JPRS L/8478

24 May 1979

[redacted]

U S S R

[redacted]

[redacted]

TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY
PHYSICAL SCIENCES AND TECHNOLOGY
(FOUO 30/79)

U. S. JOINT PUBLICATIONS RESEARCH SERVICE

[redacted]

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100050049-2

JPRS L/8478

24 May 1979

TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY
PHYSICAL SCIENCES AND TECHNOLOGY

(FOUO 30/79)

CONTENTS

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100050049-2

CONTENTS (Continued) Page

CYBERNETICS, COMPUTERS AND AUTOMATION EQUIPMENT

UDC 681.322

DESCRIPTION OF NEW M-10 SYNCHRONOUS MULTIPROCESSOR COMPUTER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 245, No 2, 1979
pp 309-312

[Article by M. A. Kartsev: "The M-10 Computer"]

[Text] The M-10 computer is a synchronous-type multiprocessor system. Its average speed is more than 5 million operations a second and it has an internal memory volume of five megabytes (1,310,720 words). Its operations system gives users working in the interactive (dialog) time-sharing mode access to translators and means for debugging programs in algorithmic languages, reference to external units on the logical level, and access to standard procedures, and use of programs from the library of standard programs as ready-loading modules (linear algebra, approximation of functions, quadratures, integration of conventional differential equations and equations in partial derivatives, and the like).

The machine operates with numbers in three formats: half-word (16 binary bit positions), word (32 bit positions), and double word (64). It also has an incomplete list of operations on 128-position numbers. The 16-position numbers are always numbers with a fixed decimal point, either whole numbers or fractions. The 32-position and 64-position numbers may have a fixed decimal point (whole or fraction) or a floating one (eight binary bit positions of order and, correspondingly, 24 or 56 binary mantissa bit positions).

The main processor part of the machine consists of two program-reorganizable processor lines. Depending on the code of the operation each line is either eight 16-position processors, four 32-position processors, or a pair of 64-position processors that perform the same operation (on different data, of course). The other processor line can simultaneously perform the same operation or a different one. Certain op codes assemble all the processors of a line into a single vector processor. For example, when performing the operation "scalar product," during one cycle the line of processors multiplies out eight pairs of 16-position numbers or four pairs of 32-position numbers and adds the resulting products with one another and with the sum accumulated in the preceding cycle.

Simultaneously with performance of operations on numbers in the main processor lines the system produces up to five lines of Boolean variables in which each binary bit position corresponds to a definite tag related to the operands participating in the operation or to the result of the operation. For example, during addition (of eight pairs of 16-position numbers, four pairs of 32-position numbers, or two pairs of 64-position numbers) the system produces lines of Boolean variables containing, correspondingly, eight, four, or two binary bit positions: ω — redundancy signs; e — signs that the items are equal to one another; m — signs that the first item in the pair is larger than the second; z — signs that the result is equal to zero; s — signs of a negative result.

These signs can be transmitted, directly or through memory, to a special processor of lines of Boolean variables which operates simultaneously with the main processor lines and is capable of performing the full range of logical operations on Boolean variables. The lines of Boolean variables obtained directly during performance of the primary arithmetic or logical operations on numbers, as the result of the work of this special processor, or read from memory, may then be used to organize conditional transfers of control or as "masks" for performance of the primary arithmetic and logical operations. If the op code for the main processor line indicates that the operation should be performed under a mask, those processors for which the corresponding bit positions of the mask contain zero's are suppressed (and during performance of an operation under an "inverse" mask the processors for which the corresponding bit positions of the mask contain one's are suppressed). The mask mechanism is an important tool for efficient organization of parallel computations. There is one other specialized processor included in the central part of the machine and designed to perform index operations (it will be discussed below).

The internal memory of the machine has three types of units: the main direct-access memory with a volume of 512 kilobytes (131,072 words); the main permanent memory, with the same volume, designated primarily to store resident parts of the operations system; the large direct-access memory with the volume of four megabytes (1,048,576 words). From the user's point of view all these units constitute a single memory field, although only the main direct-access and main permanent memories communicate directly with the central processor part. The operations system and automatic exchange unit insure timely supply of necessary segments from the large memory to main memory. Swapping (two-way exchange) between the main and large memories takes place at a speed of about 20 megabytes a second in each direction and is simultaneous with calculation in the central processor. As for external exchange, it is carried on with the full volume of internal memory, both main memory and the large memory.

If we consider that the quantum of time allocated to each user during time-sharing work is 20-80 milliseconds, the characteristics of the central processor, main memory, and large memory are coordinated.[1]

The entire internal memory is covered by a single virtual addressing system. For this the executive address for access to memory contains 22 binary bits (addressing has a precision to the half-word, that is, to the pair of bytes).

An address instruction contains 30 bit positions: four bits for the number of the register being used as a base; four bits for the number of the register being used as an index; and a 22-position displacement. Sixteen special registers are used as base and index registers; they are called the "address modifiers" and communicate with the memory and with the special processor mentioned above to perform indexing operations. An effective address for reference to memory is constructed by analogy with the IBM 360/85 and IBM 370.[2] The formation process begins by summing the contents of the base register and, if necessary, the index register with the magnitude of displacement, forming the mathematical (virtual) address. Then the mathematical address goes through the descriptor apparatus where the old bit positions of the mathematical apparatus are replaced and the physical (effective) address for access to memory is formed. The unit that forms the mathematical address belongs entirely to the user (during the quanta of time allocated to him); the descriptor unit belongs to the operations system. Memory protection circuits are also linked to the descriptor apparatus.

An important feature of the machine is the broad and variable format of access to main memory: from two to 64 bytes can be removed from it in one access.[3]

The instructions by which the central control unit works also have a variable format, from four to 24 bytes. If the instruction is complete, then in one machine cycle (1.8 microseconds) the following are performed: one operation by the control unit (which may be transfer of control, transmission of a command word to a channel, an indexing operation, and so on); two arithmetic-logical operations (in the two main processor lines); two accesses to main memory for operands using different addresses and one more (the third) access for the next instruction; and also, possibly, exchange of data files with other machines of the complex, which will be mentioned further. A direct operand may be taken from memory simultaneously with the instruction, but its format together with the format of the instruction may not exceed the maximum format of access to memory.

External data exchange is carried on through a multiplex channel with a total carrying capacity of about seven megabytes per second. The multiplex channel has 24 duplex subchannels, and up to six similar external units can be connected to each of these subchannels. The external units of the basic machine complex include terminals built on the basis of typewriters and punched tape equipment, alphanumeric line printers, punched card equipment, and an engineering console typewriter which is used to keep the machine log. Terminals based on dash-line display with keyboards and light pens, magnetic tapes and discs, and other peripheral YeS computer units can also be connected

to a channel through supplementary interconnecting devices. The channel has its own buffer memory with a volume of 64 kilobytes. Channel command words are stored in it, but it may also address any other cells of internal machine memory directly.

Alongside performance of computations in the central part of the machine and data exchange between the main and large memories, external exchange carried on through the multiplex channel is a kind of third process taking place in the machine parallel in time with the first two. The fourth and fifth parallel processes occurring simultaneously with these three are monitoring the working condition of system equipment by special circuits and monitoring user programs (checking whether they have privileged operations, checking violations of memory protection, and the like). These independent processors interact through a multilevel program interrupt system which is a part of the central control unit. Its free inputs can also accept up to 32 external signals.

The machine has circuits that make it possible to join up to seven M-10 machines into a single synchronous complex working off a common cycle generator. In each cycle of work, a machine working in the complex can output to its output line a data array of 64 bytes and receive an array of the same size from any other machine of the complex. In this case the machines use virtual addressing.[3] A special connection descriptor device operationally replaces the virtual number of the machine from which the information is received with the physical number. This should make it possible when necessary to form several subcomplexes within the synchronous complex. However, the possibility of setting up synchronous complexes has not been realized anywhere yet, and in practice the linkage registers are used as supplementary direct-access memory.

The structure of the M-10 provides the calculated speed when solving problems that possess natural parallelism,[4,5] that is, consisting primarily of operations on multidimensional vectors or functions assigned by their values in a set of discrete values of the independent variable, and so on. In certain cases when large memory volumes are required to solve problems of this type, the actual speed of the M-10 may significantly exceed its calculated value.

The basic elements of the primary logical circuits of the M-10 are Series 217 microcircuits. The direct-access memory units at both levels are built with ferrite cores that have an external diameter of one millimeter, while permanent memory uses capacitors and replaceable metallic punched cards as information carriers. The machine receives its power through a 100 kilovolt-ampere convertor of 3f 220V 50 Hz voltage into 3f 220V 400 Hz voltage; secondary power sources are mounted right in the machine unit. The first industrial models of the machine demonstrated excellent operating characteristics.

The development of the machine is largely original. A number of structural, technical, and design concepts are protected by USSR author's certificates for inventions and industrial prototypes.

FOOTNOTES

1. Kartsev, M. A., "Arkitektura Tsifrovykh Vychislitel'nykh Mashin" [The Architecture of Digital Computers], Moscow, Nauka, 1978.

2. Kattsan, G., "Vychislitel'nyye Mashiny Sistemy 370" [System 370 Computers], Moscow, Mir, 1974.

3. Kartsev, M. A., VOPR. RADIOELEKTRONIKI, SER. EVT. No 5-6, 1970.

4. Glushkov, V. M., Kapitonova, Yu. V., and Letichevskiy, A. A., KIBERNETIKA No 6, 1976.

5. Glivenko, Ye. V., PROGRAMMIROVANIYE No 1, 1977.

11,176
CSO: 1870

ENGINEERING AND EQUIPMENT

OPPORTUNITIES AND PROSPECTS FOR IMPROVING STATIC GRAVIMETERS

Moscow PRETSIZIONNOYE IZMERENIYE SILY TYAZHESTI in Russian 1978 signed to press 5 Dec 77 pp 4-10

[Chapter One from book by Vladimir Borisovich Dubovskiy, Izdatel'stvo Nauka, 84 pages, 900 copies]

[Text] Major Geophysical Problems Solved by Means of High-Precision Static Gravimeters

Recently gravimeters have appeared which have exceedingly high precision and sensitivity, which is helping to solve many fundamental problems. It must be kept in mind that gravity enters the majority of phenomena discussed as one of many parameters, and it cannot of itself provide exhaustive information on the regularities of these phenomena without the enlistment of additional information.

A major source of information on the internal structure of Earth has been experimental data on changes in gravity caused by the natural vibrations of Earth and tidal forces, and it is precisely this information which has made it possible to select the best of all models of our planet obtained by seismic methods [1].

Improvement in the accuracy of registering tidal changes in gravity and tightening of the network of tidal stations have increased the precision of determining the delta factor and have provided information on horizontal inhomogeneities in Earth's mantle down to considerable depths. The phase lag of terrestrial high tides has made it possible to form an opinion on the rheological properties of the substance of Earth.

Darwin suggested that with an improvement in the accuracy of tide and barometric observations it would be possible to estimate the mean modulus of rigidity of the upper half of the crust; according to his estimates, variations in pressure of 50 mm Hg can tilt the surface of the lithosphere 0.012", which should be accompanied by a change in gravity of 1 to 2 μgal. Proof of the role of active faults in depressions in the crust was arrived at by Nishimura, and in his studies the indirect effects were so great as compared with the direct that the nature of the reaction of the crust in them has provided interesting information on the microstructure of upper layers of the crust [2].

In addition to the recording of high tides, of extraordinary interest has been the interpretation of the instrument drift curve obtained by the Pertsev method [3]; which has produced information on downwarping of the ground under the effect of overloads of water masses; even more interesting is the ability to record the movement of inaccessible masses, e.g., with volcanic phenomena.

Anomalous phenomena in the recording of terrestrial high tides with both horizontal bobs and gravimeters, with the sufficient accuracy and density of stations, can serve as a key in interpreting the plate structure of the crust. Tomashek [4] relates these regional effects to the movement of tectonic plates.

Many interesting phenomena associated with irregularity in Earth's rotation described by N.N. Pariyskiy [5] can be accompanied by marked changes in gravity.

Study of the secular slowing of the rate of rotation has led to the conclusion that there is a cause which slows Earth's rotation (lunar and solar high tides) and the cause is not known, which accelerates Earth's rotation by 10^{-5} s per year; but in the opinion of this author it cannot be caused by known "external" causes and most likely is related to a change in the moment of inertia. On the supposition of the compression of Earth without a change in mass and distribution of densities, this would result in a change in the planet's radius at a rate of 0.45 mm per year, and in the value of gravity at the surface of 0.14 μgal per year.

The rate of irregular changes in the rotational velocity can reach values two orders of magnitude higher than secular slowing.

Based on Braun's hypothesis [6], N.N. Pariyskiy [5] discussed possible changes inside Earth which can cause this phenomenon, and it was revealed which changes in gravity on the planet's surface would accompany this. Without going into the details of this analysis, let us present only its results. For spherically symmetric strains, changes in Earth's radius equal 43 to 12 cm with an altered layer of 0.99 to 0.55 of Earth's radius, which corresponds to a change in gravity at the surface of 0.13 to 0.04 μgal. With a distribution of strains according to a second-order spherical function, with thickness of the altered layer at 27 m and with an increased density of by 0.1 g/cm^3, at a depth of 380 km the change in Earth's radius equals 0.8 m and the corresponding change in gravity is 0.25 mgal. Thus, minor changes in Earth's interior can be registered by highly sensitive gravimeters. And if the phenomenon of Earth's irregular rotation is caused by geological or tectonic features of the structure of the crust, then it is described by spherical functions of a higher order and can result in even greater variations in gravity over time. One more field of research in which the gravimetric method, as one of the most sensitive, can be used with a high return is studying the structure and presentday movements of the crust, whose ranges are fairly high and can be registered with modern instruments. The rates of vertical movements vary

from 2 to 3 mm per year in quiet zones to 10 to 15 cm per year in the most seismically active. For example, the rate of Scandinavia's uplift according to leveling data is 9 to 10 mm per year, in Garm it is 16 to 100 mm per year and at the Alma-Ata proving ground it is 50 mm per year.

For the purpose of measuring the dynamics of the straining field as the manifestation of tectonic processes of the storage of elastic energy, it is necessary to employ gravimeters, tiltmeters and strain meters with continuous registering of readings and which have sufficiently high sensitivity, and, mainly, exceptional zero stability. These same instruments can be a source of information on remanent fields of strains caused by earthquakes. Both these questions are exceedingly important in analyzing the orogenic movements of volcanism and the mechanism of earthquakes, which can render great assistance in the prediction of earthquakes [7].

Observations at the Aso volcano (Japan) prior to and during eruptions showed tilt changes by as much as 150". Nishimura et al. [8] recorded variations in the ground's dip pitch simultaneously at stations hundreds of kilometers away from one another, directly before earthquakes, with a range of 0.03", which should be accompanied by a change in gravity of 2 to 3 μgal as a minimum.

For the purpose of recording relatively slow vertical tectonic movements of 1 to 10 cm per year, a stationary gravimeter should have a sensitivity of, respectively, 0.1 to 0.2 μgal, and a stability not worse than 3 μgal per year.

At the present time a great number of studies are being made, chiefly in easily accessible regions of the Soviet Union (the Crimea, the Russian Platform, etc.), relating to revealing relative variations in gravity, but these measurements are being made sporadically and with insufficient accuracy, 0.02 to 0.03 μgal at best, which corresponds to 7 to 10 mm of displacement. For the purpose of solving the exceedingly important questions of the relationship between the strains observed in the crust and seismic phenomena, and for studying the mechanism of earthquakes and the nature of the formation of faults, it is necessary to develop a higher class of equipment.

Directly related to gravimetry are a number of key questions in theoretical physics; in particular, one of the important questions of the general theory of relativity--checking the stability of the gravitational constant at the level of 10^{-10} to 10^{-11} per year [9]--is to all appearances impossible without considerable improvement in the accuracy of recording both tidal variations in gravity and the absolute value, and without involving additional information on variations in the mean radius of Earth and the phenomena which cause them.

Plans are being made in Maryland (USA) [10] to record gravitational waves with a coincidence circuit, by means of two spaced high-sensitivity gravimeters, installed on Earth and the Moon.

Thus, with improvement in the resolution and, mainly, the longterm stability of the zero point of static gravimeters, opportunities are opened up for

studying phenomena which are both interesting in themselves, and which help to solve questions relating to many areas of geophysics and physics.

