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YADERNOY GIDROFIZIKE

(Application of Spectrographic Methods
in Nuclear Hydrophysics)

by

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ABSTRACT

A new method for spectrographic analysis of seawater contaminated with strontium 90 is suggested. The method was verified during XVI and XVII cruises of the Mikhail Lomonosov in the Black Sea. Analysis of data discloses that the concentration of strontium increases with depth. The controls employed in the processing of seawater samples aided the determination of various characteristics of radioactive strontium. Some of the data are graphed and tabulated.

Translator

APPLICATION OF SPECTROGRAPHIC METHODS
IN NUCLEAR HYDROPHYSICS

The investigation of processes that occur in the water of the World Ocean is rather difficult because of the great variety of phenomena and the great number of factors that affect the ultimate results. Part of the problems can be solved with the aid of methods used in nuclear hydrophysics--namely, the section of hydrophysics that has become established during the last decade.

As is known, the testing of nuclear and thermonuclear apparatus during the last decade filled the atmosphere with large quantities of fission products. The tests led to a global radioactive infection. Because the surface of oceans and seas makes up $3/4$ of the globe, the greater portion of radioactive wastes infest the water masses. Despite the cessation of the tests, the infestation of the ocean continues because certain quantities of fission products continue to fall out of the atmosphere. This phenomenon is intensified by increasing fallouts on ocean surface and by the discharge of radioactive wastes by rivers. The danger of infection is increasing the more so because the radioactive wastes are dumped into the ocean by several western countries. Investigation of the distribution and migration of radioactive products in the ocean enables us to draw certain conclusions about the intensity of the infection and to determine the large-scale and small-scale processes of intermixing which affect many phenomena. /27

The use of radioactive and other nuclear wastes for the determination of the processes that occur in the ocean requires very accurate measurements. The errors resulting from deficiencies of instruments have been determined in this case considerably better than the errors resulting from the complex and elaborate chemical processing of water samples when preparing them for analyses. In this connection, it is necessary to verify the chemical reactions since the quantity of strontium 90 that is separated, may vary from 20 to 80%. The determination of the quantity of strontium 90 in seawater can be achieved by a considerable number of chemical analyses. The processing is associated with certain losses of the matter. If the preliminary determination of stable strontium in a sample has not been carried out, errors may slip in when calculating the results.

The reason for this is that the content of stable strontium may fluctuate in the initial sample. Usually, the error is introducing radiostrontium absorbent into the sample. Thus, the error in determining radiostrontium is decreased by a factor of

three for possible variations of 50% in stable strontium content. By using the existing methods, the initial concentration of stable strontium is determined from ratio Sr/Cl. It is thought that this ratio is constant and cannot be substantially changed by biochemical processes. However, the small number of determinations of strontium in seawater, especially in the deep layers of oceans, and its chemical relation to calcium, make this conclusion rather uncertain.

The separation of strontium from carbonate deposits, which is based on various degrees of solubility of strontium and calcium nitrates, requires controls because, with each deposition, the loss of strontium is about 10-12%, but a single deposition is insufficient for a complete separation of strontium from large quantities of calcium. Many repetitions of such deposition may result in great losses of the element that is to be analyzed. In order to determine fluctuations in the concentration of natural strontium, as well as its losses in the process of carbonate deposition, the initial sample must be analyzed to determine the total amount of strontium and the loss must be analyzed to determine the decantate.

In order to carry out these analyses, the nuclear hydrophysics laboratory of the MGU AN USSR has worked out a method of spectral analysis of seawater for strontium. Because the emission of strontium is represented by lines 4077.714 Å; 4215.52 Å and 4607.331 Å, which lie in the area near the intense lines of calcium 3968.468 Å; 4226.728 Å and potash 4044.17 Å; 4047.201 Å, its determination by the method of flame photometry is associated with the possibility of great errors since this method is based on the filtered discrimination of wave lengths within a certain typical range. Therefore, the superposition of the radiation of potash and calcium can lead to great errors. Because there is a need for the dispersion of spectrum and the quantification of individual analytical lines of the element that is investigated, we employed a special method--namely, the spectral analysis of the solution from a fulgurator (special electrode) by the glass spectrograph *MCW-51*, which appeared to be better suited for shipboard investigations. The fulgurator represents a special construction in the form of a special tube (made of spectrally pure copper) devised in the laboratory of nuclear hydrophysics of MGU AN USSR (Fig. 1).

