Photo: Y. Ryumkin

Fig. 1. G. I. Matveychuk taking meteorological observations at Scientific Station North Pole 3 in the autumn of 1954.

THE SOVIET EXPEDITION TO THE CENTRAL ARCTIC, 1954

Clifford J. Webster

In 1932 the Chief Administration of the Northern Sea Route (G.U.S.M.P.) was founded by the Soviet government to develop an arctic shipping lane between the Atlantic and Pacific oceans. Almost immediately, the Russians realized that detailed knowledge of the Central Arctic Basin, particularly as regards ice, weather, and hydrography, was essential to the success of this route. For three decades the G.U.S.M.P. has been carrying out a continuous program of research. This has taken the form of observations from a large net of polar stations, from ships, from drifting ice stations, and through aerial reconnaissance. The most important and spectacular aspect of this program has been the penetration of the Central Arctic Basin. This has involved landings by aircraft on unprepared sea ice, the mounting of stations on drifting ice, and the establishment of a system of aerial ice and weather reconnaissance.

Previous expeditions

Before the outbreak of the Second World War the G.U.S.M.P. had amassed a considerable experience in the mounting of stations on drifting ice and in the necessary air support. The usefulness of drift expeditions had been demonstrated by Nansen's expedition in the *Fram* in 1893, and by Amundsen's drift in the *Maud* in 1922. Indeed, when the G.U.S.M.P. was founded the Russians owed the whole of their data on the Central Arctic Basin to Nansen's work in the *Fram*. They lost no time in an effort to build on his work. Between 1935 and 1937 the icebreaker *Sadko* carried out three annual drifts in the northern parts of the Kara and Laptev seas. The Russians' first effort to penetrate the Central Arctic Basin was made in 1937 by the Papanin North Pole Drift expedition. During the course of nine months, this group of four men drifted south on an ice floe from the north pole to a point off the east coast of Greenland. Their station was established by four 4-engine aircraft which carried out landings on unprepared sea ice and delivered nine tons of freight. The Papanin group contributed data which in some respects radically altered previous notions of the region. In the same year, the icebreaker *Sedov* drifted from the Laptev Sea across the Western Arctic Basin; but, being an extemporized drift, its results were less satisfactory. In 1939 the Russians felt that they still needed data from the region north of the *Sedov* drift, and, in particular, north of the coastal waters of their Eastern Arctic.[1] In that year,

[1]In the Soviet concept, Mys Chelyuskin marks the approximate boundary between the Western and Eastern Sectors of the Soviet arctic coast. In this account the terms Western Arctic and Eastern Arctic refer to the Russian sectors.

a veteran arctic pilot, I. I. Cherevichnyy, proposed an expedition in 1940 to that region which lies between 150°E. and 70°W., and which contains the so-called "Pole of relative inaccessibility". This was not done until 1941. On this occasion, a 4-engine aircraft, flying north from Ostrov Vrangelya, carried out three landings on the unprepared sea ice in April in the vicinity of 80°N. Only a few days were spent at each station, however, and serious work had still to be attempted.

Drift expeditionary work was interrupted by the Second World War, but was resumed soon after its conclusion. As part of its Fourth (postwar) Five Year Plan, the Arctic Scientific Research Institute undertook to complete the comprehensive mapping of the Arctic Basin, to intensify its studies of ice movement, and to adopt the use of automatic meteorological stations. The value of the latter had been recognized at the close of the Papanin expedition. In 1947 V. S. Antonov, Assistant Director of the Arctic Institute, announced that an automatic weather station had been built, and had been successfully used as an arctic drift station. Prof. Ya. Ya. Gakkel' was one of the designers. It was foreseen that radio buoys, intended for the study of the propagation of radio waves in the Arctic, might also be useful for the study of ice movements. At the same time, it was announced that Simonov had perfected a "drifto-graph" for charting the speed and direction of drift and the depth of the sea bottom. A portable instrument for measuring terrestrial magnetism was also produced. On this basis, drift expeditions began again, the main effort once more being in the relatively inaccessible area of the Eastern Arctic.

In April 1947 an expedition was mounted from Ostrov Kotel'nyy. Stations were set up on the ice at 80°30N., 150°00E., at 86°30N., 157°00E., and at 80°15N., 177°00E. Daily flights were made from these to surrounding points, where from one to three days were spent taking observations. At the same time, three aircraft landed a party of scientists at the pole. This party allegedly completed its program in two days; but evacuation was rendered necessary and difficult by a crack which split their floe and they had to abandon their fuel reserves to permit a short take-off. A similar expedition, led by Prof. Ya. Ya. Gakkel', was active in 1948–9. This party made observations at more than two hundred sites, and is credited with the discovery of a great submarine range which extends across the Central Arctic Basin from the Novosibirskiye Ostrova toward Greenland and Ellesmere Island. This has been named after Lomonosov, the celebrated Russian *savant* of the eighteenth century, whom the Russians regard as the founder of arctic ocean-ography. The results pointed to the need for systematic study of seasonal variations in the climate, of magnetic phenomena, and for a more detailed study of several regions. In April 1950 a further expedition was mounted in the Eastern Arctic at 76°02N., 166°30W. This party, led by M. M. Somov, drifted until it was evacuated in April 1951 at 81°45N., 162°20W. An indica-tion of its scale lies in the report that it was equipped with a cross-country vehicle (probably a GAZ-67), and received, after six months on the ice, some twenty tons of re-supply. This expedition assembled a considerable body of data on the "Pole of relative inaccessibility".

