Journal of Asian Earth Sciences 67–68 (2013) 114–137

Contents lists available at SciVerse ScienceDirect

Journal of Asian Earth Sciences

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

Petrogenesis and geodynamic setting of Neoproterozoic and Late Paleozoic magmatism in the Manzhouli–Erguna area of Inner Mongolia, China: Geochronological, geochemical and Hf isotopic evidence

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ARTICLE INFO

Article history:
Received 2 August 2012
Received in revised form 18 January 2013
Accepted 19 February 2013
Available online 27 February 2013

Keywords:
Geochronology
Petrogenesis
Tectonism
Neoproterozoic
Late Paleozoic
Granitoid
Manzhouli–Erguna

ABSTRACT

U–Pb dating and Hf isotopic analyses of zircons from various granitoids, combined with major and trace element analyses, were undertaken to determine the petrogenesis and geodynamic setting of Neoproterozoic and Late Paleozoic magmatism in the Manzhouli–Erguna area of Inner Mongolia, China. The Neoproterozoic granitoids are mainly biotite monzogranites with zircon U–Pb ages of 894 ± 13 Ma and 880 ± 10 Ma, and they are characterised by enrichment in large ion lithophile elements (LILEs; e.g., Rb, Ba, K) and light rare earth elements (LREEs), depletion in high field strength elements (HFSEs; e.g., Nb, Ta, Ti) and heavy rare earth elements (HREEs). The Late Devonian granitoids are dominantly syenogranites and mylonitised syenogranites with zircon U–Pb ages of 360 ± 4 Ma, and they form a bimodal magmatic association with subordinate gabbroic rocks of the same age. The Late Devonian syenogranites have A-type characteristics including high total alkalis, Zr, Nb, Ce and Y contents, and high FeOt/MgO, Ga/Al and Rb/Sr ratios. The Carboniferous granitoids are mainly tonalites, granodiorites and monzogranites with U–Pb ages varying from 319 to 306 Ma, and they show very strong adakitic characteristics such as high La/Yb and Sr/Y ratios but low Y and Yb contents. The Late Permian granitoids are dominated by monzogranites and syenogranites with zircon U–Pb ages ranging between 257 and 251 Ma. Isotopically, the $\varepsilon_{Hf}(t)$ values of the Neoproterozoic granitoids range from +4.3 to +8.3, and the two-stage model ages (T_{DM2}) from 1.2 to 1.5 Ga. The Late Devonian granitoids are less radiogenic [$\varepsilon_{Hf}(t)$ from +12.0 to +12.8 and T_{DM2} from 545 to 598 Ma] than the Carboniferous [$\varepsilon_{Hf}(t)$ from +6.8 to +9.5 and T_{DM2} from 722 to 894 Ma] and Late Permian granitoids [$\varepsilon_{Hf}(t)$ from +6.1 to +9.4 and T_{DM2} in the range of 680–895 Ma]. These data indicate (1) the Neoproterozoic granitoids may have been generated by melting of a juvenile crust extracted from the mantle during the Mesoproterozoic, probably during or following the final stages of assembly of Rodinia as a result of the collision and amalgamation of Australia and the Tarim Craton; (2) the Late Devonian granitoids may have formed by partial melting of a new mantle-derived juvenile crust in a post-orogenic extensional setting; (3) the Carboniferous granitoids appear to have been produced by melting of garnet-bearing amphibolites within a thickened continental crust during and following the collision of the Songnen and Erguna–Xing'an terranes; and (4) the Late Permian granitoids may have been generated by melting of garnet-free amphibolites within the Neoproterozoic juvenile continental crust, probably in the post-collisional tectonic setting that followed the collision of the North China and Siberian cratons.

1. Introduction

The Erguna metallogenic belt, situated between the Mongolian–Okhotsk and Derbugan fracture belts, is known principally for its large number of non-ferrous and precious metal deposits such as copper, molybdenum, lead, zinc, silver and gold, as well as its two world-class uranium deposits: the Streltsovka deposit in the Hongshi region of southeastern Russia and the Dornod deposit in northeastern Mongolia (Quan et al., 2002; Liu et al., 2004). The Manzhouli–Erguna area, in the northeastern part of Inner Mongolia (an autonomous region on the northern border of China), is an

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http://dx.doi.org/10.1016/j.jseaes.2013.02.016

important part of the Erguna metallogenic belt. In the past several decades, it has garnered widespread attention primarily because it is important in determining the geodynamic and tectonic evolution of the Central Asian Orogenic Belt, and because it is rich in mineral resources (Wang and Pan, 1992; Qin and Wang, 1993; Qin et al., 1999; Ge et al., 2001; Wang et al., 2006a; Li et al., 2007a; Meng et al., 2011; Xu et al., 2011; Wang et al., 2012). Considering that it is very close to Streltsovka and Dornod (Fig. 1), many researchers have presumed that the area contains similar uranium deposits (Li et al., 2009a; Zhao et al., 2011). Variscan granitoids and Jurassic peralkaline rhyolites have been proposed as the two major sources of uranium in the Streltsovka deposit (Chabiron et al., 2003), and Late Paleozoic subalkaline granitoids are thought to have been produced by the reactivation of older basement rocks.

