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Elemental and Sr–Nd–Pb isotopic geochemistry of Late Paleozoic volcanic rocks beneath the Junggar basin, NW China: Implications for the formation and evolution of the basin basement

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Abstract

The basement beneath the Junggar basin has been interpreted either as a micro-continent of Precambrian age or as a fragment of Paleozoic oceanic crust. Elemental and Sr–Nd–Pb isotopic compositions and zircon Pb–Pb ages of volcanic rocks from drill cores through the paleo-weathered crust show that the basement is composed mainly of late Paleozoic volcanic rock with minor shale and tuff. The volcanic rocks are mostly subalkaline with some minor low-K rocks in the western Kexia area. Some alkaline lavas occur in the central Luliang uplift and northeastern Wulungu depression. The lavas range in composition from basalts to rhyolites and fractional crystallization played an important role in magma evolution. Except for a few samples from Kexia, the basalts have low La/Nb (<1.4), typical for oceanic crust derived from asthenospheric melts. Zircon Pb–Pb ages indicate that the Kexia andesite, with a volcanic arc affinity, formed in the early Carboniferous (345 Ma), whereas the Luliang rhyolite and the Wucaiwan dacite, with syn-collisional to within-plate affinities, formed in the early Devonian (395 and 405 Ma, respectively). Positive $\varepsilon_{Nd}(t)$ values (up to +7.4) and low initial $^{87}Sr/^{86}Sr$ isotopic ratios of the intermediate-silicic rocks suggest that the entire Junggar terrain may be underlain by oceanic crust, an interpretation consistent with the juvenile isotopic signatures of many granitoid plutons in other parts of the Central Asia Orogenic Belt. Variation in zircon ages for the silicic rocks, different Ba, P, Ti, Nb or Th anomalies in the mafic rocks, and variable Nb/Y and La/Nb ratios across the basin, suggest that the basement is compositionally heterogeneous. The heterogeneity is believed to reflect amalgamation of different oceanic blocks representing either different evolution stages within a single terrane or possibly derivation from different terranes.

Keywords: Late Paleozoic volcanic rocks; Lava geochemistry; Sr–Nd–Pb isotopes; Oceanic crust; Heterogeneous basement; Junggar basin; NW China

1. Introduction

The Central Asia Orogenic Belt (CAOB) lies between the Siberian Craton to the north and the North China Craton to the south and extends for over 2000 km across northern China (Fig. 1A). It is believed to be the site of successive accretion of arc complexes in the Planerozoic times (Coleman, 1989; Zonenshain et al., 1990; Sengőr et al., 1993), which were then intruded by voluminous Paleozoic and Mesozoic granitic-syenitic rocks (Jahn et al., 2000a; Kovalenko et al., 2004). These magmatic rocks were formed by a complicated combination of subduction–accretion processes and late-stage extension. Two gigantic magmatic belts can be recognized in the CAOB: a northern belt extending from central-northern Mongolia to Russian Transbaikalia and a southern belt extending from Kazakhstan through northern Xinjiang (NW China) and southern Mongolia into NE China. Large quantities of isotopic data have been published on rocks of the CAOB and used to interpret the processes of Phanerozoic juvenile continental growth (e.g., Han et al., 1997; Hu et al., 2000; Jahn et al., 2000a,b; Wu et al., 2000, 2002; Chen and Jahn, 2002; Chen and Arakawa, 2005).

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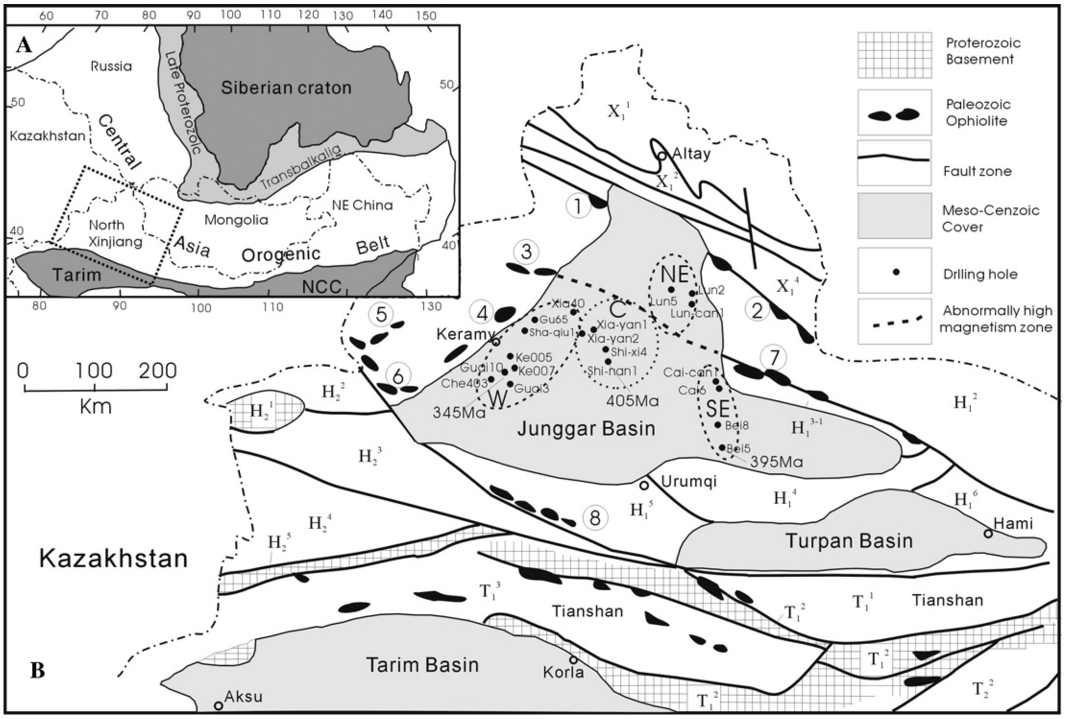

