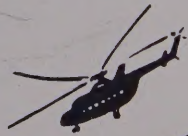
Mineral Resources to Serve People's Needs

Rudolph BALANDIN



The Soviet Experience

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Mineral Resources to Serve People's Needs

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Minerals and Modern Needs

● Industrial development is based on the treasures of the earth's interior. The iron-and-steel and non-ferrous-metals industries operate exclusively on mineral raw materials. In the chemical industry, they account for three-quarters of the total raw materials used. Much of the world's electric power is contributed by thermal and nuclear power stations using coal, gas, oil and radioactive substances. The minerals and energy obtained are used for motor, rail, water and air transport. Building materials are also produced from minerals and rocks.

Underground waters are also playing an increasingly important role in the economy and are used in industry and agriculture as well as in the home. In addition, agriculture needs minerals: for example, salt and fertilizers.

The whole of modern civilization today and in the future is based to a large extent on the utilization of underground resources.

Iron, gold, oil, coal, tungsten, uranium, sand, clay and countless other useful minerals are contained in the earth's crust. Finding them involves the use of up-to-date scientific equipment and efficient organization. Geologists need an imaginative approach plus reliable machinery to penetrate deep into the earth in order to ascertain the processes which took place on and inside the planet millions of years ago.

As little as a century ago people were only interested in minerals such as gold, silver, precious stones, coal, iron, copper, tin, lead and a few others.

Today, in our age of technology, of automation, nuclear energy and space exploration, all the elements enumerated in Mendeleyev's Table are used in industry, agriculture, everyday life and scientific research.

We rarely notice how many of the things around us originated inside the earth. Metallic, glass and earthen ware; the walls of houses; the asphalt or concrete of roads; cars and tractors: wherever you look you see the results of mineral processing.

It is not easy to find and extract mineral resources and to put them to industrial use. If successful, however, a state relying on its own mineral resources can greatly increase its industrial might and accelerate its technological progress. The Soviet Union is a case in point. Soviet geologists have a creative approach to the achievements of their predecessors, not just of the famous scientists of the past such as Mikhail Lomonosov or Pyotr Pallas, but also of rank-and-file prospectors and miners.

Although people have always looked on the earth as their mother, it is only now that we have discovered the tremendous variety of our ties with nature and not only with living nature on the surface, but also with the hidden treasures of the interior.

Why Tsarist Russia Imported Raw Materials

● Many regions of what is today the Soviet Union have been inhabited by man from time immemorial. At one time the most precious thing to be found in the earth was stone (primarily flint and obsidian, volcanic glass) from which tools and weapons could be made.

Even then, tens of thousands of years ago, underground treasures enriched people spiritually as well as materially. As they extracted the stones they needed, and later various ores and precious stones, they continued to learn about the world around them.

Each region has its own particular mineral wealth. The tribes that inhabited the Caucasus extracted obsidian, while those living on the shores of the Baltic Sea collected and mined amber – the fossilized resin of ancient trees. Today, archaeologists unearth Caucasian obsidian in the north and Baltic amber on the shores of the cold White Sea. This shows that even in those times tribes which were separated by hundreds of kilometres maintained contact, and that the mineral gifts of the earth served to further this end.

Some metals (copper, tin, iron, gold, silver) were mined in the Caucasus and Central Asia where metallurgy began to develop thousands of years ago. Some scientists maintain that Transcaucasia, including the Armenian Highland, was one of the world's first centres of metallurgy. Copper mines are known to have existed in Azerbaijan and Georgia in the 3rd-4th millennia B.C. At about the same time metal ores were also mined in the Near East, North Africa, Iran and Afghanistan.

More than two thousand years ago, the ancient Slavs inhabiting the Great Russian Plain learned how to extract ores and to smelt them in domestic kilns.

The transition from a feudal to a capitalist system of economy was accompanied by the development of industry, the growth of the cities, and the construction of engineering works. Some geological disciplines also began to take shape.

In 1719 a Mineral Board was set up in Russia with a staff of "ore reporters" whose duty it was to find and report on mineral deposits. Today such specialists are called geological prospectors. At that time the Donets Coal Basin was discovered in the Ukraine and outcroppings of coal in the area of what is today the Siberian city of Kuznetsk. The first reports about oil started coming in from Bashkiria. The Urals began to develop into a major centre producing iron, copper and precious and semi-precious stones.

The academician Mikhail Lomonosov (1711-1765) was the founder of geological science in Russia. A man of great and varied talent, he excelled in geology, geography, physics, chemistry, poetry and art. In his geological works he gave a correct explanation of the origin of ores (in particular, the solidification of molten masses underground) and oil (the transformation of vegetable remains underground). He maintained that there was a vast variety of minerals to be found in Russia and recommended that they were found and used. The methods of geological prospecting he proposed were fairly advanced for his time.

However, Lomonosov's theoretical views and practical proposals failed to gain active support since mineral prospecting and mining were regarded as an occupation of secondary importance. Russia was almost exclusively an agrarian country where industry developed slowly and on a very small scale.

The theoretical achievements of individual scientists could easily have been used to organize systematic mineral prospecting. This, however, did not happen in Russia. Why not? Was it that no one realized the importance of tapping the underground wealth?

At the end of the last century the Russian chemist Dmitri Mendeleyev wrote that almost all industry was based on mineral processing, noting bitterly that while Russia was richer in coal than England, it not only did not sell it to other countries but even had to import some from abroad. The same was true of oil and many other minerals. For example, early this century developed countries used 61 chemical elements, only 27 of which were mined in Russia. The rest were imported. Consequently there was not only an unjustifiable expense on the purchase of raw materials abroad, but also the development of the relevant industries was hindered since they lacked a reliable supply of cheap local raw materials.

Although it had geologists of world renown Russia nevertheless suffered from an acute general shortage of specialists. Thousands of experts were needed to study the mineral wealth of the world's largest state and they required geophysical instruments for probing the earth, geochemical and mineralogical laboratories and drilling machines. Success could only be expected if these requirements were fulfilled.

Finally, the overall level of the country's industrialization was also extremely important. As long as Russia remained a predominantly agricultural country with a semi-feudal system of production relations and backward technology there could be no question of systematic and rapid reclamation of mineral wealth.

The First World War, which broke out in 1914, proved to be a tough endurance test for the Russian Empire, a test its decayed state structure could not survive. A bourgeois revolution broke out in February, 1917, followed in October by a socialist one. Then came the Civil War and foreign military intervention.

Those were unbelievably difficult years. The main task was to hold out. At times it seemed an impossible task since only a small fraction of the country's territory remained under Soviet control.

When the Civil War ended in 1921, the country, torn by hunger, economic dislocation, epidemics and a vast loss of human life, was on the brink of catastrophe. Agriculture was in disarray and industry had almost ground to a halt. Iron-and-steel production, the basis of the country's industry, had dropped to less than one-fiftieth of the pre-war 1913 level.

The situation was aggravated by the political isolation created by the surrounding capitalist countries and an acute shortage of equipment, technical documents, engineers and technicians.

This was the position in the young Soviet state when it embarked upon the building of the economic basis of socialism.

Starting from Scratch

● The reader may find it boring that in this booklet the descriptions of geological achievements often begin with the words "after the October Revolution", "in Soviet times", etc. This is, however, inevitable since Soviet geologists virtually had to start from scratch.

The Communist Party set the course for the speediest possible way of restoring the national economy and organizing large-scale industrialization.

To achieve this, a well-developed mining industry was needed in order to supply other industries with raw materials and fuel. But one problem was where to start looking for underground mineral wealth in a country as large as Russia. Would the resources suffice to meet all the requirements of industry?

At that time few people in the world believed that a vast, predominantly agricultural country bled white by war and economic ruin could be successfully industrialized. The opinion was expressed in the capitalist press that the Soviet Union would not find enough coal and iron for industrialization, that it had no copper and silver, and that it had less gold resources in the ground and unmined than France had in its treasury.

To industrialize and win economic independence it was necessary to conduct various geological investigations, and to accurately assess the size of known deposits and the quality of the minerals they contained in the shortest possible space of time. A mistake by geologists always entails unjustified expense and does tangible harm to the national economy. Conversely, every mineral deposit which is discovered and surveyed enriches the country, creating a base for the emergence of a complex of mining and manufacturing enterprises, and vitalizing the region concerned.

It was stated in the decisions of the 16th Congress of the Communist Party held in 1930: "Promotion of the development of the national economy necessitates a rate of geological work which should be considerably in advance of the rate of development of industry in the interest of the timely provision of mineral raw materials."

The 1930's witnessed a determined large-scale effort to eliminate the blank spaces which abounded on Russia's geological map. The transference of power into the hands of workers and peasants and the nationalization of land had roused unparalleled enthusiasm. People had come to feel that they were masters of their country and were responsible for the development of its economy.

Geological committees and specialized research institutes were set up. Geological work developed rapidly over most of the country's territory. Specialists were trained and expeditions were organized.

Despite the difficult economic situation the allocations for geological prospecting increased rapidly. Between 1929 and 1932 they rose 14 times and 400 times as compared with the pre-revolutionary times. In the short period from 1930 to 1932 the number of geological field teams doubled and the number of technical personnel increased from 1,702 to 5,956. By way of comparison, before the revolution the national geological committee consisted of only 50.

In the words of the Academician Ivan Gubkin, *

* Ivan Gubkin (1871-1939), Chairman of the Council for the Study of Productive Forces of the USSR Academy of Sciences, took a direct part in solving major problems of the industrial development of Siberia and the Soviet Far East.

"where but recently individual scientists roamed and worked with nothing but compasses and hammers in their hands, we now see hundreds of Soviet scientists equipped with drilling rigs and the most advanced geophysical instruments. Relying in their work on powerful scientific research institutions, they are unriddling the secrets of the earth; they are constantly finding new wealth there and hand it over to industry."

Finding a deposit is the first step in geological prospecting. It is comparatively simple, rarely involves large expenditure and in the past was often quite accidental.

To assess the size and quality of a deposit, geological exploration is conducted. If the result is positive, the deposit is surveyed, a painstaking process demanding a large amount of drilling and various investigations. After that the deposit is considered ready for development.

The Needs of a Developing Industry

● *Iron.* In the autumn of 1918, when the Civil War was raging, Academician Pyotr Lazarev was given the task of investigating the magnetic anomaly at Kursk in Central Russia, a region long noted for its magnetic instability. More than a hundred years earlier it had been proposed that the compass was affected by vast iron ore deposits. Such reports had roused no interest on the tsarist government's part, while the efforts of individuals and small private companies had been insufficient to assess the deposit accurately.

Lazarev's expedition explored the Kursk magnetic anomaly with the help of geophysical instruments. The first results were encouraging. The Soviet government found the work of the expedition to be of paramount importance.

In the spring of 1922, Lenin was informed that data concerning rich resources of iron ore near Kursk had been received. He gave instructions that the information should be checked and that, if the data were confirmed, "we must get the work going as fast as possible, without in any case stinting the necessary gold appropriations, and establishing special supervision to have the necessary equipment received from abroad (diamond, drilling, etc.) with the maximum speed."

