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Timing of Paleozoic amalgamation between the North China and South China Blocks: Evidence from detrital zircon U–Pb ages

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ABSTRACT

LA-ICP-MS U–Pb ages of detrital zircons from clastics of the undated fore-arc sedimentary unit (FAS) along the Shangdan Suture and the Middle–Upper Devonian Liuling Group in the South Qinling belt are used to establish the maximum depositional age and provenance of these tectonic units which were deposited on both sides of the Shangdan suture zone between the North China Block (NCB) and South China Block (SCB). The new data and geological evidence show that the FAS was deposited in a fore-arc basin with an exclusive source of the clastics in the North Qinling Belt (NQB). The depositional age of FAS is limited by the youngest U–Pb 455 Ma-ages of detrital zircons from clastics and the intrusive age of 435 ± 7 Ma of mafic dykes between the Late Ordovician–Early Silurian, while the NCB was still separated from the SCB by the Shangdan Ocean. However, detrital zircon U–Pb ages from six samples of the Middle Devonian Liuling Group indicate sources in both NQB and SCB suggesting pre-Middle Devonian collision of NCB and SCB. All results indicate deposition of the FAS in a forearc setting upon an active continental margin during Late Ordovician–Early Silurian, while the Middle–Upper Devonian Liuling Group represents a marine foreland basin after closure of the Shangdan Ocean. Together with the unconformity between Middle Devonian and pre-Devonian strata, this reveals still evolving subduction and accretion on the southern side of the NQB during the Ordovician-Early Silurian, and the Early Devonian collision between the NCB and SCB.

1. Introduction

The amalgamation of the Pangea supercontinent is one of the most important global tectonic processes, and several models for the Pangea reconstruction were suggested based on paleomagnetism and timing of the collision between the main continents. However, there are still controversies on the amalgamation of the East Asian continents, especially the timing of the collision between the North China Block (NCB) and South China Block (SCB) which resulted to the Qinling Orogenic Belt (QOB) (e.g. Ames et al., 1996; Enkin et al., 1992; Hacker et al., 1998; Hsü et al., 1987; Kröner et al., 1993; Li et al., 1993, 1994; Mattauer et al., 1985; Meng and Zhang, 1999; Okay and Sengör, 1993; Sengör, 1985; Wang et al., 1989; Xu et al., 1988; Zhai et al., 1998; Zhang, 1988; Zhao and Coe, 1987). Almost all the reconstruction models for the Pangea supercontinent suggest a collision between the NCB and SCB after 240 Ma (Collins, 2003; Golonka, 2007; Metcafe, 2009; Scotese, 2004; Stampfli and Borel, 2002; Torsvik et al., 2008; van der Meer et al., 2010), and various models of Late Triassic continent — continent collision have been proposed (Hsü et al., 1987; Li et al., 1994; Sengör, 1985; Wang et al., 1989; Yin and Nie, 1993) based on paleomagnetic data (Enkin et al., 1992; Zhao and Coe, 1987) and ultrahigh-pressure metamorphism at ~230 Ma in the easternmost Qinling-Dabie belt (e.g., Ames et al., 1996; Hacker et al., 1998; Li et al., 1993; Okay and Sengör, 1993). However, some authors argued an Early Paleozoic age of collision (Kröner et al., 1993; Mattauer et al., 1985; Ren et al., 1991; Xu et al., 1988; Zhai et al., 1998), while a Devonian collision model was suggested according to the Pb isotopic composition of granitoids (Zhang et al., 1997) and the geochemistry of Devonian sediments (Gao et al., 1995).

Detrital zircon is a commonly found accessory phase in sedimentary rocks, and its U–Pb geochronology is widely used as a powerful tool for sedimentary provenance studies (Andersen and Griffin, 2004; Fedo et al., 2003; Guan et al., 2002; Luo et al., 2004; McLennan et al., 2001; Moecher and Samson, 2006; Payne et al., 2006). The age pattern of detrital zircon may provide valuable information on the evolutionary history of their source region (Bruguier et al., 1997; DeCelles et al., 2000; Fedo et al., 2003; Košler et al., 2002; McLennan et al., 2001; Nutman, 2001; Veevers et al., 2005; Weislogel et al., 2006; Zhang et al., 2006). Moreover, the youngest age of detrital zircon constrains the maximum age of deposition (Fedo et al., 2003; Nelson, 2001).

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In this study, samples of conglomerates from the fore-arc basin (FAS) to the south of the Shangdan suture and sandstones from the Middle Devonian Liuling Group were collected for U–Pb dating of detrital zircons (Fig. 1). Our dataset provides new constraints on the depositional age and nature of the provenance of the sediments, which will shed light on the timing of the convergence between the NCB and SCB, and the Paleozoic tectonic evolutionary processes of the QOB, as well as the amalgamation of East Asian continents within the Pangea supercontinent.

