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Focus paper

The Russian-Kazakh Altai orogen: An overview and main debatable issues

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ABSTRACT

The paper reviews previous and recently obtained geological, stratigraphic and geochronological data on the Russian-Kazakh Altai orogen, which is located in the western Central Asian Orogenic Belt (CAOB), between the Kazakhstan and Siberian continental blocks. The Russian-Kazakh Altai is a typical Pacific-type orogen, which represents a collage of oceanic, accretionary, fore-arc, island-arc and continental margin terranes of different ages separated by strike-slip faults and thrusts. Evidence for this comes from key indicative rock associations, such as boninite- and turbidite (graywacke)-bearing volcanogenic-sedimentary units, accreted pelagic chert, oceanic islands and plateaus, MORB-OIB-protolith blueschists. The three major tectonic domains of the Russian-Kazakh Altai are: (1) Altai-Mongolian terrane (AMT); (2) subduction-accretionary (Rudny Altai, Gorny Altai) and collisional (Kalba-Narym) terranes; (3) Kurai, Charysh-Terekta, North-East, Irtysh and Char suture-shear zones (SSZ). The evolution of this orogen proceeded in five major stages: (i) late Neoproterozoic–early Paleozoic subduction-accretion in the Paleo-Asian Ocean; (ii) Ordovician–Silurian passive margin; (iii) Devonian–Carboniferous active margin and collision of AMT with the Siberian continent; (iv) late Paleozoic closure of the PAO and coeval collisional magmatism; (v) Mesozoic post-collisional deformation and anarogenic magmatism, which created the modern structural collage of the Russian-Kazakh Altai orogen. The major still unsolved problem of Altai geology is origin of the Altai-Mongolian terrane (continental versus active margin), age of Altai basement, proportion of juvenile and recycled crust and origin of the middle Paleozoic units of the Gorny Altai and Rudny Altai terranes.

1. Introduction

The Altai orogenic belt is a north-western part of the Central Asian Orogenic Belt (CAOB), which is located between the East European, Siberian, North China and Tarim cratons and encompasses an immense area from the Urals in the west, through Altai-Sayan and Transbaikalia in Russia, Kazakhstan, Kyrgyzstan, Uzbekistan, north-western China, Mongolia, and Northeast China to the Okhotsk Sea in the Russian Far East (Fig. 1). It is one of the largest accretionary orogens on Earth and evolved over some 800 Ma thus representing an ideal natural laboratory to unravel geodynamic processes during voluminous Phanerozoic continental growth (e.g., Şengör and Natal'in, 1996; Vladimirov et al., 1998; Buslov et al., 2001; Windley et al., 2007; Kruk et al., 2011; Safonova et al., 2011b; Kröner et al., 2014). The diverse terranes of different geodynamic origin have been accreted to active continental margins of the above four cratons during the subduction of the Paleo-Asian Ocean (PAO). The Altai orogen is a foldbelt formed between the collided Kazakhstan, Siberian and Tarim continental blocks. Geographically, it is located in south-western Siberia (Russian Altai), East Kazakhstan (Kazakh Altai), western Mongolia (Mongolian Altai) and north-western China (Chinese Altai). The Russian-Kazakh part of Altai formed at the southern margin of the Siberian continent and represents the first stage of CAOB tectonic evolution. Most tectonic reconstructions on the CAOB, despite different approaches, consider its oceanic units as fragments of the Paleo-Asian Ocean (PAO). All scientists who ever been working in

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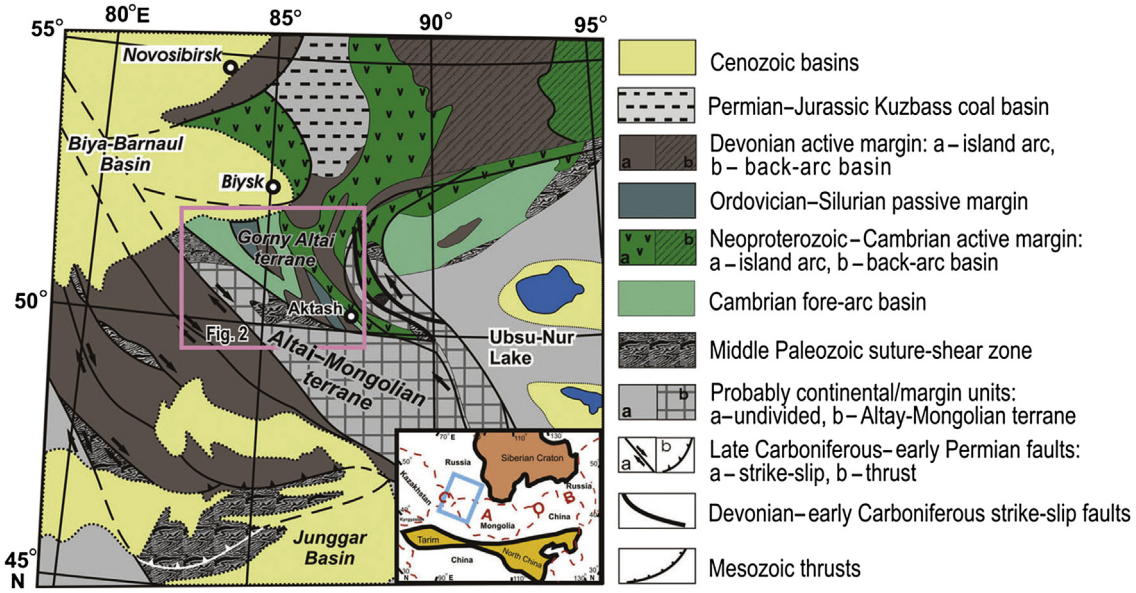

