CEP IV
WP-32
Item 4c of the Agenda
Russia
Original : in the English Language

RUSSIAN ANTARCTIC EXPEDITION ENVIRONMENTAL IMPACT ASSESSMENT (PRELIMINARY STAGE)

LIST OF ACRONYMS

RAE - Russian Antarctic Expedition
ATCM - Antarctic Treaty Consultative Meeting
EIA – Environmental Impact Assessment
SPA – Specially Protected Area
SSSI - Site of Special Scientific Interest
HSM- Historic Sites and Monuments
CCAMLR – Convention for the Conservation of Antarctic Marine Living Resources
CEMP - CCAMLR Ecosystem Monitoring Program
SMA – Specially Managed Areas
NA – Non-recoverable Area
RA – Recoverable Area
CIA – Conventionally intact area
AARI – Arctic and Antarctic Research institute

1. INTRODUCTION

In 1991 in Madrid, the Antarctic Treaty Consultative Parties, including Russia, have signed the Protocol on Environmental Protection to the Antarctic Treaty (hereinafter referred to as the Protocol), which put forward the environmental protection issues as the most critical obligations of the States, Parties to the Antarctic Treaty. According to the Protocol, Antarctica was designated as a natural reserve and a natural scientific laboratory of world importance that should be preserved for future generations. On May 24, 1997, the Russian Federation ratified the Protocol at the Federal Law level. In January 1998, the Protocol has come into legal force after being ratified by all Consultative Parties.

According to the requirements of the Protocol, any activity in Antarctica before its commencement has to be preceded by an environmental impact assessment (hereinafter, EIA). The EIA procedures are set forth in Annex 1 to the Protocol (See Annex 1). The EIA of activity of the Russian Antarctic Expedition (hereinafter, RAE) was performed in compliance with the "Guidelines for Environmental Impact Assessment in Antarctica" adopted at the ATCM-XXII and the documents that take into account the specific features of RAE activities presented by Russia at ATCM-XXII. It also contains information enumerated in the "List of evidence to be included to the data on environmental impact assessment of activity planned in the Antarctic Treaty area" (adopted by the Roshydromet order No. 139 of December 12, 1999).

The legal and methodological bases of the development of this document are considered in detail in accordance with the official position of Russia in the Antarctic Treaty system.

The proposed types of activity, characteristics of the areas of its implementation and technical data of the expedition equipment and instruments are described.
Special attention is devoted to the analysis of the expedition activity impact on the Antarctic environment.

Beginning from 1998, the RAE activity is undertaken in the regime of the minimum permissible parameters defined by the Decision of the Government of the Russian Federation of August 27, 1997 No. 113 "On activity of the Russian Antarctic Expedition" (Annex 2).

The scientific objectives of national studies are formulated in the Subprogram "Study and Research of Antarctica" of the Federal Program "World Ocean" whose structure is contained in Annex 3.

Thus, these documents formulate the principles of multiyear strategy of the activity of Russia in the southern polar area. It does not envisage significant changes from year-to-year in the RAE aims and goals, applications for new types of activity or areas of their implementation. This EIA can be considered for several years until the RAE changes the types and areas of activities.

The EIA was performed at the JSC "Institute of Geo-Ecology" based on the materials submitted by RAE and on literature sources.

2. LEGAL AND METHODOLOGICAL BASES

2.1. National documents on implementing the "Protocol on Environmental Protection to the Antarctic Treaty" in the Russian Federation

After ratification of the Protocol on May 24, 1997, the Decision of the Government of the Russian Federation of December 18, 1997 No. 1580 "On ensuring the implementation of the Protocol on Environmental Protection to the Antarctic Treaty" was adopted. The Federal Service of Russia for Hydrometeorology and Environmental Monitoring (Roshydromet) was entrusted with the functions for providing coordination and organization of work of the Federal executive bodies on fulfilling the obligations of the Russian Federation. The Roshydromet was authorized to issue permits for activity in the Antarctic to the Russian individual persons and legal entities as agreed with several Ministries and Agencies based on the Conclusion on the Assessment of the impact of this activity on the Antarctic environment and the dependent and related ecosystems. The Government of the Russian Federation requested Roshydromet and other interested federal executive authorities to develop a draft procedure for issuing permits.

Further step in Protocol implementation was the Decision of the Government of the Russian Federation of December 11, 1998 No. 1476 "On the adoption of the Procedure for consideration and issuance of permits for activities of the Russian individual persons and legal entities in the Antarctic Treaty Area". The adopted

Procedure defines types of activity requiring a permit, terms necessary to obtain a permit for the proposed activity; processing of applications and necessary documents for the activity including an environmental impact assessment and control for observing requirements to the activity in the course of its conduct and penalties.
At the present time, Roshydromet has adopted a package of documents determining a mechanism for implementing these decisions including:

- Application to obtain a permit for the activity in the Antarctic.
- List of evidence to be included to the data on the impact assessment of the activity planned.
- Provision about the Commission on considering applications for activity and issuing conclusions on these applications.
- Regulations of the Commission on considering applications for activity of the Russian individual persons and physical entities in the Antarctic Treaty Area.
- Procedure for restriction and suspension of the permits for activity.
- Provision on the order of designating observers of the activity and fulfilling the functions they are entrusted with.
- Provision on the order of designating responsible representatives of the Russian Federation and fulfilling the responsibilities they are entrusted with (from the personnel of the ongoing Russian Antarctic expedition);
- Permit form.

