dabie orogenesis, central China: Science in China (D), v. 44, p. 52–63.

Lin, W., Faure, M., Wang, Q., Monié, P., and Panis, D., 2005a, Triassic polyphase deformation in the Feidong-Zhangbaling massif (Eastern China) and its place in the collision between the north China and South China blocks: Journal of Asian Earth Sciences, v. 25, p. 121–136, doi: 10.1016/j.jseaes.2004.01.014.

Lin, W., Wang, Q., Faure, M., and Arnaud, N., 2005b, Tectonic evolution of the Dabieshan orogen in the view from polyphase deformation of the Beihuaiyang metamorphic zone: Science in China, v. 35, p. 127–139.

Liou, J.G., Zhang, R.Y., Wang, X., Eide, E.A., Ernst, W.G., and Maruyama, S., 1996, Metamorphism and tectonics of high-pressure and ultrahigh-pressure belts in the Dabie–Sulu region, China, *in* Yin, A., and Harrison, T.M., eds., Tectonic Evolution of Asia: Cambridge, Cambridge University Press, p. 300–344.

Liu, S., Heller, P., and Zhang, G., 2003, Mesozoic basin development and tectonic evolution of the Dabieshan orogenic belt, central China: Tectonics, v. 22, , p. 12-1–21, doi: 10.1029/2002TC001390.

Liu, X., Jahn, B.M., Liu, D., Dong, S., and Li, S., 2004, SHRIMP U-Pb zircon dating of a metagabbro and eclogites from western Dabieshan (Hong'an block, China), and its tectonic implications: Tectonophysics, v. 394, p. 171–192, doi: 10.1016/j.tecto.2004.08.004.

Lu, G., Zhu, G., Li, X., Wang, D., Song, C., and Liu, G., 2002, Relationship between the Tanlu faulted belt and the petroleum geology of the Hefei basin: Petroleum Geology and Experiment, v. 24, p. 216–222.

Ma, X., and Wu, D., 1987, Cenozoic extensional tectonics in China: Tectonophysics, v. 133, p. 243–255, doi: 10.1016/0040-1951(87)90268-X.

Meng, Q.-R., and Zhang, G.-W., 1999, Timing of collision of the North and South China blocks: Controversy and reconciliation: Geology, v. 27, p. 123–126, doi: 10.1130/0091-7613(1999)027<0123:TOCOTN>2.3.CO;2.

Meng, Q.-R., Wang, E., and Hu, J.-J., 2005, Mesozoic sedimentary evolution of the northwest Sichuan basin: Implication for continued clockwise rotation of the South China block: Geological Society of America Bulletin, v. 117, p. 396–410, doi: 10.1130/B25407.1.

Miall, A.D., 1996, The Geology of Fluvial Deposits: Berlin, Springer-Verlag, 582 p.

Niu, B., Fu, Y., Liu, Z., and Ren, J., 1993, ^{40}Ar/^{39}Ar thermochronology for blueschist facies rocks in Northern Hubei province and its geologic significance: Chinese Science Bulletin, v. 38, p. 1309–1313.

Northrup, C.J., Royden, L.H., and Burchfiel, B.C., 1995, Motion of the Pacific plate relative to Eurasia and its potential relation to Cenozoic extension along the eastern margin of Eurasia: Geology, v. 23, p. 719–722, doi: 10.1130/0091-7613(1995)023<0719:MOTPPR>2.3.CO;2.

Okay, A.I., and Şengör, A.M.C., 1992, Evidence for intracontinental thrust-related exhumation of the ultra-high-pressure rocks in China: Geology, v. 20, p. 411–414, doi: 10.1130/0091-7613(1992)020<0411:EFITRE>2.3.CO;2.

Ratschbacher, L., Hacker, B.R., Webb, L.E., McWilliams, M., Ireland, T., Dong, S.W., Calvert, A., Chateigner, D., and Wenk, H.R., 2000, Exhumation of the ultrahigh-pressure continental crust in east central China: Cretaceous and Cenozoic unroofing and the Tanlu fault: Journal of Geophysical Research, v. 105, p. 13,303–13,338, doi: 10.1029/2000JB900040.

