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Precambrian geology of the Kazakh Uplands and Tien Shan: An overview

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ABSTRACT

A comprehensive review of new data on geology and geochronology of Precambrian terranes in the western Central Asian Orogenic Belt reveals new insights into its evolution. At the present surface, these terranes mostly consist of Meso- to Neoproterozoic sedimentary, magmatic and metamorphic assemblages, with insignificant Paleoproterozoic rocks. Archean material is represented exclusively by detrital and xenocrystic zircons in younger strata. Meso- to Neoproterozoic felsic magmatic rocks were mostly sourced from Neoarchean and Paleoproterozoic continental crust, indicating its reworking and potential wider presence at deeper crustal levels. Most Meso- to Neoproterozoic assemblages are of intraplate origin. The supra-subduction assemblages of Neoproterozoic and Mesoproterozoic ages are of limited extent.

We propose to recognize the Issedonian and Ulutau-Moyunkum groups of terranes, separated by early Paleozoic Z-shaped ophiolitic suture, based on their different tectono-magmatic evolution in the Mesoproterozoic and Neoproterozoic. Distinctly different are the Mesoproterozoic and early Neoproterozoic assemblages, with lithological variations at the beginning of the late Neoproterozoic and practically no differences at the end of the Neoproterozoic.

The Issedonian group of terranes could be part of a Mesoproterozoic (ca. 1100 Ma) orogen between the Siberian, North China and Laurentian cratons. The pre-Mesoproterozoic crust of these terranes was completely reworked during the younger events. The Ulutau-Moyunkum group of terranes appear to be lithologically and geochronologically similar to the Tarim craton. Both the Issedonian and Ulutau-Moyunkum groups of terranes were metamorphosed during the Ulutau-Moyunkum event at 700 ± 25 Ma.

The breakup into currently mappable Precambrian terranes took place during end-Ediacaran to early Paleozoic times after opening of oceanic basins, whose relics are preserved in numerous Paleozoic ophiolitic sutures.

1. Introduction

In the west of the Central Asian Orogenic Belt (CAOB), which includes Paleozoic orogens of the Kazakh Uplands, Tien Shan and northwest China, Precambrian terranes constitute approximately 50% of its crust. The remainder is Paleozoic juvenile terranes, predominantly of island arc and accretionary wedge types (Yakubchuk, 2004; Degtyarev, 2012). In the middle and late Paleozoic, all terranes were incorporated into the basement of overlapping magmatic arcs, were stitched by large granitoid massifs and buried under the backarc to intra-arc sedimentary basins (Yakubchuk, 2004; Yakubchuk et al., 2012). As a result, Precambrian crust is now exposed in isolated larger or smaller areas.

Precambrian terranes were mapped in the western and southern parts of the Kazakh Uplands and Tien Shan, forming a C-shaped chain extending from Kazakhstan to northwest China. In the other parts of CAOB, Precambrian terranes exist in southern Mongolia (Kozakov et al., 2005; Demoux, 2009) and in northeast China in the transition zone to the Circum-Pacific orogens. Fig. 1 shows distribution of Precambrian crust in the Altai-Sayan orogen, northern and central Mongolia, as well as in the adjacent Neoproterozoic Angara and Baikal orogens on the periphery of the Siberian craton. Precambrian rocks are also known in the Urals. This paper will only consider the western CAOB in the Kazakh Uplands, Tien Shan and adjacent northwest China.