These regulating documents were adopted and came into force on the basis of the order of Roshydromet of December 7, 1999 No. 139.

2.2. Requirements of the "Protocol on Environmental Protection" to EIA
Article 3 of the Protocol establishes a number of environmental principles, which can be considered as guidelines to environmental protection in Antarctica and its dependent and associated ecosystems (see Annex I). The principles in paragraph C express the necessity of collecting sufficient information to "allow prior assessments of and informed judgements about, their possible impacts on the Antarctic environment and dependent and associated ecosystems and on the value of Antarctica for the conduct of scientific research". In addition, it states that "such judgements shall take account of:

(i) the scope of the activity, including its area, duration and intensity;

(ii) the cumulative impacts of the activity, both by itself and in combination with other activities in the Antarctic Treaty area;

(iii) whether the activity will detrimentally affect any other activity in the Antarctic Treaty area;

(iv) whether technologies and procedures are available to provide for environmentally safe operations;

(v) whether there exists the capacity to monitor key environmental parameters and ecosystem components so as to identify and provide early warning of any adverse effects of the activity and to provide for such modification of operating procedures as may be necessary in the light of the results of monitoring or increased knowledge of the Antarctic environment and dependent and associated ecosystems; and

(vi) whether there exists the capacity to respond promptly and effectively to accidents, particularly those with potential environmental effects".

Article 8 of the Protocol introduces the term "Environmental Impact Assessment" and proposes three categories of environmental impact:

- less than a minor or transitory impact,
- equal to a minor or transitory impact; or
- more than a minor or transitory impact

according to their significance. This article also requires from the Parties conducting an assessment of the planned activity to be undertaken in the Antarctic in compliance with the procedures set out in Annex I.

Annex I of the Protocol (Annex 1) provides a more comprehensive explanation of different impact categories and establishes a set of basic principles to conduct an EIA of the planned activities in Antarctica.

In addition, Annex I sets up a Preliminary stage for assessing the environmental impact of Antarctic activity; this stage is intended to determine if an impact produced by this activity is less than minor or transitory or not.

In accordance with the results of the Preliminary EIA stage, the activity can either:

- proceed if the predicted impacts of the activity are likely to be less than minor or transitory; or
- be preceded by an Initial Environmental Evaluation (IEE) if the predicted impacts are likely to be minor or transitory; or
- be preceded by a Comprehensive Environmental Evaluation (CEE) if the predicted impacts are to be more than minor or transitory.

No agreement on defining the criterion of "minor or transitory impacts" has so far been reached (contributions to this subject can be found in XX ATCM/IP 2, New Zealand; XXI ATCM/WP 35, New Zealand; XXI ATCM/IP 55, Argentina; XXII ATCM/IP 66, Russia, XXII ATCM/WP 19, Australia, etc.) Up to present, the difficulty with defining this criterion is due to the dependence on a number of variables associated with each activity and each environmental context. The interpretation of this term will need therefore to be made on a case by case site specific basis.

2.3. Application of the "minor or transitory impact" criterion for EIA in different areas of the Antarctic

At ATCM-XXII, Russia presented an official document, which reflects a real mechanism for applying the "minor or transitory impact" criterion that allows the clearest determination of the magnitude of environmental impacts of different activities.

The position adopted by the Russian Party in the Antarctic Treaty System in respect of these criteria is outlined below.

At the present time after the Protocol on Environmental Protection to the Antarctic Treaty has come into force, this geographical area presents a vast pristine territory including several dozens of abandoned or inhibited regions restricted in area with their own environment differing significantly from the virginal territory. According to Articles 2 and 3, Annex I to the Protocol, the "minor or transitory impact" criterion (hereinafter, referred to as MTI) is a key criterion to determine the need for conducting the Initial or Comprehensive Environmental Evaluations. Different approaches can be used in terms of defining the meaning of this criterion. In spite of attractiveness of numerical methods based on the specific spatial (geometric dimensions) or temporal characteristics of the activity, they do not possess universal qualities and cannot hence be applied to the Antarctic conditions. It is obvious that one and the same type of activity will incur a different environmental damage to virgin (intact) and transformed (impact) areas that have been repeatedly exposed to such impact. It seems reasonable to focus on the specific features of these areas and discuss the "minor or transitory impact" criterion used for EIA under the Antarctic conditions.

2.3.1. Nature of impact

For a successful identification of the "minor or transitory impact" criteria adequately reflecting the extent of anthropogenic disturbance introduced to the environmental systems, it is important to take into account that:

- any consequence of the anthropogenic impact can be considered as a result of interaction between human activity and natural system compartments;
- "minor or transitory impact" criterion is not abstract, its significance (for example, a numerical value) is determined separately for each specific case and should be within the permissible range of the specific system properties exposed to impact.

