Journal of Asian Earth Sciences 143 (2017) 249–268

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Early Jurassic calc-alkaline magmatism in northeast China: Magmatic response to subduction of the Paleo-Pacific Plate beneath the Eurasian continent

Feng Wang[a,b,*], Yi-Gang Xu[a], Wen-Liang Xu[b,c], Lei Yang[d], Wei Wu[a], Chen-Yang Sun[b]

[a] State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, PR China
[b] College of Earth Sciences, Jilin University, Changchun 130061, PR China
[c] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, PR China
[d] State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, PR China

ARTICLE INFO

Keywords:
Early Jurassic
Calc-alkaline igneous rocks
Zircon U–Pb dating
Geochemistry
Petrogenesis
NE China
Paleo-Pacific Plate subduction

ABSTRACT

The subduction of the Paleo-Pacific Plate played an important role in the regional evolution of the eastern margin of the Eurasian continent, but the timing and extent of this event remain ambiguous. To address these issues, we examine the geochronology and geochemistry of Early Jurassic intrusive rocks in eastern Jilin Province, NE China. The Early Jurassic gabbro–diorites, diorites, granodiorites, and monzogranites are found to have been emplaced at 183–185 Ma and are characterized by enrichment in large ion lithophile elements and depletion in high field strength elements, similar to calc-alkaline arc-type igneous rocks. The Early Jurassic gabbroic and dioritic rocks have $\varepsilon Hf_{(t)}$ values of +2.1 to +10.1 and Hf single-stage (T_{DM1}) model ages of 430–774 Ma, whereas the monzogranites have $\varepsilon Hf_{(t)}$ values of +6.7 to +8.9 and Hf single-stage (T_{DM1}) ages of 597–718 Ma. The gabbro–diorites, diorites, and granodiorites described in this study are genetically linked and they represent the products of the fractional crystallization of a common mafic magma that was in turn derived from the partial melting of a mantle source that was metasomatized by subduction-related fluids. In contrast, the Early Jurassic monzogranites were generated by partial melting of a depleted lower crustal block that was probably accreted during the Neoproterozoic. More importantly, the Early Jurassic calc-alkaline igneous rocks in the east part of NE China form a NE-trending belt that is oriented perpendicular to the direction of Paleo-Pacific Plate movement at that time. West of this belt, contemporaneous bimodal igneous rocks occur in the Lesser Xing'an–Zhangguangcai Ranges. This magmatic configuration is best explained by continental arc magmatism along the continental margin and extensional magmatism in a back-arc setting, in each case triggered by the initial subduction of the Paleo-Pacific Plate beneath Eurasia in the Early Jurassic.

1. Introduction

Subduction of the Paleo-Pacific Plate beneath Eurasia had a strong influence on the Mesozoic tectonic evolution of the eastern margin of the Eurasian continent and contributed to the formation of a mineralized belt in the region (Chen et al., 2012; Xu et al., 2013a, 2013b; Deng et al., 2014). The timing of the onset of this subduction remains debated. While the majority of researchers agree that subduction began during the Early–Middle Jurassic (Zhao et al., 1994; Sun et al., 2005; Wu et al., 2007a; Pei et al., 2008; Zhou et al., 2009; Yu et al., 2012; Xu et al., 2013a; Guo et al., 2015), others have suggested it started in the Triassic (Zhao et al., 1996; Zhou et al., 2014; Wilde, 2015; Yang et al., 2015) or even the early Permian (Ernst et al., 2007; Sun et al., 2015). These disagreements arise from the superimposition of two major regional tectonic events, one related to subduction of the Paleo-Pacific Plate (JBGMR, 1988; HBGMR, 1993; Zhao et al., 1994, 1996; He et al., 1998; Sun et al., 2005; Wu et al., 2007a; Pei et al., 2008; Zhou et al., 2009; Xu et al., 2013a, 2013b; Xu, 2014) and the other related to the earlier closure of the Paleo-Asian Ocean (Sengör et al., 1993; Li, 1998, 2006; Li et al., 2007; Wu et al., 2002, 2007a, 2011; Xiao et al., 2003; Sun et al., 2004; Zhang et al., 2004, 2009; Xu et al., 2009; Zhao et al., 2010; Peng et al., 2012; Cao et al., 2013; Wang et al., 2015). The discrimination of the geological records of these two tectonic regimes is critical in order to establish the timing of the initiation of subduction of the Paleo-Pacific Plate beneath the eastern Asian continent.

Recent studies have suggested that the final closure of the Paleo-

* Corresponding author at: 2199 Jianshe Street, College of Earth Sciences, Jilin University, Changchun 130061, PR China.
E-mail address: jlu_wangfeng@jlu.edu.cn (F. Wang).

http://dx.doi.org/10.1016/j.jseaes.2017.04.018
Received 7 September 2016; Received in revised form 19 April 2017; Accepted 19 April 2017
Available online 25 April 2017
1367-9120/

