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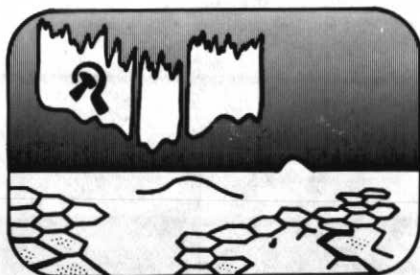
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Articles



Principal Achievements in Soviet Geocryology

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Geocryology as a science which deals with the composition, formation and development of frozen, freezing and thawing rocks emerged in the USSR in the early 1920s, but it was in the 1930s that it grew substantially as the country began looking at ways to explore and develop its northern regions. Northern development was impeded, however, by the permanent presence of perennially frozen rocks. Before launching large development projects, development planners turned to fundamental research to answer questions relating to the production of new construction techniques for building houses, roads, airports, pipeline routes and digging up mineral deposits.

Today, rich natural resources in the country's eastern and northern regions are being tapped in a planned and consistent fashion. And as the years go by, these regions will be more urgently needed to supply the country with vitally needed fuel, energy and minerals.

Under current northern development plans, major work is taking place in Southern Yakutia that is centred on the construction of an open-cast colliery, an ore dressing plant and a large thermal power station in Neryungri. At the same time, work proceeds in the Soviet far east in an effort to

develop an area located on both sides of the newly constructed 3,200 kilometre-long Baikal-Amur railway. Those projects would have been impossible to carry out had it not been for geocryological researchers currently dispatched to many regions of the north.

Fundamental geocryological research in the USSR focuses mainly on the thermo-physical principles of formation and development of the cryolite zone, the relationship between the Earth's thermal field and geological structures, the thermal evolution of the cryolite zone under natural and human intervention conditions, and on the regularities governing thermal exchanges in the atmosphere-ground cover-soil system. Thus far, tests have assisted researchers to determine how surface temperatures and the freezing of rocks are affected by climatic and water exchanges with the earth's atmosphere in various areas of the north. We now know, for instance, what thermal conditions exist within the basic geostructures of the West Sibe-

rian shield, the Siberian platform and the Verkhoyansk-Chukotka region.

After extensive research, a map has been compiled that shows the thermal flux inside the earth which covers the entire zones of permafrost rocks in those regions. Areas with highest and lowest flows also have been established, including a description of thermal features of depressive structures associated with oil and gas deposits in the Siberian platform.

A theory of geothermal fields has been developed satisfactorily. Analytical models of geothermal fields for homogeneous and heterogeneous media in dissected topography have been brought to light, including methods of development for deciphering geothermal data.

For the first time, Soviet geocryologists have conducted thorough investigations into energy exchanges between the soil-ground cover and the near-ground atmospheric system in the permafrost zone. They quantitatively defined the input-output components of heat and moisture exchanges



Figure 1 Yuri Balalayev is a meteorologist who often conducts solar radiation tests while working in Severny-Polyus-22, a drifting research station in the Arctic.

between frozen rocks and the atmosphere, and ascertained the climatic conditions which govern seasonal and perennial freezing. A good amount of fundamentally new information has also emerged on the physics of heat exchange in snow and vegetation covers, while a new trend emerged in earth sciences – the thermal physics of landscapes. This is a theory based on an energy (heat) balance method which leads to a quantitative definition of heat and moisture exchanges between separate landscapes.

The thermal physics of cryogenic phenomena is another area of major research. It has led to the development of a theory on the thermal abrasion of banks which provides answers to development methods of resources in coastal zone water reservoirs. The main principles of predicting thermal abrasion have been formulated while, for the first time in the world, a universal procedure for predicting changes in reservoir zones in the cryolite zone has been devised. Such investigations facilitated the solution of scientific and practical tasks in resource development projects on the coastal zones of the Arctic.

Persistent geological and permafrost studies led to the establishment of the fundamental principles of cryolithology. It is a fairly recent scientific trend which deals with the distribution of underground ice in frozen rocks depending on their genesis, conditions of accumulation and the degree of the freezing of deposits. Major research has also been carried out into the study of laws governing the formation and use of underground waters in the frozen zone. A comprehensive exploration of underground waters in the frozen zone of the Earth's crust, and an examination of extensive hydrogeological zones, finally led to the division of Eastern Siberia into permafrost-hydrogeological zones.

In recent years, the Institute of Permafrost of the Siberian Department of the USSR Academy of Sciences has looked into various methods of investigation of the dynamics of physical and chemical processes. They found that they could be used to study changes in the physical and chemical condition of rocks located in the upper levels of the cryolite sphere in the annual cycle. It has been established that intensive physical and chemical processes occur in the active layer but also far deeper into the levels of seasonal temperature variations in the negative values range.

The phenomenon of negative polarization of rocks which are spatially associated with cryogenic boundaries has been discovered and studied. This prompted scientists to review the theory of induced low frequency polarization of ion-conducting rocks and to assess screening effects in a horizontally-layered medium by

employing units or probing by means of induced polarization.

Interesting results also have been obtained by the Institute's geochemists. They discovered the effect of selective absorption of organic compounds on the surface of oxides and ice. What they in fact found

was that substances having strictly defined ionization potentials were absorbed from water solutions on the surfaces of oxides and ice. They also concluded that there was a link between the electron structure of anions and their capacity for incorporation in the crystal lattice of ice when elec-



Figure 2 Institute divers, equipped with sophisticated instruments, conducted numerous underwater observations from aboard the North Pole-22, a Soviet drifting station in the Arctic. The collection of hydrobiological data helped them acquire a better understanding of sea floor conditions in many areas of the ice-covered region.

