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Uplift-denudation history of the Qinling orogen: Constrained from the detrital-zircon U–Pb geochronology

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ABSTRACT

This paper presents a great number of detrital zircon U–Pb ages from the Middle Triassic to the Middle Jurassic sediments in the Jiyuan basin, southern North China. The results represent age spectra from 2.9 Ga to 216 Ma, with five peaks at 2.5 Ga, 1.9 Ga, 840 Ma, 440 Ma, and 270 Ma and two grains of ~220 Ma. The ages of 2.5 Ga and 1.9 Ga are mainly derived from the Precambrian basement of the North China Block, whereas the others are typical characteristics of the Qinling orogenic belt. An important observation is that the Qinling-sourced detrital zircons become older as the strata get younger. Samples from the Middle Triassic to early Late Triassic strata are characterized by the age peak at 270 Ma, whereas the Late Late Triassic to Early Middle Jurassic samples are dominated by age peaks at 840 Ma and 440 Ma and minor grains within 800–650 Ma. Two grains of ~220 Ma are preserved in the Late Middle Jurassic sample, which may be contributed by the Carnian deep plutons. These signatures indicate that the unroofing pattern of the Qinling orogenic belt developed by the denudation of materials from young covers to old basements and the Carnian deep plutons. Integrated with the data reported from the Hefei Basin, it is well-established that the intensity of unroofing increased from the Qinling to the Dabie orogen in the Early Jurassic, and the denudation timing of the ultra-high pressure (UHP) and high pressure (HP) rocks or Carnian plutons changed successively from the Early Jurassic in the Dabie to the Late Middle Jurassic in the Qinling orogen.

1. Introduction

The Qinling orogen is sandwiched between the North and South China blocks and has undergone multistage evolution. The tectonic transition of the Qinling orogen changed from continental collision in the Paleozoic to intracontinental compression in the Triassic times. Some geologists have studied the petrogenesis and geodynamic implications of the Late Triassic granitoids for the tectonic evolution of the Qinling orogenic belt on the deep crustal geodynamics (Jiang et al., 2010; Li et al., 2007, 2009a,b, 2010a,b, 2011, 2012; Zhang et al., 2008a; Davies and Blanckenburg, 1995; Sun et al., 2002; Qin et al., 2010). Recently, many investigations concerning mountain uplift from the sedimentary provenances of the surrounding basin have been performed in the Hefei Basin (Li et al., 2004, 2005; Liu et al., 2001, 2010; Meng et al., 2007; Wan et al., 2005), Jianghan Basin (Li et al., 2003; Wang et al., 2009; Yang et al., 2010), and Songpan-Ganzi Basin (Weislogel et al., 2006; Enkelmann et al., 2007; She et al., 2006; Zhang et al., 2008b). These basins bear unique information about the orogenic processes, but nearly all of them were studied to infer the denudation history of the Dabie orogen. There is a lack of the similar research on the Qinling orogen. Although the two orogens were formed by the collision of the North China block and the South China block, there are many differences in the collisional time and orogeny compositions. Therefore, it is necessary to excavate the orogenic process and uplift-denudation history of the Qinling orogen from the surrounding basins.

The Jiyuan basin is located to the north of the Qinling orogen and may contain detrital record of the orogenic processes for this orogen. In this contribution, we present detrital zircon U–Pb data for the Middle Triassic–Middle Jurassic sediments in the Jiyuan basin. These data, combined with previous works and regional geology, reveal an uplift-denudation history of the Qinling orogen. The orogenic processes can also help us to understand the destruction of the North China Craton from the edge to the interior.

2. Geological setting

2.1. Framework of the Qinling orogen

On the basis of the geological, geochemical and geochronological work, the tectonic framework of the Qinling orogen is expressed as a "three-plates with two-sutures" model (Zhang

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et al., 2001; Meng and Zhang, 1999), in which the South China, Qinling, and North China blocks converged along the Shangdan and Mianlue suture zones. With these two sutures, the Qinling orogen can be divided into two belts, from north to south, the North Qinling Belt and the Southern Qinling Belt (Fig. 1).

The North Qinling Belt is bounded by the Shangdan suture at the south and the Luanchuan fault at the north (Fig. 1). Widespread volcanic–sedimentary rocks are exposed in this area (Zhai et al., 1998). From south to north, the terrane mainly consists of the Qinling Group, the Erlangping Group and the Kuanping Group. As the oldest crystalline basement of the North Qinling terrane, the protoliths of the Qinling Group may have formed in the Paleoproterozoic (Dong et al., 2011b), but several units in this group are late Mesoproterozoic to early Neoproterozoic in age (Zhang et al., 1996a; Shi et al., 2013). Both island-arc type meta-basalt/meta-andesite and mid-ocean-ridge or back-arc basin type meta-basalt have been found in the Erlangping Group, so it has been suggested to have formed in a back-arc basin (Sun et al., 1996; Guo et al., 2010; Tian and Wei, 2005). The Kuanping Group includes two tectonic units of meta-basaltic and meta-clastic. The meta-basaltic represents crust remnants of a Neoproterozoic back-arc basin, whereas the meta-clastic was deposited in the Early Paleozoic (Dong et al., 2011b).