Reiners, P.W., Zhou, Z., Ehlers, T.A., Xu, C., Brandon, M.T., Donelick, R.A., and Nicolescu, S., 2003, Post-orogenic evolution of the Dabieshan, eastern China, from (U-Th)/He and fission-track thermochronology: American Journal of Science, v. 303, p. 489–518, doi: 10.2475/ajs.303.6.489.

Ren, J., Tamaki, K., Li, S., and Zhang, J., 2002, Late Mesozoic and Cretaceous rifting and its dynamic setting in eastern China and adjacent areas: Tectonophysics, v. 344, p. 175–205, doi: 10.1016/S0040-1951(01)00271-2.

Smith, G.A., 1986, Coarse-grained nonmarine volcaniclastic sediments: Terminology and depositional processes: Geological Society of America Bulletin, v. 97, p. 1–10, doi: 10.1130/0016-7606(1986)97<1:CNVSTA>2.0.CO;2.

Tian, Z., Han, P., and Xu, K., 1992, The Mesozoic–Cenozoic East China rift system: Tectonophysics, v. 208, p. 341–363, doi: 10.1016/0040-1951(92)90354-9.

Wang, D., Jin, F., Xie, X., and Liu, Y., 2000, Studies of ^{40}Ar/^{39}Ar isotopic chronostratigraphy of the Sanjianpu formation in the Hefei basin: Journal of Stratigraphy, v. 24, p. 236–242.

Wang, E., Meng, Q., Burchfiel, B.C., and Zhang, G., 2003, Mesozoic large-scale lateral extrusion, rotation, and uplift of the Tongbai-Dabie belt in eastern China: Geology, v. 31, p. 307–310, doi: 10.1130/0091-7613(2003)031<0307:MLSLER>2.0.CO;2.

Wang, Q., Li, R., Wang, D., and Li, S., 2003, Eclogite preserved as pebbles in Jurassic conglomerate, Dabieshan mountains, China: Lithos, v. 70, p. 345–357, doi: 10.1016/S0024-4937(03)00105-1.

Wang, X., Li, Z., Chen, B., Chen, Q., Dong, S., and Zhang, Q., 2000, The Tan-Lu Fault Zone: Beijing, Geological Publishing House, 374 p. [in Chinese].

Wang, Y.J., Fan, W., and Guo, F., 2002, K-Ar dating of late Mesozoic volcanism and geochemistry of volcanic gravels in the North Huaiyang belt, Dabie orogen: Constraints on the stratigraphic framework and exhumation of the northern Dabie orthogneiss complex: Chinese Science Bulletin, v. 47, p. 1688–1695, doi: 10.1360/02tb9369.

Wang, Y.L., Zhang, J., Qiu, L., Pei, L., and Xu, C., 2002, On the division of structural units of the Mesozoic to Cenozoic Hefei basin: Geology of Anhui, v. 12, p. 97–103.

Wawrzenitz, N., Romer, R.L., Oberhänsli, R., and Dong, S., 2006, Dating of subduction and differential exhumation of UHP rocks from the central Dabieshan complex (E-China): Constraints from microfabrics, Rb–Sr and U–Pb isotope systems: Lithos, v. 89, p. 174–201, doi: 10.1016/j.lithos.2005.12.001.

Webb, L., Hacker, B.R., Ratschbacher, L., McWilliams, M.O., and Dong, S., 1999, Thermochronologic constraints on deformation and cooling history of high- and ultrahigh-pressure rocks in the Qinling-Dabie orogen, eastern China: Tectonics, v. 18, p. 621–638, doi: 10.1029/1999TC900012.

Wu, F., Lin, J., Wilde, S.A., Zhang, X., and Yang, J., 2005, Nature and significance of the Early Cretaceous giant igneous event in eastern China: Earth and Planetary Science Letters, v. 233, p. 103–119, doi: 10.1016/j.epsl.2005.02.019.

Wu, H., Jiang, L., and Dai, S., 2002, Correlation of the Mesozoic sequences in the Huoshan and Maotanchang areas in Anhui province: Journal of Stratigraphy, v. 26, p. 39–45.

Xia, Q., Zheng, Y., and Etienne, D., 2003, U-Pb ages and oxygen isotope components of zircons from post-collisional volcanic rocks of Dabieshan: Geological Journal of Chinese Universities, v. 9, p. 163–171.

