*ISSN 1069-3513, Izvestiya, Physics of the Solid Earth, 2007, Vol. 43, No. 10, pp. 880–889. © Pleiades Publishing, Ltd., 2007.*
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# Middle Paleozoic Segment of the Apparent Polar Wander Path from the Siberian Platform: New Paleomagnetic Evidence for the Silurian of the Nyuya-Berezovskii Facial Province

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Received March 9, 2007

**Abstract**—The paper presents results derived from study of the Silurian of the Nyuya-Berezovskii facial province. Variegated sedimentary rocks of the Meutian and Kurungian series (Llandoverian, Wenlockian, and lower Ludlovian) are studied. Detailed thermal demagnetizations of the collections revealed two stable magnetization components; one of them ($Ds$ = 193.8, $Is$ = 19.2; $k$ = 10.7; $\alpha_{95}$ = 6.1) is bipolar and is likely to have formed during or shortly after the rock formation, i.e., in the interval from the Early Silurian to the beginning of the Late Silurian. The second component is unipolar and apparently metachronous, and its formation time can be bounded by the latest Early to the Middle Devonian. Based on the paleomagnetic results of this study, paleolatitudes and kinematics of Siberia are estimated for the Middle Paleozoic. The inferred paleomagnetic poles provide additional constraints on the Middle Paleozoic segment of the apparent polar wander path from the Siberian platform.

PACS numbers: 91.25.Dx

**DOI:** 10.1134/S1069351307100102

## INTRODUCTION

The Paleozoic stage of the geological history encompasses the vague time when, after the ~750 Ma breakup of the hypothetical Meso-Neoproterozoic supercontinent Rodinia [Dalziel, 1991; Hoffman, 1991; and others], the Siberian craton was isolated from other ancient cratons. According to current ideas [Zonenshain et al., 1990; Khain et al., 2003], the Paleo-Asian Ocean started to open at that time between the Siberian craton, the Baltic region, the Tarim basin, and ancient consolidation cores of China and Kazakhstan. This was accompanied by the formation of ensimatic island arcs and their subsequent accretion to Siberian margins; together with Precambrian microcontinents and fragments of the oceanic crust, the arcs formed the collage of terranes bounding the platform to the south (the Altai-Sayan and Baikal fold zones), west (the Yenisei Ridge), and north (the Taimyr Peninsula) [Mossakovsky et al., 1993; Didenko et al., 1994; Berzin and Dobretsov, 1993; Sengör et al., 1993; Vernikovskii, 1996; Vernikovskii and Vernikovskaya, 2006]. It is supposed that Siberia occupied such an isolated position until the end of the Middle Paleozoic, when the Hercynian orogenesis and the collision of Siberia with Euro-America, the Kazakhstan continent, and Gondwana and other blocks resulted in the formation of the Pangea supercontinent.

The existing geodynamic models describing the formation of the Paleozoic structure of foldbelts adjacent to the Siberian platform (the Baltic region and adjacent zones of the Ural-Mongolian mobile belt) are mainly based on geological evidence. Paleomagnetic data could be used for testing the geological models and quantifying the related paleoreconstructions, but such data, if available, are unreliable, fragmentary or very scanty, and sometimes contradictory and, therefore, are often unusable for solving problems of tectonics and geodynamics in the Paleozoic.

To solve the above problems of global and regional tectonics of the Paleozoic, reliable paleomagnetic data of this time period are required and apparent polar wander paths (APWPs) should be constructed, first of all, for ancient platforms, the main structure-controlling elements of the continental lithosphere.

The most significant contribution to the construction of APWPs for plates of Northern Eurasia has been made by researchers of the paleomagnetic laboratory of the All-Russia Petroleum Research Exploration Institute. This group, under the guidance of A.N. Khramov, obtained the first, pioneering data on the paleomagnetism of the Precambrian and Phanerozoic in the Siberian and East European platforms, which served as a basis for the earliest APWP reconstructions [Khramov et al., 1974, 1982; Khramov, 1991].