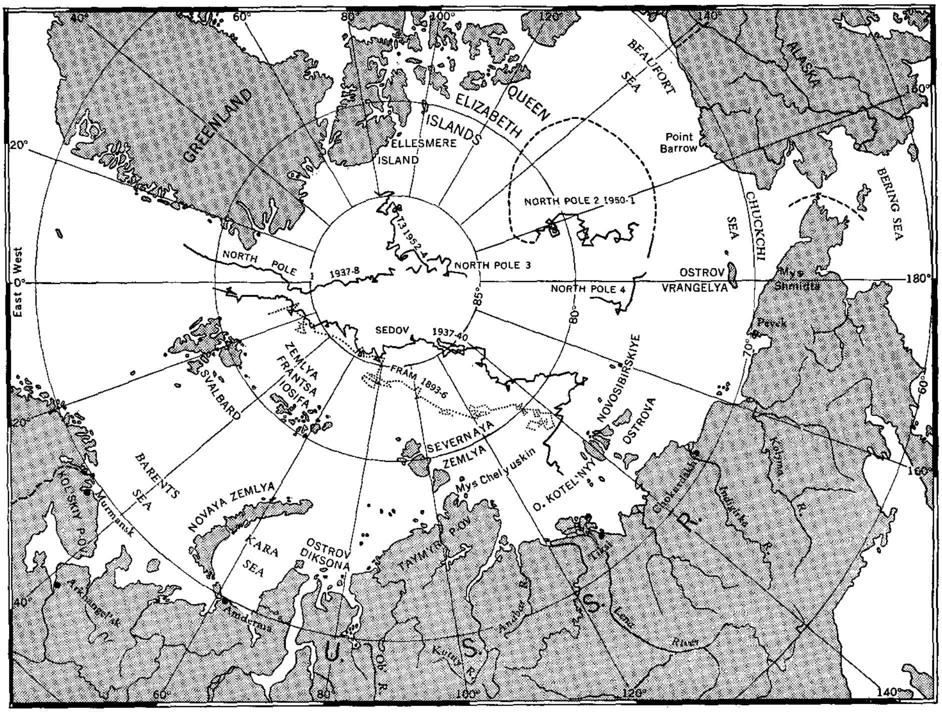

Fig. 2. Tracks of drift expeditions in the Central Arctic Basin, 1893–August 1954, as given in *Izvest. Akad. Nauk S.S.S.R., Ser. Geogr.* No. 5, 1954, p. 5.

The Papanin expedition is now known as "Scientific Station North Pole 1". The Somov expedition, apparently outranking the expeditions of 1947–9, has been designated "Scientific Station North Pole 2".

Very soon after the Revolution, the Soviet arctic authorities learned the value of the aircraft for communications, logistics, and survey in the Arctic. By the mid-'thirties, the air services of the G.U.S.M.P. had been given the specific task of aerial ice reconnaissance. By the outbreak of war, the outlines of a systematic method had crystallized. This took the form of regular flights over the coastal seas to support short-term ice forecasts, and of pre- and post-seasonal flights over the Central Arctic Basin to support long-term ice forecasts. Construction of a series of necessary coastal air bases, called for in the Third Five Year Plan, got under way in 1941–2. Unlike drift expeditionary work, this air activity was not interrupted by the war, and flights were made annually between 1940 and 1945. V. I. Akkuratov claims that an ice reconnaissance flight in October 1945 from Mys Chelyuskin to Chokurdakh via the north pole pioneered such operations in the winter darkness and led to the introduction of new techniques for landings on the pack. In the decade ending in 1946, when four flights were made into the Central Arctic Basin, at least thirty major flights had been made into this region, and a number of landings on unprepared sea ice had been carried out by heavily-laden 4-engine aircraft in mounting and supporting drift expeditions.

Fig. 3. Scientific Station

All the expeditions between 1937 and 1950 carried out a complex program of investigations. The work included measurements of the depth of the ocean; the collection of bottom samples for the study of the relief and geological history of the sea bed; measurement of water temperatures at various depths and the collection of water samples for the study of its origin and distribution through chemical analysis; the collection of plankton specimens; measurement of currents; readings of the temperature of the ice, of the layer of air overlying the ice, and of the intensity of solar radiation, to study the exchange of heat between the ocean and the atmosphere; frequent astronomical fixes to determine the drift of ice over large expanses of the ocean; regular meteorological and upper air observations; aerial ice reconnaissance; geomagnetic observations; gravimetric observations, and the study of problems of geodesy and geology.

The 1954 expedition

Early in 1954 the Soviet government undertook a program of research in the Central Arctic Basin which is the largest attempted thus far. The intention, which has been frequently repeated in the press, is to complete the exploration of the region, in order to ensure the maximum development of the Northern Sea Route. In practice, this means an effort to make sea and air navigation in the Arctic more secure; and this means, essentially, the systematic collection of all the data which are needed to improve ice and weather forecasts. A major feature of the current program is therefore the decision to attempt observations on a broader and long-term basis, instead of

Photo: Sovfoto

orth Pole 3, July 1954.

on a sporadic "expeditionary" basis. The following account is based on published Russian material and merely seeks to report results claimed and to outline Soviet theories.

The plan adopted for the 1954 expedition called for operations to be mounted jointly by the Academy of Sciences and the G.U.S.M.P. throughout that area of the Arctic Basin north of the U.S.S.R., and consisted of four parts:

A drift station under A. F. Treshnikov to be mounted in the Central Arctic by an air detachment under I. S. Kotov from bases at Ostrov Diksona, Mys Chelyuskin, and other coastal points.

A drift station under Ye. I. Tolstikov to be mounted in the Eastern Arctic by an air detachment under M. A. Titlov from bases at Tiksi, Pevek, and probably Mys Shmidta.

"The High Latitudes Air expedition" under M. Ye. Ostrekin consisting of two groups, one to be landed at the north pole by an air detachment under I. I. Cherevichnyy, flying from Ostrov Diksona, and using transit bases on Zemlya Frantsa Iosifa and on the sea ice, and the other to be flown by V. I. Maslennikov to the outer edge of the continental shelf in the northern Chukchi Sea. The work of these groups was to be coordinated with that of the drift stations and of the regular polar stations.

Regular flights by one or more "flying laboratories" along almost the whole periphery of the area of the expedition, during which meteorological and ice observations were to be made.

Freight for the whole expedition was concentrated at Ostrov Diksona, the main headquarters, during March 1954. From this point, supplies for the drift station in the Eastern Arctic were delivered eastward, probably to Mys

Shmidta. During approximately the last week of March 1954, the main party took off from a field south of Moscow in a group of aircraft consisting of a PE-8 and a number of IL-12 and LI-2 aircraft. They flew via Arkhangel'sk and probably Amderma to Ostrov Diksona. The balance of the party, containing the personnel for the drift station in the Central Arctic, flew somewhat later from Leningrad to Ostrov Diksona.

Scientific Stations North Pole 3 and 4

The most ambitious element in the 1954 program has been the mounting of two drift stations on the sea ice. That in the Central Arctic, under Treshnikov, has been designated "Scientific Station North Pole 3", and that in the Eastern Arctic, under Tolstikov, "Scientific Station North Pole 4".

The selection of a floe for "North Pole 3" seems to have been somewhat difficult. It appears that a separate transit base was necessary and that this was located north of Severnaya Zemlya. The first floe selected by Kotov to the north of this base proved unsatisfactory, and another was found 15 km. farther to the north. This, too, was unsuitable for heavy aircraft, and Kotov was forced to land some 7–9 km. to the southwest. It appears that freight and personnel had to be ferried to the selected floe by a helicopter and an AN-2 aircraft. Eight days after this floe had been located, North Pole 3 was set up in April, some 1,300 km. from the mainland at 86°00N., 175°45W.