Figure 1. The north-western part of the Central Asian Orogenic Belt: junction zone between the Kazakhstan composite continent and the Siberian continental margins across the territories of East Kazakhstan, Russia (Altai-Sayan), NW China and western Mongolia (modified from Safonova and Buslov, 2010).

the Altai accept that its tectonic structure is a collage of terranes of different ages and origins separated by numerous large thrusts, strike-slip faults and nappes. The region contains well-preserved late Neoproterozoic to early Paleozoic subduction-accretion complexes incorporating both oceanic and active margin units including accretionary complexes, fore-arc sediments, primitive- and normal island-arc rocks (e.g., Buslov et al., 2001, 2002, 2004; Dobretsov et al., 2003; Safonova et al., 2008, 2011a,c; Kruk et al., 2011). All this makes it similar to the recent tectonic settings of the western Pacific (Buslov and Watanabe, 1996; Ota et al., 2007).

The Altai orogen is a geologically important area for reconstructing the formation of the late Neoproterozoic–early Paleozoic continental crust of the CAOB, specifically, the proportions of juvenile versus recycled crust. A key question for understanding the evolution of the Altai orogen is the role of continental blocks and subduction complexes in crust formation as a result of multi-stage accretion and collision (e.g., Zonenshain et al., 1990; Sengor and Natal'in, 1996; Buslov et al., 2001; Kovalenko et al., 2004; Xiao et al., 2004; Windley et al., 2007). Many researchers believe that the CAOB resulted from accretion of oceanic arcs and/or Gondwana-derived continental blocks to the Siberian, Russian, and North China cratons and their later collision (e.g., Zonenshain et al., 1990; Didenko et al., 1994; Golonka, 2000; Buslov et al., 2001; Laurent-Charvet et al., 2003). The second type of model views the CAOB or made mainly of Paleozoic subduction-accretion materials (Şengör and Natal'in, 1996; Yakubchuk, 2008; Xiao et al., 2010), which accumulated against a few magmatic arcs of extended length. However, the origin of large crustal terranes of the CAOB, including the Altai orogen, is still under discussion.

There are four major tectonic areas within the Russian-Kazakh Altai (Buslov et al., 2001): (1) Altai-Mongolian terrane; (2) Gorny Altai subduction-accretionary terrane; (3) Rudny Altai island-arc terrane; (4) Kalba-Narym collisional terrane. The terranes are separated by suture-shear zones (SSZ). The Gorny Altai, Rudny Altai, and Kalba-Narym terranes of different ages (from east to west) consist of Caledonian and Hercynian subduction-accretionary and collisional units. The subduction-accretionary complexes include fragments of ophiolites and seamounts accreted to island arcs and/or active continental margins (Dobretsov et al., 2004; Safonova et al., 2004, 2009; Safonova and Santosh, 2014). The Charysh-Terekta SSZ separates the Altai-Mongolian and Gorny Altai terranes, the Kurai SSZs separates the Gorny Altai terrane from West Mongolia terranes, the Irtysh (or Erqis in China) SSZs separates the Rudny Altai and Kalba-Narym terranes. The Gorny and Rudny Altai terranes are separated by the north-western segment of the dextral Charysh-Terekta SSZ including the sinistral North-East strike-slip fault (Fig. 2; Buslov et al., 2004).

This paper reviews main geological, lithological and geochronological features of different terranes of the Russian-Kazakh Altai, discusses the main debatable questions of the origin of the Altai orogen with a focus on the presence/absence of a Gondwana-derived microcontinent in the Altai orogen and formation of juvenile and recycled crust and describes the main stages of Russian-Kazakh Altai evolution.

2. Altai-Mongolian terrane

The Altai-Mongolian terrane (AMT) is about 1000 km long and up to 250 km wide; it is situated at the southern borders of the Gorny Altai and Rudny Altai terranes and extends to the Chinese and Mongolian Altai (Figs. 1 and 2). The ATM is bounded by the N–E strike-slip fault in Rudny Altai, by the Irtysh SSZ in China, and by the Charysh-Terekta SSZ in Gorny Altai (Fig. 3). In Russia, the AMT is outcropped in the southern part of the Gorny Altai terrane, northeast of Chagan-Uzun Village, near to the state border with Mongolia (Fig. 3). The terrane is dominated by Precambrian rhythmically bedded quartz-feldspar or, to a lesser degree, polymictic sandstones, siliceous and phyllitic shales and slates (Dergunov, 1989). The upper flysch horizons contain violet and red sediments and sparse interbeds of acid tuffs and clayish siliceous sediments. Those rhythmic flyschoid units are isoclinally folded and transgressively overlapped by Ordovician–Devonian units, which all are indicative of a complicated geodynamic evolution of the AMT. In southern Gorny Altai, the middle Ordovician grey marine sediments of the Biryusa Formation and its analogues overlie metamorphosed and sheared basement units through basal conglomerates. The $^{207}Pb/^{206}Pb$ zircon age of felsic arc-type lavas of the Chinese Altai is 505 ± 2 Ma (Windley et al., 2002).