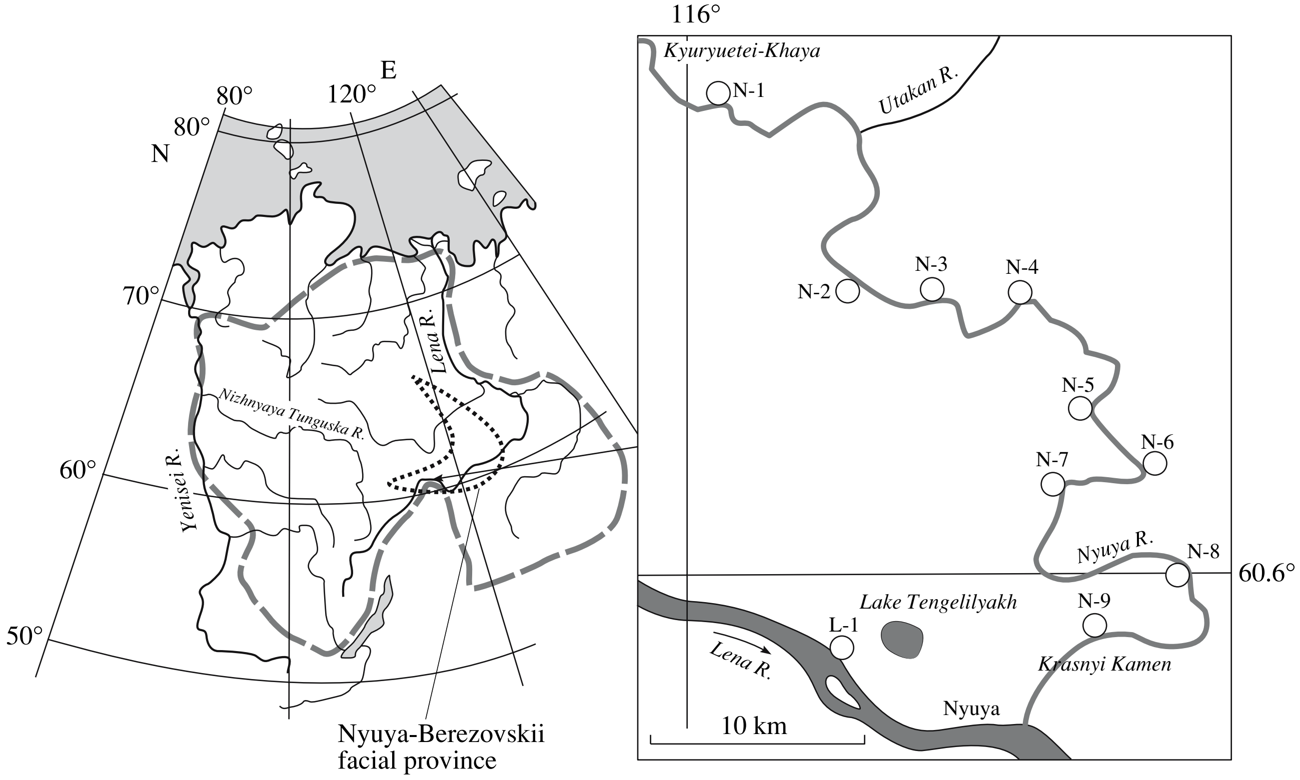

**Fig. 1.** Geographic position of the fieldwork area and objects of study. The circles and associated indices are the studied outcrops.

During recent years, the IPE RAS Laboratory of the Main Geomagnetic Field has been continuing the studies performed in Khramov's laboratory in relation to the paleomagnetism of the Siberian platform. An important goal of this research is the detailed reconstruction of the Middle Paleozoic segment of the Siberian APWP and the retrieval of new data fully complying with the modern, significantly more stringent requirements on the quality of paleomagnetic results.

Reliable paleomagnetic data on the Phanerozoic of the Siberian platform were obtained for the Early Paleozoic and Permian/Triassic boundary. Data available for the Middle–Late Paleozoic and meeting, albeit to the least degree, reliability criteria [Van der Voo, 1993] consist of only four determinations. Two of the latter relate to the boundary level $O_3$–$S_1$ [Gallet and Pavlov, 1996; Torsvik et al., 1995] and are both supported by rather poor statistics (being obtained from 20 and 9 samples, respectively). Another determination, related to the interval $D_3$–$C_1$ [Kravchinsky et al., 2002], was derived from undated subvolcanic bodies (kimberlite pipes and sills) of the Vilyui paleorift system (the Vilyui–Markha area); the age of these bodies was determined somewhat tentatively on the basis of geological considerations, which is undoubtedly a drawback of this determination. On the other hand, few U–Pb age determinations obtained for kimberlite pipes in adjacent areas (the Alakit-Markha and Daldyn fields) lie within the interval 344–362 Ma [Vasilenko et al., 2000], which corresponds to the end of the Late Devonian–beginning of the Early Carboniferous. New paleomagnetic and geochronological data have recently been obtained from Early Permian dike swarms on the SW coast of Lake Baikal [Pisarevsky et al., 2006]. However, we should note that, being obtained from a region of intense tectonics associated with the Baikal rift opening, this determination needs to be supported by data from a more "rigid" part of the platform.

The few paleomagnetic determinations for the Middle–Late Paleozoic of Siberia, obtained with the use of out-of-date methods and instruments [Kamysheva, 1973, 1975; Davydov and Kravchinskii, 1973; Pisarevskii, 1982; Rodionov et al., 1982], on the one hand, do not meet modern requirements and, on the other hand, are fairly contradictory [Smethurst et al., 1998]. In fact, the interval from the end of the Ordovician to the end of the Permian (~200 Myr) is problematic in the paleomagnetic record of the Siberian Paleozoic.

## GEOLOGY OF OBJECTS OF STUDY

The facies composition of Silurian deposits of Eastern Siberia differentiates them into five facial subregions [Tesakov et al., 2000]. Overall, in the northward direction from the Nyuya-Berezovskii and Irkutsk subregions to the Northern Taimyr, lagoonal and shallow shelf facies including redbeds give way to deep shelf

