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Stuart G. Hibben
Tel: (301) 770-3000 or
(301) 779-2850
Program Manager:
Klaus Liebhold
Tel: (301) 770-3000
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informatics inc
Systems and Services Company
6000 Executive Boulevard
Rockville, Maryland 20852
(301) 770-3000 Telex 89-521

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13. ABSTRACT

This report includes abstracts and bibliographic lists on contractual subjects that were completed in February, 1973. The major topics are: laser technology, effects of strong explosions, geosciences, particle beams, and material sciences. A section on biocybernetics and one on items of miscellaneous interest are included as optional topics.

Laser coverage is generally limited to high power effects; all current laser material is routinely entered in the quarterly laser bibliographies.

An index identifying source abbreviations and a first-author index to the abstracts are appended.

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TABLE OF CONTENTS

1. Laser Technology

A. Abstracts

Anan'in, O. B., Yu. A. Bykovskiy, N. N. Degtyarenko, Yu. P. Kozyrev, S. M. Sil'nov, and B. Yu. Sharkov. Obtaining C and Al nuclei in a laser source of multicharged ions. ZhETF P, v. 16, no. 10, 1972, 543-548.

This work is an extension of earlier spectrographic studies by the authors (Effects of High Power Lasers, December 1971, 32) on laser stripping of various metal atoms. A neodymium laser was again used developing 10-15 ns pulses at a density of 5×10^{13} w/cm^2; in the present case Al and C targets were used. The spectrographic equipment used yielded a clear resolution of highly-charged levels up through Al^{+13}. Fig. 1 gives the

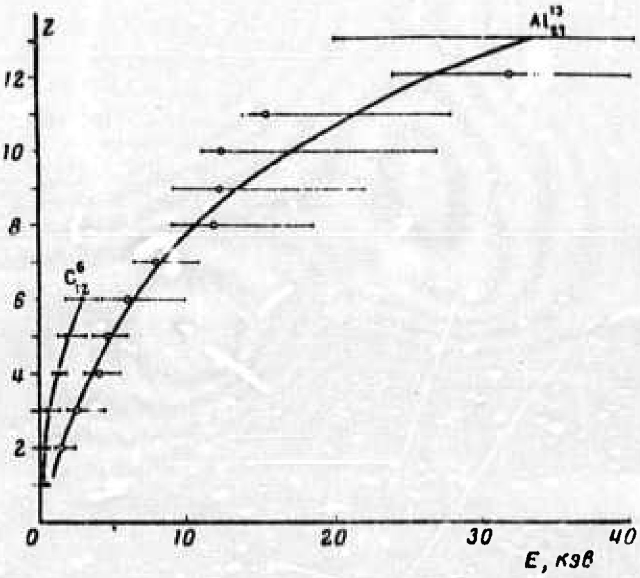


Fig. 1. Energy maxima for laser-ionized Al^{+13}_{27} and C^{+6}_{12}

distribution of energy maxima obtained for Al and C; for Al^{+13} the spread is seen to be from 18 to 50 kev. The integral number of registered ions N(z) is given in Fig. 2; data show that the Al^{+13} portion was about 10^6 ions, with

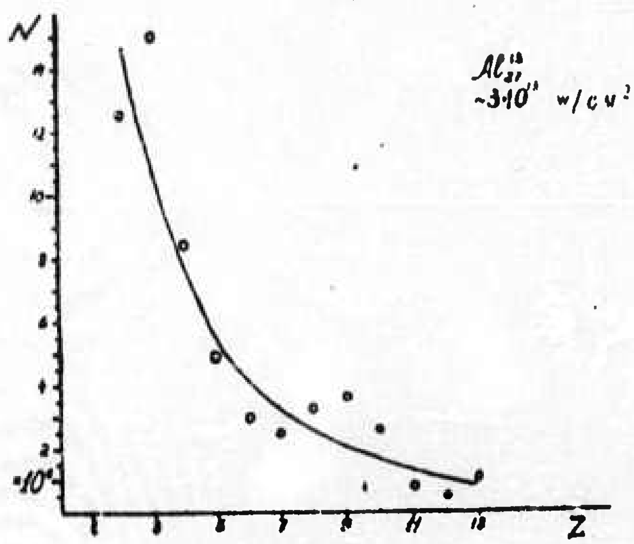


Fig. 2. Total ions per pulse recorded from Al. Detector aperture = 5×10^{-7} rad.

singly-charged ions an order of magnitude greater. Assuming an isotropic dispersion of singly-charged ions, the authors extrapolate the measured data to arrive at a figure of 10^{14} for total emitted plasma ions. The total number of ejected atoms, calculated from crater volume, was put at 10^{18}; hence the relative ion yield was on the order of 10^{-4}, which agrees with earlier findings by Bykovskiy et al (ZhETF P, v. 15, 1972, 308).

Mirkin, L. I. Production of oriented structures on metal surfaces by laser beam. DAN SSSR, v. 206, no. 6, 1972, 1339-1341.

Experiments in producing strongly oriented surface structures on various metals by laser beam heating are briefly described. Tests have established that laser heating can generate temperature rises on the order of

10^{10} deg/sec, with subsequent cooling at 10^6 deg/sec in metals or other opaque materials; the author examines the resulting surface anisotropy in several materials including steel, nickel, nickel iron and some refractory carbides. Tests were run with an Nd glass laser at 1 millisecond pulses, using various degrees of spot defocusing. The resulting crystal structure and surface texture were measured by radiography and metallography as well as photography of the treated areas.

All measurement techniques confirm a strongly oriented surface structure following laser exposure. An example cited is for nickel, which prior to irradiation showed a normal intensity distribution in radiographs, e.g. the (111) and (200) line intensities were in a ratio of 3:1, whereas following exposure the (111) line dropped by a factor of 100 or more while the (200) line was practically unchanged. Figs. 1 and 2 show radiograms of exposed specimens; Fig 3 shows surface grain structure of an exposed nickel iron alloy. It was

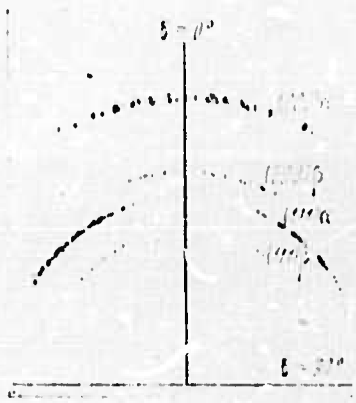


Fig. 1. Radiogram of Ni surface after laser irradiation.

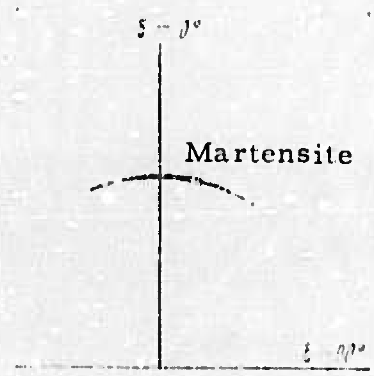
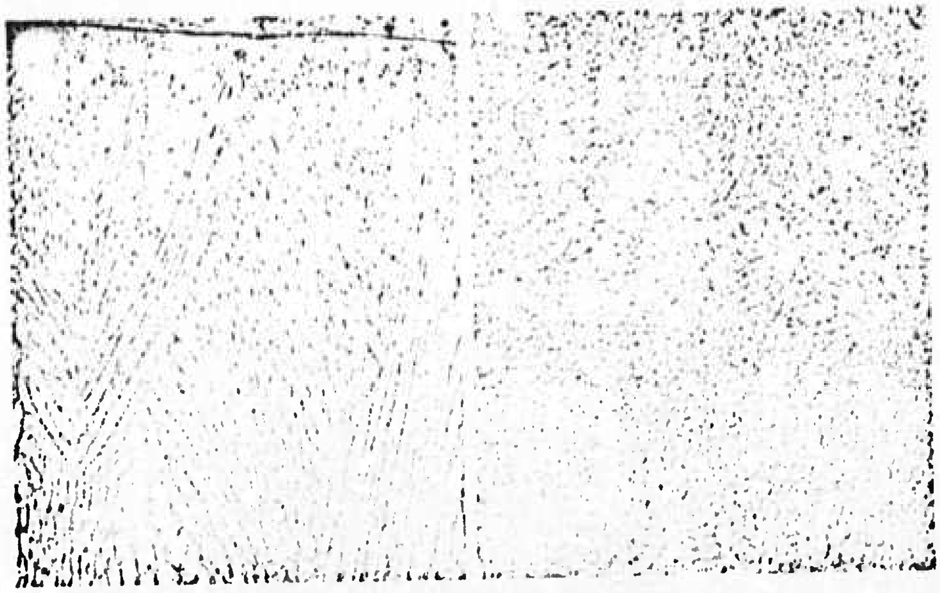


Fig. 2. Radiogram of Ni-iron alloy after laser exposure and cooling in liquid nitrogen.



a b

Fig. 3. Microphoto of fused area in Ni-iron alloy, x900. a - section along beam path; b - normal to beam path.

also observed that the most pronounced orientation effect occurred in single-phase materials, where the number of crystallization centers is relatively low.

Golodenko, N. N., and V. M. Kuz'michev. Pulsed laser heating and vaporization of metals. Radiotekhnika (Khar'kov), no. 23, 1972, 139-142.

This is a condensed version of the same study reported earlier by these authors (January 1973 Report, p. 1). Heating characteristics are analyzed of a metal surface exposed to laser pulses on the order of 10^5 w/cm^2 or greater; the idealized model of the earlier report is again used. The laser effect is treated in two stages: a heat-up or lag stage with absorption but no vaporization, followed by an abrupt start of vaporization and rapid propagation of the temperature field into the surrounding target material. The fraction of energy absorbed in the target area is then expressed by $\epsilon = \frac{\Delta t}{t_o}$ where Δt is the lag time and t_o is laser pulse duration. Fig. 1. shows ε as a function

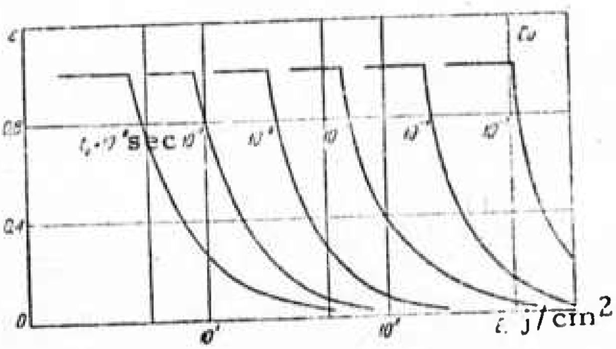


Fig. 1. Fraction of energy absorbed vs. t_o and energy density.

of t_o and energy density for a copper target. Characteristics of surface boundary motion, temperature and lag time are given in Fig. 2 as functions of laser power density, also for copper.

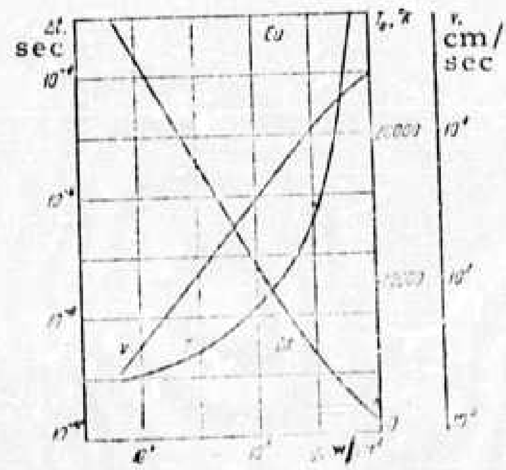


Fig. 2. Boundary velocity, temperature and lag time vs. power density.

Kondrat'yev, V. N. Vaporization from interaction of powerful energy sources with a material. ZhPMTF, no. 5, 1972, 49-57.

An extended analysis is given of heating effects of a concentrated high-energy beam on a solid surface. The specific aim is to correlate the conditions for surface vaporization with those for internal vaporization, since each of these has been claimed by various authors to be the predominant mechanism in laser beam-target studies. The model assumes a constant flux q_r^o impacting a surface and attenuating with penetration, as given by

$$q_r = q_r^0 (1 - K_r) \exp [- (x - x_v)/l_0] \tag{1}$$

where q_r = beam flux density at depth x; x_v = the vaporization boundary; K_r = mean coefficient of reflection of incident flux; and l_o is the characteristic depth of energy release in the solid. A quasistationary case is considered, in which all reflection is assumed to be from the solid face.

The model is analyzed in terms of a vaporization wave which proceeds inward from the impact area typically at a subsonic velocity. Characteristic temperature curves for fusion and vaporization of Al, Cu and Pb are derived on this basis. The correlation of surface to internal vaporization may be seen in Fig. 1 for these metals in terms of q_r^o (l_o), calculated for both stationary and fluctuating bubble formation.

A further examination shows that for target materials with relatively great depths of l_o, the presence of stationary bubbles will accelerate the transition from surface to internal vaporization. However for opaque bodies such as metals the bubble presence would appear to have a negligible effect on transition. Based on the cited model, the transition intensities

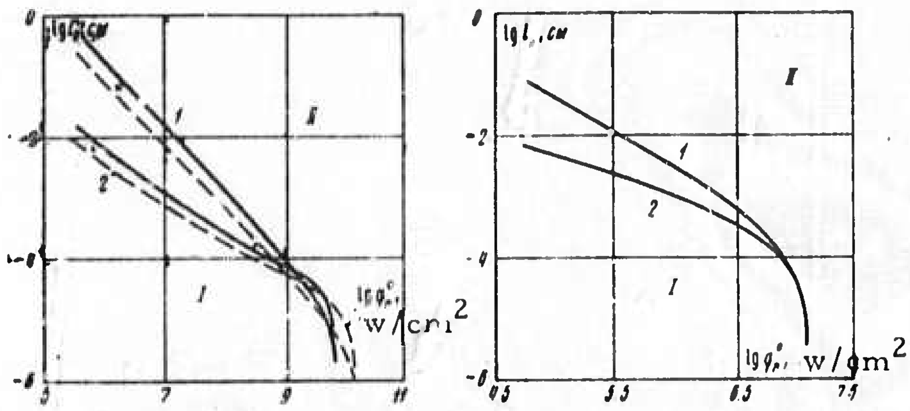


Fig. 1. Incident flux density vs. depth of energy release.
a) Al, Cu (dashes); b) Pb.
1 - fluctuating bubbles; 2 - stationary; I - surface vaporization region; II - internal vaporization region.

for Al, Cu and Pb are given respectively as 5×10^9, 3×10^9 and 10^7 w/cm^2.

Rarov, N. N., A. A. Uglov, and I. V. Zuyev. <u>Effect of heat source parameters on the depth and size of surface deformation in the liquid phase.</u> DAN SSSR, v. 207, no. 1, 1972, 83-85.

The theoretical case of liquid phase formation on a laser- or electron beam-irradiated target surface is analyzed briefly. The treatment is limited to surface intensities sufficient to generate deformation in the liquid phase owing to local vapor pressure and thermal gradients; it is further assumed that beam penetration is negligible in comparison to dimensions of the melt zone. Liquid phase deformation can then be determined using the Navier-Stokes system

$$\frac{\partial v}{\partial \tau} + (v\nabla)v = -\frac{1}{\rho}\nabla P + \nu\Delta v + g + F_s, \qquad (1)$$

where v = particle velocity and p = pressure in the liquid phase, ν = viscosity, g = internal force vector, and F_s = surface force vector. Eq. (1) together with equations for energy balance, discontinuity and mass conservation, are sufficient to define fully the surface deformation in the liquid phase. For ease of solution v = const is assumed in Eq. (1). Two general cases are solved in terms of the characteristic dimension Z of the melt zone, namely for small deformation, $(Z')^2 \ll 1$, and large deformation, $(Z')^2 \gg 1$. Limitations imposed by the assumed simplifications are emphasized in conclusion.

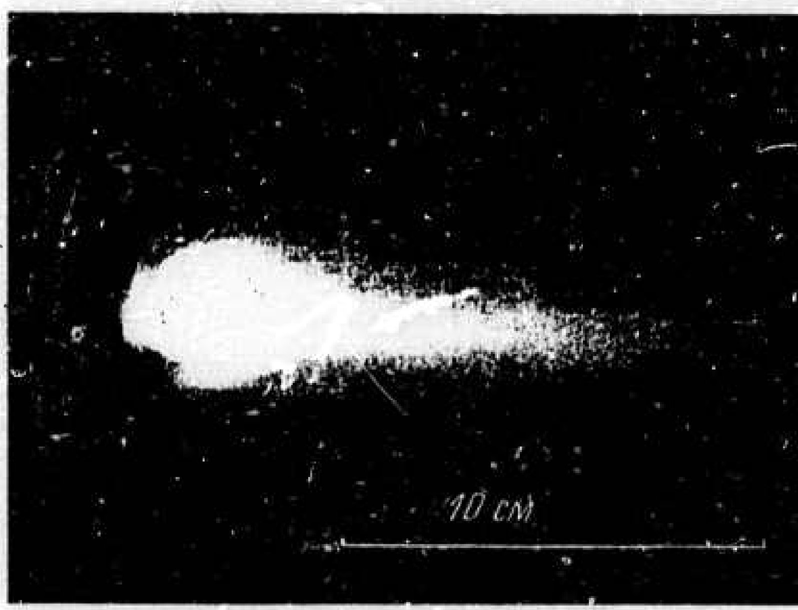
Gerasimov, B. P. Effect of laser beam scattering and absorption on strong shock wave structure. IN: Trudy Konferentsii Moskovskogo fiz.-tekhnicheskogo instituta, 1970. Seriya Aerofizicheskaya. Prikladnaya matematika, Moskva, 1971, 14-24. (RZhF, 9/72, no. 9D934)(Translation)

The structure is studied of shock waves generated in a volatile explosion cloud from the effect of powerful radiant flux on a solid. Calculations are based on gas dynamic equations for an ideal gas with a constant heat capacity in a one-dimensional plane approximation, with allowance for gas radiative heat transfer in the presence of scattering.

Results show that laser radiation scattering not only increases the radiant flux deflected from the shock wave front but also substantially affects the radiation field within the wave.

Batanov, V. A., F. V. Bunkin, A. M. Prokhorov, and V. B. Fedorov. Gas dynamic structure of a plasma flare generated by intense optical radiation evaporation of metals. ZhETF, v. 63, no. 4, 1972, 1240-1246.

This is a rework of two previously published articles by the same authors (cf. December 1972 Report, pp 4 and 6) on flare characteristics of laser-irradiated metals. Target materials included bismuth, lead, aluminum and brass. A neodymium laser was used at 1 millisec pulse lengths, developing up to 10^7 w/cm^2 over a 1 cm diameter target area; tests were done at ambient pressures up to several atmospheres. An extensive analysis of test results is given, with emphasis on a critical surface temperature at which a transition from liquid metal to liquid dielectric can be identified. The present article includes clearer pictures of flare development, as shown in Figs. 1 and 2.



laser beam

Fig. 1. Flare from Bi target. $I = 5.5 \times 10^6$ w/cm^2, $\tau = 0.8$ ms, p = 1 atm; exposure time exceeds pulse duration.

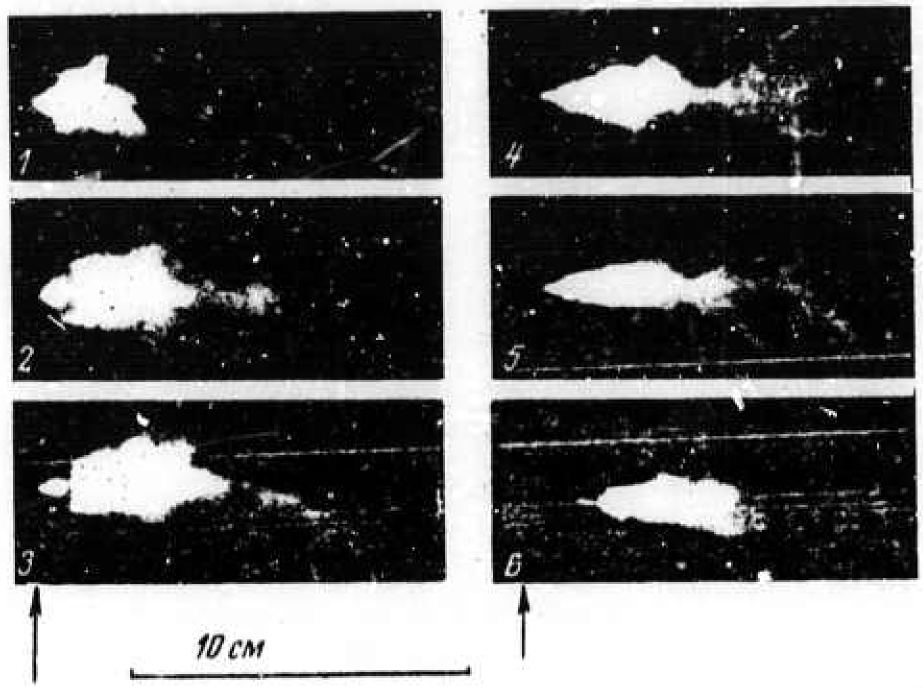


Fig. 2. Development of flare from Bi target. $I = 10^7$ w/cm^2, p = 2.6 atm. Time between frames is 0.16 ms; arrows indicate target surface.

Apanasevich, P. A., and V. G. Dubovets. Theoretical analysis of interaction of high-power polarized radiation with an isotropic resonant medium. ZhPS, v. 17, no. 5, 1972, 796-803.

An analysis is developed of the interaction of powerful polarized radiation with an arbitrary medium, in which the medium is for convenience assumed to be a resonant system of randomly ordered linear or circular dipoles. Proceeding from an expression for the vector field in the medium, the authors derive expressions relating radiation polarity to the absorption or amplification properties of the medium. An approximate solution is obtained for the case of limited radiation power, as well as a more general one applicable to any incident power level.

B. Recent Selections

i. Beam Target Effects

Arifov, U. A., T. U. Arifov, and D. D. Gruich. Generation of multicharged metal ion beams using powerful pulses from a ruby laser. IAN Uzb, Seriya fiz-mat. nauk, no. 6, 1972, 43-48.

Fersman, I. A., and L. D. Khazov. Surface damage mechanism of a transparent dielectric irradiated by a short optical pulse. Kvantovaya elektronika (Moskva), no. 4 (10), 1972, 25-31.

Letokhov, V. S., and A. A. Makarov. Kinetics of infrared laser excitation of molecular oscillations. ZhETF, v. 63, no. 6, 1972, 2064-2076.

Plis, A. I., Ye. L. Tyurin, and V. A. Shcheglov. Heating of materials by short duration laser pulses. ZhTF, no. 12, 1972, 2568-25'

Ulyakov, P. I. High temperature vaporization of metals. I-FZh, v. 24, no. 2, 1973, 256-261.

Veyko, V. P., G. A. Kotov, M. N. Libenson, and M. N. Nikitin. Thermochemical effects of laser radiation. DAN SSSR, v. 208, no. 3, 1973, 587-590.

ii. Laser-Plasma Interaction

Basov, N. G., E. M. Belenov, V. A. Danilychev, O. M. Kerimov, and I. B. Kovsh. Optical breakdown in compressed gases from CO_2 laser radiation. ZhETF, v. 63, no. 6, 1972, 2010-2014.

Galeyev, A. A., G. Laval', T. O'Neal, M. N. Rozenblyum, and R. Z. Sagdeyev. Parametric backscatter of a nonlinear electromagnetic wave in plasma. ZhETF P, v. 17, no. 1, 1973, 48-52.

Kaliski, S. Conductive laser heating of nonhomogeneous plasma. Bulletin de l'Academie Polonaise des Sciences, serie des sciences techniques, no. 12, 1972, 211(963)-215(967).

Letokhov, V. S., Ye. A. Ryabov, and O. A. Tumanov. Effect of CO_2 laser pulse on molecular gas luminescence. ZhETF, v. 63, no. 6, 1972, 2025-2032.

Lugovoy, V. N., and A. M. Prokhorov. Heating and confinement of plasma in crossed light beams. ZhETF P, v. 17, no. 1, 1973, 52-55.

2. Effects of Strong Explosions

A. Abstracts

Deribas, A. A., A. N. Kiselev, G. Ye. Kuz'min, and E. Sh. Chagelishvili. Shock wave interaction with cermets. IN: Sbornik. Dinamika sploshnoy sredy, Novosibirsk, no. 8, 1971, 103-117 (RZhMekh, 7/72, no. 7B231).

Parameters are calculated of a plane shock wave generated by detonation of an explosive charge on a material surface and propagating in a semi-finite solid layer. Parameters of a glancing detonation wave at the surface are also calculated. The materials are a series of three-component tungsten carbide-cobalt cermets. The shock adiabats of the three-component systems were calculated using known adiabats of each component. The shock adiabat calculated for a VK-8 alloy agreed satisfactorily with an experimental value determined in the 100 - 600 kbar pressure range. An x-ray diffraction analysis of the shock compressed specimens indicates that shock adiabats can be calculated for pressures to 2 Mbar.

Rakhuba, V. K. and N. N. Stolovich. Effect of geometric dimensions of an exploding conductor and discharge current parameters on energy conversion efficiency. IAN B, Seriya fiz-energ nauk, no. 4, 1972, 119-123.

The effect of a cylindrical exploding wire diameter and discharge circuit parameters on electrical energy conversion into mechanical energy is investigated. Aluminum membrane detectors were used for measuring the mechanical work. A simplified diagram of the experimental installation is given.

Experimental data are presented in Fig. 1 on the deformation

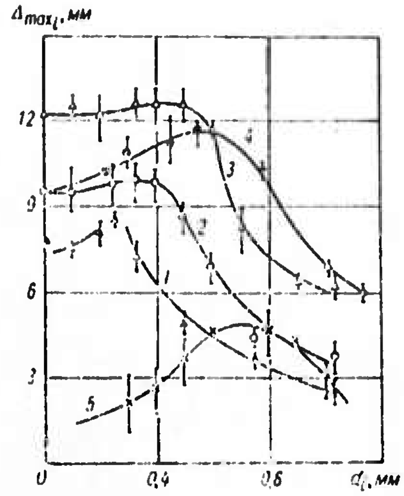


Fig. 1. Relationship of the deflection Δ_{max} of a membrane detector to the diameter of the exploding wire d_i at the following discharge-circuit parameters: C_o = 3 μf, L_o = (5 to 7)x10^{-7} henry (1-4) and C_o = 900 μf, L_o = 4x10^{-6} henry (5): 1 - 27, 2 - 32, 3 - 40, 4 - 32, 5 - 5 kv.

of aluminum membrane detectors, 1.5 mm thick and 125 mm in diameter. Curves 1, 2, 3, and 5 are for explosion of a copper wire; curve 4 is for an aluminum wire.

Fig. 2 is derived from dimensionless variables of Fig. 1 data, in the form of a relative generalization of curves 1-4, dealing with membrane-detector data, along with the cylindrical-detector data of curve 5.

The deformation processes of the membrane sheet detectors and the cylindrical indicator detectors in terms of dimensionless variables are both characterized by the same relationship. Other conditions being equal, the diameter of the exploding wire is found to exert the greatest influence on the maximum deformation value.

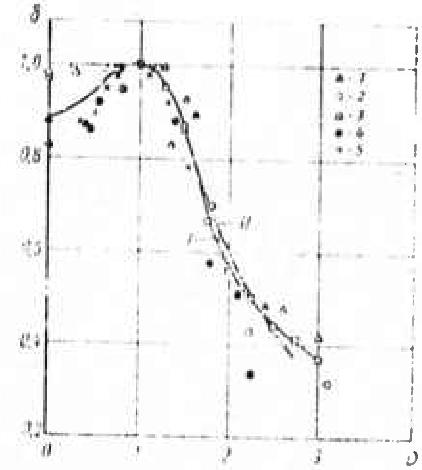


Fig. 2. Effect of discharge-circuit parameters and diameter D of the exploding wire on the dimensionless deflection δ of a membrane detector: 1 - 27, 2 - 32, 3 - 40, 4 - 32, 5 - 5 kv. I - Calculation results based on $\delta = 1.25D^{-1.1}$ for $1.25 \leq D < 3.0$; $\delta = 1.03D^{-0.37}$ for $1.0 \leq D \leq 1.25$; II - Based on an alternate formula for A = 2.6, B = 2.66.

Bychenkov, V. A., and V. V. Gazhdiyeva. Calculation of an explosion in an unstable porous medium. IN: Trudy 2-y Vsesoyuznoy konferentsii po chislovym metodam resheniya zadach teorii uprugosti i plastichnosti, 1971, Novosibirsk, 1971, 85-94. (RZhMekh, 9/72, no. 9V591)(Translation)

A model is constructed for porous medium deformation. The spherical part of the stress tensor is given as a specific volume and internal energy function, and the deviator part is determined by the condition of plasticity (Tresca or Coulomb) and the proportionality requirement of the tensor deviator inelastic part of the deformation rate. The condition of brittle destruction of the grains (elementary components) of the porous medium is also introduced. Destruction of the medium from macrocrack formation is discussed. Orthogonal to the cracks, the stress in this case is considered to be equal to zero. Equations of motion are derived for the spherically symmetrical motion. The equation system for the numerical calculations is presented in finite-difference form. The calculation is mentioned of the detonation in sand of an explosive pellet. The results are presented in a graph of explosive cavity expansion (for the initial stages of motion) in comparison with radiography data.

Kuznetsov, V. M. Explosive demolition of rocks. IN: Sbornik. Dinamika sploshnoy sredy, Novosibirsk, no. 8, 1971, 71-77. (RZhMekh, 9/72, no. 9V589)(Translation)

Views on the efficient use of explosives in the crushing of rock are mentioned. A probability law on fragment distribution by size is presented (in specific cases, this law reduces to normal or Poisson distributions). A scheme of brittle failure is proposed to assist in identifying the distribution parameters. The coefficient of stress intensity and the maximum pressure in the compression wave are assumed to be characteristic values of the brittle failure. The initial ordered network of cracks is unstable and the spacing between cracks is proportional to the cube root of the explosion energy. A semi-empirical formula is compiled based on the assumed distributio parameters. The formula is correlated with data on the granulometric composition of fragmented rock for a series of explosions.

Chernyshov, A. D. Conditions for shock wave propagation in media with elastic and plastic properties. IN: Sbornik. Problemy vopr. mekh. gornykh porod. Alma-A'a, Izd-vo Nauka, 1972, 183-193. (RZhMekh, 10/72, no. 10V779)(Translation)

Consideration is given to conditions for shock wave propagation in a massif. The massif properties are described by rheologic models with elastic and plastic properties. A theorem is proved which establishes an interrelationship between the dissipative processes irreversibility on the shock wave and the necessary conditions of existence for the wave transient layer structure. It is shown that by introducing the shock layer it is possible to determine all the shock wave thermodynamic limitations.

Zabudkin, I. L., Yu. G. Kuznetsov, G. I. Tambiyev, and A. N. Zordunov. Relationships for a parallel distributed charge explosion of a rock with one exposed surface. IVUZ Gorn, no. 7, 1972, 25-28.

The interaction of detonation products with the wall of a deep bore-hole in rock is analyzed, based on the theory of elasticity using composite variables. The effect of the exposed surface at the hole mouth is neglected. Two complexes of characteristic quantities are derived from the initial and boundary conditions of a radially directed blast. The physical significance of the complexes is explained. The generalized explosion process is described by the ratio of the two complexes. This analysis makes it possible to evaluate the effect of certain factors previously neglected and unaccounted for in a formula derived by dimensional analysis of experimental data. The effect of sound velocity in the rock can accordingly be evaluated by introducing the sound velocity-fissility relation into the cited complex.

Klochkov, V. F. Stress of a rock mass and its destruction characteristics from explosions near a free surface. IVUZ Gorn, no. 7, 1972, 70-75.

Normal σ_n and tangential τ_n stresses on a free surface from the underground explosion of a spherical or cylindrical charge at depths w of 0.5 - 2m (line of least resistance) are calculated at the onset and during decay of the stress field. Destruction occurs at the onset mainly owing to σ_n. During the decay period, the relative σ_n and τ_n values are functions of w and the inclination α of the axial stress vector at a surface point. At increasing w, both σ_n and τ_n decrease more rapidly from the explosion of the spherical than from the cylindrical charge. At a given w, σ_n and τ_n become extremal for certain α values in the 0-90 degree range. The optimum charge depth corresponds to a $109^o30'$ apex angle of the explosion crater, i.e. the maximum crater volume V_{max}. Only the first sumping hole should consequently contain a reinforced charge to produce V_{max}. The sumping holes fired in the preformed cavity need not contain a powerful charge.

Yeremenko, A. S., A. V. Gorlanov, Yu. A. Kalinin, V. V. Lyubimov, A. A. Mak, V. F. Petrov, L. N. Soms, and A. I. Stepanov. Study of a pulsed laser with an exploding film Q-switch. IN: Kvantovaya elektronika, no 3(9), 1972, 30-35.