Hence, the specific "minor or transitory impact" value will depend both on the impact character and on the properties of the impacted system.
Each of the aforementioned statements is considered in detail below.

2.3.1.1. Relative character of the "minor or transitory impact" criterion

An ability of a system to oppose the external impact is characterized by the preservation of its unique parameters and self-recovery during a specific period of time. Different natural systems obviously have different internal capabilities and correspondingly, the same impact (equal in value) can be insignificant for one system and detrimental for another. The system resilience depends to a great extent on its dynamic character and natural cycle duration.

Living nature objects – animals, plants and microorganisms can restore their numbers and natural habitat in case of a partial decline during a time interval comparable with the anthropogenic disturbance duration, i.e. human activity conducted in natural Antarctic systems. The time required for reconstruction will depend on the reproduction capabilities of organisms and reparation features of the ecosystems in general. Thus, all living nature objects can be referred to the category of dynamic.

The existence of non-living nature objects is determined by their annual and geological development cycles. We can conventionally divide these objects by their dynamics and correspondingly, the reconstruction capability, into two groups:
Mobile, such as glaciers, snowfields and lake systems are capable of self-recovery. The required time is determined by the annual cycle and is comparable by duration with the time of human activity.

Immobile, such as rocks or permafrost have their own evolution cycles measured at the geological time scale. The time required for reconstruction of local damage of such objects is so much greater by duration than that of impact and even of man existence as a species in general that from the viewpoint of the latter the geological objects are considered immobile. In other words, they require an infinite time at the scale of historical chronology for reconstruction. Although the scales of processes and duration of the geological cycle are incomparable with potential human transformation in Antarctica, it is necessary to consider a possible damage for future scientific activity in the given area whose results may be distorted due to the absence of anthropogenic background records.

It is important to emphasize that any scale for defining a "minor or transitory impact" criterion proposed regardless of any specific object (system) is senseless.

2.3.1.2. Concept of object interaction

In respect of the impact nature and genesis, one has to consider the interaction between man and natural Antarctic systems. It is important to stress that by character, it can be subdivided into two drastically differing categories:

I. Similar to natural processes;
II. Alien to natural processes.

The first category includes for example, such types of anthropogenic impacts as:

- visual impact (analogue – a visual contact with large animals);
- mechanical impact on media (natural analogous processes – erosion, soil displacement due to glacier flow, etc.),
- thermal, electromagnetic or biogenic pollution (natural analogues – climatic, geophysical and biological processes of local significance),
- noise from activity (analogue – noise of wind, sea surf, cries of animals);
- taking of animals, plants or sampling of natural media (analogue – natural loss).

To establish adequacy of natural and anthropogenic impacts is a task for scientists. Such activity can be standardized by the scale of impacts adequate to natural interactions.

The second category includes principally new impacts for the natural system that have no analogues and that qualitatively change the environment. These are:

- pollution by synthetic substances and spreading of alien materials in the environment;

- introduction of alien biological objects (non-local animals, plants and microorganisms).

Such types of impact can disturb the system equilibrium due to the absence of adaptation mechanisms formed in the process of evolution.

The second category impacts are most dangerous for the natural systems, since they are subject to true cumulation, i.e. they are capable to accumulate in the environment and continue their action even at the end of activity. In practice, it means that any virgin territory (they are still numerous in Antarctica) subjected to an alien impact, loses some of its initial properties for ever. The equilibrium occurring in the interaction process will bring the system to a qualitatively new level.

2.3.1.3. Damage as an accompanying factor

The “damage” notion has to be very seriously discussed and ultimately specified. From some standpoint, this notion may include any environmental man-made changes over the time of his presence in Antarctica including forced environmental transformations due to the need for maintaining life activity, without which no activity can be conducted. Forced damage is an “inevitable evil” being a peculiar payment for the study and exploration of Antarctica.

Practical activity contains by definition an environmental transformation component. In addition to invaluable scientific and logistic experience gained, the need to preserve the environment of the last continent has been clearly understood. The Protocol that was adopted almost a century after man appeared in Antarctica regulating his practical activity is also a result of this activity and experience.
It is important to note that in the environmental principles of the Protocol (Article 3, paragraph 1), the value of Antarctica as an area for the conduct of scientific research (including inherent practical activity), shall be fundamental considerations in the planning and conduct of all activities in Antarctica.

The damage inflicted on the pristine environment is a payment for the experience gained and knowledge obtained on the Antarctic nature and its environment in general.

2.3.2. Peculiar features of the Antarctic areas

Much of the territories of Antarctic stations and adjoining areas have been already transformed to such an extent that they will never serve as examples of the virginal nature of the continent. That is why, a “minor or transitory impact” criterion should differ significantly for the impact and intact areas. In view of this fact, the activities planned in the intact area can be assessed as having less than a “minor or transitory impact” only if they fully exclude the impacts referred to the second category, i.e. principally new for the given natural system.