Refining the model of the internal structure of Earth and studying the structure and rheological characteristics of the crust and upper mantle; vertical displacements of the surface in the epicenter zone as forerunners of earthquakes and the eruption of volcanos; large-scale strains associated with convection in the mantle, phase transitions and changes in the radius of Earth and its rotational velocity; the stability of the gravitational constant; and an undoubtedly great number of applied problems--this is the total list of questions awaiting a solution by means of static gravimeters.

Prospects for Improving Static Gravimeters

Static gravimeters, having higher efficiency and considerably greater sensitivity and accuracy than other types of instruments, have become more widespread. One of the first gravimeters suggested by Ising had a sensitivity of 1 to 2 mgal. Lindlad's and Malmquist's instrument made it possible to achieve greater resolution. Further progress in gravimetric instrument making is associated with the names of Hartley, Hoyt and especially Graf, whose instruments up to the present time remain some of the most precise; the root-mean-square error of a single reading is not greater than 1 to 2 μgal.

The most sensitive static stationary instruments with good zero point stability are the gravimeters of La Coste - Romberg and the superconducting gravimeter of the University of California, which makes it possible to register variations in the acceleration of gravity on the order of 0.01 μgal.

Let us consider the major errors of static gravimeters and the possibilities for reducing them to neglibly low values.

One of the most substantial and difficult-to-eliminate errors is caused by imperfect resilience of the sensitive element, which results in both long-period and short-period variations in the instrument's zero point, which exceedingly narrows the range of problems which can be solved, making completely impossible the continuous registration of quasi-static processes. The use of springs made of high-quality Elinvar and "isoelastic" alloys has made it possible to reduce the amount of this error by several orders of magnitude. We will dwell below in more detail on methods of combating this error; to all appearances, the quasi-static shift in the zero point, caused by the relaxation of stresses in the elastic element, can be reduced by very many orders of magnitude and can be eliminated totally from further consideration.

Because of the rather high thermoelastic coefficient of the elastic elements, of 100 to 5 mgal/°C, exceptionally high specifications should be imposed for heat compensation and thermostating quality, especially for highly sensitive stationary instruments. The thermostats of domestic gravimeters do not ensure sufficient temperature stability, especially over long time intervals, which can result in a shift in the zero point on the order of 2 to 3 mgal per year.

The employment of integrated temperature sensing devices, a platinum reference thermometer and a proportional regulating system has made it possible to expect a reduction in the size of errors caused by changes in temperature, of two to three orders of magnitude.

With improvement of the accuracy of land gravimeters to 0.1 μgal, some of the most difficult to eliminate error sources have become instances of perturbing acceleration. Under real conditions, for modern instruments these errors amount to 3 to 5 μgal and in a number of instances can reach 10 to 100 μgal. An especially strong effect is exerted by microseisms with relatively high frequencies close to the resonant frequencies of the elastic elements of the sensing system. The employment of an antiseismic platform with a horizontal adjustment feature can lower the level of perturbations from acceleration in the 30 to 100 Hz frequency band by two or three orders of magnitude.

In view of the fairly high sensitivity of gravimeters to tilting, the vibration-proof platform should be controlled by sufficiently sensitive and stable level sensors, as which it is possible to use the tiltmeters which we have designed, based on electrolytic fluid levels, with a resolution of hundredths of a second of angle.

The employment of a proportional control mechanism system will result in a considerable reduction in dynamic errors caused by the system's nonlinearity and the combined effect of horizontal and vertical acceleration. If a highly stable actuator is selected, at the present time it is possible to achieve constancy of the scale factor of better than 10^{-4} per year. In addition, narrowing of the dynamic range of movement of the pendulum by one or two orders of magnitude lowers the requirements for the stability of the movement sensing device.

The fabrication of the sensing system from diamagnetic materials has made it possible to hope for a negligibly slight influence of the magnetic field on the instrument's readings. Barometric compensation and hermetic sealing of the instrument's outer case have resulted in a substantial reduction in perturbations caused by slow and sudden pressure differentials.

The inclusion of digital measuring systems in the total makeup of a highly sensitive gravimeter have made it possible to improve the informativeness of gravimeters and to simplify and speed the processing of information obtained.

Bibliography

1. Magnitskiy, V.A. "Vnutrenneye stroyeniye i fizika Zemli" [Internal Structure and Physics of Earth], Moscow, Nedra, 1965.

2. Nishimura, E. TRANS. AMER. GEOPH. UNION, 1950, 31, N 3, pp 357-376.

3. Mel'khior, P. "Zemnyye prilivy" [Terrestrial High Tides], Moscow, Mir, 1968.

4. Tomaschek, R. MON. NOT. ROY, ASTRON. SOC. GEOPH., SUPPL., 1954, 6, N 9, pp 540-556.

5. Pariyskiy, N.N. "Neravnomernost' vrash..eniya Zemli" [Irregularity of Earth's Rotation], Moscow, Izdatel'stvo AN SSSR, 1954.

6. Brown, E. TRANS. YALE UNIV. ASTR. OBS., Part 6, 1926, III, p 311.

7. Bulanzhe, Yu.D. IZV. AN SSSR, FIZ. ZEMLI, 1974, No 10, pp 25-32.

8. Nishimura, E. BULL. DISASTER PREVENT. RES. INST., KYOTO, 1963, pp 115-120.

9. Dicke, R.N. SCIENCE, N.Y., 1962, 138, pp 653-664.

10. Weber, I. PHYS. TODAY, 1968, 21, p 34.

8831
CSO: 8144/1233

GEOPHYSICS, ASTRONOMY AND SPACE

UDC 550.346 550.836.4

PREDICTION OF EARTHQUAKES BY THE METHOD OF ELECTRICAL DEPTH SOUNDING OF EARTH'S CRUST BY UTILIZING THE 'PAMIR-1' MHD GENERATOR

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 245 No 1, 1979 pp 55-58
manuscript received 30 Aug 78

[Article by I.L. Nersesov, A.Ya. Sidorin, B.I. Zhuravlev, Academician Ye.P. Velikhov, Yu.M. Volkov, Yu.I. Kuksa, V.V. Vengerskiy, Yu.P. Babakov, A.V. Pisakin, Yu.I. Isayev and V.M. Nazarovskiy, USSR Academy of Sciences Institute of Earth Physics imeni O.Yu. Shmidt, Moscow]

[Text] Variations in the impedance of Earth's crust in periods of preparation for severe earthquakes have been detected in seismically active areas of the world differing with respect to conditions, such as in Japan [1, 2], the USSR [3], the USA [4], the PRC [People's Republic of China] [5]m etc. The results of observations made it possible to suggest that the method of electrical sounding of the crust could be used for the purpose of predicting severe earthquakes. But the low power of sounding field sources used in these studies substantially limited the capabilities of this method, since, because of the small distances between the field source and observation points, the magnitude of the impedance was governed by the resistance of comparatively not too deep layers of the crust subject to the influence of surface conditions. When the distance between the field source and observation point is increased, an increasingly greater influence on the magnitude of the impedance begins to be exerted by deeper layers of the crust, i.e., the sounding depth increases.

In sounding depths which include the main areas of location of seismic centers, a greater range of variation in impedance and an improvement in the sensitivity of the method should be expected [6]. The employment of a powerful current source, which is needed to increase the sounding depth, at the same time makes it possible to arrange an extensive network of receiving stations over a large area and also to obtain more detailed information on the dynamics of processes at a seismic center, which is necessary for developing a procedure for localizing the epicenter of a seismic event in preparation.

The analysis made in [6] demonstrated that, for the purpose of reaching depths on the order of 10 to 15 km, which are of practical interest, it is sufficient to employ pulsed energy sources with power on the order of 10^3 kW and a generated pulse length of 1 to 5 s. These power and current pulse length values are

achieved when using powerful pulsed MHD [magnetohydrodynamic] generators developed in the Soviet Union.

For the purpose of further advances in research in the area of earthquake prediction by the method of electrical depth sounding of Earth's crust, in the seismically active Garmskiy Rayon in the Tadzhik SSR an experiment has been begun on earthquake prediction and studying the physics of processes at a seismic center by employing the powerful "Pamir-1" pulsed MHD unit. This unit is in the form of a two-channel self-excited pulsed MHD generator operating on the combustion products of double-base solid fuel with additions of alkali metals.

Both plasma generators are identical and make it possible to achieve a bulk consumption of combustion products of as much as 25 to 30 kg/s. The unit's magnetic system consists of three identical planar windings between which the MHD channels are located. The windings are copper, and the maximum induction in the system reaches 4.5 teslas. The total weight of the magnetic system is 8.4 tons.

The MHD channels have an electrode zone length of 1 m, and the electrodes are made of graphite or metal plates, and the insulating walls, out of glass-fiber-reinforced plastic. The input Mach number is $M_0 = 2.4$. The maximum generated power of each channel is 12 to 15 MW. The generated pulse has a trapezoidal shape and a length of about 2 s.

The "Pamir-1" unit is located in the center of the Garmskiy geophysical testing ground on the northern slope of the Petra Pervogo [Peter the First] Range and operates on an electric dipole approximately 3 km long with a total resistance of approximately 1.5 Ω, which makes it possible to achieve a dipole moment on the order of $3.5 \cdot 10^6$ A·m. The signals emitted can be registered confidently at distances of 35 to 40 km from the supplying dipole, which makes it possible to obtain information on the electrical characteristics of the crust at depths of as much as 12 to 20 km.

During the field test seasons of 1976 and 1977, the results of which are discussed in this paper, receiving equipment was installed at six seismic stations in the testing ground, at each of which measurements were made of two horizontal components of the electric field. The observation system is illustrated in fig 1. In this same sketch are shown the epicenters of earthquakes with energy at the center of more than 10^{10} J (energy class $K \geq 10$; H is the depth of the hypocenter), which occurred in the area studied, during the observation period. In addition, also shown is the epicenter of one of the most severe earthquakes in this area, with $K = 13.0$, which occurred after the termination of observations in 1977.

Experiments with the MHD generator were conducted systematically at the rate of approximately once every two weeks. The impedance was determined with an accuracy of a constant factor by dividing the steady-state values of the field at the receiving stations by the corresponding value of the current in the supplying dipole, which is equivalent to operating on direct current.

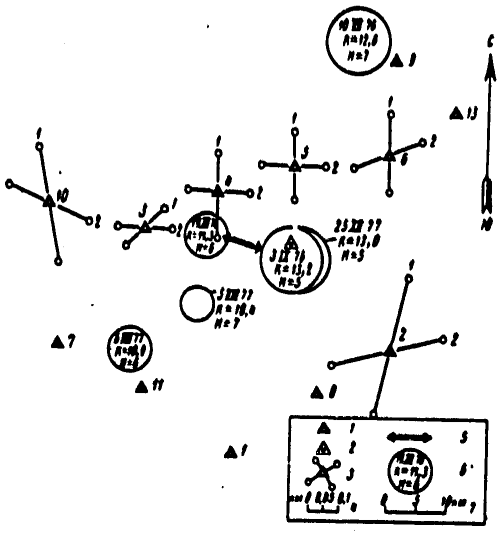


Figure 1. Observation System: 1--stationary seismic stations; 2--temporary seismic station; 3--orientation of dipoles at receiving stations; 4--scale of receiving dipoles; 5--dipole of MHD unit; 6--earthquake epicenters; 7--scale of sketch

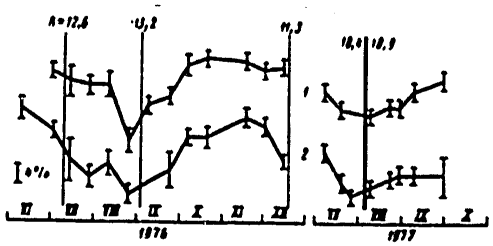


Figure 2. Variations in Impedance, Measured from Steady-State Values of MHD Generator Pulse at Dipoles 1 and 2 of Station 2. The vertical scale indicated is common to both dipoles.

As a result of the observations, variations in impedance of up to 30 percent were detected. The coincidence of extreme impedance values with moments of severe earthquakes and the increase in the range of variation at receiving stations located near earthquake epicenters make it possible to suggest that the variations detected are caused by processes of earthquake preparation. As an example, in fig 2 are shown variations in impedance at station 2, as a percentage of the mean value, and the relative errors of each measurement are indicated. The moments of earthquakes with $K \geq 10$ are designated by vertical lines.

For the purpose of sounding the crust, a secondary operating mode was also employed, which included discharging the battery for the capacitors of the initial excitation system of the "Pamir-1" MHD unit through the feeding dipole, which made it possible to achieve approximately the same dipole moment, but the pulse was bell-shaped and had a length at half-height on the order of 0.2 s. In this case a spectrum analysis was made of the signals, and the impedance was determined at different frequencies by dividing the components of the spectra of signals registered at the receiving stations by the respective components of the current pulse spectrum.

Since the spectral density of these signals in the range of frequencies close to zero turned out to be comparatively low, for the purpose of ensuring the required measurement accuracy, the procedure was employed of averaging the data by the sliding mean method, with a five-day gap and a one-week interval. The averaging gap was selected out of consideration that the error in the averaged results would be smaller than the values of variations in impedance during a period on the order of magnitude of the averaging gap. Such an averaging procedure makes it possible to isolate only longterm variations which can be associated with the severest earthquakes. For example, the period for preparation of an earthquake with energy at the center on the order of 10^{13} J, according to statistical estimates, equals approximately three months [7].

In fig 3 are shown variations in impedance, averaged by this method, at different frequencies for dipole 1 of station 2. The root-mean-square errors indicated in fig 3 are governed not only by the measurement accuracy, but also by the rate of variation in impedance within the averaging gap. An important feature of the results obtained is the different nature of variations at different frequencies. Since a frequency dependence is evidenced only with dimensions of anomalous objects comparable to the skin depth for the frequencies considered, this fact testifies to the fact that the variations registered are caused by processes taking place in large volumes of deep layers of the crust.

For the purpose of determining the influence of conditions on the surface of the ground on the magnitude of the impedance, a combined correlation analysis was made of variations in impedance and the level and temperature of water in rivers, the temperature and humidity of the air, atmospheric pressure, etc. The analysis demonstrated the lack of a firm relationship between variations in impedance and these values.

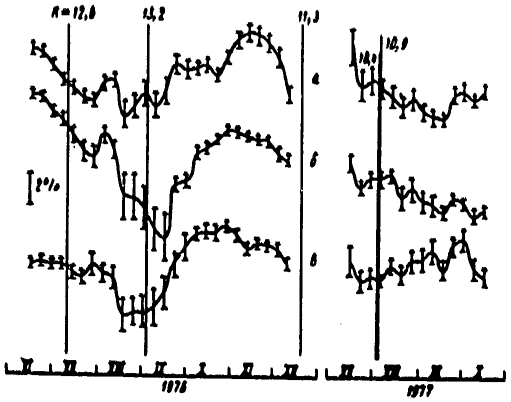


Figure 3. Variations in Impedance at Frequencies of 0.2 (a), 0.6 (b) and 1 Hz (c), Measured at Dipole 1 of Station 2 While Employing Discharging of the Battery for Capacitors of the "Pamir-1" Unit

At the same time a correlation was observed between variations in impedance and strains in the crust. For example, at station 3, where strains in the crust are registered in terms of the north-south and east-west components, the correlation factor between series of non-averaged impedance values and values of strains for these respective components was shown to be within the range of -0.46 to 0.56 for different variants of displacement in terms of time.

In comparing the behavior of variations in impedance with different geophysical processes, it was established by hydrometeorological factors that the key factor with which variations in impedance over time are associated is variation in the stressed state of the crust of the seismically active area. The relatively low correlation factor between variations in impedance and strains can be caused by the fact that in electrical depth sounding actually registered are the integral effects of variation in the stressed state of large volumes of the medium, and the strain meter measures strains only in the area of the receiving station.

Thus, the results obtained demonstrate the need for further study of electromagnetic processes at the center of an earthquake in preparation, and the fruitfulness of methods which have been developed for electromagnetic sounding of the crust, both for studying the physics of a seismic center, and for developing efficient methods of predicting the location, strength and time of destructive earthquakes.