In 1923, samples of iron ore from a depth of over 150 metres were obtained. Their quality proved to be low and it was decided to discontinue the work which was only restarted at the insistence of specialists. Four years later their persistence was rewarded and they reached deposits with an ore content of up to 65 per cent.

The search for iron ore was not limited to the Kursk magnetic anomaly. Thanks to the geologists' efforts the stocks of iron ore increased five-fold in the south of the European part of the country and in the Urals and three-fold in the Kerch Peninsula of the Crimea. Rich iron ore deposits were also found in the south of Western Siberia, and in Eastern Siberia for the first time. In the first fifteen years of Soviet power several iron ore deposits were discovered in Kazakhstan.

Pre-revolutionary Russia had ranked tenth in the world for its deposits of iron ore. Fifteen years after the October Revolution, the USSR possessed the largest number of explored iron ore deposits.

Coal. Soviet geologists had to work hard to find a reliable supply of fuel for their young country and to assess the prospects for the future more accurately. Prospecting was conducted primarily in little-known regions.

Even the relatively well-explored Donets Coal Basin provided a surprise by revealing new deposits.

The Moscow Lignite Basin remained one of the least known areas and its systematic survey began in 1918. In fifteen years the reserves known to be there had increased 200 times.

A great deal of coal was necessary for the burgeoning Urals iron-and-steel centre where Europe's largest iron-and-steel plant based on Mt. Magnitnaya's deposits was built during the First Five-Year Plan period (1929-32). The Chelyabinsk region in the Urals and the Pechora lignite region in the north were also rapidly surveyed.

Extensive coal prospecting was also conducted over vast areas in the Asian part of the country. Many new coal-bearing regions were found, including the Kuznetsk Basin in the south of Western Siberia, the Karaganda Basin in Kazakhstan, and the South-Yakut Basin in Eastern Siberia.

Non-ferrous metals. Prior to 1917, the development of the non-ferrous-metals industry was based primarily on increasing imports of lead, copper and zinc. The country's own stocks of these ores were very poorly researched. Many deposits discovered by private companies were kept secret to maintain high prices and to gain an advantage over competitors. The overall information about the quantity, quality and distribution of deposits was utterly inadequate.

The economic blockade imposed by the capitalist countries after the October Revolution compelled the USSR to look for its own sources of non-ferrous metals. Prospecting was first conducted in areas where there were known deposits of complex ores: Kazakhstan, Central Asia, the Urals, the Altai, Eastern Siberia and the Caucasus. Consequently, during the First Five-Year Plan period the Urals, formerly the principal copper-bearing region, ceded its place to Kazakhstan, even though the explored reserves of copper in the Urals trebled, whilst potential deposits increased seven-fold.

In all, from 1929 to 1932 the country's stocks of copper rose by 900 per cent, those of lead by 280 per cent and those of zinc by 330 per cent.

Summing up the results of the First Five-Year Plan, Academician Gubkin wrote: "We can confidently say that, with some additional study of the deposits we already know, the requirements of the Soviet non-ferrous-metals industry can be fully met in the near future. Thus. . . by the end of the Second Five-Year Plan we shall be able to come to the world market not as a buyer, but as a supplier of non-ferrous metals."

Diamonds. Although diamonds are undoubtedly one of the most beautiful precious stones they are of use primarily because of their hardness. Diamond is used to drill the hardest rock and to machine the hardest alloys and it is employed in numerous industries, greatly increasing the speed and quality of work. Diamond-reinforced drilling bits increase the speed of drilling two to three times and cut the cost by half. Thus this mineral which is produced deep in the earth is in turn used to explore it.

Diamond deposits were only discovered in Russia in the middle of this century although small diamonds had been found from time to time in placers and river sands in the Urals. The demand for diamonds grew rapidly, especially with the development of heavy industry, and the USSR had to purchase them abroad at considerable expense.

The geologists' search was long and unsuccessful. Shortly before the war Vladimir Sobolev noticed the chemical and mineralogical similarity between the rocks found widely on the Siberian Platform and those in which the diamond-bearing "pipes" of South Africa had been discovered. The latter are so called because they form huge pipes reaching depths of many kilometres and filled with a clay-like rock called kimberlite.

In 1947 geological parties went to the Siberian taiga in search of kimberlite pipes. The going was very tough there, with intense heat, humidity and mosquitoes in summer and severe frosts which often freeze the mercury in thermometers in winter. Almost all the ground is permafrost, thawing in summer to a depth of only one or two metres. Even huge pipes the size of a sports stadium are very hard to find in such conditions.

Although the first tiny grains of Yakut diamonds were found in river drifts in 1948, several more years passed before primary deposits were discovered. It was finally established that kimberlite pipes do exist in Siberia and the first geological forecasts were confirmed. However, the first diamond-bearing pipe was only found in the autumn of 1954 when field work was coming to an end in the Daldyn River valley in Central Siberia.

The discovery of diamond deposits in Siberia was a remarkable achievement rewarding an organized and purposeful search based on convincing scientific forecasts.

What are the principles which govern Soviet geology?

As the largest state in the world, the USSR needs numerous centres supplying industry with raw materials or else they would have to be transported over thousands of kilometres.

In addition, the discovery of large deposits is only the first step since they become the basis of new industrial enterprises, thus helping to open up distant or isolated areas. Roads and settlements appear. Agriculture begins to develop. When geologists discover underground resources, the density of industry, the dynamics and structure of population distribution and the landscape are radically changed.

Although it is essential to choose the right direction, this is not sufficient in itself to guarantee success.

One of the important factors ensuring the success of the geological service in the USSR is centralized leadership which makes a comprehensive plan of prospecting work possible since vast new regions and not just individual scattered areas of known deposits have to be studied. In one place outcroppings of coal are found, in another, copper or iron ore, and rare metals in yet another. All these data have to be considered on the scale of the whole country so as to determine the direction of future explorations.

Extensive long-term co-ordination is impossible for private entrepreneurs. Their actions are limited in scope and serve primarily narrow private interests rather than those of the entire state. In so far as the land and everything in it belongs to the state, the findings of geological exploration make it possible to ascertain to what extent the developing economy will be supplied with mineral raw materials, both in the immediate future and in the long term. In turn, this makes it possible to draw up a plan for the development of all sectors of the national economy without fear of denying some of them vital materials and, consequently, to choose the optimum rational solution for the distribution of productive forces, industrial centres and cities.

Prospecting was originally co-ordinated and reviewed by the Geology Committee under the Council of People's Commissars which later became the world's first Ministry of Geology. In addition to this national centre, geological committees have been set up in the republics and large regions in order to direct prospecting with regard given to local conditions.

Siberia — a New Industrial Centre

● When considering how the Soviet Union exploits its mineral wealth one involuntarily recalls that it occupies one-sixth of the world's land surface. The western, European part including the Urals, had to some extent been studied even before the October Revolution. To the east, however, beyond the Urals, lay vast and often totally unexplored territories. It was not known what mountain ranges, rivers and lakes were there and even things visible on the surface of the earth remained a mystery.

The eastern part of Russia had been assigned the role of the economically backward supplier of precious metals for the industrialized centre. Strange as it may seem, its economic development had suffered regression thanks to the discovery of a whole number of gold deposits. Fabulous profits were gained by the owners of goldfields, to which capital and manpower flowed from other extractive industries. A mining and iron-and-steel industry was only developed in the Rudny Altai, in the south of Siberia, and to some extent in Transbaikalia.

The October Revolution proclaimed the equality of the many peoples living in Russia. However, national inequality could only be effectively eliminated by doing away with economic inequality. This idea was emphasized in the decisions of the 10th Congress of the Communist Party held in 1921. But what was to be done first? How could the economic backwardness of the eastern regions be overcome?

Various proposals were made. Some people suggested a continuation of the priority development of the extraction of raw materials, to be supplied to the European part and for export. Others held that the eastern regions should be turned into independent industrial centres.

A third viewpoint, one supported by Lenin, won the day: the eastern regions should be developed in harmony with the economic and social progress of the entire country. Their mineral resources should be studied, taking into consideration the interests of the state as a whole and not simply local ones.

Although the plans were based on this viewpoint, they were difficult to realize because of the considerable economic and cultural backwardness of the Asian part of the country. It seemed this backwardness could only be overcome with the help of foreign capital and specialists.

Extensive geological exploration was the first step in opening up the eastern regions. It proceeded along two lines: study of the general geological conditions of the area and the distribution of rocks of different ages and composition, and at the same time prospecting for deposits of specific minerals.

First of all it was necessary to restore the gold mining industry of Siberia which had fallen into decline during the Civil War. This was very important. The prospects for the further development of gold extraction in the area were, however, unclear. Geologists were called upon to discover what quantities of precious metals lay hidden in Siberia and where they were to be found.

In 1923 a gold-bearing region was discovered in the Aldan River valley in the north-east of Siberia. A large expedition was dispatched there to search for gold and other minerals.

One of the members of the expedition, Sergei Obruchev, discovered a vast mountain system which he called the Chersky Range. He also found traces of gold in the area of the Kolyma River.

In 1928 a specialized expedition headed by Yuri Bilibin, a young geologist who had just begun an independent career, was dispatched to look for gold deposits. The difficulties with which the expedition had to contend can be judged from the fact that it worked in totally unexplored areas without reliable maps and surmounted obstacles such as mountain ranges, fierce rivers and bogs. It had neither experienced geologists nor skilled workers.

It may seem hard to believe that, as early as 1930, Bilibin was able to give a remarkably accurate analysis of the potential occurrence of gold in the regions he had investigated. There was, in fact, nothing surprising in this since major geological discoveries were for the first time based on scientific forecasts and on the study of the general laws governing the structure of the earth's interior. Previously, gold prospectors had always relied mainly on good luck. Now the geological study of Siberia was thorough and systematic.

As distinct from earlier decades, work was not limited to the search for the most valuable deposits. In keeping with the plans of the Party and government, the eastern part of the country was to be industrially developed. This called, among other things, for the establishment of an iron-and-steel industry based on local raw materials.

Prospecting for coal and iron ore was started in the Kuznetsk Basin in the south of Siberia. The huge stocks of coal which were found there constituted the basis for the first industrial enterprise in Siberia, the Kuznetsk iron-and-steel plant, which was built during the First Five-Year Plan period.

However, the deposits of local iron ore proved insufficient to support the large plant. The search for new deposits was conducted with the participation of not only scientists, professional geologists and miners, but also many local residents, and this combination of scholarship and the active interest of the masses yielded magnificent results. In three years several iron ore deposits, many times larger than the reserves previously known, were discovered in the south of Central Siberia.

At the same time the opening up of the Norilsk coal and complex ore deposits was started on the Taimyr Peninsula. Those who had discovered them said even then that the region would become one of the country's largest industrial centres and they were right. In 1940, the first stage of a mining and ore-dressing combine, which eventually became the largest in the Soviet Union, was put into operation in that region of permafrost, long Arctic nights and temperatures dropping to –50°C.

Tin, molybdenum and tungsten ores were found in Transbaikalia. The search went on for copper, lead and some other metals and non-metal minerals.

