

244135

JPRS 83829

6 July 1983

# USSR Report

EARTH SCIENCES

No. 27

19990510 135

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EARTH SCIENCES

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## METEOROLOGY

### PETROSYANTS INTERVIEWED ON RESULTS OF PIGAP PROGRAM

Moscow ZNANIYE-SILA in Russian No 4, Apr 83 pp 6-8

[Interview with M. A. Petrosyants, doctor of geographical sciences, head, Department of Meteorology and Climatology, Moscow State University, by Z. Kanevskiy, ZNANIYE-SILA correspondent: "Lessons of the PIGAP"]

[Text] ZNANIYE-SILA has already more than once dealt with matters relating to the change in climate on our planet and prediction of these changes. And more than once our discussion has been with one of the well-known meteorologists of our country, M. A. Petrosyants, doctor of geographical sciences, head of the Department of Meteorology and Climatology at Moscow State University. Every time, in taking leave from the scientist, we have agreed to return again to the complex and "eternal" problem of structure of the earth's atmosphere. Now, after completion of the PIGAP (GARP) experiment (Program for Investigating Global Atmospheric Processes), we held our next meeting. This conversation was held with our correspondent Z. Kanevskiy.

\*\*\*\*\*

[Question] Mikhail Aramaisovich, you have played the most active role in organizing and implementing the GARP program (our journal discussed this in No 11, 1979) and now you are participating in an analysis of the results. What are the first results of the processing?

[Answer] A hydrometeorological observation system more or less satisfactorily taking in the atmosphere of the entire planet in both its hemispheres was created in 1979 for the first time in human history. It was very complex, including meteorological and aerological networks of stations, 40 or more scientific research ships and several aircraft with automatic observation systems aboard, drifting buoys scattered over the entire surface of the Antarctic Ocean, research balloons drifting together with air currents and constantly operating polar orbital satellites, as well as five geostationary satellites seemingly "suspended" around the equator... If the "science of 1979" was distributed uniformly over the earth's area, we would find that there was a minimum of 1 measurement per day (with 2, 3, 4 being far more common) per area of 500 x 500 km.

A gigantic volume of material was collected, its processing is far from completed, but we can already draw some interesting conclusions.

First of all, the importance of hydrometeorological information itself is becoming clearer. Its role is manifested particularly clearly in the example of the southern hemisphere, where, as is well known, there are considerably fewer observation points than in the northern hemisphere.

Meteorologists are using the equations of hydrothermodynamics for describing atmospheric movements. Mathematical modeling has penetrated into the very heart of our science and has become the basis for weather forecasting. However, it must always be remembered that meteorologists deal with atmospheric movements of the most different scales, both temporal and spatial, and the entire diversity of atmospheric movements cannot be described by any one single system of equations.

Thus, before the global experiment, but also after it, numerical forecasting of the intensity and position of pressure fields, that is, air pressure fields, was satisfactory for two days for the southern hemisphere, no more. However, when information began to be received from the front of the global experiment with its branched observation network it was found that the very same mathematical models make it possible to give an adequately reliable forecast for an entire five days in advance! Here you also have an answer to the sacramental phrase: "Weathermen always grumble if they lack information." Indeed, there was not enough information, the experiment confirmed this truth beyond doubt. Fragmentary data and the forecast was realistic for only two days in advance. Abundant information and you have the long-awaited, wished-for forecast for five days in advance! (I note that the density of measurements during the time of the experiment nevertheless obviously remained inadequate. Atmospheric phenomena propagating over an area of less than 500 x 500 km were missed and escaped the attention of meteorologists, like a tiny fish slipping through a net designed for large fish.)

In addition, the First Global Experiment discovered an extremely intensive air circulation in the upper troposphere of the tropical zone, at an altitude of 10-12 km. It was found that in winter there is an active transport of air across the equator there, from one hemisphere to another. This phenomenon was discovered for the first time; earlier only timid assumptions had been advanced. And it speaks for itself that if we strive to comprehend the behavior of the atmosphere over a long period of time it is impossible to limit ourselves to the hemisphere in which some process is transpiring; the entire earth must be considered. When an attempt was made to exclude one hemisphere from consideration the forecast for the other worsened considerably.

[Question] It is not entirely clear about the air transport at great altitudes. It is customary to think that everything is stable there, at least that the temperature is uniform. When you are flying in a large aircraft you usually hear the voice of the stewardess: "The temperature outside is -40°," be it summer or winter. Please clarify.

[Answer] No, this is only an apparent stability. In the northern latitudes the transitional layer between the troposphere and stratosphere, called the tropopause, is situated lower and accordingly, the stratosphere begins lower, from

8-10 km. Accordingly, in the polar latitudes the stratosphere is warmer than in the tropics; its temperature is about  $-48^{\circ}$ . In the tropical latitudes, however, there is an exceedingly powerful convective air exchange and the thickness of the troposphere there attains 16-17 km; the temperature at this altitude is already  $-70^{\circ}$  (indeed, as is well known, the temperature in the troposphere decreases with altitude).

At first glance the picture is paradoxical: over the equator and tropics there is an extremely low-temperature region, over the temperate latitudes the stratosphere is warmer, whereas over the Arctic in summer it is still warmer! Without question, in the stratosphere the temperatures are not so variable as at the earth's surface, but in the course of the year they obviously change. The air masses in this case flow from one hemisphere to the other at great altitudes and each of these masses has its particular density and other characteristic properties. It is found that at great altitudes relatively warm air is transported from the polar regions toward the equator and cold air is transported in the opposite direction.

All the changes transpiring in the atmosphere are rather small in amplitude and the variations of the meteorological elements are relatively small. For example, pressure variations at the earth's surface do not exceed 200 mb. If the seasonal drops are considered, they fall in the range of only 50-80 mb, whereas the diurnal changes in pressure values, directly related to weather changes, fit completely within the limits 10-15 mb. Relative to the pressure value itself, these changes are but a very small fraction, but the meteorologist must be able to detect and predict them! But we have evidently got off the subject. In today's discussion we did not want to go into the business of forecasting.

[Question] Yes, we wanted to talk exclusively about the PIGAP. However, there is no way to get away from the word "forecast." Indeed, the First Global Experiment itself was directly tied in to the problem of improving the weather forecasting method. Therefore, my next question is specifically this; precisely what did synoptic meteorology gain from the investigations of 1979?

[Answer] One of the most important tasks of PIGAP was the creation of reliable methods for so-called intermediate-range forecasting. Accordingly, it was also planned to use the equations of hydrodynamics to give computations of the principal parameters for one or two weeks in advance. As a result of the experiments it was found that in definite situations it is possible to give a successful forecast for ten days in advance. On the average, however, it is for five or six days in advance. Prior to the experiment a successful forecast was given for not more than four days in advance. In the course of the experiment, as you see, for six and even ten days. This is a definite victory, because now each percent of probable success of a forecast is literally increasing in a geometrical progression.

It must not be forgotten that this success of the First Global Experiment was possible only with that volume of information which was ensured by the scale of the observations of 1979. Now the system, as we say, has been degraded: the aircraft have been flown away, the research ships have departed, a number of other components of the global observation network have not been maintained and meteorologists have returned to a modest figure: a successful forecast

with an advance time of five days. For the time being this is the limit. But if at any time the entire global observation system is restored the possibilities are again increased.

[Question] In the Arctic, at Dikson, only one experimental weatherman was at work several decades ago. He contrived (pardon, another word not to pick up) with an accuracy to almost a quarter hour to predict the appearance of a fog and the onset of a blizzard. This was a truly high art, based, it goes without saying, on a solid and rigorous knowledge of theory, the local characteristics of weather and the specific indicators of its appearance. An invaluable gift! But the weatherman himself admitted that if he was sent to another region with whose environment he was unfamiliar his forecasts would be far less successful. And here I would like to ask a question: should not the system of observations themselves be reexamined, should not the parameters remaining in the shadow be given particular attention, is it impossible to dispense with something?

[Answer] The PIGAP program answered this question. Scientists compared the traditional complex observation system with a system consisting only of surface stations measuring only air pressure and space vehicles providing all the remaining meteorological parameters. And it was found that the forecast obtained using the space system was poorer than when using an integrated system including surface, aerological and space observation systems.

In order to make it clearer why we do not depend solely on meteorological satellites, I will cite one example. A photograph from such a satellite is received for each specific region of the earth only once a day. It is clear that the surface meteorologist absolutely would not be content with such a "frequency." Some experiments gave an unexpected result. It was found that in the northern hemisphere, where there are many surface observation stations, satellite data introduce a relatively modest contribution to improvement in the quality of forecasts. In the southern hemisphere the picture, as we have seen, is different. Hence the conclusion: the observation system must be integrated, that is, consist of meteorological stations, aerological stations with launchings of radiosondes and a meteorological satellite service; this is the fundamental of fundamentals, departure from which in no way is justifiable. The observation method remains as before.

[Question] Professor Sergey Petrovich Khromov, an outstanding expert in meteorology, many years ago heading the Department of Meteorology and Climatology in the Geography Faculty of Moscow State University, gave very great importance to the study of cloud cover, regarding a knowledge of the life of clouds to be the alpha and omega of synoptic meteorology. With one and the same type of cloud cover the rain can either pour down or not occur at all! Can we say correctly that recently more has been learned concerning the physical chemistry of the atmosphere and clouds in particular?

[Answer] In actuality, cloud cover is the key regulator of weather and climatic changes. Clouds are diverse and frequently by unpredictable means intervene in the heat balance of the planet. Meteorologists understand this and are striving to take them into account. The network of special actinometric stations

making observations of direct, scattered, total, reflected solar radiation, the number of hours of sunshine and radiation and heat balances is growing. Automatic equipment is being introduced making it possible to register data around-the-clock and year-round. Actinometric stations register the real expenditures and receipts of heat directly related to clouds: their presence or absence. We are able to identify the type of cloud cover, to determine the form and altitude of the lower boundary of clouds (a special instrument, the IVO, cloud cover altitude measuring system, has been developed).

Many institutes are involved in study of atmospheric physics and chemistry. True, for the time being there has been a predominance of studies related to atmospheric chemistry, to the nature of small admixtures. However, investigations are also being made of microphysical processes in clouds: condensation, formation and fusion of droplets and evaporation in clouds (such work is being carried out at the Central Aerological Observatory at Dolgoprudnyy near Moscow, at the Institute of Experimental Meteorology at Obninsk, at the Ukrainian Scientific Research Institute of the State Committee on Hydrometeorology at Kiev and elsewhere). Microphysical processes in clouds are quite complex and for the time being are not taken into account explicitly in prognostic schemes.

When we observe a cloud we can say roughly whether it is a water or crystal-line cloud, but for the time being all this is visual, there is no routine information on the microphysical structure of clouds yet available to us other than from radar images which are becoming accessible 1-2 hours prior to the falling of precipitation and give incomplete information on the "microphysics" of clouds. But a forecast must be given. Here we "substitute" for the true properties of very specific clouds some mean properties of different types of clouds. It is understandable that meteorologists cannot always be in the clouds. The cloud thickness is now sounded from aboard special aircraft laboratories only for research purposes. It need only be added that as long as we miss information from "up top" the rain will fall. Or it will not fall, recalling the words of Sergey Petrovich Khromov!

[Question] Will the PIGAP experiment be continued?

[Answer] Formally work under the PIGAP program has been completed. It is being replaced by the new World Climate Program. It includes both the investigation of climate and the formulation of its theory, as well as allowance for the influence exerted on it by human activity. It is necessary to learn to predict changes in the meteorological regime from year to year, and this in essence is the same as the problem of long-range weather forecasting. In our country all such problems are dealt with by the State Committee on Hydrometeorology and Environmental Monitoring and the Academy of Sciences. All the work is coordinated by the State Committee on Science and Technology. Its chairman is Academician G. I. Marchuk, who has long worked in the field of theoretical meteorology. He advanced the idea of a special "responsibility" of the world ocean for the dynamics of climate. The program, given the conventional name "Razrezy" (Cross-Sections), involves multiyear observations in those regions of the ocean where there are energy-active zones, that is, where there is the most energetic exchange of heat between sea water and air. Now several such zones have been found in the Atlantic and one in the Pacific Ocean, the region

of the Bermuda Triangle, the Gulf Stream and Kuroshio.

We know a great deal about the atmosphere. And this knowledge shows us that to comprehend the life of the atmosphere is immeasurably more complex, for example, than to precompute the position of planets in the solar system. When you deal with the moon, for instance, you must take into account the force of attraction of the moon by the earth, the centrifugal force of the moon and to some degree the perturbing influence of the sun and Jupiter. These bodies can be considered with great accuracy as real material points. And this is all that there is to it. However, when you consider the atmosphere, and the relevant parameters, you also come up against what at first glance seems to be an extremely small number of factors: the force of the pressure gradient (that is, the drop of atmospheric pressure), Coriolis force (the deflecting force of the earth's rotation)... But these forces are operative in a liquid medium, in the air, in the ocean, and here all possible turbulent stresses arise; enormous transports of heat and moisture arise which lead to a marked change in the pressure field. At the same time, atmospheric movements occur over the earth's real surface with its infinitely diverse relief. Accordingly, the problem of precomputing atmospheric movements is immeasurably more complex.

Nevertheless, the overall picture is not so gloomy. General planetary investigations have been made within the framework of the PIGAP, yielding much which is useful and instructive. New studies are beginning from which we expect much. Mathematics and computers have entered solidly into everyday life of both theoretical meteorologists and practical weathermen. Short-range forecasting is quite satisfactory for today: 85-88% probable success for one-two days in advance. It is particularly important that forecasts of dangerous phenomena have justified themselves very well. The results of prediction of the temperature background for five and even ten days in advance are acceptable. The situation is worse with monthly forecasts, which are exceedingly necessary, but at the same time methodologically most difficult. In our day a monthly forecast has a probable success of 65%, in other words, of each 10 predictions three or four are incorrect. Is this a lot or a little?

Probably each branch of the national economy must determine the strategy for use of the meteorological information. National planning agencies sooner or later must formulate something similar to a "bill of fare": determine in advance, taking into account a quite prolonged period in the past, what is more advantageous: trust the forecast, and in case of failure of the weathermen, to bear definite losses or ignore predictions and rely on mean long-term values and also bear definite losses when these means differ sharply from the observed conditions. This could be called "business-like relationships" with the weather.

The PIGAP is completed. Also being completed is the processing of the data obtained as a result of this global international experiment. Work on study of the most complex of the earth's envelopes -- the atmosphere -- is continuing within the framework of the new World Climate Program. It will eventually lead to new discoveries; other possibilities will appear for predicting the earth's weather and climate.

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BOUNDARIES OF EARTH'S CLIMATIC ZONES

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian  
No 2, Mar-Apr 83 (manuscript received 14 May 82) pp 18-25

VITVITSKIY, G. N., Geography Institute, USSR Academy of Sciences

[Abstract] In 1975 the author, in IZV. AN SSSR: SER. GEOGRAF., No 5, p 27, 1975, proposed global boundaries of the earth's climatic zones on the basis of radiation and circulation criteria. In this new article the boundaries are refined using the mean latitudinal air pressure and temperature values at sea level, total cloud cover and precipitation. In mapping the climatic zones more precise data on the precipitation field in the tropics and air temperature outside the tropics have been used. Figure 1 is a full-page map of the newly drawn climatic boundaries. In each hemisphere there are four latitude zones with different seasonal and annual radiation balance values for the earth-atmosphere system and in each hemisphere there are six circulation zones. Although the latitudinal boundaries of the radiation and circulation zones do not match, they provide basic information for determining the latitudinal boundaries of the climatic zones. The latitudinally averaged values of a number of climatic indices are used in bringing these into consistency. Seven zones are defined, equatorial, tropical, Trade Winds, subtropical, temperate, subpolar and polar, and the distinguishing characteristics of each are outlined. The boundaries of the climatic zones, naturally, do not everywhere correspond to the mean latitudes, but are dependent on inhomogeneity of the earth's surface. Figures 1; references 12: 9 Russian, 3 Western.  
[128-5303]

## CYCLIC NATURE OF DEVELOPMENT OF PLANETARY HYDROMETEOROLOGICAL PROCESSES

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian  
No 2, Mar-Apr 83 (manuscript received 6 Oct 82) pp 5-17

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[Abstract] The author generalizes investigations of Soviet scientists made over a period of years in validating the cyclic (aperiodic) nature of development of hydrometeorological processes. Synoptic, seasonal, annual and multi-year cycles are defined and discussed. With respect to synoptic cycles, all the synoptic conditions in the extratropical latitudes of the northern hemisphere fit into 13 types of elementary circulation mechanisms. The frequency of occurrence of the different elementary circulation mechanisms and their duration determine atmospheric circulation and the nature of weather not only of individual seasons and years, but also climate as a whole. The duration of these processes varies from 2 to 10 days, most being 3-5 days. During this time a very definite direction in the development of synoptic processes is observed. Then there is a complete restructuring of processes which results in the formation of a different type of atmospheric circulation. In the arctic seas there are seven types of elementary processes with a definite complex of hydrophysical conditions, including circulation of waters and thermohaline fields, nature and movement of the ice cover and level variations. The formation of each type is associated with definite meteorological conditions. With respect of seasonal cycles, in their investigation it is particularly important to determine the beginning, end and duration of natural meteorological and hydrophysical seasons, the phases of their development, amplitude and nature of variations (annual and semi-annual waves). The classification of atmospheric synoptic processes made it possible to detect a dependence between elementary and seasonal planetary cycles. The principal features of the synoptic seasons are determined by the frequency of recurrence and sequence of change of elementary cycles. There are 10 generalized seasonal schemes of atmospheric circulation in the northern hemisphere. The seasonal cycles in the oceanosphere differ substantially from those characteristic of the atmosphere with respect to both phases of development and their total duration. With respect to annual cycles, the spatial scales are determined by the meridional extent of the natural zones and the specifics of development of hydrometeorological processes in their individual parts. Each successive annual cycle is formed on a different quantitative basis of the preceding annual cycle. This determines the qualitative character (intensity and nature of development) of the new annual cycle. This explains the year-to-year variability of natural conditions. All this has been confirmed, for example, by a classification of annual cycles of hydrometeorological processes developed for Soviet arctic seas. With respect to multiyear cycles, there are three such cycles which can be called circulatory or climatic epochs. It appears that there is a meridional cycle with a duration of about 20 years and a zonal cycle with a duration of about 35 years. Figures 4; references: 10 Russian.  
[128-5303]

