Труды Карельского научного центра РАН. 2026. № 2. С. 92–96
Transactions of the Karelian Research Centre RAS. 2026. No. 2. P. 92–96
DOI: 10.17076/geo2152

УДК 551.24:551.71 (540)

EARLY PRECAMBRIAN CRUSTAL EVOLUTION OF THE BUNDELKHAND CRATON, INDIAN SHIELD

V. K. Singh[1], **A. Slabunov**[2]*

[1] *Department of Geology, Institute of Earth Science, Bundelkhand University (284128 Jhansi, India)*
[2] *Institute of Geology, Karelian Research Centre, Russian Academy of Sciences (11 Pushkinskaya St., 185910 Petrozavodsk, Karelia, Russia), *slabunov@krc.karelia.ru*

The Earth's crust of the Bundelkhand Craton formed during the Paleo-Neoarchean (3.56–2.5 Ga) through subduction and accretion–collision processes. Early tonalite-trondhjemite-granodiorite (TTG) associations, along with the associated amphibolites and quartzites, were formed during the Archean. At ~2.85 Ga, a subduction zone was formed in the southern part of the South Bundelkhand terrane. Some fragments of its supra-subduction portion are preserved as basalt and banded iron formation (BIF) sequences in the Girar greenstone belt. About 2.81 Ga ago, a subduction system was formed along the southern margin of the older TTG core and the associated mafic–ultramafic crust in the Central Bundelkhand terrane. Its fragments are preserved as basalt, rhyolites and BIF sequences in the Mauranipur belt, as well as manifestations of eclogite-facies metamorphic events. 2.8 Ga ago, the large Ikauna mafic-ultramafic lopolith was formed in the central part of the Southern Bundelkhand terrane. Its formation was probably provoked by a mantle plume. Ca 2.7 Ga ago, early accretionary processes, indicated by metamorphism under up to amphibolite-facies conditions, took place in the South and Central Bundelkhand terranes. A major accretionary-collisional event, during which the consolidated block of continental crust was formed, took place in the Late Neoarchean (2.54–2.50 Ga). In the Paleoproterozoic (2.0–1.8 Ga), the craton was reworked by plume and directed deformations associated with a collisional system along the margin of the Columbia Supercontinent. In the Neoproterozoic, Early Precambrian complexes were overlain by Vindhyan basin sediments and were exposed as late as in the Phanerozoic.

Keywords: Archean; Proterozoic; crustal evolution; geodynamics; Indian Shield; Bundelkhand Craton

For citation: Singh V. K., Slabunov A. Early Precambrian crustal evolution of the Bundelkhand Craton, Indian Shield. *Trudy Karel'skogo nauchnogo tsentra RAN = Transactions of the Karelian Research Centre RAS*. 2026. No. 2. P. 92–96. doi: 10.17076/geo2152

Funding. This study is a contribution to the research carried out by the Institute of Geology KarRC RAS, Project FMEN-2023-0009. The research is implemented under the Memorandum of Understanding between Bundelkhand University, Jhansi, India and Karelian Research Centre RAS, Petrozavodsk, Russia.

В. К. Сингх[1], А. И. Слабунов[2]*. ЭВОЛЮЦИЯ ЗЕМНОЙ КОРЫ БУНДЕЛКХАНДСКОГО КРАТОНА ИНДИЙСКОГО ЩИТА В РАННЕМ ДОКЕМБРИИ

[1]Геологический факультет Бунделкхандского университета (Джанси, Индия, 284128)
*[2]Институт геологии КарНЦ РАН, ФИЦ «Карельский научный центр РАН» (ул. Пушкинская, 11, Петрозаводск, Республика Карелия, Россия, 185910), *slabunov@krc.karelia.ru*

