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Geochronology and geochemistry of Late Devonian and early Carboniferous igneous rocks of central Jilin Province, NE China: Implications for the tectonic evolution of the eastern Central Asian Orogenic Belt

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ABSTRACT

This paper presents new results on zircon U–Pb dating, Hf isotope analyses, and trace and major element analyses of Late Devonian and early Carboniferous metavolcanic rocks and early Carboniferous alkaline granites of central Jilin Province, NE China, and uses these data to constrain the late Paleozoic tectonic evolution of the southern margin of the Central Asian Orogenic Belt (CAOB). Zircon U–Pb ages, determined using laser ablation–inductively coupled plasma–mass spectrometry, indicate that Late Devonian Jifanggou Group metarhyolites formed at ~360 Ma, whereas the early Carboniferous Panling Formation metabasaltic andesites and metarhyolites and the Silengshan alkaline granite formed at ~340 Ma. The Late Devonian metarhyolites, which exhibit zircon $\varepsilon_{Hf}(t)$ values of +2.77 to +8.94 and corresponding two-stage model ages (T_{DM2}) ages of 969–1525 Ma, are geochemically similar to I–A-type granites, which is indicative of formation from a primary magma generated by partial melting of juvenile lower crustal material in an extensional environment. The early Carboniferous metabasaltic andesites and metarhyolites are geochemically bimodal, with SiO_2 concentrations of 52.1–61.4 and 72.8–75.1 wt.%, respectively. The former are enriched in Ba, Sr, Th, and U, and are depleted in K, Rb, Nb, Ta, and Ti, whereas the latter are enriched in light rare earth elements (LREEs) and large ion lithophile elements (LILEs; e.g., Rb, K, Th and U), and are depleted in heavy REEs (HREEs), high field strength elements (HFSEs; e.g., Nb, Ta, Ti, and P), and Sr. Zircons from the metabasaltic andesite and metarhyolite units have $\varepsilon_{Hf}(t)$ values of +9.80 to +12.8 and +11.0 to +13.1, respectively, and corresponding single-stage model ages (T_{DM1}) and two-stage model ages (T_{DM2}) of 468–606 and 584–776 Ma, respectively. Silengshan alkaline granite samples contain minor amounts of riebeckite, are relatively LREEs and LILEs enriched and HREEs and HFSEs depleted, and have markedly negative Eu anomalies, features that are typical of A-type granites. These granite samples have zircons with $\varepsilon_{Hf}(t)$ values of +8.04 to +13.4 and corresponding T_{DM2} ages of 549–1037 Ma. These data suggest that the primary magma that formed the early Carboniferous metabasaltic andesites was derived from partial melting of depleted lithospheric mantle material that had been modified by subduction-related fluids, whereas the primary magmas for the coeval metarhyolites and the Silengshan alkaline granite were derived from partial melting of newly accreted crust. These early Carboniferous igneous rocks formed in an extensional setting within the eastern segment of the southern CAOB.

1. Introduction

Northeast China is located in the eastern segment of the southern margin of the Central Asian Orogenic Belt (CAOB), an area referred to as the Xing'an–Mongolia Orogenic Belt (XMOB). This region consists of several microcontinental massifs, including the Erguna, Xing'an, Songnen–Zhangguangcai Range, Jiamusi, and

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Khanka massifs (Fig. 1a; Wu et al., 2007, 2011; Meng et al., 2010, 2011a; Tang et al., 2013), which amalgamated during the Paleozoic (Tang et al., 2013; Fig. 1a). This amalgamated continent is usually referred to as the Burean–Jiamusi Block or paleoplate (Li, 1995, 1998, 2006). However, the tectonic history of this amalgamated continent and the interactions between this continent and the North China Craton (NCC) during the late Paleozoic are currently unclear and somewhat controversial. Some researchers consider that the final closure of the Paleo-Asian Ocean occurred during the Middle Devonian (Xu and Chen, 1997; Xu et al., 2013), or between the Late Devonian and early Carboniferous (Tang, 1990; Shao, 1991). Other researchers have suggested that an early Paleozoic arc may have collided with the NCC during the latest early Paleozoic (Li et al., 2009; Zhang et al., 2010a; Liu et al., 2013), a passive continental margin associated with the northern NCC may have existed until the early Carboniferous (Li et al., 2009), and that southward subduction of the Paleo-Asian Ocean plate between the NCC and the Burean–Jiamusi Block occurred between the late Carboniferous and the early Permian (Li, 2006; Li et al., 2009; Cao et al., 2012, 2013).

These conflicting results reflect the prevailing uncertainty of the tectonic activity between the amalgamated continent (usually named the Burean–Jiamusi Block) and the northern margin of the NCC (i.e., the eastern segment of the southern CAOB) during the late Paleozoic. However, the central Jilin Province, an under-researched area in terms of understanding late Paleozoic tectonism (Cao et al., 2012, 2013), is a key area that can advance our understanding of the late Paleozoic tectonic evolution of the eastern segment of the southern CAOB.

