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USSR Report

EARTH SCIENCES

(FOUO 1/82)

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METEOROLOGY

UDC 551.509.616/617+519.2

CLOUD PHYSICS AND ARTIFICIAL MODIFICATION OF CLOUDS

Moscow TRUDY ORDENA TRUDOVOGO KRASNOGO ZNAMENI INSTITUTA PRIKLADNOY GEOFIZIKI: FIZIKA OBLAKOV I AKTIVNYKH VOZDEYSTVIY in Russian No 46, 1981 (signed to press 26 Aug 81) pp 2, 121

[Annotation and table of contents from collection of articles "Cloud Physics and Artificial Modification of Clouds", edited by N. I. Vul'fson, doctor of physical and mathematical sciences, and O. I. Shipilov, candidate of physical and mathematical sciences, Moskovskoye otdeleniye Gidrometeoizdata, 390 copies, 121 pages]

[Text] Annotation. This collection of articles is devoted to a number of problems related to preparations for and implementation of an experiment for artificial augmentation of precipitation in the basin of Lake Sevan. The articles in the collection deal with the problems involved in technical support of the experiment, meteorological conditions for carrying out experiments, the seeking of new methods for the modification of clouds, etc. For the first time in the USSR the collection of articles contains a number of studies on the methods for statistical evaluation of the effect of modification. The collection is intended for specialists in the field of cloud physics and artificial modification and for specialists in the field of mathematical statistics and also for all those who are interested in the problem of artificial modification of weather.

Contents

5303
CSO: 1865/87

UDC 551.590

COLLECTION OF ARTICLES ON HELIOGEOPHYSICAL FACTORS IN WEATHER AND CLIMATE

Leningrad TRUDY ORDENA TRUDOVOGO KRASNOGO ZNAMENI GLAVNOY GEOFIZICHESKOY OBSERVATORII IM. A. I. VOYEYKOVA: GELIOGEOFIZICHESKIYE FAKTORY POGODY I KLIMATA in Russian No 443, 1981 (signed to press 11 May 81) pp 129-135

[Abstracts of articles from "Transactions of the Order of the Red Banner of Labor Main Geophysical Observatory imeni A. I. Voyeykov: Heliogeophysical Factors of Weather and Climate), edited by L. R. Rakipova, doctor of physical and mathematical sciences, and N. I. Yakovleva, candidate of physical and mathematical sciences, Gidrometeoizdat, 680 copies, 135 pages]

[Text] Abstracts

UDC 551.590

REFINED PHYSICOSTATISTICAL SCHEME FOR SUPERLONG-RANGE FORECASTING OF MEAN MONTHLY AIR TEMPERATURE ANOMALIES FOR THE NORTHERN HEMISPHERE

[Abstract of article by Borisenkov, Ye. P. and Borisova, L. Ye.]

[Text] A study was made of the possibility of superlong-range forecasting of the temperature background for the northern hemisphere by the physicostatistical method. The paper gives the results of an evaluation of forecasts of the temperature anomaly for regions of the northern hemisphere prepared using a refined scheme. As a result of the improvement in the method it was possible to increase the probable success of the forecasts. Figures 1, tables 1, references 14.

UDC 551.590.2

RELATIONSHIP OF HELIOPHYSICAL AND CIRCULATION FACTORS IN DROUGHT FORMATION

[Abstract of article by Pokrovskaya, T. V. and Yefremova, N. I.]

[Text] Data are given on the probability of droughts in the European USSR, in northern Kazakhstan and in southeastern Western Siberia in dependence on the phase of the 11-year cycle of the index of geomagnetic disturbance K_p as an indicator of solar corpuscular radiation and in dependence on the sign of the deviation of the G. Ya. Vangengeym indices of atmospheric circulation from the norm, as well as the corresponding L. A. Vitel's indices. The conclusion is drawn that the probability of droughts is not less closely associated with solar activity than with atmospheric

circulation. A catalogue of the yields of spring wheat in northern Kazakhstan for 1880-1977 is given. Tables 3, references 17.

UDC 551.590:630.551

INFLUENCE OF THE SPRING GEOMAGNETIC INDEX K_p ON YIELD VARIATIONS OF AGRICULTURAL CROPS

[Abstract of article by Rakipova, L. R., Yakovleva, N. I. and Andreyeva, L. K.]

[Text] Correlations between the geomagnetic index K_p in spring and yield variations of spring wheat were obtained for the territory of the USSR. These correlations confirm the similar correlations derived earlier for the territory of Europe and Canada. Figures 1, tables 1, references 5.

UDC 551.515

CATALOGUES OF DROUGHTS FOR THE EUROPEAN USSR AND GEOMAGNETIC DISTURBANCE

[Abstract of article by Girskaya, E. I., Sazonov, B. I. and Ul'yanova, T. N.]

[Text] Seven catalogues of droughts for the European USSR are compared. These catalogues are used in checking the hypothesis of T. V. Pokrovskaya concerning the predominance of droughts on the ascending branch of geomagnetic activity K_p. Tables 2, references 15.

UDC 551.509+551.524

CORRELATION OF SEVERE WINTERS AND SOLAR ACTIVITY

[Abstract of article by Yefanova, A. V.]

[Text] A study was made of severe winters on the continents of the northern hemisphere in the 11-year solar activity cycle. It is shown that they are most probable near the Wolf number maximum. The annual variation of geomagnetic disturbance prior to severe winters as a rule is greater than the mean long-term level of the K_p index. Figures 1, tables 5, references 9.

UDC 551.536

ENERGETIC ATMOSPHERIC MANIFESTATIONS DURING 11-YEAR GEOMAGNETIC DISTURBANCE CYCLE

[Abstract of article by Vorob'yev, Ye. V. and Priyemov, V. N.]

[Text] Data for 1891-1972 were used in a spatial and temporal analysis of a computational characteristic of the atmosphere -- temperature at the mean energy level T_{mean} as a function of the phase of geomagnetic disturbance K_p. This temperature characterizes the mean temperature of a column of the atmosphere and is one of the principal parameters determining the potential and kinetic energy of the atmosphere.

The changes in T_{mean} from phase to phase of K_p attain and even exceed 1°C. The authors discuss the spatial and seasonal characteristics of the T_{mean} distribution. The most significant changes occur in the northern latitudes with a localization of centers in the northern part of North America, the Pacific Ocean and the Atlantic Ocean. The revealed patterns have practical use in a diagnosis of the thermal state of the atmosphere. Figures 2, tables 4, references 8.

UDC 551.590

POSSIBILITY OF USE OF L. A. VITEL'S CHARACTERISTICS FOR STOCHASTIC FORECASTS OF DROUGHTS IN WESTERN SIBERIA

[Abstract of article by Dmitriyeva, S. V.]

[Text] A study was made of the possibility of using the L. A. Vitel's barocirculation characteristics for a stochastic forecast of droughts. A preliminary scheme for the forecasting of droughts is developed. Figures 2, tables 2, references 7.

UDC 551.515.7

MACROSYNOPTIC CHARACTERISTICS OF DEVELOPMENT AND MOVEMENT OF ANTICYCLONES DURING DROUGHT PERIODS OF 1963, 1972 AND 1975

[Abstract of article by Serdyuk, V. N. and Kotlyar, I. V.]

[Text] The general characteristics of macrosynoptic processes, development and movement of anticyclones characteristic for all the considered months with drought are revealed. It is shown that during drought periods there was a predominance of moving anticyclones forming in the high-altitude frontal zone over northern Europe. The regions of droughts were situated primarily under the influence of the peripheral parts of anticyclones. There is a conjugate character of the processes developing in the space of the Atlantic-American and European sectors of the hemisphere. Figures 2, references 14.

UDC 551.590

PREDICTION OF EXTREMAL WEATHER PHENOMENA

[Abstract of article by Sazonov, B. I.]

[Text] In the example of droughts in the European USSR a study was made of methods for investigating extremal weather phenomena. The author notes the peculiarities of manifestation of extremal weather phenomena. The rhythm and periodicity of their manifestation are noted. Recommendations are given on methods for a superlong-range forecasting of weather phenomena, together with some considerations on possible physical factors favoring their appearance. Figures 1, tables 5, references 7.

UDC 551.51+551.509

POSSIBILITY OF USING THE G. YA. VANGENGEYM CLASSIFICATION IN LONG-RANGE FORECASTING OF SUMMER PRECIPITATION IN CHINESE PEOPLE'S REPUBLIC

[Abstract of article by Kim Mun Yuk]

[Text] The predictors of summer arid seasons for different forms of circulation of types W, E and C are determined with the use of discriminant analysis with an advance time from several months to 10 years. Figures 2, tables 5, references 4.

UDC 551.590

METHOD FOR PREDICTING MEAN MONTHLY QUANTITY OF PRECIPITATION OVER EUROPEAN USSR DURING WARM SEASON

[Abstract by Getmanova, G. F.]

[Text] A method is presented for predicting the mean monthly quantity of precipitation over the European USSR during the warm season of the year for a period of three months in advance. As predictors use was made of: 1) forecasts of the anomaly of mean monthly air pressure and temperature in the northern hemisphere obtained using the coefficients of expansion of meteorological fields into double Fourier series; 2) water temperature gradients in the North Atlantic, computed using data from weather ships; 3) precipitation (mm), read at the points of intersection of a standard grid of points over the territory of the USSR. The evaluation of forecasts on the basis of both dependent and independent material was positive. This approach to solution of the problem of forecasting of the quantity of precipitation can be useful for solving other practical and scientific research problems. Tables 3, references 5.

UDC 551.521:551.524

ROLE OF NITROGEN OXIDES IN FORMATION OF OZONOSPHERE

[Abstract of article by Rakipova, L. R. and Trubnikov, B. N.]

[Abstract] This is a review of modern concepts concerning the catalytic influence of nitrogen oxides on the processes of ozone formation under the influence of solar ultraviolet and corpuscular radiation. The article gives the principal chemical reactions and systems of equations of hydrothermodynamics taking this factor into account. References 10.

UDC 551.513

INVESTIGATING TROPOSPHERE-STRATOSPHERE INTERACTION WITH ALLOWANCE FOR OZONE HEATING FUNCTION

[Abstract of article by Rakipova, L. R., Trubnikov, B. N. and Shcherba, I. A.]

[Text] The authors investigated the influence of variations of ozone heat influxes caused by a change in ozone content with different solar activity levels on the vertical propagation of macroscale disturbances. Expressions are derived for the indices of refraction and absorption of macroscale waves, taking into account the ozone heating function. An evaluation of the influence of solar activity on the logarithmic decrement of attenuation of macroscale waves in the atmosphere is presented. Figures 2, tables 1, references 9.

UDC 551.521:551.524

EVALUATION OF DYNAMIC AND THERMAL EFFECTS OF 'OZONE-TEMPERATURE' FEEDBACK

[Abstract of article by Rakipova, L. R.]

[Text] The article gives quantitative evaluations of the influence of the negative feedback between temperature and the ozone content in the upper stratosphere on temperature and the wind velocity components. The importance of this correlation for the hydrothermodynamic regime of the ozonosphere is demonstrated. Such evaluations were obtained for the first time. Tables 1, references 6.

UDC 551.513

INFLUENCE OF WINTER STRATOMESOSPHERIC WARMINGS ON TROPOSPHERIC PROCESSES IN THE MIDDLE LATITUDES

[Abstract of article by Karimov, K. A., Rakipova, L. R. and Gaynutdinova, R. D.]

[Text] In the specific cases of mesospheric warmings in 1978 and 1979 the authors give an analysis of the propagation of disturbances from the stratosphere to the troposphere. It is shown that stratomesospheric warmings exert an influence on the temperature regime of the troposphere and favor the development of high-altitude tropospheric ridges. Figures 7, references 3.

UDC 630:551.5

DEPENDENCES OF GRAIN CROP YIELD VARIATIONS ON TIMES OF SPRING RESTRUCTURINGS OF STRATOSPHERIC CIRCULATION

[Abstract of article by Yakovleva, N. I. and Vorob'yeva, N. I.]

[Text] The spatial distribution of the correlation coefficients between the dates of spring restructurings of stratospheric circulation and variations in the yield

of spring wheat in deviations from the theoretical curve for the territory of the USSR is analyzed. A positive correlation over the territory of the European USSR was found, whereas a negative correlation was observed over northern Kazakhstan. Figures 1, references 16.

UDC 551.590.2

CORRELATION ANALYSIS OF RELATIONSHIPS OF MEAN JANUARY METEOROLOGICAL FIELDS IN TROPOSPHERE AND STRATOSPHERE IN HIGH LATITUDES WITHIN 11-YEAR SOLAR CYCLE

[Abstract of article by Rakipova, L. R., Kidiyarova, V. G. and Shcherba, I. A.]

[Text] A study was made of the year-to-year changes in the correlation coefficients between the mean January distributions of geopotential and temperature at the 500 and 30 mbar surfaces in the high latitudes during the period 1965-1977. It is shown that the correlation coefficients characterizing the interrelationship of the troposphere and stratosphere vary from year to year. Their variability is in phase with the mean January geopotential values at the 30 mbar surface and in antiphase with the variability of the mean zonal wind components in the middle stratosphere. In years of the solar activity maximum the stratospheric-tropospheric relationships weaken, the mean zonal geopotential increases and the standard deviations of geopotential decrease. Figures 2, tables 1, references 8.

UDC 551.594.1:551.590.21

INFLUENCE OF SOLAR FLARES ON ELECTRIC FIELD STRENGTH IN FREE ATMOSPHERE

[Abstract of article by Tsvetkov, A. V.]

[Text] The author examines the influence of solar flares on strength of the electric field in the free atmosphere. Taking into account that solar flares change atmospheric conductivity with time, on the basis of solution of the differential equation

$$\mathrm{div}\left(\sigma E + \varepsilon_0 \frac{\partial E}{\partial t}\right) = 0$$

it is possible to determine the dependence of the vertical electric field E(z,t) on the nature of conductivity (z,t). References 5.

5303
CSO: 1865/58A

OCEANOGRAPHY

OCEANOGRAPHIC INVESTIGATIONS IN NORTHWESTERN INDIAN OCEAN DURING SPRING-SUMMER 1980

Sevastopol' KOMPLEKSNYYE OKEANOLOGICHESKIYE ISSLEDOVANIYA INDIYSKOGO OKEANA in Russian 1981 (signed to press 10 Apr 81) pp 7-18

[Article by Yu. T. Shchetinin, V. K. Kosnyrev, Ye. A. Agafonov and V. A. Urdenko, from monograph "Multisided Oceanological Investigations of the Indian Ocean", B. A. Nelepo, academician Ukrainian Academy of Sciences, responsible editor, Morskoy gidrofizicheskiy institut AN USSR (MGI AN USSR), 300 copies, 155 pages]

[Text]

Abstract: The principal scientific results obtained on the 22d voyage of the scientific research ship "Akademik Vernadskiy" under the CIFRIO program are discussed. The features of distribution of the fields of hydrological, hyhydrochemical, hydrooptical and hydrobiological characteristics are analyzed. The nature of the relationship between biological productivity of the upper layer of the ocean and synoptic eddy structures is discussed.

During March-June 1980 the Marine Hydrophysical Institute of the Ukrainian Academy of Sciences carried out oceanographic investigations in the northwestern part of the Indian Ocean. The principal purpose of these investigations was a determination of the relationships between the characteristics of biological productivity in the ocean and hydrophysical fields at the scales of synoptic processes. The research method involved the implementation of a series of multisided macroscale surveys of the polygon and micropolygons (Fig. 1).

Figure 2a shows a map of the macroscale survey of the polygon carried out on the 22d voyage of the scientific research ship "Akademik Vernadskiy." At all drift stations there was a complex of hydrological, optical and biological studies, registry of sound-scattering layers, microwave and electrical measurements. At suspended hydrological stations (denoted by a symbol) these studies were supplemented by the taking of samples for hydrochemical analyses and observations of the resistance of materials to corrosion. At a number of stations work was carried out for studying the characteristics of oceanic turbulence; measurements were made of current velocities; nuclear hydrophysics, hydrobionics and zoology were studied.

The first macroscale survey was made from 15 March through 4 April 1980. During this time specialists on the scientific research ship "Akademik Vernadskiy" occupied 117 drift stations, including 41 hydrological stations with suspended instruments. The

specialists of the Marine Hydrophysical Institute of the Ukrainian Academy of Sciences during this same period carried out investigations of the vertical distribution of the hydrological characteristics using the ISTOK complex on other ships of the joint expedition. Measurement data from these ships were transmitted by radio to the scientific research ship "Akademik Vernadskiy" and subjected to primary processing in the shipboard computation center.

After departure from the port of Victoria three automatic buoy stations were set out for studying the dynamics and structure of an eddy formation in the region of discovery of a synoptic eddy (Fig. 2b) and a survey was made of two micropolygons during the period from 14 April through 8 May 1980. The distance between the stations along the meridian was 30 miles and along the parallel -- 20 miles. During this period 95 stations were occupied, of which 71 were with suspended instruments.

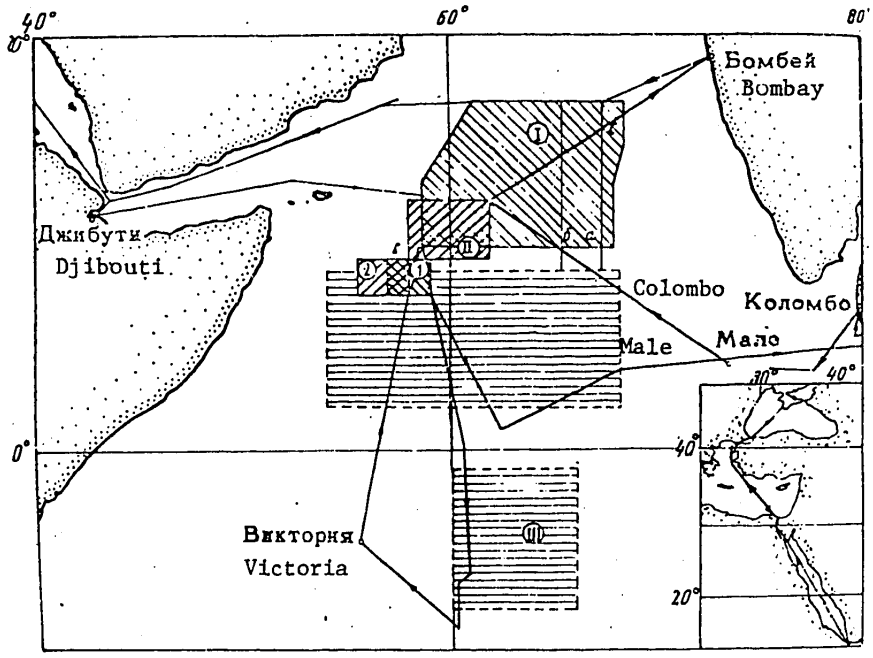

Fig. 1. Map of track of 22d voyage of scientific research ship "Akademik Vernadskiy" and location of regions of macroscale surveys: I, II -- "Akademik Vernadkiy," III -- "Chatyr-Dag"; 1, 2 -- micropolygons and a, b) meridional profiles.

After departure from the port of Singapore there was a second macroscale survey (Fig. 2c) during the period 20 May through 5 June 1980. The distance between stations along the meridian was 40 miles and along the parallel was 30 miles. A total of 50 stations were occupied, of which 14 were hydrological stations with suspended instruments.

Upon completion of a layover in the port of Bombay the ship proceeded to the point of setting-out of automatic buoy station 4 (Fig. 2c). This stage in the work, after removal of the automatic buoy station, was continued by the implementation of

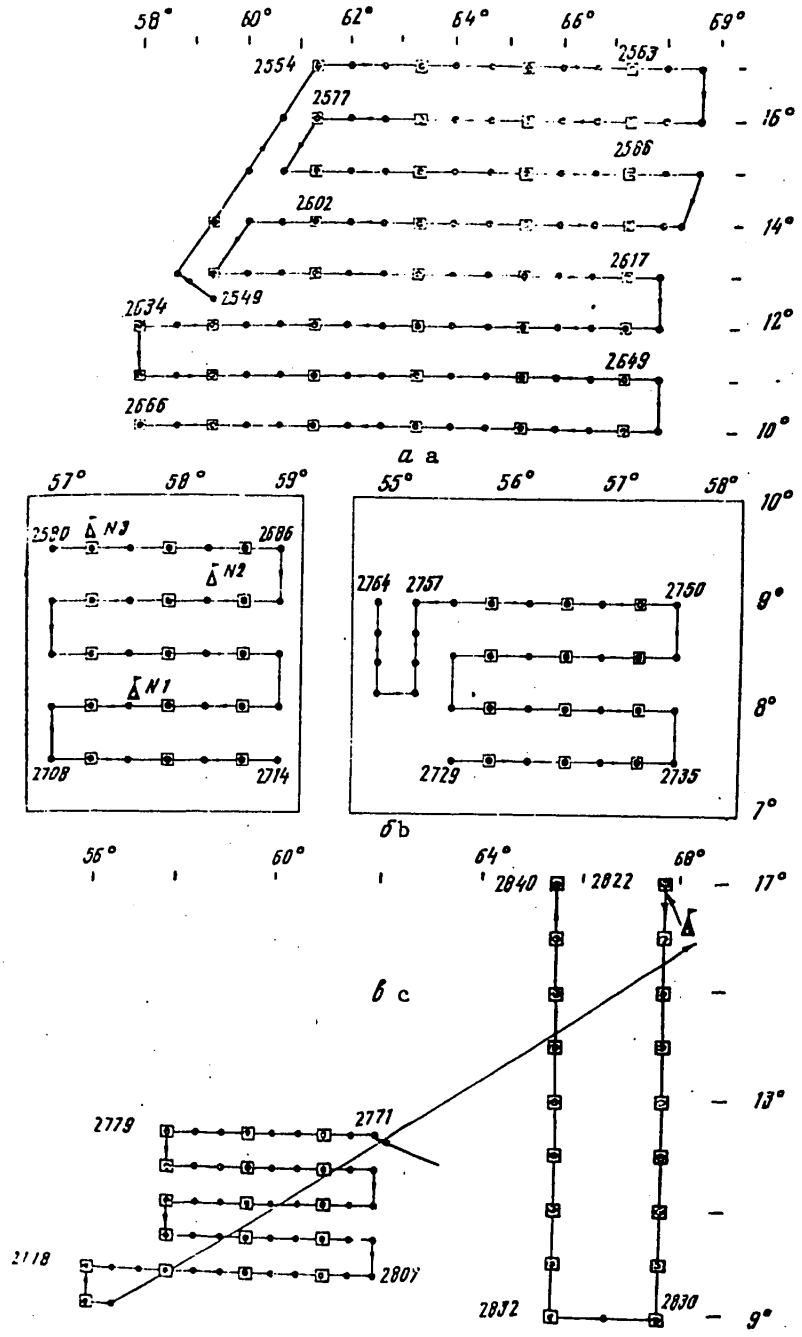

Fig. 2. Diagrams of surveys made by the scientific research ship "Akademik Vernadskiy."

two meridional profiles which were situated in the region of the first macroscale survey. The profiles were run during the period from 15 June through 22 June 1980 along 67°20' and 65°20'E between 10 and 17°N. Along the central part of the Red Sea during the period from 25 June through 29 June 1980 hydrological and hydrooptical studies were carried out which were completed with the setting-out of automatic buoy station 5 (Fig. 1)

These investigations made it possible to determine the background characteristics of hydrological, hydrochemical, hydrooptical and hydrobiological fields in the ocean, evaluate the level of the eddy energy and biological productivity, intensity and kinematics of eddy formations and obtain some statistical characteristics of the eddy field in the polygon. Before proceeding to an exposition of the scientific results we will give a brief summary of the principal features of the investigated region of the ocean.

The Indian Ocean differs from the other oceans in the monsoonal character of the winds blowing over it. From May through September the southwest monsoon prevails, whereas from November through March it is the northeast monsoon. The reversal of the monsoon usually occurs in April and October during the course of a relatively short period of time. The monsoonal character of atmospheric circulation is closely related to the regime of water circulation, whose restructuring also occurs relatively rapidly. It is precisely the six-month cycle of the wind regime which is one of the reasons for the variability of water masses in this region of the ocean. Another distinguishing characteristic is a well-expressed stratification of the waters vertically and also the presence of considerable horizontal gradients of the fields of temperature, salinity and density in each of the individual layers. The enumerated features are manifested in the structure and dynamics of the water masses in the investigated region of the ocean.

