[AMERICAN JOURNAL OF SCIENCE, VOL. 310, NOVEMBER, 2010, P. 812–825, DOI 10.2475/09.2010.03]

A ONE-BILLION-YEAR GAP IN THE PRECAMBRIAN HISTORY OF THE SOUTHERN SIBERIAN CRATON AND THE PROBLEM OF THE TRANSPROTEROZOIC SUPERCONTINENT

D. P. GLADKOCHUB*, T. V. DONSKAYA*, M. T. D. WINGATE**,§,
A. M. MAZUKABZOV*, S. A. PISAREVSKY***,§,†, E. V. SKLYAROV*,
and A. M. STANEVICH*

ABSTRACT. Available geochronological data substantiate the existence of an apparent ca. one billion year gap in geological activity in the southern part of the Siberian craton. The duration of the gap is about 0.8 to 1.1 Ga in the Sayan Uplift and at least 0.9 Ga in the Baikal Uplift. We suggest that the absence of major geological activity in this interval might be due to the southern margin of Siberia occupying an internal position within a Transproterozoic supercontinent, that is, a fragment of Nuna that did not disperse until the late Neoproterozoic breakup of Rodinia. The absence of Mesoproterozoic–early Neoproterozoic sedimentary successions in southern Siberia could possibly be explained by their removal by erosion. Ediacaran subsidence following the breakup of Rodinia may reflect the solidification of magma chambers that fed Neoproterozoic mafic dike swarms. We suggest that a combination of these factors (dike emplacement and erosion) has a significant influence on global tectonics, controlling the uplift and subsidence of ancient cratons.

Key words: Nuna, Proterozoic, Rodinia, Siberia, supercontinent, tectonics

INTRODUCTION

The majority of Precambrian cratons were amalgamated between 2.1 to 1.8 Ga (see overview in Windley, 1998, and references therein). The global Paleoproterozoic accretional and collisional processes, which were responsible for the "birth" of ancient cratons, are marked by large orogenic belts in Laurentia, South America, Western Africa, Baltica, Australia, Northern China, and Siberia (for example Hoffman, 1997; Zhao and others, 2004; Cawood and Korsch, 2008).

Zhao and others (2002) tested the possibility of the Pre-Rodinian supercontinent using lithostratigraphic, petrological, and geochronological comparisons and postulated direct links between South America and West Africa, Western Australia and South Africa, Laurentia and Baltica, Siberia and Central Australia, and North China and India. This hypothetical supercontinent was originally named Nuna by Hoffman (1997), but is also known as Columbia or Hudsonland (for example Williams and others, 1991; Condie, 2000, 2002; Rogers and Santosh, 2002; Meert, 2002; Pesonen and others, 2003; Zhao and others, 2004).

Several researchers suggested that Nuna was assembled during the late Paleoproterozoic (for example Condie, 2000, 2002; Rogers and Santosh, 2002; Pesonen and others, 2003; Zhao and others, 2004). Based on geological correlations, Rogers and Santosh (2009) suggested that the final assembly of Nuna occurred between 1.90 Ga and 1.85 Ga. Meert's (2002) analysis of available paleomagnetic data suggests that this supercontinent was not assembled by 1.77 Ga, but could have existed at c. 1.5 Ga.

---

* Institute of the Earth's Crust, Siberian Branch of the Russian Academy of Sciences, Lermontov Str. 128, Irkutsk 664033, Russia

** Geological Survey of Western Australia, 100 Plain Street, East Perth, WA 6004, Australia

*** School of Geosciences, The University of Edinburgh, The King's Buildings, West Mains Road, Edinburgh, EH9 3JW, United Kingdom

§ School of Earth and Environment, University of Western Australia, Crawley, WA, Australia

† Corresponding author: Sergei.Pisarevsky@ed.ac.uk

However, the majority of paleogeographic reconstructions assume that Nuna was formed prior to the Mesoproterozoic.

Zhao and others (2002) suggested that Nuna broke up between 1.6 and 1.2 Ga and that this event was marked by emplacement of mafic dike suites, anorogenic anorthosite-mangerite-charnockite-granite (AMCG) suites, and mantle-derived intrusions. Rogers and Santosh (2004) agreed, but emphasized the dominant role played by AMCG magmatism in the process of breaking up the supercontinent. In their reconstruction, the main AMCG suites and granite-rhyolite associations are located in cratonic interiors, a mode of occurrence more typical of anorogenic magmatism related to intraplate extension than of supercontinent dispersal (Windley, 1998; Sears and others, 2005). Condie (2002) presented a hypothesis of incomplete breakup of Nuna by the early Mesoproterozoic (1.6-1.5 Ga) into at least two large continents, named Atlantica (Amazonia, Congo, West Africa, North Africa, and Rio de la Plata) and Arctica (Laurentia, Siberia, Baltica, northern Australia, and North China) by Rogers (1996). Condie (2002) suggested that these large continents subsequently became parts of Rodinia in the late Mesoproterozoic, but did not cite any evidence to support this suggestion.

Hou and others (2008) argued that c. 1.3 to 1.2 Ga giant radiating dike swarms of the Canadian shield, Australia, and East Antarctica are indicators of the final breakup of Nuna. They suggested the existence of a late Mesoproterozoic mantle plume between North America and Australia–East Antarctica. This model is similar to the abovementioned Condie's (2002) reconstruction, and suggests that the breakup of Nuna only slightly predated the assembly of Rodinia (Li and others, 2008).

The Siberian craton could have been an important part of the Mesoproterozoic supercontinent. However, Siberian Mesoproterozoic paleogeography was poorly known until recently owing to a paucity of precise geochronological and paleomagnetic data. The main aim of this paper is to re-examine the igneous complexes and sedimentary suites of southern Siberia, in view of recently published data, and to re-assess the role of Siberia in the Nuna supercontinent. In this review, we discuss only the internal parts of the Siberian craton. The relicts of Mesoproterozoic ophiolites and island arcs accreted to Siberia in the Neoproterozoic and Early Paleozoic have been discussed elsewhere (for example Donskaya and others, 2000; Kuzmichev and others, 2001; Khain and others, 2003; Vernikovsky and others, 2003).

PROTEROZOIC DEVELOPMENT OF THE SOUTHERN SIBERIAN CRATON

The Siberian craton is one of the largest early Precambrian lithospheric units of northern Eurasia, and extends for more than 2500 km from the Arctic Ocean in the north to Baikal Lake in the south. Most of the craton is covered by 2 to 14 km of Mesoproterozoic to Lower Cretaceous sediments and Permian-Triassic traps. The basement is exposed in the Aldan-Stanovoy and Anabar shields, in some outcrops of the Olenek uplift, and in smaller uplifts along the southern craton margin. The internal structure of the covered parts of the craton was reconstructed mainly using aeromagnetic and gravity data, and information from deep boreholes and xenoliths in kimberlite pipes. The Siberian craton is described as an association of Archean and Paleoproterozoic terranes (blocks) welded by orogenic belts and shear zones (for example Rosen and others, 1994; Rosen, 2003; Khiltova and others, 2003; Smelov and Timofeev, 2003; Gladkochub and others, 2006a; Pisarevsky and others, 2008). These models differ in the details of locations and configurations of terranes and orogenic belts, but all agree that the final assembly of the Siberian craton occurred at ca. 1.90 to 1.85 Ga. In the model of Rosen and others (1994) and Rosen (2003), modified by Gladkochub and others (2006a), the Siberian craton includes four Archean (Tungus, Anabar, Aldan, Stanovoy) and one Paleoproterozoic (Olenek) superterranes (fig. 1A).