Bibliography

1. Yamazaki, Y. BULL. EARTHQ. RES. INST., UNIV. TOKYO, Vol 46, 957 (1968).

2. Yamazaki, Y. TECTONOPHYSICS, Vol 22, 159 (1974).

3. Barsukov, O.M. and Sorokin, O.N. IZV. AN SSSR, FIZIKA ZEMLI, No 10, 100 (1973).

4. Mazella, A. and Morrison, H.F. SCIENCE, Vol 185, 855 (1974).

5. Yamazaki, Y. GEOPHYS. SURV., Vol 3, 123 (1977).

6. Velikhov, Ye.P., Volkov, Yu.M. et al. "Trudy VI Mezhdunarodn. konfer. po MGD generatorami, Vashington, 9-13 iyunya 1975 g." [Proceedings of the Sixth International Conference on MHD Generators, Washington, 9-13 Jun 75], Vol 5, 1975, p 211.

7. Rikitake, T. BULL. SEISMOL. SOC. AM., Vol 65, 1133 (1975).

8831
CSO: 8144

GEOPHYSICS, ASTRONOMY AND SPACE

UDC: 550.83:(551.14+550.34)

CORRELATION BETWEEN SEISMICITY AND VELOCITIES OF LONGITUDINAL SEISMIC WAVE PROPAGATION ALONG THE MOHOROVICIC DISCONTINUITY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 243 No 4, 1978 pp 1010-1013

[Article by N. A. Shilo, An. A. Nikolaevskiy, Al. A. Nikolaevskiy, and G. A. Yegorova]

[Text] In recent years, studies have been performed of the correlation between earthquake foci, specifics of the structure of the earth and potential field anomalies.

One aspect of these studies have been the study of the relationship of seismicity with values of boundary velocities (V_{gm}) along the Mohorovicic Discontinuity, is determined by deep seismic sounding. The parameter V_{gm}, has been shown by N. A. Belyaevskiy [1], directly reflects the lateral heterogeneity of the upper mantle, i.e., like seismicity, characterizes the tectonic activity of the earth. We should therefore expect these parameters to be interrelated.

The study involved all of the seismically active (>6 arbitrary units) territory of the USSR, within which the parameter V_{gm} and seismicity have been comparatively reliably studied. Combined analysis was conducted, using maps of the distribution of values of V_{gm} in isolines [1] and seismic-statistical material, taken, in order to standardize the results of the comparison, only from the "Atlas of Earthquakes in the USSR" [2].

The data from deep seismic sounding indicate (Figure 1) that the upper mantle beneath the seismic belt of the USSR is distinguished by significant velocity heterogeneities, with definite relationships between the distribution of V_{gm} and regional pecularities of the manifestations of seismicity. For example, beneath the highly seismically active Eastern Caucasus, where over 80% of all epicenters of the Caucasus region are concentrated, including 89% of epicenters of earthquakes with magnitude >5 3/4, we find a block of primarily medium and high values of V_{gm}, 8.1-8.3 km/s. The western Caucasus, the seismic activity of which is two orders of magnitude [3] lower than the eastern Caucasus,

encompasses an area where the values of $V_{gm} \leq 8.0$ km/s. The boundary between the western and eastern Caucasus regions is a deep transverse fault, described by N. S. Shatskiy [4], coinciding with a band of large gradiants in V_{gm}, controlling the Dzhavakhstskiy region of high seismicity.

The area of the central portion of the Caspian Sea, which has low seismicity, is superimposed over a block of relatively low values of V_{gm}, near 8.0 km/s. Within the Turkmenian seismically active region, all epicenters of earthquakes with M>4 are located above sections of development of V_{gm} near 8.2 km/s. Sections with V_{gm} 8.3 km/s correspond to aseismic regions.

The highly seismic east central Asia, like the eastern Caucasus region, is related to a block where the values of V_{gm} vary from 8.1 to 8.3 km/s. The seismically active region of eastern Transbaikal, characterized by low values of seismicity, averaging six units, is superimposed with a block of differentiated [5] values of V_{gm}, 7.8-8.1 km/s. Within this block, high focal seismicity tends toward zones where the values of V_{gm} drop suddenly.

In order to study the quantitative relationships using the deep seismic sounding data, blocks of homogeneous values of V_{gm} were delineated, and for each of them, conversion factors [2] were used to determine the mean density (ρ) of the standard epicenters, using epicenters of earthquakes of energy class 12 as a unit. The calculation included the epicenters of crustal foci in the continental regions of the seismic belt (Table 1), which in the far eastern zone of transition they also included subcrustal foci down to a depth of 200 km for earthquakes with M>4. Each calculation was related to an area of 1,000 km^2.

The tabular data, processed by means of the method of least squares, indicates that in the continental regions of the seismic belt, the variation ρ of crustal earthquakes as a function of values of V_{gm} is represented by a linear regression of the form $\rho = 1.2V_{gm}-0.26$ in the interval of values of V_{gm} of 7.8-8.3 km/s; the correlation coefficient is 0.95, probability at least 85%. This relationship apparently results from processes of compaction and decompaction of matter as a result of its differentiation within the mantle. The transformation of the material composition of the subcrustal layer which occurs in this process causes changes in the density and corresponding changes in the volume of rock making up the upper mantle and terrestrial crust, resulting in the development of intensive stresses, which can form the foci of crustal earthquakes [6]. The nature of the correlation indicates that the process of formation of relatively high velocity, dense volumes in the subcrustal layer, occurring in relationship with the surrounding environment, facilitates more active entry of the mantle energy into the earth.

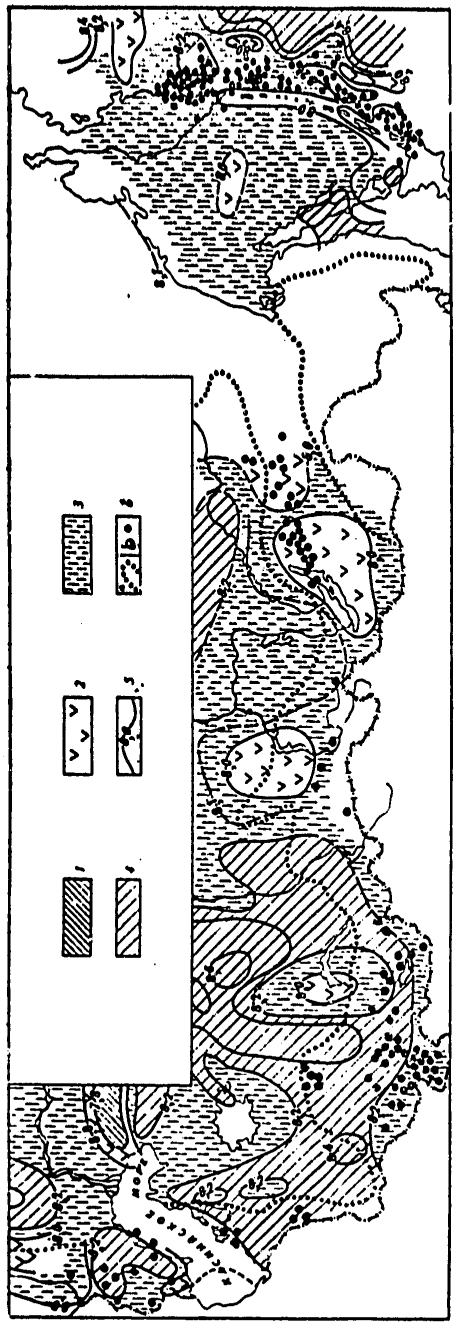


Figure 1. Map of propagation velocities of longitudinal seismic waves along the Mohorovicic Discontinuity (after N. A. Belyayevskiy and I. S. Vol'vovskiy, supplemented). Values of boundary velocities on the M surface (km/s): 1, less than 7.8; 2, 7.8 to 8.0; 3, 8.0 to 8.2; 4, over 8.2; 5, isolines of boundary velocities; 6, seismologic data; a, boundaries of six-unit zones; b, epicenters of earthquakes.

Table 1

Continental Seismically Active Regions	ρ for mean values of V_{gm} (km/s)				
	7.8	7.9	8.0	8.1	8.2-8.3
Western Caucasus	-	0.09	-	-	-
Eastern Caucasus	-	-	0.2	0.5	0.6
Caspian	-	-	0.21	-	-
Turkmenian	-	-	-	0.4	-
Altay-Sayan	-	0.08	-	-	-
East Asian	-	-	-	0.55	0.6
Baikal	0.15	0.17	-	-	-

In the transient zone, there is also a relationship between seismicity and V_{gm}. Here, the most seismically active block ($\rho = 0.59$) is the continental slope of a deepwater trench, where the values of V_{gm} vary from 8.1 to 8.3 km/s. Lower activity ($\rho = 0.20$) is observed in a block of lower values of V_{gm}<8.0 km/s, to which the band of active volcanos of the Kurial Islands and Kamchatka belongs.

It is remarkable that these relationships are retained in general in other seismically active retions as well. For example, from data published in [7], we can see that in the territory of the USA, an increase in the level of seismicity occurs in the direction from arch elevations, where values of V_{gm}<8.0 km/s, toward the oceanic regions, characterized by higher values of this parameter.

Comparing V_{gm} and seismicity with the distribution of mean velocities of longitudinal waves in the crust [8], we find that there is no relationship between these parameters, i.e., foci of earthquakes may be encountered at various levels and in crustal layers of various compositions, which is actually observed [9].

The relationship of seismicity and V_{gm} with mantle and gravitational (in the reduction of Buge) anomalies in the continental regions is generally weak, since the effect of pecularities of the structure of the upper mantle is overshadowed by the influence of both internal heterogeneity of the crust and large variations in crustal thickness [10]. In the transient zone, where the gravitational and magnetic anomalies reflect pecularities of the structure of the upper mantle [11], the following relationship obtains: the growth of the values of V_{gm} and seismicity corresponds to an increase in the stress along gravitational and magnetic anomalies. Thus, gravitational and magnetic anomalies also indicate a variation in the level of seismicity with pecularities of the structure and composition of the mantle substance.

Summing up, we must emphasize that the pecularities of distribution of V_{gm}, in combination with other geological and geophysical data, allows

us to conclude that there is a direct relationship between seismicity and lateral heterogeneities of the upper mantle. This conclusion, which seems important to us, may be of great significance for the study of seismic phenomena.

REFERENCES

1. N. A. Belyayevskiy, Zemnaya kora v predelakh territorii SSSR [The Earth's Crust within the Territory of the USSR], Moscow, 1974.

2. Zemletryaseniya v SSSR [Earthquakes in the USSR], Moscow, 1961.

3. G. A. Shenkareva, Sov. geol. No. 8 (1966).

4. N. S. Shatskiy, Izv. AN SSSR, ser. geol. No. 5 (1948).

5. N. N. Puzyrev, M. M. Mandel'baum et al, Rol' riftogeneva v geologicheskoy istorii Zemli [The Role of Reef Forming in the Geologic History of the Earth] Novosibirsk, 1977.

6. V. V. Belousov, Aktiviz rovannyye zony, noveyshiye tektonicheskiye dvizheniya i seysmichnost' [Activated Zones, Recent Tectonic Movements and Seismicity] Moscow, 1964.

7. M. Bott, Vnutrenneye stroyeniye Zemli [The Internal Structure of the Earth] Moscow 1974.

8. I. S. Vol'vovskiy, Seysmicheskiye issledovaniya zemnoy kory v SSSR [Seismic Studies of the Terrestrial Crust in the USSR] Moscow 1972.

9. A. A. Borisov, G. A. Shenkareva, Bioll. MOIP, otd. geol., Vol 47, No. 6 (1972).

10. A. A. Borisov, Glubinnaya struktura territorii SSSR [The Deep Structure of the Territory of the USSR] Moscow, 1967.

11. A. G. Gaynanov, O. N. Solov'ev, DAN, Vol. 151, No. 6 (1963).

6508
CSO: 8144/1168B

GEOPHYSICS, ASTRONOMY AND SPACE

'AIR & COSMOS' DETAILS ELMA PROCESSING EQUIPMENT

ELMA Program

Paris AIR & COSMOS in French 14 Apr 79 pp 38-39

/Article by Albert Ducrocq/

/Text/ It was with great solemnity that the Soviets had announced on March 27, the beginning of the experiment, whose purpose was processing on board the Salyut 6, the material which the French had entrusted them.

If the events had taken place as foreseen, the performance of this experiment would have coincided with the visit to Moscow of the President of the French Republic. We were aware of the value attached by the Soviets to the Franco-Soviet space collaboration for reasons both political and technical; this was yet another proof.

This time, for the rest, one great step forward has been taken. Hitherto, applications had been practically excluded from the programs of cooperation between France and the Soviet Union. Indeed during the first stage, the scientific experiments involved were aimed at a better knowledge of the Earth's environment or the universe itself, while this scientific project was crowned with a joint program for the study of gamma astronomy, a program called upon to assume considerable dimensions during the next few years, if only because one of the first applications of the "specialized block" which the Soviets are preparing to use was to be the transportation of the gamma telescope built by the French.

A second project concerned biological studies in particular, with the implementation of the Cytos program, whose success we described last year.

The third stage is represented today by the processing of materials in space. This is the problem which is experiencing nowadays an explosive development all over the world. After having understood that satellites are an ideal tool both for the development of the Earth, and to assure telecommunications on a large scale, the decision-makers have suddenly discovered that the orbital plant might easily soon upset some of the economic data.

By undertaking to cooperate for the processing of materials in the state of weightlessness, the French and Russians have chosen to launch jointly into space applications, opening wide a door, which had hitherto been kept hardly ajar with the SRET experiments, which had formerly been directed, on one hand to the study of the wear of photo-batteries in space, and on the other, to testing the behavior of passive cryogenic systems..

It was during a meeting in Leningrad, in September 1976, that the decision decision was made to process in the furnaces of a Salyut station, a packet of specimens, designated as ELMA, for ELaboration of MAterials.

At that time, the schedule foreseen had been that:

--The year 1977 would be devoted by the French to the preparation of this parcel, with the agreement of Soviet specialists.

--This parcel would be in flight at the beginning of 1978. After recovery the specimens produced in space would be studied jointly by the French and Soviets.

Postponement of a Progress

The operation was delayed for known reasons, the first being the shift in the Salyut 6 Program. The station was to be launched before Summer 1977. It was placed into orbit only on 29 September. And then the Soyuz 25 incident occurred, forbidding its immediate occupancy.

The delay led to postponing to October 1978 the departure into space of the ELMA parcel. The Russians had then planned to place it on board the Progress 4, which was launched on 3 October. It seems that purely administrative reasons had then prevented the parcel from reaching Moscow in time.

This being the case, after the return of Kovalenok and Ivachenkov on 2 November, it was expected that another manned Soyuz would leave soon. But a defect had been detected in the tank pressurization system on board the Salyut 6. The Soviets had to attempt to determine its exact nature, to perfect on the ground a repair procedure, and to test it in a simulation. All this took more than 3 months, and will explain why Lyakhov and Ryumin should have been launched into space only on 25 February.

They did not carry with them the parcel. Actually it appears now that there is a very general rule: in the direction from Earth to space, the orbital stations are launched almost without equipment, and the Soyuz hardly accepts any cargo. Transportation of pracels is assigned to Progress.

The ELMA parcel was thus placed on board Progress 5 launched from Baykonur on 12 March. And this space truck also brought a new furnace to Salyut 6, Kristall 3, which could be used longer than Kristall 2; its arrival seems to us to confirm the fact that the Russians really intend to make maximum use of their station. We recall that it was Progress 1 which had brought

the Splav 1 furnace (used for the Czech experiment Morava 1 and for a preparation of crystals of cadmium and mercury telluride by the Polish cosmonaut). The furnace Kristall 2 of Salyut 6 had been brought by Progress 2 (we recall that Kristall 1 had been carried by Salyut 5). The Kristall is a computer controlled equipment weighting 28 kg, capable of generating a temperature between 0 and 1100°C; this furnace permits production of crystals in vapor phase transportation.

After the new Kristall is installed, therefore, the ELMA specimens would be introduced into the furnaces Splav 1 and Kristall 3 on March 25....

They are expected to return to Earth on a forthcoming Soyuz (the Soyuz being the only vehicle returning from a station of the type of Salyut 6), since the French researchers have been notified that they should go to Moscow during May to recover their specimens.

Spherical Crystals

What are these specimens?

They come from four laboratories, the first one being the Solid State Physics Laboratory.

The first objective in the experiments prepared by the Department of Diffusion and Technology of Materials (CNRS /National Center for Scientific Research/-Meudon-Bellevue) was to form single crystals from liquid balls put into position, since this question was worthy of explanation.

