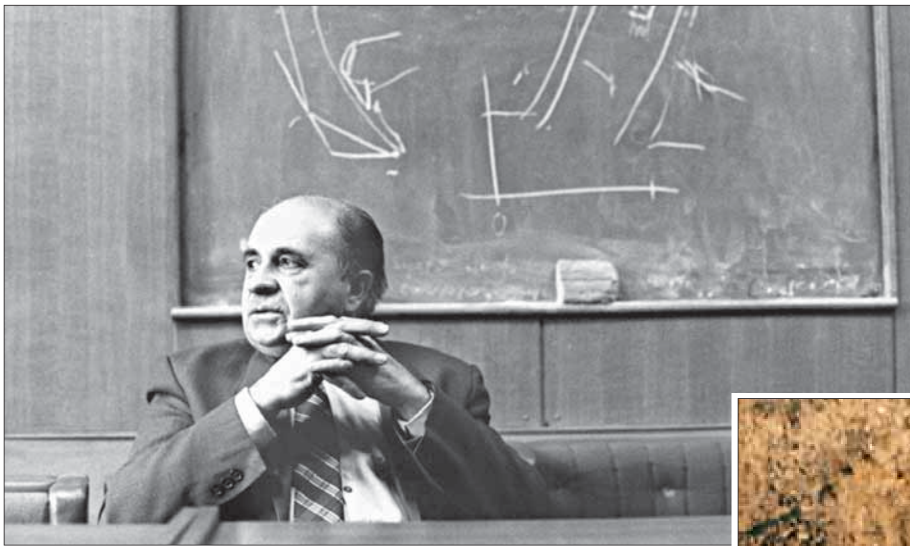

28 In 2013 nuclear physicists marked the 85th birth anniversary of Boris Kadomtsev (1928-1998), one among the illustrious cohort who, with Lev Artsimovich at the head, conceptualized and realized the idea of tokamak setups.

89 Mineralogy as a geological science is as old as the hills. The first descriptions of minerals came from Hellene philosophers. Ore mining followed many centuries later. The kingdom of minerals has many enigmas to it and holds magic attraction. Look for a story by Tatyana Zdorik who has authored many works on minerals.

59 Back in the 5th millennium B.C. it became customary to bury the dead in mounds sitting in steppelands in what is now Russia—in the Volga-Dniester interfluve and north of Caucasia. Most likely it was in those times that man came to be regarded as an individual and not just a tribesman. The hand-wrought burial mounds symbolized one’s passage to the land of the great majority.

A few relict lakes filled with petrified deposits have been discovered in the Maritime Territory of the Russian Far East. The rock structure that has preserved rather well makes it possible to get imprints of constituent slates. Experts of the Far Eastern Geology Institute are studying plant remains in two lakes like that.

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Caucasia played a great part in the life and creativity of the Russian poet Mikhail Lermontov (1814–1841) whose birth bicentennial is marked this year. Its snow-mantled peaks and turbulent rivers, its highlanders, their tales and culture inspired his poetic muse. Pyatigorsk, the Northern Caucasia capital, is a major landmark in the Lermontov memory lane. More about Pyatigorsk, in this number of our magazine.

Lermontov's house in Pyatigorsk.

RIVER PLUMES IN SOCHI WATER AREA

by Pyotr ZAVYALOV, Dr. Sc. (Geogr.),
Deputy Director of the Shirshov Institute of Oceanology (RAS),
Pyotr MAKKAVEEV, Dr. Sc. (Geogr.),
Head of the Biological Hydrochemistry Laboratory
of the same institute

How does anthropogenic impact influence water quality characteristics of the Black Sea water areas adjoining estuaries of the rivers Mzymta, Sochi, Khosta, Kudepsta, Bitkha and others within the limits of the Sochi resort city? Data of ground and satellite observations provide an actual situation of pollution in this region. For a number of years staff members of the Shirshov Institute of Oceanology have been carrying on these observations.

AS EVIDENCED BY STATISTICS

In general for the World Ocean total many-year average volume of river runoff is estimated approximately at 40,000 km^3 per year, which makes up about a quarter of water-balance input of the ocean (the remaining three quarters are provided by atmospheric precipitation to its surface). But for separate shelf regions and also internal and adjacent seas a relative value of continental runoff can be by an order of magnitude higher than for the whole ocean. For the Black Sea this index (about 340 km^3 per year) exceeds atmospheric precipitation (240 km^3 per year) and approaches evaporation value (390 km^3).

River runoff is a main source of getting of dissolved and suspended substances of a continental origin including products of anthropogenic pollution into the sea. According to official data of the RF Ministry of Natural Resources and Ecology an annual runoff to the Russian seas includes 200,000 t of ammonium nitrogen, 60,000 t of phosphorus, 50,000 t of metals (iron, copper, zinc, etc.), 30,000 t of oil products and above 1,000 t of phenols. These and other substances of a continental origin have substantial and in many cases negative effect on ecosystems. Therefore, to forecast the routes of distribution of river runoff in sea shelfs is a major practical task.

The dynamics of such processes is rather complex and is not studied comprehensively. Continental waters, leaving the river estuary, spread over the surface and form in the sea specific structures called in modern

View from the airplane of the Mzymta river estuary. Sochi, Adler region, May of 2013.

literature "river plumes". Their spatial scales vary from tens of meters to tens, and for large rivers also to hundreds, of kilometers. Besides, in most cases they maintain well-defined boundaries with the surrounding sea waters. It is just dynamics of plumes which can explain transfer processes of terrigenous (i.e. brought from dry land) impurities in a coastal area.

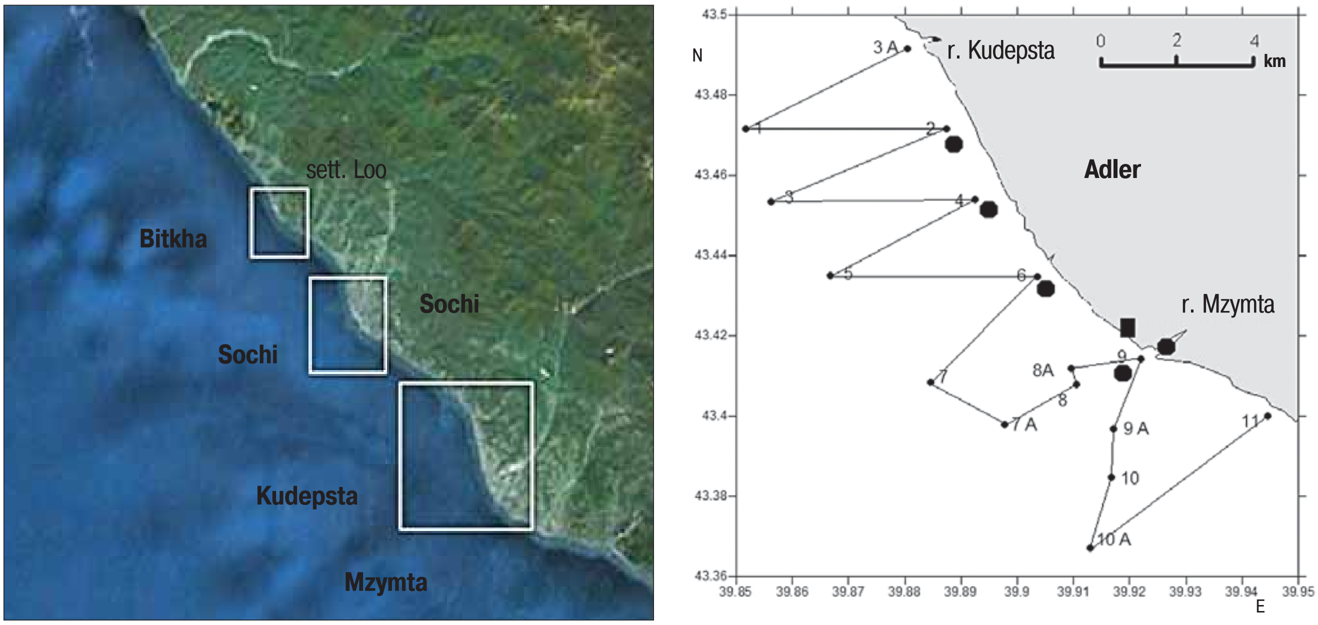
Being an inland and almost closed aquatic area the Black Sea* is especially subjected to the influence of a river runoff. The number of large and small rivers, flowing into it, approaches 1,000, including above 30 within the limits of Russia. All of them are comparatively small, and their total average many-year volume is about 7 km^3 per year, which makes up only around 2 percent of the total freshwater runoff to the Black Sea, that's why specialists paid comparatively slight attention to them in scientific literature. However, though they are an insignificant component of the hydraulic balance for the sea as a whole, their runoff has an appreciable effect on the land-sea system locally, biological productivity of the Russian Black Sea shelf and also the quality of waters in this region.

The problem of their pollution is especially urgent in the aquatic areas close to big cities. First of all it refers to Sochi, the biggest health resort of the country. Industrial and domestic wastes getting to the sea with the runoff of the rivers Mzymta, Sochi, Kudepsta, Khosta and others are one of the dangerous sources. The published data prove that concentration of oil products in the river water within the city exceeds the maximum allowable parameter 10-15 times and that of heavy metals 3-5 times. The intensive construction on the coastal line and especially construction of new port facilities in Adler near the estuary of the river Mzymta and also in the area of the central marine passenger terminal near the estuary of the river Sochi are another factor of seawater quality deterioration in Sochi in recent years. Plumes of turbid water with a high content of suspended and dissolved organic substances near the river estuaries include a considerable quantity of hard domestic wastes (plastic and glass bottles, polyethylene bags, paper, wood fragments, etc.). When the river plumes containing wastes get in contact with the coastal line of beaches and embankments, they essentially impair recreation conditions in a number of regions of the resort city.

NEW METHODS OF STUDIES

Monitoring of the seawater pollution and quality indicators is carried out in Sochi on a regular basis by the Rosgidromet services. The value of these observations is determined by long-term nature of the data. But their limited spatial and time resolution (to our knowledge, the question here is 4 measurements per year in 8 separate points) does not allow to describe details of pollutant distribution, localize their sources

* *See*: M. Flint, "The Black Sea: Problems and Prospects", *Science in Russia*, No. 4, 2007.—*Ed.*



Location of the testing grounds and example of a measurement organization scheme.
Broken line—a ship's movement, sampling points are numbered, black circles—points of installed anchored current meters, black square—point of installed portable weather station.

and also trace their synoptic dynamics under the action of wind and coastal sea currents. These problems require measurements with much higher resolution and using special numerical models.

For this purpose the special *Small Rivers of the Black Sea* program was launched at the RAS Institute of Oceanology in 2006 within the framework of the annual all-embracing field works. In 2009-2013 studies were carried out within the Greater Sochi (rivers Mzymta, Kudepsta, Khosta, Bitkha and others). Practically all expeditions were carried out in the same period of the year, in spring (May), which usually agrees with flood runoff of rivers in this region.

The small-size ship measurements were taken in the form of 3-5 transverse coastal sections up to 4 km long, as a rule, from isobath 5 m to isobath 50 m with a distance between adjacent sections of 1-3 km. At each section several stops (stations) were made for measurements and water sampling. Continuous recording of parameters of the near-surface sea layer was conducted also when the ship moved between stops. The continuous-flow probing system and also an ultraviolet fluorescent lidar* specially worked out at the RAS Institute of Oceanology were used for this purpose. Flow-type sensors recorded temperature and salinity, oxygen concentration and separate chemical components in sea water during the ship's movement, while the lidar analyzed fluorescence spectra of dissolved and suspended substances in water and made express analyses of chlorophyll, suspended matter and dissolved organic substances. Thus, spatial resolution starting from units of meter unusually high for such measurements was provided.

Anchored stations equipped with current speed meters were installed on all testing grounds to study transfer of pollutants and terrigenous substances. Similar devices were installed also directly near river estuaries to trace changes of a river water discharge. Moreover, a portable weather station operated on the seashore, and 10-minute averaged data of wind speed and direction as well as basic meteorological elements were recorded during a whole period of measurements. Then all data were processed in a specially developed numerical model which will be discussed below.

WATER QUALITY INDICATORS

The areas of polluted water in the form of bright plumes almost always associated with river estuaries are clearly traced on the inland shelf for all testing grounds in the horizontal distribution of mineral and general suspended matter, dissolved organic substances and also of a majority of chemical indicators. The linear sizes of such tails differ for various regions of the city, the most extended of them were observed usually in Adler near the Mzymta river estuary. Their average sizes make up about 2 km (area of a respective region

* Lidar is an optical radar for remote sensing of air and water media.—*Ed.*

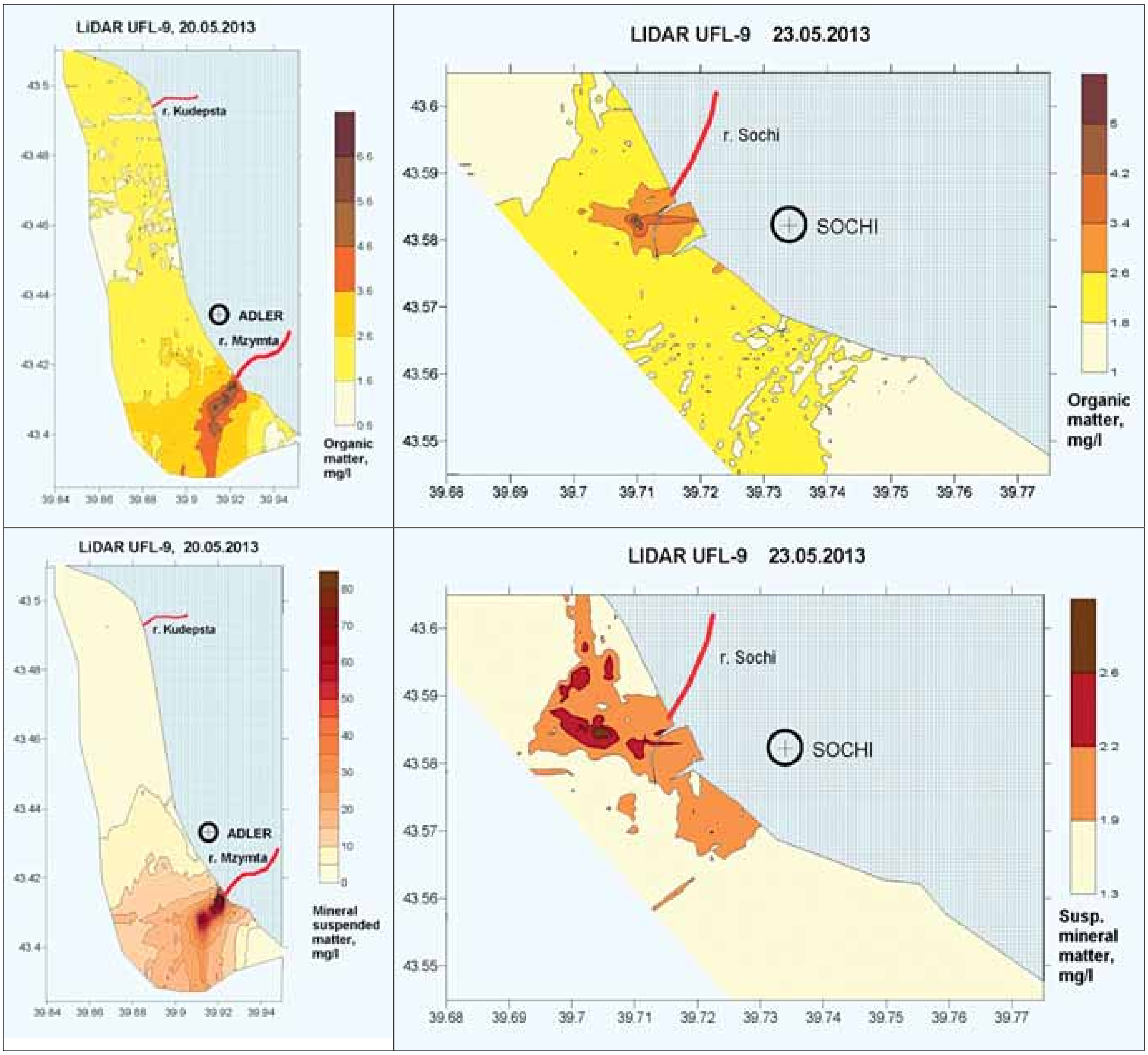
Ultraviolet fluorescent lidar measures pollution in the sea water area of the city of Sochi.

reaches 4-5 km^2 on an average) but there were also observed "gigantic" tails (more than 50 km^2). Our observations recorded the 16 km maximum extension of the polluted area from the Mzymta river estuary. It is noteworthy that this river brings to the sea by an order of magnitude more of terrigenous suspended matter than the river Sochi, though the average many-year volumes of their runoff differ only thrice. In general, the runoff structures in the estuary areas of the rivers Sochi, Kudepsta, Khosta and others have, as a rule, essentially lesser sizes than Mzymta, but at the same time they are not characterized by lesser concentrations of pollutants.

For example, a total concentration of dissolved organic substances in the seawater close to the Bitkha river estuary (Loo—Uch-Dere region) exceeds the background values more than 15 times, concentration of phosphates more than 3 times, silicon—18 times, nitrites and nitrates—6 times and ammonia nitrogen almost 40 times. This river is worthy of a separate discussion. The point is that the river runs through the largest area of domestic wastes in Sochi. The harm inflicted by the dump to regional ecology was a cause of protest meetings and a subject of a discussion in the local and central media. But a degree and a spatial scale of the seawater pollution associated with the dump area and the Bitkha river runoff were practically not studied. Our measurements showed for the first time that this pollution in the said region was really extremely high. True, luckily, the pollution has been localized in a relatively small zone and is mainly spreading in the direction of the Dagomys region along the coastal strip of 100-200 m wide and about 1 km long. The administration of the adjacent resorts has to inform their guests of the situation and think over protection measures. A high concentration of dissolved organic substances is typical also of plumes of other rivers in Sochi.

It should be noted that the situation in some indicators deteriorates every year before our eyes. For example, according to our measurements, the average content of terrigenous suspension in seawater near the Mzymta river estuary was increasing steadily and more than doubled for the last 6 years. The same is true, for example, for concentrations of silicon and nitrites. But the content of oxygen dissolved in seawater, on the contrary, decreased, and today the state of subsurface water is close to hypoxia which cannot but affect the ecosystem's functions and vital activity of biocommunities. But we should bear in mind that the content of a river runoff is very inconstant. The cited data relate to a limited number of point measurements made only in a spring period, therefore they surely do not expressly prove the existence of unidirectional yearly trends. Nevertheless, the noted tendencies seem quite instructive.

As a whole, the accumulated data leave no doubts that seawater in the resort city of Sochi is highly pol-

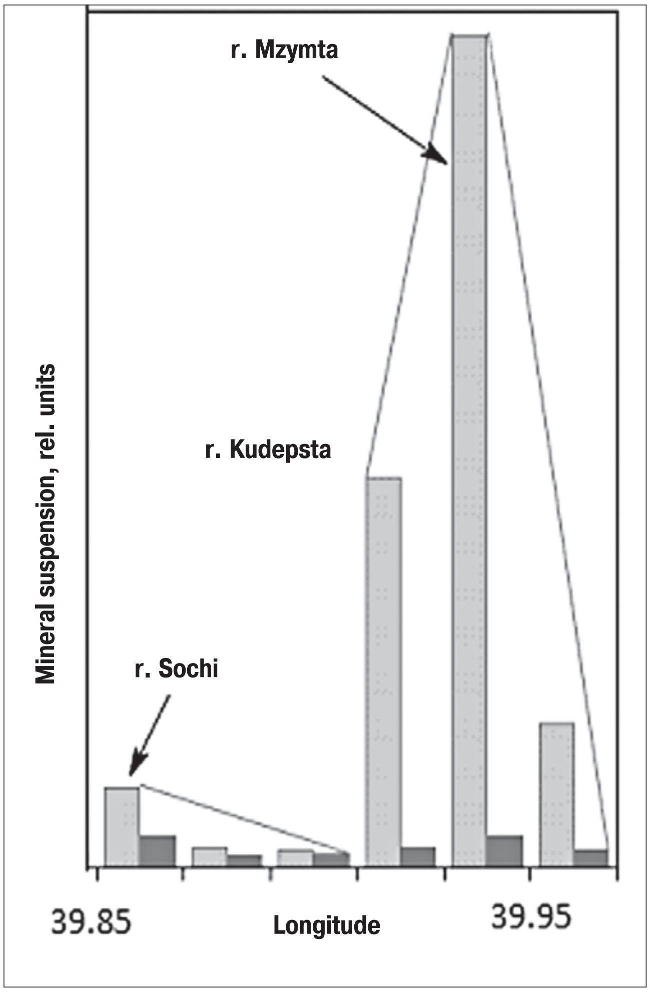


Maps of concentrations of dissolved organic substances (above) and mineral suspension (below) near the Mzymta river estuary (left) and Sochi (right). May of 2013. Dark regions indicate pollution.

luted, and runoff of the local rivers is the main source of this pollution. But the impurities are dissimilar in space and time, they are localized in the form of tails or plumes, whose sizes and location depend on the intensity of a river runoff and also conditions of wind and sea currents. We have already showed that the ecological situation is slowly changing every year, but the local effects of pollutants are apt to change faster. It is illustrated by satellite pictures of river plumes (shown in red and yellow colors). Obviously, their sizes and location change radically during several days and often even in one day.

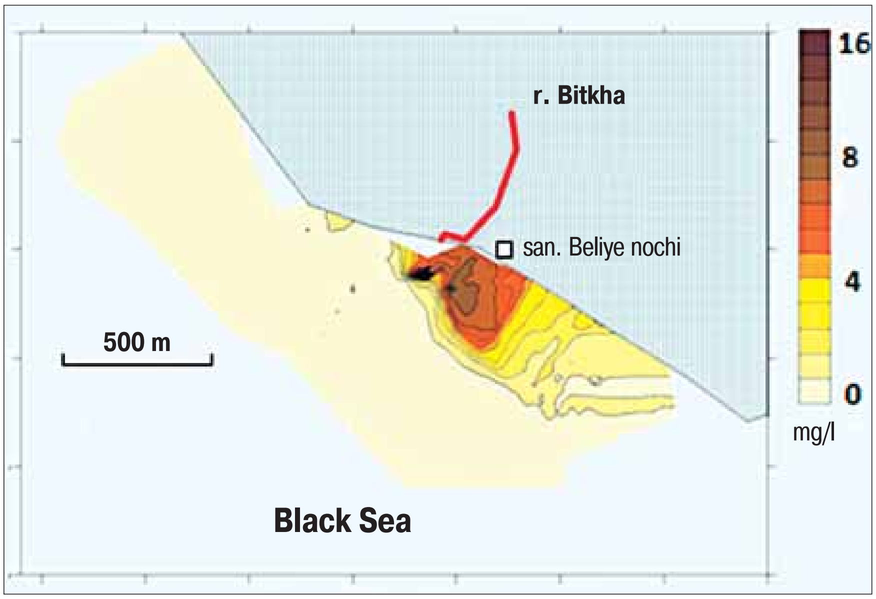
The calculations show that the main cause of such changeability is wind effects. Indeed, river water is less concentrated than clean seawater, therefore it forms a stable and relatively thin, as if sliding on a sea surface, layer. A major part of wind energy is transferred just to this layer, that's why even a moderate wind can move quickly and efficiently polluted continental waters. Our ability to forecast, at least in a short-term perspective, the state of river plumes is important for practical purposes. We can get answers to many questions by means of numerical modeling. For example, what direction and force of winds is most risky for

Relative concentrations of mineral suspension in the seawater on the section taken along isobath 7 m. Arrows indicate location of estuaries of some rivers.

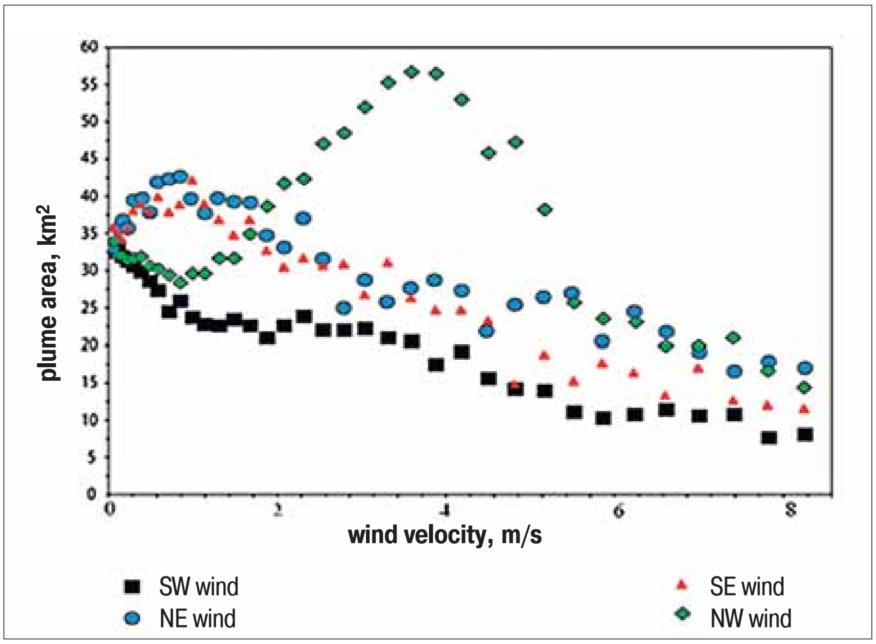


Average concentrations of some hydrochemical quality indicators of seawater near the estuaries of the rivers Mzymta, Kudepsta, Khosta, Sochi and Bitkha.
1—content in water of a lower current of the river before exit to the sea;
2—content in sea surface waters opposite the river estuary, beginning of the “plume”;
3—background content in sea surface waters at a distance of 2-3 km from the estuary.

Estuary region			pH	Phosphates microgram/l	Silicon microgram/l	Nitrates microgram/l	Nitrites microgram/l	Ammonia nitrogen microgram/l
Mzymta	1	river	8.34	28.7	2490	5.2	167.3	
	2	plume	8.38	39.3	924	12.7	78.1	13.3
	3	sea	8.40	18.2	492	7.8	43.5	4.8
Kudepsta	1	river	8.14	22.9	2280	14.2	468.7	
	2	plume	8.15	22.9	516	8.8	28.9	
	3	sea	8.20	32.1	733	12.7	62.9	7.5
Khosta	1	river	8.43	0.9	1898	4.3	211.7	
	2	plume	8.36	2.6	1080	3.2	131.6	2.7
	3	sea	8.28	1.6	244	1.1	4.5	1.8
Sochi	1	river	No measurements were carried out					
	2	plume	8.38	6.8	603	2.7	72.7	14.8
	3	sea	8.34	2.8	130	1.1	7.8	5.9
Bitkha	1	river	8.36	50.6	2931	28.8	466.2	
	2	plume	8.28	10.8	231	0.6	6.2	11.8
	3	sea	8.30	3.3	123	0.1	0.9	0.3



Map of concentration of dissolved organic substances near the Bitkha river estuary.



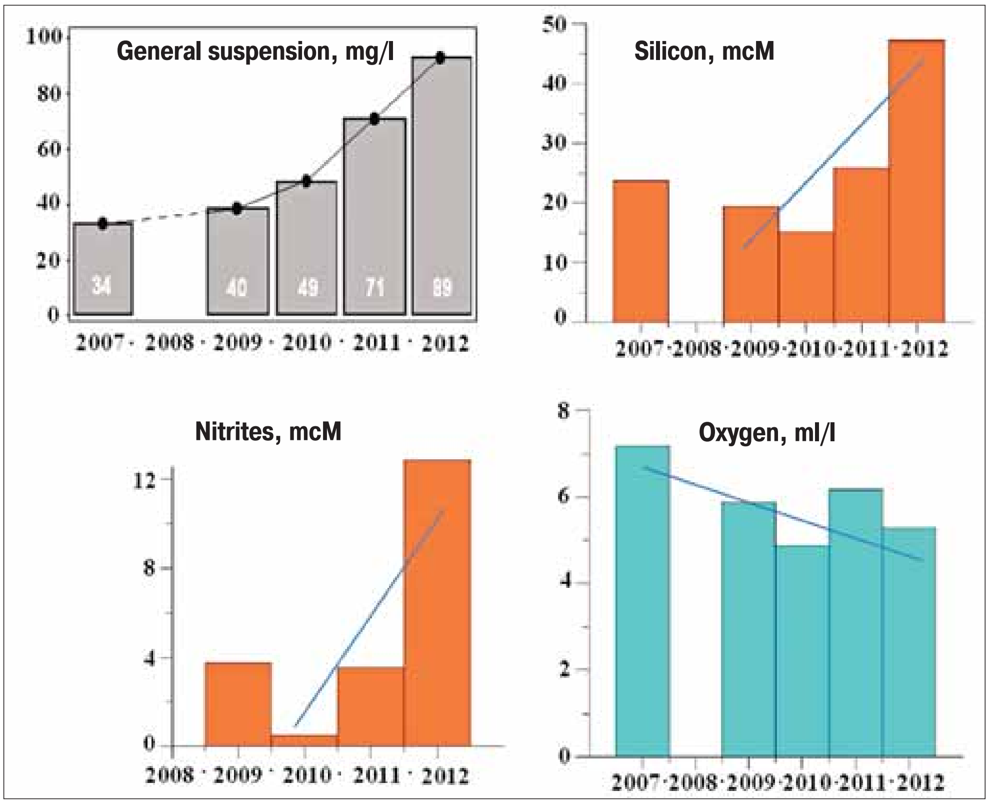
Dependence of a plume pollution area of the Mzymta river on wind velocity given at different directions of wind.

carrying suspension and solid wastes from the Mzymta river to the city beaches of Adler?

NUMERICAL MODELING OF PLUMES

To calculate water movements in a coastal zone one uses usually numerical models based on the Euler method (the 18th century Swiss, German and Russian mathematician and mechanic, member of the St. Petersburg AS, Leonard Euler). This means that the sea together with the continental runoff is regarded in them as a continuous medium, and solve a complete system of equations of its movement (Navier-Stocks equation) on difference grids. But for river plumes such approach can meet with difficulties during reproduction of high-gradient zones near outer boundaries of the desalinated region and on its lower boundary. This can well be explained physically as due to low compactness the plume in many instances behaves as a "foreign" floating object on the sea surface, and it is difficult to describe it within the framework of the concept that it forms a sole continuous medium with the sea.

The Lagrange method (French mathematician and mechanic, foreign honorary member of Petersburg AS from 1776) is an alternative to the Euler method, and it considers balance of forces for certain volumes of water. Let us point out here that such method was not



Some hydrochemical indicators of sea waters near the Mzymta river estuary as measured in different years.

used before to solve the said problems. The numerical model based on this method was developed at the RAS Institute of Oceanology to reproduce transfer of pollutants in the Sochi water area. Plume is represented here as a set of an ample quantity of separate particles or elementary water "columns", which bend to friction force of wind, force of lateral and vertical friction with adjacent water layers, pressure gradient force and the Coriolis force*. Instead of solving transfer equations for a medium as a whole we follow the movement of separate particles tracing the plume, and each particle is treated as a material point. As water moves, it is mixed with its underlying layers in an elementary column, while its salinity changes from zero to values typical of seawater, which results in gradual dissipation of the plume. The new mathematical model turned out to be not only physically adequate but also very sparing as regards numerical resources and rapid action.

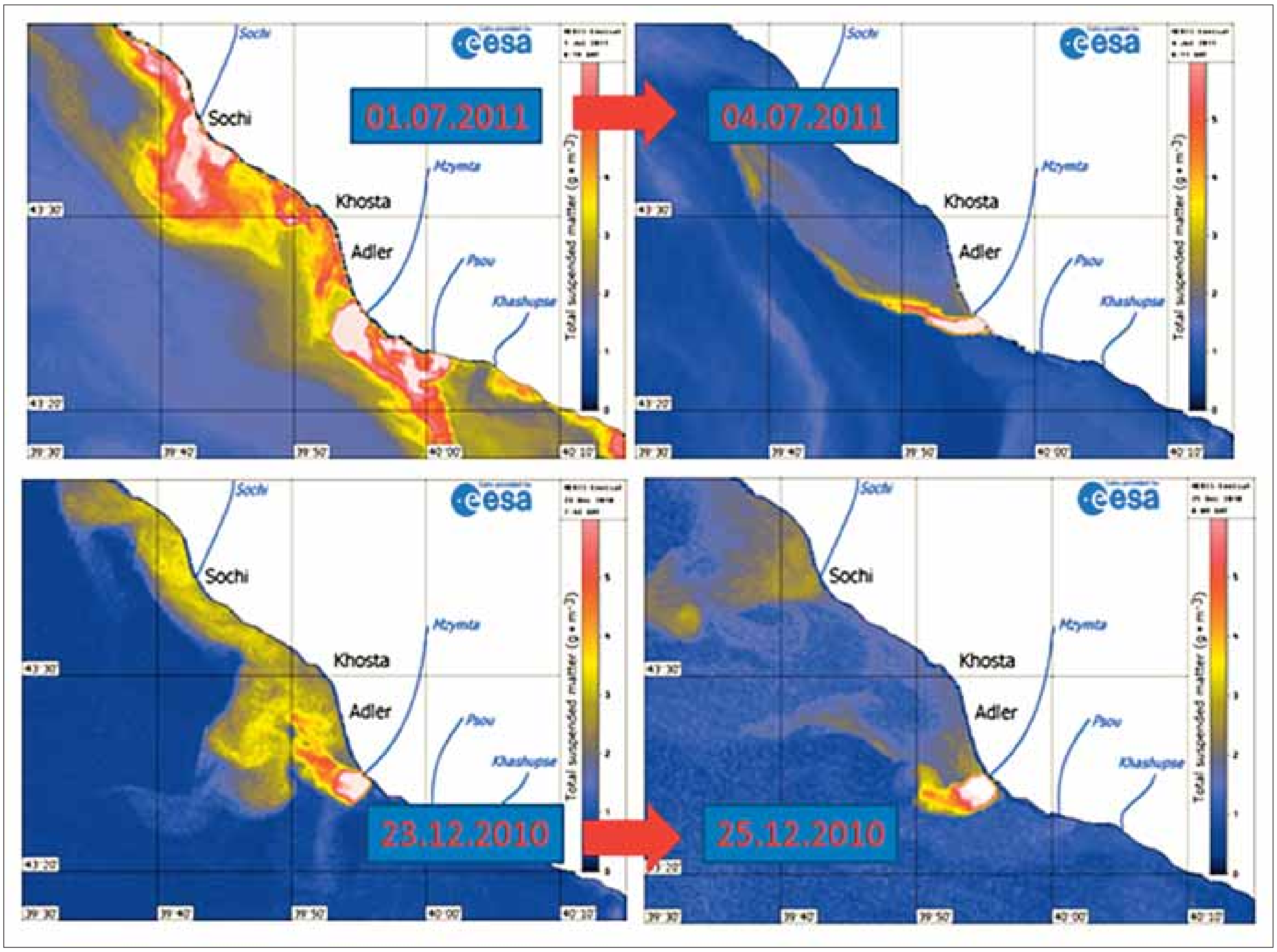
Alongside with the analysis of the field and satellite observations, the conducted experiments allowed to construct a physical classification of river plumes in the Sochi water area and establish a connection between distribution of terrigenous pollutions and characteristics of the wind effect.

Plumes of an isotropic or almost round shape are met most frequently (about 40 percent of all instances). As appeared they are mostly formed in the absence of wind or in case of a gentle wind. Turbid waters of such tail do not directly contact with the shore (except for the estuary zone), they are characterized by anticyclonic rotation and distribution in the south-western and western directions.

The south-eastern along the bank wind contributes to the formation of a tail spreading in the northern direction with the longest linear extension (in case of the Mzymta river plume—up to the Kudepsta region and further). But its area is not so large due to the limits of a coastal strip. Plumes of just such type greatly promote accumulation of pollutants in a coastal zone. They are observed approximately in 20 percent of cases. But the along the bank wind of north-western rhumbs causes appearance of pollution tails extended in the southern direction (also about 20 percent of cases) to the frontier with Abkhazia.

The second in prevalence (above 10 percent of cases) form of plumes is associated with the effect of south-western winds (sea breeze). In such case the plume appears pressed to the shore area near the estuary, as a result of which it is accumulated in this zone and spreads but slightly to either side from the estuary. Pollution plumes of such type are characterized by the least values of the area and linear extent.

* The Coriolis force (after the name of the 19th cent. French mechanic)—one of the inertial forces introduced to register effects of rotation of a movable reading system on a relative movement of the body.—*Ed.*



Satellite pictures illustrating quick changes of a distribution area, shape and direction of river plumes in the Sochi region.

Moderate and strong offshore north-eastern winds cause formation of the least prevailing form of plumes presenting a narrow and strongly extended strip in the south-western or western direction of a small area but relatively large horizontal extent. The offshore wind carries polluted waters to the open sea contributing to its rapid mixing and decontamination of the coastal zone.

Of interest are also model dependencies of an area of a river pollution zone in the sea on the wind speed. Very strong winds always cause pollution dissipation due to intensification of vertical mixing. But in the range of moderate winds these dependencies presuppose a maximum area of the plume at some intermediary values of their speed. The background sea currents and a number of other factors also exert influence on the formation of pollution plumes and transfer of terrigenous substances at the given conditions of a river runoff.

The general conclusion arising from our observations is as follows. The Sochi authorities face the problem of development of a system of measures on ecological control, while scientists should be concerned with the problem of pollution monitoring and forecast at the level of modern requirements for measuring technologies and numerical models.

The results cited in the paper belong to a big team. The authors are thankful, in particular, to the staff workers of the Shirshov Institute of Oceanology Boris Konovalov, Cand. Sc. (Biology), Alexander Osadchiev, Cand. Sc. (Phys. & Math.), Vadim Pelevin and Dmitry Solovyov, a research assistant at the Marine Hydrophysical Institute of the NAS of Ukraine, for the supplied material.

Illustrations supplied by the authors

RUSSIAN REANIMATOLOGY TODAY

by Viktor MOROZ,
Corresponding Member of the Russian Academy of Medical Sciences, Head of the Negovsky Institute of Reanimatology (Moscow)

The problem of life and death has always been vital to people since ancient times. Combating death was their cherished dream that has come true thanks to Vladimir Negovsky (1909-2003), an outstanding scientist, member of the Academy of Medical Sciences of the USSR (elected in 1975), the founder of a new trend in medicine—reanimatology.

THE BIRTH AND HISTORY OF THE REANIMATOLOGY INSTITUTE

Back in the 1930s Vladimir Negovsky was working as practicing physician and then as research fellow at the laboratory of pathophysiology of the Central Institute of Hematology and Blood Transfusion under Professor Sergei Bryukhonenko who created the world's first artificial circulation device—autojector (blood movement in it was maintained automatically by two diaphragmatic pumps connected to electric motors). Vladimir Negovsky saw that death was not a fact, but a process, which could and should be studied. His ideas captured the interest of several young research fellows of the institute. By using an arterial centripetal (moving directly to the heart) pumping of blood with epinephrine (adrenaline), they revived test animals and even achieved their stable survival. Full of enthusiasm and sure that profound studies in this direction would yield positive results, Negovsky turned the Government of the USSR with a request to create a special laboratory. In 1936 that laboratory was set up, it was to look into the problem formulated as "Recovery of Vital Processes in Death-Like Phenomena". A small group of enthusiasts headed by Negovsky started their struggle for death prevention.

Vladimir Negovsky laboratory, Nikolskaya street, Moscow.

Negovsky Institute, Petrovka street, Moscow.

Owing to research done by Negovsky and his followers, it became possible to realize the old human dream of bringing the dead back to life or sustaining life in critical conditions. Such work is going on at the research institute named now after Negovsky.