Complicated ice conditions north of Ostrov Vrangelya and cloudy weather also impeded the selection of a landing site for "North Pole 4". It was not until eight days after the expedition left Moscow, and probably at the end of March, that a transit base was established some 600 km. north of Mys Shmidta. After a further four days of reconnaissance from this base, a floe suitable for a drift station was found. One week after its transit base had been set up, North Pole 4 was established in April about 100 km. farther north, at 75°48N., 175°25W. The personnel for the drift station were flown out by Titlov.

Each station is equipped with living and working quarters in the form of tents and prefabricated huts. The huts consist of panels made of plywood and wood pulp which is said to be 4–5 times lighter than wood and to possess insulating qualities 3 times superior. The tents, which were originally designed by S. A. Shaposhnikov for use by the "mobile groups" of previous expeditions, are modelled on the Chukchi *yarang*, and consist of a collapsible framework of duralumin tubes, covered with two layers of canvas. These are separated by an air space and the outer layer is dark, the inner white. The basic unit appears to be a hemispherical tent. This can be increased in size by elongation, i.e., the hemisphere is divided into two parts, between which a semi-cylindrical extension is inserted. The floor consists of three layers: a bottom waterproof fabric, then a layer of reindeer hides, and finally a top layer of plywood sheets. The tents seem to be used primarily as working quarters. The huts, which are delivered in seventeen sections, consist of living room, kitchen, and hall, accommodate four men, and are mounted on runners. They weigh 700–750 kg., and can be moved by the occupants, if necessary. Good pictures of these huts have only recently been released in

Photo: Y. Ryumkin

Fig. 4. Two prefabricated huts at North Pole 3, which have been joined together, autumn 1954.

Photo: Y. Ryumkin

Fig. 5. Interior of the mess-hut at North Pole 3, showing L. Razbash setting the table. In the left background the "wall newspaper" can be seen; in the right background the board shows the chess game being played between North Pole 3 and 4.

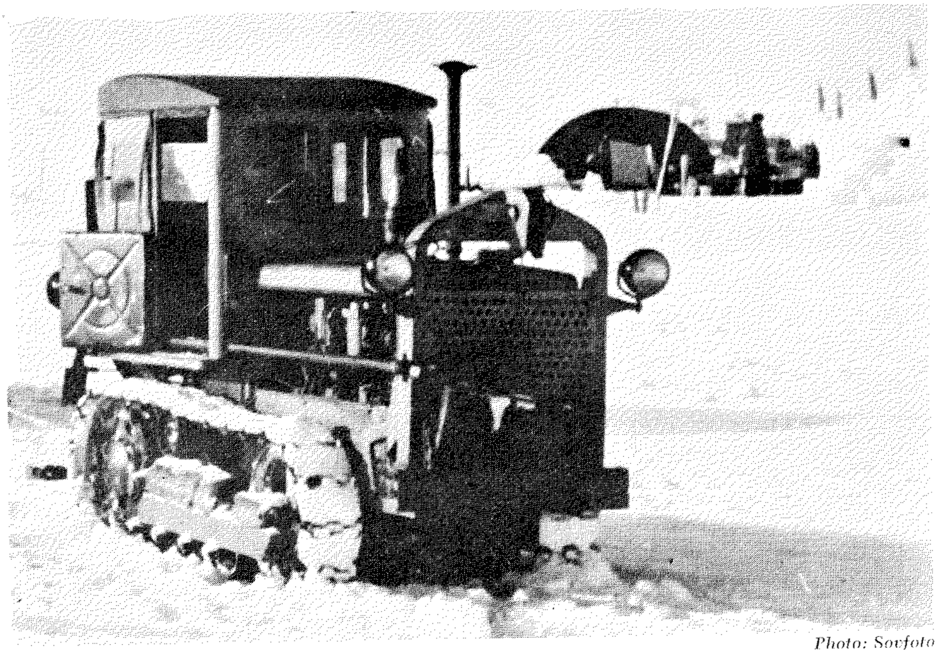

Photo: Sovfoto

Fig. 6. The KD-35 tractor at North Pole 3, August 1954.

Photo: Soviet Union

Fig. 7. V. A. Shamont'yev taking a depth sounding at North Pole 3.

Photo: Soviet Union

Fig. 8. A. D. Malkov with the pyrheliometer at North Pole 3.

Photo: Y. Ryumkin

Fig. 9. Interior of the radio station at North Pole 3, showing, left and right, K. M. Kurko and L. Razbash, radio operators, and centre, A. F. Treshnikov, leader of the ice station.

the press although TASS stated on 29 July 1954 that the Sovetskiy Timber Works was completing the second consignment. Snow houses also appear to have been built at each station. Stoves of "special construction" have been supplied for heating purposes. Cooking is done on ranges using liquid gas, probably propane. Each station has a mess, a bath, a library, and a cinema. At least North Pole 3 has an upright piano.

No radically new instrumentation has been revealed in the Soviet press. Some unexplained modifications have been made to the dip circle. The Stevenson screens are mounted at the unusual height of 6–8 feet; this may merely reflect the use of a standard quadrupod for areas of heavy snow and ground drift. Radio aerials are of ordinary design, and communications have frequently been disrupted when these have been broken by gales and icing. The radiosonde equipment appears to be normal. The press states that a special plant has been provided to generate hydrogen locally for the balloons. At the site of radiosonde observations, a theodolite has been shown. In clear weather, at such latitudes, this instrument may be useful for observing wind speeds at relatively great heights. There is no evidence of radio or radar for this purpose. At North Pole 3 an instrument resembling a nephoscope has been shown. The pyrheliometer has been photographed with as many as three black discs attached. At least one type of hydrological winch is power-driven, and is fitted with 10,000 m. of steel cable. The fact that only a light, short, manual ice auger has been shown probably indicates that holes for soundings are blasted, rather than bored, through the ice. One cylindrical

Photo: Y. Ryumkin

Fig. 10. Transit base for North Pole 3, showing the arrival during the polar night of an LI-2 aircraft. The bottles in the foreground contain gas for heating purposes. The cross-country GAZ-69 automobile will transfer passengers and freight to the ice station over a route cleared by a tractor.

metallic case, used by the oceanographers, appears to be a type of echo sounder, and may be of original design.

Each station has a large helicopter, possibly an AN-2 aircraft, a GAZ-69 automobile, and a KD-35 tractor (28 d.b.h.p., about 4 tons weight), fitted with a blade, which has been used to develop and maintain their airstrips. With this equipment, alternate sites have been established and provisioned on each floe.