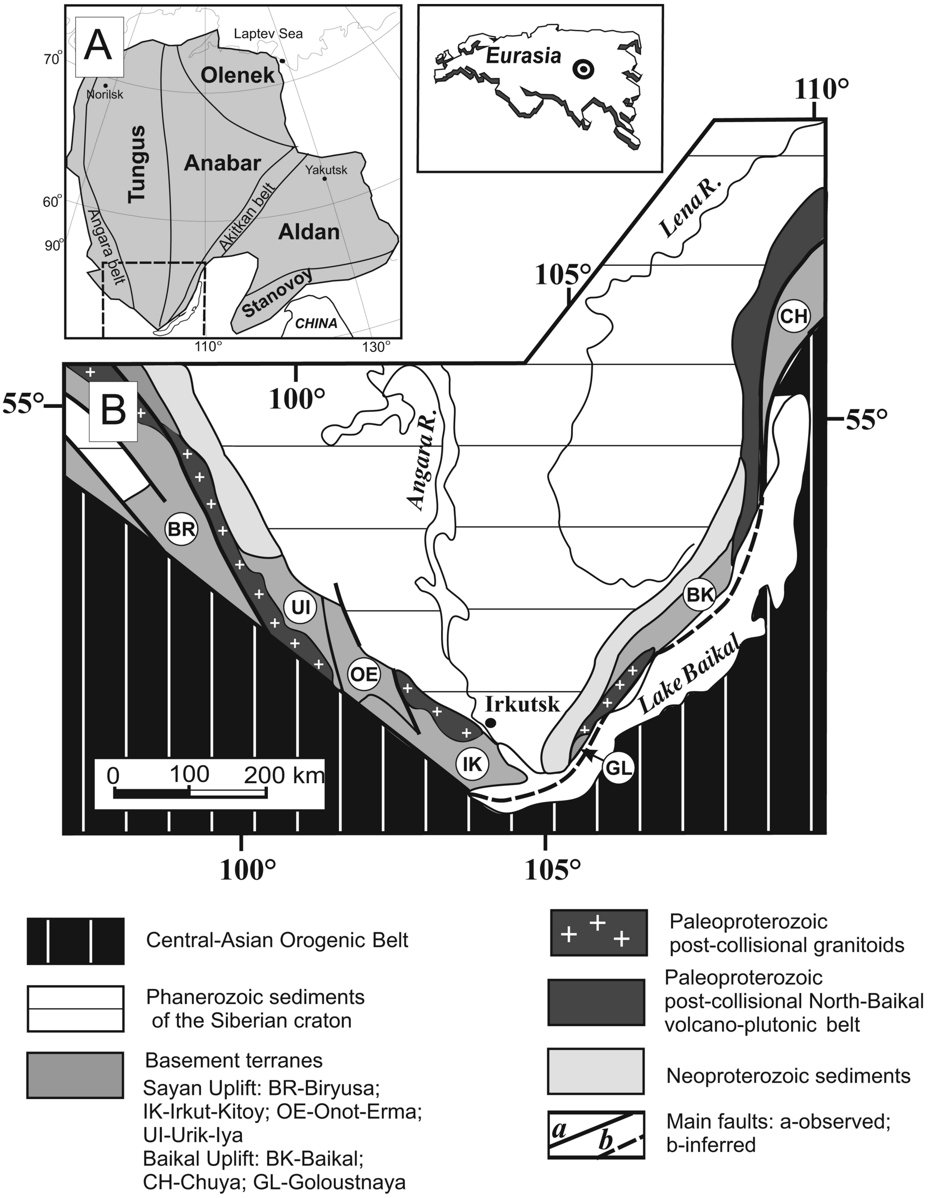

Fig. 1. (A) Major terranes and orogenic belts of the Siberian craton. (B) Simplified geology of the southern margin of the Siberian craton.

The southern Siberian craton (fig. 1) includes the southern extremes of the Tungus and Anabar superterranes and the southern parts of Angara and Akitkan belts (Rosen and others, 1994; Rosen, 2003; Gladkochub and others, 2006a). This part of the Siberian margin is a zone of high-grade metamorphic complexes and collisional and post-collisional granites (Aftalion and others, 1991; Rosen and others, 1994; Gladkochub and others, 2001a; Poller and others, 2004, 2005; Gladkochub and others, 2006a). The ages of post-collisional granites (including rapakivi-like granites and felsic volcanics) are mainly between 1.88 and 1.84 Ga (Neymark and others, 1991; Levitskii and others, 2002; Donskaya and others, 2002, 2003, 2008; Nozhkin and others, 2003; Turkina and others, 2003; Larin and others, 2000, 2003, 2006; Poller and others, 2004, 2005). Consequently, we suggest that coeval accretion/collision events occurred not only between the superterranes, but also along the southern Siberian margin. The latter may be indicative of a major collision with some other craton (Laurentia?). The time of this collision coincided with major orogenic events in other continents and is considered by some workers as the time of the Nuna assembly (for example Rogers and Santosh, 2009). Thus the first major peak of tectonic, metamorphic, and igneous activity in the Precambrian history of southern Siberia represents cratonic amalgamation as part of the Paleoproterozoic assembly of the Nuna supercontinent.

A second peak of tectonic and igneous activity in southern Siberia occurred in the late Neoproterozoic (c. 0.8-0.7 Ga), when numerous mafic dike swarms intruded the southern craton margin. Neoproterozoic mafic dikes are found in the Biryusa (BR), Urik-Iya (UI), Onot-Erma (OE), Irkut-Kitoy (IK), and in the Baikal (BK) terranes (see fig. 1B) (Gladkochub and others, 2001b). Recent ^{40}Ar-^{39}Ar plagioclase ages of these dike swarms appear to decrease towards the southwest from 780 to 740 Ma (Sklyarov and others, 2003; Gladkochub and others, 2006b), and may reflect the development of a Neoproterozoic rift in this direction. This rift-related extension and dike intrusion led to development of a passive continental margin along the southern Siberian margin. Thus, the second peak in tectonic and igneous activity and sedimentation presumably represents rifting that caused the Neoproterozoic breakup of the Rodinia supercontinent (Li and others, 2008, and references therein).

The period of almost one billion years between these two peaks, from c. 1.8 to 0.8–0.7 Ga, remains a very poorly understood interval in the geological history of southern Siberia. The traditional view (see reviews in Mitrofanov, 1987a, 1987b; Gladkochub and others, 2006a; Pisarevsky and others, 2008) is that this mid-Proterozoic period was characterized by continuous sedimentation along the craton margin, together with sporadic volcanic activity (in the Chaya, and Khota formations) and emplacement of subvolcanic intrusions (Chaya, Angaul, and Nersa dike suite). However, the ages of these volcanic rocks and dike swarms were unclear and provided poor constraints on the age of the sedimentary succession.

To improve our understanding of Siberia's geological record, we conducted geochronological studies of volcanic and dike complexes regarded as mid-Proterozoic by Bukharov (1987), Domyshev (1976), and Mitrofanov (1987a, 1987b). The marginal uplifts of the southern Siberian craton basement were our key targets. The discussion below excludes certain areas, for example the Baikal-Patom Highland, which has inadequate geochronology. The southern part of the Siberian craton comprises the Baikal and Sayan Uplifts. The Sayan Uplift consists of the Biryusa (BR), Urik-Iya (UI), Onot-Erma (OE), and Irkut-Kitoy (IK) terranes, whereas the Baikal Uplift encompasses the Goloustnaya (GL), Baikal (BK), and Chaya (CH) terranes and the North-Baikal volcano-plutonic belt (fig. 1B). Our new geochronological results have significant implications for the chronostratigraphy of sedimentary sequences in southern Siberia.

Baikal Uplift

The upper Precambrian stratigraphy of the sedimentary section in the Baikal Uplift (fig. 2) is based on the unified legends for the 1:50000 scale geological maps of east Siberia (Mitrofanov, 1987b). Figure 2A shows stratigraphic positions of volcanic rocks and dikes with their previously accepted age assignments.

The age of the volcano-sedimentary Akitkan Group of the North Baikal volcano-plutonic belt (southern part of the Akitkan belt, according to Rosen and others, 1994; fig. 1) until recently has been constrained by Rb-Sr geochronology as latest Paleopro-