In conditions of weightlessness, if a liquid mass is placed in conditions which do not secure its rapid vaperization--this being the case a priori if one is far from the boiling point--it will tend very naturally, under the effect of surface tension, to assume a shape which will assure its minimum surface, the elementary minimum surface being that of a sphere. In other words, you get a ball. For reasons other than those which led the heavenly bodies to assume the shape of spheres, a liquid mass at rest will tend in space conditions, to give rise to balls.

Now imagine then cooling these balls--let the temperture drop below the melting point--and its crystallization is induced. In olden days, a classical joke among students was saying that naphtaline crystallizes in the spherical system. Well this is the natural action induced by space: the production of crystals which should be balls....

At least this is what theory says.

The technique was tested in 1973 on board the Skylab, while the use of its furnace for experiments of this nature gave results which appeared for a time quite surprising. In some cases it was possible to obtain spherical crystals, much more perfect in all respects than those obtained on the Earth (since the space produced crystal has at its center a 6 times lower dislocation density than a crystal produced on the Earth), whereas other experiments resulted in unexpected effects.

Thus the experiment M 562 consisted in melting three cylindrical specimens of indium antimonide, liquefied over 6 cm in quartz amplues and then resolidified. The first was not doped, the second contained tellurium and the third tin. Specimens 1 and 3 gave beautiful crystals, with however on their periphery, small cavities attributed to the presence of gases between the crystal and the wall; the latter did not occur in the case of the specimen doped with tellurium.

But the most puzzling results were obtained with the M 560 experiment which had been set up by Dr H. Walter of the University of Alabame. The material used was also indium antimonide, whose application as we know is advantageous in semi-conductor technique. Three specimens, consisting of one crystal each, were placed in a container, whose internal side was in graphite, while the lower part had a hemispheric shape. The specimen was "pinched" at the top; it was found that it melted over a length of about 2 cm. It was expected that this liquefied fraction would assume, when it resolidified, the shape of a magnificent sphere just as the physicists had imagined.

However, reality turned out to be quite different. The specimen continued to adhere to the bottom of the container, while the melted fraction was content to assume the shape of a spindle....

And the Soviets were not much luckier with their 'Sphere' experiment, whose objective, as indicated by the name, was to apply the lack of gravity to creating perfect spheres: what they actually obtained were little hedgehogs, since the specimens assumed a more or less elongated shape and had furthermore been decorated with needles.

There is a fairly simple explanation. The Americans certainly had grounds for assuming that in a weightless state, a liquid mass "should" take the form of a sphere. But there should be nothing to impede the process. And this would imply that:

--no perturbing action would arise (adherence to a wall, presence of impurity, presence of germs) whose importance in a non gravitational state may risk becoming a source of aberrations;

--that assuming that a liquid ball did form, it would not be subject to any type of agitation.

The Bellevue Simulations

And so we find the conditions as imperative as they are general, to be satisfied before we can dream of processing in weightless conditions any high quality material. We should be able to control all the parameters after conducting beforehand all the necessary studies to reveal the effect of each of them, these studies having indicated ipso facto, all the precautions to be taken before planning an operational processing of materials in space.

And, prior to the ELMA experiment, one of the things which may be said to the credit of the CNRS Aerothermy Laboratory is that it has studied over a long period the behavior of a liquid ball.

At Bellevue, Mrs H. Rodot carried out simulations by placing a liquid ball in another liquid of the same density, the two substances being, it goes without saying, non miscible. The following pairs were retained: anilin + water to which 3 percent hydrobromic acid (density: 1.022) was added, silicone oils (polydimethysol oxane) + water/ethanol (density close to 0.950). This did not constitute a complete model of space environment, since this type of simulation involved the reaction of the bath, which obviously does not exist in space. But it was already an excellent approach to the problem and it was possible to obtain the confirmation of a phenomenon, since Mrs Rodot had last June, shown us the film of this simulation which, by the way, we were able to see concretely.

We observed thus how great was the instability of a liquid ball. As soon as it is touched by a hammer simulating the part which in gravity-free conditions, may have the function of placing it in proper condition taking into account residual gravity, the ball seems literally to start shivering: waves are formed on its surface, rapidly travel all around it, giving rise finally to a system of stationary oscillations, whose damping seems to be slow....

The studies conducted at Bellevue concern both the system of percussions caused to a liquid ball and its vibration in natural frequency and in forced oscillations (experiements carried out between 0.10 and 40 Hz with a precision of 0.03 Hz).

It was possible to derive a certain number of conclusions, which were taken into account in preparing the ELMA experiments of the Solid State Physics Laboratory, while the researchers revealed in particular the essential role of two parameters: interface tension and viscosity (the silicone oils offer a range of samples permitting the viscosity to vary in the proportion of 1 to 200). On the other hand it was found, that the larger the diameter of the sphere, the more it is sensitive to low frequencies....

Asga and Phosphides

Two other experiments were also prepared by this CNRS Meudon-Bellevue laboratory. Their purpose was:

1. The processing of asga crystals. We have already had several occasions of emphasizing the stakes involved, since asga, or gallium arsenide is in the eyes of many specialists, the great semiconductor of the future, called upon to replace in many applications, silicon, just as the latter had taken the place of germanium. In particular, asga was to permit the production of high yield photo batteries (23 percent or more), which on the scale of the foreseeable future, will certainly be more costly than the silicon batteries (since the cost of the latter is dropping very much today with the development

of techniques permitting recourse to amorphous silicon). But they may prove to be valuable, when it is desirable to have maximum watts for a definite number of square meters. For the immediate future, the researchers are contemplating not so much the processing of asga in space, as the acquisition of data from which, with the space medium used as laboratory, it should be possible to improve to a considerable extent, the production of asga on the Earth's surface by methods close to conventional means. Kovalenok and Ivanchekov had themselves attempted to produce spatial asga using Kristall 2; the Russians will not fail to compare the French technique with their own.

2. Crystallization in solution of an alloy of gallium and indium phosphides, or more specifically a compound of the type $Ga_xIn_{1-x}P$. The electronic interest of such an experiment is obvious: gallium and indium are elements of the same family--that of atoms containing 3 peripheral electrons--whereas phosphorus has 5 peripheral electrons, the objective being to obtain by judicious doses (indium, which is heavier, is lazier than gallium), the perfect semi-conductor ready to "swing" for a determined excitation from the conductor state to that of insulator....

Prospects Offered by ELMA

Paris AIR & COSMOS in French 21 Apr 79 pp 46-48

/Article by Albert Ducrocq/

/Text/ It is still too early to measure the consequences on the Salyut 6 occupancy program, of the failure of Soyuz 33, when the Soviet, Nikolay Rukavichnikov and the Bulgarian Georgiy Ivanov had, as we know, to return to the Earth on April 12, without linking up with the station.

This did not prevent Lyakhov and Ryumin from continuing to work. And, in any case, these cosmonauts could bring back with them the ELMA packet which has been processed in the furnaces Splav 1 and Kristall 3 since March 25 by virtue of the new Franco-Soviet cooperation program concerning the processing of materials in weightless conditions.

Last week we discussed broadly the role of one of these laboratories--the Meudon-Bellevue Solid State Physics Laboratory--whose objectives are on one hand a knowledge of the crystallization of spherical baths, and on the other, the study of the crystallization in solution of materials used in electronics, specifically, asga and gallium-indium phesphide.

Although the improvement of these materials may shortly be of great interest for various applications, we refer mainly to the fundamental research intended to promote progress in our science of crystals.

The second laboratory involved in the ELMA program is the Magnetism Laboratory at Grenoble, whose reputation is well known, since Professor Neel's studies have revived to a great extent researches on magnetism, by sweeping away

many ideas arising to begin with from the fact, that after all magnetism is well known, and there could be no possibility of imagining new magnets, in view of the fact that the list of simple elements had been established exhaustively: nickel and cobalt were formerly considered the best magnets, materials. We know today this is not at all true, rare earths offer very astonishing resources if it is possible to create composite materials with the required care. At the time of the Apollo-Soyuz flight, the experiment MA 020, showed that it was possible, under the aspect of magnetic performances, to obtain in gravitationless conditions, excellent composite bismuth-manganese materials.

The products prepared by CNRS /National Center for Scientific Research/ at Grenoble were cerium manganese and neodymium-cobalt composite materials, for the purpose of obtaining a die.

It would be extremely interesting to know up to what level the coercitive force of the magnets may reasonably be increased in the foreseeable future. We consider indeed that with the present level of technical knowledge, the most economical formula to store up a medium amount of energy is a rotation system, with the conservation time depending on the wear of the works, which would be very low if we were able to generalize the technique of the magnetic dies. The latter permits a shaft to turn without any contact with its support because both of them carry polar parts of the same sign. And on the other hand we already mentioned the saving of energy which would be allowed if the electromotors of the motors could be replaced by powerful permanent magnets.

The progress achieved in the past 15 years in the area of magnets can only accelerated a priori by resorting to space and to the control means it provides.

Metallurgical Experiments

The third laboratory is also at Grenoble, but it belongs to the Atomic Energy Commission.

Planned under the direction of Mr Malmejac, who is Head of the Metallurgy Department of the Center for Nuclear Studies, two experiments were of specific metallurgical nature, these experiments are set up within the framework of a vast research programmed directed towards the use of Spacelab, since--independently of their cooperation with the Soviets, the French are also to participate in the NASA socalled "Space Processing" programs known as Spar V, Spar VI and Spar VIII.

Two furnaces have been created for the first Spacelab mission, by the Germans (Dornier) and CNES /National Center for Space Studies/ respectively, the second furnace being designated as GHF "Gradient Heating Facility", in the ESA terminology.

As may be imagined, the GHF will consist of two elements:

--A multipurpose furnace weighing 17 kg. With a length of about 60 cm and a diameter of 18 cm, it has three heating elements so as to assure a rigidly controlled temperature inside the enclosure in which the containers are introduced; a pump maintains a pressure lower than 10^{-3}Torr. Let us not forget that, as far as the mathematicians are concerned, the term gradient has a very precise meaning: it indicates the spatial variations of a quantity, in this case the derivative of the temperature along the axis of abscissas, which will be that of the furnace enclosure, assumed to be perfectly cylindrical. In crystallogenesis, it is absolutely necessary to rely on walls for which we know that at each point, the temperature has a very determined value. In the initial project, a maximum temperature of 1250°C had been foreseen for the heating elements for a peak electric consumption of 800 W, and a gradient of 100°C/cm had been estimated. We know today we can do better.

--An electronic control block (42.5 x 26 cm x 21 cm) weighing approximately 15 kg meant for controlling the rise in temperature of the furnace, the subjection to imposed temperatures in the course of a process, and finally, cooling, the consideration of variations in time of the temperature representing another, no less important aspect of the problem.

The two ELMA experiments of the CEA (Atomic Energy Commission) of Grenoble are established in the context of preparation for the Spacelab missions. Their purpose is to study the solidification of aluminum, in which a little copper was added, and that of tin, in which a little lead was incorporated. For a long time, metallurgists have known the effects of these additions, they did not understand them properly, and especially they had poor control over them, probably because on the Earth's surface, the structures have a broadly random aspect, those obtained in the state of weightlessness show prospects of becoming models.

Solid State Chemistry

A last group concerns finally the experiments prepared at Bordeaux by the CNES Solid State Chemistry Laboratory, under the direction of Mr Paul Hagenmuller.

This laboratory carried out a special effort within the framework of a research program which was started about 10 years ago. It was indeed in 1969 that Mr Jean-Claude de Launay, a native of Brittany who had studied at the University of Rennes, joined this CNES Laboratory, in which he is today in charge of a program of space experiments related to problems of crystal production.

At first, the idea was to manufacture fine crystals for the internal requirements, since the Bordeaux Center has specialized in studies concerning the phenomenon of crystal growth, of which the extreme complexity was

estimated by the specialists. When there is a germ, that is a crystal to which other atoms are added, what are the factors which lead the new atoms to come and occupy certain sites rather than others?

Everything would no doubt be very simple if we were dealing with pure elements. But the requirements of electronics--and the Bordeaux Center is studying metal-insulator transitions--will require that doping agents, in rigidly determined amounts, should be added to certain substances, the performances of the crystal being dependent on the rigid control of the doping rate and also by the distribution of deposits which should be perfectly uniform.

So many reasons inducing Mr Jean-Claude Launay and his group to take interest in the working conditions offered in space, and discussions had already started with a view to the Bordeaux laboratory carrying out a possible experiment on board the Skylab. The initiative for this came from the Americans who at that time were seeking desperately over the world laboratories or research centers interested in "space processing."

Finally, concrete collaboration would be started with the Soviets on the occasion of a meeting, which was held, a few months after the completion of the Skylab flight, and when the Russians themselves were beginning to take great interest in the problem of processing of materials in space, in October 1974 in Kiev, a meeting in which the CNES was represented by Mr Pesanti, whose functions had previously consisted in studying these materials at Bretigny.

As we said, the ELMA program itself was decided at the meeting held in Leningrad in September 1976.

Transportation in Vapor Phase

Aside from the production of vanadium oxide crystals created in solution, the Bordeaux team proposed to study with ELMA 1 the growth of germanium single crystals in gravity-free conditions. It should be emphasized that this experiment of the CNRS at Bordeaux is the only one which in this ELMA 1 program concerns the growth of a crystal by transportation in vapor phase, whose interest is well known.

The traditional method was operating with "eutectics," the name of eutectic being given to the coexistence of the liquid and the solid phases, a little like a champagne bucket in which ice and water are found, while the proportion of liquid increases if heat is supplied to the system, while the consequence of heat absorption is the extension of the solid phase. This is a means which seems natural to create crystals. Since the body is brought above its liquefaction temperature, it is cooled slowly; if a crystal is introduced, it acts as a germ which will be enriched by the solidification of a liquid mass in contact with it.

But in gravity free conditions, there is another method consisting very simply in resorting to the Watt principle, called cold wall principle. In an enclosure containing a certain substance in the gaseous state, it is sufficient to introduce a cold part, which will be accomplished simply by lowering the temperature of a wall, and the body may solidify against this wall, a little like frost on the ground. One should a priori be able to obtain particularly fine crystals, because the atoms arrive in some way one after the other, without pushing each other about, if we were able to retain good working conditions, while these atoms come and occupy the 'places' assigned to them by the crystal already formed, by its structure.

The experiment had been tested on board the Skylab with the M 556 experiment which related to germanium compounds (germanium selenide and telluride). The Americans had observed that much finer crystals were obtained in space than on Earth, on condition of operating under very high pressure (the best results having been obtained using an argon atmosphere).

A Beginning

After the recovery, there will certainly be a very long study of the crystals: it is expected to last at least one year.

The researchers are contemplating already now an ELMA 2 operation which they have begun to prepare.

And whatever happens, it is agreed that the ELMA program is only a beginning. It is impossible to predict what materials will in the future be manufactured advantageously in space, or propose manufacture schedules. It is certain that the same principle will hold good in the science of materials as for biology: the very fact that work in space produces new conditions is fruitful. It is as at least a powerful work tool.

For the rest, the specialists are not wrong. It is characteristic that for most of the manned space flights, the Academies of Sciences of the countries concerned should have prepared a material processing program in space. Since the Salyut 6 was launched, up to now more than 70 experiments have been carried out using the Splav and Kristall furnaces. We had mentioned earlier the American projects. We know the Japanese projects...

The important question will be to define the operational technique, since the specialists are faced with a paradoxal situation to the extent that man's presence is highly desirable to start the experiments going, while it is perturbing in their execution, the most interesting satellite being, meanwhile the ultracompact satellite which would offer lowest differential and residual gravities.

So far as the French are concerned, the solution for the future is called Minos. We had given earlier (AIR ET COSMOS no 736) the broad lines of this project which would consist in creating a satellite especially designed for processing materials (in particular with an electric power of about 10 watts on board). It would be visited occasionally by a manned vehicle.

Since there is but one truth, the Soviets have an identical project, and this situation should very naturally induce pursuing the collaboration between France and the USSR in this area of material processing, a pursuit which could go very far if it was found that it provided a French astronaut with the opportunity of flying on board a manned Soviet spacecraft. Indeed the principle of a cooperation in this sense is fully established: the French have the capability of building Minos comparatively quickly, whereas they would no doubt require some time to acquire the manned craft permitting them to visit it. In these circumstances this Minos would have to be built by the French within the framework of a Franco-Soviet collaboration, while the Russians would provide the spacecraft to visit it.