Земная кора Бунделкхандского кратона сформировалась в палео-неоархее (3,56–2,5 млрд лет (Ga)) в ходе субдукционных и аккреционно-коллизионных процессов. В палеоархее образовалась ранняя ассоциация тоналит-трондьемит-гранодиоритов (ТТГ), а также сопряженные с ними амфиболиты и кварциты. В 2,85 Ga формируется зона субдукции в южной части Южно-Бунделкхандского террейна, фрагменты надсубдукционной части которой сохранились в Гирарском зеленокаменном поясе в виде толщи базальтов и BIF. Около 2,81 Ga формируется субдукционная система к северу от древнего ядра Южно-Бунделкхандского террейна, ее фрагментами являются базальты, риолиты и BIF Мауринипурского зеленокаменного пояса, а также проявления эклогитового метаморфизма. В 2,8 Ga в центральной части этого террейна, вероятно, под влиянием мантийного плюма сформировался крупный Икоунский мафит-ультрамафитовый лополит. Около 2,7 Ga происходят ранние аккреционные процессы, зафиксированные в Южно- и Центрально-Бунделкхандском террейнах метаморфическими преобразованиями в условиях доамфиболитовой фации. В позднем неоархее (2,54–2,50 Ga) происходит главное аккреционно-коллизионное событие, в ходе которого образуется консолидированный блок континентальной коры. В палеопротерозое (2,0–1,8 Ga) земная кора кратона претерпела преобразования под воздействием плюма и наведенных деформаций от коллизионного орогена на краю суперконтинента Колумбия. В неопротерозое раннедокембрийские комплексы оказались перекрыты осадками синеклизы Виндхая и были выведены на поверхность только в фанерозое.

Ключевые слова: эволюция земной коры; геодинамика; архей; протерозой; Индийский щит; Бунделкхандский кратон

Для цитирования: Singh V. K., Slabunov A. Early precambrian crustal evolution of the Bundelkhand Craton, Indian Shield // Труды Карельского научного центра РАН. 2026. № 2. С. 92–96. doi: 10.17076/geo2152