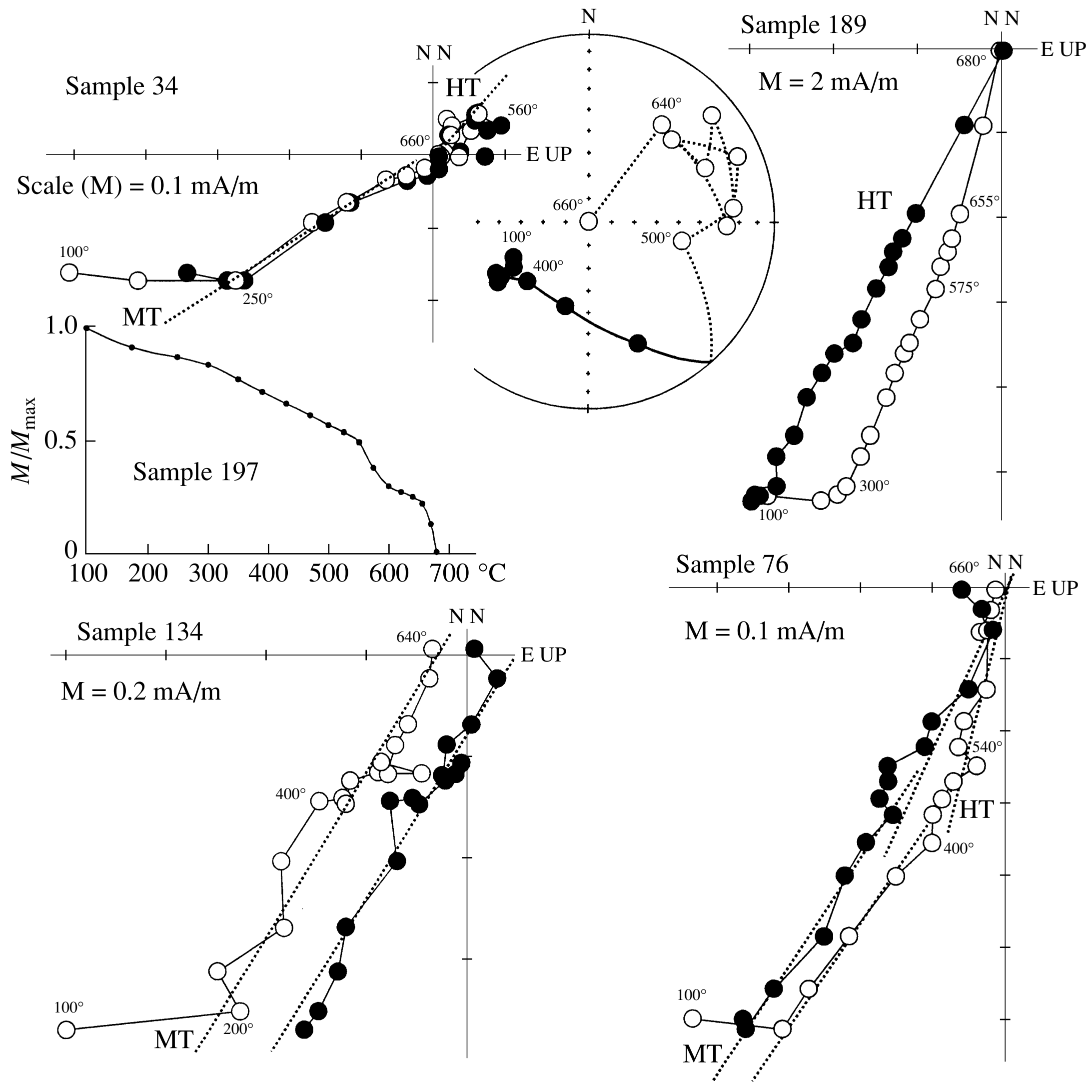

**Fig. 2.** Results of detailed thermal demagnetizations. The solid (open) circles in the Zijderveld diagrams are projections of vectors onto the horizontal (vertical) plane. The solid (open) circles in the stereogram are vector projections onto the lower (upper) hemisphere.

facies represented by mudstones with graptolites and rare limestone interbeds [Tesakov et al., 2000]. Objects including redbed varieties are promising for paleomagnetic studies and, in the Siberian platform, are represented by Silurian sections of the Nyuya-Berezovskii facial province studied in this work (Fig. 1).

The Meutian and Kurungian series of an overall thickness of about 330 m are identified in Silurian sedimentary sequences of the Nyuya-Berezovskii facial province [Tesakov et al., 2000]. The first series includes the Melichanian and Kurungian formations, and the second consists of the Nyuya and Neryukteian formations. Sequences of the Meutian and Kurungian series are composed of gray, occasionally variegated, dolomites and dolomitic marls including thin members of variegated siltstones and mudstones. Silurian deposits conformably, with a gradual transition, rest on the redstone series of the Upper Ordovician [*State Geological* ..., 1984], but the relationships between the Silurian sequences of this province and Devonian deposits are unknown [Tesakov et al., 2000]. Structurally, the province belongs to the Vitim-Dzherba syncline, extending northeastward from the Vitim River mouth to the Dzherba River; the core of this structure is composed of Lower Silurian rocks, while its limbs are composed of Cambrian–Ordovician deposits [*State Geological* ..., 1984]. According to our observations, beds of the Nyuya and Lena sections are distorted by subhorizontal folding deformations (deep angles of beds rarely exceed 10°). In relict fauna complexes, the Meutian and Kurungian series are comparable with the Llandoverian, Wenlockian, and lower Ludlovian ages [Tesakov et al., 2000] of the International time scale,

