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Russian Oceanographic Vessel "VITIAZ" - Techniques and Equipment

by

K.R. Vale, A.R. Brown and A. Turpie

RUSSIAN OCEANOGRAPHIC VESSEL "VITIAZ" - TECHNIQUES AND EQUIPMENT

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RUSSIAN OCEANOGRAPHIC VESSEL "VITIAZ" - TECHNIQUES AND EQUIPMENT

Introduction

The Soviet Research Vessel VITIAZ (Photo No. 1) was open for inspection in Sydney Harbour on Thursday, January 14, 1971. Messrs. K. Vale, A. Brown, D. Jongsma, B. Willcox and J. Cull inspected the vessel during the morning and attended a seminar and social gathering with the Russian scientists at the Australian Museum in the afternoon and evening. On the following day a group of Russian scientists visited Canberra and spent some time at the Bureau of Mineral Resources; a further social evening was held at the Australian National University that evening. A. Turpie visited the vessel in Sydney on January, 16.

This report summarizes impressions of the vessel, its equipment and work.

The vessel and its equipment appeared to be completely declassified There was complete willingness on the part of the Russians to discuss their work and equipment, and visitors were permitted to move freely around the ship and discuss or photograph anything they wished. Many of the Russians were able to speak fair English but naturally the rate of communication was slow and coupled with the large number of visitors, our appreciation of detail was not as good as we would have wished.

The Ship

The VITIAZ was commissioned for Soviet oceanography in 1949. It is a single screw vessel of about 110 metres length and about 3000 tons gross (6000-7000 tons displacement). Its home port is Vladivostok. (The vessel is an ex German cargo ship, built in 1939, which was captured by the British during the Second World War and was part of the wartime aid programme to Russia).

The vessel has no special stabilizer or station keeping facilities. However, it is reputed to be a particularly comfortable riding vessel with a roll period of around 15 seconds. It has accommodation for about 60 scientific personnel and carries a crew of about 70. The accommodation appeared to be excellent with spacious sleeping quarters and areas set aside for relaxation and recreation. It is, however, short on airconditioning for work in tropical conditions.

The laboratories are not well grouped and are distributed around the vessel and on different decks. Cabins at the rear of the ship make it necessary to stream all gear from booms.

In summary it is an old and adapted vessel. It is not very efficient but still comfortable and reasonably effective. It is understood that the ship will probably remain in service for a further five years.

Present cruise

It is understood that a normal cruise is around three months and rotates in emphasis between geology, geophysics, biology and physical oceanography. This cruise, the 49th undertaken by the VITIAZ, is principally geophysics but a substantial complement (10) of geologists is carried.

The scientific personnel includes 1 Academician, 5 Professors, 15 Doctors and others, including technicians, making a total of about 60. Equipment requiring continuous watch is worked on a shift basis of 4 hours on, 8 hours off.

The aims of the present cruise include a sample study of a number of problems around the western margins of crustal plates within the western Pacific region. It is intended to obtain better recognition or definition of problems for a series of future research projects in which greater emphasis will be placed on Geodynamics in contrast to past emphasis which related to the International Upper Mantle Project.

The continental and island geological connexions are of vital importance to the study of the dynamic problems at plate margins. This is one of the reasons for the large complement of geologists aboard. Another contributing factor is that the setting up of refraction and heat flow stations provides opportunity for bottom photography and sampling and other contributions to superficial geology and this in general involves different geologists to those who would contribute to the Geodynamic problems.

Two areas of particular interest are the older apparently less complex island arc region including Japan and the younger more complex region including the Bismarck Archipelago. Also of interest are the areas around New Zealand and Macquarie Island. The VITIAZ and other Soviet vessels expect to return regularly to the Australian Region in future years to pursue these and other projects. There will be scope for international co-operation in these future projects. During parts of the present cruise D. Grainger (B.M.R. Resident Staff, Port Moresby), B. Plummer (electronics technician, University of N.S.W.) and a scientist from Hawaii Institute of Geophysics had been aboard and some two ship seismic refraction surveys had been conducted with RV MAHI from Hawaii Institute of Geophysics.

The scientific work aboard the VITIAZ on this cruise was divided into eight study groups:

Bottom topography.
Deep structure of the crust (by seismic refraction).
Thickness and structure of sediment cover (by seismic profiling).
Magnetics.
Gravity.
Sediment and sub-sediment structure (by seismic reflection).
Geochemistry of the ocean floor.
Land geology of islands visited.

Equipment

The equipment on board the VITIAZ is discussed under the following headings:

1. Navigation.
2. Seismic Profiling.
3. Deep Seismic Reflection.
4. Seismic Refraction.
5. Magnetics.
6. Gravity.
7. Bottom Sampling.
8. Heat Flow.
9. Geochemistry, etc.