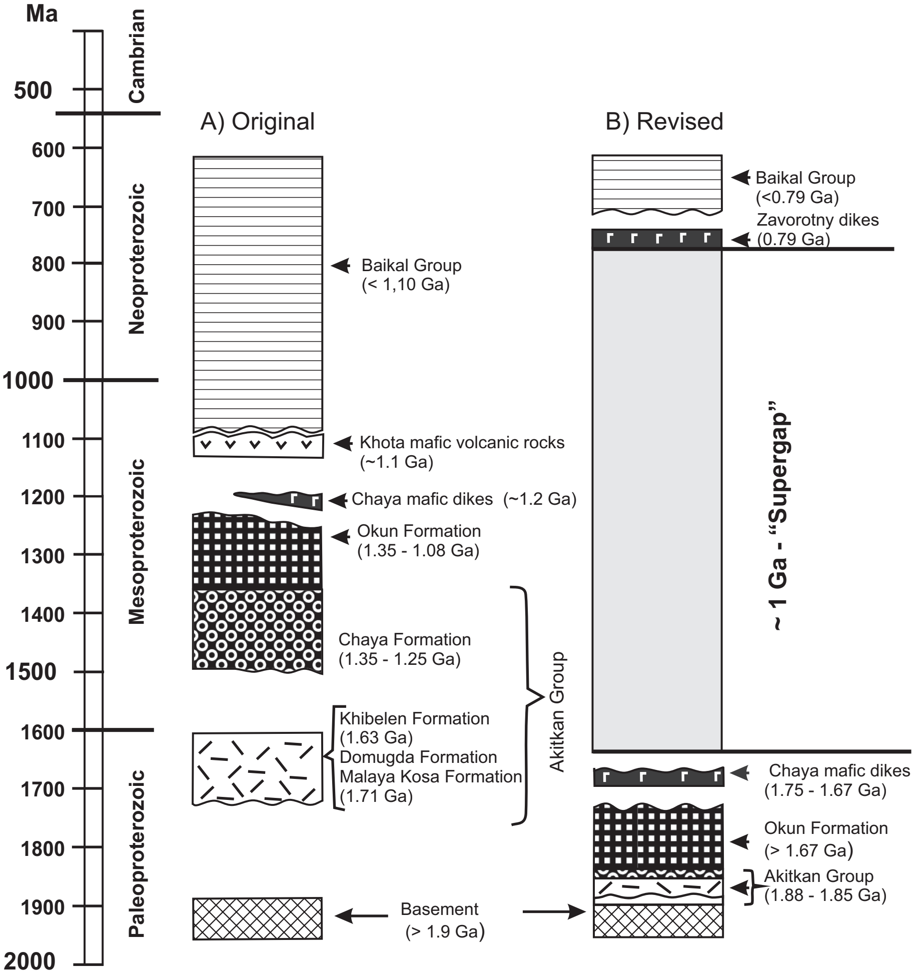

Fig. 2. Schematic stratigraphic sections for the Baikal Uplift showing original (A) and revised (B) chronostratigraphic assignments.

terozoic to Early Mesoproterozoic in age (Gerling, 1968; Yaschenko and others, 1972; Brandt and others, 1978; Sryvtsev, 1986). Ages of the lowest formations (Malaya Kosa, Domugda, Khibelen) were suggested to be 1.71 to 1.63 Ga (fig. 2A). Whole-rock Rb-Sr dates of 1350 ± 60, 1300 ± 33, and 1245 ± 45 Ma were reported for volcanic rocks of the overlying Chaya Formation (fig. 2A) and their subvolcanic equivalents (Sryvtsev, 1986). The uppermost Okun Formation of the Akitkan Group had been considered to be Mesoproterozoic—c. 1350 to 1080 Ma—based on K-Ar glauconite dates (Sryvtsev, 1986). The Okun Formation is cut by the previously undated dolerite Chaya dikes (fig. 2A), for which an age of 1200 to 1000 Ma was estimated (Sryvtsev, 1986). However, the recent study of Gladkochub and others (2007) showed that the Chaya swarm comprises at least two generations of dikes. One of the younger dikes was dated at 787 ± 21 Ma (^{40}Ar-^{39}Ar, plagioclase; Gladkochub and others, 2007). To distinguish between these two dike generations, we shall hereafter refer to the younger suite as the Zavorotny dikes, because the dated dike is located near the Zavorotny peninsula.

The enigmatic undated Khota mafic volcanic rocks were traditionally described as the lowermost strata of the Baikal Group (fig. 2A), but no direct contacts have been found. Consequently, these volcanic rocks have variously been considered to be Paleoproterozoic (Aleksandrov, 1990), mid-Riphean (Ryabykh and Ryabykh, 1979; Maslov, 1983; Maslov and Kichko, 1985), or late Riphean (Postnikov, 2001; Gladkochub and others, 2007; Stanevich and others, 2007). The unmetamorphosed sediments of the Baikal Group represent the topmost strata of the Precambrian stratigraphic section in the Baikal Uplift (fig. 2). Their age was estimated to be middle to late Riphean (~Ectasian to Cryogenian) based on geological and biostratigraphic data (Stanevich and Faizulina, 1992; Khomentovsky and others, 1998; Dolnik, 2000). According to the age suggested for the underlying Okun Formation, the Baikal Group should be younger than c. 1.1 Ga (fig. 2A).

New geochronological data for the volcanic rocks of the Akitkan Group, Khota volcanics, and gabbro and dolerite dikes of the Chaya suite, allow a reappraisal of this section (fig. 2B). Volcanic rocks of the Khibelen and Domugda Formations of the Akitkan Group have been dated at 1.88 to 1.85 Ga (U-Pb, zircon; Neymark and others, 1991; Larin and others, 2003; Donskaya and others, 2008). A new U-Pb zircon age for volcanic rocks, and nearly coeval sedimentary rocks, of the Chaya Formation of the Akitkan Group is 1863 ± 9 Ma (Donskaya and others, 2007). Deposition of volcanic and sedimentary rocks lasted for less than ten million years (Donskaya and others, 2007). These dates demonstrate that the Akitkan Group (including the Chaya Formation) is roughly coeval to the 1.86 to 1.84 Ga post-collisional granites (see above). Consequently the Akitkan Group belongs to the basement of the Siberian craton.

A U-Pb baddeleyite age of 1752 ± 3 Ma (Gladkochub and others, 2010) and a Sm-Nd mineral isochron age of the 1674 ± 29 Ma (Gladkochub and others, 2007) for the Chaya dolerite dikes that crosscut the Okun Formation (fig. 2), require the Okun Formation to be moved from the Mesoproterozoic (Riphean) part of the section to the Paleoproterozoic.

The 787 ± 21 Ma Zavorotny dikes (Gladkochub and others, 2007) are apparently coeval with the Nersa dolerite dikes in the Sayan Uplift (see below). We consider this age as an older limit for the Baikal Group, because sedimentary rocks of the Baikal Group are not crosscut by Zavorotny dikes anywhere in the Baikal region. The younger limit for the Baikal Group is considered to be Vendian (Sovetov and Komlev, 2005) or even late Vendian (Ediacaran) (Kuznetsov and others, 2003). Volcanic rocks included previously in the Riphean Khota Formation (fig. 2), have yielded an Early Permian U-Pb zircon age of 274 ± 3 Ma (Gladkochub and others, 2008a), and therefore must be regarded as a different subvolcanic complex. There are no known sedimentary successions that occur in the time interval between the emplacement of dikes of the Chaya suite at c. 1.67 Ga and the Nersa suite at c. 0.75 Ga. Furthermore, there are no indications of magmatic activity or metamorphism in this >0.9 Ga interval.

Sayan Uplift

New data suggest an even longer hiatus and absence of geological activity in the Sayan Uplift (fig. 3) compared to the Baikal Uplift.

Latest Paleoproterozoic and Mesoproterozoic sediments of the Kalbazyk Group, and of the Ingash and the Ermasokh formations, are found in the Urik–Iya Graben of the Sayan Uplift. Sediments of the Kalbazyk Group (fig. 3A) are traditionally regarded as latest Paleoproterozoic (Mitrofanov, 1987b), because they are crosscut by dikes of the Angaul suite, dated by Domishev (1976) at 1.6 ± 0.1 Ga (Rb-Sr whole-rock isochron). The undated Ermasokh formation has been considered as lower Riphean (early Mesoproterozoic). This formation is cut by the previously undated Chernoziminsk granites. The Ermasokh Formation is apparently overlain by the Ingash Formation (Mats and Taskin, 1973), although this was challenged by Sezko (1988) who

