ISSN 1028-334X, Doklady Earth Sciences, 2015, Vol. 462, Part 1, pp. 444–448. © Pleiades Publishing, Ltd., 2015.
Original Russian Text © V.E. Pavlov, A.V. Shatsillo, 2015, published in Doklady Akademii Nauk, 2015, Vol. 462, No. 3, pp. 319–324.

GEOLOGY

Place of Birth of the Siberian Platform

V. E. Pavlov[a, b] and A. V. Shatsillo[a]

Presented by Academician M.A. Fedonkin November 29, 2013

Received December 5, 2013

DOI: 10.1134/S1028334X15050177

According to modern concepts [1, 2], the Siberian Craton, as a whole, formed in the Late Paleoproterozoic, approximately 1.9–1.8 Ga ago, as a result of accretion–collision processes which led to amalgamation of ancient Archean and Early Proterozoic continental blocks (terranes and/or superterranes). The accretion of superterranes of the Siberian Craton in modern coordinates was followed by formation of a huge Himalayan-type collision orogen. Formation of collusion zones was accompanied by synchronous areal granulite metamorphism in the adjacent terranes, which led to the formation of a fairly uniform field of high temperatures and pressures, which is typical of a middle–lower continental crust thickened during a collision. A significant part of the Siberian Platform, if not all, was subjected to regional metamorphism.

After termination of the collision processes and uplifting, the erosion of the mountain structure began. As a result, the middle crustal levels were relatively quickly exhumed forming the peneplain, which was later overlapped by Riphean–Phanerozoic sedimentary cover of the Siberian platform. During exhumation, the temperature of metamorphic rocks dropped below the Curie points of magnetic minerals. Here, rocks acquired remanent magnetization.

If the above-proposed pattern is correct, then it should be logical to assume that the paleomagnetic record in metamorphosed rocks of the crystalline basement of the Siberian Platform should reflect the direction of the geomagnetic field at the termination of regional metamorphism, that is, approximately, at the formation time of the Siberian Platform. In this case, regardless of the age of rocks of the Siberian Platform basement and their geographical location, most of the rocks must have paleomagnetic directions corresponding to closely grouped paleomagnetic poles located in the same area of the Earth. It is reasonable that we are talking only about those rocks that preserved ancient magnetization. Due to this, when comparing the poles it is necessary to take into account subsequent tectonic movements within the Siberian Platform [3].

Thus, the paleomagnetic method is the simplest and the most illustrative way to clarify the existing concepts, describing the process of the formation of the Siberian Platform. If paleomagnetic poles recorded in metamorphic rocks of different parts of the Siberian Platform (for example, the Aldan and Anabar shields) are close to each other or they are juxtaposed, then, the above hypothesis receives strong support. Otherwise, it should be corrected or neglected.

In order to apply the paleomagnetic method proposed, it is necessary to observe three conditions:

(1) Exhumation of rocks (or, more precisely, cooling in the temperature range of 700–350°C when the greater part of the paleomagnetic signal is formed) must occur during a time period not exceeding 10–20 Ma. Otherwise, as a result of the movement of the Siberian Platform, the paleomagnetic pole could be shifted and the rocks could have recorded some of its average position. This, however, does not have a fundamental importance for solving the task.

(2) Exhumation of rocks could occur over a time period when the magnetic field rarely changed its polarity. Otherwise, the signal recorded in metamorphic rocks as a result of the imposition of numerous antipodal components could be impossible to interpret. The results of analysis of the data obtained for Paleoproterozoic rocks [4] evidences that this condition is quite likely.

(3) After the formation of magnetization, the study areas did not experience significant declinations and turns. This condition can be monitored by convergence of regional paleomagnetic data.