In future, it seems to be very promising to create an Inventory of Antarctic Territories that will record in the chronological order all types of the conducted activity with the indication of routes, description of the types of activity and potentially inflicted damage. This Inventory will help to delineate the most clean (intact) and polluted (impact) areas of Antarctica with the aim of their more rational use and will help to preserve the intact territories for future scientific research.

In order to standardize the approach to defining a "minor or transitory impact" criterion in planning the activity in Antarctica, it is advisable to identify the following groups of areas differing in the extent of environmental transformation (inflicted environmental damage):

a) Non-recoverable areas (NA) (irreversibly (completely) transformed)

- territories of operating and abandoned (scientific) stations and seasonal bases including areas for support of their activities.

Depending on the age and size of the station and the inflicted environmental damage, the area can comprise up to several square kilometers. The environment of these areas has been changed as a result of multiyear man activity and has lost its pristine character forever. Provided the conservation was properly done excluding any possibility of further damage, artificial landscape reconstruction (reclamation) in such areas is not advisable due to the following:

- these areas are part of the historical process of man/environment interaction being thus of a specific historical value;
- they have already been sufficiently studied, developed and adapted for man habitation;
- a dynamic equilibrium in interaction with the environment has been established in the NA territory;
- measures to reconstruct the disturbed landscape will have an additional environmental impact and the damage inflicted can be greater compared to the existing levels;
- reconstruction of the initial landscape may lead in the future to errors at the conduct of scientific research.

Some areas of former intense human activities, referred to the NA category, have been already listed as the historic sites, for example, the former whaling base on Deception Island.

The NA present areas of man habitation with the necessary environment including the entire infrastructure. Knowledge stored in the NA can serve as a basis for further studies. Within the NA, there should be a program of environmental impact monitoring and the area management plan regulating all activity. Any activity within the NA shall be regulated by the established standards and rules.

In the process of activity carried out in the NA territory, the environmental elements have been adapted to the specific types of impact resulting in the dynamic equilibrium within a conventionally enclosed "man-environment-NA" system. The environmental component areas have attained stability to some specific types of impact and continuation of similar activity within this system will not inflict any additional damage.

The term "damage" applicable to this category of Antarctic areas means "additional damage" and will be used in the cases where a new adverse environmental impact is either significantly greater than the existing levels or qualitatively differs from the already existing types of impacts.

b) Recoverable areas (RA) (reversibly (partly) transformed areas)

- fieldwork areas;
- territories along the sledge-tractor traverses.
- areas of airborne and shipborne logistics operations beyond the station territory.
- buffer zones between the NA and a conventionally intact area (up to 100 km long).

These are boundary (separating) areas between the intense man activity (increased activity) areas and the intact areas. Any activity undertaken here requires a preliminary EIA. The application of the term "damage" is possible on condition similar to NA.

c) Conventionally Intact areas (IA)

- other areas of Antarctica (territories outside a buffer zone).

These Antarctic areas are of actual value due to their pristine (virgin) character and purity. The access to these areas will have to be strictly regulated and a "minor or transitory impact" criterion should be defined for all types of the supposed impact.

In conclusion, it is stressed that a "minor or transitory impact" criterion is of a relative character and to determine its absolute magnitude the following should be taken into account:

- individual capability of natural systems and objects of self-recovery, including the duration of the natural evolution cycle and the range of natural fluctuations;
- character of anthropogenic impact in terms of its similarity to the natural processes;
- anthropogenic background of the area.

The "minor or transitory impact" criterion and the requirements to justify any proposed activity for three indicated types of areas should be different. Since main activities are centered at present in the NA, a simplified EIA procedure for these areas appears financially reasonable and not contradicting the basic principles of the Protocol.

2.4. General principles of the EIA Process for activity in the Antarctic

The EIA is a process whose ultimate objective is to provide the decision-makers with an indication of the likely environmental consequences of the proposed activity.
The Process of predicting the environmental impact of any activity and evaluating its significance is the same regardless of the apparent magnitude (volume) of this activity. Some activities require no more than a cursory examination to determine their impact, although it must be remembered that the evaluation level depends on the significance of environmental impacts, rather than on the scale or complexity of the activity. Thus, the picture that emerges with respect to the activity impacts will determine how much further the EIA process needs to be taken and how complex it should be.

2.4.1. Considering the activity

An activity presents an event or a process resulting from or related to and/or that might lead to the presence of man in the Antarctic. An activity may consist of several actions, e.g. ice drilling activity may require actions such as equipment transportation, establishment of a field camp, power generation for drilling, fuel handling, drilling operations, waste management, etc. An analysis of activity should consider all phases involved (e.g. construction, operation or potential dismantling or decommissioning phases).

