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Geological Surveys by Russian Mining Engineers in the Last Quarter of the 19th Century

Irina V. Voloshinova and Anton B. Mokeev
Department of History, National University of Mineral Resources "Mining",
21st Line 2, Vasil'evsky Island, 199106 Saint Petersburg, Russia

Abstract: Geological prospecting and exploration that were conducted in Russia in the 18th century, built a material foundation to understand the geological structure of the country but mostly of its European part. The overall volume of prospecting operations, carried out on the territory of Russia at the time was insignificant. The industrial revolution that began in Russia in the period and growing needs of the mining business in the second half of the 19th century made it necessary to dispatch prospecting and exploration parties to the Urals, Altai, Siberia, Caucasus, the Donets Basin and other regions of Russia. Developing vast territories of Russia and its numerous fields was impossible without a detailed study into their geological aspects and mapping. This study focuses on the contributions to the geological exploration of Russia made by major mining engineers, geologists and directors of the Mining Institute in last quarter of the 19th century. This study is based on such sources as archival materials, monographs and legislative acts.

Key words: Geological prospecting, geological mapping, mineralogy, mineralogical society, geological committee

INTRODUCTION

The body of literature on the history of geological explorations in Russia and on Russia's leading mining engineers is very extensive. These are synthesis studies of the Geological Committee (Geolkom) (Khabakov, 1950) and the Mining Institute; works on specific geological expeditions (Karpinsky, 1881; Kulibin, 1883; Zuev, 2004); biographies of prominent geologists and mining engineers (Kleopov, 1964; Shafranovsky, 1964). Information about scientific and practical activities of some mining engineers is very scarce, although, they were ranked among the heads of the Mining Institute, worked closely with the Geolkom and contributed greatly to the geological study of the country but reviews of their professional life were limited to their work at the institute. The study draws the example of scientific and practical activities undertaken by the professorate of the Mining Institute and the Geological Committee to define their role and contribution to the geological exploration of the country in the last quarter of the 19th century.

MATERIALS AND METHODS

The main methods include aspects of the regional approach presented using the Russian material in monographs on the history of geological prospecting as well as features of the situational approach utilized to consider the history as a result of collaboration between various historians. The basis of the article has been provided by archival materials and published sources.

RESULTS

By the end of the 19th century, joint efforts of mining engineers and directors of the Mining Institute and Geolkom experts helped study more than two-thirds of European Russia including the Urals and the caucasus as well as begin explorations of the Kuzbass, Amur region, Primorye and Sakhalin. Works in Central Asia created geological maps of large areas in Turkmenia, Kazakhstan and Tajikistan. The total scale of prospecting operations at the national level was large enough and Russia's subsurface deposits were continuously explored. But a number of objective factors militated against the plans of a full-fledged exploration of Russia and rational geographical distribution of its industry.

DISCUSSION

In the 18th century, the territory of the Russian Empire was expanded by thousands versts to the East. The Volga and Ural regions were no longer the country's

Corresponding Author: Irina V. Voloshinova, Department of History, National University of Mineral Resources "Mining", 21st Line 2, Vasil'evsky Island, 199106 Saint Petersburg, Russia

outskirts and the government launched large-scale prospecting of natural resources to be discovered in the Ural Stone Belt. In 1737-1743, the Volga region and the Urals were studied by the first physical expedition which was initiated by the Academy of Sciences and led by Ivan Kirilov and Vasily Tatishchev. And in 1768-1774, the second similar expedition was sent to the area, headed by Peter Pallas. Materials obtained by the 18th century geological expeditions laid the basis for an ambitious geodesic effort by the Russian government an ordnance survey. It was aimed at producing accurate maps of all regions in the Russian Empire. The works began already in 1765 in the St. Petersburg and Moscow provinces. Surveyors gradually moved throughout the rest of European Russia, mapping more and more area. In total, topographic surveyors traveled across 36 provinces and the result was an own verst map for each uezd. No such high precision maps had existed before. It soon became apparent that Russia's economic needs and defense interests required no simple geographical descriptions from scientists but in the first place detailed nationwide geological surveys (Erofeev, 2013).