We carried out a paleomagnetic study with the purpose to clarify this hypothesis. As a result, metamorphic complexes of different composition of different age series, exposed in the Uchur and Malyi Aim river valleys (Aldan Shield), were studied. Most outcrops

[a] *Institute of Physics of the Earth, Russian Academy of Sciences, Bolshaya Gruzinskaya ul. 10, Moscow, 123995 Russia*
[b] *Kazan (Volga region) Federal University, Kremlevskaya ul. 18, Kazan, 420008 Russia*
e-mail: pavlov-home@rambler.ru, shatsillo@gmail.com

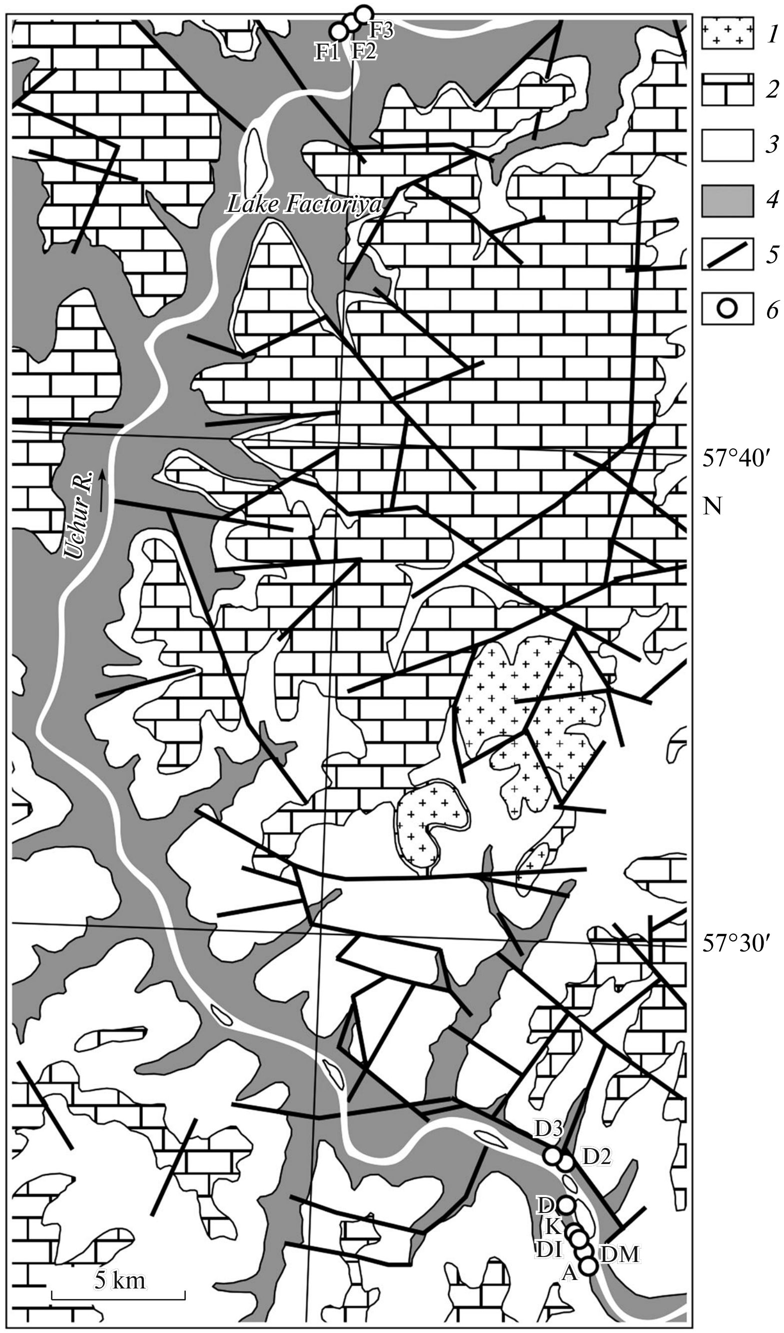

Fig. 1. Geological scheme of the study area in the Uchur River valley with location of the outcrops studied. *1*—Mesozoic granites; *2*—Vendian–Lower Cambrian deposits; *3*—Lower Riphean deposits; *4*—Early Precambrian basement complexes, *5*—faults, *6*—sampling sites.

studied during our field works are located in the middle reaches of the Uchur River near the mouth of Suklan Creek and a few kilometers below Factoriya Island (Fig. 1). The strongly folded rocks sampled, referred to the Upper Sunnagin and Kyurikan formations, are represented mainly by biotite–hypersthene and biotite–amphibole gneisses, which are interbedded with garnet–biotite and garnet–sillimanite gneisses, sometimes marbles and amphibole—plagioclase or phlogopite–diopside–plagioclase schists. In the Malyi Aim River valley (the western slope of the Omnya uplift), about 20 km above the Lata River mouth, small outcrops of biotite–amphibole gneisses of the Batomga Group were investigated.

