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Geochronology, geochemistry, and deformation history of Late Jurassic–Early Cretaceous intrusive rocks in the Erguna Massif, NE China: Constraints on the late Mesozoic tectonic evolution of the Mongol–Okhotsk orogenic belt

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ABSTRACT

This paper presents new zircon and sphene U–Pb ages, biotite and hornblende $^{40}Ar/^{39}Ar$ ages, Hf isotopic data, and geochemical data for five Mesozoic plutons in the Erguna Massif of NE China. These data are used to constrain the late Mesozoic tectonic evolution of the Mongol–Okhotsk orogenic belt. This new dating, when combined with previously published ages, indicates that the Late Jurassic–Early Cretaceous (J_3–K_1) intrusive rocks can be subdivided into three stages that represent periods of magmatism during the Late Jurassic (~155 Ma), early Early Cretaceous (~137 Ma), and late Early Cretaceous (~123 Ma). In addition, the rocks have undergone later deformation recorded by peak ages of ~137 and ~123 Ma. The Late Jurassic and early Early Cretaceous intrusive rocks in the study area are dominantly syenogranites and are either A-type granites or are classified as alkaline series, suggesting that they formed in an extensional environment. The late Early Cretaceous intrusive rocks in this area are generally monzogranitic and were emplaced as dikes in an extensional environment, along with coeval bimodal volcanics. These data, combined with the presence of regional unconformities in the northern part of Hebei Province and western part of Liaoning Province, and the spatial distribution of coeval volcanic rocks in NE China, suggest the Late Jurassic and early Early Cretaceous magmatisms and the early Early Cretaceous deformation in this area occurred in an extensional environment related to the delamination of a thickened part of the crust after closure of the Mongol–Okhotsk Ocean. In comparison, the late Early Cretaceous deformation and magmatism occurred in an extensional environment related to either delamination of the previously thickened crust related to the Mongol–Okhotsk tectonic regime or the subduction of the Paleo-Pacific Plate, or the combined influence of these two tectonic regimes.

1. Introduction

Tectonically, NE China is thought to be the eastern segment of the Central Asian Orogenic Belt (CAOB), which is located between the Siberian and North China cratons (Fig. 1a; Jahn et al., 2000, 2004; Li, 2006; Sengör et al., 1993; Windley et al., 2007; Xiao et al., 2004). The Paleozoic tectonic evolution of NE China was dominated by closure of the Paleo-Asian Ocean and the amalgamation of microcontinental massifs (including, from west to east, the Erguna, Xing'an, Songnen–Zhangguangcai range, and Jiamusi massifs; Sengör et al., 1993; Sengör and Natal'in, 1996), whereas the Mesozoic tectonic evolution of NE China was characterized by north–south extension and subsequent overprinting by the circum-Pacific and Mongol–Okhotsk tectonic systems (F. Wang et al., 2012; Meng et al., 2010, 2011a; W. Wang et al., 2012; Wu et al., 2004, 2007; Xu et al., 2009, 2013).

Recently acquired geochronological and geochemical data for intrusive and volcanic rocks in NE China have allowed the identification of the spatial–temporal extent of the influence of the Paleo-Asiatic and circum-Pacific tectonic regimes (Cao et al., 2013; Meng et al., 2011b; Wu et al., 2011; Xu et al., 2009, 2013). However, little research has been undertaken on the tectonic evolution of the Mongol–Okhotsk tectonic regime and its influence on NE China (Meng et al., 2011a; W. Wang et al., 2012). This regime partly controlled the Mesozoic formation and tectonic evolution of the eastern part of the Eurasian continent. In addition, the Mongol–Okhotsk Ocean developed during the late Paleozoic, as indicated by a zircon U–Pb age of 325 ± 1 Ma from a leucogabbro within the Adaatsag ophiolite in central Mongolia (Tomurtogoo et al., 2005).