There is an interesting story connected with the mica deposits which had been discovered before the revolution in the valleys of the Vitim and Mama rivers in mid-Siberia. Not surprisingly, they roused the interest of General William S. Graves, a commander of the American interventionist force and a board member of Westinghouse Electric Corporation, a major consumer of mica. However, the Americans were never able to work these deposits and their troops left Siberia in 1920.

Denied a military victory in Siberia, the Americans set their sights on an economic one and made a bid for the purchase of the right to develop the Mama mica deposits.

The region was inaccessible. It had no roads and mica extraction required heavy capital investments. The Americans were consequently so sure of the success of their undertaking that reports appeared in the press that an American enterprise was about to start mining Mama mica. But the press was a bit too hasty. The Soviet government decided first to make a thorough study of the situation. A geological expedition was dispatched and the deposits were found to be rich in high-grade mica. It was decided to extract the mineral independently. By 1928, Siberia already accounted for 90 per cent of Soviet mica production. The export of mica rose sharply, as did the profits in foreign currency.

As Lenin's electrification plan got under way the demand for high-grade mica for large generators increased significantly, and the Siberian mica deposits assumed great state importance.

The opening up of Siberia's mineral wealth proceeded rapidly: more was done in one decade than in the previous hundred years. This is all the more remarkable in view of the devastation caused by the Civil War, the absence of machinery and the shortage of funds and specialists.

This unprecedented geological offensive was conducted simultaneously in different regions of the east of the USSR and its success was largely thanks to efficient planning. The information obtained by the many expeditions and investigating parties provided additional knowledge of the structure of the earth's interior and made it possible to plan future work effectively.

It was a truly unparalleled, strategic offensive aiming to place Siberia's mineral wealth at the service of society. How timely and important this work was became evident during the Second World War.

On June 22, 1941, Hitler's army perfidiously invaded the Soviet Union and advanced rapidly seizing the areas where industry and agriculture were most highly developed: the Ukraine, Byelorussia and the western part of the Russian Federation. In the autumn of the same year the enemy reached the approaches to Moscow.

However, the fascists' hopes for a lightning victory were dashed and, despite heavy losses, the Soviet army offered increasingly firm resistance. At Moscow the invaders were not just stopped, but were actually thrust back. It was the first major German defeat in the Second World War. Stalingrad and Kursk followed.

However, in order to hold out and win, the Soviet army needed tanks, planes, guns and ammunition. One thousand three hundred and sixty large, primarily munitions factories (enough to turn a whole country into an industrial power) were evacuated from the western regions to the east. Women, elderly people and juveniles stood at the benches instead of the skilled male workers who had gone to the front. The problem was, however, how to survive without mineral raw materials. Without Krivoi Rog iron ore, Donets coal and Nikopol manganese?

The loss of the western industrial regions vastly complicated the situation for the USSR. It was necessary to renew industry's supply of iron and copper ore, zinc, cobalt, manganese, tungsten, coal and oil but it would have been impossible to do so if deposits of various minerals had not already been discovered in the east. Now, however, basing themselves on the results of previous investigations, geologists prepared a whole number of deposits for exploitation.

By late 1941 they had completed the survey of the Polunochnoye manganese deposit in the Urals. New deposits of nickel, an important strategic raw material, were also found. An intensive search was conducted for bauxites, the raw material for making aluminium. (After the occupation of the western part of the country the Urals remained the Soviet Union's sole aluminium producer.)

The mineral resources of Western Siberia and Kazakhstan were also being actively reclaimed. Complex ore deposits were discovered in the Altai. Drilling for oil was started in Western Kazakhstan. The scale of detailed prospecting in the extensive Kuznetsk Coal Basin, now the principal supplier of solid fuel, was greatly expanded. New copper deposits were found in Central Kazakhstan.

Geological field teams were pioneering in the trying conditions of the Siberian taiga and the

Arctic tundra, constantly finding new areas with large amounts of rare and precious metals and new coal and iron ore deposits.

The geologists' heroic work was not embodied exclusively in the armour of tanks and the lead of bullets, and it not only made it possible to mobilize the underground wealth of the Urals and the eastern regions for wartime needs. In the trying war years the Soviet geologists or, to be more precise, those who had not been called to fight, worked not just for the current needs of the country, but also for the future.

The study of the country's geological composition continued: by 1939, about 45 per cent of its territory had been encompassed by geological survey, whereas in 1945, the year when the war ended, the figure reached 73 per cent. The base had been created for the rapid restoration of the economy.

The Union of Theory and Practice

● A geologist is always a researcher. His main job is to learn about the structure of the earth's interior, the history of minerals and rocks, the relief and landscape. Such problems are not always directly connected with economic activity, that is, with the utilization of mineral raw materials. They also influence attitudes.

There was a time when people believed that the universe was enclosed, with a stone, glass or metallic firmament above and the solid earth under their feet. It seemed impossible for man to rise above the vault of the heavens or to penetrate into the depths of the earth which was believed to house hell, the abode of Satan and the souls of sinners.

Man eventually came to feel cramped within the narrow bounds of this invented world. Science opened up a new world before him, a world with unbelievably distant stars in boundless outer space, and with the earth's crust under his feet hiding the traces of the distant past, of billions of years of geological history.

Scientific knowledge is the first step in the reclamation of natural resources. The second step (extraction and utilization) requires powerful machinery and a highly industrialized national economy. Theoretical knowledge is again deepened and expanded at this further stage. Penetration into the depths of the earth and the exploitation of mineral resources result in the accumulation of new knowledge, and ensure new successes.

For many centuries geological theory and practice were strictly separated. Theoreticians philosophized about life on earth and its origins, the age of rocks and the causes of their formation, the growth of mountains, and so on, while men in the field gradually accumulated information concerning the peculiarities of the occurrence of gold, silver, copper, iron, precious stones and other resources.

Although theoretical geology began to merge with practical geology in the last century, the two disciplines remain divorced in part even today. In Russia, for instance, the theoretical study of the structure of the earth's crust and of the distribution of different rocks and minerals was conducted almost exclusively by institutions of the Academy of Sciences, while the practical work of geological prospecting was for the most part directed and financed by individual industrialists, firms and joint-stock companies. Such a situation is generally characteristic of the capitalist system.

True, in pre-revolutionary Russia, too, many scientists sought to combine theoretical investigation with practical work which would bring the country economic returns. This aim was pursued, for instance, by Mikhail Lomonosov. But it was exceedingly difficult to realize such intentions in the conditions of Russia's feudal and capitalist social structure.

It was within the precincts of the Russian Academy of Sciences that, in the early 20th century, the idea was born of starting a comprehensive study of the country's natural resources, including an "inventory" of its known and possible underground wealth. This tremendous undertaking was started during the First World War, bearing in mind, above all, the needs of the munitions industry. The allocations for this work were insignificant and work progressed slowly.

In the very first years after the October Revolution all scientists who were willing to co-operate with the new power were provided with conditions necessary for theoretical research. At the same time they were required to put their knowledge to the service of socialist construction.

The Academy of Sciences established research institutes and departments headed by leading scientists and specializing in precious metals and stones, non-metal minerals, rare and radioactive elements, building materials, soils and gases, etc. Interdisciplinary explorations in different regions of the country were organized and co-ordinated by the Expeditionary Research Commission.

The results of combined efforts have already been mentioned, for example, the discoveries made by

Bilibin and Obruchev. Even more eloquent, however, are the successes of Soviet scientists and practical geologists in creating the mineral base for the chemical industry which, prior to the Revolution, operated almost exclusively on imported raw materials.

In the 1920's Academician Alexander Fersman * undertook several expeditions in the Kara-Kum Desert in Central Asia where he discovered a sulphur deposit. Soon afterwards, the Soviet Union's first sulphur plant was built there thus obviating the need to continue imports.

Academician Nikolai Kurnakov, ** a noted chemist, organized the Kara-Bogaz-Gol Committee which started a comprehensive exploration of Kara-Bogaz-Gol of the Caspian Sea.

Connected with the sea by a narrow strait, the gulf is like a giant pot in which water evaporates rapidly. Its salt water kills all life. Its shores, covered by salt-marshes, are also dead. A swift current flows constantly into the gulf. In former days people believed that there was a bottomless hole on the floor of the gulf down which the Caspian waters rushed and seamen used to give the dangerous gulf a wide berth.

In the beginning of this century it was discovered that the gulf is, in fact, a vast deposit of mirabilite (Glauber salt), a valuable raw material from which soda is obtained. However, until the October Revolution the commercial exploitation of the deposit

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* Alexander Fersman (1883-1945), one of the founders of geochemistry and pioneer in the application of geochemical methods in geological prospecting.

** Nikolai Kurnakov (1860-1941), Vice-Chairman of the Commission for the Study of the Natural Productive Forces of Russia under the USSR Academy of Sciences.

of Kara-Bogaz-Gol went no farther than stock-exchange machinations.

In October, 1921, a comprehensive study of the gulf was started by an expedition of the Academy of Sciences. It was established that the depositing of mirabilite crystals begins in autumn when the temperature decreases to +6°C. In spring, when the water gets warmer, the sedimented salts dissolve. These seasonal changes in natural conditions regularly inducing depositing of minerals made it possible to work a mirabilite deposit with periodically renewed stocks.

Scientific recommendations were put to use and in 1929, commercial extraction of Kara-Bogaz-Gol salts began. This was carried out in winter and early spring, and in summer mirabilite was dried on the shore.

Geologists continued their work in the area, finding deposits of sulphur, lignite and sulphur pyrite.

Another major centre of the chemical industry appeared 2,000 kilometres to the north of Kara-Bogaz-Gol, on the banks of the Kama River in the Central Urals. Although common salt had been mined there since the 15th century, potassium salt, an excellent mineral fertilizer, had to be imported by pre-revolutionary Russia from Germany.

In the late 19th century, Academician Kurnakov conducted a chemical analysis of brine from the Solikamsk salt mines in the Urals and found it to contain more than five per cent of potassium chloride. He estimated that every year the Solikamsk mines dumped tens of thousands of tons of potassium salt which tastes bitter and is eliminated in the course of common salt production. The waste was poured into the Kama, which it polluted, whilst the state annually spent more than two million gold roubles on the purchase of potassium salt abroad.

A layer of potassium salt was discovered during drilling operations in Solikamsk, but no further steps were taken in the search for this very valuable mineral because of the negligence of tsarist officials.

The search was renewed after the October Revolution. At first, theoretical investigations were conducted by Kurnakov. In addition to chemical experiments, he and his colleagues studied the occurrence of salt layers and attempted to recreate the contours of the sea which no longer existed but in which the salts had accumulated hundreds of millions of years ago.

The scientists' thoughts led them along the shores of the Permian sea, the abode of huge weird-looking amphibians, the long-extinct relatives of our frogs, and they drew on their maps the outlines of that invisible bygone sea, the traces of which now lay buried in the form of salt beds.

A firm theoretical understanding provided the basis for practical work and the theoreticians suggested looking for potassium salt deposits near Solikamsk.

In the autumn of 1925, the first reconnaissance borehole was sunk in the Solikamsk area. At a depth of 92 metres it reached a layer of potassium salt. In 1931, the first Soviet potassium salt mine produced the first thousand tons of the mineral.