We will describe the specific hydrometeorological situation prevailing during the period of investigations in the polygon. The onset of the work (mid-March) fell during the period of ending of the winter monsoon and was characterized by weak winds of 4-8 m/sec of northerly and northeasterly directions. The main part of the investigations (late March-April) fell in the transitional period, primarily during calm weather. The final phase (late May-June) coincided with the onset of the summer monsoon; the wind velocity averaged 10-18 m/sec; the direction varied from SW to WSW.

An analysis of the distribution of temperature and salinity carried out on the basis of data from a macroscale survey and surveys of micropolygons demonstrated that the synoptic variability in the region of the investigations is characterized by cyclonic and anticyclonic eddy formations with a characteristic scale of 60-200 miles. In the area of the polygon there were found to be seven cyclonic and five anticyclonic formations (Fig. 3). The intensity of these formations was relatively small: the maximum rise of the 16° isotherm, selected for mapping the eddy field, was 70 m.

Two successive surveys, carried out in one of the cyclonic eddies, made it possible to determine its kinematic characteristics -- the direction and velocity of movement. During the period from 4 April through 1 May 1980 the center of the eddy

formation was displaced by 270 miles, which gives an average velocity of movement of about 9 miles/day. The direction of movement was WSW. A distinguishing characteristic of all the detected formations is their close relationship to the stratification of the waters. To all intents and purposes not one of these formations was manifested in the temperature field of the ocean surface by a spot of cold or warm water. This indicates a weak resultant vertical transfer within the limits of the eddy, which is traced most frequently in the layer 100-400 m; deeper the picture becomes "blurred" and it is difficult to identify any formations on the basis of their manifestations in the density and temperature field. In contrast to the temperature field, individual eddy formations were rather clearly traced on the basis of salinity anomalies at the ocean surface. A comparison of the position of these anomalies with maps of dynamic topography indicates that in the process of eddy formation there was a capture of mass, after which the advective flows led to the transport of this anomaly into a region with other characteristics of water masses.

A characteristic form of synoptic variability of the ocean in the region of investigation is also the presence of a hydrological front intersecting the polygon from the southwest to the northeast. On the basis of the nature of its position this front probably corresponds to the southern and southeastern peripheries of a macroscale cyclonic circulation occupying the northern part of the Arabian Sea. The meandering of this front could be one of the reasons for weak eddy formation within the limits of the polygon.

Now we will discuss another form of manifestation of synoptic variability of the ocean -- zones of upwelling of deep waters. These zones can be seen in the northwestern, northeastern and southeastern corners of the macroscale polygon. It is assumed that here the upwelling of deep waters corresponds to the zones of traditional intensive upwelling along the shores of the Arabian Peninsula and the western coast of the Indian subcontinent. As a result of change in the wind or dynamic regime in these zones the generation of eddy formations can occur which thereafter are advectively transported to other regions. A preliminary T,S analysis, made on the basis of survey data, indicated that a cold cyclonic eddy, traced in the micropolygon, had T,S characteristics corresponding to the zone of the Arabian upwelling.

We note the exceedingly rapid variability of the form of eddy formations observed on the basis of survey results. This indicates either a wave nature of the eddy formations (superpositioning of rapid baroclinic Rossby waves) or that they are unstable.

A hydrological survey carried out during the period of development of the summer monsoon was considerably inferior in scale to the winter survey. Nevertheless, in the area of the polygon it was possible to detect a cold cyclonic formation with a characteristic horizontal scale of about 150 miles. The maximum rise of the 16° isotherm in this formation was 25-30 m. The same as before, the eddy was not manifested in the temperature field of the ocean surface but was easily detected from the anomalous values of salinity, which at the center of the eddy was 36.55°/oo; in the surrounding waters it was 36.2°/oo.

Fig. 3. Map of depth of 16°C isotherm according to data in first macroscale survey.

Dynamics of waters. The most complete information on the circulation of waters in the Arabian Sea was obtained during the period of ending of the winter monsoon and in the transition period. A hydrological survey of the macroscale polygon and a survey of two micropolygons made it possible to compute and plot maps of dynamic topography relative to the reading surface 1500 db. On these maps it is possible to discriminate six eddy formations (3 cyclonic and 3 anticyclonic) on the basis of their manifestations in the upper 200-m layer of the ocean (Fig. 4). In these formations the velocities of rotational motion are relatively small, usually 9-11 cm/sec, but not more than 20 cm/sec. The clustering of dynamic contour lines observed in the southern and eastern parts of the macroscale polygon is evidently the axis of a macroscale cyclonic circulation forming during the winter in the northern part of the Arabian Sea. The current velocities on the axis are 3-21 cm/sec. The pattern of circulation of waters, similar to that shown, is traced to a depth of 200 m; deeper the pattern of circulation is "blurred," although the position of the center of the circulation and the character of the circulation are maintained to a depth $\approx$ 800 m.

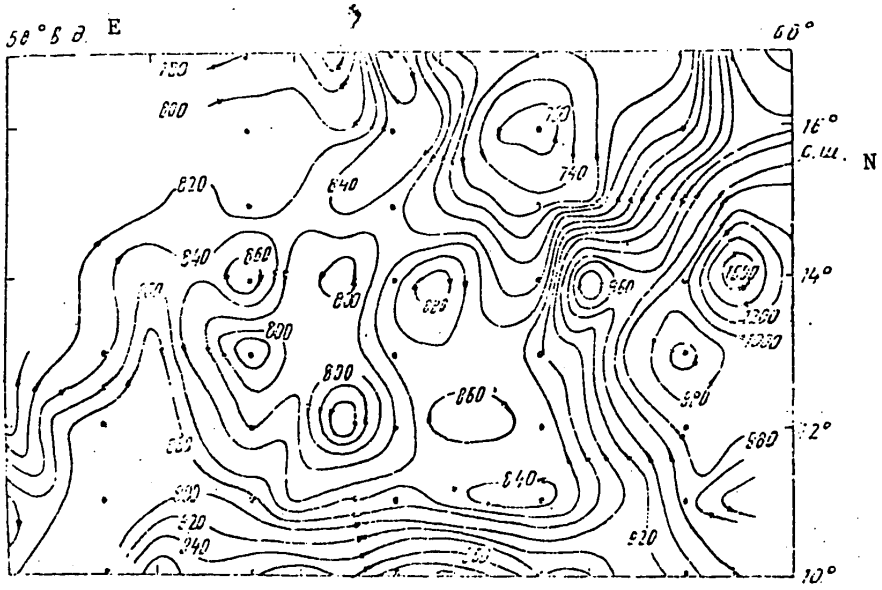

Fig. 4. Dynamic topography at 0° horizon.

The maps of dynamic topography, computed for the micropolygons, show that the geostrophic currents in the eddy cyclonic formation, completely outlined in the second micropolygon, retain their sign to great depths. The current velocity in this eddy varies in the range 10-30 cm/sec. By comparing the successive positions of the center of the cyclonic formation on the three maps, it is possible to estimate the velocity of movement at about 8-9 miles/day.

The data from experimental measurements carried out with the three automatic buoy stations agree entirely with data on currents obtained by the dynamic method. An analysis of graphs of the mean daily progressive vectors indicates that the change in direction and velocity modulus of the current is closely related to the passage of a cyclonic eddy through the system of automatic buoy stations on the first 3-4 days and the passage of an anticyclonic eddy in the middle and at the end of the observation period. At all three buoys the current velocity regularly decreased with depth. The velocity maximum was usually situated at the horizons 50, 100 m and the minimum was at the horizons 800, 1500 m. The minimum current velocity is noted at a depth of 800 m as well when using data computed by the dynamic method. Despite the fact that the horizontal gradients of the temperature and salinity fields at these depths are extremely significant, the current velocities are nevertheless small. This fact can be attributed to the influence of intermediate Arabian Sea waters which form an almost horizontal pycnocline.

The characteristics of the hydrological structure and circulation of waters are closely related to the distribution of the hydrochemical and hydrooptical characteristics. The Arabian Sea is characterized by a three-layer structure of the distribution of chemical characteristics with depth: a) the surface homogeneous layer (to depths of 50-80 m); b) the layer of maximum vertical gradients (to depths of

125 m); c) the subsurface or intermediate layer, extending to the lower limit of observations (500 m).

An analysis of the influence of eddy disturbances on the variability of the fields of biogenous elements indicated that the results in many respects are identical to the conclusions drawn when carrying out work under the "Polimode" program. A cyclonic eddy was discovered during the microsurveys; it moved toward the southwest with a velocity of about 9 miles/day. It was traced most clearly from the upwelling of waters in the layer 100-200 m. At the center of the zone of upwelling of waters there was an increase in phosphorus concentrations (by approximately 20 μg/liter) and silicon (by a factor of 2-3) in comparison with the concentration in the surrounding waters. At the horizon 500 m the influence of upwelling was almost absent.

Now we will examine the hydrooptical characteristics in the zones of eddy formations. The investigations carried out in the micropolygons revealed that the anomalies caused by eddy formations in the transparency field occupied a relatively thin layer 50-200 m and the greatest vertical displacements of the transparency isolines corresponding to the background conditions did not exceed 50-60 m. In the immediate neighborhood of the center of the circulation, determined from the hydrological data, there were two anomalous regions, one of which corresponds to an uplift of the jump layer; the other corresponds to its subsidence. Both regions were situated on the line of movement (trajectory) of the eddy. By comparing the spectral changes in the attenuation index in the zones of rising and sinking of the jump layer it can be noted that the waters corresponding to the region of rising are related in spectral composition to deep waters, whereas the region of subsidence is filled with surface waters. One gets the impression that the eddy causes not only an upwelling of waters, but also their subsidence on the periphery. However, insignificant vertical velocities of such movements and their localization in the thin layer near the surface did not favor an intensification of the processes of exchange of deep and surface waters under the conditions of the open ocean.

Now we will examine the principal characteristics of the biological productivity of waters in the investigated region of the ocean at different trophic levels and we will give an evaluation of this productivity as a whole.

The quantities of primary production during the period of the winter monsoon were characterized by relatively low values. The average production of the surface layer was 2.5 mg $C \cdot m^{-3} \cdot day^{-1}$; for the entire photosynthesis layer -- about 50 mg $C \cdot m^{-2} \cdot day^{-1}$ with considerable variations (0.1-10.5 mg $C \cdot m^{-3}$ and 10.8-447.2 mg $C \cdot m^{-2}$). The main mass of photosynthetically active phytoplankton was concentrated in the upper 25-m layer with maxima, as a rule, at the surface or at a depth of 10 m; at greater depths the synthesis of phytoplankton was very weak.

Investigations during the period of the summer monsoon indicated a very insignificant decrease in the level of primary production of organic matter by phytoplankton. The maximum quantities of primary production in individual zones did not exceed 5 mg $C \cdot m^{-3}$ and 155 mg $C \cdot m^{-2}$ respectively. In the course of both periods there was a "spottiness" in the distribution of more or less productive zones.

Within the limits of the investigated ocean area there were no sharp differences in the concentration of chlorophyll "a" during different seasons. For example, during the period of the winter monsoon the order of magnitude varied in the range 0.01-0.10 $mg \cdot m^{-3}$; for the entire layer 0-100 m the concentration was 8.14 $mg \cdot m^{-2}$. The maximum chlorophyll contents were observed in the layer 40-80 m, where its concentration in individual cases attained 0.2-0.3 $mg \cdot m^{-3}$. At the same time, the assimilation number, characterizing the rate of photosynthesis per unit of chlorophyll, was minimum at these depths.

In the micropolygons, where the cold cyclonic eddy was outlined, there was some increase in chlorophyll "a" both for the surface and for the layer 0-100 m (up to 0.04 $mg \cdot m^{-3}$ and 9.49 $mg \cdot m^{-2}$ respectively). In the second micropolygon, where the cold eddy was completely outlined, the chlorophyll content in the photosynthesis layer on the average attained maximum values 13.0 $mg \cdot m^{-2}$. The main mass of chlorophyll here was concentrated at a depth of about 50 m and in individual regions attained 0.46 $mg \cdot m^{-3}$.

In the distribution of the quantities of primary production and chlorophyll "a" there was a general increase in their quantities in a direction from northeast to southwest.

Thus, with respect to the level of production of primary organic matter by phytoplankton and content of chlorophyll "a" the investigated ocean area can be classified as oligotrophic and is transitional to mesotrophic waters. Regions of increased productivity were observed in part in local zones associated with the divergence of water masses in disturbances of the cyclonic type.

On the basis of the richness of bacterioplankton this ocean area can be classified as mesotrophic waters. The bacterial population of the surface layer in the macropolygon and two micropolygons on the average varied in the range 500-700 thousand $cells \cdot ml^{-1}$. It was possible to define the ocean areas richest in bacterial life and those which were relatively impoverished. The highest quantities of bacterioplankton (about 1 million $cells \cdot ml^{-1}$) were discovered in the northwestern part of the macropolygon. In general, the northern part of the polygon stood out due to an increased development of bacterial life. This productive zone extended in a southwesterly direction.

Zooplankton is the next link in the trophic chain of the biocoenosis. An analysis of the data obtained both with total exploitation of the layer 0-100 m with a net and with specific exploitation of the sound-scattering layer indicated the following.

Net seston in all stages of the investigations in different parts of the investigated region was represented primarily by two groups -- copepoda and chaetognatha. According to visual evaluations there was a predominance of the first group, being 50-90% or more of the biomass of zooplankton. A distinguishing characteristic of seston during the period of ending of the winter monsoon (March-April) was the greater content of detritus and slime -- residues of different jellylike forms (medusa, Portuguese man-of-war). In some cases the quantity of detritus was 50% or more of the seston biomass. With the onset of the period of the southwest monsoon the fraction of detritus (primarily macrodetritus) decreased sharply; remnants of jellylike forms completely disappeared. In the zooplankton there was an

increase in the volume of copepoda in the early stages of development; other mass components of zooplankton were the young of chaetognatha and the larvae of gastropoda. During this period at virtually no station was there any abundant development of jellylike forms. All this is evidence that the onset of the summer season is characterized by a rather significant change in the phases of succession of zooplankton and an intensification of development of the most massive forms of first- and second-order consumers (an indication of "rejuvenation" of the community).

The intensity of development of zooplankton in the layer 0-100 m was also different at different moments in time. For example, during March-April the greatest concentrations of net seston (150-250 mg-250 $mg \cdot m^{-3}$ or more) were observed in the northwestern and northern parts of the polygon, which is evidently associated with cyclonic circulation in the Arabian Sea. Over the greater part of the polygon the concentration of seston was at the level 50-150 $mg \cdot m^{-3}$. On the average for the entire region the seston concentration was 120 $mg \cdot m^{-3}$. Repeated investigations, carried out in the southwestern part of the region in late May-early June, indicated that despite changes in the composition of net seston, its concentration nevertheless remained at the former level (the average biomass was 110 $mg \cdot m^{-3}$). At the end of the second-beginning of the third 10-day period in June there was an appreciable increase in the biomass of seston, on the average to 148 $mg \cdot m^{-3}$.

Specific catches in the sound-scattering layer indicated that the characteristic representatives of these layers (regardless of their type) were myctophida and their young, euphuesia, chaetognatha, copepoda, etc. At stations situated in the northwestern part of the polygon, there was a great quantity of roe, hypothetically of squid. There were no significant differences in the composition of the sound-scattering layer in different seasons of the investigations. The concentration of animals in the sound-scattering layer is 4-5 times less than that in the upper 100-m layer of the ocean.

In general, with respect to the level of development of zooplankton the open waters of the Arabian Sea (according to the Bogorov-Rass classification) can be classified as moderately productive, but the relatively uniform distribution of plankton and the absence of its aggregations in individual sectors impede an accumulation of organisms of higher trophic levels, including those of interest for the fishing industry (squid, fish).

In this connection the question arises of the reasons for the relatively low (biological in general and commercial in particular) productivity of the investigated region. The prevailing opinion that the principal factor limiting bioproductivity in the tropical zone of the oceans is a low content of biogenous elements in the euphotic layer is scarcely correct for this region. Hydrochemical investigations indicate that the content of biogenous elements in the euphotic layer is rather great and exceeds by many times the requirements of the number of algae present. The latter is confirmed by data on the low concentrations of biogens, the low content of chlorophyll "a" in the water and the low levels of primary production. It seems most probable that the consumption of the biogenous elements by the algae present in the eutrophic layer in great quantities and the development of organisms of subsequent trophic levels on this basis is limited primarily by

the dynamic factor -- by the absence of conditions leading to the accumulation of developing plankton. Under conditions of an inadequacy of food for the plankters-filtrators there should be a considerable increase in the role of detritus as a buffer component in the food chain of the pelagic ecosystem, especially since its content in the water in individual periods is extremely significant. According to the computations which have been made, the food requirements of herbivorous zooplankton in the investigated period are satisfied by approximately 40-50% by the production of phytoplankton.

A detailed analysis of the collected data will make it possible to obtain more reliable information concerning the characteristics of development of the biological community in this region of the ocean and establish a close relationship between its degree of development, hydrological and dynamic factors.

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CSO: 1865/82

USE OF DYNAMIC-STOCHASTIC MODEL IN PROCESSING HYDROPHYSICAL MEASUREMENTS IN INDIAN OCEAN

Sevastopol' KOMPLEKSNYYE OKEANOLOGICHESKIYE ISSLEDOVANIYA INDIYSKOGO OKEANA in Russian 1981 (signed to press 10 Apr 81) pp 99-107

[Article by I. G. Protsenko, I. Ye. Timchenko and V. D. Yarin, from monograph "Multisided Oceanological Investigations of the Indian Ocean", B. A. Nelepo, academician Ukrainian Academy of Sciences, responsible editor, Morskoy gidrofizicheskiy institut AN USSR (MGI AN USSR), 300 copies, 155 pages]

[Text]

Abstract: A dynamic-stochastic model is used in constructing synchronous maps of hydrophysical fields on the basis of density surveys carried out during the 22d voyage of the scientific research ship "Akademik Vernadskiy" in the Indian Ocean. The authors analyze the results of computations. The conclusion is drawn that a dynamic-stochastic approach to an analysis of observations is highly promising for the processing of data under expeditionary conditions at a real time scale.

Dynamic-stochastic model. The broadening of expeditionary oceanographic research is bringing to the forefront the problems involved in the routine quantitative interpretation of the collected information. The use of dynamic-stochastic models for the processing of hydrophysical observations is highly promising for these purposes [1-3].

The dynamic-stochastic model presented in this study includes a three-dimensional thermohydrodynamic model for predicting the density and current fields in an open oceanic basin, a model for computing the parameterized covariation matrix of errors and a procedure for the statistical assimilation of individual measurements. As in [1-3], the use of a dynamic-stochastic model is used in processing data for the density field. However, in contrast to the mentioned studies, the hydrodynamic part of the model is far simpler, which made it possible to apply it numerically using a shipboard electronic computer under expeditionary conditions.

In a study of macroscale geostrophic movements we use a system of differential equations of a hydrodynamic model describing the superpositioning of low-frequency baroclinic Rossby waves and inertial oscillations

$$\frac{\partial u}{\partial t} - lv = \frac{g}{\rho_0}\int_z^H \frac{\partial \rho}{\partial x}\,dz + \frac{\partial}{\partial z}\nu_z\frac{\partial u}{\partial z}, \tag{1}$$

$$\frac{\partial v}{\partial t} + lu = \frac{g}{\rho_0}\int_z^H \frac{\partial \rho}{\partial y}\,dz + \frac{\partial}{\partial z}\nu_z\frac{\partial u}{\partial z}, \tag{2}$$

$$w = \frac{\beta}{l}\int_0^z v\,dz - \frac{1}{\rho_0 l}\left(\frac{\partial \tau_x}{\partial x} - \frac{\partial \tau_y}{\partial y}\right), \tag{3}$$

$$\frac{\partial \rho}{\partial t} + u\frac{\partial \rho}{\partial x} + v\frac{\partial \rho}{\partial y} + w\frac{\partial \rho}{\partial z} = \frac{\partial}{\partial z}\varkappa_z\frac{\partial \rho}{\partial z} + \varkappa_x\Delta\rho. \tag{4}$$

The system of differential equations (1)-(4) describes the evolution of the vector of state of the ocean, whose components are the projections of the velocity vector of currents u, v, w onto the Cartesian coordinate axes x, y, z, and also the density ρ. Here ν_z is the coefficient of vertical turbulent exchange; $\varkappa_z$, $\varkappa_x$ are the coefficients of vertical and horizontal diffusion; l is the Coriolis parameter; $\beta = \partial l/\partial y$; g is the acceleration of free falling; τ_x, τ_y are the components of wind shearing stress. The covariation function of the deviation of the theoretical evaluation of density from the measurements will be represented in the form

$$\rho(x, y, z, x_1, y_1, z_1, t) = \varphi_x(x - x_1, y - y_1)\,\varphi_z(z - z_1)\,\sigma(x, y, z, t)\,\sigma(x_1, y_1, z_1, t), \tag{5}$$

where $\sigma(x, y, z, t)$ is the standard deviation of the field of errors; the functions φ_x, φ_z are the standard normalized correlation functions of uniform fields with a unique dispersion.

In accordance with [3], we will write the equation for the function of dispersion of errors

$$\frac{\partial \sigma^2}{\partial t} + u\frac{\partial \sigma^2}{\partial x} + v\frac{\partial \sigma^2}{\partial y} + w\frac{\partial \sigma^2}{\partial z} + 2c\sigma^2 = \frac{\partial}{\partial z}\varkappa_z\frac{\partial \sigma^2}{\partial z} + \varkappa_x\Delta\sigma^2 - 2\varkappa_z\left(\frac{\partial \sigma}{\partial z}\right)^2 - 2\varkappa_x\left[\left(\frac{\partial \sigma}{\partial x}\right)^2 + \left(\frac{\partial \sigma}{\partial y}\right)^2\right] + \sigma_\omega^2, \tag{6}$$

where

$$c = \frac{\partial}{\partial z}\varkappa_z\frac{\partial \varphi_z}{\partial z}\bigg|_{z=z_1} + \varkappa_x\Delta\varphi_x\bigg|_{\substack{x=x_1\\ y=y_1}}.$$

In equation (6) σ^2 represents the dispersion of excitation and is a probabilistic model of small-scale phenomena not taken into account by the hydrodynamic model (1)-(4).

At the time of receipt of the measurement $\tilde{\rho}(x_A, y_A, z_A, t)$ at the point A the density and dispersion of error in the correlation radius is made more precise using the formulas

$$\hat{\rho}(x, y, z, t) = \rho(x, y, z, t) + \frac{\sigma^2(x, y, z, t)}{\sigma^2(x_A, y_A, z_A, t)}\,\varphi_z(z - z_A) \times \tag{7}$$

$$\cdot \varphi_x (x-x_A, y-y_A) \left[\rho (x_A, y_A, z_A, t)-\rho (x_A, y_A, z_A, t)\right],$$

$$\hat{\sigma}^2 (x, y, z, t) = \sigma^2 (x, y, z, t) \left[1-\varphi_z (z-z_A) \varphi_x (x-x_A, y-y_A)\right]. \quad (8)$$

We will use the following boundary conditions

$$\rho_0 \nu_z \frac{\partial u}{\partial z} = -\tau_x, \quad \rho_0 \nu_z \frac{\partial v}{\partial z} = -\tau_y, \quad \rho = \rho_1, \quad \sigma^2 = \sigma_1^2 \text{ when } z = 0; \quad (9)$$

$$\frac{\partial u}{\partial z} = \frac{\partial v}{\partial z} = 0, \quad \rho = \rho_1, \quad \sigma^2 = \sigma_{H_1}^2 \qquad \text{when } z = H_1, \quad (10)$$

where H_1 is the depth of the horizon below which the density is considered homogeneous.