The South Qinling Belt, fragmented from the South China Block in the Middle Paleozoic, intervenes between the two sutures (Fig. 1). The main Precambrian metamorphic rock sequences consist of the Paleoproterozoic Douling Group, the Mesoproterozoic Wuguan Group, and the Neoproterozoic Wudangshan Group and Yaolinghe Group (Zhang et al., 1995a). The sedimentary cover includes Sinian clastics and carbonate rocks, Cambrian–Ordovician limestones, Silurian shales, and Devonian to Carboniferous clastic rocks and limestones. A few remnants of the Upper Palaeozoic–Lower Triassic clastic sedimentary rocks are also present in the northern part of the South Qinling terrane (Zhang et al., 2000; Dong et al., 2011a).

2.2. Evolution of the Qinling orogen

The extensive magmatism and metamorphism, which is recorded by the collisional granitoids and mafic–ultramafic rocks, indicate a Grenvillian orogenic event on the southern margin of the North China Block during late Mesoproterozoic to early Neoproterozoic (Wang et al., 2005, 2013; Dong et al., 2008; Liu et al., 2009). Accompanied by the break-up of the Rodinia in the early Neoproterozoic time, the North China Block and the Yangtze Block were separated by the Shangdan Ocean. The Shangdan Ocean kept extending until 514 Ma, then subducted towards the north, which caused extension and formation of the Erlangping back-arc basin and the North Qinling island-arc terrane. The Erlangping back-arc basin started subduction towards the south under the North Qinling island-arc terrane before 508 Ma, which is indicated by the UHP–HP metamorphic rocks occurring on the northern side of the North Qinling island-arc terrane (Liu et al., 2007, 2009; Yan et al., 2007; Dong et al., 2011b). The North Qinling terrane collided with the North China Block at 457–430 Ma, which is proved by the intruded granites in the Qinling Group. The Shangdan Ocean was finally closed at the Middle Devonian, then the North Qinling terrane was uplifted and exhumed. However, no intense mountain building occurred subsequently, maybe due to the development of Mianlue Ocean in the Late Paleozoic (Lai et al., 2008; Jiang et al., 2010; Ratschbacher et al., 2003; Yan et al., 2008). The island-arc volcanics from the Permian to Early Triassic indicated the subduction of the Mianlue Ocean (Dong et al., 2011b), which resulted in the final collision between the North China Block and the South China Block. The Qinling orogen was built in the Late Triassic with extensive syn-collisional granitoids of ages 228–215 Ma (Lai et al., 2008; Jiang et al., 2010; Wang et al., 2007; Qin et al., 2010). As the orogen uplifted, the Upper Triassic–Lower Jurassic foreland basin was formed in front of the foreland fold-thrust belt.

3. Stratigraphy of the Jiyuan basin

The Jiyuan basin is regarded as a Triassic–Jurassic synorogenic basin (Liu et al., 2013). During the Early to Middle Triassic, the Jiyuan basin was an intracratonic terrestrial depression on the southern margin of the North China Craton. Fine-grained sediments and approximate deposition thicknesses indicate a relatively stable tectonic setting. When the South China, Qinling and North China blocks converged in the Late Triassic, the eastern part of the North China Block was uplifted to erode. Although the Jiyuan basin was still undergoing continuous deposition, great changes took place in the depositional environment, sedimentary sequence and

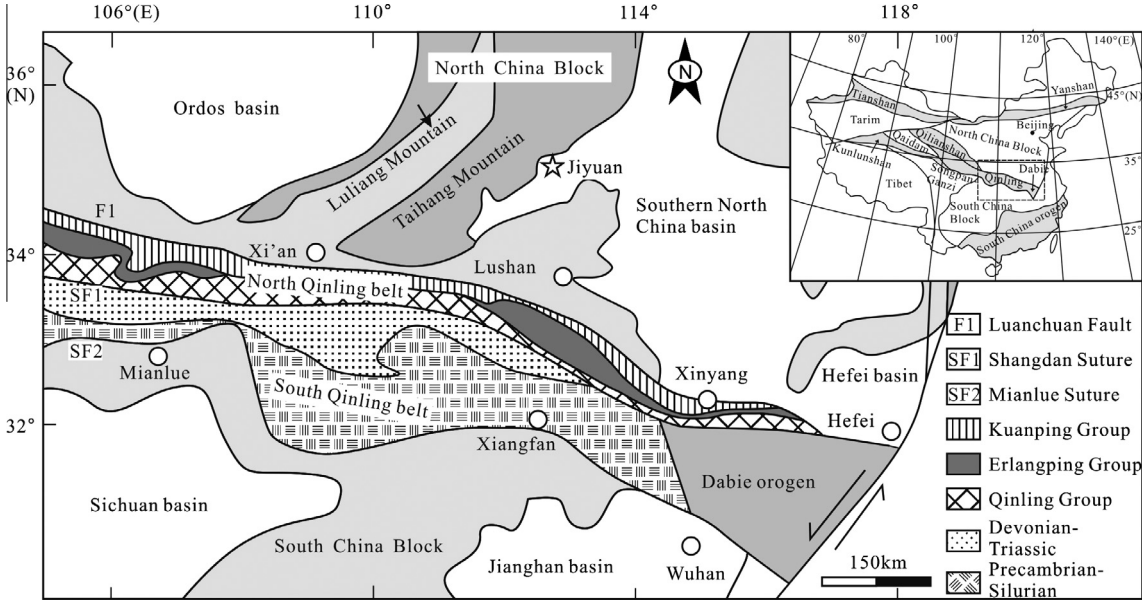

Fig. 1. Schematic tectonic map of the Qinling orogen, showing the location of Jiyuan area near the Qinling orogen.