Journal of Asian Earth Sciences xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Middle–Late Mesozoic sedimentary provenances of the Luxi and Jiaolai areas: Implications for tectonic evolution of the North China Block

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ARTICLE INFO

Article history:
Received 13 August 2014
Received in revised form 29 June 2015
Accepted 7 July 2015
Available online xxxx

Keywords:
Middle–Late Mesozoic
Detrital provenance
Zircon geochronology
Garnet geochemistry
North China Block
Tectonic evolution

ABSTRACT

Provenances of sedimentary rocks may provide important constraints on the tectonic evolution of the North China Block (NCB). Previous studies have demonstrated that the northern NCB (NNCB) and the Xing-Meng orogenic belt (XMOB) supplied massive detritus southward into the hinterland of the NCB during the Jurassic. In order to study the evolution of sedimentary provenance during the Middle–Late Mesozoic, U–Pb geochronology and Hf isotopic geochemistry of detrital zircon grains and chemical compositions of detrital garnets from sandstones in the Luxi and Jiaolai areas, eastern NCB, were analyzed in combination with published data on the Jurassic sandstones. The Late Paleozoic–Mesozoic (367–139 Ma) zircons in the lowermost Cretaceous Mengyin Formation samples from the Luxi area show εHf(t) values of −15.3 to −3.2 and +1.3 to +10.0, which are very similar to the results of analyses of the Jurassic formations. Further, the increased amount of Mesozoic zircons and granulite-derived garnets in the Mengyin Formation samples, compared to those in the Jurassic samples, indicates there was more detritus supply from the NNCB than from the XMOB. In the overlying Qingshan Formation samples, zircon grains do not exhibit Paleozoic ages, but most of them have Early Cretaceous ages and negative εHf(t) values, which are similar to the zircon grains extracted from the widespread Early Cretaceous igneous rocks in the NCB. This suggests that the provenance might have changed to a locally derived source. In contrast, the zircon population of the Early Cretaceous sandstones from the Jiaolai basin is dominated by grains of mid-Neoproterozoic age (700–900 Ma) which signifies contribution from the Sulu orogen. Moreover, the detrital garnet assemblages of sandstones in the Luxi area are not consistent with those from representative metamorphic rocks in the Sulu orogen. The above results seem to confirm that the Mesozoic sedimentary provenance of the Luxi area had no evident connection with the Sulu orogen. Instead, the differential uplifting and exhumation of deep crustal rocks in the NNCB and the XMOB, associated with closure of the Mongol–Okhotsk Ocean, might exert a dominant control on sedimentary provenances in the wide hinterland of the NCB from the Jurassic period to ~136 Ma (the upper boundary age of the Mengyin Formation).

1. Introduction

Situated on the junction of three major Phanerozoic tectonic domains, namely the Paleo-Asian Ocean Tectonic Domain, the Western Pacific Tectonic Domain, and the Tethys Tectonic Domain in the north, east, and south, respectively, the eastern North China Block (NCB) experienced a great tectonic regime transition (Zhao et al., 1994, 2004a; Ren et al., 1997; Zhai et al., 2004a, 2004b; Li et al., 2007b, 2012) and evident lithospheric thinning or destruction (Windley et al., 2010; Zhu et al., 2011; Zhu et al., 2012a, 2012b, and references therein) during the Mesozoic Era under a complex tectonic setting. The NCB has thus been a hotspot for geodynamic studies. A general consensus on the peak period (130–120 Ma) of lithospheric thinning was reached through comprehensive studies (e.g. Zhu et al., 2011, 2012b). However, regarding the tectonic regime transition, there are different opinions concerning the geodynamic setting (e.g. Zhai et al., 2004a; Xu et al., 2013c) and the precise timing of occurrence (Niu et al., 2004; Zhai et al., 2004b; Zhao et al., 2004a; Zhang et al., 2005a; Dong et al., 2008; Zhu et al., 2010). In these circumstances, many issues concerning the formation of the basin-range system and the paleogeographic framework of the eastern NCB during the Middle–Late Mesozoic time, especially the tectonic transitional

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http://dx.doi.org/10.1016/j.jseaes.2015.07.008
1367-9120/

period, remain controversial (e.g. Wu et al., 2007; Zhang et al., 2008c, 2008d; Li et al., 2012, 2013).