1. Navigation

Equipment includes Loran C, radar, ship's log and presumably gyro-compass. Loran C is operative only in the north Pacific. The ship is out of range of established Loran chains while in the south Pacific. Consequently, celestial fixes and land intersections based on international navigation charts form the basis of navigation to which the ship's track, determined by conventional dead reckoning, is tied. Ship's heading and engine revs are varied as little as possible. In other words the system is crude and unsophisticated. This inhibits the re-occupation of stations, accurate plotting of ship's track and accurate estimating of ship's velocity. The low order of accuracy for ship's velocity reduces the quality of the gravity data. It was stated that the Russians will have satellite navigation equipment available in the near future but it was not known if it would utilize the U.S. Navy Transit satellites or an independent Soviet system.

2. Seismic Profiling

There were two recorders aboard; one was a Russian model and the other was a Japanese "Nippon Electric NE-20A" dry paper instrument which automatically stamped time intervals onto the records. One recorder was intended to be used with high frequency filters (40-100 Hz) to give higher resolution for shallow information. The other recorder used a lower frequency band (20-40 Hz).

Two energy sources were used - a sparker transducer and airguns. The sparker was a Russian 15 kilojoule (10 kV) model similar to the E.G. and G. 21 kilojoule unit but with only 3 electrodes; the electrodes were about a foot long and were stated to be very slow burning and to last about a year. A 10 second firing interval was normally used for the sparker although 2 or 5 second intervals could also be selected. Several Lamont-type, 30 cubic inch (½ litre), fixed capacity airguns, operating at pressures of 22000 lbs/sq.in. were also carried. (These were in fact Russian copies of a Japanese copy of the Lamont airgun). A 1000 cubic inch (15 litre) airgun was also reported as being used but this was not seen. Firing interval for the airguns was 10 to 20 seconds. To date, the sparker and airguns had always been used separately; however, a synchronization circuit with delay capable of variation from 2 to 7 msecs had been built to permit simultaneous firing of the two to give an expanded spectrum to the energy pulse. This system had not yet been tried out. /

The hydrophone streamer used, a Japanese model with a 20 metre active section at 120 metres from the ship, was unsuccessful at the normal speed of 12 knots. A replacement streamer was under construction using Russian components and having a longer active section further from the ship.

In summary the profilers were conventional in design and operation. They had not been particularly successful on this cruise due to poor performance of Japanese supplied equipment. The solution of the problems appears to be in hand.

3. Deep Seismic Reflection

The recording equipment (photo number 2) consisted of a set of 36 channel exploration amplifiers; however, only 12 channels were used. These were claimed to be of high quality with a wide frequency operating range, being suitable for long distance refraction if necessary. The amplifiers were fed by a 12-channel reflection type streamer (photo number 3) of conventional design but unusual layout. The total length of the streamer was 1 km with 50 metre active sections each containing 64 hydrophones, arranged so as to display a triangular or diamond weighting function. Towing depth was 12 metres. The quality of the streamer appeared to be particularly good with both the strength and acoustic noise cancelling quality to permit operation at 12 knots. It appears to match the Chesapeake cable owned by B.M.R. in acoustic performance and the CGG cable being used at present by B.M.R. in mechanical performance. The Russian cable was attacked and largely destroyed by sperm whales a day or so out of Sydney.

On the recording side, the Russians had a roll type 2 inch analogue magnetic tape recorder with a claimed dynamic range of 90 dB which was achieved by split signal dual recording in inverse phase and reconstruction with noise cancelling on playback. This is a feasible principle that B.M.R. was at one time (and probably still would be) keen to obtain but was not developed commercially by the equipment manufacturers.

Playbacks, stacking, deconvolution, etc. were done on return to Russia either by analogue or by A to D conversion and digital processing. For A to D conversion, 2 millisecond samples were used.

Of special interest was the Russian system of using small explosive charges for their reflection work. They use a 200 gram charge fired electrically every two minutes. The detonator is energized as the charge slips off the end of the firing line (see Fig. 1). The energizing takes place at 10 metres depth and, by using a delay detonator, the charge sinks to 25 metres before exploding. At this depth it is claimed that bubble pulse does not interfere. Using this equipment and charges of 50 grams, good reflections down to 8 seconds of record time were recorded in the Bay of Biscay in 1969.

4. Seismic Refraction

The Russians used the deep reflection firing system to fire charges up to 200 kg in size. Again, a delay detonator was used which allowed the charge to sink to 90 metres before exploding.

