SCIENTIFIC RESEARCH OF « VITYAZ » DURING IGY

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Soviet scientists have carried out oceanographic investigations as part of the IGY program in the Atlantic, Indian and Pacific Oceans, as well as in arctic and antarctic waters. The main amount of research in the Pacific basin was performed by the *Vityaz,* a research vessel of the Institute of Oceanology, U.S.S.R. Academy of Sciences.

Between June 1957 and March 1959, four cruises were made by the *Vityaz* in the central, northeast and northwest Pacific. During these cruises, the *Vityaz* covered 73 700 miles and occupied 618 comprehensive oceanological stations. 60 experts specialized in different sciences took part in the *Vityaz*'s scientific work. The following divisions were formed : aerometeorology, hydrology, chemistry, geology, hydrography, geophysics, ichthyology, plankton, benthos, and nautical technics.

The study of the oceanic and atmospheric circulation, the characteristics and distribution of water masses, wave processes, oceanic thermic balance, chemistry of the oceans, geological structure of the sea bottom and distribution of marine organisms were the subjects generally studied during these four cruises. Each expedition also had its own program, based on the area covered. Thus a major task of the *Vityaz* during its second cruise, which included navigation along two meridian profiles in the Central Pacific, consisted in explaining the zonal distribution of oceanological characteristics. A diagram showing the routes followed in the *Vityaz* cruises appears in figure 1.

The first cruise in compliance with the IGY program took place from 28 June to 11 October 1957. The *Vityaz* spent a total of 105 days at sea and covered 17 000 nautical miles. 165 stations were occupied. The expedition's scientific operations were headed by Professor A. D. Dobrovolski. The westernmost portion of the Pacific between the islands of Japan, the Philippines, New Guinea and the meridian of 155° east longitude was studied. Comprehensive oceanological research during this cruise took place along twelve sections. Valuable information was obtained on the origin of the Kuroshio, and an important aspect of the cruise was the investigation of the Bougainville and Mariana deeps.

The second *Vityaz* expedition, led by Professor V. G. Bogoroff, a corresponding member of the U.R.S.S. Academy of Sciences, was carried out from 5 November 1957 to 27 February 1958. The main work of this cruise took place in the Central Pacific, along the meridian of 174° west longitude from latitude 33° north to New Zealand and thence along meridian 172° east to latitude 30° north. The expedition lasted 115 days; 133 oceanological stations were occupied and the Tonga and Kermadec deeps were studied. A total of 17 500 miles were covered. It should be

mentioned that these operations of the *Vityaz* were closely connected with the antarctic cruise of the *Ob,* which did comprehensive oceanological research along meridians from the coasts of Antarctica to New Zealand and along meridian 160° west to subtropical areas. These activities have enabled analysis of the distribution of oceanological features and fauna along a meridian from Antarctica to the Kuriles.

The third *Vityaz* cruise, from 20 March to 20 June 1958, repeated observations taken during the initial cruise. The scientific program was headed by V. P. Petelin, but was considerably shortened owing to radioactivity in the area southwest of the Caroline Islands. 135 oceanological stations were occupied, and the vessel covered 14 800 miles.

The fourth and last IGY cruise of the *Vityaz* took place in the Northwest Pacific, from 5 October 1958 to 14 March 1959. During 160 days, the *Vityaz* covered 24 500 miles. Observations of great depths took place at 205 stations. The scientific work was supervised by N. N. Sissoef. A large portion of the Northwest Pacific was covered, from the shores of Alaska and North America to the meridian 175° west and latitude 20° north. Wide use was made of automatic current-recording equipment at great depths (below 5 000 metres). This enabled a large amount of accurate data to be obtained on deep-sea currents.

Considerable information was obtained on physical, chemical, biological and geological features of the Pacific through the scientific work accomplished during the four cruises of the *Vityaz.* All these data are at present being processed, but some of the results are already available. The instrument measurements of deep-sea currents indicate a velocity of 10 to 12 cm per second at an approximate depth of 1 000 m, and in certain areas nearer the coast, velocities of the order of 50 to 70 cm p.s. During cruise 4, the *Vityaz* recorded a current velocity of 12 cm p.s. at 3 000-m depths and more. These velocities were unexpected, as at such depths it was believed that the limit attained was 3 to 5 cm p.s. Investigation also revealed that the countercurrent between the trade winds widens with depth, and sinks below the trade-wind currents in the shape of a deep-sea countercurrent. It attains a width of 12° at a depth of 500 m, whereas width at the surface amounts to but 6 or 7°. Limits of currents are subject to rapid, considerable shifts. Thus a comparison of observations along the two meridian profiles in the central area of the Pacific shows that the north trade-wind current along 172° E is spread over an area from lat. 18° N to 14° N, whereas along 174° W, it extends from 22° N to 8° N. The countercurrent between the trade winds flowing along 172° E extends from 14° N to 4° N, whereas along 174° W it covers the area between 8° N and 4° S. The south trade-wind current along 172° E extends from 4° N to 14° S, whereas along 174° W it is no more than 600 miles wide.