All that seem simple. In theory....

9018
CSO: 3100

PHYSICS

UDC 621.373.826.038.823

INERT GAS HALIDE ELECTRON-BEAM CONTROLLED LASERS

Alma-Ata IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian
Vol 43, No 2, Feb 79 pp 239-245

[Article by N. G. Basov, L. A. Vasil'yev, V. N. Volchkov, V. A. Danilychev, O. M. Kerimov, A. I. Milanich, V. N. Lomakin, N. D. Ustinov and T. S. Khachapuridze, Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR]

[Text] Theoretical studies of the electroionization method of stimulation have shown the feasibility of attaining high efficiency (of the order of 50%) in lasers based on mixtures of inert gases with halides [Ref. 1, 2], which has attracted the attention of experimental workers to lasers of this type [Ref. 3-5].

In this paper an investigation is made of the energy, threshold and spectral characteristics of XeF, XeCl and KrF lasers, as well as discharge characteristics in mixtures of $Ar:Xe(Kr):NF_3(CCl_4)$. The gas mixtures were ionized by an electron beam with the following parameters: electron energy about 150 keV, average current density 3.5-6 $A \cdot cm^{-2}$, beam cross section 2.5×50 cm, beam current pulse duration at half height about 150 ns. The electron pulse generator design is analogous to that described in Ref. 6. A laser chamber with volume of the active medium of $2.5 \times 5.0 \times 2.3$ cm or about 300 cm^3 was evacuated to a pressure of about 10^{-3} mm Hg. The gases used in the experiments were Ar, Kr (with 1% Xe impurity), high-purity Xe, and NF_3 with 6% nitrogen impurity. The spectral measurements were done with an ISP-30 quartz prism spectrograph.

Shown in Fig. 1 are curves for the critical field E_{HD} (the maximum electric field strength where an electron beam will not initiate breakdown of the discharge gap) and the specific energy P_H corresponding to the given E_{HD} that is invested in the gas by the field, as functions of the concentration of NF_3 and the pressure of the mixture. It can be seen that E_{HD} and P_H are determined chiefly by the concentration of NF_3 and depend weakly on the pressure of the mixture. At fixed pressure and NF_3 concentration in the mixture greater than about $2 \cdot 10^{17}$ cm^{-3}, the specific energy P_H is practically constant and increases at a lower NF_3 concentration.

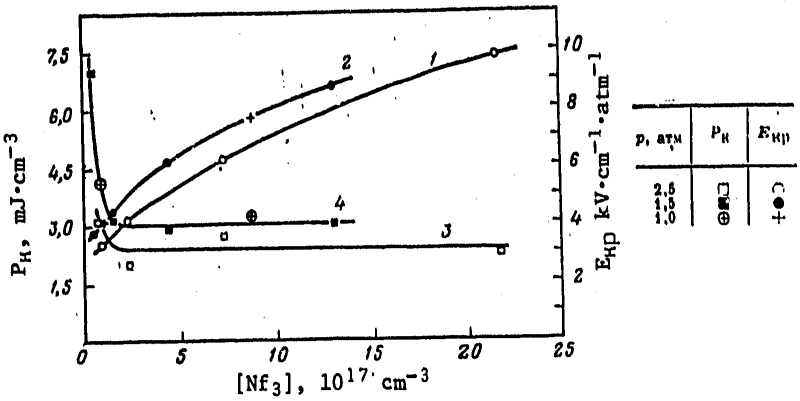


Fig. 1. Dependence of the critical field (1, 2) and specific energy (3, 4) on NF_3 concentration and pressure of the mixture. Beam current density j_e is 3.5 A·cm^{-2}, capacity about 6000 pF.

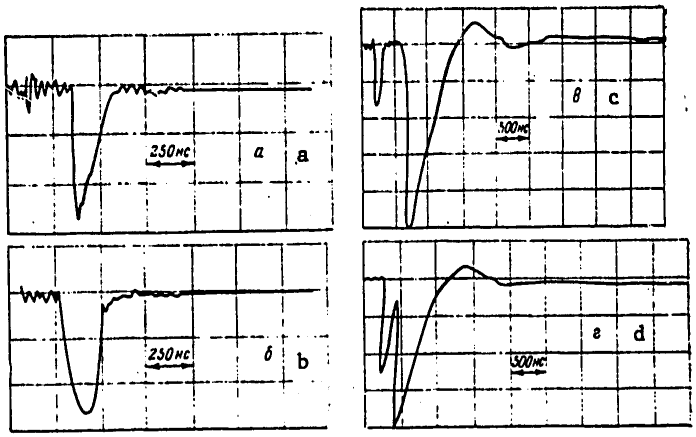


Fig. 2. Oscillograms of current of the beam (a) and discharge current (b-c): a--beam current density $j_e = 6$ A·cm^{-2}, b-d--mixture Ar:Xe:NF_3 = 1000:10:1, discharge voltage U ≈ 4 kV, 250 ns/div (b), ~6 kV, 5 μs/div (c), ~10.5 kV, 0.5 μa/div (d) [нс = ns]

For field strengths greater than E_{HP}, the discharge current pulse is followed by breakdown of the discharge gap (see Fig. 2c). The dependence of the breakdown delay time τ on the specific power invested in the gas from field Q_E is shown in Fig. 3. It can be seen that the delay τ decreases as Q_E

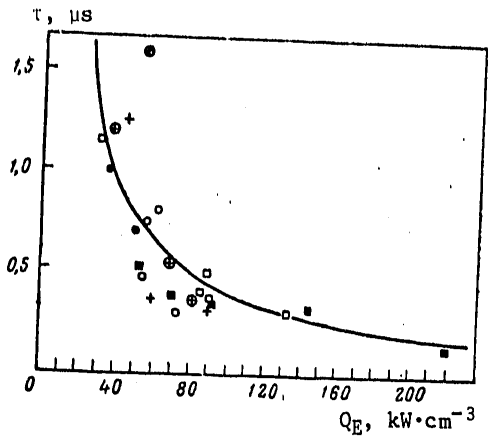


Fig. 3. Discharge gap breakdown time delay τ as a function of the specific power Q_E

Points	$[NF_3]$, 10^{17} cm^{-3}	p, atm	NF_3 : Xe : Ar
●	6,65	3,0	1 : 20 : 100
○	3,33	1,5	1 : 20 : 100
⊕	3,33	3,0	1 : 20 : 220
+	1,11	1	1 : 20 : 220
□	1,11	3,0	1 : 20 : 700
■	0,79	3,0	1 : 20 : 1000

increases. At a beam current density of 3.5 A·cm^{-2} breakdown set in after the current pulse throughout the entire range of investigated voltages, pressures and NF_3 concentrations. For a current density of 6 A·cm^{-2} breakdown begins to occur during the beam current pulse at a specific power greater than about 200 kW·cm^{-3}. In the investigated current density range of 3.5-6 A·cm^{-2}, NF_3 concentrations of 0.38-6.7·10^{17} cm^{-3} and pressures of 1-3 atm the dependence of τ on Q_E is extrapolated by the hyperbola $\tau Q_E \approx 0.04$ J·cm^{-3}.

Similar discharge current oscillograms for stronger than critical fields ($E_{кр} \approx 3$ kV cm^{-1} atm^{-1}, mixture of Ar:Xe:CCl_4 = 1500:50:1, $j_e \approx 6$ A·cm^{-2}, C = 0.28 μF) were also observed in a mixture containing CCl_4. However, in the case of mixtures that contain CCl_4 breakdown always developed on the trailing edge of the electron current pulse and with variation in electric field strength from $E_{кр}$ right up to the intensities of static breakdown, it shifted along the trailing edge of the current pulse. Thus the range of variation of τ for a mixture containing CCl_4 was ~100 ns.

The oscillogram in Fig. 2b shows that the discharge current nearly copies the beam current. Consequently there is a "pure sticking" state, and recombination of electrons can be disregarded. Then the discharge current density

can be calculated from the formula

$$j_p = env_{др} = \frac{j_e \frac{dE}{dx} p}{W[NF_3]} \frac{v_{др}}{c}, \quad (1)$$

where j_p and j_e are the discharge and beam current densities, e is the charge on the electron, n is electron concentration, $v_{др}$ is the electron drift velocity, dE/dx is the stopping power of Ar (about 6 kV cm^{-1}·atm for electrons with energy of 150 keV), p is the pressure of the mixture, W is the electron-ion pair production energy, $[NF_3]$ is the NF_3 concentration, and c is the constant of sticking of electrons to the NF_3 molecule.

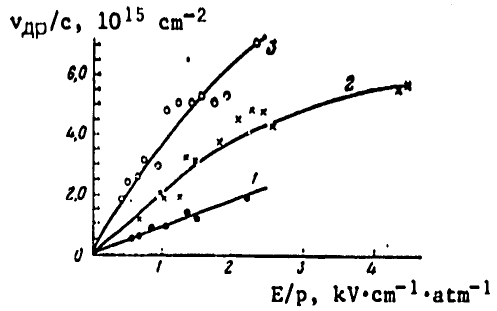
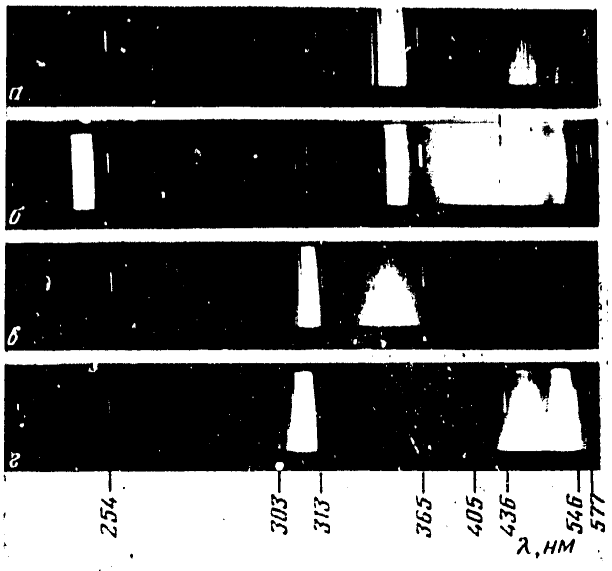


Fig. 4. Dependence of the ratio $v_{др}/c$ on E/p. The concentration of NF_3 (%): 1--0.097; 2--0.30; 3--0.72

By using the experimentally measured relation between discharge current and field strength E, pressure p, and formula (1), let us calculate the dependence of the ratio $v_{др}/c$ on E/p for different concentrations of NF_3 (see Fig. 4). As a result of inelastic collisions of electrons with the NF_3 molecule when the NF_3 concentration is increased for a given E/p, there is a shift in the electron distribution function into the lower energy region where the transport cross section in Ar is smaller [Ref. 7]. This leads in turn to an increase in the drift velocity of electrons. Extrapolating the dependence of $v_{др}/c$ on $[NF_3]$ to zero concentrations of NF_3, and taking the value $v_{др} \approx 4 \cdot 10^5$ $cm \cdot s^{-1}$ as the drift velocity of electrons in pure argon (E/p = 1 V·cm^{-1} $torr^{-1}$) [Ref. 7], we determine the constant of sticking of electrons to the NF_3 molecule: $c \approx 1.5 \cdot 10^{-9}$ $cm^3 \cdot s^{-1}$. The constant of sticking of electrons to the CCl_4 molecule was determined in an analogous way: $c \approx 3 \cdot 10^{-9}$ $cm^3 \cdot s^{-1}$.

In this paper an investigation was made of the spontaneous emission spectra of Ar:Xe(Kr):NF_3, Ar:Xe:CCl_4 and Xe:CCl_4 (see Fig. 5). In addition to previously known bands [Ref. 8, 9], two new wide bands were observed in the spectrum of mixtures of Ar:Xe:CCl_4 and Xe:CCl_4 with a maximum close to 350 and 500 nm. The 350 nm band is apparently related to the transition of



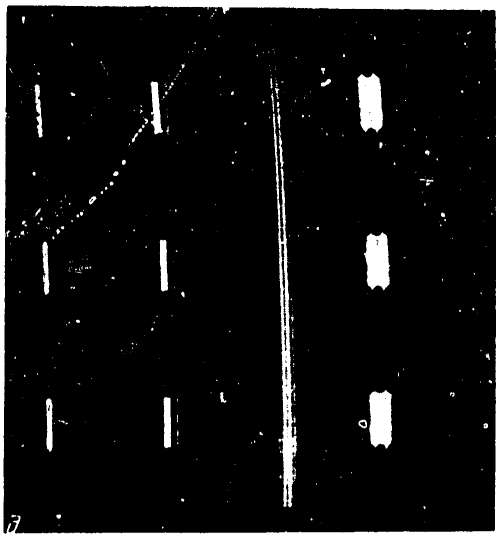


Fig. 5. Spectrograms of spontaneous (*а*, *б*, *в*, *г*) and laser (*д*) emission of mixtures:

а--mixture Ar:Xe:NF_3 =1000:10:1, p = 3 atm

б--mixture Ar:Kr:NF_3 =1000:10:1, p = 3 atm

в--mixture Ar:Xe:CCl_4 =1000:10:1, p = 3 atm

г--mixture Xe:CCl_4=1000:1, p = 1 atm

д--mixture Ar:Xe:CCl_4 =1500:50:1, p = 2 atm

XeCl molecules from the upper bound state ($^2\Sigma_{1/2}$) to the lower repulsive state ($^2\Pi_{1/2}$ or $^2\Pi_{3/2}$), while the 500 nm band is related to emission of the Xe_2Cl molecule. Superimposed on the 500 nm band are a large number of absorption lines. A dip close to 500 nm is observed on all spectra that is due to a drop in sensitivity of the RF-3 photographic film that was used.

Stimulated emission of the XeF electron-beam controlled laser ($\lambda = 353$ nm) was observed over a wide range of mixture compositions, pressures, discharge capacitor voltages and mirror reflectances. The optimum Ar:Xe:NF_3 mixture is close to 1000:10:1 (Fig. 6). Typical curves for the energy of XeF laser emission energy as a function of the discharge capacitor voltage are shown in Fig. 7.

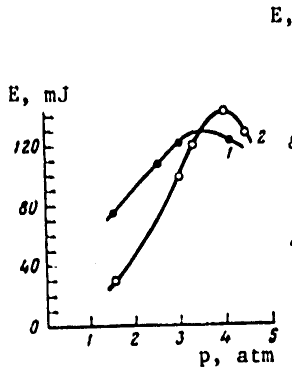


Fig. 6

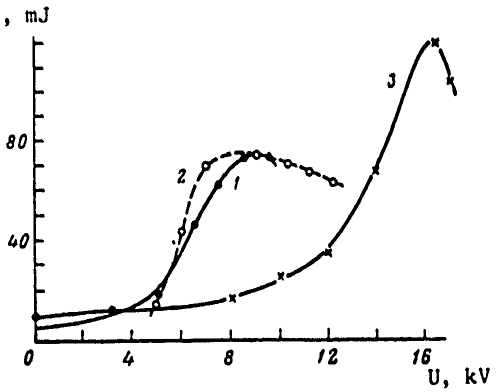


Fig. 7

Fig. 6. Dependence of emission energy E of the XeCl laser on pressure p: $j_e = 6$ A/cm^2, $C = 0.28$ μF, $R_1 = 57\%$, $R_2 = 98\%$. Mixture Ar:Xe:NF_3 = 1000:10:1 (curve 1), 2000:10:1 (curve 2)

Fig. 7. Dependence of emission energy of the XeCl laser on voltage U: mixture NF_3:Xe:Ar = 1:10:1000

Curve	p, atm	R_1, %	R_2, %
1	1.5	57	98
2	1.5	8	98
3	3.0	57	98

At a pressure of 1.5 atm and mirror reflectances of 98 and 57%, emission was initiated by pumping with a single electron beam ($E = 5$ mJ, $j_e = 6$ A·cm^{-2}, specific power invested in the gas from the beam $Q_e = 50$ kW·cm^{-3}). For voltages greater than 5 kV, a sharp increase in emission energy was observed due to saturation of the laser transition. The energy reduction in laser emission at voltages greater than 8-9 kV is associated with the fact that

the duration of the stable stage of the semi-self-maintained discharge (Fig. 2d) at these voltages becomes less than the duration of the beam current.

Substituting a quartz substrate (R = 8%) for the 57% mirror (see Fig. 6 curve 2) produced almost no change in the maximum value of energy for a pressure of 1.5 atm (for p = 3 atm the maximum energy was cut almost in half).

