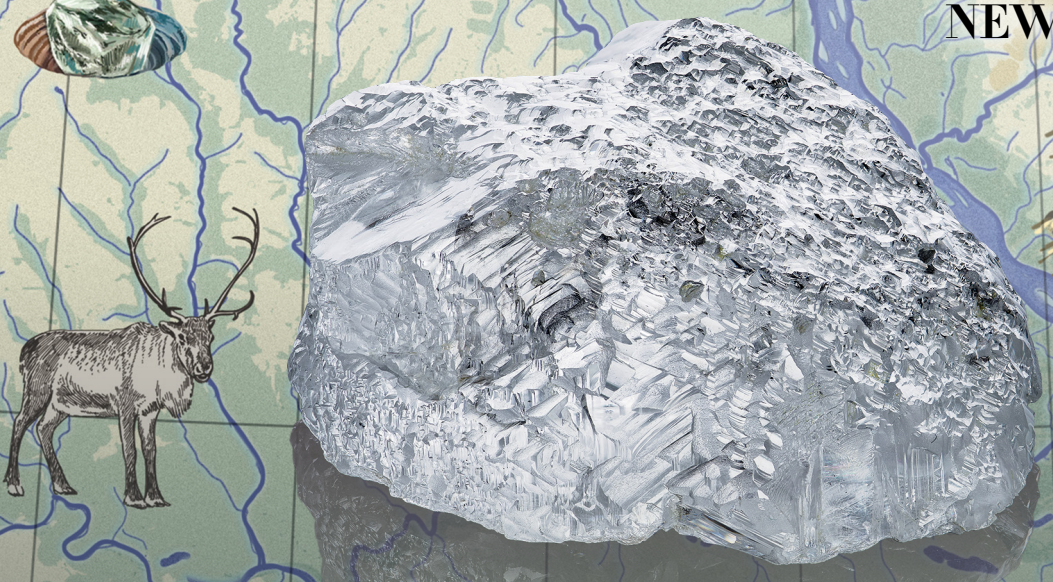
ALROSA

IN-HOUSE PUBLICATION OF THE LARGEST DIAMOND MINING COMPANY
SUMMER **2020**

BUSINESS POTENTIAL IN DIAMOND FLUORESCENCE

ALROSA CEO Sergey Ivanov:

“CRISES OPEN UP NEW POSSIBILITIES FOR BUSINESSES AND GIVE PEOPLE NEW PURPOSE”



A MAP OF WONDERS

DIAMONDS AND OTHER GEMS OF YAKUTIA

THE CANARY TRACE

Yakutia's volcanic diamond pipes could have formed as a result of volcanic activity on the territory of today's Madeira, Canary and Azorean islands. You may object: but Siberia is so far from Africa's northwestern coast! To this, we answer: hundreds of millions years ago, this is where the Siberian craton used to be. Konstantin Konstantinov, Doctor of Geology and Mineralogy and the leading scientist at ALROSA's Geo-Scientific Research Enterprise (NIGP), explains how paleomagnetism, the Earth's "ancient compass", can point toward hidden diamond deposits.

The Earth's ancient compass

Today there are over 30 known kimberlite fields unevenly distributed across the territory of the Siberian craton. These fields are believed to be 375–345 million years old, meaning that their kimberlite bodies (unlike the diamonds, which can be much older) date back to the late Devonian – early Carboniferous period (D3–C1).

To ensure the efficiency of their geological exploration work, the scientists have to come up with a geodynamic model of kimberlite formation, which can help reveal the reasons and patterns behind the distribution of diamond fields. To do this, one has to first reconstruct the Siberian craton's paleographic location – that is to establish its former location at almost four hundred million years ago. The question is, which geophysical technique should we use?

Everyone knows that Earth has a magnetic field. Simply put, it's a giant magnetic bar located at the planet's center and oriented along its rotational axis (according to the dipole model of magnetic fields). This means that the position of a geographic pole and the average magnetic pole always coincide (see fig. A) The magnetic field lines extend from two poles (N for northern, S southern), where the field is the most intense.

This geomagnetic field protects us from solar radiation. We also use this field for navigation. From physics classes at school we know that in a free, suspended on an inextensible cord, for instance, state the compass needle aligns with magnetic meridian D (declination), pointing toward the North Pole, and that its dip angle J (inclination) to the horizon depends on the geographic latitude. At the North Pole, the needle will be in the vertical position pointing down, and at the South Pole it will point up, and at the equator it will stay in a horizontal position.

Ancient travelers used this rule for determining their location, as well as mapping and routing. Since ancient times, the Chinese used so-called "pointers" made from a black-colored lodestone.