Thus, practical workers supply theoreticians with factual material. In turn, the latter orient the former on specific undertakings, advising them as to where they should look. This union is very characteristic of Soviet geology. Unified state plans co-ordinate the efforts of geologists working in different regions.

The extensive scale of geological work under Soviet power necessitated the training of large numbers of geologists and technical specialists in very diverse fields. Geological faculties were organized in almost all universities and in a number of polytechnical institutes and, in 1930, the world's first Institute of Geological Prospecting was opened in Moscow. Geological disciplines began to be taught in specialized secondary schools.

As a result, to this day more than 100,000 specialists with a higher or secondary geological education have been trained. Geologists have at their disposal 10,000 drilling rigs, tens of thousands of lorries and tractors and thousands of planes and helicopters.

In the past, geologists were customarily regarded as tireless nomads. But that was true primarily of the 1920's, the most trying period in the history of Soviet geology when it was necessary to contend primarily with the elements, physical difficulties and privations.

In recent years the situation has changed radically. Geologists have to deal with intricate instruments, process vast amounts of information (not infrequently by mathematical methods) and take into account the findings of theoretical research.

This is only natural. Geology has changed, and not only from a technical point of view. Formerly, geologists worked in unexplored or little-studied regions and have discovered most of the mineral resources which could be identified from the surface and lay close to it. They did so, for the most part, with the help of geological hammers and a sound knowledge of geology, more rarely with the help of geophysical instruments and by drilling comparatively shallow bores.

The search today has to be conducted in more difficult conditions reaching ever deeper into the earth and dealing with smaller and poorer deposits.

The geologists' work has also become more complex as regards changes in technology and the transition to a 100-per-cent utilization of mineral raw materials which calls for the use of numerous, sometimes very complicated methods, to obtain large amounts of varied geological information. Deposits discovered long ago have to be restudied and reassessed. That is why geologists today include physicists, chemists, technologists, economists, mathematicians and cybernetists.

It may seem strange, but geologists with traditional skills are again in demand at present: specialists who are adept with geological hammers, compasses and other simple tools and who are also well equipped with a wealth of geological knowledge, who are familiar with minerals and rocks and have a sharp eye and a keen wit.

Here is an example. In the past ten years several copper-nickel and lead-zinc deposits have been discovered in the USSR. A new mercury province has been found in the east, fluorite deposits in South Kazakhstan, and tin-bearing areas in Central Asia. All these discoveries were made in regions fairly well studied by geologists before and without the use of any sophisticated methods or instruments.

In addition to good specialists in individual disciplines, some branches of geology now need more broad specializations. The reason is that geology is now one of the sciences studying man's activity on earth, and the ways in which he is changing the biosphere. Without taking geological factors into consideration it is impossible to save the environment from destruction. It was no accident that the science of the biosphere, recognized the world over, was founded by Vladimir Vernadsky, a prominent Russian geochemist.

The Soviet Union, which had only a hundred geologists 64 years ago, today has the world's largest national contingent of mineral prospectors. A country which once trained most of its geologists abroad, today teaches geological disciplines to students from many other countries.

The "Black Blood" of the Economy

● Archaeologists single out the stone, copper, bronze and iron ages in the history of mankind. Our age could be called that of oil.

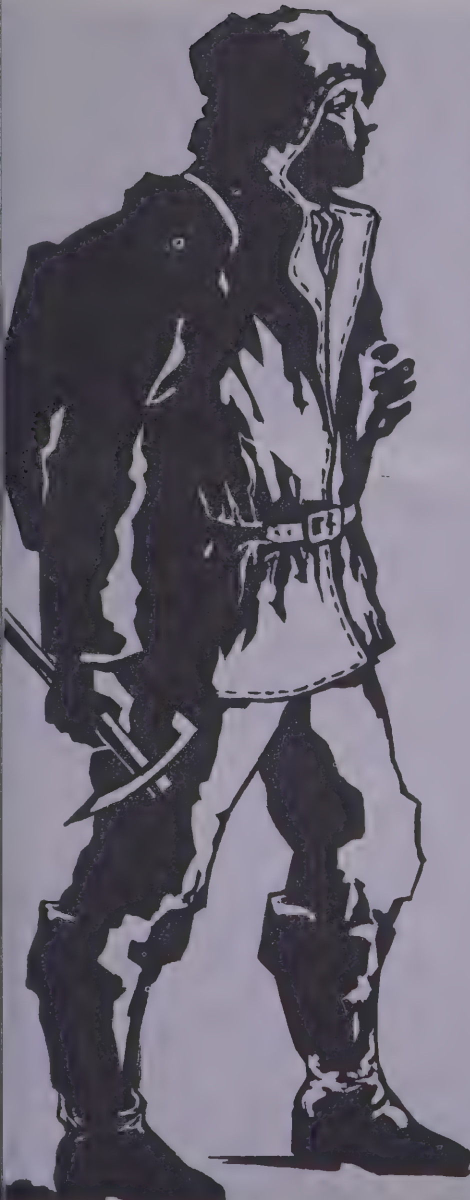
Oil pipelines stretch for thousands of kilometres as though connecting different countries by a single circular system. The oceans are plied by supertankers carrying whole lakes of oil.

Huge floating drilling platforms work out at seas.

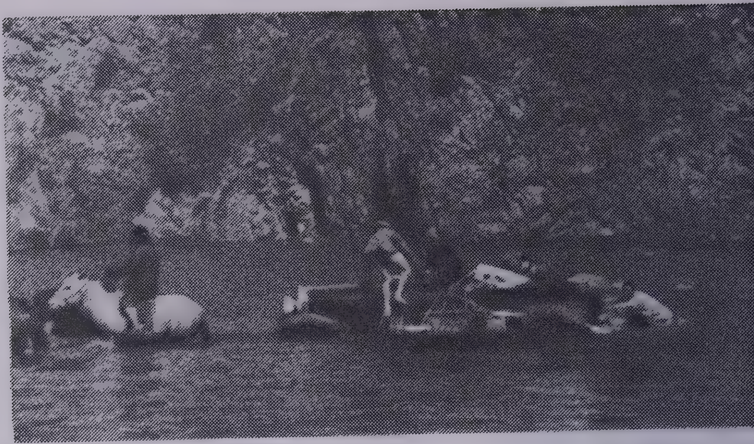
The industrially developed capitalist countries are afflicted by "oil fever". Oil has become a major factor in the world economy and international relations.

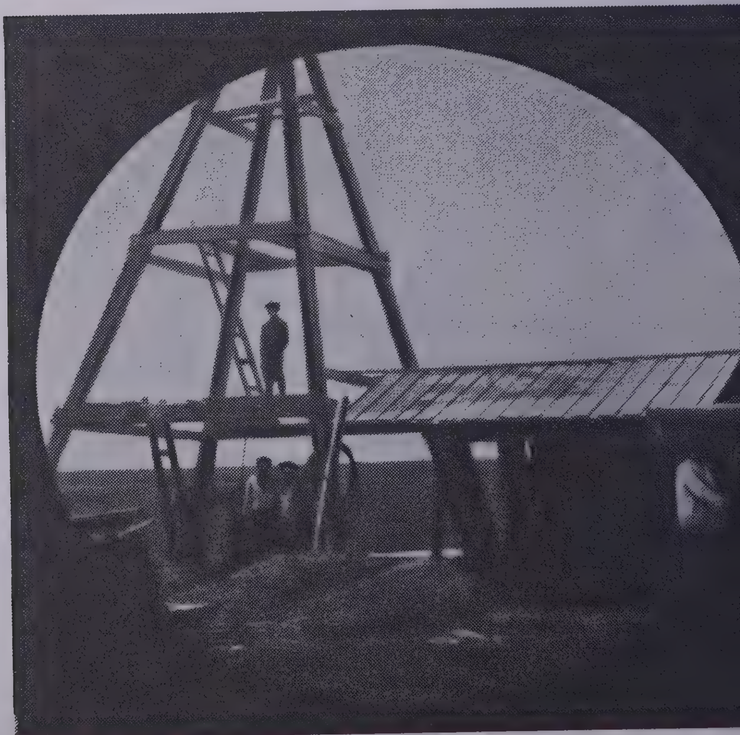
But all the complicated transformations and movements of oil on the surface of the earth, all the vicissitudes of its fitful fortune are nothing more than a short moment in the history of this liquid treasure.

As a rule, oil deposits cannot be detected on land by recognizing peculiarities in the landscape. Since



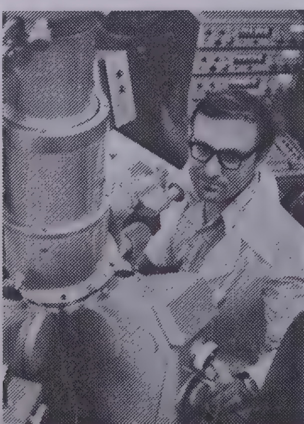
Gaea, the Greek personification of the earth, was worshipped by the ancient Greeks as the goddess who nourished everything living on it. They were right since much of what surrounds us originated in the womb of the earth. But Gaea hid her treasures deep underground and they are sought by geologists, people on whom our well-being greatly depends.

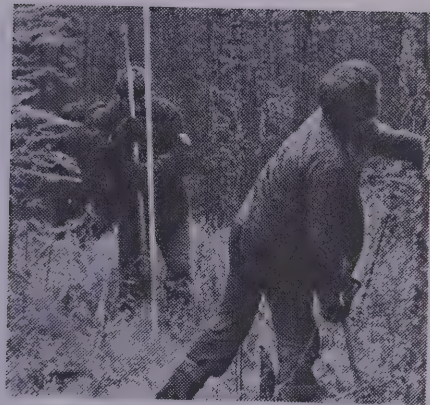




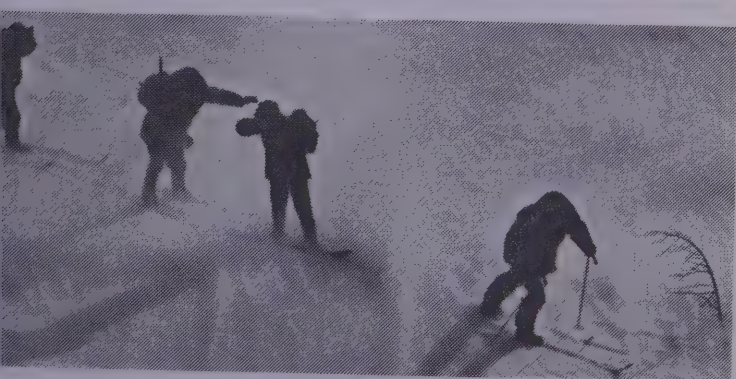
The 1920's. The first Soviet geological expedition with horses helping trucks, wooden drilling derricks and primitive equipment. However, it was precisely then, despite the many difficulties, that the foundations of the country's powerful system of mining mineral raw materials were laid with the discovery of big deposits which supply industry to this day.

Geologists feel their life has not been in vain if they discover just one really good mineral deposit. By this criterion, Patcheim Tazhibayeva, Corresponding Member of the Kazakh Academy of Sciences (right), has already justifiably lived quite a few lives.