Q-switching experiments are described using an aluminum film on a poly (ethyleneterephthalate) substrate, exploded by the electric discharge of a low inductance capacitor. The feasibility of Q-switched laser operation with various active media having large cross-sections is cited as the main advantage of the system studied. Energy, time, and space characteristics are determined for ruby and Nd-glass pulsed lasers, Q-switched by the described system. The experimental set up (Fig. 1)

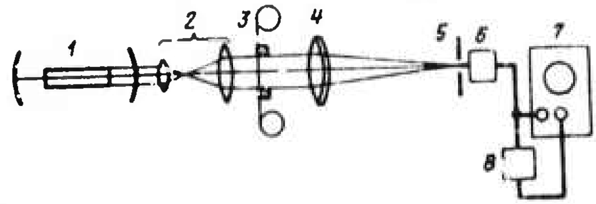


Fig. 1. Diagram of Q-switching time measurement:

1 - illuminating laser, 2 - telescope, 3 - exploding film, 4 - objective (f = 1,600 mm), 5 - diaphragm, 6 - photomultiplier, 7 - oscilloscope, 8 - optical delay line.

features an exploding film located outside the laser cavity and a delay mechanism for synchronizing the laser pulse with the film explosion. Oscilloscope traces show that the film clears up completely, when the energy input rate is increased and the total energy supplied exceeds the metal vaporization energy. The minimum clearing time τ_s is 60 nsec. A high voltage and small inductance in the discharge circuit, plus a sufficiently high ratio of discharge energy to the film surface area are required for rapid Q-switching. Time τ_s increases gradually with decreasing diaphragm apertures, because of light scattering by the explosion products.

Laser characteristics are also affected by radiation interaction with the exploding film. The interaction was studied by placing the film in the cavity. In this case, when τ_s is decreased (e.g., to ~2 nsec for a 300 Å thick film) a flare is observed on the film surface. The emission interaction with the explosion products results in increased losses in the cavity and decreased power output. The emission losses from the substrate vaporization correspond to 88% of the transmissivity of the open Q-switch and a 3-4 j/cm^2 emission power density. A critical power density ~1j/cm^2 exists at which rapid vaporization of a 300 Å thick Al film produces a 50 ns single pulse, even at τ_s = 350 nsec. Above this critical value the pulse is distorted by substrate vaporization, and Q-switching is impaired. The angular distribution of the single-pulse laser emission indicates that the Q-switching film automatically compensates for mirror misalignment owing to plasma heating by laser radiation.

Pokrovskiy, G. I., and I. S. Fedorov. Vozvedeniye gidrotekhnicheskikh zemlyanykh sooruzheniy napravlennym vzryvom (Construction of hydroengineering earthworks by directed explosions). Moskva, Izd-vo Stroyizdat, 1971, 216 p. (RZhMekh, 9/72, no. 9V597 K)(Translation)

The monograph contains 13 chapters and deals with various aspects of the effects of those explosives which are used in construction work for the destruction and movement of rock.

The first chapter discusses the effect of an explosion on various rocks and soils. The flow rate of the explosion energy is examined, particularly the cavity role (air or water filled) around the charge in explosion efficiency. Chapter 2 is devoted to "fill" explosions on slopes. Features of a crater on a slope are mentioned and a simplified diagram of slope collapse from an explosion is presented. Factors governing fill formation and rock consolidation after collapse are compiled in Chapter 3. It is shown that the fill density is a function of the slope height and the component rock strength. Chapter 4 is on problems of rock motion during cratering and fill explosions by concentrated and flat charge systems. Charge setting for cratering explosions is considered in Chapter 5. It is concluded that the rock displacement rate is independent of the escape of explosion products through the charge hole when the hole cross section is two orders smaller than the charge chamber cross section. In Chapter 6 a theory of destruction of a rock mass by an explosion is developed together with methods for calculating compression wave displacemer and stresses. It is shown that at the normal explosion effect indices of 1.5 - 2, split-off breakdowns merge with those around the charge. A method of calculating charges for the erection of embankments by loosening is presented in Chapter 7. Detailed consideration is given to a system of fragmented rock overflow under a linear increase of the coefficient of loosening to a maximum value at the free surface.

Current experience in the erection of earth dams by directed explosions is reviewed in chapters 8, 9, and 10. The types of dams erected by directed explosions are discussed as well as problems of dam filtration, stability, and sedimentation. Results of blasting in connection with the building of dams on the Terek river, near the city of Alma-Ata, the Baypazy hydraulic complex, and the upper cofferdam of the Nurek hydraulic complex are described. The cost effectiveness of constructing dams by the explosion methods is illustrated on the basis of the Baypazy dam. Data on explosion effects on the physicomechanical properties of soils and rock are presented in Chapter 1. Compression zone dimensions are given for sand, clay, and loam, as well as nose for destruction zones from an explosion in monolithic rock. Chapter 12 outlines the manner in which demolition method dams should be operated and studied. In the last chapter a theory of underground explosion modelling is described together with methods for simulating cratering explosions under laboratory and field conditions.

Pachepskiy, Ya. A. Calculation of powerful underground explosions. IN: Sbornik. Nauchnaya konferentsiya Institut mekhaniki Moskovskogo universiteta 22-24 May 1972. Moskva. 1972, 29-30. (RZhMekh, 9/72, no. 9V590)(Translation)

The problem of a confined explosion in an unbounded rock massi is considered. Test data are used to construct a mathematical model of rock behavior over a broad range of parameter variations. Methods are examined for calculating brittle failure of materials.

Solodilov, T. A., T. A. Abbasov, D. Kh. Babayev, and Yu. G. Ganbarov. Method for determining explosion depth. Otkr izobr, no. 28, 1972, no. 352243.

A method is proposed for the precise measurement of the embedding depth of explosive charges, based on recordings made by a single sensor and the pulsation period variation factor of the explosion-generated gas sphere.

Klevtsov, I. V., and M. I. Rasner. Increasing the time span of massive explosions in quarries. Gornyy zhurnal, no. 10, 1972, 31-32.

Results are discussed of applying time-span control methods to minimize the air shock wave and fragment dispersion effects during massive blasting of quarry blocks. Methods include group charging, sequential blasting, sectional charge-ordering, maximizing explosion delay gaps, adjusting the charge column height, and simultaneous secondary crushing of boulders during massive blasting.

Conclusions are: (1) The duration of massive explosions in quarries can be increased up to 10 seconds using specified block alignments and blast sequencing based on given block mass conditions; (2) The maximum admissible delay factor between adjacent boreholes when arranging air-gap charge systems should be within the 165 to 270 msec range; (3) Blasting work on a series of quarry blocks piled one on top of the other should be done by using detonation fuses sequentially connected from the bottom block upwards.

Luk'yanov, G. A. Rotational relaxation in a freely expanding nitrogen jet. ZhPMTF, no. 3, 1972, 176-178.

A numerical analysis is presented of the free axisymmetric expansion of a supersonic nitrogen jet, with allowance for rotational relaxation. The earlier assumption of the negligible effect of rotational relaxation has led to a significant discrepancy between theoretical and experimental data for a sonic nozzle. Free nitrogen jet expansion from a round nozzle is calculated at moderate temperatures, e.g., 300° K. The effects of viscosity and thermal conduction are assumed to be negligible along with a Boltzmann energy distribution of rotational degrees of freedom. Rotational relaxation is described by the equation

$$\frac{dT_r}{dt} = \frac{T - T_r}{\tau_r} \qquad (1)$$

where T_r and T are totational and translational temperatures, $\tau_r = Z\tau$ is the rotational relaxation lifetime, τ is the mean free path, and Z is the number of collisions until translational-rotational equilibrium is established. In addition to (1), a set of six equations in a cylindrical coordinate system describes the flow parameters. These equations are solved by the method of characteristics.

Finite difference equations of characteristics and relationships along the flow lines are used to compute the parameters at the initial nozzle exit section, in the flow, at the nozzle edge, and on the symmetry axis. The computed T_r and T data are compared with analogous data calculated without allowance for the rotational relaxation effect, and experimental data from the literature. The comparative T_r and T versus $x_t = x/r_a$ plots (r_a is the nozzle exit section radius) show that the discrepancy between the earlier calculated and experimental T_r data is reduced significantly when the rotational relaxation effect is taken into account. At $p_o r_a$ = 7.5 torr x mm (p_o is the receiver pressure) T_r calculated with allowance for rotational relaxation agreed more closely with the experimental data for Z = 5 than for Z = 10, whereas at $p_o r_a$ = 240 torr x mm, the discrepancy between the data for Z = 5 and Z = 10 was insignificant. For a small number of collisions, T_r is only slightly affected by the rotational-translational energy exchange.

Kazhdan, Ya. M. Asymptote of flow during shock wave impact on a wedge-shaped cavity. ZhPMTF, no. 3, 1972, 129-138.

An asymptote for the flow behind a shock wave front after impact on a metal cavity edge is determined assuming that this flow is divided into two regions. In region I, where

$$\varepsilon r^{\alpha-2} \ll 1, \quad r = \sqrt{\xi^2 + \eta^2} / c_0, \quad \alpha = \pi / 2(\pi - \gamma) \quad (1/2 < \alpha < 1) \tag{1}$$

the flow is described by an acoustic approximation on the assumption that the wave amplitude $\epsilon \leq 1$. In region II, where

$$\varepsilon r^{\alpha-2} \approx O(1) \tag{2}$$

the flow at $\epsilon \longrightarrow 0$ is approximated by equations of an incompressible fluid. Assuming symmetric flow with respect to the y-z plane, it is sufficient to formulate an asymptotic solution for the region between the symmetry axis and an unknown free boundary $\eta_1 = \eta_1(\xi_1)$, $\xi_1 \geq 0$. For a given apex half-angle $\gamma < \pi/2$, the boundary problem solution is reduced to that of a nonlinear singular integral equation for the real function

$$f(u) = \arg \zeta'(u) + \pi / 2 + \gamma \tag{3}$$

where $\zeta'(u)$ is a derivative of the $\zeta(u)$ complex function with $\zeta = \xi + i\eta$. A numerical solution of the integral equation is obtained by iteration for γ values in the 0 to $\pi/2$ range. The iteration procedure is outlined. The function $f_n(u)$ was determined after n iterations. For ease of calculations, the function R_{n1} was substituted for f_{n1} according to the formula

$$f = R[1 + (-u)^{(4\gamma-3\pi)/2\pi}] \tag{4}$$

where $\beta = \gamma - f(0)$ is the apex angle between the symmetry axis and the free boundary. The function $R_n(\tau)$ was used to formulate the free boundary profile $\eta(\xi)$ and the velocity η_A at the free boundary apex. The $\eta(\xi)$ profiles (Fig. 1) and tabulated η_A, β, and γ values were calculated for $\epsilon = 0.1$ and $C_o = 5.5$ km/sec. The tabulated data suggest that an arbitrarily small

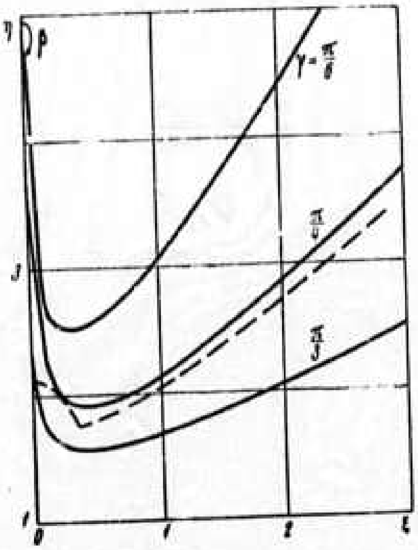


Fig. 1. Free boundaries in the ξ-η plane. Broken line calculations were by the difference method for $\gamma = \pi/4$.

deviation of γ from $\pi/2$ results in a finite change of β.

Bronshten, V. A. Propagation of spherical and cylindrical blast waves in a heterogeneous atmosphere with allowance for counterpressure. ZhPMTF, no. 3, 1972, 84-90.

An approximation method of parallel layers is introduced to calculate the characteristics of a weak spherical blast wave and cylindrical shock wave propagating in a downward direction in a heterogeneous exponential atmosphere. Such a problem arises, for example, in attempting to evaluate the flight and explosion of the Tunguska meteorite. Since the blast wave from an explosion at 5-10 km above the ground is greatly attenuated at the surface, counterpressure must be taken into account. The three-dimensional problem of cylindrical wave propagation at an angle i to the horizontal plane (Fig. 1) is initially reduced to a two-dimensional problem by

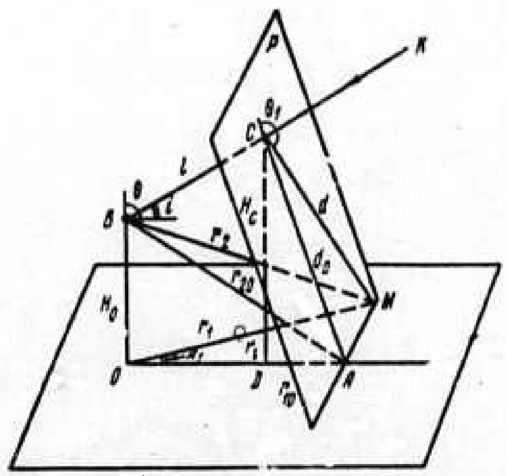


Fig. 1. Diagram of cylindrical and spherical wave propagation.

applying the plane cross-section principle, i.e., neglecting propagation along the cylinder axis.

The two dimensional problem is further reduced to a one-dimensional problem by parametrization in terms of the angle θ_1. Similarly, the two-dimensional problem of spherical blast wave propagation is made one-dimensional by parametrization in terms of the angle θ. In both cases, the one-dimensional problem is solved by the method of parallel layers, involving a division of the atmosphere into parallel, small-thickness layers. The atmosphere within each layer is considered to be homogeneous and wave transition across the inter-layer boundary is assimilated to the boundary transition between two media. Wave propagation within each homogeneous layer is described by known approximation formulas. The effect of atmospheric heterogeneity on shock wave propagation is expressed by the parameter

$$\beta = (r_0 |\cos \theta|) / H^* \qquad (1),$$

where $r_o = (E/p_{io})^{1/\nu}$, E is the blast energy, p_{io} is the nonturbulent air pressure at the elevation H_o of the explosion point B, and H^* is the homogeneous layer height. Using an approximation formula the excess pressure $q = (p_2 - p_1)/p_1$ at the shock wave front propagating in a heterogeneous atmosphere from a moderately elevated point, and its propagation velocity, can be rapidly evaluated.

Elizbarashvili, T. Sh. Detonation wave characteristics in rocks. AN Gruz SSR. Soobshcheniya, v. 67, no. 3, 1972, 633-636.

The effect of the propagation direction of a detonation wave front is discussed with respect to the rock surface. The formation and propagation characteristics of the reflected expansion and refracted shock waves are considered for the cases when the detonation wave strikes the rock surface at an angle α = 90 degrees or α = 0-90 degrees. In the 0-90 degrees range (the most common case) and at a detonation velocity $D_d < D_{refr}$, the angle ω_1 satisfies the equality $D_d/\sin\omega_1 = D_{refr}$. When $\omega_1 < \alpha < 90$ degrees, the incident, reflected, and refracted waves do not intersect at one point and energy is transferred to the rock across a stressed zone. The calculations verify the advantage of using a priming charge distributed lengthwise over a concentrated charge.

Lyakhov, G. M., V. N. Okhitin, and A. G. Chistov. Shock waves near an explosion site in soils and water. ZhPMTF, no. 3, 1972, 151-159.

A solution is presented to the problem of two-dimensional shock wave propagation in multicomponent soils and water at distances from the explosive charge for which the pressure p is at least tens of thousands of atmospheres. It is assumed that a small thickness and large surface area explosive charge is instantly detonated in the medium. The medium is represented by a mathematical model developed earlier by one of the authors (Lyakhov) for a three-component medium containing solid particles, water, and gas. The model is only applicable at $p > p_*$ when skeleton compressibility is negligible. Wave propagation at a time t = 1, when the expansion wave front R_1 attains the initial cross-section, is described using the model

$$p = (1 - x)^{3/2}, \; u = 1 - (1 - x)^{1/2} \qquad (1)$$

in the region $0 \le X \le X_R^{(2)}$ and by

$$p = p_T, \quad u = u_T, \quad D = D_T = u_T V_0 (V_0 - V_T)^{-1} \qquad (2)$$

in the region $X_R^{(2)} \le X \le X_S$ (Fig. 1)

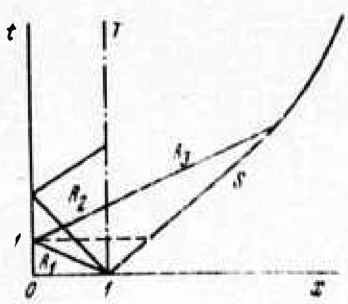


Fig. 1. Wave propagation diagram: R_1 - expansion wave front, R_2 - expansion wave detonation products boundary, R_3 - reflected expansion wave, S - shock wave front, T - contact discontinuity (detonation products-medium interface).

The initial shock wave parameters p_T, u_T, and V_T in (1) and (2) were calculated for the three media (Table 1).

Table 1. Characteristics of three-component media α_1, α_2, α_3 - volumetric content of the gas, liquid, and solid components, respectively.

Media	Medium characteristics				Dimensionless parameters			Dimensional parameters		
	α_1	α_2	α_3	ρ_1, г/см³	p_T	u_T	V_T	p_T, кг/см²	u_T, м/сек	ρ, г/см³
First	0	0.4	0.6	1.99	0.578	0.166	0.66	$54 \cdot 10^3$	696	2.42
Second	0.02	0.33	0.65	2.05	0.582	0.165	0.68	$54.6 \cdot 10^3$	692	2.50
Third	0	1	0	1	0.408	0.258	1.10	$38.3 \cdot 10^3$	1080	1.45

Computation of u, p, and D was done separately for five different regions by the method of characteristics. The p, u, and discontinuity shift y versus t plots at the gas chamber boundary (T) show the gas chamber relative dimensions in three media types studied. The p, u, and D versus x and p(t) plots in the S region indicate, in agreement with experimental data, that p, u, and D in a water-saturated soil (α_1 = 0) are higher than in water, but decrease significantly in the presence of even small amounts (α_1 = 0.02) of air in water-saturated soil. The decrease in these parameters is accentuated at increasing distances from the explosion site.

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3. Geosciences

A. Abstracts

Prozorov, A. G., and Ye. Ya. Rantsman. Statistics on the earthquakes and morphological structure of eastern Central Asia. IN: Akademiya nauk SSSR. Doklady, v. 207, no. 2, 1972, 341-344.

A correlation between successive earthquakes is analyzed, and the parameters describing the correlation are compared with morphological structure. The method is based on the comparison of the local statistics of the complete and randomly compiled earthquake catalogs. The following results are obtained:

1. There exists a positive influence for weak earthquakes ($E = 10^9 - 10^{12}$ j): their recurrence probability increases by some value p in the proximity of the initial earthquake. For normal earthquakes this increase is statistically significant at τ = 30-40 days and d < 50 km. For intermediate earthquakes the positive influence is smaller, but still statistically significant at τ = several days and d = 10-20 km.

2. Sequences of weak normal earthquakes are identified for which $d \leq d_o$ and $\tau \leq \tau_o$. Assuming d_o = 15 km and τ_o = 3 hours, then the first-order error (identifying a fictitous sequence of independent earthquakes) does not exceed 7%, while the second-order error (missing a sequence) reaches 43%. If d_o = 50 km and τ_o = 40 days, the second-order error is too high. Strong earthquake sequences with thresholds of τ_o = 10 days and d_o = 25 km have been identified.

3. A significant decrease of p in the focal-depth range of 120-160 km is observed for intermediate earthquakes (see Fig. 1)

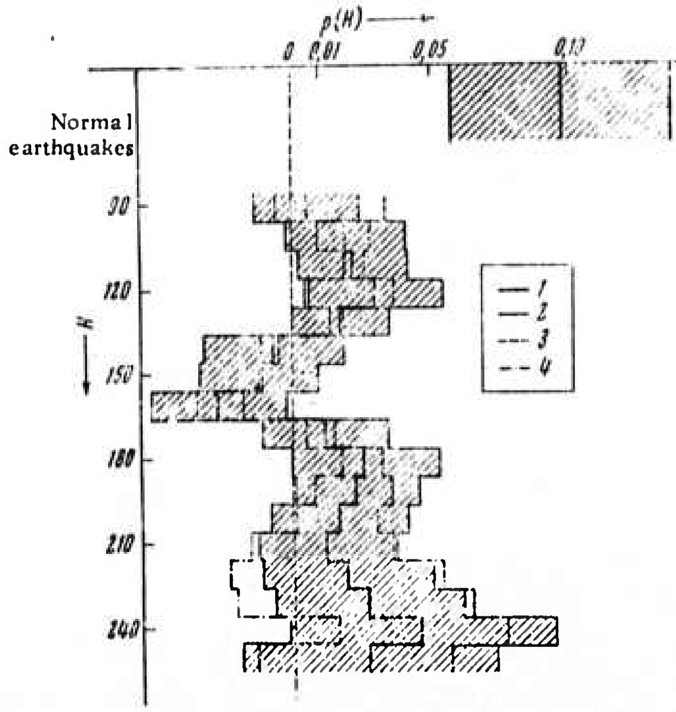

Fig. 1. Positive Influence p of an Initial Earthquake on Subsequent Ones within the Time Interval $\tau \leq 15$ Days and Distance $d < 18$ km.

Analyzed earthquakes were: group V intensity for 1952-1956 and $E = 10^{9} - 10^{12}$ j for 1957-1961.

1 - estimated p; 2 - 90% confidence level of the estimation; 3, 4 - estimated p for 1952-1956 and 1957-1961, respectively.

This depth interval corresponds approximately to an assumed waveguide.

4. The correlation between p and γ (recurrence graph slope) and morphological structure is analyzed. High p (large number of sequences) is confined to regions with thick sedimentary cover (region V in Fig. 2),

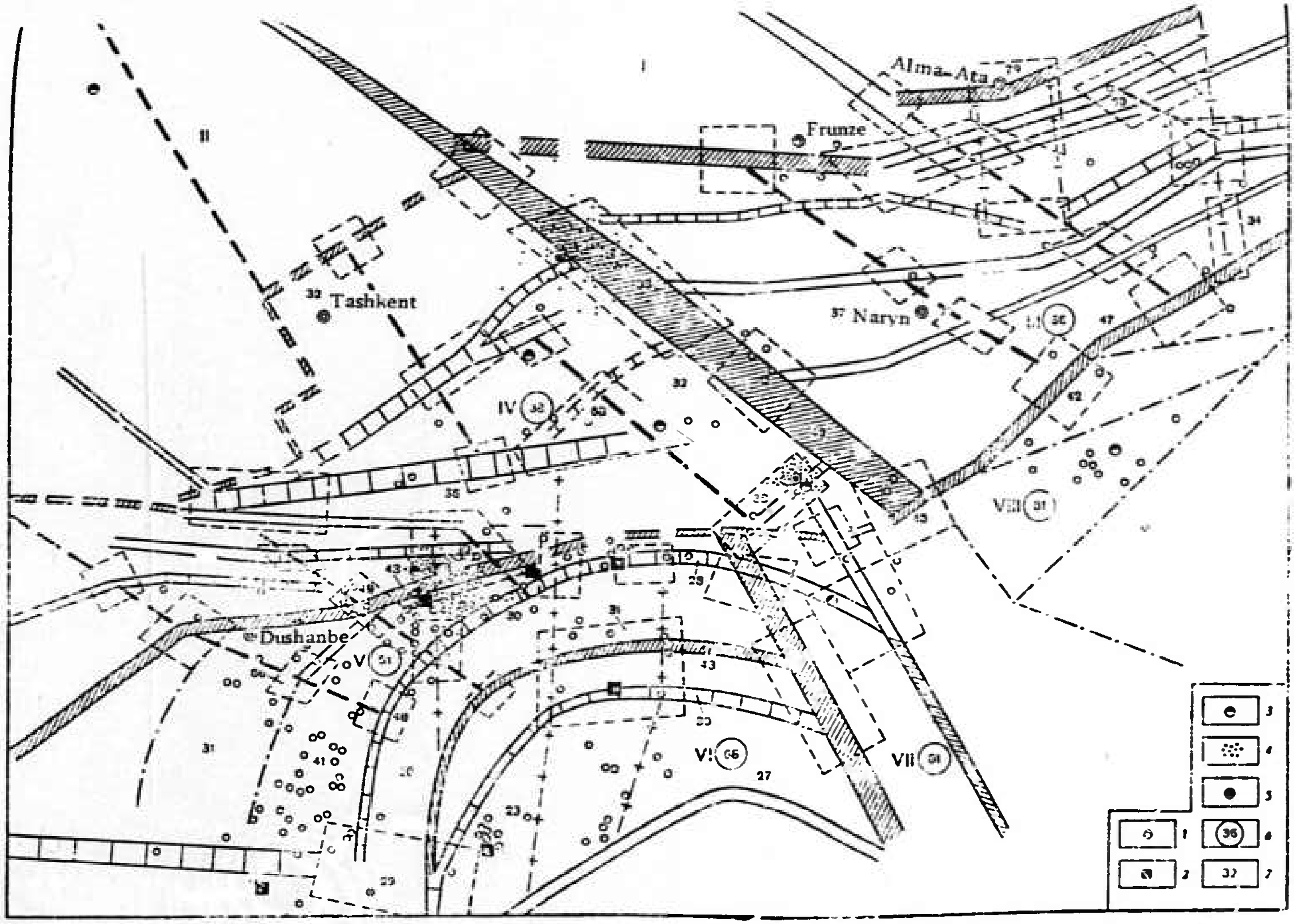

Fig. 2. Morphological Structure of the Eastern Part of Central Asia.

1 - Sequences of interrelated earthquakes; 2 - the same, according to a randomly compiled catalogue; 3 - sequences of interrelated strong earthquakes; 4 - aftershocks; 5 - epicenters of the Chatkalskoye, Khaitskoye and Ulugchatskoye earthquakes; 6 - γ for morphological structures indicated by roman numerals, determined from earthquakes with $E = 10^{15} - 10^{18}$ j from 1880 - 1965; with $E = 10^{14}$ j from 1925-1965, and with $E = 10^{12} - 10^{13}$ from 1962-1965; 7 - γ for smaller structures, determined from earthquakes with $E = 10^{9} - 10^{16}$ from 1962-1965.

as well as regions with exposed crystalline rock. High γ is confined to regions with high tectonic stresses (Tien-Shan, Pamir).

5. Deviation of p and γ from average values can be attributed to the build-up of a strong earthquake. Thus, anomalous earthquake sequences were observed in the past at sites where subsequent strong earthquakes occurred

6. The distribution of seismic activity in Central Asia with respect to morphological structures changed significantly during the 1895-1965 period;

7. The hypothesis that a strong earthquake induces "distant aftershocks" at the sites of future strong earthquakes was examined. The significant of the existence of "distant aftershocks" is found to be 99% at a = 0.05.

Kuznetsov, V. L., G. F. Bgatova, and V. V. Alekseyev. Technique for regional seismic studies of the basement of the western part of the Siberian platform. Geologiya i geofizika, no. 11, 1972, 78-85.

Experimental deep seismic sounding studies were conducted for the purpose of developing field procedures and observation method for studying the upper part of the basement of the Siberian platform. A discrete observation system was developed, intended for the recording of the seismic waves from three major interfaces: layer I - within the sedimentary layer; layer F - basement surface; and layer III - within the basement.

The crustal model inferred from the experimental data, taking some earlier results into account, is shown below in Figure 1.

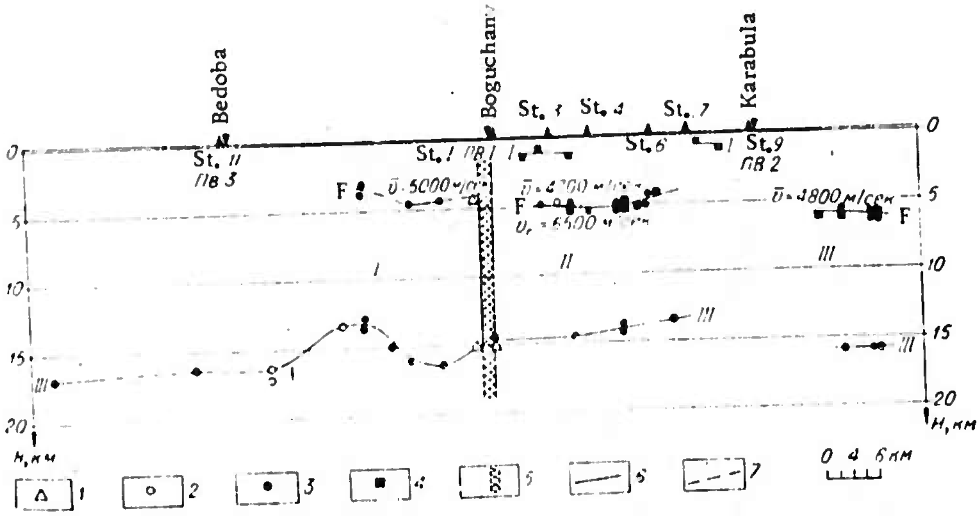

Fig. 1. Seismic Section Along the Bedoba-Karabula (Krasnoyarsk region) Profile.

1 - depths determined from reflected waves (1965); 2 - from reflected waves (1969); 3 - from reflected waves (1970); 4 - from refracted waves (1970); 5 - assumed fault; 6 - seismic interfaces; 7 - assumed seismic interfaces.

Surkov, V. S. Deep structure and near-surface tectonics of the Altay-Sayan folded region. Geologiya i geofizika, no. 11, 1972, 15-24.

The results of a complex interpretation of geological and geophysical data on the crustal and upper mantle structure of the Altay-Sayan folded region are summarized. The relation between the deep structure and the tectonics of the region is considered.

The density discontinuities determined for the lower crust and the upper mantle are illustrated in Fig. 1. The low-density zone in the

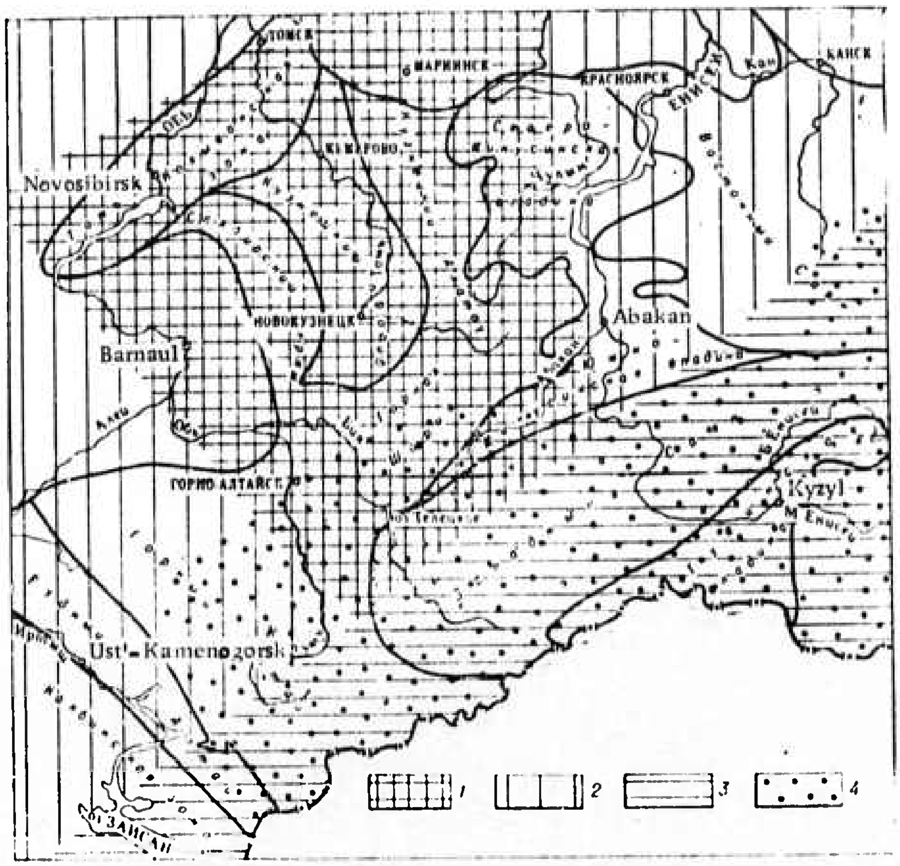

Fig. 1. Outline of Density Discontinuities in the Lower Crust and Upper Mantle in the Altay-Sayan Folded Region (compiled by V. Surkov, P. T. Morsin, and O. G. Zhero).