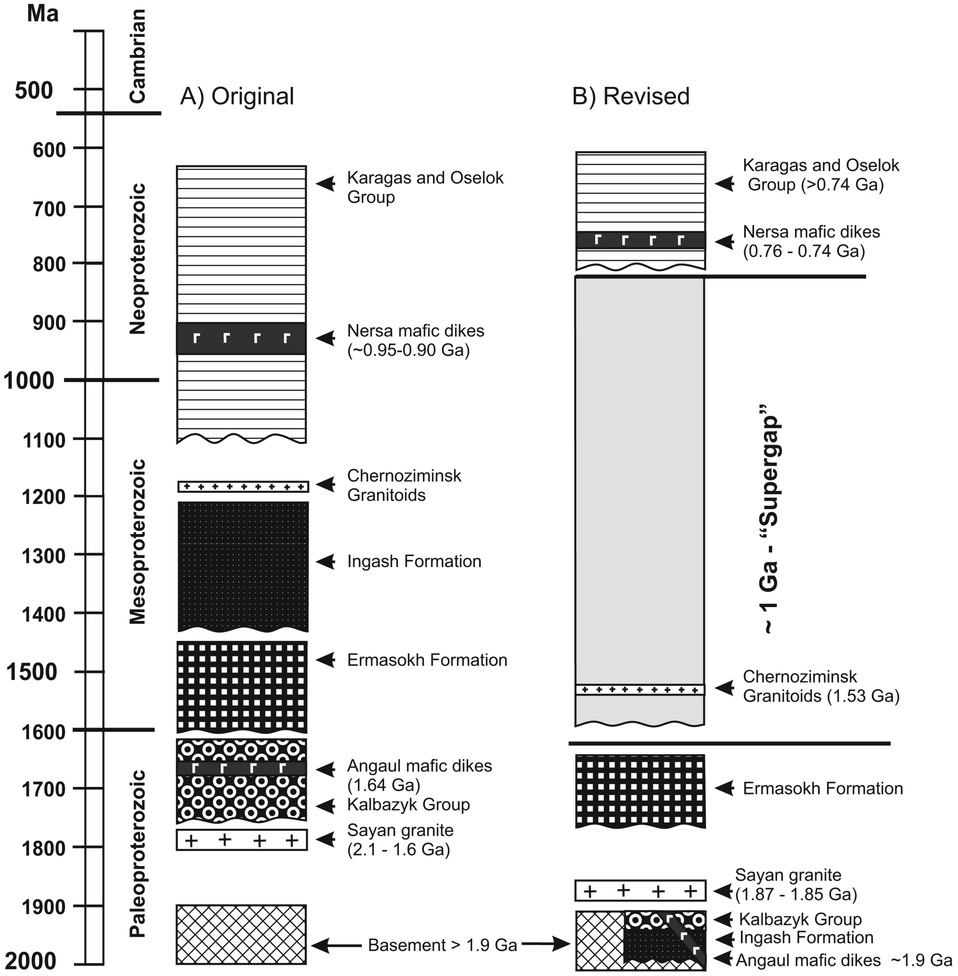

Fig. 3. Schematic stratigraphic sections for the Sayan Uplift showing original (A) and revised (B) chronostratigraphic assignments.

suggested an older age for the Ermasokh Formation. The Ingash Formation is intruded by post-collisional Sayan granites, initially suggested to be Neoproterozoic. However, Brintsev (1994) reported Pb-Pb isochron ages of 2.1 to 1.6 Ga for these granites. The age of the upper Karagas and Oselok Groups in the Sayan Uplift was traditionally considered to be Neoproterozoic (Sezko, 1988). Mafic dikes of the Nersa suite are ubiquitous in the Sayan uplift. Domishev (1976) suggested that their age is c. 0.95 to 0.90 Ga.

A SHRIMP U-Pb zircon age of 1904 ± 24 Ma for the amphibolitized dolerites of the Angaul suite (Gladkochub and others, 2008b) indicates that the Kalbazyk Group is older (>1.9 Ga) than latest Paleoproterozoic, as was suggested previously. The 1.87 to 1.85 Ga U-Pb zircon age of the post-collisional Sayan granites (Levitskii and others, 2002; Turkina and others, 2003, 2006; Didenko and others, 2005) places the Ingash Formation also into the Paleoproterozoic (fig. 3B). Consequently, the Kalbazyk Group and the Ingash Formation of the Urik-Iya Graben must be considered as parts of the basement of the Sayan Uplift (fig. 3B). The ^{40}Ar-^{39}Ar biotite age of c. 1.53 Ga for granites of the Chernoziminsk Complex (Gladkochub and others, 2002) provides a younger limit for the Ermasokh Formation, and an older limit is provided by the c. 1.85 Ga age of the post-collisional Sayan granites. Granites of the Chernoziminsk Complex are represented by a few small veins and could not be interpreted as a significant igneous event within the studied area.

Mafic dikes of the Nersa suite were recently re-dated at c. 0.75 Ga (Sklyarov and others, 2003; Gladkochub and others, 2006b). The dikes intrude metamorphic basement rocks (>1.87 Ga), post-collisional granites (1.87-1.85 Ga), and the lowest strata of the Karagas Group, but do not cut the upper Karagas Group, which therefore must be younger than 0.75 Ga. Sovetov and Komlev (2005) suggested a Vendian (late Cryogenian-Ediacaran) age for the overlying Oselok Group based on global correlation of stable isotope (δ^{13}C) data and the presence of glacial deposits in the lower part of the group.

These new data suggest geological tranquility in the Irkut-Kitoy and Biryusa terranes of the Sayan Uplift for 1.1 billion years, between 1.85 and 0.75 Ga (fig. 3B). In the Urik-Iya terrane, this quiescence also lasted for at least 0.8 billion years. Some sedimentary successions in the Biryusa and Sharyzhalgai blocks apparently contain even longer hiatuses. In summary, available geochronological data suggest a c. 1 Ga gap in geological activity in the southern Siberian craton, and require a major revision of the models for its Precambrian evolution.

DISCUSSION

The absence of evidence for magmatism, metamorphism, and tectonism in the southern Siberian craton over about one billion years might reflect a location of this region within a large long-lived supercontinent. Southern Siberia occupied a stable intracontinental position since c. 1.85 Ga, following final assembly of the Paleoproterozoic supercontinent Nuna. The onset of Neoproterozoic rifting in this region coincided with beginning of the breakup of Rodinia (Li and others, 2008).

Plagioclase ^{40}Ar-^{39}Ar ages of c. 780 to 740 Ma for Neoproterozoic mafic dikes in southern Siberia are slightly older than the c. 723 Ma Franklin intrusions of northern Laurentia (Heaman and others, 1992) and similar in age to the 780 Ma Gunbarrel dikes in northwestern Laurentia (Park and others, 1995; Harlan and others, 2003). Thus, new data from southern Siberia support the existence of a Transproterozoic supercontinent, a fragment of Nuna that comprised at least Siberia and Laurentia (Gladkochub and others, 2004, 2008b), and was transformed into Rodinia before dispersing in the late Neoproterozoic.

Paleomagnetic data suggest that Siberia and Laurentia-Greenland could have been parts of a larger continent between c. 1.0 to 0.7 Ga (for example Gallet and others, 2000; Pavlov and others, 2000, 2002; Yarmolyuk and Kovalenko, 2001; Metelkin and others, 2005, 2007; Gladkochub and others, 2006; Li and others, 2008). Pisarevsky and Natapov (2003) tested various published Siberia-Laurentia reconstructions (Hoffman, 1991; Condie and Rosen, 1994; Frost and others, 1998; Rainbird and others, 1998; Sears and Price, 2000) with available paleomagnetic data and found that the best fit between these two continents with the southern margin of Siberia facing the northern margin of Laurentia (fig. 4) requires the presence of some additional continent, or microcontinents, between them (for example, northern Alaska, Chukchi Peninsula). These terranes would have been juxtaposed against northern Laurentia prior to the c. 125 Ma opening of the Canadian Basin (for example Zonenshain and others, 1990; Embry, 1998; Natal'in, 2004; Drachev, 2004). Gladkochub and others (2006a, 2006b) slightly modified the Pisarevsky and Natapov (2003) reconstruction using a comparison of mafic igneous complexes in two cratons. Recent paleomagnetic data from the 1473 ± 24 Ma mafic

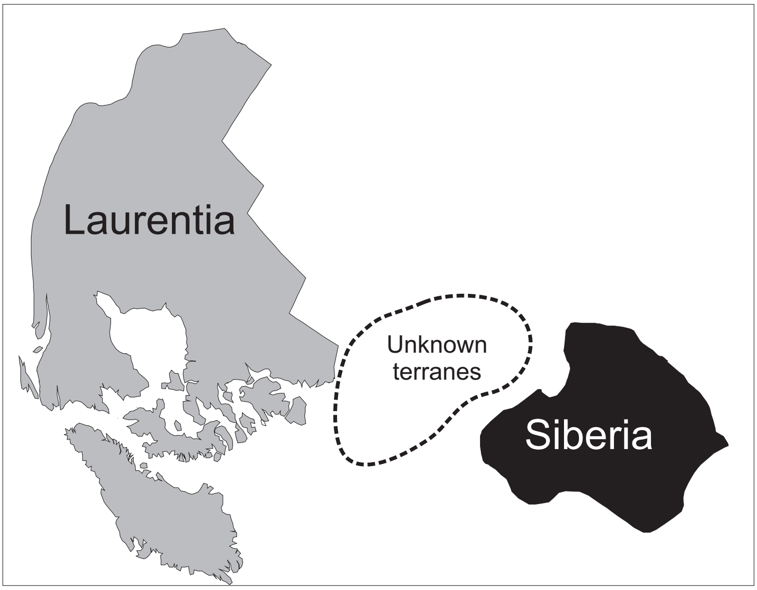

Fig. 4. Mesoproterozoic reconstruction of Siberia and Laurentia after Pisarevsky and Natapov (2003) and Wingate and others (2009). Siberia is rotated to Laurentia about an Euler pole (+anticlockwise) at 65.0°N, 144.0°E, +141.8°. Laurentia is shown in its c. 1470 Ma position rotated to the absolute framework at 0°, 129°E, +103.2°.