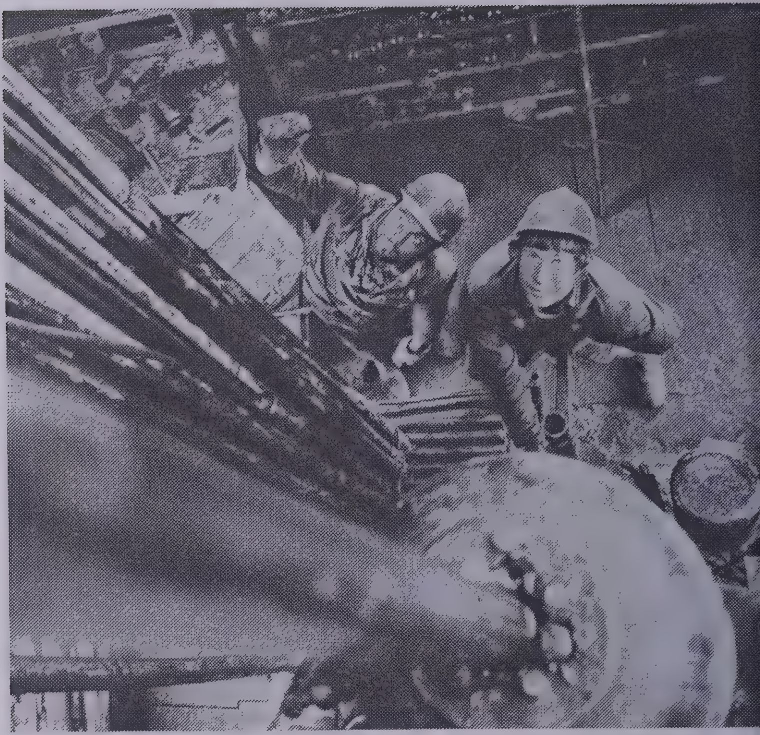


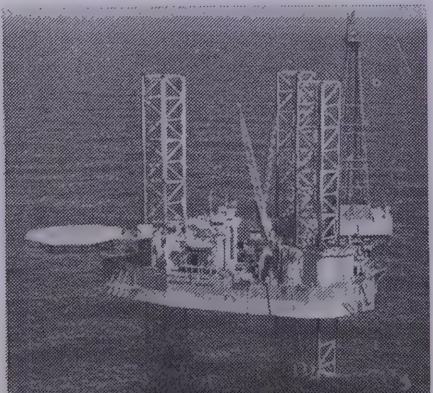


A lack of roads, blizzards, frosts, and other physical difficulties have been the geologists' working conditions ever since geology came into being. However, today, geological prospecting is also done by remote control.



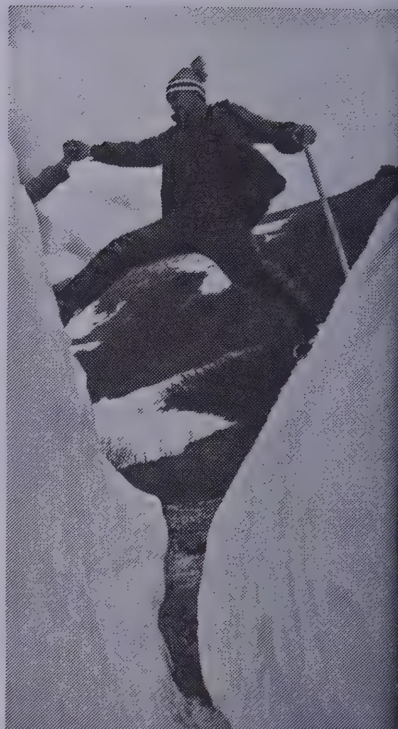
PROFESSION: GEOLOGIST

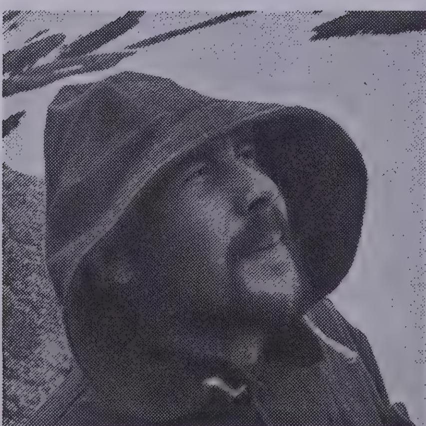




Our time is called the age of oil. It is becoming increasingly difficult to meet the industry's growing demand for "black gold" Prospecting has to be done at great depths and off-shore.

Geologists cannot chose their conditions for work. If necessary, they act as professional mountaineers. Through their efforts coal, oil, peat, copper, mercury, molybdenum, gold, titanium, tungsten, cobalt, chromium, iron, manganese and other minerals have been found in Kamchatka (the Far East).

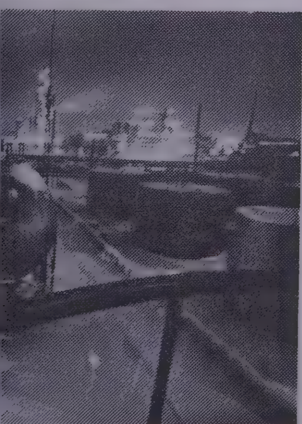


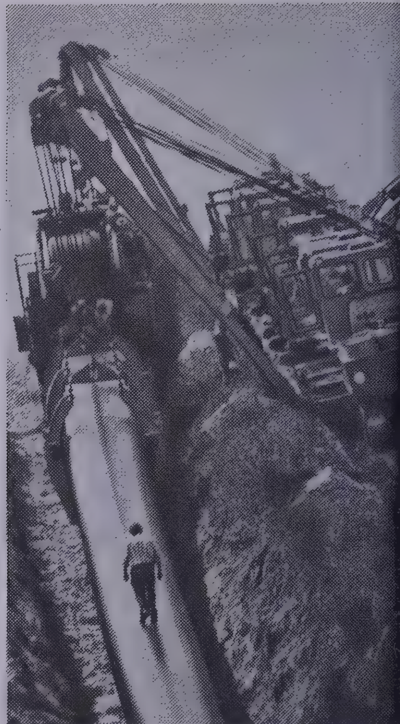


KAMCHATKA, THE TREASURE PENINSULA

Geologists have discovered vast pools of thermal waters there. The country's first geothermal power station operates on them.

The search for a mineral deposit can last for years. When it has finally been found, surveyed and assessed, the extracting industry takes over.

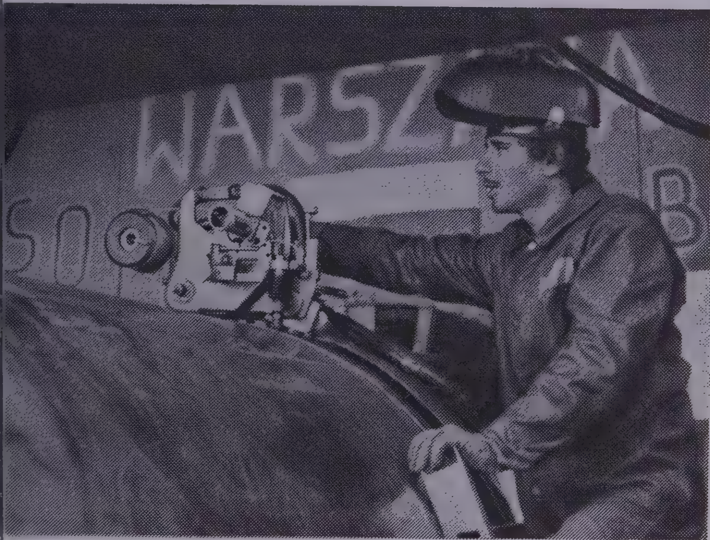


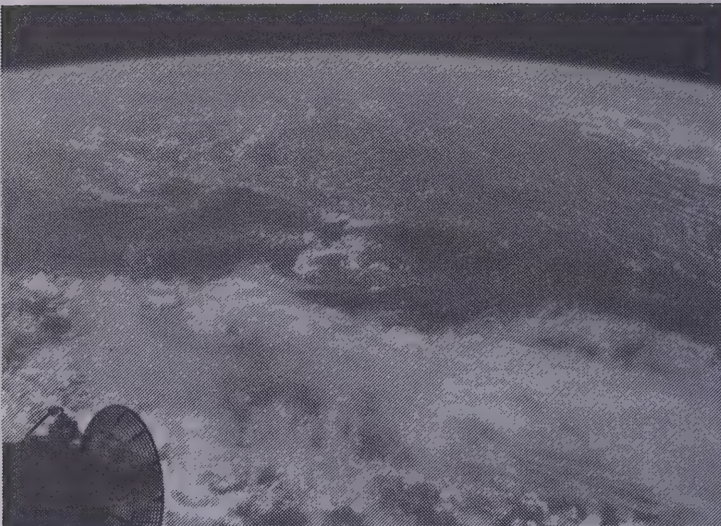


European socialist countries will receive annually 15,500 million cubic metres of Ural gas along the *Soyuz* pipeline stretching over 2,700 kilometres from Orenburg to the western border of the USSR.

THE HORIZONS OF CO-OPERATION

ongolia. The young city of Erdenet has sprung up near Asia's rgest mining and ore-dressing combine built with the assistance the USSR.





Invading the domain of geology, one of the most earthly professions, cosmonautics has wrought many changes in the methods of mineral prospecting since the structure and composition of the earth's interior is better seen from great altitudes. Many new deposits have been found thanks to photographs taken in outer space.

olden times people only knew the oil deposits where the underground fire dragon broke through to the surface: for example, around the city of Baku in the East Caucasus. Saturated with oil and gas the rocks there form mud volcanoes which sometimes erupt. Near one of the local oil springs fire-worshippers had built a temple with an eternal fire burning in it.

It was here that commercial oil-mining first began in Russia. Until the middle of this century this was the largest centre of oil extraction in Russia and then in the USSR. As early as 1919-20, the search for oil was started in some areas along the Volga and later in the Perm and Bashkirian pre-Urals. Between 1927 and 1940 the volume of geological prospecting work connected with oil there increased 50-fold.

Oil and gas outcroppings are extremely rare in the vast expanses of the pre-Urals and Siberia, and it was generally believed that there were no large oil deposits in Siberia. Some enthusiasts did try to look for oil there, but without success.

It was difficult to know how best to conduct the search. If deep holes were drilled just on the off chance, even if there were oil, it would be extremely expensive. The only rational approach was to rely on scientific forecasts.

Oil is a liquid. It generally accumulates in pools, not where it originates, but in various hiding places called traps which differ in structure and mode of occurrence.

The mobility of oil creates additional difficulties for prospectors who have to single out areas where there are rocks capable of producing oil (mother rocks), then reconstruct the underground movements of oil-bearing substances and, finally, pinpoint the underground oil traps.

The first general forecast was given by Academician Andrei Arkhangelsky * in 1929. He called attention to the existence of thick seams of lime rich in organic substances on the outskirts of the Siberian Platform (an extensive region between the Yenisei and Lena rivers). There are also folds there in the upper parts of which oil can accumulate. Ivan Gubkin vigorously supported this idea and suggested that a search for oil be started in Western Siberia.