The Luxi area is located in a key position, neighboring several significant geological units (Fig. 1). Successive Jurassic–Cretaceous sequences are exposed, making this area a significant window into the Mesozoic evolution of the eastern NCB. Recently, several scholars conducted provenance studies on the Jurassic deposits in the Luxi area and had presented various explanations. The key dispute was focused on whether there were additional detritus supplied from the Xing-Meng orogenic belt (XMOB) and/or the Sulu orogen and/or the northern Qinling orogen, in addition to the contribution from the main source, the northern NCB (NNCB) (Li et al., 2013; Xu et al., 2013b; Yang et al., 2013). Detrital zircon geochronology has been widely used for provenance studies, as one prevalent and efficient approach (e.g. Fedo et al., 2003; Li et al., 2005; Morton et al., 2005). However, in some cases, only relying on this approach may result in significant bias due to underestimation of the contribution of the zircon-poor (free) lithologies in the source, or incorrect interpretation due to different sources that share the same age populations (Fedo et al., 2003). This problem holds true for any single mineral and data type under similar situations (von Eynatten and Dunkl, 2012). In addition, the heavy mineral assemblages of the sandstones from the Jurassic–Cretaceous sediments in the Luxi area show that garnet is one of the most dominant heavy minerals, and it even accounts for a larger proportion than the zircon in most samples (Bu et al., 2012b).

Therefore, integrated analysis of in situ LA-MC-ICP-MS U–Pb geochronology and Hf isotope geochemistry on detrital zircon grains and chemical compositions of detrital garnets from the Jurassic–Early Cretaceous sandstones from the Luxi and Jiaolai areas are conducted, with the aim of elucidating the evolution of the Middle–Late Mesozoic sedimentary provenance of the Luxi and Jiaolai areas more comprehensively. Important constraints are placed on the Middle–Late Mesozoic tectonic evolution of the NCB based on the above results coupled with age-controlled chronostratigraphic correlations.

2. Tectonic units and stratigraphic framework

2.1. Geological characteristics of the tectonic units

The NCB is bounded by the XMOB to the north and the Qinling–Dabie–Sulu orogenic belt to the south and southeast (Fig. 1). Archean to Paleoproterozoic metamorphic basement of the NCB generally underwent multiple high-grade amphibolite or granulite facies metamorphism and is widely exposed on the northern and eastern margins. The U–Pb ages of zircon grains from the basement rocks are concentrated in the two main groups of 2600–2450 Ma and 1950–1750 Ma (Zhai and Santosh, 2011; Zhao and Cawood, 2012). The NNCB encompasses the Inner Mongolia Paleo-Uplift (IMPU) and the Yanshan belt from north to south, which are separated by the Pingquan–Gubeikou–Chicheng–Shangyi fault (Zhang et al., 2007) (Fig. 1). The Late Paleozoic to Early Mesozoic