## NUMERICAL MODELING OF INFLUENCE OF THERMALS ON CUMULUS CLOUD DEVELOPMENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 5 Oct 81) pp 274-281

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[Abstract] The authors obtain a numerical solution of the equations of thermo-dynamics with a variable turbulence coefficient for carrying out an investigation of different cumulus cloud regime when there is a conditionally stable stratification above the layer of accumulation of thermal energy. More than 60 numerical experiment with different periods of appearance of individual thermals were carried out. The results are illustrated in Figures 1 and 2, revealing the influence of individual successive thermals on the development of a convective cloud. Figure 1 shows the change in the Stokes stream function with time, this making it possible to trace the development of eddy structures and the cumulus cloud under the influence of successive thermals. It is shown that a cloud (with the stipulated parameters) develops in the following way. Due to additional impulses there is a further ascent of air and intensive heat release due to phase transitions. The dimensions of the cloud increase because the heat of phase transitions favors the cloud growth and the upper boundary rises. At the same time a descending flow appears in the lower part of the cloud. In this place the cloud begins to evaporate and the lower boundary rises. In the mature stage of cloud development a descending flow appears over it in which the vertical velocity is directed downward, this later facilitating cloud destruction. The temperature deviations from the background level in the upper and lower parts of the cloud are usually negative. The negative temperature deviations in the upper part are possibly attributable to intensive mixing of the cloud with the surrounding medium. In the lower part of the cloud the negative temperature deviations are attributable to the fact that the thermals continue to move upward by inertia, cooling in the process. The numerical experiments described here indicate that the influence of individual successive thermals is manifested both in an increase in the lifetime and size of the cloud and the appearance of new characteristic features of cloud development, such as the formation in the cloud of several spatial eddy structures and a bimodal distribution of liquid-water content with altitude. The computations reveal an essentially inertial character of convective movements. Figures 2; references 14: 12 Russian, 2 Western.  
[120-5303]

## OCEANOGRAPHY

### FIRST CRUISE OF NEW RESEARCH SHIP 'SHOKAL'SKIY'

Moscow PRAVDA in Russian 27 Apr 83 p 6

[Article by N. Bratchikov, PRAVDA correspondent, Vladivostok]

[Text] The fleet of the Far Eastern Scientific Research Institute of the USSR State Committee on Hydrometeorology and Environmental Monitoring has been supplemented by a new scientific ship. Several days ago the "Shokal'skiy," after overcoming three oceans, arrived from Leningrad in the bay of Leningrad, the Zolotoy Rog. Here it was not to remain tied up to the wharf for a long time. The "Shokal'skiy" set sail for the Pacific Ocean.

We stroll with A. Rumyantsev, head of the oceanological detachment, on the deck. Alongside -- side-to-side -- rises the giant of the scientific fleet of our country, the "Akademik Korolev." In comparison with it the "Shokal'skiy" looks like a baby. Here, in the city bay, it tosses considerably. And what, I think, will it be in the open sea, especially if the scientists encounter severe meteorological conditions. I discuss this with my companion. Aleksandr Yevgen'yevich smiles:

"The saying goes: 'Good things come in small packages.' And that's how it is with the 'Shokal'skiy.' The vessel is loaded with automated equipment and computers."

The oceanographic laboratory is connected to the hydrochemical laboratory. The oceanographers get their material using bathometer-probes lowered to a depth as great as 2,100 m. The chemists scrupulously investigate this material. A. Rumyantsev has eight people under him. Senior engineer M. Oleynikov bears the responsibility for all the hydrophysical characteristics. Studies are made of water temperature, salinity, density and heat conductivity. V. Menovshchikov watches over the instruments.

The people here are experienced. Each specialist has tens of voyages behind him. But not all is the same at sea: the meteorologists, in contrast to other investigators, spend nine months a year at sea and only three on shore. While there they must carry out and summarize their scientific observations and then have their time off. And then, again to their ship. Seasoned seamen and others treat the scientists with respect and consider them "their buddies": a storm rages and the scientists remain on deck.

The chemists do their work sitting down. They are busy with their test tubes and flasks. But aboard the "Shokal'skiy" the style of their research work has changed radically. M. Gorelkin, head of the hydrochemical detachment, pushing a side door, invites us into the laboratory.

The little room is packed with instruments, you can hardly turn around. There is no one here and no one is necessary. A single operator can handle all the analyses. The heart of the laboratory is an automatic chemical analyzer, such as exists on no other scientific research ships in the Far East.

Mikhail Ivanovich pours sea water into transparent capsules only a bit bigger than a thimble. They are placed on a rotating disk. It is sufficient to press the "start" button and the process of investigating the elements begins automatically. The first test tube is opened and in a very thin stream the sea water flows into different blocks for determining the content of phosphorus, silicon and other substances. The automatic recorder and the laboratory computer are cut in automatically. Two records are made simultaneously, graphic and digital. A comparison makes it possible to confirm the absolute accuracy of the data. All the indices from the instruments are fed into the central shipboard computation center. It is connected with other laboratory computers--oceanological, meteorological, aerological.

"Does the new voyage differ in any way from traditional investigations?" I ask A. Dunayev, deputy captain for scientific affairs.

"We must obtain an evaluation of the present-day status of these waters -- their changes under the influence of hydrometeorological factors. Then it will be necessary to investigate the peculiarities of the spatial structure of hydrophysical and hydrochemical fields, their characteristics as a function of season. In the northwestern part of the Pacific Ocean it is necessary to clarify the principal patterns of macroscale interaction between the water and the atmosphere..."

What is it that attracts Far Eastern meteorologists to the zone where the "Shokal'skiy" will make tens of runs? The warm current, the Kuroshio, has its genesis here. It participates in the formation of climate over an extensive Far Eastern territory of our country. According to recent concepts, the Kuroshio is not simply an oceanic river, transporting enormous masses of warm water. The current consists of different eddies which are not easily studied. Permanent scientific meteorological posts in the ocean will make it possible to draw conclusions concerning long-range weather changes. The investigations will also make it possible to compile a map of the biological productivity of seas in the Far East.

5303

CSO: 1865/143

## AUTOMATION OF HYDROPHYSICAL RESEARCH

Kiev VISNYK AKADEMIYI NAUK UKRAYINS'KOYI RSR in Ukrainian No 3,  
Mar 83 pp 63-68

[Article by B.O. Helyepo, academician, Academy of Sciences UkSSR and  
H.V. Smyrnov, candidate of technical sciences.]

[Text] The expansion of world ocean experimental research with utilization of new measuring equipment and systems made substantial changes in our concepts about the character of hydrophysical field variability in the wide spectrum of their space-time scale. Because of the importance of these processes in the climate formation of our planet there is an urgent need for a further development of the experimental basis, preparation of new methods for experiment fulfillment and the automation of information received.

To evaluate the automation level of hydrophysical research we will study table 1 giving data on metrological characteristics of individual measuring channels obtained at the Marine Hydrophysical Institute, Academy of Sciences UkSSR and other institutions of a similar nature in our country and abroad (USA, FRG).<sup>1</sup> We can see that in most parameters the instruments developed at MHI are comparable to better local and foreign samples and, in a number of instances, are even of higher quality. Yet, the information cited allows for an evaluation of oceanographic instrument building from somewhat outdated positions without consideration of new goals and requirements.<sup>2-4</sup> For research fulfillment today in any area of the space-time variability range material on accompanying background characteristics is essential. This requires that measuring be done simultaneously with several instruments which should provide information corresponding in time of realization recording, discreteness of measuring channel inquiry and metrologic characteristics, that is create a system of experiment automation.

In utilizing such a system information on the process researched or the essential, most simple analysis of experimental material must be received operatively.

Large measuring systems are expensive and may be unnecessary if in the research process the program and observation methods are modified

Table 1. Comparative characteristics of hydrophysical means of measuring produced by MHI AN UkSSR and other institutions in our country and abroad.

Parameter measured	Characteristic of measuring channel	Indices achieved		Other organizations	
		MGI, AN UkSSR		in USSR	Abroad
Температура, град. С 1 (-2...+35)	Чутливість, град. С/од. 9 Нестабільність, град. С/рік 10 Інерційність, С 11	5.10 <sup>-4</sup> ... 2.5.10 <sup>-3</sup> 0,01 ... 0,04 0,04		5.10 <sup>-4</sup> ... 7.10 <sup>-3</sup> (Ю) 0,01 ... 0,04 (НВО «Термоприлад») 0,03 ... 0,5 (НВО «Термоприлад»)	5.10 <sup>-4</sup> (NBIS, США) 1.10 <sup>-4</sup> (SBE, США) 0,006 (NBIS, США) 0,03 (NBIS, США)
Питома електропровідність, 2 см/м (0 ... 6,5)	Чутливість, см/м од. 9 Нестабільність, см/м рік 10 Просторове розрізнення, см 12	(1...2,5)·10 <sup>-4</sup> (1...5)·10 <sup>-3</sup> 0,5...0,7		(7...12)·10 <sup>-4</sup> (Ю, СКБГМП) 0,5 (ВНДИМ) 7...10 (Ю, СКБГМП)	1.10 <sup>-4</sup> (NBIS, США) 0,1.10 <sup>-4</sup> (SBE, США) 1.10 <sup>-3</sup> (NBIS, США) 0,8 (NBIS, США)
Тиск, кГ/см <sup>2</sup> (0 ... 600) 3	Чутливість, проц./од. 9 Нестабільність, проц./рік 10	1.10 <sup>-2</sup> 0,15...0,5		2,5.10 <sup>-2</sup> 0,15...0,5	0,15.10 <sup>-2</sup> (NBIS, США) 0,2 (NBIS, США)
Швидкість поширення звуку, м/С (1400...1600) 4	Чутливість, м/С од. 9 Нестабільність, м/С рік 10	(0,5...1,5)·10 <sup>-2</sup> 0,5		—	1,5.10 <sup>-2</sup> (МЕ, ФРН) 0,08 (МЕ, ФРН)
Швидкість течії, см/С (0 ... 140) 5	Чутливість, см/С од. 9 Нестабільність, см/С рік 10	0,04...1,5 1,5...4,5		1,0 (ААНДИ, СКБГМП) 5,0 (ААНДИ, СКБГМП)	0,1 (NBIS, США)
Показник ослаблення прямогоного світла, м <sup>-1</sup> (0,04...0,8) 6	Чутливість, м <sup>-1</sup> од. 9 Нестабільність, м <sup>-1</sup> рік 10	0,04 0,05		0,004 (Ф) 0,05 (Ф)	0,0012 (МЕ, ФРН) 0,03 (МЕ, ФРН)
Освітленість, люксів (10 <sup>-3</sup> ... 10 <sup>-4</sup> ) 7	Чутливість, люкс/од. 9 Нестабільність, проц./рік 10	0,0001 ... 100 10		10 (Ю) 20.10 <sup>-5</sup> (ІнБПМ) 5 (ІнБПМ)	10 (Тейлор, США)
Біолюмінесцентний потенціал, мквт/см (2.10 <sup>-4</sup> ... 2.10 <sup>-3</sup> ) 8	Чутливість, мквт/см од. 9 Нестабільність, проц./рік 10	8.10 <sup>-5</sup> 5			

Note: Abbreviations used in table -- Ю - Institute of Oceanology, AN USSR; SKBHMP - Special Design Bureau for Hydrometeorologic Equipment (Moscow); VNDIM - All Union Scientific Research Institute of Metrology (Leningrad); AANDI - Arctic and Antarctic NDI USSR State Hydrometeorology Committee (Leningrad); IF - Physics Institute AN BRSSR; ІНБПМ - Institute of Biology of Northern Seas AN UkSSR.  
KEY: 1. Temperature 2. Specific electric conductivity 3. Pressure 4. Speed of sound dispersion 5. Current speed 6. Direct light weakening index 7. Illumination, lux 8. Bioluminescence potential 9. Sensitivity 10. Lack of stability 11. Inertia 12. Space differentiation

but the system created cannot provide the modified experiment.

A conclusion follows: modular type measuring systems should be designed permitting component change and providing for changes in system technical characteristics through programming moderate measuring channel inquiries, numbers of inquiry channels; category of information received, state of its primary treatment in the process of experiment fulfillment.

This concept was at the foundation of work in automation of experimental research at the Marine Hydrophysical Institute, AS UkSSR. A requirement for the solution of the given task was an analysis of the whole spectrum of physics tasks, discovery of the most informative parameters of environmental variability and a determination of basic technical requirements for measuring channels.

Table 2 gives some informative environment parameters utilized widely in experimental research in various ranges of space-time ocean variability. Of course, the whole spectrum of possible measuring parameters cannot be cited here, therefore, the table shows only the approach principle in system construction.

The second aspect which determined basic directions for hydrophysical research automation was the preparation of a general scheme of hydrophysical parameter modular measuring system (Fig. 1).

To develop a typical measuring system or an aggregated unit in the complex production quality management system, enterprise standards were created and introduced regulating these parameters: functional completeness (providing for measuring and signal treatment); structural completeness (providing for a synthesis of various systems, on which specific task solution is dependent); parameter completeness (system construction according to given criteria).

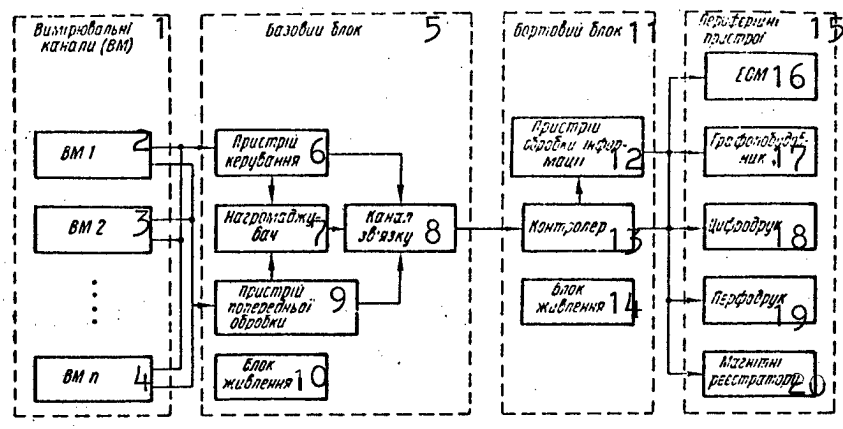


Figure 1. Diagram of typical modular measuring system.

Key: 1. measuring channels (MC) 2. MC 1 3. MC 2 4. MC n  
 5. base bloc 6. steering device 7. accumulator  
 8. connection channel 9. prior treatment device 10. feeding bloc  
 11. board bloc 12. information processing device  
 13. control 14. feeding bloc 15. peripheral attachments  
 16. EOM 17. graph builder 18. code print 19. perforated print  
 20. magnetic registers.

Problem solution, then, followed in four directions:

1. Planning of primary hydrophysical parameter measuring transformers. In the measuring system structure the attachments noted have supposedly a beginning position serving as the immediate connection between the parameter measured and the measuring system, affecting the characteristics of the latter, its "individuality" considerably.

Table 2. Some environment information parameters in experimental research in various ranges of space-time ocean variability.

Research Direction	Parameters Measured								
	t	x	p	v	φ	σ	t'	x'	v'
Thin structure	x	x	x			x			
Turbulence					x		x	x	x
Short-period internal waves	x	x	x	x	x	x	x	x	x
Internal waves of tidal and passive periods	x	x	x	x	x	x			
Synoptic variability	x	x	x	x	x	x			
Seasonal	x	x	x	x	x	x			
Semiannual	x	x	x	x	x	x			

Primary measuring transformers, now utilized in oceanic apparatus, are noted for substantial variety both as to work principles and design. There is wide use of analogue, numeral and frequency transformers in which design takes into account high pressure, thermal strokes, marked accelerations and vibrations and the aggressiveness of measured environment.

The solution of numerous research tasks calls for transformers which would measure small scale, quickly changing processes. This is often combined with requirements for high sensitivity. A decisive meaning here is acquired by such parameters of primary measure transformers as quick action, degree of space variation, minimal scale of measured local dissimilarities, minimal distortions in the picture of parameter division. The final requirement is that regardless of type of measure transformer and its physical action principle, there exists a characteristic common to all contact transformers -- invasion of area researched and a disturbance of the previously existing picture of measuring parameter field division.

This source of systematic errors is not the only one for the measuring complex in general, however, it often determines border differentiation capability of econographic equipment.

Thus the solution of these tasks during instrument design provided an opportunity to work out parameter rows of primary measuring transformers constructing them so that they are utilized as units in composing modular systems.