The activity and the individual actions should be defined through a planning process, which considers the physical, technical and economic aspects of the proposed project and its alternatives. Consultation with relevant experts to identify all these aspects is an important part of this initial scoping process. It is important to accurately define all aspects of the activity, which could have environmental impacts. The rest of the EIA process relies on this initial description, which should occur during the planning process. The following aspects of the proposed activity and its alternatives should be clearly identified:

- the purpose and the need for activity;
- the principal characteristics of the activity that might cause impact on the environment; for instance, periods of operation of the activity, descriptions of technologies, types of energy and consumption, numbers of personnel;
- the relationship of the proposed activity to relevant previous or current activities;
- a description of the activity's location and geographical area, indicating the adjoining infrastructure, access roads, etc.;
- timing of the activity (including calendar dates as well as overall duration);
- location of the activity with regard to areas with special management requirements (SPA, SSSI, HSM, CCAMLR CEMP sites, already proposed ASPAs, ASMAs, etc.);
- precautionary measures that are integral to the project including during the construction, operational and decommissioning phases.

Careful consideration of all planned activities of different operators is required to determine the full scope of the activity so that the impacts can be properly assessed. This is necessary to avoid preparing a number of separate EIAs on actions, which indicate an apparent low impact, when in fact, taken in its entirety, the activity actually has potential for impacts of much greater significance. This is particularly common where a number of activities take place at the same site (either spatially and/or temporarily), i.e. there is a probability of their cumulative or combined impact. When defining an Antarctic activity, experience gained in similar projects undertaken within and outside the Antarctic Treaty System Area (e.g. the Arctic) may be an additional and valuable source of information.

Once the activity is defined, any subsequent changes to the activity must be clearly identified and addressed according to when they occur in the EIA process (e.g. if the change occurs once the EIA document is completed, then an amendment to the EIA or a rewrite of the document may be necessary depending on how significant the change is). In every case it is important that the change and implications (in terms of impacts) is assessed in the same manner as other impacts previously identified in the EIA process.

3. DEFINING THE PROPOSED ACTIVITY

3.1. Name (type) of activity planned
Russian Antarctic Expedition

3.2. Aim and goals
The RAE aims are based on fulfilling the decisions of the Government of the Russian Federation of August 28, 1997, No. 1113 "On the Activity of the Russian Antarctic Expedition" and of September 9, 1999 No. 1027 "On measures to ensure the interests of Russia in the Antarctic", as well as of the directions of the Subprogram "Study and Research of the Antarctic" of the Federal Program "World Ocean". The on-going activity of Russia in the Antarctic aims to support the achieved national positions in the Antarctic Treaty System due to maintaining a network of wintering stations on the mainland and continuing active work during the seasonal period.

The RAE activity aims to develop the results obtained for a long-term period over a wide range of basic and applied programs given a specific geographic position of the Antarctic, its international-legal status and resource-raw material significance ensuring the geopolitical interests of Russia in the southern polar area based on the expedition infrastructure created during this period.

The main RAE goals are to:

- ensure the presence of Russia in the Antarctic and continue scientific research given the economic conditions and geopolitical interests of Russia in the southern polar area;

- conduct expedition studies under the Projects of basic and scientific-applied investigations and developments in the southern polar area in the framework of Federal Programs of the Russian Federation;

- ensure operation of year-round Mirny, Vostok, Progress and Novolazarevskaya stations and Bellingshausen and Druzhnaya-4 field bases in the regime of minimum permissible parameters;

- perform comprehensive environmental monitoring of the Antarctic at four Russian Antarctic stations, including the monitoring programs on climate, continental and sea ice, Southern Ocean water, biosphere, magnetosphere and ionosphere, seismic state of the lithosphere of the Southern Ocean and monitoring of the anthropogenic impact on the environment;

- undertake seasonal expedition studies and engineering activities at the Antarctic stations and onboard the research vessels;

- carry out nature protection measures aiming to make all types of the expedition activity to comply with the requirements of the Protocol on Environmental Protection to the Antarctic Treaty.

3.3. Justification of the need and advisability of activity

The need for the RAE activity was formulated in the Decree of the President of the Russian Federation "On the Russian Antarctic Expedition", Decisions of the Government of the Russian Federation and in the Federal Program "World Ocean" (Subprogram "Study and Research of the Antarctic"). The monitoring activities in the framework of the WMO Global network is dictated by the obligations of Russia as a member of the World Meteorological Organization.

Types and areas of RAE activities are determined by the annual plan-programs of scientific studies and activities agreed upon with the Scientific Council on the Arctic and Antarctic Research of the Russian Academy of Science and approved by the Federal Service of Russia for Hydrometeorology and Environmental Monitoring.

All RAE activities are to be carried out in the NA territories and water areas (Russian Antarctic stations), RA – Southern Ocean seas and at the sledge-caterpillar traverse routes Mirny – Vostok – Mirny, Novolazarevskaya – ice barrier – Novolazarevskaya and aircraft flight routes in the vicinity of Prince Charles Mountains and Grove nunataks.