These studies were continued after World War II and the Negovsky laboratory became (in 1948) "Laboratory of Experimental Physiology of Resuscitation" of the Academy of Medical Sciences of the USSR, and in 1977, "Research Laboratory of Reanimatology" of the Academy of Medical Sciences of the USSR. From the very start the laboratory started active research in a new sphere—pathophysiology of vital functions decay and recovery in critical and terminal states. Negovsky put forward a key idea on the role of the brain in the process of dying. He wrote: "For a long time it was assumed that the last contraction of the heart meant the last stroke of life. We no longer say so since for several minutes after cessation of the heart beat, the body status remains reversible in the sense that the central nervous system is capable of recovering its functions. Actually the still persisting signs of brain viability may signal the last "stroke" of life".

In the 1940s-1950s the laboratory faced many problems, some of them of technological nature, but the enthusiasm of its workers helped to cope. Although research carried out in those years was mostly experimental yet and aimed at elucidating the pathogenetic mechanisms of critical and terminal states, Negovsky was trying hard to adopt reanimatology methods in clinical practice. In 1946 an intensive care unit was set up at the Bakulev surgery hospital.

In 1959 a center involved with shock and terminal states was established at the Botkin Municipal Clinical Hospital. And in 1964 the country's first intensive care department of general profile appeared there, together with the affiliated Moscow mobile intensive care center servicing Moscow hospitals.

Vladimir Negovsky and his team at experimental work.

Research into the terminal state pathogenesis made it possible to understand many important processes taking place during dying and subsequent resuscitation. Basic data were obtained on the loss and recovery of vital functions during dying because of various causes. Different stages of dying were distinguished, and thus it became possible to validate the possibility of recovery of vital functions during clinical death. For these results Negovsky and his team members Maria Gaevskaya and Yevstolia Smirenskaya as well as Professor Fyodor Alexeyev were awarded a State Prize of the USSR. Extensive experience of Moscow hospitals was used for filing general clinical recommendations. The first instructions "On Introduction into Practice of Methods for Restoration of Vital Functions in a State of Agony or Clinical Death" based on these recommendations were issued in 1952 by the USSR Ministry of Health and re-issued in 1955 and 1959. In 1958 the Ministry of Health distributed instructions for organization of intensive care units at hospitals. Mobile teams of intensive care medics equipped with respiration support, blood transfusion, and heart defibrillation facilities were also organized at that time.

HEART FIBRILLATION CONTROL

Problems of heart fibrillation control were an important area of research at the Negovsky laboratory. Its medical scientists formulated a theory with respect to processes implicated in ventricular fibrillation and in its arrest by electric pulses; they proved the universal nature of electric pulse therapy for various kinds of cardiac arrhythmia. Our medics were the world's pioneers by suggesting a method of heart defibrillation by bipolar pulses; this method was recognized as most effective and safe in other countries, too. In 1970 for their electric pulse therapy studies laboratory scientists (Vladimir Negovsky and Naum Gurvich) and a team of scientists headed by Alexander Vishnevsky, a famous Russian surgeon, were awarded a State Prize of the USSR.

In 1958 US Senator Hubert Humphrey visited the Negovsky laboratory. He was impressed by the depth and scale of our studies of resuscitation. Later he addressed US Congress saying he suggested organizing under the aegis of national health institutes specialized centers involved with the physiology of death, reanimation, and related problems. He said the United States should compete with the USSR in a bold search for approaches to at least a partial victory over death.

Proceeding from the findings of his laboratory, in 1961 Vladimir Negovsky presented a report at the International Congress of Traumatologists in Budapest, Hungary. He pointed to the birth of a new medical science—reanimatology with a focus on nonspecific pathological reactions, pathogenesis, therapy, and prevention of terminal states and on life support in critical states. Accordingly, in 1969 the USSR Ministry of Health issued instructions on a national reanimatological service. Professor Peter Safar, a leading American reanimatologist, told Negovsky, he would always be considered a founder of reanimatology by beginning research into dying and resuscitation. He had developed many basic definitions and concepts in this new sci-

Vladimir Negovsky memorial study at the Moscow Institute of Reanimatology.

Scientists at experimental work.

ence. The American medic said he had learned much from Negovsky's concepts and views.

REANIMATOLOGY TODAY AND TOMORROW

Today reanimatology is an important specialization of the three stem lines in medicine: therapy, surgery, and anesthesiology/resuscitation. Anesthesiology/resuscitation investigates problems of life support, provisional replacement of organs and systems (artificial kidney, circulation, liver, ventilation of the lungs) and their functions in critical, terminal, and postresuscitation conditions caused by diseases, injuries, wounds, blood loss, shock, intoxication, and also in various surgical interventions, including transplantations.

In 1985 the national Academy of Medical Sciences set up the world's first Institute of Reanimatology on the basis of the Negovsky laboratory. Today we can see Vladimir Negovsky's memorial room there. In 1988-1995 this institute was headed by Viktor Semenov, Corresponding Member of the Russian Academy of Medical Sciences. In 1995 Vladimir Moroz, the author of the present article, became its head. During the 1990s, a hard time for our country, the institute retained its research collective to become a leading research and clinical center working on problems of anesthesiology and reanimatology. Our scientists are carrying out experimental studies and promoting introduction of their results and new technologies in clinical practice. Our researchers are making a contribution in technological problem-solving related to the manufacture of specialized facilities (defibrillators, resuscitation devices). In 2004 our institute suggested creating a National Council for Reanimation (NCR). One priority task for it involves resuscitation technologies for use at the prehospital stage. NCR—a Russian organization—is a member of the European Council for Resuscitation (ECR).

NEW TRENDS

The main trends in modern reanimatology concern research into the nature of critical and terminal pathological conditions and postresuscitation diseases at the organic, cellular, subcellular, and molecular levels. We mean studies of the trigger mechanisms of irreversible injuries of the brain, neurological disorders, and abnormalities of circulation and respiration functions, of endocrine and immune systems, and hemostasis in critical states, during dying and subsequent recovery of their functions. Our scientists have brought out formative regularities in postresuscitation abnormalities of the brain and viscera caused by disoxia and toxemia as key components of postresuscitation pathogenesis as well as impairment of the structure of the hydrate membrane enveloping biopolymer molecules, and immune and microcirculatory failures.

We also centered on the molecular mechanisms of dying and recovery of vital functions after critical blood losses, on the significance of apoptosis* and necrobiotic processes (necrobiosis—dying) in the pathogenesis of posthypoxic encephalopathy (PE) and visceral dysfunctions. We have detected clinical and extraclinical pneumonia risk genotypes and collected important data on DNA aberrations, apoptosis, and necrosis of blood cells in patients with severe combined injury**, blood loss, and hemodynamic disorders. Thus, we have validated the role of the genetic factor in the development of critical states and obtained new data on cell membrane injuries at the nanostructural level.

Studies of the genetic, metabolic, structural, and functional injuries concomitant to critical states have led to the discovery of mechanisms implicated in critical, terminal, and postresuscitation states. Today the focus is on experimental validation and clinical tests of methods for correction of the critical state hypoxia (oxygen insufficiency). New combination methods for hypoxia correction have been developed on the basis of relevant data. Among other things, the concept of using Perfluothane—a blood plasma substitute with a gas transport function—has been substantiated. Perfluothane is a perfluorocarbon-based drug improving blood microrheology*, microcirculation and oxygen balance. It protects cell membranes, improves the course of the reperfusion (oxygen-dependent) process, and reducing the intensity of degenerative changes in the viscera.

A new-generation perfluorocarbon emulsions (dissolving oxygen easily) with better characteristics have been obtained at the Negovsky Institute with the use of a new class of emulsifiers. For basic studies in this sphere, specifically, in creating Perfluorocarbon media for regulating the vital activity of organs, cells and organism at large, Viktor Moroz, Corresponding Member of the Russian Academy of Medical Sciences, was awarded a Prize of the Government of the Russian Federation (1999), and in 2002 he merited a "Vocation Diploma"—the First National Prize for Russia's Best Physicians.

The Institute of Reanimatology is playing a leading part in reanimatology research. Thanks to activities of the Biophysical Laboratory (headed by Prof. Alexander Chernysh) at our institute, we have obtained data on the mechanisms of action and cellular effects of Perfluorane. Changes in the erythrocyte membranes nanostructure in health, disease, and during Perfluorane treatment were studied by a new method—atomic force microscopy.

Our scientists are focusing on the improvement and experimental and clinical development of methods for preventing organic disorders and for intensive care during the postresuscitation period; they are handling reanimatological technologies and life support systems in critical, terminal and postresuscitation states. Research

* Apoptosis—programmed cell death, self-destruction process regulated at the cell level as the cell breaks into apoptotic (dead) bodies enclosed in the plasmatic membrane.—*Ed.*

** Combined injury relates to traumas inflicted on two or more anatomic regions of the body by a traumatic agent.—*Ed.*

* Blood microrheology, variable blood viscosity in the microcirculation system, dependent on bloodflow.—*Ed.*

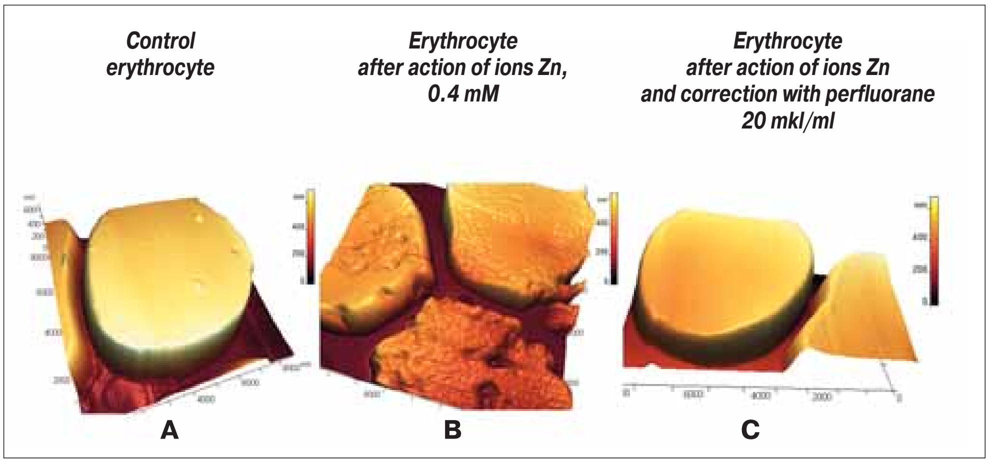
Scientists at clinical work (at intensive care units of the Botkin Municipal Clinical Hospital).

Modern cardiopulmonary resuscitation methods taught by instructors of the European Council for Resuscitation.

and practical aspects of extracorporeal detoxication* are studied as a substitute therapy in septic shock, acute renal, hepatic, hepatorenal failures of different etiology. Multistaged uses of low-energy laser technologies and other modern reanimatological methods and technologies are under study as well. Novel systems of life support and modern sophisticated reanimation facilities have been designed and adopted in practice, as well as methods to correct disorders in critical and terminal states. High technologies and nanotechnologies are actively introduced in diagnostic and therapeutic procedures.

The Negovsky Institute is working to develop and improve the philosophy of the anesthesiological and reanimatological service and to organize intensive care by means of cardiopulmonary resuscitation methods at the prehospital stage. We have devised principles of a universal state system for training the population to be able to give first medical aid and resuscitation procedures in disaster management and have drawn up a Cardiovascular Resuscitation Protocol in Premedical Aid.

* Extracorporeal detoxication involves therapeutic methods making use of blood-cleansing devices that eliminate external toxic substances getting in.—*Ed.*



Erythrocyte membrane nanostructure in health (A), at zinc intoxication (B), and after Perfluothane treatment (C). Atomic force microscopy.

MECHANISMS AND METHODS IN ARDS TREATMENT

Comprehensive studies of mechanisms and methods for the treatment of acute respiratory failure has become one of the priorities of our research and clinical work in recent years. Experimental studies have demonstrated morphological changes occurring in the lungs due to various destructive factors. Clinical studies in patients with acute respiratory distress syndrome (ARDS)* brought out specific features of the pathogenesis and clinical signs of direct and indirect lung injuries. We detected the accumulation of extravascular liquid in the lungs during various ARDS scenarios and saw the prognostic significance of this parameter. Accordingly, our scientists were the first to develop an algorithm of differential diagnosis, and differentiated therapy for ARDS caused by different factors. Thus, it became possible to create a new classification and adopt it in practice.

The introduction of modern technologies has demonstrated the efficiency of differentiated (depending on ARDS causes) intensive care measures. For the first time ever the period of respiratory support and treatment in intensive care units and the mortality rate were brought down.

The achievements of the Institute of Reanimatology were honored at the governmental level. Our scientists—Viktor Moroz, Corresponding Member of the Russian Academy of Medical Sciences, heading the team, Gennady Ryabov, Member of the Russian Academy of Medical Sciences, Prof. Arkady Golubev, Prof. Yuri Churlyaev, and Alexei Vlasenko, Cand. Sc. (Med.), were awarded a Prize of the Government of the Russian Federation in Science and Technology “For Improving the Efficiency of Diagnosis and Treatment of Acute Respiratory Distress Syndrome (ARDS) on the Basis of New Most Progressive Medical Technologies”.

EDUCATION ACTIVITIES

The work of our institute cannot be divorced from its education activities. The training of skilled specialists for research, academic, and practical work has been our priority since the very beginning. Certification cycles, theoretical and clinical training (at our clinic, too) is an important part of our activity. Our research results are published in international and Russian journals, presented at international and Russian scientific forums—congresses, conferences, workshops. New technologies developed at the Institute of Reanimatology are confirmed by numerous patents. We are publishing the research and practical journal “General Reanimatology” (since 2005), monographs, research papers, proceedings of conferences, and methodological recommendations. Our specialists are contributing to the filing of normative documents and recommendations of the Federation of Anesthesiologists and Reanimatologists.

Russian reanimatologists have scored results of world significance in recent years; a new trend in medicine—reanimatology—has come to stay. We can say with good reason that the Negovsky Institute of Reanimatology is Russia’s only research center specialising in anesthesiology and reanimatology, a leader in this vital area.

Illustrations supplied by the author

* Acute respiratory distress syndrome (ARDS) is a deadly inflammatory involvement of the lungs characterized by diffuse infiltration and severe hypoxemia. This pathological condition is caused by many factors directly or indirectly affecting the lungs and after resulting in death (up to 80-90 persent). This syndrome calls for intensive care and forced ventilation of the lungs.—*Ed.*

ARCTIC ROUTES OF LASER

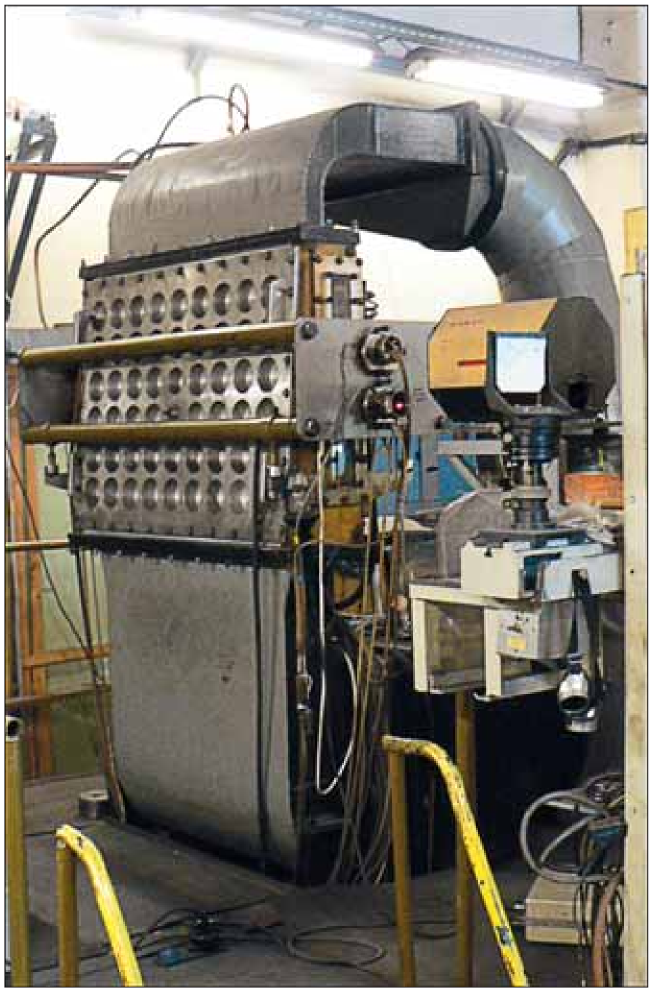
by Vera PARAFONOVA, journalist

How can one kill a gas blowout well? Only by its fragmentation (cutting to blocks) and consequent separation using special equipment. Several years ago to conduct remote accident recovery works the members of the State Scientific Center of the Institute of Innovative and Thermonuclear Research (Troitsk) (*Rosatom* State Corporation) together with the *IRE-Polyus* Research and Development Association (Fryazino, Moscow Region) suggested a mobile laser up to 24 kW power technological complex MLTK-20 whose coherent (monochromatic) radiation provides remote cutting of heavy-walled elements of emergency oil-gas derricks to pieces. The latest design of physicists passed ground tests and was repeatedly used in elimination of open-gas blowout.

LEADING POSITIONS

The history of the Scientific Center where promising types of lasers are developed today started in 1956 when the Magnetic Laboratory of the USSR Academy of Sciences was organized on the initiative of Acad. Anatoly Alexandrov* in Krasnaya Pakhra (Moscow Region). In 1961 it was incorporated into the Kurchatov Institute

* *See*: N. Ponomarev-Stepnoi, "At the Head of the Nuclear Branch", *Science in Russia*, No. 2, 2003; Ye. Velikhov, "Unable to Live Otherwise"; M. Mokulsky, "Rebirth of the Nation's Genetics"; V. Popov, "Scientific Works of Academician Alexandrov", *Science in Russia*, No. 1, 2013.—*Ed.*



Fast-flow electric-discharge CO_2 laser LT-1 with a closed gas-dynamic circuit and lateral flow volume.

of Atomic Energy (IAE)*, on whose basis primarily the Plasma Power Engineering Division was created in 1970 and then the IAE branch in 1971 reorganized into the Institute of Innovative and Thermonuclear Research in Troitsk in 1991.

The 1970s are rightfully considered time of the uppermost creative effort of the institute. It was just then that the institute headed by Acad. Yevgeny Velikhov** (from 1971 to 1978) made an advance in a number of sciences such as physics of plasma, laser technology, superconductivity and magnetohydrodynamic (MHD) generators. Today the institute holds leading positions in controlled thermonuclear synthesis, physics of high- and low-temperature plasma, plasma power engineering, and physics and technology of high-power gas-discharge lasers. The institute provides fundamental research primarily in safety of atomic power engineering and also introduces technologies based on CO_2, CO, excimer and solid-state lasers into other spheres.

MOBILE LASER

In the 1970s the institute developed a fast-flow CO_2 laser of continuous action with a closed gas-dynamic circuit LT-1, which is introduced into enterprises of 10 industries. It is used for cutting of nuclear fuel elements and used up highly-active parts, welding of elements of the reactor protection system and heat exchangers, surface treatment of blast-furnace tuyeres thus twice increasing their heat stability, hardening of cutting tools and stamping equipment and also cementation of low-carbon steels which extends service life of pile-driving equipment four times.

Comparatively small divergence of CO_2-laser beam allowed orientation of the first plant LT-1 alone to a remote performance of operations. It cut a centimeter layer of concrete in the process of “shelling” (cleaning) at a distance, welded and cut steel sheets for industry, construction and even cut a stainless pipeline just without rotating a pipe (a laser beam rotated) and gas supply to the cutting area.

Apart from the problems of remote usage of this plant when access to the accident source was hindered, there appeared problems of mobile shifting of this plant to the place of possible accidents for elimination of their consequences. Therefore, already early in the 1990s the institute scientists and engineers took up developing a portable version of high-power laser. Besides, they took account of possible reduction of its weight and size due to utilization of a carbonic acid gas/open air mixture as a working medium in the open cycle.

Just so an idea emerged of developing mobile laser technological complexes based on CO_2 lasers (MLTK) promising for accident recovery and disassembling works in atomic, gas, oil refinery and other industries. They met the basic requirement in such cases, i.e. prompt delivery of the required equipment to any place

* *See*: A. Gagarinsky, Ye. Yatsishina, “From a Secret Laboratory to a National Research Center”, *Science in Russia*, No. 2, 2013.—*Ed.*

** *See*: V. Shafranov, “Beyond the Pale of What Is Known”, *Science in Russia*, No. 1, 2010.—*Ed.*

Mobile laser complex MLTK-50 in the territory of the TRINITI Scientific Center.

by all types of transport (ground, water and air) and its on-line use for elimination of accident problems during dozens of minutes.

The mobile complexes MLTK-5 and MLTK-50 passed field tests already at the end of the 1990s. The first complex was created in 1998 on the basis of a gas-discharge CO_2 laser of closed circuit with pumping by self-sustained discharge and output radiation power 5 kW on a car frame of a container truck semitrailer and could machine large-scale metallurgical, mining, chemical and other equipment. It could also be used in shipbuilding for replacement of several stationary plants and in the mining industry for rock breakup at a distance of up to 30 m from the place of action.

ATMOSPHERIC ENERGY

In 1992-2000 by order of OAO *Gazprom* the TRINITI scientific center developed MLTK-50 on the basis of a pulse-periodic electroionization CO_2 laser of open circuit and radiation power up to 50 kW. In 2002 the following persons were granted the RF Government bonus for this work: the institute scientists and engineers Vladimir Vostrikov, Valery Gavrilyuk, Alexander Krasyukov, Valery Kuznetsov, Valery Naumov, Vladimir Cherkovets, Leonid Shachkin, Vladimir Shashkov and their colleagues from the Yefremov Research Institute of Electrophysical Equipment (St. Petersburg), the Raspletin *Almaz* Science and Technology Association and the *Gazobezopasnost* company (Moscow).

Freshness of the idea when developing the complex was based on utilization of surrounding atmospheric air with addition of 5 percent carbonic acid gas as the main working medium. Laser beam was brought to the atmosphere through a special gas-dynamic seal and directed to an object by mirrors of a forming guidance telescope. The plant installed at a distance of up to 80 m from the object could cut metal structures and reinforced concrete during accident recovery works at atomic power stations and oil and gas wells, eliminate consequences of earthquakes and other natural disasters, dismantle ships including atomic ships and submarines to metal scrap, clean coastlines from oil products after oil spillage and water surface from oil film. MLTK-50 was installed on two serial car semitrailers, and the layout of its equipment weighing less than 50 t allowed railway transportation.

In October of 2000 in the course of field acceptance tests the complex proved useful in cutting fragments of gas fittings with over 100 mm diameter and up to 20 mm wall thickness at a distance above 50 m. The laser beam broke through a 5 m flame. At the next stage it cut gas pipes of 250 mm diameter and metal structures up to 50 mm thick. Its energy (radiating wavelength 10.6 mcm) was transported to a distance of 20-70 m in the atmosphere passing through 6 m firefront. Fragmentation and removal of the damaged gas equipment in the mouth of a gas well shooting out flame ended successfully. The gasmen were not satisfied only with the weight and size characteristics of this complex.

YTTERBIUM LASER

Early in the 21st century compact high-power optical fiber laser sources appeared in laser technology. It has become clear that similar systems with fiber-optic delivery of energy (distance up to 300 m) successfully fit in the institute's concept of creation of multifunctional mobile MLTK. Finally, the series of fiber plants

Autonomous mobile laser complex MLTK-2 ready for shipment to any point of the country.

suggested by *IRE-Polyus* Research and Development Association (Fryazino) allowed the institute specialists to create a mobile complex family of a new generation.

The first complex MLTK-2 of 2 kW power based on ytterbium laser was created by order of *Rosatom* state corporation. It solved one of the difficult problems in atomic power engineering associated with the end of service life and removal from service of nuclear objects, namely, fragmentation of parts and units and multiple reduction of their radiation and ecological danger. Due to high productivity, possibility of remote handling of works and reduction of a volume of secondary radioactive wastes liable to disposal laser technologies provide substantial advantage in such cases as compared with conventional chemical methods.

The mobile complex MLTK-2 operates in national industry almost for 10 years and demonstrates excellent technical characteristics in remote cutting of metal structures up to 20 mm thick at a distance of dozens of meters from the test object. During breaks in technological tasks with a visit to the dislocation site this complex is used for commercial precision cutting of metal sheets of different thickness (up to 14 mm). Besides its constituent three blocks 3 m long and weighing 970 kg can be transported by any delivery vehicle. Upon arrival the set-up time of the complex is less than 10 minutes.

The complex MLTK-3 is also good for dismantling of construction structures by using three laser sources of 1 kW power. It consists of seven equipment modules each not exceeding 100 kg and working independently.

BEAM-LIQUIDATOR

The complex MLTK-20 developed at the institute in 2010 in cooperation with the *IRE-Polyus* Research and Development Association (Fryazino), *ETAN-Promgaz* (Moscow), *Sistema* Research and Production Center (Moscow), Vavilov Optico-Physical Laboratory (St. Petersburg) and other organizations to order of the *Gazprom Gazobezopasnost* company is one of the latest developments of the RF SSC TRINITI. Continuous ytterbium laser emission sources each of 8 kW power with a cooling system are installed in three out of the four container blocks of less than 2 t each (to compare with 48 t MLTK-50). Laser emission is brought from each source to a forming telescope installed in the fourth container block by a fiber-optic route up to 90 m long. The guidance, positioning and control systems of the complex are also installed here.

Such layout (modular structure) allows usage of laser blocks not only as a part of MLTK-20 but also separately depending on a pattern of operations. The four-block assembly can provide guidance of a 24 kW laser beam to any given zone, for example, cutting of metal structures at a distance of up to 70 m. The set-up time of the complex in field conditions does not exceed half an hour at a continuous operational life of the main equipment. The cutting speed reaches 2 m/h and depends on metal thickness. Besides, the complex output power can be increased by attachment of additional container blocks.

The first full-scale tests of MLTK-20 were carried out in May of 2011 in the *Dosang* Training Center of

Three containers of the technological complex MLTK-20 include sources of continuous fiber laser radiation.

The fourth container includes a three-channel telescope with systems of a laser beam guidance to the target and of complex control, and also an operator's workstation.

Gazprom (Astrakhan Region). One may state that it was its first world demonstration. For the first time the complex was transported on the car semitrailers at a large distance (1,000 km) by Russian spring roads. During the tests the complex cut gas fittings of blowout wells with 50 mm thick walls to fragments at a distance of 40 m. It took place in the presence of several dozens of specialists from Russia, the CIS and foreign countries. But the first full-scale test of MLTK-20 was conducted in July of 2011. Having covered above 5,000 km of national roads the complex was delivered to a gas field of the Yamalo-Nenets Autonomous Area. Let us point out that the high-power laser facilities developed at the TRINITI Scientific Center for elimination of accident consequences were used for the first time in the world.

Mobile laser technological complex MLTK-20 on "fighting" positions.

BLOWOUT WELLS

On July 12, 2011, an open gas blowout took place as a result of explosion at drilling on the West-Tarkosalinsk gas field (Purovsky District, Yamalo-Nenets Autonomous Area). Four days later MLTK-20 was delivered by motor transport to the place of accident. The derrick damaged elements (above 240 t of metal) blocked the well mouth and hindered elimination of the accident and conducting of the stipulated for such cases recovery work. The laser complex was to cut massive steel parts of the damaged structure, make free and cut off a flow pipe flange. Formally such wells were "shot" by means of artillery guns which turned also rather valuable and expensive equipment into a scrap heap. But this was not our case. Though MLTK-20 operated under extreme conditions (high-power thermal radiation of the gas flame prevented from advancing nearer than 70 m) the heaps of metal structures were removed and the flange was cut off. Thereafter the gasmen plugged by their own means the gas blowout which carried to the atmosphere almost 20 mln rubles daily. The total time of laser radiation generation due to a reliable operation of MLTK-20 was over 30 hours.

On August 19, 2013, an accident took place on the Samburg oil-gas condensate field (Yamal Peninsula) 150 km to the north of Novy Urengoy. The institute specialists promptly loaded a laser complex on board of a transport airplane IL-76 and sent it to the place of accident. On the next day the laser complex set to work. The situation was complicated by the fact that in contradistinction to the previous well, which was not yet put into operation, that one was already functioning. Therefore, the work had to be done with utmost care. The thermal radiation from the powerful flame of about 10 m diameter did not allow to deliver the equipment closer than 60-70 m. Nevertheless, MLTK-20 after 2.5 days of practically uninterrupted operation managed to cut off 9 out of 12 elements of the oil-gas fittings, namely, a blowout preventer flange of the wellhead, which allowed the artillerymen to easily remove an upper part of the locking device without damaging the basic equipment and clear the route of the gas flow vertically upwards.

LASER-ASSISTED PILOTING OF SHIPS

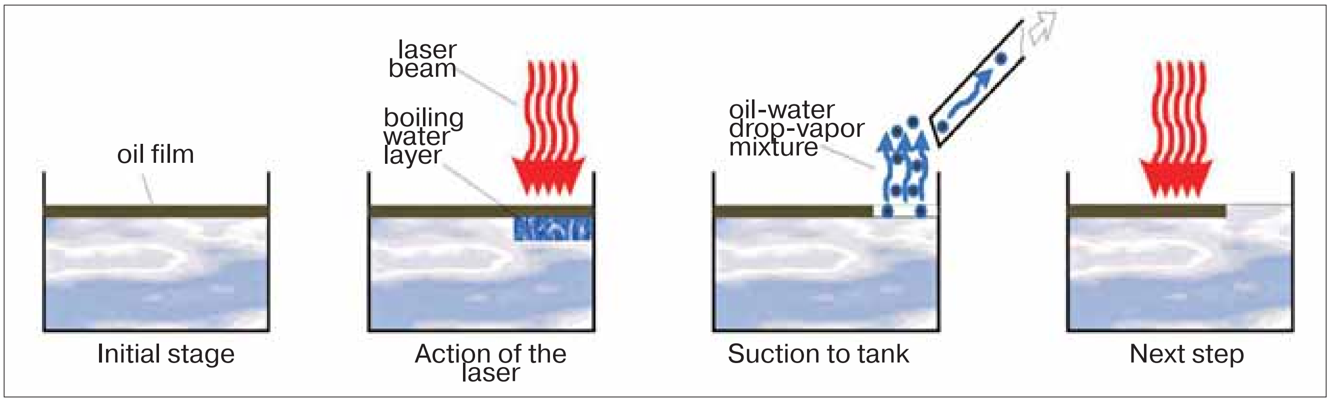
It was planned to use the gas-discharge MLTK-50 also for cleaning of a water surface from a thin "rainbow" of oil film difficult to be removed by other means. This is especially the case today. In the period of industrial and technological development of the Arctic Regions where active construction of drilling rigs for development of oil and gas off-shore and shelf deposits is under way, there arise problems, in particular, of protection of the marine environment and coastal belt from oil- and gas-condensate contamination. Therefore, *Gazprom* company as a main developer of natural resources in the region takes an active interest in a reli-

Dislocation of the complex MLTK-20 near a gushing forth accident well.

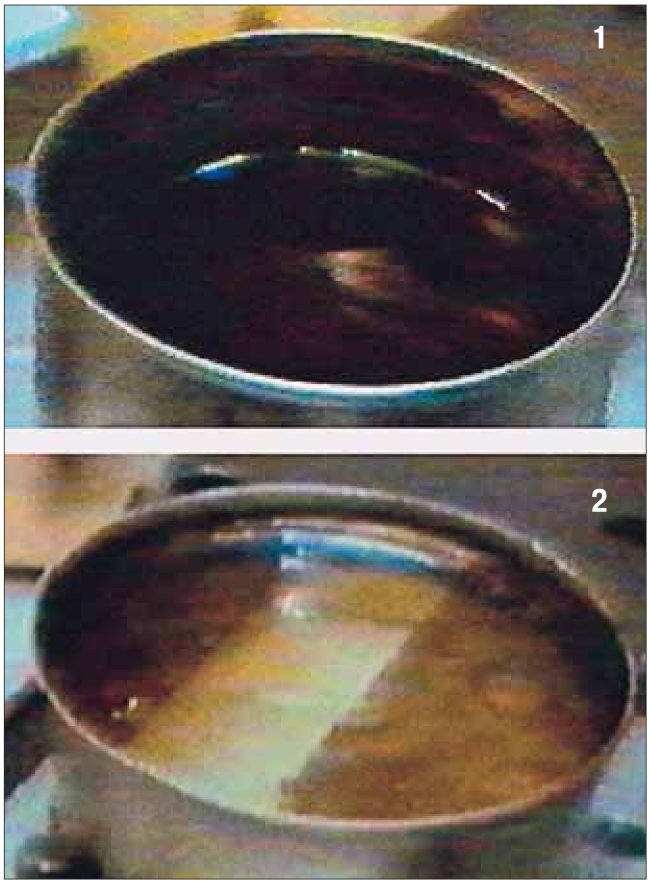
The wall thickness of a gas fitting cut off by laser of MLTK-20 varies from 30 to 40 mm.

able and trouble-free operation of the Arctic offshore oil fields and development of promising technologies of prevention and elimination of liquid hydrocarbon accidental spills in the regions of severe climatic and ice conditions.

At present by agreement with *Gazprom*, the TRINITI Scientific Center is already carrying on an approbation of the method of laser combustion of oil. The crux of the matter lies in search for an efficient remote thermal method of oil spill elimination in the conditions of shore and drifting (pack) ice depending on weather and ice factors. Physicists already now suggest setting fire to an oil film from a distance of hundreds of meters by using a reaction of the conventional combustion mechanism. According to them first a small volume of oil shall be heated till it starts evaporating, then a laser-induced spark shall



Principle of water surface cleaning from thin oil film by CO_2 laser.



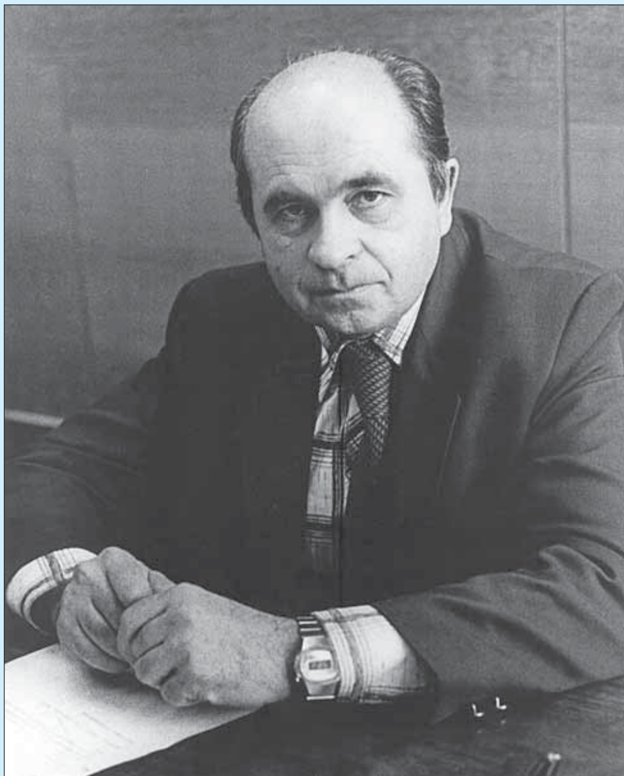
Water surface contaminated with oil (1) and water surface cleaned by CO_2 laser (2).

burn it and afterwards insignificant residues of a “tar” film shall be collected.

It was intended to carry on such works already in the 1990s by the laser complex MLTK-50. But there were too many sceptics at that time. Now, after the carried out experiments, there are practically no such people left. During a week the specialists covered a surface of ice cubes with oil and tried to clean it by laser radiation. This method helped destroy even that oil film, which was covered with a 10 cm layer of snow. True, the process took place under -20° C. But in the Arctic Regions temperatures are different—around -50-60 $^{\circ}$C. Therefore, in the near future we shall develop modes of operation of a laser complex which will meet the permafrost conditions.

The institute staff members are already concerned about a next step in using mobile complexes as they can become indispensable in ship piloting. Since 2000, transportation by sea is becoming more and more popular as well as development of the Northern Sea Route—the shortest from Europe to Asia. In the context of the marked growth of transport operations there is an increased need in the atomic icebreaker fleet. How can we make their trips easier in ice conditions? The Troitsk specialists suggest reduction of ice strength by laser. The tests have proved that from a distance of 50 m it is easy to obtain vertical cuts, but horizontal cuts are more difficult to get. But this is also a matter of the near future. You know, atomic icebreakers generate sufficient amount of electric power, so a part of it can be used for operation of a laser unit.

Illustrations supplied by the TRINITI Scientific Center



85th birth anniversary
of Academician Boris KADOMTSEV

"Nature's determinism is not absolute, it follows neither the rules of quantum mechanics nor the rules of classical mechanics, random processes are hidden in it. Absence of determinism is a piece of good luck for us as we live in a live developing world and not in the world which could be predicted by means of some equations."

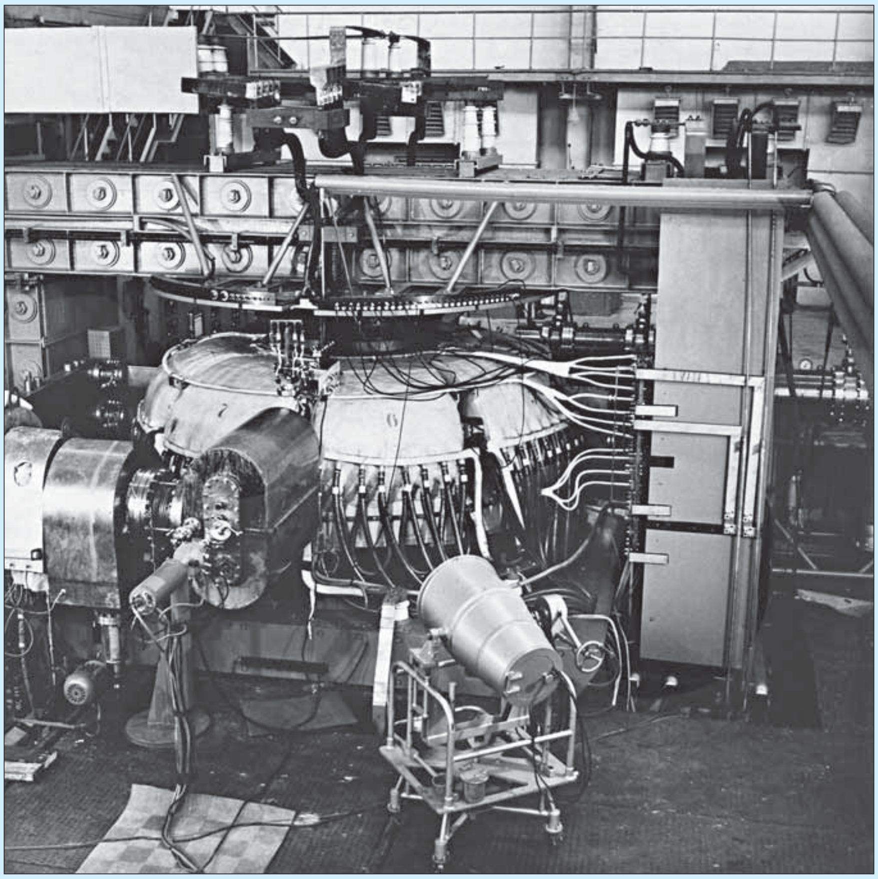
Academician Boris Kadomtsev

THE PRECIOUS FRUITS OF HIS TALENT

by Marina KHALIZEVA,
Science in Russia observer

Nuclear physicists marked the 85th birth anniversary of Boris Kadomtsev (1928-1998) in November of 2013. A lead nuclear physicist honored with State (1970) and Lenin (1984) Prizes, he is among the fathers of the theory of high-temperature plasma and controlled thermonuclear fusion (CTF). His works gained recognition worldwide and made him a leader of our theoretical school of hot plasma physics. Boris Kadomtsev was in the cohort of outstanding physicists who, with Lev Artsimovich at the head, pioneered in the theory of stationary systems with a thoroid magnetic field, the famous tokamaks.