At these stations oceanographical, hydrographical, meteorological, actinometric, magnetic, and geophysical observations are being taken. From both stations detachments are flying out by helicopter to take similar observations on the ice at a distance from the main base. A party from North Pole 3 has worked as far as 100 km. to the north of its station. Sea ice conditions are being constantly studied, including those changes in its mechanical properties which are associated with increasing age. Probably in July 1954, a delegation of the Academy of Sciences spent two weeks at the drift stations. The purpose of the visit was to discuss the enlargement of the scientific program in the fields of geology, geomorphology, and hydrobiology. It is apparently desired to enlarge the collection of data on the relief of the sea bottom and on the formation and age of sea ice. It is hoped that the results will yield more precise knowledge of the age of the Arctic Basin.

Both drift stations are equipped with electric light, radio, and telephone. Radio communication is constantly maintained between each station and the mainland. Meteorological observations are broadcast eight times daily. These give surface pressure, air temperature, wind direction and speed, height and type of cloud, and precipitation. Upper air observations are also reported. One daily broadcast gives depth, bottom samples, water temperatures at various levels, and the location of the oceanographic station. It is not known how many other weather stations have been established in conjunction with the expedition. The press has not stated that automatic weather stations play a role in the present program.

Both drift stations are obviously intended to function over a period of many months and possibly of several years. The leader of North Pole 3 has stated that his party will spend the winter of 1954–5 in the Central Arctic. The problem of re-supply as well as of air communications in general, has therefore entailed the development of airstrips. The press has referred to the delivery to both stations of mail, passengers, and of fresh provisions; but no pictures of airstrips or of heavy aircraft at either station have been released. Only helicopters have been shown at North Pole 3 and 4. The press has shown a photograph of Treshnikov and his colleagues smoothing out an airstrip with shovels; and the "wall newspaper" published at his station has contained an article urging the station complement to improve their strip. These may simply be references to a local landing site for the helicopter and the AN-2. It is possible that at least two, and perhaps several, transit bases are still in use, and that two of these are the sites of the major air terminals serving the drift stations.

High Latitudes Air expedition

The "High Latitudes Air expedition" under the geophysicist Ostrekin was given the task of determining the precise location of the Lomonosov Range in the vicinity of the north pole. It was also required to repeat some of the magnetic observations made in this region in 1937 by Papanin. The press has said nothing about the nature of the work in the northern Chukchi Sea, but this possibly involved investigation of the floe vacated by Somov's party in 1951. Ostrekin's party seems to have used at least two IL-12 aircraft, both of which appear to have made landings on unprepared sea ice, a large helicopter, and an AN-2 biplane. A transit base was established on Zemlya Frantsa Iosifa. The use of light aircraft supports an inference from the press that more than one transit base was necessary on the sea ice; it is believed that at least two were required, one to the north, and the other to the south of the

Photo: Ogonyek

Fig. 11. Interior of the flag-aircraft of the Ostrekin expedition to the north pole, showing, left to right, M. Ye. Ostrekin, V. F. Burkhanov, I. I. Cherevichnyy, and D. I. Shcherbakov; standing, V. P. Padalko, a veteran arctic navigator.

Photo: Ogonyek

Fig. 12. Ye. I. Tolstikov, leader of Scientific Station North Pole 4.

archipelago. From the site or sites where they landed near the pole, this party sent out air-lifted detachments to work at distances of 40–50 km. Several dozen landings seem to have been made at various points around the pole. Observations were taken by the detachments at each position over varying periods. The Ostrekin party was to complete its work in about a month. In July 1954 the Soviet government announced that it was back in Moscow.

Meteorological flights

The Soviet press has said little of the fourth element of the 1954 expedition. It has merely referred to one or more "flying laboratories" which have carried out flights over the Central Arctic Basin. Some of these have reached the north pole.

Personnel connected with the expeditions

Many eminent arctic specialists are engaged in the current program. The Academy of Sciences is represented by Academician D. I. Shcherbakov, Secretary of its Geological-Geographical Section, and by the Corresponding Member Ye. K. Federov. The latter was the geophysicist on the Papanin expedition in 1937. V. F. Burkhanov, head of the Main Administration of the Northern Sea Route, is director of the 1954 expedition to the Central Arctic. Suyumov is Scientific Secretary of the whole expedition. The known senior officers of the expedition include the oceanographers Professors N. N. Zubov and Ya. Ya. Gakkel', the eminent geographer and specialist in hydrometeorology, G. A. Ushakov, and M. M. Somov, Deputy Director of the Arctic Institute, who led the drift expedition of 1950–1. Several veteran arctic pilots and navigators have been active. I. Mazuruk flew the flag aircraft, which was probably navigated by V. I. Akkuratov. M. A. Titlov flew in the party for North Pole 4, I. S. Kotov flew in that for North Pole 3. In addition, M. V. Vodop'yanov and Alekseyev appear to have served as advisers. M. I. Kozlov, V. M. Zadkov, and I. G. Bakhtinov were also active.

The press has announced the names of seventeen members of North Pole 3. These are A. F. Treshnikov, oceanographer, formerly with the Arctic Institute, veteran of the drifts of 1948–50, leader; V. A. Shamont'yev, hydrologist, deputy leader and Party organizer; A. F. Babenko, helicopter pilot; A. I. Dimitr'yev, hydrologist; V. G. Kanaki, veteran arctic meteorologist, probably from the Arctic Institute, director of scientific work; M. S. Komarov, mechanic; K. M. Kurko, radio operator; A. D. Malkov, meteorologist; G. I. Matveychuk, in charge of the meteorological detachment; G. A. Ponomarenko, hydrologist; N. Ye. Popkov, meteorologist; P. P. Poslavskiy, meteorologist with twenty-three years' arctic experience; I. M. Sharikov, hydrometeorologist and cook; L. Razbash, radio operator; I. Tsigel'nitskiy, engineer; V. Volovich, medical officer; and Ye. Yatsun, photographer and cinema operator.

The press has said less about North Pole 4, and only ten names have been released: Ye. I. Tolstikov, meteorologist, leader; A. G. Dralkin, hydrologist, deputy leader; M. I. Ivanov; M. Izvekov, hydrometeorologist; Paleyev, medical officer; Shirkov; Shutyayev, mechanic; Vasil'chenko, tractor driver; I. V. Zavedeyev, radio operator; and M. Zinchenko.