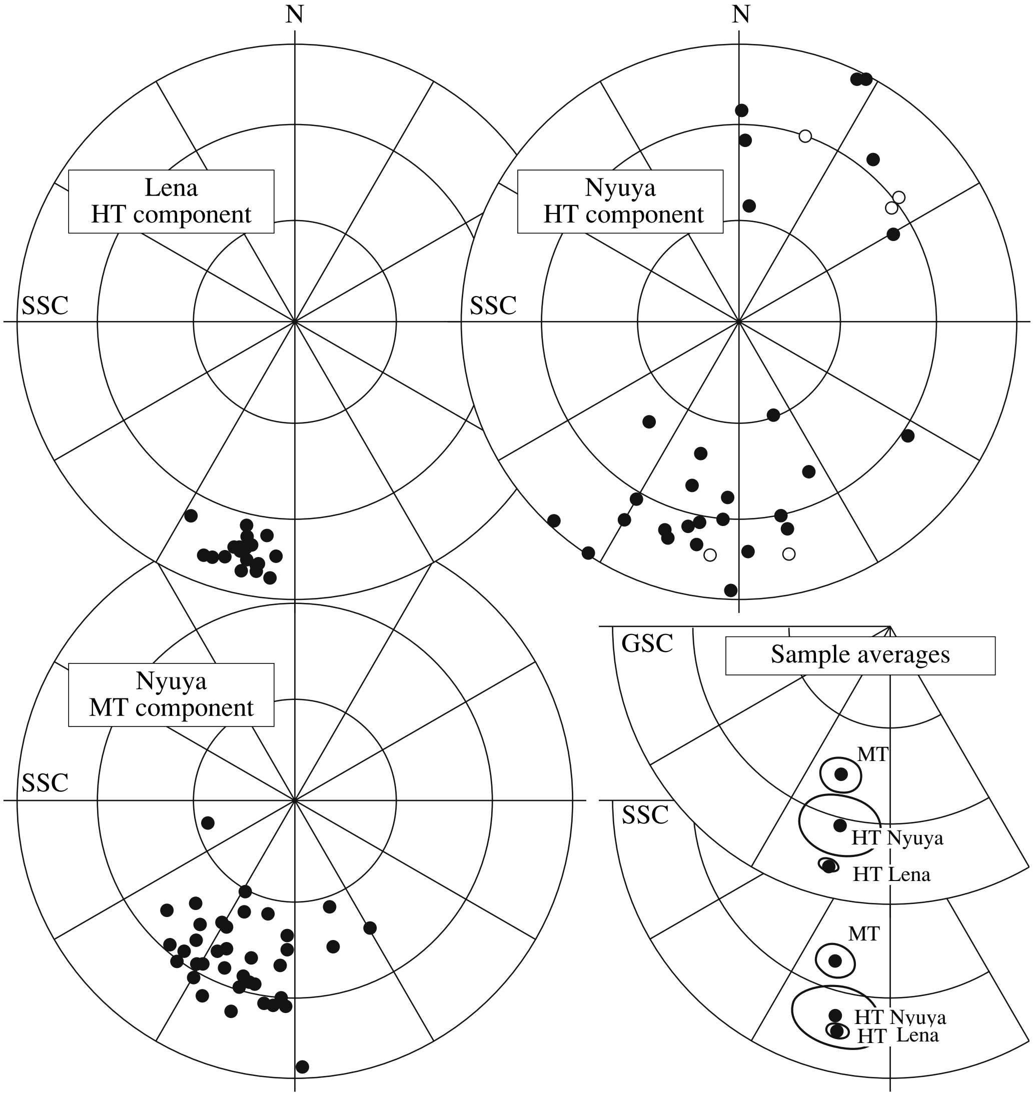

**Fig. 3.** Distributions of vectors of the HT and MT magnetization components in the studied objects. The solid (open) circles are projections onto the lower (upper) hemisphere. GSC and SSC are, respectively, the geographic and stratigraphic systems of coordinates.

corresponding to an interval of 443–422 Ma. Silurian deposits were sampled in nine outcrops of the Nyuya River banks (Fig. 1) from the Kyurutai-Khaya landform to the Krasnyi Kamen landform and on the left bank of the Lena River about 8 km upstream from the settlement of Nyuya; in all, 200 oriented samples of variegated varieties were collected.

## RESULTS OF LABORATORY MEASUREMENTS

Laboratory measurements were made with the use of instruments of paleomagnetic laboratories of the University of Santa Cruz (United States) and the University of Munich (Germany). All samples were subjected to detailed thermal demagnetization (12–19 steps) until complete destruction of the natural remanent magnetization (NRM), using TSD-1 and TSD-2 thermal demagnetization devices. The NRM was measured on a 2G-Enterprise SQUID magnetometer in rooms shielded from the external geomagnetic field.

A significant number of samples from the Nyuya sections carry no useful paleomagnetic signal: either the rocks are remagnetized by the present field or the NRM vector changes its direction chaotically during demagnetization. Two stable magnetization components are recognizable from the remaining part of the collection (~40% of the total number of samples):

(1) A high temperature (HT) component directed toward the origin of coordinates in Zijderveld diagrams. It is identified from 3–16 (on average, 7) points in the interval 200–620°C with unblocking temperatures ranging from 500°C up to $T_C$ of hematite (Fig. 2, sample 76). An HT component of reversed polarity is recorded in a small number of samples, but the quality of paleomagnetic records in these samples is rather