The founder of the Russian school of geological cartography and the author of one of the first geological maps in Russia was a professor of geology at the St. Petersburg Mining Institute, G.P. Gel'mersen (General Map of the Mountainous Formations of European Russia, 1841) which brought him the Demidov Prize of the Academy of Sciences in 1843. Gel'mersen began his geological studies in little-known areas of the Urals, Altai and Central Asia in the 1830s. Over several decades he explored coal, oil and iron ore districts (Donetsk and Dabrowski Coal Basins, Urals deposits, brown coals on the territory of Kiev, Grodno, Kherson and Moscow regions), mud volcanoes and oil fields on the Taman and Kerch Peninsulas. From 1865-1872, he served as the Director of the Mining Institute. It was in his leadership that the Mining Institute was reorganized from a closed military training center in an open civil educational institution.

In 1845, England saw the publication of Geology of Russia in Europe and the Ural Mountains (in the Russian translation The Geological Description of European Russia and the Ural Mountain Range, Parts 1-2, 1849) by Sir Roderick Impey Murchison, a well-known English geologist who first described and investigated the Silurian, Devonian and Permian geological periods. The visit by R. Murchison to Russia was caused by a dispute which received wide publicity in the scientific world, between two scientists of the Mining Corps., geologist G.P. Gel'mersen and paleontologist E.I. Eichwald. Paleontology, then a young discipline, put much clarity in old geology. G.P. Gel'mersen defined geological formations using mineralogical and physical characteristics and followed traditional methods without considering paleontological data. Based on observations, he classified a series of strata that lay near Novgorod as new red sandstone. Paleontologist Eichwald studied the fossils from these strata and immediately concluded that Gel'mersen was wrong and the beds belonged to the Devonian system. Gel'mersen took Eichwald's statement as a personal insult. To resolve the dispute, the opponents appealed to the greatest authority of the time a famous German geologist, Leopold von Buch (1774-1853) who announced that Eichwald was right.

This dispute aroused deep interest of R.I. Murchison. With a wish to compare the sediments studied by him in England and the formations described by Gel'mersen and Eichwald, Murchison proposed the Russian government to arrange a special expedition to explore the geological structure of European Russia. Having obtained the required consent, Murchison invited Edouard de Verneuil, a French paleontologist and Alexander von Keyserling, a budding naturalist, later a well-known zoologist, geologist and traveler to take part in his expedition. In spring 1840, the three scientists arrived in St. Petersburg (Shafranovsky, 1964).

The assignment to accompany Murchison in his trip around Russia was given to mining engineer N.I. Koksharov. He was also to compile geological and paleontological collections and carry out practical survey of the Carbonifeorus formations. Murchison highly appreciated the role of the young mineralogist in his expedition. Subsequently, when he prepared his geological map of Russia for publication, he felt it necessary to put the name of the young Russian in the signature to the work scientist along with his own name: "On-site observations were made together with Lieutenant Koksharov".

This map was improved by Russian mining engineers. A graduate of the Mining Institute, Vasili G. Erofeev, taught there paleontology. V.G. Erofeev was responsible for preparation of illustrative materials for lectures on paleontology and he correlated the geological map with paleontological illustrations of individual systems. He arranged the fossils on colored tablets, painted in the symbolic colors from Murchison's geological map. It was an innovative method of organically connecting paleontology and a geological map which later was adopted in many countries. This allowed students to easily memorize the geological age of the fossils as the knowledge was absolutely necessary to make geological description and draw sheets of the Russian geological map (Romanovsky, 1982). Over time, V.G. Erofeev

upgraded his initial technique by developing very illustrative keys for faunas in all stratigraphic periods. They were published in the Russian translation of Murchison's Geology of Russia. Students and professionals made use of them for many years. These keys were based on the same paleontological collections of the Mining Museum where Vasili Erofeev continued to work in parallel to his entire pedagogical service. In the mid-60s, he was actively assisted in this endeavor by a senior student of the Institute, A.P. Karpinsky, an outstanding Russian geologist in the future (Romanovsky, 1982).