For a mixture of $Ar:Xe:NF_3 = 1000:10:1$ (p = 1.5 atm, $R_1 = 98\%$, $R_2 = 8\%$), the pumping power at which saturation of the laser transition was observed was 80 $kW \cdot cm^{-3}$. Since the amplification factor necessary for saturation of the laser transition during a pumping pulse is $2 \cdot 10^{-2}$ cm^{-1} (calculation according to Ref. 4), the efficiency of conversion of pumping energy to emission energy is

$$\eta = \frac{\alpha/\sigma\hbar\omega}{Q\tau} \approx 2{,}5\%$$

($\Delta N = \alpha/\sigma$ is inversion, $\hbar\omega$ is the quantum energy, $\sigma = 4 \cdot 10^{-16}$ cm^2 [Ref. 10] is the induced transition cross section, $\tau = 16$ ns is the lifetime of the upper laser level).

The maximum efficiency of the XeF laser was about 1.5% (mixture $Ar:Xe:NF_3 = 1000:10:1$, p = 1.5 atm). The maximum energy (power) of emission of the XeF laser is achieved at a pressure of 4 atm (mixture $Ar:Xe:NF_3 = 2000:10:1$, $E/p = 2$ $kV \cdot cm^{-1} \cdot atm^{-1}$, $Q_e = 150$ $kW \cdot cm^{-3}$, $Q_E = 230$ $kW \cdot cm^{-3}$), amounting to 0.14 J (about $3.5 \cdot 10^6$ W).

In contrast to the electron beam-controlled XeF laser, lasing on the KrF molecule ($\lambda = 249$ nm) in a mixture of $Ar:Kr:NF_3$ was observed in a narrow range of mixture compositions at a field strength close to that of static breakdown. The energy of laser emission for an optimum mixture of $Ar:Kr:NF_3 = 600:20:1$ was several mJ, the threshold pumping power for a pressure of 1.5 atm and mirror reflectances of 98 and 93% is about 200 kW/cc.

Just as for the XeF laser, stimulated emission on the XeCl molecule ($\lambda \approx 308$ nm, see Fig. 5) was observed over a wide range of mixture compositions, pressures and voltages. The emission spectrum shows six lines, the most intense ones having wavelengths of about 308.5 and about 308.2 nm. The distance between lines, equal to 0.20-0.26 nm, shows that the emission spectrum corresponds to transitions from the upper state ($^2\Sigma_{\frac{1}{2}}$) to different vibrational levels of the lower weakly bound state ($^2\Sigma^+_{\frac{1}{2}}$) [Ref. 9].

The optimum $Ar:Xe:CCl_4$ mixture is close to 1500:50:1. The maximum energy (power) of laser emission is 270 mJ (about $4 \cdot 10^6$ W) attained close to the voltages of static breakdown of the discharge gap (see Fig. 8). The oscillogram of laser emission (see Fig. 9) shows that transition to the mode of saturated gain at voltages greater than 9-10 kV (Fig. 8) is accompanied by the appearance of a spike on the lasing pulse that continues to grow as the

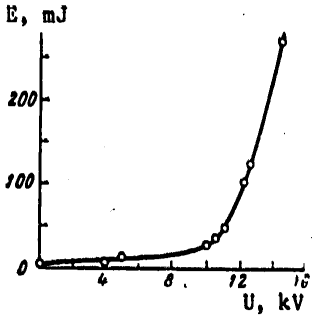


Fig. 8

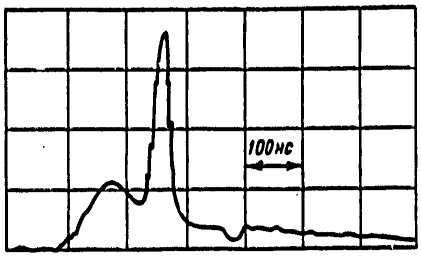


Fig. 9

Fig. 8. Dependence of the energy E of XeCl laser emission on voltage U: $j_e = 6$ A·cm^{-2}, $C = 0.28$ μF, $p = 2$ atm. Mixture Ar:Xe:CCl_4 = 1500:50:1
Fig. 9. Oscillogram of XeCl laser emission. Scanning 100 ns/div. The breaks on the pulse correspond to the axial period of the cavity $2L/C \approx 10$ ns

voltage increases. The threshold pumping power at which saturation of gain begins to take place was $Q = Q_e + Q_E = 70 + 100 = 170$ kW/cc. In contrast to the XeF laser, the emission energy of the XeCl laser rises with increasing voltage right up to the voltage of static breakdown of the discharge gap. This is because in the case of the XeCl laser breakdown takes place at practically the same time at all voltages, and therefore pumping is effective only on the leading edge of the pulse. The maximum efficiency is realized for a mixture of Ar:Xe:CCl_4 = 1500:50:1 ($p = 2$ atm) and is estimated at 4%.

REFERENCES

1. W. H. Long, APPL. PHYS. LETTS., Vol 31, p 393, 1977.

2. A. G. Molchanov, Yu. M. Popov, KVANTOVAYA ELEKTRONIKA, Vol 1, 1974, p 1122.

3. R. S. Bradford, W. B. Lacina, E. R. Ault, M. L. Bhaumik, OPTICS COMMUNS., Vol 18, 1976, p 210.

4. C. H. Fisher, R. E. Center, APPL. PHYS. LETTS., Vol 31, 1977, p 106.

5. Yu. I. Bychkov, N. V. Karlov, I. N. Konovalov, G. A. Mesyats, A. M. Prokhorov, V. F. Tarasenko, PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, Vol 3, No 20, 1977, p 987.

6. N. G. Basov, A. N. Brunin, V. A. Danilychev, O. M. Kerimov, A. I. Milanich, L. D. Khodkevich, PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, Vol 3, 1977, p 1297.

7. S. Braun, "Elementarnyye protsessy v plazme gazovogo razryada" [Elementary Processes in a Gas Discharge Plasma], Gosatomizdat, Moscow, 1961.

8. N. G. Basov, V. A. Danilychev, V. A. Dolgikh, O. M. Kerimov, V. S. Lebedev, A. G. Molchanov, PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 26, 1977, p 20.
I. A. Mangano, J. H. Jacob, M. Rokni, A. Hawryluk, APPL. PHYS. LETTS., Vol 31, 1977, p 26.
J. Tellinghuisen, G. C. Fisone, J. M. Hoffman, A. K. Bays, J. CHEM. PHYS., Vol 64, 1976, p 4796.

9. J. M. Hoffman, G. C. Tisone, A. K. Bays, J. CHEM. PHYS., 1976, p 2484.

10. M. Rokni, J. H. Jacob, J. A. Mangano, R. Brochu, APPL. PHYS. LETTS., Vol 30, 1977, p 457.

11. J. G. Eden, S. K. Searles, APPL. PHYS. LETTS., Vol 30, 1977, p 287.

6610
CSO: 8144/1228

SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

UDC 528.01/.06(047.31)

NEW DIRECTIONS IN THE WORK OF THE STATE GEODETIC SERVICE

Moscow GEODEZIYA I KARTOGRAFIYA in Russian No 3, 1979 pp 14-25

[Article by L. A. Kashin]

[Text] Noting the 60th Anniversary of the State Geodetic and Cartographic Service, the beginning of which was established by the decree "On an institution of the Higher Geodetic Administration," signed by V. I. Lenin on 15 March 1919, Soviet geodesists recall that the VGU was created to study the territory of the country in the topographic sense for purposes of raising and developing its productive forces. To accomplish this goal, the VGU, among the most important trends of activity, was entrusted with:

-- production and management of main geodetic work on a government scale;

-- combining and directing all types of survey work by eliminating parallelism;

-- organizing scientific investigations in the field of geodesy, astronomy, optics, cartography, instrument building and surveying in general.

These propositions of Lenin's decree have also not lost their significance at the present. They are of determining significance in the activity of the Main Administration of Geodesy and Cartography attached to the USSR Council of Ministers -- the legal successor of the Higher Geodetic Administration.

Enormous changes have occurred during the past 60 years in the development of science and technology. The scientific and technical revolution did not leave a single branch of science and technology untouched. It also had an enormous effect on the development of geodesy and cartography. Geodesists were one of the first to scientifically evaluate and practically utilize artificial earth satellites. As a result a new trend -- space geodesy -- appeared.

Surveys from space laid the basis for space cartography. In 1977 the Soviet Union read a communication at the United Nations Organization in which the desire was noted to place the advances of Soviet space science and technology in the field of remote sounding of the earth from space at the service of

the international association. According to this, readiness to cooperate with interested states in conducting space surveys of their territories was expressed. This cooperation has been expanded each year, especially with the socialist countries.

The GUGK [Main Administration of Geodesy and Cartography] was entrusted with the task of providing photographic surveys from space and the related cartographic work. TASS has frequently related in its communications the launches of artificial earth satellites of the "Kosmos" series, designed to investigate the earth's natural resources in the interests of different sector of the national economy of the USSR and of international cooperation. The information coming from the satellites is processed and utilized mainly to compile topical maps required by the most diverse sectors of the national economy and science. The significance of topical maps compiled from space photographs is enormous and it is difficult to overestimate it. The least investigated and most difficultly accessible areas of the Pamirs, the Arctic and the Antarctic can be mapped successfully from space survey materials.

Geodetic and topographical work is now being developed on the basis of extensive use of modern electrooptical light and radio range finders and aerophotographic and special types of surveys. Computer technology has been introduced especially widely into practical investigations. Geodetic and photogrammetric calculations based on the use of modern computers have achieved such a level that problems which quite recently were regarded as practically unrealistic are now being solved -- these are primarily strict mathematical processing of geodetic and photogrammetric plots which require joint solution of many thousands of normal equations. Because of the extensive use of computers, digital modeling of terrain has begun to be introduced into topographical work and problems of complete automation of map compilation are being solved. Information computer centers in which mathematicians, electronic engineers and so on are working successfully, besides specialists of geodetic profile, have been organized in the production enterprises of GUGK.

In the given article we consider two of a number of new trends in the activity of the Main Administration of Geodesy and Cartography, of important scientific and national economic significance -- these are study of deformations of the earth's crust by geodetic methods and mapping the continental shelf.

Studying the Deformations of the Earth's Crust by Geodetic Methods

Systematic high-precision astronomical-geodetic (triangulation, trilateration and polygonometric), levelling and gravimetric measurements and aerial photo surveys can make a significant contribution to the development of theory and in the future to organization of earthquake prediction. This problem corresponds to the main trend of modern geodesy, which has as its goal the study not only of the shape, dimensions and gravitational field of the earth, but also variation of them in time.

The problem of detecting earthquake precursors and subsequently of predicting them is one of the most complex scientific problems faced by mankind. This problem is complex and is not only of scientific, but also of social significance, since many seismically active regions are densely populated. The main and organizing role in solving it has been allocated to the USSR Academy of Sciences in our country. Scientists-geophysicists, seismologists, geologists, geodesists, originators of automated control systems and other specialists are participating in solution of this problem.

The scientific problems of geodesy related to study of earthquake precursors were solved and are being solved by conducting measurements on the earth's surface, but hypotheses on its inner structure, for example, the known theory of isostatic compensation developed in the mid-19th century, were also earlier taken into account to a specific degree in the theory of geodesy. Russian geodesists regarded the earth as early as the 19th century as a dynamic celestial body. In 1881 the Military Topographic Department of the Main Staff, confirming the program of geometric levelling, felt it was necessary to establish three-four special marks so that they could serve for further investigations of continental rises. As a result all high-precision levelling programs in the USSR were constructed with regard to problems of studying the vertical component of deformations of the earth's crust. Thus, the Second Geodetic Conference attached to Gosplan of the USSR, held in 1927 with the participation of such prominent scientists as Yu. M. Shokal'skiy, F. N. Krasovskiy, A. A. Mikhaylov and others, felt it was feasible in its decisions, "taking into account the great scientific interest and enormous practical importance of the existence of slow fluctuations of land, to recognize as timely study by repeated levellings of high accuracy and if possible by repeated triangulation work in those regions in which these motions may be regarded as previously established." The well-known geologist A. P. Gerasimov noted at this conference that the national economic importance of studying slow epeirogenic motions of land is great and that there is only one method of this study -- accurate geodetic investigations. On this basis, systematic repetition every 20-25 years is provided in all instructions on high-precision levelling of the territory of the USSR.

A broad front of work on repeated levelling was organized during the second half of the 1940's and is continuing at present. In 1977, the Main Administration of Geodesy and Cartography worked out a new program for development of a levelling network of the USSR prior to 1990 in which continuation of new and repetition of existing levelling lines, especially in seismic and the eastern regions of the country, is provided.

In 1970 the USSR Academy of Sciences, the Ministry of Geology of the USSR and the Main Administration of Geodesy and Cartography attached to the USSR Council of Ministers, with regard to problems of bringing order to construction in seismic regions, began organization of experimental geophysical (geodynamic) test areas in a number of cities (Tashkent, Alma-Ata, Frunze, Dushanbe and others) to observe deformations of the earth's crust, seismic activity and other geophysical phenomena for purposes of detecting possible earthquake precursors and to conduct additional investigations to improve

methods of seismic microregionalization. Since this time scientific and technical cooperation has begun to be developed between TsNIIGAiK [Central Scientific Research Institute of Geodesy, Aerial Surveying and Cartography], enterprises of GUGK and a number of institutes of the USSR Academy of Sciences and the academies of sciences of the union republics on study of deformations of the earth's crust. Vice-presidents of the USSR Academy of Sciences A. P. Vinogradov (deceased) and A. V. Sidorenko, academicians M. A. Sadovskiy and I. P. Gerasimov and corresponding members of the USSR Academy of Sciences Yu. D. Bulanzhe, V. A. Magnitskiy, A. F. Savarenskiy and S. L. Solov'yev devoted and are devoting a great deal of attention to problems of geodetic study of deformations of the earth's crust.

It should be especially emphasized that an "epoch" of geodetic data has been established in practically all seismic regions of the USSR due to implementation of the state program for development of a triangulation network of classes 1, 2 and 3 and of levelling test areas of classes I, II and III. Geodetic points with different density, secured to the terrain by centers and bench marks, cover a large part of the country. Thus, enormous territories are test areas on which various scientific-technical problems can be solved, including those on determining deformation of the earth's crust, especially after strong earthquakes, for example, such as those which have occurred during the past few years in Tashkent, Gazli, Dzhambul, Chilik and other locations. Repeated measurements carried out after earthquakes in state geodetic networks of higher classes revealed deformations of the earth's crust characterized by values from 50 mm at Tashkent to 1 m at Gazli. A significant contribution was made to study of modern motions of the earth's crust and to microseismoregionalization of the cities of Alma-Ata, Tashkent and others due to the geodetic investigations conducted by enterprises of GUGK in Central Asia, Southeastern Kazakhstan and on Kamchatka.

Study of deformations of the earth's crust by geodetic methods has now been organized in several tens of geodynamic and technogenic test areas located in many regions of the country. The Central Order of the Badge of Honor Scientific Research Institute of Geology, Aerial Surveying and Cartography imeni F. N. Krasovskiy is responsible for scientific-methodical management of geodetic work in the geodynamic test areas. Many production enterprises participate in the work. Some of them (Nos. 6, 12 and 2) conduct this work at a high scientific-technical level.

Development of methods of studying deformations of the earth's crust by geodetic methods is related to solving a number of organizational and scientific-technical problems. In organization of investigations, one must see that the required geodetic work is carried out after each earthquake with intensity of 4-5 points to determine the components of deformations by each of three axes of the spatial coordinate system used. Geodetic measurements, by characterizing quantitatively the deformations occurring on the earth's surface, can obviously make the greatest contribution at the given stage of development of science only to the general theory of earthquake origin.

Scientific investigations should be expanded at the institutes and enterprises of GUGK and cooperation should be developed with other scientific research organizations of the country, primarily with geophysical, seismological and geological institutes of the USSR Academy of Sciences and of the academies of sciences of the union republics. Scientific-technical cooperation on technogenic test areas should be developed primarily with organizations of the oil- and gas-producing industry, construction and operation of large hydroengineering installations. Hypotheses have recently been advanced that variation of the pressure caused by the mass of water of newly constructed large reservoirs or variation of pressure in the earth's interior due to oil and gas production in seismic regions, may be a cause of earthquakes.