**Table 1.** Paleomagnetic directions from the studied outcrops

| Outcrop ($\varphi = 60.7°$; $\lambda = 116.3°$) | $N$ | Geographic system of coordinates | | | | Stratigraphic system of coordinates | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $D$ | $I$ | $k$ | $\alpha_{95}$ | $D$ | $I$ | $k$ | $\alpha_{95}$ |
| HT component | | | | | | | | | |
| Nyuya R., outcrop N-1 | 2 | 193.7 | 40.2 | 13.4 | 74.7 | 194.2 | 43.0 | 17.0 | 65.0 |
| Nyuya R., outcrop N-2 | 11 | 202.8 | 37.4 | 7.5 | 17.9 | 200.8 | 31.6 | 6.6 | 19.2 |
| Nyuya R., outcrop N-4 | 11 | 187.1 | 30.6 | 7.6 | 17.7 | 187.7 | 22.5 | 6.4 | 19.5 |
| Nyuya R., outcrop N-7 | 7 | 196.3 | 13.5 | 9.8 | 20.3 | 198.1 | 10.2 | 9.8 | 20.3 |
| Nyuya R., outcrop N-8 | 2 | 184.7 | –22.8 | 37.6 | 41.9 | 184.7 | –25.8 | 37.6 | 41.9 |
| Nyuya average | 33 | 194.3 | 26.7 | 6.9 | 10.3 | 194.4 | 21.3 | 6.5 | 10.7 |
| Lena R., outcrop L-1 | 23 | 194.5 | 12.3 | 182.2 | 2.2 | 193.1 | 16.7 | 138.8 | 2.6 |
| All samples of normal polarity | 46 | 191.5 | 21.1 | 13.9 | 5.8 | 190.6 | 20.8 | 15.7 | 5.5 |
| All samples of reversed polarity | 10 | 28.7 | –15.5 | 5.6 | 22.3 | 29.7 | –10.0 | 4.9 | 24.2 |
| Total ($\gamma/\gamma_c = 21.3/16.1$) | 56 | 194.4 | 20.3 | 10.7 | 6.1 | 193.8 | 19.2 | 10.7 | 6.1 |
| Outcrop average | 6 | 193.0 | 19.1 | 11.3 | 20.5 | 193.1 | 16.9 | 11.6 | 20.5 |
| MT component | | | | | | | | | |
| Nyuya R., outcrop N-2 | 6 | 203.2 | 53.2 | 21.4 | 14.8 | 199.2 | 46.8 | 22.0 | 14.6 |
| Nyuya R., outcrop N-4 | 6 | 210.7 | 41.5 | 46.6 | 9.9 | 207.2 | 33.6 | 41.5 | 10.5 |
| Nyuya R., outcrop N-5 | 3 | 204.9 | 39.7 | 124.6 | 11.1 | 206.1 | 46.7 | 60.1 | 16.0 |
| Nyuya R., outcrop N-7 | 15 | 187.7 | 35.2 | 22.8 | 8.2 | 192.2 | 32.9 | 22.8 | 8.2 |
| Nyuya R., outcrop N-8 | 9 | 205.0 | 49.5 | 15.0 | 13.7 | 203.9 | 46.7 | 15.0 | 13.7 |
| Sample average | 39 | 198.3 | 42.9 | 18.5 | 5.5 | 199.1 | 39.5 | 19.8 | 5.3 |
| Outcrop average | 5 | 202.0 | 44.1 | 68.0 | 9.3 | 201.6 | 41.5 | 84.9 | 8.4 |

Note: $D$ and $I$ are the declination and inclination; $N$, $k$, and $\alpha_{95}$ are statistical parameters (the number of samples/outcrops, the concentration of a vector distribution, and the confidence radius corresponding to the 95% probability); and $\gamma/\gamma_c$ is the angular distance divided by its critical value at the 95% probability.

poor (Fig. 2, sample 34), which is likely to be responsible for a significant scatter in vectors of the given component and a negative reversal test for groups of normal and reversed polarities (Fig. 3, Table 1).

In the red dolomitic marls of the Lena section composing the youngest of the studied Silurian horizons (the lowermost Ludlovian), the paleomagnetic record quality is much higher than in the Nyuya sections: Zijderveld diagrams demonstrate here an “ideal” single-component magnetization determined during thermal demagnetization in the interval from 300°C up to $T_C$ of hematite (Fig. 2, sample 189); this magnetization coincides in direction with the Nyuya HT component and is characterized by a fairly concentrated distribution of unit vectors (Fig. 3). Note that, in Lena samples, thermal demagnetization curves exhibit a characteristic bend (best expressed in sample 197 (Fig. 2)) near $T_C$ of magnetite; this fact, as well as the single-component type of Zijderveld diagrams, can be regarded as a positive composition test [Pechersky and Didenko, 1995].

(2) A middle temperature (MT) unipolar component that does not pass through the origin of coordinates in Zijderveld diagrams and is identified in a lower temperature interval compared to the HT component (Fig. 2, samples 34, 76, and 134). The component is revealed in Nyuya samples, on average from six points, in a “diffuse” temperature spectrum from 200 to 560°C ($T1$) at blocking temperatures of 350–640°C ($T2$).

The fold test in Enkin’ s modification [Enkin, 2003] applied to the HT component is indefinite for both sample values and outcrop averages; for the MT component, this test is positive on the sample level, but comparison of outcrop averages yields an indefinite result. Because outcrops containing well-defined HT and MT components are few and the statistical “weight” of outcrops varies significantly, we calculated the average directions of corresponding components using the entire set of sample-derived vectors in stratigraphic coordinates. These coordinates were chosen because of a positive fold test for sample-averaged directions of the Nyuya and Lena HT components (Fig. 3). As seen from Fig. 3, corresponding averages in stratigraphic coordinates coincide at a statistically significant level ($\gamma/\gamma_c = 4.8/12.3$), and this fact favors the joint analysis of HT components from the Lena and Nyuya sections.

