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Re-deciphering the tectonic jigsaw puzzle of northern Eurasia

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Abstract

Northern Eurasia consists of the East European, Siberian, North China, and Alai-Tarim cratons, fragments of the supercontinent Rodinia, and the orogens of the Baikalides, Timanides, Uralides, Altaids, and Mongolides. These can be collectively classified as the Central Asian supercollage. The Baikalides and Timanides host Meso- and Neoproterozoic magmatic arc terranes that were sutured with the adjacent East European and Siberian cratons in the end of the Neoproterozoic. The Paleozoic part of the supercollage consists of three almost synchronous and subparallel Neoproterosoic to Paleozoic magmatic arc and turbidite superterranes, as well as overlap assemblages, bent into the world's largest oroclines. Analysis of their structural pattern, supported by paleontological, lithological, and paleomagnetic data, indicates that these superterranes might have been produced via formation of arc–backarc systems at the margin of combined North China, East European and Siberian cratons and then deformed during Paleozoic westward-directed strike-slip translation between the clockwise rotating Siberian and eastward moving North China cratons. It is proposed that this development took place against the respective breakup of the above-mentioned cratons from the northern and southern margins of Eastern Europe in the Neoproterozoic, initially as a group of cratons called Nena, which reassembled in late Paleozoic to early Mesozoic times into Laurasia, part of the new supercontinent Pangea.

In Mesozoic–Cenozoic times, the subduction-related continental growth of northern Eurasia continued in the Nipponide, Kamchatka and Kolyma–Alaska orogenic collages of the northern Circum-Pacific, which consist of Paleozoic to Cenozoic turbidite to island arc superterranes and overlap assemblages, generally younging towards the Pacific oceanic plate and also severely oroclinally bent. It is proposed that terranes of the Kolyma–Alaska and Kamchatka collages were translated westward, dextrally relative to Siberia, whereas Nipponides were translated northward, relative to North China, similarly to the better constrained Mesozoic–Cenozoic reconstructions of southeastern Asia. The two groups of collages started to collide along the Mongol-Okhotsk suture zone in the south of the Siberian craton in the end of the Mesozoic and then continued to collide along the presently active plate boundary at the island of Sakhalin.

The proposed scenario suggests similarities in Paleozoic evolution of the Central Asian and Mesozoic–Cenozoic evolution of the northern Circum-Pacific supercollages, both possibly formed in response to westward subduction and related strike-slip translation of the (Paleo)-Pacific oceanic plates. The individual superterranes might have been consequently translated for as much as 4000–6000 km and oroclinally bent during such translation or/and rotation of the adjacent cratons.

Keywords: Central Asian supercollage; Altaids; Baikalides; Mongolides; Northern Circum-Pacific; Oroclinal and strike-slip tectonics

1. Introduction

In the 20th century, it was recognized that northern Eurasia consists of Precambrian cratons (Eastern Europe, Siberia, Tarim and North China), as well as Neoproterozoic–Paleozoic (Ural-Mongolian or Central Asian) and Mesozoic–Cenozoic (Circum-Pacific) fold belts (Suess, 1908; Stille, 1957; Muratov, 1974).

After the discovery of plate tectonics, evolution of the Circum-Pacific through subduction-related processes was proposed, accepted and advanced relatively quickly (Coney et al., 1980; Plafker et al., 1989; Bogdanov and Tilman, 1992; Parfenov, 1995; Sengör and Natal'in, 1996a, 1996b; Nokleberg et al., 1998; Chekhov, 2000; Khanchuk, 2000). However, some workers (Plafker et al., 1989; Sengör and

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Natal'in, 1996b; Khanchuk, 2000) recognized the importance of strike-slip translation along the Pacific convergent margin, whereas others suggested that northern Circum-Pacific magmatic arcs originated almost in the middle of the Pacific ocean, subsequently drifted northward and accreted to Asia (Stavskiy et al., 1988; Zonenshain et al., 1990; Sokolov et al., 1997; Nokleberg et al., 1998).

Although even the first plate tectonic interpretations of the Paleozoic Central Asian fold belt (Zonenshain, 1973) suggested that it formed in the Paleo-Asian embayment of the Paleo-Pacific Ocean, its complex internal structure was the reason behind long-lasting debate on its evolution. Peive et al. (1980) emphasized that Central Asian orogens have a mosaic structural pattern that was produced largely due to tectonic accretion of the oceanic crust and its transformation into continental crust. In response to this, Zaitsev (1984) indicated that the internal pattern of the belt is clearly structured in oval-shaped manner; and it contains numerous Precambrian metamorphic massifs, which cannot be explained through simple accretion.

