[PS]Early Paleozoic Drift Kinematics of the New Siberian Islands Terrane: Two Possibilities from Paleomagnetic Data*

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Abstract

The New Siberian Islands (NSI) archipelago is located in the East Siberian Sea in the junction region of various structural elements: the Verkhoyansk-Kolyma folded area, the Taimyr-Severnaya Zemlya folded area, and the submerged Lomonosov and Mendeleev ridges in the Arctic Ocean. It is also one of the few sites available for direct geological study on the Eastern Arctic shelf. Based on research results from field work in 2011 and 2013, we could prove that the geological basement of the De Long and Anjou island groups is Precambrian and the overlying Paleozoic sections formed within the same terrane. The boundaries of the NSI terrane are actively debated and are probably continued from the Lyakhovsky Islands in the southwest to the southern parts of the submerged Mendeleev Ridge.

Some models for the Paleozoic tectonics and structural affinity of the NSI terrane infer that the Paleozoic sedimentary section formed on the passive continental margin of Siberia, while others link its origin with marginal basins of Baltica and Laurentia, or regard the NSI terrane as an element of the Chukotka-Alaska microplate. Our paleomagnetic studies of the sedimentary, volcanogenic-sedimentary and igneous rocks of the Anjou (Kotelny and Belkovsky) and De Long (Bennett, Jeannette and Henrietta) island groups let us calculate an apparent polar wander path for the Early Paleozoic. From this path, we conclude that the NSI terrane could not have been part of the continental plates listed above, but instead had active tectonic boundaries with them. Paleomagnetic data indicate that the terrane underwent a gradual, slow drift in the tropical and subtropical regions of the Earth – 40° latitude at most. The main ambiguity of the tectonic interpretation of our new data is due to not knowing the true polarity. Consequently, it is uncertain what geographic hemisphere the NSI terrane was in during the recording of the paleomagnetic signal. Therefore, we present two possible tectonic scenarios of its Paleozoic history and discuss them on plotted corresponding global reconstructions describing the paleogeography and probable mutual drift kinematics of the Eastern arctic terranes.

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Arctic ocean floor map

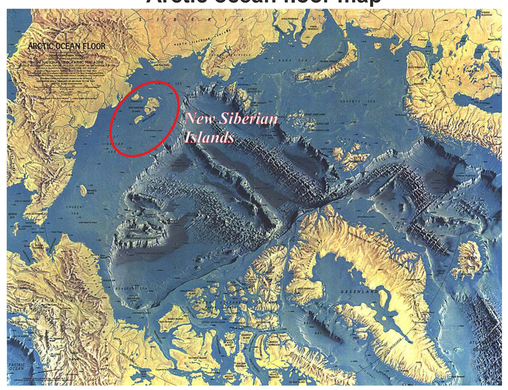

Fig. 1. The location of New Siberian Is. archipelago on the bathymetric map of the Arctic ocean.

The current structure of the Arctic Ocean was formed in the Mesozoic and Cenozoic and is related to the evolution of the Amerasian and Eurasian basins. However the main direction of our investigations is the reconstruction of the Neoproterozoic – Paleozoic tectonic history of the Arctic based first of all on paleomagnetic data. The most complete paleomagnetic information for the Neoproterozoic and Paleozoic of the Arctic can be obtained by studying the territory of the continental margin and the archipelagos on the shelf.

One of the key element on the Arctic shelf is the New Siberian Islands archipelago. The paleomagnetic results, which form the basis of our reconstructions are published recently in [Vernikovsky et al. (2013), Metelkin et al. (2016), Zhdanova et al. (2016), Matushkin et al. (2016), Chernova et al. (2017a,b) etc.]. The results of complex geological and paleomagnetic investigations permit creation of two possible models of tectonic evolution of East Arctic region in the Early Paleozoic.