2. Design and unification of measuring transformers and systems of information transfer into a board attachment, in fact, the creation of a unified measuring channel module.

Basic requirements for measuring transformers were determined by the following factors: the type of change of measured parameter at the entry of measuring transformer; required accuracy and differentiation capability determined on the basis of conditions resulting from physical tasks; form of information transfer which depends on task conditions; and operation conditions.

The measured parameter variability range requirements were considered in solving the above problems. Also taken into account were thermal strokes, vibration load, observation length, the level of present element basis, convenience and ease of measuring transformer contact with sensitive elements and recording equipment.

In addition, an important task in modular design of measuring systems is creating a universal contact channel able to transfer a maximal extent of information.

A number of unified measuring transformers were created strictly in accordance with the general ideology of modular design measuring systems and provide the following types of analogue-numeral attachments: direct conversion of interval into code, direct conversion of frequency into code, integrating, balancing conversion, post-discharge balancing, and monitoring.

3. Designing unified board attachments. An analysis of needs from hydrophysical systems showed that to provide for modernization and system development founded on modular design the most promising are board attachments based on microprocessors and micro-EOM. A micro-processor should receive, convert and introduce information into base (ship) EOM.

Use of microprocessors and micro-EOMs allows for the creation of a flexible measuring system. It collects data from various, almost unlimited, sources, processing and retrieving on request on recording attachments and EOM, doing also self-calibration and adjustment of individual measuring devices.

Microprocessors and micro-EOMs built into a board attachment provided an opportunity to expand the functional possibilities of the equip-

ment without increasing its cost too much; increasing measuring accuracy thanks to automatic inclusion of calibration results, exclusion of systematic error with consideration of destabilizing factors and non-linear sources; also increasing equipment flexibility because of the possible work regime programming. A bloc-diagram of board attachment for microprocessor and micro-EOM is given in Figure 2.

A modular system of construction provides an opportunity to compose systems with any type of given functions. The whole bloc composition is put together in the form of constructionally and functionally complete units.

4. Designing a unified construction of submerged measuring complex attachments. The following was considered in designing them: hydrostatic pressure, cyclic signal-changing temperature action and surrounding environment aggressiveness regarding attachment body material.

The factors noted have a decisive influence on body construction in general and on its components (containers, caps, condensation units, etc.) and also on material selection. In addition, body construction is greatly dependent on measuring purpose, the type of primary transformers and their use.

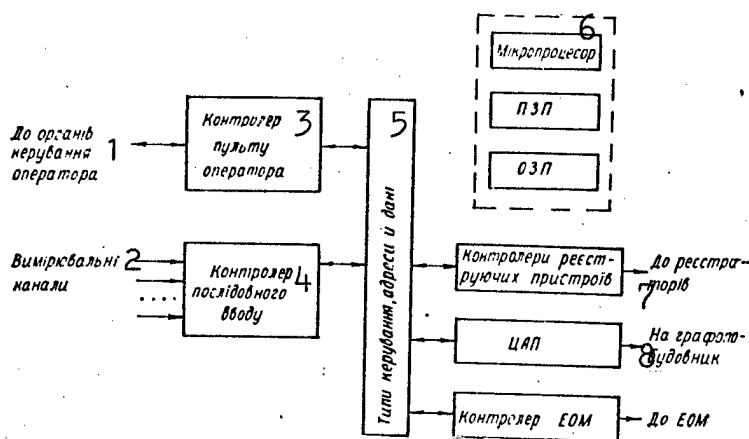


Figure 2. Bloc diagram of board attachment.

Key:

1. To operator direction devices 2. Measuring channels 3. Operator control panel 4. Serial input control 5. Types of direction, addresses and data 6. Microprocessor 7. Recording attachment controls - to recorders 8. To graph construction

At present a unification has been done on some of the utilized materials, their standard sizes, fitting places of primary measuring transformers, cable lead-ins, internal diameters, types of chassis, etc. In solving these tasks optimal container dimensions were

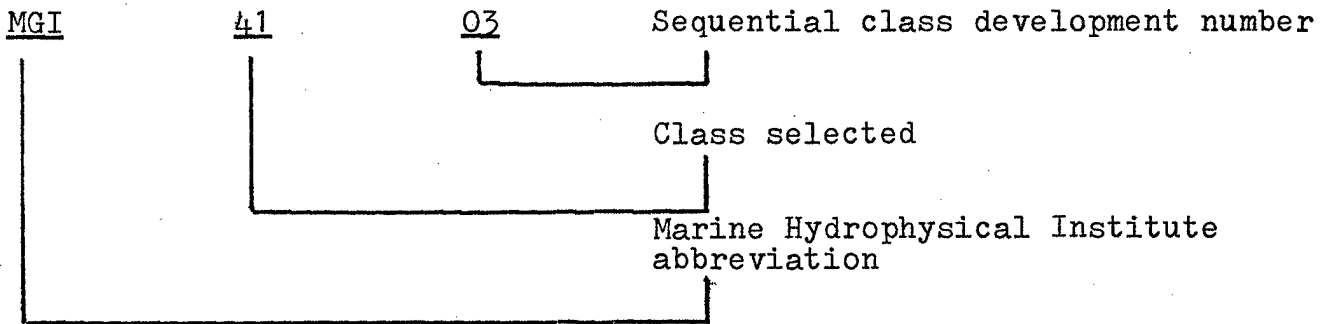
determined both from the point of a rational wire diagram placement, as well as optimal hydrostatic pressure. Material is selected on the basis of cost, labor expenditure, operational convenience, corrosion stability and high mechanical characteristics.

The introduction of modular design measuring systems at MHI, Academy of Sciences, UkSSR permitted the establishment of a single system of product naming and coding. Product names are short and contain their most significant functional and operational characteristics. Product codes are formed according to classification signs and are composed of three letters and four numbers: MGI -- abbreviation (Russian language) for Marine Hydrophysical Institute. The first two numbers indicate production class (first-group number, second-number of oceanographic measuring system type), third and fourth numbers are sequential within the class.

There are ten groups in the classification of oceanographic measuring systems according to assignment and branch application: 1- hydrologic; 2- hydrooptic; 3- hydrochemical; 4- hydrophysical; 5- hydrobiologic; 6- metrologic; 7- navigational; 8- special; 9- combined; 10- technical.

System utilization methods and primary measuring transformer locations may be divided into five types: 1- sounding; 2- towing; 3- floating; 4- object; 5- stationary.

The following is an example of code inscription on a hydrophysical measuring complex:



The solution of the hydrophysical research automation problem through the creation of modular measuring systems for hydrophysical parameters promoted a more complete experimental research in accordance with the conditions of specific tasks, decreasing the development cost of individual systems, lowering expenditure because of equipment unification and decreased dates for complex development. The introduction of similar systems will also promote better quality patent applications for measuring devices invented.

#### FOOTNOTES

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4. "Fizika okeana" Ocean physics, In vol. 2, chief editor V.M. Kamenkovych, A.S. Monin, Nauka, 1978, 455 p. (Oceanology; Vol. 1 Ocean Hydrophysics).
5. G.V. Smirnov, S.A. Lavrov, M.E. Rabinovich, S.G. Buynov "Rezultaty proektirovannya pervychnykh izmeritel'nykh preobrazovateley temperatury" Results of designing primary measuring temperature transformers, Sevastopol: MGI AS UkSSR, 1981, 50 p.

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9443  
CSO: 1865/124

FINLAND BUILDING RESEARCH SHIPS FOR USSR

PM140854 Moscow IZVESTIYA in Russian 13 Apr 83 p 3

[Report by V. Shmyganovskiy: "Soviet Orders"]

[Text] A symposium on the development prospects of the scientific research fleet was held at the Moscow offices of the Finnish-Soviet Chamber of Commerce, in conjunction with the USSR Academy of Sciences and the Sudoimport All-Union Association.

"Our shipyard," A. Mannone, director of the Holming company which organized the symposium, announced, "has built a unique ship, unrivaled in many aspects of its equipment, the Academician Mstislav Keldysh, which has already carried out several complicated missions in the waters of the Pacific Ocean. The ideas which underlie the design, construction and operation of the ships have become the basis for further joint research by specialists from the USSR and Finland."

In 1984-1985 Holming will deliver to us another 3 scientific research vessels of 2,600 tons each. The keel of the first of them was recently laid in Finland. It is particularly characteristic of the scientific fleet now that it makes maximum use of electronic computers, which have proved their capacity for reliable functioning under storm, tropical or icy conditions.

CSO: 1865/140

UDC 535.417(008.8)

RESTRICTIONS IMPOSED BY LIGHT REFRACTION ON HOLOGRAPHIC INTERFEROMETRY OF STRATIFIED FLUIDS

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 12 Aug 81 after revision 19 Apr 82) pp 348-350

VOROPAYEV, S. I., GAVRILIN, B. L. and ZHMUR, V. V., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] In the method for determining density changes by means of holographic interferometry a basin with transparent walls is filled with a fluid with the required initial vertical density distribution and holographic measurements are made. Then the perturbations to be studied are introduced into the fluid, resulting in a redistribution of density inhomogeneities. The length of the optical path  $L$  from the observation point to any point in the fluid where there are density changes will change. An interference pattern will arise in the observation plane which is governed by the difference in the path  $\Delta L$  between the rays creating the holographic image of the unperturbed object and the image of the perturbed object. This interference pattern is registered and the basis of  $\Delta L$  measurements it is possible to determine the change  $\Delta n$  of the refraction coefficient along the light ray path. If light refraction is neglected it is assumed that the  $\Delta n$  value at each horizon is proportional to  $\Delta L$ . But that assumption is valid only in the case of small vertical gradients of the refraction coefficient, the case of weak stratification. With strong stratification light refraction cannot be neglected because a significant error can arise. Formulas are given for evaluating the relative error in determining the refraction coefficient under these conditions. It is shown that in some cases the relative error introduced into the measurement of light refraction can exceed 30%. References 6: 2 Russian, 4 Western.  
[135-5303]

## INCREASING ACCURACY OF SHIPBOARD MEASUREMENTS OF WIND VELOCITY AND DIRECTION USING AERODYNAMIC TESTS OF SHIP MODEL

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 5 Nov 81 after revision 17 Aug 82) pp 355-360

ROMANOV, Yu. A., FEDOROVA, I. B., CHERVYAKOV, M. S. and SHAPIRO, G. I.,  
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[Abstract] Although shipboard measurements are the main source of data on wind velocity over the ocean, the accuracy of such measurements remains low. Evaluations of the required accuracy of shipboard observations for solving different problems in marine meteorology are presented. In order to evaluate the wind field distortions by a ship at the points where the wind sensors are situated and in order to introduce quantitative corrections to the sensor readings the authors carried out aerodynamic tests of a model of the research ship "Akademik Mstislav Keldysh." These investigations revealed that it is possible to introduce corrections to the readings of sensors mounted at the top of the mainmast for compensating the influence of the ship's hull and superstructure in the entire range of course angles. It is possible to introduce corrections for the sensors on the prow boom and foremast only for course angles less than  $120^\circ$ . It was impossible to introduce corrections near the wings of the main bridge due to the irregular, eddylike nature of the airflow around the ship. A specific method is proposed for shipboard wind measurements on the "Akademik Mstislav Keldysh" and Figure 2 can be used for making the required corrections. It is noted that there are other sources of error, such as the ship's drift and rolling, local fluxes from heated parts of the vessel, etc., which are not taken into account. The correction factors for ships of other architecture must be based on model tests of these ships. Such corrections should be determined for all scientific research ships. Figures 2; tables 1; references 10: 9 Russian, 1 Western.  
[135-5303]

## INFLUENCE OF FINE STRUCTURE OF CURRENT VELOCITY FIELD ON TRANSPORT OF MATTER IN OCEAN

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 21 May 82) pp 249-254

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[Abstract] The fine structure of the current velocity field can evidently exert a substantial effect on formation of the field of concentration of matter in the ocean. The investigation was made in an unbounded ocean in

which the water layer was divided into  $n$  quasihomogeneous layers in which the coefficients of turbulent exchange  $K_x(j)$ ,  $K_z(j)$  and current velocity  $u_j$  are stipulated. These parameters are considered constant within each layer, but vary from layer to layer. It is also assumed that at the internal boundaries of the layers the current velocity experiences a discontinuity, at the boundary itself being equal to the half-sum of the velocity values in the adjacent layers. The problem is solved in this formulation by the integral Fourier transform method. A final form of a general solution is obtained which describes the field of concentration of matter in an individual layer of the system. In order to close this system it was necessary to introduce additional hypotheses for the flows of matter through the boundaries of the layers. This makes it possible to compute the concentration of matter from an instantaneous linear source. In the presence of a fine structure of the current velocity field the advective transport mechanism, leading to an intensification of inhomogeneities of the field of concentration of matter, operates considerably more rapidly than the diffusion mechanism, leading to a smoothing of these inhomogeneities. On the basis of the solution obtained numerical computations are made of concentration profiles and a qualitative comparison of these is made with the types of vertical distribution of a concentration of dye obtained by G. Kullenberg (ADVANCES IN GEOPHYSICS, Vol 18A, 1974). Figures 4; references 11: 5 Russian, 6 Western.  
[135-5303]

UDC 551.465.062

#### VARIABILITY OF HYDROPHYSICAL FIELDS IN WESTERN PART OF INDIAN OCEAN EQUATORIAL ZONE

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 21 Jul 81 after revision 22 Dec 81) pp 232-237

POLONSKIY, A. B. and SHAPIRO, N. B., Marine Hydrophysical Institute, Ukrainian Academy of Sciences, Sevastopol'

[Abstract] On the 39th voyage of the "Mikhail Lomonosov" (April-August 1980) specialists made observations of currents, temperature and salinity in the equatorial zone of the Indian Ocean. Most of the work was done in the western part of this zone ( $2^{\circ}\text{S}$ - $2^{\circ}\text{N}$ ,  $61^{\circ}$ - $64^{\circ}\text{E}$ ) in the transitional period between the northeasterly and southwesterly monsoons (April-May, polygon 1) and during a well-developed southwesterly monsoon (July, polygon 4). The observations included sounding of the upper 1,500-m layer on meridional sections along  $61^{\circ}$ ,  $62^{\circ}$ ,  $63^{\circ}$  and  $64^{\circ}\text{E}$  with a distance of 20 miles between stations and measurement of currents with automatic recorders at autonomous buoy stations set out at the equator, at  $1^{\circ}\text{S}$  and  $1^{\circ}\text{N}$ . The investigations were made to evaluate the seasonal variability of hydrophysical fields related primarily to restructuring of atmospheric circulation. Details are given concerning work in each polygon. A replacement of the northeasterly wind by a westerly wind results in a restructuring of the hydrophysical fields. An easterly jet is rapidly formed in the surface layer at the equator; it carried water of an increased salinity.

The jet is of drift origin. The formation of this easterly jet is accompanied by the convergence of currents at the equator, which should lead to a subsidence of waters and therefore a deepening of the UQL and an intensification of the jump layer, but with persistence of the Tareyev Current (Equatorial Counter-current). This restructuring of equatorial circulation is accompanied by meandering of easterly currents and there is a wave with a period of about 20 days expressed in the upper 200-m layer. The observations in polygon 1 were repeated 1.5 months later in polygon 4, making it possible to trace restructuring of hydrophysical fields associated with replacement of westerly winds by a well-developed south-westerly monsoon. Work in polygon 4 occurred in the presence of a steady southerly wind. It was confirmed that with a southerly wind a surface westerly current is formed at the equator, accompanied by the upwelling of waters at the equator and to the south of it, whereas an easterly jet is formed at about 3-5°N. The upwelling of waters in the surface layer at the equator in turn leads to a decrease in the thickness of the upper quasihomogeneous layer and an increase in the vertical temperature gradients in it. The data presented in the article show that the characteristics of the upper quasi-isothermic layer in the equatorial zone and their variability are closely related to the peculiarities of macroscale circulation, indicating a need for taking horizontal inhomogeneity into account in the modeling of the equatorial upper quasihomogeneous layer. The observed restructuring of hydrophysical fields in general corresponds to the concepts formed on the basis of hydrodynamic modeling of equatorial circulation. Figures 4; references 16: 11 Russian, 5 Western.  
[135-5303]

UDC 551.465.53

#### CIRCULATION AND STRUCTURE OF WATERS IN TYRRHENIAN SEA

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 21 Dec 81 after revision 7 Jul 82) pp 223-231

KRIVOSHEYA, V. G., Southern Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Gelendzhik