**Table 2.** Paleomagnetic poles of the Middle Paleozoic of the Siberian platform (the state for the period 1982–2007)

| No. | Object of study | Age of rocks | λ, deg | φ, deg | PLONG | PLAT | A95 dp/dm | Source |
|---|---|---|---|---|---|---|---|---|
| 1 | Angara R. | $O_3$car | 100.0 | 58.8 | 140.5 | –31.6 | 4.9/9.6 | [Pavlov and Gallet, 2005] |
| 2 | Lena R. | $O_3$ash | 116.4 | 60.5 | 118.1 | 3.1 | 14.8 | [Torsvik et al., 1995] |
| 3 | Moyero R. | $O_3$ash-$S^1$ | 104.0 | 67.5 | 124.1 | –13.9 | 5.9 | [Gallet and Pavlov, 1996] |
| 4 | Lena R. | $S_1$ | 116.0 | 60.3 | 102.0 | –3.0 | 8.9 | [Rodionov et al., 1982] |
| 5 | Lena R., Nyuya R. (HT component) | $S_1$-$S_2$lud$^1$ | 116.3 | 60.7 | 101.9 | –18.6 | 4.6 | This work |
| 6 | The same with the correction for the closure of the Vilyui rift | | | | 128.0 | –19.0 | | |
| 7* | Nyuya R., PreF | $S_1$-$S_2$lud$^1$ | 116.3 | 60.7 | 98.6 | –5.5 | 4.9 | This work |
| 8* | Lena R., PreF | $O_2$ | 113.7 | 60.1 | 92.5 | 4.0 | 4.7 | [Shatsillo et al., 2004**] |
| 9* | B. Patom R., PostF | $R_3$ | 117.2 | 60.0 | 100.7 | 4.3 | 9.6 | [Shatsillo et al., 2004] |
| 10* | B. Patom R., SF | $R_3$ | 117.2 | 60.0 | 97.1 | 2.6 | 35.4 | [Shatsillo et al., 2004] |
| 11* | Lena R., PreF | V | 117.5 | 60.0 | 100.5 | 7.6 | 5.7 | [Shatsillo et al., 2004] |
| 12* | Average pole of the Lena–Nyuya remagnetization (7–11) | | | | 97.9 | 2.6 | 5.6 | |
| 13* | The same with the correction for the closure of the Vilyui rift | | | | 119.7 | 0.9 | | |
| 14* | B. Zhidoi R. | $V_1$ | 103.0 | 52.0 | 112.2 | –2.5 | 7.8 | [Shatsillo, 2005] |
| 15* | Angara R., PreF | $O_{2-3}$ | 100.0 | 58.8 | 1.5 | 116.2 | 8.3/12.3 | [Shatsillo et al., 2004] |
| 16 | Vilyui R., Markha R. | $D_3$-$C_1$ | 116.0 | 63.5 | 149.7 | 11.1 | 8.9 | [Kravchinsky et al., 2002] |

Note: φ and λ are the latitude and longitude of an object; PLAT and PLONG are the latitude and longitude of a paleomagnetic pole; A95 (dp/dm) is the radius (semiaxes) of the confidence circle (oval). The correction for the opening of the Vilyui paleorift is calculated from data for the Aldan megablock in accordance with [Pavlov and Petrov, 1997]; the Euler pole is (PLAT = 62, PLONG = 117) with a counterclockwise rotation through 25°.

* Poles of the Middle Paleozoic remagnetization: PreF, SF, and PostF are, respectively, prefolding, synfolding, and postfolding magnetizations.

** Partial reinterpretation of data from [Pavlov et al., 1999].

## DISCUSSION

**Comparison with data available for the Middle Paleozoic.** Paleomagnetic poles calculated from HT and MT components differ at a significant level from all known post-Silurian paleomagnetic poles of the Siberian platform but are consistent with the available few determinations from rocks of a similar age (Table 2). This fact together with the above arguments suggests that magnetization was acquired by the study rocks during or shortly after sedimentation. The poles of the MT and HT components are close but differ at a statistically significant level ($\gamma/\gamma_c = 13.5/7.1$), implying that these components were acquired at different, albeit close, times.

Analyzing the pole of the MT component, it is of interest to invoke data on regional overprinting of rocks in adjacent midstream areas of the Lena River [Shatsillo et al., 2004]. In this region, within a wide age range (from the late Riphean to the Ordovician) of rocks of different compositions (subvolcanic basic bodies and terrigenous carbonate rocks), metachronous pre-, syn-, and postfolding magnetization components coinciding in coordinate systems of their formation are widespread. At a statistically significant level, the pole of the MT component is indistinguishable from the aforementioned remagnetization poles, and it is noteworthy that this region includes poles obtained by Rodionov et al. [1982] and Torsvik et al. [1995] from rocks of the Early Silurian and Late Ordovician, respectively (Table 2, inset in Fig. 4a). This fact was previously considered [Pavlov et al., 1999] as an argument for the Late Ordovician–Early Silurian age of the overprinting widely developed in the region. However, if the HT component is suggested to be older than the MT component, we should admit that the regional remagnetizing event took place no earlier than the Late Silurian. The closeness of the poles derived in [Rodionov et al., 1982; Torsvik et al., 1995] to the pole of the MT component indicates that the magnetization components used for their calculation are likely metachronous.

A strong argument in favor of the primary nature of the HT component (and, accordingly, the secondary nature of the MT component) is gained from comparison of the HT pole with the pole from Moyero transitional bed of the Late Ordovician–Early Silurian [Gallet and Pavlov, 1996]. As seen from Table 2 and Fig. 4a, the HT and Moyero poles almost coincide after the introduction of a correction for the opening of the Vilyui paleorift system [Pavlov and Petrov, 1997].

Possibly, the overprinting processes not only involved structures of the Lena midstream area but also were developed over a larger territory of the southern