Since the late 1870s, Erofeev was engaged in the geological exploration of the Samara, Simbirsk, Kazan, Novgorod, Chernigov and Ekaterinoslav provinces. This research resulted in a tabulated summary of geological formations in these areas. In 1877, Vasili Erofeev estimated possibilities of oil production in some Volga provinces and made a negative conclusion. In 1879, he visited the Borovichi uezd in the Novgorod Province to assess the prospects of the Borovichi coal field and determined that coal "albeit mediocre but is suitable to many technical applications." Erofeev is largely acclaimed for his major discovery of rock salt deposits in the Slavyano-Bakhmut salt-bearing region of the Donbass in Southern Russia. He even identified the exact drilling site for exploratory wells (near the village of Briantsevka) that revealed rich deposits of rock salt. A.P. Karpinsky wrote about this discovery: "This has given rise to the development of an extensive and entirely new mining industry in southern Russia where it has never been expected to be found" (Karpinsky, 1945).

Following the adoption of the Mining Institute's new Charter in 1866, Erofeev was elected one of the first nine professors at its departments. He headed the Department of Paleontology. In addition, V.G. Erofeev was author of the first finely lithographed paleontology course book Fossil shellfish that was the only learning aid for students and provided guidance to many engineers in their research (Nikitin, 1885). His successor as head of the Department of Paleontology became Professor V.I. Moller, a mining engineer, corresponding member of the Russian Academy of Sciences, who had a vast experience of geological and paleontological research. In 1861, he was dispatched to investigate the Carboniferous system of the Urals and in 1862 the geological structure of the Samara Bend. In 1863-1867, he was engaged in geological explorations in the Nizhny Novgorod Province. In 1870, V.I. Moller was sent to the Urals to study the coal deposits located in the middle of this ridge in order to determine their importance in the design of the Ural Mining Railway which was prepared at the time (Central State Historical Archives, F.37, Op.53, D.399, L. 18).

Moller (1975) devoted much effort to geological survey. As early as in 1869, he published a geological map at a scale of 20 miles in one inch which showed the Western slope of the Ural mountain range, between the flows of the Vishera and Belaya rivers. This map was based on personal works conducted by expeditions in 1860, 1861, 1863, 1864, 1866, 1867 and 1868 and a study into available literary data. In addition to its high scientific value, this map was of great practical importance, since it first showed the strata layout in the carboniferous system and coal-bearing deposits and it served as a basis for prospecting of coal fields.

After he completed the geological map of the Urals Western slope, V.I. Moller got down to a detailed investigation into some areas on the slope, most promising from a practical view point. For example, between 1871 and 1874, V.I. Moller on the instructions of the Mining Department carried out thorough geological explorations in the Ilim and Utka river state-owned lands. The work was organized to verify the possibility of finding coal on the territory of the state-owned mining lands on the Western slope of the Urals. As a result, these explorations identified the geological structure of the Ilim and Utka river state-owned lands and gave a negative conclusion on coal deposits there suitable for development.

In 1876, using these works as a model, V.I. Moller organized and carried out detailed explorations of the Aleksandrovskaia plot of woodland in the Urals with its famous Lun'evka coal deposits. Years-long studies into carboniferous deposits on the Western slope of the Urals provided V.I. Moeller with rich paleontological material. When he analyzed it, V.I. Moeller concentrated first on brachiopods and trilobites and then on foraminifera. The research into the latter in 1878-1880 produced two monographs that elaborated on 14 generic types and 43 species of foraminifera in the carboniferous limestone of Russia. A study of the vertical proliferation of foraminifera gave V.I. Moeller an opportunity to identify in the carboniferous limestone of Russia three divisions which were characterized by remains of various foraminifera. High scientific importance of V.I. Moller's monograph on foraminiferal species was recognized by the Imperial Academy of Sciences which was awarded this research the Academician Brandt Prize in 1881. In 1893, Professor Moller (1980) was appointed Director of the St. Petersburg Mining Institute. Then in 1880, V.I. Moller initiated geological explorations in order to draw up a ten-verst map of the Western slope of the Southern Urals. V.I. Moller was directly involved in these exploratory studies, mainly in the Ufa and Sterlitamak uezds.