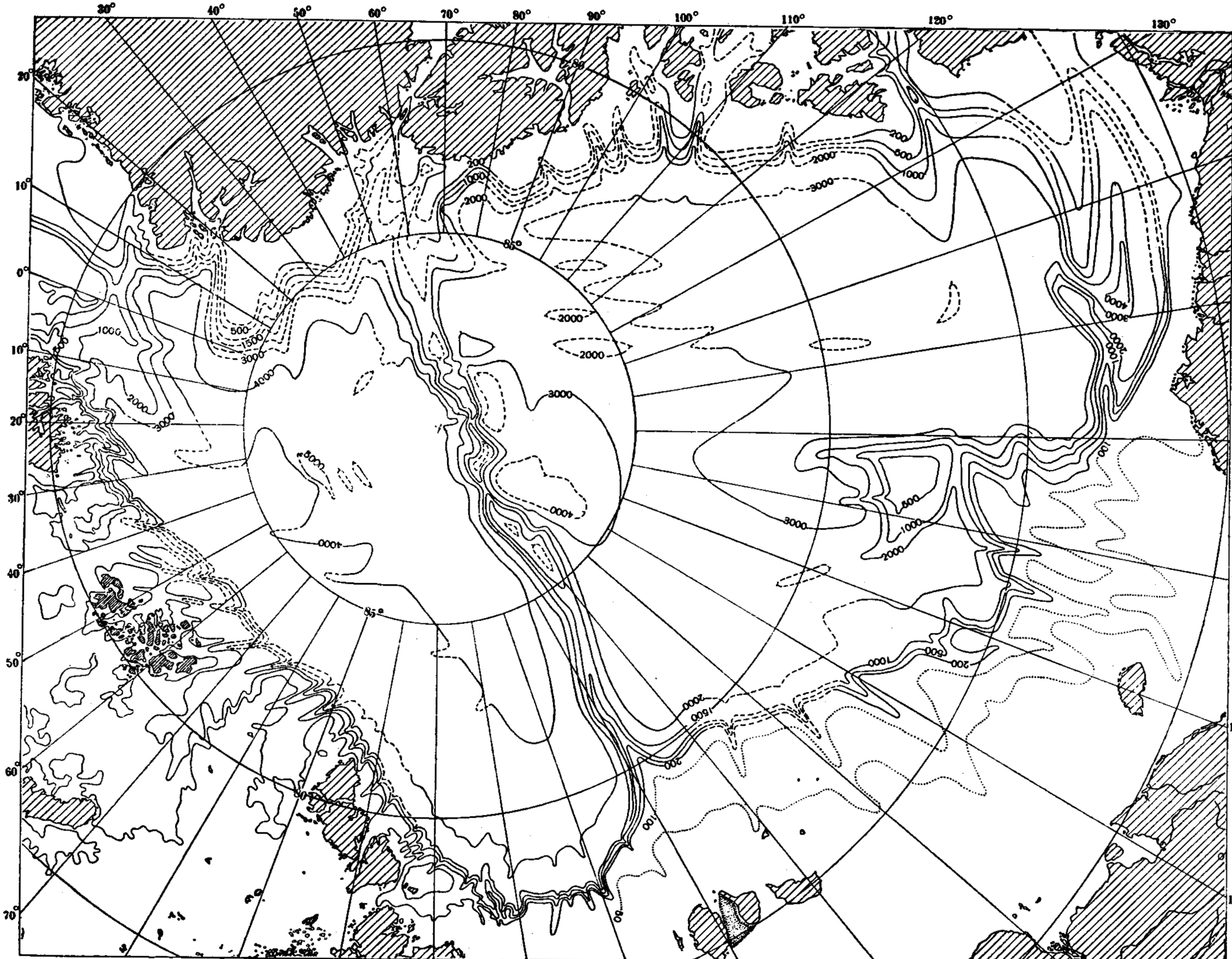

Fig. 13. Bathymetric map of the Central Arctic Basin, from *Izvest. Akad. Nauk S.S.S.R., Ser. Geogr.* No. 5, 1954, facing p. 8.

It is possible that as many as twenty to thirty persons may form the permanent complement at each drift station. The majority are between the ages of 22 and 35, and a third have spent an average of over 12 years in the Arctic. It is not known how many persons have visited the drift stations. The delegation from the Academy of Sciences which V. G. Kort, Director of the Institute of Oceanology, reported on 29 July 1954 had spent two weeks at the stations, probably included the oceanographer Zenkevich, the ice specialist P. A. Shumsky, the microbiologist A. E. Kriss, Chief of the Marine Microbiology Department of the Institute of Microbiology, and one Yurin from Moscow University.

Nothing is known about the personnel of the Cherevichnyy-Ostrekin party which landed at the north pole, nor about the detachment which was flown by Maslennikov to the northern Chukchi Sea.

Dolgin, who directs the special flights over the Central Arctic Basin is a meteorologist. P. A. Gordienko and N. A. Volkov, his assistants are, respectively, an ice specialist, and an officer of the Arctic Institute.

Scientific results

Scientific results of the work done in the Central Arctic Basin since 1947 have not yet been released in detail. A number of press reports since February 1954 have, however, provided an outline of the results obtained since 1948, but little has been revealed of the results of the present expedition.

Oceanography and hydrography

Since the discovery of the Lomonosov Range by Prof. Gakkel"s expedition in 1948, oceanographical and hydrographical studies have been principally directed towards an understanding of the implications of this range.

It has been established that the range has elevations of 2,500 to 3,000 m., and it is claimed that the Ostrekin party has confirmed that it stretches from the Novosibirskiye Ostrova across the north pole to Greenland and Ellesmere Island, a distance of 1,800 km. It thus divides the Arctic Ocean into two major basins. In some places its peaks rise to 954 m. from the surface; its slopes are steep and saddles of a depth of 1,500–1,600 m. and spurs are characteristic. Preliminary data indicate that the range was formed in Mesozoic or Tertiary times, and originally rose above the surface of the Arctic Ocean. It has been established that the floor of the Arctic Ocean is complex, and, like that of the Mediterranean, has been formed by the rising and sinking of the earth's crust. A number of lesser elevations divide the ocean into a series of deeps. The widest and the deepest lies north of the Greenland, Barents, Kara, and Laptev seas. This extends along the Lomonosov Range, and is bounded on the south, between Svalbard and Greenland, by the Nansen Sill and by the continental shelf of the Barents and Kara seas. Its maximum depth is over 5,220 m., at which reading the *Sedov* did not find bottom. A smaller deep is located on the opposite side of the Lomonosov Range. This is roughly oval in shape, and runs north from the 85th parallel between the meridians of 160°E. and 90°W. In this region, depths of up to 4,000 m. have been found. To the south, this deep is bounded by a great underwater plateau, with depths of 2,300–2,800 m. A third deep, lying north of the Chukchi and Beaufort seas, has depths up to 3,820 m. This deep is linked by a narrow strait with the smaller deep of the Beaufort Sea, which has depths of up to 4,689 m. Evidently, in addition to the Lomonosov Range, there exists a further and older folded system of approximately parallel ranges which intersect the Lomonosov Range at angles of 60 to 120 degrees. Another series of elevations runs from the Chukchi Sea to the region of the Nansen Sill and joins Svalbard and Greenland. The Russians draw attention to the fact that the Lomonosov Range lies parallel to the continental slope of the Barents and Kara seas, along the thrust line of which there took place, when the Lomonosov Range was formed, a tectonic dislocation of the earth's crust. The older system of folds evidently forms a chain of mountains and crests which parallel the North American continental shelf. Where these systems intersect, very high mountains exist.