Boris Kadomtsev spent his tender years in Penza, a large city in central Russia. Of inquisitive mind, he had a strong bent for natural sciences. As a magna cum laude high school graduate, in 1946, at age 16, he entered Moscow University where, attending lectures of Professor Igor Arnold on mathematics, he felt a strong interest in theoretical physics and structure of matter. Joining the Structure of Matter Department, he started learning the nuts and bolts of nuclear physics. Graduating from Moscow University with honors in 1951, the young physicist joined the Physics and Energy Institute at Obninsk, a



T-3 tokamak (1962) at the Kurchatov Institute, the world's first to rigger a reaction of controlled thermonuclear fusion.

science town about 100 miles south of Moscow, where for as long as four years he kept working on theoretical problems of nuclear power under Dr. Dmitry Blokhintsev, a top nuclear physicist of the day. Boris Kadomtsev condensed his knowledge acquired there in his doctoral candidate dissertation presented in 1954.

Seeking to improve his mind and background, Kadomtsev began to attend the famous seminars of Lev Landau at which he, Kadomtsev, learned a good deal on science news. In 1955, among a small group of Obninsk nuclear physicists, he took part in the work of a national conference handling nuclear research problems held on the initiative of Igor Kurchatov* and attended by the flower of the national nuclear science. Kurchatov was heading the Soviet nuclear project. That conference was a turning point for Kadomtsev. "It all began with Kurchatov's vigorous, go-ahead speech," Kadomtsev wrote in his book of reminiscences. Not only fresh, imaginative ideas and approaches were needed for attacking the problem of controlled nuclear fusion but also a broader involvement of young blood in tackling this grandiose problem so important for humanity's future... "The seminar impressed me immensely, and I firmed up in my decision that high-temperature plasma was the most interesting field of physics. I began cherishing plans to go over to LIPAN*."

The following year Kadomtsev joined a research team headed by Mikhail Leontovich, a man of great erudition who played a crucial part in high-temperature plasma studies and in rearing young physicists, such as Vitaly Shafranov, Stanislav Braginsky, Vladimir Kogan, Boris Trubnikov and Dmitry Sivukhin who had just begun digging into plasma physics, a new and fertile area of research. Kadomtsev found himself

* *See*: Ye. Velikhov, "Pride of Russian Science"; V. Sidorenko, "Pioneer of Soviet Atomic Power Engineering"; Yu. Sivintsev, "A Few Unforgettable Meetings"; R. Kuznetsova, V. Popov, "Scientific Heritage of Academician Kurchatov", *Science in Russia*, No. 6, 2012.—*Ed.*

* In 1943, in keeping with the decision of the USSR Academy of Sciences, No. 2 Laboratory was set up to handle the nuclear problem. In 1949, at Kurchatov's suggestion, it was reorganized into a Laboratory of Measuring Instruments, LIPAN in Russian abbreviation; in 1956 LIPAN became an Institute of Atomic Energy. After Kurchatov's death in 1960 the Institute was named for him, and became the Kurchatov Institute. In 1991 it was reorganized again into the Russian Research Center "Kurchatov Institute" and then again, in 1991, into the National Research Center; then once again, in 2009, into the National Research Center "Kurchatov Institute".—*Ed.*

Startup of the world's biggest thermonuclear tokamak T-10. Boris Kadomtsev in the middle. 1975.

out in that collective, he was a perfect fit there. He was on the same wavelength with his fellow researchers. New bold and inventive ideas were born here, with the very climate propitious for their materialization. Already in the first few years as a member of the team Kadomtsev carried out pioneering research studies of convective plasma instability in a glow discharge and plasma convection in an open axially symmetrical trap. As another eminent nuclear physicist, Vitaly Shafranov, put it, Kadomtsev's research works "were milestones in CTF, for they debunked the bogy of 'Bohm's plasma diffusion'* in a magnetic field that seemed universal and inevitable and left no hope for the technical feasibility of a thermonuclear reactor."

Kadomtsev was out to explain the phenomenon of "self-organization" of non-equilibrium plasma in continual energy pumping. The first results of his inquisitions reported at the First Conference of the International Atomic Energy Agency (IAEA) on CTF and plasma physics (held in 1961 in Salzburg, Austria) brought him world fame. Kadomtsev concentrated then on the theory of cooperative processes in high-temperature plasma; he distilled his findings in a monograph that made him a top specialist in this important field of cooperative phenomena. In 1961 Kadomtsev defended his doctoral dissertation, and in 1962 was elected to the national Academy of Sciences as its corresponding member.

* Abnormally fast equalization of plasma particles concentration perpendicular to the lines of force of an outer magnetic field, a phenomenon first described in 1949 David Bohm of the United States.—*Ed.*

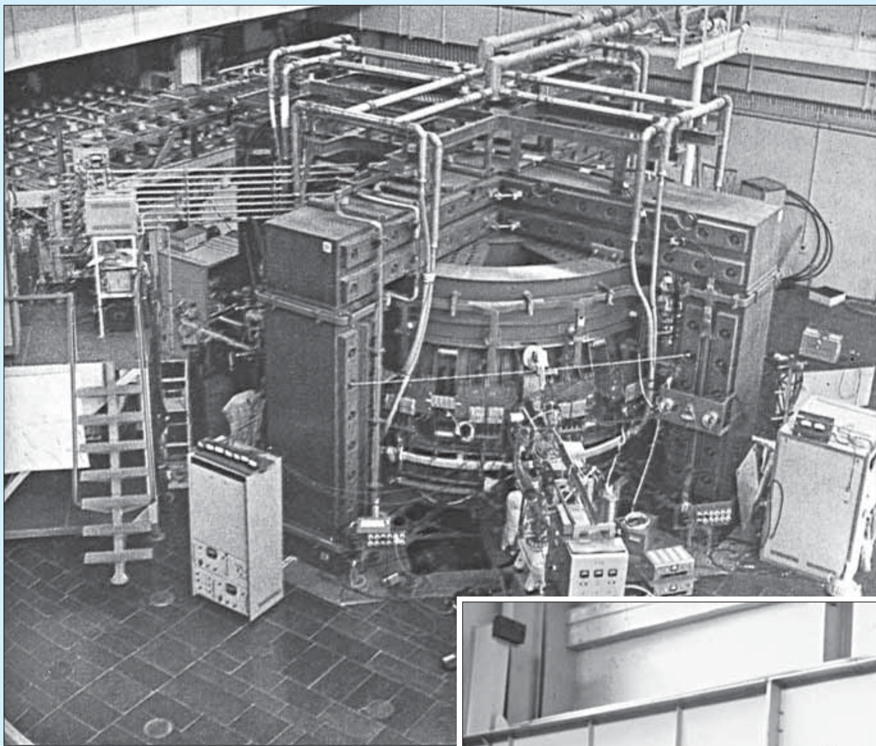
In the mid-1960s Kadomtsev turned to research into plasma instabilities in toroidal systems, the tokamaks and stellarators.* In his paper on plasma confinement in toroidal traps with failed magnetic surfaces (1967) he opted for tokamaks** as the best experimental tool since they made it easier to build closed magnetic surfaces. Thus, as Vitaly Shafranov stressed it time and again, Kadomtsev was the first to outline the idea of a technical feasibility of a thermonuclear reactor on the tokamak basis, and that spurred Lev Artsimovich*** as the head of the national CTF program in stepping up experimental research in the area. Tokamaks gained world recognition, especially in countries concerned with controlled thermonuclear fusion. The first CTF reaction was realized in 1970 on the T-3 tokamak at the Kurchatov Institute. Soon after, Kadomtsev was honored with full membership in the Science Academy.

Boris Kadomtsev had a style of his own. As Dr. Yuri Dnestrovsky, his colleague, confided, "Kadomtsev had an ambivalent relationship to computer technology. Although aware of the need of computers in dif-

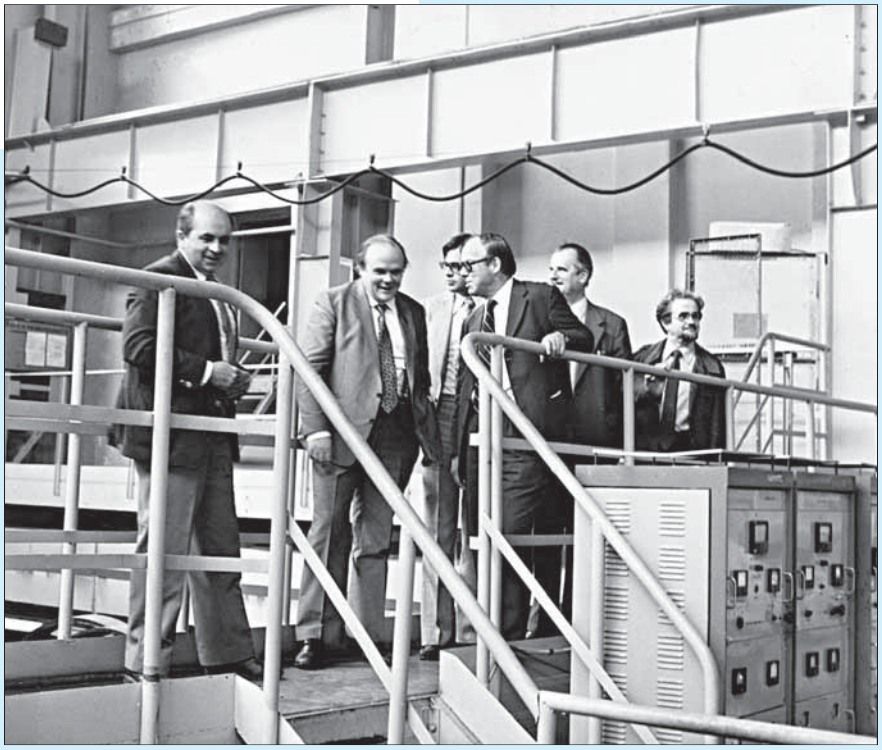
* Traps having closed magnetic surface. Unlike the tokamak, the sellarator has its poloidal magnetic field induced by a current in external coils. Its idea was first proposed in 1951 by Lyman Spitzer, Jr., of the United States.—*Ed.*

** *See*: V. Strelkov, "Creator of the Tokamak", *Science in Russia*, No. 4, 2012; M. Khalizeva, "The Fate and Magic of Talent", *Science in Russia*, No. 3, 2013.—*Ed.*

*** *See*: Ye. Velikhov, "Thermonuclear Combustion"; V. Strelkov, "No Royal Ride in Thermonuclear Research"; M. Petrov, "Talent Is Judged by Work", *Science in Russia*, No. 1, 2009.—*Ed.*



The T-10 program geared to ITER, the International Thermonuclear Experimental Reactor.

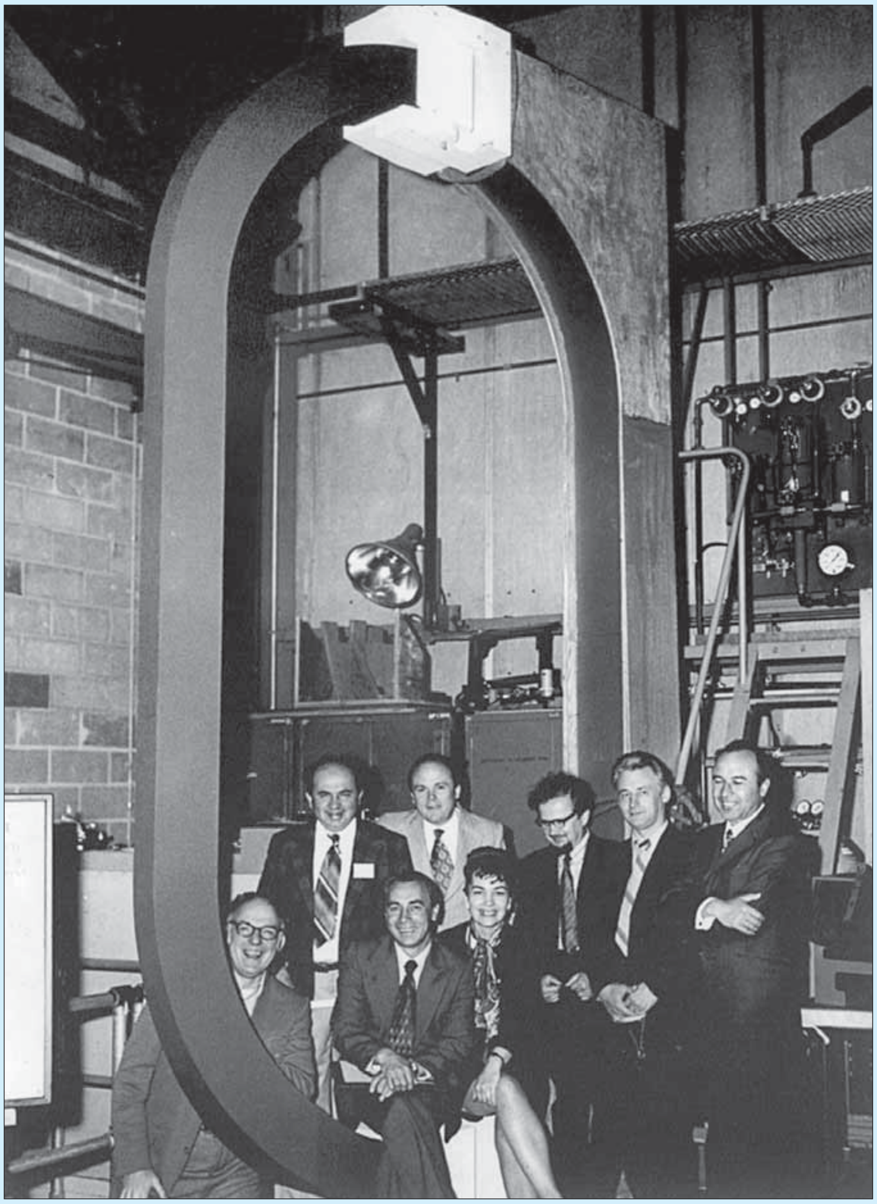


Hans Blix, IAEA Secretary General, and a group of Soviet nuclear physicists inspecting T-10 tokamak. Left to right: Boris Kadomtsev, Yevgeny Velikhov, Hans Blix, Nikolai Semashko, Georgi Yeliseev, 1978.

ficult problem solving, he never used them. He sought to bring out a simplest model and exterpolate it on plasma processes. That is, he saw the answer beforehand, and before developing an algorithm or a model he got down to the truth in a reasonable way. Although the intermediate stages could not be explained now and then, the upshot was always correct."

His great days in research came in the 1970s as Kadomtsev was working on plasma heating and confinement in a tokamak. His verve and go-aheadism in experiment, his eagerness to get down to the brass tacks in analysis and an ability of interpreting his results in pithy terminology revealed an impassioned researcher. At that time Kadomtsev authored his classical works on controlled nuclear fusion, such as *On Stripping Instability in Tokamaks*, and *Tokamaks and Dimensionalities Analysis* (1975), eye-opening in what concerned critical situations in CTF.

His inquisitive and inventive nature hankered for more than just one area of research, no matter how



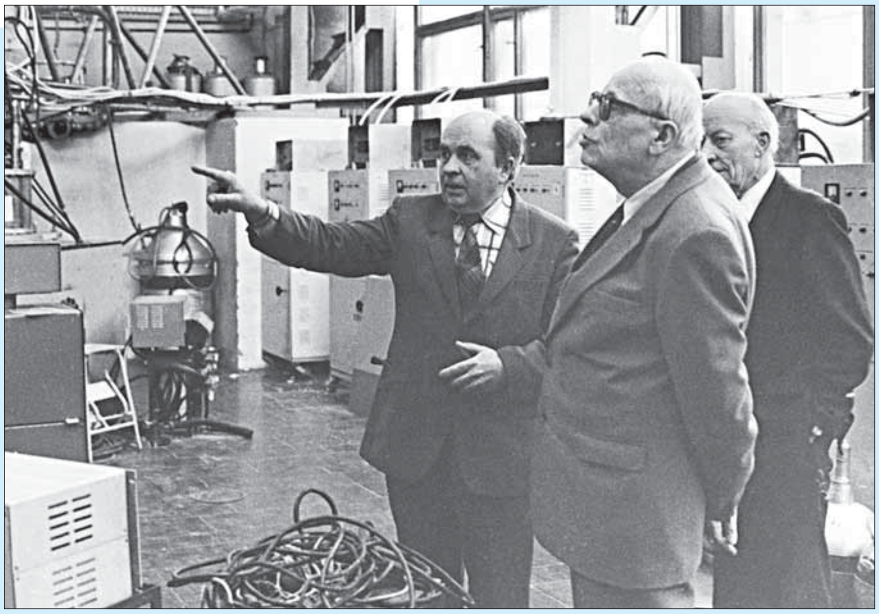
At the Plasma Physics Laboratory in Princeton, USA, on the erection site of the PDX setup.

intriguing and thrilling. We can see that in a two-volume edition of his selected works published posthumously in 2003 by PHYZMATLIT Publishers (concerned with physics and mathematics literature) with the financial backing of the Russian Foundation of Basic Research. What a staggering breadth of vision! In this edition we find works on high-temperature plasma and controlled nuclear fusion, on quantum mechanics, on mater in supermagnetic fields... on nonlinear and stochastic processes, solutions, ball lighting, and what not! In 1997 Kadomtsev produced a book titled *Dynamics and Information* dealing with a subtle relationship between dynamic systems and information processes (a problem closely related to quantum computers). This book had a phenomenal sale, and it had to be published again two years later in an edition twice as large. It sold out overnight again, snatched by "thoughtful readers" (a pat phrase with Kadomtsev for people eager to learn of what was new—a thinking bunch prone to get down to the heart of the matter).

Kadomtsev turned to way-out matters like that but now and then—for plasma physics was his forte and lifelong passion.

It became experimentally clear in the mid-1970s that tokamaks were a real thing. So the task of building an experimental reactor came to the fore, a reactor that could show a practical possibility of generat-

World thermonuclear leaders. Left to right: R. Pease (Britain), B. Kadomtsev (Russia), T. Okawa (USA), Ye. Velikhov (Russia), G. Grieger (FRG), D. Ryutov (Russia). 1981.



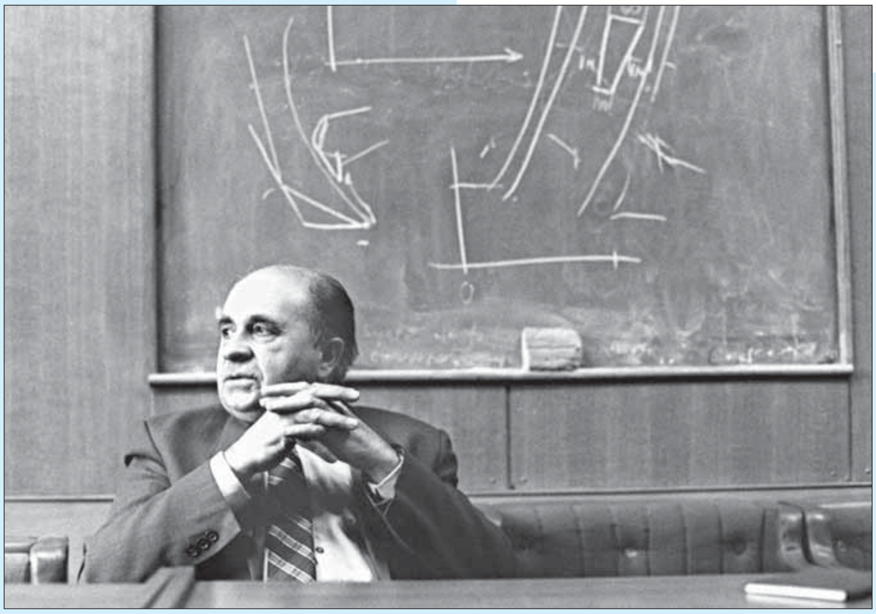
Together with Acad. Andrei Sakharov, a nuclear physics doer, a ground-breaker in CTF and plasma physics. Kurchatov Institute, 1987.

ing thermonuclear power and addressing related engineering problems. Yet there were doubts about the technical feasibility of such plans. Kadomtsev, he was on the other side of the barricade among the optimists, though he was clearly conscious that it was an uphill road full of snags that would call for concerted efforts of many insiders, bent on basic research. Small wonder that he supervised the national project of the world's first experimental reactor, the ITER (International Thermonuclear Experimental Reactor)*, an eloquent acronym to the Russian ear, synonymous with the abbreviation denoting people of the engineering and technological profession. According to Yevgeny Velikhov heading the ITER program, without his authority it would be pretty hard to move from pure physics to nuclear power.

It took as long as ten years to select a body of international experts for the project, and all that time it was the butt of controversy—was it science or power? It was on the horns of the dilemma. Policy-makers clinched the matter: an ITER agreement was reached in 1985 at a meeting of Mikhail Gorbachev and Ronald Reagan. Next, in 1988 and then in the 1990s the project was conceptualized and entered the design stage. It had to cross a thorny patch even at that

* *See*: V. Glukhikh et al., "On the Brink of Thermonuclear Era", *Science in Russia*, No. 3, 2003; L. Golubchikov, "Tokamak—International Challenge", *Science in Russia*, No. 1, 2004; L. Smirnova, "Discoveries at the Large Hadron Collider", *Science in Russia*, No. 1, 2013.—*Ed.*

Boris Kadomtsev and Yevgeny Velikhov. 1991.



Seminar.

stage, but it made through between Scylla and Charybdis, largely thanks to Kadomtsev, a lead expert on tokamaks. He became the first chairman of ITER's Consultative Committee and helped in resolving so many deadlocks. The 1990s were especially bad, what with a financial crunch and shutdown in this country. That is why Russia was able to contribute but 3 percent of the total bill instead of the stipulated 25 percent. Nonetheless the ITER steering committee met us halfway, for it was clearly aware that the intellectual input of our nuclear physicists was commensurate with that of the other parties to the project, and even superior in some matters. So we had to redress the financial shortfalls by our brainwork.

Today peaceful uses of thermonuclear power are within reach: in 2006 ground was broken at Cadarache, France, for the ITER complex, with China, the European Union, Japan, Russia, South Korea and the United States taking part. Thus the many years of hard application by the world thermonuclear community fructified. Kadomtsev contribution is there as well. The first trial plasma experiments are slated for 2019 to be followed by full-scale tests as of 2027.

Boris Kadomtsev also taught at the Moscow Institute of Physics and Technology. He took his teaching activities in good earnest as his supreme duty. For a long time he was in charge of the Plasma Chair of the

Department of Physical and Molecular Chemistry there. His brilliant lectures in which he did his best to outline fundamentals of plasma physics were instrumental in forming a dedicated following of plasma physicists. In 1976 these lectures were summed up in a book on cooperative phenomena in plasma brought out by NAUKA Publishers. In 2001, that is after Kadomtsev's death, it was translated into English for the twenty-second volume of *Reviews of Plasma Physics* edited by Mikhail Leontovich.

His nonfiction book on pulsars (2001) was intended for college and high-school students. In it Kadomtsev described the physics of neutron stars, the pulsars. Presented in the conversational form, it belongs rather to popular science. Its English edition (2010) was recommended as reading matter by the American Association of Physics Teachers. Thanks to Rosolino Bucieri, an Italian astronomer, it was published in Italian too.

Kadomtsev also served as editor-in-chief of the Russian-published journal *Uspekhi physicheskikh nauk* dealing with physics updates. Its executive secretary, Maria Aksentieva, recalled his tender care and attention where the authors and their contributions were concerned. Always benevolent, he would never say anything bad. Only once he was unable to contain himself. "What a canaille!", he exploded. That was his worst in ten years as editor-in-chief. But he was well-meaning as a rule. "This man carries a positive sign"—he would speak about likeable people.

Kadomtsev, a minion of fortune. But no, that would be a bit thick. Actually he had a hard going. Fortune tested his fiber time and again. But he always came through with dignity. By his very nature—which was a given—Kadomtsev was an armchair scientist capable of consorting with only a few like-minded followers. Not a born leader he was to sway crowds. He was not after honors and fame. An egonaut, he was committed to science and craved to learn down to his last days.

Man supposes, God proposes. In 1973, with the death of Lev Artsimovich, Kadomtsev stepped into his shoes as head of a large collective involved with plasma. This research center (Institute of Nuclear Fusion) actually steered the national thermonuclear research program. He shouldered an awesome responsibility—the fates willed it so. As Yuri Dnestrovsky, his coworker, says that was at variance with his character makeup and frame of mind. Still, awake to this burden of responsibility, he carried on. He played a great part in the advancement of plasma physics, drawing in, bold, inventive ideas and fresh blood in abidance by the core stance of the Kurchatov Institute: find a happy mean between basic and applied science. Yevgeny Velikhov, our foremost nuclear physicist, hits the nail on the head: "Boris Borisovich [Kadomtsev], with his deep insight into the philosophy of science, its immanent development laws, and its orientation to a mission of practical application, sustained this atmosphere that helped the Kurchatov Institute to survive in the hard years of political and economic reform."

Kadomtsev forged many cooperative ties expanding the range of research programs of the Institute. At his initiative a new research department was set up there to look into the possibility of hybrid (combination) setups that could generate power through nuclear fusion and fission.

Administrative and managerial chores made heavy inroads on his time leaving but little elbowroom for science, a life issue to him. His colleagues saw him chafe under this burden, especially with the Soviet Union's breakup. He took it hard. In the early 1990s our country lost much of its science potential, and many can-do physicists working shoulder to shoulder with him, and his pupils had to seek fortune elsewhere rather than eke out a living at home, with Kadomtsev unable to help them out. His innate decency did not let him shake off the managerial load. Now add his sense of motivation and his yearning for individual creative work, and inability to help his collective over the hump of economic turmoil. This stressful situation was a cause of his untimely death. That is why Kadomtsev will live on also as a man of great moral commitment.

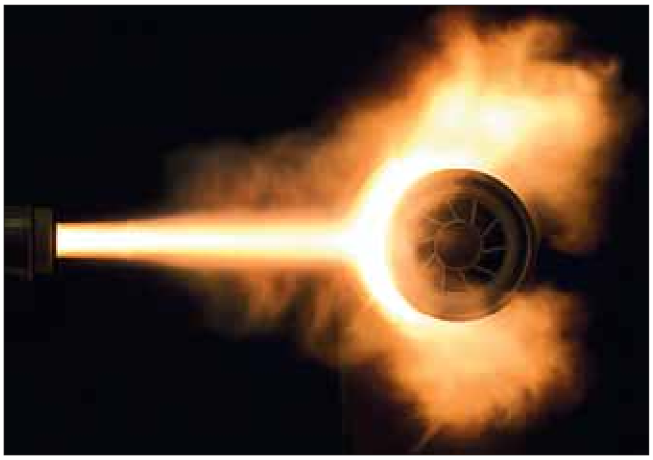
Photos by courtesy of the National Research Center "Kurchatov Institute"

THE "TAME" DETONATION

What is gas detonation? First of all, it is an explosion, often fierce and destructive. The heart of this process is a high-speed (supersonic) combustion of gas fuel (acetylene, propane, butane, etc.) forming a powerful shock wave in which energy of chemical conversion transforms into thermal and kinetic energy (temperature—up to 4,000 ^{o}C, flow rate—over 1 km/sec). The main task here is to tame the "fiery beast" and make it work for the benefit of people.

This problem has been studied in the RAS SB Institute of Hydrodynamics named after M. Lavrentyev (Novosibirsk) over 50 years. As early as in the 1960s, Bogdan Voitsekhovsky (Academician from 1991), Vladislav Mitrofanov, and Marlen Topchiyan (future doctors of sciences in physics and mathematics) discovered cellular structure of detonation front and spin detonation that were later registered as discoveries, and a series of studies carried out in conjunction with colleagues from Moscow was awarded the Lenin Prize, the highest national award of that time. Later on, the fundamental

Vladimir Ulyanitsky, Head of the Laboratory of Detonation Flows of the RAS SB Institute of Hydrodynamics, and research engineer Alexander Kovalenko.



Shot of the detonation gun.
Spraying of a protective hard alloy covering.

results of studies were actively transformed by employees of the Institute who proposed technical solutions and new industrial technologies. They became a topic of the interview given by Vladimir Ulyanitsky, Dr. Sc. (Tech.), Head of the Laboratory of Detonation Flows of the RAS SB Institute of Hydrodynamics, to the correspondent of the *Science in Siberia* newspaper Yulia Alexandrova.

According to the scientist, one of the applications of gas detonation is detonation spraying when explosion energy is used to form protective coverings on the surface of components of different design and purpose. The particles of powdered material are heated up by explosion products to melting point and gather bullet speed. When colliding with the processed detail, they firmly stick to its surface forming a layer of compact covering. To realize this process in practice, special equipment is required. The first generation of such devices was designed in our country in the 1970s, but, as a rule, they were developed by engineers who were not specialists in explosion physics, which affected stability of the process and quality of coverings.

In the early 1980s, the USSR Ministry of Aircraft Industry proposed the Institute of Hydrodynamics to focus on these problems and improve the equipment that was already widely used to produce aircraft engines. After this task was successfully completed, a team of young specialists led by Tamara Gavrilenko and Yuri Nikolayev, Cands Sc. (Phys. & Math.), decided to take up a challenge and design a totally new apparatus. In two years, they presented a detonation gun "Ob" that differed fundamentally from its predecessors by process stability, high quality of received coverings and new technological potentialities. Approximately ten national and foreign patents prove unique nature of the proposed solutions. The first sample of this device was put into operation in the late 1980s at the aircraft engine building plant in Ufa; concurrently, its industrial production was launched at Berdsk electromechanical plant in the Novosibirsk Region. Unfortunately, in the 1990s, the production was terminated. The Laboratory was forced to switch to new tasks not typical of the subsivisions of the Academy of Sciences in favorable conditions—we mean studies aimed to find ways of application of advanced technology for public consumption. Scientists proved that technology of strengthening main parts used in aircraft engineering could be successfully applied to repair all types of components and spare parts for cars, locomotives, machines, other types of equipment and even to renew complex joints, for example, internal-combustion engine cylinder blocks, compressors of refrigerating plants, etc.

The Laboratory not only demonstrated fundamental options of the technology under consideration, but proposed a complete technological cycle. Eventually, all production equipment is successfully put into operation and used at small motor repair plants and works in Siberia, Kirgizia, Uzbekistan, and even in Moscow.

Great demand for the technology is explained by its high economic efficiency. For example, less than a kilo of a powdered material can renew a multikilogram crankshaft of a truck or a bulldozer. Moreover, the renewed component becomes, after increasing its wear resistance, even better than a new one.

In the late 1990s, the Laboratory was proposed to challenge another technological task. OAO *Galogen* (Perm), one of the major national producers of chemicals, addressed local specialists to consider the idea of metallization of fluoroplastic products. This plastic characterized by unique useful properties has one unpleasant technical "defect": it is impossible to stick it by any means, which limits its application options. Detonation spraying successfully solved this problem, even though the proposed approach initially seemed incredible. Is it really possible to cover plastic with metal by way of explosion? Fertile imagination! But it turned out that "delicate" gas detonation can introduce half-fused particles of aluminum into polymer without damaging it and then form a solid metal covering that can be glued to any surface.

The scientists patented their idea and then took it to its commercial use: the first specialized apparatus capable of covering fluoroplastic with metal was put into operation in Perm in 2005. It became a prototype of detonation spraying devices of a new generation. Creation of multifunctional instruments was very expensive, and national industry could not afford it yet. Fortu-

CCDS2000 detonation complex with 3 coordinate system of scanning of the processed parts.

nately, the technology got into a focus of close attention of the National Engineering School in Saint-Etienne (France). Starting from the 1980s, Prof. Igor Smurov has been working in this field and established a Russian-language laboratory there. By the way, he was granted a megagrant and today he is realizing it at the Moscow State Technological University *Stankin*, which means that the technology developed by Novosibirsk scientists is being promoted in Moscow by the professor from France.

The first multifunctional computer complex of a new generation was sent to France in the summer of 2007. In fact, it was the first special-purpose detonation spraying robot able to process components of irregular shape. Engineering solutions used in this device are protected by three Russian patents.

The working up of the commercial product of value was financed by the company *Siberian Technologies of Protective Coverings*, which is now producing these units at the technology park of the Novosibirsk Science Center. The company also attracts customers and sells the equipment. Moreover, employees of the RAS SB Institute of Hydrodynamics take part in the improvement of technologies, including adjustment of equipment and training of specialists.

The company was one of the partners to improve the design solution of the CCDS2000 unit (Computer Controlled Detonation Spraying), which was brought to the level of world export standards. This expanded export geography. The consumers are both large research centers and industrial enterprises, such as aircraft and machine-building plants in China. The work arose interest in Russia too: strengthening and protective coverings for modern drilling and oil production, oil and gas transportation equipment are made using detonation spraying technology. The resources of the above-mentioned computer complex of a new generation were actively used to expand options of the detonation spraying equipment.

The new technology is actively used in other industries too. For example, a high voltage ceramic insulation of electrophysical units operating in a highly radioactive environment — the technology was used to improve high current transformers manufactured by the Novosibirsk Institute of Nuclear Physics named after G. Budker for the Fermi National Accelerator Laboratory (USA). Together with the Institute of Catalysis named after G. Boreskov, scientists of the RAS SB Institute of Hydrodynamics developed reactors for high-temperature conversion of gasoline-air mixture into synthesis gas where the detonation covering is used as a catalyst carrier. The Laboratory led by Vladimir Ulyanitsky in conjunction with the Institute of Chemistry of Solids is developing new composite nanostructural materials characterized, inter alia, by high antibacterial properties of nanoparticles of silver produced during formation of a composite using detonation spraying technology.

There are many joint projects implemented in association with other RAS SB institutions, in particular, with the Institute of Inorganic Chemistry named after A. Nikolayev and the Institute of Theoretical and Applied Mechanics named after S. Khristianovich, Tomsk and Krasnoyarsk laboratories. Detonation coverings invented originally for nuclear industry are also used in power plants. In collaboration with the French colleagues, scientists from Novosibirsk proved efficiency of detonation spraying technology for the ITER project—the first in the world thermonuclear reactor being built near Marcel. The national aircraft industry is not forgotten either. Modern detonation spraying equipment makes it possible to produce coverings for aircraft components, wear resistance of which is many times higher than that achieved traditionally. The first devices of a new generation designed at the RAS SB Institute of Hydrodynamics will soon be sent to OAO *Kuznetsov* (Samara) and Ufa Motor-Building Production Enterprise.

Yu. Alexandrova, *Gas Detonation Innovations.— "Science in Siberia" newspaper, No. 47, 2013*

Illustrations supplied by Vladimir Ilyanitsky and Vladimir Novikov

Prepared by Sergei MAKAROV

THE FATE OF THE WAR WAS DECIDED IN THE SOUTH

by Acad. Gennady MATISHOV,
Chairman of the RAS Southern Scientific Center,
Yevgeny KRINKO, Dr. Sc. (Hist.),
Deputy Director for Science of the Institute of Socio-Economic
and Political Studies of RAS SSC (Rostov-on Don),
Vladimir AFANASENKO, Research Assistant of the Laboratory of History
and Ethnography of the same institute

The Great Patriotic War of 1941-1945 holds a prominent place in the fate of Russia. Despite numerous studies related to this war its history still has blind spots including *inter alia* combat operations in the Russian south in 1942-1943. Their significance was underestimated in the Soviet time, and only in recent years there appeared works whose authors abandon previous stereotypes. It is impossible to make head or tail of the combat operations in the space between the Don and Volga rivers to Caucasia, between the Azov and Caspian seas, and to understand the causes of temporary successes of the enemy without referring to declassified archives and memoirs of the direct participants of the events.

After the successful battle near Moscow ill luck pursued the Soviet troops, and Wehrmacht again seized the initiative. In the summer of 1942-autumn of 1943 the fate of the country was decided in the south of Russia. It was just where the events developed which could ultimately affect the war outcome. The following battles were of prime importance: in a large bend of the Don (07.07-23.08.1942), in the direction of Astrakhan (01.08-28.12.1942), Gudermes-Kizlyar (25.08-17.09.1942) and Grozny (02.09-30.12.1942), strategical battles near Ordzhonikidze (25.10-13.11.1942) and Stalingrad (17.07.1942-02.02.1943), Rostov-on-Don combat operations (20-24.07.1942, 08-14.02.1943) and breakthrough battles of the Mius front (17.02-30.08.1943) and the so-called *Blue Line* (13.02-09.10.1943). They became the principal landmarks of the fundamental turning point in the war.

ACTIONS OF THE GENERAL HEADQUARTERS

In the summer of 1941-winter of 1942 the Soviet leadership headed by Joseph Stalin set and solved vital tasks in the military-political and military-economic spheres. The first decisive steps were taken at the very end of summer of 1941 when the USSR and Great Britain led jointly troops into Iran on August 25. More than a 100-thousand Soviet military grouping with 522 aircraft took control of the whole northern territory of this country.

Earlier, on August 16, the CC of the All-Union Communist Party (Bolsheviks) and the USSR Council of People's Commissars took a decision to construct a new railway from Kizlyar to Astrakhan and a section Akhtuba-Paromnaya and at the same time the Volga crossings near Astrakhan and Stalingrad. The new railway was

Soviet soldiers in battles for Caucasia.

put into operation on August 4, 1942, a record-breaking time, and played a significant role in the battle for Caucasia are coming a kind of road of life for the Red Army formations defending it. A tight schedule was also used in the construction of the railways Stalingrad-Vladimirovka-Baskunchak, Ilovlya-Petrov Val-Saratov, Guryev-Kandagach-Orsk and some other directions, which provided transportation of troops and military impediments in the most intense period of combat actions in the south of the country.

Of great importance in securing victory over the enemy was creation, together with our allies, of a military-industrial bridgehead in Iran, whose potential allowed in many ways for compensation of the Soviet losses in military technology borne in the beginning of the war. The allies constructed motor-car assembly and aircraft plants in the territory of Iran, aerodromes, storage hangars and berths, laid new or reconstructed the existing highways and railways from the ports of the Persian Gulf to Transcaucasia and Central Asia. Through "the Persian corridor", the Caspian Sea and the Volga by the railway Kizlyar-Astrakhan-Kamyshin-Saratov cars, tanks, aircraft, petroleum products, ammunition, strategic raw material, foodstuffs, uniform, medicines and many other things were delivered to the USSR. The trans-Iranian route was rather important in the most complicated and crucial moment in the war from the summer of 1942 to the spring of 1943. Already in March of 1942 the Soviet pilots received the first 72 bombers in Tehran, and all in all through the "Persian corridor" 742 aircraft, 8,816 lorries and hundreds of thousands of tons of other military impediments were delivered in 1942.

In the second half of 1942, after Arctic convoy PQ-17 heading for the USSR with strategic cargo and military equipment from the USA, Canada and Great Britain had been destroyed, deliveries under the Lend-Lease Act to the USSR through the North Atlantic were stopped for almost half a year (except for convoy PQ-18, which also suffered heavy losses). From the start of combat operations by Japan against the USA transportation opportunities through the Pacific Ocean also were limited. Therefore, in the second half of 1942 the trans-Iranian route acquired paramount importance. Through Iran 28.8 percent of the total cargo under the Lend-Lease Act were delivered in 1942 and 33.5 percent in 1943. Without the support of the allies it would have been difficult for the Red Army to withstand in 1941-1942 and moreover to carry out strategic offensive operations in 1943-1945. All in all, 4,160 thous. tons of cargo or almost a quarter of all deliveries to the USSR was owing to the "Persian corridor" in the war years.

Certainly we must take into account an uninterrupted delivery of troops and combat equipment by the Caspian military flotilla and shipping companies between Astrakhan, Makhachkala, Krasnovodsk, Baku and ports of Iran, Azerbaijan and Turkmenia. The military impediments were also transported by highways between Baku-Derbent-Makhachkala and Sukhumi-Tuapse. The regiments and divisions were transferred from

Basic communications of lend-lease deliveries through Iran.

Transcaucasia to the front lines near Gizel, Ordzhonikidze and Malgobek by the Georgian Military Road and the Ossetian Military Road. As a result, the delivery of arms and military impediments became a large-scale engineering and technical operation using railway, motor-car and air transport. This is how it was assessed by the Soviet leaders, who highly appreciated the role of lend-lease in achieving victory in the war. According to Marshal of the Soviet Union Georgi Zhukov "without the American Studebakers it would have been impossible to carry our artillery. In general, for the most part they made up our front-line transport". He also wrote: "It must be admitted that American supplies helped us form our reserve forces and continue the war."