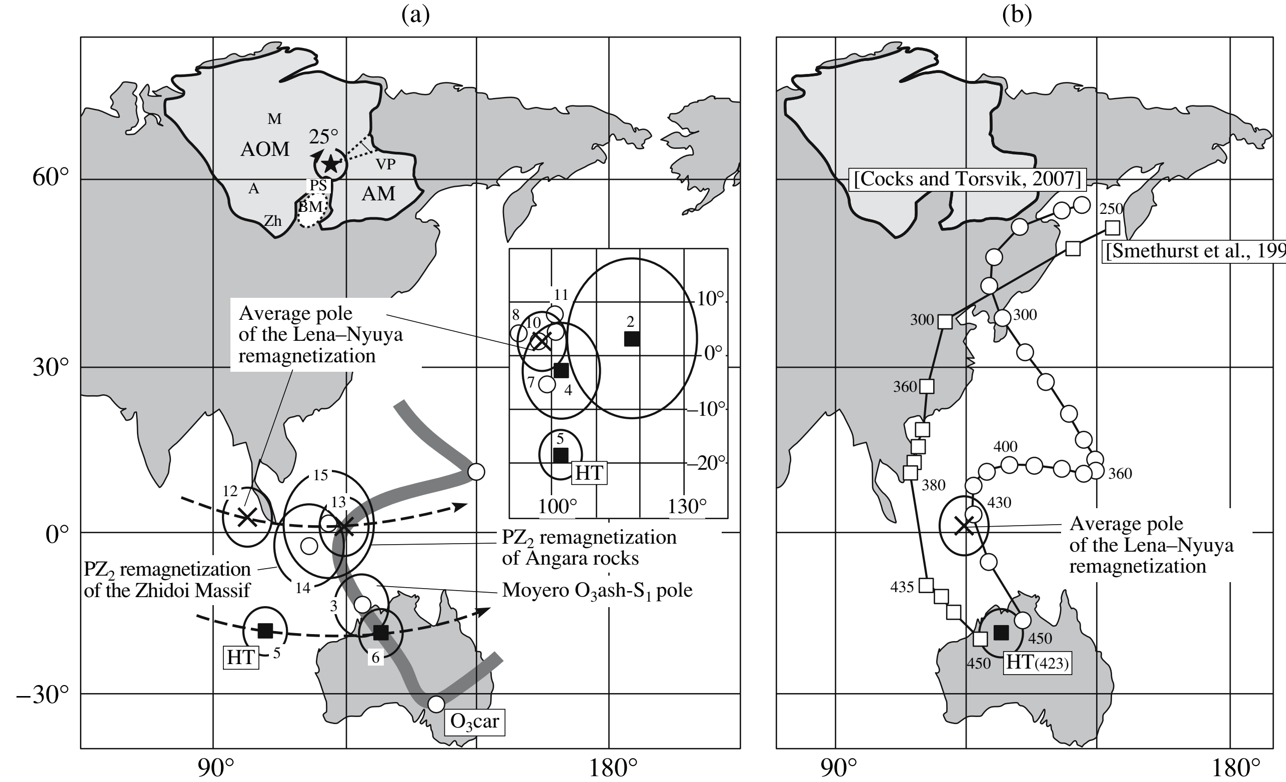

**Fig. 4.** (a) APWP segment and poles obtained from the Angara-Olenek megablock of the Siberian platform (Late Ordovician–Early Carboniferous) with the use of recent determinations: A and Zh, remagnetized Angara and Zhidoi rocks; M, Moyero R.; AOM and AM, Angara-Olenek and Aldan megablocks; BM, Barguzin microcontinent; VP, Vilyui paleorift; PS, Patomskii synclinorium. The star is the rotation pole for the closure of the Vilyui paleorift system (according to [Pavlov and Petrov, 1997]), and the broken arrows show pole shifts due to the correction for closure. The inset shows the distribution of Lena–Nyuya remagnetization poles (circles) and the average pole (cross), as well as $O_3$–$S_1$ poles [Rodionov et al., 1982; Torsvik et al., 1995] and the pole of the HT component (squares). The pole numbers in the figure and inset are the same as in Table 2. (b) Comparison of our data with recent variants of the APWP curve from the Siberian platform.

Siberian margin. In particular, close directions were obtained from the Zhidoi Massif of the Irkutsk cis-Sayan region (the Vendian; Table 2, Fig. 4a) [Shatsillo, 2005]; close postfolding directions were also fixed in Vendian sedimentary rocks of this region [Shatsillo, 2006] and Ordovician deposits of the Angara River (Table 2, Fig. 4a) [Shatsillo et al., 2004]. It is noteworthy that, after the introduction of a correction for the opening of the Vilyui rift, the Lena–Nyuya remagnetization coincides with remagnetization poles from the Angara-Olenek block (the Zhidoi Massif, Angara) (Table 2, Fig. 4a).

**Estimation of the overprinting age.** Whereas the formation time of the HT component can be rather reliably bounded by the Middle Silurian (the youngest age of rocks is 423 Ma), only the following indirect data can be used for estimating the age of the MT component.

(1) The minimum age of rocks recording the MT component indicates that it formed no earlier than the Late Silurian.

(2) The comparison of the position of the MT pole with Late Silurian poles from Siberia (Fig. 4) suggests that the age of the MT component is no younger than the Late Devonian–Early Carboniferous.

(3) The possible cause of the overprinting could have been transfer of the rocks into an active water exchange zone at the Silurian/Devonian boundary marked by a sedimentation break. Moreover, regional metamorphism ages of Late Precambrian rocks in an adjacent region (the Patomskii synclinorium) are known to lie within the interval 430–405 Ma [Ivanov et al., 1995]. In turn, regional metamorphism of the Patomskii synclinorium could be due to a collision of Siberia and the Barguzin microcontinent that took place, according to [Bukharov et al., 1993], in the interval from the end of the Early to the Middle Paleozoic (the position of these structures is shown in Fig. 4a).

Thus, the available data set suggests that the overprinting processes could have occurred from the end of the Silurian through the Middle Devonian, i.e., in the interval 423–383 Ma.