1 - High-density zone in the lower crust; 2 - Intermediate-density zone in the lower crust; 3 - Low-density zone in the lower crust; 4 - Low-density zone in the upper mantle.

upper mantle (density decrement 0.05 g/cm^3) is related to a region of intense present uplifting (Gornyy Altay, western Sayan, etc). Zones of high and low density in the lower crust, outlined in the western and southeastern part of the region are apparently related to differing crustal composition, femic and sialic, respectively. Isopach maps for the crust and granitic metamorphic layer are shown in Fig. 2. It was established that the Moho discontinuity relief

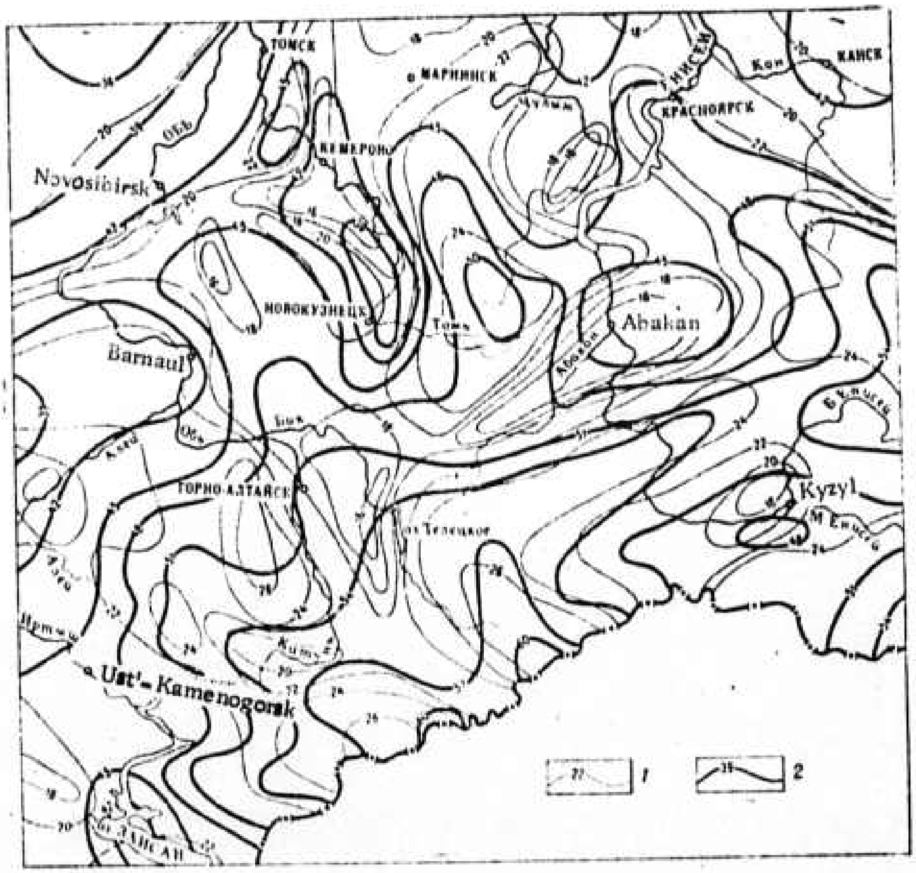

Fig. 2 . Isopach Map for the Crust and Granitic-Metamorphic Layer in the Altay-Sayan Folded Region (compiled by V. S. Surkov and P. T. Morsin).

1 - Isopachs for the granitic-metamorphic layer; 2 - isopachs for the crust.

reflects both the present and ancient tectonics of the region. Thus, a general sinking of the Moho discontinuity to the south is related to neotectonic surface structures, while local depressions and uplifts are related to ancient ones. The tectonic development of the Altay-Sayan folded region is considered in the light of new data on deep structure.

Smirnova, M. N. Effect of weak earthquakes on the Pyatigorsk mineral springs. IN: Akademiya nauk SSSR. Izvestiya. Fizika Zemli, no. 7, 1971, 80-83.

An analysis is given of the effect of the weak earthquake of 16 June 1946 on the mineral springs of Pyatigorsk in the Caucasus. The mineral springs are confined to two semicircular latitudinal and a meridional faults (see Fig. 1). The effect of the earthquake was manifested in the

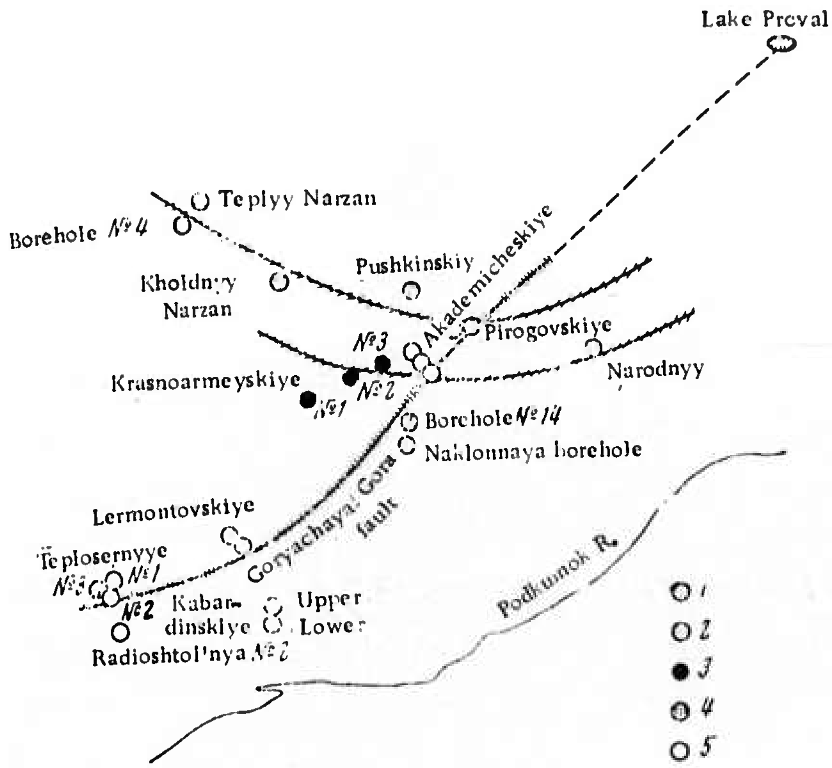

Fig. 1. Locations of he Pyatigorsk Mineral Springs

Composition of the springs: 1 - carbonic acid springs; 2 - carbonic acid and hydrogen sulfide springs; 3 - ferrous carbonic acid and hydrogen sulfide springs; 4 - alkali salt springs, 5 - radon springs.

following ways:

1. The level of Proval Lake (see Fig. 1) rose from 2.95 to 1.8 m (sic) one month before the earthquake. Subsequently the level fell to 3.2 m (sic);

2. The discharge rate and temperature of the mineral springs underwent changes over 1-2 months before, and 2-3 months after the earthquake. The observed variations were diverse (see Fig. 2). In

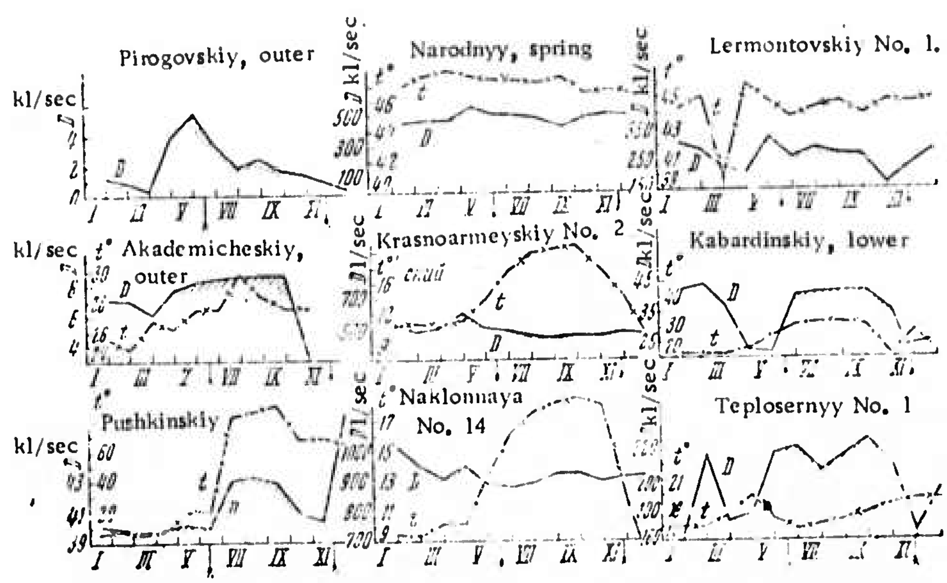

Fig. 2. Changes in the Activity of the Pyatigorsk Mineral Springs in 1946 (t - temperature, D - discharge).

the upper group of springs (Pirogovskiye, Akademicheskiye, Pushkinskiy, Teplyy and Kholodnyy Narzan), which are confined to the intersection of the faults, the discharge increases preceding an earthquake, sharply increases or decreases during an earthquake, and decreases after an earthquake (Fig. 2a). In the inner* Pirogovskiye and inner* Akademicheskiye springs, a temporary

* This description applies to inner Pirogovskiyeand inner Akademicheskiye while the illustration is shown for outer Pirogovskiyeand outer Akademicheskiye (see Fig. 2).

discontinuation of the discharge occurred after the earthquake. In the lower group of springs (Lermontovskiy No. 2 Lower Kabardinskiy, Teplosernyye No. 1, Radioshtol'nya No. 2), the discharge decreased sharply preceding the earthquake, increased during, and decreased or stabilized afterwards (Fig. 2c). The activity of the outlying springs of the upper group (Narodnyy, Krasnoarmeyskiy No. 1, No. 2, No. 3, Borehole No. 14, Naklonnaya borehole) was not affected by the earthquake (Fig. 2b).

The temperature of the upper springs increased slightly before the earthquake, increased considerably during, and decreased subsequently (Fig. 2a, b). In the lower group of springs, the temperature did not change or changed very slightly in the 1-2° C range.

Dzhanuzakov, K.. and B. Il'yasov. Effect of earthquake energy on seismic-wave attenuation in southern Fergana. IN: Akademiya nauk KirSSR. Izvestiya, no. 5, 1972, 15-20.

Results of estimates of the effect of earthquake energy on the attenuation of seismic waves from near earthquakes are presented. The records of 500 earthquakes (1965-67) with $E = 10^7 - 10^{11}$ j, h = 3-5 - 15 km, Δ = 15-170 km by eight seismographic stations are analyzed. Observational data on the maximum amplitude of seismic waves were corrected for the local conditions at seismographic stations (correction factor 0.62 - 1 72). Empirical expressions are derived for : a) the relation between the attenuation factor and energy class K = lgE(j)

$$n_k = \frac{10^{1.8+0.034K}}{K^2}$$

and b) the relation between the maximum amplitude and hypocentral distance and energy class

$$A = \frac{10^{\alpha+\beta K}}{R^{n_k}},$$

where $\alpha = 3.7 \pm 0.5$; $\beta = 0.03 \pm 0.1$ (derived from $\lg A = \lg q(K) - n_k \lg R$, where $q(K) = \alpha + \beta K$).

Kogan, A. L. First attempt at a crustal study in Antarctica by deep seismic sounding. Geologiya i geofizika, no. 10, 1971, 84-89.

The first results of deep seismic sounding investigations in Antartica performed in 1969 in the coastal zone of East Antartica (Novolazarevskaya station area) are described. The observations were made along a 430-km-long profile and at two receiving stations north and south of the profile (see Fig. 1). The preliminary results of these investigations, as well as the observing system and instrumentation used were reported earlier.*

Instrumentation consisted of an SS-24P seismic system modified by V. M. Davydov and B. P. Mishen'kin, an OS-8 seismic-recording oscillograph, and a set of NS-3 vertical and horizontal seismometers.

Deep seismic soundings were performed using the point seismic sounding method and discrete correlation of seismic waves.

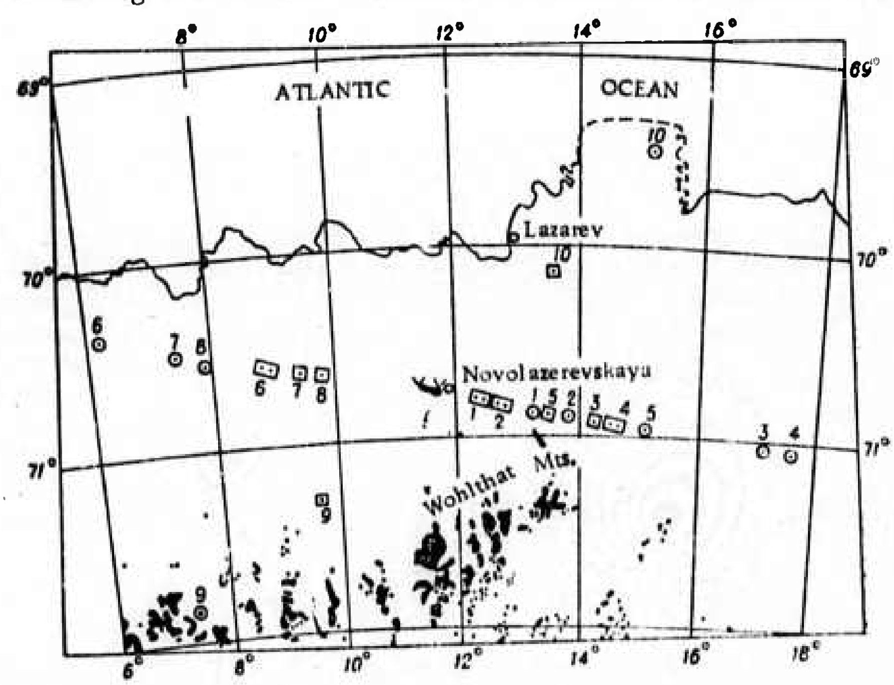

Fig. 1. Location of DSS Observation Points

1 - Recording points; 2 - resulting DSS points; 3 - shot points.

*) Deep seismic sounding in Queen Maud Land. (Solovyev, D. S., and A. L. Kogan. Informatsionnyy Byulleten' Sovetskoy Antarkticheskoy Ekspeditsii, no. 7, 1970, 33-38.

The observing system consisted of two fixed shot points 15.7 km apart in the middle of the profile (at the east and west ends of the Schirmacher Ponds). The maximum recorder-to-shot point separation was 225 km and the minimum, 54 km. The length of a linear array of six groups of vertical and horizontal (in the x-axis direction) seismometers was 1000 Each array consisted of three seismometers connected in parallel and buried 25-50 cm in ice or snow. Charges of 100 to 2000 kg were detonated at depths of 37 and 50 m, on the bottom of lakes located at the east and west end of Schirmacher Ponds. Both lakes were covered by 2.4 m of ice. It was established that the level of background noise was low. A special type of noise occurring on certain days was attributed to the formation of thermal cracks in the body of the glacier and was discovered during special observations of background noise. Intense shear waves were consistently recorded at long distances. In the initial part of horizontal seismograms, the horizontal component of compressional waves was recorded.

In the preliminary analysis of the records, refracted phase and wide-angle reflections from the Moho discontinuity, as well as crustal waves, were identified, and several records are given. Wide-angle reflections from the Moho discontinuity were absent from the records at recording point 10 on the Lazarev shelf. Very intense wide-angle reflections from intercrustal interfaces were recorded immediately prior to the reflected phase from the Moho discontinuity at recording points 3 and 4.

The crust in the coastal zone of East Antartica (15-150 km inland from the present coast line) is characterized by block structure (Fig. 2). Three large blocks, separated by deep seated faults, are identified. The existence of these faults has been established by gravity and magnetic data, as well. The western fault probably penetrates the upper mantle and is not evident on the day surface of the glacier, while the eastern fault is very distinctly evident. The depth to the Moho discontinuity in the central block is 38-40 km, which indicates continental type of crust. Within the western block, the crustal thickness decreases from 38 to 34 km. A crustal thickness of 32-33 km at the 50 km observation point of the profile was determined from gravity

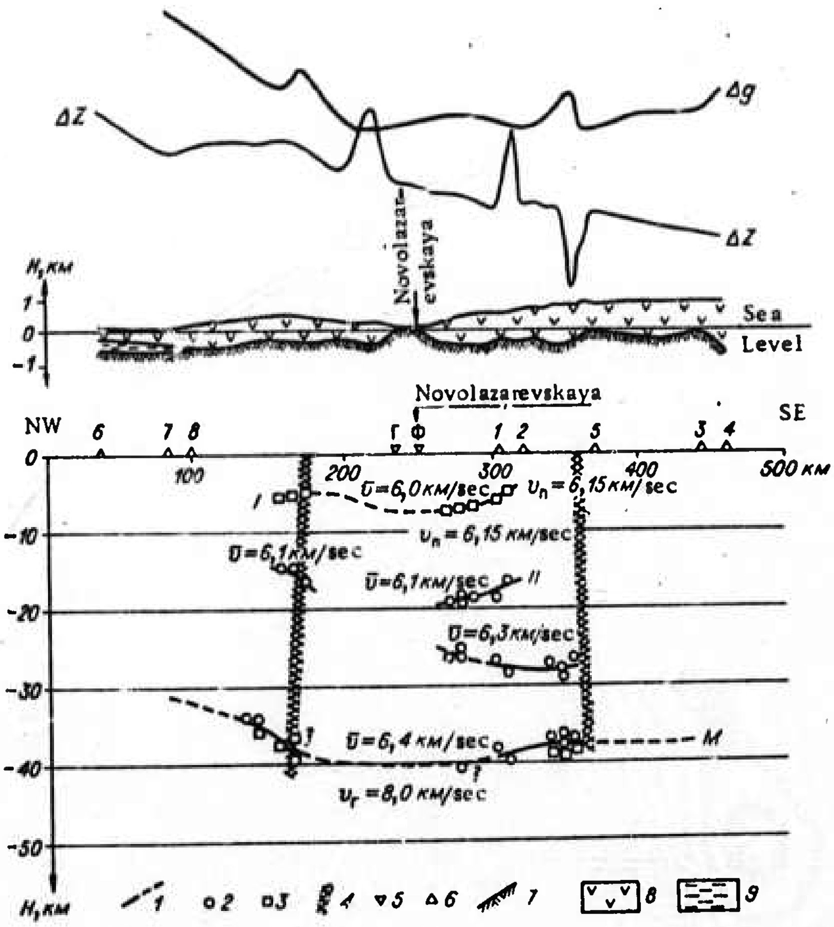

Fig. 2. Preliminary Section of the Earth's Crust in Queen Maud Land, East Antarctica.

1 - seismic interfaces; 2 - depths from reflected waves; 3 - depths from refracted waves; 4 - zones of deepseated faults; 5 - shot points; 6 - observing points; 7 - bottom of the glacier; 8 - ice; 9 - water; Δ g - residual gravity anomaly, Δ z - vertical component of magnetic field, I - boundary of equal layer velocities, II - assumed Conrad discontinuity, M - Moho discontinuity.

the crustal thickness decreases from 38 to 34 km. A crustal thickness of 32-33 km at the 50 km observation point of the profile was determined from gravity data. The crustal thickness (see Fig. 2) of the eastern block, as data. The crustal thickness (see Fig. 2) of the eastern block, as revealed by gravity data, is equal to the thickness of the central block. The crustal thickness increases southward, reaching 41 km at recording point 9, while it decreases northward reaching 29 km at recording point 10 (Lazarev shelf). This decrease of the crustal thickness and absence of wide-angle reflections from Moho discontinuity in the shelf region leads to the assumption of a transitional type of crust. Within the central block, two reflection interfaces are found at depths of 18 and 28 km. The interface occuring at 18 km is interpreted as the top of the "basaltic" layer. It was established that the average crustal velocity is 6.4 km/sec, while the "basaltic" layer velocity is 6.65 km/sec and the Moho discontinuity velocity is 8.0 km/sec. The velocity distribution in the upper crust is shown in Figure 3. The layer velocities increase from 5.5 to 6.3 km/sec over a 15 km depth range.

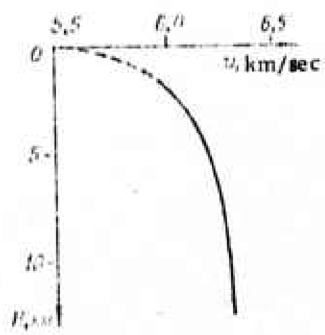

Fig. 3. Velocity Distribution from Data of Generalized Time Distance Curve of First Arrivals.

The residual gravity anomalies are in agreement with seismic data on the Moho discontinuity along the profile, but not at recording points 9 and 10 (low and high values, respectively).

It is concluded that the DSS results verified the crustal thickness as predicted from gravity data and the relief of the bottom and top of the glacier.

Khrometskaya, Ye. A. Strong earthquakes in the USSR in 1967. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 5-11.

The network of seismological observatories operating in the USSR during 1967 provided reliable determination of earthquakes with M≥ 4 1/2, originating in the USSR and adjacent regions. The coordinates of computer- determined epicenters and the magnitude of earthquakes summarized in this article were taken from the Seismological Bulletin of the Network of Seismograph Stations of the USSR (Seysmologicheskiy byulleten' seti seysmicheskikh stantsiy v SSSR). The article contains a catalog-type listing of the following data on 137 earthquakes with M≥ 4 1/2* originating in the USSR and adjacent region in 1967: date, origin time (GMT), epicenter coordinates, focal depth, magnitude and the name of the region where the epicenter originated. The distributions of the earthquakes in individual seismic zones with respect to magnitude is as follows:

Earthquake magnitude	Total with $M \geq 4\frac{1}{2}$	$4\frac{1}{2} \leq M < 5$	$5 \leq M < 6$	$6 \leq M < 7$	$7 \leq M < 8$
Carpathia	3	3	-	-	-
Crimea	-	-	-	-	-
Caucasus	5	5	-	-	-
Kopet-Day	1	1	-	-	-
Central Asia					
crustal	23	14	8	1	-
subcrustal	30	15	14	1	-
Altay Sayan	3	3	-	-	-
Baykal	3	-	2	-	1
Far East					
crustal	45 with M ≥ 5	-	36	8	1
subcrustal	18 with M ≥ 5	-	13	5	-
Arctic	1	-	1	-	-

* M ≥ 5 for earthquakes in the Kurile-Kamchatka and Hindu Kush regions

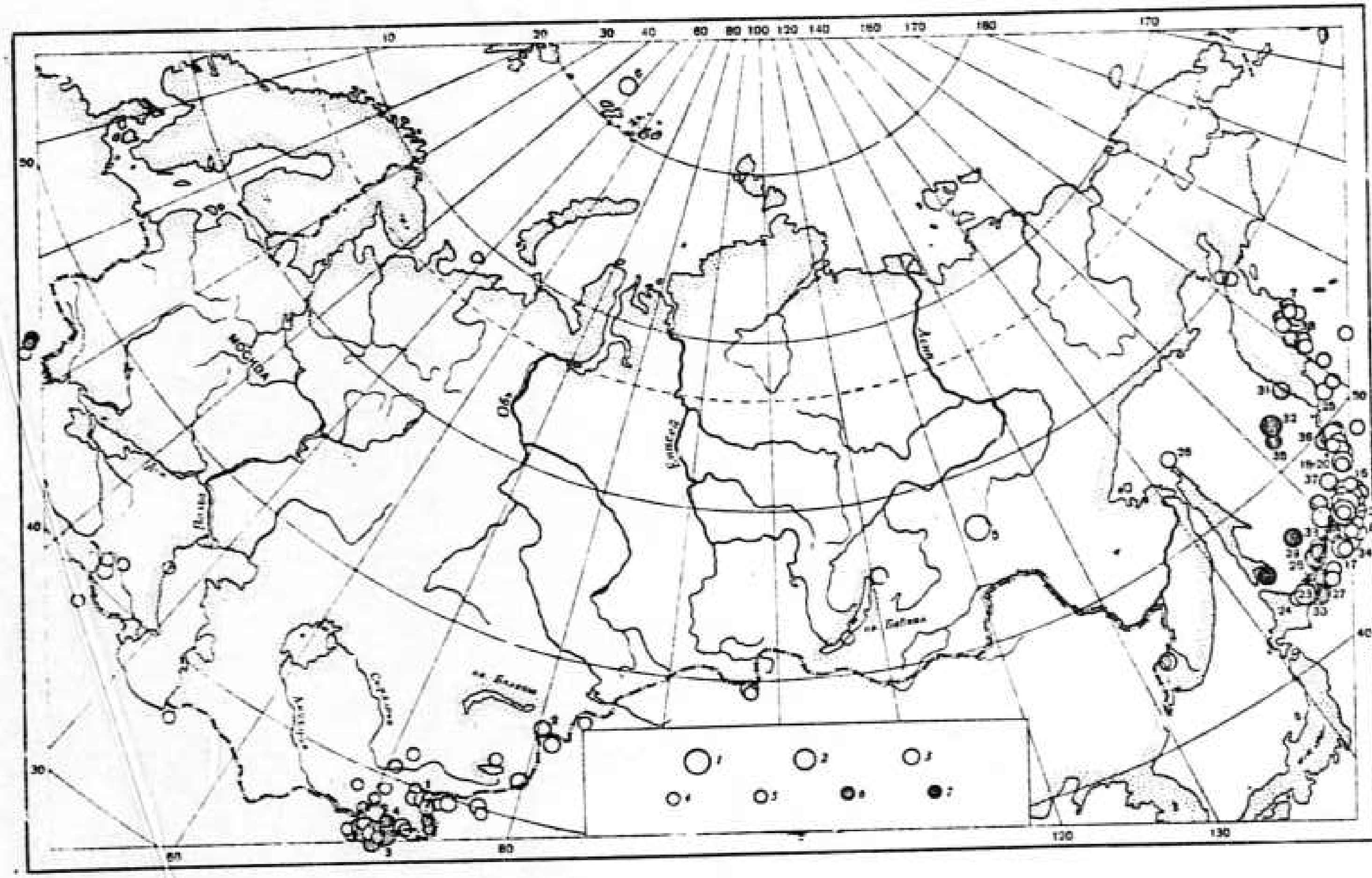

Fig. 1. Epicenter Map of Earthquakes with $M \geq 4\ 1/2$ in the Territory of the USSR in 1967

Magnitude: 1 - $7 \leq M < 8$; 2 - $6 \leq M < 7$; 3 - $5 \leq M < 6$; 4 - $4\ 1/2 \leq M < 5$. Focal depth (in km) 5 - $H < 60$; 6 - $60 < H \leq 300$; 7 - $H \geq 300$.

An epicenter map for the earthquakes is shown in Figure 1. A graph of cummulative strain energy released in individual seismic zones during 1967 and a graph showing the variation of strain energy released in the principal seismic zones in the USSR during 1957-1967 are given in the article. Similar to previous years, seismic activity in 1967 was at its highest level in the Far East seismic zone. It had been gradually decreasing after a significant increase in 1963, reaching a minimum in 1966 and increasing again in 1967. A brief description of seismic activity in individual zones in 1967 is given.

Kostyuk, O. P., and I. M. Rudenskaya.
Earthquakes in Carpathia. IN: Akademiya
nauk SSSR. Institut fiziki Zemli.
Zemletryaseniya v SSSR v 1967 godu(Earth-
quakes in the USSR in 1967). Moskva,
Izd-vo Nauka, 1970, 12-14.

The earthquakes in Carpathia during 1967 originated mainly in the Vranchea region of the Carpathian chain in Rumania and in Transcarpathia in the USSR and Rumania. The earthquakes were located on the basis of records from the Soviet Carpathian network of seismographic stations (L'vov, Uzhgorod, Mezhgor'ye, Rakhov, Kosov, and the temporary station at Morshin), as well as data from other Soviet (Kishinev, Chernovtsy, Simferopol', Yalta, Alushta, Feodosiya) and non-Soviet (Hungary, Poland, Bulgaria, Czechoslovakia, Yugoslavia) seismographic stations. A catalog listing of the following data on 20 earthquakes in Carpathia in 1967 is given: date, origin time (GMT), epicenter coordinates, focal depth, accuracy class, energy class K = lg E(j) and the name of the region where the earthquakes originated. An epicenter map for the earthquakes in Carpathia during 1967 is shown in Figure 1. In 1967, as in previous years, the Vranchea region was the most active with 15 deep earthquakes (H = 80-180 km). Macroseismic

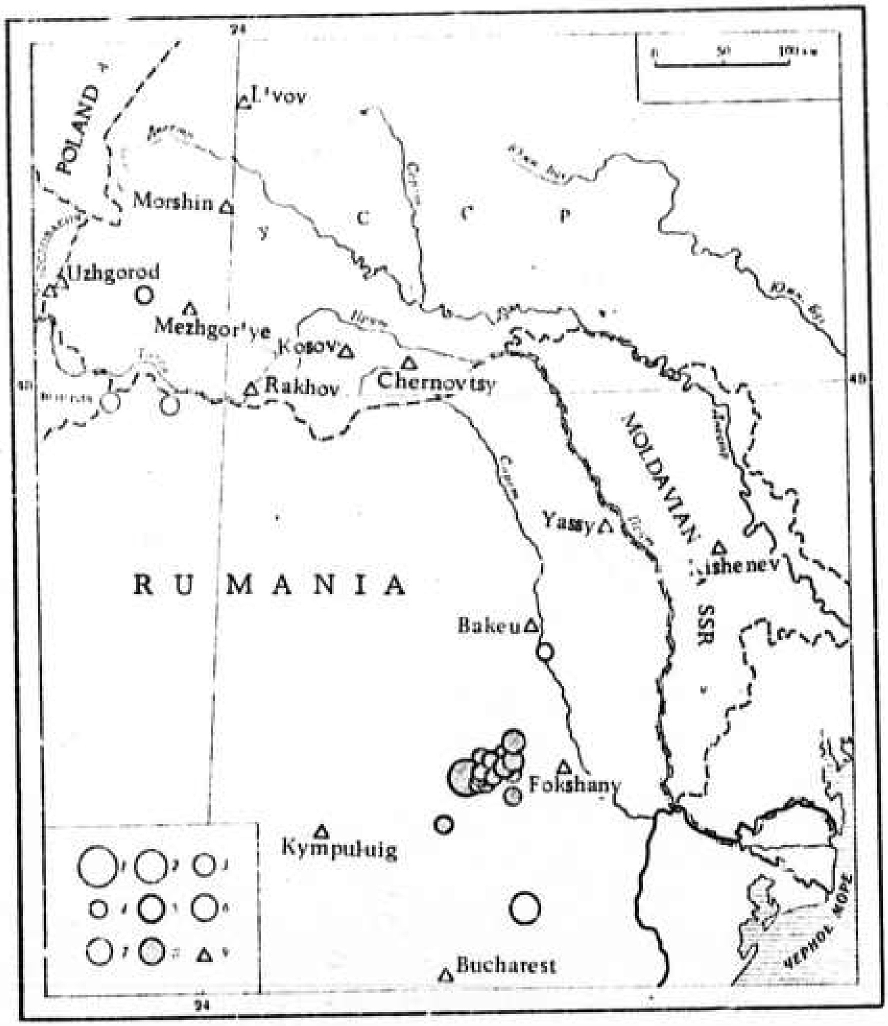

Fig. 1. Epicenter Map of Earthquakes in Carpathia in 1967.

Earthquake energy (in joules): 1 - $E = 10^{13}$; 2 - $E = 10^{12}$; 3 - $E = 10^{11}$; 4 - $E = 10^{9}$. Accuracy class: 5 - A, B; 6 - not classified. Focal depth (in km): 7 - $H \leq 60$ km; 8 - $100 \leq H \leq 180$ km; 9 - seismographic stations

data on three earthquakes with $E = 10^9$ j originating in Transcarpathia are given.

Dubinskiy, I. B., A. F. Kostina, and S. A. Kapitonova. Earthquakes in the Crimea. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 21-22.

Observations of earthquakes originating in the Crimea seismic zone during 1967 were conducted at the Alushta, Yalta, Feodosiya and Simferopol' seismographic stations. The stations were equipped to determine epicenter coordinates of earthquakes with $E \geq 10^7$ j. All 19 earthquakes observed originated in the Black Sea in a region between 44.°1 - 44.°6 N and 34.°3 - 35.°0 E.

A catolog listing given in the article contains the following data on 19 earthquakes: date, origin time (GMT), epicenter coordinates, focal depth (16 shocks), accuracy class, energy class K = lgE(j) and the name of the geographical region where the earthquake originated. An epicenter map for earthquakes in the Crimea seismic zone during 1967 is shown in Figure. 1. Seismic activity in this zone in 1967 was characterized by somewhat increased activity in the Yalta-Alushta group of hypocenters.

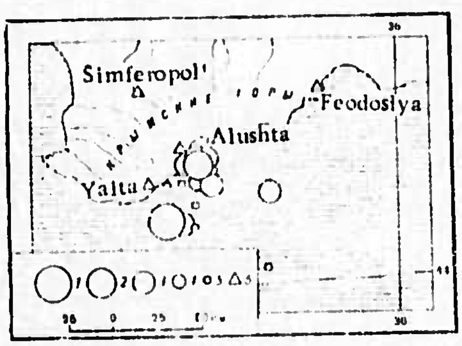

Fig. 1. Epicenter Map of Earthquakes in the Crimea in 1967.

Earthquake energy (in joules): 1- $E = 10^{10}$; 2- $E = 10^9$-10^{10}; 3- $E = 10^8$; 4- $E = 10^7$-10^8; 5- $E = 10^7$; 6- stations.

Tskhakaya, A. D., E. A. Dzhibladze, V. G. Papalashvili, T. M. Lebedeva, Ts. A. Tabutsadze, L. K. Darakhvelidze, L. A. Kakhiani, L. V. Labadze, Z. Z. Sultanova, and V. P. Alimamedova. Earthquakes in the Caucasus. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 23-29.