The boundaries of the continental shelves have been more exactly defined. North of Bering Strait the shelf forms a huge submarine peninsula which reaches 80°N., i.e., practically 600 km. farther north than was previously thought. The Somov expedition drifted over this peninsula three times, and found pebbles at all depths. It has been established that the Eurasian continental shelf slopes off much more steeply than was previously imagined. North of the Laptev Sea the angle of descent reaches as much as 18 degrees. The Russians state that the depth of 5,440 m., measured by Wilkins in 1927 at 77°46N., 175°00W., on which doubt had been cast by the 1941 expedition, has been shown to be erroneous. Depths of 2,048 m. and of 1,928 m. have been recorded 11 km. north and 28 km. northeast of this point, respectively.

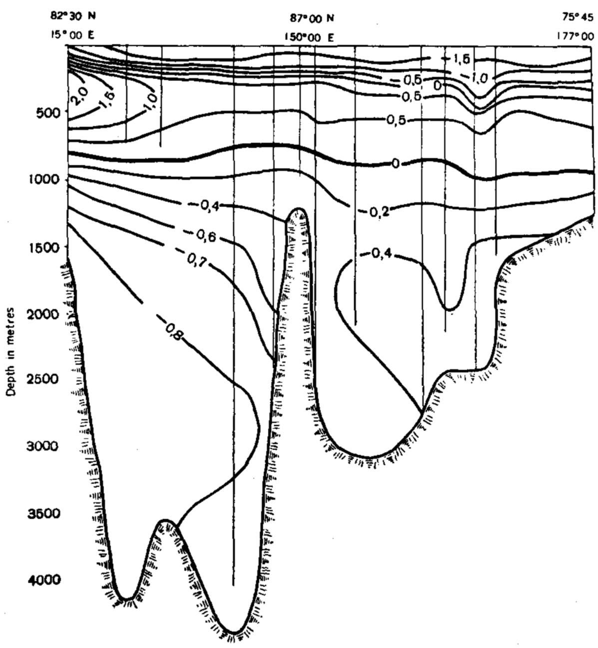

Fig. 14. Water temperatures (°C) on a section across the Lomonosov Range, from *Izvest. Akad. Nauk S.S.S.R., Ser. Geogr.* No. 5, 1954, p. 8.

Hydrological studies have also confirmed the existence of two major basins separated by the Lomonosov Range. Waters at the bottom of the Central Arctic Basin are Atlantic in origin. Cold bottom waters spread north from the Greenland Sea, and reach the foot of the Lomonosov Range, but do not cross it. These are colder than the waters at great depth on the other side of the range. But warm Atlantic waters, with positive temperatures, have been found below the cold surface layers in all parts of the Arctic Ocean. Waters from the Pacific penetrate considerably farther north from Bering Strait than was previously known.[1]

The development and migration of zooplankton and phytoplankton has been studied at great depths on a year-round basis. Large quantities and many varieties of copepoda have been found, at depths of up to 3,400 m. Specimens taken in the Eastern Arctic in 1948 included types not previously known. These findings are hailed as upsetting the theories of the scarcity of plankton in the Arctic Ocean and of the relative uniformity of benthic fauna throughout the world. In the Eastern Basin, between 160°E. and 60°W., the waters near the bottom are different, and the fauna is poor. In this region, the richest collections were made at a depth of 100 m., where a current from the Pacific has been identified.

Wildlife

The presence of polar bear, fox, seal, and of flocks of ducks, gulls, and snow bunting has been reported at distances of over 1,000 km. from the mainland.

Ice

The relief of the bottom has an important effect on the distribution and drift of ice through its effect on the water circulation at all levels. While emphasizing this, the Russians claim that they have confirmed their earlier conclusion that the general drift in the Central Arctic depends on the predominant isobaric pattern. West of the Lomonosov Range, the drift of the sea ice is anti-clockwise, east of the range, it is clockwise. In the west, the ice is mainly two to three years old, is frequently carried into the Barents and Kara seas, and is frequently renewed. There may, however, be considerable periods when the ice follows a closed trajectory; the radius of this trajectory varies greatly, from a small line subtending the northern part of the Laptev Sea, to a very long diameter which extends across almost the entire Western Basin of the Arctic Ocean. In the east, the ice is thicker, older, and far less mobile; regions of dynamism and of quiet have been distinguished. The line of drift on one side of the Lomonosov Range is independent of that on the other; on neither side is the line of drift constant. Ice from east of the range occasionally moves off at a tangent to join the movement toward the North Atlantic; but the actual discharge of ice into the Greenland Sea is very irregular. The Russians claim that, during the southward drift, the rate of

[1]Recent work done from the Scripps Institution of Oceanography has also led to the same conclusion.

degradation exceeds that of accretion; during the northward drift, the reverse relationship obtains. Thus the sea ice is periodically rejuvenated–about once every four to five years. During the drift northward from Ostrov Vrangelya, the pack tends to loosen up. The speed of drift is generally about 1–1.5 miles in 24 hours. The slackening of the ice, consequent on a change of weather, may produce drift velocities of up to 1 mile per hour. Normally, the average speed of drift is greatest from February to April, and least from July to September.

It is claimed that ice conditions east of the Lomonosov Range are the key to ice conditions along the entire Northern Sea Route, and that the interaction of the reverse drifts on each side of this range account for the so-called Ayon and Taymyr "ice-massifs", or ice clusters, which lie athwart the Northern Sea Route. Within the crude outlines of this highly generalized picture, the Russians admit that the drift is far more complex, and the ice far older, than they had originally appreciated. The basic laws governing drift are not yet known, nor are the laws governing seasonal changes in the drift. It is hoped that a major achievement of North Pole 4 will be the discovery of a new and fundamental "ice current".