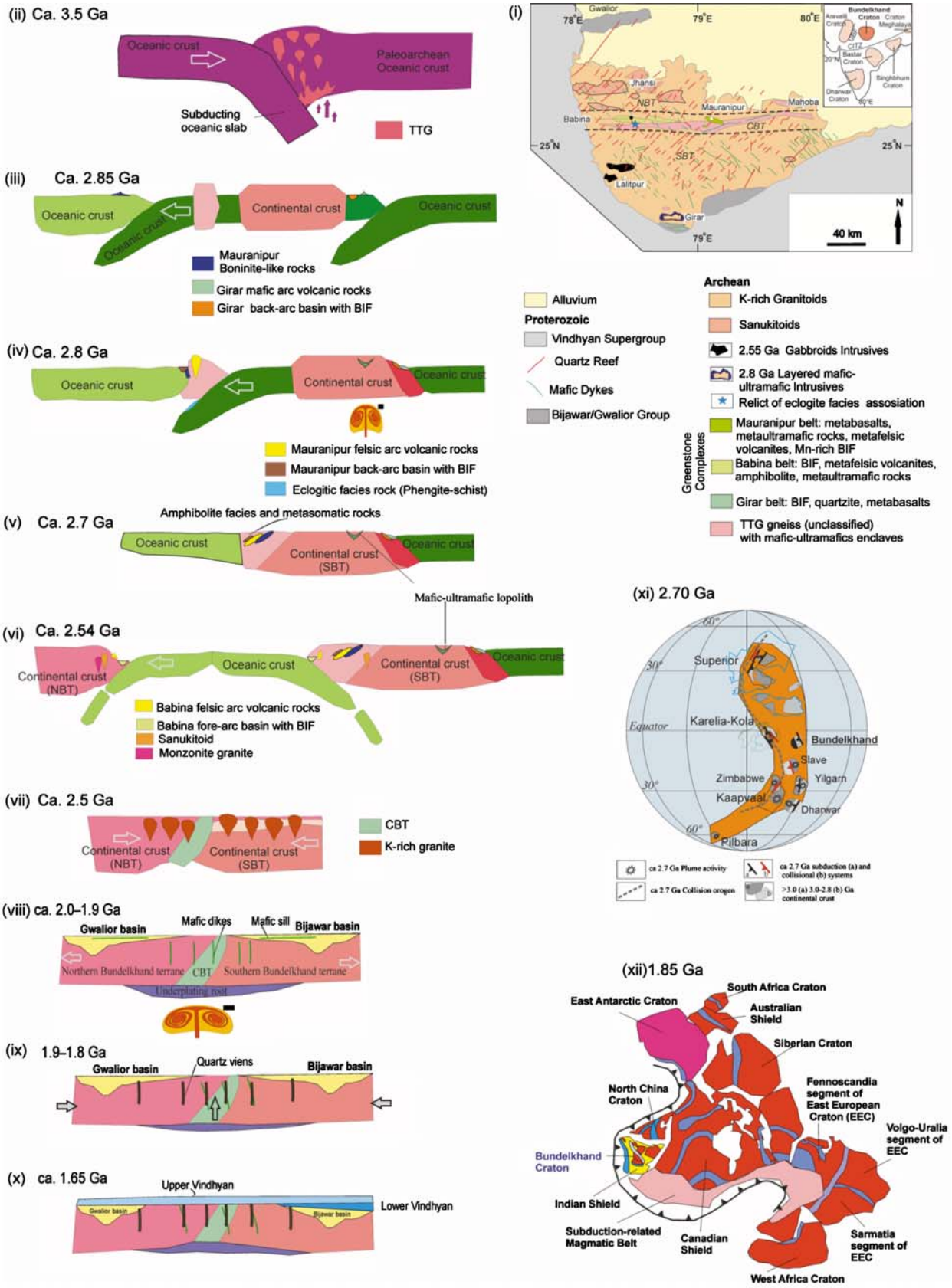
Финансирование. Работа является вкладом в исследования ИГ КарНЦ РАН по теме FMEN-2023-0009. Исследования проводятся в рамках Меморандума о взаимопонимании между Бунделкхандским университетом (Джанси, Индия) и КарНЦ РАН (Петрозаводск, Россия).

Introduction

The Bundelkhand Craton is the largest outcrop of early Precambrian rocks in the northern part of the Indian Shield [Ramakrishnan, Vaidyanadhan, 2010] (Fig., i). This craton is semicircular, covering an area of approximately 2900 km^2. Our understanding of the crustal evolution of the Bundelkhand Craton has greatly changed over the past decade [Roy, Purohit, 2018; Jain et al., 2020; Pati, Singh, 2020], mainly due to extensive geochronological information becoming available and to some geological discoveries (primarily a system of greenstone belts, Neoarchean sanukitoids and gabbro [Joshi, 2014; Slabunov, Singh, 2019; Slabunov et al., 2024, 2025]). This paper is the first attempt to briefly summarize these data in the form of graphic geodynamic models.

Main results and discussion

The Bundelkhand Craton is predominantly composed of Neoarchean K-rich granite, with smaller occurrences of Archean tonalite-trondhjemite-granodiorite (TTG), greenstone complexes, layered intrusions, granitoid and gabbroid massifs (Fig., i). The Bundelkhand Craton is sur-



Geological map of the Bundelkhand craton and inset map showing the cratons of the Indian Shield (i), Geodynamic evolution of the Bundelkhand Craton crust during 3.5–1.65 Ga (ii–x) and the Bundelkhand Craton locations on the Kenorland (xi) and Columbia (xii) supercontinents in the Neoarchean (ca. 2.7 Ga) and Paleoproterozoic (ca. 1.85 Ga) [Singh et al., 2020; Mishra et al., 2022; Nance, 2022; Slabunov, Singh, 2022; Slabunov et al., 2025]. NBT, CBT, SBT; denote North, Central and South Bundelkhand terranes

rounded by three Paleoproterozoic basins to the northwest, south and southeast, which are overlain by the Paleo-Neoproterozoic Vindhyan Supergroup [Roy, Purohit, 2018]. The Indo-Gangetic alluvial plains separate the Bundelkhand Craton from the Himalayan collisional orogen [Mishra et al., 2022].