3.4. Description of RAE research and scientific-applied activity

3.4.1. Basic scientific research in the Southern Polar Area

The expedition activities are conducted under the basic scientific research projects formulated in the subprograms "Study and Research in Antarctica" and "Study of the World Ocean nature" of the Federal Program, departmental program of the RF Ministry of Natural Resources "Geological-geophysical studies of the Antarctic", RAS program of basic studies and projects of the Russian Foundation of Basic Studies and departmental programs of Roskartographiya and Navigation Hydrographic Group of the RF Ministry of Defense. They aim to undertake controlled in-situ experiments and collect data on the state of different natural compartments in the Southern Polar Area that will be later used in plan scientific research and developments.

3.4.1.1. Studies of the atmosphere

<u>Studies of the ionosphere</u>

The main objective is acquisition of scientific data on the state of ionization of the upper atmosphere to address practical issues of radio-communication, radio-forecasting and radio-navigation and to investigate the nature of geophysical processes and their relation to solar phenomena.

The studies are performed at Mirny station on a daily basis (00, 01, 05,15, 30, 45, 55, 59 minutes of each hour) with records of altitudinal-frequency characteristics to a standard 35 mm film.

The observations are made using AIS type equipment by an impulse method for the vertical sounding of ionosphere at running frequency and scanning of 1 to 18 MHz (Mirny) and a digital ionosonde (Vostok) 24 h a day.

Studies of the atmospheric electrical field

The studies of the atmospheric electrical field aim to:

- determine the seasonal and daily variation of the surface electrical field vertical component at Vostok station;
- investigate the processes influencing the surface electrical field variations;
- reveal the main ionosphere-magnetosphere parameters influencing the surface atmospheric electrical field variations;

The studies are carried out the year-round by the method of passive instrumental laboratory measurements.

The work is made by specialist-magnetologist of Vostok station.

Studies of the Earth's geomagnetic field

The program envisages studies under the international AGONET Project including passive instrumental measurements.

The work is made by specialist-magnetologist of Vostok station.

Stratospheric sounding of space rays

The scope of work includes constant stratospheric sounding of space rays using special radio-sondes at Mirny Observatory during the wintering period. Launches of radio-sondes are made daily at 10.00 (Moscow time). During solar flares and in other cases of increased emission intensity, more frequent launches of instruments are made (every 3-4 hours).

The work is performed by one person of the wintering team (FIAN) with assistance of specialists-aerologists carrying out the upper-air sounding program (AARI).

3.4.1.2. Studies of the cryosphere

Seismic studies of subglacial Lake Vostok

Based on the data collected by Russian scientists during the 41st - 45th RAE, the RAE will continue the studies directed to:

- determine the general lake morphology parameters;
- study the thickness of sedimentary deposits in the deep water area of the lake basin.

For this purpose, using transportation vehicles available at Vostok, it is planned to make observations over a network of seismic profiles in the western and eastern directions from Vostok station.

Seismic sounding will be performed by means of the method of reflected wave record. Seismic oscillations will be excited by blasts of five 50-m lines of detonating cord laid onto the snow surface.

Specialists of the seasonal RAE team (PMGRE) will participate in this work.

Radar studies of the subglacial Lake Vostok

Radar sounding of the subglacial Lake Vostok will be made parallel to seismic observations over the same networks and routes. Radio-echo sounding will be performed from board the transported carrier using a digital radar station.

The radar transmitter emits the sounding signals via the antenna to the glacial body. The reflected signals are received by the receiving antenna, digitized and recorded to a computer block. Information on the survey coordinates is recorded simultaneously.

The observations are carried out over a network of radar profiles along the western subglacial lake edge and in its southeastern area from Vostok station. A total length of radar profiles will comprise 470 km.

The RAE will continue studies to delineate the lake boundaries in its western and southern parts.

Specialists of the seasonal RAE team (PMGRE) will participate in this work.

3.4.1.3. Studies of the hydrosphere

Oceanographic studies

An oceanographic transect using ship-based CTD-sondes will be made. The southern transect station will be occupied on the shelf when the ship is at its maximum possible (by ice conditions) southern location. The spacing between the stations will comprise 10 miles up to a 500 m isobath. At the upper portion of the continental slope, in the depth range between 500 m to 2000 m, the stations will be made at a spacing of 3 miles and farther north at a spacing of 10 miles.

The water samples will be collected at standard depths by rosettes with determination of salinity, dissolved oxygen, nutrients, silicon, phosphates, nitrates and nitrites. AARI specialists from the seasonal RAE team and personnel of the hydrological team of the research expedition vessel “Akademik Fedorov” will participate in the work.

Study of biochemical processes in Antarctic water areas

The expedition studies en-route and in the vicinity of Antarctic stations include the following types of measurements and sampling:

- measurements of aerosol concentrations, their granulometric, mineralogical and chemical composition;
- determination of dissolved forms of elements and sampling for neutron-activation analysis;
- study of substance, mineralogical and chemical composition of water suspended matter and dissolved nutrients;
- study of organic substances, including lipides and aliphatic hydrocarbons in the surface layer of seawater and filtration suspended matter in the “ice-water” contact zone;
- study of light and dark 14CO2 assimilation in the surface water layer;
- collection of suspended matter to determine the isotope composition (д ?14) of organic carbon and of other elements;
- study of total numbers, distribution and rate of microbiological processes with 35S and 14C trace compounds in the snow cover, ice cores and seabed sediments.