intrusions of the Olenek Uplift (Wingate and others, 2009) together with other available Siberian and Laurentian paleopoles (Ernst and others, 2000; Meert and Suckey, 2002; Veselovsky and others, 2006; see also the summary of Pesonen and others, 2003 and Pisarevsky and Bylund, 2010) allow a similar reconstruction of Siberia and Laurentia to have existed as far back as the early Mesoproterozoic. Hence, if Laurentia and Siberia were connected at the end of the Mesoproterozoic, this connection should have existed since at least 1.5 Ga. A similar reconstruction was published by Veselovsky and others (2006). Didenko and others (2009) reported new paleomagnetic data from 1.87 Ga rocks of the Akitkan Group (see above) and concluded that a late Paleoproterozoic Laurentia–Siberia reconstruction is different for that time. Therefore, the assembly of Nuna would appear to have occurred between 1.87 and 1.50 Ga. The abovementioned 1.86 to 1.84 Ga post-collisional granites suggest that southern Siberia collided with some continent or terranes, to result in the Sayan and Baikal uplifts. Pisarevsky and Natapov (2003) suggested that these could be the terranes of present Arctica (Chuckotka, northern Alaska, and others), although this is yet to be established.

Thus, paleomagnetic data suggest that the southern margin of Siberia faced the northern margin of Laurentia, since the late Paleoproterozoic–Mesoproterozoic assembly of Nuna until the late Neoproterozoic breakup of Rodinia and opening of the Paleo-Asian Ocean (Khain and others, 2003). The duration of this interval is close to one billion years and fits with the duration of the apparent gap in geological activity in southern Siberia. We suggest that Siberia and Laurentia, together with interstitial terranes, formed a rigid continental block—a large fragment of Nuna. Evidence also suggests (see references in Salminen and Pesonen, 2007; Pisarevsky and Bylund, 2010), that Baltica also was a part of this same block until c. 1.27 Ga.

The absence of Mesoproterozoic sediments in southern Siberia could be explained by their removal by erosion and transportation from the marginal Sayan and Baikal uplands to adjacent basins.

CONCLUSIONS

A synthesis of geochronological data appears to substantiate the existence of a gap of about one billion years in geological activity and sedimentation in the southern Siberian craton. The prolonged (~1 Ga) absence of significant geological events in the region might be caused by location of the southern margin of the Siberian craton in the internal part of the Transproterozoic supercontinent. According to Gladkochub and others (2004, 2008b), this long-lived (c. 1.8-0.7 Ga) amalgamation of two ancient cratons formed a fragment of Nuna that persisted through the entire Mesoproterozoic and broke apart only in the late Neoproterozoic, during opening of the Paleo-Asian Ocean.

The gap in geological activity is about 1.1 to 1.2 Ga in the Irkut-Kitoy and Biryusa terranes (Sayan Uplift), at least 0.9 Ga in the Baikal Uplift, and at least 0.8 Ga in the Urik-Iya terrane. The absence of sedimentary sequences of Mesoproterozoic to early Neoproterozoic age could be explained by intense erosion of this high-standing region, which represented a high orogenic (mountain) belt since the Paleoproterozoic (~1.9 Ga).

ACKNOWLEDGMENTS

The authors have greatly enjoyed working with Alfred Kröner and are honored to contribute to this special issue in honor of his 70th birthday. We are grateful to Peter Cawood, Lev Natapov, and Andrey Khudoley for their reviews. This work was supported by the Russian Foundation for Basic Research (projects no. 08-05-00245; 09-05-01005), the Siberian Branch of the Russian Academy of Sciences (ONZ-10), and the Ministry of Education and Science of the Russian Foundation (RNP.2.2.1.1.7334 (REC"Baikal") and GK-02.740.11.0446). M. T. D. Wingate publishes with permission of the Executive Director of the Geological Survey of Western Australia.

References

Aftalion, M., Bibikova, E. V., Bowes, D. R., Hopwood, A. M., and Perchuk, L. L., 1991, Timing of Early Proterozoic collisional and extensional events in the granulite-gneiss-charnokite-granite complex, lake Baikal, USSR: A U-Pb, Rb-Sr and Sm-Nd isotopic study: The Journal of Geology, v. 99, p. 851–861, doi: 10.1086/629556.

Aleksandrov, V. K., 1990, Thrusts and Thrust Structures in the Baikal Area: Novosibirsk, Nauka, 202 p. (in Russian).

Brandt, S. B., Bukharov, A. A., Raklinskii, E. I., and Perminov, A. V., 1978, On the absolute age of the magmatic complexes of the Baikal and Primorskii ranges (Western Transbaikalia): Sovetskaya Geologia, No. 3, p. 142–148 (in Russian).

Brintsev, V. V., 1994, Precambrian granitoids of north-western Sayan Ridge: Novosibirsk, Nauka, 184 p. (in Russian).

Bukharov, A. A., 1987, Activated zones of ancient platforms: Novosibirsk, Nauka, 201 p. (in Russian).

Cawood, P. A., and Korsch, R. J., 2008, Assembling Australia: Proterozoic building of a continent: Precambrian Research, v. 166, p. 1–35, doi: 10.1016/j.precamres.2008.08.006.

Condie, K. C., 2000, Episodic continental growth models: afterthoughts and extensions: Tectonophysics, v. 322, p. 153–162, doi: 10.1016/S0040-1951(00)00061-5.

——— 2002, Breakup of a Paleoproterozoic supercontinent: Gondwana Research, v. 5(1), p. 41–43, doi: 10.1016/S1342-937X(05)70886-8.

Condie, K. C., and Rosen, O. M., 1994, Laurentia-Siberia connection revisited: Geology, v. 22, p. 168–170, doi: 10.1130/0091-7613(1994)022⟨0168:LSCR⟩2.3.CO;2.

Didenko, A. N., Vodovozov, V. Yu., Kozakov, I. K., and Bibikova, E. V., 2005, Paleomagnetic and geochronological study of post-collisional Early Proterozoic granitoids in the Southern Siberian platform: methodological and geodynamic aspects: Izvestiya, Physics of the Solid Earth, v. 41, p. 156–172.

Didenko, A. N., Vodovozov, V. Yu., Pisarevsky, S. A., Gladkochub, D. P., Donskaya, T. V., Mazukabzov, A. M., Stanevich, A. M., Bibikova, E. V., and Kirnozova, T. I., 2009, Palaeomagnetism and U-Pb dates of the Palaeoproterozoic Akitkan Group (South Siberia) and implications for pre-Neoproterozoic tectonics, *in* Reddy, S. M., Mazumder, R., Evans, D. A. D., and Collins, A. S., editors, Palaeoproterozoic Supercontinents and Global Evolution: Geological Society, London, Special Publications, v. 323, p. 145–163, doi: 10.1144/SP323.7.

Dolnik, T. A., 2000, Stromatolites and micro-phytolites in Riphean and Vendian stratigraphy of the folded periphery of the southern Siberian craton: Novosibirsk, GEO, Izd. SO RAN (in Russian).

Domyshev, V. G., 1976, Riphean basites of the Baikal-Sayan-Yenisei margin of the Siberian platform: Novosibirsk, Nauka, 157 p. (in Russian).

Donskaya, T. V., Sklyarov, E. V., Gladkochub, D. P., Mazukabzov, A. M., Salnikova, E. B., Kovach, V. P., Yakovleva, S. Z., and Berezhnaya, N. G., 2000, The Baikal collisional metamorphic belt: Doklady Earth Sciences, v. 374, p. 1075–1079.

Donskaya, T. V., Sal'nikova, E. B., Sklyarov, E. V., Gladkochub, D. P., Mazukabzov, A. M., Kovach, V. P., Yakovleva, S. Z., and Berezhnaya, N. G., 2002, Early Proterozoic Postcollision Magmatism at the Southern Flank of the Siberian Craton: New Geochronological Data and Geodynamic Implications: Doklady Earth Sciences, v. 383(2), p. 125–129.

Donskaya, T. V., Bibikova, E. V., Mazukabzov, A. M., Gladkochub, D. P., Kozakov, I. K., Kirnozova, T. I., Plotkina, J. V., and Reznitskiy, L. Z., 2003, Granitoids of the Primorsky complex of the Western Baikal area: geochronology and geodynamic typification: Russian Geology and Geophysics, v. 44(10), p. 968–980.