The Bundelkhand Craton is subdivided into three terranes: the North-, Central- and South Bundelkhand terranes (Fig., i) [Singh et al., 2021].

The oldest (3.56–3.2 Ga) TTG–granitoid complexes [Kaur et al., 2016; Nasipuri et al., 2019] in the Central Bundelkhand terrane are generally associated with mafic–ultramafic rocks [Singh et al., 2019] and quartzites, which resemble other cratonic rocks of the Indian shield. The 3.4 Ga mafic–ultramafic rocks from the Babina greenstone belt were derived from a long-term depleted mantle source [Singh et al., 2019]. Their geochemical characteristics and associated rock assemblages suggest subduction processes occurring in an intra-oceanic arc setting during the Paleoarchean (Fig., ii).

The Bundelkhand Craton contains two Archean supracrustal greenstone complexes: the Central Bundelkhand and South Bundelkhand [Raza, Mondal, 2019; Slabunov, Singh, 2019; Hiloidari et al., 2021].

Around ~2.85 Ga, a subduction zone formed in the southern part of the South Bundelkhand terrane (Fig., iii). Some fragments of its suprasubduction components are preserved as a basalt and BIF sequences in the Girar greenstone belt [Slabunov, Singh, 2019; Hiloidari et al., 2021].

About 2.81 Ga ago, a subduction system was formed south of the old TTG core associated with the mafic and ultramafic crust of the Central Bundelkhand terrane (Fig., iv). Its fragments are preserved as basalt, rhyolites and BIF sequences in the Mauranipur greenstone belt [Slabunov, Singh, 2019], and as manifestations of eclogite-facies metamorphic events in the Babina greenstone belt [Sibelev et al., 2021].

Around 2.8 Ga, the large Ikauna mafic-ultramafic lopolith [Slabunov et al., 2024] was formed in the central part of the South Bundelkhand terrane, likely triggered by a mantle plume (Fig., iv).

Ca 2.7 Ga ago, early accretionary processes occurred, as indicated by metamorphism reaching up to amphibolite-facies conditions in the South and Central Bundelkhand terranes [Sibelev et al., 2021] (Fig., v). The Bundelkhand craton was part of Kenorland Supercontinent at that time (Fig., xi).

The ca. 2.58–2.55 Ga period marks a renewed phase of crustal growth, during which felsic subduction-type volcatites [Slabunov, Singh, 2019], BIFs formed in the Central Bundelkhand terrane, along with sanukitoids, granitoids, gabbro, gabbro-diorite complexes in the North and South Bundelkhand terranes (Fig., vi).

About 2.5 Ga ago, all the terranes were amalgamated through accretion-collision processes, forming an integral fragment of consolidated crust (Fig., vii). During this stage of crustal evolution, Neoarchean (2.53–2.51 Ga) K-rich granites, the most common group of rocks in the craton, were formed [Singh et al., 2020].

During the Paleoproterozoic (2.0–1.7 Ga), the Bundelkhand Craton was rimmed by the Bijawar and Gwalior rift-related basins [Colleps et al., 2021] (Fig., i, viii). These structures caused both extensional and compressional deformation of the craton and were associated with significant magmatic and hydrothermal activity (Fig., ix). Giant quartz veins were produced by this activity, which manifested itself twice: at ca. 1870 Ma and ca. 1780 Ma [Slabunov, Singh, 2022]. These Paleoproterozoic (1.9–1.8 Ga) giant quartz veins of the Bundelkhand Craton could have been produced by plume activity along the margin of the Columbia Supercontinent [Mishra et al., 2022] (Fig., xii).