Paleotectonic reconstructions for two scenarios of the East Arctic tectonic evolution

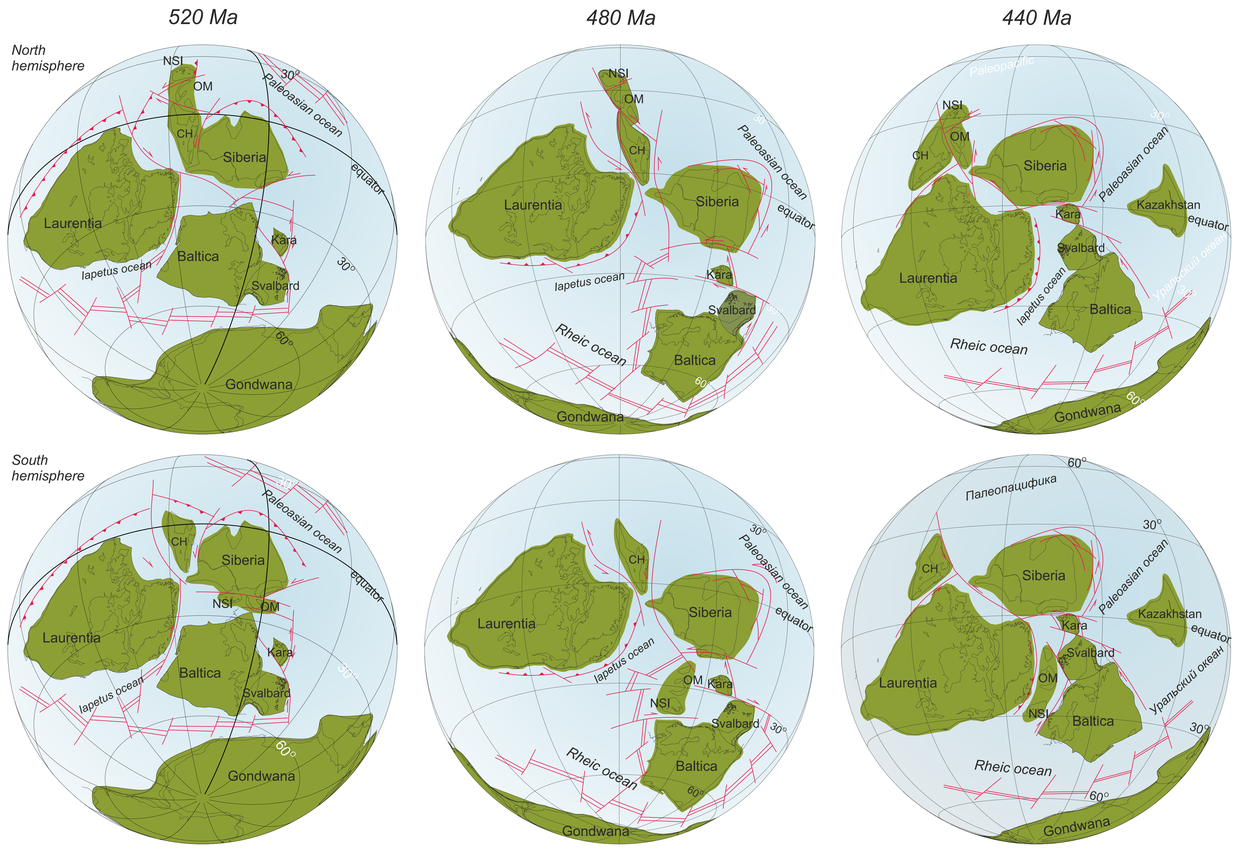

Fig. 5. Paleotectonic reconstruction in which two variants of NSI terrane position in the Early Paleozoic are presented: on top - N-scenario for nothern hemisphere, on bottom - S-scenario for southern hemisphere. NSI - New Siberian Islands terrane, OM- Omulevka terrane, CH - Chukchi-Alaska terrane.