Prospecting crews were sent to the Yenisei and Ob valleys but the work was interrupted by the war. Quicker results could be gained by prospecting in the pre-Urals and along the Volga. A major oil producing region emerged there and it came to be called the Second Baku.

After the war geophysical expeditions set about studying the structure of the West-Siberian Platform. The drilling of deep exploratory stratigraphic wells began at different, widely dispersed points. The task was to ascertain the geological structure of the region and its prospects as regards oil.

The West-Siberian Platform is a huge stone "plate" of about three million square kilometres embedded in the world's largest continent. It stretches for 2,500 kilometres from north to south and for 1,000-1,900 kilometres from west to east and borders on the Arctic Ocean, the Kazakhstan steppes, the Ural Mountains and the Mid-Siberian Highlands.

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* Andrei Arkhangelsky (1879-1941), Director of the Geological Institute of the USSR Academy of Sciences, 1934-39.

The bottom of the platform is composed of the oldest rocks and is fissured. The strata remains of former seas and continental fluvial and lake deposits rest on it. It is hard to guess where oil traps could be found.

In 1948-50 fifty holes, from 500 metres to 2-3 kilometres deep were drilled in the West-Siberian Platform. Geophysicists surveyed the crust along sections totalling several tens of thousands of kilometres in length, but they found neither oil nor natural gas.

Opinions were divided. Some geologists suggested continuing the search on a large scale; others were convinced that oil should be looked for in the south of the platform in comparatively old Devonian rocks; while still others voiced serious doubts about the possibility of discovering oil in Western Siberia at all.

Nevertheless, geological prospecting continued, albeit at a slower rate. However, one night in September, 1953, a powerful blast awakened the residents of the taiga settlement of Beryozovo: the earth boomed and rumbled; hot water and sand poured down. The blast was caused by the eruption of oil gas and was tremendously powerful. Strings of heavy metallic drilling rods were ejected from the well. A three-ton crown block flew into the taiga.

Luckily, no one was harmed. On the contrary, the catastrophe pleased the geologists since it was the first signal from the depths of Western Siberia that there was indeed oil and gas there and that they were on the right track.

However, even the right track does not lead to its destination very quickly and seven more years were to pass before the first oil gusher blew in Siberia.

Discoveries followed rapidly from then on.

Prospecting using geophysical, geological, drilling and geochemical methods started in the north of the Tyumen region. It was a broad, well-planned offensive.

The decisive success came in 1961 with the discovery of the Megion and Ust-Balyk oil deposits in the middle reaches of the Ob and the Taz gas deposit in the north of the region.

The year 1963 saw the discovery of four oil and three gas deposits; 1964, eight oil and two gas deposits; 1965, 12 oil and gas deposits, and so on.

Oil extraction grew equally quickly. Three years after the discovery of the Megion deposit annual oil production in Western Siberia reached five million tons; in another two years, 44 million tons; towards the end of the Tenth Five-Year Plan period (1976-1980) Western Siberia supplied half of the country's oil (over 300 million tons annually) and a third of the country's gas (over 160,000 million cubic metres annually).

Natural conditions are harsh in Western Siberia and the size of the oil and gas area is unusually large: more than two million square kilometres, that is, 24 times greater than the Baku area. Nevertheless, prospecting for oil and gas is most effective there. This not only emphasizes that Western Siberia is rich in oil and gas. What is also important is that the geologists now know their way in the depths of the gigantic platform and that they conduct prospecting on a reliable theoretical basis.

Tapping the underground wealth of Western Siberia, and in particular oil, continues at a rapid rate. The outlook of what but recently were very sparsely populated areas is changing with the constant appearance of new settlements, towns, roads and oil and gas pipelines.

Towards the end of the 11th Five-Year Plan period (1981-1985) it is planned to raise the output of Western Siberia's oil to 385-395 million tons (including gas condensate) and of gas to 330-370,000 million cubic metres.

The oil and gas reserves of Western Siberia have become the basis of Soviet economic development.

A Railway Line into the Future

● The Baikal-Amur Railway (BAM in its Russian abbreviation), which is now under construction, is to breathe life into heretofore unreclaimed regions of Eastern Siberia and the Far East. "The construction of BAM," wrote Yevgeni Kozlovsky, USSR Minister of Geology, "is to play a role of vast importance in the solution of the many different problems concerning the economic and social development of our eastern regions. It will open the way to new sources of mineral raw materials and fuel, on the basis of which iron-and-steel, coal, chemical and other industrial enterprises will be built.

"The BAM zone is rich in ores of non-ferrous and rare metals, iron ore, coal and lignite, asbestos, mica, phosphates and other minerals. Although some of these deposits are already being mined, the vast territory as a whole still remains to be thoroughly explored and the known deposits constitute only a fraction of the mineral wealth yet to be discovered."

The project of this second trans-Siberian railway line was drafted even before the Second World War and work on some sections of track actually started then. At that time there were only a few small settlements along the planned route.

It would be far too expensive to build a railway line in immensely difficult conditions simply in order to ease some of the load on the existing line lying to the south. Of course, after building the railway it is immediately possible to develop the taiga lying along it. At first, however, it is necessary to conduct geological survey and prospecting and to explore some of the most promising deposits.

It is senseless to establish new cities before ascertaining the geological structure of the zone along the line and the location of the future main centres of mineral mining and processing. The line should be routed taking the location of mineral deposits into account, or additional branch lines will be needed subsequently.

Moreover, ores usually contain admixtures complicating their extraction and dressing, and increasing costs. However, comparatively poor ores can contain exceptionally valuable admixtures which can make mining worthwhile. Moreover, an inaccurate evaluation of a deposit can result in projected enterprises being built on the basis of poor deposits which will be rapidly depleted. Consequently, a vast construction project like BAM should only be started after the area has undergone a thorough geological survey.

This is why the construction of the second trans-Siberian line began comparatively recently, in the mid-seventies. It was preceded by many years of fruitful work by geologists who discovered and explored dozens of mineral deposits, including oil and gas. The gases of the region contain large amounts of helium, which can be extracted as a by-product. Coal has also been found. There are good prospects for zinc and lead in the valleys of the Lena and Kirenga rivers where deposits of bauxites and refractory kaolin clays have also been found.

To the east of the Lena there are deposits of oil, gas, non-ferrous metals, mica, apatite, marble and other minerals; and in the Baikal area, deposits of asbestos, copper and nickel ores, complex ores, rare metals, mercury, antimony, fluorite and talc, etc.

In the permafrost of rocks about a thousand million years old the fantastic world of the past takes material shape before the geologist's eyes. Tree ferns raise their lacy fronds, their smooth tall trunks resembling ornamented columns. The humid soil is covered with a carpet of vegetation. From time to time giant dragon-flies flit by, small insects creep along and lizards rustle in the grass, breaking the otherwise total silence. Only from the edge of the forest can a cracking and crashing be heard as mammoth reptiles go in search of food.

The world of former geological eras is hardened in the mineral strata. There is a deposit of coking coal near Berkakit on the periphery of the South-Yakut Coal Basin. Not very far from it, in the area of the Udokan Range and the Chara River, there are deposits of iron and copper ores. The latter, which is rich and easy to dress, lies in thick beds close to the surface. A thousand million years ago there was a sea where the Udokan Range lies today. Its traces are borne by Udokan sandstones, helping geologists to reconstruct the conditions in which the copper-bearing rocks were formed.

Further east along the railway's route we reach the Pacific Ore Belt which is rich in tin, tungsten, lead and zinc. Many of the deposits of the Belt still await to be discovered.

The next stage of the geological reclamation of the region is connected directly with the construction of the railway, adjacent roads and the first towns and settlements and is still under way. Detailed exploration is conducted on deposits of iron, copper and complex ores, coal, and apatites for priority industrial projects in the mining and industrial centres. At the same time the search for new deposits and general geological surveys continue.

The 1980's will see a new era in BAM's history. The railway line will be opened and the population in the area will increase considerably. Heavy drilling equipment will be brought into the taiga to probe deeper into the earth's crust. The new information obtained will make more accurate calculations possible and subsequent geological forecasts will stimulate new practical undertakings.

The better a region is surveyed, the more reliable its potential deposits of raw materials and the better its economic prospects. In turn, the greater its economic potential, the more varied and exacting the demands made on those whose job it is to study the interior of the earth.

Agriculture is also affected by the geologists' work.

Mineral Fertilizers

● One of the tasks of geology is to provide agriculture with relevant geological information, mineral fertilizers, an underground water supply and building materials.

Almost all land suitable for farming has already been reclaimed in the USSR, and the main task now is to raise its productivity through amelioration, mechanization and the extensive use of fertilizers.

The Soviet Union is the world's major producer of mineral fertilizers which it is now exporting. Their production has increased rapidly: from 5.5 million tons in 1950 to more than 100 million tons in 1980.

The Soviet Union has huge deposits of potassium salts in Byelorussia and the pre-Urals and apatite in the Kola Peninsula. Smaller but nevertheless significant deposits of phosphorites are being exploited in the Moscow region, the Baltic states, the Ukraine and Kazakhstan, and of potassium salts, in the west of the Ukraine and the northern Caspian region, as well as deposits of limestone, chalk, dolomite and gypsum. Most of the latter are to be found in the Non-Black Soil and Black Soil Zones of the European part of the USSR, where farming has been conducted for millennia, and in Kazakhstan, where large tracts of virgin land were put to the plough comparatively recently.

The Non-Black Soil Zone has, for the most part, soddy-podzolic and podzolic soils characterized by overacidity and a scarcity of certain chemical elements. Hence their low fertility. However, nutrient substances with which to enrich them are found in the Non-Black Soil Zone itself.

Agricultural needs are best satisfied by geologists in Byelorussia who have completed the survey of the Soligorsk potassium salt deposit which is one of the largest in the world with four large fertilizer plants operating there. A detailed survey has also been carried out of the deposits of dolomites which are used for liming soils and enriching them with magnesium.

Although fertilizers improve soils and thereby increase crop yields, their extraction and processing cause undesirable changes in the natural environment such as the appearance of artificial hills and ridges of rock, of artificial depressions from strip mines and whole lakes of slime–the liquid waste of dressing mills. Chemically-active substances such as salts threaten soils and underground springs with salination. The benefits derived from mineral fertilizers compensate many times over for the harm their production causes; but agriculture suffers just the same. Polluting substances may accumulate over the years and this must be prevented.

Geologists again come to the farmers' aid since success in combatting waste depends in no small measure on their research. If there is detailed knowledge available about a deposit it can be worked comprehensively and in the most rational way possible, ideally, without waste. Hydrogeologists (specialists in underground waters), monitor the level of chemical pollution and recommend measures to prevent the salination of soils and underground springs.

Another important duty of the hydrogeologist is to supply land improvement specialists with information. Today, any project to drain or irrigate land takes into account the whole complex of natural conditions, including the peculiarities of underground waters.