Xu, B., Grove, V., Wang, C., Zhang, L., and Liu, S., 2000, ^{40}Ar/^{39}Ar thermochronology from the northwestern Dabieshan: Constraints on the evolution of Qinling-Dabie orogenic belt, east-central China: Tectonophysics, v. 322, p. 279–301, doi: 10.1016/S0040-1951(00)00092-5.

Xu, J., Zhu, G., Tong, W., Cui, K., and Liu, Q., 1987, Formation and evolution of the Tancheng–Lujiang wrench fault system: A major shear system to the northwest Pacific Ocean: Tectonophysics, v. 134, p. 273–310, doi: 10.1016/0040-1951(87)90342-8.

Xu, W., Wang, Q., Yang, D., Liu, X., and Guo, J., 2005, SHRIMP zircon U-Pb dating in Jingshan "migmatitic granite" and Bengbu, and its geological significance: Science in China (D), v. 48, p. 185–191.

Xu, Y., Zhao, M., Xu, C., Xu, M., and Qiu, L., 2002, Characteristics of the Mesozoic strata in Well An`can–1 of the Hefei basin: Petroleum Geology and Experiment, v. 24, p. 223–227.

Xue, A., and Jin, W., 2001, Petroleum Geology of Hefei Basin and its Tectonic Coupling with the Dabieshan Orogen: Beijing, Petroleum Industry Press, 173 p. [in Chinese].

Xue, F., Rowley, D.B., Tucker, R.D., and Peng, Z.X., 1997, U-Pb zircon ages of granitiods from the North Dabie Complex eastern Dabieshan, China: The Journal of Geology, v. 105, p. 744–753.

Yin, A., and Nie, S., 1993, An indentation model for the North and South China collision and the development of the Tan-Lu and Honam fault systems: East Asia: Tectonics, v. 12, p. 801–813.

Zhang, H., Gao, S., and Zhong, Z., 2002, Geochemical and Sr-Nd-Pb isotope compositions of Cretaceous granitiods: Constraints on tectonic framework and crustal structure of the Dabieshan ultrahigh-pressure metamorphic belt, China: Chemical Geology, v. 186, p. 281–299, doi: 10.1016/S0009-2541(02)00006-2.

Zhang, Y., Dong, S., and Shi, W., 2003, Cretaceous deformation history of the middle Tan-Lu fault zone in Shangdong Province, eastern China: Tectonophysics, v. 363, p. 243–258, doi: 10.1016/S0040-1951(03)00039-8.

Zhao, X.X., and Coe, R.S., 1987, Paleomagnetic constraints on the collision and rotation of north and south China: Nature, v. 327, p. 141–144, doi: 10.1038/327141a0.

Zhong, Z., Suo, S., and You, Z., 1999, Regional scale extensional tectonic pattern of ultrahigh-pressure and high-pressure metamorphic belts from the Dabie massif, China: International Geology Review, v. 41, p. 1033–1041.

Zhou, J., Zhao, Z., and Deng, H., 1999, Tectonic evolution of the Hefei basin and analysis of its petroleum potential: Acta Geologica Sinica, v. 73, p. 15–24.

Zhou, X., and Li, W., 2000, Origin of late Mesozoic igneous rocks in southeastern China: Implications for lithosphere subduction and underplating of mafic magmas: Tectonophysics, v. 326, p. 269–287, doi: 10.1016/S0040-1951(00)00120-7.

Zhu, G., Liu, G., Dunlap, W.J., Teyssier, C., Wang, Y., and Niu, M., 2004, ^{40}Ar/^{39}Ar geochronological constraints on synorogenic strike-slip movement of Tan-Lu fault zone: Chinese Science Bulletin, v. 49, p. 499–508, doi: 10.1360/03wd0357.

Zhu, G., Wang, Y., Liu, G., Niu, M., Xie, C., and Li, C., 2005, ^{40}Ar/^{39}Ar dating for strike-slip motion on the Tanlu fault zone, East China: Journal of Structural Geology, v. 27, p. 1379–1398, doi: 10.1016/j.jsg.2005.04.007.

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