The positions of the drift stations now functioning have been announced as follows:

	April '54	15 July '54	10 August '54	15 Sept. '54
North Pole 3	86°00N., 175°45W.	88°02N., 151°40W.	89°30N., 140°00W.	89°34N., 54°30W.
North Pole 4	75°48N., 175°25W.	77°22N., 174°20E.	78°00N., 174°00E.	79°40N., 178°27E.

It is reported that North Pole 2 was abandoned in April 1951 at 81°45N., 162°20W. and that this floe, by June 1954, had drifted in a clockwise direction to 75°40N., 175°05W. At this point, a party was again landed to carry out detailed observations. It is possible that this was the group from the High Latitudes Air expedition which was flown into the Chukchi Sea by Maslennikov.

Although both drift stations have been mounted on floes of old pack ice, a good deal has been published since March 1954 about ice islands. An early release claimed that these do not move with the pack, but, being affected by deep, subsurface currents, follow an independent trajectory. Yet the course which the Russians indicate coincides generally with that recorded by Canadian and American observers and with that indicated by the Russians for the pack itself in the Eastern Basin of the Arctic Ocean. Similarly, Burkhanov has made an effort to refute the notion of their stability, but Zubov has emphasized their age and solidity; a late release has simply stated that some ice islands have been seen to break up into relatively small fragments. Another writer has spoken of their drift as continuing over many years or even centuries. Ice islands are hailed as the explanation of land formations reported by earlier explorers but never found again, such as Sannikov Land and Andreyev Land. The Russians began by claiming that they had sighted ice islands before the West, attributing the first description to Admiral Makarov at the turn of the century, and claiming sightings by arctic aviators since 1939. A recent and more serious article simply states that the Russians first saw these in 1946. It is reported that the icebreaker *Mikoyan* tied up beside an ice island in 1947 to the north of Ostrov Vrangelya, and disembarked a party to carry out detailed studies. Ice islands are described as varying in shape, attaining sizes of 600 to 700 sq. km., and a maximum elevation above the sea of 10 to 12 m. The largest,[1] found in April 1948 at 82°30N., 173°00E., measured 28 by 32 km.

A study has been made of the process of the break-up of floating sea ice, and of the formation of cracks, leads, and open patches. The thawing of sea ice under the influence of the sun's rays has been studied on the under as well as the upper surface of the pack. It has been noticed that cracks occasionally form in the pack which do not alter their direction as they cross fields of differing thickness and age, even those composed of very old ice. The formation of such fissures is connected with the passage of waves in the water layers immediately below the ice. It has been established that the break-up and movement of the ice is very closely connected with changes in synoptic conditions; these processes are intensified by the penetration of cyclones into the Arctic.

Meteorology

In recent years meteorological observations have embraced almost the whole of the Central Arctic Basin. These have destroyed the older idea of a permanent high pressure area[2] and of predominantly anticyclonic weather in the region. The work of North Pole 1 showed that cyclones, often quite intense, and usually accompanied by cloudy weather and precipitation, penetrate the region. Cyclonic activity is characteristic of the whole cold period of the year. A relatively large number of deep cyclones have been encountered by various "mobile groups". The spring is characterized by complex weather patterns, and an intensive movement of warm air masses toward the pole. Over the coastal seas, cyclones are frequently active, with well developed warm and cold fronts. As a rule, as these penetrate the Arctic, following a wide variety of paths, they occlude rapidly. In summer the warm air masses are not modified appreciably, and, in this period, active fronts are observed in the Central Arctic. Interesting data have been assembled on the penetration into the Central Arctic of warm air masses from the Atlantic and Pacific oceans. These masses often disperse above the 100–200 m. cold earth layer throughout the troposphere to a height of 7–8 km., along the edge of the deep anticyclone which is centred over Alaska, and which gradually displaces itself eastward. Such a synoptic situation gives rise to outbreaks of cold arctic air from the polar regions over the European U.S.S.R. and western Siberia.

New data have shown that Sverdrup's theory of a layer of cold air lying over the ice needs further examination. The lower boundary of the layer of inversion is marked by turbulence which causes a vertical distribution of temperatures characteristic of unstable air masses. The so-called "cold layer" would be better named the "unstable layer". Until recently, changes in the altitude of the lower level of the stratosphere remained an open question. Regular radiosonde ascents have shown that the height of the tropopause over the Central Arctic Basin, including the region near the pole, is subject to the

[1]Presumably T2.
[2]This view has also been reached by North American scientists.

same fluctuations as over the mainland. The hypothesis of a continuously low stratosphere has been refuted. Similarly, new data have altered the notion of the vertical stratification of the atmosphere over the Central Arctic. Measurements of direct, diffused, and reflected radiation, of air temperature, of wind speed, and of ice and snow temperatures at various horizons, have yielded data for the study of the exchange of heat between the sea and the atmosphere. Contrary to previous ideas, the drift of 1950–1 showed that the annual radiation balance was positive, rather than negative. Such findings have great importance for the study of the global circulation of the atmosphere.

Terrestrial magnetism

Important data have been collected on the magnetic anomaly in the polar region. Investigations carried out, for the first time, between the magnetic north pole in the Canadian Archipelago, and the location of the previously imagined second magnetic pole, and to the northeast of the Novosibirskiye Ostrova, have shown that the second magnetic pole does not exist. Instead, the region of the supposed second magnetic pole was found in 1948 to be the centre of an enormous magnetic anomaly which extends across the entire Arctic Ocean. The meridians cluster near the Poluostrov Taymyr, and, to the northeast, form a thin bundle which stretches across to the magnetic north pole. Near the anomaly the horizontal component is greatly reduced, and measures 1,500 gammas instead of zero, while the inclination, or dip, is about 88.5 degrees, instead of 90 degrees. A close connection has been established between this magnetic anomaly and the Siberian maximum of the vertical component of the geomagnetic pole, which lies at the upper reaches of the Anabar and Kotuy rivers. Local magnetic anomalies have also been observed at various points in the Central Arctic. Sufficient data have been gathered to rule out the existence elsewhere in the Arctic of a second magnetic pole.