In the liquid vertical boundaries of the considered region

$$\rho = \rho_r, \quad \sigma^2 = \sigma_r^2. \quad (11)$$

At the initial moment in time when t = 0

$$u = u^0, \quad v = v^0, \quad \rho = \rho^0, \quad \sigma^2 = (\sigma^2)^0. \quad (12)$$

The numerical solution of equation (1)-(8) with the boundary (9)-(11) and initial (12) conditions was found in a computation grid which in the horizontal direction contains the uniformly spaced grid line intersections $(x_i, y_j)x_i = i\delta x$, $y_j = j\delta y$; i = 1,...,L; j = 1,...,M and in the vertical direction the nonuniformly spaced horizons z_k, k = 1,...,N. Equations (1), (2), (4), (6) were written with use of a natural filter scheme. With respect to the derivatives in the horizontal direction the scheme was explicit with a second order of approximation. In equation (6) the last term on the right-hand side was taken in the computation layer. Along the vertical coordinate the equations were approximated by the balance method, after which the resulting system of algebraic equations was solved by matrix fitting along z. On the boundary for equation (6) there was stipulation of the condition of an exponential increase from zero to unity for the normalized dispersion of the field of errors:

$$(\sigma^2)^{n+1} = \frac{(\sigma^2)^n + \sigma_0^2 \delta t}{1 + c\delta t}, \quad (13)$$

where $(\sigma^2)^{n+1}$ is the value of the function in the computation layer; δt is the time interval in the numerical scheme.

Such a choice of behavior of the dispersion of error on the boundary is attributable to the fact that the values of the density field at the boundary points remained constant in the absence of information and changed only after assimilation of the measurement at the boundary points and at points adjacent to the boundary, whereas the real field changed at each moment in time. Accordingly, the dispersion of error in determining the field at the boundary increased with time and attained a maximum value after an interval equal to the time correlation radius of the density field.

On the basis of this model we processed data for hydrophysical polygons investigated under the program for complex investigations of the fishery resources of the Indian Ocean [4].

Results of Computations

The first polygon, in which numerical computations were made, was situated in the region 60°-68°40'E, 10-17°N (Fig. 1). Nine horizons were selected in the vertical direction: 0, 50, 100, 200, 500, 1000, 1500, 2000, 3500 m. The components of the wind shearing stress were determined using data on observations of the velocity of the near-water wind made on the ship. The values of the initial density field were taken from the ATLAS OF THE INDIAN OCEAN. The stationary diagnostic solution of equations (1)-(3) was used for the values of the initial velocities. The dispersion at the initial moment was assumed equal to the dispersion of the density field. The values of the model parameters were: $\delta_x = 10^7$ cm, $\delta_y = 0.84 \cdot 10^7$ cm, $\gamma_z = 10$ cm^2/sec, $\mathcal{H}_z = 10$ cm^2/sec, $\mathcal{H}_x = 10^7$ cm^2/sec.

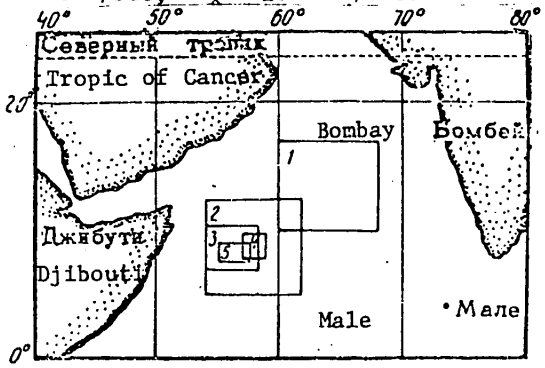

Fig. 1. Location of hydrophysical polygons in Arabian Sea.

In accordance with equations (1)-(8) computations were made of the hydrodynamic characteristics for 20 days (the time from the beginning to the end of the macroscale survey) with a time interval $\delta t = 3$ hours. At the times corresponding to the time of occupation of the hydrological stations (Fig. 2 in [7]) the procedure of statistical assimilation of observational data was carried out.

An analysis of the level surface (Fig. 2,a), representing an integral characteristic of the density field and graphically reflecting the dynamic processes transpiring in the water layer, indicated that during the time of implementation of the macroscale survey in the polygon there were four well-expressed eddy formations -- two cyclonic (in the northern and southwestern parts) and two anticyclonic (in the eastern and southern parts), and also a number of less intensive eddies. The level drop between the minimum in the cyclone and the maximum in the anticyclone was 32 cm per 200 miles. There is a general tendency to a rise in the ocean level from northwest to southeast with the sharpest gradients in the frontal zone passing through the polygon in the direction from the southwestern to the northeastern corner.

Figure 2,b shows a map of the level surface constructed by the objective analysis method on the basis of data arbitrarily related to one time. A comparison of maps of the level surfaces in Fig. 2,a,b shows that in general they are similar, but

as a result of use of the equations of dynamics and successive analysis of the data the cyclone in the northern part of the polygon moved to the north (evidently under the influence of a current directed from the southwest to the northeast). In the west the cyclone changed its form and the region of the zero surface was propagated to the southwest.

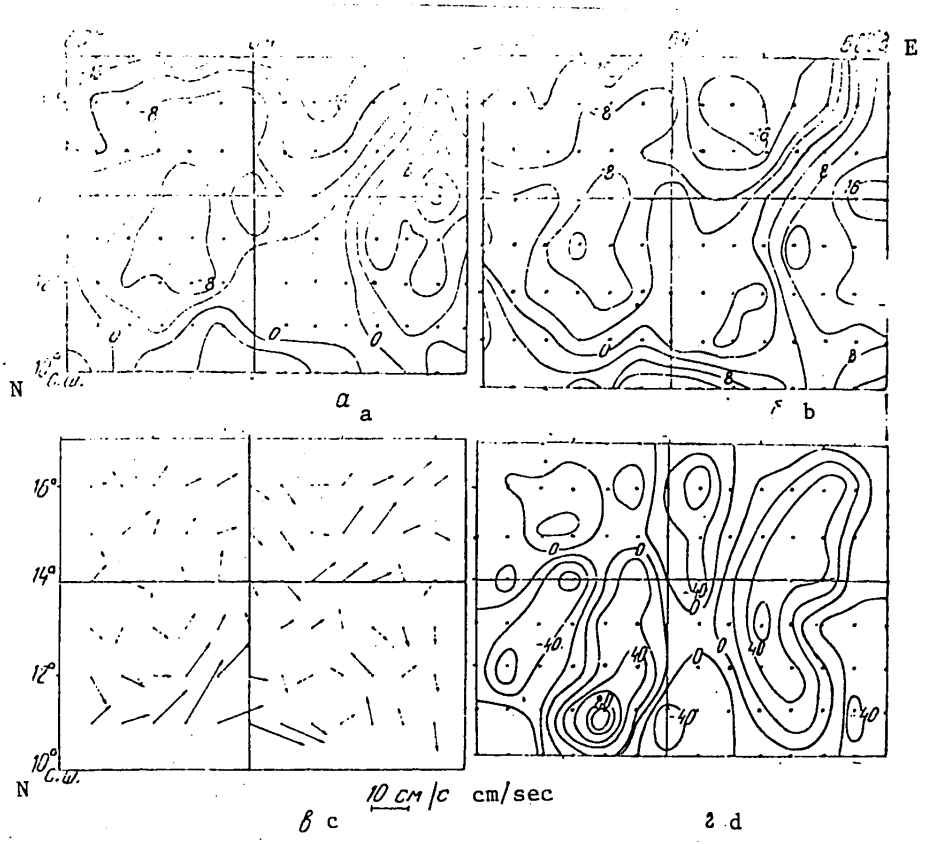

Fig. 2. Level surface: a) obtained from dynamic-stochastic model; b) constructed by objective analysis method; c) map of horizontal currents at 200-m horizon; d) vertical velocity at 200-m horizon.

Figure 2,c is a map of the current vectors at the 200-m horizon. In general, the fields of horizontal velocities are similar for all the computation horizons. The velocity modulus decreases with depth. For example, the maximum velocity modulus at a depth of 50 m, registered in the southwestern part of the polygon, is 45 cm/sec; at the 1000-m horizon its value decreased to 15 cm/sec. Along the line of the maximum gradients of the level surface there is a relatively intensive flow directed from southwest to northeast. To the left of it there are two eddy formations with a cyclonic direction of velocity; to the right of it there are two major eddies of the anticyclonic type. Except for the southwestern cyclone, all the eddies lie partially outside the polygon. The velocity modulus in

the southwesterly flow on the average is obviously greater than the orbital velocities in the eddy formations. Thus, the dynamics of the eddies occurs against the background of the energy exchange of the mean flow and eddy formations of a synoptic scale.

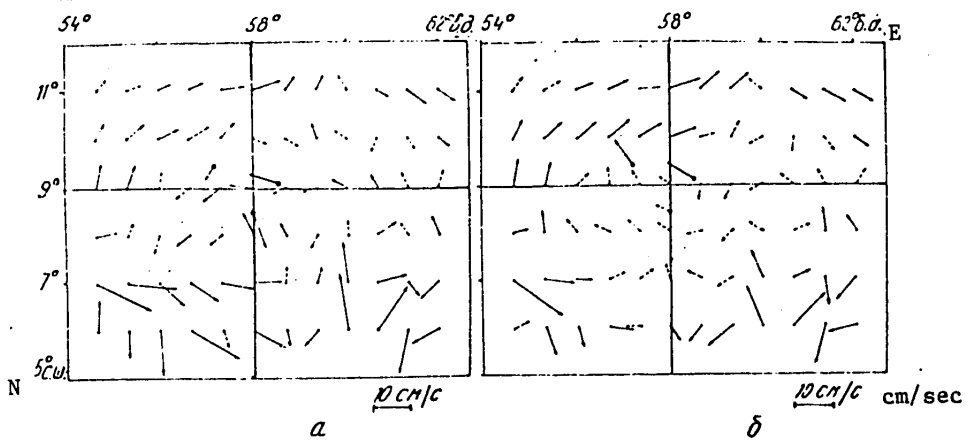

Fig. 3. Map of horizontal current vectors: a) obtained on 16 April 1980 and b) 20 April 1980.

An examination of the vertical component of current velocity (Fig. 2,d) makes it possible to conclude that the zones of upwelling of deep waters lie on the western periphery of anticyclonic eddy formations and on the eastern periphery of cyclonic eddies. For zones of subsidence the opposite picture is observed. The velocities of upwelling and subsidence of waters increase with depth. Within the limits of the polygon the values of the vertical component of current velocity fall within the interval 10^{-2}-10^{-3} cm/sec. The density field to a depth of 600-700 m is characterized by a domelike rising or dropping of the isopycnic lines relative to the mean level in zones of anticyclonic or cyclonic eddies respectively. At the lower-lying horizons the indicated feature is expressed less clearly.

Second polygon. In this region the scientific research ship "Akademik Vernadskiy" investigated two micropolygons (Figure 1, 2). This was situated in the region 54°-62°40'E, 5-12°N. The investigation of the micropolygons was preceded by a macroscale survey with participation of the scientific ship "Professor Vodyanitskiy." Due to the unsatisfactory quality of the measurements in this polygon the sounding data were subjected to additional processing. The "surges" on the vertical profiles were smoothed and at the computation horizons the mean values of the density field and its dispersion were reduced in accordance with the data for the first polygon by means of subtracting the nonclosure between the mean values, multiplied by a coefficient equal to the ratio of the standard deviations, computed for each group of data. The density field obtained in this way was used as the initial field. Hydrodynamic computations were made for the period 9-16 April 1980 (beginning of work for surveying of the first micropolygon and the setting-out of three multiday buoy stations).

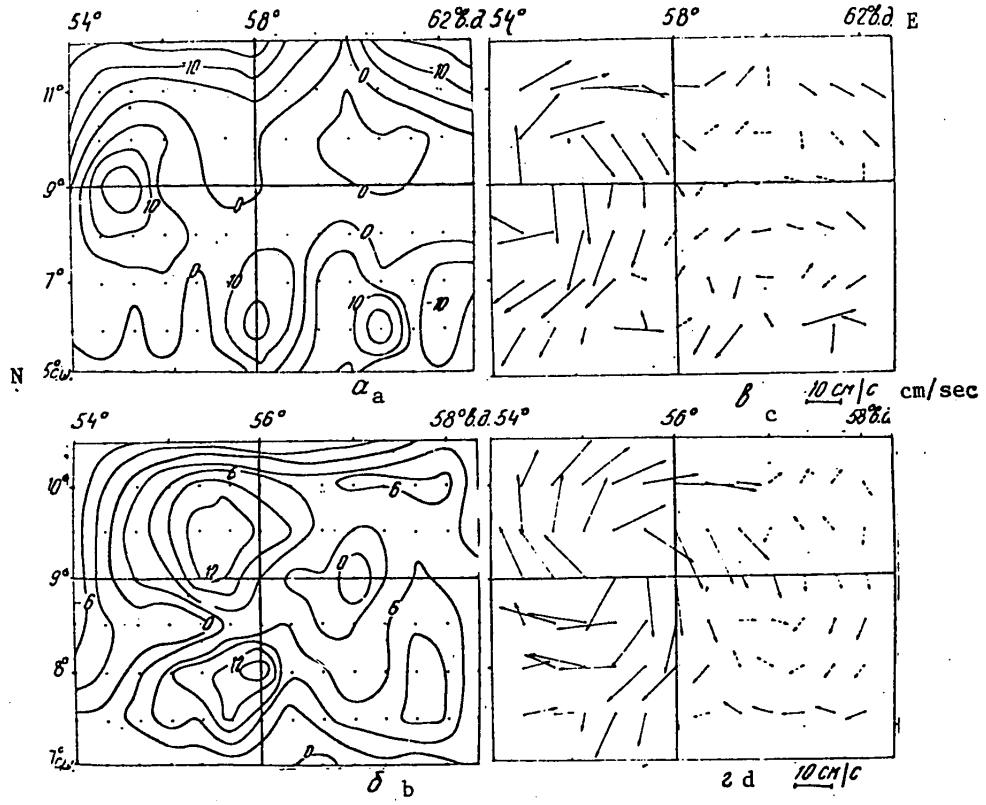

Fig. 4. Level surface: a) second polygon; b) third polygon; map of horizontal current vectors: c) second polygon; d) third polygon.

Figure 3,a is a map of the horizontal velocities at a depth of 500 m; the figure shows the velocity vectors (the location of the buoy stations is denoted by circles), measured at the automatic buoy stations. Despite the relatively long time of the forecast, there is agreement with observations. Figure 3,b shows the horizontal velocities for the 500-m horizon, obtained at the end of the survey of the first micropolygon. They were computed using the dynamic-stochastic model, taking into account the new data on the density field and to a great degree approach the measurements. The measured current vectors are greater in absolute value than the velocities obtained as a result of computation of the dynamic-stochastic model.

Figure 4,a is a map of the level surface relating to the end of the survey of the fifth micropolygon (28 April 1980). Since in the numerical model the interval of the computation grid is twice as great as the distance between the stations in the micropolygons, some data were not taken into account. Nevertheless, in the western part of the micropolygon there is a region of the upwelling of waters caused by the presence of an anticyclonic eddy whose eastern periphery passed through the micropolygon.

The third polygon, for which the data of the first and second micropolygons were completely processed, had a spatial interval half as great and was situated in the region 54°-58°20'E, 7°-10°30'N. On the map of the level surface obtained on 28 April 1980 there were certain peculiarities. The anticyclonic eddy formation was expressed by two centers of subsidence of the isopycnic lines (Fig. 4,b). The level gradients in this variant were greater than in computations in a coarser grid. A comparison of the maps of the horizontal current vectors at the 200-m horizon (Fig. 4,c,d) reveals that the principal features of the anticyclonic circulation coincide in both variants.

Summary

The region of investigations was characterized by a complex hydrological structure of the fields, which made it difficult to trace their evolution on the basis of asynchronous data of polygon measurements. Nevertheless, the use of a dynamic-stochastic model made it possible to carry out a generalization of the collected data and construct maps of fields consistent with the results of hydrological soundings. At the same time, the possibilities of employing the dynamic-stochastic approach with a low-capacity electronic computer under shipboard conditions have been demonstrated. The proposed model can be used as a basis for an automated system for the processing of hydrophysical information operating at a real time scale.

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NONCONTACT METHODS FOR MEASURING OCEANOGRAPHIC PARAMETERS

Moscow NEKONTAKTNYYE METODY IZMERENIYA OKEANOGRAFICHESKIKH PARAMETROV in Russian
1981 (signed to press 19 May 81) pp 2, 120-123

[Annotation and table of contents from collection of articles "Noncontact Methods for Measuring Oceanographic Parameters", edited by S. V. Viktorov, candidate of physical and mathematical sciences, Moskovskoye otdeleniye Gidrometeoizdata, 560 copies, 124 pages]

[Text] Annotation. These articles examine the results of theoretical and experimental investigations directed to creation of noncontact methods and means for measuring oceanographic parameters. The greatest emphasis is on measurement of the characteristics of sea waves, ice, temperature of the sea surface and contamination of the sea surface by petroleum products using instruments carried aboard flightcraft. The collection of articles contains the following sections:
1. Active SHF methods.
2. Passive SHF methods.
3. Measurements in IR range.
4. Laser methods.
5. Space and aerial surveys in optical range.
6. Ultrasound methods.
7. Methodological problems of noncontact measurements.
The collection of articles is intended for a wide range of scientific workers and engineers working in the field of study of natural resources of the earth and world ocean and students in the advanced courses of the corresponding fields of specialization.

Contents

Methodological Problems of Noncontact Measurements

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SPECTRAL ANALYSIS OF RANDOM OCEANOLOGICAL FIELDS

Leningrad SPEKTRAL'NYY ANALIZ SLUCHAYNYKH OKEANOLOGICHESKIKH POLEY in Russian 1981 (signed to press 30 Jan 81) pp 2-4

[Annotation and table of contents from monograph "Spectral Analysis of Random Oceanological Fields", by Konstantin Vasil'yevich Konyayev, responsible editor K. D. Sabinin, doctor of physical and mathematical sciences, Gidrometeoizdat, 1360 copies, 206+ pages]

[Text] Annotation. This book contains a systematic exposition of multidimensional spectral analysis and its oceanological applications. Traditional and some special procedures for the collection and processing of data are presented, including recently developed autoregression methods ensuring a high resolution. The errors in spectral evaluations and some fundamental limitations of the analysis are discussed. The book contains various examples of analysis of oceanological fields, such as synoptic eddies, internal and wind fields and fields of acoustic noise. The book is intended for oceanologists, meteorologists and other researchers and also for students at universities and other hydrometeorological institutes.

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UDC 681.325

MONOGRAPH ON INTERFACE FOR PROGRAMMABLE INSTRUMENTS IN SYSTEMS FOR AUTOMATING EXPERIMENTS

Moscow INTERFEYS DLYA PROGRAMMIRUYEMYKH PRIBOROV V SISTEMAKH AVTOMATIZATSII EKSPERIMENTA in Russian (signed to press 19 Mar 81) pp 2-5, 261-262

[Annotation, introduction and table of contents from monograph "Interface for Programmable Instruments in Systems for Automating Experiments", by Nikolay Ivanovich Gorelikov, Aleksandr Nikolayevich Domaratskiy, Sergey Nikolayevich Domaratskiy, Vitaliy Alekseyevich Liskin, Nikolay Vasil'yevich Popenko and Leonid Semenovich Sitnikov, responsible editor L. S. Sitnikov, doctor of technical sciences, Izdatel'stvo "Nauka", 4250 copies, 263 pages]

[Text] Annotation. This monograph is devoted to the interfaces used in ensuring an orderly exchange of information between self-contained measurement instruments, peripheral equipment and an electronic computer. The authors give a description of the IEC BUS interface, the basis for which was the HP-1B interface of the Hewlett-Packard Company for programmable measurement instruments. The interface functions and the controlling sequences are described in a high-level language. A description of the algorithms for the exchange of information between instruments along IEC BUS lines is given. Also examined are examples of the practical realization of interface elements for different instruments, an electronic computer and peripheral equipment, as well as problems relating to the construction of data measurement systems based on the described interface.

Introduction. The intensification and increased cost of scientific research is giving rise to an insistent need for creating systems for automating experiments. The principal purposes of such systems are the automated collection, registry, processing and display of information, and in case of necessity, also monitoring of the experiment, which assumes the integration of measurement, recording and monitoring instruments into a unified complex. It is most effective to create systems for the automation of an experiment on the basis of a combining of instruments of a unified standard information line, which assumes a modular construction of the system and application of the programmed control principle. Recently considerable efforts have been made in this direction and a number of standards have been proposed, the best known of which is the KAMAK standard. The KAMAK standard has come into the broadest use both in the automation of scientific research and in industry in those cases when the need arises for creating automation systems, including an electronic computer, and having a variable makeup of measurement converters and sensors, input and output devices for experimental data, measurement instruments and peripheral equipment. However, the experience with use of the KAMAK standard

accumulated up to the present time makes it possible to note a number of limitations characteristic for it, the most important of which is a considerable excess of working elements, in many cases unjustifiable in those applications where there is no need for the maximum speed. The most suitable standard for constructing automation systems with a limited range of measurement and control equipment is a standard which would make it possible to employ in the system any instruments, including those produced by industry and at a particular moment not adapted to systems application. It goes without saying that not one interface is ideal or identically well suited for satisying the many frequently mutually exclusive requirements. Nevertheless, the standard of the Hewlett-Packard Company, serving as the basic standard for the International Electrotechnical Commission for the interface for programmable instruments, makes possible the successful solution of most of the problems involved in creating measurement and control systems having rather broad functional possibilities. The International Electrotechnical Commission (IEC) interface ensures the combining of instruments into systems with their connection to a single standard information line. A great advantage of this standard is the absence of restrictions on instrument designs and assurance of the possibility of connection of these instruments, with or without small modifications, to virtually any instruments produced by industry. The merits of the IEC interface are revealed clearly in those cases when the user (or developer) is faced with the one-time task of creating a system for automation of an experiment (or test system) and there is neither the time nor money for special development work on such a system. In such cases the IEC standard connecting element makes possible the easy joining together of measurement, registry and control instruments, electronic computer and peripheral equipment in any combination in the desired system.

The IEC interface has now come into extensive use throughout the world. Such well-known firms as "Solartron," "DEC," "DGC" and "Honelway" include the standard IEC bus in their hardware. It can be said with assurance that the IEC interface will find extensive use in our country as well. However, its adoption is made difficult due to the absence of publications containing not only a detailed description of the standard, but also examples of the practical embodiment of its equipment and programming devices. This book intends, insofar as possible, to fill this gap and facilitate the speediest possible introduction of the IEC interface into practical Soviet instrument making. The book is intended for a broad range of specialists, especially instrument makers and the developers of systems for the automation of an experiment and industrial test systems. The book can also be useful to specialists in the field of automatic control systems, engineers and scientific workers directly engaged in experimentation in the most different fields of science (physics, chemistry, geophysics and oceanology, biology and medicine, etc.) and students in the corresponding fields of specialization at colleges and universities. Figure 1 is a key which will be of assistance in working with the book and will help in saving time when studying the IEC interface.

Work on writing of the book was divided among the authors in the following way: Chapter 1 was written by N. I. Gorelikov, A. N. Domaritskiy and L. S. Sitnikov, Chapter 2 by A. N. Domaritskiy, S. N. Domaritskiy and N. V. Popenko, Chapter 3 by V. A. Liskin and N. V. Popenko, Chapter 4 by A. N. Domaritskiy, S. N. Domaritskiy and L. S. Sitnikov, Chapter 5 by S. N. Domaritskiy, Chapter 6 by N. I. Gorelikov, V. A. Liskin and N. V. Popenko. Chapters 1 and 4 were edited by N. V. Popenko.

The authors would like to express appreciation to A. G. Blagodarev, M. M. Borkovskiy, K. V. Grinberg, V. A. Merzlyak and P. V. Shcherbakov for participation in the development of a number of devices described in the monograph, and to L. I. Lyubomudrov and G. I. Mesyatsev for a series of valuable comments on the presentation of the material and finalizing of the work.