Establishing extensive cooperation between specialists in the field of various earth sciences may produce the greatest effect in the study of the problem of earthquakes, since it will be carried out at the juncture of these sciences. Moreover, geodesists must rely on geological and geophysical data to study variation of the earth's parameters and of its gravitational field in time. The prominent Soviet geodesist Corresponding Member of the USSR Academy of Sciences F. N. Krasovskiy wrote as early as 1944 concerning this problem that there is no doubt of the importance of problems of physical geodesy both in the scientific and in the practical sense and, therefore, relationship and contact of the astronomer-geodesist with geophysicists and geologists are important in his scientific work. There are already examples of these relationships, but they are as yet inadequate and do not exhaust all the capabilities which the geological service of the country and academic science have at their disposal.

Space surveys have begun to be used extensively during the past few years for geodetic purposes, in addition to the developed high-precision astronomical-geodetic and levelling networks. Aerial space surveys may be a source of valuable information for seismological research as well. Thus, for example, a strong earthquake occurred on 2 November 1978 in the Alayskaya Valley of Central Asia. If one considers the typical points of the vertical velocity profile of motion of the earth's crust along the Andizhan-Osh repeated levelling line (Figure 1) and the space photograph of the Alayskaya Valley, one may note that the position of the points of variation of the direction of the velocities of the vertical deformation component coincides with the lines of geological faults in the earth's crust (Figure 2), interpreted from space materials.

The relative height variations of levelling bench marks of class 1 along the Andizhan -- Kara-Su -- Osh line, laid during the period from 1971 through 1978 in the seismically active region of the Alayskaya Valley, are shown in Figure 1. This repeat levelling 60 km long revealed a general rise with respect to Andizhan by an average of 30 mm in April 1977, which had changed to subsidence in May-June and continuing to October. A rise began anew in 1978 and the heights of the bench marks were close to the position which they had in 1971-1974. The fluctuation amplitude during 1 year comprised 40 $\pm$ 5 mm. The nonuniform vertical motions of the earth's crust in this region are distinctly followed in the graphs of Figure 1. The "peaks" which

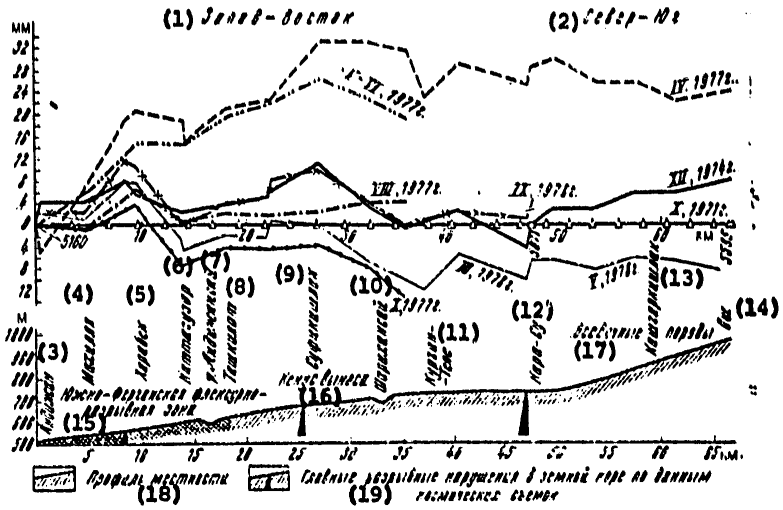


Figure 1. Graphs of Relative Height Variation Along Andizhan -- Kara-Su -- Osh Levelling Line of Class 1

KEY:

1. West-east
2. North-south
3. Andizhan
4. Makhallya
5. Kharabek
6. Kattaguzar
7. Andizhansay River
8. Tashkilot
9. Sufikishlak
10. Sharikhansay
11. Kurgan-Tele
12. Kara-Su
13. Kashgarkishlak
14. Osh
15. Southern Fergana flexure-fault zone
16. Alluvial fan
17. Sedimentary rock
18. Terrain profile
19. Main fault disturbances in the earth's crust from space survey data

retain their constant value and which characterize change of directions, correspond to locations of intersection of the levelling route by geological fault lines of the earth's crust. The western part of levelling passes through the Southern Fergana flexure-fault zone. Part of the Kara-Su -- Osh levelling route passes through a single tectonic block and is characterized by a general rise or subsidence of the entire group of bench marks. The nature of the modern vertical motions of the earth's crust determined from the results of levelling is in good agreement with data of geological interpretation of space surveys carried out at the State Center Priroda. The use of space survey materials permits one not only to refine the earth's geological structure, but also to plan geodetic investigations on a scientific basis.

Geomorphological analysis of repeat levelling shows that changes in the directions of vertical motions are in good agreement with the intersected morphological structures of the flat-lowland relief of the Alayskaya Valley. The typical points of the profile coincide with river beds, alluvial fans and constriction of valleys.

Thus, planning geodetic measurements to study deformations of the earth's crust on special geodynamic test areas and also high-precision geodetic triangulation and levelling networks in seismic regions of the country should be carried out on the basis of geological, geophysical and geomorphological data using space surveys.

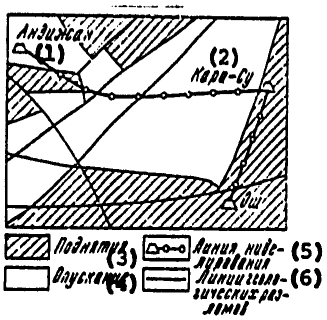


Figure 2. Diagram of Geological Faults Along the Andizhan -- Kara-Su -- Osh Line

KEY:

1. Andizhan
2. Kara-Su
3. Uplifts
4. Subsidence
5. Levelling line
6. Geological fault lines

An important scientific achievement in study of deformations of the earth's crust by repeat levelling methods is establishing a correlation relation between the rates of vertical motions of the earth's crust, terrain relief and its morphological structures. Moreover, the results of investigations carried out on geodynamic test areas of Kazakhstan confirm the hypothesis of Professor Yu. A. Meshcheryakov on the elastic nature of deformations occurring in the earth's crust, expressed by three types of motions α, β and γ. Determination of these principles may play an important role in geophysical interpretation of the results of geodetic measurements. It is also known that the vertical component of deformations of the earth's crust obtained from levelling cannot be separated from variation of the earth's gravitational field, since the geodetic heights during levelling are read from a level surface. Consequently, primary significance should be given in study of deformations of the earth's crust to high-precision gravimetric measurements, of course provided that the existing precision of gravimetric measurements should be increased by approximately an order.

Deformations of the earth's surface are characterized by rates which are calculated by dividing the differences of geodetically measured values of excesses or lengths of lines by the number of years which have passed between measurements. If one takes into account that even a slight increase in measurement accuracy is achieved by expenditures of a large amoung of labor and facilities, in most cases it is economically and technically feasible to increase the time interval between repeat measurements. And a twofold increase of accuracy compared to mean characteristics of existing geodetic plots of higher classes may also be achieved. Less accurate measurements, which served the reading epoch, will always yield a rather accurate result over a long time interval with the linear nature of deformations.

Unfortunately, geodetic methods of measurements are still hardly operative throughout the world. Therefore, when developing new methods and means of geodetic measurements to study deformations of the earth's crust and variation of the earth's parameters, one must strive to increase not only their accuracy but also their operative nature and also to reduce labor expenditures.

Under specific geological conditions (clearly marked tectonic disturbances and faults in the earth's crust), stationary seismological, geophysical and other investigations may be accompanied by geodetic measurements at permanently operating stations. However, plans for organizing these geodetic stations should be scientifically and technically substantiated by geologists and geophysicists and should be confirmed by the results of experimental work. Satellite and other methods of space geodesy may play an important role in global study of motions of large blocks of the earth's crust.

An important role should be allocated to organization of calculations; therefore, it is planned to create data banks which characterize deformations of the earth's crust over the entire territory of the country and of its large regions with automatic printout of the results in digital and graphical form for operative use of the stored information at the computer centers of GUGK.

The most complicated problem of modern geodesy -- study of time variation of the earth's parameters, closely related to study of deformations of the earth's crust and the problem of earthquake prediction -- can be solved successfully only through the combined efforts of scientific institutes and production enterprises of GUGK in close cooperation with institutes of the USSR Academy of Sciences and of the academies of sciences of the union republics and with the broad participation of scientists-geodesists of vuzes and other institutions of the country.

Mapping the Shelf

The significance of mineral-raw material and biological resources of the shelfs of the seas increases each year in economics.

The problem of efficient and effective use of the biological and mineral resources of the shelfs acquires especially important national economic and scientific significance at present, when a 200-mile fishing or economic zone has been established almost everywhere on the seas. In the Main trends of development of the national economy of the USSR for 1976-1980, adopted by the 25th CPSU Congress, it is planned to extensively organize geological prospecting work in the shelf zones of the seas and oceans of the USSR, primarily for oil and natural gas, and to develop the scientific bases for efficient use and protection of soils, interior, the plant and animal world, air and water basins and fishing in the coastal waters of the USSR.

It is known that the shelf zones of the seas are rich in organic and inorganic resources. Oil production on the Caspian shelf has for many years been a significant part of the oil-producing industry of our country. The biological resources of the sea will also acquire ever greater significance in time in the economics of many countries. Therefore, development of the shelf is a complex problem of state importance and scientific and economic justification of solving it must be provided.

The mining of mineral resources should be closely related to reproduction of the entire natural complex. A special position has been allocated in solving this problem to mapping the shelf and to topographic-geodetic support of mineral prospecting and mining and also to scientific research and conducting total management in utilization of the biological resources of the sea. State mapping of the USSR shelf was begun by the Main Administration of Geodesy and Cartography in 1974 in the interests of various sectors of the national economy and science. This year GUGK has begun to develop methods of topographic-geodetic investigations on the shelf. More than 50 organizations have reported their technical requirements on topographic-geodetic and cartographic materials for the shelf zones of the seas of the USSR. These materials were primarily required to carry out geological prospecting and geophysical work, to compile forecasts of mineral production, to construct and operate underwater and surface engineering installations, to organize and manage fishing and also to solve other national economic and scientific research problems. The need for mapping and topographic surveys not only of the shelf but of many large lakes, reservoirs and rivers was also determined. The latter is related to problems of land reclamation in the coastal zone of the Caspian, Black, Azov, Aral and other seas and to solving the problem of transferring part of the runoff of northern rivers to southern regions and to environmental protection measures.

A number of complex technical problems has arisen with regard to making topographic surveys and conducting geodetic work on the shelf, lakes and large reservoirs. Unlike navigation charts designed to provide navigation safety, topographic maps of the shelf should not only dependably report the topography of the sea bottom relief, but also its geomorphological structure, the nature of soils and the entire variety of biological resources. All engineering communications lines, including those covered by a layer of detritus, their characteristics and also other data must be shown on topographic maps of oil-producing regions.

It becomes obvious that the higher the information content of maps of the shelf, the greater their economic and scientific value. The problem of the information content of shelf maps is, we feel, the key question in the problem of topographic surveying of the shelf. It is known that the most informative are photographic charts, which may transmit very many details of the photographed surface, geological structure and morphological structure of the relief as a function of the resolution of the camera apparatus. Since it becomes important not only for science but also for practical purposes to known what processes occur on the underwater surface of the shelf due to the effect of natural forces and the activity of man, periodic repetition of surveys of the sea shelf and especially of large reservoirs and lakes is required.

As many specialists feel, development of the biological resources of the seas requires detailed and extensive study of the conditions of formation, distribution and time variation of biological and industrial productivity. Photographic maps may become a valuable production and scientific material for solving the problems indicated above.

Topographic surveying of water basins is a more complicated technical problem than surveying land areas, since the continental surface is located under a layer of water of different transparency and chemical composition. The work is complicated by the distance of surveying sites by tens and even hundreds of kilometers from the initial geodetic base and frequent wave action of the water surface.

With regard to the increasing national economic significance of the shelf and the technical difficulties of conducting topographic-geodetic work on it, problems of mapping it and geodetic support have now become an integral part of the overall scientific-technical problem of state significance -- study of the world ocean and its resources. The attention of many scientists and specialists has been attracted to developing methods and hardware for topographic surveying of the shelf and for creating a geodetic base on it. The Main Administration of Geodesy and Cartography has begun development of the technical requirements, means and methods of conducting surveys of underwater engineering communications, creation of a geodetic base for surveys and manufacture of photographic maps. This work is being conducted and specific positive results have already been obtained.

When solving problems of mapping the shelf, more than 1.5 centuries of experience and the scientific advances of the hydrographic service of the country and the cooperation of geodesists and cartographers with hydrographers are used extensively. Based on the fact that the natural morphological structures of the relief, the geological structure of the sea bottom and land and the communications lines connecting the sea to shore are continuous, while the shoreline is inconstant, the surface of the land and sea bottom on topographic charts can be depicted in a unified coordinate system and heights and in single cartographic projection. Gauss equatorial-cylindrical projection with standard nomenclature for the entire scalar series is used for topographic maps of the USSR shelf.

Based on study of the requirements of sectors of the national economy with regard to the future significance of shelf zones, it is feasible for state mapping of the shelf to be carried out on a scale of 1:25,000 and 1:50,000 for difficultly accessible regions of the Arctic seas with subsequent compilation of smaller scale charts in all cases. Regions of intensive development and exploitation of minerals must be mapped in larger scales. When planning and developing geodetic networks along the sea shores, high density of them and the possibility of geometric linking of the established points with the sea basin should be provided. The bottom relief on topographic maps of the shelf, unlike navigation charts, should be shown by contours rather than by isobaths. The cross-sectional height of the relief is established by contours, as on topographic maps of land areas, depending on the scale of the survey, the steepness of cliffs and the brokenness of the surface. The accuracy of surveys should be established mainly as a function of the scale of the created topographic maps and the cross-sectional height of the relief and also as a function of the instrument accuracy of the best of the instruments used to measure depths. When establishing criteria for surveying the sea bottom, the nature of the relief is divided by three geomorphological types: flat-lowland with angles of inclination up to 2°, dissected plains with angles of inclination from 2 to 6° and severely dissected plains, underwater mountains and ridges with angles of inclination of more than 6°.

Introduction of a unified system of heights in surveys of the shelf relief became possible as a result of advances achieved in development of high-precision levelling. Lines of this levelling are laid along the coasts of all seas of the country with accuracy of height transfer characterized by mean square error equal to 15-20 cm with respect to the initial beginning -- the level of the Baltic Sea.

Extensive investigations are being conducted at TsNIIGAiK and at enterprises of GUGK on increasing the information content of shelf maps and study of the technical requirements on them on the part of agency organizations and scientific institutions. For example, indication of the ice thickness, the heights of high and low tides, the velocities of bottom and wind currents from data of many years of observations and also the results of gravimetric and magnetic surveys and seismic profiling, is typical for topographic maps of the shelf. Detailed characteristics of the biological resources and engineering communications lines enrich the content of shelf maps. The data which cannot be depicted by means of cartography are presented in the form of information placed on the margins or the reverse side of the map. It is better if a topographic map is supplemented by a photographic map. Complete sets or individual photographs may now be attached as a supplement to the topographic map when many problems of remote sounding of the bottom surface through the water and air medium have not yet been resolved.

It is quite obvious that solving problems of mapping the shelf and even more so of creating photographic maps only by existing photographic hardware is practically impossible. Therefore, new highly efficient instruments, equipment and process flow diagrams must be developed which would permit a

significant increase of labor productivity and would yield qualitatively new data about the shelf. On this basis, investigations and development of hardware and methods of sonar surveying, which permits one to obtain a photographic image of the sea bottom, are primarily being carried out at GUGK. Space surveying in different bands of the spectrum and special types of aerial photosurveys are also being employed.

A side-looking sonar was developed in 1975 at TsNIIGAiK under the supervision of B. M. Malakhov and investigations were begun on developing a metric sonar. The problem of producing sonar photographs, which can be strictly mathematically converted to orthogonal projection and will serve as the input information for determining the heights of relief points and of underwater objects, has been posed. Introduction of sonars into topographic surveying of the shelf permits an increase of the distance between tacks and of obtaining photographic information about the sea bottom very important for geologists and other investigators. Sonar photographs obtained by experimental devices provide a clear picture of the geomorphological structure of the sea bottom and of underwater objects.

Figure 3

Sonar images of sections of the shelf are shown in Figures 3 and 4. The shapes of the relief and their geomorphological structure are clearly visible in Figure 3 and pipelines located under the layer of silt are visible in Figure 4.