A network of twenty nine seismograph stations was in operation in the Caucasus in 1967. Twenty four of these stations were equipped with high sensitivity seismographs. In addition to the records of these stations, data from the Seismological Bulletin of the Institute of the Physics of the Earth (Moscow), as well data from seismographic stations in Poland, Turkey, and Finland, were used in the analysis of earthquakes. A catalog listing is given for the following data on 759 earthquakes originating in the Caucasus during 1967: date, origin time (GMT), epicenter coordinates, focal depth, accuracy class, magnitude (11 shocks), energy class K = logE(j) and the name of the region where the earthquake originated (with macroseismic data given for 13 shocks). The distribution of the earthquakes with respect to energy is as follows:

Earthquake energy (joules)	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}	10^{13}
No. of earthquakes	5	73	232	269	103	63	10	3	1

Two epicenter maps, one for earthquakes with $E \geq 10^9$ j (Fig. 1) and the other for $E < 10^9$ j (Fig. 2), are given.

Seismic activity in the Caucasus seismic zone in 1967 was significantly lower than in 1966. A brief description of the macroseismic effects of several earthquakes is given.

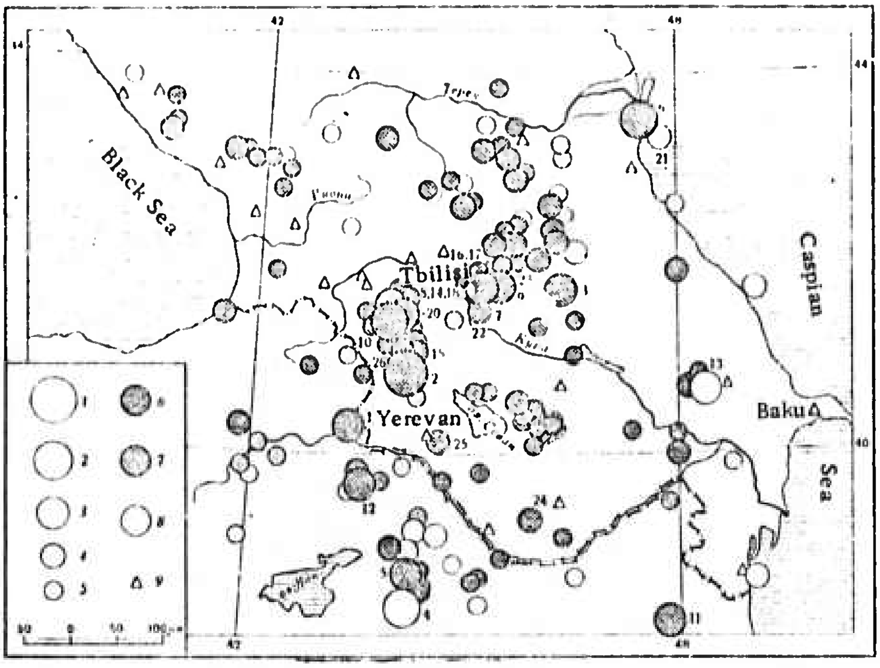

Fig. 1. Epicenter Map of Earthquakes with E $\geq 10^9$ j in the Caucasus in 1967.

Earthquake energy (in joules): 1- 10^{13}; 2- 10^{12}; 3- 10^{11}; 4- 10^{10}; 5- 10^9. Accuracy class: 6- a, b, A; 7- B; 8- n/c; 9- seismograph stations. Numerals denote earthquakes with E $\geq 10^{11}$(j) (nos.1-13) and earthquakes for which macroseismic data exist (nos14-26).

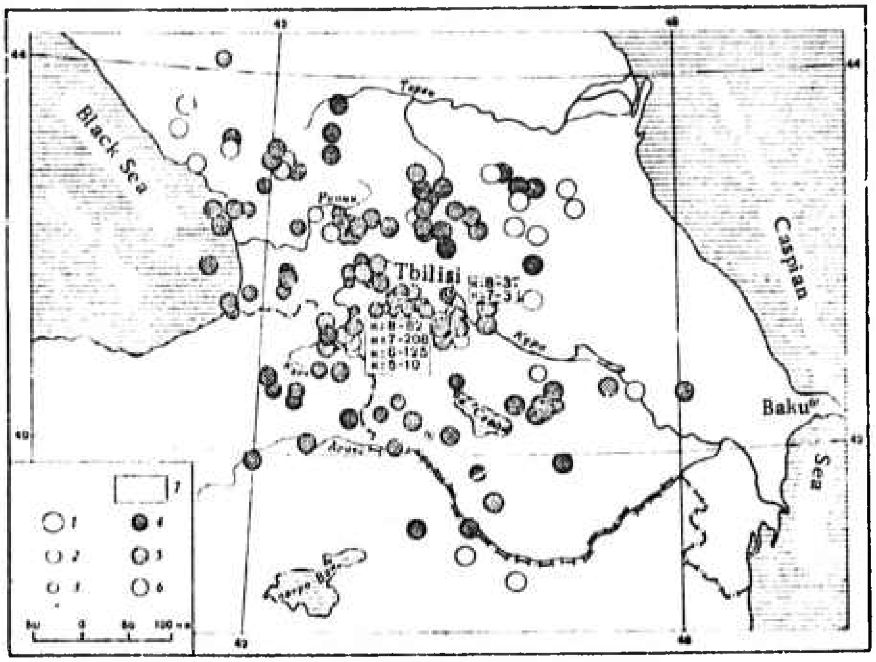

Fig. 2. Epicenter Map of Earthquakes with E < 10^9 j in the Caucasus in 1967.

Earthquakes energy (in joules): 1- 10^8; 2- 10^7; 3- 10^6. Accuracy class: 4- a, b, A; 5- B; 6- n/c: 7- area of epicenter concentration, numerals denote the number of earthquakes with corresponding energy class K = lgE (j).

Nepesov, R. D., K. D. Lagutochkina, G. L. Golinskiy, G. N. Kallaur, and N. Ye. Kolesnikova. Earthquakes in Kopet Dag. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 36-41.

Observations of earthquakes in the Kopet Dag seismic zone during 1967 were conducted at the Kizyl-Arvat, Ashkhabad, Vannovskaya and Krasnovodsk seismographic stations. The last two stations were equipped with high sensitivity seismographs. The location of the seismographic stations in Kopet Dag is unfavorable; thus, only earthquakes with $M \geq 4$ ($E \geq 10^{11}$ j) can be determined. However, some earthquakes with $M < 4$ were determined using additional data from the Turkmen geological-geophysical expedition which was equipped with "Zemlya" seismic recording systems. The article contains a catalog listing of the following data on 72 earthquakes with $E \geq 10^5$ j in Kopet Dag during 1967: date, origin time (GMT), focal depth (10 shocks), accuracy class, magnitude (16 shocks), energy class K = lg E (j) and the name of the region where the earthquake originated. An additional listing is given showing macroseismic data for 12 earthquakes with $E \geq 10^7$ j which were recorded in the Kopet Dag seismic zone. The energy distribution of the earthquakes in Kopet Dag during 1967, is as follows:

Earth quake energy (in joules)	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}	Total
No. of earthquakes	2	3	6	9	17	21	8	9	75

The distribution of local earthquakes with (S-P) $\leq$ 10 sec recorded by one or two stations is as follows:

Earthquake energy (in joules)	10^4	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	Total
Vannovskaya station No. of earthquakes	3	22	42	52	37	10	-	-	166
Ashkhabad No. of earthquakes	1	2	5	9	6	7	1	-	31
Kizyl - Arvat No. of earthquakes	-	-	-	-	1	-	-	-	1
Krasnovodsk No. of earthquakes	-	2	2	1	1	-	-	-	6
Vannovskaya and Ashkhabad No. of earthquakes	-	-	7	41	30	16	1	-	95
Ashkhabad and Kizyl - Arvat No. of earthquakes	-	-	-	-	1	-	-	1	2
Vannovskaya and Kizyl - Arvat No. of earthquakes	-	-	-	-	3	-	1	1	5

An epicenter map is shown in Figure 1. Most epicenters are concentrated in the Ashkhabad and Shirvan-Kuchan regions, where disastrous earthquakes occurred in the past. The remainder of the article contains macroseismic data on several earthquakes.

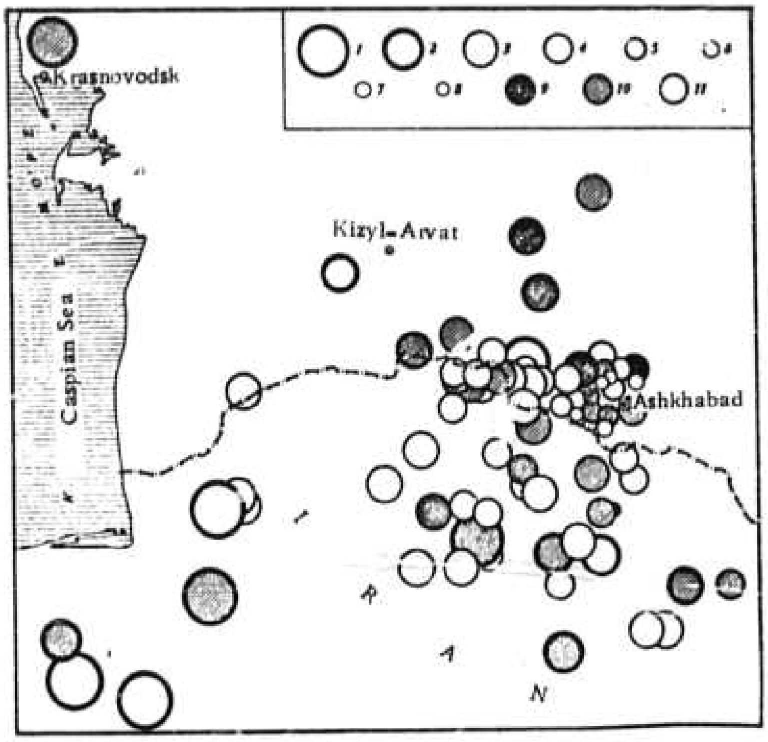

Fig. 1. Epicenter Map of Earthquakes in Kopet Dag in 1967.

Earthquake energy (in joules): 1- 10^{12}; 2- 10^{11}; 3- 10^{10}; 4- 10^{9}; 5- 10^{8}; 6- 10^{7}; 7- 10^{6}; 8- 10^{5}. Accuracy class: 9- A; 10- B; 11- n/c.

Azizov, T. S., Ye. G. Astaf'yeva, A. A. Vlasova, K. Dzhanuzakov, A. I. Zakharova, R. N. Ibragimov, V. K. Iodko, A. P. Katok, T. A. Kinyapina, A. A. Kon'kov, R. I. Kurochkina, V. K. Kuchay, K. Kurmanaliyeva, V. A. Nechayev, M. P. Pavlovskaya, Ye. A. Rozova, O. A. Romanova, P. G. Semenov, E. M. Khaitov, V. N. Yakovlev, and D. Kh. Yakubov. Earthquakes in Central Asia. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 42-90.

The network of seismographic stations which operated in Central Asia in 1967 was the same as in previous years and was capable of determining epicenters of earthquakes with $E \geq 10^9 - 10^{10}$ j originating within the Soviet part of the Central Asia seismic zone. The article contains a catalog listing of the following data on 1236 earthquakes with $E \geq 10^9$ j (580 crustal and 706 subcrustal) occurring in Central Asia in 1967: date, origin time (GMT), epicenter coordinates, focal depth, accuracy class, magnitude (73 events), energy class $K = \lg E(j)$ and the name of the region where the earthquake occurred. In addition to the catalog, a listing is given of 50 strong earthquakes with $E \geq 10^{12}$ j (a few with $E = 10^{11}$ j). The energy distribution of earthquakes in 1967 and 1966 originating in the crust is as follows:

Earthquake energy (in joules)	10^9	10^{10}	10^{11}	10^{12}	10^{13}	10^{14}	10^{15}
No. of earthquakes							
1967	256	219	70	23	6	5	1
1966	364	206	74	15	6	1	-

An epicenter map for earthquakes with $E \geq 10^{10}$ j is shown in Figure 1. Seismicity in Central Asia in 1967 was marked by high activity in the southern Tien Shan region of crustal earthquakes and in the Pamir - Hindu-

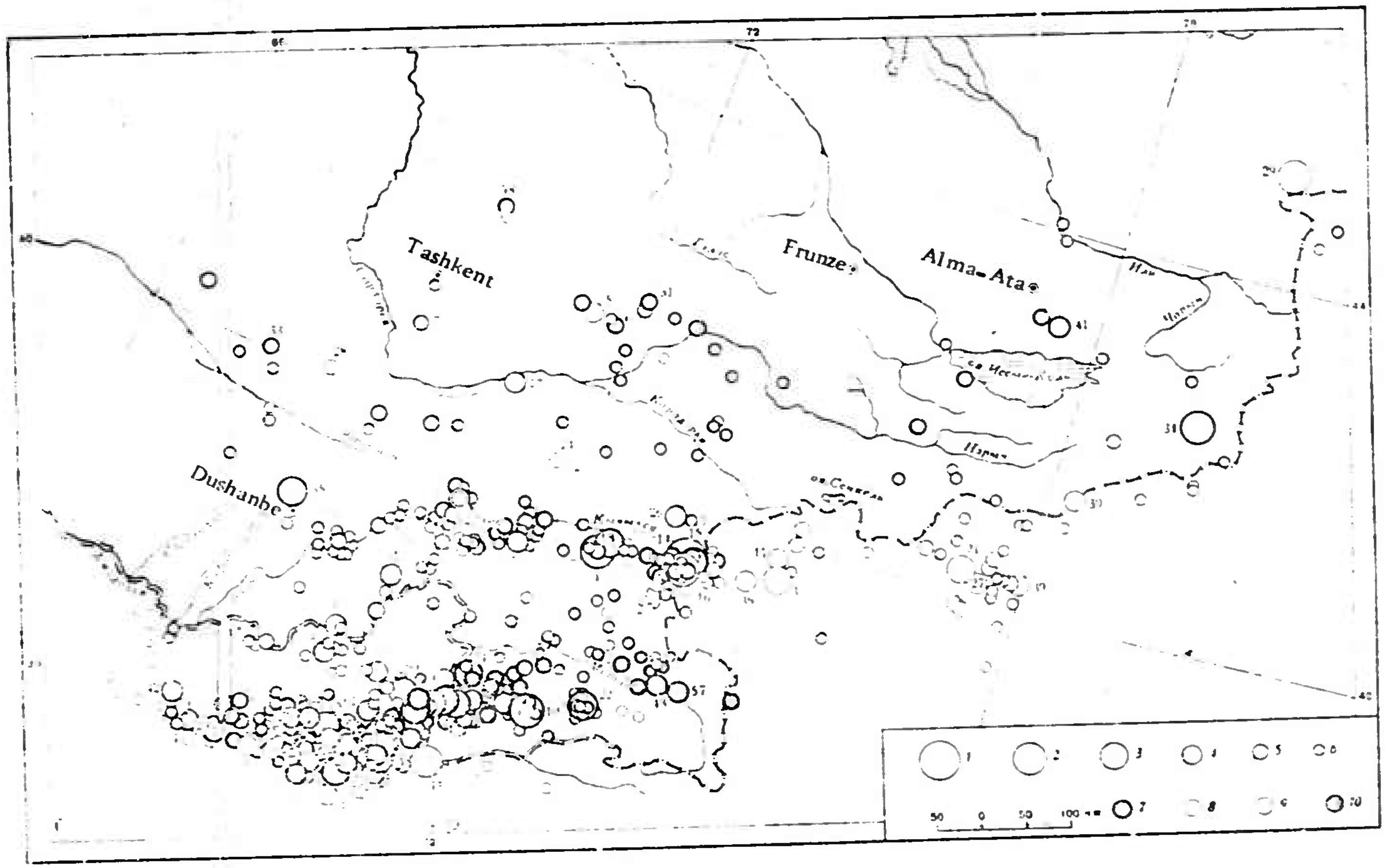

Fig. 1. Epicenter Map of Earthquakes with $E \geq 10^{10}$(7) Originating in Central Asia in 1967

Earthquake energy (in joules): 1- 10^{15}; 2- 10^{14}; 3- 10^{13}; 4- 10^{12}; 5- 10^{11}; 6- 10^{10}. Accuracy class: 7- class A, B; 8- n/c. Focal depth (in km); 9- $H \leq 60$; 10- $60 < H \leq 300$.

Kush region of deep earthquakes. More than a third of all earthquakes in Central Asia occurred in the southern Tien Shan (1 event with $E = 10^{13}$ j; 6 with $E = 10^{12}$ j). Nineteen strong earthquakes occurred in Pamir - Hindu-Kush (6 crustal shocks with $E = 10^{12}$ j; 13 deep events - one with $E = 10^{14}$ j and twelve with $E = 10^{13}$ j). Descriptions of seismic activity in various regions of the Central Asia seismic zone and macroseismic effects of 17 strong earthquakes are discussed.

Kurochkina, R. I., and I. L. Nersesov.
Earthquakes in northern Tien Shan. IN:
Akademiya nauk SSSR. Institut fiziki
Zemli. Zemletryaseniya v SSSR v 1967
godu (Earthquakes in the USSR in 1967).
Moskva, Izd-vo Nauka, 1970, 90-99.

Observations of earthquakes in northern Tien Shan in 1967 were conducted at nine regional-type and three general-type seismographic stations. The Orta-Merke and Charyn stations did not operate in the second half of the year. A catalog listing of data on 336 earthquakes occurring in northern Tien Shan during 1967 is as follows: date, origin time (GMT), epicenter coordinates, focal depth (100 shocks*), accuracy class, and energy class $K = \lg E(j)$. The distribution of the earthquakes with respect to energy is as follows:

Earthquake energy (in joules)	10^5	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}	10^{13}
No. of earthquakes	3	43	162	90	26	7	3	1	1

An epicenter map for the earthquakes is shown in Figure 1. The most seismically active regions in 1967 were the Kungey-Alatau and Terskey-Alatau (western and eastern ends) ridges. The parameters of the recurrence

* The majority of these shocks originated in the regions of the Chilik and Charyn rivers where temporary stations were located.

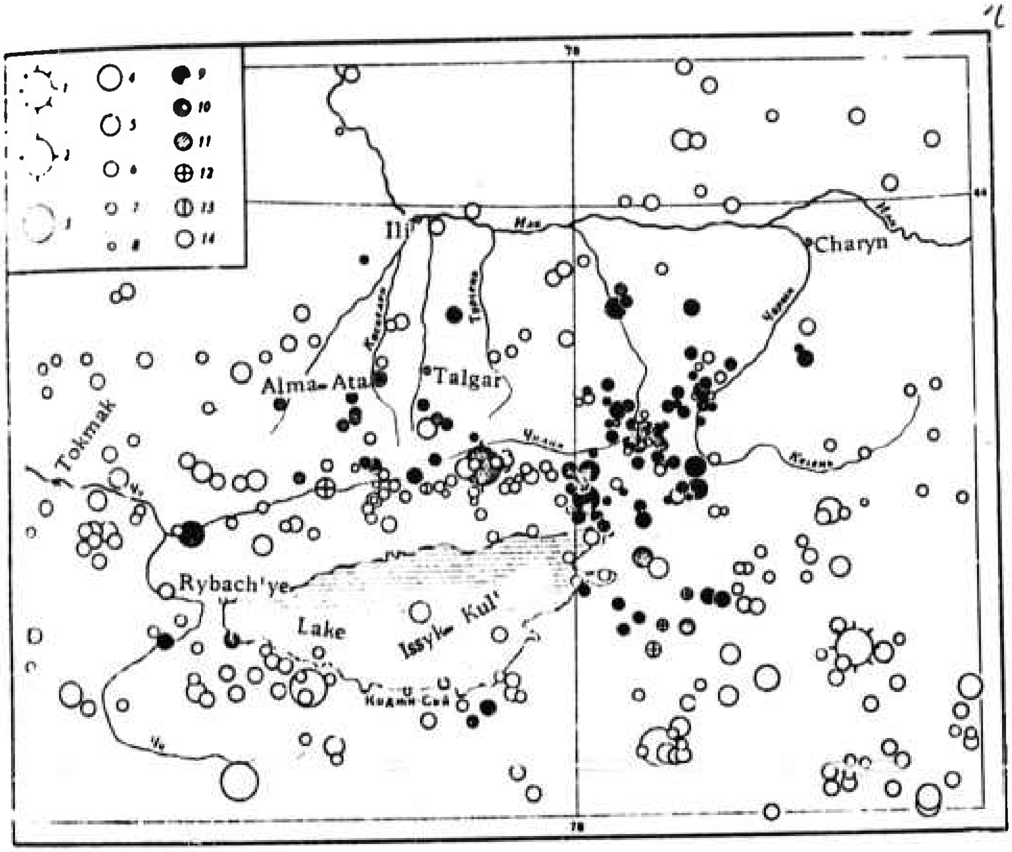

Fig. 1. Epicenter Map of Earthquakes Originating in Northern Tien Shan in 1967.

Earthquake energy (in joules): 1- 10^{13}; 2- 10^{12}; 3- 10^{11}; 4- 10^{10}; 5- 10^{9}; 6- 10^{8}; 7- 10^{7}; 8- 10^{6}. Focal depth (in km): 9- h = 0-5; 10- h = 6-10; 11- h = 11-15; 12- h = 16-20; 13- h > 20; 14- undetermined.

graphs plotted for the 1929-67 (entire period of instrumental observations) 1965, 1966, and 1967 periods are as follows:

Period	1929-67	1965	1966	1967
A_{10}	0.056	0.1	0.076	0.076
γ	0.44	0.42	0.52	0.48

Seismic activity A_{10}* in the last three years was higher than the average

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* Number of earthquakes of energy $E = 10^{10}$ j per year over an area of 1000 km^2.

for all periods of instrumental observations. Graphs of the cummulative strain energy release for the 1929-1967 and 1807-1967 (extrapolated from macroseismic data) are given in the article.

Tsibul'chik, I. D., and A. G. Filina. Earthquakes in the Altay-Sayan zone. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 100-108.

Observations of earthquakes in the Altay-Sayan seismic zone in 1967 were conducted at nine seismographic stations equipped with SK-3M systems. The earthquake epicenters were determined using data from the Altay-Sayan network and additional data from the Baykal network of seismographic stations. The following data on 114 earthquakes with $E \geq 10^9$ j originating in the Altay-Sayan seismic zone in 1967 are given: date, origin time (GMT), epicenter coordinates, energy class K = lgE(j), accuracy class, and the name of the region where the earthquake originated. The distribution of all recorded earthquakes with respect to energy is as follows:

Earthquake energy (in joules)	10^6	10^7	10^8	10^9	10^{10}	10^{11}	10^{12}	10^{13}
No. of earthquakes	17	159	182	81	25	6	-	2

Two epicenter maps are shown, one for earthquakes with $E \geq 10^9$ j (Figure 1) and the other for $E < 10^9$ j (Figure 2). Earthquake epicenters are concentrated within three areas which are indicated in Figure 1 by 1, 2, and 3. Temporal variation of seismic activity for the three epicentral areas is shown in Figure 3. Focal mechanism solutions are given for 2 earthquakes with

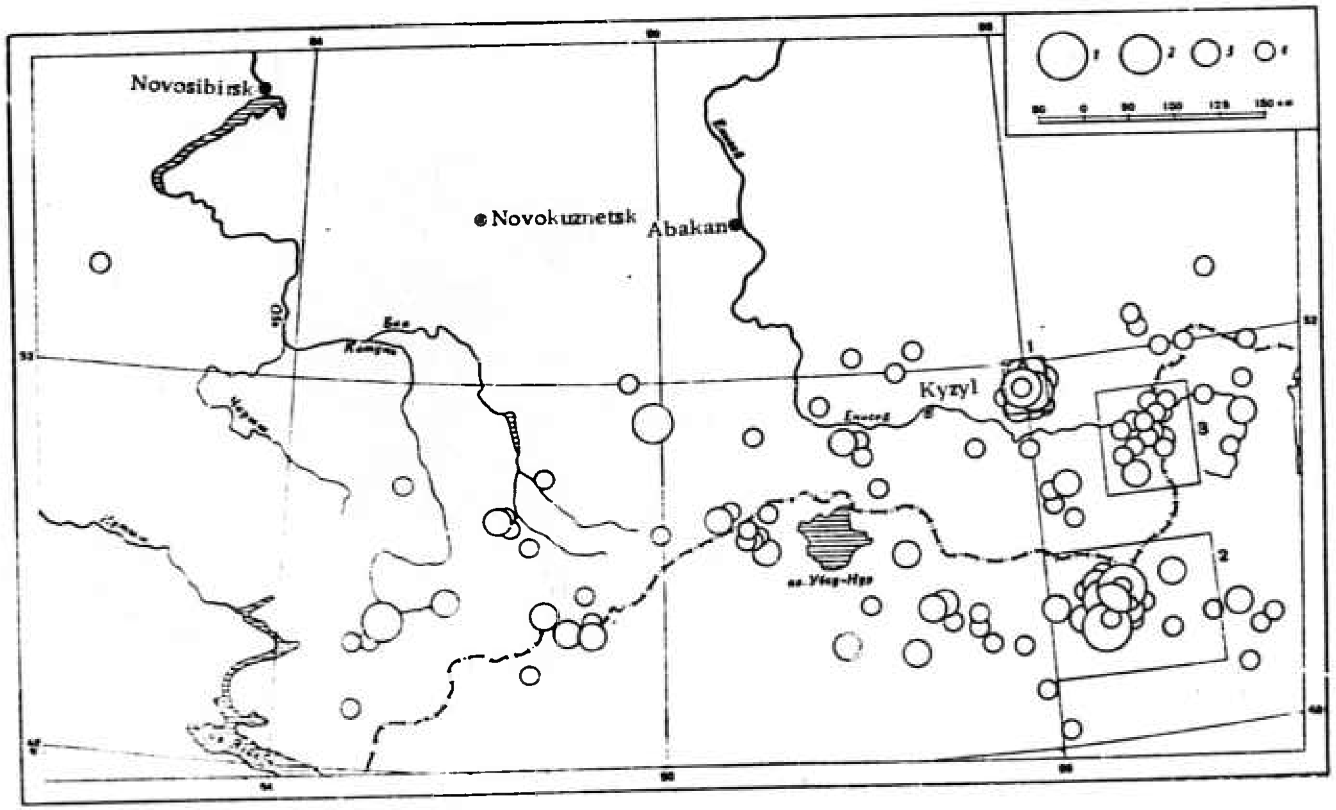

Fig. 1. Epicenter Map of Earthquakes with Energy $E \geq 10^9$ j Originating in the Altay-Sayan Zone During 1967.

Earthquake energy (in joules): 1 - 10^{13}; 2- 10^{11} 3 - 10^{10}; 4- 10^9.

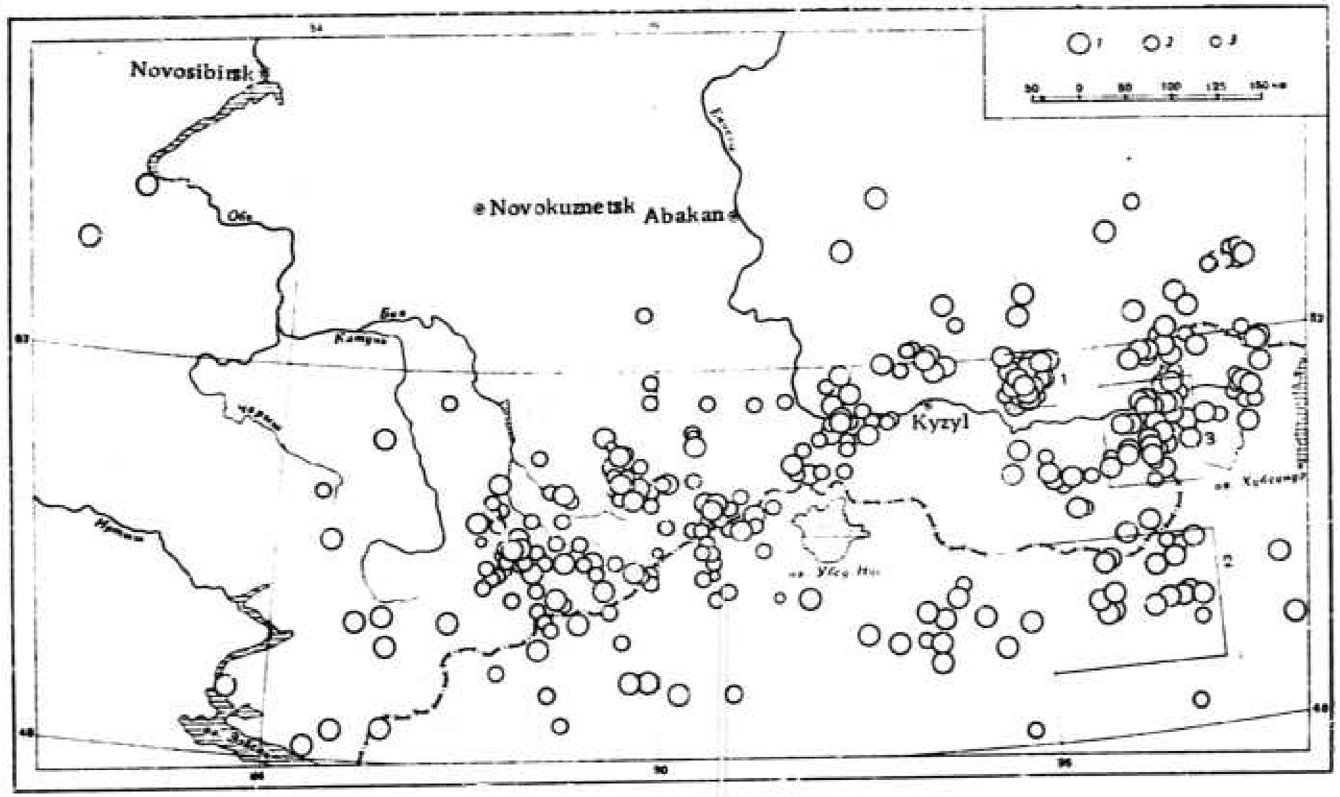

Fig. 2. Epicenter Map of Earthquakes with E < 10^9 j in the Altay-Sayan Zone during 1967

Earthquake energy (in joules): 1 - 10^8; 2 - 10^7; 3 - 10^6.

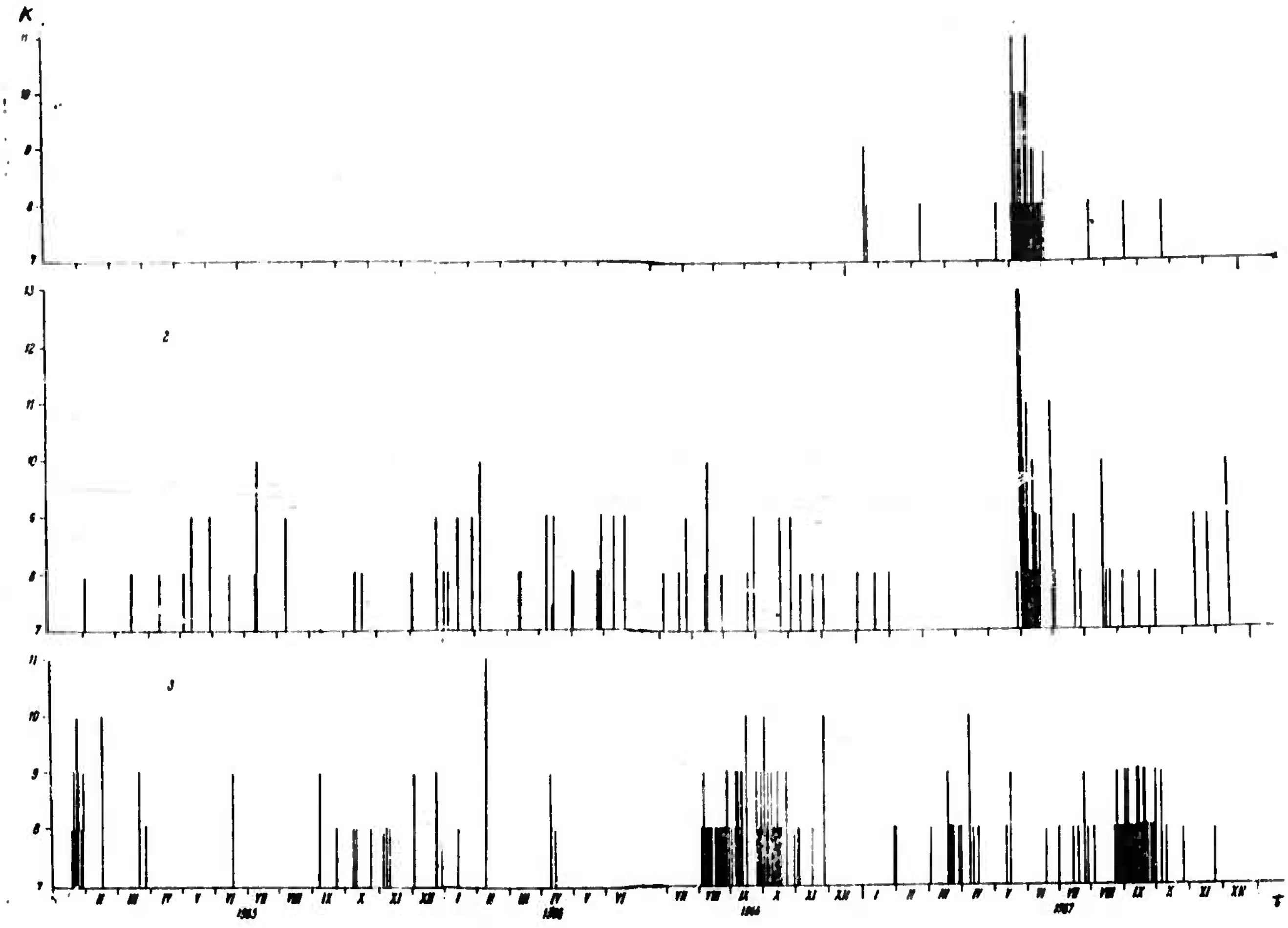

Fig. 3. Variation of seismic activity with time for each of the epicentral areas marked in Figure 1 :

1- between $51.^{\circ}5$ - $52.^{\circ}0$ N and $95.^{\circ}7$ - $96.^{\circ}3$ E; 2- $48.^{\circ}7$ - $50.^{\circ}0$ N and $96.^{\circ}0$ - $98.^{\circ}7$ E; 3- $50.^{\circ}5$ - $51.^{\circ}6$ N and $97.^{\circ}1$ - $98.^{\circ}7$ E.