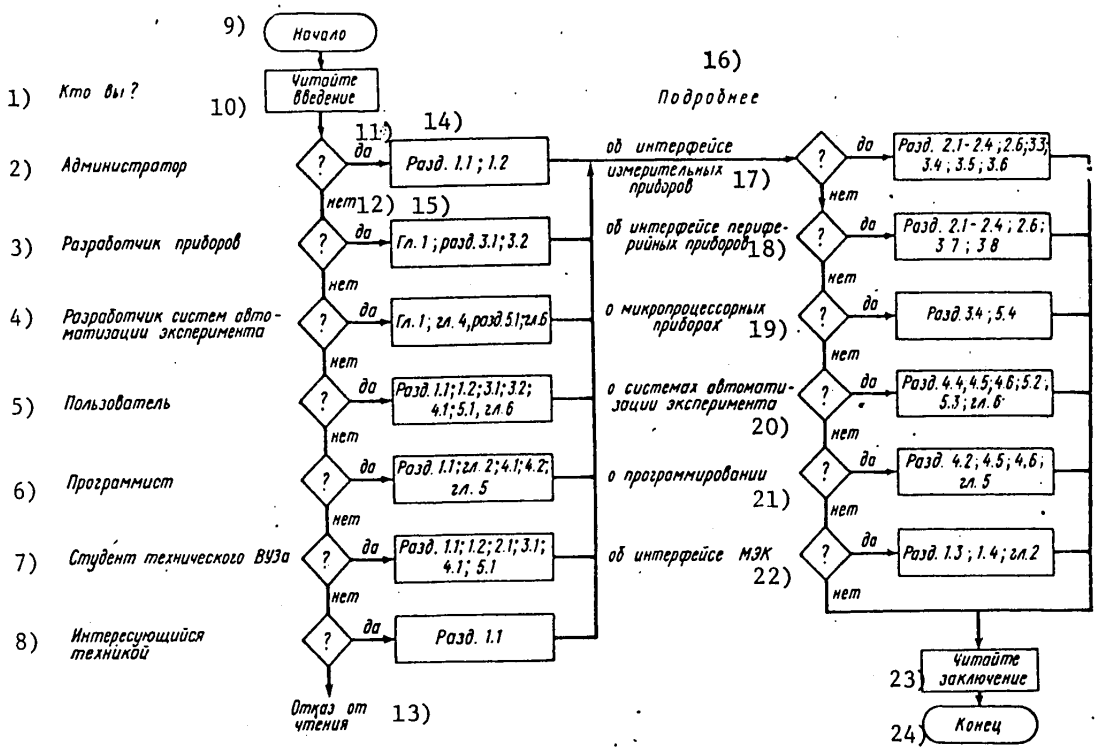

Fig. 1. Key to book.

KEY:

1) Who are you?
2) Administrator
3) Instrument developer
4) Developer of systems for optimizing experiment
5) User
6) Programmer
7) Student at technical school
8) Person interested in technology
9) Beginning
10) Read introduction
11) Yes
12) No
13) End reading
14) Section
15) Chapter
16) In greater detail
17) On interface of measurement instruments
18) On interface of peripheral devices
19) On microprocessor devices
20) On systems for automating experiment
21) On programming
22) On IEC interface
23) Read conclusion
24) End

Contents

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MONOGRAPH ON BOTTOM GEOLOGY AND GEOPHYSICS IN EASTERN PART OF INDIAN OCEAN

Moscow GEOLOGIYA I GEOFIZIKA DNA VOSTOCHNOY CHASTI INDIYSKOGO OKEANA in Russian 1981 (signed to press 26 Jun 81) pp 2, 254-255

[Annotation and table of contents from monograph "Bottom Geology and Geophysics of the Eastern Part of the Indian Ocean," responsible editors P. L. Bezrukov (deceased), corresponding member, USSR Academy of Sciences, and Yu. P. Neprochnov, doctor of physical and mathematical sciences, Institut okeanologii imeni P. P. Shirshov, Izdatel'stvo "Nauka", 650 copies, 256 pages]

[Text] Annotation. This monograph, based on materials of the 54th and 58th voyages of the scientific research ship "Vityaz'," gives the results of multisided geological and geophysical investigations carried out in 1973 in the eastern part of the Indian Ocean. On the basis of an analysis of the collected materials the monograph gives a description of bottom relief, the magnetic and gravitational fields, structure of the sedimentary layer and deep structure of the earth's crust in the East Indian Ridge, Central, West Australian and Cocos Basins and in the Sunda Trench. Materials on petrography, petrochemistry and geochemistry of the magmatic rocks in the region are systematized. The new geological and geophysical data are compared with data from deep-water drilling. The tectonics and history of geological development of the eastern part of the Indian Ocean are considered. The monograph is of interest for specialists in the field of marine geology and geophysics and also for college students. Figures 99, tables 14, references 233.

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SOUND ABSORPTION IN TURBULENT MEDIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 17, No 11, Nov 81 (manuscript received 22 Dec 80) pp 1217-1219

[Article by V. P. Kuznetsov and A. V. Berezutskiy, Institute of Oceanology, USSR Academy of Sciences]

[Text] Turbulence exerts a great influence on many processes in the ocean [1], and in particular, turbulent fluctuations of the speed of sound and current velocities lead to fluctuations of the amplitude and phase of waves passing through the medium.

The propagation of acoustic waves in a turbulent medium is accompanied by the phenomenon of scattering of waves on random inhomogeneities of the medium arising as a result of nonlinear interactions of the principal types of movements of the fluid or normal hydrodynamic modes: potential, eddy and entropic. The most general analysis of such interactions was presented in [2].

A great number of studies have been devoted to the development of a theory of sound scattering in a turbulent medium, but this problem was solved most precisely in [3-5]. As was noted in [5], turbulence exerts an influence on the propagation of acoustic waves in two ways. First, the presence of turbulent temperature fluctuations leads to fluctuations of the speed of sound. Second, acoustic waves are entrained by movements of the medium and therefore turbulent movement introduces additional random distortions in the field of the acoustic wave. In a general case the acoustic wave itself perturbs this turbulence. However, in existing theories the reverse effect of sound on the eddy velocity field is usually neglected, that is, an approximation of the stipulated turbulence is considered, and therefore the energy exchange between the potential and eddy modes is not taken into account. It is obvious that in the approximation of the stipulated turbulence the processes of inelastic scattering of the acoustic wave or the processes of sound absorption by turbulence are ignored.

In [6] an expression was derived for the decrement of sound absorption in a homogeneous and isotropic turbulent medium:

$$\Gamma_H \approx VM^2L^{-1}, \qquad (1)$$

where V is the eddy component of the velocity of fluctuating movement, L is the external turbulence scale, $M = Vc_0^{-1}$ is the Mach number. This absorption was caused by the transfer of the energy of perturbed eddy movement in the wave number spectrum;

it predominates in the case of large Rayleigh numbers of turbulent movement. In the case of small Reynolds numbers, characteristic for microscale oceanic turbulence, developing in interlayers with a fine structure of hydrophysical fields, viscous eddy scattering is most important. The expression for the decrement of sound absorption in homogeneous and isotropic turbulence, caused by viscous attenuation of the eddy, will have the form

[B = viscous]

$$\Gamma_{\text{в}} \approx \nu M^2 L^{-2}, \tag{2}$$

where ν is kinematic viscosity. The processes of sound absorption by turbulence begin to play an appreciable role under the condition of smallness of the turbulence scale in comparison with the wavelength of sound, that is, with $kL < 1$. It is important that both expressions of the absorption decrement (1) and (2) are not dependent on the sound frequency.

In [6, 7] the sound-eddy interaction was examined within the framework of a single formal scheme -- the Wild diagram technique -- for the canonical equations of motion of an ideal fluid. It is clear that in adhering to this scheme it is impossible to obtain effects related to dissipation and therefore below we have written a related system of equations describing the dynamics of the potential and eddy modes in a dissipative medium. The authors of [6, 7] derived a nonlinear canonical transform for variables in which the eddy and potential movements of the fluid are separated to the greatest degree. Since the concepts of potential and eddy movements of a fluid are a purely kinematic characteristic of the flow, within the framework of hydrodynamic equations it is possible, with mathematical rigor and soundness, to separate completely the eddy and potential modes, representing the full field of velocities in the form of the sum of the eddy and potential components:

$$\mathbf{u}(t, \mathbf{r}) = \mathbf{V}(t, \mathbf{r}) - \nabla\varphi(t, \mathbf{r}), \quad \operatorname{div}\mathbf{V}(t, \mathbf{r}) = 0. \tag{3}$$

In these variables the system of equations describing only the interactions of the types eddy-eddy and eddy-sound (that is, linear sound and an eddy of finite amplitude) can be represented in the following form:

$$\frac{\partial^2\varphi}{\partial t^2} - c_0^2\Delta\varphi = \frac{\partial}{\partial t}\left[b\Delta\varphi + \Delta^{-1}\frac{\partial^2}{\partial x_\alpha \partial x_\beta}\left(V_\alpha V_\beta - 2V_\alpha \frac{\partial\varphi}{\partial x_\beta}\right)\right], \tag{4}$$

$$\left(\frac{\partial}{\partial t} - \nu\Delta\right) V_i = X_i + \Delta_{i\alpha}\left[e_{\alpha\beta}\frac{\partial\varphi}{\partial x_\beta} - \frac{\partial}{\partial x_\beta}(V_\alpha V_\beta)\right], \tag{5}$$

where

$$b = \frac{1}{\rho_0}\left[\frac{4}{3}\eta + \zeta + \varkappa\left(\frac{1}{c_v} - \frac{1}{c_p}\right)\right]$$

is the coefficient of sound attenuation, $\nu = \eta/\rho_0$,

$$e_{\alpha\beta} = \frac{\partial V_\alpha}{\partial x_\beta} - \frac{\partial V_\beta}{\partial x_\alpha}; \quad \Delta_{i\alpha} = \delta_{i\alpha} - \Delta^{-1}\frac{\partial^2}{\partial x_i \partial x_\alpha};$$

Δ^{-1} is an integral operator, the reverse of the Laplacian, X_i are the components of the external forces, c_0 is the speed of sound.

The right-hand side of the wave equation (4) contains terms describing the phenomenon of the dissipation of an acoustic wave, radiation and scattering of waves by the eddy field of velocity. This equation (4) is similar (with an accuracy to replacement of the variables) to the wave equation in studies [3, 5, 8]. Equation (5) differs from the known equation of turbulence theory [9] only by the presence of the term $e_{\alpha\beta\vartheta}\varphi/\partial x_\beta$, describing the effect of sound on the eddy component.

Assume that

$$V(t, r)=V'(t, r)+\delta V(t, r), \qquad |V'|\gg|\delta V|, \tag{6}$$

where V'(t, r) is the unperturbed eddy field of velocity satisfying equation (5) in the absence of sound, that is, with $\varphi = 0$; $\delta V(t, r)$ is the perturbation of the eddy field of velocity caused by the presence of sound.

Substituting expression (6) into the system of equations (4) and (5), linearizing and omitting the effects of generation and scattering of sound in an unperturbed eddy field V'(t, r), in the case of small Reynolds numbers of turbulent movement we obtain the following system of equations for $\varphi(t,r)$ and $\delta V(t,r)$:

$$\frac{\partial^2\varphi}{\partial t^2}-c_0^2\Delta\varphi=\frac{\partial}{\partial t}\left[b\Delta\varphi+2\Delta^{-1}\frac{\partial^2}{\partial x_\alpha\,\partial x_\beta}(V_\alpha\delta V_\beta)\right], \tag{7}$$

$$\left(\frac{\partial}{\partial t}-\nu\Delta\right)\delta V_i=\Delta_{i\alpha}e_{\alpha\beta}\frac{\partial\varphi}{\partial x_\beta}. \tag{8}$$

Here and in the text which follows the prime on V(t, r) is omitted.

Expressing the perturbation of the eddy field $\delta V(t,r)$ from equation (8) and substituting into (7), we obtain the wave equation

$$\frac{\partial^2\varphi}{\partial t^2}-c_0^2\Delta\varphi=\frac{\partial}{\partial t}\left[b\Delta\varphi+2\Delta^{-1}\frac{\partial^2}{\partial x_\alpha\,\partial x_\beta}\left(V_\alpha\hat{L}\Delta_{\beta i}e_{ij}\frac{\partial\varphi}{\partial x_j}\right)\right]. \tag{9}$$

We will represent the wave field in the form of the sum of the mean $\langle\varphi\rangle$ (coherent part) and scattered φ' fields:

$$\varphi(t, r)=\langle\varphi\rangle+\varphi', \qquad \langle\varphi'\rangle=0. \tag{10}$$

Averaging equation (10) for the set of inhomogeneities and assuming that $\langle\varphi\rangle\gg\varphi'$, we find

$$\frac{\partial^2\langle\varphi\rangle}{\partial t^2}-c_0^2\Delta\langle\varphi\rangle=\frac{\partial}{\partial t}\left[b\Delta\langle\varphi\rangle+2\Delta^{-1}\frac{\partial^2}{\partial x_\alpha\,\partial x_\beta}\left(\langle V_\alpha\hat{L}\Delta_{\beta i}e_{ij}\rangle\frac{\partial\langle\varphi\rangle}{\partial x_j}\right)\right]. \tag{11}$$

Thus, a closed wave equation is derived for the coherent part of the field with a determined coefficient, expressed through the correlation matrix of the unperturbed eddy field $\langle V_iV_j\rangle$.

Then, carrying out a Fourier transform of equation (11)

$$\Psi(\omega, k)=\frac{1}{(2\pi)^4}\int_{-\infty}^{+\infty}\Psi(t, r)e^{i(\omega t-k\cdot r)}\,dt\,d^3r$$

and assuming the eddy field V(r) to be a stationary homogeneous random field

$$\langle V_i^*(k)V_j(k_1)\rangle=F_{ij}(k)\delta(k-k_1),$$

where $F_{ij}(k)$ is the spectral tensor of turbulent fluctuations of the eddy component of the velocity field, we obtain the following dispersion equation:

$$k^2\left(1-\frac{i\omega b}{c_0^2}\right)-\frac{\omega^2}{c_0^2}=\frac{2i}{\omega}\int_{-\infty}^{+\infty}\frac{(\mathbf{q}\cdot\mathbf{k})(\mathbf{q}-\mathbf{k})^2}{(-i\omega+\nu q^2)q^2}k_ik_jF_{ij}(\mathbf{q}-\mathbf{k})\,d^3q. \tag{12}$$

In the case of isotropic turbulence

$$F_{ij}(\mathbf{k})=F(k)\left(\delta_{ij}-\frac{k_ik_j}{k^2}\right)$$

the dispersion equation (12) assumes the form

$$k^2\left(1-\frac{i\omega b}{c_0^2}\right)-\frac{\omega^2}{c_0^2}=\frac{2ik^2}{\omega}\int_{-\infty}^{+\infty}\frac{(\mathbf{q}\cdot\mathbf{k})F(|\mathbf{q}-\mathbf{k}|)}{-i\omega+\nu q^2}\left[1-\frac{(\mathbf{q}\cdot\mathbf{k})^2}{q^2k^2}\right]d^3q. \tag{13}$$

The method for approximate analysis of the dispersion equations in the theory of wave propagation in randomly inhomogeneous media was developed in [10]. Without dwelling on the details, we obtain a dispersion equation for the case of a Gaussian spectrum:

$$F(k)=\frac{1}{(2\pi)^{3/2}}\langle V^2\rangle L^3\exp\left(-\frac{k^2L^2}{2}\right).$$

Under the condition $kL<1$ and $4\nu^2/L^4\omega^2\ll 1$ we obtain

$$\omega^2=c_0^2k^2\left[1+M^2-i\omega\left(\frac{b}{c_0^2}+\frac{4\nu M^2}{\omega^2L^2}\right)\right], \tag{14}$$

hence the effective absorption decrement is

$$F_{\text{eff}}\approx\frac{\omega^2b}{2c_0^2}+2\frac{\nu M^2}{L^2}. \tag{15}$$

Thus, the process of sound absorption in a homogeneous and isotropic medium is not dependent on frequency in the region of low-frequency acoustic oscillations (below the frequency $V/\pi L$).

Qualitatively the same character of attenuation of low-frequency acoustic waves is observed in the ocean.

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UDC 550.38:550.37

STATISTICAL CHARACTERISTICS OF NATURAL ELECTROMAGNETIC FIELD IN SEAS AND OCEANS

Moscow PROBLEMY MORSKIKH ELEKTROMAGNITNYKH ISSLEDOVANIY in Russian 1980 (signed to press 25 Jul 80) pp 38-45

[Article from monograph "Problems of Electromagnetic Research at Sea", by N. N. Karnaushenko, A. S. Kukushkin and A. I. Zhilina, Institut zemnogo magnetizm, ionosfery i rasprostraneniya radiovoln, 300 copies]

[Text] The authors of [1] described methods and apparatus for investigating the natural electromagnetic field in the ocean in the frequency range above a few Hz. The natural electromagnetic field in the ocean constitutes the total effect of the fluctuating and pulsed components, whose sources are both in the water itself and outside it [2, 3].

In this article we give the statistical characteristics of the horizontal electric and magnetic components of the natural electromagnetic field in the frequency range 10-200 Hz at depths up to 100 m in deep-water regions of the tropical zone of the Atlantic Ocean, at depths to 250 m in the region of the continental slope of the Atlantic Ocean, in regions with the coordinates:

φ = 9-12°N λ = 17-19°W
φ = 10-12°S λ = 25-30°W
φ = 31°N λ = 14°W

and also in the central deep-water parts of the Tyrrhenian and Black Seas in regions with the coordinates: φ = 40°N, λ = 12°E,
φ = 42°30'-43°30'N, λ = 31-36°E

Horizontal electric component. In the frequency range 10-94 Hz the mean field strengths decrease with an increase in frequency at a constant depth by one or two orders of magnitude or in conformity to a linear law (at a logarithmic scale), Fig. 1. In the range of frequencies 110-190 Hz the decrease was less than an order of magnitude. In particular, it is possible to discriminate the region of the continental slope of the Atlantic Ocean. In comparison with the deep-water part the mean values of field strength are one or two orders of magnitude greater (layer 0-100 m). For the continental slope the mean field strength values at the horizons 150-200-250 m are identical in the limits of one order of magnitude, decreasing linearly in the frequency range 10-94 Hz (at a logarithmic scale). In the region of the continental slope it was not possible to detect any pattern of change in field strength with depth at identical frequencies. The mean field strength values for different depths in the layer 0-100 m at identical frequencies frequently are

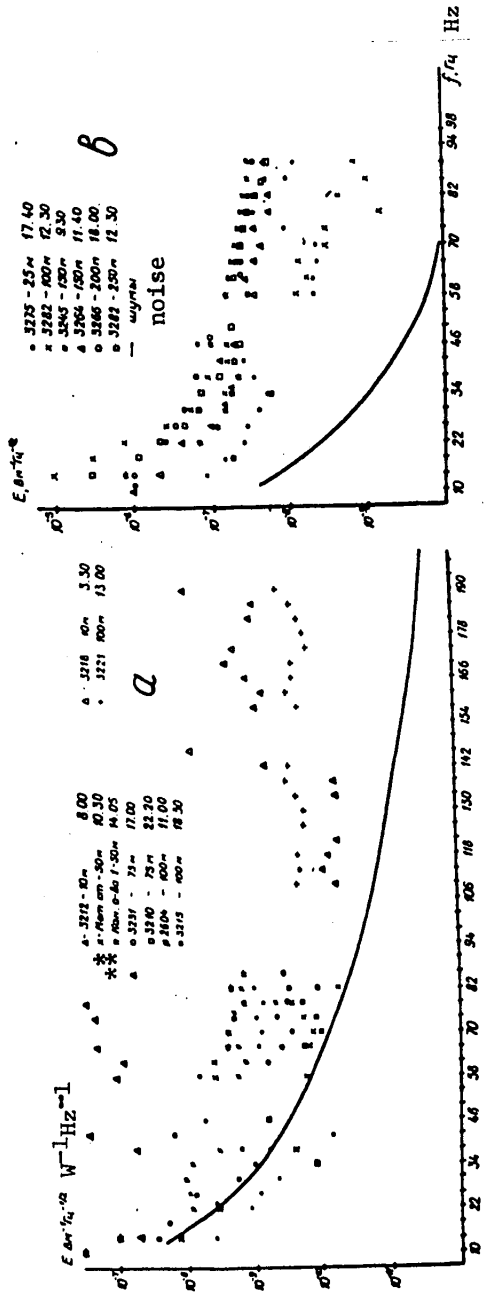


Fig. 1. Dependence of mean values of strength of electric component of natural electromagnetic field in sea and ocean on frequency and depth: a) abyssal part of tropical zone of Atlantic Ocean; c) in region of continental slope of Atlantic Ocean.

in the limits of the same order of magnitude. One of the reasons for the absence of a clear dependence of the change in field strength on depth can be the continental slope effect and the presence of a pulsed component. A comparison of the mean values of strength of the electric component for different regions of the Atlantic Ocean and Tyrrhenian Sea revealed that the mean values for the continental slope of the Atlantic Ocean are an order of magnitude greater than for the abyssal part of the Atlantic Ocean and the Tyrrhenian Sea. We assume that this is attributable to the presence of local field sources over Africa, which substantially changes the external electromagnetic background [4].

Schumann resonances are inconspicuous [5], since the total electromagnetic field was measured without separation into fluctuating and pulsed components. This phenomenon was mentioned in [6], which gives the results of processing of measurements of the horizontal electric component of the field in the Tyrrhenian Sea in series registered in the absence and presence of the pulsed field component. The Schumann resonances are traced clearly for the first records and poorly for the second. A comparison of the strength levels for the horizontal electric component with the data in [7] show the coincidence of the results within the same order of magnitude of intensity for identical depths and frequencies. Series were processed in [7] after discriminating the pulsed component.

The horizontal magnetic component is represented in the form of two orthogonal components MI and MII, Fig. 2.

For the abyssal part of the Atlantic Ocean the mean field strength values decrease by two orders of magnitude at the same horizon in the frequency range 10-94 Hz and decrease with an increase in depth (90-115 m) at the same frequency by an order of magnitude. In the continental slope region of the Atlantic Ocean there is a tendency to a decrease with frequency (10-94 Hz) by an order of magnitude at the same horizon, but a definite dependence on depth for the same frequency cannot be traced due to the presence of a pulsed component. For the regions of the Black and Tyrrhenian Seas available data at one of the horizons (65 and 90, 115 m) confirm a decrease by 1-2 orders of magnitude with an increase in frequency from 10 to 90 Hz.

The dependences on frequency and depth for the mean square values of the deviations in strength are similar to those shown in Figures 1 and 2; in order of magnitude they are comparable to the mean values.

The checking of the investigated series for stationarity on the basis of a nonparametric test of the series [8] with a significance level 0.05 indicated that for 70% of them the stationarity hypothesis is applicable. Below we give an analysis of the statistical processing of series satisfying the stationarity condition. Figure 3 shows sample spectral densities of strength of the electric and magnetic fields in the seas and oceans. The form of the spectra varies. In addition to the spectra for which most of the power is concentrated at the low frequencies for a particular spectral window, as is characteristic for smoothly changing series, there are spectra for which the power is distributed in a wider band of frequencies of the spectral window. The nature of the spectra confirms the presence of a pulsed component in the initial records. Especially conspicuous is the appearance of a pulsed component in the analysis of histograms carried out on "Rayleigh" paper (Fig. 4a). It

is known that for processes with a normal distribution of the instantaneous values the envelope has a Rayleigh distribution. An analysis (Fig. 4a) shows that in the region of large field values the approximating straight lines have a bend, which confirms the presence of a pulsed component.

The sample normalized autocorrelation functions are represented in Fig. 4c.

The correlation radii do not reveal a distinct dependence on depth and frequency for all field series; their range of change is from 0.3 sec to 4 sec.