Paradoxically, the Kara-Kum and Kyzyl-Kum deserts in Central Asia abound in lakes and marshy depressions overgrown with reeds. These are due to the presence of fresh and brackish underground waters close to the surface. Hydrogeologists find these sources and recommend where artesian wells should be bored to make ponds for livestock. At times so many wells are bored that steps have to be taken to protect the subterranean waters: the wells are fitted out with reliable taps and reconnaissance bores are plugged with cement.

A different but equally paradoxical situation is to be observed in the west of the USSR, in the Polesye Lowland of Byelorussia, where bare sands can be seen amidst extensive marshes. This results from drainage ditches lowering the level of subterranean water. Vegetation subsequently withers and dunes form on the tops of hills.

Hydrogeologists discovered this and recommended building covered and vertical drainage systems, which only lower the water level underground over limited areas, and systems of irrigation and drainage regulating the seepage of water to the surface.

An important role in land reclamation is played by specialists in geological engineering. They study processes on and beneath the surface which influence farming, for example, erosion, ravine formation, landslides and subsidence and compile maps helping to make rational use of farmland and combat undesirable phenomena sometimes caused by incorrect methods of cultivation such as ploughing along slopes, incorrect siting of ditches, etc.

Geological help in land amelioration is particularly important in the Soviet Union because it is conducted on a much greater scale there than anywhere else in the world. Over 25 million hectares have already been reclaimed.

It is also essential to find new mineral deposits. Agricultural production is developing vigorously in the eastern regions. The rapidly developing agriculture of Siberia and the Far East already accounts for almost one-third of the Soviet Union's requirements in phosphorous fertilizers. They are supplied mainly from the Kola Peninsula over several thousand kilometres away, naturally at considerable cost. The same is true of potassium salts, although the distance is somewhat shorter.

The construction of the Baikal-Amur Railway will have an envigorating effect on the agriculture of Siberia and the Far East. Geologists have discovered several deposits of phosphate there and regions where potassium salt can be found. They are also studying subterranean waters and several hot springs have been found.

Thermal waters are a special kind of mineral. They are already used in the agriculture of the Far East to heat hotbeds and hothouses. In Kamchatka, a land of volcanoes, industrial enterprises have subsidiary farms using thermal waters. Similar farms will soon be established in Central Siberia, the kingdom of permafrost. Siberian hydrogeologists have compiled maps of hot water springs in the region of the BAM to be used in hotbeds and hothouses.

By discovering new deposits of phosphorites, potassium salts and dolomites, etc., geologists contribute to the production of additional millions of tons of grain, cotton, sugar-beet, potatoes and other crops. Thanks to them, soils receive mineral fertilizers, and animals and plants, pure subterranean water.

To Harmonize with Nature

● Volcanic eruptions, earthquakes, land-slides, avalanches, subsidence, shifting dunes, quagmires and marshes, quicksands and soft clays, icy rocks and underground ice, which do not like heat, soluble salts and combustible gases–these and many other things are studied by geological engineers in planning measures designed to achieve harmony between engineering installations and natural conditions, in particular geological ones.

New projects are growing like mushrooms and engineering enterprises have transformed vast areas. Suffice it to recall BAM, the West-Siberian Lowland, or the plan to channel some of the waters of northern rivers to the steppes and deserts of Central Asia and Kazakhstan. Work is in progress all over the country, from the Byelorussian marshes to Kamchatka and the Kurile Islands, from the Taimyr tundra and islands in the Arctic Ocean to the Kara-Kum Desert and the "roof of the world", the Pamirs.

Cities are a special concern of geological engineering. They are growing in all dimensions, expanding to areas not always favourable for construction, and geological surveys are needed before buildings can stand firmly. Cities are also growing upwards. Naturally, the taller a building, the greater the pressure it exerts on the ground and the more sensitive it is to uneven ground, settling, and earth tremors.

Finally, cities are growing downwards. There are systems of underground transport, passages for pedestrians, warehouses and garages. There are about 150 subterranean power stations in the world. In 1963 a vast underground shopping centre was completed in the Japanese city of Osaka and it is now visited by over a million people daily. In Sweden, a parking lot for 500 cars has been excavated in the slope of a precipice. In Zürich, Switzerland, a parking lot has been built under the Limmat River.

However, underground towns have a long history, an important fact for modern urban construction.

Thousands of cities are centuries old and, over the years, the ruins of ancient settlements, underground passages, caves, cellars, galleries, wells and other such installations have been partly preserved underground. There are famous ramified networks of underground stone quarries in Odessa and Kerch and large caves in Kiev. Incidentally, in Kiev the layer of urban debris and waste reaches a depth of 17 metres, a unique stratum.

About one-fifth of Paris stands on catacombs and nature, as we know, abhors a vacuum. Rocks sag and subside, endangering the stability of whole areas, roads and underground communications not just of separate buildings.

A dangerous situation took shape in Damascus a dozen years ago when the roofs of ancient stone quarries began to subside, destroying the buildings above. The cause of this unexpected catastrophe was discovered with the help of Soviet geological engineers.

Ironically, the process was triggered off by community improvement measures such as the laying of underground communications, the construction of sewerage and water supply systems, and street flushing. As a result the soil in the roofs of the ancient mines was dampened, became weakened and caved in.

The construction of the Kiev metro caused numerous phenomena to take place. The walls of open pits crumbled and slumped. Drainage dried the ground too severely resulting in settling and subsidence. Artificial freezing led to frost humps, whilst thawing weakened the ground significantly.

Subterranean tunnelling is often accompanied by the appearance of hollows and cavities and other deformations on the surface which have a calamitous effect on surface buildings.

Cities sink their roots tens of metres into the earth. The ground under them is penetrated in all directions by tunnels and other engineering networks. Building density in the cities is very high, and the greater the scale of urbanization, the greater the need for reliable, exhaustive geological information.

Geologists have to learn to see through the earth to depths of 100 or more metres where there are strata left by ancient towns and settlements. Below them are traces of great glaciers, the valleys of former rivers, clay galls left by ancient lakes, sea sands and limestones, remnants of the warm seas that once existed there. Such geological sections often occur in the most densely populated regions of the country and the geologist must learn, theoretically and with the help of instruments, any engineering peculiarities they may have as well as their history. This is necessary to make city buildings stable. The better we know the space beneath cities, the more efficiently their deep roots will work.

Geological engineering, a comparatively new science, is extensively developed in the Soviet Union. The first chair of geological engineering was opened in the Moscow Institute of Geological Prospecting back in 1933. Vladimir Vernadsky's works opened up new horizons for geological engineering: the study of the way people are transforming their environment, the biosphere, which includes the hydrosphere, the atmosphere and the upper part of the earth's crust.

Geological engineering encompasses technology, engineering installations and the natural environment.

Recent years have seen the emergence of one more important problem in geological engineering: the study of possible ways of burying industrial waste deep underground and the examination of projects to build oil and gas storage areas underground. In addition, measures are being taken on an increasingly large scale for artificially replenishing water-bearing strata. Man is actively transforming the upper sections of the earth's crust. For these transformations to be of maximum use and minimum harm, geological engineering research is essential.

It is very dangerous to underestimate the importance of a comprehensive study of the natural environment during the construction and exploitation of large engineering installations, cities and mining complexes. This is often the case under capitalist conditions. Not infrequently private entrepreneurs act independently only pursuing the interests of their own firms, joint-stock companies or enterprises. Such uncoordinated spontaneous actions often do serious harm to the national economy and to the population.

For example, in 1962, the earth opened up and swallowed a whole factory in Johannesburg. Later a house sank to a depth of 30 metres there. Such subsidence is believed to be the result of the pumping out of large amounts of underground water and of mining operations: some gold-mines lie within the city limits. Abandoned mines cave in, as do large cavities in soluble rocks lying above gold-bearing strata, thus resulting in the formation of pits on the surface.

Another tragic accident took place in South Wales, Britain, on October 21, 1966, when part of a coal-mine slag heap suddenly started to slide. A mud flow streamed down the valley, engulfed a farm and destroyed several houses, killing 116 children and 28 adults.

Such things happen, even though geological engineering work is conducted in capitalist countries as well. The point is that it is not always comprehensive enough and is not carried out on a sufficiently large scale. In addition, private entrepreneurs often ignore the warnings and recommendations of geological engineers to protect immediate profits and to avoid increases in the cost of equipment.

In addition to taking an active part in socialist construction and ensuring that the economy is supplied with mineral raw materials, the Soviet geological service works to protect the earth's interior and the environment.

To put nature to the service of man requires first of all precise knowledge – a guarantee of technical progress. Technology makes it possible to extract and process minerals.

Only two decades ago it seemed, in the words of the famous philosopher, John D. Bernal, that technical systems would soon make up a new, man-made nature, much more complex and at the same time much more flexible and obedient to man's creative genius than Mother Nature had ever been.

Today such notions are no longer current. Instead, proposals are made to be on friendly terms with nature and to accompany its rational exploitation with its protection. This means that the main role should be played by the sciences concerned with nature, geology included.

Man is part of nature. Therefore, by impoverishing and destroying the environment we are impoverishing and destroying social ties, the human personality. By conducting extensive geological work on earth and by refashioning our domain, the biosphere, we assume a tremendous responsibility for the destiny of everything that lives, for the well-being of future generations.

However, this is all just theorizing. The question which remains is what this should mean in practice: How should the geologist act?

The first principle for the protection of mineral resources was formulated by Alexander Fersman almost half a century ago. He stressed the necessity for using the entire excavated mass of rock, i.e. the comprehensive utilization of mineral products. True, at that time Fersman had the rational utilization of natural resources with minimum energy loss primarily in mind. In the case of minerals, rational exploitation with minimum losses of energy and raw materials is the basic principle for protection of the earth's interior. In the USSR this has been further realized by the public ownership of minerals, forests and waters. The nationalization of mineral deposits created the most favourable conditions for their systematic, comprehensive and effective study and utilization and for protection against unscrupulous exploitation.

In addition to everything else, protection of mineral resources is economically profitable. It has been estimated that comprehensive utilization can increase by 25 per cent the potential of the industries engaged in the extraction and processing of minerals. In the non-ferrous-metals industry alone, over sixty elements are produced as by-products.

But it would be incorrect to use current economic gains alone as the yardstick to gauge the benefits of environmental protection. What we protect today will serve our children and grand-children. It takes a mineral deposit tens of thousands and even millions of years to form, while it can be exhausted within a few decades. Although we can restore vegetation, for example, by planting greenery in abandoned quarries and on mine dumps, there is no chance of renewing mineral resources.

And yet the picture is not all that gloomy.

Recall the development of the Kara-Bogaz-Gol Gulf where the sedimentation of salts is artificially renewed every year: there is something like an annual harvest of a mineral "crop". A similar induced production of useful minerals takes place in some lakes in the area of the Caspian and in Kazakhstan.

In the case of some salts this process is fairly simple since they settle easily when the temperature drops or rises. Not all salts, however, lend themselves to artificial regeneration: for instance, potassium salts settle very reluctantly.

Such problems face miners, technologists and chemists and not only geologists. There has even appeared a special discipline, geotechnology, which is called upon to devise methods of extraction without excavation (for instance, through dissolving minerals underground and pumping them to the surface), and methods for creating mineral deposits artificially.