In the late Proterozoic (1.74–0.85 Ga), the older rocks of the craton and early rift-related structures provided the basement for the Vindhyan Supergroup succession (Fig., x). This 4.5–9 km thick sedimentary sequence (comprising conglomerate, sandstone, shale, limestone, quartzite) with stromatolites and scarce interbeds enriched in felsic tuffaceous material constitutes the largest Proterozoic sedimentary basin of the Indian Shield [Roy, Purohit, 2018].

The latest endogenic activity in the region is displayed by the Mesoproterozoic (ca. 1.1 Ga) Majhgawan kimberlite [Ramakrishnan, Vaidyanadhan, 2010].

The Archean rocks of the craton were exposed during the Phanerozoic, but this event has not been precisely dated yet.

Main conclusions

1. The continental crust of the Bundelkhand Craton formed during the Archean (3.56–2.5 Ga) through subduction, accretion and collision processes.

2. In the Proterozoic, the earth crust of the craton was affected by mantle plumes and collision processes. In the Neoproterozoic, Early Precambrian complexes were overlain by Vindhyan basin sediments.

References

Colleps C. L., McKenzie N. R., Sharma M., Liu H., Gibson T. M., Chen W., Stockli D. F. Zircon and apatite U-Pb age constraints from the Bundelkhand Craton and Proterozoic strata of central India: insights into craton stabilization and subsequent basin evolution. *Precambrian Res.* 2021;36:106286. doi: 10.1016/j.precamres.2021.106286

Jain A. K., Banerjee D. M., Kale V. S. Tectonics of the Indian subcontinent. Springer Cham.; 2020. 576 p. doi: 10.1007/978-3-030-42845-7

Joshi K. B. Petrological, geochemical and U-Pb zircon geochronological studies of the Bundelkhand granitoid complex, Central India: constraints on Archean crustal evolution: PhD (Cand. of Geol.) thesis. Delhi; 2014. 310 p.

Hiloidari S., Satyanarayanan M., Singh S. P., Bhutani R., Subramanyam K. S. V., Srinivasa Sarma D. Evidence for Mesoarchean subduction in Southern Bundelkhand Craton, India: geochemical fingerprints from metavolcanics of Kurrat-Girar-Badwar Greenstone Belt. *Geochemistry*. 2021;81:125787. doi: 10.1016/j.chemer.2021.125787

Kaur P., Zeh A., Chaudhri N., Eliyas N. Unravelling the record of Archaean crustal evolution of the Bundelkhand Craton, northern India using U-Pb zircon–monazite ages, Lu–Hf isotope systematics, and whole-rock geochemistry of granitoids. *Precambrian Res.* 2016;281:384–413. doi: 10.1016/j.precamres.2016.06.005

Mishra S., Slabunov A. I., Nainwal H. C., Singh V. K., Singh P. K., Nesterova N. S., Svetov S. A. Palaeoproterozoic S-type granites from Garhwal Himalaya, NW India: geochemistry, Sm–Nd isotope systematics and tectonic implications. *Geol. J.* 2022;57(6):2443–2463. doi: 10.1002/gj.4421

Nasipuri P., Saha L., Hangqiang X., Pati J. K., Satyanaryanan M., Sarkar S., Bhandari A., Gaur Y. Paleoarchean crustal evolution of the Bundelkhand Craton, north Central India. *Earth's Oldest Rocks*. 2nd ed. Amsterdam: Elsevier; 2019. P. 793–817. doi: 10.1016/B978-0-444-63901-1.00031-9

Nance R. D. The supercontinent cycle and Earth's long-term climate. *Ann. NY Acad. Sci.* 2022;1515:33–49. doi: 10.1111/nyas.14849

Pati J. K., Singh A. K. Bundelkhand Craton. *Proc. Indian Natl. Sci. Acad.* 2020;86(1):55–65. doi: 10.16943/ptinsa/2020/49792

Ramakrishnan M., Vaidyanadhan R. Geology of India. Vol. I. Geological Society of India. Bangalore; 2010. 556 p.