IN THE LARGE BEND OF THE DON

In July of 1942, after the German troops captured the city of Voronezh, there developed large-scale sanguinary battles in this region especially in crossings through the Seversky Donets, Don and Manych rivers. The enemy concentrated 900 thous. soldiers and officers, above 1.2 thous. tanks, above 17 thous. guns and mortars and 1,640 war planes in the south. The opposing troops of the Bryansk, South-Western and Southern fronts numbered 1,715 thous. men, about 2.3 thous. tanks, 16.5 thous. guns and mortars and 758 war planes. The enemy was in the rear of the South-Western front armies. The Commander-in-Chief of the South-Western direction Marshal of the Soviet Union Semyon Timoshenko and

Assembly of MK-2 tank "Matilda" for the USSR (Great Britain).

his headquarters lost control of the troops and already on July 12 found themselves in Stalingrad. In the region of Millerovo the units of the 9th, 24th and 39th armies were encircled, and dozens of thousands of Soviet soldiers fell prisoner.

After the three-day battles on July 24 the 1st tank army headed by Colonel-General Ewald von Kleist captured Rostov-on-Don, an important transport junction considered to be "Gates to Caucasia". In the July battles the Soviet troops suffered heavy losses, while the enemy got a chance to approach the oil fields of Maikop, Grozny and Baku. It was then that the People's Commissar of Defense issued Order No. 227, which contained the well-known words: "Not a step backward!" The troops of the Southern Front withdrew from Rostov-on-Don not to get encircled like the spring "boiler" near Kharkov. The commander of the Southern Front General Rodion Malinovsky was demoted for the surrender of the said city but he made the only correct decision in that situation.

Field studies, topography of the locality and stories of direct participants and battle witnesses make it possible to understand how the peculiarities of the terrain and climate affected the operations and their results, to comprehend the "trench truth" of the war. The Soviet soldiers displayed mass heroism in sanguinary rearguard actions. For example, on July 27 an unknown soldier exploded the Veselovsky reservoir dam at the price of his life. This delayed the crossing of the Manych river by the German armored matériel for three days and enabled the retreating to the south Soviet troops to disengage from the enemy. On July 31, the 4th tank army of Colonel-General Hermann Hoth turned from Bolshaya Martynovka on the left bank of the Don to Kotelnikovo, thus strengthening the German grouping in the direction of Stalingrad.

In the Black Sea area of operations the enemy started bombing Sukhumi in July of 1942 and broke into Novorossiisk on September 6. Five days later it seized a major part of the city except for its south-eastern industrial territory. Due to heavy losses the German troops assumed the defensive near Novorossiisk, which lasted for more than a year. On September 9 between Maikop and Nalchik the German mountain infantry and a division of chasseurs, well trained and fully equipped, seized almost all mountain passes of Western and Great Caucasus. Thrice during September-November the main forces of the 17th army tried to break through to Tuapse but failed to seize the city.

The considerable superiority of the enemy in tanks and aviation enabled it to create powerful striking forces in the most important strategic lines. Early in August of 1942, the German military command concentrated only in the Caucasian direction 535,000 soldiers, 564 tanks, 4,540 guns and mortars, about 500 war airplanes. The enemy surpassed the troops of the North Caucasian Front: in personnel—1.5 times, in guns and mortars—2.1 times, in tanks—4.3 times, in airplanes—2.7 times. In the rear of the army group *A* there was a corps headed by General Helmut Felmi, whose mission was to advance to Iran and Iraq and further to the Persian Gulf and India. The Af-

Breakthrough of the Wehrmacht armies in the south in the summer of 1942.

rican corps of Field-Marshal Erwin Rommel, located at that time only at a distance of 100 km from Alexandria, was advancing to meet Felmi's corps.

NEAR ASTRAKHAN

In the mid-August of 1942, the German troops were stopped near Khulkhuta village at a distance of about 100 km from the Caspian Sea and 120 km from Astrakhan. This city served as a strategic point of oil and lend-lease cargo delivery from Iran, troops and fighting gear for the army in the field. The Luftwaffe airplanes tried to destroy the city, but the enemy failed to capture it. The German front area up to 300 km long between Stalingrad and Caucasian groupings was covered for almost five months by the reinforced 16th motorized division of Major-General Sigfrid Henrici. To oppose the enemy, the Soviet command raised urgently the 28th army headed by Lieutenant-General Vasily Gerasimenko. It was based on the 34th Guards' rifle division of Major-General Iosif Gubarevich, created on the basis of the 7th air-landing corps in Moscow and urgently transferred to the south. Actually in Nogai and Kalmyk steppe zones a real raid war was developed from September of 1942 to January of 1943. The German reconnaissance and subversive groups approached the Volga in several places and cut off repeatedly the road to Kizlyar-Astrakhan.

THE GUDERMES-KIZLYAR DIRECTION

Forcing the Don and Manych rivers, the enemy quickly approached the Terek three weeks later. The 1st tank army captured Mozdok on August 25, 1942, planning to proceed to Gudermes and Makhachkala on the left bank of the Terek. On August 29 the enemy seized the Chervlyonnaya railway station, 25 km to the north-east of Grozny. The blasted bridge across the Terek closed a route to Dagestan for the 40th German tank corps. Seven Guards' brigades, formed of raiders and also of separate amphibious and cadet rifle brigades with successful experience of defensive and offensive battles, were urgently transferred from under Moscow

German mountain jaegers in Central Caucasia (September of 1942).

via Astrakhan and Makhachkala to the Gudermes region. The troops were strengthened with tank battalions and brigades fitted with equipment delivered through the "Persian corridor".

Naursky and Shelkovsky districts of the present Chechen Republic witnessed large-scale combat actions with the use of tanks and aviation. There in September-October the German 1st tank army suffered heavy casualties especially in armor. The then Deputy People's Commissar of Oil Industry and later Chairman of the USSR State Planning Committee Nikolai Baibakov described an episode of bitter fighting near Chervlyonnaya early in September of 1942: "From the trenches I saw two fierce massed assaults of the German troops. Despite close fire of our artillery and aviation, whereby the field pitted by bombs and shells was actually covered with bodies of the dead and injured, they did not stop and continued to advance. They fell down and got up again, ran, crawled, emerged with fanatic horror-struck faces near the Russian trenches and being fired point-blank by our soldiers as if thrust back to the ground fell backwards. Before my eyes several thousands of German soldiers were killed. This awful sight will be always in my mind!" According to the wartime reports 96 out of 150 German attacking tanks were knocked out and destroyed in the mid-September near the Ishcherskaya village.

GROZNY IN FLAMES

The Mozdok-Malgobek battle in September 1947 played a pivotal role in the defense of the North-Eastern Caucasia. During September the Ingush city of Malgobek changed hands five times. But the Soviet defense in depth proved to be irresistible for the German troops. (Let us point out here that the battle details at the approaches to Grozny are not yet adequately studied by historians.) The Soviet troops created seven antitank stoplines using natural barriers. The hollows, ravines and ditches of the Alkhan-Churt valley between Malgobek and Grozny were filled with crude oil. In the face of breakthrough by the German tanks they could be stopped by a wall of burning oil. On October 10 and 12 the enemy conducted powerful bombing of Grozny by 130 and 152 Luftwaffe airplanes respectively. The burning oil streamed to the city through breaches in the destroyed dikes burning to ashes everything on its way. The massed bombing actually wiped Grozny off from the face of the earth but the city was never captured by the enemy.

The Soviet command carried out active maneuvering in the foothills of the Caucasus by deploying divisions and corps along the frontline between Ordzhonikidze, Malgobek, Naurskaya and Gudermes. The shock troops, armor, bombers, fuel and foodstuffs were delivered to the most dangerous parts of the front. The battalions of armored trains and antitank artillery which crippled substantially German tank and mechanized forces played an important role in the defensive actions. The heroic defense of the Soviet troops in Gudermes-Kizlyar and Grozny directions forced the enemy first to lower rates of the advance and then to stop.

DEFEAT OF WEHRMACHT NEAR ORDZHONIKIDZE

The advance of the German 1st tank army through the Elkhotovskiye Gates started on October 25, 1942. The enemy tried to seize the Georgian and Ossetian Military Roads. Near Nalchik the weakened Soviet

37th army stood on the defensive. In the 6 km breakthrough zone Wehrmacht had 3-fold superiority in manpower, 11-fold—in guns, 10-fold—in mortars and absolute supremacy in tanks. On October 28 the enemy captured Nalchik and on November 1 cut off the Ossetian Military Road near the Alaghir village. The next day Wehrmacht troops captured the village of Gizel 3 km to the west of Ordzhonikidze. To deliver a decisive thrust the Soviet command transferred to this area two Guards' rifle corps and several tank brigades, the main forces of artillery and aviation.

The turning point in the strategic warfare near Ordzhonikidze started on November 5, 1942, when the Soviet troops stopped the enemy advance and passed to the counteroffensive. The Gizel grouping of the German 3rd tank corps was actually encircled completely. Escaping complete destruction and leaving behind military equipment the German troops started withdrawal to the Dzuarikau village on the night of November 11. Breaking the enemy resistance, the formations of the left flank of the 9th army seized Gizel on November 11. Following the retreating enemy, the Soviet troops reached the Fiagdon river on November 12. For Wehrmacht November 5 and 6, 1942, became a non-return time and the foothills of Northern Caucasus—a non-return place, while for the Red Army it was a place, where liberation of Motherland from the enemy started.

THE BATTLE OF STALINGRAD

In September of 1942 the main war events on the Volga developed around Stalingrad. The tank, artillery and oil refining plants were located in the city. The striving of Wehrmacht to capture Stalingrad was explained also by political factors. Already on August 23, 1942, the German 14th tank corps managed to break through to the Volga. In September street fightings started in Stalingrad. The task of the Soviet troops in defensive operations was to exhaust and render lifeless the shock grouping of the enemy thus creating conditions for assuming the offensive. The powerful support to the small units of the 62nd army of Lieutenant-General Vasily Chuikov was given by the heavy artillery and regiments of rocket launchers from the left bank of the Volga and its islands. In the ruins of Stalingrad the German troops lost their mobility, their tanks could not advance among the stone débris. The battles were conducted for every house.

In the heat of street fightings the preparations for a counteroffensive near Stalingrad were under way in conditions of top secrecy. Provisions were made in advance for two bases at a significant distance from the city for covert concentration of reserve units. The base of the southern group was in the Trans-Volga region in the flooded areas of the Volga estuary in the area of Kapustin Yar, Cherny Yar, Nizhni Baskunchak, Soleny Baskunchak and others. The northern grouping was concentrated in the region of Saratov and Kamyshin and also in the Don forests. During two autumn months the reserve units were drawn together and concentrated for an impetuous attack. (These massed actions remain practically an unknown page of the battle of Stalingrad.) It is important to note that elaboration of and preparation for two battles were carried out at one historic moment. Besides, both events in Caucasia and on the Volga developed according to the common scenario. This allows to characterize the operations near Ordzhonikidze after the battle of Stalingrad as Stalingrad-2.

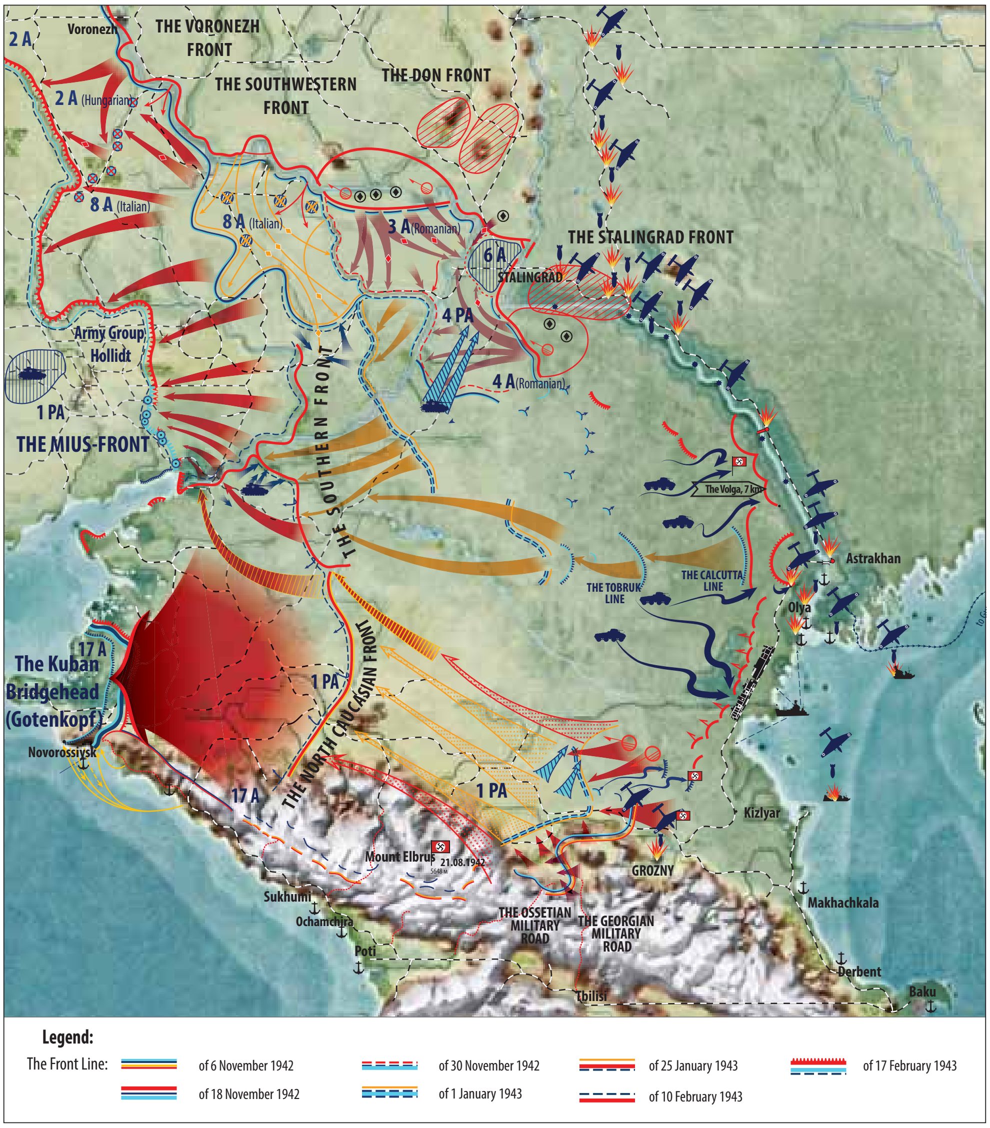
On November 19 a powerful thrust was delivered to the enemy from the northern base by the troops of the South-Western Front. On November 20 the Stalingrad Front troops launched an offensive from the south. The choice of the direction of main thrusts, their suddenness and infallible determination of weak points in the enemy defense proved to be extremely important. On November 23 the South-Western and Stalingrad fronts met in the region of the Sovetsky village near the city of Kalach and closed a ring of encirclement near Stalingrad.

The encircled grouping numbered not 80-85 thous. men as evaluated by the Soviet military intelligence but almost 250 thous. effectives. Therefore, the attempt to divide at once the 6th army of Friedrich von Paulus into two parts and defeat it failed. For its all-round defense the enemy used the fortifications of the Stalingrad enclosing created in 1941-1942 for the city defenders. Despite supplying by air and an attempt of the breakthrough battle, the ammunition and food stocks of the 6th army were running dry. The troops of the Don Front broke the enemy defense and on February 2, 1943, forced the encircled German army to surrender.

In December of 1942 the German Army Group A in Caucasia lost finally offensive resources and found itself under the threat of encirclement. The general offensive of the Northern and Black Sea military forces of the Transcaucasian Front started on January 1, 1943. The troops of the Southern (the former Stalingrad) Front moved towards them in the direction of Rostov-on-Don and Salsk. By skilful maneuvering of reserves Field-Marshal Erich von Manstein stopped the Soviet offensive on the line of the Manych and Seversky Donets rivers in late January. The enemy retreated from Northern Caucasia having divided into two groups. The main forces of the 1st tank army retreated through Rostov-on-Don to the Donets Basin, and the remaining units stepped back to the Taman Peninsula, where they joined in with the 17th army into a powerful grouping numbering above 20 divisions.

BREAKTHROUGH OF THE MIUS FRONT

The Soviet troops liberated Rostov-on-Don on February 14, 1943, but their further offensive was stopped



Liberation of the Don region and Northern Caucasia (1942-1943).

by the German 104 km long defense line called the Mius Front. It began from the Sambek village near the Taganrog Bay, then passed along the Mius river and approached the Krasny Luch city of the Voroshilovgrad (today Lugansk) Region. The Soviet troops first faced the impregnable German combat formations at the Mius Front in the winter of 1941. During the first half of 1942 there were made vain attempts to break the enemy defense. In its degree of impregnability, strength of fire and number of permanent defenses the Mius Front can be compared with such widely known defense complexes as the Finnish Mannerheim Line, the French Maginot Line, the German Siegfried Line or the Soviet Molotov Line*.

*Molotov Line is a line of fortifications constructed by the Soviet Union in 1940-1941 along a new western border after annexation of Lithuania, Latvia, Estonia, western regions of Ukraine and Belorussia, and also Bessarabia.—*Ed.*

In the spring and summer of 1943 the Soviet troops assaulted repeatedly the German defensive positions. A bitter battle took place in the vicinity of the high point 277.0 (Saur Tomb burial mound) on July 30-31, 1943, on the boarder of Rostov and Stalin (today Donetsk) regions. The German command used élite tank units withdrawn in the heat of the battle of Kursk. In two days the enemy lost 239 tanks and self-propelled guns there. It is twice more than the German tank losses in the famous battle of Prokhorovka in the same period. Only on August 18, 1943, the Southern Front of Colonel-General Tolbukhin managed to break through the Mius Front in the vicinity of the Kuibyshevo village of the Rostov Region, and on August 30 the city of Taganrog was liberated. The operation was worked out with the participation of Marshal of the Soviet Union Alexander Vasilevsky, Chief of the Red Army General Staff. The success was achieved first of all due to maximum concentration of forces, especially artillery and armor in a narrow strip of the breakthrough.

GOTENKOPF—GOTH'S HEAD

In the Taman Peninsula the Soviet advance was abutted against a powerful defensive line called by the Germans as *Gotenkopf* (Goth's Head), today more known as the *Blue Line*—113 km long from Novorossiisk to the Temryuk Lagoon. Eight defensive lines about 40 km deep accounted in full for a rugged topography such as a swampy estuary of the Kuban, Adagum, Protoka and other rivers, a woody and hilly terrain in the center with heights up to 200 m and a mountain terrain near Novorossiisk. For seven months sanguinary battles did not stop at this peculiar Mius Front 2. The Soviet troops suffered heavily in frontal attacks but with no success.

In the second half of April 1943, a big air engagement began in the sky over Kuban, which lasted till June 7. Sometimes the number of group air battles reached 50 involving up to 50-100 airplanes at each side. Not a few Soviet ace fliers distinguished themselves in these actions. Namely, the famous Alexander Pokryshkin, whose fighter P-39 *Aerocobra* shot down 23 Luftwaffe airplanes in the region of the *Blue Line* in April-May of 1943. The order of the North-Caucasian Front read: "Air domination has passed to our side. It has determined also the further ground situation". On September 10 the troops of the said front headed by Colonel-General Ivan Petrov penetrated the seemingly impregnable *Blue Line* and on October 9 fully liberated the Taman Peninsula.

Thus, from August of 1942 to October of 1943 in intense battles the enemy was flung back from the boarders of Dagestan, Chechnya, Ingushetia, the Caspian coastline, the Volga estuary and Astrakhan to the Crimea and the Donetsk Basin, in all for more than 1,000 km. If we now take a careful look at the events of the summer of 1942-autumn of 1943 at the southern flank of the Soviet-German front as a part of a single process of confrontation, the scale of the battles of Stalingrad and in Caucasia and their place in the history of the biggest defeats of the German troops become more apparent. It should be noted that 138 men were given the title of a Hero of the Soviet Union for the defense of Caucasia and 103 men were awarded this title for the battle of Stalingrad.

In the battles of 1942-1943 the Soviet troops passed from a strategic defense to a strategic offensive. The sanguinary battles accompanied by pulverizing of whole armies took place in a period under review in all directions of the Soviet-German front including the western and north-western directions. But a turning point in the war began just in the south, where the Soviet troops gained experience of big victorious battles in which their operational and tactical art developed and improved. The gained victories testified to an increased skill of the Soviet command to concentrate different arms of service in a short time for a breakthrough of the enemy defense in a narrow strip and organize coordination of striking and supporting forces, reserves, infantry, armored troops, cavalry and aviation.

Main battles in the south of Russia in 1942-1943

Battles	Time	Losses		Number of Heroes of the Soviet Union
		Red Army	Wehrmacht	
Battle for Caucasia (Stalingrad-2)	25.07.1942-09.10.1943	1,065,910	421,200	138
Battle for Stalingrad (Stalingrad-1)*	17.07.1942-02.02.1943	1,129,619	890,522	103
Mius Front 1	11.10.1941-30.08.1943	833,000	110,000	38
Blue Line (Mius Front-2)	13.02-09.10.1943	268,513	128,429	69

** Including the losses suffered in the Don river bend from July 17 to August 23, 1942*

The analysis of the events in a period of the summer of 1942-autumn of 1943, i.e. the breakthrough of the German troops in the south and the sanguinary battles on the Don, Manych and Volga rivers, in Northern Caucasia, the Azov region and Taman, proves that they played a decisive role in a breaking point of the Great Patriotic War. The victory in bitter battles in the south was achieved by maximum coordination of all efforts and mass heroism of the people. Meanwhile, the number of the official places of memory (in particular, a share of hero-cities) is much less here than in the center and the north-west of the country.

The historical justice should triumph. The city of Ordzhonikidze (today Vladikavkaz) deserves the high title of Hero-City but it never received it. The Matveev Barrow and Krymsk, Ishcherskaya and Chervlyonnaya, Elkhotovo and Gizel villages and also other localities are worthy of the title of a City of Military Glory. The places of the sanguinary battles from Krasny Luch in Donbas to Sambek in the Azov Region, from Gudermes to Mozdok, from Nalchik to Ordzhonikidze, from Novorossiisk to Temryuk are actually the fields of military glory of all peoples of the former USSR. For the sake of memory of above 5 mln of lost soldiers and civilians of our region this imbalance in the policy of memory should be eliminated. Today it is imperative for all peoples of the multinational south of Russia.

The work has been implemented within the framework of RSSF project No. 14-01-00300 "The Don's Big Curve-Place of Decisive Battles of the Great Patriotic War (1942-1943)".

Illustrations supplied by the authors

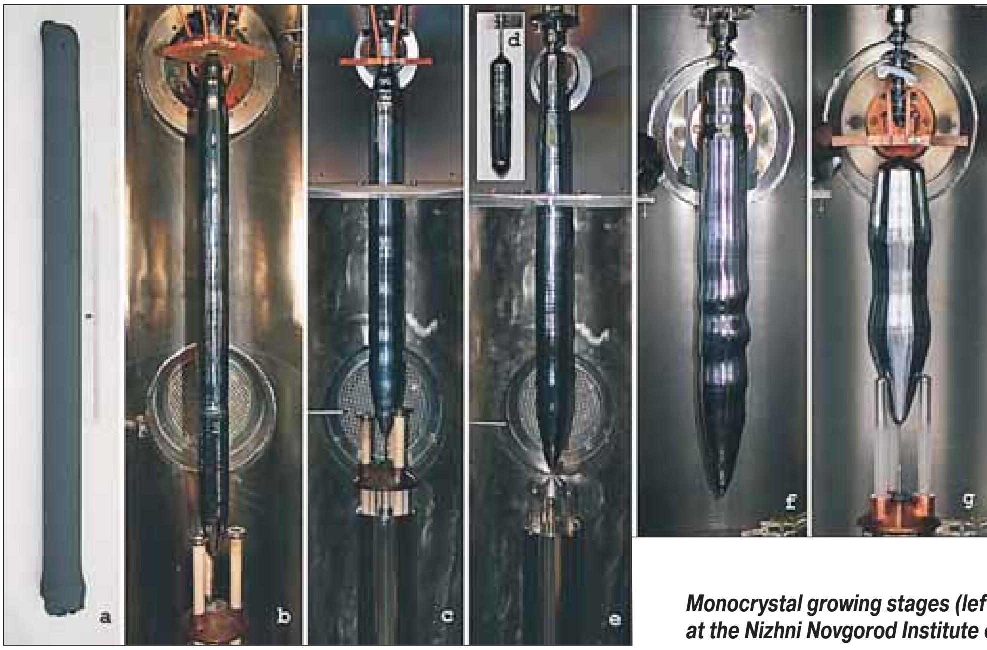
GRADE OF PURITY

Many physical standards are determined through fundamental constants—except the kilogram, calculated the "old way": this is the mass of a platinum/iridium (Pt/Ir) cylinder manufactured more than a hundred years ago exactly for that purpose. Today physicists and chemists are out to determine a mass unit on the basis of a Si-28 isotope. Taking part in this work are also Russian scientists of the Institute of High Purity Chemistry named after Devyatykh (IHPC) in Nizhni Novgorod. More, in an interview of Dr. Andrei Bulanov, deputy director for science, to the newspaper *Poisk* (*Search*).

The Mendeleyev Periodic Table lists only twenty-two monoisotopic elements, while the greater part of others are a mix of 2 to 10 stable elements. Their physical and chemical characteristics are essentially different, and studying each one is of major interest to basic research and the materials science.

To see how the mass of an isotope affects its characteristics, we should achieve all-out grade purity of substances under study. By now the lowest concentration of impurities has been attained for silicon (Si) and Germanium (Ge), the elementary semiconductors. Many physical and physical-chemical properties of these native elements in high-grade monocrystals (single crystals) have been studied in much detail. Therefore we sought to get high-quality Si and Ge isotopes. Native silicon (Si) is a mix of three stable isotopes having atom masses 28, 29 and 30, their concentrations, 92.23, 4.67 and 3.10 percent. Germanium (Ge) has five isotopes, with their masses and concentrations 70 (20.84%), 72 (27.54%), 73 (7.73%), 74 (36.28%) and 76 (7.61%).

Pt-Ir standard.



Monocrystal growing stages (left, a semicrystal obtained at the Nizhni Novgorod Institute of High Purity Chemistry).

Si and Ge isotopes have found a variety of applications, namely in X-ray monochromators, in ionizing radiation detectors, and also in registration of double neutrino-free β-decay. Yet another spin-off for silicon—new semiconductors, including what we call superlattices composed of isotopes of 28 and 29, or 29 and 30 atomic masses.

Getting substances with low concentrations of impurities is a multistage process that includes separation of isotopes in the form of a volatile compound, high-degree purification of the substance thus enriched, and isolation of a monoisotopic element from it, to be followed by its extra cleansing and growing a single crystal from it. *Rosatom* enterprises have a good record of isotope separation in gas centrifuges, with volatile-fluorides used for better purity. To isolate the element from a compound like that we need either extra chemical reagents (contaminating the product) or special physical conditions (plasma, hard laser radiation, electric arc).

We are making use of an upgraded hydride method that takes in the stages of synthesis, high purification and thermal decomposition of a monoisotopic hydride at t ~800 °C. For instance, the synthesis of Si hydrides, the monosilanes, is predicated on reaction of Si tetrafluoride interacting with Ca hydride. Monoisotopic silanes thus obtained are separated from admixtures by low-temperature filtration and distillation. Next, the purified substances are subjected to pyrolysis (high-temperature breakdown), with a polycrystal being precipitated on a special growth rod made from a corresponding monoisotope.

Our institute began the work of getting large specimens of Si-28 late in the 1990s. Our first single crystal contained as much as 99.89 percent of the stock isotope. Then we brought up the concentration to 99.93 and 99.98 percent. The final stage of this work concurred with a period when our research center joined the Avogadro Project launched in 2002 by the International Board of CIPM Directors (Eurocommission) involved with mass measurements. The aim was as follows: calculate a physical constant, the Avogadro* number, with very high accuracy. At that time 1 kg native silicon spheres were being used for that. European Union research centers making mass and volume measurements determined their molar mass. Proceeding from these data, it became possible to obtain the most exact value of the Avogadro constant. The error margin was only a three decimillionth. The principal cause in the way of better accuracy was pinpointed, and that was isotopic inhomogeneity of native silicon.

Further accuracy of this value was attained by using a highly enriched, chemically pure and structurally perfect Silicon-28 single crystal. To handle this objective research institutes of European Union and Russia joined hands. Our country was to shoulder the job of getting the stock material from Silicon-28 in the form of a polycrystal. An isotope-enriched variety of silicon was obtained by the *Tsentrotekh-SP(b)* company. We, in our turn, grew a 5,983 g crystal in the shape of a rod

* The Avogadro number (constant), the number of molecules in a mole of any substance or the number of atoms in a gram-atom of any chemically elementary substance; named after Amedeo Avogadro, an Italian physicist and chemist.—*Ed.*

Si-28 spheres.

61.5 mm across. The concentration of the basic isotope was nearly hundred percent: 99.99382±0.00240 percent. Meanwhile das IKZ Institut in Berlin, Germany, specializing in crystal growing had our crystal grown into the desired Silicon-28 monocrystal by the method of noncrucible zone smelting. Then the Australian Center of Precision Optics (ACPO) manufactured two identical spheres from it, 96.3 mm in diameter and 1 kg in mass. By measuring their volume, density, atomic lattice and molar mass, it became possible to bring down the error of the calculated Avogadro number to a three hundred-millionth fraction, or almost what was wanted.

In their chemical and isotopic purity our monocrystals are superior to specimens grown before. Such silicon-derived single crystals differ essentially in many characteristics both amongst themselves and from isotopic samples of native Si, specifically in heat conductivity, low-temperature photoluminescence intensity, fine spectral structure, refraction index and other significant characteristics. Our high-grade monocrystals offer good prospects for quantum computers, spin electronics, fiber optics wave guides in the near infrared range, for a new generation of detectors of nuclear particles and ionizing radiation. The novel Si-28 technology has also been used for growing single crystals of other rare Si isotopes with a concentration index above 99.9 percent.

Obtaining high-grade germanium isotopes is another line of our activity. Teaming up with an electrochemical plant in Zelenogorsk, Krasnoyarsk Territory, we have devised a method of separating Ge isotopes with a hydride of this element, the monogermanium, as a working medium. Taking native monogermanium, we isolated Ge isotopes of atomic masses 76, 74, 73 and 72 by centrifugation. Monocrystals were grown from them after purification. The Ge-76 monocrystal contains above 88 percent of the basic isotope, and the Ge-74 polycrystal, as much as 99.93 percent.

Pooling with Nizhni Novgorod University and the RAS Fiber Optics Research Center, we have measured the optical and thermal characteristics of Si and Ge monocrystals. The results of our studies attest to a significant effect of their composition on such characteristics as heat capacity and conductivity as well as luminescence and light absorption. There are plans to get Ge-73 and Ge-72 isotopes enriched to 99.9 percent and look into their characteristics. Turning to international projects, Dr. Bulanov said that in 2012 a Kilogram Project had been launched by das RTB Institut of Physics and Technology in Germany so as to beat the results of the Avogadro Project. The one kilogram spheres obtained earlier from monoisotopic Si-28 deviated from sphericity by 99 nm. And thus the main “input” to the error in the Avogadro constant came from the nonsphericity factor (error in determining the sphere volume), and not from the isotopic composition. Joining the new project, the Nizhni Novgorod Institute was to grow two polycrystals, each about 6,000 g in mass. The stock material for one of the crystals—silicon fluoride enriched to 99.997 percent—is already available at the Zelenograd electrochemical works and handed to our Nizhni Novgorod Institute, Dr. Bulanov said. Work is underway to obtain a source silicon hydride, the monosilane, and to handle the job of its further purification.

Das Berlin IKZ Institut will grow a single crystal from which das RTB Institut will excise two 1 kg spheres diverging from sphericity by <30 nm. So, using four spheres from the monoisotopic Si-28, scientists hope to fulfill the purpose of the Avogadro Project—calculate the Avogadro constant with an error not above a two-centimillionth. This fundamental objective, we are hoping, is within reach.

V. Yanchilin, No Extras.—Newspaper “Poisk”, No. 45, 2013

Illustrations supplied by A. Bulanov

Prepared by Sergei MAKAROV

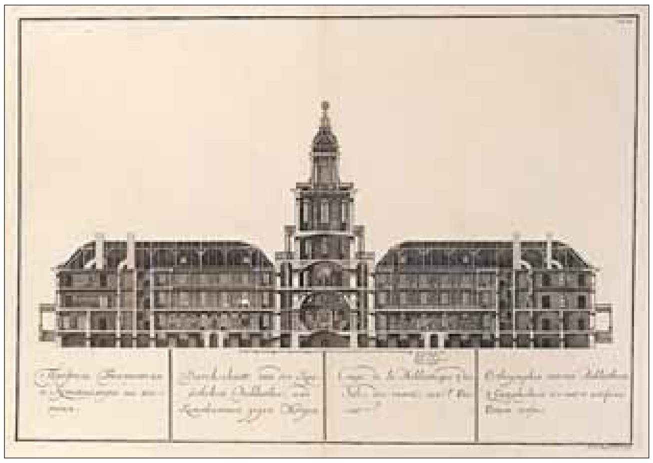
FORMATION OF ETHNOGRAPHIC SCIENCE IN RUSSIA

by Larisa PAVLINSKAYA, Cand. Sc. (Hist.),
Head of the Department of Ethnography of Siberia,
RAS Museum of Anthropology and Ethnography
named after Peter the Great

The Age of Enlightenment begun in Russia in the 18th century was a period of formation of science in the country, which reached the level of developed European states in the course of the century. Such rapid rise was mostly preconditioned by the policy implemented by the Emperor Peter I, who was eager to make Russia one of the advanced European countries. Establishment of the St. Petersburg Academy of Sciences in 1724 was one of the most important achievements of Peter I: for several decades it headed scientific, cultural, educational, and even political development of the Russian Empire.

The Academy moved to a building on the bank of the Neva River in St. Petersburg constructed specially for this institution in 1728. The building also hosted the first State Museum of Natural Sciences and History Kunstkammer with a library and an observatory. Pursuing the objective of making our country a part of the European world as soon as possible, the emperor invited well-known scientists, architects, and artists from Germany, France, the Netherlands, and Italy with the intent to form basics of a new culture and make a new capital—St. Petersburg—its symbol. Speaking of exact and natural sciences, including profane art, the reforms implemented by Peter the Great played a key role. In terms of ethnography, not only the reforms, but also the nature of our country, uniting peoples of Slavonic, Finno-Ugric, Turkic, Tunguso-Manchurian, Paleoasian, and Mongolian linguistic communities in one territory, was of great importance.

This ethnic peculiarity was a reason of rapid development of ethnographic studies, which in the 18th century by its scale and methodology left behind in many ways the European countries. As centralized governing of the vast territory of the Empire, by that time already including a significant part of Eastern Europe and Northern Asia with such multinational make-up of population, was impossible without their profound understanding (it was not by chance that the first studies of the country aimed to collect and study ethnographic artifacts were



The Kunstkammer Library was located in the western wing of the second floor. Engraving, 1741.

organized by Peter I). As a result, ethnography as a science in Russia initially had a research nature and was promoted by the Academy of Sciences, while in Europe it developed exclusively as a part of missionary activities. To understand all this it is necessary to assess the volume of appropriate information collected by Russian ethnographers in the early 16th-17th centuries—the period of assimilation of the main geographical and cultural space of the future empire.

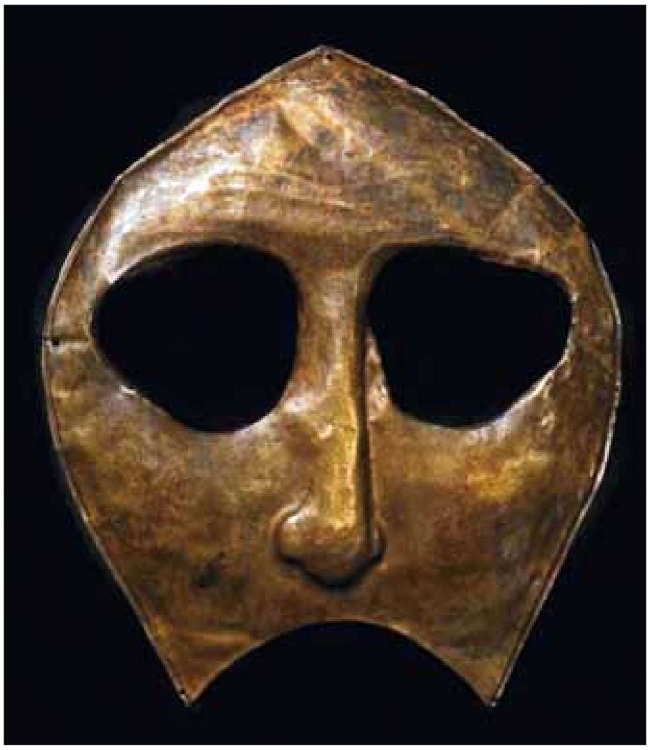
Russian chronicles describing the life of most peoples inhabiting the European part of Russia and peoples of Western Siberia were among the sources that played a direct or indirect role in the formation of national ethnography. Speaking of the resources that were of great use in studies of Siberia and are still rather valuable are so-called "Instruction Records" of voivodes and salesmen of Siberian stockaded towns, "Tsar's Deeds and Decrees", including "interviews" of service class, a majority of which survived till our days thanks to the members of academic expeditions of the 18th century.

The first works describing peoples, mainly of Siberia as one of the most mysterious part of the country, were published in the 17th century—*On the Siberian Tsardom and Tsars of That Great Tsardom* (the author is unknown, 1645), *Journey Across Siberia from Tobolsk to Nerchinsk and Chinese Border* (Nikolai Spafary, 1675), *Description of New Lands, or Siberian Tsardom* (Nikifor Venyukov, 1675-1698), etc. In general, in the 17th century there already existed a great amount of reliable data on the peoples inhabiting Russia and neighboring states. This is proved by a unique work by the Burgomaster of Amsterdam Nicolaas Witsen *Northern and Eastern Tartaria* (1692, published in Russian in 2010) that was to a large extent dedicated to the peoples of the Russian Empire.

As a man greatly interested in area studies and especially peoples and cultures of faraway countries, in 1664 Witsen visited Moscow as a member of the Netherlands Embassy headed by Jacob Borel. He stayed in Moscow for about a year and got acquainted with representatives of different social strata who provided him with information on the territory and population of the vast Russian Empire. Thus, the data collected by this author reflect, first of all, the knowledge of the 17th cent. Russians about different peoples of their own country. Witsen continued collecting information on our country after he returned to Holland: he received letters from Russia and information from Russians visiting Amsterdam. In terms of geography, the work by Nicolaas Witsen covers the territory of the Volga Region, Ural, Siberia, Mongolia, Central Asia, Caucasia, and the Crimea. It contains data on the nature and climate of these lands, maps of Siberia and Far East, and what is more important—description of local peoples, their customs, habits, beliefs, and legends. Moreover, he proposed the first rough linguistic classification of languages of the peoples inhabiting these regions. The work *Northern and Eastern Tartaria* was acquired by St. Petersburg Academy of Sciences and played an important role in preparing large-scale expeditions to Siberia held in the first half of the 18th century.

At the turn of the 17th-18th centuries, another prominent figure Semyon Remizov appears in national Siberian studies. He was a service class representative by birth, but for his military merits he was introduced to the class of "boyar children". However, he became famous as a historian of Siberia and a cartographer. He is the author of the outstanding work of those times *History of Siberia* (Remizov chronicle), based on the data obtained during careful examination of a great volume of sources (chronicles, documents of Siberian offices, legends and stories, drawings and maps). The author, though from the Christian and educational standpoint, tried to carry out a comparative analysis of historical, ethnographic, and geographical data and assess the process of joining of Siberia to Russia and its significance for the state. Remizov made numerous maps of the Siberian region and drawings of Siberian stockaded towns, which enriched substantially national history, ethnography, and geography. His famous *Drawing Map of Siberia* incorporates 23 maps covering the whole region.

