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Early Mesozoic tectonic settings of the northern North China craton

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ABSTRACT

This paper aims to reconstruct early Mesozoic tectonic settings of the northern North China craton based on investigations of Triassic–Middle Jurassic successions and age determinations of some lithostratigraphic units and dikes cutting tilted early Mesozoic strata. It used to be regarded that the northern North China craton experienced fold–thrust deformations in the Triassic to Early Jurassic based on the occurrences of unconformity beneath Triassic/Lower Jurassic units, synorogenic conglomerate, and Late Triassic thrusting. We revisited early Mesozoic stratigraphy of the Xiabancheng basin in the middle Yanshan belt to restore tectonic environments during that period of time. Detrital zircon data reveal that the Liujiagou and Ermaying Formations are actually of Middle and Late Triassic ages, respectively. Field observations show that the Ermaying and Xingshikou Formations are conformable, making up a sequence from fluvial to alluvial-fan facies. It is also noticeable that Lower–Middle Jurassic Xingshikou through Xiahuayuan succession is typified by fining- and deepening-upward depositional trend and contains abundant volcaniclastic rocks, indicative of continued subsidence of the Xiabancheng basin in a volcanic setting. All the results cast doubts on the long-held view that the first phase of shortening in the northern North China craton happened in the Late Triassic or Early Jurassic. The angular unconformity beneath Upper Jurassic Tiaojishan volcanics registered shortening in the northern North China craton, which plausibly took place around 170 Ma on account of zircon U–Pb ages of two dikes penetrating deformed Middle Triassic–Lower Jurassic strata and ages of Tiaojishan volcanics above the unconformity. Given the widespread occurrence of magmatism, rift basins and metamorphic core complexes during the Triassic and Early Jurassic, it follows that the northern North China craton was more likely under an extensional setting during the early Mesozoic.

1. Introduction

The North China craton (NCC) behaved as a cratonic basin from late Paleoproterozoic to early Paleozoic time, characterized by widespread deposition of epeiric carbonate and siliciclastic facies (Ye, 1983). Middle Ordovician limestone is separated by a regional disconformity from Upper Carboniferous–Permian carbonate and clastic deposits. The northern NCC shares similar stratigraphic and sedimentological evolution to the craton interior during the Mesoproterozoic to Paleozoic, but underwent distinct tectonic processes from the Mesozoic, characterized by alternating contractional and extensional deformations (Cui et al., 2002; Davis et al., 2001). Several phases of shortening have been recognized in the Yanshan belt in the northern NCC (Cui et al., 2002; Davis et al., 2001; Zhang et al., 2004; Zhao, 1990) (Fig. 1). Late Mesozoic folding and thrusting are quite evident (Davis et al., 2001), albeit precise ages and duration of individual events remain a matter of debate. Early Mesozoic contraction was proposed according to the presence of unconformities and syntectonic conglomerate (Zhao, 1990). It was also believed that large-scale overthrusting commenced in the Yanshan belt as early as in the Middle Triassic (Cui et al., 2002; Yang et al., 1996; Zhao, 1990) and resulted from final closure of the Paleo-Asian Ocean north of the NCC (Zhao et al., 1994). Main arguments for Late Triassic or Early Jurassic shortening include: (1) the presence of unconformities between Middle Triassic and Lower Jurassic units, (2) molasse occurrence as presented by Xingshikou conglomerate, (3) extensive Late Triassic magmatism, and (4) Late Triassic thrusting.

Triassic–Middle Jurassic strata are exceptionally well preserved and exposed in the middle Yanshan belt, and interpreted as deposits of a foreland basin (S.F. Liu et al., 2007, 2012; Yang et al., 1996) (Fig. 1). We revisited Triassic–Middle Jurassic stratigraphy and sedimentation of the Xiabancheng basin in the last two years, and come to a different conclusion. This study aims to reconstruct early Mesozoic tectonic environment of the northern NCC by an integrated approach. We will first constrain the ages of Triassic lithostratigraphic units through detrital zircon geochronology, and then investigate key stratigraphic contacts and depositional processes by field observations and facies analysis. The timing of crustal shortening is determined by dating dikes cutting across folded strata in conjunction with the ages of the overlying Tiaojishan volcanics. It is shown that Triassic–Early/Middle Jurassic