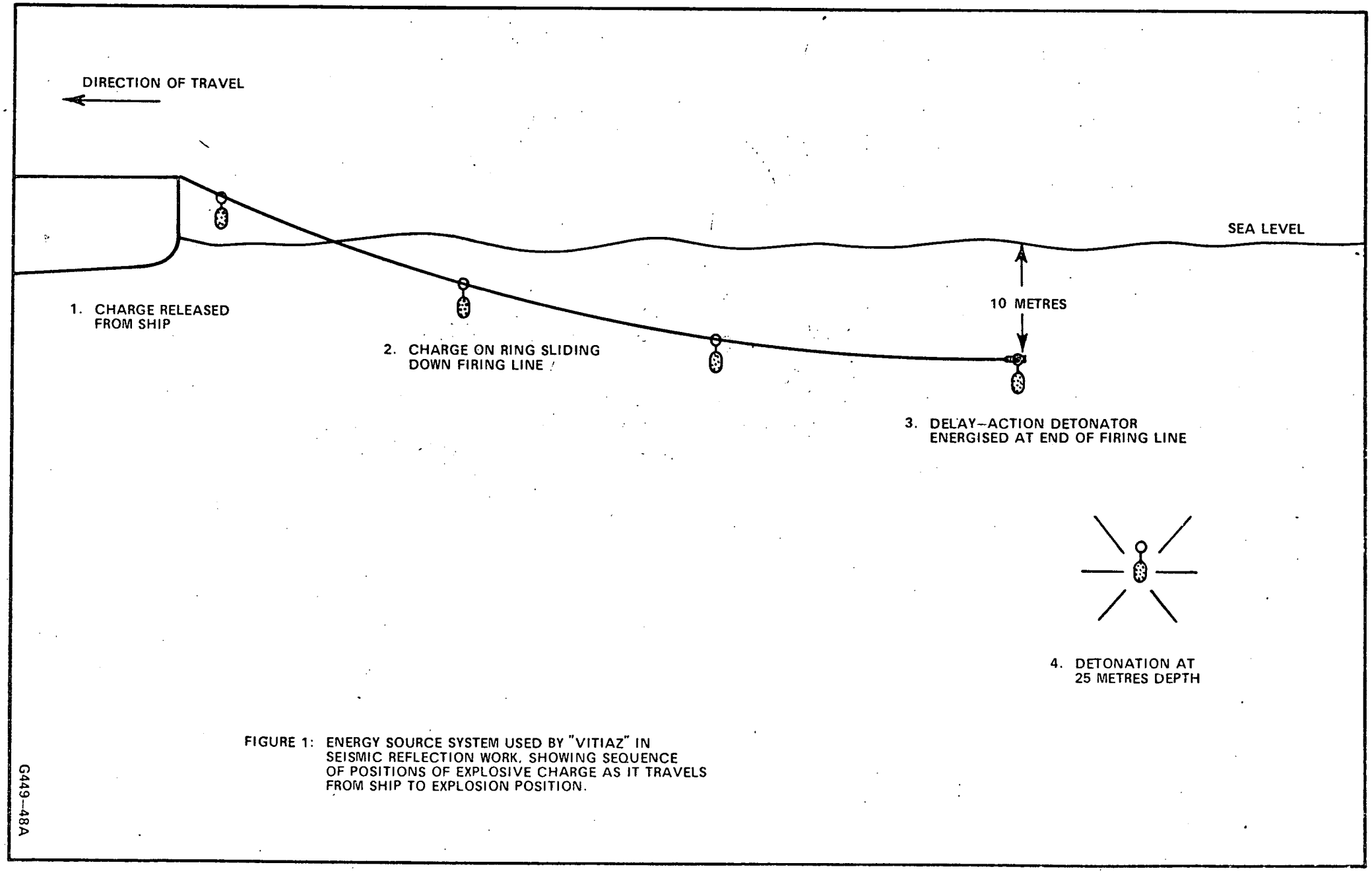


FIGURE 1: ENERGY SOURCE SYSTEM USED BY "VITIAZ" IN SEISMIC REFLECTION WORK, SHOWING SEQUENCE OF POSITIONS OF EXPLOSIVE CHARGE AS IT TRAVELS FROM SHIP TO EXPLOSION POSITION.

G449–48A

Three different types of hydrophone receivers were used - an ocean bottom seismometer (photo number 4) attached to a recovery buoy (photo number 5); a similar seismometer out suspended in the water; and a telemetering radio buoy similar in principle to that used by B.M.R.

The first two types were 3-component seismometers (all components gymbal mounted, mutually at right angles) with frequency recording range of 1-30 Hz, a 100 kHz timer with an accuracy of 10^{-9}, and an 8-channel FM tape recorder capable of continuous recording for 6 to 10 days at a tape speed of 1 mm/sec. Six seismic channels were recorded, the three components at two different sensitivities, plus one clock channel with a pulse every second. The recovery buoy attached to the bottom seismometers was detectable at a range of 15 km in good weather. The size of the explosive charges used with these hydrophones varied from 2 kg near the hydrophone to 100 kg at a distance of 100 km.

The radio buoys used a 30 mHz carrier signal and had a 50 km range and 3-5 day duration.

Using a combination of these systems, the VITIAZ carries out single ship refraction in a variety of recording geometries. Recently it had engaged in a co-operative programme of two-ship refraction with the Hawaiian Institute of Geophysics vessel MAHI to the east of Japan to measure seismic velocity anisotropy and relate this to assumed direction of sea floor spreading. For this programme the MAHI satellite navigation system was used to give the necessary navigational precision.

5. Magnetics

A Russian built proton precession magnetometer of similar performance to the Varian instrument used on B.M.R. surveys was used. The sensor consisted of 4 elements - 2 parallel pairs mutually at right angles to each other and the axis of the cylinder. No preamplifier was required. The magnetometer was polarized every 10 seconds and numerical values printed out on paper. At the same time, digital values were punched on to paper tape at a central punch.