The monograph *Brief Description of the Ostyak People* (1715) by Grigory Novitsky is the earliest ethnographic work of the 18th century in the Russian language and one of the first ethnographic works in the history of world science (SPb., 1884). In 1712 Novitsky (who was exiled to Tobolsk on a charge of Hetman Mazepa's treason case) as a member of the "apostle expedition" headed by metropolitan of Filofei (Leshchinsky) arranged by order



Mask-guise of the spirit-protector of the shaman and clan territory. Brass. Tunguses of Transbaikalia, 18th century.

Figurine of a soldier in armor. Walrus tusk. Chukchi man, 18th century.

of Peter I to baptize Siberian peoples, took a trip along the Ob River in the settlement area of the Ostyak people (Khanty). The journey resulted in a detailed description of the traditional Ostyak culture not yet exposed to Russian influence. Novitsky described all aspects of life of this people: dwelling, clothes, food, rites, beliefs, customary law, etc. The author also presented his ethnographic observations on the general history of Siberia available at that time, described Ob and its tributaries, natural wealth and even trade relations between Russia and China. Moreover, Novitsky was the first enthusiast who made an attempt to elucidate ethnic history of the region by studying local legends on the Chud people who once had allegedly inhabited territories along the Ob River. In fact, this work contained the main principle of ethnographic description of peoples and their culture.

Systematic studies of the Siberian region commenced in 1719. From 1719 to 1727, on the instructions of Peter the Great, the German scientist Daniel Gottlieb Messerschmidt who was in service of the Russian tsar, worked in Siberia. In the 18th century ethnography was one of the branches of political and historical geography, and finally formed as an independent subject only in the 19th century. That's why the researcher was instructed, inter alia, to describe local flora and fauna, search for medicinal plants, ancient monuments and manuscripts, as well as to study culture and languages of the Siberian peoples. Messerschmidt examined the territory from the Ob River to Transbaikalia and collected an enormous material on almost all aspects of human and natural life, including notes, collections and maps made by him. All materials collected by Messerschmidt were donated to the St. Petersburg Academy of Sciences established in 1724. Unfortunately, the best part of the collection burnt down in the fire of 1747.

Further development of national ethnography up to the mid-19th century was carried on by the Academy. It organized numerous expeditions, mainly to Siberia and the Volga Region, on a scale never repeated in the history of science. To be more precise, the Academy organized over 50 expeditions—both individual trips of scientists and complex multiyear studies carried out by large teams of specialists in different scientific spheres. Each expedition made its own contribution to the accumulation of information on different peoples and formation of methods and methodology of ethnographic science. The most important expeditions were the *Great Northern Expedition* (or the Second Kamchatka Expedition) held in 1733-1743 and the *Physical Expedition* (or the Academic Expedition) of 1768-1774. The land team of the Second Kamchatka Expedition arranged studies of the indigenous population of Siberia was headed by the German Professor of History Gerhard Friedrich Müller, member of the St. Petersburg Academy of Sciences. For 10 years the group collected a vast material on the history and ethnography covering almost all territories of Siberia from Ural to Kamchatka. Müller described Siberian archives, copied all documents and formed one of the most valuable funds on the history of Siberia.

The historical and ethnographical team of the expedition carried out a number of studies that have scientific value even today. Müller's main work *Description of the Siberian Tsardom and All Events Taking Place There*, from the beginning and especially from the time of its *Conquering by the Russian Empire till Our Days* (SPb, 1750-1764), based on numerous documents, stories and personal observations of the author, is not only the first general history of Siberia, but also a unique ethnographic material on the origin of certain peoples, their ethnic and cultural relations and interaction. Unfortunately, some of Müller's ethnographic works, dealing with the methodology of description of traditional culture and vocabularies of languages and dialects of Siberian peoples remain still unpublished. Müller and his colleagues brought from the expedition numerous collections dedicated mostly to the culture of aboriginal peoples of Siberia, and archeological artifacts of the Scythian-Sarmatian period found in the course of excavations. The materials were donated to the Kunstkammer, where all collections made by the scientists in the course of expeditions were kept, which made it one of the biggest museums of the world and the collection—the most important source for scientific studies.

The monograph by Müller's disciple and assistant Stepan Krasheninnikov *Description of the Land of Kamchatka* (SPb, 1755), a result of four-year independent studies in the eastern part of the Siberian region, was highly appreciated by coevals and scientists of subsequent generations. The ethnographic part of the monograph includes data on the origin of aboriginal peoples, their historical development and ethnicons, characteristics of the ethnic composition of population, housekeeping, material culture, beliefs, rites, and holidays. Krasheninnikov carried out a detailed and profound analysis of the traditional culture of the Itelmen, Koryaks, and partially Aleutians, and made valuable observations in the field of ethnopsychological peculiarities of the studied peoples; it is worth mentioning that the studies reflect a high level of tolerance and true humanism of the scientist. In 1740, in parallel with Krasheninnikov, another German scientist Georg Wilhelm Steller worked in Kamchatka. His principal work *Description of the Land of Kamchatka* (Frankfurt, 1774) also contains a vivid description of the traditional culture of the indigenous population; however, some pieces were taken from the materials collected by Krasheninnikov.

Jakob Lindenau, Müller's assistant and interpreter, who in 1741-1745 made a number of trips to the northern and eastern parts of Siberia—along the Anadyr, Kolyma, Alazeya, Indigirka rivers and the Okhotsk seaboard—revealed himself as a gifted ethnographer. His ethnographic essays on Yakuts, Tunguses (Evenks), Lamuts (Evens), Yukhagirs, Buryats, and some other peoples, are a sort of monograph depicting all main aspects of traditional culture—from housekeeping and economic activities to religious beliefs, including also vast linguistic materials.

Alongside with the ethnographic studies of Siberian peoples, scientists actively worked in the Volga Region and Southern Ural, which was preconditioned by expansion of the empire southwards and to the south east within the bounds of the Great Steppe due to taking of Russian citizenship by the "Junior Horde" of Kazakhs. These works were headed by two prominent state figures—from 1734 by Ivan Kirillov, compiler of the *Atlas of the Russian Empire*, and from 1737 by Vasily Tatishchev, author of the *History of Russia*, who arranged a special "Orenburg Expedition". The latter played an especially important role in the development of methodology of ethnographical science. It was Tatishchev who formulated the concept of "political and historical geography", which clearly determined tasks of ethnography as a science (1739), which included studies of the origin of peoples on the basis of a comparative analysis of languages and working out of historical and linguistic classification of peoples. He also compiled a questionnaire including 198 questions to collect geographical, historical and ethnographic, archeological and anthropological data, which was widely used by scientists during the 18th century.

Pyotr Rychkov who took part in the Orenburg Expedition greatly promoted ethnographic studies in the Volga Region, Southern Transurals, and Central Asia. His main works are *History of the Orenburg Territory* (SPb.,1759)

Censer.
Bronze. China, 18th century.

and *Topology of the Orenburg Province* (SPb.,1762). The first one represented description of peoples inhabiting the Orenburg Province—Tatars, Bashkirs, Kalmyks, Mordovians, Cheremises (the Mari), and Chuvashes, and the population of neighboring territories—the Turkmen, Uzbeks, Karakalpaks, Kirghiz-Kaisaks, residents of Khiva and Tashkent. The research led by Rychkov was highly estimated by the Academy of Sciences—he was awarded title of the Corresponding Member.

The ethnographic studies of the first half of the 18th century were continued in the form of five Academic Expeditions of 1768-1774 led by prominent scientists of that time, professors and adjuncts of the Imperial Academy of Sciences in natural history: Pyotr Simon Pallas, Ivan Lepekhin, Samuil Gottlieb Gmelin, Johann Güldenstädt, Johan Falk, and Johann Gottlieb Georgi; as for the main enthusiasts, there were captain Nikolai Rychkov (Pyotr Rychkov's son), students Vasily Zuev, Nikita Sokolov, and Nikolai Ozertskovsky who later on became academicians. For six years participants of the expeditions explored a vast territory of the expanding Russian Empire from Caucasia to the White Sea and from Moscow to Transbaikalia. As a result, they collected an enormous volume of information on the cultural traditions of a majority of peoples inhabiting these lands, that later formed a basis for numerous scientific works. Thus, the

Buddhist sculpture "Buddha Shakyamuni". Bronze. Tibet, 18th century.

five-volume book by Pallas *Journey Across Various Provinces of the Russian Empire* (SPb., 1773-1788) contains detailed data on the peoples of the Volga Region and Siberia, partially collected by his assistants Zuev and Sokolov. Pallas was especially interested in Mongols and Kalmyks. The materials he collected incorporated not only personal observations, but also Mongolian historical chronicles, were generalized in the fundamental work *Collection of Historical Data on the Mongolian Peoples*—a forerunner of historical ethnography. Pallas laid fundamentals of comparative linguistics in his 4-volume *Comparative Vocabulary of All Languages and Dialects in the Alphabetical Order* comprising European, American, African languages and languages of the South-Eastern Asia (1790-1791).

The first truly scientific study of the Nenetz people and Khanty was the monograph by Vasily Zuev *Description of the Ostyaks and Samoyeds Inhabiting the Berezovsky District of the Siberian Region* (M.-L., 1947), in which traditional culture of two peoples is presented in the context of a profound and comprehensive comparative analysis, including such in-depth layers of social relations as exogamy, large family community, and property stratification of the society. The most socially oriented work by Ivan Lepekhin *Diary of the Journey Across Provinces of the Russian State* (SPb., 1795) combines delicate obser-

Holiday dress.
Silk, golden thread. Kazan Tatars.
Mid-18th century.

vations over the life of Russian peasants, workers, the clergy, the Chuvash people and Zyryans, with an in-depth analysis of social structure.

However, the book by Johann Georgi *Description of All Peoples of the Russian State, Their Rites, Beliefs, Customs, Dwellings, Clothes, and Other Memorable Things* (SPb., 1776-1777) is considered a true apotheosis of the 18th century ethnographic science. This first consolidated monograph dedicated to the peoples of Russia is based on personal field observations made by the author and carefully selected data collected by other scientists. The vast work covers not only peoples of the Russian Empire but also inhabitants of some neighboring territories—Transcaucasia, Khanate of Bukhara, and Khiva. The monograph is composed of a series of essays, each dedicated to a separate people. In terms of composition, the essays have a single structure worked out by the 18th century science that has been preserved in ethnography till our days. The description includes the following: name of the people (ethnicon), inhabited area, number, physical type and psychological peculiarities, language, management system and common law rules, housekeeping, type of settlement and dwelling, clothes, food, family life-style, beliefs and rites. The author went beyond the limits of traditional ethnographic description: he also made a comparative historical analysis of the origin of peoples, identified main linguistic communities and classified them. All this makes it possible to consider Georgi's monograph as the final ethnographic study of the 18th century concentrating all scientific achievements of the past century and being a kind of model for scientists of future generations. Clearly, not all essays are equal by their content. The most detailed and accurate essay is dedicated to the culture of peoples inhabiting the European part of Russia, Western and Central Siberia; peoples of Caucasia, Central Asia and Far East are presented in less detail and even with a number of inaccuracies. However, this does not belittle this work in the history of both Russian and global ethnographical science.

Thus, by the late 18th century national ethnography was finally formed. Scientists and enthusiasts worked out principles of description of peoples and their culture, which laid foundations for future anthropological and ethnopsychological studies. There was developed a linguistic classification incorporating nearly all peoples of the Russian Empire. The methodology and procedure of studies of ethnic history applicable to a separate people or big ethic communities were elaborated. And, finally, a constellation of gifted Russian scientists who promoted future development of ethnographic studies in the next century was brought up.

In the late 18th-early 19th centuries, two lines of research—Slavonic and American studies—originated within Russian ethnography, which was the first step of national science in studying cultures of other states and continents of the Earth.

Illustrations supplied by the author

WHAT BURIAL MOUNDS BURY

by Sergei KORENEVSKY, Dr. Sc. (Hist.),
RAS Institute of Archeology, Moscow, Russia

The first burial mounds appeared in Eurasia about 6 or 7 thousand years ago, just on the eve of the Iron Age. They were built by numerous tribes such as the Huns, Scythians, Sauromatae, Alans, Polovtsians (Cumans), Mongolians, Celts, Slavs and Teutons, who lived in the ancient times and in the early Middle Ages and who are well known from written evidence. The same custom held independently also on the American continent among the Hopewells inhabiting in the 1st-5th cent. A.D. the northeastern and mideastern parts of what is now the United States, and the Mississippian tribes populating the Midland between the 7th and 17th centuries of the Common Era. This tradition went out of existence only with the spreading of Christianity and Islam, largely in the 10th to 13th centuries.

Kurgan burial mounds are as much a part of the landscapes of Russia's steppe, forest-steppe and forest belts. Many legends haunt these monumental testimonies of bygone ages. Now what is the origin of the word *kurgan*? The Etymological Dictionary of the Russian Language (Alexander Preobrazhensky, 1959) says it comes from the Cuman *kurman*, or a fortress. The same interpretation is in the Dictionary of the Russian Language of the 11th-14th Centuries (Nauka Publishers, 1981).

Burial kurgans are the artificial barrows raised over the tomb, sometimes with a ring of undressed stone blocks around them. That's the actual meaning... But if we take The Encyclopedic Dictionary of Old Russian published in 1893 by Izmail Sreznevsky, a Slavonic philologist, ethnographer and paleographer elected to the St. Petersburg Academy of Sciences in 1851—this dictionary gives several meanings of the *kurgan*, and does not trace it to the Turkic roots. The author dates the earliest written evidence when this

A raddle-strewn burial. Latter half of the fifth millennium B.C.

word was first mentioned to 1223, the year of the battle of the Russians and Cumans against Mongolians on the river Kalka (Donetsk region today). The Novgorod Chronicles of the 13th and 14th centuries read: Prince Mstislav Udaloi (Mstislav the Bold) of Galicz, crossing the Dnieper with a force of 1,000, routed "the Tartar sentries", whereupon the rest of the troop headed by the chieftain Gemyabek fled "to the Cuman kurgan".

A comment from Nikolai Kostomarov, an eminent Russian historian and writer: "The fugitives hid voivode Gembyak in a hole in some Polovtsian (Cuman) kurgan." This could not be a fortress (for the Cuman nomads had none, and they were enemies of Mongols and Tartars who would never shelter them)—it was a barrow piled on top of a tomb. So, *kurgan* could not be borrowed from Turkic dialects: incidentally, in Turkish a burial mount is called *höyk, tepe* or *tumsek*.

The word *kurgan* has come to stay in the Russian, Ukrainian and Belorussian languages. Other Slavic peoples are using different words standing for a "barrow", "tomb" and the like. West Europeans, who knew well such burial traditions, have other words for that short of "fortress".

In our view the term *kurgan* is of native, Russian origin that came into being in time out of mind. It is a compound noun with its first syllable, *kur* being very productive as a stem for nouns, adjectives and verbs related to smoke (we in Russian have such collocations as the *kurnaya izba* meaning "a hut without a chimney to its stove"; *voskurenie*, or "incense burning", "fumigation") and also to a sacrificial bird (*kuritsa*, a "hen"). The other syllable, *gan*, is the root of the old Russian word *gananie* ("guessing", "fortune-telling"). We get a curious combination tied in with the burial rite, ritual bonfire and fortune-telling on the sacred mound.

The great Ipatovo Kurgan:
a) before diggings;
b) machine-aided diggings.

Burial mounds appeared when man came to be regarded as an individual, not just as an adjunct to a tribe (there had been collective, tribal *polyandria*, or common graves, in large cemeteries before). Kurgans, the hand-wrought burial mounds, meant eminent domain of a particular tribe. They were revered by many peoples as a space of passage into the land of "the great majority".

In Eastern Europe the first kurgans were raised by tribes (Caucasoids or Aryans) inhabiting steppelands between the Volga in the east and the Dniester in the west as well north of Caucasia in the 5th century B.C. We cannot tell exactly what languages they were speaking, though they had much in common as far as burial ceremonies were concerned: the dead were laid to rest in holes (catacombs) on their back, their legs knee-bent and hands furnished with a plate made of flint; they were supposed to be ready for resurrection and action. The tomb was aspersed thick with raddle. But some tombs had no barrows.

Initially the burial kurgans were not large—about 1 meter tall and 12 to 15 meters across. Next, in the 4th century B.C., giant *kurgans* made their appearance—as high as 10 and even 25 meters, and 100 meters in diameter. Such giants were piled by tribes of the Maikop archeological culture of the 4th and 3rd centuries B.C.*

* Maikop culture, named so for a kurgan near the town of Maikop in northern Caucasia, and explored in 1897 by Nikolai Veselovsky, an archeologists and oriental scholar. This civilization took in a large area of the North Caucasus, in particular, Adygeia, the Krasnodar and Stavropol Territories, Kabardino-Balkaria, Chechenia and Ingushetia.—*Ed.*

Findings from the Maikop Kurgan.

Those people cultivated land, raised cattle, sheep and goats as well as hogs, and they were expert bronze-, silver- and goldsmiths. They lived in small settlements in plains.

The large Maikop kurgans are interesting in many ways. They were built in stages, step by step, and undergone regular repairs when part of the ground subsided. They came to be rebuilt into rather intricate constructions, and their layout shows the ancient builders knew fundamentals of geometry. Giant earth mounds above single burials did not grow overnight. One such giant in North Ossetia, 6 to 8 meters tall and 50 meters across (explored between 1993 and 1996), was raised in two or four stages. But some burials had barrows piled on top rather quickly, just at one go. Their erection involved many hands. Thus, the Great Maikop Kurgan, as high as ten meters, is 36,520 cubic meters big, which means that a crew of 100 had it built in just two or three months.

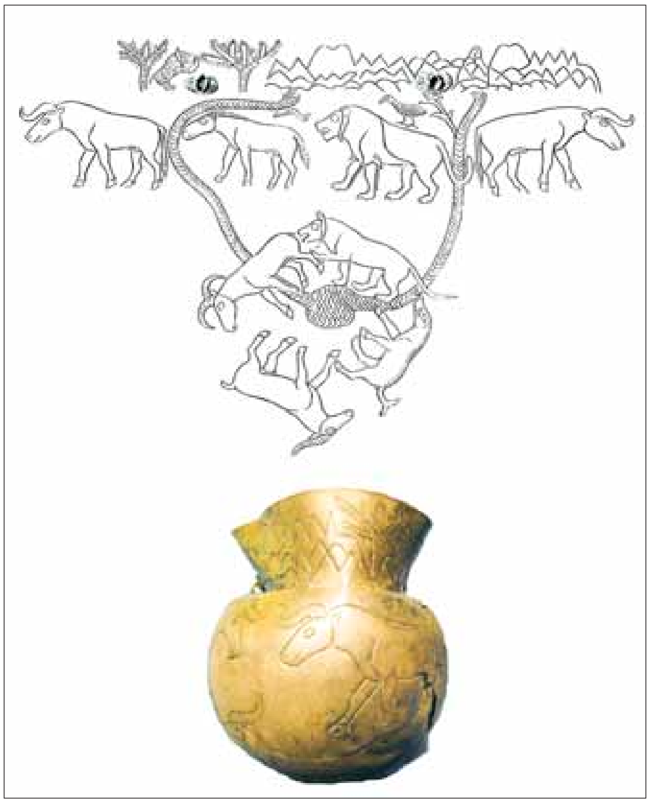
One kurgan may enclose several burials of different ages and cultures. In Eurasian kurgans, however, we identify the first, primary burial, and secondary, subsequent tombs buried in. So the mound had to be piled up, and it grew ever higher and wider.

The ultimum vale ceremonies and the rites of passage into the other world were closely connected with magic and the faith in preternatural. In Eastern Europe's first kurgans the dead were laid on their back with legs bent in the knee and feet flat on the ground. The ancients must have believed the feet were the seat of the human soul, and therefore even down in the grave they should touch Mother Earth. This supposition is not at all groundless: according to Slav myths, the magic *navja* bone was home to the foot (navja, the soul).

The cult of raddle was likewise widespread. This red paint symbolized vital vim, blood and resurgence. That is why raddle was aspersed on the burials. The magic of the earth was of special note: black earth sites were chosen for kurgans as a sign of fertility; and yellow clay impregnations stood for the solar canopy of heaven. The artificial mound signified the heavenly spheres. One took care of securing people in the land of the living against the evil effects of the deadman's soul should he rise from the dead. His vault was closed with boards and stones piled up above to keep him in and not let him out and do wrong to his kinsmen. If the crypt was of stone, it was sealed tight.

Since the dead were to go to the land of their forefathers, they were supplied with things vital for the passage and buried together with their bodies (some ritual traditions dispensed with that custom, though). There were certain essential rules in keeping with the pecking order—the hoards of chieftains were more rich. Archeologists picking in a mix of buried items can pass judgement about the level of weapons, crafts and social stratification.

The Great Maikop Kurgan is perhaps the richest—its treasures are in care of the State Hermitage Museum in St. Petersburg. That mound had a ten-meter barrow above a 5.3x3.7x1.4 m pit, where within a crypt partitioned in three, three men were interred. The largest section was set apart for the chieftain whose head was bedecked with two golden ribbons, and breast, with ornate pentapetalous flowers of double golden foil superb in their workmanship; they probably symbol-



The silver goblet of the Maikop Kurgan.
Top, pictorial images of the world,
magic trees, beasts and fowls.

The golden grivna neckless
worn by the "Ipatovo princess".

ized magic plants described in Iranian-Mesopotamian myths as the Tree of Life.*

Retrieved from the vault were tools of bronze, weapons and precious vessels flush against the walls. Two silver goblets with chased-in images are on a par with world masterpieces. One depicts a beast—most likely, a boar—rising on hind paws before two Trees of Life growing at the foothills of a mountain country. Two rivers flow into a body of water over there (lake or ocean); stalking below are mighty beasts—a lion, a wild boar, a giant bull... A procession of smaller animals—cheetahs, mountain billy goats and rams is portrayed on the other goblet, its bottom jazzed up with a flower ornament. So we get a picture of the world.

The mix of magic objects of the Great Maikop Kurgan has four statuettes of bulls wrought of gold and two of silver; they were impaled on pivots during burial rituals. Remarkably, the foreheads of these animals were festooned with festive stripes, their ornaments down; such signs of the Tree of Life were also on the bottom of the goblet with the cheetahs on. A great many embossed figurines of lions and bull-calves were placed above and around the dead body.

* A very popular motif of various myths and legends connoting life universal in its implications, and genesis in the evolutionary sense.—*Ed.*

The grivna in the hands of archeologists.

Such *objects d'art* were related to the Tree of Life cult current in Western Asia as of the 4th millennium B.C. The mistress of that tree was, according to the popular beliefs of the peoples of Anterior (Southwestern) Asia and Sumerians*, *Inanna*, the goddess of love, fertility, war, passion and discord. Every so often the richest tombs belonged to her priestesses. Could not the Maikop Kurgan be the grave of one of them? Perhaps. But it is much older than Sumerian tombs.

Sensational finds were discovered in 1998 in a burial place believed to be dating to the second century B.C. Its 8 meter kurgan near the town of Ipatovo of the Stavropol Territory was raised above the grave of a Sauromatan** queen 20 to 25 years of age and about five inches tall. The neck of that woman was bedizened with a grivna necklace composed of hoops hasped together. The hasp was furnished with eyelets with a golden needle in. This attire was proof of the royal rank: putting it on in her early childhood, the maiden carried it on lifelong. Other golden objects were likewise unearthed—massive spiral bracelets with heads of animals at the end; and a finger-ring made from a Hellene coin of Alexander the Great times and an inscription on the reverse.

In her left hand the "Ipatovo princess" held a bowl of wood and sheet gold (fastened with tiny nails) depicting a deer and a griffin (a mythical creature with the head and wings of an eagle and the body and legs of a lion). The collections of objects she took into the other world comprised leather clutches with amulets, beads and toiletries (these vanity cases adorned with pearls); a Greek amphora of clay probably filled with wine; a looking glass of bronze, a set of mascots (like a shark's tooth); and a short iron sword sheathed in a scabbard of leather.

Such spectacular finds give an insight into the origins and evolution of the human race that has traveled all the way from beastly creatures to a society of humanitarian values with a sense of personal identity. Archeology is helpful in this regard, particularly, by showing how states came to be. Together with historical ethnology it is studying evolutionary societal models and civilizations, and social structures of the past (e.g., the phenomenon of leadership with a leader, or chieftain, at the head of closed communities of several villages and settlements). Archeology has a magic of attraction to it, just like traveling to the ocean floor or out into space. It is an eye-opening science.

Illustrations supplied by the author

* Sumerians inhabited the south of Mesopotamia, a region between the Tigris and the Euphrates, in the third millennium B.C. The Summerians represented the first civilization out there with a written language.—*Ed.*

** Sauromatae, Iranian tribes settling down in the third and fourth millennia B.C. in stepplands between the Tobol in the east and the Danube in the east.—*Ed.*

...CAUCASIA, HIS POETIC CRADLE...

by Olga BAZANOVA,
Science in Russia observer

Pyatigorsk, a major administrative center of North Caucasia, is also famous as a spa health resort, and by its mud baths. Its foundation date harks back to the year 1780 when a fort was built out there. In 1803 Emperor Alexander I signed an edict that stressed the great significance of Caucasian mineral springs and mapped out plans for establishing a spa resort over there. Pyatigorsk is a meaningful name. First and foremost, because this town is a mecca for those who worship the great Russian poet and novelist Mikhail Yurievich Lermontov (1814-1841) and who are all set to celebrate his birth bicentennial in 2014. As Professor Boris Eichenbaum, a literary critic, says, Pyatigorsk is a historic place intimately linked with Lermontov's life and creativity, his tragic and untimely death.

Pyatigorsk, or a "Town of Five Mounts", cuddles at the foot of a five-domed mountain, Beshtau. Much credit is due to Johann Anton Hildenstedt, a member of the St. Petersburg Academy of Sciences, who between 1769 and 1775 explored the plant and animal kingdom of the locality, its lakes and mineral springs. In 1793 another explorer, Peter Simon Pallas, went thither too. An eminent German naturalist, geographer and traveler, Palas was in the Russian service. Soldiers of the fort's garrison (the name of that fort was Konstantingorsk) told him about the curative baths found to be good for skin diseases and rheumatism. Getting down to brass tacks, Palas found out those were thermal baths carved in rock long ago, in times out of mind, at the foot of Mount Mashuk, now within the Pyatigorsk city limits. The German made a chemical test of the warm water gushing forth from subterranean mineral springs.

The news of the salutary Caucasian waters spread like wildfire, and sick sufferers trekked in doves to "Warm Waters" (Goryachevodsk) for relief. Feodor Gaaz, a Moscow physician, visited these parts in 1809 to look around. He made a close study of the springs and struck new ones. He confirmed the curative properties of the waters and was the first among medica to recommend them for treatment. Alexander Nelyubin, a St. Petersburg doctor, teacher and writer, kept up this work, and he summed up his findings in a capital description of Caucasian mineral waters that holds even in our days.

And so it came to pass that in the selfsame year of 1825 a Penza landlady, Elizaveta Arsenieva, brought her ten-

The Pyatigorsk Eagle, a symbol of Caucasian spas.

year grandson Michel Lermontov to her sister, Ekaterina, staying at Goryachegorsk—frail in health, Michel had to recuperate. [Mikhail Yurievich Lermontov was born in Moscow to Captain Yuri Petrovich Lermontov and Maria Mikhailovna, neé Arsenieva. His parents moved to the Tarkhanov estate at Penza and soon after that separated. When Lermontov's mother died, little Michel became the ward of his grandmother Elizaveta Alexeyevna Arsenieva.] Although Michel had been to the Caucasian mineral springs before that, this time Caucasia kindled poetic sentiments in his young tender soul and three or four years after, he tested his quill and put down his first spirited verses. Euterpē, the Poetic Muse, fired his heart. Thus from the tender nail Michel Lermontov showed a lyrical bent. The Muse got a mighty hold of his imagination in the university days, in 1830 to 1832 (in 1830 Lermontov entered Moscow University). The Caucasus and its snow-mantled peaks, these "thrones of Nature" beckoned to him, and inspired a great many lyrical poems like *The Cross on a Cliff*, *The Caucasus*, *The Chain of Mountains Blue I Love*...

Meanwhile the health resort kept growing and developing apace largely thanks to the active efforts of General Alexei Yermolov serving at that time as governor of the "Caucasian Province". At his request two master architects came from St. Petersburg, the Swiss-born brothers, Giuseppe and Giovanni Bernardazzi. In 1828 they finished the construction of the first town hotel, the *Restauratia*, that evolved into a community center (housing the Research Institute of Kurortology today). In 1831 the Bernardazzis built the Nicholas Baths, the oldest mud-treatment facility in Russia (changing its name to the Lermontov Baths: in 1837 the poet was there for a course of cure sessions)*. The two builders took care of a natural cave on the western slope of Mount Mashuk—they made it deeper and cosier; known today as the Lermontov Grotto, it is one of the most spectacular sights in Pyatigorsk.

Landscape architecture and gardening was also an important part of this activity. A large orchard and a linden-lined boulevard were laid out; the boulevard became a popular flower garden, The Parterre. This work proceeded alongside with road building. Furthermore, the health resort hired Feodor Conradi as head doctor who, in 1831, published his *Inquisitions About Mineral Waters and the Latest Tidings on Caucasian Mineral Springs*. General Georgi Emanuel, who succeeded General Yermolov in the capacity of the "Caucasian proconsul", went on with further urban development projects. Giuseppe Bernardazzi was taking an active part: in 1830 the government endorsed his plan for town renewal, and Goryachevodsk ("Hot Waters") was elevated to a provincial town status and changed its name to Pyatigorsk ("Town of Five Mounts"). Going on with the work of beautifying the Parterre Garden, the Swiss architects built a superb grotto there named for Diana, the Roman goddess of the moon, the woods and of hunting (Artemis in Greek mythology), a symbol of womanly grace and fertility. This creation was dedicated to the members of the first research expedition to Mount Elbrus, the tallest peak in Russia, organized by Emanuel in 1829.

In 1831 Giuseppe Bernardazzi built a stone rotunda with eight columns dubbed Aeolian Harp (after Aeolus, the Greek god of the winds) and modeled after the Aeolinan Temple put up by William Chambers near London. The floor of this grotto was furnished with strings that played music when blown by the wind. An esplanade, offering a breath-taking view of Mount Elbrus, Pyatigorsk and its outskirts, was built around the grotto.

Convenient roads and walkways were cut across to the mud baths and springs, and to the places of entertainment, for one, to the Pit, a sink of karst origin (called so

* Both houses were built to the design of Joseph Charlemagne of St. Petersburg.—*Ed.*

Restauratia, now housing the Kurortology Institute.

by Anton Hildenstedt in 1773): this cave, 41 meters deep, is a conical depression getting narrow toward the bottom; its vault took form as a result of stripping and rock washouts. The grotto's bottom has a warm mineral lake (t^o=25-42^o centigrade); it is 11 m deep, 15 m across, and of bright greenish-blue color due to the presence of hydrogen sulphide and sulpur bacteria.

In 1793 Pallas measured the cave in-depth and described it. Decades after, in 1857, local researchers got down to exploring this wonderous natural phenomenon. The following year a 60 m tunnel was cut through to the lake shore to enable the inquisitive lot to come closer and take a look. But there was no tunnel in the Lermontov days—one could peep into the "blue lake" only from above, standing on a platform erected by the Bernardazzi brothers; those who had the guts to get down were able to do so by getting into the basket fixed within and have a go.

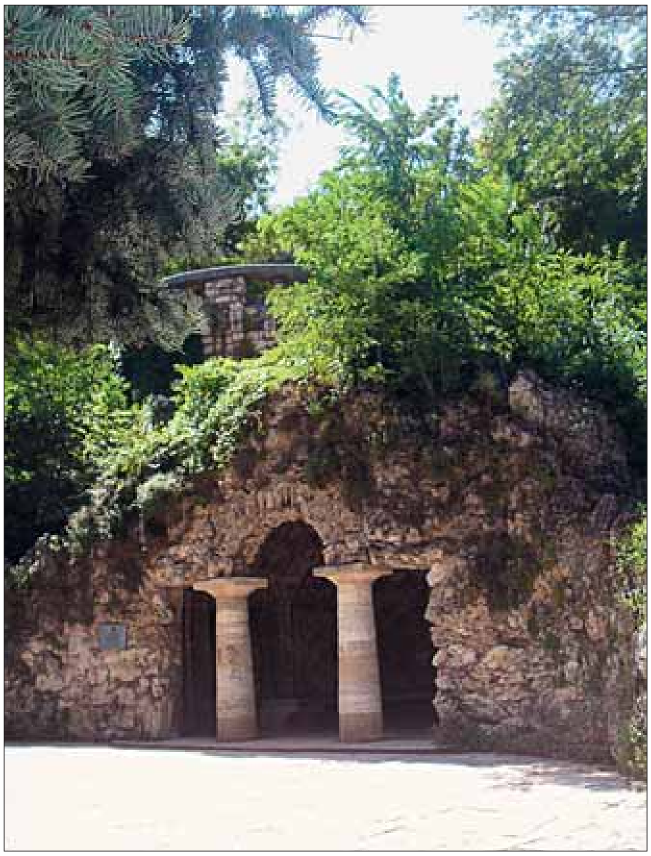
This spectacular natural monument, together with pavilions put up in the 1820s and 1830s, are silent witnesses of the great poet staying there. He stepped into the buildings known to us, trod the paths of the place, took in the lovely natural scenes. And he did a bit of socializing by mixing with the "water springs beau monde"—guests from St. Petersburg and local nobles. He immortalized his experiences in the novel *The Hero of Our Time*. Visiting Pyatigorsk is always a nourishing trip down the Lermontov memory lane.

Lermontov was destined to come back and end his days out there, in the Caucasus. He had to: on the twenty-ninth of January, 1837, the great Russian poet Alexander Pushkin died after the duel he lost to Dantes. Lermontov worshiped Pushkin as his idol. He responded with scathing, acrimonious lines in the poem *Death of the Poet*:

The Poet's dead—in bond of honor—
He fell, by rumour vilified...
Lermontov blamed the powers that be and the St. Petersburg beau monde for this tragic duel.
... But you, the arrogant descendants
Of fathers for their churlish villainly renowned...
... You who surround the throne in eager droves, you vandals...
... Who would have Freedom,
Genius and Glory hung!...
All your black blood can't wash away nor shall it ever
Redeem the Poet's righteous blood!

Riled, the authorities started criminal investigations. Lermontov was arrested and sent in the rank of ensign to the Dragoons Regiment on active duty in the Caucasus where a war was on against the rebellious highlanders.

This poem made Lermontov famous overnight, it was distributed in manuscripts in St. Petersburg. And it outraged the government. Lermontov fell ill on the way to his regiment and spent some time taking a cure in the Pyatigorsk spa. "I came crippled by rheumatism all over," he wrote to his friend Svyatoslav Rayevsky. "The men carried me out of the vehicle, I was unable to walk; but within a month the waters set me right, and now I am



Diana Grotto.

as sound as ever...” Thereupon Lermontov went to Tiflis (Tbilisi today) as an ensign of the Nizhni Novgorod Dragoons regiment. The routes of the poet’s wanderings are often hard to trace. Here’s what we read in the letter:

“Since I left Russia I have been in continual peregrination, traveling now on post-chaise, now on horseback; I rode all over the Line*, from Kizlyar down to Taman; I have crossed the mountains, I have been to Shusha, Kuban, Shemakha, and Kakhetia wearing Circassian-style clothes, with a rifle slung over the shoulders... Nights I slept in the open field to the howling of jackals; I ate of the churek bread, and even drank of the Kakhetian wine...”

The poet’s sensitive soul imbibed avidly the striking impressions of the mountain wonderland. The Caucasian folk songs, tales and legends captured his mind and came to be transmuted into many poems and writings of his. First and foremost, that was the novel *The Hero of Our Time*. Such poems as *The Captive*, *Mtsyri*, *Haji Abrek, Tamara*, The *Dagger, As Haste I Northwards, Gifts of the Terek, A Cossack Lullaby, Clouds, Forgiveness* among many, many others were conceived over there, in the Caucasus. A superb master of the brush, Lermontov made quite a few pictorial sketches.

Early in 1838 Czar Nicholas I pardoned the “inditer of unorthodox verses” and let him come back to St. Petersburg (true, with his grandmother Arsenieva, who carried weight, interceding for him). Two years later, in 1840, Lermontov published his first (and the only one in his lifetime) collection of poetry with twenty-eight poems, and then also *The Hero of Our Time* (first in installments appearing in *The Otechestvennye zapiski**) and afterwards, in a separate edition. This novel laid the beginning of Russian psychological prose.

In 1840 Lermontov was arrested again, this time for a duel with the son of the French Ambassador Barante. Upon the investigation he was sent in the rank of lieutenant to the Tenginsky Infantry Regiment in the Caucasus, where he acquitted himself in military operations. Here’s what we read in the military review journal, “This officer, braving danger, fulfilled his mission with extraordinary gallantry and in cold blood...” As commander of a “Flying Hundertschaft” recruited from volunteers—daredevils and superb swordsmen, mostly army officers reduced to the ranks, Cossacks and Kabarda mountaineers,—Lermontov was in many skirmishes and, as one of his comrades-in-arms recalled, he was always “the first target of predatory fire and, heading the task force, was beyond any praise in his selfless bravery”.

In May of 1841 Lermontov is back in Pyatigorsk again after a two-month furlough in Petersburg. While over there, at the end of 1840, he tried to resign from the army in order to devote himself to literary pursuits, but his application for discharge was refused. Back in Pyatigorsk, he and Captain Alexei Stolypin (nicknamed “Mongo”**), his kinsman and old buddy of the Cadet School, rented a thatched adobe cabin which stood near the mansion of General Verzilin a Cossack *ataman* (war lord), a haunt of young army officers. On one such soirée, on the thirteenth of July, 1841, a dramatic quarrel broke out which, as Emperor Nicholas I put it, stole from Russia “one, who could stand in good stead of Pushkin to us”.

Lermontov was larger than life—multidimensional, full of contradictions. Small wonder that most different opinions are uttered concerning his ego, his creations and his early death. Writers and literaty critics—those who lived in the 19th century and our contemporaries, too—are not at one on that. According to Emma Herstein, a literary critic, the Lermontov biography and creativity need a good deal of research. “Thorough and systematic studies of archival treasures... may yield many

* With reference to the Caucasian Defense Line comprising border fortifications and put up in the 18th and 19th centuries. It furnished protection to Russian troops during the Caucasian War of 1817-1864 waged by Russia against local tribes.—*Ed.*

* A literary journal that impacted Russia’s public thought in 1818 to 1884.—*Ed.*

** Mongo is one of the two characters at the jolly short poem *Mongo*—*Tr.*

Lermontov Grotto.

fresh findings and discoveries" (*Lermontov's Destiny*, 1964).

We do not know all there is to the tragic duel between the poet and Nikolai Martynov, a retired army major once enrolled in the same Cadet School as Lermontov. There is a mix of fact and fancy on this score. So we had better hear what eyewitnesses had to say.

Brother officers recalled: Martynov was "a very handsome young officer of the Guards... always courteous and merry, he sang romances rather well and wrote fairly good verses. He was eager for promotion... up to the rank of general." But in 1841 he tendered his resignation all of a sudden (possibly caught red-handed in foul play at the cards). Martynov changed greatly: he "let immense sideburns grow, would wear a simple Circassian dress, furnished with a long dagger, and had a white papakha [Caucasian tall hat of sheepskin] on; always morose and taciturn..." As Nikolai Lorer, an exiled Decembrist (implicated in the conspiracy of December 1825 as a group of army officers refused to swear fealty to the new emperor, Nicholas I), recalled, Martynov became the butt of jeers and derision among the comrades, with Lermontov being most caustic..."