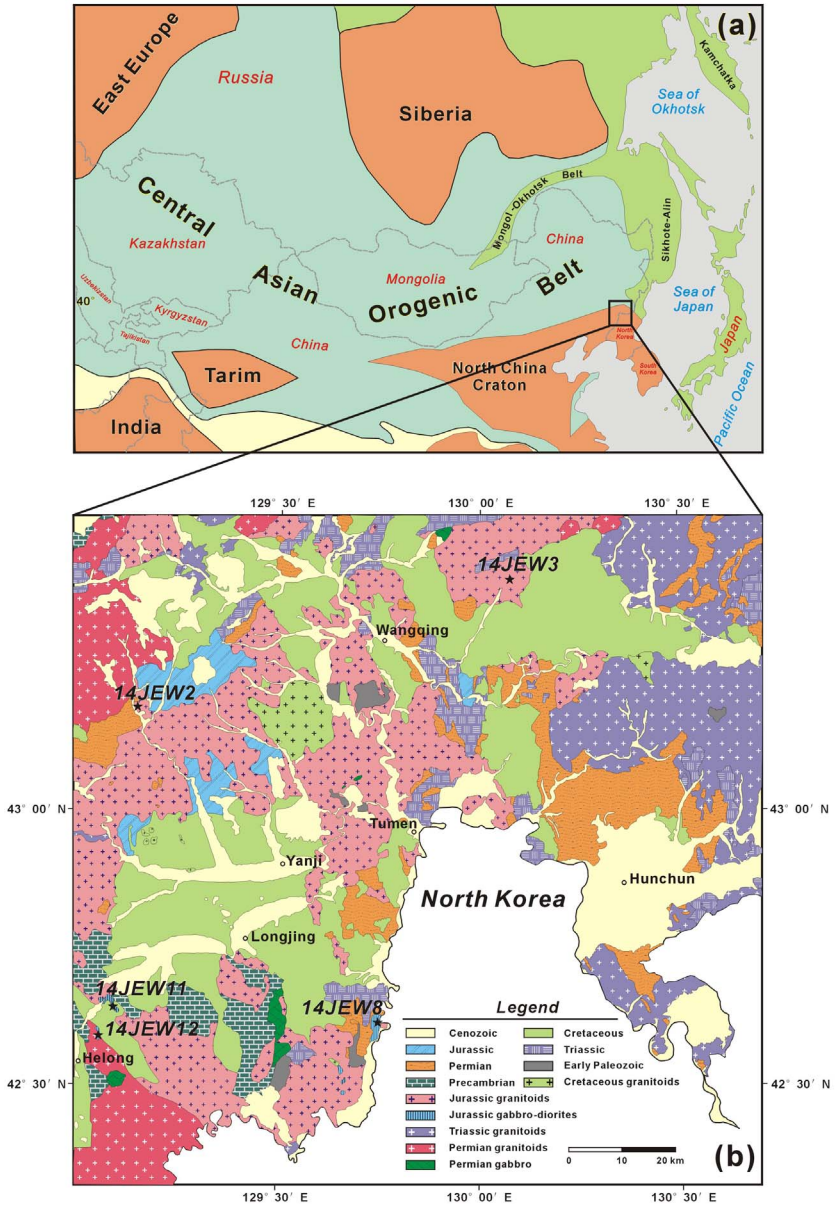

Fig. 1. (a) General map showing the location of the study area, modified after Safonova and Santosh (2014). (b) Detailed geological map of eastern Jilin Province showing sample locations, modified after JBGMR (2007).

Asian Ocean occurred during the earliest Mesozoic (Zhang et al., 2009; Zhao et al., 2010; Wu et al., 2011; Peng et al., 2012; Cao et al., 2013). Furthermore, the Late Triassic bimodal volcanism in the eastern part of NE China, which records post-orogenic extension related to the final closure of the Paleo-Asian Ocean, indicates that subduction of the Paleo-Pacific Plate beneath Eurasia did not persist beyond the Late Triassic (Xu et al., 2013a; Guo et al., 2015; Wang et al., 2015a). Therefore, the identification of the earliest subduction-related calc-alkaline igneous rocks (i.e., after the Late Triassic) is key to constraining the timing of the initiation of subduction of the Paleo-Pacific Plate.

The eastern part of NE China (including eastern Jilin Province) is characterized by immense volumes of igneous rocks whose rough geochronological framework has only recently been established (Wu et al., 2011; Xu et al., 2013a, 2013b). The region examined in the present study is located in the eastern margin of Eurasia (Fig. 1) and is an ideal area for studying the subduction history of the Paleo-Pacific Plate. However, there are still competing views on the Mesozoic tectonics of NE China, especially with regard to the eastern part of this region (Wu et al., 2011). Furthermore, few studies have examined the geochronology and petrogenesis of mafic intrusions in NE China, largely because these rocks occur only sporadically and are volumetrically small relative to granitoids (Yu et al., 2012; Guo et al., 2015; Wang et al., 2015).

To address this shortcoming, we present new LA–ICP–MS zircon ages and whole-rock geochemical data for Early Jurassic calc-alkaline intrusive rocks from east Jilin Province. These data are used to constrain the Early Jurassic tectonic setting of the area and to support our interpretation that the calc-alkaline magmas formed as a result of subduction of the Paleo-Pacific Plate. Thereby, we constrain the timing of the initiation of subduction of the Paleo-Pacific Plate beneath the Eurasian continent.

2. Geological background and sample descriptions

Tectonically, NE China is considered to represent the eastern segment of the Central Asian Orogenic Belt (CAOB), which is located between the North China Craton (NCC) and the Siberian Craton (Sengör et al., 1993; Sengör and Natal'in, 1996; Li, 2006; Windley et al., 2007;