The Russians were proud of their cable which was sufficiently well shielded and impedance matched to allow transmission and reliable detection of signals at 1 microvolt level.

6. Gravity

Two Askania gravity meters similar to the one used on the 1967 B.M.R. survey in the Timor Sea were mounted on a stable platform in opposed orientation to give cancellation of cross coupling errors in the combined output. B.M.R. used accelerometers to sense the gravity meter motion and the Talwani developed cross coupling computer to compute and cancel cross coupling.

The two methods achieve comparable accuracy, but the Talwani system is substantially cheaper. The accuracy achieved by the Vitiaz system is largely destroyed by the lack of adequate navigation.

The parameters recorded were corrected gravity and 2 components of table tilt. (The latter was not used to apply gravity corrections but only to check the sea state etc). Surprisingly the gravity meters were mounted on one side of the ship in an upper deck laboratory.

7. Bottom Sampling

This was done by means of a conventional gravity corer. It is understood that the tripweight consisted of the casing containing the thermal gradiometer (see Section 8). Four cores (mainly calcareous ooze) had so far been recovered on this cruise - the cores had a diameter of approximately 5 cm and length of about 40 cm.

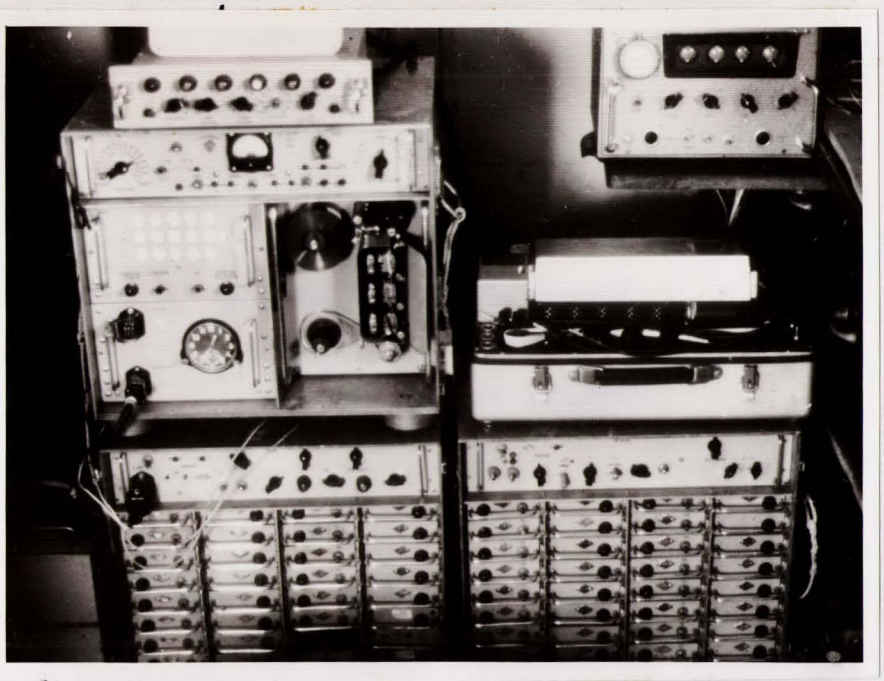
8. Heat Flow

The instrument used (photo number 6) was a Japanese Thermal Gradiometer, the same as used by RV MAHI. It consists of a cylinder containing electronics and a pen recorder at the head of a long slender probe which penetrates the ooze on the ocean floor. Thermistors measure the temperature gradient in the floor sediments and this, with thermal conductivity measured on a core obtained at the same locality, yields heat flow through the crust.