Raza A., Mondal M. E. A. Rocks of Mauranipur-Babina Greenstone Belt, Bundelkhand Craton, Central India: implication for tectonic settings during the Archaean. *Geological Evolution of the Precambrian Indian Shield*. Society of Earth Scientists Series. Springer; 2019. P. 577–607. doi: 10.1007/978-3-319-89698-4_22

Roy A. B., Purohit R. Indian Shield: Precambrian evolution and Phanerozoic reconstitution. Elsevier; 2018. 375 p.

Sibelev O. S., Slabunov A. I., Singh V. K., Mishra S. Metamorphism of the Central Bundelkhand greenstone complex of the Bundelkhand Craton, Indian Shield and its geodynamic setting. *Geological and Geo-Environmental Processes on Earth*. Springer Nature; 2021. P. 143–154. doi: 10.1007/978-981-16-4122-0_9

Singh P. K., Verma S. K., Moreno J. A., Singh V. K., Malviya V. P., Oliveira E. P., Arima M. Geochemistry and Sm–Nd isotope systematics of mafic-ultramafic rocks from the Babina and Mauranipur greenstone belts, Bundelkhand Craton, India: implications for tectonic setting and Paleoarchean mantle evolution. *Lithos*. 2019; 330–331:90–107. doi: 10.1016/j.lithos.2019.02.010

Singh V. K., Slabunov A. I., Nesterov N. S., Singh M. M., Bhatt S. C. Tectonostratigraphic terranes of the Bundelkhand Craton (Indian Shield). *Geological and Geo-Environmental Processes on Earth*. Springer Natural; 2021. P. 155–164. doi: 10.1007/978-981-16-4122-0_ 10

Singh V. K., Verma S. K., Singh P. K., Slabunov A. I., Chaudhary N., Mishra S. Archean crustal evolution of the Bundelkhand Craton: evidence from granitoid magmatism. *Archean Granitoids of India: Windows into Early Earth Tectonics. Geological Society, London, Special Publ.* 2020;489:235–259. doi: 10.1144/SP489-2018-72

Slabunov A. I., Egorova S. V., Singh V. K. Mesoarchaean mafic–ultramafic Ikauna layered intrusion, Bundelkhand Craton, India: geology, U–Th–Pb age (SHRIMP) and correlation. *International Geol. Rev.* 2024;66(22): 3814–3826. doi: 10.1080/00206814.2024.2361465

Slabunov A., Kervinen A., Mishra S., Singh V. Neoarchean gabbroids of the Southern Bundelkhand terrane, Bundelkhand Craton: new geochronology data and geodynamic settings. *Transactions of the Karelian Research Centre of the Russian Academy of Sciences*. 2025;5:39–43. doi: 10.17076/geo2154

Slabunov A. I., Singh V. K. Giant quartz veins of the Bundelkhand Craton, Indian Shield: new geological data and U-Th-Pb age. *Minerals*. 2022;12(2):168. doi: 10.3390/min12020168

Slabunov A., Singh V. K. Meso-Neoarchaean crustal evolution of the Bundelkhand Craton, Indian Shield: new data from greenstone belts. *Int. Geol. Rev.* 2019;61(11): 1409–1428. doi: 10.1080/00206814.2018.1512906

Поступила в редакцию / received: 28.07.2025; принята к публикации / accepted: 06.02.2026.
Авторы заявляют об отсутствии конфликта интересов / The authors declare no conflict of interest.

СВЕДЕНИЯ ОБ АВТОРАХ:

Сингх Винод Кумар

д-р наук, профессор

e-mail: vinodksingh@bujhansi.ac.in

Слабунов Александр Иванович

д-р геол.-мин. наук, главный научный сотрудник, руководитель лаборатории геологии и геодинамики докембрия

e-mail: slabunov@krc.karelia.ru

CONTRIBUTORS:

Singh, Vinod

PhD, Professor

Slabunov, Alexander

Dr. Sci. (Geol.-Miner.), Head of Laboratory, Chief Researcher