These scientific and practical prospecting expeditions yielded a diverse array of new materials on geology and mineralogy. The Mineralogical Society, founded in 1817, led all geological investigations of Russia (since 1864 the St. Petersburg Imperial Mineralogical Society). Mineralogy which had predominantly a descriptive nature included crystallographic (crystal morphology) and chemical fields that evolved in parallel. In Russia, the first discipline was initially developed by a mining engineer, director of the Mining Institute (1872-1881), N.I. Koksharov, who became the founder of the new scientific field in Russia, replacing the outdated method of qualitative description of minerals with a mathematically precise crystallographic study, chemical analysis and physical research. The list of Koksharov's works consisted of 155 titles that in addition to descriptions of minerals, contained articles, dealing with general issues of mineralogy and crystallography and results of the study into artificial compounds. In 1865, Koksharov became Director of the Mineralogical Society. His scientific work Materials for Mineralogy of Russia consisted of 11 volumes (1853-1892). The general index provides more 400 names of Russian minerals described by Koksharov. There was a whole group of minerals first discovered in Russia: euclase, brookite, yellow cancrinite, wollastonite, halkofinit hydrohetaerolite, copper sulphate. Koksharov discovered a number of new mineral species and variants: ilmenorutile, clinochlore, kotschubeite, waluewite, bagrationite, mursinskite and others. The main value in Koksharov's work is attributed to the results of goniometric measurements that are still ranked among the most accurate and advanced assessments in mineralogical crystallography (Grigor'ev and Shafranovsky, 1949).

At this time, there Russia brought about creation of multiple cartographic documents required to manage different sectors of its economy. These materials served as a basis for corresponding general maps of economic sectors and even atlases which started to be published in the second half of the 19th century. But, the compiled geological maps were already out of date. Developing vast territories of Russia and its numerous fields was impossible without detailed studies into their geological aspects.

Forward-looking Russian geologists insisted that a Geological Committee should be established whose task would be to conduct geological surveys and prepare a comprehensive geological map of Russia. Creation of a geological survey was objectively related to the country's transition to a capitalist path of development. Rapidly expanding industries needed a continuous growth in raw materials and the efforts by voluntary scientific societies and university geologists were not nearly sufficient to ensure it. The first European country to pioneer the capitalist path was United Kingdom and it was this country that was the first to set up its own State Geological Survey. This took place back in 1832. A geological survey then created in Austria in 1849, in Canada in 1853, in France in 1855, in Sweden in 1858, in Italy in 1868, in Hungary in 1872, in Germany in 1873 and in Russia only in 1882 while objectively this should have happened back in the 60s. The reason for this setback was typical of Russia of that period: the tsarist bureaucratic officialdom hindered any progressive undertakings. For almost 20 years, it also stifled the initiative by Russian geologists to start the country's first geological institution. V.I. Moller was among those geological scientists, who spared neither effort nor time and energy and persistently worked to achieve their goal of creating a geological survey in Russia.

In 1863, G.P. Gel'mersen published an article "The Current State of Geology in Russia" where he pointed out that it was expedient to place all geological investigations in the country under the government control in other words, it was necessary to have an organization in Russia, similar to the British Geological Survey.

In the first half of February 1870, a memorandum addressed to the Minister of Finance M.Kh. Reutern was received from Duke Nikolai Maksimilianovich of Leuchtenberg. A few years later V.I. Moller admitted: "The first project I created was presented to former Minister of Finance M.Kh. Reutern by His Imperial Highness, Duke Nikolai Maksimilianovich". This curious detail and the fact that the memorandum was fully supported by Academician G.P. Gel'mersen, added particular interest to the document. It was the first time when the question of a state geological institution was discussed thoroughly and constructively. In particular, "Leuchtenberg's memorandum" proposed to differentiate positions full-time mining engineers and geologists and create for the latter a special institution at the Mining Institute. The state geologists aimed to "carry out as detailed geological explorations of the Russian Empire as possible, according to the plan previously formulated by the Institution Council and approved by the Minister of Finance." In addition, it was envisioned that "a general geological map of Russia was to be drawn up with a predetermined scale." April 6, 1871, the Minister of Finance ordered a special commission chaired by G.P. Gel'mersen be set up to discuss these proposals.

After several years of arduous work, the Commission came up with the "Project" of the future geological institution. March 10, 1876, it was signed. The eight signatories also included V.I. Moller. The outcome of the matter of was determined through the participation of

Russia (represented by V.I. Moller) in a number of international commissions on geological cartography. Before, the II International Geological Congress in 1881 in Bologna, V.I. Moller was to prepare a specific version of Russia's participation in these international events. And he convinced the Mining Department to return to the issue of establishing a national geological survey and January 21, 1880, he presented his variants (two) of the process, under which costs should not exceed 30,000 rubles a year. This proposal by V.I. Moller was combined with the slightly modified 1876 project and finally all parties came to the variant that satisfied both the Mining Department and the Ministry of Finance (Romanovsky, 1982).