Further works (Zonenshain et al., 1990; Mossakovskiy et al., 1993; Didenko et al., 1994; Filippova et al., 2001; Kheraskova et al., 2003; Bykadorov et al., 2003) classified the Precambrian metamorphic crustal fragments as microcontinents that were drifted from Eastern Gondwana in the Neoproterozoic and then drifted across the Paleo-Asian Ocean in the same manner as it was proposed for more recent Gondwana fragments in the Tethys belt (Sengör and Natal'in, 1996b). It was proposed that the drifting microcontinents became incorporated into the basement of multiple magmatic arcs and were additionally split into smaller fragments during backarc and intra-arc spreading. At the end of the Paleozoic, their collision with each other between the Siberian and North China cratons produced the 'mosaic-type' Central Asian belt.

To the contrary, Sengor and his colleagues (Sengör et al., 1993; Sengör and Natal'in, 1996a,b) emphasized that the recognized oval-shaped pattern of the Central Asian belt (Hamilton, 1970; Zaitsev, 1984) can be interpreted as a system of oroclinally bent magmatic arcs whose origin can be kinematically linked with the paleomagnetically recorded Paleozoic clockwise rotation of Siberia relative to Eastern Europe and collision of North China and Tarim cratons in the late Paleozoic to the early Mesozoic. These workers reclassified the Central Asian belt as an orogenic collage, in which they distinguished the Uralides, Altaids, and Manchurides. They specifically emphasized that Paleozoic flysch is remarkably similar across the collage and proposed that its huge width is a result of duplication along the giant arc-parallel strike-slip faults, principally similar to Circum-Pacific tectonism (Sengör et al., 1993). Precambrian metamorphic blocks inside the Altaids were interpreted as the pediments of the Neoproterozoic–Paleozoic Kipchak and Tuva-Mongol arcs that, contrary to the traditional interpretation, might have been drifted from the combined Eastern Europe and Siberia cratons.

Yakubchuk et al. (2005) proposed to classify all Neoproterozoic to early Mesozoic orogens between the major cratons as the Central Asian supercollage. Although employing the same methodology as Sengör et al. (1993), Yakubchuk et al. (2005) revealed different structural pattern inside the collage and, therefore, suggested different reconstructions. They emphasized that only Vendian to Paleozoic turbidite terranes of Central Mongolia could be directly traced to the Circum-Pacific collages, whereas similar turbidite terranes in the internal parts of the Altaids occur behind the Precambrian metamorphic terranes of Mongolia. It was demonstrated that Neoproterozoic to Paleozoic rocks can be grouped into the three continuous, subparallel, almost synchronous and metallogenically similar magmatic arc and turbidite superterranes that might have been formed at the Paleo-Pacific convergent margin (Yakubchuk et al., 2005).

Such triple repetition of similar superterranes in the Central Asian supercollage can be explained either through the opening, co-existence, and suturing of the three marginal backarc basins or through huge strike-slip translation and duplication of similar superterranes and overlap assemblages. The description of individual terranes and superterranes of the Central Asian supercollage can be found in Yakubchuk et al. (2005). This paper attempts to analyze the relationships between these terranes and how they might have been evolved in the context of subduction-related crustal growth of northern Eurasia since Neoproterozoic times. First of all, it will focus on revision of the superterranes, continent-scale groups of lithological terranes of similar composition. This may help to recognize major tectonic features that could be missed or misinterpreted during previous detailed studies. This approach requires broad generalization of the large amount of data, referred to throughout the study. However, some ideas expressed in this paper might not have enough supporting data, and, therefore, they allow optional and conceptual interpretations.

2. Methodology

The orogenic collages consist of metamorphic terranes, representing fragments of adjacent cratons and Neoproterozoic orogens. They also include Vendian to the early and middle Paleozoic turbidite and island arc terranes overlapped by magmatic arc and sedimentary basin assemblages.

To reveal the internal architecture of these orogens, Sengör et al. (1993) and Sengör and Natal'in (1996a,b) proposed identifying the individual units inside the orogens as combination of a magmatic arc and an adjacent subduction-accretionary wedge in its front. One can add to this that the magmatic arc may be ensimatic (or immature), if it formed on the oceanic crust, and ensialic, if it occurs above the Precambrian granite-metamorphic basement. With time, the arc magmatism might have migrated oceanward, overlapping the growing accretionary wedge during