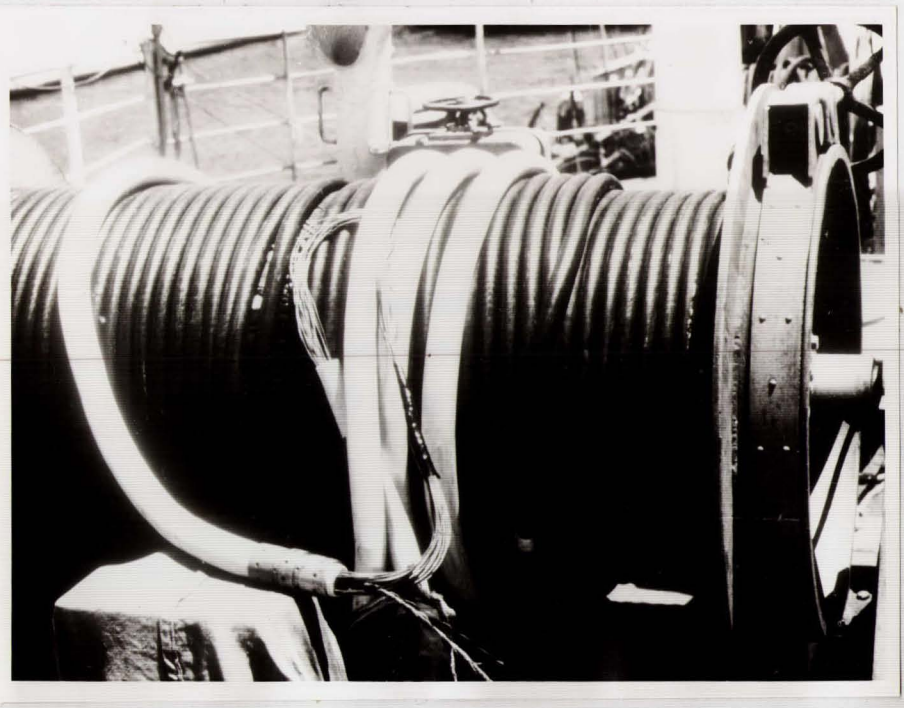
9. Geochemistry

Emphasis was placed on the geochemistry of basic and ultrabasic rocks of the sea floor and land areas. The land geology group included geologists with special interests in the genesis of these rocks. The VITIAZ has laboratory facilities for thin section preparation, petrology, mineralogy and spectrographic geochemical determinations.

1. "Vitiaz" berthed at Circular Quay, Sydney.



2. Deep seismic reflection recording equipment.



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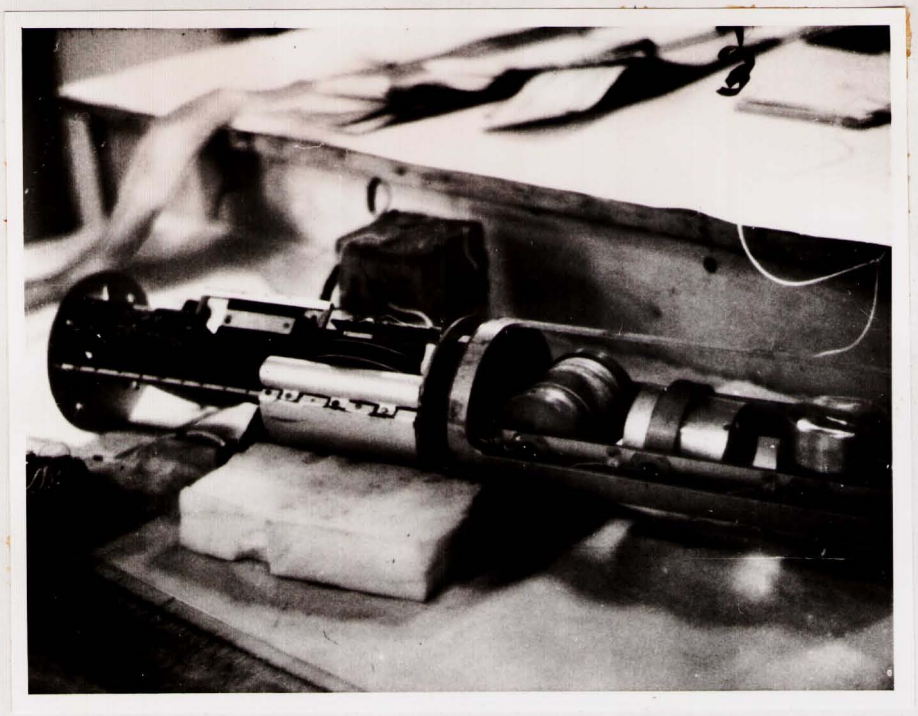

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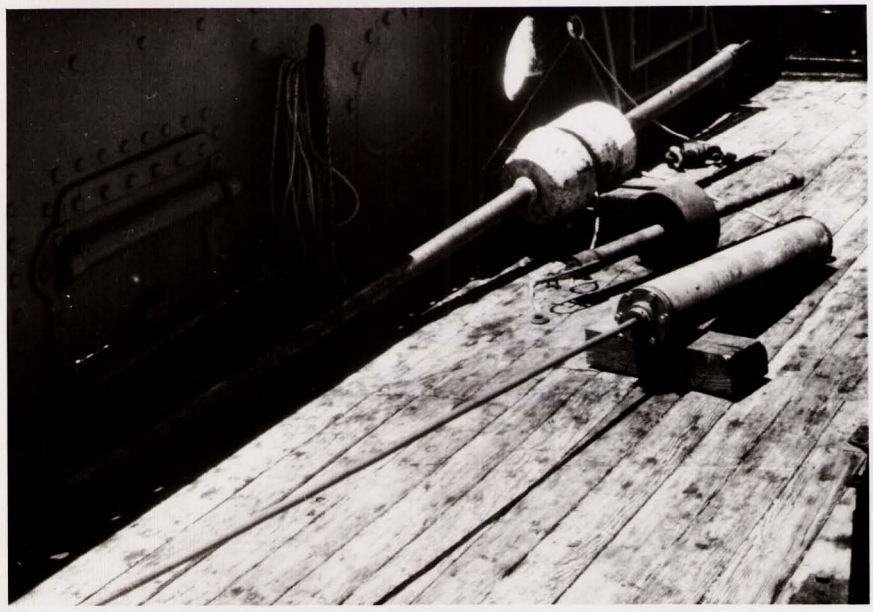
5. Recovery buoy for seismometers, showing radar reflection on mast.