January 19, 1882, a decree of Emperor Alexander III established the Geological Committee or Geolkom under the Mining Department. This was Russia's first state research geological institution. The scope of its responsibilities included the systematic investigation into the country's geology and mineral wealth, drawing of a general geological map and later geological surveys of individual mining areas (PSZRI T.2. No. 614). March 15, 1882 went down in history of the Russian geological survey as a significant date. This day saw the first meeting of the Geological Committee. According to the opinion of the Emperor, the Geological Committee ought to perform as follows: conducting systematic studies into the geological structure of the Russian territory. Compiling and publishing a detailed geological map. Amassing a systematic collection of rocks and minerals. Cooperating with other agencies as well as individuals on all aspects of geology.

Geolkom members were Russia's most prominent geologists. The Geological Committee's first director became 80 years old Academician G.P. Gel'mersen. But already November 1, 1882, G.P. Gel'mersen informed the Committee that "following his petition" he was dismissed from the post of director and that V.G. Erofeev was appointed as his successor. He had an invaluable experience and conducted vital geological studies that gave rise to salt production in Southern Russia.

Sciences advanced both at the Mining Institute and in St. Petersburg and Moscow Universities; these institutions had brilliant names in their faculties and strong departments. But no one set them an integral, comprehensive scientific and practical goal; they were engaged in the development of individual, albeit subtle, complex and challenging but still individual problems; no wonder that university and institute scientists themselves turned to Geolkom and it of course was willing to accept their services. It was considered a great honor to be "seconded" to the institution. Geolkom employed the "seconded" only after careful selection above all because of its limited ability to pay which further raised its prestige. December 1882 saw the first issue of News of the Geological Committee (Izvestiia geologicheskogo komineta) published which regularly presented main results of Geolkom's activities in the form of annual reports. Geolkom developed first guidelines (instructions) on geological maps drawing and unified graphic symbols.

Already in 1883, it prepared instructions for persons seconded by the geological committee to conduct systematic investigations into the geological structure of Russia and make its geological map which detailed requirements for frequency and accuracy of observations, methodology in analytical works, delivery system for reports on field works and their practical approval in the "Presence of the Committee".

Regional geology evolved on the basis of geological mapping from drafting route and general (small-scale) maps to large-scale ones for mining and oil areas. In Russia, geological surveys and developed methodological materials brought about a new school of geological cartography of the Geological Committee which had a significant influence on world geological cartography.

The creation of the Geological Committee made it possible to launch systematic geological studies in Siberia and the Far East. Along with the study of the raw material base of ferrous and non-ferrous metals and coal, the Geological Committee began exploring deposits of mineral water and agrochemical minerals. In the 19th century, the portfolio of minerals mined in Siberia became significantly broader.

Geological investigations into Siberia also stepped up as the construction of the Trans-Siberian Railway gained momentum. Geolkom was engaged in geological explorations along the route of the proposed railway. The operations were carried out by three mining parties: the West Siberian one (led by A.A. Krasnopol'sky), the Mid-Siberian one (led by K.I. Bogdanovich) and the Amur one (led by D.L. Ivanov). Route geological maps along the railway became the basis for the areal study of the regions.

In 1888, the Irkutsk Mining Department established the position of the state geologist. This was the beginning of the stage of planned systematic studies into vast territories along the constructed railway. Construction of railways required a huge amount of ballast, cement, bricks and other building materials. Therefore, numerous geological parties were busy identifying non-metallic minerals (clay, sand, stone and other). The railway fuel needs contributed to the exploration of coal deposits. At the end of the 19th early 20th century, Tankhoiskoe, Tarbagataiskoe, Holbonskoe,

Kharanorskoe and other coalfields were discovered and put into operation. In 1891, it was found out that coals were present in the North-Eastern part of Yakutia (Zyrianskii coal basin). Coal mining began in the previously known and newly discovered fields in the Kuzbass, Khakassia and other regions of Siberia (Elert, 2009).

One of the most essential results of the geological survey was the discovery of large deposits of phosphates in the Kostroma and Yaroslavl provinces, manganese in Ukraine of iron, gold, platinum, chromium, rock salt and coal in the Urals. In 1892, Geolkom started its Donetsk saga led by F.N. Chernyshov. L.I. Lutugin and N.O. Lebedev began compiling a detailed one-verst (1:42 000) geological map (Shafranovsky, 1951).