Donskaya, T. V., Mazukabzov, A. M., Bibikova, E. V., Gladkochub, D. P., Didenko, A. N., Kirnozova, T. I., Vodovozov, V. Yu., and Stanevich, A. M., 2007, Stratotype of the Chaya Formation of the Akitkan Group in the North Baikal volcanoplutonic belt: age and time of sedimentation: Russian Geology and Geophysics, v. 48(11), p. 707–710.

Donskaya, T. V., Bibikova, E. V., Gradkochub, D. P., Mazukabzov, A. M., Bayanova, T. B., De Waele, B., Didenko, A. N., Bukharov, A. A., Kirnozova, T. I., 2008, Petrogenesis and age of the felsic volcanic rocks from the North Baikal volcanoplutonic belt, Siberian craton: Petrology, v. 16, p. 422–447, doi: 10.1134/S0869591108050020.

Drachev, S. S., 2004, Siberian Arctic continental margin: constraints and uncertainities of plate tectonic model: AGU Fall Meeting Supplements, Abstract GP43C-07.

Embry, A. F., 1998, Counterclockwise rotation of the Arctic Alaska plate: best available model or untenable hypothesis for the opening of the Amerasia Basin: Polarforschung, v. 68, p. 247–255.

Ernst, R. E., Buchan, K. L., Hamilton, M. A., Okrugin, A. V., and Tomshin, M. D., 2000, Integrated paleomagnetism and U-Pb geochronology of mafic dikes of the Eastern Anabar shield region, Siberia: Implications for Mesoproterozoic paleolatitude of Siberia and comparison with Laurentia: The Journal of Geology, v. 108, p. 381–401, doi: 10.1086/314413.

Frost, B. R., Avchenko, O. V., Chamberlain, K. R., and Frost, C. D., 1998, Evidence for extensive Proterozoic remobilization of the Aldan Shield and implications for Proterozoic plate tectonic reconstructions of Siberia and Laurentia: Precambrian Research, v. 89, p. 1–23, doi: 10.1016/S0301-9268(97)00074-0.

Gallet, Y., Pavlov, V. E., Semikhatov, M. A., and Petrov, P. Yu., 2000, Late Mesoproterozoic magnitostratigraphic results from Siberia: Paleogeographuc implications and magnetic field behavior: Journal of Geophysical Research, v. 105, B7, p. 16481–16499, doi: 10.1029/1999JB900354.

Gerling, E. K., editor, 1968, Precambrian geochronology of the Siberian platform and its folded surrounding: Leningrad, Nauka, 333 p. (in Russian).

Gladkochub, D. P., Sklyarov, E. V., Men'shagin, Yu. V., and Mazukabzov, A. M., 2001a, Geochemistry of Ancient Ophiolites of the Sharyzhalgai Uplift: Geochemical International, v. 39(10), p. 947–959.

Gladkochub, D. P., Sklyarov, E. V., Donskaya, T. V., Mazukabzov, A. M., Menshagin, Yu. V., and Panteeva, S. V., 2001b, Petrology of Gabbro-Dolerites from Neoproterozoic Dike Swarms in the Sharyzhalgai Block with Reference to the Problem of Breakup of the Rodinia Supercontinent: Petrology, v. 9(6), p. 560–577.

Gladkochub, D. P., Donskaya, T. V., Mazukabzov, A. M., Sklyarov, E. V., Ponomarchuk, V. A., and Stanevich, A. M., 2002, The Urik-Iya Graben of the Sayan Inlier of the Siberian Craton: New Geochronological Data and Geodynamic Implications: Doklady Earth Sciences, v. 386(7), p. 737–741.

Gladkochub, D., Sklyarov, E., Pisarevsky, S., Donskaya, T., Mazukabzov, A., 2004, The Siberian craton and its evolution in Rodinia: 32nd International Geological Congress, Abstract volume, pt. 2. Abstract 188-5, p. 869.

Gladkochub, D. P., Pisarevsky, S. A., Donskaya, T. V., Natapov, L. M., Mazukabzov, A. M., Stanevich, A. M., and Sklyarov, E. V, 2006a, Siberian Craton and its evolution in terms of Rodinia hypothesis: Episodes, v. 29(3), p. 169–174.

Gladkochub, D. P., Wingate, M. T. D., Pisarevsky, S. A., Donskaya, T. V., Mazukabzov, A. M., Ponomarchuk, V. A., and Stanevich, A. M., 2006b, Mafic intrusions in southwestern Siberia and implications for a Neoproterozoic connection with Laurentia: Precambrian Research, v. 147(3-4), p. 260–278, doi: 10.1016/j.precamres.2006.01.018.

Gladkochub, D. P., Donskaya, T. V., Mazukabzov, A. M., Stanevich, A. M., Sklyarov, E. V., and Ponomarchuk, V. A., 2007, Signature of Precambrian extension events in the southern Siberian craton: Russian Geology and Geophysics, v. 48(1), p. 17–41, doi: 10.1016/j.rgg.2006.12.001.

Gladkochub, D. P., Mazukabzov, A. M., Donskaya, T. V., De Waele, B., Stanevich, A. M., and Pisarevsky, S. A., 2008a, The age and origin of volcanics in the Riphean section of the Siberian craton (*western Baikal area*): Russian Geology and Geophysics, v. 49(10), p. 749–758, doi: 10.1016/j.rgg.2008.03.002.

Gladkochub, D. P., Sklyarov, E. V., Donskaya, T. V., Stanevich, A. M., and Mazukabzov, A. M., 2008b, A Period of Global Uncertainty (Blank Spot) in the Precambrian History of the Southern Siberian Craton and the Problem of the Transproterozoic Supercontinent: Doklady Earth Sciences, v. 421(2), p. 224–229.

Gladkochub, D. P., Pisarevsky, S. A., Donskaya, T. V., Ernst, R. E., Wingate, M. T. D., Söderlund, U., Mazukabzov, A. M., Sklyarov, E. V., Hamilton, M. A., and Hanes, J. A, 2010, Proterozoic mafic magmatism in Siberia: an overview and implications for paleocontinental reconstruction: Precambrian Research, v. 183, p. 660–668, doi: 10.1016/j.precamres.2010.02.023.

Harlan, S. S., Heaman, L., LeCheminant, A. N., and Premo, W. R., 2003, Gunbarrel mafic magmatic event: a key 780 Ma time marker for Rodinia plate reconstructions: Geology, v. 31, p. 1053–1056, doi: 10.1130/G19944.1.

Heaman, L. M., LeCheminant, A. N., and Rainbird, R. H., 1992, Nature and timing of Franklin igneous events, Canada: Implications for a Late Proterozoic mantle plume and the breakup of Laurentia: Earth and Planetary Science Letters, v. 109, p. 117–131, doi: 10.1016/0012-821X(92)90078-A.

Hoffman, P. F., 1991, Did the breakout of Laurentia turn Gondwanaland inside-out?: Science, v. 252, p. 1409–1412, doi: 10.1126/science.252.5011.1409.

——— 1997, Tectonic genealogy of North America, *in* Van der Pluijm, B. A., and Marshak, S., editors: Earth Structure, an Introduction to Structural Geology and Tectonics: New York, McGraw Hill, p. 459–464.

Hou, G., Santosh, M., Qian, X., Lister, G. S., and Li, J., 2008, Configuration of the Late Paleoproterozoic supercontinent Columbia: Insights from radiating mafic dyke swarms: Gondwana Research, v. 14, p. 395–409, doi: 10.1016/j.gr.2008.01.010.

Khain, E. V., Bibikova, E. V., Salnikova, E. B., Kröner, A., Gibsher, A. S., Didenko, A. N., Degtyarev, K. E., and Fedotova, A. A., 2003, The Palaeo-Asian ocean in the Neoproterozoic and early Palaeozoic: new geochronologic data and palaeotectonic reconstructions: Precambrian Research, v. 122, p. 329–358, doi: 10.1016/S0301-9268(02)00218-8.

Khiltova, V. Ya., Berkovskiy, A. N., Kozakov, I. K., Didenko, A. N., and Kovach, V. P., 2003, The main structural domains of the Siberian platform basement: geological, geophysical, geochronological and isotope geochemistry data, *in* Karyakin, Yu. V., editor, Tectonic and Geodynamics of the Continental Lithosphere, v. 2: Moscow, GEOS, p. 276–279.

Khomentovsky, V. V., Postnikov, A. A., and Faizullin, M. Sh., 1998, The Baikalian in the type locality: Russian Geology and Geophysics, v. 39(11), p. 1505–1516.

Kuzmichev, A. B., Bibikova, E. V., and Zhuravlev, D. Z., 2001, Neoproterozoic (∼800 Ma) orogeny in the Tuva-Mongolia Massif (Siberia): island arc–continent collision at the northeast Rodinia margin: Precambrian Research, v. 110, p. 109–126, doi: 10.1016/S0301-9268(01)00183-8.