The studied metamorphic complexes are overlain by Riphean subhorizontal deposits of the Uchur-

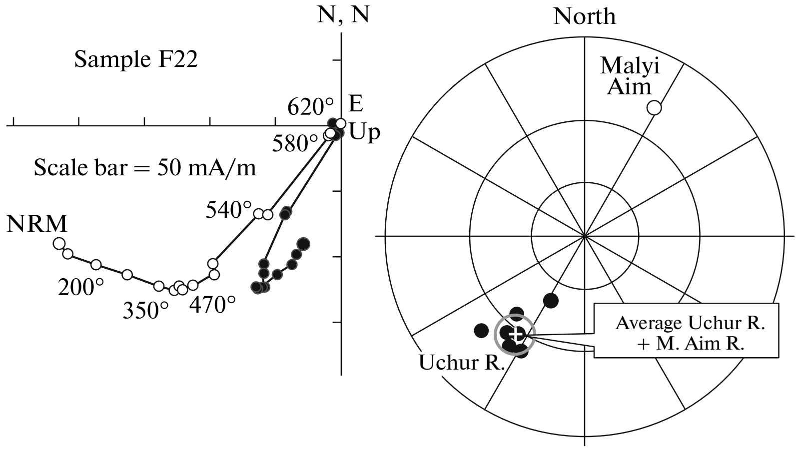

Fig. 2. Typical Zijderveld diagram (left) for samples of metamorphic rocks sampled in the Uchur River valley. The stereogram (right side) shows the distribution of mean directions (for sites) of distinguished characteristic magnetization components in the modern coordinate system.