6. Japanese Thermal Gradiometer, showing probe which contains three thermistors.

TERRITORY OF PAPUA AND NEW GUINEA

DEPARTMENT OF LANDS, SURVEYS AND MINES

GEOLOGICAL SURVEY

NOTE ON INVESTIGATION
71—001

The Oceanological Cruise of the Soviet Research Vessel "Vitiaz" December 1970

(INVESTIGATION No. 71201)

BY

D. J. GRAINGER

C O N T E N T S

SUMMARY

In December 1970 the Soviet research vessel "Vitiaz" visited several Territory ports during a cruise in the Bismarck Sea. D. J. Grainger of the Geological Survey of Papua - New Guinea took part in the survey and provided local geological information. He also led a three day geological excursion from Lae to Goroka. From 15th to 21st December the "Vitiaz" made geophysical observations during the cruise from Lae to Rabaul via the Mussau Trench. Grainger disembarked at Rabaul.

THE OCEANOLOGICAL CRUISE OF THE SOVIET RESEARCH VESSEL "VITIAZ" DECEMBER 1970

INTRODUCTION

In December 1970 the Soviet research vessel "Vitiaz" made a cruise in the Bismarck Sea and visited several Territory ports. The work of the "Vitiaz" was geological and geophysical research as part of an international programme on the exploration of the upper part of the earth's crust including its structure, physical fields, seismology, and the collection of samples from the ocean floor and from the islands. The Bureau of Mineral Resources in Canberra was invited to send representatives to take part in the cruise and it was decided that an officer of the Geological Survey of Papua-New Guinea should provide local geological knowledge.

MOVEMENTS

According to the original itinerary the "Vitiaz" was to arrive at Lorengau on Manus Island on 1st December, where A. Brown, marine geophysicist from the Bureau of Mineral Resources in Canberra, and D.J. Grainger of the Geological Survey of Papua-New Guinea would join the ship for a cruise of one week to Madang and Kavieng. Brown has experience of marine geophysical work on Australian and United States research vessels and was to compare known techniques and equipment with those used by the Russians.

Grainger and Brown flew from Port Moresby to Madang on 29th November and by charter flight to Manus Island on 30th November. Adverse weather conditions north of the Bismarck Sea resulted in the protraction of a geophysical programme between the "Vitiaz" and the United States research vessel "Mahe"; the visit of the "Vitiaz" was therefore delayed. Grainger and Brown were recalled to Port Moresby and arrived on December 4th. Brown subsequently returned to Canberra.

The new itinerary of the "Vitiaz" was for the ship to arrive at Lae on December 12th and for its last Territory port-of-call to be Kavieng on about 16th December. Grainger joined in Lae. Subsequent changes and additions were made to the programme and he disembarked at Rabaul on 21st December. B. Plummer, a senior electronics technician from the University of Sydney also joined the "Vitiaz" in Lae for the cruise to Sydney. He was to co-operate with the Russians on seismic equipment and techniques.

THE "VITIAZ" AND ITS SCIENTIFIC PROGRAMME

The research vessel "Vitiaz" (Captain Anatoly Svitaylo) is a converted German cargo ship of about 3,200 tons. It was captured by the British in the Second World War and was part of the wartime aid programme to Russia. At the end of the war it was refitted and converted to a research vessel for the Institute of Oceanology in Moscow. It made its first scientific voyage in 1949. Its home port is Vladivostok. The ship has a crew of about 60.

During the period of the Cold War it was used on surveys in the Sea of Okhotsk, Bering Sea and the Sea of Japan. It was not until the International Geophysical Year in 1957-58 that research began in the open Pacific. Since then annual cruises of several months duration have been made in the Pacific; several of them involving combined research programmes with United States vessels. In 1959 the "Vitiaz" reported a depth of 36,204 ft. (11,055 m) in the Marinas Trench; the greatest ocean depth located. Its route on the present cruise is from Vladivostok to Japan, Fiji, New Guinea, New Caledonia, Australia (Sydney), Tahiti, Fiji, Japan, and Vladivostok.

The main purpose of the "Vitiaz" cruises is to carry out research into the structure, properties and composition of the earth's crust. The scientific staff numbers 60 and is under the direction of Dr. Gleb Udintsev of the Institute of Oceanology in Moscow. Research programmes include the following (the names of group leaders are given in parentheses):

1. Seismic studies including continuous sparker traverses and combined sparker and air-gun traverses. (Dr. Alexis Sozoktin). These enable profiles to be obtained of the sea-bed and the underlying strata.

Deeper penetration is possible using reversed refraction methods which necessitate the co-operation of two vessels. (Dr. I. ". Kosminskaja). Such work was carried out by the "Vitiaz" and "Mahe".