[Abstract] The Tyrrhenian Sea is the deepest and most isolated basin in the western part of the Mediterranean Sea. The structure of waters in the Tyrrhenian Sea is represented by three main water masses: 1) surface, 2) intermediate, 3) deep. The water structure has been very well studied, but the hydrophysical characteristics of these water masses and their seasonal variability have not yet been studied adequately. The author has used a great volume of abyssal hydrophysical data (temperature and salinity), including most of the observations made during the last 30 years; 522 of the 1,220 stations were occupied in winter (December-April) and 698 in summer (June-September). The values averaged within 1/2° squares were used in constructing maps of the distribution of hydrophysical characteristics and geostrophic currents were computed for the sea surface and the horizon 400 m. Figure 1 shows the mean geostrophic currents at the surface for winter and summer; Figure 2 is a corresponding map for the 400-m horizon; Figure 3 is a graph of

the distribution of mean potential temperature values along a run between Corsica and Sicily during winter; Figure 4 is a graph of mean salinity values among the same run in winter. The analyzed data indicate that the circulation of waters in this sea, including intermediate and deep waters in both winter and summer, for the most part has a cyclonic nature. However, this circulation is complicated by individual (constant or temporary) circulations of lesser scales. In winter a counterclockwise transport of surface waters is formed; this unified transport has two centers--the Sardinian and Corsican cyclonic circulations. In summer the transport of surface waters common for the entire sea weakens, whereas the Sardinian and Corsican cyclonic circulations are intensified and other eddy formations arise. The Sardinian and Corsican cyclonic circulations, which persist from season to season and affect the intermediate horizons, are among the most stable (quasistationary) dynamic formations in the water circulation system. The circulation of waters in this sea probably has a predominantly wind nature. Circulation plays a primary role in formation of the structure of waters in the Tyrrhenian Sea. Most of the intermediate water mass, upon emergence from the Gulf of Tunis, is entrained into the system of currents in this sea and then in somewhat transformed form continues its movement to the west. Figures 5; references 11: 6 Russian, 5 Western.  
[135-5303]

UDC 551.465.42(261)

CLIMATIC STRUCTURE OF LEVEL AND SURFACE GRADIENT CURRENTS IN WORLD OCEAN  
DURING SUMMER AND WINTER

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 4 Feb 82 after revision 2 Apr 82) pp 217-222

BREKHOVSKIKH, A. L., DEMIN, Yu. L. and SHAKHANOVA, T. V., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] The results of computations of the climatic sea surface level field and the field of surface gradient currents in the world ocean are examined in a 1° grid. These computations were made on the basis of the mean long-term density fields for winter and summer stipulated at 31 standard horizons. The seasonal density changes relate only to the upper 200-m layer; at greater depths only the mean annual fields are considered. The hydrological data were furnished by S. Hellerman, supplemented by the seasonal climatic fields of atmospheric pressure prepared at the Hydrometeorological Scientific Research Center. These were used in computing the fields of wind stress components; the input parameters were selected in such a way that the mean values of the components were close to the tables published by Hellerman in MONTH. WEATH. REV., Vol 95, No 19, pp 507-626, 1967. The computations were made using the Sarkisyan quasigeostrophic model. Figure 1 is a full-page map of the topography of reduced level of the world ocean in winter. It was compiled after smoothing of the initial density field using a Tukey filter. The map agrees qualitatively with modern concepts concerning general circulation of the world ocean. The principal qualitative difference between this map and those published earlier is that all the major

circulations in the world ocean are closed along the western shores. The general pattern of circulation is more detailed; jet currents are better expressed; all the northern subtropical anticyclonic circulations are closed; the subpolar cyclonic circulation is better expressed; tropical cyclonic circulations in the Atlantic Ocean are well defined. The map of level topography for summer is very similar to that published by A. L. Brekhovskikh in OKEANOLOGIYA, Vol 20, No 4, pp 607-612, 1980. Table 1 gives the characteristic velocities of gradient currents during summer and winter in the Atlantic Ocean; Tables 2 and 3 give corresponding data for the Pacific and Indian Oceans. Figures 1; tables 3; references 10: 9 Russian, 1 Western.  
[135-5303]

UDC 551.465.5

NUMERICAL EXPERIMENTS WITH BAROCLINIC QUASIGEOSTROPHIC MODEL OF LOCAL PREDICTION OF SYNOPTIC MOVEMENTS

Moscow OKEANOLOGIYA in Russian Vol 23, No 2, Mar-Apr 83 (manuscript received 10 Nov 82) pp 197-203

KAMENKOVICH, V. M., LARICHEV, V. D. and KHAR'KOV, B. V., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] The authors present the results of test numerical experiments with a baroclinic quasigeostrophic model of prediction of synoptic movements in the open region of the ocean developed earlier (Kamenkovich, V. M., et al., OKEANOLOGIYA, Vol 21, No 6, pp 949-959, 1981). Earlier experiments along these lines (Kamenkovich, V. M., et al., OKEANOLOGIYA, Vol 22, No 5, pp 719-725, 1982) confirmed the choice of the numerical schemes and indicated the fundamental possibility of a local prediction using a quasigeostrophic model for a time of approximately several characteristic periods of the predicted movements. The cases of both constant and real  $N(z)$  are considered. The errors in predicting synoptic fields in dependence on the parameters of the investigated solution are given. The test computations with the values of the determining parameters confirmed the possibility of local predictions of baroclinic movements in the ocean for a time equal to one or two periods (several months). The collocation method of vertical approximation was considerably more precise than the finite-difference method. The accuracy of the computations has little dependence on whether the Väisälä frequency is constant or variable in depth, although it worsened with an increase in the stratification parameter. With four computation levels a satisfactory accuracy was attained for the first baroclinic mode; with the same number of levels and an increase in the number of the baroclinic mode the accuracy of the computations usually decreased. Figures 5; references 8: 5 Russian, 3 Western.  
[135-5303]

## FINE THERMOHALINE STRUCTURE OF WATERS IN CENTRAL RED SEA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 4 Feb 82) pp 301-308

NOZDRIN, Yu. V. and PLAKHIN, Ye. A., Institute of Oceanology, USSR Academy of Sciences

[Abstract] During the 30th voyage of the "Akademik Kurchatov" in the winter of 1979-1980 specialists carried out investigations of the fine stratification of waters in the central basin of the Red Sea in the region 18°N. A total of 191 soundings were carried out with the registry of temperature and conductivity and these were used in computing salinity and density. This article describes the principal characteristics of the fine thermohaline structure of the upper layer of the Red Sea. The multiple soundings made at 14 stations yielded data on the spatial dimensions and intensity of microstructural formations. Temperature inversions were observed on all profiles in the layer 40-80 m. The average thickness of the layer with maximum temperature inversion was 23 m, for salinity--16 m; the mean temperature inversion was 0.58°C, whereas the mean salinity inversion was 0.68°/oo. The inversion layer was hydrostatically stable. An analysis was made of the horizontal distribution of fine-structured inhomogeneities on the basis of data from a hydrophysical section; the run was 90 miles in length with stations being occupied each 10 miles. Temperature inversions were observed at all stations with insignificant changes in the thickness and intensity of the inversion layer. In the constantly observed temperature inversion layer there were high-frequency temperature and salinity fluctuations. A whole series of additional parameters were measured or computed and are tabulated or represented in graphic form. Figures 4; tables 2; references 10: 5 Russian, 5 Western.  
[120-5303]

UDC 551.466.2

## SPECTRAL FORM OF ENERGY-CARRYING WATER SURFACE COMPONENTS AND WEAK TURBULENCE THEORY OF WIND WAVES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 1 Mar 82) pp 282-291

ZAKHAROV, V. Ye. and ZASLAVSKIY, M. M., Institute of Oceanology, USSR Academy of Sciences

[Abstract] In an earlier study entitled "Kinetic Equation and Kolmogorov Spectra in the Weak Turbulence Theory of Wind Waves" (IZV. AN SSSR: FAO, Vol 18, No 9, pp 970-979, 1982) the authors demonstrated that outside the pumping and dissipation intervals the spectra of slightly nonlinear surface gravity waves are determined by the fluxes of integral dynamic characteristics. Continuing

work along these lines, in an article "Pumping and Dissipation Intervals in the Kinetic Equation of the Weak Turbulence Theory of Wind Waves" (IZV. AN SSSR: FAO, Vol 18, No 10, pp 1066-1076, 1982), it was demonstrated that for wind waves the pumping  $k > k^+$  and dissipation  $k > k^-$  intervals are localized in the region of quite small scales, with  $k^- \gg k^+$ . On the basis of this earlier cycle of investigations, the authors show that for adequately developed wind waves the form of the spectrum in the energy-carrying region is determined by a dimensional analysis of the kinetic equation for wind waves where the Kolmogorov spectrum with respect to the wave action flux  $S(\omega) = a p^{1/3} g^{4/3} \omega^{-11/3} \theta_s (\omega/\omega_m)$ , where  $a$  is a dimensionless coefficient dependent on the angular distribution of energy with  $\omega - \omega_m$ ,  $\theta_s$  is the "spread" Heaviside function, cutting off the spectrum at the frequency of the spectral maximum  $\omega_m$ . The derived expression for  $S(\omega)$  is in satisfactory agreement with the experimental data, which makes it possible to determine the dimensionless coefficient  $q$ . There is a discussion of the overall qualitative picture of development of the spectrum of wind waves, making it possible to explain a number of their known characteristics, such as the localization of the equilibrium interval in the microscale region of the wave spectrum, the "overshoot" effect in the curves of spectral components and decrease in the narrowness of the wave spectrum as the waves develop. Figures 5; references 13: 8 Russian, 5 Western. [120-5303]

UDC 551.465

#### VERTICAL MOVEMENT OF OCEAN WATER

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: GEOLOGIYA, GEOGRAFIYA in Russian No 6, Issue 1, Mar 83 (manuscript received 1 Nov 81) pp 105-109

RZHONSNITSKIY, V. B.

[Abstract] Vertical movement of ocean water significantly influences the distribution of temperature, salinity and other water characteristics and carried dissolved oxygen from the surface down into lower levels, and biogenous substances from the depths into the photosynthesis layer, thus facilitating the development of life in the ocean. The primary factor preventing vertical movement of water in the ocean is the increase in density with depth. Adiabatic temperature changes cause the density of descending water to decrease, of rising water to increase, hindering the process. The vertical force acting on a volume of water as it descends from one level to a lower level is calculated. It is found that the force of vertical stability is  $10^{-10}$  to  $10^{-6}$  g/cm<sup>4</sup>. These stability forces cause accelerations of approximately  $10^{-7}$ - $10^{-3}$  cm/s<sup>2</sup>, which is the same order of magnitude as the accelerations caused by most forces acting on ocean water. Wind forces exceed stability forces in the top ten meter water layer under most conditions, causing intensive vertical mixing in this layer. Forces acting on lower levels of water in the ocean often do not exceed the vertical stability forces. References 4 (Russian). [146-6508]

## SIMPLE OCEAN CLIMATE MODEL

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 5, Apr 83  
(manuscript received 1 Sep 82) pp 1195-1198

VERBITSKIY, M. Ya. and CHALIKOV, D. V., Leningrad Department, Institute of Oceanography imeni P. P. Shirshov, USSR Academy of Sciences

[Abstract] This article completes a cycle of works dedicated to the creation of simple thermodynamic models of individual components of the atmosphere-ocean-large ice sheet climatic system. In previous works, one dimensional models were used to consider the influence of the ocean either indirectly by selecting an effective diffusion coefficient in the ocean-atmosphere system, or by introducing an inertial seasonal factor in the form of local heat reservoirs. This article analyzes a meridionally extended ocean model of fixed angular width. The ocean is divided vertically into two areas: an upper layer including the main thermocline and an abyssal zone. Considering that the model computed is a first iteration in the process of determining the conditions in the ocean-atmosphere system, the general agreement of calculated data and empirical data is judged satisfactory. The authors promise to write a separate article concerning the sensitivity of the model to changes in parameter values. Figures 2; references 6: 3 Russian, 3 Western.  
[144-6508]

UDC 551.465

## THERMODYNAMIC MODEL OF SEASONAL EVOLUTION IN OCEAN-ATMOSPHERE SYSTEM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 5, Apr 83  
(manuscript received 1 Sep 82) pp 1198-1202

KAGAN, B. A., KYABCHENKO, V. A. and SAFRAY, A. S., Leningrad Department, Institute of Oceanography imeni P. P. Shirshov, USSR Academy of Sciences

[Abstract] A correct description of the reaction of the atmosphere to an external perturbation must include simultaneous determination of the intensity of heat transfer from the upper, quasi-homogeneous layer of the ocean and its thickness. This served as the impetus for construction of a thermodynamic model of the ocean-atmosphere system, described in this article. The equations derived can estimate, based on known external parameters and proper values of numerical constants, the climatic characteristics of the ocean-atmosphere system. Results of calculation properly reproduce the general regularities of seasonal evolution in thermal mode of the individual elements of the system. The authors note in particular proper reproduction of the phase delay in temperature fluctuations in the upper quasi-homogeneous layer of the ocean relative to variations in heat influx to the surface of the ocean and continental surface in the moderate and low latitudes. Figure 1; references 4: 2 Russian, 2 Western.  
[144-6508]

## TERRESTRIAL GEOPHYSICS

### SITE SELECTED FOR SUPERDEEP BOREHOLE IN UKRAINE

Kiev PRAVDA UKRAINY in Russian 4 Feb 83 p 1

[Article by V. Petrenko: "Objective -- 'Underground Space'"]

[Text] The site for drilling the first superdeep hole in the Ukraine has been approved. Its drilling will begin this year.

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Even from our school geography lessons we recall this figure: 6,000 km, that is approximately the average distance from the earth's surface to its center. But what is there in the mysterious depths of "underground space"?

"The deepest of the boreholes drilled in the world are microscopic in comparison with the thickness of the earth's crust," says Ya. N. Belevtsev, academician, Ukrainian of Sciences, chairman of the Commission on Superdeep Drilling in the Ukrainian SSR, deputy director of the Institute of Geochemistry and Physics of Minerals, Ukrainian SSR, director of the Division of Metallogeny. "Only a few dozen holes (of the millions which have been drilled) have exceeded a depth of 7 km. However, those of a 15 km depth, to which the programs for superdeep drilling, supported by the corresponding technical possibilities, are directed, will yield a great deal for fundamental science and for practical work. The direct study of 'underground space' should bring new information concerning the origin and evolution of the planet, should substantially broaden our knowledge concerning the stores of mineral-raw material resources, should help in revealing the secrets of the mechanism of deep processes in the earth's crust, should make it possible to predict such threatening natural phenomena as earthquakes and volcanic eruptions. In our country there is an interdepartmental council on the problem 'Study of the Earth's Deep Layers and Superdeep Drilling' of the USSR State Committee on Science and Technology. In different regions of the Soviet Union promising sites are being selected for the drilling of superdeep holes."

"Recently the Kola superdeep hole (in Murmanskaya Oblast) has become the best known: already in the summer of 1979 it had taken away the crown from the 'Bertha Rogers' borehole (9,583 m) in Oklahoma which had held the title of the world's deepest borehole. Now the Kola borehole has already exceeded 11.6 km, but its planned depth is 15 km. Then in Azerbaijan work began on the drilling of the Saatly borehole, which eventually should also attain a depth of 15 km."

"And now, in turn, there will be still another superdeep hole, this time in the Ukraine. But precisely where to drill it?"

"There are several sites of particular interest in the territory of the republic for us geologists," responds Ya. N. Belyayev. "For drilling the first superdeep hole in the Ukraine we have proposed the Krivoy Rog iron ore basin."

"Now earlier explored considerable reserves of rich and poor ores are being worked intensively in the Krivbass. The depth of many shafts exceeds 1 km. It has been demonstrated that it is technically possible and economically feasible to produce ores at depths of 1,500-2,000 m. But it is also necessary to think of the future. The tasks set before the mining and metallurgical industries require the broadening of the raw material base, improvement of methods for deep prediction and evaluation of mineral deposits."

"Our commission selected in the field and proposed to the Ukrainian Ministry of Geology and the USSR Ministry of Geology a site for the drilling of a superdeep hole -- to the northwest of the mine imeni V. I. Lenin, near the village of Novoivanovka in Krivorozhskiy Rayon in Dnepropetrovskaya Oblast on lands ill-suited for agricultural production. The selected point was recently approved by the chairman of the Interdepartmental Council on the Problem 'Study of the Earth's Deep Layers and Superdeep Drilling,' Ye. A. Kozlov, USSR Minister of Geology."

"The drilling of the borehole (like the Kola and Saatly boreholes) will be accomplished using an apparatus of the 'Uralmash-15000' type. In such a complex there is no ordinary drill rig at the surface for rotating the column of drill pipes. The drilling is accomplished with a turbodrill and this is driven into motion by a clayey mud entering the borehole within the drilling pipes, propelled there under great pressure by powerful pumps. This reduces by a factor of almost 2 1/2 the weight indices and substantially simplifies the drilling technology."

"The deeper the borehole, the greater is the fraction of the time 'eaten away' by the raising-lowering operation," says Ya. N. Belevtsev. "How to increase the time of 'net' drilling? Without tiring the readers with technical details, I will say only that the original solutions proposed by specialists of branch organizations will make possible the replacement of a blunted drill tool by a new one without raising the drilling column at the same time."

"An important role is also played by the choice of borehole construction. At the Krivoy Rog superdeep borehole, which is being drilled for the most part in hard crystalline rocks, plans call for using the so-called 'advancing open hole' method which has well recommended itself. It facilitates, accelerates and reduces the cost of drilling and the carrying out of the necessary borehole geophysical operations."

"Plans call for beginning the drilling of the Krivoy Rog superdeep hole in the third quarter of this year," said Ya. N. Belevtsev in conclusion.

"It is proposed that 4,000 m be drilled prior to the end of the five-year plan. The drilling technique proposed by specialists of the All-Union Scientific Research Institute of Drilling Technology and the borehole design recommended by

Ukrainian geologists will make it possible, after reaching a 7-km depth (first stage), to deepen the borehole to its planned depth of 12,000 m (second stage). Then if everything goes well, it will be entirely possible to continue the storming of "underground space" to the 15-km depth. In short, a fascinating journey into the unknown stands before us..."