Precambrian terranes were previously interpreted to consist of some Archean and mostly Paleo-, Meso- and early Neoproterozoic rocks (Filatova, 1983; Zaitsev, 1984). The stratified units of metamorphic terranes are often intruded by metamorphosed (foliated) granitoids. Previous isotopic dating of these intrusive massifs (Zykov et al., 1977, 1983) provided a framework for the stratigraphic correlations in this area. Zaitsev (1984) proposed the most elaborate and consistent stratigraphic and intrusive correlation charts and models of Precambrian tectonic evolution. He recognized Paleoproterozoic (Karelian) and Mesoproterozoic (Issedonian) tectonic cycles, each culminating in orogenic events at ca. 1800 Ma and 1100 Ma, respectively. The Issedonian tectonism at 1100 ± 50 Ma was recognized by Zaitsev in the 1970s

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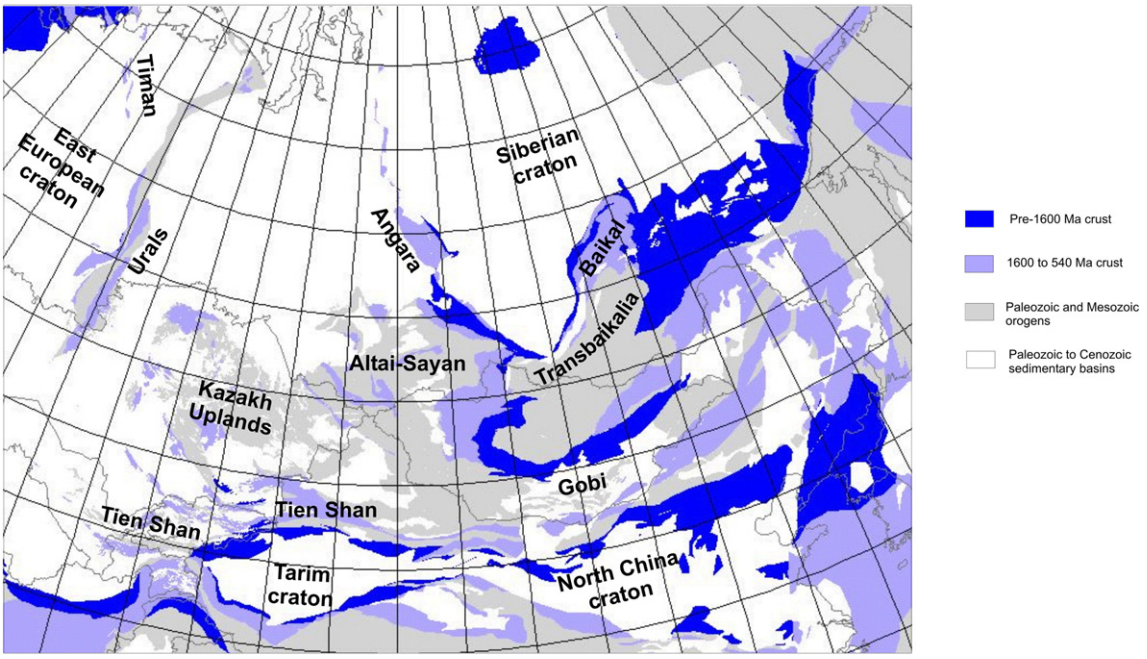

Fig. 1. Distribution of early and late Precambrian continental crust in the Central Asian Orogenic Belt and adjacent cratons. In the eastern CAOB, metamorphic terranes form several groups in Transbaikalia/Mongolia and in the Russian Far East/northeast China. In the western CAOB, they are known in the Kazakh Uplands, Tien Shan and South Gobi.

(Zaitsev, 1984). It was derived from the name of the Scythian tribe that populated the area in the 7th to 1st centuries BC. It was assumed that, as a result of Issedonian orogenesis, all Precambrian massifs constituted a single continent. At the same time Neoproterozoic (Baikalian or Pan-African) events were not recognized in the western CAOB at all (Zaitsev, 1984).

Avdeev et al. (1992) also recognized the importance of the Mesoproterozoic deformations at ca. 1100 Ma, recorded in almost all Precambrian massifs of the Kazakh Uplands and Tien Shan. The Issedonian event was followed by peneplaination and accumulation of quartzite successions, very similar in different parts of this area.