But for the continental slope and the surface layers of Atlantic Ocean waters there is a tendency to a decrease in the correlation radius with an increase in frequency. At individual horizons there are the following values of the correlation radii: for the strength of the electric component of

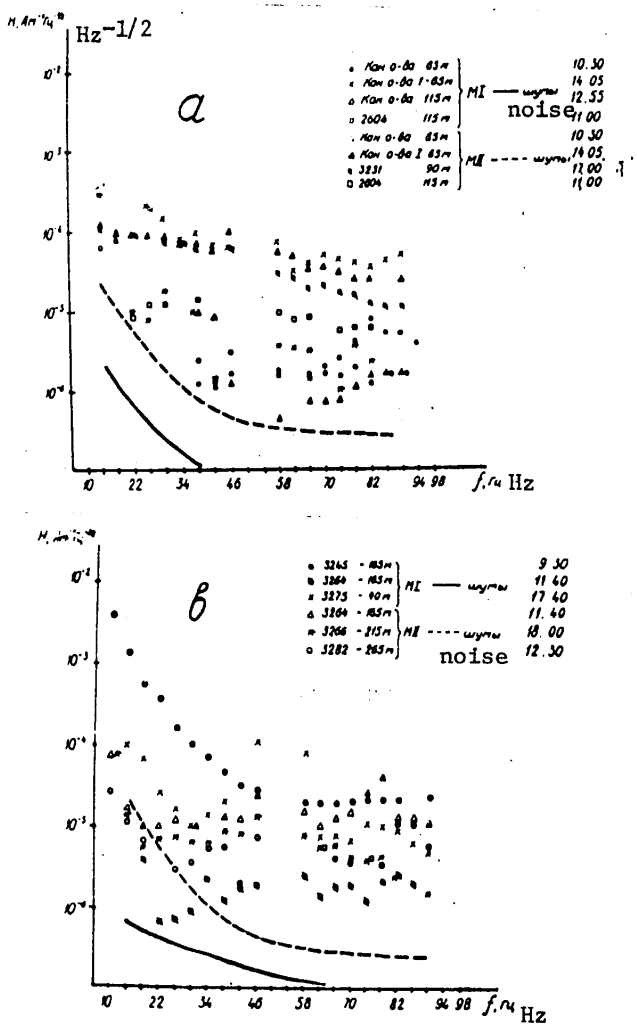


Fig. 2.

the abyssal part of the Atlantic Ocean at the horizon 100 m a value of the correlation radius 1-1.5 sec predominates; for the strength of the magnetic component in the abyssal part of the Atlantic Ocean and Black Sea values 1-1.5 sec predominate; for the Tyrrhenian Sea -- 0.3 sec; in the region of the continental slope of the Atlantic Ocean for depths of 40 m, 165 m and 265 m there is a predominance of values 0.5 sec, 1 sec and 2 sec respectively.

Conclusions

1. It was possible to obtain integral levels of strength of the electric and magnetic components of the natural electromagnetic field in the range 10-200 Hz at depths up to 100 m for abyssal regions of the tropical zone of the Atlantic Ocean, Tyrrehian and Black Seas; at depths as great as 250 m in the shelf zone of the Atlantic Ocean.

2. A linear law of decrease of the investigated fields (at a logarithmic scale) with an increase in frequency was established.

3. A preliminary statistical processing of expeditionary data was carried out, from which it follows that there is a need for separate investigation of the fluctuation and pulsed components of the natural electromagnetic field.

4. The natural electromagnetic field in seas and oceans at depths as great as 100-200 m in the frequency range above a few Hz is caused for the most part by the total atmospheric electromagnetic background.

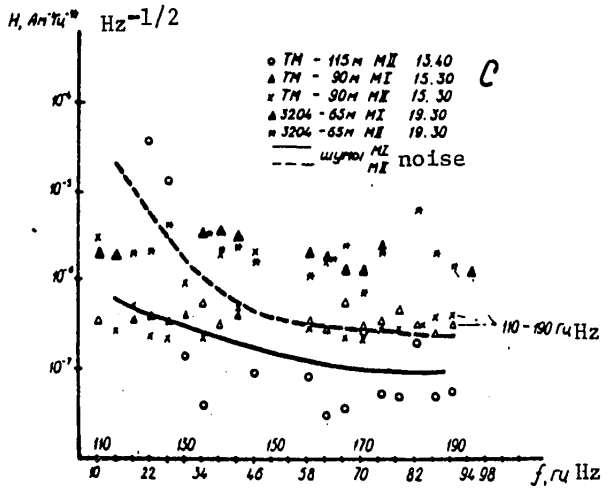
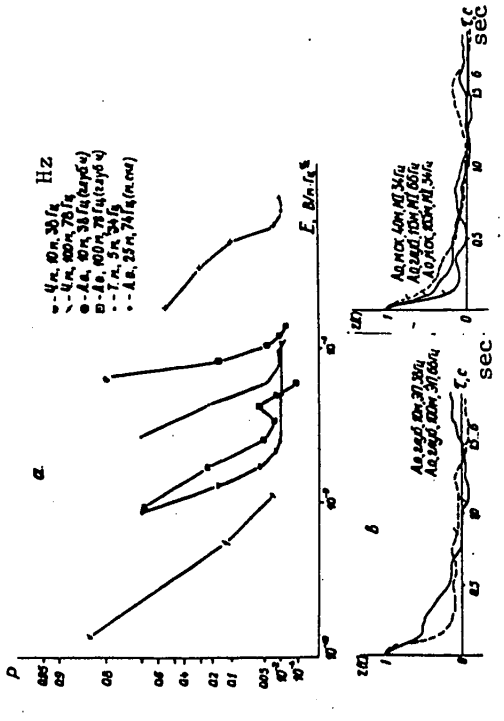
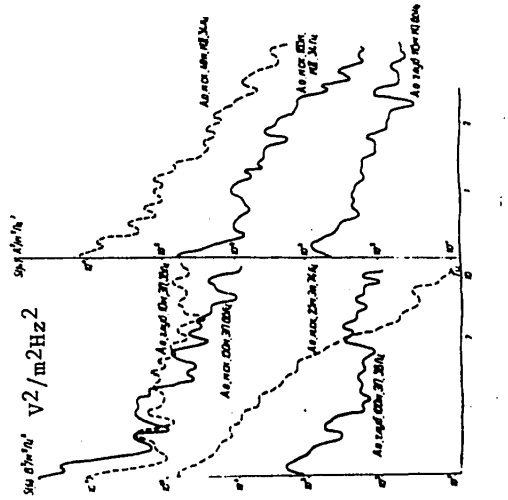


Fig. 2. Dependence of mean values of strength of magnetic component of natural electromagnetic field in seas and oceans on frequency and depth. a) abyssal part of tropical zone of Atlantic Ocean; b) region of continental slope of Atlantic Ocean; c) abyssal parts of Tyrrhenian and Black Seas.



M CK = continental slope
A O = Atlantic Ocean
Ч M = Black Sea

Fig. 4. a. Histograms of strength of electric and magnetic components of natural electromagnetic field in seas and oceans. b. Normalized autocorrelation functions of strength of electric and magnetic components of natural electromagnetic field in seas and oceans.



ЭП = electromagnetic field
ГЛУБ = depth
T M = Tyrrhenian Sea

Fig. 3. Spectral densities of strength of electric and magnetic components of natural electromagnetic field in the seas and oceans.

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SEA MEASUREMENTS OF CONSTANT ELECTRIC FIELD USING DIFFERENCE APPARATUS

Moscow PROBLEMY MORSKIKH ELEKTROMAGNITNYKH ISSLEDOVANIY in Russian 1980 (signed to press 25 Jul 80) pp 33-37

[Article from monograph "Problems of Electromagnetic Research at Sea", by O. V. Nazarenko, A. V. Kryukov, B. F. Degtyar', Ya. K. Zanders and S. V. Zakharov, Institut zemnogo magnetizm, ionosfery i rasprostraneniya radiovoln, 300 copies]

[Text] The natural field method is finding ever-increasing use in studies at sea directed to solution of problems in geological mapping and geological engineering. In this method the useful signal is the "constant" component of the earth's natural electric field and its temporal variations, caused by ionospheric and industrial sources, are noise. Since the amplitudes of the temporal variations can be commensurable with the intensities of the anomalies subject to study, the methodological procedures directed to the suppression of variations or their recognition are of considerable importance. Below we give the results of experimental testing of apparatus and instrumentation for difference measurements of the electric components, making possible a substantial weakening of the influence of noise of remote sources.

A block diagram of a model of analog apparatus developed for testing the difference measurements method is shown in Fig. 1a. The apparatus contains two identical channels for the amplification and registry of signals, a device for discriminating and registering the difference signal, and also a device for compensating the emf of electrode polarization or calibration of channels. Taking into account the necessity for galvanic decoupling of the input circuits of the channels, as the basis we used a d-c amplifier developed at the Siberian Scientific Research Institute of Metrology. This amplifier, in an "MDM" scheme with a balanced transformer modulator, is quite simple and reproducible under laboratory conditions. In order to enhance the reliability and stability of the amplifier we introduced certain nonfundamental changes into its circuitry: there was a replacement of operational amplifiers, a change in the size and type of individual elements, an increase in output. In the labratory tests of the fabricated amplifiers (with the introduced changes) we obtained the following technical specifications:

-- measurement range -- ± 0.5, 1.0, 2.0 mV;
-- nominal output voltage (with $R_H \geqslant 100$ ohms) -- ± 5 V;
-- principal error -- not greater than 1%;
-- level of characteristic noise reduced to input, in band 1 Hz not greater than 0.1 μV;

-- input resistance -- 30-50 kilohms;
-- frequency band at 3-db level -- 0-18 Hz.

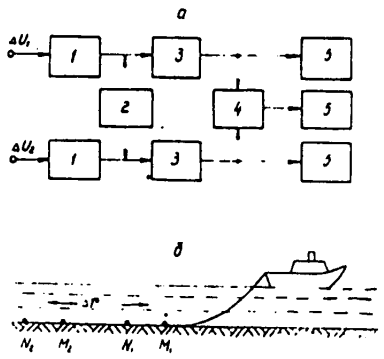

Fig. 1. Block diagram of apparatus (a) and difference outfit (b) for measuring electric field. 1) compensator of emf of electrode polarization, 2) calibration unit, 3) amplifier, 4) unit for discriminating difference signal, 5) recorder

The unit for discriminating the difference signal is a summing stage based on an operational amplifier with a high-power output; the transfer constant of the stage is changed by commutation of the resistors in the feedback circuit.

A diagram of the apparatus for difference measurements of the electric field is shown in Fig. 1b. It consists of two identical receiving dipoles $M_1N_1 = M_2N_2$, spaced at the distance Δr and towed by a ship. Such an apparatus differs in that during movement of the ship the variations of the electric field caused by remote variable sources will be registered on the channel records simultaneously, whereas the electric field anomalies will be registered with a time shift determined by the distance and rate of movement of the ship. In the case of identical channels the signal at the output of the unit for discriminating the difference signal will be free of temporal variations and characterizes the electric field anomaly.

The choice of the length of the dipoles MN and the distances between them Δr requires special attention because the shape of the resultant curves will be dependent on their relationship to the extent of the electric field anomaly.

On the other hand, the length of the dipoles MN is determined also by purely technical factors, such as the response of the apparatus and the quality of the electrodes. When employing copper nonpolarizing electrodes and the described amplifier we used dipoles with a length from 20 to 100 m.

The distance between the dipoles is determined by methodological considerations; its maximum value is limited by the length of the cable used in towing and its minimum value is fixed by the mutual influence of the channels during calibration and compensation of emf of electrode polarization. When carrying out the work this distance was selected as equal to 100 and 200 m, which ensured a convenient displacement of the electric field anomalies on the channel records.

In order to reduce towing noise (the influence of the ship's electric field, vibration and change in the vertical position of the electrodes) the length of the cable to the nearest dipole is not less than 3-5 sea depths, taking into account the size of the ship and the rate of towing. Figures 2-4 show fragments of records obtained during continuous profiling with the difference apparatus with a length of the dipoles 50 m, obtained in the regions of the Baltic and Barents Seas. Figure 2 (Gulf of Riga) shows intensive industrial noise appearing on the channel records and absent on the signal record, where anomalies of the natural field are virtually absent. The degree of suppression of the noise of remote sources, which can be characterized by the coefficient

$$\delta = \frac{\Delta U_1 + \Delta U_2}{2\Delta U_{dif}},$$

on the basis of the results of processing of segments of the tapes where electric field anomalies are absent, is extremely high and 30-80[x]. It should be noted that the degree of suppression of the "high-frequency" noise is essentially dependent on the identity of both the amplitude-frequency and phase-frequency characteristics of the channels.

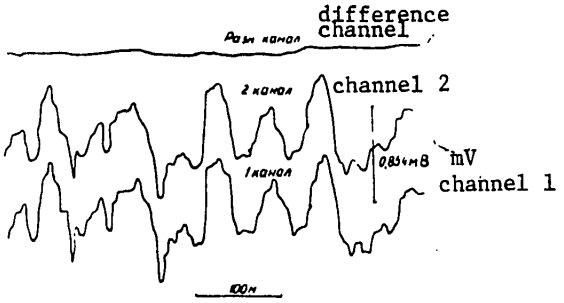

Fig. 2. Example of suppression of industrial noise of remote sources by difference apparatus (continuous profiling, Gulf of Riga).

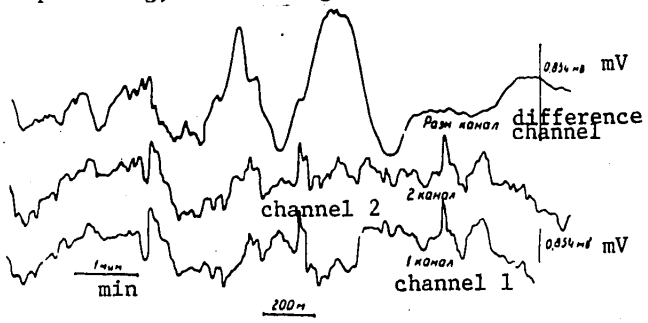

Fig. 3. Example of discrimination of electric field anomaly by difference apparatus under conditions of intensive noise.

Figure 3 shows an example of discrimination and detection of an electric field anomaly from the record of a difference signal in the presence of noise exceeding the useful signal.

An example of the reproducibility of an electric field anomaly is shown in Fig. 4. The control record was obtained by repeated running of the segment of the profile each three days. Some discrepancy in fine details can be attributed to the position error, which is estimated at ±20 m.

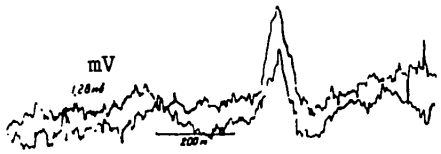

Fig. 4. Example of reproduction of electric field anomaly (repeated measurement -- after 3 days).

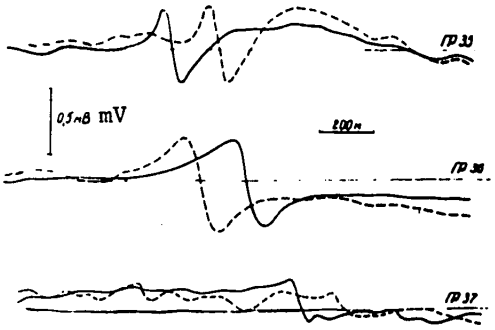

Fig. 5. Example of tracing electric field anomaly along several profiles at sea.

Figure 5 shows an example of the tracing of an anomaly along several profiles (only the channel records are shown; the records were matched for one of the channels). The different displacement of the record for the other channel is attributable to the different directions of ship movement along the profile.

Experience has shown that the use of the difference apparatus and the described model of the apparatus made it possible to discriminate anomalies of the constant natural field, whose amplitude was 3-5 times less than the amplitude of the noise of remote sources, that is, for practical purpose carry out measurements under the conditions under which the use of ordinary electric field apparatus and the usual instrumentation could not give any positive results.

The experimental studies, carried out in a considerable volume, confirmed the effectiveness and high yield of geological data from measurements of the electric field with the difference apparatus. In our opinion, the next tasks in this field are the testing of multichannel difference apparatuses and the formulation of practical recommendations on interpretation of the results.

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INVESTIGATION OF CONTACT-TYPE PRIMARY DEVICES FOR MEASURING ELECTRIC FIELD IN SEA

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[Article from monograph "Problems of Electromagnetic Research at Sea", by M. M. Bogorodskiy, Institut zemnogo magnetizm, ionosfery i rasprostraneniya radiovoln, 300 copies]

[Text] In the field of development of methods and instrumentation for measurements of the electric field in the sea, carried out in the interest of solution of many timely problems in geophysics and for practical purposes [1-7], a considerable number of studies have already been made [2, 8-17]. A reduction in the noise of amplifiers [18-20] made it possible to broaden the range of interest in electric phenomena in the sea. The changeover to measurements on short bases [8, 11, 12, 17] and to more complex methods, such as divergent methods [21, 22], forced researchers to turn to a search for ways in which to reduce electrode noise [9, 11, 15, 23, 24] and other imperfections of electrodes and "hydroconductors" [the term was proposed by V. N. Mitrofanov]. Below we give the results of experimental and theoretical investigation of the effect exerted on the measurement electrodes and hydroconductors by temperature, pressure and flow velocity, obtained at the Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, and discuss the possibilities of suppressing or taking into account all these noise-forming factors.

1. The effect of temperature on Ag-AgCl electrodes of the IELAN-IZMIRAN system [25] was investigated using the circuitry of a nonisothermic diffusion cell of the first type [26]

$$\underset{\substack{t_0\\ \text{comparison electrode}}}{\text{Ag–AgCl} \mid \text{AgCl paste} \atop \text{sea water}} \quad t_0 \mid \text{sea water} \mid \underset{t_2=t_0+\Delta t_2}{\text{AgCl paste} \atop \text{sea water}} \mid \underset{\substack{t_1=t_0+\Delta t_1\\ \text{investigated electrode}}}{\text{AgCl–Ag}} \qquad (1)$$

The temperatures t_1 and t_2 were detected by vitrified microthermistors. The investigated electrode initially was exposed at a temperature t_0 and then was rapidly shifted to another part of the cell; in this case the temperature of the medium surrounding the electrode changed in a jump. The potential change of the investigated electrode $\Delta\varphi$ was a linear function of both measured temperatures

$$\Delta\varphi\ (\mu V) = 294\Delta t_1^0 + 54\Delta t_2^0 \qquad (2)$$

This meant that the boundary between the AgCl packing and sea water has an appreciable temperature response, like many other interphase boundaries [26]. Due to the inconstancy of the temperature coefficient, the presence of temperature hysteresis in many types of electrodes [27-29] and the presence of an external active surface of the electrode (2) the conclusion was drawn in [30] that only the use of hydroconductors, separating the entire active mass of the electrode from the influence of the surrounding medium, can substantially lessen their temperature response in periods less than the thermal inertial time of the electrode.

An investigation of the thermoelectric potentials in salt bridges filled with sea water [31] was carried out using the circuitry of a nonisothermic diffusion cell of the second type [26].

thermostat Ag-AgCl	sea water salinity S_1	sea water salinity S_2	sea water salinity S_1	thermostat AgCl-Ag	(3)
$t_0=20°$	t_1	t_2	$t_0=20°$		

with S_1 = 36°/oo and S_2 values from 36°/oo to fresh water. With filling of the entire cell (3) with 36°/oo water and temperature changes t_1, t_2 in the range from 4 to 35° the potential readings were in the range of measurement error, in this case $\pm 3\mu V$. Other combinations of salinities indicated that if the electrodes penetrate a more saline hydroconductor, the electrode connected with the warmer contact of water masses becomes positive. The thermoelectromotive force increases by approximately 21% with a shift of the interval (t_1, t_2) by 10° in the direction of high temperatures. In the stipulated interval (t_1, t_2) the thermoelectromotive force increases with an increase in the difference in salinities (S_2 - S_1). A generalization [32] of the results in [31] gave an estimate of the thermoelectromotive force for an arbitrary closed thermohaline path in the form

$$V_* \ (\mu V) = -4.71 \ \ e^{0.019[t-2S(t)]} \ t \qquad (4)$$

where t (in degrees) and S (°/oo) are characteristics of the momentary point of the path and the asterisk shows that the formula was derived by an approximation of the data. The nomogram for this evaluation, having an accuracy of 6% and which is very graphic, made it possible to assert that the hydroconductors, retaining their concentration along the path [33], to a high degree were subject to noise from temperature oscillations near their electrometric apertures, moreso than others allowing diffusion of the components of the surrounding medium into the hydroconductor cavity. This conclusion was used for practical purposes in creating a divergent measurement apparatus [22] operating in Lake Ladoga.

2. The pressure of the medium creates interference during vertical soundings [5], in measurements at shallow depths [6] and under tidal conditions. An investigation of the baroresponse of Ag-AgCl electrodes fabricated at IZMIRAN [21] was carried out using a pressure chamber [34] consisting of two interconnecting chambers, one of which, containing the electrode to be investigated, was hermetic, whereas the other, containing the comparison electrode, was nonhermetic. The two chambers were interconnected by a flexible hose filled with a 3.5% NaCl solution.

The static baroresponse β was determined as the ratio of the increment of electrode potential $\Delta\varphi$ to the increment of hydrostatic pressure Δp; the standard pressure drop was 10 m H_2O, that is, 1 bar; the temperature changes in the

hermetic chamber were adiabatic. For each electrode we computed the individual baroresponse β_n, whose values usually fell in the range from -70 to +140 $\mu V \cdot bar^{-1}$ and the dispersion $\sigma(\beta_n)$, attaining 180 $\mu V \cdot bar^{-1}$. For individual electrodes there were anomalies in the form of a gigantic, up to 2 $mV \cdot bar^{-1}$, baroresponse and in the form of unidirectional relaxation [26, p 269] of the electrode potential, being restored with the same sign after the removal of pressure. The determination of baroresponse can be used in sorting the electrodes because electrodes with anomalous baroresponse were always defective.

For the purpose of increasing response and reproducibility of measurements it was proposed in [35] that electrodes immersed in an electrolyte be subjected to vibration and a vacuum with subsequent exposure in the same electrolyte at atmospheric pressure. It was demonstrated in [21, 35] that as a result of such processing the mean baroresponse of a consignment of electrodes $\bar{\beta}$ is about -6.5 $\mu V \cdot bar^{-1}$ with a dispersion of this value of about 0.6 $\mu V \cdot bar^{-1}$, which reduces by more than an order of magnitude the estimate of the error introduced by static baroresponse. This is particularly important in the operation of complex, such as divergent, electrode systems [22].

We discovered the dynamic baroresponse γ, introduced as the ratio of the increment of electrode potential to the increment of the rate of pressure change, in an experimental evaluation of the errors caused in the shallow water zone by the influence exerted on the measurement electrodes by pressure changes [36]. Tests were made of four pairs of Ag-AgCl electrodes of the IELAN-IZMIRAN system taken from one consignment and in pairs isolated from other environmental effects. One pair was first processed in order to reduce the baroresponse [35]; the bottom pressure values were estimated from the shape of the wave. The effect of dynamic baroresponse exceeded by an order of magnitude the anticipated unwanted extraneous interference from static baroresponse, for unprocessed pairs being 150-300, and for a processed pair about 60 $\mu V \cdot bar^{-1} \cdot sec$.

In the case of collapsing crests the effect was 4-5 times greater.

An estimate of the contribution of dynamic baroresponse for the unprocessed electrodes used in the surface layers of a deep sea with waves of class V-VI is, taking the cited data into account, a value of about 100 μV, that is, is of the same order of magnitude as the contribution of static baroresponse. In the case of processed electrodes [35] the estimate of the contribution of dynamic baroresponse under deep sea conditions and the same class of waves was 3-4 times greater than the contributions of static baroresponse. This raises the question of the need for taking into account and seeking ways to compensate the baroresponse of electrodes.

3. The active surface of the electrodes is protected against the movement of the electrolyte in order to avoid the interference associated with this [37] by the use of housings of one kind or another [11] or hydroconductors are employed [8, 11, 14, 17, 22]. Electrokinetic phenomena arise with flow around such housings or during filtering of the electrolyte in the medium through their porous elements [36, 38].