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CSO: 1865/142

## EVALUATING EFFECTIVE CHARACTERISTICS OF WAVE SPECTRA APPLICABLE TO PREDICTION OF HYDROCARBON DEPOSITS

Kiev GEOFIZICHESKIY ZHURNAL in Russian Vol 5, No 1, Jan-Feb 83  
(manuscript received 30 Jan 81) pp 69-77

GRIN', N. Ye. and ANTONOVA, L. P., Geophysical Institute, Ukrainian Academy of Sciences, Kiev

[Abstract] The presence of inhomogeneities in a medium of the "deposit" type can be reflected in the wave field and in its spectral composition. The presence of petroleum-saturated zones causes an increase in absorption and an attenuation of waves. This article gives evaluations of the spectral characteristics, their effective values and parameters in the example of specific seismogeological conditions prevailing in the Bogatoyskoye gas-condensate deposit in the Dnepr-Donets Basin. The authors propose the following approach for making use of the effective parameters of wave field spectra. The width of the spectrum, steepness of rising and attenuation relative to the frequency axis or some stable point, such as the center of gravity, or other features having physical meaning, can be used as effective characteristics. In this study as such characteristics it was decided to use the coordinates of the center of gravity of the spectrum and also the values in the region of low and high frequencies limiting some rectangle in area equal to the initial spectrum of a signal constructed on the basis of the coordinates of the center of gravity. (The frequency of the spectrum center of gravity is related to the apparent frequency of the wave process.) It is shown that two types of spectra can be distinguished. The first type of spectra in time section data corresponds to interference processes in regions relating to parts of the section not associated with a deposit. The second type relates to deposits and the space directly surrounding them. Although some positive data were obtained for predicting deposits on the basis of such spectra, it is shown that the problem still remains ambiguous and its solution is dependent on the geological and geophysical characteristics of the region and section. However, use of the indicated qualitative criteria favors a narrowing of the ambiguity in deciding if a deposit is present. Figures 5; references: 10 Russian.  
[100-5303]

INVESTIGATING PROPERTIES OF SEISMIC HORIZONS IN RELATION TO DEVELOPMENT OF  
MULTIWAVE SEISMIC PROSPECTING

Kiev GEOFIZICHESKIY ZHURNAL in Russian Vol 5, No 1, Jan-Feb 83  
(manuscript received 13 Jul 82) pp 56-68

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[Abstract] This is an analysis of the amplitude spectra of idealized models of the principal types of seismic horizons in the earth's crust (the parameters of all these types are summarized in a table): layers with high, low and intermediate velocities, with a gradient change of properties with depth, layered-inversion and gradient-inversion packets. The latter two types occur widely and correspond to complexly structured zones in the sedimentary cover and in the consolidated shell. The phase spectra are of auxiliary importance and can be used in identifying sectors of a general decrease or increase in velocity. Two variants of media are discussed: stable and differentiated with respect to the  $\gamma$ -ratio of propagation of transverse and longitudinal waves. The first of these variants simulates the gas saturation of layers with reduced velocity and the second simulates the filling of collectors with fluids. A great many conclusions can be drawn from an examination of the spectral characteristics of different types of seismic horizons, such as the following. The spectral characteristics of the simplest models have a clearly expressed periodicity governed by the structure of the horizon and its acoustic properties. For transverse waves the frequency periods are less than for longitudinal waves. In the case of a gentle dip there is a complication of the form of the spectra due to the joint influence of the parameters of the longitudinal and transverse waves. For media differentiated with respect to  $\gamma$  this complication sets in with lesser dips. The characteristics of a layer with low velocity are most stable with a change of dip; the characteristics of a layer with intermediate properties are least stable. With constant  $\gamma$  the reflection coefficients for transverse waves have the same interval of change of ordinates as longitudinal waves but they have spectral properties in a far broader range of dip angles (to the second critical angle). The introduction of differentiation with respect to  $\gamma$  leads to a more considerable increase in the reflection coefficients of transverse waves. The general patterns of change of the reflection coefficients for longitudinal and transverse waves are identical. In the case of filling of collectors with gas their values are commensurable in the low-frequency region; in the high-frequency interval they differ as a result of more intensive absorption of transverse waves. With saturation of collectors by fluids the reflection coefficients for transverse waves are considerably higher than for longitudinal waves. The transverse reflected waves method is therefore promising for use in exploration for petroleum deposits. These and a great many other characteristics made clear in this study show that the use of the spectra of waves fields of different types affords a possibility for determining the internal structure of seismic horizons, evaluation of the petroleum- and gas-saturation of collectors and tie-in of data from seismic prospecting to the results of investigations by the earthquake exchange waves method and makes it possible to solve other prospecting problems. Figures 8, tables 1; references: 15 Russian.  
[100-5303]

## STRUCTURE OF SEISMIC PROCESS IN DIFFERENT STAGES OF DEVELOPMENT OF CARPATHIAN EARTHQUAKE OF 4 MARCH 1977

Kiev GEOFIZICHESKIY ZHURNAL in Russian Vol 5, No 1, Jan-Feb 83  
(manuscript received 27 Aug 81) pp 32-38

SAGAMOVA, Ye. A., Geophysical Institute, Ukrainian Academy of Sciences, Kiev

[Abstract] An entire monograph has been devoted to the Carpathian earthquake of 4 March 1977 (KARPATSKOYE ZEMLETRYASENIYA 4 MARTA 1977 GODA I YEGO POSLEDSTVIYA, Moscow, Nauka, 1980). This was the first strong event in the Vrancea focal zone for which it was possible to trace the development of the seismic process in space and time on the basis of data for 25 years (1952-1976) for earthquakes in this region. The most important of the patterns of spatial and temporal development of the process is the drawing out of the epicenters of foreshock deep earthquakes during the years 1972-1976 prior to the main tremor into a narrow linear zone with an extent of 52 km and a width of 12 km, seemingly indicating the direction of the future main fracture. A study of the foci of these earthquakes in the vertical plane made it possible to determine the volumetric dimensions of the earthquake focus and to draw conclusions on the direction of motion of the fracture. This, together with the new analysis of materials presented in this article, can be used in the future for predicting strong Vrancea earthquakes. The author here examines the totality of seismic observations characterizing the seismic process during the earthquake and in its aftershock period. The consistency of all the observations made in different stages (before, during and after the earthquake) confirms the reliability of the defined foreshock pattern and the possibility of using it in the future for predicting strong earthquakes. The correspondence of the patterns of the foreshock process of this earthquake to the fundamental concepts of the theory of avalanche-unstable fracturing is confirmed. Figures 3, tables 1; references 34: 20 Russian, 14 Western.  
[100-5303]

UDC 622.011.4+622.023

## MODEL OF SAWTOOTH-LIKE FRACTURE IN EARTH'S CRUST

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 4, Apr 83  
(manuscript received 13 Dec 82) pp 835-838

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[Abstract] The author proposes a model of a shear fracture of a sawtooth form in rocks making it possible to explain many aspects of the preparation for and transpiring of destruction processes at different scales. The basis for this model is an evaluation of shearing stresses in the crust and the relationship

of the principal constants of the destruction process for phenomena at different scales. The basis of the model is the concepts of M. A. Sadovskiy concerning typical scales of natural fracturing of rocks (DAN, Vol 247, No 4, 1979) and the principal concepts of the mechanics of destruction (G. P. Cherepanov, MECHANICS OF BRITTLE FRACTURE, New York, 1979). The first part of the article gives a classification of fracturing scales. The second part deals with the characteristics of a sawtooth-type fracture. The structure of such a fracture is modeled: some sides are in contact with one another and are subjected to friction, whereas others are in a state of dilatation. The surface of friction has a sawtooth substructure whereas the dilatational region is a zone of loosening of material and accompanying effects (increase in rock volume, development of pores and fissures, magma intrusions, hydrothermal intrusions, weathering). The evolution of the main fracture is described. The model described here has all the merits of other models and also explains the processes of restoration of the physical parameters after an earthquake. The model limits the sphere of operation of dilatancy to the small zone of dilatation and thereby frees it of the defective assumption of anomalously high shearing stresses in large rock volumes and logically it is far simpler than earlier models and it can be used in quantitative computations. The model is used in estimating the scale factor for the friction and destruction constants. Some considerations on the maximum energy of earthquakes are also presented. Figures 1; references 15: 13 Russian, 2 Western.  
[127-5303]

UDC 622.32

#### FILTRATION MODEL OF EARTHQUAKE SEQUENCE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 4, Apr 83  
(manuscript received 27 Nov 82) pp 831-834

BARENBLATT, G. I., KEYLIS-BOROK, V. I. and MONIN, A. S., corresponding member, USSR Academy of Sciences, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences; Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] The source of accumulation of the energy set free during earthquakes is the relative movement of lithospheric plates or microplates along the faults separating their zones and one of the factors controlling this energy release may be the migration of fluids in fault zones. The water serves as a lubricant reducing friction in the fault zone by several orders of magnitude. The article outlines a very simple schematization of the phenomenon. The general idea is formulated as follows. With an increase in pressure in the reservoir the water moving from the reservoir through the porous fault zone with a finite velocity penetrates into the first block and when the porosity in it attains a critical value the shearing stresses in the blocks are removed and the first movement (earthquake) occurs. The pressure disturbance is propagated very rapidly in the second block. After bursting into the first and second blocks the pressure in the reservoir decreases and some time is required

for its restoration. Then the water bursts into the third block, etc. The energy of the next earthquake is released in the block to which the water has penetrated and can be computed as the potential energy of the stressed state of that block. The proposed model is consistent with the empirical power law of frequency of recurrence of earthquakes. According to the model the foci of successive earthquakes increase in distance from the input reservoir together with the front of the filtering fluid. In this process the rate of movement of the plate slowly increases and since the water volume in the fault zone also increases the water bursts into successive blocks transpire with increasing frequency (assuming that the input reservoir is adequately replenished with water from an external basin). The migration of the epicenters of weak earthquakes in the direction of an impending focus of a strong earthquake, their anomalously high grouping and fluctuations of the regime, level and composition of ground water in the fault zone are the precursors of strong earthquakes which follow from the proposed filtration model. Within the framework of this model it is possible to explain the reverse migration of earthquakes in a definite time interval. The model can also be applied to a case when lithospheric plates moving relative to one another are situated one above the other, as in subduction zones. References: 2 Russian.  
[127-5303]

UDC 550.838

#### PRINCIPLES FOR FABRICATING DIGITAL MAGNETIC RECORDING APPARATUS FOR GEOPHYSICAL RESEARCH

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 6, Jan 82 pp 118-124

VEKSLER, B. Ye., All-Union Scientific Research Institute of Nuclear Geophysics and Geology

[Abstract] Investigations at the All-Union Scientific Research Institute of Nuclear Geophysics and Geology have been directed to the development of instruments for digital magnetic recording (IDMR) for the registry of data in the following logging methods: acoustic, nuclear-magnetic, various modifications of radioactive methods, pulsed neutron, multisonde neutron, precise spectrometric,  $\gamma$  -  $\gamma$  density, and interborehole sounding. A feature in common for all these methods is that the registered data, tied into a definite borehole depth, also change in time, making it necessary to register highly variable processes. A theoretical and experimental analysis of the prospects for registry of highly variable processes in the geophysical investigations of boreholes has made it possible to formulate the requirements which must be met by the required registry apparatus. Such apparatus must have a great dynamic range (up to 80 db) and a wide frequency range (up to 500 KHz). There must be provision for the possibility of registry when different logging methods are combined. The input of data into a computer on a magnetic carrier requires registry in a digital code in the format of the YeS computer. The apparatus should include a specialized field logging display (visualization unit) enabling the operator in the course of the logging process to observe

the registry of data on the magnetic carrier. The "Plast-1" apparatus was developed on the basis of these and other requirements. Figure 1 is a schematic diagram of this apparatus; 18 components are identified and their functions are described. The apparatus consists of 3 units: data transformation unit, matching and control unit, unit for storage on magnetic tape. The assembly measures 820 x 526 x 500 mm. The results of work with the "Plast-1" are presented; tests have been carried out in different regions of the country. The tests revealed a high performance of the apparatus, which has proven its worth in registry of primary data and data obtained in the logging of boreholes by standard methods. Figures 2; references: 16 Russian.  
[62-5303]

UDC 550.837

#### DEVELOPMENT AND PROSPECTS FOR USING OPTICAL FIBER GEOPHYSICAL CABLE

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 6, Jun 82 pp 105-110

PYATAKHIN, V. I., All-Union Scientific Research Institute of Nuclear Geophysics and Geology

[Abstract] In developing modern data measurement systems for geophysical research in boreholes it is difficult to ensure transmission of a great volume of data through telemetric channels with admissible losses and distortions. Standard armored cables now in use for this purpose do not meet this requirement. The author discusses the possibilities of using optical fibers for this purpose. Figure 1 illustrates samples of an optical fiber geophysical cable; different variants are discussed. The proposed optical channel affords a possibility for carrying out virtually any number of simultaneous measurements of different types of fields in boreholes regardless of their depth. This innovation will be particularly important for the registry of data in super-deep boreholes. The specialists of the All-Union Scientific Research Institute of Nuclear Geophysics and Geology have now developed a model of a system for the telemetric measurement of the energy spectra of gamma radiation on the basis of analog transmission of data from scintillation detectors through an optical fiber communication line. Testing of the characteristics of this telemetric channel revealed that it can be entirely effective with extremely long optical waveguides. For example, in the case of an attenuation of 5 db/km or less the length of the cable can be 6 km or more with an extremely small decrease in the energy resolution of the system as a whole. The use of such telemetric systems will facilitate the creation of modern nuclear-geophysical apparatus, such as gamma spectrometers with controllable neutron sources for the analysis of elements in deep and superdeep boreholes. Figures 2; references 11: 7 Russian, 4 Western.  
[62-5303]

## EXPERIENCE IN USING GEOPHYSICAL TYPES OF LOGGING IN STUDYING SUPERDEEP HOLES

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 6, Jun 82 pp 8-15

KARUS, Ye. V. and NARTIKOYEV, V. D., All-Union Scientific Research Institute of Nuclear Geophysics and Geology

[Abstract] The article gives a review of the information yield of nuclear-geophysical and electromagnetic types of measurements in boreholes applicable to the crystalline rocks of the basement. (The results of seismoacoustic investigations of superdeep holes were given by Ye. V. Karus, et al. in IZV. VUZov: GEOL. I RASV., No 5, 1981,) Nuclear geophysical logging methods in combination with core data are the basic means for a detailed lithological-petrographic breakdown of the section and clarification of the genesis of different geological processes. Rock density in the section of superdeep holes is studied using data from density gamma-gamma logging and a core sample. The combined use of continuous and point density measurements makes possible the most complete determinations. Among these two methods, density gamma-gamma logging has a greater productivity, representativeness and reliability because there is a rapid and continuous study of the rock in its natural bedding without disruption of its structure and moisture content distortions with a precise tie-in of the measurements in the depth of the hole. Data can be obtained for sectors for which no core is available. The natural gamma radiation spectrometry method makes it possible to determine radioactive elements (potassium, uranium, thorium), data on whose content facilitate a lithological-petrographic breakdown of the section and a determination of the mineralogical composition of rocks. The pulsed neutron-neutron logging method is used in determining such neutron parameters as the diffusion coefficient and the mean lifetime of thermal neutrons in rocks. Measurements of these parameters make it possible to judge the presence in crystalline rocks of chemical elements absorbing and retarding neutrons, this making it possible to identify individual types or groups of rocks, or trace the variability of different rocks subjected to metamorphism. The spectrometric neutron gamma logging method makes it possible to analyze the presence of different elements in crystalline rocks, especially iron, nickel, chromium, titanium, silicon and other elements. This makes possible a lithological-petrographic breakdown of the section, detection of intervals of accumulation of elements and discrimination of rock types. Standard neutron logging with superthermal and thermal neutrons and neutron gamma logging in the investigation of crystalline rocks are used in a lithological-petrographic breakdown of the section, determination of zones of intensive absorption of thermal neutrons and determination of water in rocks. The merits and shortcomings of each of these methods are considered. Magnetometric measurements in superdeep holes are made for a lithological-petrographic breakdown of the section, detection of magnetic ore bodies and a determination of their bedding elements. Electrical methods make it possible to study the electrical properties and parameters of crystalline rocks, make the geological section more precise and detect zones of sulfide and oxide mineralization, as well as carbonaceous rocks. References: 9 Russian.