Other researchers also proposed several events in the Precambrian evolution of the Kazakh Uplands and Tien Shan between the end of the Archean and late Neoproterozoic (Kiselev et al., 1992; Kozakov, 1993). However, the interpretation of their tectonic significance remained obscure in these studies.

During the last decade, Kröner et al. (2007, 2013, 2017), Degtyarev et al. (2008, 2015), Tretyakov et al. (2011a, 2011c), Tretyakov et al., 2012a, 2012b, 2015a–c) and Turkina et al. (2011) obtained new precise isotopic data on Precambrian rocks in the Kazakh Uplands and Tien Shan. In contrast to the previous perception of a wide presence of Archean to Paleoproterozoic rocks (Abdulin and Zaitsev, 1980b; Abdulin, 1986; Filatova, 1983; Abdulkabirova, 1987), the new data confirmed the presence of Mesoproterozoic rocks and, most importantly, demonstrated the existence of Neoproterozoic stratified assemblages and intrusive complexes. The presence of early Precambrian sedimentary successions appeared to be very limited. At the same time, Archean and Paleoproterozoic crust was recorded in Nd model ages from Meso- to Neoproterozoic felsic magmatic rocks and in detrital zircons in metasedimentary sequences (Kröner et al., 2013; Kovach et al., 2014; Rojas-Agramonte et al., 2014; Degtyarev et al., 2015; Tretyakov et al., 2015c, 2016c).

This study attempts to revise the lithostratigraphic and intrusive correlations across the entire area of the Kazakh Uplands and Tien Shan on the basis of new data, which are still not exhaustive. We also attempt to reconstruct geodynamic settings that existed in the area during the growth of Precambrian terranes.

2. A general outline of lithology, age and geodynamic settings

The Precambrian rocks form several narrow (200 km or less), but very long (up to 2600 km) ribbon-shaped terranes in the western Kazakh Uplands and Tien Shan (Fig. 2). Early Paleozoic accretionary wedges with dismembered ophiolites separate these terranes from each other. These are the Kokchetav, Stepnyak-Ishkeolmes, Erementau-Niyaz, Aktau-Mointy, Zheltau, Issyk-Kul, Chinese Central Tien Shan and Ulutau-Sarydzhaz (including subterranes of Ulutau, Baikonur, Karatau-Talas, Chu-Kendyktas, Chatkal and Naryn-Sarydzhaz).

In plan view, the Precambrian terranes form a C-shaped cluster at the southwestern limb of the Kazakhstan orocline, a product of multiple Paleozoic deformations (Degtyarev, 2012: Yakubchuk et al., 2012). Gradual and long term bending of the orocline is constrained by a combination of structural, geochronological and paleomagnetic data (Bazhenov et al., 2012; Levashova et al., 2012). Along the eastern flank of the C-shaped cluster, the Precambrian terranes are bordered by juvenile early Paleozoic accretionary wedge and island arc terranes, among which Precambrian rocks are not proven, although several areas with metamorphosed rocks were identified (e.g. Matak Horst and Edrei; Zaitsev, 1984).

In the west and north of the Kazakh Uplands, Precambrian terranes are overlain by middle Paleozoic to Mesozoic-Cenozoic sedimentary basin sequences, with very limited exposure only in the Chatkal area of the Tien Shan (Fig. 2). However, drilling and geophysical data (Abdulin and Zaitsev, 1980b; Zaitsev, 1984) allowed to recognize buried terranes, such as small South Turgai and large Syrdaria. The latter is possibly exposed only in the Chatkal area and was proposed to occupy the entire southwestern 'corner' of the CAOB (Abdulin and Zaitsev, 1980b; Zaitsev, 1984).

In the south, the Precambrian terranes are limited by the well-exposed Turkestan and Atbashi-Inylchek sutures with Paleozoic ophiolites, forming a major divide with the Alai-Tarim craton. In the west, the possible equivalent of the Turkestan suture can be proposed in the Transurals suture exposed in the west-east-trending river valleys. This suture must be treated as a principal divide between the Paleozoic