Fig. 1. Sampling locations and the ophiolite suites surrounding the Junggar basin in northern Xinjiang. (A) The locality of the study area (Junggar basin) in the Central Asia Orogenic Belt (modified after Jahn et al., 2000a). (B) Sampling locations within Junggar basin and the distribution of ophiolite suites surrounding the basin: ① Jaheba ophiolite belt; ② Armantai ophiolite belt; ③ Hongguleleng ophiolite belt; ④ Darbut ophiolite belt; ⑤ Mayilershan ophiolite belt; ⑥ Tangbale ophiolite belt; ⑦ Kalameili ophiolite belt; ⑧ Bayaangou-Dannahu ophiolite belt. The symbols are as follows: W, western Kexia area; C, central Luliang uplift; NE, the northeastern Wulungu depression; SE, southeastern Wucaiwan depressions.

The Junggar basin, a triangular feature of ~200,000 km^2 in northern Xinjiang Province (Fig. 1B), is filled with about 10 km of continental sedimentary rocks, the oldest of which are early Permian (Xie et al., 1984; Coleman, 1989). The nature of the basement beneath the basin has long been controversial because of the paucity of stratigraphic, geochemical and geochronological data. Some workers considered the Junggar basement to represent a micro-continent of Precambrian age (e.g., Ren and Jiang, 1980; Zhang et al., 1984; Wang, 1986; Watson et al., 1987; Wu, 1987), whereas others interpreted it as a fragment of Paleozoic oceanic crust (e.g., Li et al., 1982; Jiang, 1984; Hsű, 1989; Feng et al., 1989; Chen and Jahn, 2004; Chen and Arakawa, 2005). Xiao et al. (1992) suggested that the northern Xinjiang region was formed by the convergence of three principal plates (Siberia, Kazakhstan and Tarim): the Junggar basin and Tianshan Mountains were considered to be part of the Kazakhstan plate, whereas the Altay Mountains in northernmost Xinjiang were considered to mark the southern part of the Siberian plate.

Volcanic rocks obtained from boreholes through the paleo-weathered crust of the Junggar basin in the southern belt of the CAOB (see Fig. 1A) offer an ideal opportunity to probe the nature of the basement beneath the basin. In this paper, elemental and Sr–Nd–Pb isotopic geochemistry and zircon Pb–Pb ages of drill core samples are used to investigate the composition and tectonic setting of the basement rocks and thus shed light on the formation and evolution of the basin. The boreholes are located in the western Kexia area, the central Luliang uplift, and in the northeastern Wulungu and southeastern Wucaiwan depressions. The locations are abbreviated as "Kexia" (W), "Luliang" (C), "Wulungu" (NE) and "Wucaiwan" (SE) (Fig. 1B).

2. General geologic setting

The Junggar basin is filled with thick continental sedimentary rocks not older than early Permian (XBGMR, 1993) and surrounded by a number of Paleozoic ophiolite belts (Fig. 1). A variety of granitic rocks, including M-, A- and I-types, have been found around the basin (Xiao et al., 1992; Tu, 1993). Early published data suggested that most of the granitic rocks were intruded between 320 and 350 Ma (Lu and Liu, 1989; Zhou, 1989; Shen and Jin, 1993) with a few at ~400 Ma (Hu et al., 1997). However, recent SHRIMP results suggest that the granitoids from the Junggar terrain mostly intruded in a post-collisional, extensional regime between 300 and 280 Ma (e.g., Han et al., 1997; Chen and Jahn, 2004; Chen and Arakawa, 2005).

Two NW-trending ophiolite belts, the Armantai-Jaheba belt (① and ② in Fig. 1B) and the Hongguleleng-Kalameili belt (③ and ⑦), are present in the northeastern part of the basin. The Armantai-Jaheba belt extends eastward into Mongolia, and is composed of metamorphic peridotite,