It was at Verzilov's that Lermontov and Martynov clashed in a bitter quarrel; As Martynov testified in his evidence after the fact, "Ever since his arrival at Pyatigorsk Lermontov would seize every opportunity to say something foul to me... At the evening party in a private home... he made me lose all patience... I told him to cut it out and stop those jeers intolerable to me... He cut me short and, to cap it all, told me, 'Instead of empty threats, you'd better act. I never refuse from duels, you know, and so you shall never scare me on this point'... in fact, I'm not one who challenges, but I'm challenged."

The duel fixed on the fifteenth of July, on a patch of ground picked out at the foot of Mount Mashuk (we cannot tell the exact place though). Lermontov rode thither with Mikhail Glebov, his second and bud serving in the same regiment. On the way the poet let his second into his creative plans, "I have conceived the plan of two novels, one dealing with the deadly battle of the two great nations [Napoleonic France and Russia], with the plot beginning in Petersburg, actions in the heart of Russia [Moscow] and at Paris, and the dénouement in Vienna; the other novel will be from Caucasian life, the scene laid in Tiflis under Yermolov... It will do with the Persian war and the catastrophe as Griboyedov* was killed in Teheran... Meanwhile I have to bide my time before getting down to the work of laying the foundation for these novels... In a fortnight or so I will have to join my detachment, by the autumn we shall sally forth, and who knows when we are back!" Lermontov had no thought of death. Yet on July 15, 1841, between 18 and 19 hours, a fatal short rang out, under a thunderstorm and torrential rain.

Lermontov had yet another second, Prince Alexander Vasilchikov; he said he wondered at the merry expression of the poet's face during the duel. And at the signal "You now meet!", Prince Vasilchikov recalled, Lermontov "stayed motionless and, raising the cock, held his pistol with the muzzle up shielding himself, like an experienced duelist, with his hand and elbow... Martynov stepped quickly to the barrier and fired. Lermontov fell as if mowed off... We rushed to him. A wound steamed in his right side, and his left side bled—the bullet pierced the heart and lungs..."

Late in the evening the poet's body was brought to his home, and his blood-soaked service coat was cut up and burned. Two days later, his fellow officers carried the coffin on their shoulders to the local graveyard at the foot of Mashuk. His kinsfolks and friends as well as local officials and many holiday-makers came to the grave to throw a pinch of soil on it. In eight months his grandmother Arsenieva obtained permission to bury the poet's ashes within the family vault at the hereditary estate Tarhany near Penza. And so on March 27, 1842, the

* Griboyedov, Alexander Sergeevich (1795-1829), an eminent Russian poet and playwright, author of the famous comedy *Wit Works Woe.—Tr.*

The Parterre Garden.

sealed coffin of lead set forth on its long journey, and on April 21 “the son of sufferings” found peace on his ancestral estate.

A memorial tombstone was put up in 1901 at the supposed place of the duel (the exact spot still unknown!). St. Petersburg sculptors lent a hand in setting up a Lermontov memorial—large enough, what with the expected influx of devotees. It included a stele of Kislovodsk sandstone (architect Boris Mikeshin, 1915); built around the complex was a decorative fence made of pillars imitating pistol cartridges linked by a chain (architects, Vassily Kozlov and Leopold Augustus Dietrich). Giant griffins were installed at the four corners of the obelisk, with their heads inclined and turned away—an ambivalent symbol like many other things related to Lermontov.

Meanwhile Pyatigorsk kept growing as a national spa resort. Semyon Smirnov, a local doctor and a man of many parts, talked other medics as well as druggists, chemists and geologists into joining a Russian Balneological Society (1863). It was the nation’s first body to study mineral waters, muds and adequate treatment procedures. It became the base for the Pyatigorsk Kurortology Institute established in 1920.

From among the many architectural objects added to Pyatigorsk in the latter half of the 19th century we should single out the elegant Elizabethan Drinking Gallery of white stone erected in 1850 in place of the old Elizabethan Springs famous in Lermontov’s lifetime and mentioned in *The Hero of Our Time*. Made of wood, that wellspring fell into decay. The new spa gallery was built by Samuel Upton, also the architect of the Michael Gallery (1848-1854) and Warm Sulphur Baths (1861).

Yet another attraction—the Yermolov baths built in 1880 by Vladimir Grozmani of Vladikavkaz in the Parterre garden. This is an imposing structure of local sandstone, one of Pyatigorsk’s best. It is composed of two crosses joined together, with a small cylindrical tower crowned by a dome in the center of each cross. The towers are furnished with window slits all around. The façade of the building is adorned with decorative masonry and iron-clad pieces. The main entrance is of two doors surmounted by a round rosette window.

Pyatigorsk, the last refuge of the great poet, was Russia’s first town to commemorate him. His bronze monument on a granite pedestal was dedicated in 1889. Alexander Opekushin of St. Petersburg depicted the singer of the Caucasus sitting on a cliff ledge, his glance traveling towards the snow-capped peaks; a bronze lyre cum wreath is at the foot of the memorial. A large square, named for Lermontov, surrounds it.

New spectacular monumental structures appeared in Pyatigorsk is the early 20th century as well. One of them was built in 1901 on Mount Goryachaya (“Hot Mountain”) next to Mashuk. This sculptural composition shows an eagle wrestling with a snake, an allegory of the potent strength of salubrious springs vanquishing disease. It has become an official symbol of the Caucasian spas. Ludwig Shodky, a local architect, had it built of cement, a short-lived material that had to be renovated time and again. So in 1973 it was replaced by bronze, and that’s

Lermontov monument.

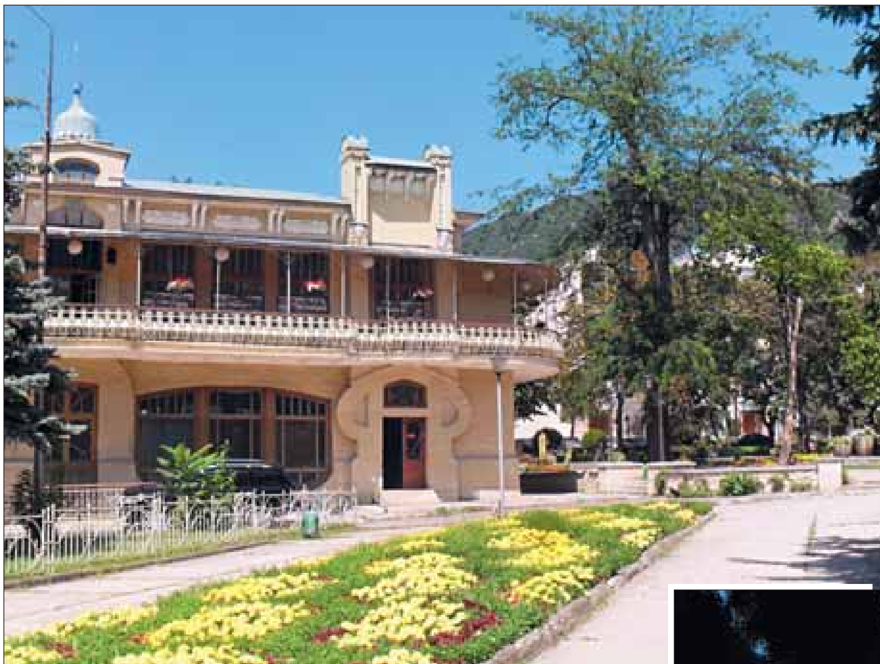
what we can see today. Shodky came up with his design of a large "Fairy-Tale" Fountain that displays a round water pool with a hill and grotto in the middle; the entries to the grotto are guarded by bearded gnomes.

Posh buildings in different architectural styles rose here and there. Here are just a few: the Lermontov Gallery; Town Hall (1902); the Classic School (Gymnasium) for boys (1903); architect Klepinin's house (1905); the Hermitage and Bristol hotels; the exchequer; the printing-house (1908); the mud baths... Some of the most imposing structures were built in the moderne style, such as Gukasov's coffee-house and his tenement house looking like a smallish castle and dubbed Elsa Cottage after his wife, Elsa; a community center (now the Small Opera House), a mansion built by Kuznetsov, an architect...

There were other welcome additions, in particular, the Lermontov Cabin, which opened its door to guests in 1912. This is one of the nation's oldest literary-memorial museums and the only one dedicated to the great poet to have survived whole as it was. In 1973 it expanded into a State Memorial Museum that took in the nearest historical town block.

The cabin, whose owner was a Chilyaev, comprised a passage, antechamber, pantry and four chambers; the poet roomed with his kinsman, Stolypin. It was there, in that cabin, that Lermontov penned his last lyrical masterpieces—*The Cliff, The Dream, Tamara, Lone's the Mist-cloaked Road Before Me Lying.., The Sea Princess, The Prophet*... Pechorin, the protagonist of *The Hero of Our Time*, lived in such lodgings. "Yesterday I... rented a flat on the edge of the town, at the foot of Mashuk: in a thunderstorm the clouds will get down right to my roof. Today at five o'clock in the morning I opened the window, and my room was filled with the scent of flowers growing in the modest front garden. The branches of blossoming cherry-trees are looking into my windows, and now and then the wind will blow in their white petals onto my desk. The view on three sides is just fantastic..."

The cabin is filled with so many memorabilia: pictures and lithographs of Caucasian scenes, furniture and items related to the camp life of army officers of the early eighteen-hundreds,—say, a full-dress coat of the Tenginsky Infantry Regiment. The drawing room of the Lermontov lodgings was a meeting-place of his friends. It has a card-table, and a sofa with a Caucasian gun, German pistol and Cossack dagger hung from a Turkoman carpet above. But the sleeping-room furniture is gone, unfortunately. It exhibits things brought in from the poet's Petersburg apartment, a gift from Eugenia Shan-Girei, Lermontov's second niece: an armchair of black leather and a desk with sheets of paper, a quill and books on top. Fixed on the wall is a nice Caucasian scene by Leo Lagorio, a master landscape-painter.



Pyatigorsk architecture of the Silver Age.

Lermontov cabin.

Peter Martynov, a journalist who stayed in Pyatigorsk in the 1870s, described Lermontov's mode of life there as told by Chilyaev, the owner of the cabin. "He kept open house.., and should anyone turn with a request for help or favor, he never said 'No!' and did his best. He got up now at an early hour, and now rather late, at nine o'clock or after... He would go out to drink waters or take baths, and then he had his cup of tea. Thereafter he would leave and come back around two o'clock for dinner, always in company of his buds... After dinner they would take coffee, smoke and chew the rag on the little balcony. Tea was brought in about six o'clock in the evening, and then everybody left. There were strolls in the evening, dances, flirting with ladies, and the cards... Lermontov did play occasionally, but within bounds, and did not stake high... Sometimes in the morning Lermontov mounted his fiery Circassian steed and rode out of town... He adored mad fancy riding—lost to everything, he raced like wind about the steppe..."

The literary section of the Lermontov museum is in the Verzilin house where young officers were socializing. Put on display are manuscripts, letters and Lermontov works published in this and other countries. There are numerous photographs, portraits and pictures—*A View of the Cross Mountain* painted by Lermontov and copies of his pictures made by other artists. The water colors of Grigori Gagarin, his buddy, depict Cossacks and highlanders, and views of Goryachevodsk and neighboring mountains.

Mihály Zichy, a Hungarian artist and a great admirer of Lermontov, contributed some drawings after his visit to Pyatigorsk in 1881, in particular, Pyatigorsk views, illustrations to *The Hero of Our Time* and *The Demon*. And we can also see the water color *A Clash in the Caucasian Mountains*, and *The Daryal*, a turbulent mountain river mentioned in Lermontov's works (landscape by Lagorio).

A fine arts section is housed in the building owned by collegiate assessor Umanov, where Alexander Arnoldi, a fellow who served in the same regiment as Lermontov, lived. It exhibits a gallery of Lermontov portraits, pictures and sculptures by Vassily Kozlov, Leopold Augustus Dietrich, Anna Golubkina... There are quite a few battle and genre scenes as well illustrations to Lermontov works by Valentin Serov, Mikhail Vrubel, Ilya Repin, Boris Kustodiev, Ivan Bilibin...

Vissarion Belinsky, a famous literary critic of that time, called the Caucasus a cradle of the Lermontov poetry. "After Pushkin no one was able to thank the Caucasus so poetically for its wondrous scenes, august and vestal in their beauty."

Lone's the mist-cloaked road before me lying;
On and on it winds and draws me far.
Night is still, all earthly sounds dying;
Nature lists to God, and star speaks to star*...
(Lermontov, Pyatigorsk, 1841).

* Translated by Irina Zheleznova, Raduga Publishers, Moscow, 1983.

Illustrations supplied by the author

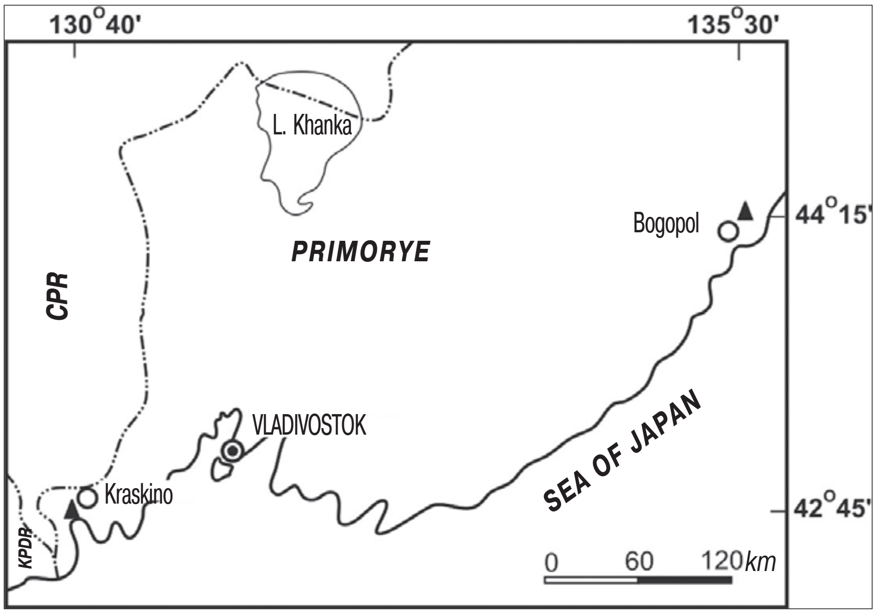
OLIGOCENE FLORAS OF PRIMORSKI KRAI—UNIQUE ASSOCIATIONS OF ANCIENT PLANTS

by Boris PAVLYUTKIN, Dr. Sc. (Geol. & Miner.), leading research assistant of the Laboratory of Regional Geology and Tectonics,
Igor CHEKRYZHOV, research assistant of the Laboratory of Geochemistry, Far-Eastern Geological Institute, RAS Far-Eastern Branch (Vladivostok)

The Earth's sedimentary crust keeps not only the chronicle of the works of our distant forbears—the object of interest of historians and archeologists—but also no less interesting testimonies of evolution of different components of the environment. Moreover, the latter had been registered in the natural "memory book" long before the appearance of man himself. Undoubtedly the plant cover also belongs there.

Non-specialists are usually greatly impressed by fossilized residues of the plants, growing for the last 65 mln years. This is natural as it was just in that interval called the Cainozoic that a majority of them acquired an appearance close to the contemporary. In the geochronological interval of 33-35 mln years, the plant world of the early Cainophyte, which had formed in the late Cretaceous, when dinosaurs were still alive, changed into the plant cover of the late Cainophyte. So, we will talk here about two representatives of the late Cainozoic geoflora, the location of which coincides with the southern sector of Primorski Krai.

Paleobotany as a scientific trend in paleontology is based on studies of fossilized vegetative (leaves, leafy and leafless shoots, wood) and generative residues (fruits, seeds, spores, pollen). If the abovementioned objects get



Location of Voznovo and Kraskino floras (poured triangles).

into a water body, they have a chance to pass to a fossilized state under a layer of mineral ooze or volcanic ash. In the conditions of oxygen deficit there take place complex processes of mummification, then fossilization (petrification) or coalification in them—depending on physico-chemical specifics of the medium.

After such changes the plant residues often preserve fine details of anatomy, due to which paleobotanists determine their belonging to concrete taxonomic groups and reveal conformity to families and species of contemporary flora. This can be achieved, first of all, in regard of plants existing in the Cainozoic, the youngest era in geological history of the Earth. The residues of leaves, which are called leaf imprints not too accurately, are a predominant macroobject specialists have to deal with. In fact, they are pseudomorphoses of the mineral substance according to plant residues, well known in geology, and often preserving fine peculiarities of the leaf tissue structure. Their abundance in burials is conditioned mainly by mass leaf shedding in unfavorable climatic circumstances—adaptation to progressing cooling and clearly marked seasonal character of the climate during the Cainozoic. Sometimes such burials are formed during explosive volcanic eruptions, but leaf residues in such layers are usually preserved too badly due to mechanical and thermal action of ash particles on them.

The so-called evergreen plants predominating in the regions of subtropical and tropical climates change leaves not seasonally but through their gradual rotation. Therefore, the possibility of their transfer to the fossilized state is essentially lower than in deciduous plants. Associations of buried plant residues—taphocenoses give us information on the composition of wood cover (trees, shrubs, ligneous lianas) in the setting of sedimentary basins and allow to restore in general terms the forest nature of past years. As for the grass component, it is studied mainly by remains of fruits, seeds, spores and pollen.

Small lakes in the alleys of rivers, estuaries, lagoons and big lake reservoirs play a role of water basins accumulating products of fallen leaves. The lake reservoirs, as a rule, are thin layered, therefore plant residues get into them and then swelled and heavy smoothly go down to the bottom and cover the surface of the silt layer. This conditions their safe keeping while turning into a fossilized state.

Traces of some ancient lakes with accumulated thickets of thin-fragmented, clayey silts of tung-oil trees were discovered in the territory of Primorski Krai. They had passed different stages of diagenesis (lithification) and turned into hard rocks of rocky and half-rocky type. Their thin-plated separateness in combination with solidity allows to take the rocky massif to pieces and get leaf imprints in perfect state.

For the last 10 years we have been studying complexes of plant residues, collected in the rocks formed in 2 lake paleobasins, located in the environs of Bogopol (Kavalerovsky district) and Kraskovo (Khasansky district). The sedimentary thickets containing them are known in geology as Voznovo and Fatashinskaya suites (complexes of mountain rocks) respectively. Our collections count around 2,000 leaf imprints, leafy shoots of the Coniferales, fruits and seeds, forming 2 plant

Female tsuga cone (Tsuga sp.*); x2.

* Names, marked by the asterisk, refer to the plants of the Voznovo flora.—*Ed.*

Carpellate cone (Pinus sp.*).

Leaf of Ginkgo ox. gr.adiantoides (Ung.) Heer*.

Shoot with female cones of Glyptostrobus europaeus (Brongn.) Heer; x2.

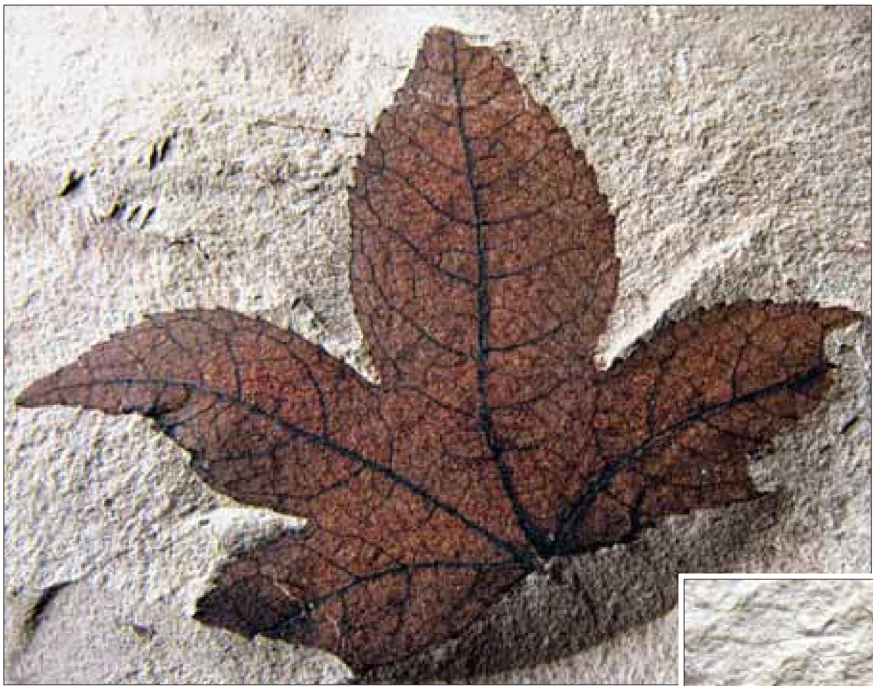
complexes—Voznovo and Kraskino ones. Corresponding floras are distinguished by their exclusive taxonomic wealth, including representatives of more than 100 species of each.

The geological age of the abovementioned suites, starting from the early stage of their studies by the outstanding Russian paleobotanist, Corresponding Member of the USSR Academy of Sciences, Afrikan Krishtofovich (1885-1953), was dated by the Oligocene (23-34 mln years). The successive link between the early Kraskino and following Voznovo floras was emphasized as well. Later on Russian specialists reconsidered this conclusion (mainly under influence of the results of studies of floras analogous in composition) and began to refer the complexes in Primorski Krai to the younger Miocene (5.3-23 mln years), connecting their formation with its warmest stage—the so-called climatic optimum.

Our long studies based on a rather more representative paleobotanical material confirm the correctness of Krishtofovich's conclusion on the belonging of the aforesaid floras to the Oligocene. Moreover, the obtained data show the conformity of the Kraskino complex to the basal one, i.e. to the earliest Oligocene. This conclusion was made due to the findings of the plants in its composition unknown before, which are typical of the Eocene preceding the Oligocene. The presence of such plants (first of all, representatives of archaic genera of trochodendroides and archeampelos), geohistorically nowhere going over the limits of the early-late Oligocene (~28.5 mln years), undoubtedly proves the pre-Miocene age of the plant complexes consisting of them. However, these plants are represented in them by a single specimen, while the base of the given floras is formed by the beech, Ulmaceae, birch and Juglandaceae families—common flora components of the turgai (the term first introduced into paleobotany by Krishtofovich) ecological type. This makes it impossible to consider Kraskino and Voznovo floras together with the preceding Eocene floristic complexes.

The composition of both burials demonstrates predominance of mountain slope plants, while the typical representatives of river valleys (poplar, willow, elm, Judas-tree, liquidambar) are represented by single specimens. Among the Coniferales here predominate the Pinaceae, Taxodiaceae and Cupressaceae families, but groups of flowering plants in them are compositionally (structurally) essentially different. While the Kraskino flora shows absolute predominance of almost all known genera of the beech family (beech, chestnut, oak, castanopsis, lithocarpus, cyclobalanopsis and even notophagus, widely spread today only in the Southern Hemisphere), the Voznovo flora abounds in the Ericales order and Betulaceae. In our opinion, this is explained by the fact that they are of different age (Voznovo is younger) and also by coincidence of their locations with different gypsometric levels. The Kraskino flora reflects the plant cover of the lower-middle belt of the mountains, while the Voznovo flora corresponds to the higher gypsometric level—formation of an oak-birch forest with a rich undergrowth mainly of the Ericaceae family. The latter include representatives of 7 genera: *Rhododendron, Menziesia, Gaultheria, Enkianthus, Arbutus, Vaccinium, Lyonia*. Prior to our studies this information was not available.

The Kraskino flora is characterized by unique generic and specific diversity of the beech family, noted neither in the previous Eocene floristic complexes not in the



Leaf of Liquidambar europaea A. Br.*.

Leaf of Trochodendroides arctica (Heer) Berry.

following, younger, ones. Oak (*Quercus*) is presented in it at least by 12 species, beech (*Fagus*)—by 7, chestnut (*Castanea*)—2; rather diverse are also evergreen representatives of the beech family from the *Cyclobalanopsis* genus. Not a single of the known fossilized floras can boast of such a rich composition. And this gives an undoubted vividly marked originality to the object. The second peculiarity of the Kraskino flora is connected with its transitional type, it reflects an intermediate, rather short according to geological standards, stage of change of 2 geofloras in the Northern Hemisphere: early Cainophyte (late Cretaceous—Eocene) and late Cainophyte (Oligocene—Pleiocene). The later is connected with a well-known combination of words "relicts of Turgai flora".

Now let's turn to the most significant plants from both phytohorizons—Voznovo and Kraskino ones. In the environs of the village of Bogopol in the layers of the Voznovo suite were found remains of Ginkgo leaves (*Ginkgo* ex gr. *adiantoides* (Ung.) Heer), resembling segments of fern *Adiantum*. The Ginkgo genus belongs to the Ginkgoaceae family, characteristic of the plant world of the Mesozoic—dinosaurs' contemporary. The only still existing species *G.biloba L.* was found in China—a natural reserve of many plants extinct in other regions. Today it is spread in the culture in the regions with a moderate heat climate.

Pseudolarix japonica Tanai et Onoe abundantly represented in the Voznovo collection belongs to the Pinaceae family. Today only one of its species, represented in the mountain forests of the eastern part of Central China, is widely known. It belongs to the Coniferales shedding leaves in autumn, like larch, but unlike the latter, its cones decompose during maturation. So, only a needle is usually found in fossilized state (it has a widened upper part, often with a rounded apical point, while larch has acuminate one), and also glumes, slightly covering alate seeds in the cone before its maturation. *Preudolarix* is a tall tree, beautiful in autumn attire (that's why it is called golden larch), very popular in regions with appropriate climatic conditions.

Leaf of Platanus aculeata Klimova.

The Voznovo flora abounds also in pine species (*Pinus* spp.*) The observant readers must have noticed that pine leaves (needles) are grouped differently. For example, in Far-Eastern Korean pine, even in scientific editions mentioned as Korean cedar, and in Japanese stone pine they are grouped in fives, while in widespread Scots pine (*Pinus sylvestris* L.) and *Pinus Funebris* Kom., usually found in western regions of Primorye—in twos. In the North-Eastern China and Japan predominates Japanese black pine (*Pinus thunbergii* Parl.). The Voznovo collection presents remains of pine leaves in the form of bundles consisting of 2, 3, 4 and 5 needles. In addition to needles and seeds, here was found an original fusiform cone, resembling a weight in ancient clocks. Such cones are typical of *Pinus monticola* Dougl from the group of five-needled, its seeds are small with a long wing (such seeds are also represented in the Voznovo collection).

An impressive element of the phytocomplex under consideration is *Tsuga* sp.—a typical representative of the Pinaceae family, well-known perhaps for everyone from the novels of Fennimore Cooper as hamlock. The species is widespread in Japan, South-Western China and in the American continent mainly in mountain coniferous forests, though certain species, for example, *T.canadensis* (L.) Carr., belong to valley associations. In addition to solitary needles and fragments of leafy shoots, the Voznovo collection contains well-preserved female cone.

Metasequoia occidentalis (Newb.) Chaney, dominant in the Voznovo burial, belongs to coniferous plants of the *Taxodiaceae* family. Its representatives had a wide area of distribution in relatively recent geological past. In the fossilized state we usually find falling leafy shoots, sometimes small elegant female cones. Some genera of this family belong to the group of the plants shedding twigs (in autumn such plants shed not leaves, but terminal shoots). Falling shoots of *Metasequoia* for a long time were referred to the extinct species of another representative of the family-taxodium, three species of which dwell at present in marshy localities of the south-eastern states of the USA and mountain forests of Mexico. But in 1940 the plant was discovered alive in the Chinese province of Hupei. At present this species known as *M.glyptostroboides* Hu et Cheng is cultivated in all continents in regions with a moderate heat climate. It is very popular in China with people growing trees and gardens.

Glyptostrobus europaeus (Brongn.) Heer, belonging to the Taxodiaceae family, found in the Voznovo collection, is also referred to the group of coniferous plants shedding twigs. The only contemporary species of the genus—*G.pensilis* Koch.—is spread in the limited territory. This small tree grows, like willow, along channels in the Northern Vietnam and Southern Chine, i.e. in tropical zones. In geological past the genus dwelt in an enormous territory of the Old and New World, including more moderate climatic conditions, and in the opinion of many paleobotanists was represented by several species. In the Voznovo flora one can find terminal shoots, fragments of twigs, sometimes with small cones.

Present in this collection is also *Thuja iwasae* Huz. belonging to the *Cupressaceae* family. The latter is presented by 2 genera in the contemporary dendroflora of Primorye: *Janiperus* and *Microbiota*—endemic, widespread in Sikhote-Alin, a zone located above the border of forest vegetation. In the past geological epochs, according to findings, the set of genera of the Cupressaceae family in the territory of Primorye was richer, in particular, for its plant cover rather common were thuya, cedar, Thujopsis and libocedrus.

In the Voznovo suite rather common are also leaf remains of *Tetracentron piperoides* (Lesq.) Wolfe—a species, very rare in the fossilized state. Finding of its residues is probably the first trustworthy one in tertiary (Paleogene-Neogene) sediments in the territory of Pri-

* sp.—abbreviation of Latin *species*, meaning an absence of any link with a concrete species, spp.—a group of such species.—*Ed.*

Leaf of oak (Quercus ussuriensis Krysht.).

Leaf of oak (Quercus kodairae Huz.).

morye. The contemporary dendrioflora knows only one of its species—*T.sinense* Oliv, widespread in mountain forests of Central and South-Western China. The species converges (by leaves) with rather well-known *Cercidiphyllum japonicum* Siebold et Zucc., differing by detail of nervation and the form of glands at the tips of denticles.

Of great interest is a finding in the Voznovo complex (the first in the Far East, including fossilized floras in Japan, Korea and China) residues of the leaves of *Arbutus primorica* Pavlyutkin)—a representative of the *Ericaceae* family, which includes the well-known *Ledum* and *Rhododendron*, and also cowberry and bog whortleberry. The *Arbutus* genus, whose edible fruits resemble strawberry, has at present a disjunctive area of distribution. Its contemporary species grow in two geographically remote regions. The Mediterranean in *A.andrachne* L., US Western territories are known for 3 species: *A.texana* Buckl. The fossilized Voznovo *Arbutus* is more like *A.menziesii*, the area of distribution of which cover coastal regions of the State of Washington and an adjacent territory of Canadian south-west.

The Voznovo suite also includes leaf residues of *Rhododendron* belonging to several species, including *Rhododendron voznovicum* Pavlyutkin. The area of distribution of a majority of representatives of this genus at present is mainly connected with mountain slopes. In areas with moderate heat and colder climatic types *Rhododendrons* look like shrubs, but in mountain subtropics, for example, in moss-grown forests of the Chinese province of Yunnan they acquire habitus of rather big trees. A great number of species due to their high ornamental appearance have become an object of selection, especially in Japan.

The leaf of liquidambar (*Liquidambar europaea* A.Br.) from the Voznovo collection belongs to the *Hamamelidaceae* family, a generic majority of which at present is


Leaf of oak (Quercus sp. nov.).

Leaf of arbutus (Arbutus primorica Pavlyutkin*).

found in subtropical and tropical climatic zones. The *Liquidambar* genus counting 3 (according to other estimates 4) species has a disjunctive area of distribution: the south of Asia Minor, central and southern provinces of China, including Taiwan, and south-eastern states of the USA. According to the established views, this is an evidence of antiquity of the genus and of its dominant character at one time. The latter is fully confirmed by paleobotanical data. The leaf from the Voznovo collection is five-lobed, which is characteristic of *L.europaea* and *L.styraciflua* L., well known under the name of redgum.

The Voznovo fossilized horse chestnut—*Aesculus* sp. is a representative of the *Hippocastanaceae* family. It is well known that horst chestnut has nothing to do with a real chestnut, which belongs to the *Fagaceae* family, and is not even its distant relative. This is one of the misunderstandings established in plant toponimics. One of the contemporary species of horse chestnut (*A.hippocastanum* L.), widespread in culture in western and south-western regions of the former USSR, is mentioned in once very popular songs and is an object of pride for citizens of Kiev and Odessa. The Voznovo horse chestnut leaf differs from the contemporary European species (*A.hippocastanum*) and its close relative *A.twibinaa* Blume, and is to greater extent like *A.sylvatica* Bart.

The Kraskino plant complex contains leaves of *Trochodendroides arctica* (Heer) Berry—a plant, rather polymorphous, abundantly represented in Late Cretaceous-Eocene floras by several morphotypes. The latter are regarded as independent species by some paleobotanists, while others think that they are forms within one common species. The specimens found by as belong to the *cocculifolia* form due to the similarity with the *Cocculus* genus leaves. The *Trochodendroides* genus is related to the so-called formal taxons, i.e. to such taxons whose systematic state remains a mystery for scientists.

The layers of plant residues in the Kraskino complex often contain big leaves of *Platanus aculeate* Klimova). The *Platanus* genus, represented in geological past by a great number of species, was widespread in Northern Hemisphere. At present the plane in the natural state

Part of a compound leaf of horse chestnut (Aesculus sp.*).

grows in Caucasia, where it is known under a local name chinara, and in the North American continent (local name—sikimora). It has big-lobed dentate leaves. By the Oligocene the genus had mainly disappeared in Asia, except for one species *Platanus kerrii*, growing in the limited territory in Northern Vietnam. The fossilized *Platanus aculeate* is obviously one of the last species, which had finally disappeared by the mid-Oligocene.

In the Kraskino burial was found a great number of oak (*Quercus*) leaf residues, represented by more than 10 species, among them *Quercus ussuriensis* Krysht.) big petiolate leaves of which are notable for sharp teeth with concave sides and rounded hollows between them. This species was first discovered and described by Krishtofovich in the Kraskino flora composition back in the 1930s. Its close analogs has not been found in the contemporary flora. *Quercus kodairae* Huz., represented here, is also related to the extinct group of the *Quercus* genus of obscure kinship.

For the first time in this complex we have established a new oak species—*Quercus* sp.nov., related to a typical genus section. Its leaves represent papilliform processes on the apical points of spherical teeth and a relatively long leaf-stalk. It differs by these characters from outwardly similar contemporary species—Mongolian oak, dentate oak and Vutaishansky. The first two are common for the territory of Primorye, the third grows at the north-east of China and in Korea.

Oak in the Voznovo flora is presented by one species, in the Kraskino complex by several ones. A part of them does not have close analogs in the contemporary dendroflora and is related, probably, to different extinct morphological groups, including *Fagus uotanii* Auz., for the first time described together with tertiary floras of Korea. Its leaves have big teeth with thin acuminate tips, absent with contemporary species; moreover, this character is well preserved in all numerous specimens.

Several maple species (*Acer* spp.) have been found in the floras under consideration. In the fossilized state are often observed not only leaves, but also fragments of collective fruits in the form of the so-called double-winged seed. The later disintegrates during maturation into two winged seeds (samaras), shifting due to rotation in air flow (like helicopter fans) to a rather significant distance. This is the so-called anemochorous type of seed separation. In conclusion we must emphasize that uniqueness of the considered Oligocene floras of Primorye is not limited by their taxonomic richness and perfect state of plant residues. Their significance, as of appropriate geological objects Voznovo and Fatashinskaya suites—is determined by coincidence with a boundary interval between the Eocene and Oligocene—time of change of two geofloras: early and late Cainophyte.

Illustrations supplied by the authors

PERSISTENT POLLUTANTS IN THE RUSSIAN ARCTIC

by Alexei KONOPLYOV, Dr.Sc. (Biol.),
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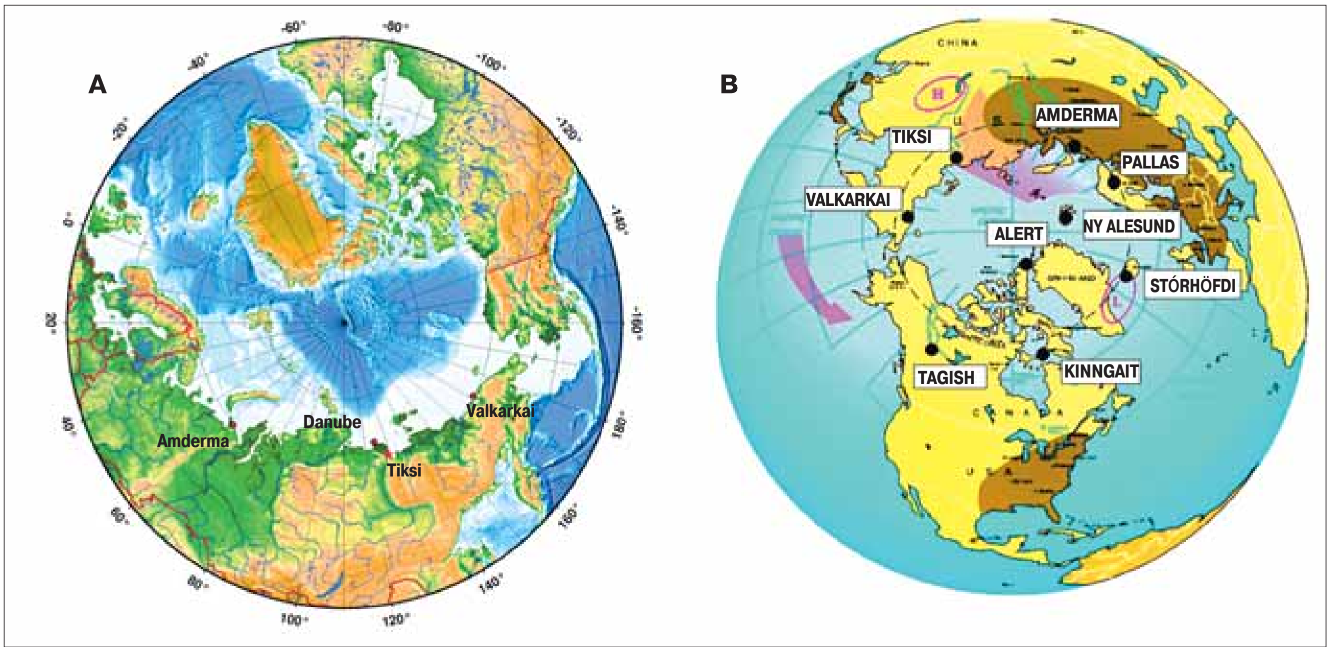
Yuri TSATUROV, Assistant Director of *Rosgidromet*

After scientists detected increased concentrations of persistent pollutants in the organisms of the indigenous population of the North, the problem of existence of such compounds in the Arctic Regions has become especially acute. Such substances do not decompose for a long time, accumulate in living bodies, are easily transported to large distances and are abundant in the environment. They include first of all persistent organic pollutants and some heavy metals, for example, mercury. People living in the North are often exposed to the negative effects of these substances originating from industrially developed regions (North America, Western Europe, and South-Eastern Asia).

The Arctic Monitoring and Assessment Program (AMAP) was launched in 1991, in 1997 the first assessment report was published stating that this region is an integral part of the rest of the world, and pollutants get to this territory from sources located far away from its borders.

The second and third AMAP reports were issued in 2002 and 2009 respectively. The obtained data were helpful for preparation of protocols on the persistent organic pollutants and heavy metals for the Convention on Long-Range Transboundary Air Pollution of the UN Economic Commission for Europe, Stock-



Russian (A) and global (B) monitoring stations of POP in the atmosphere of Arctic Regions.

holm Convention on Persistent Organic Pollutants, and getting ready for negotiations intended to develop a global legally binding agreement on mercury. The pollutant monitoring in the Arctic Regions makes it possible both to detect sources, critical channels of dissemination and assess efficiency of implementation of international treaties.

In 2001, Russia signed and in 2011 ratified the Stockholm Convention on Persistent Pollutants aimed to protect man's health and environment from negative effects of pollutants by way of their decreasing or eliminating in full.

Recently the international community has been concerned about wide dissemination and constantly growing concentrations of polybrominated diphenyl ethers (PBDE) in the environment. They are industrial chemicals used to produce plastics, textiles, electronic circuit boards (to prevent their inflammation); they are also used as additives to produce chemical polymers. Like POP, they can be carried to long distances and accumulate in living bodies.