IORAN specialists of the seasonal RAE team and personnel of the hydrological team of the R/V "Akademik Fedorov" will participate in the work.

3.4.1.4. Studies of the lithosphere

Marine geological-geophysical studies in the Cosmonauts Sea
The seasonal work program envisages to fulfill marine geophysical surveys onboard the R/V "Akademik Alexander Karpinsky".

These expedition surveys will be fulfilled in the western Cosmonauts Sea. The main geological objectives of marine geophysical studies are:

- study of the regional structure of the sedimentary mantle and preliminary assessment of the oil-gas bearing perspectives of the Cosmonauts Sea;
- determination of the nature and structure of the sedimentary basin foundation;
- study of the Earth's crust deep structure in the ocean-continent joint zone.

The work program includes seismic profiling by the wave reflection method using a pneumatic gun in a complex with gravimagnetic observations.

The work program onboard the R/V "Akademik A. Karpinsky" from January to March will be fulfilled by the staff of the scientific-technical service of the PMGRE ship.

3.4.1.5. Studies on biology

Studies of sea ice biology
The work will be carried out in the areas of oceanographic studies onboard the R/V "Akademik Fedorov" and from ice in the vicinity of the coastal Russian stations. The work program includes the collection of ice cores and surface water sampling, plankton vertical collections of samples from surface to bottom by standard horizons. The concentrations of the mineral forms of phosphorus, silicon, nitrates and pH will be determined in the collected ice samples.
It is also planned to undertake cultivation of ice microorganisms for a subsequent study of ice flora tolerance exposed to the impact of different environmental factors under the conditions of the stationary IORAN laboratory. Part of the samples will be fixed for subsequent determinations of the species composition of micro-communities inhabiting sea ice.

The work will be performed by the seasonal team specialists (IORAN).

Influence of geophysical fields on the biochemical and chemical processes
The program will be carried out onboard the R/V "Akademik Fedorov" and at the inland Vostok station. The experiments aim to study the impact of gravity and other geophysical fields on the processes in living and non-living nature. The fluctuations of the Redox potential rate and intensity of Pu239 decay as typical indicators of the intensity of biochemical reactions depending on the variability of the state of the ambient natural geophysical fields will be investigated.

It is planned to establish the dependencies of the oxidation rate in physiological solutions depending on geographical latitude, gravity acceleration and other geophysical phenomena.

3.4.2. Monitoring of natural media of the Antarctic

3.4.2.1. Monitoring of the atmosphere

<u>Monitoring of the ozonosphere</u>
The program of ozonosphere monitoring includes:

- passive measurements of aerosol-optic parameters of the atmosphere;
- passive measurements of the integral solar radiation attenuation.

The studies are conducted the year-round by the wintering team participants at Mirny, Vostok and Novolazarevskaya stations.

<u>Monitoring of the free atmosphere</u>
The temperature-wind sounding of the atmosphere in Antarctica is carried out by standard methodologies once a day (00 hours (UTC). During the International Geophysical Interval, additional launches of radiosondes are made at 12 UTC.

Upper-air observations at Mirny and Novolazarevskaya stations are conducted by the RAE wintering team (AARI).

<u>Monitoring of surface atmosphere and radiation balance components</u>
Meteorological observations of the atmospheric pressure, air temperature and the underlying surface, air humidity and wind speed and direction are performed using a weather semi-automatic station MILOS-500. Observations of clouds, meteorological visibility range, precipitation, snow cover depth and density, duration of sunshine and atmospheric phenomena are made using standard methods. The observations are carried out at standard synoptic hours 4 times a day.

Monitoring of the radiation balance components is performed using standard actinometric instruments and methodologies. The observations of total solar radiation are made using sensors of the MILOS-500 complex at Mirny, Vostok, Novolazarevskaya and Bellingshausen stations and in the future at Progress station. Four persons of the RAE wintering team participate in meteorological and actinometric observations (AARI).

<u>Monitoring of atmospheric circulation in the south-polar atmosphere</u>
The observations are based on the analysis of satellite information received at Mirny station and on the entire complex of hydrometeorological parameters and information received at the Russian Antarctic stations and the expedition vessels.
The program will be fulfilled by one specialist of the wintering team of Mirny Observatory (AARI).

3.4.2.2. Monitoring of land and sea ice

For monitoring purpose, regular satellite shipborne and coastal observations of the ice cover state in the seas of the Southern Ocean are used. The observations are conducted as interrelated, complementary and comprehensive monitoring of the marine part of the southern cryosphere to achieve the scientific-operational, regime, research and applied objectives.

Monitoring of sea ice

During the seasonal period, the R/V “Akademik Fedorov” and the R/V “Akademik A. Karpinsky” carry out a program of shipborne satellite observations for a successful scientific-operational support of ice navigation. Satellite observations onboard the ships are supplemented by visual ice observations using standard methods in order to interpret satellite data and determine the characteristics of ship ice performance.
The work is made by 3 persons of the RAE wintering team at Mirny, Novolazarevskaya and Bellingshausen stations and by the seasonal team specialists onboard the R/V “Akademik Fedorov” (AARI) and the scientific-technical service of the R/V “Akademik A. Karpinsky””.