The northern boundary of subtropical waters shifted by as much as 250 miles within three months (from 22° N to 18° N).

These facts indicate an extreme complexity and considerable variation of the oceanic circulation. It is clear that the research on deep-sea circulation commenced during the IGY should continue.

Optical observation of great depths also provided interesting results. It was found that the various structures of water masses have their own particular hydrooptical characteristics. In areas where the waters mix,

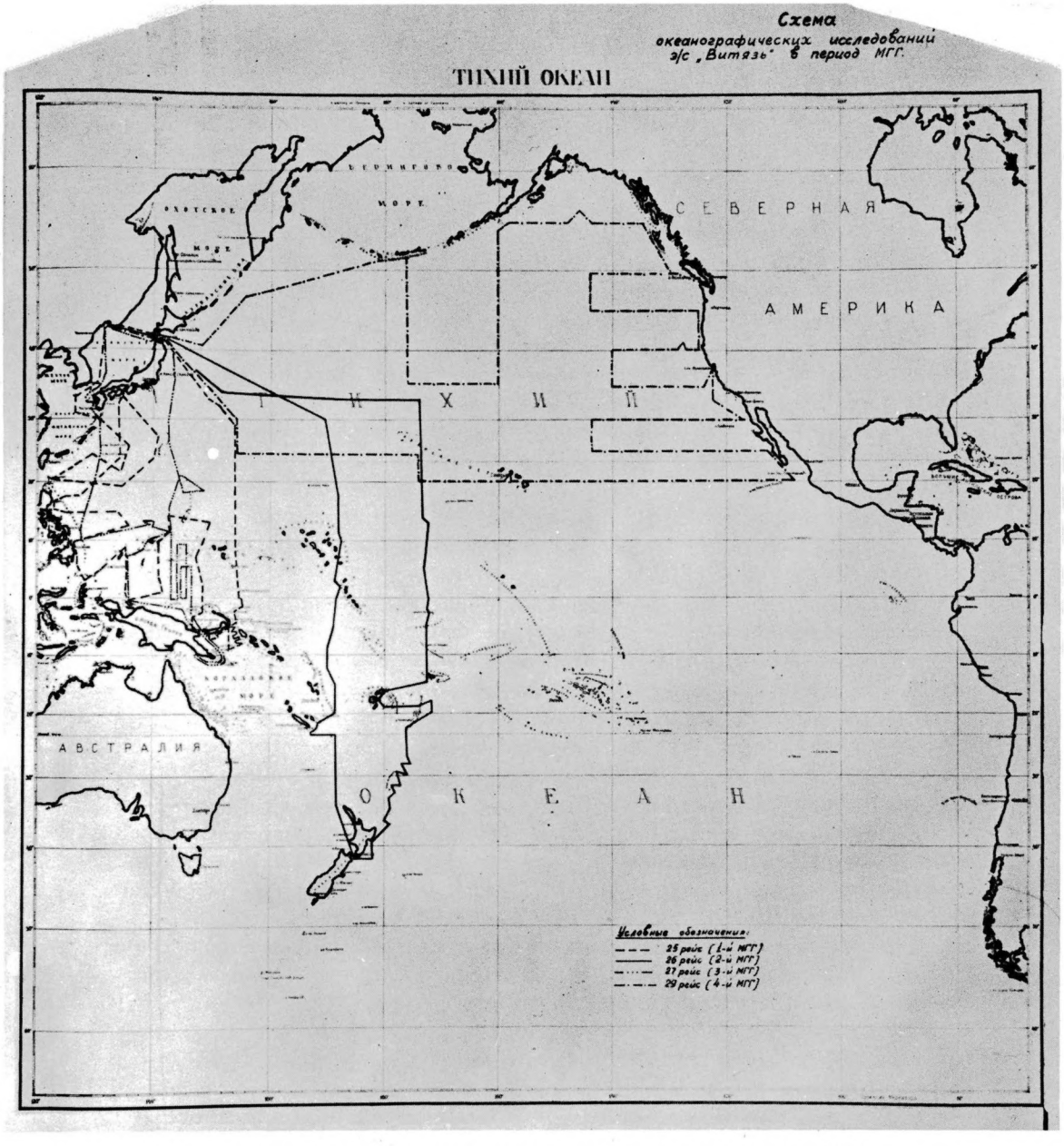

FIG. 1. — Chart of Oceanographic Research of *Vityaz* during IGY.
Legend :
— — — 25 trips (IGY cruise 1)
———— 26 trips (IGY cruise 2)
— ... — 27 trips (IGY cruise 3)
—.—.— 29 trips (IGY cruise 4)

there is a sudden drop in transparency; in convergence areas this decrease may be observed down to 2 000 or 3 000 metres.

The geological research of the *Vityaz* enabled a clearer picture of the Pacific bottom relief and structure to be obtained. In various areas, a series

of hitherto unknown submarine elevations and peaks were discovered. Some of these are probably submerged islands. The morphometry of deep-sea depressions was obtained in greater detail, and considerable data on bottom deposits were collected. The study of long bottom cores will contribute to better understanding of the history of the Pacific and of paleoclimatic changes that have occurred.

A detailed study of Pacific depressions had already been undertaken by the *Vityaz* in 1949 (Kurile-Kamchatka Trench) and was continued during the IGY. These investigations have resulted in information on 14 out of the 18 deeps so far known in the Pacific. A new deep of more than 6 000 m was found in the neighbourhood of the Santa Cruz Islands, at a place where a break existed in the Western Pacific abyssal canal system.

The maximum depths in the Tonga (10 840 m) and Kermadec (10 030 m) Trenches were determined by sounding. In the Mariana Trench, the greatest depth in the World Ocean was measured, amounting to 11 034 m. Fairly detailed research in the vast geosynclinal region of the Western Pacific supplied new indications as to structure of the earth's crust in this area.

Seismo-acoustic investigations during the four cruises of the *Vityaz* showed that the layer of friable sedimentation in the Pacific sea-bed was not more than 1 000 m thick.

Important data were obtained by abyssal and superabyssal trawling (beyond 5 000-6 000 m). The record haul was obtained in the Mariana Trench, at a depth of 10 700 m. The trawl collected twelve species of bottom organisms, including a large number of unknown varieties.