N-scenario supposes the normal polarity of geomagnetic field while rocks forming and placing the NSI terrane in the northen hemisphere. Such an option is advantageous because of the minimum horizontal displacements of the terrane resulting from the analysis of the entire set of paleomagnetic data. On the other hand, in this case in the Early Cambrian it should be over a significant distance from Verkhoyansk margin of Siberia with which there was a obvious biogeographic link at that time. We assume that this space could be occupied by Omulevka and probably Chukchi-Alaska continental terranes which enabled the fauna to migrate along the shelf. In the Ordovician, supposed is the disintegration of this system and further convergence with the Siberia. The downside of this model is that such a NSI position is too far from Baltic which is supposed to be main provenance area of detrital zircons (Ershova et al., 2016) and this fact should be sought for another explanation.

The second variant (S-scenario) assumes a more typical Early Paleozoic reverse polarity of the geomagnetic field and the southern position of the NSI terrane. In accordance with the paleomagnetic data, together with the Omulevka terrane, it could be located near its current position, but under another orientation relative to Siberia that gives the explanation of the fauna similarity of the Verkhoyansk and NSI sedimentary basins. In this configuration, the NSI terrane could also be in a close proximity to western Scandinavia, which could be the provenance area for detrital zircons that are demolished probably from the territory of the Baltic (Ershova et al., 2016). However, global paleogeographic constructions impose certain limitations on this model. At the beginning of the Ordovician, as a result of the Iapetus opening, the "separation" of the NSI-Omulevka terrane group is reconstructed, which is recorded by a sharp change in the direction of the apparent drift of the paleomagnetic poles, and then a coordinated movement is expected near the Scandinavian margin of the Baltic. The main problem of this option is the "too" southern paleomagnetic position of the NSI terrane recorded by paleomagnetic data while Iapetus closing. At 440 million years ago, when the space of this paleo-ocean was minimal, the NSI block according to this model should be located inside of this convergent system and its further movement to the current position in the global kinematic picture is difficult. The velocities of the Late Paleozoic drift (~ 20 cm / year) are also very significant. To occupy its current position, the NSI block must "catch up" with Siberia, which all this time moves north with a clockwise rotation.

Thus, the geological and geophysical facts accumulated to the present time proves the unity of the Anjou and De Long sedimentary basins, the subtropical position of the NSI terrane during Early Paleozoic and, from our point of view, more reasonably describes its location in the northern hemisphere.

Geological map of the northeast Russia

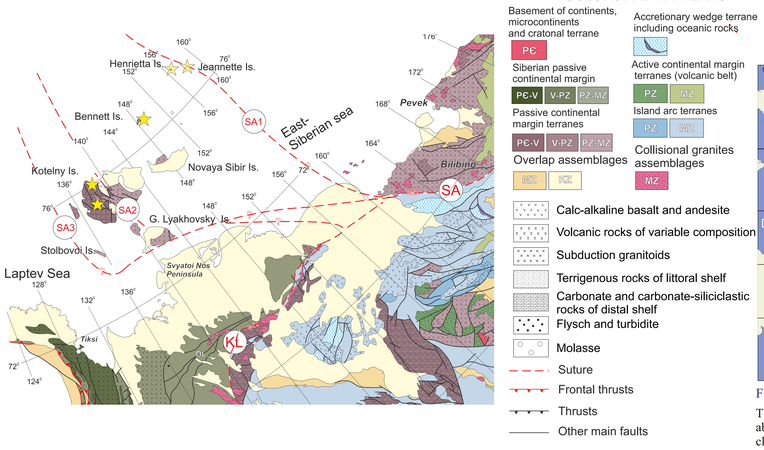

Fig. 2. The position of investigated objects on the geodynamic map of the New Siberian Islands and Russian East-North (Metelkin at al., 2016). The yellow stars - the location of paleomagnetic sites. Sutures: KL — Kolyma Loop (Kolyma–Polousny), SA — South Anyui (SA1–SA3: possible continuations).