Source [39] gives estimates of the tribopolarization potentials φ_{trib} for an electrode with a porous housing [5, 38] in the form of an elongated ellipsoid of revolution ($\varnothing$ 2 cm, ℓ = 12 cm).

$$\varphi_{trib} = K_1 \cdot \zeta \cdot \varkappa^{-1} U_\infty^2;\ K_1 \simeq 7.5 \cdot 10^{-5} m^{-5} sec^2 ohm^{-1} \quad (5)$$

where ζ is the electrokinetic potential of the housing material relative to a medium electrolyte with the conductivity $\varkappa$, U_∞ is the velocity of longitudinal flow around the housing. The tribopolarization potential is formed due to electrokinetic filtration currents arising as a result of the hydrodynamic difference in pressures on the elements of the porous housing.

The estimate of φ_{trib} for electrodes with a continuous housing of the same configuration having electrometric apertures in the intake part has the form [39]:

$$\varphi_{trib} = K_2 \cdot \zeta \cdot \varkappa^{-1} \cdot U_\infty^{13/7};\ K_2 \simeq 2 \cdot 10^{-6} m^{-20/7} sec^{13/7} ohm^{-1} \quad (6)$$

In this case the tribopolarization potential is formed by the spreading-out currents of a convective surface current caused by flow of the surrounding medium around the electrode housing.

For the practical use of the estimates (5), (6) we measured the electrokinetic potentials of a number of construction materials in solutions of the sea water type. Some results of these measurements, supplementing the data in [39], are given below. The estimate (5) which we made coincides satisfactorily with observations in [38]. A comparison of the estimates (5) and (6) shows that the rejection of a porous housing in favor of a continuous (solid) housing or in favor of a channelized hydroconductor reduces the level of electrokinetic interference by 1 1/2-2 orders of magnitude. The tribopolarization can be reduced further by means of optimum positioning of the electrometric aperture on the electrode housing or the hydroconductor line and also by means of fabricating the housings from an optimum material (ebonite and polypropylene being used for this purpose).

Name of material	ζ (mV) with salinity of				
	0.58°/oo	1.34°/oo	4.08°/oo	12.2°/oo	36.2°/oo
poly-4-methyl-pentane-1	-44.2	-38.4	-28.3	-21.6	-14.2
polycarbonate	-19.2	-13.6	-9.8	-8.3	-6.6
industrial polypropylene	-5.3	-3.0	-2.3	-3.1	-2.3
ebonite (shavings) from	-12.5	-19.9	-14.9	-12.4	-8.0
to	+2.1	+3.5	+2.9	+2.1	+0.6
mean temperature	19.7°	18.6°	17.2°	15.3°	14.8°

4. In conclusion we give a table of estimates

Factors	Evaluation of noise immunity	
	Electrodes	Hydroconductors
temperature	20* - 1200 μV/degree	0.07** μV/degree·°/oo
salinity	≃ 500**** μV/°/oo	
pressure:		
static	6-140**** μV·bar^{-1}	
dynamic	60-300*** μV·bar^{-1}sec	
tribopolarization	porous housing	
with flow velocity	6****-26*** μV	(0.02-0.11)**** μV
U_∞ = 5 m·sec^{-1}	solid housing	(0.06-0.45)*** μV
	(0.02-0.11) μV****	
	(0.06-0.45) μV***	

****) S≃36°/oo; ***) S≃12°/oo; **) S≃12-36°/oo; *) Pb-PbCl from [9].

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5303
CSO: 1865/66

TERRESTRIAL GEOPHYSICS

UDC 550.831

ARTICLES ON THEORY AND METHODS OF INTERPRETATION OF GRAVIMAGNETIC FIELDS

Kiev TEORIYA I METODIKA INTERPRETATSII GRAVIMAGNITNYKH POLEY in Russian 1981 (signed to press 23 Jun 81) pp 2, 397-412

[Annotation and abstracts from collection of articles "Theory and Methods for the Interpretation of Gravimagnetic Fields", edited by V. I. Starostenko and V. N. Strakhov (responsible editors), S. S. Krasovskiy (deputy responsible editor), V. G. Kozlenko, L. I. Koyfman and V. N. Nikolenko, Izdatel'stvo "Naukova dumka", 700 copies, 412 pages]

[Text] Annotation. This collection of articles consists of reports presented at the All-Union Seminar on the Interpretation of Gravitational Anomalies (Kiev, 1980). These materials characterize the level attained by Soviet gravimetry both in the field of theory and methods for interpreting such fields and in the solution of practical problems in the range from constructing density models of the planets to the interpretation of gravity observations in underground mines. The reports also deal with ways to bring about further development of theoretical and applied research in the field of gravimetry, including the principles of combining gravimetry with data obtained by other methods. The collection is intended for a broad range of geophysicists and geologists engaged in the study of the earth's deep structure, as well as college students specializing in the field of geology.

Abstracts

UDC 550.83

SOME TIMELY PROBLEMS IN THEORY OF INTERPRETATION OF GRAVITY ANOMALIES

[Abstract of article by Strakhov, V. N.]

[Text] Some timely problems in the theory of interpretation of gravity anomalies are considered.

UDC 550.83

NONLINEAR METHOD FOR ANALYTICAL CONTINUATION OF TWO-DIMENSIONAL FIELDS AND ITS USE IN THE INTERPRETATION OF GRAVITY AND MAGNETIC ANOMALIES

[Abstract of article by Angelova, Ye. I.]

[Text] The article examines the theoretical principles of a nonlinear method for the analytical continuation of two-dimensional potential fields and also problems

relating to its practical realization. In model and practical examples the author demonstrates the possibility of using the method in the interpretation of anomalous fields. Figures 6, references 7.

UDC 550.831.016

SEPARATION OF COMPLEX GRAVITY ANOMALIES

[Abstract of article by Antonov, Yu. V.]

[Text] A study was made of the problems involved in the separation of complex anomalies on a straight line running between anomalous bodies. In particular, the author examines the methods and technology for the separation of a complex anomaly from two bodies situated on different sides of a vertical axis and also from bodies situated one above the other. The proposed numerical schemes were tested in model and practical examples. Satisfactory results were obtained. Figures 6, tables 4, references 12.

UDC 550.838

DIRECT AND INVERSE PROBLEMS IN ARTIFICIAL MAGNETIZATION METHOD

[Abstract of article by Voskoboynikov, G. M., Gurevich, Yu. M., Zbykovskaya, T. A., Martyshko, P. S., Prutkin, I. L. and Tsyrul'skiy, A. V.]

[Text] Mathematical methods for solving direct and inverse problems in the artificial magnetization method are presented. Figures 5, references 17.

UDC 550.344+550.834

CONDITIONS OF UNIQUENESS OF INVERSION OF SEISMIC TRAVEL TIME CURVES

[Abstract of article by Geyko, V. S.]

[Text] It is demonstrated that if the travel-time curve of a refracted wave from a surface source is known and if at least one of the following conditions is satisfied: a) the travel time curve of a wave reflected from a horizontal discontinuity lying below the deepest waveguide is known; b) the travel-time curve from a deep source situated below the deepest waveguide is known; c) the measure $H(u) = \mathrm{mes}\{z: z \geqslant 0,\ v^{-1}(z) \geqslant u\}$ is analytical in some segment $[c,d]$, where $0 < c < \alpha < \infty$, $c < \alpha_n$, $H(\alpha_n) = z_n$, $\underline{z}_n$ is the depth of the lower end of the deepest waveguide, and there is, in the interval $[c, \infty]$ such an analytical function $A(u)$ that with $u \in [c, \alpha]$ $A(u) \equiv H(u)$, in all these cases there is unambiguous determination of: 1) velocity $v(z)$ outside the waveguides; 2) the measure $H_k(u) = \mathrm{mes}\{z: z \in L_k,\ v^{-1}(z) \geqslant u\}$ for each L_k of the waveguide L_k $k = 1, n$. References 7.

UDC 550.83

AUTOMATED SYSTEM FOR INTERPRETING GRAVIMETRIC DATA

[Abstract of article by Gol'dshmidt, V. I., Kuz'min, Yu. I. and Shabaldin, V. N.]

[Text] The article describes the first stage of an automated system devised for interpretation of gravimetric data realized using an electronic computer of the YeS type (principal programming language -- FORTRAN-IV) which it is intended will be a subsystem of a more general system for use in ore geophysics (ASOM RG). Figures 5, references 8.

UDC 550.3

INFORMATION CONTENT OF GEOPHYSICAL EXPERIMENTS

[Abstract of article by Gol'tsman, F. M.]

[Text] Formulas are proposed for determining the informational content of geophysical experiments. There is a discussion of the dependence of the information content on the decision rules and different transformations of probability tables. Tables 2, references 3.

UDC 550.83

CONSTRUCTION OF SECTIONS OF MAGNETICALLY ACTIVE SOURCES USING A COMPLEX OF OBSERVATIONS

[Abstract of article by Kalinina, T. B.]

[Text] A statistical method is proposed for determining the parameters of magnetically active (density) sources from a complex of observed potential fields and their derivatives. Also examined is a method for investigating the resolution and effective depth of the method. Examples are given illustrating the desirability of a complex interpretation in the construction of sections of magnetized and density sources. Figures 1, tables 1, references 2.

UDC 550.83

STATISTICAL METHODS FOR CONSTRUCTING DENSITY SECTIONS OF KNOWN GEOMETRY FROM GRAVITY ANOMALIES UNDER NOISE CONDITIONS

[Abstract of article by Karatayev, G. I.]

[Text] A study was made of the problems involved in determining the densities of disturbing bodies of an arbitrary but known configuration on the basis of the anomalous gravity field complicated by different kinds of noise. The proposed methods can be used in obtaining effective evaluations of densities of disturbing masses in a deep geological section. References 10.

UDC 550.831

EQUIVALENT REDISTRIBUTIONS IN CLASS OF DENSITY DISCONTINUITIES

[Abstract of article by Korbunov, A. I.]

[Text] The article gives integral representations of optimality classes of density discontinuities whose parameterization is accomplished by the density drop at the contact, a zero approximation (asymptote) and evaluation of the reliability of construction of the zero approximation. A computation scheme is developed for constructing the elements corresponding to the observed field from the indicated classes. Examples of the computations are given. Figures 10, references 6.

UDC 550.831.01

ANALYTICAL REPRESENTATION OF INTERNAL AND EXTERNAL FIELDS OF ATTRACTION OF BODIES WITH VARIABLE DENSITY BOUNDED BY FIRST-ORDER SURFACES

[Abstract of article by Kravtsov, G. G.]

[Text] The author discusses the results of a rigorous solution of the internal and external direct problem of Newtonian potential for an arbitrary polyhedron with a density of masses varying linearly in an arbitrary direction. An analytical correlation is established between the Laplacian of potential and the Gauss integral for the solid angle of visibility of the polyhedron surface. Similar expressions giving the relationship of the third partial derivatives of gravitational potential are derived and cited. Figures 2, references 3.

UDC 550.831

INTERPRETATION OF GRAVITY ANOMALIES STIPULATED IN LIMITED REGION

[Abstract of article by Kudrya, A. V.]

[Text] A numerical scheme is proposed for the interpretation of gravity anomalies from three-dimensional bodies stipulated in a limited observation area. Conditions are derived whose satisfaction ensures a stable determination of the mass-geometry parameters of the body. References 13.

UDC 550.38

ONE EVALUATION OF ACCURACY IN SOLVING SYSTEMS OF LINEAR ALGEBRAIC EQUATIONS

[Abstract of article by Levenkor, Ya. B.]

[Text] The relative character of the concept of a poorly stipulated system is demonstrated in the example of solution of systems of linear algebraic equations with Gilbert matrices. A lower estimate of the number of precise figures in the

components of the solution is obtained theoretically regardless of the employed method and with the most general assumptions concerning the nature of rounding-off errors. The determined evaluation was tested in solving systems with square matrices and its effectiveness is thereby confirmed. Table 1, references 4.

UDC 550.83.016:552.33/571.56/

METHODS AND ALGORITHMS FOR EVALUATING PARAMETERS OF THREE-DIMENSIONAL GEOLOGICAL BODIES FROM MAGNETIC ANOMALIES

[Abstract of article by Loyter, P. P. and Yushmanov, V. V.]

[Text] A study was made of the problem of choosing a model for complex geological bodies in the initial stages of interpretation. On the basis of magnetometric data work was done for determining the deep structure of the Bilibinskiy magma complex of a central type (Aldan shield). Figures 2, references 4.

UDC 550.83

HARMONIC DENSITIES AND INVERSE POTENTIAL PROBLEM

[Abstract of article by Margulis, A. S.]

[Text] The role of harmonic densities in the inverse potential problem is investigated. The necessary and adequate condition for solubility of a problem in the class L_z was obtained, as well as a theorem of smoothness of normal solutions. An exhaustive characterization of densities not giving rise to an external potential is given. An integral representation of the operator of orthogonal projection of the space L_z onto the subspace of harmonic densities is presented, as well as a method for solving the V. N. Strakhov "sweeping out" problem. References: 13.

UDC 550.831.01

REGULARIZING ALGORITHMS FOR TWO- AND THREE-DIMENSIONAL INVERSE PROBLEMS IN GRAVIMETRY WITH USE OF A BPF SYSTEM

[Abstract of article by Melikhov, V. R., Rambkhatla, G. S. S. and Bulychev, A. A.]

[Text] This is a discussion of the results of a methodological testing of a new high-speed apparatus used in the method for solution of linear inverse problems in gravimetric prospecting. References 4.

UDC 550.831:553.981.06.012:519.2

USE OF REGULARIZATION IN INTERPRETATION OF GRAVIMETRIC PROSPECTING DATA FOR PURPOSE OF DIRECT SEARCH FOR PETROLEUM AND GAS DEPOSITS

[Abstract of article by Mudretsova, Ye. A., Komarova, G. M. and Filatov, V. G.]

[Text] The article gives algorithms and programs for the interpretation of gravimetric prospecting data on the basis of use of the regularization method for the

purpose of direct search for petroleum and gas deposits under the VGF, Vybor and MIF programs. The algorithm for the MIF program is presented in detail and it was tested in model and practical examples. Figures 3, references 17.

UDC 550.88

EVALUATION OF RATE OF CONVERGENCE OF ONE CLASS OF ITERATION METHODS USED IN SOLVING LINEAR INCORRECT PROBLEMS IN GEOPHYSICS

[Abstract of article by Oganesyan, S. M.]

[Text] The results of an investigation of the convergence and rate of convergence of one class of iteration methods are given. By means of construction of the nonlinear operator C it is shown that for the iteration method $x_{n+1} - Cx_n$ there is a linear or superlinear rate of convergence. The form of the construction of the linear operator C generalizes the method of modified monotonic images. References 23.

UDC 550.83

PSEUDOSOLUTIONS AND THEIR USE IN INCORRECT GRAVIMETRIC PROBLEMS

[Abstract of article by Oganesyan, S. M. and Starostenko, V. I.]

[Text] The author gives some new properties of an element introduced by V. A. Morozov for minimizing the generalized A. N. Tikhonov parametric functional and L -- the pseudosolution. References 5.

UDC 550.831

REALIZATION OF THE TRIAL-AND-ERROR METHOD WITH USE OF AN INTERACTIVE TERMINAL WITH A GRAPHIC DISPLAY IN THE INTERPRETATION OF MAGNETIC AND GRAVITATIONAL OBSERVATIONS

[Abstract of article by Pashko, V. F., Sapozhnikov, V. G. and Meshkova, O. P.]

[Text] Realizations of the trial-and-error method with use of interactive terminals with a graphic display are described and the effectiveness of use of such realizations is examined in the example of the program of the CGG Company in variants modified by the authors in the solution of test and practical problems. Various aspects of further improvement of such systems are discussed. Figures 5, references 28.

UDC 550.83

ECONOMICAL SOLUTIONS OF SOME CLASSICAL DIRECT PROBLEMS IN GRAVIMETRY AND MAGNETOMETRY

[Abstract of article by Strakhov, V. N. and Lapina, M. I.]

[Text] Possible methods for economical computations for the solution of direct problems in gravimetry are considered. Tables 9, references 16.

UDC 550.831

METHOD AND RESULTS OF THREE-DIMENSIONAL MODELING OF THE GALESHCHINSKOYE IRON ORE DEPOSIT (KREMENCHUG) ACCORDING TO GRAVIMETRIC DATA

[Abstract of article by Andreyev, V. I., Koyfman, L. I. and Korenevich, K. A.]

[Text] An optimization of three-dimensional iteration density modeling of the Galeshchinskoye iron ore deposit was carried out in the first approximation using an electronic computer. The results clearly define the geometry of the structure and the possibility of a predictive basis for the deposit. The employed method is recommended in the solution of such problems for complex geological structures. Figures 2, tables 1, references 8.

UDC 550.31:551.1

GRAVITATIONAL MODEL OF DEEP GEOLOGICAL STRUCTURE ALONG PROFILE MARKARA-POYLY (LESSER CAUCASUS)

[Abstract of article by Babadzhanyan, A. G. and Oganesyan, L. B.]

[Text] A new variant of a gravitational model of the upper part of the earth's crust along the profile Markara-Poyly has been constructed. Positions were determined more precisely and there is a quantitative characterization of fault zones detected by "Zemlya" stations and the results of geological mapping. A decrease in the number of blocks with depth was established. Figures 2, references 17.

UDC 550.834.32:831.072

DATA FROM MODELING OF THE WAVE AND GRAVITATIONAL FIELDS ALONG DEEP SEISMIC SOUNDING PROFILES IN DNEPR GRABEN

[Abstract of article by Baranova, Ye. P. and Kozlenko, V. G.]

[Text] The article examines the results of choice of velocity models satisfying the wave fields observed along deep seismic sounding profiles in the northwestern part of the Dnepr-Donetsk depression and also computations of gravity field anomalies along it. For the first time under the conditions of the Dnepr-Donetsk depression it was possible to discriminate local high-velocity bodies situated in the axial part of the aulacogen, which confirms its rift nature. The structure of the regional velocity model of the earth's crust is determined rather unstably. In order to increase the effectiveness of seismic modeling it is necessary to automate the trial-and-error testing method and also to develop principles for optimizing the solution under conditions of incomplete information on the wave field. Figures 1, references 9.

UDC 550.83:550.36:551.24

DENSITY MODELS OF TECTONOSPHERE OF CONTINENTAL REGIONS WITH DIFFERENT ENDOGENOUS REGIMES

[Abstract of article by Bur'yanov, V. B., Gordiyenko, V. V., Pavlenkova, N. I. and Yurov, Yu. G.]

[Text] The gravitational field along the two profiles Vorkuta-Black Sea and St. Tropez-Brest, intersecting all the presently known varieties of regions with individual endogenous regimes of the continental type,was studied. A "norm" was introduced; this is equal to the difference in the effect of the crust (whose density was assumed to be negative relative to the mantle) and the intensity of the Bouguer anomaly observed in the region. It was established that within the limits of the East European platform there are no mantle anomalies which are reliably discriminated with the attained accuracy in computations (15-20 mgal). In active regions there are extremely diversified mantle disturbances with an intensity of 50-200 mgal. Figures 2, references 8.

UDC 550.831:551.241/26/

CHOICE OF REDUCTION FUNCTION IN INTERPRETATION OF GRAVITY ANOMALIES IN OCEAN BY TRIAL-AND-ERROR METHOD

[Abstract of article by Bur'yanov, V. B., Karabovich, S. V., Rusakov, O. M. and Solov'yev, V. D.]

[Text] In the interpretation of gravity anomalies of structures on the ocean floor by the trial-and-error method the authors propose that use be made of a reduction function of a normalized section of the mature oceanic crust of an abyssal basin, based on genetic considerations. Allowance for its gravitational effect not only increases the reliability of the determined density discontinuities in the earth's crust, but also makes it possible to detect the gravitational effect caused by density inhomogeneities of the upper mantle. Figures 2, references 10.

UDC 550.931

DETECTION OF PATTERNS OF DENSITY MODELS OF DEEP STRUCTURES ALONG BEREGOVO-CHERNIGOV PROFILE

[Abstract of article by Geyko, V. S., Koyfman, L. I., Korenevich, K. A., Kupriyenko, P. Ya., Krasovskiy, S. S., Livanova, L. P. and Tsvetkova, T. A.]

[Text] On the basis of data collected on the distribution of velocities it was possible to make a precise determination of the seismic section within the limits of the considered profile. All present-day geological, geophysical and petrological data fit in well in the quantitatively consistent seismic and density models. Figures 2, references 23.

UDC 550.831:550.834

MODELS OF MEDIUM IN MULTISIDED INTERPRETATION OF GRAVITATIONAL FIELD AND SEISMIC OBSERVATIONS

[Abstract of article by Golizdra, G. Ya.]

[Text] Three types of medium models S, U and M are introduced by the author for a multisided interpretation of the gravity field and seismic observations. The results of an independent interpretation of two methods are summed and made consistent in model S. All the parameters of the density and velocity models coincide in the U model. Model M, of an intermediate type, can be used. The construction of models of the medium is accomplished by the trial-and-error method. The formulation of problems in multisided interpretation is dependent on the type of model of the medium. References 17.

UDC 550.831

COMPUTER COMPUTATION OF FIELD IN INTERPRETATION OF GRAVITY OBSERVATIONS IN UNDERGROUND MINES

[Abstract of article by Golizdra, G. Ya., Plishko, I. V., Soldatenko, V. P. and Tatarinova, T. A.]

[Text] The gravity field is found within three- and two-dimensional masses by numerical integration of expressions reduced to a single integral. The peculiarities of the integrands are liquidated by discriminating the Δ-neighborhood of the computation point. Algorithms were developed and FORTRAN was used in preparing programs for computers of the YeS type: "Poligon," "Piramida," "Liniya" and other programs. References 2.

UDC 550.36:550.83

DEEP HEAT AND GRAVITY ANOMALIES

[Abstract of article by Gordiyenko, V. V.]

[Text] The author examines three variants of change in the density of crustal rocks and the earth's mantle during heating: before attaining critical stresses, after attaining them, with exceeding the temperature of partial melting. Examples of gravity anomalies in tectonically active regions associated with temperature change of density are cited and it is shown that they coincide well with the discrepancy in observed fields and the gravitational effects of the crust. References 15.

UDC 550.312.834

POSSIBLE HETEROGENEITY OF PLANETARY GEOPOTENTIAL ANOMALIES

[Abstract of article by Deynenko, Yu. P. and Kozlenko, V. G.]

[Text] On the basis of data on density and velocity inhomogeneities situated in the earth's deep layers it is postulated that planetary anomalies of the gravity field have an interference character, that is, are caused by a combining of the effects of anomalous masses situated at different depths. Figures 1, references 2.

UDC 550.831:553/470.324/

ROLE AND PLACE OF GRAVIMETRY IN STUDY OF DEEP STRUCTURE OF VORONEZHSKIY CRYSTALLINE COMPLEX AND SEARCH FOR DIFFERENT MINERALS

[Abstract of article by Zhavoronkin, I. A., Vasserman, I. S. and Nadezhda, L. I.]

[Text] A study was made of the problems involved in use of results of interpretation of gravity anomalies for investigating the regional deep structure of the Voronezhskiy crystalline complex and the search for different minerals in it. There was found to be a high effectiveness in use of gravitational prospecting in combination with other geophysical methods in the deep geological mapping of a region covered by sediments, study of the structure of iron ore deposits, search for bauxites and mapping of potentially nickel-bearing intrusions of basic and ultrabasic compositions. Figures 4, references 9.

UDC 550.838:518.5

INTERPRETATION OF GRAVITATIONAL AND MAGNETIC ANOMALIES OF THE ZVIZDAL'-ZALESSKAYA ZONE

[Abstract of article by Zeygel'man, M. S.]

[Text] The method and the principal procedures used in the interpretation of gravitational and magnetic anomalies over a complex of basic rocks, which in the geological literature is known as the Zvizdal'-Zalesskiy dike, are examined. The principal results of the interpretation are given. These substantially change the prevailing concepts concerning the deep structure of the complex. Figures 2, references 7.

UDC 550.83:551.14/15

FORMALIZED MODELS OF DISTRIBUTION OF MASS AND HEAT AND GLOBAL SUMMARIES OF PHYSICAL FIELDS IN GEODYNAMICS AND METALLOGENY

[Abstract of article by Klushin, I. G.]