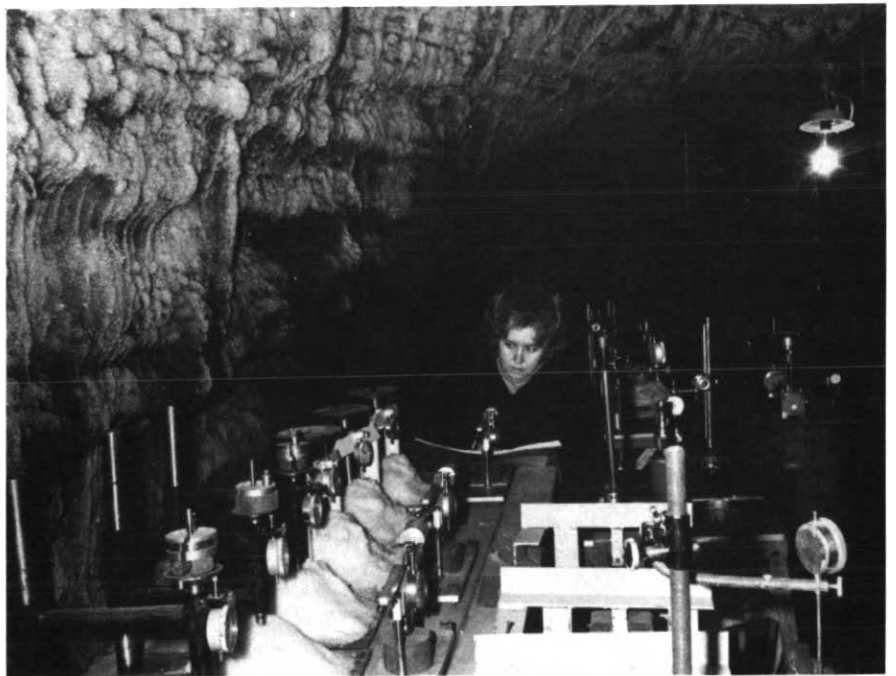


Figure 3 Scientific researcher Tatyana Ermolayeva testing certain physical and mechanical properties of permafrost soil which has been subjected to various pressure conditions in this underground laboratory of the Soviet Permafrost Institute in Yakutia, northern USSR.

trolite solutions freeze. It has been found that the rate of migration of salts in frozen sand, in the absence of a temperature gradient, is determined by the charge on the surface of the mineral skeleton and ice.

Routine studies are conducted on the geocryological conditions in alpine regions of the republic of Kazakhstan and Central Asia, where perennially frozen rocks extend over an area of 170,000 km². The cryolite zone in loose detrital formations is no more than 200 metres thick and may, in fact, reach up to 360 metres in several hard rock areas. Geocryological conditions which are essential to the formation of glacial mud flows also have been under observation, as they pose a threat to many cities of Central Asia and Kazakhstan. Researchers established a direct link between activation of glacial mud flows and the retreat of glaciers leaving behind much ice-filled morainic massifs which, when thawing, are potential sources of glacial mud flows.

Methods have been elaborated for mapping stone glaciers, while data have been obtained on their structure and the rates of their advance. The role of stone glaciers in transporting products of rock destruction has been assessed, including the demonstrated need of taking their movement into account when building high in mountainous regions.

The Institute takes part in investigations and feasibility studies for nearly all major construction projects in Siberia, the Far East and the Far North. Institute researchers have already described existing geocryological conditions in diamond pipes, tin ore deposits in the northeast, coal deposits in Southern Yakutia and primary deposits of gold and non-ferrous metals. Extensive geocryological studies in the Baikal-Amur Railway zone (BAM) have now been completed.

Fundamental research in engineering geocryology helped solve key problems in controlling the temperature of foundation ground, improving farm lands and restoring damaged landscapes. The degree of efficiency of plastic foam heat-insulating linings which reduce the thawing depth of the frozen ground has been determined. Those investigations made it possible to work on a promising method of regulating the thawing depth and the temperature of ground. This may lead to an increase in the bearing capacity of structural foundations and raise the dependability of foundations in use.

In agricultural research, scientists have made studies of optimizing methods of basin and sprinkler irrigation on hay and feed crop areas in Central Yakutia. Work also has been carried out on surface deformations arising when underground ice melts during the creation of new arable lands. In Central Yakutia, between 20 and 30 per

cent of recently utilized ploughlands became unusable within two to three years because of thermally produced trenches of 1.5 to 2 metres deep under ice veins.

In recent years, technicians have devised methods of electric logging of frozen rocks in dry boreholes. For the first time data were obtained on the true electrical conductivity of frozen layers of diamond bearing districts up to a depth of 150 metres.

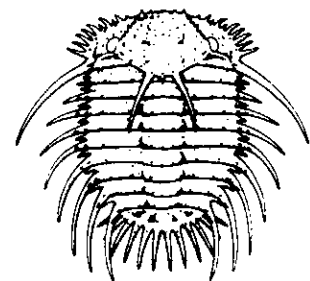
In its course of geocryological research in the Arctic, the Institute has conducted various tests on creating an artificial ice-island from sea water on the Kara Sea shelf for the purpose of drilling oil wells. Quantitative characteristics of heat transfer which were needed for the development of an optimum technology for carrying out production tests were obtained for the first time in the history of Soviet science. In the same area, studies are now under way to develop methods for laying underground gas pipelines with thermosiphon anchors.

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