In 2011 the representative collection for paleomagnetic investigations of the Lower Paleozoic of New Siberian Archipelago was collected. The rocks studied were mostly O-S limestones, dolomites on Kotelny Island and the Ordovician flysch deposits on Bennetta Island. In 2013 the investigation was concentrated on the De Long archipelago. On Jeannette Island we studied and sampled a small section along-shore. The geology of the island is comprised of deformed volcanogenic-sedimentary series, intruded by gabbro-dolerite dykes. Our Ar-Ar investigation shows that dykes had formed in two stages - in the Ediacaran and probably in the Early Ordovician time. Also the volcanogenic-sedimentary sequences of Henrietta Is. were studied. The Ar/Ar age of 520 Ma was obtained from basalts flows which are overlain as it appears by the Cambrian volcano-terrigeneous section.

Fig. 3. The different paleomagnetic sites on the Kotelny, Bennett, Jeannette and Henrietta Is.

APWP for NSI terrane

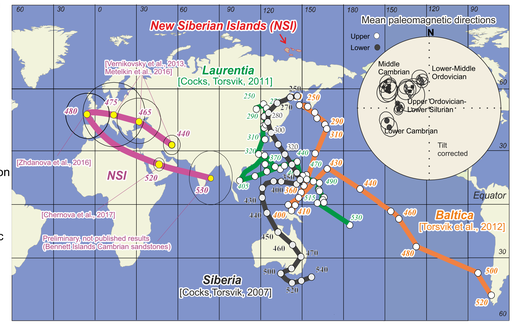

Fig. 4. APWP for the NSI in comparison with APWPs of Siberia, Laurentia and Baltica.

The Ordovician-Silurian poles were discussed in [Metelkin et al. (2016)] and they suggest the idea about terrane history of NSI block. Here also we can see that pole for Jeannetta Islands dolerites is close to Early Ordovician pole for Kotelny Islands deposits but whose exact age reflecting the position of the pole is still debated. We assumed according to our geochronology and paleomagnetic data that these dikes were formed in the Early Ordovician (Zhdanova et al., 2016). The 520 Ma is the rough age of sedimentary and magmatic rocks of Henrietta Is. from which the paleomagnetic pole was calculated (Chernova et al., 2017a,b). And also we present the preliminary result on Early-Middle Cambrian sandstones of Bennett Island. So such APWP illustrates the smoth movement of NSI terrane in subequatorial latitudes and up to Early Ordovician the NSI migrated away from the equator with counterclockwise direction and from 480 Ma some event changed its trajectory to the opposite. The close proximity of the poles of De Long and Anjou Islands confirms our previous conclusion concerning the unified nature of the New Siberian Islands terrane and its independent history.

Table. Mean paleomagnetic directions, paleomagnetic poles coordinates and paleolatitudes based on paleomagnetic study of Early Paleozoic archipelagos Anjou and De Long, used for the NSI APWP (Fig.4)

№	Objects, age	n/N	Geographic coordinates				Stratigraphic coordinates				Paleomagnetic poles			Plat
			D	*I*	*k*	*α95*	*D*	*I*	*k*	*α95*	*PLat*	*PLong*	*A95*	
1	Koteny Is., limestones 440 Ma	43/45 (4)	208.3	81.5	87.0	9.9	272.0	53.9	558.5	3.9	33.7	55.7	5.1	34.4
2	Bennett Is., sandstones 465 Ma	25/33 (3)	298.5	54.1	109.3	11.9	307.7	57.4	178.4	9.3	45.5	31.9	11.0	38.0
3	Kotelny Is., dolomites 475 Ma	23/25 (2)	278.3	77.5	25.7	51.4	315.6	59.1	414.0	12.3	48.9	13.8	18.1	39.9
4	Jeannette Is., dolerites, 480 Ma	39/45 (3)	308.7	44.8	55.5	16.7	344.4	56.0	468.7	5.7	49.2	357.4	5.9	36.5
5	Henrietta Is., sandstones, tuffs, basalts 520 Ma	56/65 (6)	294.5	25.4	19.0	14.2	295.5	34.0	282.0	3.6	23.7	45.7	3.2	18.6
6	Bennett Is., sandstones 530 Ma	18/22 (2)	247.8	46.5	184.3	18.5	249.2	37.0	265.1	15.4	15.5	83.6	18.0	20.6

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