**Middle Proterozoic APWP segment and the paleogeographic position of the Siberian platform.** The data obtained in this study provide additional constraints on the APWP from the Siberian platform [Smethurst et al., 1998; Cocks and Torsvik, 2007]. On the one hand, our results place the Middle Silurian pole (Fig. 4b) farther to the south as compared with the variants proposed in [Smethurst et al., 1998; Cocks and Torsvik, 2007], but, on the other hand, comparison of the calculated pole with the Moyero pole of a similar age (Fig. 4a) [Gallet and Pavlov, 1996] confirms once more the necessity of introducing a tectonic correction for the opening of the Vilyui paleorift system on the basis of combined data from the Angara-Olenek and Aldan megablocks of the Siberian platform obtained for pre-Late Silurian and possibly younger (up to Middle Devonian?) determinations (which was not taken into account in the variant of Smethurst et al. [1998]).

On the whole, the inferred data in conjunction with the available determinations [Kravchinsky et al., 2002] reliably point to the presence of a kneelike bend in the Middle Paleozoic Siberian APWP segment corresponding to the Silurian/Devonian boundary (Fig. 4a). At this time, the predominantly northward movement of the platform without significant rotations, which had continued since the Late Ordovician, changed to a clockwise rotation. Possibly, the onset of opening of the Vilyui paleorift system might have been related to this change in the movement pattern of the Siberian platform corresponding in time to the regional remagnetization.

The inferred paleomagnetic data provide constraints on the position of the Siberian platform in the Silurian (Fig. 5a). In the Silurian, the southern (in geographic coordinates) margin of the Siberian platform faced northward and the platform itself was located at equatorial and subtropical latitudes of the Northern Hemisphere. In the Middle Silurian, the studied region was located at about 10°N; by the Early–Middle(?) Devonian, it had moved into the 30°–40°N interval and experienced an insignificant (~7°) counterclockwise rotation. Estimation of the northward drift velocity of Siberia from the Middle Silurian through the Lena–Nyuya remagnetization time imposes additional constraints on the time of the remagnetizing event and the age of the corresponding pole. As seen from Fig. 5b, it is unlikely that metachronous magnetization could have been acquired before the Emsian because this would imply that the northward movement velocity of the platform exceeded 15 cm/yr.

## CONCLUSIONS

(1) Reliable new paleomagnetic data are obtained for Silurian sedimentary rocks of the Nyuya-Berezovskii facial province of the Siberian platform. The paleomagnetic pole calculated from the high temperature magnetization component corresponds to the formation time of rocks (the Llandoverian–lower Ludlovian). The pole of the middle temperature metachronous magnetization component likely corresponds to the latest Early or the Middle Devonian.

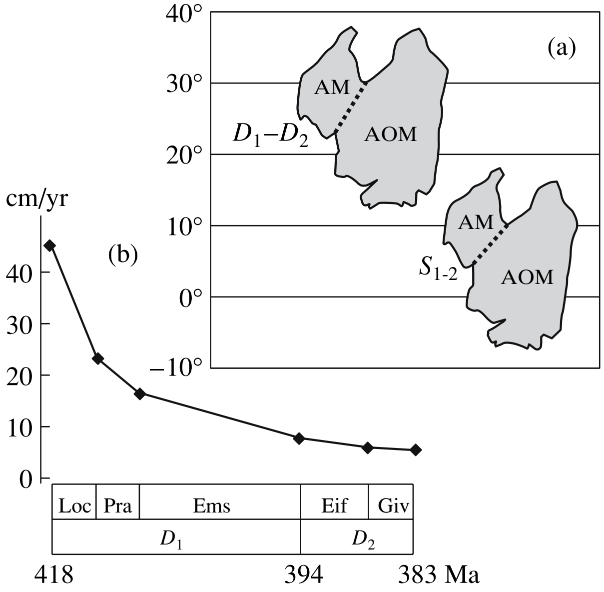

**Fig. 5.** (a) Paleogeographic position of the Siberian platform in the Silurian–Devonian: AM, Aldan megablock; AOM, Angara-Olenek megablock (the Vilyui paleorift is closed in the reconstruction). The reconstruction in the Devonian is calculated from the average pole of the Lena–Nyuya remagnetization. (b) Velocity of the northward drift of the Siberian platform from the mid-Silurian (423 Ma) through the Early–Middle Devonian as a function of the Lena–Nyuya remagnetization age.

(2) In conjunction with the available paleomagnetic determinations, the inferred data point to the presence of a large geological event of Late Silurian–Early Devonian age that involved vast territories of the southern Siberian platform and caused regional remagnetization of rocks at that time. This remagnetization coincided in time with a dramatic change in the platform movement pattern from the northern drift predominant in the Late Ordovician–Silurian to a clockwise rotation that continued until the beginning of the Carboniferous.

(3) A sharp bend in the Siberian APWP curve corresponding to the remagnetization time suggests that, at this time, the moving platform encountered an obstacle (e.g., the Barguzin microcontinent) slowing down the northern drift. Possibly, the onset of opening of the Vilyui paleorift system was also related to this crucial event.

(4) The new paleomagnetic data modify the existing APWP models of Siberia and are usable for estimating the paleogeographic position and kinematic characteristics of the platform in the Silurian–Middle Devonian.

## ACKNOWLEDGMENTS

We are grateful to R. Coe and S. Zhao (University of Santa Cruz, United States) and S. Gilder, V. Bachtadze, and M. Weiss (University of Munich, Germany) for the possibility of performing measurements using instruments of their laboratories and for technical recommendations. This work was supported by the Russian Foundation for Basic Research, project nos. 07-05-00880 and 07-05-00750; grant no. MK-139.2007.5 from the President of the Russian Federation; and the program of the RAS Division of Earth Sciences "Geodynamic Evolution of the Lithosphere of the Central Asian Mobile Belt (from Ocean to Continent)."

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