2. Geological setting

The Qinling orogen is located between the NCB to the north and the SCB to the south, extending for several thousand kilometers from the Dabie Mountains in the east to the Qilian Mountains and Kunlun Mountains in the west. It is bounded by the Lingbao–Lushan–Wuyang fault to the north and by the Mianxian–Bashan–Xiangguang fault to the south (Fig. 1a). Both of the boundary faults are Mesozoic–Cenozoic intracontinental thrusts, along which the Qinling belt was overthrust onto the South NCB and the North SCB, respectively. Two ophiolitic sutures are well documented, the Shangdan suture (Dong et al., 2011a) and the Mianlue suture (Dong et al., 1999, 2004, 2011b; Li et al., 1996; Meng and Zhang, 1999; Zhang et al., 1995, 2001). The Shangdan suture is marked by the occurrence of a mount of ophiolitic mélange and the FAS, which was formed by the closure of an Early Paleozoic ocean between the NCB and SCB (Dong et al., 2011a, b; Faure et al., 2001; Ratschbacher et al., 2003; Xue et al., 1996; Zhang et al., 1995, 2001). The Qinling belt itself can be divided into the North Qinling and South Qingling belts by the Shangdan suture (Fig. 1a). These two units originally belonged to the NCB and SCB, respectively. Many investigations

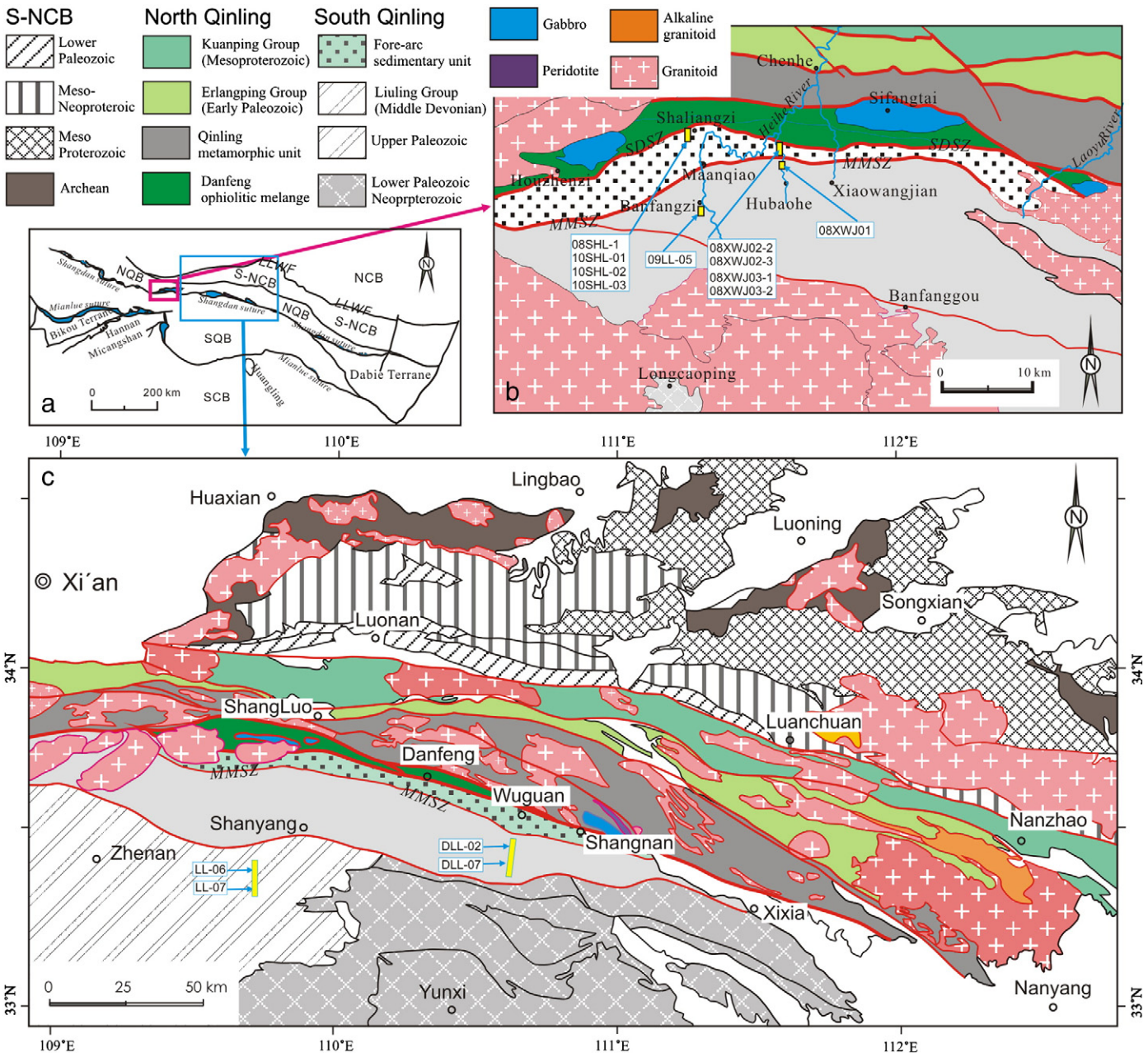

Fig. 1. (a) Sketch map showing the tectonic division of the Qinling and the location of the study area. (b) Simplified geological map showing the sample locations in the western Qinling belt. (c) Simplified geological map showing the sample locations in the eastern Qinling belt.