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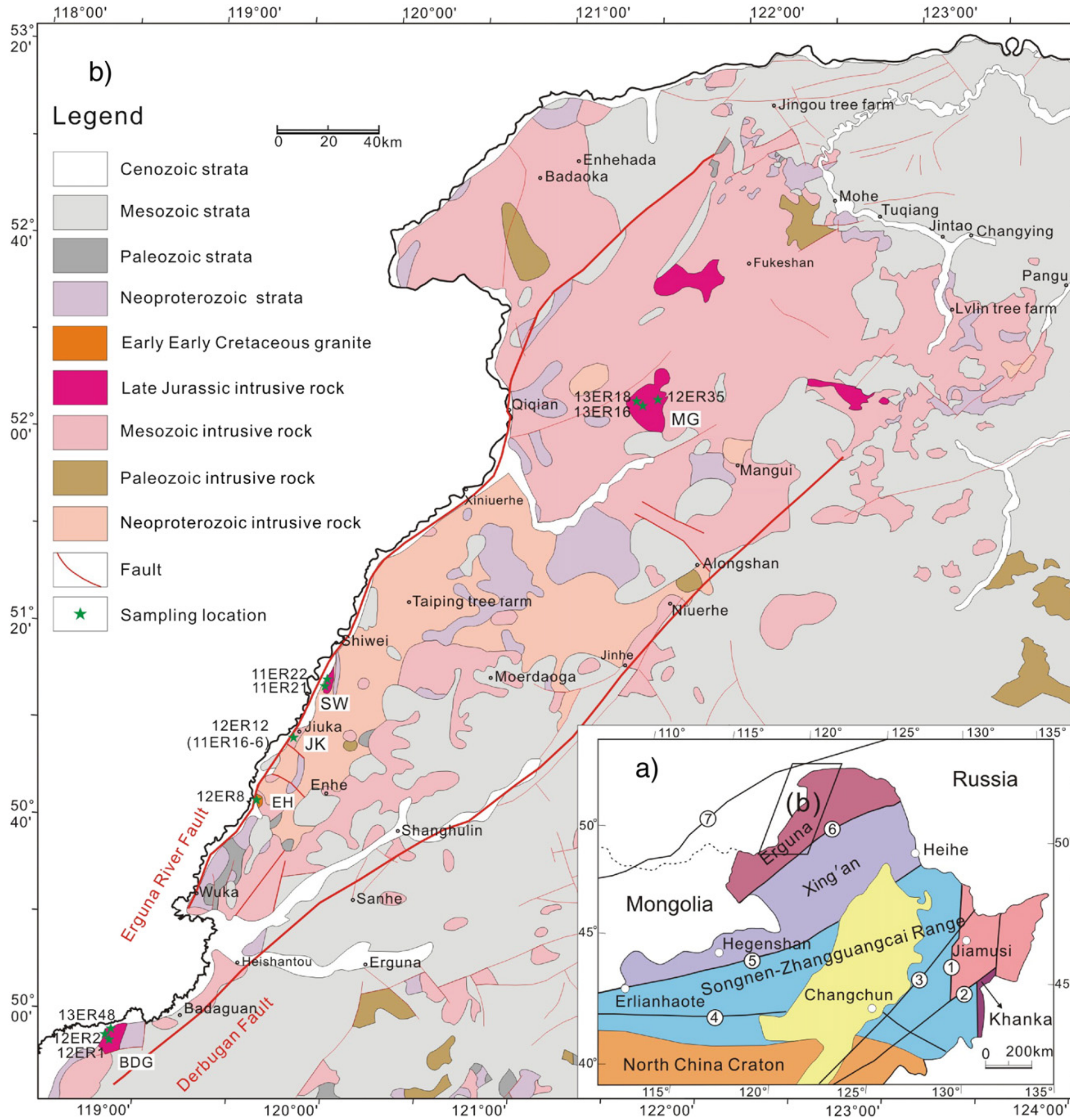

Fig. 1. (a) Tectonic sketch map of NE China, modified after Wu et al. (2011). 1: Mudanjiang Fault; 2: Dunhua–Mishan Fault; 3: Yitong–Yilan Fault; 4: Solonker–Xar Moron–Changchun Fault; 5: Hegenshan–Heihe Fault; 6: Xiguitu–Tayuan Fault; 7: Mongol–Okhotsk orogenic belt. (b) Detailed geological map of the study area within the Erguna Massif.

Calc-alkaline volcanic belts and granitoid intrusions along the northern and southern margins of the Mongol–Okhotsk orogenic belt are thought to be associated with late Paleozoic to Early Jurassic northward- and southward-directed subduction of the Mongol–Okhotsk oceanic lithosphere, respectively (Parfenov et al., 2001; She et al., 2012; Sorokin et al., 2002, 2003, 2005; Tang et al., 2014, 2015; Tomurtogoo et al., 2005; Wang et al., 2015; Wu et al., 2011; Xu et al., 2013; Zorin, 1999). The closure of the Mongol–Okhotsk Ocean was predominantly the result of rotation of the Siberian Craton with respect to the Mongolian microcontinent, which caused the collision of the two continental blocks and formed the Mongol–Okhotsk orogenic belt (Zonenshain et al., 1990; Zorin, 1999; Zorin et al., 1995). The presence of a Middle Jurassic muscovite granite and adakitic intrusive rocks (Li et al., 2015), and coeval thrust–nappe tectonics in NE China (Zhang et al., 2011) suggests that the Mongol–Okhotsk Ocean to the northwest of the Erguna Massif closed during the Middle Jurassic. However, the late Mesozoic tectonic evolution of the Mongol–Okhotsk orogenic belt after ocean closure remains unclear. This problem can be split into two components: (1) late Mesozoic magmatism along the Mongol–Okhotsk orogenic belt, which can be examined using primary zircon and sphene U–Pb geochronology and whole-rock geochemistry; and (2) the deformation history of this area, which can be examined using petrography and geochronology using $^{40}Ar/^{39}Ar$ dating of biotite and hornblende and U–Pb dating of metamorphic zircon and sphene. The ability to directly date deformation by radiometric techniques is a powerful tool that has improved our understanding of the temporal evolution of orogenic belts (Resor et al., 1996). Here, we present new zircon and sphene U–Pb dating, biotite and hornblende $^{40}Ar/^{39}Ar$ dating, and geochemical analysis of the Late Jurassic–Early Cretaceous (J_3–K_1) intrusive rocks in the Erguna Massif, immediately to the southeast of the Mongol–Okhotsk orogenic belt. These data reveal