[62-5303]

## VELOCITY OF DESTRUCTION FRONT AND DYNAMIC STRESSES ON FRONT ACCOMPANYING SHOT IN SOLID MEDIA

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 2, Jan 83  
(manuscript received 25 May 82) pp 332-336

KULIKOV, V. I., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] The basis for most computations of the destructive effect of a shot in solid media is the concept of a limiting stress, it being assumed that behind the shot wave front there is propagation of a destruction front as a phase surface at which one of the components of stresses or some combination of components attains a definite critical value. Attempts to use such criteria in the processing of experimental data on dynamic destruction have often led to confusing results. Accordingly, the author carried out an experimental study of the motion of the destruction front, the stressed state directly in front of and behind the front and the nature of the destruction itself. Observations of the destruction front were made during a shot in optically transparent glass and in a monocrystal of aluminum potassium sulfate. The shot waves in the glass were excited by explosive charges with a mass of 0.2 g in a spherical cavity between two glass plates glued with epoxy resin; the glued sample measured 150 x 150 x 150 mm. The shot was registered with a slit photorecorder. The shot waves in the monocrystal of aluminum potassium sulfate were excited by the focusing of laser radiation within the sample; an energy of laser radiation  $\sim 1$  J was released in a volume  $\sim 0.05$  mm<sup>3</sup> in  $\sim 30$  nanosec. These shot waves were registered with an interferometer. The theory of limiting stresses is not supported by these examples of the destruction of glass and aluminum potassium sulfate; according to theory, the destruction front should have propagated far more rapidly. The velocity of the front differs from the theoretical limiting velocity of growth of an individual fracture. This difference can result from the branching of fractures, their deviation from a linear radial direction of growth and the mutual influence of adjacent fractures on one another. Figures 4; references 8: 7 Russian, 1 Western.  
[80-5303]

UDC 550.34.094

## TEMPORAL VARIATIONS OF AMPLITUDES OF SEISMIC WAVES DURING SEISMIC PROBINGS OF EARTH'S CRUST IN SOUTHERN TAJIKISTAN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 2, Jan 83  
(manuscript received 3 Aug 82) pp 329-332

KULAGIN, A. V. and GAMBURTSEV, A. G., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] A study was made to determine whether there are changes in the parameters of the wave field in different structural stages of the earth's crust

and whether they are in phase. The investigation was made by processing data collected during long-term seismic probings of seismically dangerous zones in southern Tajikistan with the use of shot sources, the observation system being selected in such a way as to register waves passing through different crustal layers. The  $P_g$ ,  $P_C$ ,  $P^*$ ,  $P^{refl}$  waves were registered at epicentral distances 130 km; these waves were associated with the "granite" layer, the top of the crustal waveguide, the "basalt" layer and the Mohorovicic discontinuity. Ten work cycles were carried out, each consisting of approximately 9 probings. The time interval between successive shots varied from 1 to 7 days. The time interval between successive cycles was 2-9 months. An analysis of the data indicated that the parameters characterizing the "waveguide" and "basalt" layers vary with periods 11-12 and 160 days. A study was then made to ascertain the degree to which these variations are out of phase in different crustal layers. It was found that the cyclic variations of the amplitude ratios controlling these two layers with the characteristic periods 12 and 160 days are not in phase and there is an anomalous behavior of the structural functions caused by preparation for and the consequences of earthquakes. An analysis of out-of-phase variations in state of the medium in different structural stages of the crust and in its different blocks can be considered as an intermediate-range precursor of earthquakes. Figures 3; references: 7 Russian.  
[80-5303]

UDC 550.311+532.546

#### HYDRODYNAMICS AND STRUCTURE OF TWO-PHASE ASTHENOSPHERE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 2, Jan 83  
(manuscript received 22 Jun 82) pp 324-329

KARAKIN, A. V. and LOBKOVSKIY, L. I., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] The stationary plane hydrodynamic problem is examined for a system consisting of two layers situated in a gravity field. The concepts concerning the structure and dynamics of the asthenosphere developed here make it possible to propose the following scheme of concentration of melt and its upward migration. There is a vertical filtration of magma in two-phase layers. At the top of each of these layers the melt is localized in caverns which can be joined into a system of horizontal channels. Through these channels the magma is capable of flowing for great distances laterally. If the pore pressure decreases in some zone, such as due to local unloading caused by the presence of faults in the lithosphere, the magma will rush into this zone, resulting in a concentration of melt. This evidently leads to a concentration of magma and heat in narrow rift zones in the ocean; as a result of bending of the bottom of the lithosphere under the mid-oceanic ridges and intense "drainage" of the axial zone, caused by the spreading process, the melt caverns arising at the bottom of the lithosphere, being joined into channels, flow out toward the center, creating a powerful source of basaltic volcanism there. A similar mechanism of the concentration of melt can lead to intraplate volcanism of the

Hawaiian type. If the caverns are arranged uniformly at the base of the lithosphere over a considerable area, the bursting of the magma filling them through to the surface will form trap rock outpourings. The movement of the melt from the lower two-phase layers to the upper layers through single-phase intercalations can occur by rising of the caverns in "sealed" form in a single-phase medium. The magma filling them can burst upward through channels in the single-phase layer, feeding the above-lying two-phase layer with deep magma. This will lead to mixing of magmas of different types and favor variability of the chemical composition of the outpouring magmas. The concepts developed here concerning a two-phase asthenosphere and the results are entirely applicable to an analysis of the process of differentiation of mantle matter in the transitional layer from the core to the mantle. Figures 3; references 10: 4 Russian, 6 Western.  
[80-5303]

UDC 550.83.015:550.837.2

#### NATURAL ELECTRIC FIELDS OF DEEP ORIGIN

Moscow SOVETSKAYA GEOLOGIYA in Russian No 2, Feb 83, pp 103-112

ABRAMISHVILI, T. D., DZHASHI, G. G. and RYSS, Yu. S., Geophysical Institute, Georgian Academy of Sciences; "Rudgeofizika" Scientific and Production Association

[Abstract] Many years of investigations by the Geophysical Institute, Georgian Academy of Sciences, in the copper-pyrrhotite zone on the southern slope of the Greater Caucasus revealed the presence of unusual natural electric fields. Similar fields had been discovered earlier in the Rudnyy Altay. These fields are described in detail, followed by an exploration of the possible factors responsible for their existence. The anomalies in the Caucasus were considerably more intense but smaller in extent than the anomalies in the Rudnyy Altay. The different character of the anomalies is evidently related to the deeper position of the Zaysansko-Altayskaya structure in comparison with the young structures of the Greater Caucasus. There is a close relationship between the observed deep natural field and geological structures, creating prerequisites for the prediction and detection of new structures. The mechanism of formation of deep natural electric fields can be represented schematically as follows. Hydrogen and other components penetrate along zones of dislocations from the deep parts of the earth. In regions of replacement of n-conductivity by ionic conductivity within the limits of the asthenosphere, and also its branchings, extending upward into the earth's crust, particularly in areas of volcanism and intrusive magma hearths, conditions prevail for development of electrode-anode reactions similar to reactions in fuel cells. These reactions lead to a difference in electrode potentials in the zone of transition from n-type conductivity to ionic conductivity. This in turn causes the development of a galvanic cell which will generate a current in the ionic-conducting crust, creating anomalies over the anode poles in the region of hydrogen supply and negative anomalies over cathode poles in adjacent sectors. Due to the more

localized nature of the anode poles in comparison with the cathode poles there will accordingly be a more compact form and greater intensity of the positive anomalies in comparison with negative anomalies. It may be that the variations of the deep natural electric field in time, reflecting changes in intra-terrestrial processes, will serve as criteria for prediction of tectonic movements and earthquakes. Figures 4; references: 16 Russian.  
[130-5303]

UDC 550.834:551.7:553.98

SEISMOSTRATIGRAPHIC METHOD AND ITS USE IN STUDYING USSR PETROLEUM AND GAS BASINS

Moscow SOVETSKAYA GEOLOGIYA in Russian No 1, Jan 83 pp 92-104

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[Abstract] The seismostratigraphic method makes use of the latest advances in seismic prospecting, stratigraphy, facies and formation analysis of sedimentary strata. The objectives of the method include determination of the age of sedimentary deposits, reconstruction of the sedimentation sequence, ascertaining the mineralogical composition and features of formation of sedimentary strata. The practical application of seismostratigraphy is the search for and mapping of nonanticlinal petroleum and gas traps. Seismostratigraphy is still in its infancy and its content has not yet been finally defined. Seismostratigraphy is a synthetic method and involves geological interpretation of data from seismic prospecting, breakdown of the seismic time section into genetically unified quasisynchronous sedimentation-seismic complexes and the discrimination of seismic facies within them. A large table outlines the elements of a system for seismostratigraphic research for both general seismostratigraphy and special seismostratigraphy in the search for the exploration of petroleum and gas deposits. The following subjects are considered: reasons for vigorous development of seismostratigraphy; possibilities of seismostratigraphy for breakdown of sections; determination of age of sedimentary rocks on basis of cyclicity of relative changes in sea level; possibility of using graphs of global cyclicity of sea level; principal methodological rules of seismostratigraphy; technical conditions for seismostratigraphic research. The possibilities of using seismostratigraphy in petroleum and gas prospecting and exploration are discussed, with particular application to the USSR. Figures 3; tables 1; references 8: 6 Russian, 2 Western.  
[131-5303]

## DIRECT PROBLEMS IN INTERPRETING EARTH'S NATURAL ELECTROMAGNETIC FIELD

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 1, Jan 83 (manuscript received 19 Oct 81) pp 133-140

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[Abstract] Direct problems play an important role in the interpretation of magnetic variations but fundamental difficulties in interpretation associated with the adequacy of models of the medium and field remain unsolved. In selecting a model of the medium it is virtually always assumed that conductivity in the earth is stratified in layers and does not change within the limits of the layer. This imposes a serious limitation on the correspondence of the model of the medium to the really existing conductivity distribution in the earth. For this reason it is necessary to find methods for solving electrodynamic problems for an arbitrary scalar function for conductivity in the earth  $(x, y, z)$ . This necessitates solution of equations with coefficients variable with respect to the three coordinates. Since the sources of the natural electromagnetic field are both magnetic and electric, in order to solve the problem formulated above the author limits consideration of the problem to the magnetic aspects. The computation method is fully described and the convergence of the computation method is demonstrated in special and general cases. Formulas are derived which are extremely convenient for computing different models of the earth due to the rapid convergence of the process of computation of the required Fourier coefficients. After computing the field components  $H_x^i(x, y, z)$ ,  $H_y^i(x, y, z)$ ,  $E_x^i(x, y, z)$  and  $E_y^i(x, y, z)$  it is possible to introduce impedances and on their basis--apparent resistivity, and then study their properties in dependence on the model of the medium and the real spatial distribution of the external field. References: 3 Russian.

[102-5303]

## PRINCIPAL TRENDS AND RESULTS OF DEVELOPMENT OF THEORY AND NUMERICAL MODELS OF SEISMIC RESEARCH METHODS

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 1, Jan 83 (manuscript received 9 Jul 82) pp 110-124

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[Abstract] Major successes have been attained in seismic prospecting for detecting petroleum and gas deposits. However, there are many fundamental difficulties which have arisen in the development of seismic methods in relation to new geological problems, the need for studying nonstandard forms of bedding of deposits under conditions of a complex geological structure of the investigated regions. Among such tasks is the search for and exploration of the

nonstructured deposits in the Tyumen region, especially the lithological traps of the Bazhenovskaya suite; study of the highly dislocated and deeply buried Paleozoic complex of Western Siberia; exploitation of promising regions in Eastern Siberia covered with trap rocks and regions of Northern Siberia with a horizontally highly variable upper part of the section in permafrost zones. There has been no effective solution of some important problems in geological prospecting in the European part of the country which have remained unsolved since the 1950's, such as the search for and exploration of structures of reef genesis, structures under salt domes, mapping of gently sloping structures with a small amplitude of arch rising. These and many other difficulties are related to inadequate development of theory and numerical methods for the interpretation of seismic data and methods for taking into account a whole series of factors involved in the complex structure of real geological media and also the inadequate resolution of existing kinematic methods for the interpretation of data and other limitations of the kinematic concept of processing of observations. Similar difficulties are also encountered in seismic methods for investigating the earth's lithosphere and the method for deep sounding of the crust as a result of increased requirements on the accuracy and reliability in describing the real structure of the investigated objects. These difficulties cannot be overcome on a purely technical basis, but only with an increase in the density of the observation system, the use of more powerful or high-frequency and specially oriented sources, more sensitive recording apparatus and data processing computers with a higher capacity. There is a need for the development and introduction of new physical principles and more modern mathematical methods for the processing of observations for taking into account those factors of structure of the medium and information on seismic processes which are not taken into account within the framework of existing methods. The author reviews the principal studies devoted to the development of the theory and methods for numerical solution of direct and inverse problems in kinematic and dynamic seismics for complexly structured media. This is followed by a discussion, based on the published literature, of the practical use of new numerical methods and the dynamic concept of seismic research. Figures 2; references 54: 48 Russian, 6 Western.  
[102-5303]

UDC 550.341

#### METHOD FOR DETERMINING PARAMETERS OF RADIATION FOCUS

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 1, Jan 83 (manuscript received 23 Apr 82) pp 95-102

SHCHEGLOV, V. I., Institute of Geology and Geophysics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] On the basis of a two-dimensional model of an earthquake focus proposed earlier by the author (FIZ.-TEKHN. PROBL. RAZR. POLEZN. ISKOP., No 5, 1978), a new method is outlined for computing the parameters of a radiating fracture plane of the length  $L$  and the width  $W$  on the basis of three experimentally observed characteristics: radiated energy  $E$ , seismic moment  $M_0$  and

rigidity  $\mu$ :  $L/W \approx 0.3(M_0/E)^{1/3}$ . It is shown that such parameters of an earthquake focus as seismic slippage  $D$ , jumps of stress  $\Delta\sigma$  and strain  $\Delta\gamma$ , energy  $E$  and seismic moment  $M_0$  are determined by the parameter  $p = W/L$ , being some functional of medium strength, and the width of the plane  $W$ , equal to the diameter of the elasto-plastic zone at the end of the shear fracture:  
 $\Delta\gamma = kp^2$ ;  $\Delta\sigma = \mu kp^2$ ;  $D = kW_p^2$ ;  $E = kk_1\mu W^3p^4$ ;  $M_0 = \mu kW^3p$ ,  $k = 43.8 \cdot 10^{-3}$ ,  $k_1 = 0.62$ . It is shown that with  $p \rightarrow 1$  the values of the parameters  $\Delta\sigma$ ,  $\Delta\gamma$ ,  $D$ ,  $E$  and  $M_0$  increase. For an isometric fracture plane ( $p = 1$ ) the jumps of stresses  $\Delta\sigma$  and strains  $\Delta\gamma$  are always constant and it therefore follows that the scatter in  $\Delta\gamma$  and  $\Delta\sigma$  values determined by the Brune method is related to errors in determining the initial data. The proposed method makes possible a stable determination of earthquake focus parameters, opening the way to an understanding of the principles for constructing a dynamic model of the seismic process. Figures 4; references 12: 3 Russian, 9 Western.  
 [102-5303]

UDC 551.24(265.5+262.5)

RELICT AND RIFTOGENIC DEPRESSIONS OF ABYSSAL REGIONS OF BERING SEA, SEA OF OKHOTSK AND BLACK SEA

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA B: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 3, Mar 82  
 (manuscript received 29 Sep 82) pp 34-37

SHIPILOV, E. V., CHAITSKIY, V. P. and GOLOVACHEV, E. M., Scientific Research Institute of Marine Geophysics, Krasnodar

[Abstract] Geological and geophysical studies of internal and marginal seas make it possible to discriminate two types of abyssal depressions: relict (ancient) and riftogenic (recent). The following criteria are used in such a classification: geomorphological; tectonic; stratigraphic; formational; tectonophysical; geothermal; geophysical; geodynamic. All these predetermine a differentiated approach to evaluation of the prospects for finding petroleum and gas in these abyssal sedimentary basins. The different characteristics of these two types of depressions are discussed. Relict depressions include the Aleutian depression in the Bering Sea, the Kurile depression in the Sea of Okhotsk and the Western Black Sea depression in the Black Sea. The formation of the relict depressions of the marginal seas occurred during the period of formation of the island arcs, in the Late Cretaceous-Paleocene or Eocene-Oligocene. As a result of these processes an intensive accumulation of sediments began, attaining 4-5 km (or twice this figure) in the Aleutian and Kurile depressions and up to 13-16 km in the Western Black Sea depression, accompanied by an appreciable decrease in the thickness of the earth's crust. The riftogenic depressions include the Komandorskaya, Sakhalin and Eastern Black Sea depressions. The deposits in depressions of this type belong to the Late Oligocene-Quaternary system. The thickness of the sediments in these depressions average 1-3 km in the Komandorskaya depression, 3-4 km in the Sakhalin depression and 10-12 km in the Eastern Black Sea depression, with the thickness

of the earth's crust being the same or somewhat less than in the relict type: 6-12 km. Both types of depression should be objects of close attention with respect to the possibilities of finding petroleum and gas because within these depressions there are great thicknesses of sediments; they are characterized by an increased heat flow; different types of reservoirs and traps are formed near deep faults and at the boundaries of blocks at different levels.

References 7: 5 Russian, 2 Western.

[132-5303]

UDC: 551.1:550.83(265)

COMPLEX GEOPHYSICAL CHARACTERISTICS OF PRIMARY TECTONIC STRUCTURES ON PACIFIC OCEAN BED AND PROBLEMS OF TERRESTRIAL CRUSTAL DEVELOPMENT

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 6, Nov-Dec 82  
(manuscript received 24 Nov 81) pp 28-35

KUNIN, N. Ya. and SEMENOVA, G. I., Institute of Earth Physics USSR Academy of Sciences, Moscow

[Abstract] A discussion is presented of the results of general regionalization of the Pacific Ocean bed into large areas. The basis of regionalization was data on the depths of the Mohorovicic boundary. The bed of the Pacific Ocean is divided into two large areas differing quite basically in their thickness and crustal structure: the eastern Pacific circle-shaped area of relative mantle upthrust occupying some 60% of the bed, and the western Pacific isometric area of relatively deeper metal surface occupying some 40% of the Pacific bed. A stratigraphic model of the bed is presented. The western Pacific area features thicker layer of the crust with greater variability of layer thicknesses. The transition from one area to the other is sharp, occurring over a narrow band, seen as a flexure in the M surface relief. It is assumed that the two areas have different histories of formation. The broad development of juvenile and contemporary vulcanism around the western and particularly eastern edge of the western Pacific area (Hawaii) and the difference in relief and crustal parameters indicate that the crust in this region may not be older than in the eastern area. References 52: 28 Russian, 24 Western.