As a matter of fact, people have practised geotechnology since olden times. For example, Yerofei

Khabarov, a famous Russian explorer of the 17th century, had a salt works where salt was obtained by evaporating underground brine. Today, geologists are looking with growing interest at natural solutions circulating in the earth's crust since a host of useful minerals can be obtained from them.

The geysers of Kamchatka transport to the surface arsenic, antimony and mercury. To the south of Kara-Bogaz-Gol lies the Cheleken Peninsula where wells produce brine from which 300 to 500 tons of lead, 50 tons of zinc, 25 tons of copper, 18-24 tons of cadmium and six to eight tons of arsenic are extracted annually; in addition to 1,200 tons of boron and 7,200 tons of strontium. The high concentration of useful components makes this brine a kind of "liquid ore".

Underground ore-bearing waters are to be found in different regions and at different depths. Geotechnological methods make it possible to create "liquid ores" artificially.

Today, underground waters are the main source of iodine and bromium. Sodium, potassium, magnesium, boron, tungsten, fluor and lithium, Glauber salt, soda, arsenic, and other minerals are also extracted commercially from them. The possibilities of the pitless extraction of strontium, caesium, rubidium, molybdenum and rare-earth elements are being studied in the USSR and a number of other countries.

Transferring to wasteless mineral extraction and processing is important not only from the point of view of the protection of mineral wealth, but also in order to save other natural resources and the whole biosphere. Excavations cause the environment tangible harm in the form of huge strip mines, dumps, stone quarries, mountains of processed sand in river valleys, chemically active solutions and dust. Today man transports vast quantities of rock which formerly could have only been moved by all the mighty geological forces on the earth's surface taken together, say, wind, water, and gravity.

The problems of the regional exploitation and protection of mineral wealth are exceedingly complicated and largely remain unsolved. This is understandable, for it is impossible to change the techniques and to develop new technology which conforms to the requirements of environmental protection overnight. However, Soviet geologists are among the first in the world to have begun the study of the earth's interior not just to exploit its mineral resources, but also in order to be able to protect and renew them. In this they are helped by Soviet legislation as well as by their professional skill, reliable technology and the fine traditions of Russian geological science.

The Fundamentals of Legislation of the USSR and the Union Republics on Mineral Wealth, which was adopted in 1975, states:

"State ownership of mineral wealth in the USSR constitutes the basis of mining relations, i.e. social relations in the sphere of utilization and conservation of mineral wealth, creates conditions for planned, rational and comprehensive utilization of mineral wealth, makes for correct distribution of the productive forces of the country and high rates of development of the national economy, and constitutes one of the principal factors in laying the material and technical foundations of communism. . .

"The Soviet state is concerned not only with satisfying the country's increasing requirements in mineral raw materials and meeting other requirements of the national economy involving minerals utilization, but with preserving natural riches for future generations.

"The Soviet legislation on mineral wealth is called upon to promote its most rational utilization and conservation."

It will be noted that measures for environmental protection, including those involving mineral resources, were taken immediately after the victory of the Revolution. Lenin proclaimed in his "Report on Land" at the Second All-Russia Congress of Soviets on November 8, 1917: "All mineral wealth—ore, oil, coal, salt, etc., and also all forests and waters of state importance, shall pass into the exclusive use of the state." From that moment on, the country's mineral resources ceased being a means for the enrichment of individuals or organizations. They were placed at the service of the people and have since been exploited in accordance with this principle. And this means that the protection of mineral resources, which has also become a matter of state concern, began to be carefully planned, with due account being given both to the immediate consequences and the long-term prospects.

The Horizons of Co-operation

● The vast territory of the Soviet Union, the exceptional variety of natural conditions both on the surface and underground, the abundance of mineral resources, the large scale of engineering construction, the good organization of the geological service and the high professional competence of the geologists of all specialities–all this makes the USSR a useful and reliable partner in geological research in different parts of the world.

"The successes in establishing the USSR's supply of mineral raw materials and the progress made concerning major scientific problems," writes Academician Alexander Sidorenko, Vice-President of the USSR Academy of Sciences, "have won Soviet geology deserved credibility in other countries and promoted the development of the Soviet Union's international contacts in the sphere of geology." Soviet geologists have helped their colleagues in many countries to set up a national supply of mineral raw materials and have played a part in the discovery of many underground treasure-stores in India, Vietnam, Afghanistan, Syria, Cuba and other countries.

The socialist countries' assistance to young states has one very important feature: neither the USSR nor the other CMEA countries are interested in turning developing countries into their economic satellites, the suppliers of cheap raw material, nor in following the example of the United States in the case of foreign oil and acting in accordance with the principle: first we shall use up yours, and then each will use his own.

Back in 1965 the USSR lifted all customs duties on imports from developing countries. Soviet aid, credits and deliveries of equipment are generally paid for by the developing countries by deliveries of their traditional export goods.

Leonid Brezhnev stated that "the Soviet Union fully supports the legitimate aspirations of the young states, their determination to put an end to all imperialist exploitation, and to take full charge of their own national wealth".

The imperialist monopolies' approach to providing economic, scientific and technical aid is quite different. They go out of their way to keep hold of export markets, sources of superprofits and reliable sources of raw materials for their enterprises. Hence their efforts to prevent the former colonies from establishing their own industry and, in particular, their own metallurgical and energy supply.

The character of co-operation between the developing and socialist countries is illustrated, among other things, by the following fact. According to Indian press reports, enterprises built in India with Soviet assistance contribute up to 35 per cent of the steel and up to 80 per cent of the metallurgical equipment produced in the country and account for more than half of oil extraction and one-third of oil refining.

Until the middle of this century India imported practically all its oil and oil derivatives. Then this industry fell under the control of the ESSO, Caltex and Burmah Shell multinationals which seized control of almost all the country's extraction, refining and distribution of oil. The Indian government's attempts to transfer the oil industry into the public sector was vehemently resisted by the oil monopolies.

In 1955, the Indian government requested Soviet assistance in prospecting for "black gold" and, several months later, the first group of Soviet oil specialists arrived. In the course of three years Soviet and Indian geologists discovered large gas deposits in Punjab and oil deposits on the coast of the Gulf of Cambay in Anklesvar (Gujarat), and elsewhere. Over 40 oil and gas deposits were subsequently found with the participation of Soviet specialists. They are now being worked efficiently.

In a country afflicted with an acute unemployment problem, the discovery of oil acquires social as well as economic importance. The deposits become centres for the construction of refineries, fertilizer and petrochemical plants, etc. The city of Baroda (Gujarat) alone now has a large industrial centre employing about 50,000 people.

On May 18, 1979, the Soviet daily, *Pravda,* reported on the successful co-operation of Soviet and Algerian geologists surveying the Hassi-Messaoud oil deposit, the largest in the Algerian Sahara. Soviet hydrogeologists are also carrying out investigations in the area.

The fifty years of joint work between Soviet and Mongolian geologists is one of the most vivid examples of fruitful international co-operation in this sphere. Incidentally, Mongolia's national geological personnel have been trained in Soviet-Mongolian expeditions and in Soviet educational establishments.

In the past few years alone Soviet specialists have helped their Mongolian colleagues to discover and survey deposits of tin, phosphorites, copper-molybdenum ores and gold. Many of the newly-discovered deposits are already being put to use. The first stage of Asia's largest Erdenet copper-molybdenum ore-mining and dressing combine has been completed. Deposits of fluor spar and non-ferrous metals are also being developed. Fourteen coal mines are in operation, and mining will soon be started in the Bagar-Nur coalfields and are hoped to produce two million tons of coal annually.

Joint Soviet-Mongolian geological expeditions are organized within the framework of the Complex

Programme for the Further Deepening and Improvement of Co-operation and the Development of Socialist Economic Integration among CMEA Countries.

Joint geological studies have been conducted in the Balkans, Carpathians and the Caucasus. This work included the drawing up of geophysical, geochemical and geological maps and the consideration of data concerning 720 mineral deposits.

"The main results of this international co-operation," said the Chairman of the CMEA Standing Commission on Geology, "are better knowledge, from the geological point of view, of the territory of the CMEA countries, the discovery of new mineral deposits and the study of known ones, and the forecast valuation of the stocks of principal raw materials.

"All this contributes to the development of extractive industries. Here are a few figures. In the past fifteen years the commercial reserves of natural gas in the CMEA countries have increased by 120 per cent, those of coal, by 20 per cent, copper, by 80 per cent, bauxites, by 30 per cent, manganese ores, by 250 per cent, and nickel ores, 50-fold. There has also been a sharp increase in the known stocks of phosphorites, potassium salts, and native sulphur."

The desire of many countries to co-operate with the USSR in the field of geology is very natural. Soviet geologists have to work with almost all kinds of rocks, minerals and geological structures, and with the sediments of all known geological eras. They also have to conduct a wide variety of engineering and hydrogeological research. They include specialists in old platforms (in Siberia, for instance), where diamonds, iron and copper ores and precious metals, etc. are found and specialists in the youngest mountain ranges such as the Caucasus and Kamchatka. Increasing numbers of Soviet geologists study the sea and ocean bed and shelf zones between continents and oceans.

In short, Soviet geologists can in fact study all possible geological conditions without the need to travel abroad. Consequently, wherever they happen to work in the world they come across familiar problems and underground structures similar to those in the USSR.

One more important circumstance. Thanks to co-operation with the USSR many countries can make use of satellites in geological studies. The exploration of our planet from outer space makes it possible to detect deep-lying structures, large tectonic geofractures, etc.

It is only natural for a country where everything has been placed at the service of the people to readily share its experience, knowledge and economic prowess to benefit other peoples, all the more so since many of them were long denied the chance of using their own natural resources.

* * *

The range of work performed by Soviet geologists is wide indeed: from outer space to the depths of the earth, from well-established areas to uninhabited Arctic wastes. They also work in dozens of other countries throughout the world. Wherever they are working, their common aim is to reclaim underground resources for the benefit of people.

Баландин Рудольф Константинович
НЕДРА ЗЕМЛИ — НА СЛУЖБУ НАРОДУ
на английском языке
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Rudolph BALANDIN

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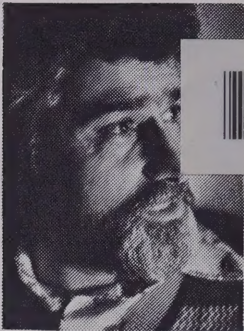

Rudolph Balandin, born 1934, geologist and writer, graduated from the Ordzhonikidze ... rospecting in ... ological field ... oviet Union.

The Soviet Experience

Since the publication of his first article in 1959, Rudolph Balandin has written over 100 articles, essays and short stories and 20 popular-science books (two of them are now in translation) devoted to the sciences of the earth, environmental protection, and man's geological activity.

Modern civilization, our well-being today and tomorrow depend in large measure on our use of underground resources. They are hard to find and extract. If, however, a state is successful in this and can rely on its own mineral resources, this will considerably increase its industrial potential and hasten its scientific and technical progress. A good example of this is furnished by the Soviet Union.