$E = 10^{12}$ j and 2 with $E = 10^{13}$ j, originating in areas 1 and 2, respectively. The stress state in the two areas is as follows: In area 1, a slightly inclined compressive stress axis and a more inclined tensile stress axis lie in a north-south direction, transverse to the surface tectonic structures; a nearly horizontal intermediate stress axis is parallel to the tectonic structure. In area 2, the slightly inclined compressive and intermediate stress axes lie in the north-south direction and transverse to the surface tectonic structures, while a nearly horizontal tensile stress axis lies parallel to the tectonic structures.

Golenetskiy, S. I., L. A. Misharina, F. V. Novomeyskaya, K. I. Bukina, G. I. Perevalova, E. A. Tret'yak, Ye. V. Fomina, L. R. Leont'yeva, M. S. Kol'tsova, and Zh. G. Mashkintseva. Earthquakes in Baykal. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970. 109-121.

Observations of earthquakes in the Baykal seismic zone during 1967 were conducted at twenty-three permanent and temporary seismographic stations which were equipped as follows:

Station	Seismograph	Station	Seismograph
1. Irkutsk	SK, SG	13. Bodaybo	SKM-3
2. Kyakhta	SK	14. Chara	VEGIK
3. Kabansk	SK	15. Nelyaty	VEGIK
4. Barguzin	SKM	16. Sredniy Kalar	VEGIK
5 Alla	VEGIK, SKM-3 after October	17. Uakit	USF
6. Nizhneangarsk	SKM	18. Arshan	SKM-3
7. Orlik	SKM-3	19. Udokan	VEGIK
8. Kumora	SKM-3	20. Naminga	SKM-3
9. Mondy	SKM-3	21. Zapadnyy	VEGIK
10. Turan	SKM-3	22. Lurbun	VEGIK
11. Tupik	USF, SKM-3 after October	23. Tyrgan	VEGIK
12. Zakamensk	SKM-3		

The response curves for the seismographic systems of the Baykal region stations are shown in Figure 1. The following data are given

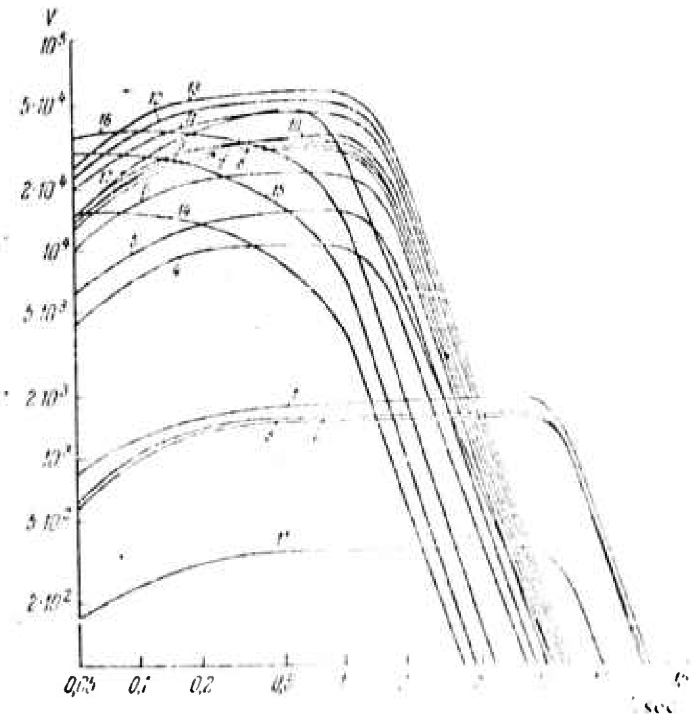

Fig. 1. Response Curves for the Baykal Seismographic Stations. (Curve numbers correspond to above list).

for 297 earthquakes with $E \geq 10^9$ j originating in the Baykal seismic zone* in 1967: date, origin time (GMT), epicenter coordinates, accuracy class, magnitude, energy class $K = \log E$ (j), and the name of the region where the earthquake originated. The distribution of 1809 earthquakes in the Baykal region with respect to energy is as follows:

Earthquake energy (in joules)	10^{13}	10^{12}	10^{11}	10^{10}	10^9	10^8	10^7	10^6	10^5	10^4
No. of earthquakes	2	2	14	30	146	449	763	379	20	1

The epicenter maps are given, one for earthquakes with $E \geq 10^9$ j (Figure 2) and the other for all earthquakes (Figure 3). Most of the earthquakes in Baykal in 1967 occurred at a depth of about 5 - 10 km (Figure 4). Most of the earthquakes in the Baykal seismic zone in 1967, as in previous years, were confined to the Baykal rift zone. Their epicenters fall in a strip, wide in the southwestern part of the Baykal rift zone and narrow in the South and Central Lake Baykal areas, divides into three branches: 1) the northern branch extending along the east coast of the North Lake Baykal and the Upper Angara basin; 2) the central branch extending along the Barguzin ridge, the northern part of the Barguzin basin, and the Severo-Muyskiy ridge; and 3) the southern branch intersecting the Ikatskiy ridge and reaching the Muyskaya basin. Two concentrations of epicenters in the Baykal rift zone are observed: one between the Upper Angara and Muyskaya basins and another between the Muysko-Kundinskaya and Chara basins. The temporal distribution of earthquakes with $E \geq 10^8$ j along the Baykal rift zone (shown in Figure 5) was uniform during 1967. The cummulative strain energy release graph for the Baykal rift zone is given in the article. The slope of the recurrence graph ** for the rift zone is $\gamma \sim -0.5$ (the same as for the entire Baykal seismic zone). Seismic activity in the southwestern part of the rift zone was less than in the northeast (the average value of

* three strong earthquakes originating outside the Baykal zone are also listed

** $\lg N = f(k)$ where $k = \lg E(j)$

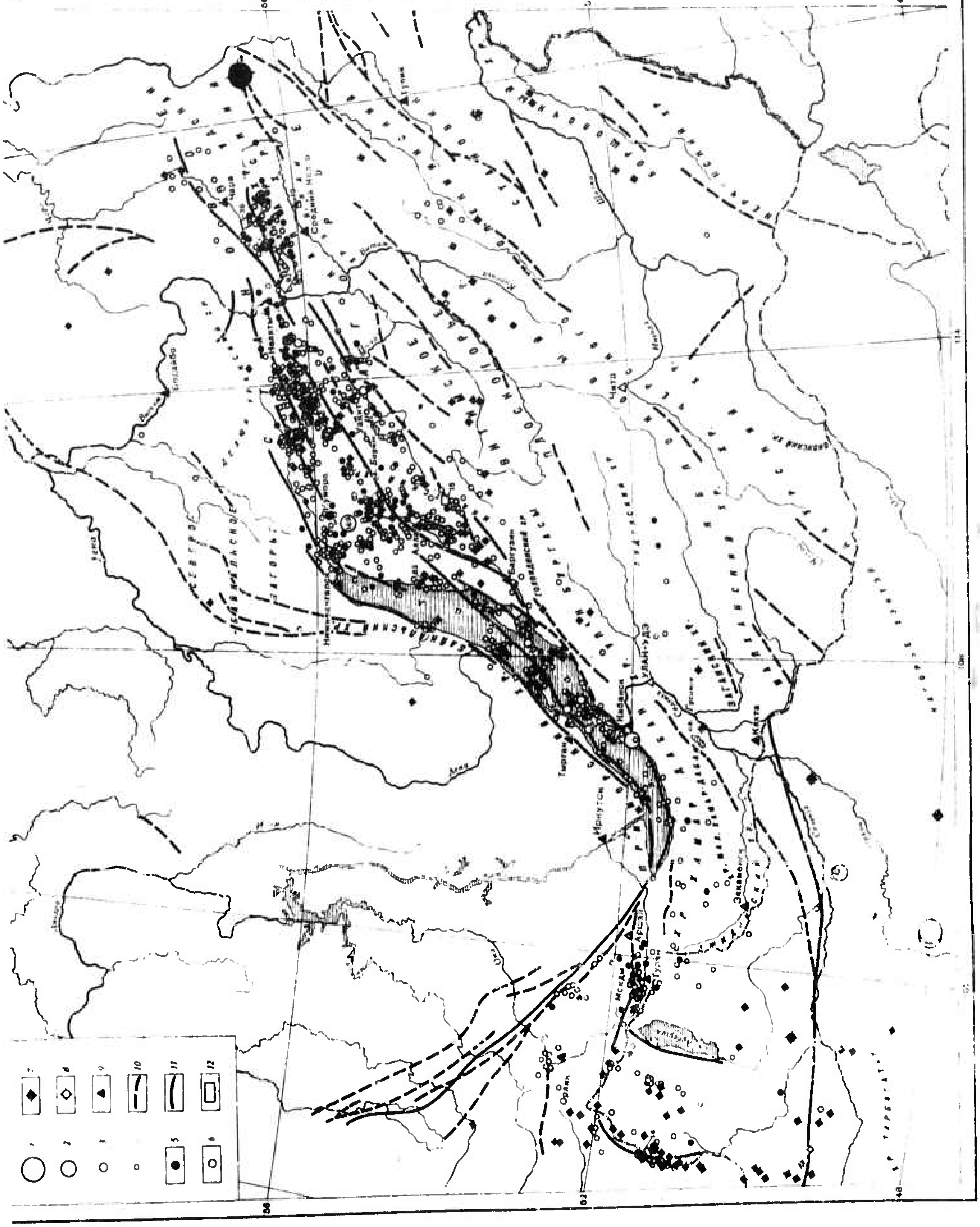
Иркутск
Улан-Удэ
Чита
Кяхта
Нижнеангарск
Баргузин

Fig. 3. Epicenter Map of All Earthquakes in Baykal in 1967

Earthquake magnitude: 1- $6 \leq M \leq 7$; 2- $5 \leq M < 6$; 3- $4 \leq M < 5$; 4- $M < 4$. Accuracy class: 5- a; 6- b; 7- A; 8- B; 9- seismograph station; 10- fault; 11- revived fault; 12- area of epicenters concentration, numeral denotes the number of earthquakes with $E \leq 10^8$ j.

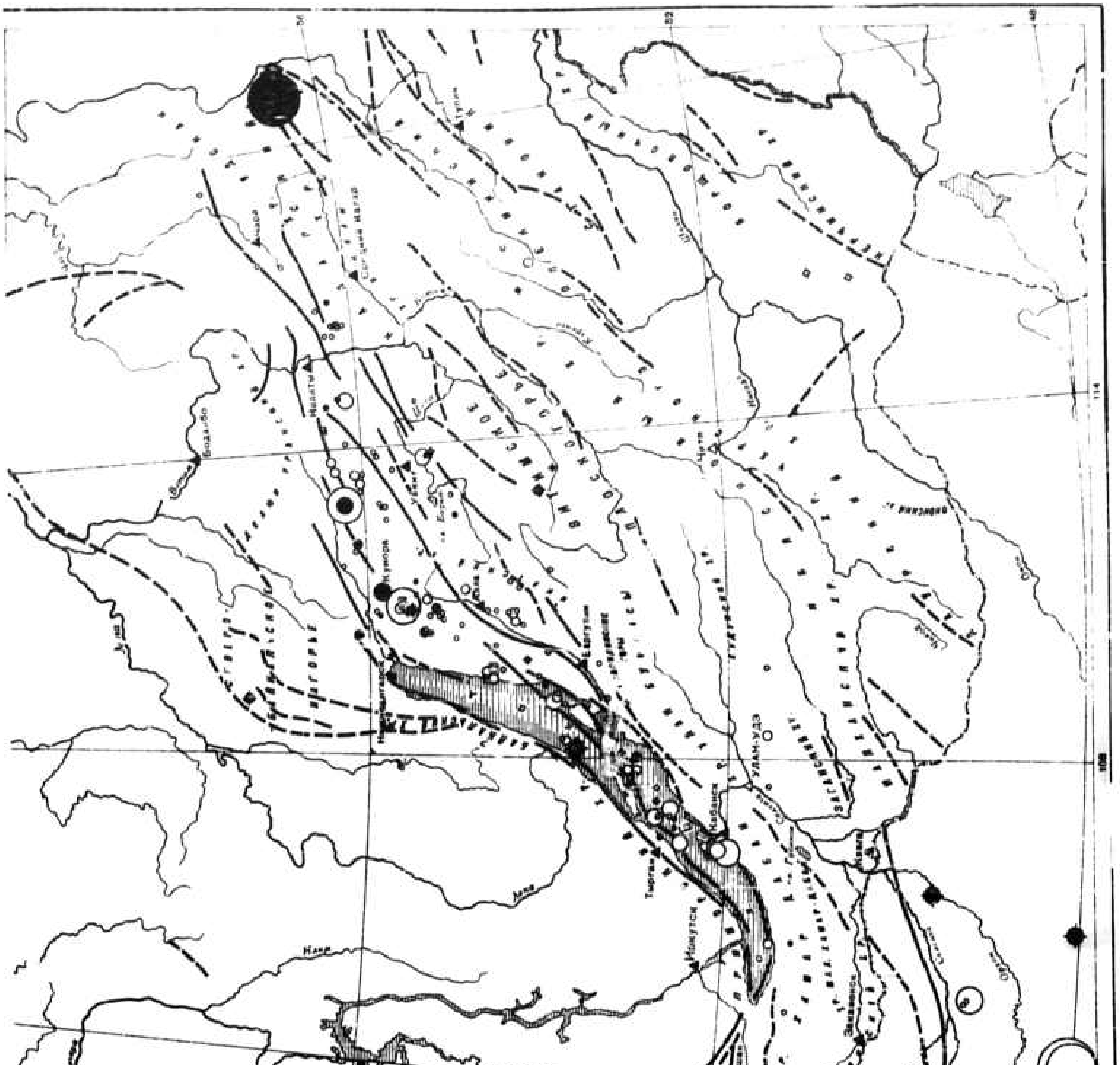
УЛАН-УДЭ
Кабанск
Иркутск

Fig. 2. Epicenter Map of Earthquakes with $E \geq 10^9$ j in Baykal in 1967

Earthquake energy (in joules): 1 - $E = 10^{16}$; 2 - $E = 10^5$; 3 - $10^{13} \geq E < 10^{14}$; 4 - $10^{12} \leq E < 10^{13}$; 5 - $10^{11} \leq E < 10^{12}$; 6 - $10^{10} \leq E < 10^{11}$; 7 - $10^9 \leq E < 10^{10}$;

Accuracy class: 8 - a; 9 - b; 10 - A; 11 - B; 12 - seismograph stations; 13 - faults; 14 - revived faults; 15 - area of epicenter concentration, numeral denotes the number of earthquakes with $E = 10^9$ j.

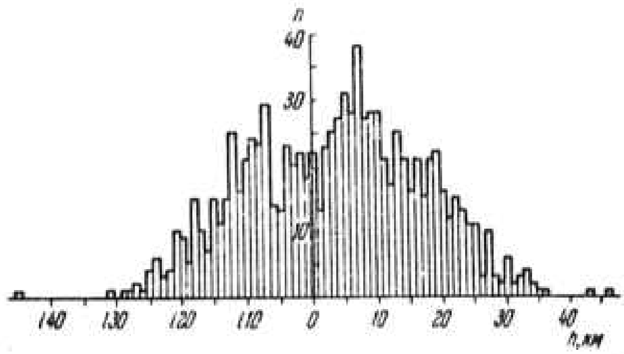

Fig. 4. Distribution of Baykal Earthquakes with Respect to Focal Depth.

h - focal depth; n - number of events

A_{10}* for the rift zone is about 0.08). A seismic activity ** map for the Baykal seismic zone is shown in Figure 6. Seismic activity was highest in the central part of the eastern shore of northern Lake Baykal and in the northeastern part of the Barguzin ridge (A_{10} = 2.0.).

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* number of earthquakes with $E = 10^{10}$ j per year over 1000 km^2

** calculated from the formula $A = \frac{N \cdot 10^{10}(1-10^{-\gamma})}{ST\, 10^{-\gamma(K-K_0)}}$,

where N- number of earthquakes with $E \geq 10^8$ j; averaging area S = 1700 km^2; observation period T = 1 year; energy class of earthquakes for whose seismic activity level is calculated as K_o = 10; energy class of earthquakes recorded without lapse K= 8.

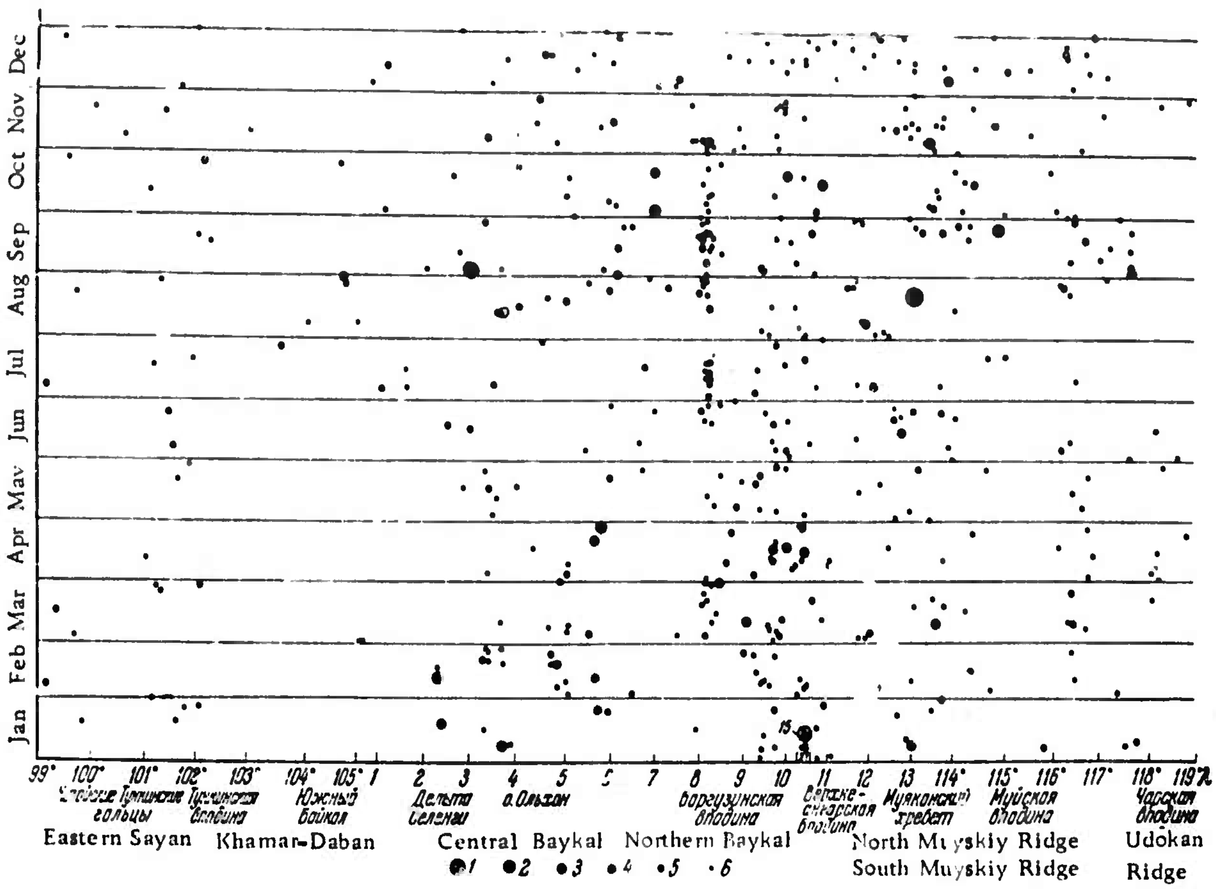

Fig. 5. Variation of Seismic Activity with Time in the Baykal Rift Zone During 1967.

Earthquake energy (in joules): 1 - $E=10^{13}$; 2 - $E=10^{12}$; 3 - $E=10^{11}$; 4 - $E=10^{10}$; 5 - $E=10^{9}$; 6 - $E=10^{8}$. Numbers denote the number of earthquakes.

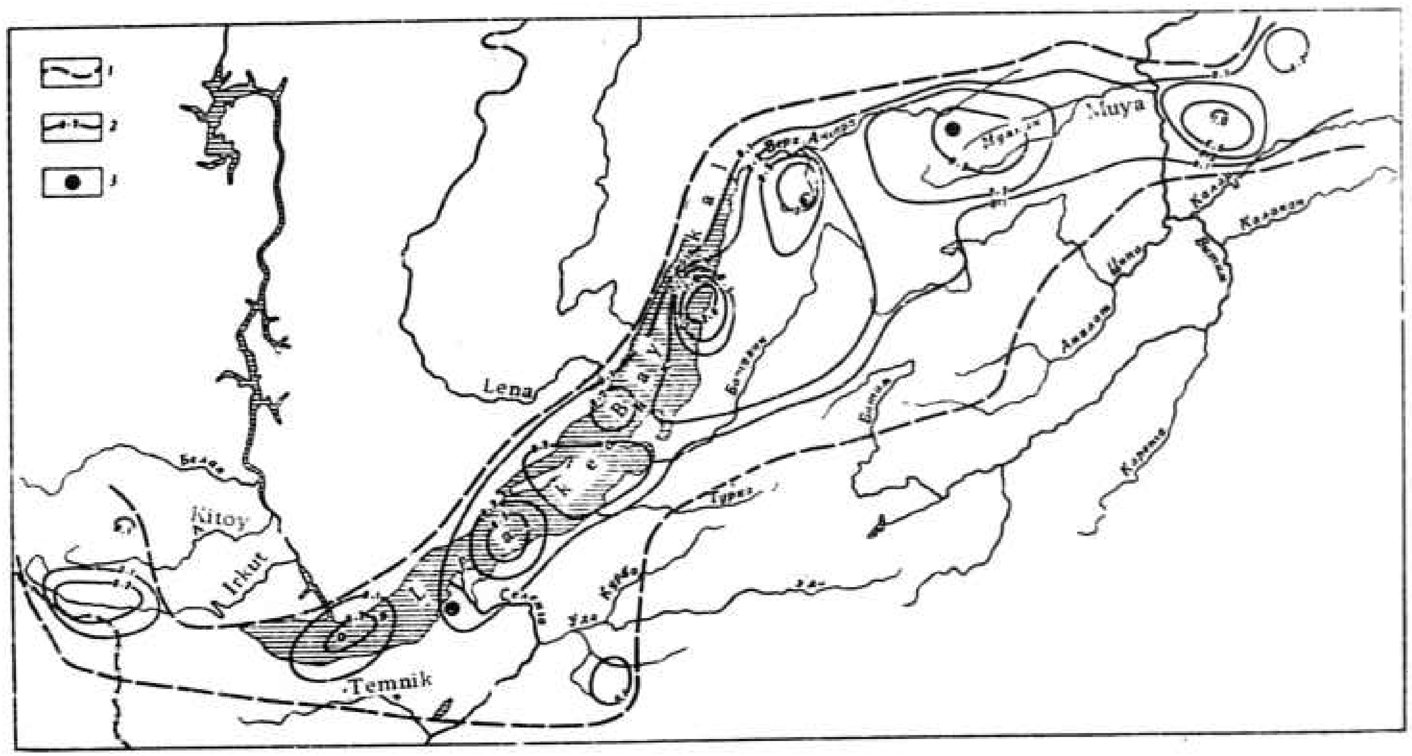

Fig. 6. Seismic Activity Map for Baykal in 1967.

1 - Boundary of the region for which seismic activity is calculated; 2 - contours of seismic activity $\cdot 10$; 3 - epicenters of the strongest earthquakes.

Poplavskaya, L. N., L. S. Oskorbin, L. F. Volkova, and A. N. Boychuk. Earthquakes in the Far East. IN: Akademiya nauk SSSR Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 150-188.

Two new regional seismographic stations were added in 1967 to the existing network for the Far East seismic zone, one on the island of Urup in October and another on the island of Iturup in December. The newly set up stations facilitated lowering the recording threshhold to $E \geq 10^9 - 10^{8.5}$ j for earthquakes originating in the Simushir-Urup, northern Iturup, and Kunashir regions. However, the existing network does not provide data for the determination of epicenter for all earthquakes with $E < 10^9$ j in the southern and central parts of the Kurile Islands region, and with $E < 10^{10.5}$ j in the northern part. Two catalogs of earthquakes in the Far East (excluding Kamchatka north of 52° N and the Commander Islands) are given: 1) a catalog listing the following data on 660 earthquakes with $E \geq 10^9$ j originating in the Kurile Islands and Kamchatka south of 52° N in 1967: date, origin time (GMT), epicenter coordinates, focal depth, accuracy class, magnitude, energy class k = lg E(j), and the region where the earthquake originated, with macroseismic data for 89 shocks; 2) a catalog listing the following data on 114 located earthquakes originating in Sakhalin in 1967: date, origin time (GMT), epicenter coordinates, seismographic recording stations, energy class, and the name of the region where the earthquake originated. The seismicity of the Kurile Islands and the Sakhalin region in 1967 are considered separately.

<u>Kurile Islands</u>. The distribution of earthquakes in the Kurile Islands with respe·t to energy and magnitude is as follows:

Earthquake energy (in joules)	10^7	$10^{7.5}$	10^8	$10^{8.5}$	10^9	$10^{9.5}$	10^{10}	$10^{10.5}$	10^{11}	$10^{11.5}$	10^{12}			
Earthquake magnitude												$5\frac{3}{4}$	6	6 1/[illegible]
No. of earthquakes	17	62	144	182	218	147	131	64	47	34	12	3	5	5

The location of the epicenters of earthquakes with $E \geq 10^9$ j is shown in Figure 1 and $E < 10^9$ j in Figure 2.

The locatio·n of the hypocenters of earthquakes originating between the volcanic arc and the Kurile-Kamchatka Trench is shown in Figures 3 and 4. Figure 3 represents a projection of hypocenters onto a vertical plane parallel to the axis of the Kurile-Kamchatha Island arc at a distance of 130 km from the coast. Figure 4 shows projections of hypocenters onto a vertical plane perpendicular to the axis of the island arc for five separate sectors of the Kurile Islands region (indicated by A, B, C, D, E in Figure 1).

A map of epicenter density is shown in Figure 5, while the variation of epicenter density along the Kurile Islands arc is shown in Figure 6. The distribution of the earthquakes with respect to focal depth is shown in Figure 7. The variation of seismic activity with time for each of the sectors is shown in Figure8. The expression for the recurrence graph obtained for earthquakes with H = 0-80 km is $\lg n = 6.4 - 0.44\ K$.

Seismic activity in the Kurile Islands region in 1967 was hig··r than in 1964-1966 (1 shock with M = 7 followed by aftershocks occurred in the epicentral area of the disastrous 1963 Urup earthquake). Maximum activity, migrating toward Simushir Island during 1963-67, occurred on the island of Urup in 1967. In 1967, some redistribution of the epicenter density

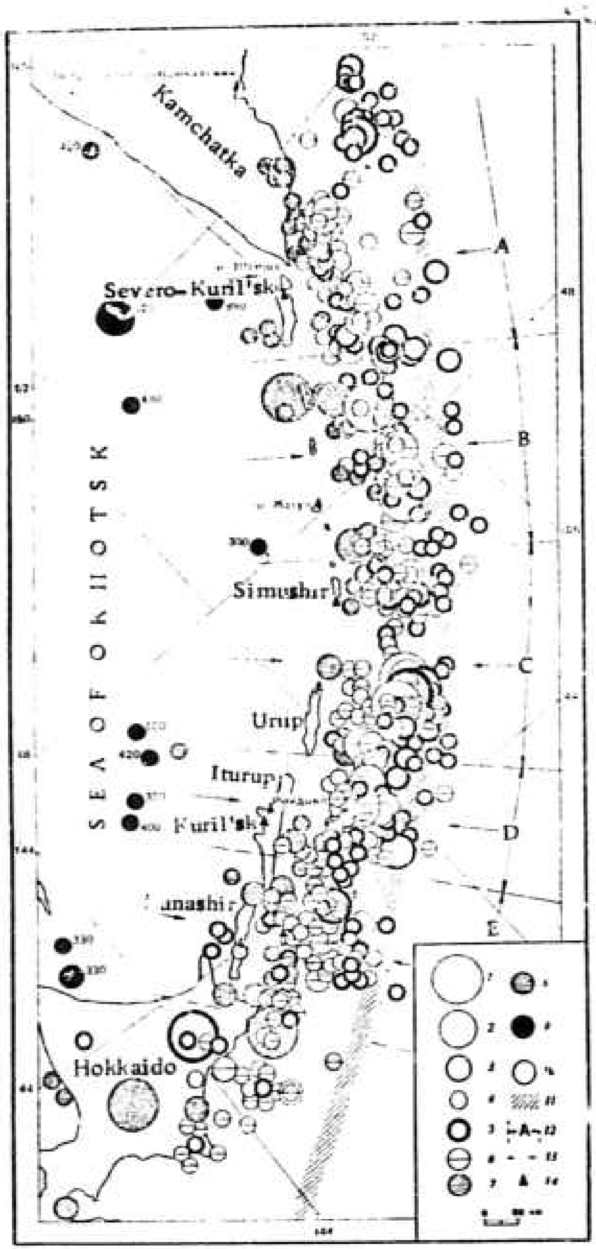

Fig. 1.

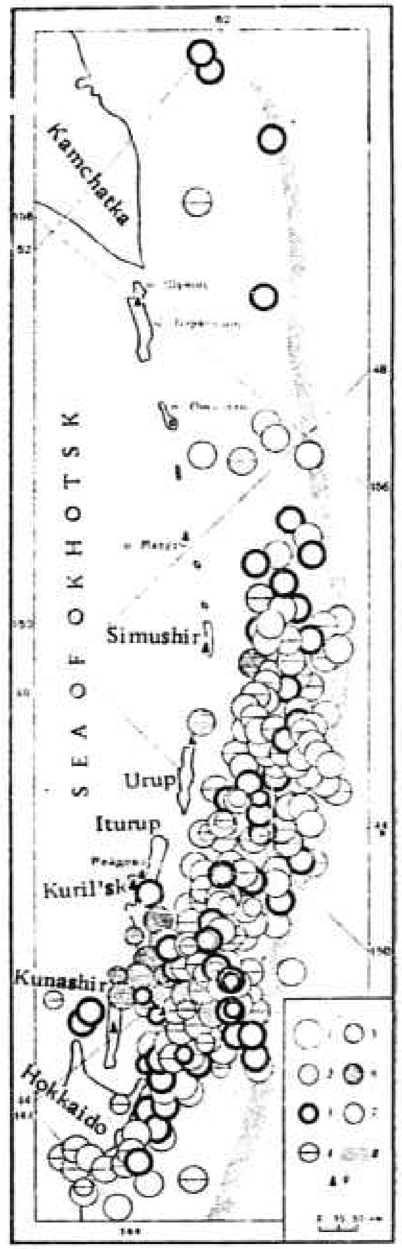

Fig. 2.

Fig. 1. Epicenter Map of Far East Earthquakes with $E \geq 10^9$ j ($M \geq 4$)

Earthquake magnitude and energy (in joules): 1- $M > 6$; 2- $10^{13} > E > 10^{12}$; 2- $10^{12} > E > 10^{11}$; 4- $10^{11} > E > 10^{9}$. Focal depth (in km): 5- $0 \leq H \leq 30$; 6- $30 < H \leq 60$; 7- $60 < H \leq 90$; 8- $90 < H \leq 300$; 9- $300 < H$; 10- focal depth assumed to be $0 \leq H \leq 70$; 11- bottom of the Kurile Trench; 12- sectors of the Kurile Islands region; 13- location of sections shown in Figures 3 and 4. 14- seismographic stations.

Fig. 2. Epicenter Map of Far East Earthquakes with $E < 10^9$ j

Earthquake energy (in joules): 1- $10^9 > E = 10^8$; 2- $E < 10^8$. Focal depth (in km): 3- $0 \leq H \leq 30$; 4- $30 < H \leq 60$; 5- $60 < H \leq 90$; 6- $90 \leq H \leq 300$; 7- focal depth assumed to be $0 \leq H \leq 70$; 8- bottom of the Kurile Trench; 9- seismographic stations.