2. Echo sounding to obtain sea-bed topography
3. Gravity measurements
4. Magnetic measurements
5. Heat flow measurements through the earth's crust (in collaboration with the University of Tokyo; three Japanese geophysicists participated).

6. Geology (a) Marine geology and especially the geochemistry of basic and ultrabasic rocks of the sea-floor. (Dr. Leonid Dmitriev).

(b) Land geology (Academician A. Pieve). There is a wide range of interests within this group including the genesis and petrography of basic and ultrabasic rocks (Pieve) structual geology of island arcs (Dr. V. Krasheninnikov) and basement complexes (Dr. N.S. Markov).

The "Vitiaz" has equipment for sediment coring, dredging of rock samples, and sea-floor photography. There are laboratory facilities for thin section prepa ation, petrology, mineralogy, and spectrographic geochemical determination.

7. Marine biochemistry

Co-operation between the geologists and geophysicists has enabled theories to be propounded for the formation and composition of the earth's crust, in the context of sea-floor spreading and plate tectonics. Drs. Udintsev, Dmitriev, Sozokhtin and Kosminskaja are currently working on the theory of a gravity-convection induced mechanism for plate tectonics.

Dr. Udintsev and Dr. Kosminskaja could speak reasonably good English; the other group leaders and many of the scientific staff spoke English with varying degrees of competency. General conversation and scientific discussion was not difficult.

LAE-GOROKA GEOLOGICAL EXCURSION

Until the "Vitiaz" arrived at Lae there was no information available on the proposed scientific programme. Grainger joined the ship at Lae and learned that it was intended to make a geological excursion to Goroka to study aspects of the geology of the Markham Valley and the Highlands Highway, and a visit to Salamaua to investigate the Papuan Ultrabasic Belt. Owing to the co-operation of the Administration in Lae both were made. Grainger led the excursion to Goroka.

13th December

Departed from Lae.
Visited outcrops of Upper Miocene Mena Series sediments in the Sankwep River near Lae, and examined alluvial terraces of the Busu River. Drove along Markham Valley and examined Pliocene Ouba Series sediments at the Leron Bridge. Examined Miocene sediments and basic rocks of the Kassam Pass. Stayed the night at Goroka.

14th December

Examined road sections on Daulo Pass in vicinity of Chuave. Stayed the night at Kainantu.

15th December

Returned to Lae making further examinations of basic rocks and sediments near Kainantu and on the Kassam Pass.
Rejoined "Vitiaz".

The geological group visiting Salamaua had collected rock samples and made observations for a distance of about 30 km south along the coast.

The "Vitiaz" sailed from Lae in the evening of 15th December.

VOYAGE OF THE "VITIAZ"

From Lae the "Vitiaz" sailed to Astrolabe Bay arriving on the afternoon of 16th December at Garagassi Point 30 km south-southeast of Madang (see Plate 1.). The purpose of the visit was to honour a famous Russian naturalist, Miklouho - Maclay, who worked in the area in 1871. The local villagers were able to show the Russians where Miklouho - Maclay had built his house and a plaque was left at the spot in memory of Miklouho - Maclay and to commemorate the visit of the "Vitiaz". It is interesting to note that Miklouho - Maclay was the first white man to visit that area of New Guinea and he is still remembered in the local legends. Several Russian words have been incorporated into the local language including those for axe (Miklouho - Maclay introduced the first steel axes), knife, and watermelon. The present "Vitiaz" is the third ship of that name; the first landed Miklouho - Maclay and gave its name to the Vitiaz Strait between Long Island and the mainland.

The "Vitiaz" sailed from Garagassi Point in the evening of 16th December and made a continuous sparker seismic traverse

of the Bismarck Sea on its voyage to the Mussau Trench on the north side of the Equator north of the St. Mathias Group of islands. The Bismarck Sea has an unusually thin veneer of sediment.

The Mussau Trench reaches depths of 6000 m. It is of interest because of its well-developed fault-scarp structures. Attempts were made to obtain dredge samples of rocks outcropping in the trench but they were unsuccessful, on one occasion because of strong bottom currents, and a second time because of damage to the dredge. Successful heatflow measurements were made.