Kuznetsov, A. B., Anisimova, S. A., Melnikov, N. N., Geletii, N. K., Dolnik, T. A., and Letnikova, E. F., 2003, Isotope chemostratigraphy of the Baikal Group in the Southwestern Baikal region: Preliminary data, *in* Isotope dating for geodynamics and metallogeny, Proceedings 2nd Russian Workshop on Isotope geochronology: St. Petersburg, Tsentr Informatsionnoi Kultury, p. 233–236 (in Russian).

Larin, A. M., Kotov, A. B., Sal'nikova, E. B., Kovach, V. P., Makar'ev, L. B., Timashkov, A. N., Berezhnaya, N. G., and Yakovleva, S. Z., 2000, New data on the age of granites of the Kodar and Tukuringra complexes, Eastern Siberia: geodynamic constraints: Petrology, v. 8, p. 238–248.

Larin, A. M., Sal'nikova, E. B., Kotov, A. B., Kovalenko, V. I., Rytsk, E. Yu., Yakovleva, S. Z., Berezhnaya, N. G., Kovach, V. P., Buldygerov, V. V., and Sryvtsev, N. A., 2003, The North Baikal volcanoplutonic belt: age, formation duration, and tectonic setting: Doklady Earth Sciences, v. 392 (7), p. 963–967.

Larin, A. M., Sal'nikova, E. B., Kotov, A. B., Makar'ev, L. B., Yakovleva, S. Z., and Kovach, V. P., 2006, Early Proterozoic syn- and postcollision granites in the northern part of the Baikal fold area: Stratigraphy and Geological Correlation, v. 14, p. 463–474, doi: 10.1134/S0869593806050017.

Levitskii, V. I., Mel'nikov, A. I., Reznitskii, L. Z., Bibikova, E. V., Kirnozova, T. I., Kozakov, I. K., Makarov,V. A., and Plotkina, Yu. V., 2002, Early Proterozoic postcollisional granitoids in southwestern Siberian craton: Russian Geology and Geophysics, v. 43, p. 679–692.

Li, Z. X., Bogdanova, S. V., Collins, F. S., Davidson, A., De Waele, B., Ernst, R. E., Fitzsimons, I. C. W., Gladkochub, D. P., Jacobs, J., Karlstrom, K. E., Lu, S., Natapov, L. M., Pease, V., Pisarevsky, S. A., Thrane, K., and Vernikovsky, V., 2008, Assembly, configuration, and break-up history of Rodinia: a synthesis: Precambrian Research, v. 160, p. 179–210, doi: 10.1016/j.precamres.2007.04.021.

Maslov, V. K., 1983, Interruptions in sedimentation and correlation of cross sections of Middle-Upper Riphean in the Western Baikal area: Geologiya i Geofizika (Soviet Geology and Geophysics), 24 (7), 30–41 (26-36) (in Russian).

Maslov, V. K., and Kichko, A. I., 1985, Ore zoning in Middle-Upper Riphean deposits of the western and northwestern Baikal areas: Litologiya i Poleznye Iskopaemye, v. 6, p. 83–96 (in Russian).

Mats, V. D., and Taskin, A. P., 1973, Proterozoic stratigraphy of Sayan region and western part of Baikal mountain area: Geologiya i Geofizika (Soviet Geology and Geophysics), v. 7, p. 26–36 (in Russian).

Meert, J. G., 2002, Paleomagnetic evidence for a Paleo-Mesoproterozoic Supercontinent Columbia: Gondwana Research, v. 5, p. 207–215, doi: 10.1016/S1342-937X(05)70904-7.

Meert, J. G., and Stuckey, W., 2002, Revisiting the paleomagnetism of the 1.476 Ga St. Francois Mountains igneous province, Missouri: Tectonics, v. 21, 1007, doi: 10.1029/2000TC001265.

Metelkin, D. V., Belonosov, I. V., Gladkochub, D. P., Donskaya, T. V., Mazukabzov, A. M., and Stanevich, A. M., 2005, Paleomagnetic directions from Nersa intrusions of the Biryusa terrane, Siberian craton, as a reflection of tectonic events in the Neoproterozoic: Russian Geology and Geophysics, v. 46 (4), p. 398–413.

Metelkin, D. V., Vernikovsky, V. A., Kazansky, A. Yu., 2007, Neoproterozoic evolution of Rodinia: constraints from new paleomagnetic data on the western margin of the Siberian craton: Russian Geology and Geophysics, v. 48, p. 32–45, doi: 10.1016/j.rgg.2006.12.004.

Mitrofanov, G. L., 1987a, Tectonics of the Southern Siberia: explanation of the Tectonic map of southern part of the Eastern Siberia (scale 1:1500000): Irkutsk: SNIIGGiMS, 104 p. (in Russian).

——— editor, 1987b, Stratigraphic and paleontological data for the legends of geological maps of the Eastern Siberia (scale 1:50000): Irkutsk: SNIIGGiMS, 172 p. (in Russian).

Natal'in, B. A., 2004, Phanerozoic tectonic evolution of the Chukotka-Arctic block: problems of the rotational model: AGU Fall Meeting Supplements, Abstract GP43C-04.

Neymark, L. A., Larin, A. M., Yakovleva, S. Z., Sryvtsev, N. A., and Buldygerov, V. V., 1991, New age data on the rocks of the Akitkan Group, Baikal-Patom fold area: results of U-Pb zircon dating: Doklady Akademii Nauk SSSR, v. 320 (1), p. 182–186 (in Russian).

Nozhkin, A. D., Bibikova, E. V., Turkina, O. M., and Ponomarchuk,V. A., 2003, U-Pb, Ar-Ar, and Sm-Nd isotope-geochronological study of porphyritic subalkalic granites of the Taraka pluton (Yenisei Range): Russian Geology and Geophysics, v. 44, p. 842–852.

Park, J. K., Buchan, K. L., and Harlan, S. S., 1995, A proposed giant radiating dyke swarm fragmented by the separation of Laurentia and Australia based on paleomagnetism of ca. 780 Ma mafic intrusions in western North America: Earth and Planetary Science Letters, v. 132, p. 129–139, doi: 10.1016/0012-821X(95)00059-L.

Pavlov, V. E., Gallet, Y., and Shatsillo, A. V., 2000, Paleomagnetism of the upper Riphean Lakhanda Group of the Uchur-Maya area and the hypothesis of the late Proterozoic supercontinent: Fizika Zemli, v. 8, p. 23–34 (in Russian).

Pavlov, V. E., Gallet, Y., Petrov, P. Yu., Zhuravlev, D. Z., and Shatsillo, A. V., 2002, Uy series and late Riphean sills of the Uchur-Maya area: isotopic and palaeomagnetic data and the problem of the Rodinia supercontinent: Geotectonics, v. 36, p. 278–292.

Pesonen, L. J., Elming, S.-A., Mertanen, S., Pisarevsky, S. A., D'Agrella-Filho, M. S., Meert, J. G., Schmidt, P. W., Abrahamsen, N., and Bylund, G., 2003, Paleomagnetic configuration of continents during the Proterozoic: Tectonophysics, v. 375, p. 289–324, doi: 10.1016/S0040-1951(03)00343-3.

Pisarevsky, S. A., and Bylund, G., 2010, Paleomagnetism of 1780–1770 Ma mafic and composite intrusions of Småland (Sweden): implications for the Mesoproterozoic Supercontinent: American Journal of Science, v. 310 p. 1168–1186, doi:10.2475/09.2015.15.

Pisarevsky, S. A., and Natapov, L. M., 2003, Siberia and Rodinia: Tectonophysics, v. 375, p. 221–245, doi: 10.1016/j.tecto.2003.06.001.

Pisarevsky, S. A., Natapov, L. M., Donskaya, T. V., Gladkochub, D. P., and Vernikovsky, V. A., 2008, Proterozoic Siberia: a giant promontory of Rodinia: Precambrian Research, v. 160, p. 66–76, doi: 10.1016/j.precamres.2007.04.016.

Poller, U., Gladkochub, D. P., Donskaya, T. V., Mazukabzov, A. M., Sklyarov, E. V., and Todt, W., 2004, Timing of Early Proterozoic magmatism along the Southern margin of the Siberian craton (Kitoy area): Transactions of the Royal Society Edinburgh: Earth Sciences, v. 95, p. 215–225, doi: 10.1017/S0263593300001024.