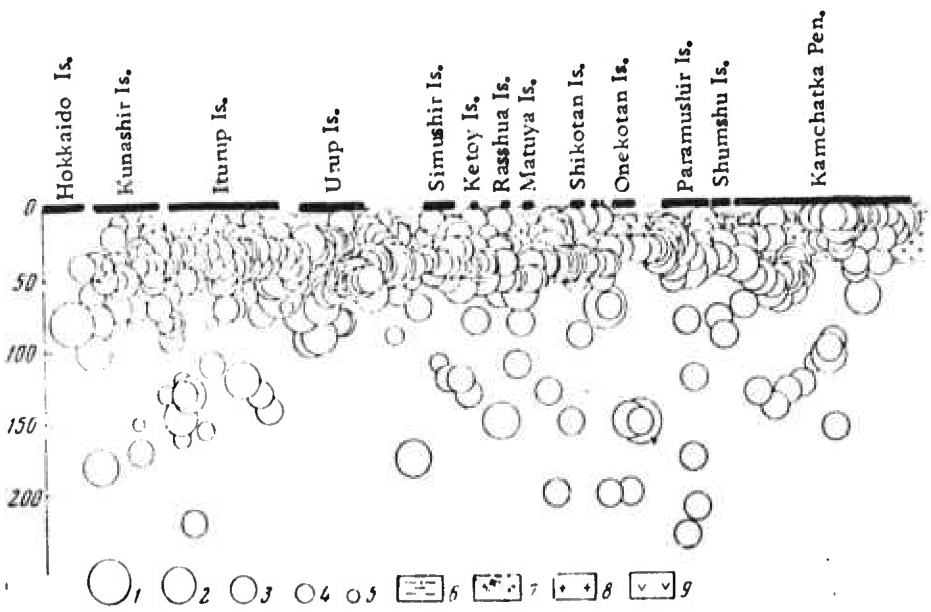

Fig. 3. Projection of Hypocenters of Kurile Earthquakes in 1967 Originating between the Kurile Volcanic Chain and the Kurile Trench onto a Vertical Plane along the Kurile-Kamchatka Arc at a Distance of 130 km from the Coast

1-4 - the same as in Fig. 1; 5- $E < 10^9$ j; 6- water; 7- sedimentary layer ($V_P < 3.5$ km/sec); 8- "granitic" layer ($V_P = 5.2$-6.4 km/sec); 9- "basaltic" layer ($V_P = 6.4$-7.0 km/sec).

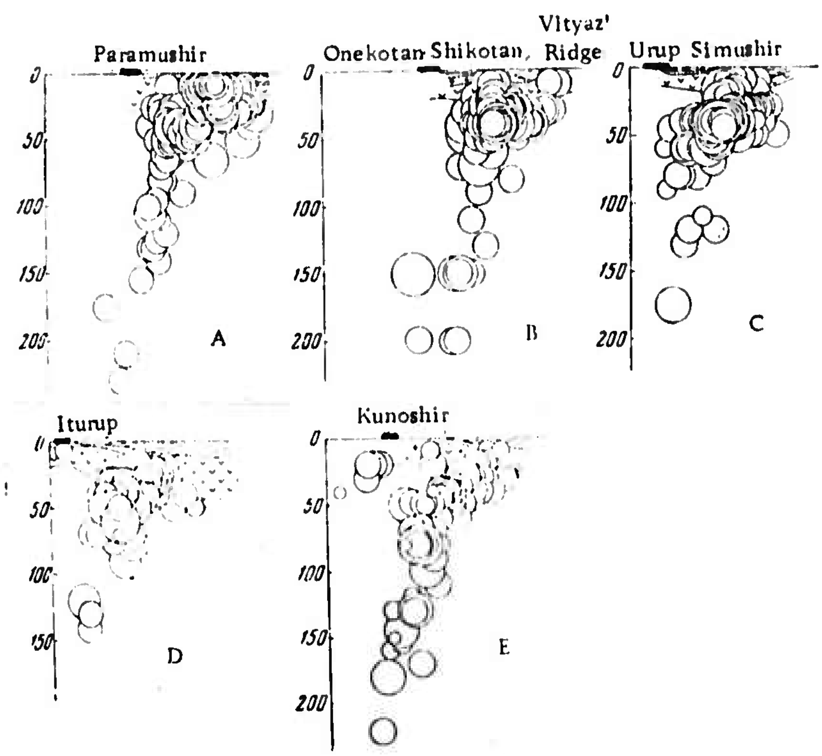

Fig. 4. Transverse Vertical Projection of Hypocenters of Kurile Earthquakes in 1967 Originating within Each Sector in Figure 1.

Designations are the same as in Figures 1 and 2.

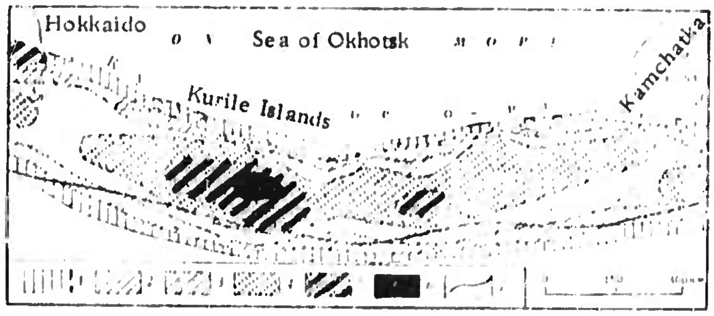

Fig. 5. Epicenter Density (P) Map for the Kurile Epicentral Region, Reduced to M = 4 Using the Recurrence Graph.

1 - $P_{M=4} \leq 1$; 2 - $1.1 \leq P_{M=4} \leq 3$; 3 - $3.1 \leq P_{M=4} \leq 9$;

4 - $9.1 \leq P_{M=4} \leq 27$; 5 - $27.1 \leq P_{M=4} \leq 81$; 6 - $81.1 \leq P_{M=4} \leq 243$

7 - bottom of the Kurile Trench.

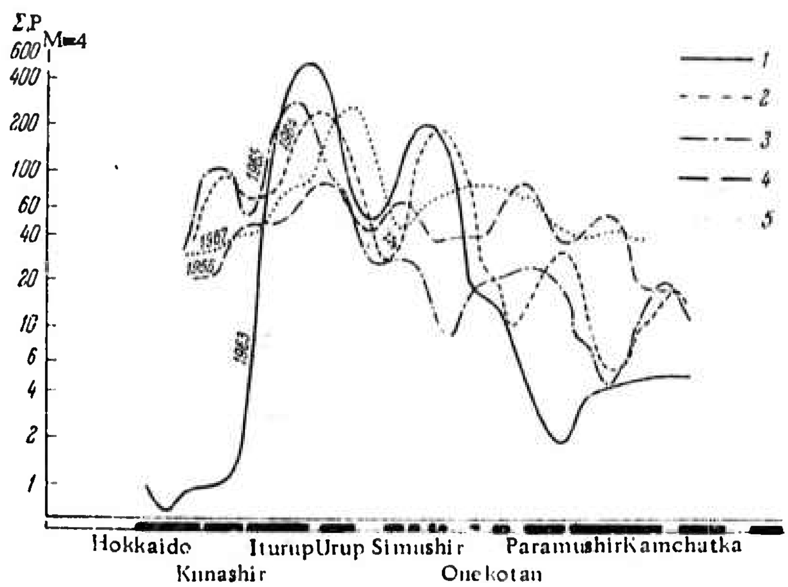

Fig. 6. Variation of Epicenter Density along the Kurile-Kamchatka Arc.

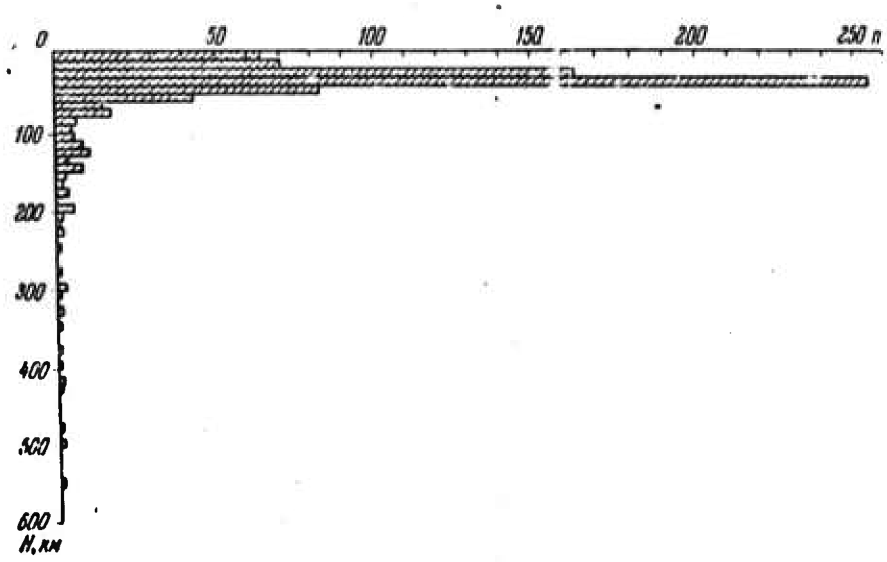

Fig. 7. Distribution of Eartnquakes Relative to Focal Depth.

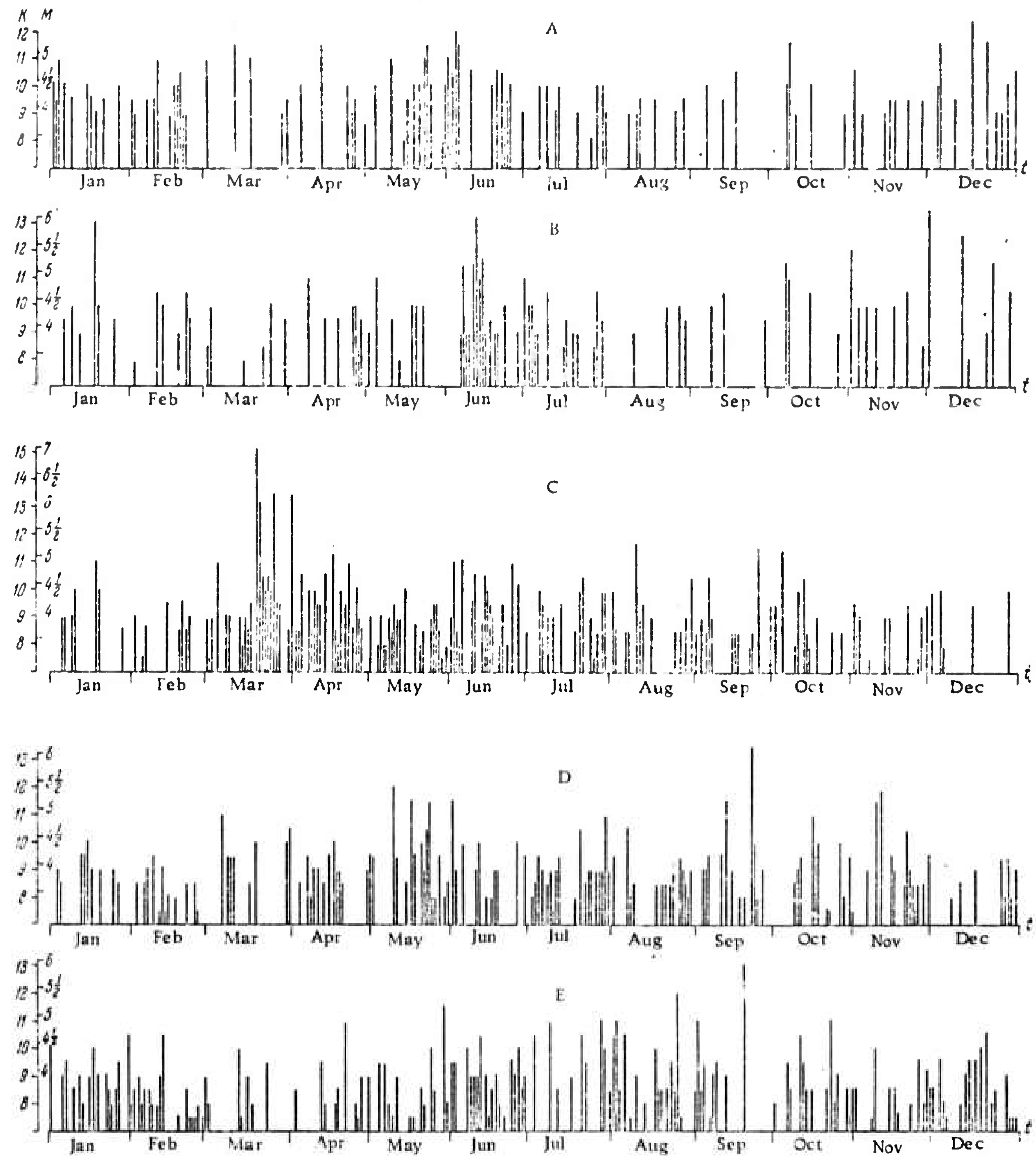

Fig. 8. Variation of Seismic Activity with Time for Each of the Sectors:

A - Paramushir; B - Onekotan-Matua; C - Simushir-Urup; D - northern Iturup; D - Kunashir.

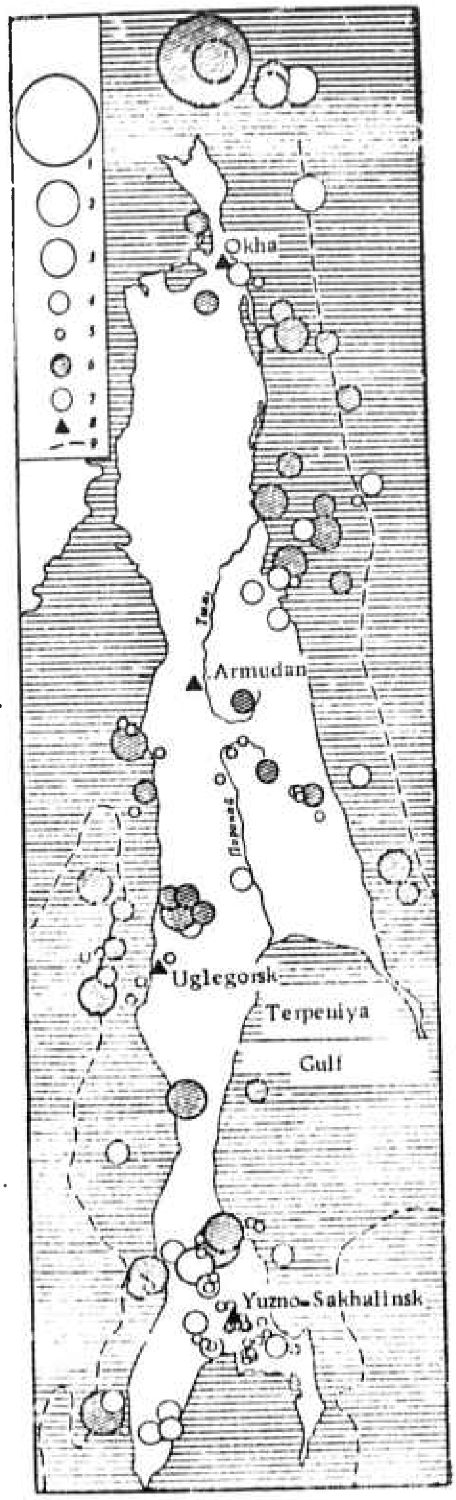

Fig. 9. Epicenter Map of Earthquakes Originating in Sakhalin in 1967.

Magnitude and energy (in joules): 1- M = 5 1/2; 2- $10^{11} \geq E > 10^{10}$; 3- $10^{10} > E \geq 10^{8.5}$; 4- $10^{8.5} \geq E \geq 7$; 5- E < 7; 6- epicenter determined from records of a group of sta ions; 7- from records of one station; 8- seismographic stations; 9- boundary of the insular shelf occurred. The number of shallow events east of the deep-sea trench increased significantly. The distribution of earthquakes with respect to depth is similar to that for 1960-67, but the number of earthquakes in the 11-20 and 50-60 km depth ranges decreased by a factor of 2. Seismic activity in each sector of the Kurile Islands arc is described.

Sakhalin. An epicenter map of earthquakes in Sakhalin during 1967 is shown in Figure 9. In addition to southern Sakhalin, Lesogorsk-Uglegorsk and Nogliki regions (active in 1964-67), and two additional regions, central Sakhalin and the northeastern part of the island, exhibited seismic activity. A strong earthquake with M = 5 1/2 occurred in the aseismic region of northern Sakhalin (aseismic based on data from 1909-1966). The rest of the article contains descriptions of the seismic activity in individual regions of the island.

Landyreva, N. S. Strong earthquakes in the world during 1967. IN: Akademiya nauk SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1967 godu (Earthquakes in the USSR in 1967). Moskva, Izd-vo Nauka, 1970, 216-221.

The Soviet network of basic seismographic stations provides reliable data on global earthquakes with $M \geq 6$. This article contains a catalog compiled from data available in the Seismological Bulletin of the Network of Seismological Stations of the USSR, listing the following data on strong earthquakes: date, origin time (GMT), epicenter coordinates, focal depth (when determined), magnitude M_L and M_{pv}, and the name of the region where the earthquake originated. An epicenter map of earthquakes with M $\geq$ 6 occurring throughout the world in 1967 is shown, as are a table giving the energy of earthquakes within individual global seismic belts and a table giving the earthquake energy released throughout the world (listed separately for the Circum-Pacific seismic belt) in 1963-67. Brief descriptions of the seismic activity in each seismic belt are included.

B. Recent Selections

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Dzhibladze, E. A., and Yu. V. Riznichenko. Seismic shakability of the Caucasus. IN: Akademiya nauk SSSR. Izvestiya. Fizika Zemli, no. 1, 1973, 9-20.

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Kislovskaya, V. V. Symposium on the magnitude and energy classificatio of earthquakes. IN: Akademiya nauk SSSR. Izvestiya. Fizika Zemli, no. 1, 1973, 109-111.

Korniets', D. V. Compressional wave velocities at high pressures and temperatures in samples of magnatic rock from the northwestern Ukrainian shield. IN: Akademiya nauk Ukr SSR. Dopovidi. Seriya B. Heolohiya, heofizyka, khimiya ta biolohiya. no. 1, 1973, 56-59.

Markov, V. K., V. V. Nasedkin, Yu. N. Ryabinin. Stratification in a melt consisting of ultrabasic alkaline material. IN: Akademiya nauk SSSR. Izvestiya. Fizika Zemli, no. 1, 1973, 3-8.

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Rusadze, A. I., and E. E. Gruzman. Deep structure of the Tbilisi area, based on seismic data. Geotektonika, no. 1, 1973, 96-103.

Rybicki, K. The stress drop during an earthquake - the model of a long strike-slip fault in the medium with a horizontal discontinuity (In English). Acta geophysica Polonica, v. 20, nos. 3-4, 1972, 273-280.

Shadrin, L. Nuclear explosion produces oil. Nauka i zhizn', no. 2, 1973, 14-19.

Shvartsman, Yu. P. Theory of the interference reception of seismic waves. IN: Akademiya nauk SSSR. Izvestiya. Fizika Zemli, no. 1, 1973, 48-57.

Zvolinskiy, N. V., G. S. Pod"yapol'skiy, and L. M. Flitman. Theoretical aspects of the problem of an explosion in the ground. IN: Akademiya nauk SSSR. Izvestiya. Fizika Zemli, no. 1, 1973, 28-47.

4. Particle Beams

A. Abstracts

Mkheidze, G. P., M. D. Rayzer, M. S. Rabinovich, and A. A. Rukhadze. Feasibility of building 20 to 50 Mev pulsed electron accelerators. KSpF, no. 3, 1972, 67-74.

The authors briefly review the limitations on present high current pulsed accelerators and suggest a compromise design for an improved charging circuit. With a single switching point, theproblem is to avoid increased bulkiness as energy storage is increased; this can be reduced by going to parallel storage with multiple switching, which however requires synchronization of switch times to the order of a nanosecond.

The charging network proposed by the authors is a voltage multiplier scheme consisting of active and passive pulse-forming lines charged to intermediate levels,which are coupled as disk sections, forming a cylinder 8 m long by 7 m diameter. Schematics of the design are given but unfortunately are illegible; however the network is referred to a design of Mesyats et al (Formirovaniye nanosekundnykh impul'sov vysokogo napryazheniya. Moskva, Energiya, 1970).

The circuit described would provide 100 nsec pulses of 60 ka at 30 Mev, using an intermediate voltage of 2 Mev. Forty sections of line are used, spaced 10 cm apart and 170 cm long; maximum field is not over 300 kv/cm and coupling capacity is 0.17 μf. The line charging unit should be of the Arkad'yev-Marx type which can charge the pulse shaper in 1 microsecond or less; the suggested example would be 5 m long by 5 m in diameter.

The authors include a table of linac characteristics, comparing several U. S. and Soviet designs of 1967-1970.

Rayzer, M. D. Transient effects during heavy-current electron beam generation. ZhTF, no. 8, 1972, 1639-1642.

Factors governing the transient development period of a heavy current pulse are analyzed. The study takes account of the fact that the current load cannot be considered purely resistive, but must include an inductance L_{ak} associated with generation of the current's own magnetic field. Hence the voltage U actually available for electron acceleration is diminished, i.e. $U = U_k - L_{ak}\, dI/dt$ where U_k is voltage delivered to cathode. The author examines U and pulse current I as functions of time and pulse shape for the vacuum diode and drift tube cases, where the relationships are essentially identical, as well as for injection into plasma. Since the ideal square pulse is not realizable, the analysis is also extended to more realistic pulse shapes, namely triangular and sinusoidal. The study shows that the nonstationary interval in question may be a limiting factor on peak attainable current, and can strongly affect the energy spectrum of the electron beam in long drift tubes.

Rukhadze, A. A. Heavy-current electron beams. VAN, no. 1, 1972, 19-23.

This is an informative review on the state of the art in high current generation. It discusses the inherent limits to current flow in terms of electron density and relativistic factor γ, and the fact that the product of electron density and velocity holds constant owing to the integral space charge of the beam.

Past and present research into powerful beam generation in the U. S. and U. S. S. R. is reviewed. Soviet activities cited as presently involved in beam applications include the group under Ya. B. Faynberg in

Kharkov; Ye. K. Zavoyskiy's group at the Kurchatov Institute for Atomic Energy, where CTR research on the "elektronnyy termoyad" (electron thermonuc) is proceeding, and R. Z. Sagdeyev's laboratory in the Institute of Nuclear Physics of the Academy's Siberian Branch, where promising CTR results are similarly being obtained with e-beam heating of a plasma. Several other potential applications for high-current beams are suggested, such as ultrahigh pressure generation, new x-ray sources, atmospheric probing, etc. (See JPRS Translation 55568, 20 March 1972).

Alferov, D. F., Yu. A. Bashmakov, and Ye. G. Bessonov. Relativistic particle emission in undulators. ZhTF, no. 9, 1972, 1921-1926.

Charged particle emission spectra in undulators are analyzed. The spectral emission distribution is found for undulators of varying lengths. It is shown that particle emission spectra halfwidths can be made much smaller than synchrotron emission spectra halfwidths. The application of undulator emission in vacuum ultraviolet and x-ray spectroscopy simplifies the problem of pre-emission monochromatization. A numerical example is described which shows that the spectral emission intensity impinging on a unit of a shield surface changes only negligibly with an increase in the undulator field, but the spectrum widens significantly. Conclusions are: 1) Particle emission in undulators is linearly polarized and directed in a narrow angular interval $\sim 1/\gamma$, where $\gamma = E/mc^2$, E, m = energy and mass of charged particle, and c = light velocity. 2) The particle emission intensities impinging on a unit frequency interval close to ω'_m (where $\omega'_m = 2\gamma^2\omega_o$, ω_o - particle oscillation frequency), are in the ratio of 18:15:1 for, respectively, an ideal undulator, an undulator with a piecewise uniform magnetic field without indefinite length gaps and a magnet with a uniform field, when the total emission intensities are equal. 3) A selection of magnets $N > 16$ is required to lower the maximum spectral distribution of emis intensity in a finite length undulator no more than 30% in relation to an infinitely long undulator. 4) A total of 80% of the particle emission intensity in an undulator with a piecewise uniform magnetic field without gaps and $N \to \infty$ occurs at the fundamental frequency. This supports the assumption, in most practically important cases, that undulators with a large number of periodic elements and sign reversals over the magnetic length are ideal. 5. The particle emission spectra fall steeply at frequencies $\omega > \omega'_m$, which in principle makes feasible threshold particle detection using an undulator with low fields. 6) An optimum value of magnetic field intensity exists in an undulator with a piecewise uniform magnetic field, which corresponds to $\alpha_m \gamma = 1$ ($\Delta\alpha = 2\alpha_m$, $\Delta\alpha$ - particle velocity deflection angle in a magnetic field), at which the spectral emission intensity impinges on a unit of the detector surface and the characteristic frequency ω'_m is maximum. 7) The relative energy dispersion of particle emission in a low field undulator is much less than in a high field undulator.

Brodskaya, B., G. Trapido, and M. Gubergrits. Light flash intensity and electrical characteristics of high current pulse discharges in electrolytes of different chemical composition. IAN Est. Khimiya, geologiya, v. 21, no. 4, 1972, 375-378.

The results are presented of an investigation of light flash intensity and its changes with time in comparison to electrical indicators of discharge development in aqueous electrolytes of various composition. Electrolytes used were aqueous solutions of ammonium chloride and sodium thiosulfate in various concentrations, as well as with the addition of 5-methyl resorcinol, which is prone to active oxidation. A description of the experimental installation is presented, together with a block diagram.

Tabulated results show that a difference in the electrical and optical discharge indicators for solutions with like electrical conductivity is caused by a change in the chemical composition and the presence of an organic additive.

The curves of Fig. 1 show that a decrease of luminescence intensity is accompanied by the capability of mineral and organic electrolytes to participate in oxidation reactions in water. The changes of luminescence intensity (quenching) shown in Fig. 2 for solutions of sodium thiosulfate, and

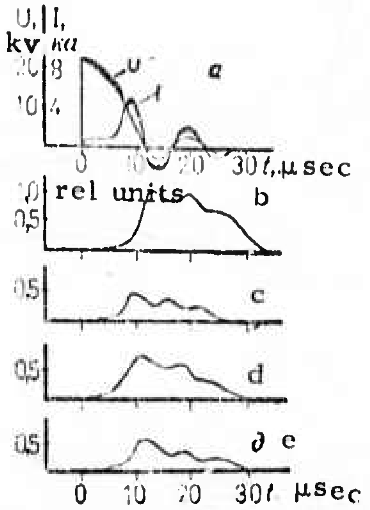

Fig. 1. Typical oscillograms of discharge current and voltage (a) and luminescence intensity in the center of the plasma channel in various electrolytes. (b) NH_4Cl (0.3%); (c) NH_4Cl (0.3%) + orcinol (0.2%); (d) $Na_2S_2O_3$ (0.9%); (e) $Na_2S_2O_3$ (0.9%) + orcinol; U = 22 kv, C = 0.32 μf, l = 15 mm, $\gamma = 6.8 \times 10^{-3}$ $ohm^{-1} cm^{-1}$.

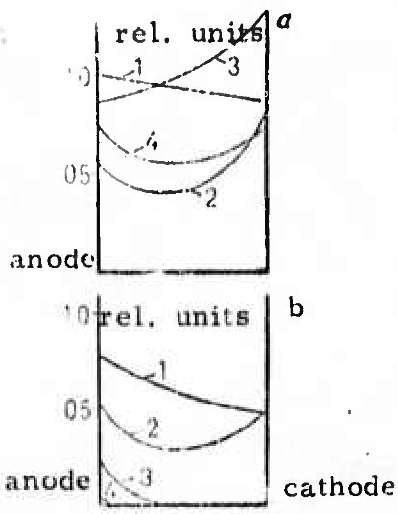

Fig. 2. Luminescence intensity distribution along the plasma channel in various electrolytes: (a) NH_4Cl; (b) $Na_2S_2O_3$; 1 - $\gamma = 6.8 \times 10^{-3} ohm^{-1} cm^{-1}$; 2 - same with orcinol additive (0.2%); 3 - $\gamma = 2.2 \times 10^{-2} ohm^{-1} cm^{-1}$; 4 - same with orcinol additive (0.2%); U = 22 kv, C = 0.32 μf, l = 1.5 mm.

with the addition of orcinol, are an indication of acceptor phenomena in the system which become more complex in the anode and cathode regions. Further studies are planned on the mechanism of the electrophysical phenomena and the chemical mechanism of these processes.

Kovpik, O. F., Ye. A. Kornilov, Yu. Ye. Kolyada, V. D. Shapiro, and V. I. Shevchenko. Excitation of low-frequency oscillations by electron beam in a hot plasma, confined by a probkotron. ZhTF, no. 10, 1972, 2056-2061.

The interaction of an electron beam with hot plasma in an open magnetic trap was investigated, along with plasma heating by ion-acoustic oscillations excited by the beam. The magnetic trap was filled with cold hydrogen plasma (density 10^{13} el/cm^3) using a titanium pulse source. The electron beam (30 kev, 20 a, and τ - 300 μsec) was then injected, as a result of which 1-10% of the electrons were heated to a temperature on the order of tens of kv from the plasma-beam interaction. After the plasma and electron beam sources were switched off the plasma was allowed to decay for 5-10 ms at 10^{-6} torr. The cold plasma component ($T_e \sim 0.1$ to 0.5 kw) disappeare from the trap in 1-5 msec, leaving only plasma with a high electron temperature ($T_e \simeq 50$ kev, $n \simeq 210^{11}$ el/cm^3) in the system. The electron beam was re-injected into the high temperature plasma at a lower velocity than the electron thermal velocity (2-15 kev), a current of 1-10 a and a duration $\tau \simeq 200$ μsec. The excited oscillation spectra in this plasma, the ion temperature, the beam energy loss, and the plasma potential were studied. Trap parameters were: $H_{max}/H_{min} = 2$, stress in the trap center = 1:1.5kg (force), spacing between plugs = 0.8 m, and vacuum chamber diameter = 20 cm. Figs 1 and 2 show oscillation spectra from an harmonic analysis of oscillograms. The

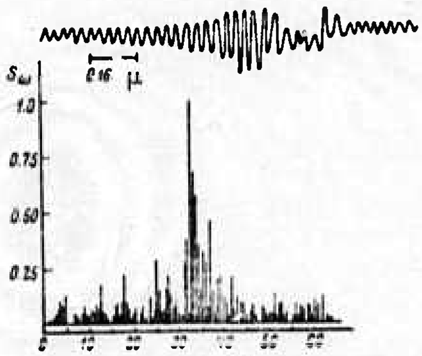

Fig. 1. Oscillation spectra in electron beam region.

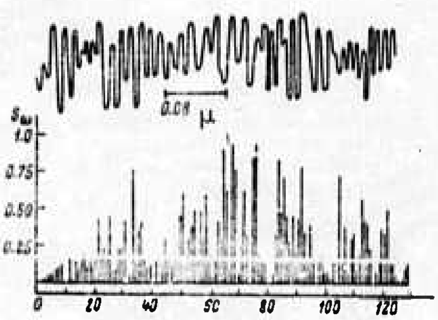

Fig. 2. Oscillation spectra on plasma periphery.

oscillation spectra are in the plasma ion frequency zone with absolute values between 30 and 120 MHz. Instability occurred at currents above critical, and a limiting beam velocity was identified which when increased had no effect on instability. The limiting velocity results from the conditions of Cerenkov resonance between beam velocity and ion-acoustic waves; its experimental value equalled 30 Cs (Cs - sound velocity), which is close to the theoretical value (10-20 Cs). Electron beam scattering at ion-acoustic oscillations and capture by the magnetic trap led to a high radial electrostatic potential formation and the excitation of centrifugal instabilities. Oscillation excitation in the trap was followed by significant ion heating. The plasma consisted of two ion-component groups with temperatures of 400 ev and 1.3 kev.

Bychkov, Yu. I., P. A. Gavrilyuk, and Yu. D. Korolev. Investigating discharge development in the nanosecond range under atmospheric conditions. 10th Int. Conf. Phenomena of Ioniz. Gases, Oxford, 1971. Contrib. paper. Oxford, 1971, 168. (RZhMekh, 8/72, 8B167)(Translation)

Electron-optical investigations are reported of discharge development in the prebreakdown phase and during rapid and gradual increases of discharge current under a variable initial electron density and field (E). In the prebreakdown phase, the ionization front traveled from the cathode to the anode at $V = (1.5\text{-}6)^{1} 10^{8}$ cm/sec with E = 55-100 kv/cm. At E = 55 kv/cm, a second front was observed moving from the anode. The discharge gap was filled with low-conductance plasma immediately before the voltage drop, at which point a diffused discharge occurred when the initial electron density was sufficiently high. The plasma from this discharge occupied a large volume, but had a low ionization velocity (10^{-4} - 10^{-5}) and the current increased due to impact ionization. A high conductivity channel was formed in the second intermediate phase.