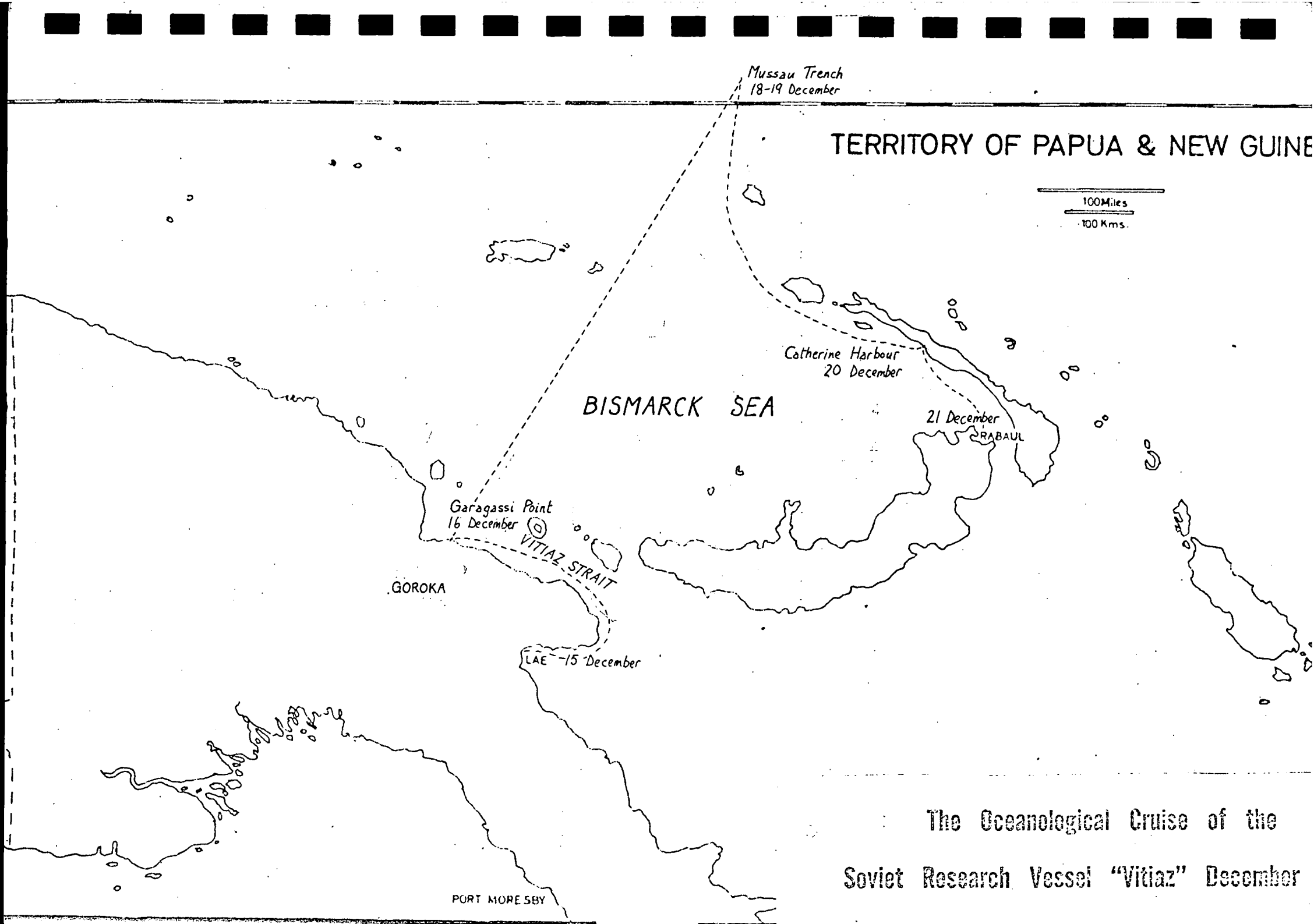
It had been intended that the "Vitiaz" would call at Kavieng on December 19th to enable a geological excursion to be made on New Ireland. Circumstances did not permit this and an alternative plan was made for a party of geologists to be put ashore at Catherine Harbour on the southwest coast of New Ireland to investigate a basic complex. Catherine Harbour was reached in the late afternoon of 20th December but, because of adverse weather and the late arrival, the plan to put geologists ashore was abondoned. The "Vitiaz" continued on to Rabaul.

The "Vitiaz" arrived at Rabaul at 7.00 a.m. on 21st December. A party of the senior Russian scientists was shown around the Volcanological Observatory by Mr. W.D. Palfreyman, the Acting Senior Volcanologist. Grainger left Rabaul by air for Port Moresby that morning.

CONCLUSIONS AND RECOMMENDATIONS

The visit of the "Vitiaz" to Territory ports and its cruise in Territory waters was an excellent example of international co-operation. The help of the Administration in providing vehicles and drivers at very short notice for the field trip to Goroka, and the assistance provided for the visit to Salamaua is gratefully acknowledged. For Grainger, the participation in the cruise of the "Vitiaz" was useful because it afforded both an exposure to current theories of geotectonics and an insight into the techniques of marine geology and geophysics.

A difficulty experienced during the finalizing of arrangements leading to participation in the cruise was the long chain of communication involved: Port Moresby - Bureau of Mineral Resources - Department of National Development - Foreign Affairs Department - U.S.S.R. Embassy - Moscow - Vladivostok - "Vitiaz". This resulted in inevitable delays and inconvenience to all concerned. It is suggested that for similar future programmes direct communication should be made with the ship following the initial diplomatic negotiations.


Mussau Trench
18-19 December
TERRITORY OF PAPUA & NEW GUINE
100 Miles
100 Kms.
Catherine Harbour
20 December
BISMARCK SEA
21 December
RABAUL
Garagassi Point
16 December
VITIAZ STRAIT
GOROKA
LAE 15 December
PORT MORESBY
The Oceanological Cruise of the
Soviet Research Vessel "Vitiaz" December