[Text] Some problems in the interpretation of geophysical data are considered, taking into account changes of model parameters with time. An approach is given

for the separation of inhomogeneities in the upper mantle into components of a different nature. A study was made of the theoretical and practical aspects of the redistribution and accumulation of asthenospheric fluids, and also problems involved in the processing of geophysical data in a study of deep structures. References 27.

UDC 550.831

VALUES AND INTERRELATIONSHIP OF COEFFICIENTS OF LINEAR DEPENDENCE BETWEEN DENSITY AND VELOCITY OF LONGITUDINAL WAVES FOR SEDIMENTARY AND CRYSTALLINE ROCKS

[Abstract of article by Krasovskiy, S. S. and Geysherik, G. M.]

[Text] For sedimentary and crystalline rocks there is a distinct correlation of the coefficients a and b in the dependence $\rho = a + bv_p$, which can be employed in the introduction of corrections for the composition of rocks and the peculiarities of regions. Figures 2, references 6.

UDC 550.83.012

OBJECT BASIS FOR MULTISIDED INTERPRETATION OF GEOLOGICAL-GEOPHYSICAL DATA

[Abstract of article by Malyshev, Yu. F. and Kulyndyshev, V. A.]

[Text] Conclusions are drawn concerning the decisive role of geophysical objects in solution of problems in the multisided interpretation of geological-geophysical data. The principles are formulated and a theoretical basis for multisided interpretation is outlined. Figures 4, references 18.

UDC 550.312

REPRESENTATION OF DENSITY OF EARTH'S LAYERS BY SERIES OF BIORTHOGONAL SYSTEMS OF POLYNOMIALS

[Abstract of article by Meshcheryakov, G. A. and Fys, M. M.]

[Text] A study was made of construction of the approximate distributions of the density of the earth's layers by means of series in biorthogonal systems of polynomials. Use is made of information on the gravitational field and also the results of seismic study of the planet. References 10.

UDC 523

SOME PROBLEMS IN INTERPRETATION OF THE EARTH'S GRAVITY FIELD IN ITS COMPARATIVE PLANETOLOGY ASPECT

[Abstract of article by Meshcheryakov, G. A., Tserklevich, A. L., Deyneka, Yu. P. and Zazulyak, P. M.]

[Text] A study was made of the problems involved in interpretation of planetary anomalies of the Earth, Mars and the Moon with regard to isostatic state of the

crust and the distribution of density inhomogeneities in the mantle of the planet. Differences in elastic stresses caused by anomalous planetary layers are found and they are interpreted. The contribution of topographic and compensatory masses in undulations of the geoid, areoid and selenoid is evaluated. Computations were made of the depths of the centers of mass of density inhomogeneities and estimates of the lateral differences in density near the top and bottom of the planet's upper mantle are given. Tables 2, references 14.

UDC 550.831.01

DISPERSION OF EFFECTIVE AND MEAN DENSITIES OF INHOMOGENEOUS LAYERED MEDIA

[Abstract of article by Novoselitskiy, V. M. and Vol'fson, O. Kh.]

[Text] A study was made of a class of layered-zonal density models in which the initial information on the density inhomogeneity of the layers is complicated by noise. For the particular class it was possible to obtain expressions for the dispersion of effective density with stipulated autocorrelation properties of noise in stratum densities. For this particular case it is shown that the dispersion of effective densities is considerably less than the dispersions of the mean weighted densities. Tables 2, references 9.

UDC 550.831

SOME EQUIVALENT REPRESENTATIONS OF GRADIENT-LAYERED MEDIA IN GRAVIMETRIC PROSPECTING

[Abstract of article by Novoselitskiy, V. M. and Gubaydullin, M. G.]

[Text] The effective density was determined for a horizontal stratum equivalent with respect to its external field to a complexly structured gradient medium. It is shown that the use of effective densities in practical interpretation makes possible a correct determination of excess density at the discontinuity of inhomogeneous graviactive strata characterized by a different gradient and also a more reliable evaluation of the lateral variability of rocks with respect to gravity anomalies in zones of development of tectonic dislocations. Figures 1, references 7.

UDC 550.83

CRITERIA FOR OPTIMUM DISCRIMINATION OF WEAK MAGNETIC ANOMALIES WITH AVERAGING

[Abstract of article by Palamarchuk, V. K.]

[Text] Criteria are examined for the optimum discrimination of anomalies based on an evaluation of the similarity of residual local anomalies to theoretical models. It is demonstrated here that by using the proposed criteria it is possible to evaluate the variable radius of averaging. Figures 2, references 3.

UDC 551.24

INFLUENCE OF THERMODYNAMIC STATE OF DIFFERENT LAYERS OF EARTH'S CRUST ON LOCAL AND REGIONAL GRAVITY ANOMALIES IN KURILE DEPRESSION

[Abstract of article by Pil'chin, A. N.]

[Text] The change in the density of granite and gabbro in a broad range of pressures and temperatures is estimated. It is shown that the indicated changes in density under the thermodynamic conditions of the earth's crust along the profile 3-DSS (deep seismic sounding profile) (Middle Kura Depression) cause gravity anomalies -- 0.67, 1.35 mgal from the "granite" and 11.8, 15.7 mgal from the "basalt" layers. Tables 4, references 6.

UDC 550.83:551.24

PRINCIPLES FOR MODELING DEEP STRUCTURE OF THE EARTH'S CRUST USING GRAVIMETRIC DATA

[Abstract of article by Rzhanitsyn, V. A., Timoshenko, V. I. and Shlyakhovskiy, V.A.]

[Text] It is shown that the effect from deep discontinuities in the earth's crust constitutes a considerable value which can characterize an extremely dissected relief of the M discontinuity under the condition of block movements along tilted faults. Figures 2, references 15.

UDC 550.831:241/26/

DETECTION OF DEEP DENSITY INHOMOGENEITIES IN NORTHERN INDIAN OCEAN

[Abstract of article by Starostenko, V. I. and Shen, E. L.]

[Text] The article contains the results of selection of a three-dimensional model of the crust in the northern part of the Indian Ocean. The density variations method is used in constructing one-dimensional density sections of the lithosphere and the principal geological structures in this region, which when put together give some idea concerning the essentially heterogeneous nature of the deep layers. Figures 1, references 7.

UDC 550.831

DENSITY VARIATIONS METHOD IN CONSTRUCTING SYSTEM OF GRAVITATIONAL MODELS

[Abstract of article by Starostenko, V. I. and Shen, E. L.]

[Text] A study was made of the possibility of using the density variation method in constructing a hierarchical series of gravitational models. This method makes it possible to use the limitations imposed by the requirement of conservation of mass and the moment of the earth's inertia in both formal and substantive forms. Table 1, references 8.

UDC 653.80

INDIRECT DETERMINATIONS OF SPECIFIC DIRECTIONS IN SOME FIGURES OF ANALYTICAL NETWORK

[Abstract of article by Akhverdov, G. B.]

[Text] Under restricted conditions, and also for the purpose of reducing the volumes of work, which increases productivity and reduces expenditures, it is desirable to construct not the standard engineering triangulation networks, but more simplified geodetic constructions. More modern methods have been developed for the creation of geodetic constructions. Such constructions, taking into account the high accuracy of modern angle-measuring instruments, make it possible to obtain high-quality (accomplished with the required accuracy) results with a decrease in expenditures by 10-15%. Figures 5, references 2.

UDC 622.83

EXPERIENCE IN DEVELOPING ANTENNA-FEEDER SYSTEMS FOR RADAR APPARATUS FOR DETERMINING GEOLOGICAL INHOMOGENEITIES IN ROCK MASSES OF NORTHERN URAL BAUXITE MINE

[Abstract of article by Nizkoshapka, V. P.]

[Text] The article contains information on the development of antenna-feeder systems for a radar apparatus with a working frequency of 150 MHz. The author examines methods for matching the antenna-feeder system and the rock. Figures 3, references 3.

5303
CSO: 1865/69

UDC 550.83.015+551.24(571.6)

ARTICLES ON REGIONALIZATION OF GEOPHYSICAL FIELDS AND DEEP STRUCTURE IN FAR EAST

Vladivostok RAYONIROVANIYA GEOFIZICHESKIKH POLEY I GLUBINNOYE STROYENIYE DAL'NEGO VOSTOKA in Russian 1977 (signed to press 19 Jul 77) pp 133-136

[Abstracts of articles from collection "Regionalization of Geophysical Fields and Deep Structure of the Far East", responsible editor Yu. A. Kosygin, academician, Institut tektoniki i geofiziki, Dal'nevostochnyy nauchnyy tsentr, Akademiya nauk SSSR, 600 copies, 136 pages]

Abstracts

[Text] UDC 550.8.015

PRINCIPLES OF AREAL AND VOLUMETRIC GEOPHYSICAL REGIONALIZATION

[Abstract of article by Malyshev, Yu. F., Bryanskiy, L. I., Kulyndyshev, V. A. and Loyter, P. P.]

[Text] The general concept of "regionalization procedure" is formulated. The problems of areal and volumetric regionalization are defined. Areal and volumetric regionalization block diagrams are constructed. The authors describe how to convert from the areal regionalization of geophysical fields to volumetric regionalization of field sources. Figures 2, references 55.

UDC 550.831.016(571.6)

FAR EASTERN GRAVITATIONAL ANOMALIES

[Abstract of article by Malyshev, Yu. F., Parfenov, L. M., Reynlib, E. L. and Romanovskiy, N. P.]

[Text] The article sets forth the methods used and the results of regionalization of the anomalous gravity field in the Far East. It was possible to discriminate two anomalous regions: transitional and continental, corresponding to the two principal geoblocks in Asia. The transitional region corresponds to a perioceanic eugeosynclinal zone. The continental region corresponds to the marginal part of the Late Mesozoic of the Asian continent. Fundamentally new data were obtained on the position and structure of the boundary zone separating these geoblocks. Within the limits of the anomalous regions it is possible to discriminate higher-order

anomalies and their geological nature is examined. Figures 1, references 16.

UDC 550.831.016(571.61/62)

LEVEL CORRELATION AND SCHEME FOR REGIONALIZATION OF GRAVITY ANOMALIES IN AMUR AREA

[Abstract of article by Sheredko, V. A.]

[Text] A deep formal regionalization of gravity anomalies in the Amur region was carried out. An examination of maps of different levels of correlation reveals a selectivity in the directions of the zones of increased field gradients, identifiable with faults. First- and second-order blocks of the anomalous field are discriminated and characterized. Figures 2, tables 1, references 2.

UDC 550.831.016(571.64)

REGIONALIZATION OF ANOMALOUS GRAVITY FIELD IN SOUTHERN SEA OF OKHOTSK

[Abstract of article by Kosygin, V. Yu., Pavlov, Yu. A. and Popov, Ye. I.]

[Text] With respect to structure and mean level of the anomalous gravity field in the Bouguer reduction it was possible to discriminate four anomalous regions: Sakhalin, Academy of Sciences Rise, Kotlovinnyy and Kurile. The description of the anomalous field of the regions is accompanied by a geological interpretation of the nature of the anomalies. Figures 2, references 17.

UDC 552.08:53(571.61/.62)

DENSITY INHOMOGENEITIES OF EARTH'S CRUST IN SOUTHERN FAR EAST

[Abstract of article by Malyshev, Yu. F., Parfenov, L. M., Reynlib, E. L. and Romanovskiy, N. P.]

[Text] The article describes a method for compiling a formalized map of rock density in the southern part of the Far East. Primarily inversion relationships were established between the density distrinution at the surface and the gravity anomalies of major tectonic elements, which is attributable to the characteristics of deep structure of the region. Figures 3, tables 1, references 12.

UDC 550.382.3:552.321:553.45(571.61/.62)

PETROMAGNETIC CRITERIA OF TIN CONTENT OF AMUR REGION GRANITOIDS

[Abstract of article by Onikhimovskiy, V. V. and Romanovskiy, N. P.]

[Text] The authors demonstrate the possibility of using a petromagnetic characterization of tin-bearing intrusions of granitoids for determining the formational affiliation and potential productivity of tin shows. An increase in the mean values

of magnetic susceptibility of tin-bearing granitoid intrusions is regarded as an index of productivity of tin ore. Tables 1, references 15.

UDC 550.83.016:551.21(571.62)

EXPERIENCE IN VOLUMETRIC GEOPHYSICAL REGIONALIZATION IN EXAMPLE OF KHINGANO-OLONOYSKAYA AND KAMENUSHINSKAYA VOLCANIC DEPRESSIONS

[Abstract of article by Bryanskiy, L. I., Malyshev, Yu. F. and Pavlov, G. A.]

[Text] One of the methods for volumetric geophysical regionalization on the basis of a combination of methods is described. Its use made it possible to obtain a map of basement structure and the volcanic formations of the Khingano-Olonoyskaya and Kamenushinskaya depressions. An attempt has been made to relate structural formations and the metallogeny of the region. Figures 4, references 5.

UDC 550.312(571.64)

ISOSTATIC STATE OF EARTH'S CRUST IN SOUTHERN PART OF SEA OF OKHOTSK

[Abstract of article by Kosygin, V. Yu.]

[Text] An evaluation of isostasy of the earth's crust was made by two methods: on the basis of isostatic anomalies and on the basis of computations of pressures at the surface of compensation. Despite a general comparability of the results, the second method gives additional information on changes of isostasy in the earth's crust, associated with the peculiarities of its structure and development. Figures 2, references 7.

UDC 550.83+551.24(571.62)

PROBLEMS IN DEEP STRUCTURE OF SOUTHEASTERN ALDANSKIY SHIELD

[Abstract of article by Karsakov, L. P., Malyshev, Yu. F. and Romanovskiy, N. P.]

[Text] On the basis of a study of geological and geophysical data an investigation was made of the nature of the Tyrkanskiy regional gravity minimum. The authors discuss the reasons for the inversion relationship between the surface density distribution and gravity anomalies. The role of Mesozoic and Precambrian granitoids, the bottom of the paleocrust and heating of the top of the mantle in the Cenozoic in the anomalous effect is examined. Figures 2, references 21.

UDC 550.83+551.24+551.21(571.66)

FEATURES OF DEEP STRUCTURE OF SOUTHERN KAMCHATKA ACCORDING TO GEOPHYSICAL DATA

[Abstract of article by Akhmadulin, V. A., Zubin, M. I., Smirnov, V. S. and Tarakanovskiy, A. A.]

[Text] A study was made of the deep structure of the region of the Tolmachevskaya volcanic-tectonic depression. On the basis of data from gravimetry and magnetometry

it was possible to construct a map of the Cretaceous basement and detect the presence of magma hearths in the earth's crust which are reflected in the results of magnetotelluric sounding. Figures 2, references 8.

UDC 550.837.211(571.62)

EXPERIENCE IN MAGNETOTELLURIC INVESTIGATIONS IN BUREINSKIY COMPLEX

[Abstract of article by Akhmadulin, V. A.]

[Text] It is shown in this article that measurements of the vertical component of the electric field in a borehole are subject to the influence of horizontal inhomogeneities of the section. The author evaluates the geoelectric profile in the southern part of the Bureinskiy complex. There was found to be conductivity anomalies in the earth's crust and upper mantle at depths of 20-40 and 60-70 km. Figures 4, references 13.

UDC 550.831.017:551.24(571.62)

METHOD FOR STUDYING DEEP STRUCTURE OF MESOZOIC-CENOZOIC DEPRESSIONS (IN EXAMPLE OF BUREINSKAYA DEPRESSION)

[Abstract of article by Bryanskiy, L. I.]

[Text] The type of correlation between the gravity field and the depth of the depression is theoretically validated for a case when stratum density varies linearly with depth. A new algorithm of the correlation method of interpretation has been developed allowing its automation. New data on structure of the Bureinskiy downwarp were obtained. Figures 2, tables 1, references 7.

UDC 550.834.3:551.24(282.257.5)

EXPERIENCE IN STUDYING BOTTOM DEPOSITS OF AMUR BY CONTINUOUS SEISMOACOUSTIC PROFILING METHOD

[Abstract of article by Kalinin, V. V., Markov, V. A. and Pivovarov, B. L.]

[Text] A study was made of the characteristics of the continuous seismoacoustic profiling method under specific fluvial conditions. As a result of use of continuous seismic profiling it was possible to detect new structural elements and refine the extent and position of those known earlier. The collected data show that in the northeastern part of the Khabarovskaya depression the depth of the Mesozoic folded basement does not exceed 200 m. Figures 2, tables 1, references 6.

UDC 551.248.2+550.348(571.61)

FEATURES OF HORIZONTAL BLOCK MOVEMENTS IN NEIGHBORHOOD OF ZEYSKAYA HYDROELECTRIC POWER STATION

[Abstract of article by Korchagin, F. G.]

[Text] The article sets forth the results of experimental investigations of the dynamics of the tectonic block near the dam. It was found that there are three types of elastic oscillations of the block. A study was made of the nature of horizontal movements of the block. The influence of the reservoir on elastic oscillations of the block is evaluated and the possibility of increasing the seismicity of the region in dependence on the regime of filling of the reservoir is examined. Figures 2, references 2.

5303
CSO: 1865/59

ARCTIC AND ANTARCTIC RESEARCH

RECENT ARCTIC POLAR BASIN RESEARCH

Leningrad PROBLEMY ARKTIKI I ANTARKTIKI: SBORNIK STATEY in Russian No 57, 1981 (signed to press 27 Jul 81) pp 123-127

[Abstracts from collection of articles "Problems of the Arctic and Antarctica: Collection of Articles)", A. F. Treshnikov, responsible editor, Gidrometeoizdat, 600 copies, 127 pages]

UDC 910.4(98,99)

PRINCIPAL STAGES AND PROSPECTS FOR STUDY OF EARTH'S POLAR REGIONS

[Abstract of article by Treshnikov, A. F.]

[Text] The principal stages and prospects for study of the earth's polar regions are examined. The article gives a brief history of the organization and implementation of research in the Arctic, beginning in 1920, when the Northern Cooperative Expedition was organized, from which the Arctic and Antarctic Scientific Research Institute (AANII) owes its origin. Soviet investigations began in Antarctica in 1956 and since 1958 the AANII has been responsible for the organization and coordination of investigations made by the Soviet Union on the sixth continent and in the Antarctic Ocean. The author gives the principal scientific results in the field of study of the ice cover of arctic seas and the Antarctic Ocean, polar oceanology, meteorology, interaction between the ocean and the atmosphere, heat balance, water and ice regimes of the lower reaches and mouths of rivers in the arctic zone, hydrochemical regime, geophysical phenomena, radio wave propagation, glaciology of polar countries, ice qualities of icebreakers, polar medicine, and economic effectiveness of hydrometeorological forecasts. Also examined is the further development of in situ investigations in the Arctic and Antarctica and the northern regions of the Atlantic Ocean, the basis for which is scientific investigations under the "POLEX," "Profiles" and "POLEX-Climate" programs.

UDC 551.46(268(269)

PROBLEMS IN OCEANOLOGICAL INVESTIGATIONS IN POLAR REGIONS

[Abstract of article by Mustafin, N. V., Nikiforov, Ye. G., Sarukhanyan, E. I., Smirnov, N. P. and Timokhov, L. A.]

[Text] The article discusses the status and outlines the prospects for solution of problems in three directions: regularities in formation of the hydrological

regime of the Arctic and Antarctic Oceans, methods for oceanological computations and forecasts, scientific-practical aids and oceanological support of branches of the national economy associated with transportation and economic use of the Arctic and Antarctica. Figures 1, tables 1, references 78.

UDC 551.464.628:554.465.42

STATUS AND PROSPECTS FOR HYDROCHEMICAL INVESTIGATIONS IN ARCTIC OCEAN

[Abstract of article by Rusanov, V. P.]

[Text] The problems involved in study of the hydrochemical regime of the Arctic Ocean associated with solution of more complex problems in polar oceanography and preservation of its waters are considered. A brief review is given of the principal scientific results obtained on the basis of a generalization of hydrochemical observations made during recent decades. Also discussed is the possibility of using some chemical characteristics of sea water as indicators of oceanological processes in the Arctic Ocean. References 18.

UDC 551.326.03

PROBLEMS IN INVESTIGATING SEA ICE

[Abstract of article by Gudkovich, Z. M., Zakharov, V. F., Kirillov, A. A. and Krutskikh, B. A.]

[Text] A study was made of the importance of sea ice as an indicator of climatic changes and the climate-forming factor, as well as their influence on man's economic activity. The authors examine the features of the physicostatistical and thermohydrodynamic methods for ice computations and forecasts, together with their probable success; the principal problems in an investigation of the thermal and dynamic processes in the ice cover, its geographical distribution and properties are enumerated. Figures 4, tables 1.

UDC 551.465.7:519.24

PROBLEMS IN MACROSCALE INTERACTION BETWEEN OCEAN AND ATMOSPHERE

[Abstract of article by Nikolayev, Yu. V. and Smirnov, N. P.]

[Text] Brief results are given of in situ and experimental investigations of macroscale interaction between the ocean and the atmosphere in the Arctic Basin and in the North Atlantic carried out during the last five years.

UDC 551.467

MODERN METHODS AND RESULTS OF INVESTIGATIONS OF PHYSICS OF ICE AND OCEAN

[Abstract of article by Bogorodskiy, V. V.]

[Text] A study was made of the problems involved in the use of active and passive radar and techniques in measuring ice thickness, studies of the rates of movement and internal structure of glaciers, and investigation of the surface temperature of Arctic seas. Also discussed are the results of use of a complex of new technical equipment in study of the dynamics of drifting ice covers. The article gives an evaluation of the results of investigations of the optical characteristics of the waters and snow-ice cover of the Arctic basin, and also new information on the micro- and mesoscale spatial-temporal variability of its hydrophysical fields. Also discussed are the results of introduction of the pressiometric method for determining the rheological characteristics of ice covers. Figures 8, references 6.

UDC 551.482+556.54

RESULTS OF AIR EXPEDITIONS IN LOWER REACHES AND MOUTH REGIONS OF ARCTIC ZONE RIVERS

[Abstract of article by Ivanov, V. V. and Nalimov, Yu. V.]

[Text] This is a review of the results of the work of air expeditions in the lower reaches and mouth regions of rivers carried out from the early 1920's through 1980. It is shown that the use of aircraft on air expeditions in the lower reaches and mouth regions of arctic zone rivers is related to observation of the ice-hydrological regime in order to ensure navigation along the Northern Sea Route and also other needs of the national economy. It is shown that the purposes and tasks of air expeditions have changed in accordance with the need to support the national economy and the development of science. At the same time the range of the observations and their volume have broadened. Multisided observations beginning in 1969 have been directed to the collection of hydrological information for scientific validation of major national economic tasks, such as year-round navigation and shifting of the runoff of rivers in the north and Siberia, as well as scientific-operational support of the national economy. Figures 1, tables 2, references 37.

UDC 551.509.334

STUDY OF ATMOSPHERIC CIRCULATION AND LONG-RANGE METEOROLOGICAL FORECASTS FOR POLAR REGIONS

[Abstract of article by Girs, A. A.]

[Text] The principal stages in development of the macrocirculation method for long-range meteorological forecasting for the Arctic and Antarctica are considered. The author formulates the tasks for further investigations for the development of this method and ways to develop a multisided method. References 2.

UDC 551.50(98/99)

TIMELY PROBLEMS IN POLAR METEOROLOGY

[Abstract of article by Voskresenskiy, A. I.]

[Text] An evaluation of the results attained in the field of polar meteorology is given against the background of existing global problems. Particular attention is given to the problems of study of natural variations of climate, anthropogenic effects and the organization of climatic monitoring. References 11.

UDC 550.385.388.2.621.371

RESULTS AND PROSPECTS OF GEOPHYSICAL RESEARCH

[Abstract of article by Shirochkov, A. V.]

[Text] The article gives the results and prospects of investigations of the ionosphere, geomagnetic field and radio wave propagation in the Arctic and Antarctica. It is noted that data from geophysical observations are being used successfully in the practice of prognostic centers of the ionospheric-magnetic service formed in 1973 in the State Committee on Hydrometeorology and Environmental Monitoring system.

UDC 629.124.791.551.467

ENSURING ICE QUALITIES OF ICEBREAKERS AND TRANSPORT SHIPS FOR NAVIGATION IN ICE

[Abstract of article by Maksutov, D. D.]