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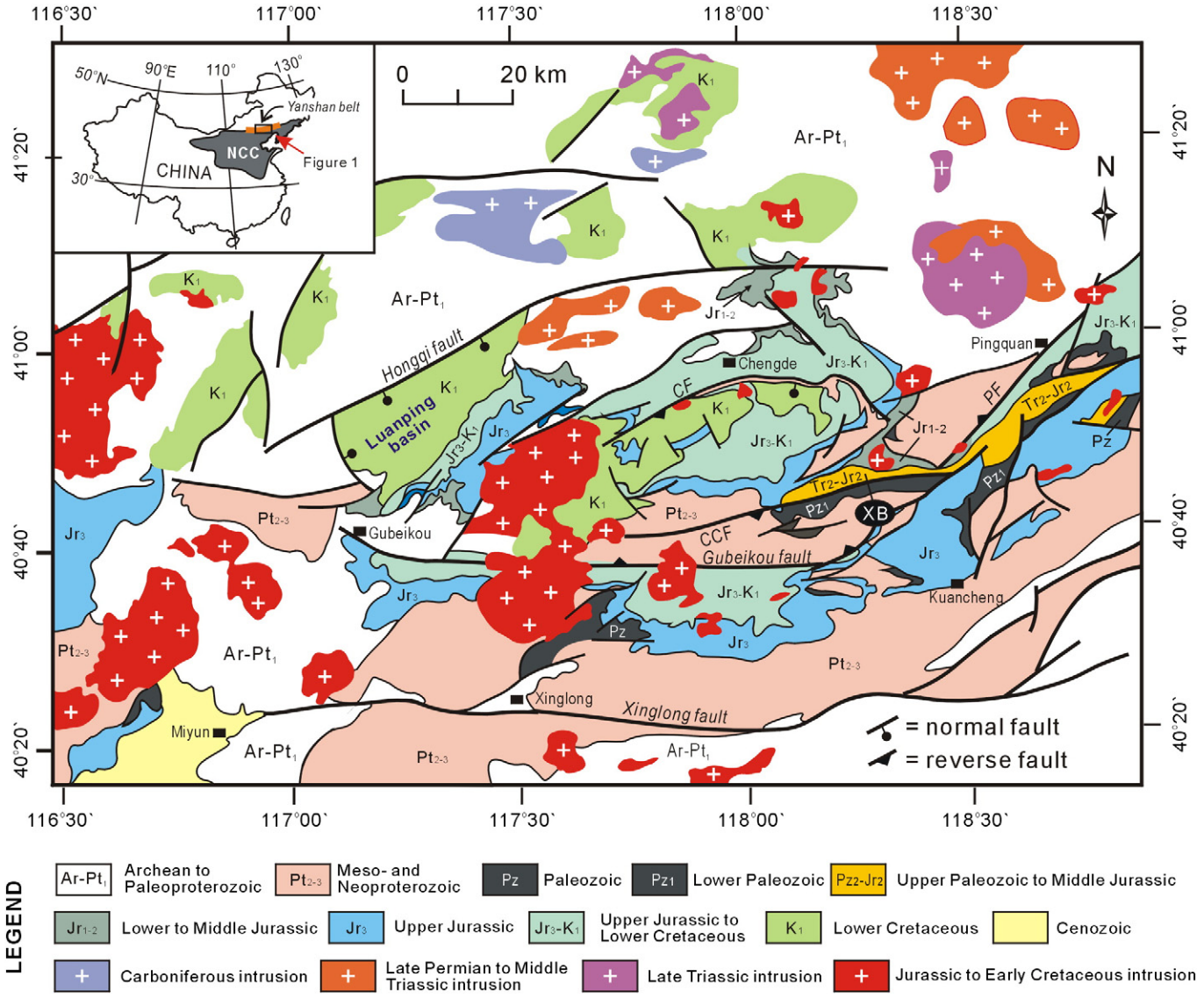

Fig. 1. Simplified tectonic map showing structural framework, distribution of strata, and intrusions of various ages in the middle Yanshan belt of the northern North China craton (NCC). Note the restricted distribution of Triassic to Middle Jurassic strata in the Xiabancheng basin (XB). CF—Chengde fault, CCF—Chengde County fault, PF—Pingquan fault.

sequence in the middle Yanshan belt is conformable, and it, together with the underlying late Paleoproterozoic to Paleozoic strata, had not undergone fold–thrust deformations until the Middle Jurassic. The results challenge the long-held notion that the first phase of crustal shortening took place in the northern NCC in the Late Triassic or Early Jurassic, and therefore necessitate reconsidering previous models for early Mesozoic tectonics of the NCC.

2. Regional geology

The northern NCC, especially the Yanshan belt, is structured by a number of faults and folds that basically developed in the Mesozoic, and regarded as a typical intraplate orogen (cf. Davis et al., 2001). NE-striking thrust faults are distributed throughout the Yanshan belt, and characterized by east- and southeast-directed displacement (Zhang et al., 2002). E–W-trending faults are common in the western and middle Yanshan belt (Zhang et al., 2004), but their spatial and temporal relationships with NE-striking faults remain poorly understood. Structural framework and evolution of the middle Yanshan belt have extensively been investigated (Chen, 1998; Davis et al., 2001; Zhang et al., 2004). E–W-trending faults, such as the Gubeikou and Chengde County faults (Fig. 1), were thought to have come into being since the Late Triassic (Zhao, 1990). Magmatism was active in late Paleozoic and Mesozoic (Fig. 1), as manifested by Late Carboniferous, Early Permian, Triassic, and Late Jurassic–Early Cretaceous granitoids (cf. S.H. Zhang et al., 2010) and widespread volcanics, such as Upper Triassic Shuiquangou andesite (Hu et al., 2005a), Early Jurassic Nandaling basalt (Zhao et al., 2006), Middle–Late Jurassic Tiaojishan andesite (cf. Liu et al., 2006) as well as Early Cretaceous Zhangjiakou rhyolite and Yixian basalt (Chen and Chen, 1997; Niu et al., 2004). A number of fault-bounded basins exist in the Yanshan belt, and they are usually attributed to end-Triassic and Late Jurassic thrusting (Cope et al., 2007; He et al., 1998; J. Liu et al., 2007) and Early Cretaceous extension (Cope and Graham, 2007; Cope et al., 2010; Meng et al., 2003; Wei et al., 2012).

Early Mesozoic strata have been carefully studied in the middle Yanshan belt (HBGMR, 1996; Liu et al., 2005; Mi et al., 1996; Yang et al., 1999). Triassic successions are thought to be of Lower–Middle Triassic age, and overlain unconformably by the Lower Jurassic Xingshikou Formation (e.g. HBGMR, 1989). An angular unconformity was claimed between steeply-dipping Mesoproterozoic–Paleozoic strata and flat-