Within the framework of the 3rd Conference of the parties to the Stockholm Convention, the Global Monitoring Plan for Persistent Organic Pollutants was approved. It is to create a harmonized organizational infrastructure to collect comparable monitoring data to identify temporary trends associated with persistent organic pollutants and concentrations in the environment, as well as to get information relating to the regional and global transport of such substances. The main research efforts should be focused on the background regions not affected by local sources of pollutants.

Traditionally, the environmental monitoring in Russia is implemented by *Rosgidromet* bodies. The data are presented in the form of Annual Reviews of environmental pollution (air, land and ocean waters, soils) in Russia. Since persistent organic pollutants are semivolatile, resistant to decomposition, and have bioaccumulation properties, they are able to migrate by air and water basins at a distance of thousands of kilometers from the places where they are used and accumulate in soils and water ecosystems. That is why atmospheric air, surface waters (benthic sediments) and biological objects are indicative in the context of influence on man's health. Besides, initially, experts of the UN Environment Program proposed to use air, bivalved mollusks, bird eggs, fish and/or sea mammals (depending on regional and national peculiarities), breast milk and human blood as matrices of the global POP monitoring.

Persistent pollutants are transported globally mostly by air. That's why studies of atmospheric air—assessment of pollutant concentrations and precipitation on the underlying surface—are of a top priority. Therefore, *Rosgidromet* is first of all striving to organize a network of air monitoring stations. The main effort is focused on Russian Arctic Regions, as a region at a high pollution risk. Scientists compare national data with the results obtained by foreign global monitoring stations.

In Russia, such monitoring was carried out at the polar Dunai station in Yakutia, in the estuary of the

Permanent air sampling station on the POP content in the settlement of Amderma.

Atmospheric air sampling on the POP content at the Tiksi hydrometeoobservatory in 2010-2011.

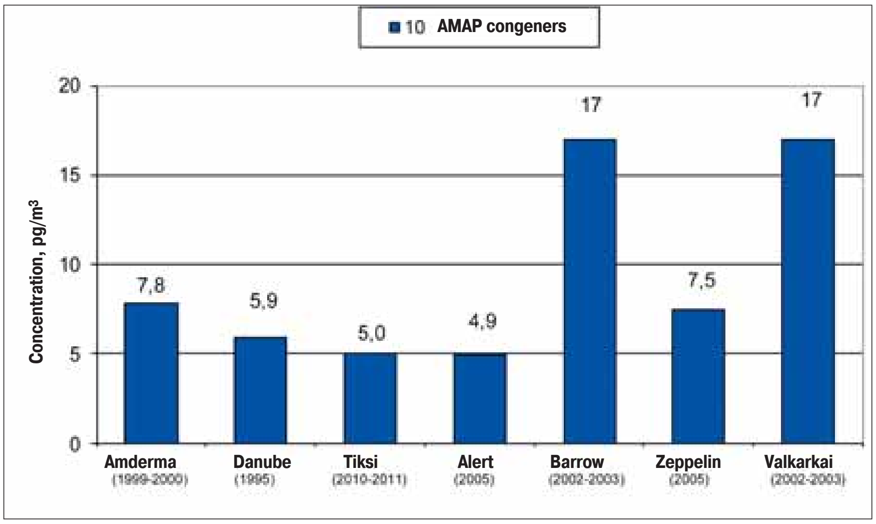
Lena River (1993-1994), at Amderma station in the Nenets Autonomous Area (1999-2001), on the coastline of the Kara Sea, on the arctic border between Europe and Asia, at the polar Valkarkai station (2002-2003 and 2008-2010), 50 km away from the town of Pevek along the coastline of the East-Siberian Sea, on the Chukotka Peninsula, and at the Tiksi hydrometeoobservatory in Yakutia (2010-2011).

As a result it became obvious that in the northern part of Chukotka concentrations of a number of substances from the list of the Stockholm Convention increased (Valkarkai settlement) as compared with the results obtained at other national (Amderma and Dunai settlements) and foreign stations. It might be explained by ingress of pollutants from more southern Asian territories of Russia and neighboring countries.

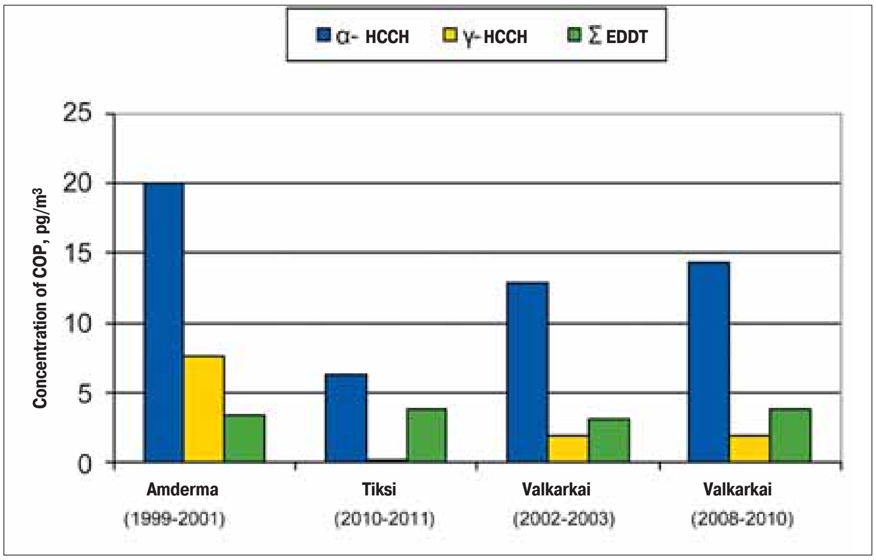
Tiksi is one of the arctic stations where minimal concentrations of the PCBs (organic substances consisting of all chlorinated derivatives of diphenyl) are registered. The maximal concentrations of tetrachlorinated PCBs were registered there in summer, in autumn they decreased, reached minimal values in winter and increased again in spring. The dominating organochlorine pesticide registered at Tiksi and other Russian monitoring stations is α-hexachlorocyclohexane. In the Russian Arctic Regions, scientists registered increased concentrations of pesticides never used in our country, such as mirex, heptachlor, chlordans, etc.

It was established that polybrominated diphenyl ethers are widely spread and are detected (in high concentrations) in the samples of air taken both in the central cities (Moscow, Obninsk) and in the settlements of the Russian North (Arkhangelsk, Amderma, Valkarkai).

In the light of ratification of the Stockholm Convention on Persistent Organic Pollutants, the priority tasks in the field of development of the national monitoring system can be formulated as follows: creation of a system of specialized scientific-methodological and regional centers in charge of POP analysis in the environment at a level compatible with the present-day global requirements; creation of a coordination training center for monitoring and analysis; centralized provision of equipment for specialized scientific-methodological and regional centers with modern analytical equipment of the same type; development or adaptation of existing methods of analysis using state-of-the-art devices; structuring of sampling process and delivery of samples to the Regional Analytical Centers with the use of *Rosgidromet* stations and other institu-



Comparison of concentrations of the sum of 10 basic polychlorinated biphenyl congeners in the ground air at the monitoring stations in the Russian and global Arctic Regions.



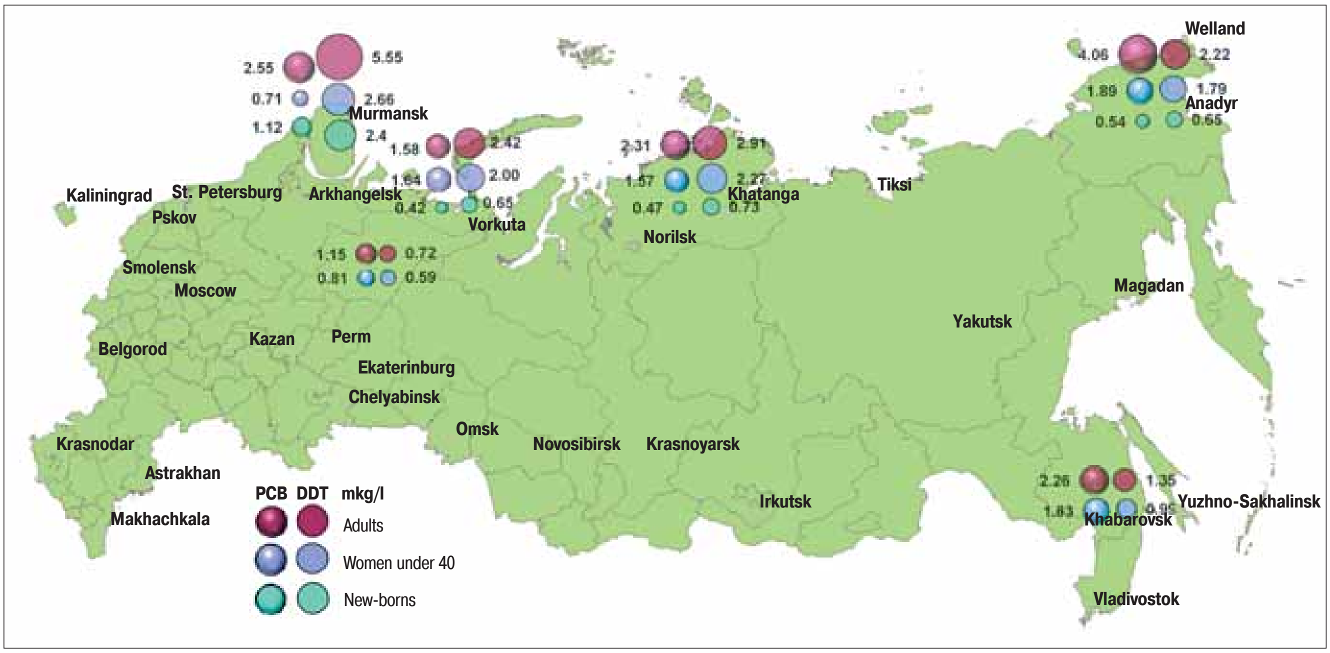
Comparison of concentrations of some organochlorine pesticides in the ground air of the Russian Arctic.

tions; provision of modern sampling equipment to net subdivisions; assessment monitoring of POP emissions by metallurgical, chemical, pulp-and-paper plants and waste disposal units (including polychlorinated dioxins and dibenzofurans, polychlorinated biphenyls); development and conducting of national data-bases on POP concentrations in the environment of our country compatible with global analogues.

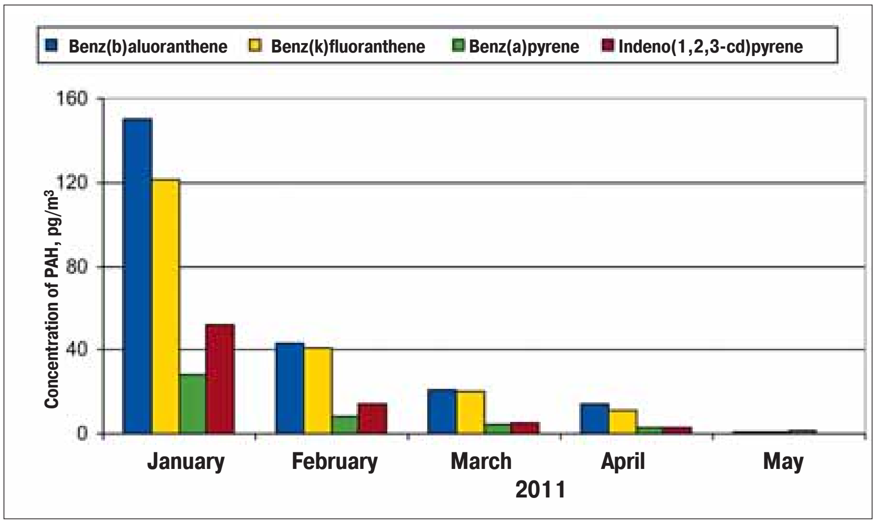
The last assessment of the Arctic environment within the AMAP Program dedicated to mercury pollution was carried out in 2011 according to the results of scientific studies in 2008-2011. Mercury belongs to the top priority pollutants strongly affecting Arctic ecosystems. Air transport is the primary channel of ingress of this substance to this region. Besides, the continuous removal of mercury from the atmosphere results in its global dissemination throughout the world.

In the Russian Arctic Regions , continuous monitoring of mercury concentrations in the air has been carried out since 2001 at the Amderma polar station, located near the geographical border between Europe and Asia. According to the results of studies it was established that in spring concentrations of mercury fall down, like in other Arctic regions of Canada, USA, Norway, and Denmark. In spring, from the late March to mid-June, variability of its concentrations essentially increases, while minimal variability was registered annually in the period from September to December. In the course of monitoring, the average annual concentrations of elementary mercury vapors in the air samples taken in the settlement of Amderma used to fall down. Apparently, this can be explained by lower emissions of mercury by European anthropogenic sources due to the approved restrictions and bans.

According to the results of monitoring in Amderma, the eruption of the Icelandic volcanoes Eyjafjallajökull in April 2010 and Grimsvotn in May 2011 led to a certain increase in the concentrations of gaseous mercury



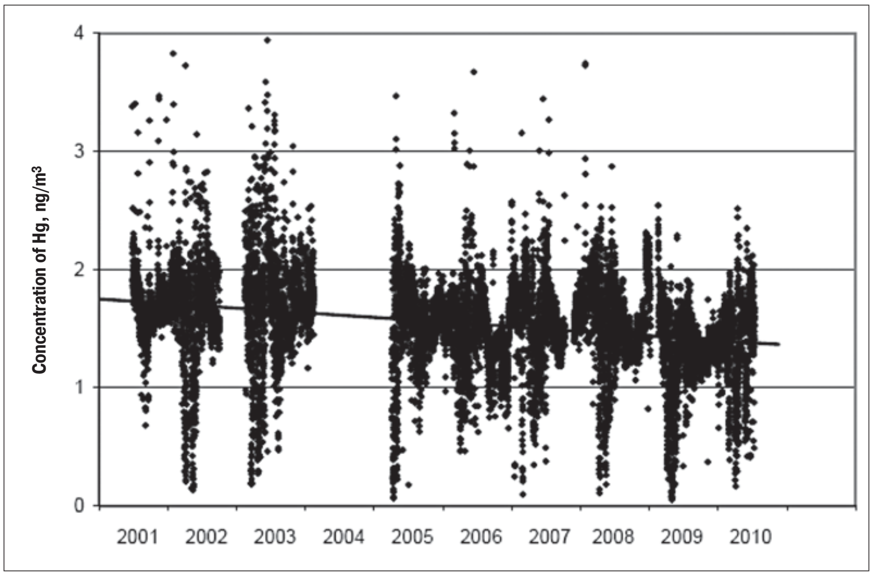
Concentrations of main POP—polychlorinated biphenyls and DDT—in the blood of the indigenous peoples of the Russian Arctic as compared with the data for the Moscow Region and southern part of the Far East (Khabarovsk Territory).



Seasonal dynamics of concentrations of polycyclic aromatic hydrocarbons in the ground air in the area of Tiksi hydrometeoobservatory.

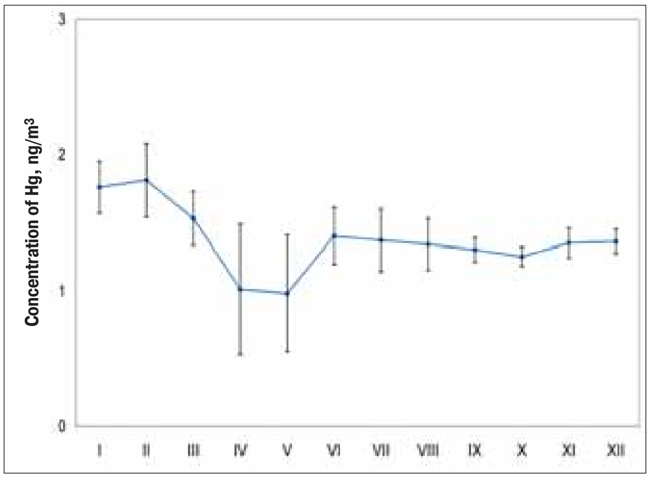
in the air samples taken at Amderma station located 2,500 km away from the eruption area. The increased concentrations of this substance in the air samples of Amderma coincided in time with annually registered events of “depletion” of mercury in the period of polar sunrise—from March to May. The data of modelling of air mass transport following the eruption of the volcanoes and calculations effected by a reverse trajectory method confirm carry-over of these masses to the area of Amderma in the period of increased mercury concentrations. Thus, the long-term monitoring of this substance in the air near Amderma made it possible to reveal the impact of eruptions of these volcanoes on mercury pollution levels globally and first of all in the Arctic Regions.

The Arctic Monitoring and Assessment Program revealed: most mercury comes to the Arctic Regions as a result of a distant transfer from anthropogenic sources located in the moderate latitudes; taking into account peculiarities of the traditional diet, peoples of the North are strongly exposed to the negative effects of the latter. Such situation made the Arctic Council initiate global international actions aimed to reduce mercury emissions. These efforts were not in vain. At present, a legally binding document—an agreement on mercury—is being developed under the auspices of the UN Environment Program. At the sessions of the Intergovernmental Negotiations Committee for preparation of a required agreement, the Arctic Council presented the main conclusions and recommendations



Time dynamics of mercury concentrations in the ground air in the settlement of Amderma (average for 4 h of monitoring).

Seasonal dynamics of mercury concentrations in the air in the settlement of Amderma in 2009. In the period from March to May "depletion" of mercury associated with the polar sunrise is registered.



of the AMAP Assessment for Mercury 2011 (hereinafter—*Assessment 2011*). In particular, the Intergovernmental Negotiations Committee made a decision that after approval and enactment of the agreement on mercury its efficiency will be assessed on the basis of data of the global mercury monitoring. In this respect, it is expedient to focus on the development of mercury monitoring stations taking samples of air, water, soil and biological objects, including within the framework of the State Ecological Program. A key role will play a network of stations of mercury monitoring in the atmospheric air of the Russian Arctic Regions.

The main task of *Assessment 2011* was to obtain updated data and find an answer to the following question: "What does the mercury pollution level depend on in the Arctic Regions and how does it affect the arctic biota?" According to the obtained data, the level of pollution is constantly increasing irrespective of reducing anthropogenic emissions of mercury in the North America, Europe and Russia. At present, annual emissions make up 2,000 tons of mercury from anthropogenic sources and 3,000-4,000 tons of mercury from natural sources (volcanoes, geothermal springs). The mercury concentration may also increase due to registered and expected climate warming as a result of mercury reemission from the underlying surface. According to *Assessment 2011*, about 100 tons of mercury gets into the Arctic Ocean from air and the same quantity from the Pacific and Atlantic Oceans together with rivers flowing into them.

The *Assessment 2011* contains also Russian data, in particular, the results of mercury monitoring in the air of Amderma settlement (Research and Production Association "Taifun", *Rosgidromet*), concentration values of mercury in biota and blood of the indigenous population of the Arctic zone of Russia, received within the framework of the project of the Global Ecological Fund "Persistent Toxic Substances, Safe Nutrition and Indigenous Peoples of the Russian North", and the results of modeling of the atmospheric mercury transfer globally, effected by the Meteorological Synthesizing Center *Vostok*. According to *Assessment 2011*, it is recommended to continue arctic monitoring of this substance in the air, biota and human organisms, in particular, to expand the geographical coverage of mercury monitoring in the objects of the environment in the Russian and global Arctic.

Illustrations supplied by the authors

THE UNEXPLORED WORLD OF MINERALS

by Maria SAPRYKINA,
Science in Russia observer

This article acquaints our readers with a remarkable scientist Tatyana Zdorik, Cand. Sc. (Geol. & Mineral.), who has been actively popularizing mineralogical science. In addition, she is a translator and author of numerous scientific textbooks and a series of articles on mineralogy. She told our correspondent Maria Saprykina about her scientific studies, creative activities and main achievement— description of a new mineral—calcircite.

— *Tatyana Borisovna, please, tell us what was the reason to focus your research efforts on minerals?*

— In some way, I was closely connected with mineralogy and geology practically right from my birth. My parents were geologists. So, I chose a profession and took a decision to enter the MSU Department of Geology under the influence of my relatives and the atmosphere of love and interest in science reigning in my family. In 1955, I finished my studies at the chair of petrography and soon after that was employed at the Department of Rare Metals of the All-Union Institute of Mineral Resources in Moscow, at that time the first national institute specializing in ores and raw materials. This research institution was established in 1923 by the USSR Ministry of Geology as the Institute of Applied Mineralogy on the basis of the Institute of Petrography "Litogea". It got its contemporary name in 1935. From that time and till our days, main efforts of the institute have been concentrated on research, expansion, and improvement of ore and raw material

Turquoise (in the hands of Tatyana Zdorik). Erdenet (Cu-Mo) Deposit, Mongolia. Museum of Geology named after V. Yershov, Moscow State Mining University.

base of ferrous and a number of branches of non-ferrous metallurgy. Today, the institute keeps developing scientific fundamentals of geological forecasting, exploration, and integrated valuation of ore fields, problems of genetic and applied mineralogy, analysis and technology of minerals.

— *What were your specific tasks as a research assistant of the Department of Rare Metals?*

— That time (I mean early 1960s) I was entrusted to explore a new type of deposits—carbonatites (in particular, tantalum and niobium deposits). Tantalum (in pure form) is a bright silver-white metal with a high melting temperature. It is a hard metal characterized by high plasticity like gold and paramagnetic properties. In terms of chemical resistance to reagents, tantalum is very close to glass; it is not soluble in acids and their mixtures. It dissolves only in the mixture of hydrofluoric and nitric acids. Niobium is also a bright silver-grey metal. Chemically it is fairly stable. It is always accompanied by tantalum. Similar chemical properties of niobium and tantalum precondition their joint presence in the same minerals and participation in common geological processes. Niobium is even able to replace titanium in a number of titaniferous minerals. In nature, niobium can be found in two forms: difuse (in rock-forming and accessory minerals of magmatic rocks) and mineral. In general, we are aware of over 100 niobium-containing minerals. It is mainly applied in rocket engineering, aircraft and space technology, radio engineering electronics, chemical instrument-making, and atomic power engineering. Production and use of niobium has been rapidly increasing, which is explained by an efficient combination of its properties such as refractoriness, small section of thermal neutron capture, capacity to form heatproof, superconductive and other alloys, corrosion resistance, low electron output function, easy processing by in-cold pressure, and weldability. By the way, niobium and tantalum are used to manufacture high specific volume electrolytic condensers (however, tantalum condensers are of higher quality).

Thus, the last 5 field seasons (3-4 months a year) I worked in the south-eastern part of Yakutia on the Mountain Lake* deposit (mountain-mass). This fact has preconditioned my future geological discovery.

— *Could you explain in more detail what carbonatites are and what you found out while studying this type of minerals?*

— To begin with, I'd like to say that carbonatites are a type of rare metal deposits. By now, scientists established a stage character of mineral formation typical of it: during the first stage, coarse-grained calcites with inclusions of titanium and zirconium minerals are formed: during the second stage—middle-grained calcites with supplementary minerals of titanium, uranium and thorium; during the third stage—fine-grained calcite and dolomite aggregate with niobium mineralization: during the fourth stage—fine-grained masses composed of dolomite and ankerite and inclusions of rare-earth carbonates. Carbonatites have a massive, banded, knotty, and plicated (composed of minor folds) texture, and a varied grain structure. In other words, these minerals are deep mantle rocks formed under the continents. Besides, alkali carbonate magma

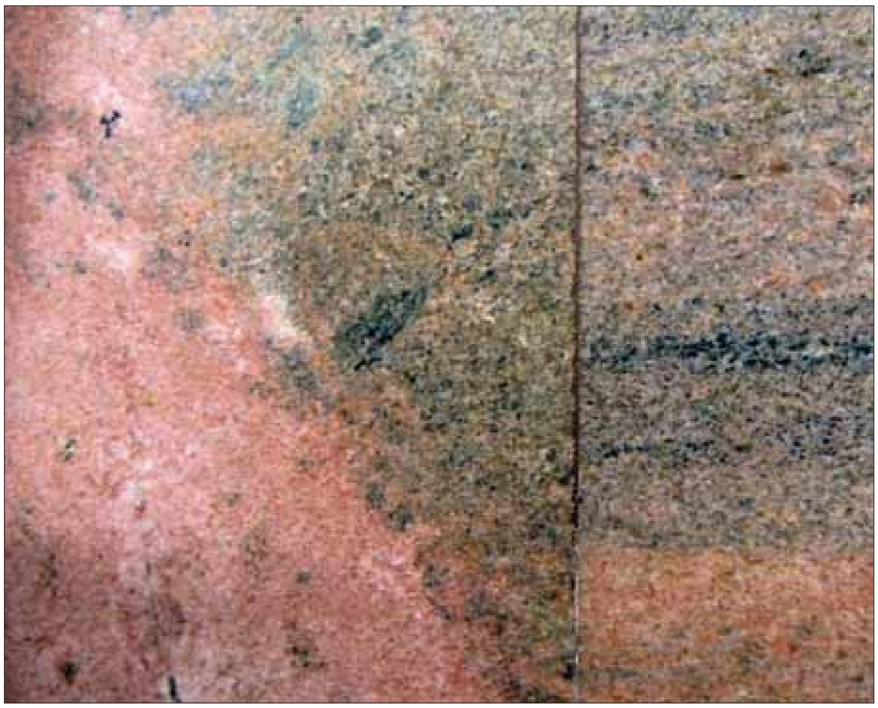
*The areas of rare metal carbonatites in the southern and south-eastern part of Yakutia (Mountain Lake, Arbagastakh, and other massifs) are main potential sources of niobium, tantalum and rare earths.—*Ed.*

Expert gemmologist Vladimir Chernavtsev (enthusiast of using gem stones in the interior décor of metro stations) running an excursion. Mayakovskaya metro station. January of 2012.

absorbs such elements as strontium, barium, rare earths, thorium, uranium, phosphorus, zirconium, titanium, niobium, and tantalum. Mobile complex compounds of these elements are preserved in a highly alkaline medium of carbonatites during their lifting to the upper horizons of the crust and form different minerals—high grade ores of iron, phosphorus, copper, tantalum and niobium, rare earths, zirconium, etc.

As for my direct work duties, in addition to annual reports on long-term expeditions to carbonatite deposits, I collected a lot of information for my scientific work and published results of these studies. Thoroughly studying the rocks, I found a new mineral and gave it a sounding name—calcircite, proceeding from its chemical composition, and described it in detail in my works. But I realized that purely scientific works are not easy to understand for the public at large (and sometimes even totally incomprehensible!), and was eager to make both professional scientists and ordinary people, interested in mineralogy and far from the world of science, get acquainted with my work and discoveries.

I was speculating on a number of options to make my great ambition come true, and, as a professional geologist, took the following decision: to tell about my discoveries to the public at large in the simplest and most comprehensive form possible. That was a real success! I was a co-author of numerous popular scientific books on minerals, including books for school children



Vladimir Chernavtsev and Tatyana Zdorik examining pink marble (from Burovshchina, South Baikal Area) at Barrikadnaya metro station. January of 2012.

("Hello, Mineral!", "Open Slightly the Malachite Box", "Stone Giving Birth to Metal", etc.). In addition, if we have touched my research works, it is necessary to point out that I am one of the four authors (my coauthors were mineralogists V. Matias, I. Timofeev, and L. Feldman) of a volumetric scientific paper *Minerals and Rocks of the USSR* (1970). This illustrated reference book is a complete guide dedicated to minerals and rocks widespread in the territory of Russia. It is also meant for ordinary tourists, regional ethnographers, members of geological expeditions, professional geologists, and, in general, for all inquisitive people interested in and enjoying the mysterious world of minerals.

— *Tatyana Borisovna, the books you named are still popular among various categories of readers. I would like to thank you for the interesting account and ask the last question: what are your future plans?*

— I hope that in the future my scientific works and articles will encourage young scientists to get seriously engaged in the further development of mineralogical knowledge. The mysterious world of minerals still keeps secrets to be solved.

Berbankite. Mountain Lake, Aldan, Yakutia. Sample kept at the RAS Museum of Mineralogy named after A. Fersman (Tatyana Zdorik, 1965).

Strontianite with inclusions of bastnasite and berbankite with inclusions of chlorites. Mountain Lake, Aldan, Yakutia. Sample kept at the RAS Museum of Mineralogy named after A. Fersman.

You have asked me about my recent achievements... For the last few years, I am carried away by translation of works in geology and mineralogy. This is one more sphere of my professional interests. I have translated a number of factual books on minerals from German: Herbert Bank *In the World of Semi-Precious Stones* (1979), Verner Gilde *The Mirror World* (1979), *Environmental Essays on Nature and Man* (1982), etc.

Best wishes to Tatyana Borisovna, new successes in her creative work, good health and long life.

Illustrations from the Internet sources

Photo by A. Yevseeva

THOSE DIVINE CARPENTERS OF SUMER*

by Lyudmila AVILOVA, senior researcher,
Institute of Archaeology, RAS, Moscow, Russia

What caught the eye of archeologists in the dig of the Royal cemetery of the city of Ur in Sumer was a set of tools in the grave goods pointing to a higher social status of the dead, i.e. the kings and their families. Leonard Woolley, who began these excavations in 1919, dated the burials to the Pre-Dynastic Period. Today such burials are dated to the Early Dynastic III Period (first half of the third millennium B.C.). Now this is a commonly accepted point of view.

First, a few words about the items found in the dig. The burial under the number 580 where a child was interred and also known as the "grave of a princess" has such things as festal weapons (a golden dagger, a spear made of electrum, natural alloy of gold and silver; a bronze adze). There is also a set of carpentry tools, like an adze of gold, two chisels of gold and one of bronze, and a saw of bronze.

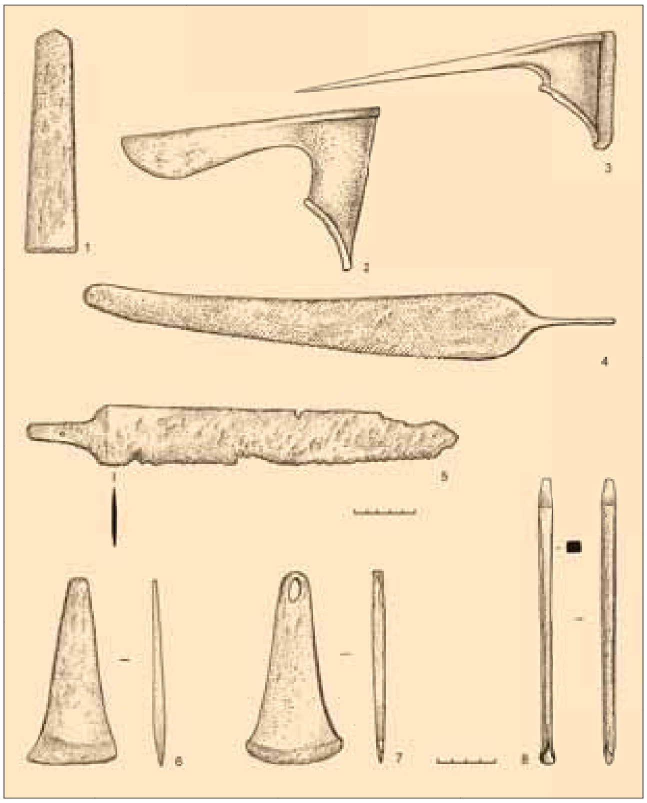
Grave 800, likewise known as the burial place of Queen Shubad/Pu-abi, also has a large set of carpentry tools comprising several bronze saws and one of gold, as well as five golden chisels of different types; a bronze drill and an adze.

Recovered from King Meskalamdug's burial (No. 755) was a saw of bronze alongside golden and electrum weapons (a dagger, broad battle axes).

As a matter of fact, precious royal regalia together with carpenter's tools were found not only in Mesopotamia of the Bronze Age but also in Anatolia, in the famous Priam's Treasure at Troy II where, along with two golden diadems, jewelry, vessels and potēria was also a bronze saw. That is, precious carpentry is present together with other valuables and holies.

Now why did Sumerians place carpentry tools side by side with jewelry and symbols of power in the tombs of kings and royal family members? This is quite natu-

* Sumer—an ancient region in the Lower Euphrates River Valley. Sumerian—designating language of an ancient people of Babylonia, probably of non-Semitic origin. Also, the language of the Sumerians extinct since the third century B.C.—*Tr.*



Carpentry tools from Mesopotamia and Syria of the Early Dynastic Period: 1-4—Royal cemetery of Ur; 5-8—hoard of Tell Hazna I; 1, 3, 4—gold; 2—silver, copper/bronze.

ral as far as the royal regalia and festal weaponry are concerned. But why carpentry? There was some ritual meaning to that.

The building activities were held to be an important function of deified rulers, the esnis or priest-kings (a term of the French archaeologist Pierre Amiet) in maintaining law and order in city-states. This is why the otherwise utilitarian tools could be also made of precious metal as symbols of royal authority (L. Avilova, 2008; 2010). More than that, carpenter's tools were thought to be attributes of gods—thus, the Sun-god Shamash was depicted holding a saw.

Thanks to the Sumerian and Akkadian* texts available to us we can collate archeological, pictorial and literary materials so as to get down to the true meaning of particular objects.

The motif of holding back the original chaos and establishing an orderly Cosmos (Weltordnung) keynotes the Sumerian and Babylonian myths. Man evolves as Creator-Demiurge impersonated in the gods Enlil and Enki. The Enki-Ninmah myth says that man was created from clay to toil for the gods, till the land, tend the cattle and nourish the gods with sacrificial food. The role of Enki as the builder establishing civilization and order in the Land of Sumer is the leitmotif of a long Sumerian epic text, "Enki and the World Cosmos". Enki, the god of wisdom, teaches fundamentals of civilization and life laws (the *me* notion). Listed as the core values are such things as the power of the gods, the power of the king, the royal throne, the symbols of royal power, the offices of priests; also peace, justice, weapons and, what is of particular interest to us, the practical skills like metal and wood working, and building. Enki the god lays foundations for houses with his own hands, he makes a mold for mud brick and builds homes, barns and sheepcotes, he "forges fortune" for Sumerian cities (Samuel Noah Kramer, 1965).

The many divine heroes were likewise involved in demiurgic activities. Enlil, for instance, invented the wheel and brought in grain cultivation; Enmerkar, he invented the written language, while Gilgamesh broke ground for town building by erecting a defense wall around the city of Uruk.

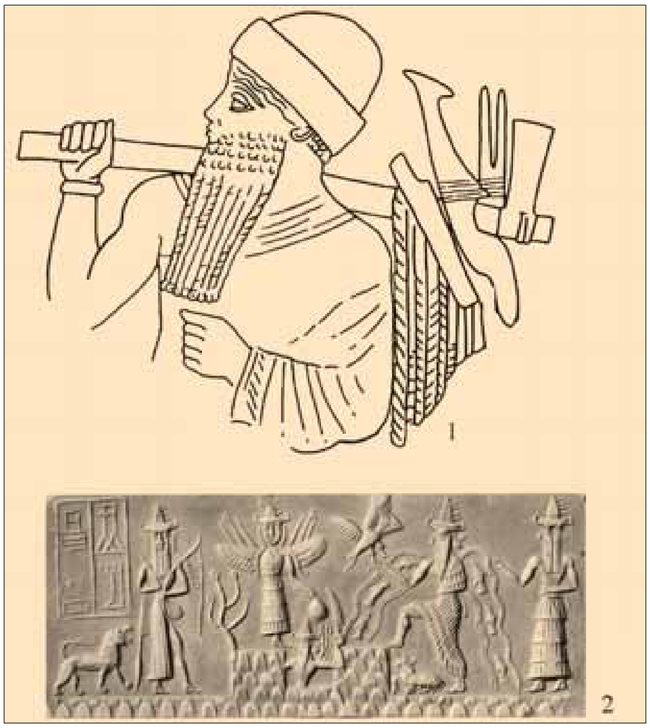
* With reference to Akkad, an ancient country north of Babylonia populated by the Akkadians, a Semitic people.—*Tr.*

Symbolizing the creative forces of Nature, the Sumerian gods were also the saint-patrons of city-states. Such supernatural ideas merged into the cult of a warlord, and then of a king and a priest-king.

The chief of a Mesopotamian city-state (nome) of the Jamdat Nasr and Early Dynastic Periods (end of the fourth and early half of the third millennium B.C.) was actually a priest-leader in keeping with his basic social function (this name suggested by Igor Dyakonov, our Sumerologist). That deity supervised the procurement of farm products needed for sustaining the cult of gods and for building the temples; also, he was responsible for the proper performance of irrigation systems essential for the abundant supply of produce and reserve stocks used in exchanges; he oversaw the crafts largely centered around the temples. He also assumed the role of a warlord in the event of military conflicts. All that speeded up social stratification and called for an ideological premise for the leader as a divine ruler working for the commonwealth (Antonova, 1998).

The king's building activities were just as important as the defense against enemies and the people's prosperity. Available to us are the inscribed foundation pegs of King Gudea of Lagash (22nd century B.C.) concerning the renovation of the main temple of the patron-saint of the city, the god Ningirsu. Gudea lands his own role in the construction work.

Fragment of a diorite statue of Gudea, lord of Lagash (22nd cent. B.C.). Slate with the plan of the temple he raised.

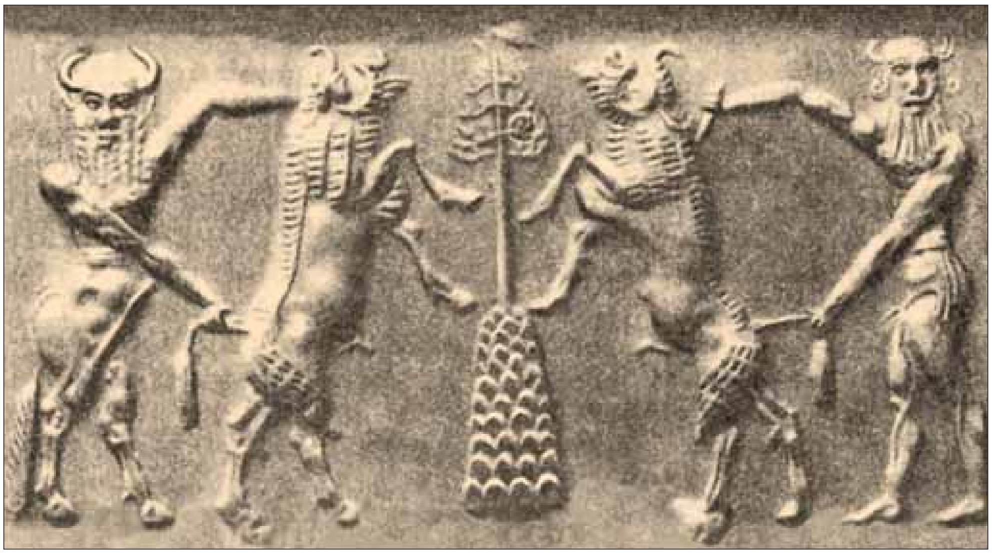


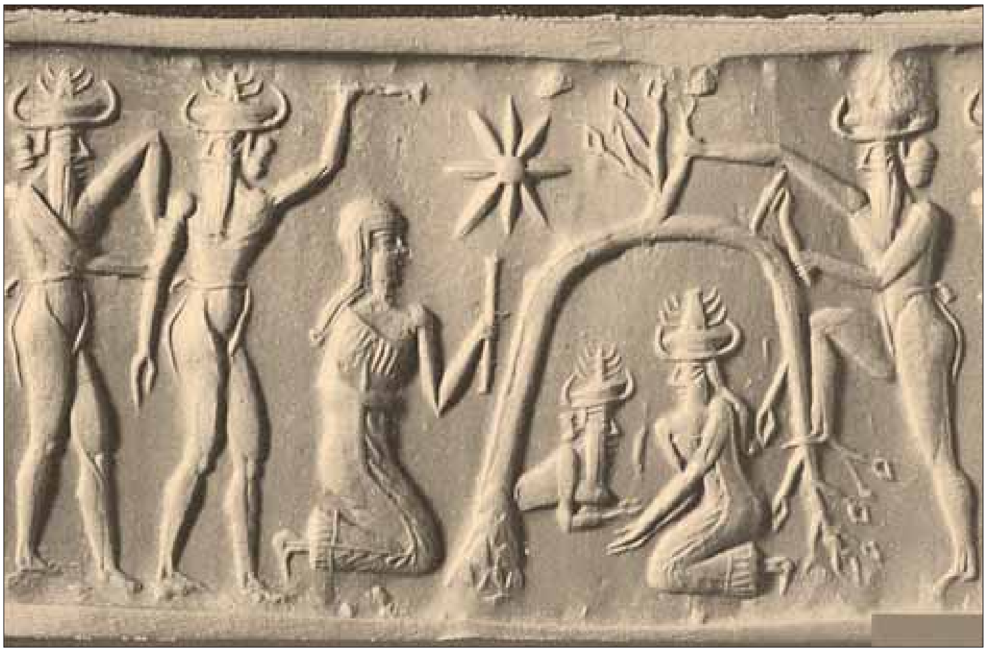
Pictorial materials from Mesopotamia:
1—King Ur-Nammu of Ur as builder on the Ur-Nammu stele (22nd-21st cent. B.C.);
2—impression on an Akkadian cylinder seal depicting the Sun-god Shamash marching through mountains with a saw in hand.