In recent years there has been an increasing number of studies investigating the petrogenic–metallogenic age and setting of the Manzhouli–Erguna and adjacent areas (Ge et al., 2001; Jahn et al., 2004, 2009; Wu et al., 2005, 2010; Wang et al., 2006a; Li et al., 2007a; Chen et al., 2008, 2011; Zhang et al., 2008a; Gou et al., 2010; Shatkov et al., 2010; Meng et al., 2011; Sun et al., 2011; Xu et al., 2011; Wang et al., 2012), and these studies have greatly helped in deciphering the geological history of the region. However, many of these studies focused on the geochronology and geochemistry of the Mesozoic volcanic and granitic rocks, and with few exceptions (Ge et al., 2005; Wu et al., 2005, 2011), studies of the pre-Mesozoic granitoids have been neglected, and this has hindered our more general understanding of the tectonic evolution and petrogenesis of granitoids in the region. As a result, we are still not sure how similar the generation of Late Paleozoic granitic magmas in the Manzhouli–Erguna area was to the generation of granitoids in the Streltsovka area, and if the similarities are strong, to what extent the granitoids in the Manzhouli–Erguna

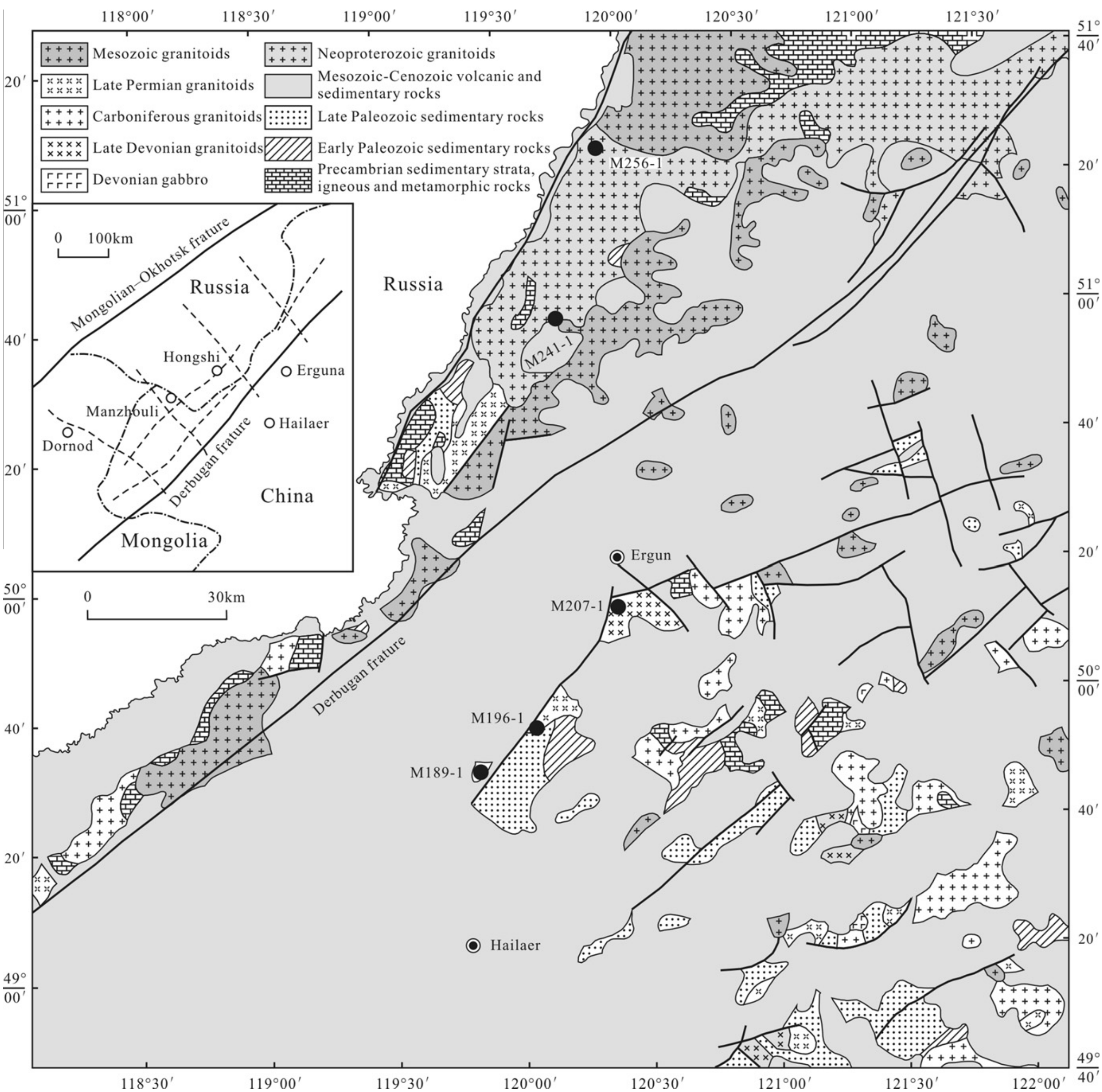

Fig. 1. Distribution of Neoproterozoic and Late Paleozoic granitoids in the Ergun area.