Topographic maps of the shelf on a scale of 1:10,000 for individual sections of the Caspian Sea were compiled in 1976-1977 using sonar photographs. Besides the relief, all the underwater and surface objects: pipelines, boreholes, communications and electric power transmission lines, trestles, pile footings and so on and their characteristics are shown on these maps. The maps received high marks of petroleum workers. They contribute to an increase of the economic effectiveness of conducting planning and construction work and periodic inspections of communications lines during operation and serve a general state function -- protection of the natural resources of the sea. One can determine from these maps how the shelf is utilized and how efficiently and economically the industrial activity of enterprises is being accomplished on it.

Figure 4

A method of determining the coordinates of objects and also methods of converting sonar photographs to given projection and scale by using computers have been developed and tested for sonar surveying. An underwater pipe and cable finder has been created and a method of working with it has been developed at the Scientific Research Institute of Applied Geodesy for route surveys of engineering communications. This device has been used since 1975 in surveying underwater communications lines. The use of a laser depth gage installed on an aircraft or helicopter may be very promising for producing topographic surveys of the shelf. This, we feel, will produce a great economic effect. The problem of topical mapping of the shelf using space technology is being solved. Periodically repeated space surveying makes it possible to operatively observe rapidly changing objects of shallows and to follow the dynamics of development of the underwater relief, variation of the shoreline, to determine geological structures and so on. A method of interpreting space photographs of the water basins of the shelf by using opto-electronic image converters made by using four- and six-channel cameras (MKF-6), is being

developed. The bottom of shallows, the turbid debris cones of rivers and accumulations of zooplankton are usually easy to survey in the zone of 500-600 nm. Sounding in the infrared band of the spectrum permits one to determine sea currents and sections of pollution of the shelf by industrial discharges and other phenomena related to variations and sharp drops of temperatures.

For example, the dynamics of the shoreline in the northern part of the Caspian Sea for more than 100 years was determined from space photographs and materials of stored topographic surveys of the Corps of Military Topographers. Space photographs have already made it possible to obtain interesting scientific data on the shallow waters of Lake Baykal, Lake Issyk-Kul' and Lake Balkhash and the Caspian and Aral Seas. The problem is to expand the sphere of practical application of space surveys for purposes of mapping the relief.

The effectiveness of large-scale topographic surveys of the shelf is determined to a significant degree by the state of their navigation-geodetic support. In this regard new high-precision short-, medium- and long-range distance measuring systems both in ship and aircraft variants should be developed and existing ones should be improved.

Without determining the coordinates of objects and the location of investigations with the required accuracy, their practical value is frequently lost and the efforts of investigators and monetary funds are expended with low efficiency. A network of reference marine geodetic points, primarily in regions of future marine production areas, should be developed and created to facilitate orientation and determination of location on the open sea.

Development and introduction of automated systems for determining the coordinates of points of the shelf in any given time interval with printout of data on a board or punch tape for subsequent input into an automated coordinate graph, development of an automated instrument-technological short-range complex based on a radiogeodetic system and mobile self-contained underwater labor equipped with sonar photographing and geophysical devices, introduction of digital modeling with conversion of photographic images to a given digital form and reverse and introduction of interpretation of shelf photographs on the basis of electrooptical image conversions are provided in the plans of scientific research work to increase labor productivity in topographic surveys of the shelf. Solution of the posed problems, based on extensive use of computer technology, is already yielding positive results. Photographs of the sea bottom obtained from automated underwater apparatus are presented in Figures 5 and 6. These detailed photographs permit an increase of the information content of shelf maps.

With regard to economic development of the shelf, it has become necessary to provide engineering-geological support in solving such problems as laying underwater communications lines in a given direction, determining the parameters of pipes and the depth of their laying in the soil by the contactless method, sighting floating drill rigs at the mouth of wells located at great

depths, finding and determining the location of underwater structures, pipes and cables, the precise position of which was unknown for some reason.

Figure 5

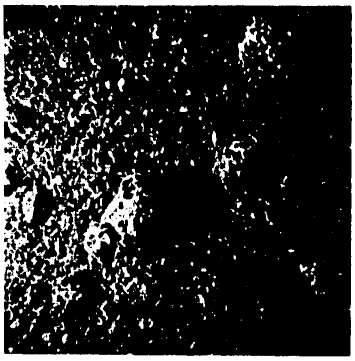


Figure 6

The practice of organizing surveys of the shelf showed that all available material, especially hydrographic surveys, primarily should be studied prior to conducting survey work. Their use permits a reduction and in some cases complete elimination of marine operations. Organization of information about cartographic support and study of the shelf is acquiring ever greater significance. The problem of a normative base is also important. The regulating factor in topographic surveying of the shelf is the normative base created by the Main Administration of Navigation and Oceanography. But refinement and expansion of part of the normative documents concerning means and methods

of topographic-geodetic work and also the legends of topographic maps whose information content should be expanded, is necessary with regard to the specifics of the organizing system of enterprises of GUGK and the requirement of complex topographic and cartographic study of the shelf. Further deepening and improvement of coordinating scientific research work and production activity on mapping the shelf between all interested organizations and primarily between GUGK and GUNiO [expansion unknown] are also required.

Many enterprises and TsNIIGAiK of GUGK have already accumulated specific experience in topographic-geodetic work on the shelfs of the Baltic, Caspian, Black, Okhotsk and other seas. Study and generalization of it is one of the most important problems. But main attention should be directed primarily toward equipping the production of topographic maps of the shelf with modern equipment, complete automation of it and increasing the information content of maps.

6521
CSO: 1870

PUBLICATIONS

DEEP SEISMIC SOUNDING OF KAMCHATKA

Moscow GLUBINNOYE SEYSMICHESKOYE ZONDIROVANIYE KAMCHATKI in Russian 1978 signed to press 23 Aug 78 pp 2-6, 130

[Annotation, introduction and table of contents from book by G. I. Anosov, S. K. Bikkenina, A. A. Popov et al., Izdatel'stvo "Nauka", 800 copies, 132 pages]

[Text] Deep seismic sounding (DSS) data acquired in the central and southern parts of the Kamchatka Peninsula by the Sakhalin Complex Scientific Research Institute in conjunction with the Institute of Volcanology of the Far-Eastern Scientific Research Center of the USSR Academy of Sciences in 1970-1972 are analyzed. The characteristics of the deep structure of the different geostructures of Kamchatka are established based on the complex geological-geophysical interpretation of the results of DSS, in particular, the regions of recent volcanism. Ideas on the possible conditions of formation and localization of the magma chambers and also on the characteristics of the structure of the joining zone of the continental and oceanic lithospheric blocks in the area of southern Kamchatka are presented. Questions connected with the nature and structure of the Mohorovicic discontinuity under volcanoes are also covered in the report.

Introduction

Among the basic problems placed before soviet geologists by resolution of the 25th CPSU Congress an expanded study of the earth's crust and upper mantle in order to form a concept of the processes of formation and rules of distribution of deposits of useful minerals was specified. In terms of the primary target of investigations in the Far East, one should examine the zone where the Asiatic continent and Pacific Ocean join, which is characterized by a rare diversity of processes forming and transforming the earth's crust and its mineral resources.

Kamchatka and the adjoining parts of the Pacific Ocean, apparently fragments of a joining zone have unique peculiarities due to a complex combination of the various geological structures: island arcs, deep-sea trenches, young and old folded structures, volcanic belts and others. It is scarcely

necessary to prove that the study of these structures and the processes which occur in them are of obvious theoretical interest and have great practical significance. It is also fully apparent that investigations of the earth's depths is impossible without the use of geophysics, primarily seismic methods.

Currently, a large quantity of geological-geophysical data along the northwest sector of the juncture of the Asiatic continent and Pacific Ocean, permitting determination of the main boundaries of its structure, has been accumulated and analyzed. In many ways, deep-seismic sounding (DSS) studies which partially covered Kamchatka contributed to this.

Until the carrying out of DSS, information on the deep structure of the earth's crust of Kamchatka in the regional project was based on the results of the interpretation of small-scale gravimetric surveys and detailed seismological observations, and the tectonic zonation of the territory was primarily based on field-geology data and, to some extent, on the analysis of the structures of magnetic and gravitational fields. The latter also aroused interest in the study of the deep structure of volcanoes and their clusters.

By the time the DSS was laid out, the general structural layout of the peninsula, comprising a system of interdependent, variously-aged anticlinoria and synclinoria and superimposed young volcanic fields, was well known. However, the relationship of these structural elements with the deep structure of the crust remained unclear. Therefore the laying out of the DSS was a necessary step in the investigation of the deep structure of Kamchatka and the character of its juncture with the structures of the adjoining parts of the Pacific Ocean. Special attention was devoted to the resolution of the following basic questions:

1) examination of the general structure and character of the juncture of the oceanic and continental blocks of the crust (in particular, a study of the deep fracture tectonics and its role in the structure of the region);

2) determination of the nature of the basic seismic discontinuities in the crust (primarily the roof and foot of the consolidated crust) and the true composition of the discrete layers;

3) establishment of the features of the deep tectonics of the zones of active volcanism, including determination of the location of magma chambers.

Resolution of the enumerated questions, besides theoretical significance, has significant practical interest, since it allows us: a) to obtain more accurate information on the problem of the forming of the Kamchatka geosyncline and the character of its basement; b) to obtain a basis for the quantitative interpretation of the different geophysical fields; c) to examine the migration path of the magma to the day surface, and also the types and depths of occurrence of the magma chambers.

Studies by DSS began in Kamchatka in 1970 by the joint efforts of the Sakhalin Complex Scientific Research Institute and the Institute of Volcanology of the

Far-Eastern Scientific-Research Center of the USSR Academy of Sciences. At the present time more than 1000 km of DSS profiles have been carried out (Fig. 1). One of them (I, II, III) was located in the central part of Kamchatka and traverses the structures of the Sredinniy and Kozyrevskiy ridges, the central Kamchatka depression and the Klyuchevskiy cluster of volcanoes. Other (IV, V) are located in the southern and in the southeastern parts of the peninsula and are traced across the Ganal'skiy shelf of metamorphic rocks, the Malkinskiy-Petropavlovskiy zone of transverse dislocations and the Avachinskiy cluster of volcanoes. A land-sea profile (VI) goes out into the ocean and traverses the structures of the deep-sea trenches.

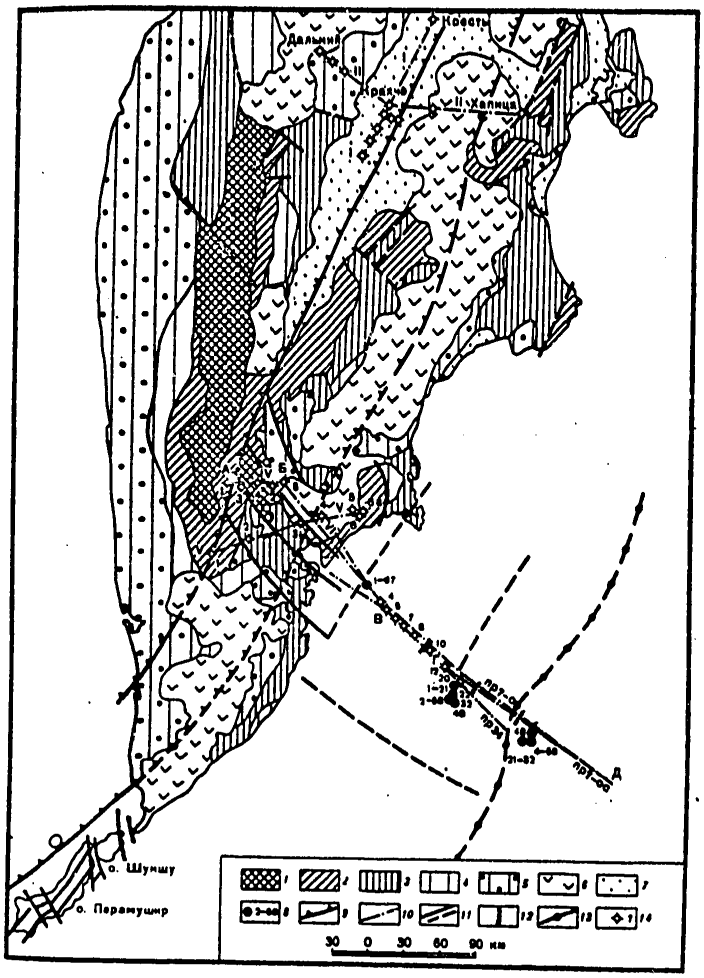


Figure 1.
Structural tectonic map of the investigated area.
1-shelves of metamorphic base;
2-5-sedimentation:
2-upper Cretaceous,
3-Paleogene-Miocene,
4-Paleogene;
5-Miocene-Pliocene;
6-Quaternary volcanic formations;
7-Quaternary non-volcanic formations;
8-sea stations in the DSS profiles;
9-major deep fractures;
10-lines of the profiles;
11-remaining fractures;
12-fractures distinguished by DSS data;
13-axis of the Kurile-Kamchatka deep-sea trench;
14-sites of detonations.
Profile III is not drawn, the line of observation coincides with profile I.

During the seismic experiment, analyses of the data, their interpretation and writing of the monograph, the authors made use of consultations and advice from I. P. Kosminskiy, V. B. Sollogubа, N. I. Pavlenkova, N. I. Davydova, P. S. Veytsman, S. M. Evereva. We would especially like to mention Yu. V. Tulinu, and V. I. Myachkina, who contributed to the success not only by their valuable advice but also by courteously putting under the management of the authors the seismic material along the sea portion of profile VI.

P. V. Portnyagina, Yu. A. Pavlov, V. V. Soinov, S. V. Veselov, coworkers of the laboratory of gravimetry and geothermy of the Sakhalin Complex Scientific Research Institute, were of great help in this study. They performed the calculations of the density and geothermal models. Consultations with A. A. Andreyev, L. N. Poplavskiy, P. M. Sychev, R. Z. Tarakanov and I. K. Tuyezov were very valuable.

Acquisition of the high-quality experimental data in the extremely difficult natural conditions of Kamchatka would have been impossible without the selfless work of the operators, technicians and scientific coworkers of the Kamchatka expedition: V. V. Argentov, S. T. Balesta, V. M. Zhil'tsov, A. M. Shkurchenko-Velichko, V. P. Yefimov, N. G. Paliya, O. I. Shishov, V. P. Yeremin, A. I. Nekrasov, T. S. Loskutova, V. I. Panin, A. V. Smirnov, V. P. Pasechko, I. N. Korchagin, Kim San Sechi, G. F. Zanyukova, L. M. Radetska and others.

These studies would not have been successful conducted without the constant attention and active support of the supervisor of the Sakhalin Complex Scientific Research Institute and Institute of Volcanology of the USSR Academy of Sciences, S. L. Solov'yev and S. A. Fedotov.

The authors express their deepest thanks to all the people mentioned. They are especially grateful to Academician A. L. Yanshin, who made a series of valuable critical comments.

Table of Contents

9351
CSO: 1870

PUBLICATIONS

RADIO TRANSMITTING EQUIPMENT

Moscow RADIOPEREDAYUSHCHIYE USTROYSTVA. CHAST' II: UCHEB. (PROGRAMMIROVANNOYE) POSOBIYE DLYA TEKHNIKUMOV (Radio Transmitting Equipment. Part II: A Programmed Textbook for Technical Colleges) in Russian 1978, signed to press 28 Mar 78 pp 2-5

[Annotation and table of contents from book by Oleg Leonidovich Murav'yev, Izdatel'stvo Svyaz', 32,000 copies, 312 pages]

[Text] This book covers the second part of the "Radio Transmitting Equipment" course. Discussed are amplitude, angular and other types of modulation; keying; questions relating to work safety procedures; and technical characteristics, circuitry and design features of typical radio transmitting equipment for the longwave, mediumwave, shortwave and ultrashortwave bands.

This book is intended for group or individual study by students at technical colleges with a combined program and is furnished with tests on three levels. This book can be used in combination with testing and training equipment.

Contents Page

8831
CSO: 1870

PUBLICATIONS

TABLE OF CONTENTS FROM SOVIET PHYSICS JOURNAL

Alma-Ata IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian
Vol 43, No 2, Feb 79 pp 439-440

[Text] Table of Contents

Materials of the Ninth All-Union Conference on Coherent and Nonlinear Optics

6610
CSO: 8144/1228

END