Gudea's statue has come down to us representing him as an architect with a slate on his knees that has a clear and geometrically true plan of the temple he had put up. Ur-Nammu, a king of the Third Dynasty of Ur (21st cent. B.C.), is depicted as a master builder carrying a kit of building instruments: an axe with a long shaft, a brick basket, a pair of measuring compasses, a mortar scoop, a trowel...

We see that building, above all the building of temples, was thought in ancient Mesopotamia, beginning from the Early Dynastic Period, to be an all-important sphere of the activity of a priest-leader, a deified ruler all set to cater to the city commune and Weltordnung. So it was quite natural to have a hoard of carpentry tools on the temple patch of the urban settlement Tell Hazna I, now in northeastern Syria. Working out there, a Russian field party discovered a hoard of tools: two different adzes, a wood chisel as well as what looked like a handsaw (Munchaev, 2005)—in the opinion of the excavator, it is a dagger supplied with a jagged blade.

The rise of city-states and statehood in Mesopotamia is closely interconnected. Temples of worship played a key role in this process—not only for celebrating the cult of local deities but also as the core elements of administrative and economic centers. The establishment of such temples preceded the setting up of cities (*A History of the Ancient East, 1983*). The officiating priests controlled farming and handicrafts; they amassed foodstuffs for exchange. Temples were the centers of learning and keepers of wisdom. Judging by the literary texts of the third millennium B.C., they were in charge of commodity exchanges and also evolved as consumers of imported building and finishing materials. Sumer in southernmost Mesopotamia (modern-day Iraq and Kuwait), not mineral-rich at all, had to trade in farm produce for building and semiprecious stones. The rather sophisticated architecture of its temples attests to the high skills of their builders and craftsmen. The construction of temples spurred the need for architects, Impression of an Akkadian cylinder seal (latter half of the third millennium B.C.). The image illuminates the text on cedar harvesting in a mountain land (Gilgamesh and Humbaba).





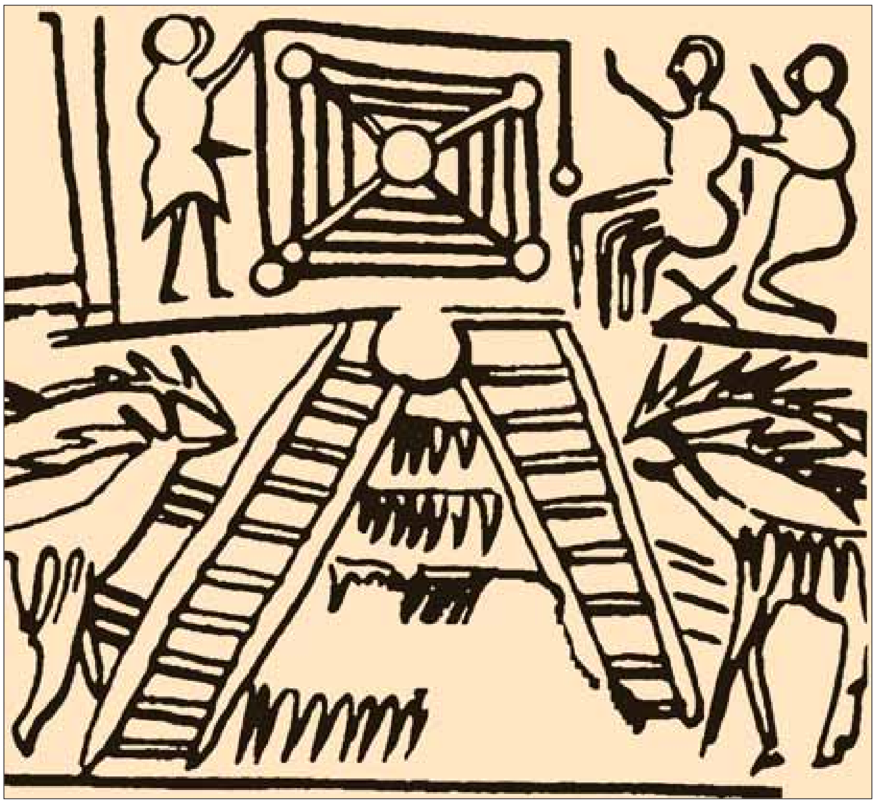
Impression of an Akkadian cylinder seal (latter half of the third millennium B.C.). The image illuminates the text about Gilgamesh working the "Huluppu" tree.

builders, masons as well as hands skilled in wood- and metalwork.

It would be in place to cite from Sumerian and Akkadian texts of the Gilgamesh epic and other poems (third and second millennia B.C.). Gilgamesh is a mythoepical character that had a real prototype, one of the kings of the First Dynasty of Uruk (first half of the 3rd millennium B.C.). These epics see building and woodworking as an important incentive of the hero. For example, the myth *Gilgamesh and Humbaba* is a tale about the journey of that hero and his warriors to a faraway mountain land with the aim of bringing to Uruk sacred cedars guarded by Humbaba the monster. Gilgamesh is motivated by the heroic desire to "raise his name". The hero procures seven cedars and slays the monster.

This epic furnishes the details of timber harvesting. One episode is impressed on a cylinder seal with a tall cedar growing on a high mountain in the center. The very placing of this event on a seal, the insignia of power, testifies to its importance for a better understanding of the hero's image and also to its importance for the owner of the seal.

Another epic narrative, *Gilgamesh, Enkidu and the Nether World*, likewise supplies evidence on this precious tree and various items made of its wood. Growing in the garden of the goddess Inanna was a wonder tree, the Huluppu. Inanna wanted it for making a



An image on a cylinder seal of the Early Dynastic Period (first half of the third millennium B.C.). A scene about the raising of a ziggurat temple.

couch and an armchair for her own self. However, a serpent and a giant bird were living in it. Gilgamesh heeded her complaints, he chased the monster bird away and slew the serpent, and then made objects called *pukku* and *mikku* (most likely, a drum and drumsticks—Kramer, 1965) from its wood. One scene of this epic is also pictured on a cylinder seal, with Gilgamesh holding a tool supplied with a crankshaft handle, and cutting branches off the felled tree. The pictures of deities in horned tiaras (crowns) on the head and that of a star (a godhead's emblem) are meant to impart a cosmic scope to this scene.

It's another question as to what kind of wood was brought in to Mesopotamia and wherefrom. The earliest bits of evidence of texts related to the third millennium B.C. during the rule of Kings Gudea and Ur-Nanshe, point at the mountains of Lebanon and Aman, and also at Mount Hebron; the later-day texts also make mention of the regions of eastern Taurus Range and Zagros Mountains (Moorey, 1994). The logs were delivered in a variety of ways: on carts, by floating, on rafts and by boat (the logs tied fast to the boat). The same author (Moorey) examines in detail the kinds of wood brought in (juniper, cedar, cypress, oak, palm, tamarisk, poplar); he gives a circumstantial description of the particular parts of the buildings where such wood was used (floors, ceilings, walls, doors, interiors; Moorey, 1994).

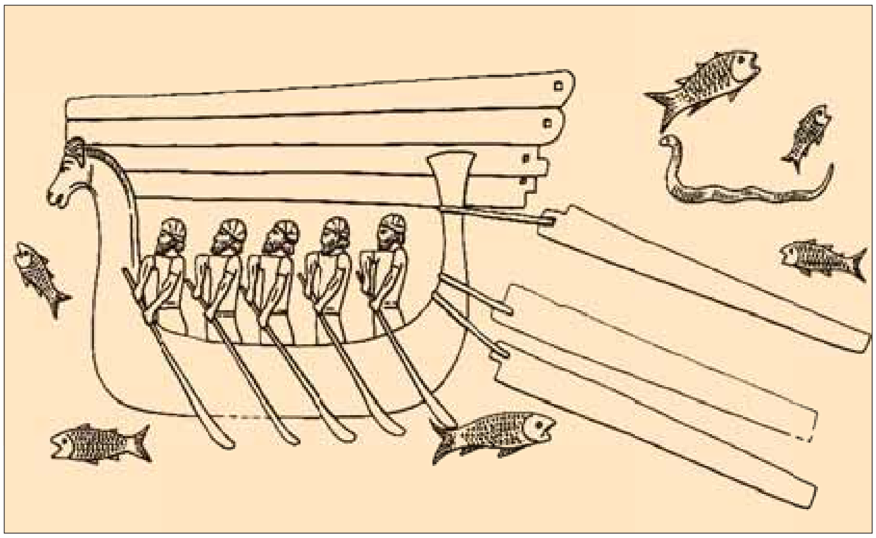
Still another narrative epic, *Enmerkar and the Lord of Aratta* also dwells on temple building, with the city ruler as master builder again. It gives a vivid description of exchanges between Enmerkar, the ruler of Uruk, and the lord of Aratta, a land lying in the north beyond the mountains and rich in gold, silver and stone. The cause of that obscure conflict was the need to erect a temple for the water god Enki in Eridu, a sacred town in Mesopotamia.

Enmerkar, the king of Uruk, dispatches a caravan of pack animals with grain supplies welcomed with glee by the highlanders, all that in exchange for building and semiprecious stones.

Then came a demand to the Aratta mountaineers on behalf of goddess Inanna who proves to be quite conversant with the art of metal mining.

There is a temple construction scene—also on a cylinder seal, the power insignia. It is not just a drawing from life but is meant to enhance the sacral motif and stress an intimate connection of the building process with religion and power.

The erection of urban fortifications was yet another sacred duty of a priest-king. In the Akkadian version of the Gilgamesh epic (*He Who Saw the Deep*) the hero,



Logs carried by water. Relief from the Sargon II palace at Khorsabad (8th cent. B.C.).

the Lord of Uruk, shocked by the compulsive thought about inevitable death because he had lost the herb of youth eternal obtained by great effort comes back to Uruk to seek solace at the sight of the city wall he had once built (*The Epic of Gilgamesh*, 2006).

We see that the building activity of Mesopotamian rulers of the Early Dynastic and subsequent periods, above all the erection and beautification of temples, was held to be an important job for the priest-king as keeper of order in his city and in the Cosmos at large. Understandably the utilitarian working implements intended for sacral rituals to be performed by the king and his family were made from the same precious metal as the highest symbols of royal power—the weapons, diadems, decorations and the like—and were within the ambit of such symbols. All the more so since the king's person was extolled and deified as one descending from gods, and upon death he became a local godhead and hero (like Gilgamesh did).

Such ideas persisted and lived on. The building trade traditionally perceived as a lofty and divine art continued to be thought so later on.

The Greek word *demiurge* (δημιουργός) stands for the artisan, artist, creator and seer; it is also God the Creator. In the Doric city-states of ancient Greece this word also denoted the supreme ruler (Weissman, 1991). The Russian language likewise interprets the moral aspect of the verb *zdati* (*to build*, construct, erect) as a supernal act of creativity.

The Bible (Old Testament) praises Divine Wisdom as a Procreatrix, a creating demiurgic be-all and end-all, as the Lord's "delight" (Parables, 8, 27-31). She builds the world in much the same way as a carpenter or mason would build a home abiding by the laws of the divine art. The home is a core Biblical value as part of the orderly Cosmos. "Wisdom hath builded her house, she hath hewn out seven pillars" (Proverbs, 9, 1).

The wise king Solomon regarded temple building as his great objective and deed. He commanded to "hew cedar trees out of Lebanon". The Bible furnishes a detailed description of how cedars were brought in (I Kings, commonly called the Third Book of the Kings, 5; 6; II Chronicles, 3-5). The material used thereby was of special importance. For one, it was prohibited to use iron tools. "And the house, when it was in building, was built of stone made ready before it was brought thither; so that there was neither hammer nor axe nor any tool of iron heard in the house while it was in building" (I Kings, 6, 7).

Sophia, the Divine Wisdom, was at home in Old Rus (Russia), where three cathedral churches (like one of Constantinople) were consecrated to St. Sophia, the patrona of the people's baptism, in the 11th century A.D. Sophia's iconography gained ground in the 15th and 16th centuries: she is represented as an angela with a fiery aspect and in regal robes (crown, shoulder-mantle, dalmatic); she personalizes a "sophós", enlightened Cosmos created in keeping with divine laws (*Myths of the Peoples of the World*, 1991).

Now in the New Testament Joseph, espoused to Mary and common law father to Jesus Christ, was carpenter: "Is not this the carpenter's son? Is not his mother called Mary?" (Matthew, 13, 55). The Greek word *tekton* (τέκτων) mentioned in the Greek translation of the Gospel according to St. Matthew denotes a builder in general (a mason, a carpenter), as well as a master and artist (Weissman, 1991). Joseph is a poor drudge: Mary, unable to bring a lamb to the temple, brings "two young pigeons, the one for the burnt offer-

Emperor Constantine with a town model. 10th-century mosaic in the St. Sophia Church of Constantinople.

ing, and the other for a sin offering", that is, they were the poor people's offering (Leviticus, 12, 7-8). But on the other hand, Joseph, though he descended from King David (Matthew, 1, 1-16), did not find it reprehensible to play a carpenter's trade.

In the Middle Ages princes, kings and emperors were often represented as church builders.

Symbolic (nonutilitarian) tools made of precious materials were part and parcel of the ideology of nascent class societies meant to make routine labor a sacral thing. In this sense deified labor was not a Modern Age invention, and not only proper to Protestantism (Antonova, 1998). It is related to a uniform world outlook of archaic society and to its mythological perception of any phenomena and of routine, utilitarian activities. The "utilitarian" and "nonutilitarian" concepts cannot be clearly distinguished in institutions prior to social class stratification. Dr. Yevgeny Chernykh, an archeologist elected to the national Academy of Sciences, touched upon these aspects in 1982: he interpreted the "rational" as the progressive-utilitarian, and the "irrational" as what pertains to the spiritual (nonmaterial), ideological, neutral and even impeding social progress.

Such things pictured the social pecking order and inculcated it on people's mind. The labor tools placed in tombs of the most rich signify the social symbolism of such tools and point to the all-important function of the priest-king who is perceived as the keeper and guarantor of building works and Ordnung at home and elsewhere, that is, in the city-states of ancient Mesopotamia, Anatolia and Syria. The presence of precious replicas in burial complexes mirrors also the principal goals of the cult of the dead—the pledge to the defunct forefathers that their progeny in the land of the living will be well-off. In a broader context it is the pledge of well-being and prosperity to their families, their communities and their state.

The intricate pattern of interaction between ideology and the core mind sets as well as their tight ties (even allowing for a relative independence of ideology) poses great difficulties in making a distinction between these two aspects of the Sumerian civilization. Ancient societies in which the tie-in of the economic and ideological spheres was rigid pose problems to researchers. It is hardly justified to draw these spheres apart as some modern-day scholars do, for these two sides of being were in unity within one Weltanschauung. For this reason the very terms—ideology and economy—may look as a simplification, as a rough divide of the actual life realities. It is difficult, if not outright impossible, to evaluate the true significance of such realities for people of the day, for these realities were in a state of continual and interactive flux and were not apprehended as essentially different. Maybe the term "extra-rational" would be more careful, even though it carries a connotation alien to the principle of the unity of world perception. To conclude, I would like to recall what Arthur Hocart, a British archeologist, said in 1970: Temples are just as utilitarian as dams and canals are, for they are necessary for well-being; dams and canals are just as ritual as temples are, for they are part of a social system of searches for welfare.

Illustrations supplied by the author

MODERN CHURCH ARCHITECTURE

by Tamara GEIDOR,
Head of the Department of History of Russian Architecture,
State Museum of Architecture named after A. Shchusev (Moscow)

After Bolsheviks took power in 1917, construction of churches in Russia was suspended or, to be more exact, terminated, which led to the loss of architectural traditions and their continuity. Church architecture revived only in the late 1980s and turned into a significant event of national culture. This was stimulated by the Law "On Freedom of Conscience and Religious Associations" adopted in 1997 by the RF Government. The process is most clearly seen on the example of Moscow architecture.

Cathedral of Christ the Savior. Originally constructed in 1837-1883, architect Konstantin Ton. It was blown up in 1931, rebuilt in the 1990s.

Church of St. Nicholas the Miracle-Worker near the Solomennaya Storozhka. Originally built in 1916, architect Fyodor Shekhtel. Dismantled in the 1960s, rebuilt in 1996-1997.

Chapel of Annunciation of Our Lady in Babushkino.

For the past two decades more than 50 Orthodox Churches and chapels, a number of structures for divine services of other confessions were built in our capital. Church complexes comprising buildings for various religious activities became rather widespread. Sometimes, there appear additional structures like clergy* houses, Sunday schools, etc., under the already existing churches.

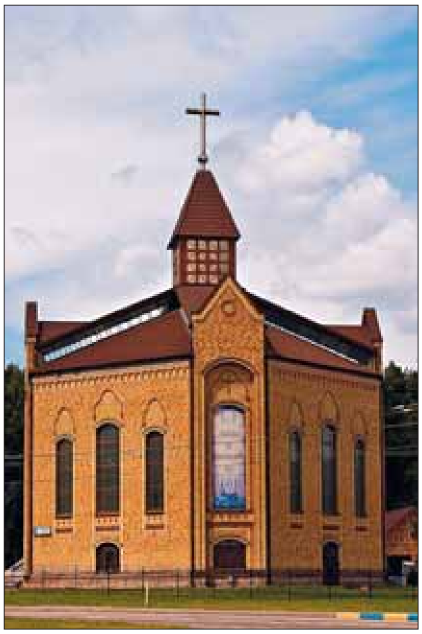
The architectural and construction process under consideration has two main directions: reconstruction of facilities demolished in the period of theomachy, and designing of new ones. The first line is a kind of rehabilitation of the idea of state religion, a symbol of resurrection of Russian Christian culture and at the same time rebirth of lost traditions by way of retrieval of the established canons. Very often many new structures repeat the demolished original buildings on the basis of the author's or measurement drawings, field outlines and preserved original fragments. For example, the grand Cathedral of Christ the Savior in Volkhonka street, the Cathedral of Our Lady of Kazan in the Red Square, the Chapel of the Icon of Iverskaya Mother of God near the Voskresenskiye Gates, and the Church of St. Nicholas the Miracle-Worker near the Solomennaya Storozhka reconstructed in the 1990s.

It has become a common practice to mark the place where once was a sanctuary and to build there a chapel (as, for example, at the corner of Petrovka Street and Stoleshnikov Lane, where a chapel was built to commemorate the demolished Church of the Nativity of the Virgin) or a memorial sign, as, for example, near the Arbat Gates, where once was the Church of St. Princes Boris and Gleb (a new church, in the classical style, has been recently built there). Such practice was rather characteristic for the late 1980s-1990s. It is worth mentioning that this noble tradition was initiated and then introduced nationwide by the Russian Fund of Architectural Heritage named after A. Rublyov.

The second line of development of modern church architecture—construction of new buildings—has become an element of national construction policy. As distinct from other countries where church architecture was developing continuously and absorbed all artistic changes, we are in a difficult situation with modern ar-

* The clergy of a parish—body of appointed ministers of Christian church.—*Ed.*

Church of the Icon of the Mother of God “Assuage My Sorrows” in Maryino.



The Golgotha Baptist Church in Bibirevo.

chitects lacking experience. It is not by chance that in the 1990s, a lot of design projects were proposed failing to address the main idea—symbolism of the structure, and sacred nature of the church building. The authors strived to put emphasis on self-expression, original forms, bright images, often failing to take the established regularities into account. Today, two decades after commencement of the church construction revival, there are already buildings characterized by various layouts, design and composition, which enables us to make some conclusions relating to the style solutions of modern church architecture.

Speaking of wooden architecture (its heyday fell on the late 1990s), ancient samples are usually reconstructed rather accurately. Shed-like* churches with two-, four- or eight- pitched roofs, altar annexes, refectory (western part of the building often separated from the central one by a blind wall) and a bell-tower are most widespread, followed by round basement chapels, i.e. “eight edge” chapels (for example, the Chapel of the Annunciation of Our Lady in Babushkino, the Chapel of Sergius of Radonezh in the Losiny Ostrov), five-sided chapels (of St. Nicholas in Otradnoye, the Chapel of the Icon of the Mother of God “Assuage My Sorrows” in Medvedkovo, and the Chapel of St. Andrew the Apostle in Lyublino, etc).

As modern urban development requires higher buildings, among present-day wooden churches, multi-tiered hipped roof structures look most natural. For example, Church of the Protecting Veil of the Mother of God in Novogorsk (Khimki, Moscow Region), the Church of Vladimir, metropolitan of Kiev, in Sviblovo, the Church of Alexei, metropolitan of Moscow, in Northern Medvedkovo. The last one is cruciform—vosmerik on a chetverik, with a hipped roof, annexes in the form of two-tiered barrels (semi-cylinders with a high pointed roof).

Stone architecture of the late 1990s-early 2000s is more diverse as compared with wooden structures. Most common layout solutions are traditional pillarless churches (for example, Church of the Life-Giving Trinity on Borisovskiye Prudy) crowned with one or more hipped roofs or one, three or five cupolas. Volumetric and spatial composition and décor of façades are often eclectic or sometimes represent a stylized design typical of Novgorod,

*Shed—the simplest wooden structure, constructed of round logs put one on another.—*Ed.*

Church of the Great Martyr George the Victorious on Poklonnaya Gora.

Church of the Saint Seraphim of Sarov and Pious Princess Anna Kashinskaya at the Donskoi cemetery.

Pskov, Vladimir, or early Moscow medieval schools*. For example, the author of the Cathedral of the Icon of the Mother of God "Assuage My Sorrows" in Maryino was rather close to the traditions of the last two schools.

Moreover, we often deal with unconcealed historical replicas, such as the Church of Resurrection of Christ in Sheremetyevo repeating the church of the same name in Sokolniki (1909-1913). The Cathedral of the Icon of the Mother of God "Joy of All Who Sorrow" in Guryanov Street is an exact analog of religious buildings in the Moscow Region (1912) in the neo-Russian, or Modern style**, constructed in honor of St. Seraphim of Sarov in the estate of Fedino and in the Serafimo-Znamensky monastery.

However, a majority of such buildings are characterized by a stylistic mixture of historical and artistic trends, i.e. use of specific decorative forms (Church of St. Tikhon in the Donskoi Monastery, Chapel of St. Sergius of Radonezh at *Moskvich* Motor-Car Factory, etc.), or "balanced" use of elements typical of a number of architectural styles, such as Cathedrals of Resurrection of Christ and of Saints New Martyrs and Confessors in Butovo, powerful icons of the Mother of God in Northern Chertanovo. The volumetric and spatial composition of the latter represents a transformed image of multi-tent ancient Russian churches of the 16th-17th centuries.

In search of an integral artistic image, architects widely use gables* (semicircular or keel-shaped end of a wall) as a dominating motif and a symbol of ancient Russian religious architecture (11th-17th centuries). At present, they are treated as the main element to generate new artistic devices and maintain a link with the national traditions. The first structures built in such manner appeared in the 1990s—the Church of St. George the Victorious on Poklonnaya Gora in honor of the victory

* *See*: V. Darkevich, "Republic on the Volkhov", *Science in Russia*, No. 5, 1998; O. Bazanova, "Sacred Sites of the Land of Vladimir", *Science in Russia*, No. 4, 2005; T. Geidor, "Masterpieces That Endure", *Science in Russia*, No. 1, 2009; O. Bazanova, "St. Trinity House", *Science in Russia*, No. 6, 2010.—*Ed.*

** See: T. Geidor, "Russian Architecture of the Silver Age", *Science in Russia*, No. 6, 2009.—Ed.

*Gable—a semicircular or keel-shaped end of an outer wall repeating the outline of the roof.—*Ed.*

Chapel of the icon of Our Lady of Kazan in the Kaluzhskaya Square.

Synagogue in Bolshaya Bronnaya Street.

of our country in the Great Patriotic War of 1941-1945 (although the volumetric composition and architectural forms of the building reflect efforts to find a new artistic image) and the Chapel of St. Nicholas under Mental Hospital No. 1 named after N. Alexeyev (Zagorodnoye Highway).

Among trilobate buildings (façades with gables) typical of the architecture of Novgorod and Pskov of the 13th-15th centuries, one can name small cathedrals of Our Lady of Kazan in the Kaluzhskaya Square and of St. Olga behind Serpukhovskiye gates. There are many cubic structures with adjoining forechurches or exedrae (semicircular deep niches) crowned with a cupola on a low round or faceted drum clearly resembling the Empire style* or neo-classicism of the 19th century (Chapel of the Icon of the Joy of All Who Sorrow at the Mitino cemetery, etc.).

Bell-towers are characterized by a great variety of architectural forms and locations. They may be detached, put on the cathedral or adjoining it (like the Cathedral of the Martyr Nicholas in Otradnoye), in the form of an arc or tiered construction (Church of the Icon of Our Lady "Life-Giving Spring" in Tsaritsyno). In general, in modern architecture this phenomenon can be referred to eclecticism, a basis of development of all new architectural styles.

* *See*: Z. Zolotnitskaya, "Lofty Simplicity and Dignity", *Science in Russia*, No. 3, 2009.—*Ed.*

Memorial mosque on Poklonnaya Gora.

From among recently constructed religious buildings of various styles one can single out structures of non-canonical look. First of all, it is the Church of Saint Seraphim of Sarov and Pious Princess Anna Kashinskaya at the Donskoi cemetery built in 1902-1910 and reconstructed in the 1990s. The original church had an unconventional form (stretched out parallelepiped) due to three tiers of crypts for 450 burials arranged in the ground floor. In 1920-1927, the church was rebuilt in the functional style* to accommodate the first Moscow crematorium. When reconstructed in the 1990s, a low tetrahedral tent erected in the central inner part of the church (at the intersection of longitudinal and diametrical axes, where side-altars are located), and a single-tiered hipped roof bell-tower above the western portal were added.

The Golgotha Baptist Church in Bibirevo looks even more unusual. Its outer appearance is absolutely unconventional: the eastern orientation of the altar is altered—the building, in the form of a cube, is located so that the cut corner is turned to the east, and a big window, through which light falls on the main altar, there is no apse, and a gallery is connecting the cathedral and an auxiliary building. In a word, the only thing suggesting the purpose of the building is a cross on its roof.

Today, there is a number of expert teams specializing in church architecture. The workshops of the Center of Architecture and Arts under the Moscow Patriarchate, the Partnership of Restorers of the Patriarchal Center of Architecture and Restoration under the Trinity Monastery of St. Sergius, Holy Danilov Monastery, Mosproekt-2 are actively functioning in Moscow and the region. Each team follows its own principles in designing artistic objects. The first team is inclined to the Russian-Byzantine style of the second half of the 19th century, the second one—to the traditions of Vladimir and Suzdal, Novgorod and Pskov schools of the 12th-14th centuries and their interpretation in the neo-Russian style of the early 20th century, the third one—to the cathedrals of the 15th-16th centuries. Besides, there is a newly established typological classification of such buildings according to their purpose: a cathedral, a parish church, a chapel, a family church, a memorial token instead of the demolished building.

As for the modern Moslem religious structures, their compositional layouts are rather conventional. Modern approach to their forms and volumetric-spatial structures shows in accentuated laconism, a strict, not to say brutal silhouette, which makes their link with the urban environment quite harmonious. The Memorial Mosque on Poklonnaya Gora (1997), making part of a complex dedicated to the victory of our country in the Great Patriotic War, has an interesting design solution. It embodies traditions of various architectural schools of the Mohammedan East, especially Tatar, Uzbek and Caucasian ones. The layout of the building represents an octagonal star crowned with a corrugated dome.

The main cathedral of the residence of the Patriarch's exarch (in Trifonovskaya Street), head of Novo-Nakhichevanskaya and Russian eparchies of the Armenian Apostolic Church, has a conventional form typical of ancient religious buildings: the centric volume, thick base of the building, drum crowned with a tent, carved

* *See*: M. Kostyuk, "Russian Avant-Garde Architecture", *Science in Russia*, No. 1, 2010.—*Ed.*

Church of the Life-Giving Trinity near Borisovskiye Prudy.

ornamental pieces on the façade. However, the whole composition with accentuated faceted forms reflects contemporary architectural interpretation of national stylistics. A number of different purpose premises (exhibition rooms, libraries, canteens for church-goers, and even parking) in the stylobate is also a phenomenon, which meets present-day requirements.

The most advanced approach of contemporary architects to the artistic solution of architectural compositions of cathedrals is embodied in the recently constructed Moscow synagogues—neo-modernist and open functional structures reflecting postindustrial aesthetics. Probably, this has become possible of meetings as the rules of organization of the inner space of the Judaic House is not closely linked with such rigid canonical requirements of its outer appearance as in Christian and Moslem religious buildings.

This is particularly true of the synagogue in Bolshaya Bronnaya Str., whose architectural forms are rather unusual. The purpose of this building is manifested only in its religious symbols, which, however, do not dominate in the whole volumetric-spatial composition: the six-pointed Star of Judah is an element of the floor in the chapel, it makes up the form of the glass roof and is plaited in the design of the fence, while the window grid of the rounded corner façade represents a stylized menorah (seven-branched candlestick). There is a spacious room for festive prayers and festivities, the canteen for priests and students of yeshiva (higher religious educational establishment), a kosher wine store (selling drinks permitted by the religion), a conference-hall and a kosher restaurant in the tower, offices of charity organizations, etc.

The overall appearance of the cathedral more than others built of late, follows principles of the modern stylistic trend named hi-tech*. There is another thing worth mentioning: this House of Meetings, belonging to the religious community of Lubavich Jews "Agudas Hasidei", incorporates the old synagogue opened in 1883 by the banker Lazar Polyakov in the territory of his estate (in 1952 its façade was reconstructed in the Stalinist classical style**).

In the late 1990s, the *Toleration and Civil Accord* foundation constructed the church complex of three religions—*The Small Jerusalem* in Otradnoye, composed of the orthodox Church of the Reverend Nicholas, the Church of Panteleimon the Healer built in the traditions of the ancient Russian architecture of the 11th-12th centuries, the synagogue in the modern brutal style and the mosque *Yardem* with two minarets constructed like those built in Central Asia and Iran. This architectural ensemble has one distinctive feature—free location of churches, which have their own sacral zones and at the same time are perceived as a unit.

*Hi-tech—a style in architecture and design, widely spread in the 1980s, characterized by use of high technologies in designing and construction, wide use of glass, plastic, metal, straight lines and simple décor elements, high pragmatism in space planning, etc.—*Ed.*

** *See*: A. Firsova, "The Empire Style in Soviet Architecture", *Science in Russia*, No. 3, 2010.—*Ed.*

Illustrations supplied by the author

THE OLDEST RUSSIAN MEMORIAL MUSEUM OF MUSIC

by Natalya GORBUNOVA,
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"Surprisingly I've got strongly attached to Klin,"—this is what the composer Pyotr Tchaikovsky (1840-1893) wrote about the town he lived the last eighteen months of his life. He moved to a house in the outlying district on May 5, 1892. It was an ideal place for his creative work: there he finished correcting scores of the opera *Iolanta* and ballet *The Nutcracker*, wrote a vocal quartet *The Night*, pieces for piano, romances and the Third Piano Concert. Today, this house is a memorial museum.

"PRESERVE EVERYTHING AS IT IS"

In Klin, Tchaikovsky wrote Symphony No. 6, which he considered his "best and most sincere" composition. On October 7, 1893, he left Klin for his last concert trip to St. Petersburg to perform the symphony for the first time. But, unfortunately, he got sick and died. Tchaikovsky never returned to Klin, and today short scores of Symphony No. 6 are kept at his House.

A bright idea—"to preserve everything in the house as it is"—was proposed by a younger brother of the outstanding musician Modest (1850-1916), who was a well-known playwright, translator and librettist of those times. It was he who established the first musical memorial museum in Russia, in cooperation with his nephew Vladimir Davydov, holder of the copyright inherited from Pyotr Tchaikovsky, and Alexei Sofronov, composer's servant and the last owner of his property.

The museum was opened on December 9, 1894—the date when the first entry was made in the visitors'

The house in Klin, where Pyotr Tchaikovsky lived from May 1892 to October 1893. Today, it is the State House-Museum of Pyotr Tchaikovsky. 1893.

Tchaikovsky in the robe of doctor of music of the Cambridge University. Photo by A. Maitland. June of 1893. Cambridge.

book. Since then, tens of such books were filled in by visitors. In the early period of the museum, they only signed their names there and later on left words of gratitude and comments.

Modest Tchaikovsky and Vladimir Davydov settled down in Klin in 1897. In order to preserve personal rooms of the composer untouched, they built an annex to the house and lived there. With no special funds available, they were forming a Tchaikovsky center as his museum for twenty years. They gathered Tchaikovsky's archives, collected his personal belongings, library, biographical materials, documents representing a history of performing of his compositions in Russia and abroad. Composer's closest friends and his students—Herman Laroche, Nikolai Kashkin and Sergei Taneev—were also of great help.

Modest Tchailovsky planned almost all basic lines of development of the museum, first of all, preservation, collection, scientific work and promotion activities. In 1915 he bequeathed the museum to the Moscow Branch of the Russian Musical Society provided that it will be managed as Mozart's house in Salzburg and Beethoven's house in Bonn, thus presenting one of the most original monuments of musical culture to Russia.

THE MUSEUM AFTER 1916

From 1916, the museum was managed by Nikolai Zhegin, its first director, a man of surprising life staunchness and commitment, appointed by the recommendation of Modest Tchaikovsky. His efforts to defend the house in the early stormy days of the October revolution were not in vain. In the autumn of 1917, he, upset by the unpredictable political situation, moved the composer's archives and most valuable artifacts to the library of the Moscow Conservatoire. All these rarities were returned to Klin only in 1924. A few years before, in 1918, Zhegin managed to obtain a pass for this unique museum at the Museum Department of the People's Commissariat of Education. It was he who did a lot to replenish the museum collection with personal belongings and archives of many famous coevals of the great musician. He also managed to expand the collection with personal belongings, letters, manuscripts, photos and documents of Tchaikovsky found by him.

In 1920 Zhegin organized the Society of Friends of the House-Museum of Pyotr Tchaikovsky. He used to hold cordial receptions on the first floor of Tchaikovsky's house and in the annex. Later on, a special guest house was constructed in close proximity to the

Destroyed memorial gates of the estate. Klin. March 1942.

Gramophone recording concert in the living-room-study of the memorial house. Summer of 1944.

museum. Among the guests were famous singers Leonid Sobinov and Antonina Nezhdanova, the composer Yuri Shaporin, conductor Nikolai Golovanov, prominent musicologist Vasily Yakovlev.

The museum was also visited by the physiologist Kliment Timiryazev (1843-1920), St. Petersburg Academy of Sciences Corresponding Member (1890), Member of the British Royal Society (1911); the prominent Moscow architect Fyodor Shekhtel, sculptor Mikhail Anikushin, in the Soviet times—cosmonauts German Titov, Valentina Tereshkova, Vitaly Sevastyanov and many others.

The Society of Friends of the House-Museum of Pyotr Tchaikovsky was rapidly becoming popular. In the first year of its existence, 275 men became its members, including many outstanding men of arts—Anatoly Brandukov, Konstantin Stanislavsky, pianists Alexander Goldenweiser and Konstantin Igumnov, the actress Olga Knipper-Chekhova, sculptor Vera Mukhina, etc. The society committed to preservation of this memorial place, expansion of museum funds with new materials and popularization of Tchaikovsky's heritage, was led by the composer Mikhail Ippolitov-Ivanov. Earlier, in May 1921, Zhegin was appointed as the museum curator (1921).The same year, by the Decree of the RSFSR Council of People's Commissars, the Tchaikovsky House-Museum was declared public property.

The museum was financed out of budget funds and royalty paid to perform compositions of Tchaikovsky and stage plays of his brother. The Society of Friends of the House-Museum of Pyotr Tchaikovsky also contributed a lot of money used to buy new materials for the museum archives, carry out scientific studies, restore the house, and hold concerts and exhibitions.

In the 1930s, on the eve of the hundredth birthday anniversary of Tchaikovsky that was celebrated in

The concert held at the House-Museum dedicated to of the 50th death anniversary of Pyotr Tchaikovsky. Singer—A. Nezhdanova, accompanist—N. Golovanov. November 21, 1943.

View of the State House-Museum of Pyotr Tchaikovsky from the park.

Living-room-study of the memorial house.

Tchaikovsky's table he worked at in his last years. The composer wrote his last works at this table, including Symphony No. 6.

1940, systematic studies of his musical heritage were initiated. The chronicle of his private and creative life was published, including letters.

EVACUATION OF THE EXHIBITS TO VOTKINSK

In the beginning of the Great Patriotic War, almost all valuables were moved to Tchaikovsky's native town of Votkinsk in Udmurtia. In August 1941 two railway cars filled with the valuable cargo left Klin: it consisted of a piano, personal belongings and unique manuscripts of the composer, his library and articles of the museum interior—the most valuable artifacts of the museum collection.

Thus, the museum was temporarily divided into 2 parts. In Votkinsk its employees organized an exposition and returned to every-day activities. Those who stayed in Klin tried to arrange dispatch of scientific and auxiliary materials—photocopies, designs, books and remaining furniture owned by Modest Tchaikovsky, but, unfortunately, nothing came of it: on November 22-23, the town was captured by German invaders. They occupied the composer's house and tailored it to their needs: the first floor was turned into a motorcycle garage and a shoemaker's workshop, the second floor was occupied by soldiers—more than 100 men. On December 15, 1941, the Red Army entered the town and Klin was the first town and the museum—the first monument of culture liberated from the fascist invaders. On December 19, a diplomatic mission headed by Anthony Eden, the then Foreign Minister of Great Britain, Ivan Maisky, USSR Ambassador to the UK, a member of the USSR Academy of Sciences, as well as more than 20 foreign correspondents visited Klin. On March 1, 1942, they participated in the opening ceremony of the museum and welcomed its first visitors. The museum organized exhibitions, excursions, scientific sessions and conferences, a study group of music. In those difficult times the museum was headed by Margarita Rittikh, an employee of the museum, musicologist and Cand. Sc. (History of Arts).

In the end of 1944, the evacuated valuables returned from Votkinsk to Klin, and on May 6, 1945, on the eve of the composer's birthday, a renewed House-Museum was again opened for public. It was its second birth.

THE MUSEUM'S SECOND BIRTH

It is worth saying that today the State House-Museum of Pyotr Tchaikovsky in Klin is one of the most valuable monuments of national culture of the world significance. It receives annually a lot of visitors who "come to visit Tchaikovsky" from different countries. In fact, judging by the scope and value of its collections (about 200,000 units), research activities and its status in the world, it is, in substance, the Tchaikovsky National Center.

The memorial house the composer lived and worked in has fully preserved its interior; the adjacent park and estate facilities; personal archives of Pyotr Tchaikovsky (first of all, his musical autographs) together with other collections of the museum represent a unique memorial complex that has been carefully preserved by its employees.

As the owner of such a rich documentary fund at present, museum is arranging and holding exhibitions both in Russia and abroad, promoting the art of the great Russian composer and our national culture as a whole.

Illustrations supplied by the author