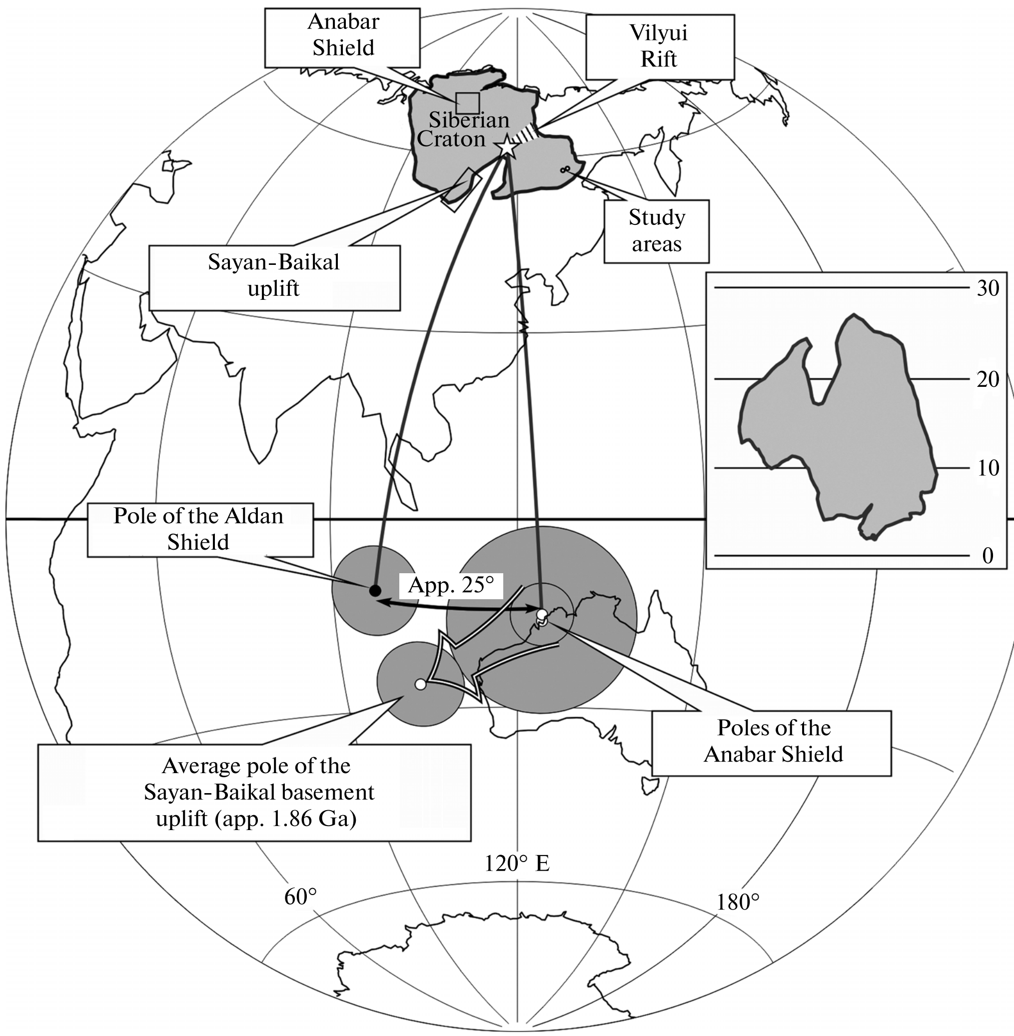

Fig. 3. Comparison of Paleoproterozoic paleomagnetic poles of the Siberian Craton and its paleogeographic position according to our data. The pole of relative rotation of the Aldan and Angara-Anabar blocks of the Siberian platform during the opening of the Vilyui Rift [3] is shown by a star; a small circle with a rotation pole is in the center. The Aldan and Angara-Anabar blocks are shown by a two-way arrow; 25° is the rotation angle with the best juxtaposition of the Anabar and Aldan poles; the direction of relative motion of the pole at the end of the Paleoproterozoic is shown by a large arrow (in the coordinates of the Anabar-Angara block). Other commentaries are in the text. The inset shows the paleogeographic position of the Siberian Platform at the time of its formation.

Paleomagnetic directions and paleomagnetic poles of metamorphic rocks of Aldan and Anabar shields and postcollision formations of Sayan–Baikal basement uplift

Outcrops	N	D	I	k	α95	P_{long}	P_{lat}	A95
Aldan Shield								
Uchur R. (φ = 57.6, λ = 131.8)								
Exp. A	3	209.0	23.4	63.2	15.6			
Exp. D2	5	221.0	35.3	34.6	13.2			
Exp. D3	3	227.5	19.9	82.1	13.7			
Exp. DP	4	207.7	49.7	66.8	11.3			
Exp. F1	3	214.4	28.8	72.9	14.5			
Exp. F2	7	218.7	26.3	39.8	9.7			
Exp. F3	5	214.1	22.3	98.7	7.7			
Average (Uchur R.)	7	216.4	29.5	46.8	8.9	96.0	–11.0	7.0
Malyi Aim R. (φ = 57.9, λ = 133.1)								
Exp. 27	5	28.6	–17.8	15.6	20.0	111.0	–21.0	15.0
Uchur R. + Malyi Aim R.						97.0	–11.0	7.0
Anabar Shield								
the same (5)						124.0	–16.0	15.0
adjusted for the opening of the Vilyui rift*						98.0	–15.0	
the same (6)						124.0	–15.0	5.0
adjusted for the opening of the Vilyui rift*						98.0	–15.0	
Postcollision formations of the Sayan-Baikal basement uplift								
Average pole, calculated for: 1) granites of the Sayan Complex of the Sharyshalgai Block (1850 ± 10); 2) Malokosinskaya Formation of the Baikal Ridge (1878 ± 4); 3) Chaya Formation of the Akitkan Ridge (1845 ± 5); 4) Chaya Formation of the Minya River (app. 1860); 5) Okun Formation of the Akitkan Ridge (app. 1850) [7, 8]						103.3	–26.0	6.8

N—a number of samples/expositions; D—declination; I—inclination; k—accuracy; α95—a radius of circle of 95% confidence; P_{long}, P_{lat}—longitude and latitude of a paleomagnetic pole; A95—a radius of circle of 95% confidence; φ and λ—latitude and longitude of objects studied; figures in brackets show rock ages, Ma.
*—a turn around the Euler pole of 25°, φ = 62.0, λ = 117.0 [3].

Maya Plate. This is evidence that, at least since the Riphean these areas were tectonically stable without local declinations and rotations.