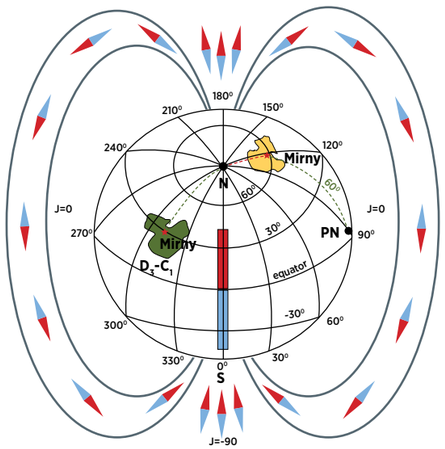
Today, the distance between Mirny (ϕ=62.5° north latitude, λ=114.0° east longitude) and the northern geographic (magnetic) pole N is: 27.5°=90°-62.5°. It hasn't always been that way: those studying the magnetism of dated geological objects on

ABOUT THE AUTHOR

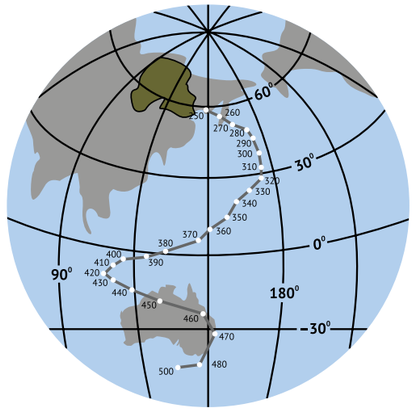
KONSTANTIN KONSTANTINOV
DOCTOR OF GEOLOGY AND MINERALOGY, EXPERT IN PETROPHYSICS, MAGNETIC MINERALOGY, PALEOMAGNETISM AS WELL AS PHYSICAL AND GEOLOGICAL AND MATHEMATICAL MODELING. GRADUATED FROM THE GEOLOGICAL PROSPECTING FACULTY OF THE IRKUTSK POLYTECHNIC INSTITUTE IN 1986. HE HAS BEEN DEVELOPING REGIONAL AND LOCAL DYNAMIC PHYSICAL AND GEOLOGICAL MODELS TO DISCOVER MINERAL DEPOSITS (SUCH AS DIAMONDS, GOLD, COMPLEX ORES, HYDROCARBONS ETC.) EVER SINCE. HE HAS AUTHORED AND CO-AUTHORED OVER 200 RESEARCH PAPERS, INCLUDING: 40 ARTICLES IN RUSSIAN AND FOREIGN JOURNALS, 1 MONOGRAPH, 2 GUIDEBOOKS. HOLDER OF THE PRESIDENTIAL GRANT, AS WELL AS THE GRANT OF THE HEAD OF THE REPUBLIC OF SAKHA (YAKUTIA). HOLDER OF THE MINERAL EXPLORATION AWARD ISSUED BY THE RUSSIAN MINISTRY OF NATURAL RESOURCES.

GEODYNAMIC INTERPRETATION OF THE SIBERIAN CRATON'S PALEOMAGNETIC DATA DURING THE KIMBERLITE FORMATION PERIOD

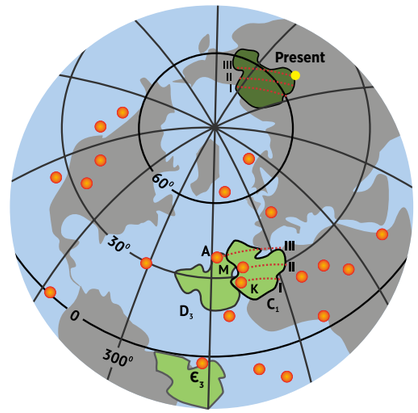
(late Devonian – early Carboniferous periods)



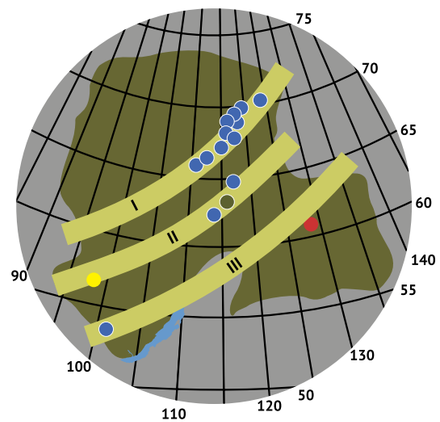
A – Current (in yellow) and paleographic (in green) locations of the Siberian craton. Aligning the calculated paleomagnetic pole (PN) with the northern geographic pole (N) according to the dipole model of the magnetic field to reconstruct the craton



B – The seeming migration trajectory of the Siberian craton's paleomagnetic pole from the late Cambrian to the Triassic period. 500, 480... million years ago