[145-6508]

## SPECIFICS OF NORTHWESTERN PACIFIC PLATE DEEP STRUCTURE

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 6, Nov-Dec 82  
(manuscript received 24 Nov 81) pp 36-42

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[Abstract] Variations in parameters of the earth's crust in individual areas of the ocean fit within the framework of a generalized model which can serve as a standard for comparison with fields observed in various regions. This article attempts such a comparison. The water area selected occupies a portion of the northwestern Pacific plate limited by the edge of the oceanic trench on the west and the Shatskiy upthrust on the southeast. The comparison involved materials on a sublatitudinal profile intersecting Zenkevich ridge and the oceanic trench. The comparison was performed by supplementing seismic sectional data along regional paths with stratral velocity isolines within the crust. The sections obtained showed that the crust of a typical oceanic plate has a block structure with blocks measuring 150-300 km and alternation of blocks with high and low velocity parameters. High velocity blocks are found when there are high velocities on the surface of the acoustical basement, their location not correlating with Mohorovicic surface relief forms. There seems to be a relationship between high velocities in the crust and high velocities below the M boundary. High velocity blocks correspond to positive anomalies of regional gravitational field. Magnetic field anomalies also correspond with high velocity blocks. Figures 4; references 20: 10 Russian, 10 Western.  
[145-6508]

UDC: 553.98.04.(265)

## PREDICTING OIL AND GAS CONTENT IN FAR EASTERN SOVIET SEAS

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 6, Nov-Dec 82  
(manuscript received 25 Jan 82) pp 69-72

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[Abstract] According to the theory of the sedimentary-migrational origin of oil and gas deposits, the sedimentary rock basins which contain oil and gas can be looked upon as restrospective dynamic systems consisting of three subsystems--the collector, mineral and fluid systems. These subsystems plus the structural-tectonic characteristics of the basins define the primary aspects of theoretical research. The main goal of studies of the collector subsystem is to locate in section and plan deposits with optimal oil and gas bearing conditions and estimate their potential. Three main tasks are noted in studies of collector subsystems: improvement of existing and development of new methods

to estimate the generation and emigration potentials of oil and gas producing deposits from geochemical data; development of methods for estimating and logging oil and gas producing properties of deposits in basins beneath seas without direct lithologic-bituminologic data; creation of standard generation and emigration models for all basins in the far east. Such problems as standardization of terminology, principles and methodologic approaches to oil and gas geology regionalization, principles and criteria for differentiating categories of land and water areas in terms of their promise for oil and gas require further research. The authors call for further development of direct and indirect methods of studying the composition and structure of the geologic cross section. References 17: all Russian.  
[145-6508]

UDC: 52.124.4(265)

#### SPECIFICS OF MICRONODULES IN CENTRAL PACIFIC TRENCH

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 6, Nov-Dec 82  
(manuscript received 5 Apr 82) pp 104-106

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[Abstract] A study was made of the problem of morphologic specifics of micronodules and regularities of their distribution over area and depth. Micronodules in the north central Pacific Ocean trench were studied using samples from 10 stations, with numerous measurements of the densities of individual micronodules for one station. One of the most common forms is a cluster of spheres of various sizes. Another common form is spheroidal; a third is flat, plate-shaped nodules, sometimes twisted. There are intermediate forms among these three. Bar graphs of the distribution of densities and dimensions of the nodules are presented. There are two distributions on the dimension histogram and two clear maxima on the density histogram, reflecting the genetic differences in the two sets. Most micronodules are concluded to be not homogeneous, but rather mixtures of genetically different formations, one related to normal sedimentogenesis, the other to the activity of frigid hydrothermal solutions. Figures 2; references 11: 3 Russian, 8 Western.  
[145-6508]

## COMPUTING CHARACTERISTICS OF POLARIZED RADIATION BY ITERATIONS METHOD

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 28 Apr 81, after revision 2 Oct 81)  
pp 322-325

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[Abstract] Investigations of the polarization characteristics (PC) of scattered radiation are made for the purposes of astrophysics, radio physics and atmospheric optics. The literature on this subject is reviewed. In this article, for solving the problem of scattering of radiation by an inhomogeneous plane-stratified layer of matter in  $(z, \mu, \varphi)$  geometry, with allowance for polarization and with an arbitrary scattering law in an event and reflection from the underlying surface, a successive approximations method is proposed for the multiplicity of scattering with integration of the vector transfer equation using the characteristics of its differential operator. For solving the problem the authors examine a horizontally homogeneous plane layer. An external parallel beam of quasimonochromatic radiation is incident on the boundary of the layer  $z = 0$  at the angle  $\theta_0$  to the normal. Diffuse radiation sources can be situated within the layer and at its boundaries. Each source can have any polarization state. It is assumed that scattering in an event occurs without a change in frequency and is described by a four-dimensional matrix. It is necessary to determine the intensity and polarization characteristic of multiply scattered radiation within the layer and the radiation reflected and transmitted by the layer. The numerical method for solving the formulated problem is discussed in detail. The AP-5 programming system was then developed for systematic studies of the characteristics of the polarized field of radiation in plane-parallel layers as a function of the different parameters exerting an influence on its formation (sources of radiation, scattering, absorption, reflection from the underlying surface, layer inhomogeneity). A comparison is made with other similar methods (Coulson, Hovenier, and others). The results make it possible to evaluate the influence of anisotropy of the scattering matrix, albedo of the underlying surface and vertical inhomogeneity of the layer on the value and angular dependence of intensity and degree of polarization of radiation and also to evaluate the contribution of multiple scattering and allowance for polarization to intensity. The proposed method is recommended for solving a broad class of problems in atmospheric optics and also sounding of planetary atmospheres and the underlying surface. References 15: 12 Russian, 3 Western. [120-5303]

## RETRIEVAL OF ATMOSPHERIC SCATTERING INDICATRICES WITH ALLOWANCE FOR ANISOTROPY OF MULTIPLE EFFECTS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 18 Dec 81) pp 318-322

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[Abstract] In IZV. AN SSSR: FAO, Vol 16, No 9, pp 901-906, 1980, the author proposed a formula making possible approximate retrieval of the single scattering indicatrix  $\mu_1(\theta)$  on the basis of measurements of the brightness indicatrix  $\mu_n(\theta)$  at the solar almucantar ( $z = z_\odot$ ). Later the errors  $\delta\mu_1'$  associated with use of that formula were investigated in detail. It became clear that the formula makes it possible to retrieve the indicatrix  $\mu_1(\theta)$  with a mean square error  $\sigma\mu_1'$  of about 5-15%. In many cases the error  $\delta\mu_1'$  has a considerable angular variation. It is clear that exclusion of the angular variation  $\delta\mu_1'$  would considerably increase the accuracy in retrieving the indicatrix  $\mu_1(\theta)$ . A suitable approximation formula was derived for this purpose; this formula was checked 11 model scattering indicatrices. A table gives the values of the mean and mean square errors in retrieving the scattering indicatrices on the basis of the approximation formula: these errors were 1.06% and 3.53% respectively. This accuracy is entirely adequate for practical purposes. Examples of use of the approximation formula are given. A method for this same purpose was proposed by Ye. V. Pyaskovskaya-Fesenkova in 1957. The computations presented in this article show that the newly proposed formula gives superior results. Figure 1, tables 5; references 6: 5 Russian, 1 Western. [120-5303]

## INFLUENCE OF WAVES ON VERTICAL PROFILES OF WIND VELOCITY AND MOMENTUM FLUX IN NEAR-WATER ATMOSPHERIC LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 11 Mar 82, after revision 20 Sep 82)  
pp 315-318

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[Abstract] New experimental data have been used in a detailed study of the influence of waves on the characteristics of the wind flow in relation to the stage in development of sea wind waves. Measurements were made in the Caspian Sea from a pile base situated 20 km from the nearest land where the sea depth was 40 m and the fetches were hundreds of kilometers with the prevailing winds being northerly. The measurements included the following: profile measurements of mean wind velocity at six horizons; fluctuation measurements of the three wind velocity components; turbulent flux of momentum and averaging of the

products  $\overline{U'W'}$  for a time period of 30 minutes; measurements of sea waves; standard meteorological observations; observations of sea surface temperature. The measurements were made when the winds were from 5 to 15 m/sec, of a northerly direction, in different regimes of wind waves from actively developing to attenuating and at the time of a slightly unstable density stratification of the atmosphere determined from direct measurements of heat and moisture flows. A total of 48 series of synchronous measurements of the mean and fluctuating characteristics of wind velocity and 25 records of wind waves were analyzed. Other data on the spectral makeup of the flux of momentum were also used. Figure 1 shows examples of the profiles of mean wind velocity in different stages of wave development; Figure 2 shows the dependence of dynamic velocity on the state of wave development; Figure 3 shows spectra of the turbulent fluxes of momentum, rises of the wave-covered surface and other parameters. It was concluded that the perturbations in the air flow induced by waves exert a significant influence on both the mean and fluctuating characteristics of the flow. The effect of these perturbations is manifested differently, depending on the stage of wave development, and essentially involves a restructuring of the wind velocity field over the waves. Figures 3; references 6: 4 Russian, 2 Western.  
 [120-5303]

UDC 551.510.61:621.375.826

RETRIEVING PROFILES OF ATMOSPHERIC OPTICAL PARAMETERS USING LASER SOUNDING DATA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 3, Mar 83 (manuscript received 28 Dec 81) pp 255-266

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[Abstract] The sounding equation is the fundamental expression used in interpreting lidar measurements. It describes the intensity of singly backscattered light in a monostatic sounding scheme when the base between the source and receiver is short, radiation and reception are in small aperture angles and atmospheric turbidity is relatively small:

$$I(z) = z^{-2} A(z_0, z) \beta(z) T^2(z_0, z), \quad (1)$$

$$T(z_0, z) = \exp \left\{ - \int_{z_0}^z \alpha(z') dz \right\} = \exp \left\{ - \tau(z_0, z) \right\}. \quad (2)$$

Here  $z$  is the distance to the sounded volume at the time  $t = 2z/c$  ( $c$  is speed of light) from the moment of radiation of a short light pulse;  $A(z_0, z)$  is an instrument function, dependent on the parameters of the source and receiver and transmission of the dark zone  $T(0, z_0)$ ;  $\alpha$  and  $\beta$  are the atmospheric attenuation

and backscattering coefficients. In determining one of the two unknown parameters  $\alpha$  and  $\beta$  entering into (1) it is necessary to stipulate the relationship between them, such as the lidar ratio  $g(z) = \beta(z)/\alpha(z)$ . The authors here examine the solution of (1) relative to  $\alpha(z)$  as being of greatest importance for practical problems. In some cases it is useful to solve (1) for  $T^2(z_0, z)$  as a functional of  $\alpha(z)$ . In the inversion of (1) relative to  $\alpha(z)$  there are a number of difficulties; such as the randomness of the  $g(z)$  ratio, shifting to the  $I(z)$  signal due to the influence of multiple scattering during the sounding of optically dense media and the instability of the sounding equation to the first two perturbing factors and errors in calibration with the increase of  $T^2(z_0, z)$ . This article gives a thorough analysis of the influence of the perturbing factors on stability and accuracy of the solution and examines problems related to writing of optimum interpretation algorithms. Then the authors propose a statistical model for lidar measurements which makes it possible to use a priori information on noise ensuring the most noise-immune algorithms possible. Figures 4; references 16: 14 Russian, 2 Western.  
[120-5303]

UDC 551.510.42

#### KINETIC MODEL OF WATERLESS FINELY DISPERSE TROPOSPHERIC AEROSOL

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 3, Mar 83 (manuscript received 9 Mar 82) pp 241-254

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[Abstract] In an earlier article (IZV. ZN SSSR: FAO, Vol 19, No 1, pp 21-35, 1983) the author gave a detailed analysis of a scheme of genesis and development of finely disperse aerosol in the atmosphere and gave a quantitative examination of the intensity and kinetics of its different components. This clarified the multiple kinetically governed quantitative relationships of parameters characterizing the state of aerosol. It also made possible an approach to formulation of a synthetic model of atmospheric aerosol and its transformations, especially outlining of a kinetic model, as is done in this new article. The task of modeling of aerosol, or the modeling of aerosol weather, involves inclusion of an entire set of diverse parameters, each of which changes in its own way under the influence of many factors, both local and regional. The objective of kinetic modeling of aerosol is the formulation of such physically predetermined relationships. The kinetic model proposed here is an independent but indispensable part of synthetic modeling which must also include chemical, microphysical, statistical, optical, stratification and geographic modeling. With respect to the nature of the dominant mechanism for the elimination of particles, the finely disperse range (1 nm-1  $\mu$ m) is divided into two subranges: microdisperse, in which the attachment mechanism predominates, and submicron, in which the rate of the particles is determined by forced elimination. Each of the subranges is described by its own set of parameters, including the characteristic times reflecting the kinetics of the processes. There are two input parameters in the model (the other parameters are regarded as their known functions). The choice of the input parameters is arbitrary. It is best to select either parameters casually determining the

state of aerosol or parameters most easily and reliably measured empirically. The selected parameters were the space filling factor  $V_{fill}$  and lifetime of the submicron fraction  $T_{sub}$  (in the first variant) or the factor of filling of space with submicron particles ( $V_{sub}$ ) and the modal size of submicron particles ( $a_v$ ) (in the second variant). The model outlined here in the form of 7 pages of tables is presented in both variants. The model is recommended for practical use in scientific and practical work. Figures 4, tables 3; references: 5 Russian.  
[120-5303]

UDC 551.511.3:532.527

#### DYNAMICS OF SINGULAR GEOSTROPHIC VORTICES IN TWO-LEVEL ATMOSPHERIC (OCEANIC) MODEL

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 3, Mar 83 (manuscript received 14 Jun 82) pp 227-240

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[Abstract] The dynamics of regions with a localized potential vorticity field can be studied by the finite elements method, using an approximate representation of the continuous field of localized eddy perturbations by a finite number of point eddies. The evolution of regions with localized potential vorticity is determined by the interaction of point eddies with atmospheric currents and with one another. This approach was used by the author in describing the dynamics of localized eddy perturbations in a two-level baroclinic model of the atmosphere (ocean). Section 2 gives the derivation of equations for the joint baroclinic geostrophic eddies and currents. Sections 3 and 4 outline analytical solutions for some simple geophysical situations. Section 5 discusses the influence of nonadiabatic factors on the evolution of geostrophic eddies. In section 6, on the basis of the examined model, an analysis is made of the dynamics of binary tropical hurricanes. The possibility of using the model for describing less intensive atmospheric eddy perturbations and the interaction between such perturbations in the atmosphere requires further investigation. Figures 3; references 23: 15 Russian, 8 Western.  
[120-5303]

UDC 551.521.3+535.361

#### EXTREMAL DISTORTION OF IMAGE OF OBJECTS OBSERVED THROUGH SCATTERING LAYER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 2, Jan 83 (manuscript received 25 May 82) pp 321-324

ZUYEV, V. Ye., academician, BELOV, V. V., BORISOV, B. D., GENIN, V. N., KABANOV, M. V. and KREKOV, G. M., Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences, Tomsk

[Abstract] A nonmonotonic nature of the dependence of image quality of objects on the position of a layer of a turbid medium along the observation path was

noted as early as 1972; subsequent theoretical investigations failed to confirm such distortions, instead indicating that with approach of such a layer to the detector the image quality of objects of any size worsens monotonically. However, the results of similar theoretical and experimental investigations, but made on the assumption of local invariance of observation systems, confirm the results obtained in the initial study. In order to cast additional light on this subject, the authors here present the results of joint theoretical and experimental studies of the dependence of image quality on the position of a scattering layer in the region of small values of the  $t$  parameter where there is an effect ( $t$ -effect) of a sharp worsening of image quality of objects of a limited size. An analysis is made of this dependence for systems having circular symmetry using the frequency-contrast characteristics  $k(t; \omega)$ , where  $\omega$  is the space frequency;  $k(\omega) = K(\omega)/K(0)$ ; the optical transfer of the observation system is

$$K(\omega) = \int_0^r rh(r)J_0(\omega r)dr.$$

The theoretical investigations involved modeling of the function  $h(r)$  by the Monte Carlo method and a determination of the dependence  $k = k(t; \omega)$  using the Hankel transform. Numerical experiments were made with a scheme for observing diffusely radiating objects through a homogeneous scattering layer of the optical thickness  $\tau$ . The dependence  $k = k(t; \omega)$  was obtained for three models of scattering media: cloud Cl, haze H and aerosol concentration of haze at a humidity of 20%. The dependence  $k(t; \omega)$  was also investigated in laboratory experiments using a solution of milk in water as the scattering medium. There was a good qualitative agreement of the  $k = k(t; \omega)$  dependence obtained theoretically and experimentally. A photographic study was then made of a luminescent test object with different positions of the layer along the observation path as a qualitative illustration of the discovered effect of extremal distortion of an image by a localized scattering layer ( $t$ -effect). The described numerical and laboratory experiments have greatly clarified the considered phenomenon. Figures 4; references 8: 7 Russian, 1 Western.  
[80-5303]

## ARCTIC AND ANTARCTIC RESEARCH

### FIRST GROUP ARRIVES AT 'SEVERNYY POLYUS-26' ARCTIC STATION

Moscow IZVESTIYA in Russian 24 Apr 83 p 6

[Article by O. Borodin, "Severnny Polyus-26" Station: "Flag Over a Floe"]

[Text] We take off at dawn, while the sun has not yet risen above the horizon. Our group consists of five An-2 aircraft and we are taking off from Zhokhov Island in the Arctic Ocean where there is a base of the Arctic and Antarctic Scientific Research Institute of the State Committee on Hydrometeorology and Environmental Monitoring. We are flying toward the north pole, to a floe already selected the day before by ice reconnaissance pilots for the basing of the new "Severnny Polyus-26" station. We know everything which can now be known concerning this floe drifting in the icy waters of the ocean theoretically, on the basis of the results of many days of observations. And although this calms me, it is not very much, because our flight is the first flight and the first landing is to be made on the floe, possibly the most complex of those which will be made during this undertaking.