Poller, U., Gladkochub, D. P., Donskaya, T. V., Mazukabzov, A. M., Sklyarov, E. V., and Todt, W., 2005, Multistage magmatic and metamorphic evolution in the Southern Siberian Craton: Archean and Paleoproterozoic zircon ages revealed by SHRIMP and TIMS: Precambrian Research, v. 136(3-4), p. 353–368, doi: 10.1016/j.precamres.2004.12.003.

Postnikov, A. A., 2001, The history of evolution of the Baikal-Vilyui basin in the Late Precambrian: *in* Supercontinents in the Precambrian Geologic Evolution: Irkutsk, IZK SO RAN, p. 208–212 (in Russian).

Rainbird, R. H., Stern, R. A., Khudoley, A. K., Kropachev, A. P., Heaman, L. M., and Sukhorukov, V. I., 1998, U-Pb geochronology of Riphean sandstone and gabbro from southeast Siberia and its bearing on the Laurentia-Siberia connection: Earth and Planetary Science Letters, v. 164, p. 409–420, doi: 10.1016/S0012-821X(98)00222-2.

Rogers, J. J. W., 1996, A History of Continents in the past Three Billion Years: Journal of Geology, v. 104, p. 91–107, doi: 10.1086/629803.

Rogers, J. J. W., and Santosh, M., 2002, Configuration of Columbia, a Mesoproterozoic supercontinent: Gondwana Research, v. 5(1), p. 5–22, doi: 10.1016/S1342-937X(05)70883-2.

——— 2004, Continents and Supercontinents: New York, Oxford University Press, 289 p.

——— 2009, Tectonics and surface effects of the supercontinent Columbia: Gondwana Research, v. 15, p. 373–380, doi: 10.1016/j.gr.2008.06.008.

Rosen, O. M., 2003, Siberian craton: tectonic zonation and evolution stages: Geotectonics, v. 37(3), p. 175–192.

Rosen, O. M., Condie, K. C., Natapov, L. M., and Nozhkin, A. D., 1994, Archean and Early Proterozoic evolution of the Siberian craton: A preliminary assessment: *in* Condie K. C., editor, Archean Crustal Evolution: Amsterdam, Elsevier, Developments in Precambrian Geology, v. 11, p. 411–459.

Ryabykh, A. M., and Ryabykh, E. M., 1979, Precambrian subvolcanic structures in the central part of the western Baikal area, *in* Precambrian subvolcanic structures of the Baikal area: Novosibirsk, Nauka, p. 55–59 (in Russian).

Salminen, J., and Pesonen, L. J., 2007, Paleomagnetic and rock magnetic study of the Mesoproterozoic sill, Valaam island, Russian Karelia: Precambrian Research, v. 159, p. 212–230, doi: 10.1016/j.precamres.2007.06.009.

Sears, J. W., and Price, R. A., 2000, New look at the Siberian connection: no SWEAT: Geology, v. 28, p. 423–426, doi: 10.1130/0091-7613(2000)28⟨423:NLATSC⟩2.0.CO;2.

Sears, J. W., St. George, G. M., Winne, J. C., 2005, Continental rift systems and anorogenic magmatism: Lithos, v. 80(1-4), p. 147–154, doi: 10.1016/j.lithos.2004.05.009.

Sezko, A. I., 1988, Main stages of the origin of continental crust in the Baikal area, *in* The evolution of Earth's crust in Precambrian and Paleozoic: Novosibirsk, Nauka, p. 7–41 (in Russian).

Sklyarov, E. V., Gladkochub, D. P., Mazukabzov, A. M., Menshagin, Yu. V., Watanabe, T., and Pisarevsky, S. A., 2003, Neoproterozoic mafic dike swarms of the Sharyzhalgai metamorphic massif (southern Siberian craton): Precambrian Research, v. 122(1-4), p. 359–377, doi: 10.1016/S0301-9268(02)00219-X.

Smelov, A. P., and Timofeev, V. F., 2003, Terrane analysis and geodynamic model of the formation of the North Asian craton in the Early Precambrian: Pacific Geology, v. 22 (6), p. 42–54.

Sovetov, Yu. K., and Komlev, D. A., 2005, Tillites at the base of the Oselok Group, foothills of the Sayan mountains, and the Vendian lower boundary in the Southwestern Siberian platform: Stratigraphy and Geological Correlation, v. 13, p. 337–366.

Sryvtsev, N. A., 1986, Structure and geochronometry of the Akitkan Group of the Western Baikal area, *in* Grabkin, O. V., editor, Problems of stratigraphy of the Early Precambrian of Central Siberia: Moscow, Nauka, p. 50–61 (in Russian).

Stanevich, A. M., and Faizulina, Z. H., 1992, Microfossils in the Late Precambrian stratigraphy of the Baikal-Patom folded area: Moscow, Nedra (in Russian).

Stanevich, A. M., Mazukabzov, A. M., Postnikov, A. A., Nemerov, V. K., Pisarevsky, S. A., Gladkochub, D. P., Donskaya, T. V., and Kornilova, T. A., 2007, Northern segment of the Paleoasian Ocean: Neoproterozoic deposition history and geodynamics: Russian Geology and Geophysics, v. 48 (1), 46–60, doi: 10.1016/j.rgg.2006.12.005.

Turkina, O. M., Bibikova, E. V., and Nozhkin, A. D., 2003, Stages and geodynamic settings of early Proterozoic granite formation on the southwestern Margin of the Siberian Craton: Doklady Earth Science, v. 388, p. 59–163.

Turkina, O. M., Nozhkin, A. D., and Bayanova, T. B., 2006, Sources and formation conditions of Early Proterozoic granitoids from the southwestern margin of the Siberian craton: Petrology, v. 14, p. 262–283, doi: 10.1134/S0869591106030040.

Vernikovsky, V. A., Vernikovskaya, A. E., Kotov, A. B., Sal'nikova, E. B., and Kovach, V. P., 2003, Neoproterozoic accretionary and collisional events on the western margin of the Siberian Craton: new geological and geochronological evidence from the Yenisey Ridge: Tectonophysics, v. 375, p. 147–168, doi: 10.1016/S0040-1951(03)00337-8.

Veselovsky, R. V., Petrov, P. Yu., Karpenko, S. F., Kostitsyn, Yu. A., and Pavlov, V. E., 2006, New Paleomagnetic and Isotopic Data on the Mesoproterozoic Igneous Complex on the Northern Slope of the Anabar Massif: Doklady Akademii Nauk, v. 411, p. 1190–1194.

Williams, H., Hoffman, P. F., Lewry, J. F., Monger, J. W. H., and Rivers, T., 1991, Anatomy of North America: thematic geologic portrayals of the continent: Tectonophysics: v. 87, p. 117–134, doi: 10.1016/0040-1951(91)90416-P.

Windley, B. F., 1998, The Evolving Continents: New York, John Wiley and Sons Inc., 526 p.

Wingate, M. T. D., Pisarevsky, S. A., Gladkochub, D. P., Donskaya, T. V., Konstantinov, K. M., Mazukabzov, A. M., and Stanevich, A. M., 2009, Geochronology and paleomagnetism of mafic igneous rocks in the Olenek Uplift, northern Siberia: Implications for Mesoproterozoic supercontinents and paleogeography: Precambrian Research, v. 170, p. 256–266, doi: 10.1016/j.precamres.2009.01.004.

Yarmolyuk, V. V., and Kovalenko, V. I., 2001, Late Riphean breakup between Siberia and Laurentia: Evidence from intraplate magmatism: Doklady Earth Sciences, v. 379, p. 525–528.

Yaschenko, M. L., Manuilova, M. M., Varshavskaya, E. S., Kutyavin, E. P., and Bukharov, A. A., 1972, Study of ^{87}Sr/^{86}Sr isotopic ratio and problem of depth of magma sources origin, *in* Simon, A. K. editor, Magmatism, formations of crystalline rocks and Earth's depth: Moscow, Nauka, p. 22–26, (in Russian).

Zhao, G., Cawood, P. A., Wilde, S. A., and Sun, M., 2002, Review of global 2.1–1.8 Ga orogens; implications for a pre-Rodinia supercontinent: Earth-Science Reviews, v. 59, p. 125–162, doi: 10.1016/S0012-8252(02)00073-9.

Zhao, G., Sun, M., Wilde, S. A., and Li, S., 2004, A Paleo-Mesoproterozoic supercontinent: assembly, growth and breakup: Earth-Science Reviews, v. 67, p. 91–123, doi: 10.1016/j.earscirev.2004.02.003.

Zonenshain, L. P., Kuzmin, M. I., and Natapov, L. M., 1990, Geology of the USSR: A Plate-Tectonic Synthesis: Geodynamics Series, v. 21, AGU, Washington, D. C., 242 p.