An extended discussion of this experiment has subsequently been published by the authors (ZhTF, no. 8, 1972, 1674).

Mamedov, M. A., and A. M. Fedorchenko. Instability of an axially-confined plasma-electron current system. RiE, no. 11, 1972, 2461-2463.

The instability is investigated of an electron current, interacting with a cold homogeneous electron plasma confined between a cathode and an anode. The electron current, with a given density and velocity V_o, is generated on the cathode plane perpendicular to its direction, and is absorbed on the anode plane at a distance L from the cathode. A linear differential equation is derived for the wave potential, and it is shown that when:

$$\nu^4 + 16\xi_p^2 > \nu^2\xi_b^2$$

and (when $\nu = (2n + 1)\pi$, $\xi_p = \omega_p L/\nu_o$, $\xi_b = \omega_b L/\nu_o$, ω_p, ω_b = electron Langmuir frequencies in plasma and current, respectively), the increment of frequency oscillations is positive, wave energy is dissipated, plasma energy increases and system oscillations attenuate with time. When $\nu^4 + 16\xi_p^2 < \nu^2\xi_b^2$, the system instability increment is negative, excitations increase with time, the system transmits energy to the wave, and oscillation swinging occurs.

Approximate dispersion equations are derived for two conditions: 1) in the high frequency region, $\omega >> \omega_p$, when the electron beam density is well below the plasma electron density, and 2) for low plasma frequencies. At $\xi_o = 2n\pi$ and a high frequency, where $n = 1, 2, 3 \ldots$ (ξ_o = $Re\xi$ is a positive real root of the equation $ReD(\xi) = 0$), the system instability increment $\gamma\omega < 0$, and oscillations increase with time; and at $\xi_o = (2n + 1)\pi$, $\gamma\omega > 0$ and system HF oscillations attenuate with time. For low plasma frequencies, when $\xi = 2n\pi$ ($n = 1, 2, 3 \ldots$), spatial acceleration exists and excitations increase in space: but when $\xi = (2n + 1)\pi$, the excitations attenuate in space.

Karasev, V. N., A. V. Minyatov, V. G. Pankratov, and V. N. Stepanov. Correlation of adsorption processes on a cathode surface with processes in the electrode region of a heavy-current discharge in plasma. ZhPMTF, no. 5, 1972, 29-32.

A method is suggested for calculating the emission characteristics of a cathode during a heavy-current discharge in plasma, taking into account the mutual effect of adsorption on the cathode surface and processes in the precathode region of the discharge. The characteristics of the electrode film, made from a plasma material, determine the work function, and thereby the discharge current density and precathode potential drop φ_s. The level of the absorbed particle film on the cathode however depends significantly on φ_s. Equations are derived for precathode region processes based on relationships reported earlier by two of the authors, Minyatov and Pankratov (ZhTF, v. 41, no. 4, 1971). The simultaneous solution of the equations made it possible to determine the precathode region characteristics of the cathode surface adsorption processes. Calculations were based on a tungsten cathode with A =

const. = 70 a/cm^{-2} deg^{2} and a lithium adsorbate. The plasma electron temperature was assumed to be $T_e = 10^4$ °K, and the plasma ions and neutral atoms temperature was $T_i = T_a = 4 \times 10^3$ °K. Fig. 1 shows typical

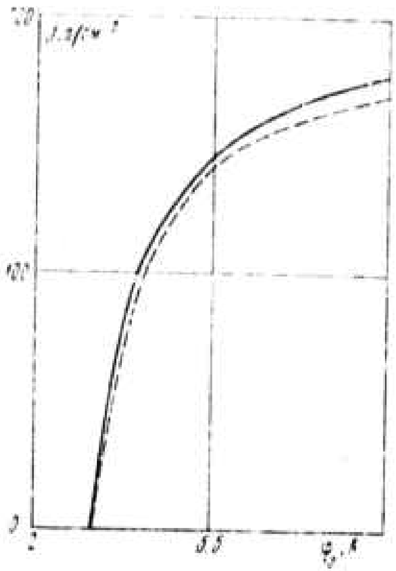

Fig. 1. Pre-cathode volt-ampere characteristics with (solid line) and without (dashes) consideration of the cathode surface dynamic absorption of the plasma materials at $n_i = 2 \times 10^{15}$ cm^{-3}.

volt-ampere characteristics in the precathode region and Fig. 2 shows cathode

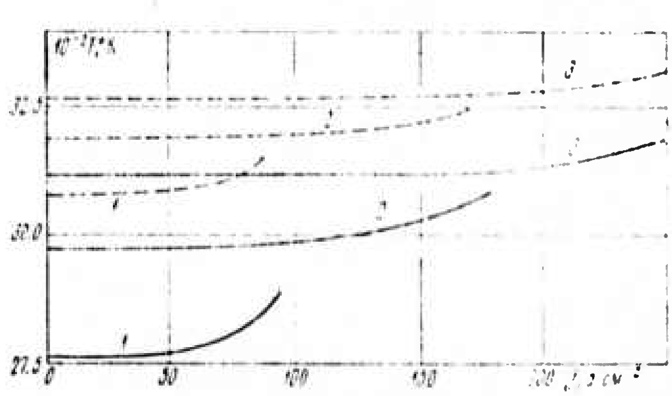

Fig. 2. Surface temperature dependence as a function of cathode current density with (solid line) and without (dashes) consideration of dynamic absorption. Curve 1 - $n_i = 10^{15}$ cm^{-3}; 2 - 2×10^{15} cm^{-3}; 3 - 3×10^{15} cm^{-3}.

surface temperature versus current density. The analysis reveals that an increase in plasma ion concentration results in a higher cathode temperature and a reduced voltage drop in the precathode layer. The increased ion concentration also leads to a decrease in the effect of adsorption on precathode processes. The relationship $T_\omega = f(j)$ (T_ω - cathode surface temperature) reflects the significant effect of precathode processes on the cathode film level. The study shows that precathode region calculations which ignore adsorption processes yield incorrect results.

Bomko, V. A., and B. I. Rudyak.
Linear accelerator of charged particles.
Author's certificate USSR, no. 334931, published March 18, 1970. (Otkr izobr, 30/72)

The proposed accelerator design is in the form of a cavity resonator with drift tubes and spatial tuning devices. To stabilize accelerating field amplitude and phase characteristics, electrically conducting movable stubs are mounted on the end wall parallel to the resonator axis.

Kapel'yan, S. N., and Z. M. Yudovin.
Vaporization of metal during a heavy-current pulsed discharge. DAN BSSR, v. 16, no. 11, 1972, 991-994.

The effect on metals of powerful thermal pulses from a heavy-current pulsed discharge is examined. Expressions are derived for thermal processes, the phase transition front temperature, and the front propagation distance. Data on the kinetic process of metal destruction by electric pulses were obtained experimentally using the device shown in Fig. 1.

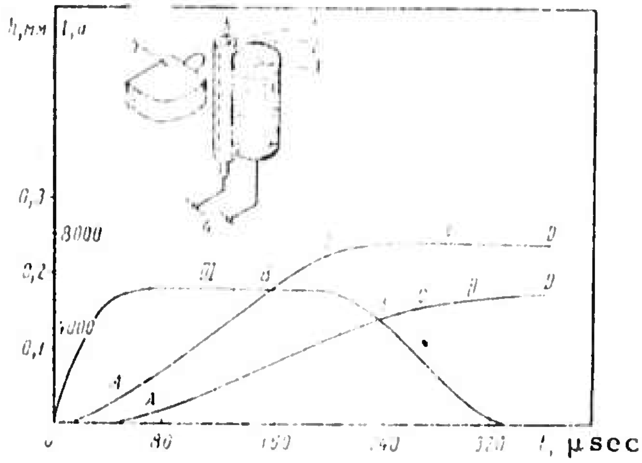

Fig. 1. Time relationship of the deepening of the vaporization front and discharge current for Zn: I - anode; II - cathode; III - current pulse. (1 - electrode targets, 2 - quartz tube, 3 - auxiliary electrode, 4 - discharge shaper lines, and 5 - streak camera).

Discharge current oscillograms and time relationships were obtained for the destructive deepening front of Pb, Cd, Sn, Zn and Al metals (Fig. 1 is a plot for Zn). The destructive deepening processes differed significantly for the anode and the cathode. Deepening in the anode began immediately with the pulse; but in the cathode, a preliminary "warm-up" occurred and noticeable deepening of the vaporization front started after 20-25 μsec. With the exception of Al, the vaporization front velocity for all metals in a steady-state regime (C_0) was higher on the anode than on the cathode (Table 1). The C_0 was identical on the aluminum anode and cathode, equalling 1.1 m/sec. The warm-up time and transient process duration for Al were 80-90 μsec and 120-150 μsec, respectively, which exceeded the corresponding values for the other metals. Thermal flux densities were calculated for various time intervals: at the initial pulse stage q_1, during the transition process, q_2, and

Table 1

		[illegible]	[illegible]	$q_1 \cdot 10^{...}$ [illegible]	$q_2 \cdot 10^{...}$ [illegible]	$q_3 \cdot 10^{...}$ [illegible]
1	2	3	4	5	6	7
Cd	A	2,1	1,75	0,11	2,6	2,9
	K	1,2		0,23	1,5	1,6
Sn	A	1,8	1,61	0,19	4,7	5,2
	K	1,1		0,39	2,9	3,2
Pb	A	2,4	1,4	0,31	3,2	3,6
	K	1,7		0,23	2,2	2,5
Zn	A	1,2	1,6	0,48	2,2	2,4
	K	0,75		0,39	1,2	1,3
Al	A	1,1	1,0	0,99	[illegible]	3,9
	K	1,1		1,03	3,6	3,9

Experimental data on vaporization kinetics.

for a steady-state regime, q_3 (Table 1). Integral current densities at the anodes and cathodes, estimated for all the metals tested, were between 1×10^5 and 4×10^5 a/cm^2.

Aleksandrov, A. F., V. V. Zosimov, and I. B. Timofeyev. Power instability of a linear pinched discharge in an opaque dense plasma. KSpF, no. 2, 1972, 25-30.

Results are described from a study of power instability of heavy-current pinched discharges in a dense optically opaque plasma, formed by electric explosion of metal wires in a vacuum. Experiments were conducted in a capacitive storage device consisting of 24 condensers, charged to 20 kv.

Discharge current duration was 25 μsec at a 160 ka amplitude. The discharge chamber was in the form of two flat electrodes spaced 25 cm apart inside a 10 cm diameter quartz vessel. Al, Cu, Ag, and W wires of 0.09 - 0.14 mm diameters were stretched between the electrodes and exploded at a chamber pressure of 10^{-5} torr. The average discharge radius and brightness temperature were determined from streak camera photos and spectrograms as a function of time. Results agreed well with earlier findings of two of the authors (KSpF, no. 6, 1970, 58). A clearly evident stage of magnetic confinement of the plasma was noted close to the time of the initial current maximum; the average discharge radius was about 1.2 cm. The character of discharge emission corresponded to black-body radiation at this moment, and the temperature, which varied slightly, was about 2 ev. Unstable radiation developed in the plasma at this discharge stage. Fig. 1 is a typical photograph of the discharge channel with highly

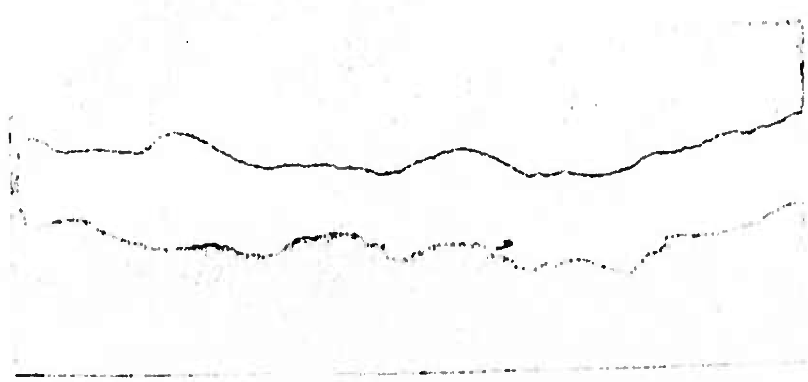

Fig. 1. Discharge with developing instability
(Al, d = 0.14 mm, U_0 = 20 kv). No scale given.

developed instability, taken during an Al-wire explosion. The authors classify instabilities into helical and constricted types. Harmonic expansion coefficients, A_n (for helical) and B_n (for constricted) in Fourier series were determined and graphs are given (e.g., Fig. 2) for A_n/A_{nmax} and B_n/B_{nmax} with respect to the dimensionless parameter $\alpha = k_z r_p$, where k_z is the wave number of the corresponding harmonic and r_p is the uniform radius of the

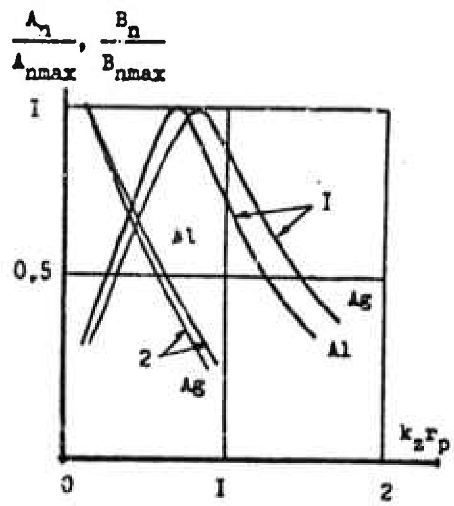

Fig. 2. Relationship of the amplitude of Fourier components to the parameter $\alpha = K_z r_p$ for: 1 - constricted excitations; 2 - helical excitations.

plasma column at a given moment. The constricted instability amplitude was maximum at harmonics corresponding to $k_z r_p \cong (0.7\text{-}0.9) \leq 1$, while the helical maximum occurred at $k_z r_p \cong 0.15$, which corresponds to $k_z = \pi/\ell$, i.e. an excitation wave length equal to twice the discharge gap length. Growth increments γ corresponding to various instability modes were calculated for specific moments of time, and were found to decrease approximately in proportion to $\sqrt{A}$, i.e. $\sqrt{M}$ (M is the ion mass). Experimental and theoretical results are in good agreement.

Gurevich, A. V., L. V. Pariyskaya, and L. P. Pitayevskiy. Ion acceleration during rarefied plasma expansion. ZhETF, v. 63, no. 2, 1972, 516-531.

Collisionless plasma expansion is calculated in a vacuum containing impurities of ion mass M_2 and charge Z_2, in addition to the basic ion mass M_1 and charge Z_1. Assuming that the characteristic inhomogeneity level is larger than the Debye radius $R_0 >> D$ and ion velocities are low in comparison with the thermal velocities of electrons, results show that the plasma dispersion process is self-similar and may be described by a nonlinear equation for the ion distribution function. A computer-aided solution is obtained for the equation and two problem formulations are analyzed.

The first problem is for the value $N_2 << N_1$ of a plasma containing a small amount of impurities of the second type. The solution reveals that the impurity ions are accelerated at a much higher rate than the basic gas ions and their concentration decreases slowly with dispersion. Many of the impurity ions are consequently captured in the field generated by the noncompensated space charge, owing to electrons overtaking the ions. At an ion energy of $\sim 500\ T_e Z_1$, for example, ion flow decreases by one-half. The thermal scattering of velocities in a developing dispersion process is negligible but the ion directional velocity is substantial; therefore, a hydrodynamic equation is used to determine the energy distribution of accelerated impurity ions, μ, passing through a unit surface at a point X_0. The energy distribution is independent of the observation point X_0 and falls relatively slowly with increased particle energy. When the similarity parameter $\rho = M_1 Z_2^2 / 2M_2 Z_1 >> 1$, the impurity ions accelerate more energetically than the basic ions and the distribution pattern becomes similar for ions with varying masses and charges. In a singly-ionized plasma the lighter impurity ions are accelerated fastest, and 0.1% of the total number of impurity ions acquire an energy of $\epsilon \gtrsim 50\ \rho Te$.

Analysis of the problem solution indicates that impurity ion acceleration is controlled by the plasma electron temperature T_e. When the electrons are rapidly heated in a freely expanding plasma, using electron beams or radiation, the multicharged impurity ions may be substantially increased (to $\epsilon \sim 10^2 - 10^3\ T_e$). The acceleration is a function of the plasma basic ion mass M_1; acceleration, for example, is higher in deuterium and tritium than in hydrogen.

The maximum ion energy in the acceleration mechanism is restricted by the condition $\epsilon << MT_e/m$, and is dependent solely on the impurity ion mass, not the charge. The theoretical results agree with laboratory experimental data (accelerating multicharged ions in an expanded rarefied plasma. The mechanism described is applicable to studies of solar and stellar bursts.

The second problem examined is on ion-containing plasma expansion in a vacuum, when N_2 has a finite value. For an undisturbed plasma the authors use the relationship: $N_{20}Z_2/N_{10}Z_1 = 0.1$. The most characteristic feature is that at a given moment of plasma dispersion the concentration of basic ions N_1 decreases slowly and tends to disappear. The impurity ion concentration drops very slowly and the N_2 begins to occupy a considerable plateau area. Concurrent with this dispersion moment, the impurity ions also display plateau characteristics. The plateau distribution function changes only slightly with the dispersion.

The plateau region was also formed under other conditions of plasma expansion in a vacuum containing an ion mixture. Solutions obtained in this study of plasma expansion are applicable in analyzing the structure of the disturbed zone surrounding rockets and space vehicles in the ionosphere.

The authors also investigated self-similar waves and ion-acoustic instability. The self-similar waves are kinetic waves related to particle velocity distribution and therefore do not occur in hydrodynamics. Their excitation begins with the dispersion process when heavy ions are accelerated and the additional force disturbs the distribution of light ions. The disturbance propagates in the form of self-similar waves travelling in the expanding plasma. Using the dispersion equation, oscillatory solutions are suggested. The dispersion equation for arbitrary ion-acoustic waves indicates the existence of a non-attenuating branch of the ionic sound, having a large wave vector $K_o D \geq 10^4$. Following the onset of dispersion, unstable rising ion-acoustic waves appear at $K \leq K_o$; and by a specific dispersion moment, all waves with the vector $K_o \gtrsim K > 0$ become unstable. This instability probably limits the investigated acceleration mechanism potential for large concentrations of impurity ions.

Vekhov, A. A., F. A. Nikolayev, and V. B. Rozanov. Investigating space-time distribution of optical plasma density in Li and In heavy-current discharges. TVT, v. 10, no. 4, 1972, 728-731.

The space-time distribution of optical plasma density of heavy-current pulsed discharges in Li and In vapors was investigated using a gas laser beam absorption method. A 10 mw He-Ne laser was used operating at $\lambda = 6328$ Å. Plasma was generated by explosion of Li (diam = 0.1 and 0.17 mm) and In (diam = 0.17 mm) wires. The discharge chamber was glass with a 10 cm i.d. and 14.5 cm spacing between electrodes. Current pulses consisted of two half-cycles; 14 kj were delivered in the chamber during the first half-cycle (70 μsec) and 3 kj during the second half-cycle. Optical plasma density $\varkappa l$ was determined from the relation $J = J_o \exp(-\varkappa l)$ where J_o, J are the quantum flows impacting on and passing through the plasma, respectively; $\varkappa$ is the absorption coefficient; and l is the absorption layer thickness. Relationships were

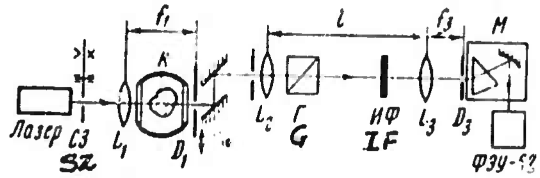

Fig. 1. Experimental sketch.

k - discharge chamber; $L_{1,2,3}$ - lenses
$D_{1,2,3}$ - diaphragms;
G - Glan prism; IF - interference filter;
M - monochromator
SZ - discharge triggering system.

obtained for ϰl with respect to time (t) and radius (r) (Figs. 2 and 3). The

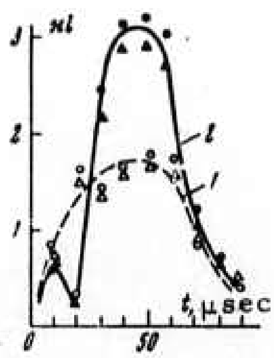

Fig. 2. Relationship ϰl (t) for Li plasma.

1 - 10 μsec; 2 - 35 μsec.

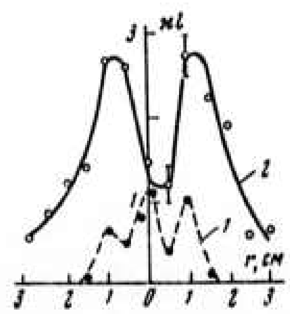

Fig. 3. Relationship ϰl (r) for Li plasma.

1 - 10 μsec; 2 - 35 μsec.

plasma absorption coefficient was plotted as a function of radius for t = 35 μsec, corresponding to the steady-state. The optical density of the plasma column was radially nonuniform; the maximum occurred at a small distance r_o from the discharge axis. A sharp drop was noted at the discharge center and boundary (Fig. 4). Discharges in which the plasma temperature is maximum at the discharge center are discussed.

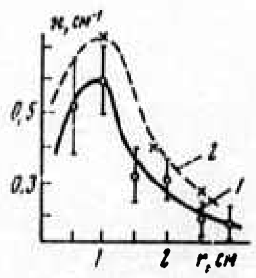

Fig. 4. Relationship ϰ(r) for 1 - Li and 2 - In. Plasma current = 200 ka.

Val'kov, Yu. A., and Yu. V. Skvortsov. Current shell dynamics of a pulsed electrodynamic plasma accelerator. ZhTF, no. 10, 1972, 2088-2104.

Current shell acceleration was investigated in a coaxial accelerator, consisting of two copper electrodes: an external one with a diameter of 10 and a 40 cm length, and an internal one with a diameter of 3.2 and a 56 cm length. A hydrogen supply inlet was placed on the internal electrode 37 cm from the accelerator end. During a selected time delay, $\sim 1.5 \times 10^{19}$ hydrogen atoms were injected into the accelerator gap through a pulse thermal valve. A condenser battery (5.4 μf), charged to 25 kv, was connected to the electrode. Discharge current reached 114 ka with a half-cycle of 3.4 μsec. The hydrogen pressure in the gap before discharge was ~1.0 torr. Relationships were plotted for magnetic and electric fields in the accelerator gap as functions of time. Current shell dimensions and the line current shape were determined along with the time and location of closed current and forebunch generation. The transition time from a combustion regime with an anode voltage drop to a cathode drop regime was examined. Results indicate that a comparatively narrow current bridge was formed during the initial discharge stage. The observed plasma acceleration is accompanied by current distribution along the electrodes and increased longitudinal dimensions of the bridge. Plasma acceleration ceased with the appearance of closed currents in the system.

Interferometric and spectroscopic measurements were used to plot time relationships of charged particle density distribution in the current shell of the accelerator gap, and also to estimate plasma temperature and localization of impurities. Experimental conclusions are:

1. In electrodynamic accelerators with pulsed hydrogen supply, current shell formation occurs with the generation of the ionization front, and not in agreement with "snow plough" and "hard current bridge" models

2. The existence of the ionization front is explained by the type of spatial density distribution and the current shell width.

3. Ion currents play a significant role in plasma acceleration.

4. The linear electric field, where it exists, is due to the Hall effect.

Zharov, V. F., V. K. Malinovskiy, Yu. S. Neganov, and G. M. Chumak. Effectiveness of relativistic electron beam excitation of an $F_2 + H_2$ laser. ZhETF P, v. 16, no. 4, 1972, 219-222.

Results are described of investigations of the integral energy characteristics of an $F_2 + H_2$ laser, pumped by a relativistic electron beam. The experimental arrangement is shown in Fig. 1. Relativistic

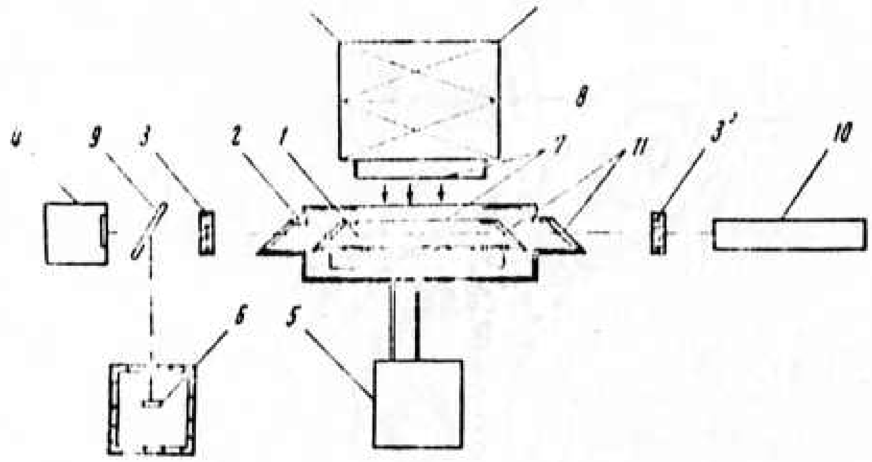

Fig. 1. Experimental sketch

1 - laser cavity, 2 - external chamber, 3, 3' - mirrors; 4 - calorimeter, 5 - gas injection evacuation system, 6 - Ge-Au detector, 7 - titanium foil (50 μ); 8 - accelerator magnetic lens; 9 - quartz splitter; 10 - alignment laser, 11 - CaF_2 windows.

electron beams from the accelerator (electron energy E = 2 Mev, beam current = 4 ka, and pulse duration $\tau \simeq 5\times10^{-8}$ sec) were transversely injected into the laser cavity through two titanium foils. The active part of the copper cavity was 5 cm long and its cross-section was 1.5 x 1.5 cm; this volume was cooled to 100 to 150° K by liquid nitrogen. The gas injection velocity into the active region did not exceed 10 torr/sec. A portion of the radiation was registered by the Ge-Au detector, which was shielded against spurious gamma rays by a small lead shell. The time constant of the measuring device was 10^{-6} sec. Laser positioning of the optical system was done by a He-Ne laser at $\lambda_1 = 0.63\ \mu$ and $\lambda_2 = 3.39\ \mu$. The duration of pulse generation was $\sim 20\times10^{-6}$ sec, and the threshold was reached at mixture pressures of 150 to 200 torr. Near the threshold, pulse generation parameters were unstable and sensitive to electron beam parameter fluctuations. Pulse consistency was good when the mixture pressure exceeded the threshold value. A relationship is plotted in Fig. 2 for laser radiation energy as a function of initial mixture pressure. The

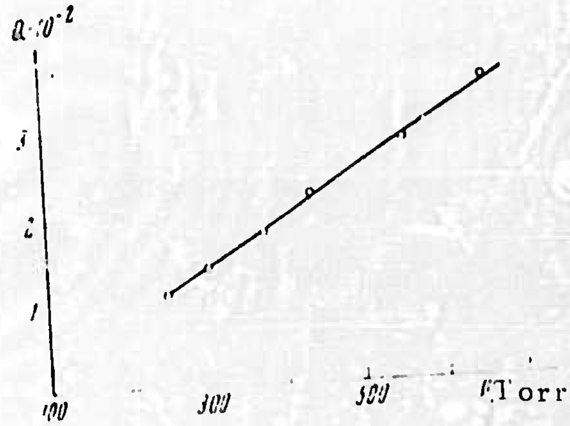

Fig. 2. Energy generation at various $F_2 + H_2$ mixture pressures.

linear characteristics of the relationship indicated the direct proportionality of the laser radiation energy to the beam energy absorbed in the mixture. The energy absorption was calculated, based on known mixture density and electron energy values. The ratio of laser output energy (Q_1) to the beam energy absorbed in the medium (Q_{abs}) was 1.5 to 1.8. In the pressure range investigated

(200 to 600 torr), the energy efficiency Q_L/Q_{abs} was found to be constant. The authors note that the absolute value of efficiency obtained is not the maximum value, since no attempt was made to optimize the resonator. The experimental results support the feasibility of using electron beams to initiate chemical reactions in laser media.

Ginzburg, V. L. Measurement of relativistic particle energy by an undulator in an optically transparent medium. ZhETFP, v.16, no. 8, 1972, 501-504.

The feasibility of using a vacuum undulator to measure relativistic particle energy W has been discussed by Motz (J. Appl. Phys. 22, 527, 1957) and Korkhmazyan (IAN Arm, 5, 418, 1970, 7). The present work examines the sharp increases in the presence of radiation intensity obtainable by use of a transparent medium in the undulator. Expressions are given for the dipole moment amplitude and energy of charged particles. In transparent media at $\beta n > 1$, the radiation energy is concentrated near the Cerenkov angle Θ_o [Θ_o = arc cos $(1/\beta n(\omega))$ $n(\omega)$ - refractive index at a frequency ω]. The undulator radiation power in the media exceeds that of undulator radiation in a vacuum to the value $W/Mc^2 \sim 10^6$. Radiation in the medium usually propagates at the angle $\Theta_o \sim 1$ and is visible. The undulator radiation energy S_g and Cerenkov radiation energy S_o were compared and the undulator radiation was found to be weaker at W ` $W_c \cong 3x10^{10}$ ev. The number of photons radiated in the undulator in the medium however would be adequate for recording even at $W >> W_c$, possibly an energy of $W \cong 3x10^{12}$. The principal disadvantage of an undulator counter in the medium is that the radiated energy S_g drops with increased particle energy W. The author points out that combining a Cerenkov counter with an undulator should prove to be an effective measurement method.

B. Recent Selections

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Zhukov, M. F., A. S. An'shakov, G. -H. B. Dandaron, and M. I. Sazonov. Investigating tungsten cathode erosion in nitrogen. IN: Sbornik. Fiz. dugovogo razryada. Novosibirsk, 1972, 142-151. (RZhF, 12/72, no. 12G167)

5. Material Sciences

A. Abstracts

Dmitriyev, V. N., L. P. Potapov, and P. P. Shiryayev. Effect of high hydrostatic pressures on tungsten surface atomic structure. DAN SSSR, v. 206, no. 5, 1972, 1093-1095.

The atomic structure of tungsten wire surface defects generated by 10-20 kbar hydrostatic pressures was analyzed using an auto-ionization microscope. The defects were studied in relationship to the pressure-induced changes in the physico-mechanical characteristics of metals and alloys. Two non-annealed W wire specimens and two annealed at 1500° C in a protective container were subjected to a hydrostatic pressure for 20 sec, 1, and 2 hr. periods at 2-3 kbar/min loading and unloading rates. Micrographs of one non-annealed surface after 1 h. of testing under 10 kbar pressure showed a decrease in atom clusters in the decorated band, linear atomic chains formed in the (121) plane, and small pockets in the (111) plane. A second non-anneale surface, similarly treated, revealed a shift of the decorated band with kink formation along the decoration boundary. Since the defects disappeared after vaporization of several tens of atomic layers, the observed effects are limited to a thin subsurface layer.

The presence of linear atomic chains, which may be attributed to the formation of interstitial atom clusters, led to the conclusion that a partial relaxation of internal microstrains occurs under a high hydrostatic pressure in the pre-deformed W. The pockets are probably the sites of dislocations emerging on the surface under pressure. Micrographs of annealed specimens subjected to 15 kbar pressure for 20 sec. reveal intercrystalline boundary migration, vacancy clusters, and screw dislocations in the (100) plane. The first two defects disappeared after vaporization of a few atomic layers. After one hour treatment under 15 and 20 kbar pressures, respectively, a strong distortion of the surface crystal structure and dislocations in the $(12\bar{1})$ and (010) planes were observed. Crystal structure remained distorted after removal of several tens of atomic layers. The surface high dislocation density is apparently caused by the high pressure application. Pre-existing dislocations also emerge at the surface under a high pressure. The described high pressure effects depend on both pressure magnitude and pressurization time.

Kovchik, S. Ye., N. S. Kogut, and I. S. Sorokivskiy. Effect of heat treatment on resistance of steels to initiation and propagation of cracks. F-KhMM, no. 5, 1972, 33-37.

Experimental data are given on fatigue resistance of two carbon steels and two machine chrome steels heat-treated by different methods. The objective was to select the optimum heat-treatment ensuring high operational relability of engineering structures. In both static and shock loading experiments the resistance γ to ring crack propagation increased with increased C content in carbon steels tempered at 100-600° C. Accelerated heat-treatment at an 8° C/sec. rate for all four steels increased the static γ, but only at tempering temperatures between 100-300° C. Micrographic analysis revealed that a change in martensite structure caused steel strengthening after accelerated heat-treatment, water or oil quenching, and tempering at 100-300° C. The advantage of accelerated heat-treatment was confirmed by data on the resistance of the steels to crack formation by ring bending. Results confirm that quenching after differing heat-treatment, the C content of steel, and the tempering temperature substantially affect the materials γ.

Lutkov, A. I., V. I. Volga, B. K. Dymov, V. N. Mikhaylov, A. S. Tarabanov, and V. N. Bobkovskiy. Study of thermal and electrical conductivities of siliconized graphite. TVT, no. 5, 1972, 1002-1006.