The lead plane is occupied by the commander, Yevgeniy Lepnitskiy. Alongside him is Velentin Ostapenko, my long acquaintance from former meetings, a true master of aviation over an enormous area from Bering Strait to the Novosibirskiye Islands. Also in the air is the flight director, the old polar worker Pavel Biryukov. When on the spot he will finally decide whether or not the floe is suitable for the basing of a new station, with a special group will prepare an area for the landing of a heavy Il-14 with the first winterers and will unpack the radio station. Biryukov has been a participant on all the "SP" stations, beginning with the "SP-16."

Our aircraft is the third in line. The crew commander is the young pilot Oleg Latushkin. He is flying to the floe for the first time and therefore in the copilot's seat beside him is the director of the flight subdivision Yuriy Georgiyevich Sysuyev, for whom this is the sixth ice navigation season.

We are flying from the eastern to the western hemisphere, across the juncture of the meridians which pass at the longitude of Vrangeli Island. In the earphones we hear the businesslike discussions concerning the course, concerning the fuel reserves in the aircraft tanks. The crews are working calmly, as if there was not drifting ice beneath them, but the solid ground. These people have probably already adapted to the Arctic. How strange! It appears that one can even adapt to the Arctic.

Several hours later we begin to descend. I see that the first plane, Ostapenko's, is going in for a landing. This temporary stop was planned. We will refuel the aircraft. The other planes meanwhile circle, without descending. The shadow of the lead "Annushka" darts through the ice, through the hummocks, along the open leads. Only from this shadow is it possible to determine how high the aircraft is above the ice because the white snow cover masks the distance.

A white eddy shoots up and the "Annushka," after traveling several tens of meters, taxis toward the hummocks. The other aircraft, in single file, go in for a landing.

We are on a floe. Not on the main floe, and yet... there is no time for sentiments. Everything is being done around us rapidly and in a businesslike way. It is difficult to believe that man has never stepped foot on this floe. Barrels of gasoline are rolled from the aircraft for refueling and light portable pumps begin to operate. And now the refueling has already been completed. A brief farewell. Two aircraft, two crews, those of Sergey Pravyakovskiy and Viktor Orlov, are returning to base, to Zhokhov Island. They must again refuel, fill barrels with gasoline and will return to this region, at which time we will return.

Meanwhile we head on, eastward. All this time an ice reconnaissance plane is flying over us, on the watch for any eventuality.

After a little more than two hours of flight our An-2 banks. We are over the objective. The first plane goes in for a landing. Amidst the packed floes with lines of hummocks I see shore ice which is level, one by four kilometers. From above it resembles a highly elongated pear. Finally!

And here is the floe itself. It appears that it is enormous. All around there is white snow, wherever you look. The motors of the An-2s fall silent and they aline themselves with the edge of the shore ice. But from the blue sky still thunders the engine roar from a low-flying Il-14. It has flown behind us. It carries the first winterers, for the time being few in number. And now they are awaiting the permission of the flight director (here, for short, they say "FD") Biryukov for landing.

We hurry toward the middle of the floe with drill in hand. Taking turns, we turn the handle, penetrating slowly into the ice. Biryukov raises a finger (the signal for the winterers) and the Il-14, in signification of recognition, tips its wings and heads for a turn.

Having himself been a flier in the past, Biryukov understands well the difficulty of such a maneuver for the pilots of a heavy aircraft and when the Il-14 comes in for a landing I see how the air controller clenches his jaw.

The Il-14, not stopping, rolls past us. It is carefully flattening the snow (in preparation for a takeoff) and then taxis up to our aircraft. The head of the "SP-26," Vasiliy Sidorov, descends to the ice and shakes Biryukov's and Ostapenko's hands firmly. But the crews of the An-2 and the group under

flight director Biryukov, together with the hydrologist L'v Savatyukin, who will remain on the floe for wintering, are already unloading the aircraft. The remaining winterers will fly in later.

Savatyukin is a candidate of geographical sciences. The subject of his dissertation was the effect of the ocean on the ice shores of Antarctica. This was the result of several winterings on the southern cap of the planet. The most difficult of these winterings was on the Shackleton Ice Shelf, when for the first time it was possible to drill through the shelf glacier. Incidentally, the station was headed by V. Sidorov. On the floe in the Arctic Ocean Savatyukin will be drifting there for the first time. But he is familiar with the Arctic. He asked to come here, to the "SP-26," from the post of director of the observatory at Amderma.

Sidorov, who for a long year of drift will be director of the large complex station, is studying the floe again and again. At the institute he is known as a builder. In Antarctica he built "Vostok" station and was its head in 1966 when the lowest temperature on the earth, -88.3 degrees, was registered there. This wintering will be an anniversary for him, the 30th.

The Il-14, not spending a half-hour on the floe, departs for the mainland at Cherskiy. But we continue to equip the flight director's camp. Two antenna masts rose above the tent and the small motor for the radio station thumped away. The busiest of all was Anastas Timofeyev. The complex radio station apparatus is being assembled under his direction and until the flight director's group is on the air we cannot leave the floe. Someone, in haste, incorrectly connected a plug to the transmitter unit. Something was not right with the switch. But now Anastas connects the transmitter and the radio man from Zhokov Island does not understand from where the new radio station is operating. The radio operator Leonid Vavilov again transmits his call letters and then the joyful news is spread throughout the world that the flight director's group at the "Severnnyy Polyus-26" station has proceeded to work.

We line up near the tent. A rocket flies upward and a red flag slowly rises into the Arctic sky. This is not the opening of the station itself. This for the time being is the only flag of the flight director's group. But this is the beautiful flag of the Soviet Union, opening still another outpost of science in the ice of the most severe ocean of the planet.

The watch in the Arctic, initiated in the 1930's by the Papanin four, is continuing.

5303  
CSO: 1865/133

## WORK OF RESEARCH VESSELS IN ANTARCTIC

Moscow PRAVDA in Russian 31 Mar 83 p 6

[Article by G. Cherkashin: "To the Shores of Antarctica"]

[Text] PRAVDA has already reported that oceanographic ships of Black Sea naval hydrographers departed in December of last year on the "Admiral Vladimirskiy" and "Faddey Bellingsgauzen" on an around-the-world Antarctic voyage.

Today we publish a report transmitted by radio from the shores of distant Antarctica.

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The day turned out to be sunny and clear and the white caps of snow on the bright indigo (the color of lazurite, or green, like malachite) floes looked like the backs of gigantic jellyfish, amidst a multitude of which the white expeditionary ship had entered. To the left and right, wherever one looked, icebergs, as if blocking the access to Antarctica, rose up among the snow-covered ice field like antitank obstacles. In comparison with them, the "Admiral Vladimirskiy" seemed brittle, like a wooden toy. Impacting on a floe, the ship shook, the stem rose up, and trembling slightly, smashed the ice.

The ship's clock on the "Vladimirskiy" showed 1150 hours when a bright neon line appeared ahead. With each mile traveled on course this line continued to grow, simultaneously becoming thicker, and finally everyone became convinced: the continent was ahead, to be more precise -- the ice shelf, the calling card of Antarctica, an inaccessible wall of ice dropping off vertically into the water, which along the continent, for a distance of thousands and thousands of nautical miles, is a sort of barrier, blocking off visitors from other continents.

It was 163 years ago that Russian seamen under the command of Bellingsgauzen discovered Antarctica and plotted the first map of the continent. This map is stored with the memorabilia of Bellingsgauzen in the Central Map Library of the Navy. The track followed by the sloops resembles a child's scrawlings. We are surprised and delighted by the resolution with which the seamen in wooden sailing ships undertook their risky "encroachments to the south." They traveled thousands of miles from their native shores and with risk to their lives entered into a voyage amidst the icebergs -- not for the sake of occupying new lands, but for the purpose of scientific research. And continuing this

tradition, Antarctica today has become the continent of science, where the people of many countries, shoulder to shoulder, are studying its complex environment and the enormous role which Antarctica plays in the climate of our planet.

We also know that Antarctica is rich in minerals. And whereas the coastal waters of Antarctica are now being furrowed by scientific research ships, the time is no longer far off when people will come here in order to extract coal, oil, gas and iron ore from the treasures stored on this continent. But for this purpose it is first necessary to solve the problem of the safety of Antarctic navigation. For the time being Antarctica is the only continent without navigational aids. The descriptions of many shores, bays and glaciers are random and inexact. Shoals, rocks above and below the water are by no means everywhere plotted on the map. Such work cannot be carried out in a year or two; years of the most careful work are being spent on this. This work is also being carried out on our expedition.

The oceanographic research ships "Admiral Vladimirskiy" and "Faddey Bellingsgauzen" without exaggeration can be called floating institutes, in which each laboratory and each section occupies an important place. As the ship proceeds it lets out a supporting-electrical cable. Connected to this are sensors for measuring the earth's magnetic field. The echo sounder tape gives a continuous record of bottom relief and depths are measured. Here the curve has crept up sharply, indicating a seamount, but on the chart there is no mount at this point. A command is sent to the wheelhouse and the ship makes new runs, furrowing the ocean surface, determining the outlines of the discovered rise. The seamount is not large and the scientific director of the expedition, Rear Admiral Lev Ivanovich Matin, announces a competition for the best name. It is named Chernomorskaya Seamount.

For a definite time interval the ships are at drift: it is time for the hydrologists to do their work. A cable is let out into the depths; suspended to this are instruments which at different horizons register water temperature and salinity; current direction and velocity are determined. At the same time water samples are raised aboard the ship from different depths for other investigations. The work is done in any weather, even in a storm.

The scientific staff of the expedition each day determines the regions for exploration work. Plans were laid to search for the earth's south magnetic pole. This pole is a real wanderer. In 24 hours it travels about 30 m, and in a year -- 10-20 km. When Bellingsgauzen returned from his voyage on the basis of his measurements he determined the position of the south magnetic pole ( $76^{\circ}\text{S}$  and  $142.5^{\circ}\text{E}$ ). The pole was situated within the continent.

In 1909 a British-Australian expedition consisting of David, Mawson and Mackay first reached the south magnetic pole and determined its coordinates directly in place:  $72.25^{\circ}$  and  $155.16^{\circ}$ . Douglas Mawson was also the first scientist who postulated that the magnetic pole moves in a northwesterly direction. Thus, it became clear that each determination of the position of the south magnetic pole will be in fact the next point in the orbit along which it moves.

In February 1983 the participants on the expedition aboard the "Admiral Vladimirskiy" and "Faddey Bellinsgauzen," under the direction of Rear Admiral L. I. Mitin and Captain L. M. Rud', for the first time carried out a broad-scale search for the position of the south magnetic pole in the open sea. Over a period of several days the ships wandered over an extensive area of the sea, making complex runs. More and more lines were plotted on the chart. Intersecting in a southerly direction, these lines gradually delimited the region through which the cluster of vertically directed magnetic lines of force moved in accordance with the diurnal variation.

The "Faddey Bellinsgauzen" had the honor of first passing over the south magnetic pole. On 3 February 1983 the scientific research ship, bearing the name of one of the discoverers of Antarctica, signed its "autograph" over the south magnetic pole in the D'Urville Sea.

And at this time the "Admiral Vladimirskiy" approached the Balleny ice mass, where in January 1977 the diesel-electric "Mikhail Somov," of the icebreaker class, was held prisoner of the ice. The flagship of the Soviet Antarctic Expedition continued its forced drift for 57 days. This happened when the "Mikhail Somov" approached "Leningradskaya" station with a new party of polar workers.

The "Vladimirskiy" also headed there: at the station there were sick personnel who had need of hospitalization. Whether it would be possible to remove them excited not only the winterers at the station and the seamen, but also all the participants of the 27th and 28th Soviet Antarctic Expeditions: a radiogram to the "Vladimirskiy" with the request for assistance came from aboard the icebreaker "Kapitan Markov," where the head of the 28th Expedition, N. A. Kornilov, Hero of Socialist Labor, was located. But there was no luck with the weather: the winds attained 50 m/sec at "Leningradskaya." The winds could also inflict a surprise on the "Vladimirskiy" as it shoved aside the ice which forms in the neighborhood of the Balleny Islands throughout the year. For this reason the Balleny ice mass is called a trap for ships.

But here the ship's captain, Commander Roman Panteleymonovich Panchenko, displayed his coolness and the ability to navigate a vessel under complex ice conditions. He expertly guided his vessel through the ice... A radiogram was received in the open ocean: "We were very pleased at the hearty meeting with our countrymen of the courageous ship. You brought us the great warmth of our native land and left a good, profound memory for many generations of Antarctic researchers. From the heart we wish you fair winds and favorable weather on the entire route of the famed Russian navigators. On behalf of the personnel of the Antarctic station Mirnyy. Serdyukov."

At dawn of the next day a helicopter succeeded in removing the ill winterers... The voyage is continuing. Each morning photographs are received from meteorological satellites from which it is possible to prepare a weather forecast. The weather favors the implementation of a survey of the shores of the Somov Sea. And this work was completed on time. A radiogram with the coordinates of the point of rendezvous in the Pacific Ocean was sent to the "Faddey Bellinsgauzen." The "Admiral Vladimirovskiy," guided by its commander and his

assistants A. G. Kudinov and B. B. Gotovko, is exploring the Ross Sea. It is necessary to shift one of the islands several miles; it is incorrectly plotted on the charts. Then, already enroute to the place of rendezvous with the "Bellingsgauzen," the same fate was experienced by another small rocky islet.

Several islands were "put in their place," a new position of the Bellingsgauzen ice shelf was determined, a considerable part of the shoreline of Eastern Antarctica was described and measured, measurements of the earth's magnetic field were made along the entire length of the track, a broad complex of meteorological observations was made, and the position of the south magnetic pole was determined...That was quite a lot. But for some reason or another I remember most clearly that remarkable sunny day when the "Admiral Vladimirskiy" was at drift at the point of discovery of the Antarctic. In the "roadsteads of Antarctica" as this historic site is now called.

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## RESEARCH IN ARCTIC AND ANTARCTIC

Moscow PRAVDA in Russian 17 Apr 83 p 3

[Excerpts from article by A. Aleksandrov, A. Ivanov and V. Tikhonov]

[Text] A very busy time has come in the Arctic for scientists and specialists: a floe has been selected for the new drifting station "Severnny Polyus-26." Scientific equipment, food and fuel are being transported to the floe. The first huts have been assembled for polar workers -- with all the necessities of life. The new settlement has been inaugurated. In short, the "SP-26" is beginning to come to life. The experienced polar researcher V. Sidorov has been designated its leader.

G. Artem'yev, performing the duties of head of the Scientific Expeditions Section at the Arctic and Antarctic Scientific Research Institute, explains: "With respect to scope and breadth of the planned scientific programs, the station is similar to the 'SP-22,' which operated, as is well known, for a full 8 1/2 years. And again it has been decided to organize work on the pack ice. Extensive facilities are being developed and they will be serviced by AN-12 and IL-14 aircraft, for which it is necessary to have airdromes with a solid runway."

The station is to ensure a full range of aerometeorological, oceanological, hydrochemical and geophysical investigations. There is also an extensive program for study of the ice cover. At the same time it was decided to continue work on the "SP-25." Thus, at the very same time there will be two major drifting stations in operation in the Arctic.

However, the study of the Arctic is not limited to this. Investigations by an expedition of the institute are being carried out on the glacier dome of one of the islands in the Severnaya Archipelago, where there is a permanent scientific research glaciological polygon. Preparations are being made for the summer landing of so-called 'jumping' high-latitude expeditions. Groups of researchers will be put ashore on the ice at different points in the ocean.

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Scientific personnel are now being replaced at all seven Soviet Antarctic stations. The tasks of the 28th expedition have begun. Multisided investigations are also being carried out at "Vostok" station, situated within the continent

at an elevation of 3,488 meters above sea level in the region of three poles: cold pole, solar radiation pole and geomagnetic pole.

The ice continent is the continent of the courageous. The investigations here are carried out under conditions of fierce subzero temperatures and violent winds. However, the people are stronger than the elements. Those who have spent the winter at "Vostok" station have confirmed this by their personal example. PRAVDA has already written about their courage. A fire at the station deprived people of heat and light when the temperature was  $-70^{\circ}\text{C}$ . The work nevertheless continued.

Seven Soviet stations are in operation and performing important work in cooperation with scientists of other countries. Their work is necessary: here, as specialists assume, is one of the principal centers of weather formation.

This season in Antarctica plans call for carrying out a broad range of aerological and geophysical investigations. Glaciologists and microbiologists are continuing their work with the drillers. The objective is to raise an ice core from a great depth in order to examine its structure and properties, microorganisms, buried in the ice for thousands of years.

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