Computations show that the biomass at a 10-km depth is 1 000 times smaller than that of the benthos at 1 000 m. The variety of species, according to the theory of Z. A. Zenkevitch, decreases 100 times.

Comprehensive research in the abyssal trenches (physical, chemical, biological and geological) showed that waters rich in oxygen easily reach the bottom, which retains no hydrogen sulphide or salts; a phenomenon of oxidation occurs. The fauna in the trench bottom is fairly varied and extensive.

There is accordingly evidence of vertical circulation of considerable intensity in these trenches, resulting in mixing of the water masses over a vertical distance of several kilometres.

Biological research showed that in the tropical zone the amount of plankton was 20 to 40 times less than in temperate latitudes. The amount of plankton moreover is subject to sudden variations in the area adjacent to the tropics (from 7-10 to 60-90 per cubic metre in the layer above 100 metres). The spread and development of plankton are closely related to the upwelling of abyssal waters which are rich in biogenetic material. This is evidenced by the quantity of plankton in the countercurrent zone between the trade winds, and by the amount of predatory fish or those, such as tuna in particular, which feed on plankton. The abundance of plankton in this area causes a 10-m decrease in water transparency and reduces the specific gravity of the sea floor, due to the large accumulation of planktonic skeletal remains. During the *Vityaz* cruises, abyssal plankton was collected in the tropical zone, in which an extreme scarcity of living organisms was noted. Thus in the Mariana Trench at a depth of over 4 000 m, the plank-

tonic biomass amounted to only 0.012 mg per cubic metre. This biological research has been very helpful in evaluating the biological structure of the ocean.

The investigation of oceanological features according to geographical zone, along meridian profiles, enabled the *Vityaz* to classify each zone according to reciprocal ratios of physical, chemical, biological and geological processes and patterns, and to confirm the uniformity of oceanic conditions. In addition to their being of theoretical significance, these results have far-reaching importance in the practical exploitation of ocean resources.

The research activities of the *Vityaz* are manifestly of great value. The scientific study of the data and material collected, when compared with the observations of other countries participating in the IGY, will solve a whole series of problems connected with present-day oceanology.