In 1885, Geolkom approved the draft general plan for the Geological Study of Russia which provided for a comprehensive geological survey of European Russia, the Donets Basin, the Urals and other regions. The 11 sheets of the 10-verst Geological Map of Russia were made within the shortest possible time (A.P. Karpinsky, S.N. Nikitin, F.N. Chernyshov, I.V. Mushketov, N.P. Barbot de Marni and others).

In 1893, the Geological Committee published the first complete geological map of the European part of Russia under the editorship of A.P. Karpinsky, scale 1: 2,520,000 (60 versts to the inch) and initiated works to draw a 10-verst general map of the same territory (1: 420,000). From this point on general geological maps of the country, created by Geolkom the A.P. Karpinsky Russian Geological Research Institute (VSEGEI) became an essential document for theoretical and mainly practical generalizations and conclusions leveraged to discover the county's mineral resource base. Active roles in the map compilation were played by members of the Mineralogical Society. Between 1882 and 1900, Notes of the Mineralogical Society (Zapiski Mineralogicheskogo Obshchestva) and Materials for Geology of Russia (Materialy dlia geologii Rossii) published 367 articles of which: on mineralogy 131, crystallography 39, geology 95, paleontology 50, petrology 23 and minerals 29 (Povarennykh, 1956).

In 1897, Russia was granted the right to hold the 7th session of the International Geological Congress which was attended by 704 delegates from 26 countries. It marked the highest-level recognition of merits and authority of the country's geological survey.

The news of the session in St. Petersburg was taken by Russian geologists as an opportunity, on the one hand, to show the global community of geologists the level of geological knowledge in Russia, on the other demonstrate the variety and diversity of geological features and landscapes in Russia: plains of Central Russia and Estonia with records of sedimentary rocks well-studied and faunistically characterized from the Paleozoic to the Cenozoic; ancient Finnish formations; young mountains of the Caucasus and Crimea; a unique storage of mineral resources the Urals. This stance was supported by the Russian government.

Session organizers paid much attention to the arrangement of geological excursions. Development of routes and their descriptions was contributed to by all prominent Russian geologists, members of the Geological Committee, professors at universities and mining institutes, local history-lovers as well as gymnasium teachers and directors. In 1896, to improve the accuracy of the geological structure and prepare guidebooks, future leaders of excursion groups traveled to the corresponding areas and drew detailed geological maps and sections. Elaborate itineraries comprised main directions and several variants of lateral branches for smaller groups. The guidebook compiled and published by the beginning of the session, contained 35 brochure chapters (660 pages) with a vast amount of geological information including photos, sections, maps and charts. It became an excellent summary of the regional geology of European Russia. In addition to the guidebook, delegates also received a geological 60-verst scale map of European Russia and the Urals published by the Geological Committee in 1893.

St. Petersburg welcomed the elite of World geology P.H. Groth, F.P Richthofen, K. Zittel and F. Zirkel from Germany, A. Gaudry, M. Bertrand and Ch. Barrois from France, J. Murray from Great Britain, J. Hall and S.F. Emmons from the USA, G. Capellini from Italy, E. Renevier, A. Heim and F.A. Forel from Switzerland and many other renowned geologists. Sessions were held from August 29 to September 5 in the halls of the Zoological Museum of the Academy of Sciences. The same building hosted an exhibition of the latest achievements in the field of geological knowledge which displayed: newest geological maps and geological literature; atlases of fossil flora and fauna; petrographic and paleontological collections including a large and comprehensive collection of soils, rocks and minerals of Japan; skeletons and skulls of large mammals; photographs of various landscapes, glaciers, mountain ranges and more (Keller, 1953).

CONLUSION

Thus, in the short period Russian mining engineers and geologists made a significant breakthrough in the geological study of their country, its mapping and other industries. They took tremendous efforts and the value of

their works can not be overestimated. The studies were conducted in conditions of underfunding, the inadequate number of mining engineers and limited personnel of geological committees, a policy of monopoly capital, national policy of tsarism that retarded the growth of national regions and many other negative factors. It was this background that made it impossible to implement plans of the full-fledged geological exploration of Russia and rational geographical distribution of its industry.

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