Here, we present results of zircon U–Pb dating, Hf isotope analysis, and whole-rock geochemistry of metavolcanic rocks from the Jifanggou Group, the Panling Formation of the Xia'ertai Group, and the Silengshan alkaline granite in central Jilin Province, NE China. These data enable us to further constrain the late Paleozoic tectonic evolution of the eastern segment of the southern CAOB.

2. Geological background and sample description

Central Jilin Province is tectonically situated in the eastern segment of the southern margin of the XMOB, and is bounded by the Songliao Basin to the west and the Yitong–Yilan Fault to the east (Fig. 1a). The southern part of central Jilin Province is located in the eastern segment of the northern margin of the NCC, and is dominated by the early Paleozoic Xia'ertai Group, minor

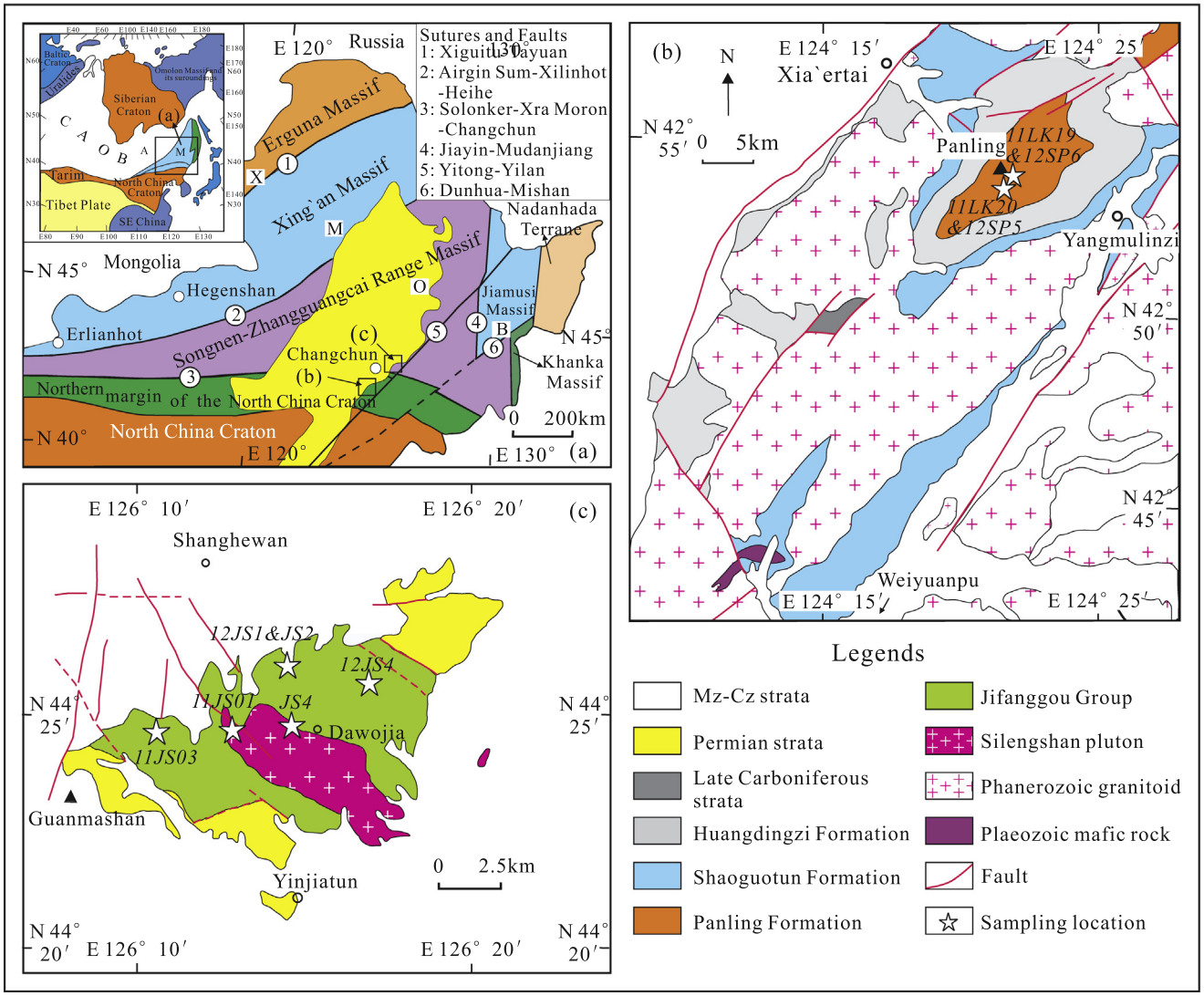

Fig. 1. (a) Tectonic sketch map of NE China; modified after Wu et al. (2007). The inset shows the tectonic location of NE China. A and M represent the Altaids and Manchrides, respectively (Sengör and Natal'in, 1996). (b) Detailed geological map of the southern Siping area in south-central Jilin Province, within the eastern part of the northern margin of the NCC. (c) Detailed geological map of the Jifanggou area in north-central Jilin Province, on the southeastern margin of the Songnen–Zhangguangcai Range Massif.