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The fulgurator is fastened to the lower clamp of the support *WT-9* as with the standard electrode for powder analysis. A 20-ml quartz beaker containing the liquid that has to be investigated is placed under the curved part of the electrode. Through the capillary hole the solution rises to the upper level of the

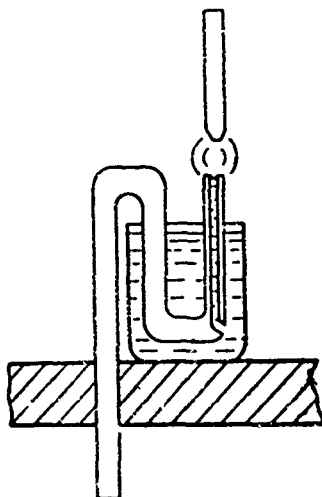


FIG. 1

electrode where vaporization takes place. With this, the liquid becomes the arc discharge. The analytical space of the arc was 2mm. The alternating current arc was fired by generator ДГ-2 , the current being 4a. The exposure time of 45 sec. was determined from the timer БПБ . The glass spectrograph ИСП-51 with a $\phi 270$ camera with type II spectral plates was used for taking the photograph of the lines. Photometry was carried out by microphotometer МФ-2 . The analytical line for strontium is 4607.33 Å. The Ca--4581.40 Å line was used for comparison purposes for introduction of excess calcium into the samples and standards for normalizing the fluctuations of calcium in seawater samples. The samples and standards were run three times.

In order to have identical conditions for the analysis of samples and standards, the latter were prepared directly from seawater. Because the chemical determination of strontium is complex in the standard, a method was devised for determining the absolute concentration of strontium in a primary reference standard. The volume of solution transported from the fulgurator into the arc is constant per unit time; also the concentration remains constant. A 30-second exposure spectrum of a calcium solution (whose concentration was adjusted for doubling the blackening of the calcium arison lines) was superimposed onto a 60-second exposure spectrum of the standard solution. /29

Then small quantities of strontium were added to the 250ml reference standard until the intensity of blackening of strontium lines equalled the intensity of blackening of strontium exposed for a minute. Afterwards, the strontium concentration in the reference standard appeared to be equal to the concentration of the artificially-added strontium.

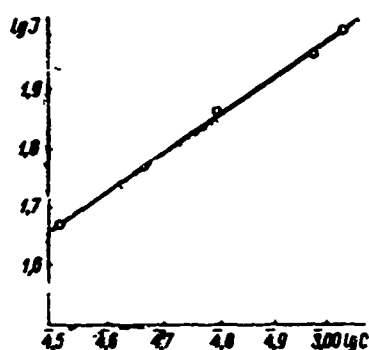


FIG. 2

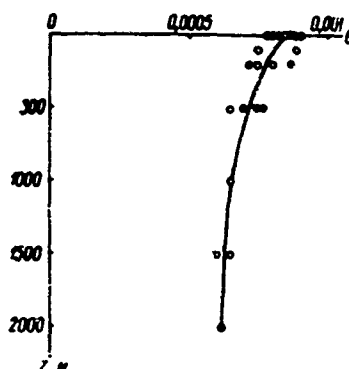


FIG. 3

We note that with the aid of this method it is possible to determine the absolute concentration of various elements from solutions within the limits of the given sensitivity of the instrument.

For analysis, we prepared four standards with concentrations 0.00032; 0.00064; 0.00090 and 0.00128% of strontium.

The calibrated graphs were plotted in logarithmic coordinates (Fig. 2). The relative error for the method of spectral analysis of strontium is \pm (7-9)%.

The described method of spectrographic analysis of strontium was verified during XVI and XVII cruises of Mikhail Lomonosov when the method was utilized for the determination of the content of stable strontium in seawater. The data on the quantity of strontium at various depths of the Black Sea are presented on Fig. 3. Analysis of the data demonstrates that the concentration of strontium decreases with depth. This fact must be accounted for when analyzing the pattern of the distribution of radioactive strontium, because in the given case the stable strontium can be considered as a carrier which introduces changes in the appraisal of the speed of propagation of radioactive contamination in the ocean.

The spectrographic control in the processing of seawater samples in laboratory also enabled us to determine the characteristics of radioactive strontium in the process of radiochemical analysis. /30
The data on the processed samples that were collected during the XVI cruise of Mikhail Lomonosov are shown in the table. It is seen that corrections substantially fluctuate. Without verification and corrections, this would lead to substantial errors.

No. of sample	No. of station	Strontium %	No. of sample	No. of station	Strontium %
1	1	42,3	18	13	44,0
3	3	70,1	19	14	69,4
4	4	39,0	20	14	19,1
5	4	23,1	21	15	19,2
6	5	19,6	22	15	22,8
7	5	18,5	23	16	76,5
8	6	41,8	24	17	37,1
9	7	19,9	25	17	50,0
10	8	50,0	26	17	64,0
11	9	68,1	27	18	30,1
12	10	16,4	28	19	13,4
13	11	41,1	29	20	28,8
14	11	79,3	30	20	30,0
15	11	25,4	31	20	74,6
16	12	31,9	32	21	53,4
17	13	36,2	33	21	30,8

The discussion shows that the suggested methods are useful and better than other methods. Undoubtedly, a continued improvement of the methods will increase the accuracy of nuclear hydrophysical characteristics of complex ocean processes.