The pattern of the behavior of the studied samples during thermal magnetic cleaning is shown in Fig. 2. The natural remaining magnetization includes two components: a relatively less stable magnetization with the direction close to that of the modern magnetic field and a more stable characteristic ancient component that trends towards the origin of coordinates and has maximum unblocking temperatures in the range of 580–620°C. The less stable component obviously has a young age and is probably associated with magnetoviscous processes and/or chemical changes of rocks in the supergene zone.

The paleomagnetic directions, similar in all outcrops, were distinguished in most of the samples studied, regardless of the composition of rocks and their locations. As shown in the stereogram (Fig. 2, table), the mean paleomagnetic directions are widely distributed in the study area and they do not depend on the dip and strike of rocks or the degree of dislocation (in modern coordinates). This evidences that the ancient paleomagnetic component is not considered to be primary. It is assumed that it formed after the deformation of rocks due to a regional process (probably, the cooling of metamorphic rocks during uplifting from the deep crustal horizons to the surface). The calculated paleomagnetic pole was compared to similar paleomagnetic poles obtained earlier from different age metamorphic complexes of the Anabar Shield [5, 6].

After the correction was made taking into account the opening of the Vilyui rift in the Middle Paleozoic [3], these poles practically coincided (table, Fig. 3).

The poles of the metamorphic complexes being considered are located close to those of the Sayan–Baikal uplift of the Siberian Craton (Angara–Anabar terrane) [7–9]. These poles were obtained from rocks that had formed already at the postcollision stage of development of the study area, viz. 1.86 Ga ago (table, Fig. 3).

The results obtained confirm the existing ideas about the almost synchronous regional metamorphism (in the Precambrian time scale), which was manifested throughout most of the Siberian Platform and was probably associated with the collision processes that led to formation of the Siberian Craton in coordinates close to the modern ones.

The juxtaposition of paleomagnetic poles obtained for the remote regions of the Siberian Platform is in agreement with the ideas of the predominance of the dipole geomagnetic field in the Late Paleoproterozoic and confirms the hypothesis of the rotation of the Aldan and Angara-Anabar blocks relative to each other in the Paleozoic. The resulting pole allows one to calculate the latitudinal and longitudinal position of the Siberian Platform during its formation (Fig. 3). In particular, the Uchur–Maya area was at that time in the equatorial region (latitudes of 10°–15°) and was rotated by 30° (or 210° depending on the choice of the magnetization polarity) with respect to their modern position. The resulting pole can be considered as the beginning of the curve of apparent migration of the pole for the Siberian Platform.

ACKNOWLEDGMENTS

This work was supported by Russian Foundation for Basic Research projects nos. (11-05-00705, 12-05-00403, 13-05-12030, and 14-05-92602) and by the Ministry of Education and Science (contract no. 14.z50.31.0017).

REFERENCES

1. O. M. Rozen and V. S. Fedorovskii, *Collision Processes and Crustal Layering* (Nauch. mir, Moscow, 2001) [in Russian].
2. O. M. Rozen, Rus. J. Earth Sci. **4** (2), (2002).
3. V. Pavlov, V. Bachtadse, and V. Mikhailov, Earth Planet. Sci. Lett. **276** (3–4), 229 (2008).
4. Y. Gallet, V. Pavlov, G. Halverson, et al., Earth Planet Sci. Lett. **339–340**, 117 (2012).
5. *Paleomagnetic Directions and Paleomagnetic Poles. Data for USSR. Iss. 1* (Leningrad, 1971) [in Russian].
6. D. I. Savrasov, Geol. Geofiz., No. 1, 94 (1990).
7. V. Yu. Vodovozov, Paleomagnetism of Early Proterozoic formations of the Southern Siberian Craton and geotectonic consequences, Candidate's Dissertation in Geology and Mineralogy (Izd-vo MGU, Moscow, 2010).
8. V. Yu. Vodovozzov, A. R. Zverev, V. M. Petrov, et al., in *Proc. Int. School-Seminar "Problems in Paleomagnetism and Magnetism of Rocks," Kazan, October 7–12, 2013* (Kazan, 2013), pp. 26–32.
9. A. N. Didenko, V. Y. Vodovozov, and S. A. Pisarevsky, Geol. Soc. London Spec. Publ. **323**, 145 (2009).

Translated by Dm. Voroschuk