Thermal conductivity λ and resistivity ρ of type PG-50, GMZ, and PROG-2400 graphites before and after impregnation with liquid silicon were measured in the 80-2,500° K range, to evaluate the thermal state of the siliconized graphite products. Conductivity was measured by the method of stationary axial heat flux, using external heaters in the 80-320° K range or internal heaters in the 400-1300° K and 1300-2500° K ranges. Temperature in the first two ranges was recorded with thermocouples and in the third range pyrometrically. The axial heat flow was determined from current and voltage drop measurements. Accuracy of the λ measurements was ± 5, ± 8-10, and ± 13-15% in the 80-320, 400-1300, and 1300-2,500° K ranges, respectively. For the highly porous PG-50 graphite with a high free Si content, λ was determined at $T < 1,300°$ K only because of optical pyrometer limitations. The λ versus T plots show 40 and 65% maximum increases in λ of GMZ and PROG-2400 graphites after siliconizing and a four-fold increase in λ in siliconized PG-50 graphite. The latter exhibits nearly the same λ as silicon carbide. It is concluded that heat transfer below 1,500° K in siliconized graphite occurs not only from graphite, but also from silicon carbide and silicon. At $T \geq 1500°$ K, the λ of the siliconized GMZ and PROG-2400 graphites decreased to its value in the original materials. Similarly to λ, the ρ of the GMZ and PROG-2400 graphites increased by 50-60% after impregnation. The increase in ρ of PG-50 was only 13% presumably due to formation of C of higher electroconductivity in th Si solution in addition to SiC of a low conductivity. The increase in both λ and ρ of siliconized graphites is due to the combined λ and electroconductivity of the graphite skeleton, silicon, and silicon carbide.

Sheyndlin, A. Ye., I. S. Belevich, and I. G. Kozhevnikov. <u>Enthalpy and heat capacity of graphite in the 273 to 3650° K temperature interval.</u> TVT, no. 5, 1972, 997-1001.

Enthalpy i_{273}^{T} and heat capacity C^{T} of eight domestically manufactured graphites were determined experimentally by a combination method reported by the authors (TVT, v. 8, no. 3, 1970). The method consists of an experimental i_{273}^{T} determination and true C^{T} calculation by differentiation of an approximate equation based on the experimental data. All but one of the graphites were very dense (1.8 - 1.9 g/cm^3) and finely-structured.

The experimental data in the 273-1000° K range are described with a ± 1.5% accuracy by the empirical equations

$$i_{273}^{T} = 0{,}322 \cdot T + 5{,}2 \cdot 10^{-5} T^{2} + 1{,}7 \cdot 10^{4} T^{-1} - 154{,}2, \text{ kcal/kg,} \tag{1}$$

$$C^{T} = 0{,}322 + 10{,}4 \cdot 10^{-5} T - 1{,}7 \cdot 10^{4} T^{-2}, \text{ kcal/kg} \cdot \text{deg.} \tag{2}$$

The data in the 600-3600° K range are described by equations containing an additional exponential term to account for an accelerated increase in calorific properties above 3,000° K. The experimental true C^{T} data (Table 1) are compared with the Soviet and American data from the literature. Although the authors' data agree well with most of the Soviet and American data, the findings are 10-15% higher than certain American data. This discrepancy is explained by the fact that the authors' i^{T} and C^{T} data at high T for different graphite brands vary within the experimental error (±2.3% at 3600° K), while the corresponding American data for four graphite brands vary up to 12%. The C^{T} variations between different American-made graphites are attributed to impurities and differences in preparation procedures. It is concluded that it is normally not necessary to determine high temperature calorific properties

Table 1. Experimental enthalpy and heat capacity of domestic graphite brands

Graphite	$T^{o}K$	Experimental i_{273}^{T}, kcal/kg	i_{273}^{T} data calculated from (2), kcal/kg	Difference $\frac{i_{exp} - i_{emp}}{i_{emp}}$ %	Experimental $\bar{C}_{273}^{T}$ data, kcal/kgxdeg
204	373	19,4	19,4	0	0,191
204	473	45,5	45,5	0	0,227
204	505,7	56,3	55,2	+2,0	0,242
204	712	126	125	+0,8	0,287
435	819	165	166,5	−0,9	0,302
435	927	211	211	0,0	0,323
АРВ	955	218	222	−1,8	0,319
435	1076	275	275	0,0	0,343
ПРОГ-2400	1133	296	300	−1,3	0,344
ПРОГ-2400	1136	297	301	−1,3	0,344
АРВ	1143	298	304	−2,[illegible]	0,343
435	1179	325	322	+0,9	0,359
204	1617	532	526	+1,1	0,396
204	2027	720	724	−0,6	0,410
204	2122	766	774	−1,0	0,415
АРВ	2611	1010	1017	−0,7	0,432
204	2717	1083	1072	+1,0	0,444
204	2718	1059	1072	−2,0	0,431
ПРОГ-2400	2771	1112	1098	+1,3	0,446
ПРОГ-2400	2892	1140	1111	+2,6	0,451
435	2950	1187	1187	0,0	0,447
П	3180	1374	1350	+1,8	0,472
П	3240	1401	1390	+0,8	0,473
435	3254	1402	1398	+0,3	0,470
435	3272	1411	1410	0,0	0,471
П	3426	1501	1483	+1,2	0,484
753	3458	15[illegible]	1546	+0,9	0,490
753	3490	1560	1574	−0,9	0,485
753	3628	1650	1694	−2,6	0,492

for each graphite when the composition and preparation techniques are similar to those of the brands studied. More accurate experimental i^{T} and C^{T} data were obtained at higher temperatures than in previous studies.

Yermolenko, I. N., A. M. Safonova, nad Zh. V. Malashevich. Structure of metal-carbon fibers made from oxycellulose salts. IAN B, Seriya khimicheskikh nauk, no. 6, 1972, 60-66.

The effect of injected metals on the structure of metal-carbon fiber materials was investigated using electron-microscopic and x-ray analysis. The elementary composition of carbon and metal-carbon fibers, made from oxidized cellulose (monocarboxyl cellulose -- MCC) and its salts (Al, Fe), was determined within the heat-treatment temperature (HTT) range of 400-1600° C. Electron-microscope photos show no essential morphological changes in carbon specimens made from MCC. The particles have a lamellar structure and are nearly equiaxial in shape. Specimens prepared at low pyrolysis temperatures were more difficult to grind in an ultrasonic disperser under the selected conditions than were high-temperature specimens. Radiogran of the tested fibers are shown in Fig. 1.

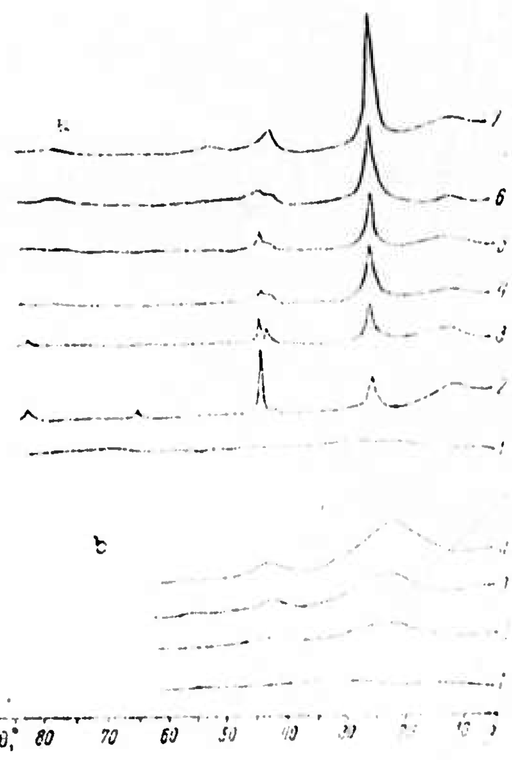

Fig. 1. Radiograms of iron-carbon fibers (a) at heat treatment temperature of: 1- 600, 2- 800, 3, 4- 1200, 5,6 - 1400, and 7- 1600° C; and (b) carbon fibers at 1- 600, 2- 800, 3- 1000 and 4- 1600° C.

Elementary analysis data (Table 1) show considerable variations in the composition of carbon fiber material as a function of HTT.

Table 1. Elementary composition of carbon and iron-carbon specimens

Specimen	HTT, °C	C	H	O	Fe
		weight, %			
Carbon	400	81,89	3,85	11,26	—
	600	89,97	3,07	6,96	—
	800	92,37	2,80	4,83	—
	1000	97,15	0,66	2,19	—
	1200	99,06	0,33	0,61	—
	1400	99,07	0,31	0,59	—
	1600	99,67	0,31	0,63	—
Iron-carbon *	400	61,37	0,56	31,07	7,90
	600	79,98	3,07	16,95	8,63
	800	98,03	1,14	0,83	11,56
	1000	99,29	0,32	0,39	11,19
	1200	96,07	0,35	3,58	5,34
	1400	98,93	0,22	0,85	3,34
	1600	99,22	0,13	0,65	0

* The carbon residue with no iron content is assumed to be 100%

The radiograms of aluminum-carbon and carbon specimens were analogous. Lines of crystalline aluminum or its compounds were absent. With increasing HTT, the carbon content in the elementary composition of aluminum-carbon specimens increased, and the hydrogen and oxygen content decreased. Essential changes occurred in the carbon fiber structure when iron was added to its composition. The external appearance of the grinding products of iron-carbon specimens differs essentially from that of the carbon and aluminum specimens. It is concluded that iron is reduced to the metallic state within the 700-800° C HTT range and, in this form, effects the formation of a more ordered carbon structure.

Okonishnikov, G. B., and V. P. Skripov. Effect of a high-pressure gas environment on mechanical properties of PMMA. FKhMM, no. 5, 1972, 72-75.

Experiments are described to determine the effect of CO_2 and Ar saturation pressure P_S on the mean ultimate tensile stress $\langle \sigma \rangle$, dynamic Young's modulus E, and viscosity of unplasticized PMMA specimens. The specimens were saturated for three days in a steel chamber under 10-50 atm CO_2 or Ar pressure at 19° C. Increased mass and coefficient of linear expansion (except in Ar) indicate that internal tensile strains are generated by absorbed gases, which may contribute to polymer fracture under applied loads. Determination of $\langle \sigma \rangle$ for the gas-saturated specimens was made in the same gaseous medium without removal after saturations. The experimental $\langle \sigma \rangle$ data (Fig. 1) suggest that, in the presence of 1-2 wt % of dissolved CO_2

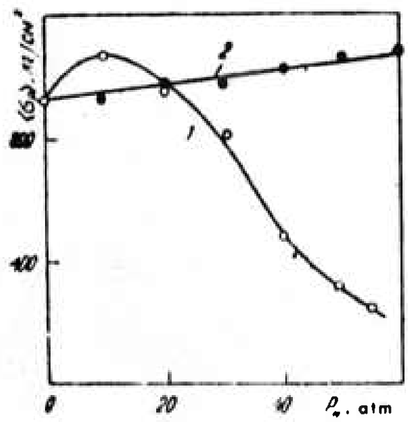

Fig. 1. Mean ultimate tensile stress for PMMA in a gaseous medium at $19 \pm 1^\circ$ C 1 - CO_2, 2 - Ar.

gas, interpack plasticizing and a decrease in strain concentration at the surface crack edges occur. In agreement with data in the literature, polymer strength is found to increase. At low P_S, the fracture pattern is typical of brittle material.

At higher P_S of CO_2, strength decreases continuously owing to CO_2 molecular penetration into structural formations and subsequent increased chain mobility. At increased temperature, the $\langle\sigma\rangle$strength of CO_2-saturated specimens at P_S = 30 and 40 atm peaks (Fig. 2) as a result of two competing processes: the initial decrease in the dissolved gas concentration,

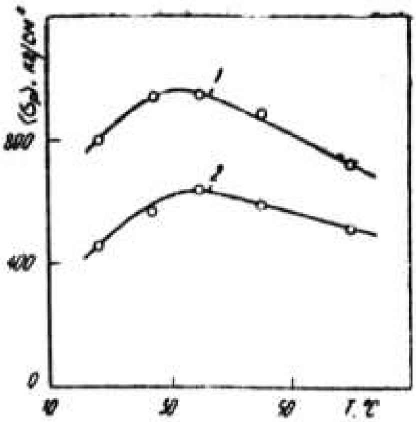

Fig. 2. Strength isobars of CO_2-saturated PMMA: 1 - P_S = 30 atm, 2 - P_S = 40 atm.

and a trivial decrease in strength. Similar to the $\langle\sigma\rangle$ isobars, the E isobars determined by a resonance method exhibit a maximum at P_S of CO_2 > 30 atm. The maximum shifts toward higher temperatures when P_S is increased. Viscosity under static load, determined from the experimental creep curves at 20 ± 1°, decreased by an order of magnitude when the P_S of CO_2 was increased by about 20 atm. It is concluded that a gaseous medium (especially CO_2) under elevated pressure can significantly affect the viscoelastic and strength characteristics of a polymer.

Klebanov, Yu. D. Pressure and temperature measurements in ultrahigh pressure chambers. PTE, no. 5, 1972, 212-213.

A method is introduced for the simultaneous measurements of temperature and pressures above 17 kbar using a single sensor. The method is based on the fact that the temperature $T_{\alpha \rightarrow \gamma}$ of the $\alpha \rightarrow \gamma$ phase transition in iron decreases noticeably with increased pressure, and consequently acts as an indicator of chamber pressures above 17 kbar. The pressure-temperature sensor consists of an Armco iron foil strip, 100 μ thick, and a chromel-alumel thermocouple with leads spot welded at the strip ends. Chamber pressure is determined from the HF resistance jump of the sensor at the $\alpha \rightarrow \gamma$ transition. The jump and temperature are recorded in potentiometer fashion by the same thermocouple, minimizing the number of chamber lead-ins. Pressures to 60 kbar were measured by this method to approximately 1 kbar accuracy. The pressure measurement data were compared to calibrated data using BiI - BiII, BiII - BiIII, and Tl II - Tl III standard phase transitions (Fig. 1).

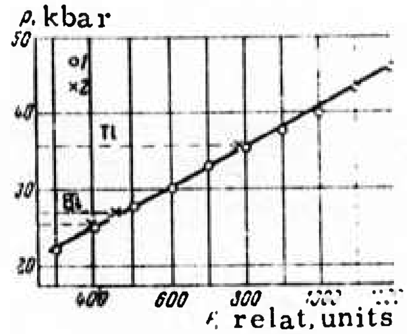

Fig. 1. Pressure calibration curve for one chamber. 1 - Experimental data from the $\alpha \rightarrow \gamma$ transition (1), and from transitions in Bi and Tl(2).

Prolonged heating to 1,200° C negligibly affected thermal emf of the thermocouple, which illustrates the high stability of the sensor. The method thus permits the measurement of given pressures within the indicated pressure and temperature ranges in the same high-pressure chamber while using a minimum number of lead-ins.

Brazhnev, V. V., Z.M. Gelunova, and P. O. Pashkov. Dynamic strengthening of metals under high pressure. FMiM, v. 34, no. 2, 1972, 378-384.

Strain hardening by impact loading was studied in technical grade annealed Armco iron, Ti, Cu, Ni, and ferrite-perlitic carbon steels at 200 to 1150 kbar pressures behind the shock wave front. The experimental impact loading diagram (Fig. 1) is based on shock wave initiation by high-speed

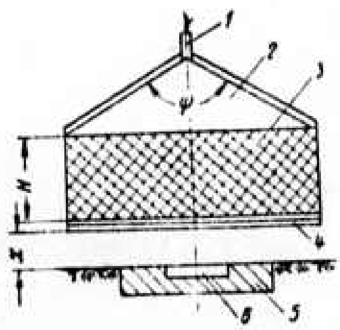

Fig. 1. Impact loading diagram:
1 - detonator, 2 - shock wave initiation system, 3 - explosive charge, 4 - striker, 5 - lead specimen holder, 6 - specimen (ψ-angle of taper, H - charge height, x - throwing distance).

impact of the striker on the specimen. Plane waves were generated at Ψ = 120 degrees and selected detonation velocities. Shock wave pressure p was dependent on impact velocity for a given specimen-striker combination. Armco-iron loaded at 450 kbar and Ψ = 90-140 deg. more than doubled in hardness.

At p = 850 kbar iron was hardened significantly only at $\Psi >$ 120 deg. Since the results of iron dynamic hardening at Ψ = 120 deg were inconclusive, all metals were loaded at $\Psi > 120$ and $\Psi < 120$ deg. using slightly divergent or convergent shock waves and concurrent specimen deformation. The experimental data illustrated by Vickers hardness HV versus p plots for iron (Fig. 2) indicate that all the metals studied exhibited the same strain

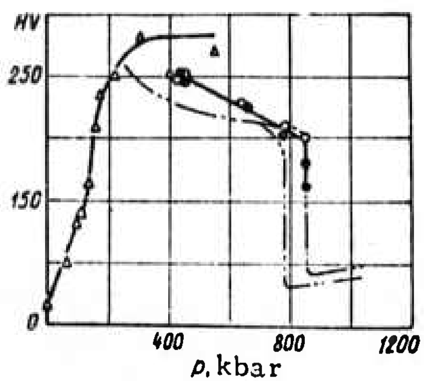

Fig. 2. Impact hardening of Armco iron:
Δ - literature data, •, o - after water cooling (convergent and divergent waves, respectively),
-. - after air cooling.

hardening pattern at systematically increased shock wave pressures. The region of increased hardening ceased for all metals at 200-300 kbar, followed by a region of constant hardening, then an abrupt decrease in metal strength to the initial value for the annealed specimen. Micrographs of the compressed samples reveal that the poor hardening capability of metals at very high p, near the elastic modulus value, is a consequence of crystal lattice instability. In contrast to Te and Ni, phase transitions in polymorphic Fe and Te occurred during the shock compression process. The transitions lead to complete recrystallization and weakening of the crystal structure.

Vishnyauskas, V. V., Yu. S. Mayauskas, and R. I. Abraytis. Erosion of refractory concrete in combustion products flow. IN: Trudy AN Lit SSR, Seriya B, v. 4, no. 71, 1972, 131-136.

High-temperature erosion of channel internal walls by an incandescent gas flow is analyzed as a particular case of ablation in the absence of chemical reactions. Using an energy balance equation and introducing the heat of erosion concept ΔH_e, the ratios of the mass losses due to mechanical wear (m_m) and sublimation (m_s) to the total mass loss m_e were calculated to be

$$k_1 = \frac{\dot{m}_{\text{м}}}{\dot{m}_{\text{э}}} = \frac{\Delta H_V - \Delta H_e}{\Delta H_{\text{по}} - \int c_p \, dT}, \quad (1)$$

$$k_2 = \frac{\dot{m}_{\text{с}}}{\dot{m}_{\text{э}}} = \frac{\Delta H_{\text{э}} - \int c_p \, dT}{\Delta H_{\text{по}} - \int c_p \, dT}, \quad (2)$$

$$k_{12} = \frac{\dot{m}_{\text{м}}}{\dot{m}_{\text{с}}} = \frac{k_1}{k_2}.$$

It follows from (1) and (2) that high-temperature erosion studies require the determination of ΔH_v; the heat of vaporization, C_p; the heat capacity, and ΔHe. The latter is determined from the equation

$$A = \Delta H_{\text{э}} / 4{,}575, \quad (3)$$

where A is given by the logarithmic temperature dependence of the erosion vapor pressure p_e. The cited theoretical deductions were verified by an experimental study of the erosion resistance of two MgO-base refractory concretes heated at a 40-50 deg/min rate by high-temperature (1900 - 2400° K) gas flow. The experimental m_e versus T data were used to calculate the p_e and ΔH_e of the two concretes. The theoretical ΔH_v of pure MgO was higher than the ΔH_e of both materials. The difference $\Delta H_v - \Delta H_e$ was explained as the effect of the experimental conditions, the medium, and the materials composition. It is concluded that the theoretical sublimation rate can be used to evaluate the erosion resistance of materials.

Kudryavtsev, G. I. Methods for preparing heat resistant fibers. Zhurnal Vsesoyuznogo khimicheskogo obshchestva, no. 6, 1972, 625-631.

The article presents a survey of domestic and foreign literature on methods of preparing heat-resistant polymer fibers. Coverage includes the initial materials, materials processing,and fibers processing to obtain the desired mechanical characteristics and an optimal degree of heat resistance. A bibliography of 33 items cites 4 articles from Western sources, and 8 foreign patents (one French, one US, and six British).

The literature survey focuses on processing methods based on the following characteristics of high heat-resistant polymers:

1) poor solubility requiring the application of such aggressive solvents as fuming sulphuric, hydrofluoric and polyphosphoric acids;

2) the extremely high viscosity of spinning solutions, previously not used in preparing artificial and synthetic fibers; and

3) the self-ordering capacity of polymers both in solution and in the solid state.

The author concludes that to produce heat-resistant fibers with optimal functional properties, in addition to maximal fiber cyclization it is also necessary to provide for suitable parameters over the entire technological process.

Obmoin, B. I., and N. K. Moroz. <u>Thermostat for NMR studies at high pressures and temperatures from 8 to 400° K.</u> PTE, no. 5, 1972, 208-210.

A thermostat (Fig. 1) is described for NMR studies of

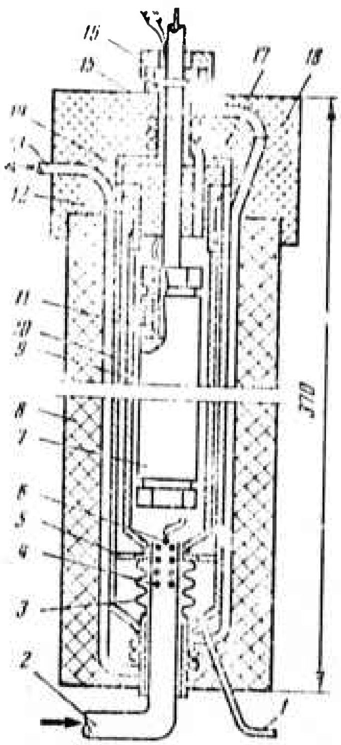

Fig. 1. Thermostat design: 1 - to sorption pump connection, 2 - gas siphon, 3 - bellows, 4 - heater, 5 - plastic star-shaped spacer, 6, 11 - thermocouples, 7 - high-pressure bomb, 8 - jacket, 9 and 10 - inner and outer walls of Dewar flask, 12 - cylinder extension of inner wall, 13 - heat exchanger, 14 - foam plastic stopper, 15 - coaxial lead-in, 16 - coupling nut, 17 - lid, 18 - split foamplastic cover.

substances at high pressures and over an expanded range of temperatures. The temperature in the bomb is coarsely controlled by adjusting the blowing rate of liquid N_2 or He through the Dewar flask. Fine temperature control and stabilization is effected by means of the heater which is connected in the power amplifier circuit. The amplifier responds to an error signal from a thermocouple connected to a potentiometer; temperature in the bomb is thus maintained constant to $\pm$ 0.05° K for long periods over the entire working range of 8° to 400° K. A specially designed lead-in makes it possible to study angular distribution of NMR spectra. The cylinder protrudes 30 mm on each side from the electromagnet interpolar gap.

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7. Miscellaneous Interest

A. Abstracts

Koldamasov, A. Ball lightning in water? Tekhnika molodezhi, no. 8, 1972, 24-26.

An experiment is described in which a spontaneous glow discharge was obtained in a high speed flow of distilled water thru a nozzle. The discharge, which the author compares to known ball lightning characteristics in the atmosphere, is generated as follows. Distilled water at a high flow rate expands abruptly at a nozzle exit into a section of tubing having a suitable dielectric liner. Severe pulsating cavitation occurs owing to the pressure drop in the exit area, resulting in extremely rapid development and collapse of bubbles each carrying a surface charge. Bombardment of the dielectric wall by the charged particles causes a strong secondary emission, including some electrons from inner atomic shells. A net charge gradient is thus developed which is positive at the wall surface and in the exit region, with an electron cloud between; under proper conditions this plasma is maintained by the dielectric property of the water.

Recombination of electrons in the wall dielectric then yields optical emission typical of the material, appearing as a continuous glow discharge. An asbestos cement liner gives a rose color, plexiglass and ebonite give yellow and blue respectively. A sketch of the apparatus is given but no other quantitative data are mentioned.

Grebinskiy, A. S. Method for antenna aperture synthesis. Otkr izobr. no. 22, 1972, no. 345555.

A method for aperture synthesis of a variable-base dual antenna interferometer is proposed. The new feature introduced is to have the antennas move relative to each other at a constant velocity along the baseline during an observation interval, which permits a shorter interval to be used. During this time the signals from both antennas are continuously and synchronously recorded and summed.

Zhitkovskiy, Yu. Yu. Correlation between reflection and scattering of sound from the ocean bottom. Akusticheskiy zhurnal, no. 4, 1972, 533-536.

Calculations are discussed relating to measurements of the effective coefficient of sound reflection from the ocean bottom under normal incidence, assuming that the bottom acts as an uneven boundary surface between two media. For simplicity, sound absorption in water during propagation is ignored and the bottom is assumed to return all the propagating sound energy to the upper half-space.

A formula for the effective coefficient of ocean bottom sound reflection under normal incidence is given as:

$$V^2_{эфф} = 4R_0^2 J_{пр} / r_0^2 J_0, \tag{1}$$

where J_{pr} is the signal strength at the point of reception, J_0 is the radiating signal strength at a distance r_0 from the transmitter, and R_0 is the distance between the transmitter-receiver point and the bottom.

The coefficient of bottom sound scattering m_0 is defined as:

$$m_0 = w_0 / J_0 S, \tag{2}$$

where w_s is the power per unit spatial angle, scattering over a bottom area S, from which the scattering signal simultaneously approaches the point of reception; and J_i is the intensity of sound wave propagation on the ocean bottom. The scattering indicatrix is approximated for surface scattering according to the Lambert law.

Calculations indicate that the sound reflection formula (1) is not always applicable for regions with strongly dissected topography. In these regions, the sound scattering indicatrix approaches the limits of the Lambert law at frequencies higher than a few kHz for which: (1) the effective coefficient of reflection is derived solely from scattering properties, and (2) the sound attenuation in water is pronounced and not uniform in all directions of the bottom effective scattering surface. This conclusion is also valid for regions in which sound bottom backscattering is primarily a function of soil heterogeneity and obeys the Lommel-Seeliger law.

The reflected signal strength at the point of reception in such regions under normal incidence should be determined experimentally for all transducer types and transducer locations relative to the ocean bottom. However, when the angular dependence of the scattering coefficients is known, the bottom signal at the point of reception in such regions may be precomputed for any given event.

Pustovalov, V. V., and V. P. Silin. Stationary turbulence of a parametrically non-stable plasma. ZhETF P, v. 16, no. 5, 1972, 308-3'1

The contribution of nonlinear shifts in the plasma oscillation frequency to the appearance of a stationary turbulence level in a parametrically non-stable plasma is calculated. It is presently feasible to compute parametrically non-stable plasma turbulence levels using approximation methods by taking into account the nonlinear interactions of developing plasma disturbances owing to induced wave scattering on particles.

The authors illustrate the stabilizing effect of a nonlinear frequency shift on the basis of aperiodic disturbances. In the parametrically-excited plasma, these disturbances arise along with plasma oscillations at the pumping wave frequency. A nonlinear dispersion equation for the high frequency plasma oscillations is examined. The real part of this equation yields a nonlinear frequency shift value $\delta\omega(\vec{k})$, which is assumed to be small; the imaginary part yields a normal expression for the linear damping decrement $\tilde{\gamma}(\vec{k})$ of the high frequency plasma waves and a nonlinear addition $\delta\gamma(\vec{k})$ to the damping factor, which can be compared to $\tilde{\gamma}$. With the $\delta\omega(\vec{k})$ and $\delta\tilde{\gamma}(k)$ values added to the plasma oscillation frequency and the damping increment, the equality condition of a parametric non-stability zero increment provides a relationship describing the stationary turbulence level. This relationship indicates that when the pumping electric field intensity exceeds the threshold value E_{thresh} (determined by linear theory of parametric resonance), the nonlinear stabilization of aperiodic parametric instability is possible even at $\tilde{\gamma} >> \delta\gamma$. The stabilization results from the nonlinear frequency shift $\delta\omega$ of high frequency plasma oscillations. The negative value $\delta\omega < 0$ increases the negative frequency difference.

An effective intensity value of the plasma oscillation electric field is given describing the stationary turbulence level and the nonlinear frequency shift of plasma oscillations in the near-threshold area. This permits determination of the effective intensity value of the electric field E_a (the aperiodic turbulence in plasma).

B. Recent Selections

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8. SOURCE ABBREVIATIONS

AiT	Avtomatika i telemekhanika
APP	Acta physica polonica
DAN ArmSSR	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	Akademiya nauk SSSR. Doklady
DAN TadSSR	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	Akademiya nauk Ukrainskoy SSR. Dopovidi
DAN UzbSSR	Akademiya nauk Uzbekskoy SSR. Doklady
DBAN	Bulgarska akademiya na naukite. Doklady
EOM	Elektronnaya obrabotka materialov
FAiO	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGiV	Fizika goreniya i vzryva
FiKhOM	Fizika i khimiya obrabotka materialov
F-KhMM	Fiziko-khimicheskaya mekhanika materialov
FMiM	Fizika metallov i metallovedeniye
FTP	Fizika i tekhnika poluprovodnikov
FTT	Fizika tverdogo tela
FZh	Fiziologicheskiy zhurnal
GiA	Geomagnetizm i aeronomiya
GiK	Geodeziya i kartografiya
IAN Arm	Akademiya nauk Armyanskoy SSR. Izvestiya. Fizika
IAN Az	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk

IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Biol	-	Akademiya nauk SSSR. Izvestiya. Seriya biologicheskaya
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport
IAN Est	-	Akademiya nauk Estonskoy SSR. Izvestiya. Fizika matematika
IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Met	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzh	-	Akademiya nauk Tadzhikskoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN TK	-	Akademiya nauk SSSR. Izvestiya. Tekhnicheskaya kibernetika
IAN Turk	-	Akademiya nauk Turkmenskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh, i geologicheskikh nauk
IAN Uzb	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IBAN	-	Bulgarska akademiya na naukite. Fizicheski institut. Izvestiya na fizicheskaya institut s ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IiR	-	Izobretatel' i ratsionalizator
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel'naya tekhnika
IVUZ Avia	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Cher	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Geod	-	Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i aerofotos"yemka
IVUZ Geol	-	Izvestiya vysshikh uchebnykh zavedeniy. Geologiya i razvedka
IVUZ Gorn	-	Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal
IVUZ Mash	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye
IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Stroi	-	Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura
KhVE	-	Khimiya vysokikh energiy
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike

LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
NTO SSSR	-	Nauchno-tekhnicheskiye obshchestva SSSR
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki
PF	-	Postepy fizyki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika
PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PSU	-	Pribory i sistemy upravleniya
PTE	-	Pribory i tekhnika eksperimenta
Radiotekh	-	Radiotekhnika
RiE	-	Radiotekhnika i elektronika
RZhAvtom	-	Referativnyy zhurnal. Avtomatika, telemekhanika i vychislitel'naya tekhnika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye

RZhF	-	Referativnyy zhurnal. Fizika
RZhFoto	-	Referativnyy zhurnal. Fotokinotekhnika
RZhGeod	-	Referativnyy zhurnal. Geodeziya i aeros"-yemka
RZhGeofiz	-	Referativnyy zhurnal. Geofizika
RZhInf	-	Referativnyy zhurnal. Informatics
RZhKh	-	Referativnyy zhurnal. Khimiya
RZhMekh	-	Referativnyy zhurnal. Mekhanika
RZhMetrolog	-	Referativnyy zhurnal. Metrologiya i izmeritel'naya tekhnika
RZhRadiot	-	Referativnyy zhurnal. Radiotekhnika
SovSciRev	-	Soviet science review
TiEKh	-	Teoreticheskaya i eksperimental'naya khimiya
TKiT	-	Tekhnika kino i televideniya
TMF	-	Teoreticheskaya i matematicheskaya fizika
TVT	-	Teplofizika vysokikh temperatur
UFN	-	Uspekhi fizicheskikh nauk
UFZh	-	Ukrainskiy fizicheskiy zhurnal
UMS	-	Ustalost' metallov i splavov
UNF	-	Uspekhi nauchnoy fotografii
VAN	-	Akademiya nauk SSSR. Vestnik
VAN BSSR	-	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	-	Akademiya nauk Kazakhskoy SSR. Vestnik
VBU	-	Belorusskiy universitet. Vestnik
VNDKh SSSR	-	VNDKh SSSR. Informatsionnyy byulleten'
VLU	-	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	-	Moskovskiy universitet. Vestnik. Seriya fizika, astronomiya

ZhETF	-	Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	-	Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhFKh	-	Zhurnal fizicheskoy khimii
ZhNiPFiK	-	Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhNKh	-	Zhurnal neorganicheskoy khimii
ZhPK	-	Zhurnal prikladnoy khimii
ZhPMTF	-	Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki
ZhPS	-	Zhurnal prikladnoy spektroskopii
ZhTF	-	Zhurnal tekhnicheskoy fiziki
ZhVMMF	-	Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki
ZL	-	Zavodskaya laboratoriya

9. AUTHOR INDEX