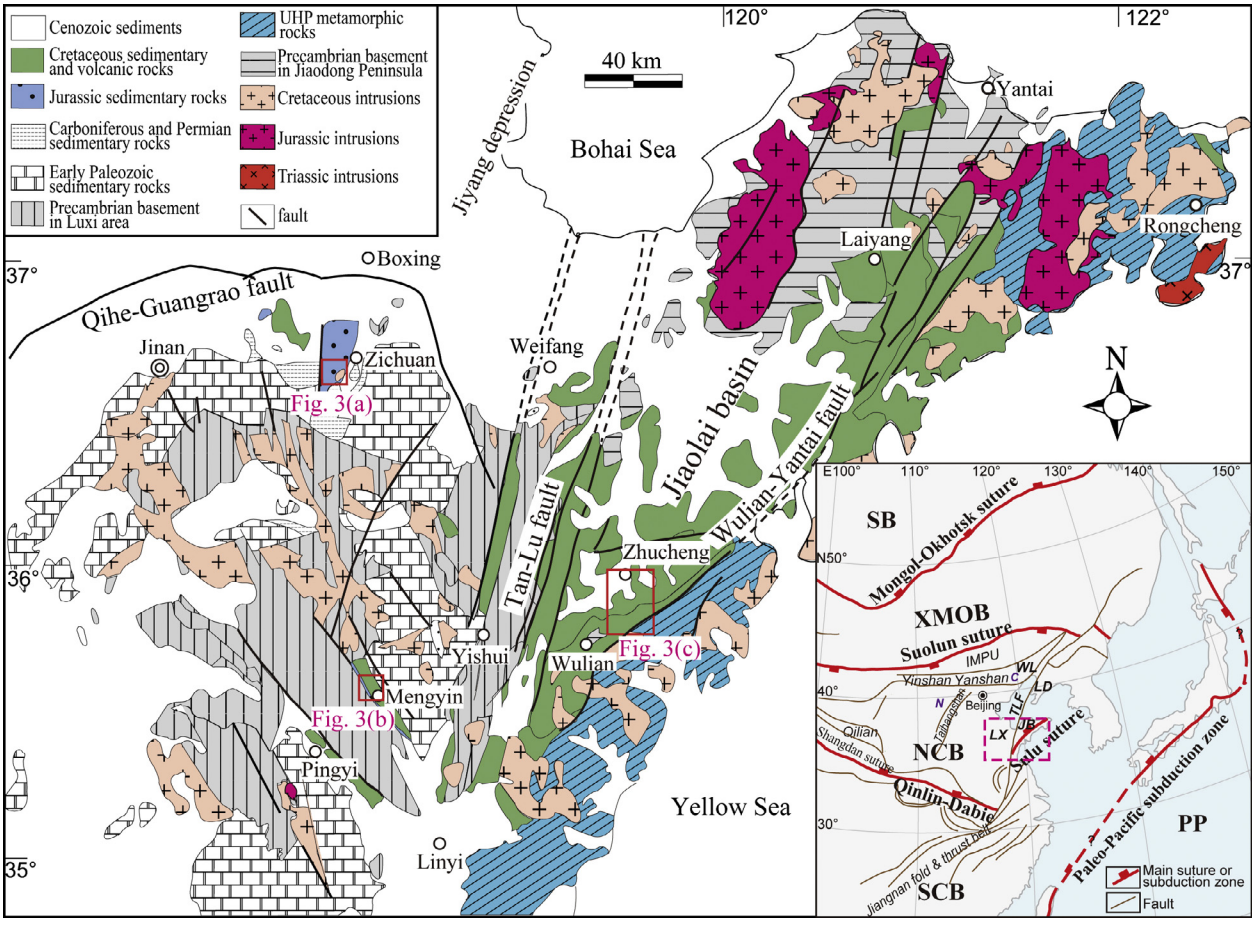

Fig. 1. Geologic map of Luxi and adjacent areas (modified after Xu et al., 2013b). The inset shows the regional tectonic background (modified from Liu et al. (2007)), in which the LX, JB, LD, WL, and TLF, respectively, denote the Luxi area, Jiaobei terrane, Liaodong Peninsula, western Liaoning Province, and Tan-Lu fault, while the letters C and N indicate location of the Chengde basin and Ningwu–Jingle basin, respectively.

Please cite this article in press as: Xu, J., Li, Z. Middle–Late Mesozoic sedimentary provenances of the Luxi and Jiaolai areas: Implications for tectonic evolution of the North China Block. Journal of Asian Earth Sciences (2015), http://dx.doi.org/10.1016/j.jseaes.2015.07.008