C – Paleomagnetic reconstructions of the Siberian craton in late Devonian (D3) and early Carboniferous (C1) periods. C – Canary islands, M – Madeira islands, A – Azorean islands



D – The location of the old, new and the assumed (in blue, red/ green and yellow, respectively) kimberlite fields in relation to the calculated hot spot tracks

Legend

Magnetic field vector

500

The seeming migration trajectory of the paleomagnetic pole (according to Torsvik, 2012)

Hot spots (according to Muller, 1993)

Assumed hot spot track (according to A. Zhitkov, 1995): I – Alakit-Kuoisky, II – Mirninsky, III – Okinsky

Known kimberlite fields

Khompu-Mayskoe kimberlite field

Biryusinsko-Chunskoye kimberlite field

Suldyukarskoye kimberlite field

the Siberian craton (1) find evidence of northern magnetic pole displacement.

By consecutively connecting the coordinates of the paleomagnetic pole over time, one can reconstruct a trajectory of its seeming migration (see fig. B). This trajectory provides a quantitative basis for addressing a wide range of scientific and applied geological and geophysical challenges as well as searching for diamond deposits. For instance, the late Cambrian period's paleomagnetic pole (dating back to 500 million years ago) is located south of Australia. However, according to the dipole model of the magnetic field, unlike the migration of the continents, the migration of this pole is only seeming. Therefore, by aligning the geographic pole with the late Cambrian period's paleomagnetic pole, we will discover that 500 million years ago, the Siberian craton used to be in the western hemisphere, in eastern Brazil. The Siberian craton's former location in the equatorial belt has been proven by numerous paleomagnetic, paleontological, paleoclimatological and other studies.

Paleomagnetology is a branch of historical geophysics that studies the magnetic fields of past geological periods preserved via natural remnant magnetization – In. Paleomagnetism refers to rocks' natural ability to record geophysical information like magnetic hard disk.

How does it occur? Almost all rocks, including sandstones, basalts, kimberlites and many others, contain magnetic minerals (such as magnetite, hematite, pyrrhotite and others). When they form – through magma cooling, particle settling or other geological processes – the magnetic minerals in them align along the existing magnetic pole, like a compass needle. In other words, within the course of their formation, the rocks record their paleographic coordinates just like travelers writing in their diaries. This magnetic needle-like property can be used to calculate the coordinates of a paleomagnetic pole. We use special magnetometers and demagnetizing devices to measure vectors, and deploy computer programs to interpret the paleomagnetic data.

African volcanoes burning through Siberia

With the help of special devices and computer programs designed to reconstruct the paleomagnetic field, scientists pinpointed the location of the Siberian craton at the time when its volcanic diamond pipes were formed. Back then, it was located to the northwest of today's African shores, next to the Strait of Gibraltar.

That was when the Siberian craton passed over three "hot spots" that, according to the studies (2), later formed the chain of modern volcanic islands: Madeira, Canary and Azorean islands. These hot spots formed as a result of a heat transfer taking place at the core-mantle boundary located 2900 km deep. They could be the source of the energy necessary for the formation of volcanic pipes.

These hot spots burning through the Siberian lithosphere(3) could leave the following "prints", or tracks: Alakit-Kuoisky, Mirninsky and Okinsky, which now contain kimberlite fields.

This hypothesis was confirmed over 10 years after its emergence, when a new kimberlite field called Hompu-Mayskoye was discovered n the northeastern section of the Oka track in 2007, with Syuldyukarskoye field discovered on the Mirny track in 2015.

The Institute of Earth's Crust of the Russian Academy of Sciences' Siberian Branch had obtained a permit and is now carrying out diamond exploration in the Biryusinsko-Chunsky district, located on the southwestern section of the Mirninsky track found in the south of the Siberian craton. If this geodynamic model of kimberlite formation is true, the search for primary diamond deposits should be concentrated within these tracks. The territory around the so-called hot spots can also prove to be rich in iron, hydrocarbons and other mineral resources.

(1) Torsvik T.H., van der Voo R., Preeden U., Niocaill C.M., Steinberger B., Doubrovine P.V., van Hinsbergen D.J.J., Domeier M., Gaina C., Tohver E., Meert J.G., McCausland P.J.A., Cocks R.M., 2012 Phanerozoic polar wander, palaeogeography and dynamics. Earth-Science Reviews 114 (3–4), p. 325–368

(2) Muller R.D., Royer J.-Y., Lawver L.A., 1993 Revised plate motions relative to the hotspots from combined Atlantic and Indian Ocean hotspot tracks. Geology 21 (3), p. 275–278.

(3) Zhitkov A.N., 1995 Paleokinematiks and pattern of kimberlite fields location on the Siberian platform based on the hypothesis of hot spots. In: Extended abstracts Sixth International kimberlite conference. Novosibirsk, p. 692–694