Observations have shown that diurnal magnetic disturbances at high latitudes in the Arctic have three maximums: morning, noon, and night. It appears that the lines of simultaneous morning maximums form a system of spirals radiating from the northwest end of Greenland, the pole of homogeneous magnetization of the earth. The Russians have drawn attention to the familiar fact that, if a stream of electrons is directed against a magnetized iron ball, these distribute themselves over the surface of the ball in spirals which emanate from its magnetic pole. Such a distribution is disclosed by luminosity. It is known that the distance between the pole of the magnetized ball and the point toward which the electrons fall depends on the energy (velocity) of the latter, and that the direction in which the spirals develop is determined by the sign of the charge born by the particles. The Russians suggest that streams of electrically-charged particles, emitted by the sun, and possessing differing velocities, penetrate the upper atmosphere of the globe, and reach different latitudes in accordance with their speed and mass. This may explain the peculiar geographical distribution of magnetic disturbances in high latitudes. Until recently, one zone of greater magnetic disturbance has been accepted in

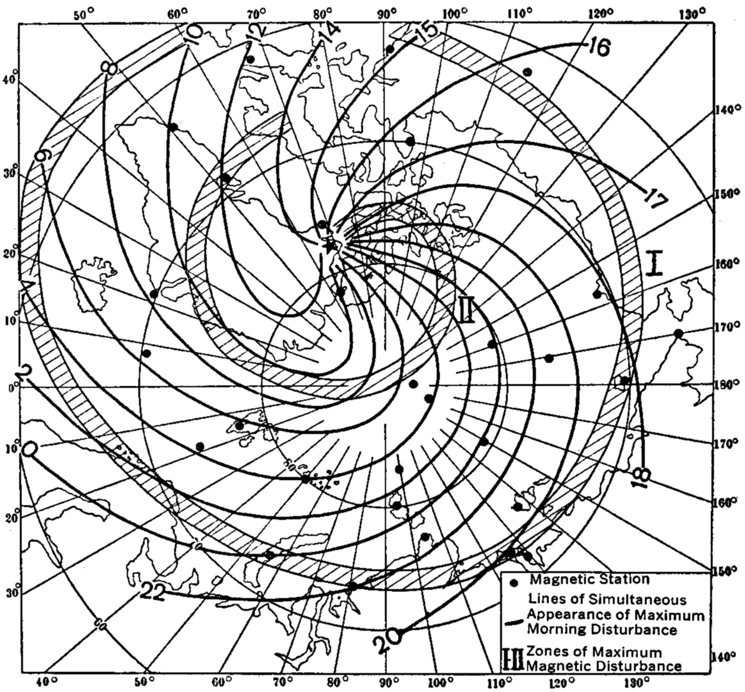

Fig. 15. Chart showing simultaneous appearance of maximum morning magnetic disturbances. The figures on the isochrons give hours in world time, from *Izvest. Akad. Nauk S.S.S.R., Ser. Geogr.* No. 5, 1954, p. 15.

the geomagnetic latitudes between 66 and 68 degrees, the region of maximum auroral activity. Sufficient data have now been collected to support the conclusion that there exists a second zone of intense magnetic disturbance, which is spiral in form, between the geomagnetic meridians of 80 and 85 degrees.[1] This hypothesis is based on the peculiarities of the midday magnetic storms in the region of the pole, and is supported by the predominance of zenithal forms of aurora and the distribution of the isolines of anomalous absorption in the ionosphere over Greenland and arctic Canada. The Russians claim that they have amassed data of great importance not only for the study of magnetic storms but also for the study of physical phenomena originating in the sun. To expand the work in this field still further, it has been announced that the Geophysical Institute of the Academy of Sciences is producing a series of precision instruments.

The 1954 expedition is on a scale surpassing that of any of the five previous Soviet efforts to explore the Central Arctic Basin. The expedition of 1941 has since been hailed as pioneering a new method—that of the successive landing of parties of scientists at a number of widely scattered points on the pack for short-term observations. Through this method, by the end of 1953, postwar expeditions had covered nearly two million square miles of the Arctic Basin. In 1954 the availability of large helicopters has made it possible to use this same method in conjunction with long-term observations at major drift stations.

[1]Recent Canadian work supports this view, but suggests that the spiral pattern is more complicated than appears in Fig. 15.

The result is that data can be collected more rapidly over a very large area (e.g., bottom profiles at least 200 km. in width can be constructed in the course of a twelve-month drift). This work has so far been concentrated mainly to the east of the Lomonosov Range, and it would appear that the implications of this range remain the principal object of study. The scale on which this study has been, and is being, pursued indicates that the problem which has been encountered here is very large and complex. If the Soviet government ever makes available the results of all this work, it will probably be clear that Soviet scientists have made an important contribution to the study of the Arctic Ocean, particularly of that part which lies between 150°E. and 70°W.

The press states that all stations were set up within twenty-three days of the departure of the main body from Moscow. It is clear that several hundred tons of freight have had to be delivered. In 1937 it took two months to establish the much smaller Papanin expedition. The apparent despatch with which the 1954 expedition was mounted indicates the experience which has been amassed by the Soviet Union in the establishment of major stations on the pack, in large scale supply and re-supply by air, and in the landing of heavy aircraft on unprepared sea ice. It is claimed that flights have been made throughout the polar night, that all landings have been made without accident, and that in no case was a landing effected more than a mile or two from the desired destination. Finally, it is claimed that no parties have experienced difficulties from the sudden development of cracks in the floes they have been occupying. But it is clearly felt that they are adequately equipped for the rapid emergency evacuation of men and equipment, should this prove necessary.

The Minister of the Sea and River Fleets recently announced that, by 1953, the annual turnover of freight along the Northern Sea Route had increased to four times that of 1940. This would indicate a figure of about 2,000,000 tons. It is likely that this increase has been achieved mainly by postwar capital development of the route. While it remains difficult to foresee a vastly greater increase in this figure in the immediate future, Soviet persistence in the effort to solve the mysteries of ice conditions in the Central Arctic clearly indicates that the route and the region are expected to acquire still greater importance for the Soviet Union.

Sources published in 1954

Bakinsky Rabochiy, August 3.
Izvestiya, June 26; July 17, 18, 21, 29, 31; August 31.
Izvestiya Akademii Nauk S.S.S.R., Seriya Geograficheskaya, No. 5, pp. 3–16.
Kommunist (Armyanskaya S.S.R.), July 20, 22, 24, 27, 29; September 24; October 23.
Komsomol'skaya Pravda, February 25.
Morskoy i Rechnoy Flot, No. 9.
News, No. 18 (September).
Ogonyek, Nos. 10 (March), 26 (June), 30 (July), 31–34 (August).
Pravda, April 29; May 16; July 18, 19, 20, 21, 22, 27; August 21, 25; September 7, 12, 17.
Radio, No. 9 (September).
Sovetskaya Belorussiya, September 22.
Soviet Union, No. 8 (August).
Vodnyy Transport, July 17, 20, 22, 24, 27; August 3, 7, 10, 14, 21, 28.