[Text] This is a review of the scientific activity of the laboratory of ice qualities of ships and the world's only experimental ice basin at the Arctic and Antarctic Scientific Research Institute and the results of their operation are given. The article reveals the great contribution of the laboratory to the creation of modern icebreakers and ships for navigation in the ice intended for solution of important problems in the national economy.

UDC 001(98/99)

PRACTICAL INTRODUCTION OF RESULTS OF SCIENTIFIC RESEARCH

[Abstract of article by Shamont'yev, V. A.]

[Text] Problems related to the practical introduction of the results of scientific research and experimental-design work of a hydrometeorological character are considered. A classification of scientific studies is given. These are divided into five types: fundamental, prognostic, scientific-practical, scientific-methodological and experimental-design. Three types of introduction are indicated:

1) national economic, in which the results of the work are used in several branches of the national economy, 2) branch, in which the results of the work are used at scientific institutes and other organizations of the State Committee on Hydrometeorology and Environmental Monitoring and 3) intra-institute, in which the results are used only at the Arctic and Antarctic Scientific Research Institute. Tables 2.

5303
CSO: 1865/88

UDC 910.2

25 YEARS OF WORK OF THE SOVIET ANTARCTIC EXPEDITION

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 10, Oct 81 pp 3-12

[Unsigned article]

[Text] Twenty-five years of work have been completed by the Soviet Antarctic Expedition. In this connection a solemn session of the USSR Academy of Sciences and the Board of the USSR State Committee on Hydrometeorology and Environmental Monitoring (Goskomgidromet) was held in the Moscow House of Scientists. Representatives of scientific institutes of the USSR Academy of Sciences, State Committee on Hydrometeorology and Environmental Monitoring, a number of ministries and departments, Party and public agencies in Moscow met here on 8 January.

The President of the USSR Academy of Sciences, Academician A. P. Aleksandrov, opened the solemn session. He congratulated all the participants in work in Antarctica who had made a major contribution to the study and exploitation of this severe region of the earth. Then A. P. Aleksandrov yielded the floor to A. F. Treshnikov, corresponding member USSR Academy of Sciences, who told of the results of Soviet Antarctic investigations over a 25-year period.

Soviet investigations in Antarctica, said the speaker, were initiated in connection with the program of the International Geophysical Year (IGY), which was observed during the period 1 July 1957 through 31 December 1958. But preparations for it developed long prior to the IGY. The International Committee of the IGY, in formulating a unified program for investigations over the entire earth, also called for a study of Antarctica. Soviet scientists warmly responded to this call.

In the Division of Sea Expeditionary Work of the USSR Academy of Sciences Presidium a planning group under the direction of I. D. Papanin, with participation of representatives of the Arctic Institute, and also a number of Moscow institutes, developed proposals concerning the organization of a Soviet Antarctic Expedition. In 1955 a decision was made to send a major expedition to Antarctica. The scientific direction of the expedition was delegated to the USSR Academy of Sciences and the preparation and technical outfitting was assigned to the Main Administration of the Northern Sea Route. (In 1958, when the expedition became annual, its organization and implementation were assigned to the Arctic Institute, which from that time was called the Arctic and Antarctic Scientific Research Institute. But as before, scientists of the USSR Academy of Sciences participate in the expeditions, as well as different institutes and departments, but the general coordination work is delegated to the Interdepartmental Commission on Study of Antarctica in the Earth Sciences Section, Presidium, USSR Academy of Sciences.)

The scientific program for the expedition, approved by the Presidium, USSR Academy of Sciences, provided for a full range of investigations of the nature of the south polar region: influence of atmospheric processes in Antarctica on general circulation of the earth's atmosphere; peculiarities of geophysical phenomena and processes in Antarctica; glacial cover of Antarctica and its dynamics; geological structure and geological history of Antarctica; physiographic and biogeographical features of individual regions of Antarctica; oceanic waters, sea ice and bottom structure of the Antarctic Ocean; biology of waters and zonal distribution of fauna in the waters of the Antarctic Ocean, and also compilation of the navigational-geographical characteristics of the Antarctic coastal zone, collection of materials for the compilation of navigation and topographic charts.

The head of the First Soviet Antarctic Expedition was Hero of the Soviet Union M. M. Somov. The key leaders of the expedition were selected from among the scientists of the institutes of the USSR Academy of Sciences, the Arctic Institute and Moscow University.

Thousands of people and hundreds of enterprises and institutes participated in the outfitting of the first expedition. The diesel-electric "Ob'" departed from Kaliningrad on 30 November 1955 and on 5 January 1956 approached the shores of Eastern Antarctica in the neighborhood of Depot Bay in the Davis Sea. On this same day a group of Soviet scientists under the direction of A. M. Gusev (the group included G. A. Avsyuk, V. G. Kort, P. A. Shumskiy, K. K. Markov, O. S. Vyalov, motion picture camera operator A. V. Kochetkov and correspondent P. R. Barashev) made their way over the shore ice to the shore and investigated dark rocks of glacial moraine. This day also marked the beginning of Soviet investigations on the Antarctic continent. But the site for a shore station was not selected here, but in the area of the Haswell Islands, at 90°E, where there are bedrock outcrops. The first scientific station and shore base was opened there on 13 February 1956; it was named in honor of one of the ships of the first Russian Antarctic expedition, led by Bellinsgauzen and Lazarev, who discovered Antarctica in 1820.

In addition to the "Ob'," two other ships sailed to Antarctica: the diesel-electric "Lena" and the refrigerator ship "Semerka." They delivered to its shores the members of the expedition, supplies, construction materials, food, aircraft, helicopters, etc. The crews of the ships, after unloading, participated in the construction of Mirnyy. Simultaneously with creation of the base there were reconnaissance flights into the heart of the continent and into neighboring regions where geologists and glaciologists collected the first data concerning the nature of extensive territories.

A sledge-tractor train was dispatched to the south from Mirnyy late in the Antarctic autumn. It advanced along the steep slope of the glacier dome against a constant strong katabatic wind and low blizzard. In one month the train covered a distance of 375 km from Mirnyy, rising along the glacier slope. There it was decided to stop. A station was created from hutments built on runners. It was officially opened on 27 May 1956 and was named "Pionerskaya." This was Antarctica's first intracontinental scientific station. Its opening marked the beginning of an important stage in the history of investigation of the sixth continent. It was the first time that man had decided to spend the winter so far from the shore in the depths of the continent at an elevation of 2,700 m above sea level.

The experience of the trek and information on the severe climatic conditions at Pionerskaya station enabled the Second Antarctic Expedition, which was headed by the author of this report, to prepare itself for an attack on the deeper regions of Antarctica on a sounder basis. Despite this, the expedition encountered enormous difficulties in its advance toward the South Geomagnetic Pole. The first 600 km the route ran through high, hard zastrugi and then, already at elevations of more than 3,000 m above sea level, a friable crystalline snow began, which would not compact as a result of the conditions of its formation at constant low temperatures; the tractor treads stuck in it and the runners of the sledges did not slide.

The temporary intermediate station Vostok-1 was established early in 1957 at a distance of 630 km to the south of Mirnyy. In the second half of the year, in the Antarctic spring, still another intermediate station was established at a distance of 860 km from Mirnyy -- Komsomol'skaya, and Vostok-1 station was rebased to the point of the geomagnetic pole at a distance of 1,410 km to the south of Mirnyy. It was opened on 16 December 1957 and was given the name "Vostok" in honor of another ship of the first Russian Antarctic expedition led by Bellinsgauzen and Lazarev. Geomagnetic observations have already been made at Vostok station at the point where the magnetic meridians converge for 22 years. Here the lowest temperatures on earth (absolute minimum -88.3°C) are observed at an elevation of 3,500 m.

The third expedition, under the direction of Hero of the Soviet Union Ye. I. Tolstikov, early in 1958 advanced even a greater distance into the depths of the ice continent. For the first time Sovetskaya station was established at an elevation of 3,662 m above sea level between Sovetskaya station and the Pole of Inaccessibility, and late in 1958 the South Pole of Inaccessibility, situated at a distance of 2,200 km from Mirnyy at an elevation of 3,800 m above sea level, was reached. Here a small base was established. Although scientific observations at this base were made for only 12 days, later it served as an intermediate base for treks into the unmapped regions of Queen Maud Land and for transcontinental treks. On subsequent expeditions other stations were opened, some of which were closed after the IGY.

The IGY ended, but scientific investigations were continued in the south polar region.

There are now seven Soviet scientific stations in operation in Antarctica: Molodezhnaya, Mirnyy, Novolazarevskaya, Leningradskaya, Bellinsgauzen, Russkaya and Vostok at the South Geomagnetic Pole. Here specialists are making systematic hydrometeorological, geomagnetic and ionospheric observations; studies are being made of auroras, cosmic rays and conditions for radio wave propagation. Rocket sounding of the high layers of the atmosphere is being carried out at Molodezhnaya. The station receives satellite information and regular hydrometeorological information from stations in other countries. Hydrometeorological information is transmitted to international data centers and is used at the Molodezhnaya weather bureau in the south polar region.

Extensive geographical, geophysical and glaciological observations have been made in Antarctica over the course of 25 years. On the basis of Soviet investigations, and also materials from expeditions of other countries, the scientists of the USSR

created a fundamental scientific study -- the two-volume ATLAS ANTARKTIKI (Atlas of Antarctica), the key authors of which were awarded the USSR State Prize.

Then A. F. Treshnikov characterized the most important scientific results obtained by Soviet scientists in Antarctica.

Precise maps of the continent and Antarctic Ocean were compiled, as well as maps of underwater and underice relief. Hundreds of new geographic names appeared on the maps; these honored participants in the Soviet Antarctic expeditions who had perished, scientists who had made a major contribution to the study of the Arctic and Antarctica. Some names honored the leading Russian and Soviet scientists, captains who navigated ships to the shores of Antarctica and Soviet cosmonauts.

Soviet investigators determined the principal features of the bedrock relief. Ranges, mountain systems, plains and valleys were discovered beneath the ice. The Transantarctic Range divides Antarctica into two parts -- eastern and western. It can be considered established that all of Antarctica, together with the shelf, is a unified continent, although the geological structure of the western and eastern parts is different, since their geological history during the last several million years was different.

The principal features of structure of the glacial cover of Antarctica were determined. In some places the thickness of the ice attains 4,000 m. A borehole whose depth attained 1,360 m was drilled at Vostok station. The age of the ice at a depth of 950 m was 46,000 years. An analysis of isotopes of oxygen present in samples of ice indicated that 15,000-10,000 years ago there was a warming of the air by approximately 5° in Antarctica. The same data were obtained by Americans in a borehole at Bard station in Western Antarctica and at the center of Greenland. At this same time the glacier sheets of Europe and America melted. Thus, changes in climate on the earth occurred simultaneously in the northern and southern hemispheres.

A study was made of the ice regime in the Antarctic Ocean, the circulation of its water and ice was described and the water masses of the Antarctic Ocean were investigated. The presence of cyclonic circulations of waters in the coastal zone and in the Antarctic Circumpolar Current causes an upwelling of the waters with the transport of nutrient salts. In these places a rich organic life develops -- phytoplankton and zooplankton -- and the krill and fish associated with them.

A rich underwater world was discovered in the coastal zone of Antarctica. The life of the animals in the coastal zone and in the Antarctic Ocean was studied.

An investigation of the geomagnetic field and the ionosphere made it possible to establish that the structure of the magnetosphere and ionosphere is identical both in the Arctic and in Antarctica; the effect exerted on them by the solar wind and cosmic radiation is manifested simultaneously on the conjugate magnetic lines. The oval of the maximum of auroras was defined and the conditions for the propagation of radio waves in the auroral zone were determined.

In conclusion A. F. Treshnikov discussed the prospects for Antarctic investigations. Stationary hydrometeorological and geophysical observations will be continued at stations, on treks, from air and space. A study will be made of the life of the Antarctic glacier and geological investigations will be made. There is a

need for further clarification of the potential resources of the Antarctic Ocean -- fish and especially krill.

Scientists will study interaction between the Antarctic Ocean, atmosphere and the ice continent for creation of a model of climate and prediction of weather. Studies will be made of magnetic and ionospheric disturbances in connection with solar activity. Background observations will be made of the state of the environment in Antarctica.

Now the 26th expedition has begun its work in Antarctica. Its program is extensive: observations at all seven stations, treks and flights into the deep regions of Antarctica, implementation of the "POLEX-South-81" program in the waters of the Antarctic Ocean on four scientific research ships, geological and geophysical investigations in Western Antarctica, and prediction of weather and ice conditions in the Antarctic Ocean for ships and aircraft.

During recent years about 300 Soviet polar researchers have spent the winter in Antarctica, whereas during the summer season more than 700 persons work there. During the 25 years more than 15,000 persons have visited there.

Ye. I. Tolstikov, deputy chairman of the State Committee on Hydrometeorology and Environmental Monitoring, presented a report on international scientific cooperation in Antarctica.

International cooperation in study of Antarctica, stated the speaker, will serve as an example of how, by the combining of the efforts of scientists of many countries, it is possible to solve in relatively short times complex scientific problems on whose solution a single country would have to spend tens of years. We polar scientists can be proud that due to our fraternal work on the sixth continent an Antarctic Treaty has been signed. It was signed and ratified by all countries participating in Antarctic investigations. The treaty entered into force on 23 June 1961. It was in keeping with the traditions developing during the IGY period: exchange of information on the plans for scientific work, exchange of information on the details of such research, exchange of scientific personnel among expeditions and stations, exchange of observational data and the results of scientific investigations. In accordance with the treaty Antarctica was declared a continent of peace. All kinds of military measures and operations and the storage of atomic production are forbidden here. Antarctica was opened for the implementation of investigations by the scientists of all countries on an equal basis.

In accordance with the treaty there are regular consultative conferences of the representatives of the countries participating in Antarctic research. At these conferences recommendations are adopted which are then approved by the representatives of these countries. For example, recommendations were adopted with respect to problems relating to the exchange of information, telecommunication in Antarctica, tourism, etc. In particular, we should note the recommendation "Coordinated Measures on Preservation of Flora and Fauna on the Sixth Continent." These recommendations proclaim Antarctica as a sort of sanctuary whose nature is being preserved by the polar workers working there.

The Soviet scientists carrying out investigations in Antarctica are in close contact with the scientists of other countries. There are bilateral and multilateral agreements for the Antarctic Ocean. Under the "POLEX-South" program Soviet and

American specialists are studying interaction between the ocean and the atmosphere. The international program "Geophysical Polygon," in which the USSR, Australia and France are participating, has the purpose of studying geomagnetic variations and their relationship to the interplanetary magnetic field. According to the International Glaciological Project, the scientists of the USSR, United States, Australia, France and Great Britain are investigating the past regime of glaciation in Antarctica and also predicting the future of its glacial cover and the ice mass balance.

Over the last 25 years about 110 foreign scientists from 14 countries have worked on our wintering expeditions: from Australia, Great Britain, Argentina, Bulgaria, Hungary, GDR, India, Mongolia, Poland, Romania, United States, France, Czechoslovakia, Japan. Mutual assistance and mutual advantage are the foundation of expeditionary life in Antarctica.

Under the severe conditions of the sixth continent the scientists of different countries are working in harmony, are assisting one another in work and in misfortune. This work is favoring a strengthening of peaceful international scientific cooperation in the south polar region, provided for in the Antarctic treaty.

Then the floor was given to V. A. Yarmolyuk, deputy minister of geology, for a report entitled "Geological-Geophysical Investigations and Mineral Resources of Antarctica." The nature and scales of Soviet geological investigations in Antarctica, stated the speaker, have changed very greatly over the course of the 25 years. During the first years they had primarily a reconnaissance nature, along profiles. Nevertheless, even then Soviet scientists were able to obtain exceptionally interesting geological material, making it possible to form the first (later reinforced) ideas concerning the geological structure of the southern continent and its minerals.

Now geological investigations have a planned character and are directed to a systematic study of the Antarctic subsurface for the purpose of creating a reliable geological basis for evaluating the prospects of finding different minerals in Antarctica. In organizational respects the investigations are usually carried out autonomously, far from permanent stations, with work being done from special temporary field bases. Each year from 150 to 200 specialists participate in such work, making use of helicopters, airplanes, ships, various kinds of land transportation and modern radio communication and navigation equipment.

A noteworthy feature of this work is that it is multisided. Geological investigations of ice-free mountainous sectors are carried out parallely with geophysical studies of ice-covered territories. At the same time, radio echo methods are employed in measuring thickness of the ice cover and areawide aerial geological-geophysical surveys are combined with geophysical measurements made by the landing on the ice of people supplied with the necessary equipment.

Up to 1975 Soviet geologists worked for the most part in the eastern part of Antarctica. Since 1976 investigations have also been made in its western part, including the shelf of the Weddell Sea and the mountains surrounding it.

Then V. A. Yarmolyuk told about the results obtained during 25 years in the principal directions of geological investigations.

The attainments of Soviet geologists have been manifested, in particular, in the field of geological mapping. The materials which they have collected have made it possible to compile and publish a series of original maps (prior to this not prepared by the geologists of other countries) and these have been included in the Atlas of Antarctica and have also been released as individual publications. Products of particularly great scientific importance were: geological map at a scale of 1:5,000,000 (1976), map of metamorphic facies at this same scale (1979) and tectonic map at a scale of 1:10,000,000 (1980).

Soviet investigators also enjoy unquestionable priority in the field of study of the internal structure of the earth's crust within the limits of Antarctica. Deep seismic sounding was carried out, making it possible to detect earlier unknown very extensive rift zones, for the most part hidden beneath a thick ice layer. A multisided interpretation of data from deep seismic sounding and other types of geophysical investigations made it possible to extrapolate the collected information to adjacent areas with a total extent of more than 1.5 million square kilometers.

A substantial contribution was made by geologists and geophysicists to comprehension of the general patterns of development of the earth's crust. Interesting data were obtained on the role of the oceanization processes in the geological development of the Antarctic sector of the earth. Many geologists have come to the conclusion that in the past Antarctica belonged to the supercontinent Gondwana and they have developed ideas concerning the reasons for and mechanism of development and breakdown of this once enormous continent.

In the field of study of mineral resources Soviet geologists have proceeded as pioneers in the largest iron ore basin in the Prince Charles Mountains (Eastern Antarctica), which with respect to its scale can be compared with the universally known Kursk Magnetic Anomaly. A number of shows of polymetals, rock crystal, mica and aluminous raw material in Queen Maud Land, Enderby Land and in some other regions of development of the ancient crystalline basement are known. Areas of interest may be the eastern and southeastern shores of the Weddell Sea, whose geological structure is very similar to the structure of the ancient platform of South Africa. The discovered eruptive breccias of deep alkaline-ultrabasic rocks show that in Eastern Antarctica there are shows of kimberlite magmatism and therefore concentrations of diamonds may be found. In some sectors of development of the platform mantle there have been discoveries of coal.

The folded system of the Transantarctic Mountains in metallogenetic respects can be regarded as promising for lead-zinc, tin, molybdenum and radioactive ores. The folded complexes of Western Antarctica are regarded as a continuation of the Andes metallogenetic province of South America, well known for its copper-molybdenum, pyrite-polymetallic and tin deposits.

Soviet geophysical investigations carried out within the limits of the major intracontinental zones of Antarctica, and also in the Weddell Sea region, indicated a considerable plunging of the basement in these regions and the presence of a rather

thick sedimentary mantle. This is a favorable factor for the formation of petroleum and gas deposits here. The enormous area of the Antarctic shelf is also a positive factor in evaluating the general prospects for finding petroleum and gas in Antarctica. However, in evaluating these prospects it is necessary to weigh carefully the feasibility of carrying out drilling and especially operational work for petroleum and gas and be sure that this work will not result in annihilation of the unique nature of Antarctica.

In conclusion, the speaker, in the name of the Board of the USSR Geology Ministry, thanked the investigators of Antarctica, including geologists and geophysicists, for their self-sacrificing and heroic work.

A report entitled "Biological Resources of Antarctica," was presented by N. P. Kudryavtsev, USSR deputy minister of the fishing industry. It is no exaggeration to state, he noted, that the Antarctic Ocean as a fishing region was discovered and mastered by the Soviet fishing industry. Systematic fishing investigations were initiated here in 1961 when the "Muksun," reconnaissance ship of the Atlantic Scientific Research Institute of Fishing and Oceanography, was sent into the Atlantic sector of the Antarctic Ocean. Between 1964 and the present time investigations have been made in this sector by the "Akademik Knipovich" of the All-Union Scientific Research Institute of Fishing and Oceanography, and in other regions of Antarctica work has been done by scientific research ships of the Pacific Ocean and Sea of Azov-Black Sea Institutes of Fishing and Oceanography and the reconnaissance ships of the USSR Ministry of the Fishing Industry. A total of 127 voyages were made during the period 1961 through 1980. We should also mention the importance of the work carried out by the Arctic and Antarctic Scientific Research Institute, Institute of Oceanology imeni N. N. Shirshov of the USSR Academy of Sciences and expeditions of the State Committee on Hydrometeorology and Environmental Monitoring. The fundamental investigations made have constituted a major contribution to study of Antarctic bioresources. They became the basis for understanding their distribution, laws of migration of schools of fish, magnitude and changes of biological productivity of waters in the Antarctic Ocean.

It has been established that the nature of the bioproductive processes in the waters of the Antarctic Ocean is determined by the totality of atmospheric, oceanological and geomorphological features of this ocean area and also the specific features of fauna -- the organisms living here. A study of these factors made it possible to predict with accuracy the distribution of commercial fish and krill and to organize the work of the fishing fleet which will be effective from the point of view of conservation of bioresources.

The investigations revealed that even now, when by no means all the regions of krill distribution have been fully studied, without lessening its reserves, it is possible to harvest not less than 30 million tons of krill annually. When all the waters of the Antarctic Ocean have been explored, this quantity evidently can be increased to 50 million tons, that is, the krill in Antarctic waters can be produced in a quantity as great as the present-day yield of fish from the entire world ocean.

As demonstrated by Soviet investigations, the reserves of some species of fish are also extremely significant. Fish concentrations have been observed in the area of South Georgia, Kerguelen, Heard Islands, etc.

The formation of concentrations of pelagic fish is directly associated with the development and concentration of highly productive zones of pelagic crustaceans. In these zones there are concentrations of luminescent anchovies, epigonus, maurolikus and other fish. These are entirely new objects of exploitation and their reserves are extremely significant. Work is now proceeding on their study and exploitation. Concentrations of bottom fish live in coastal regions of Antarctica, on the shelf and on some banks: these include different species of Nototenia, banded pickerel and Argentinidae.

Plans call for a further considerable broadening of investigations of the biological resources of the Antarctic Ocean during the 11th Five-Year Plan. The purpose of all these plans is two complex programs -- "Kril'" ("Krill") and "Pelagial'" ("Pelagic Areas"). The work under the "Kril'" program, which will continue the study of biology and krill reserves, will involve a broadening and deepening of technological investigations. Meat is even now being produced from krill; it is a high-quality protein product with a high content of noninterchangeable acids and other elements valuable for nutrition. Preserves are made from this meat which with respect to taste does not differ from canned crab. Positive results have been obtained in the preparation of fodder products from krill. It has been used in making flour for the feeding of poultry and additives to cattle fodder. Krill is also used in producing valuable chemical substances: chitin, chitosan, etc. This complex problem requires further chemical and technological investigations.

Under the "Pelagial'" program plans call for the study and exploitation of commercial concentrations of pelagic fish which are not found near the coast and which live beyond the limits of the 200-mile economic zones.

We, stated the speaker, are being guided by the principle of rational use of bioresources without disruption of their conditions for reproduction in that ecosystem which developed in the waters of the Antarctic Ocean. He congratulated the investigators of Antarctica and wished them further successes.

Then A. P. Aleksandrov proposed that congratulations be sent to the participants of the 25th and 26th expeditions and the crews of ships now in Antarctica on the occasion of the 25th anniversary of work of the Soviet Antarctic Expedition.

The motion picture film "Continent Without Boundaries" was shown at conclusion of the session.

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