Monitoring of the Southern Ocean level

Sea level observations are made on an hourly basis using a tide gauge “Priliv” produced at the AARI that has a cable communication with the onshore computer. Observations of the thermohaline structure of coastal water are made using a thermistor chain.

The work is carried out by the wintering team of Mirny station.

3.4.2.3. Monitoring of the state of the magnetosphere and ionosphere

Geomagnetic observations

Geomagnetic observations include continuous recording of the 3 components of the geomagnetic field by variometers and periodic measurement of their absolute values. During the wintering period, the digital geophysical complexes developed at the AARI Department of Geophysics will be modernized and improved.

Observations are made the year-round at Mirny, Vostok and Novolazarevskaya stations (AARI).

Vertical sounding of the ionosphere

The ionosphere sounding at Mirny and Vostok stations are made the year-round at 00, 01, 05,15, 30, 45, 55, 59 minutes of each hour with records of altitudinal-frequency characteristics to a standard 35 mm film. At 01 minute of each hour, the record is made at the maximum amplification of the receiver and at 59-minute at the minimum amplification. At other times, the sounding is made at the optimal amplification of the receiver. The observations are made using equipment of the AIS type by an impulse method for the vertical sounding of ionosphere at running frequency and scanning of 1 to 18 MHz.

In the summer season, a digital ionosonde “Bizon” will be installed at Vostok that allows 3 types of sounding – vertical-incidence, oblique-incidence and oblique incidence-backscatter.

Observations are carried out by the wintering team at Mirny and Vostok stations (AARI).

Riometer observations

Observations are made the year-round at Mirny, Novolazarevskaya and Vostok stations (AARI) being part of radiotechnical studies of the Earth's ionosphere that record the ionization level in the lower ionosphere (D-area, 60-90 km elevations).

3.4.2.4. Seismic monitoring of the Southern polar area

Seismic passive observations are undertaken at Mirny and Novolazarevskaya stations. The work program envisages continuous recording of seismic phenomena (earthquakes, microseism, ice sheet fractures, etc.) and processing and interpretation of records of these phenomena. The program is fulfilled by specialists-seismologists of the Geophysical Survey of RAS in the RAE wintering team.

3.4.3. Scientific-applied studies and developments

3.4.3.1. Hydrometeorological information support for the national activity in the Antarctic

In the framework of the system of hydrometeorological support for the national activity in the Antarctic, the work on ensuring safety of expedition operations of ships, aircraft and ground transport vehicles of RAE and preparation and transfer of hydrometeorological data on users' applications is undertaken during the wintering period.

The hydrometeorological support activity is carried out at Mirny Observatory and onboard the R/V "Akademik Fedorov" and the R/V "Akademik A. Karpinsky" by AARI specialists. Current information on the hydrometeorological and ice conditions is provided using en-route aero-meteorological and ship-based ice observations and satellite information from "Meteor", NOAA, etc.

Short-range synoptic and ice forecasts and current hydrometeorological recommendations in the framework of the hydrometeorological support system are issued by the expedition personnel and medium-range forecasts and wave forecast by the departments of AARI and the Hydrometeorological Center of Russia.

3.4.3.2. Navigation-hydrographic studies

During the RAE, a complex of hydrographic studies is carried out to ensure safety of shipping in the Antarctic and at approaches to the Russian Antarctic stations.
The RAE work program includes the following activities:

- depth measurements onboard the R/V "Akademik Fedorov" at all transit routes;
- radar surveys of the coast using receiving-indicators "Shmel-M", Shkiper-N" and "Briz";
- data collection for correction of navigation charts and shipping handbooks.

Seasonal team specialists participate in this work (GUNIO, Ministry of Defense).

3.4.3.3. Mapping of ice coasts from satellite data using GPS

The Work Program envisages coastline mapping from board the R/V "Akademik Fedorov" based on Meteor and NOAA satellite data, their interpretation and geolocation using special software packages and a ship GPS station.

The work is done by one AARI specialist.

3.4.3.4. Updating and generation of the electronic plans of Antarctic stations

The RAE carries out the topographic-geodetic surveys. These activities are related to reorganization of the infrastructure of RAE stations and the need to correct the existing topographic plans of the stations and their conversion to modern electronic-digital formats. The work is undertaken by specialists of the 191 Expedition of the State Enterprise "Aerogeodeziya" in the RAE seasonal team.

3.4.4. Environmental protection

3.4.4.1. Data acquisition to evaluate the current environmental state of the areas of Antarctic stations

It is planned to:

- assess the state of the objects of the Antarctic stations and their stability to a possible impact of adverse environmental factors in the near future;
- carry out analytical studies at the ecological laboratory of the R/V "Akademik Fedorov" to determine concentrations of anthropogenic contaminants in natural media samples collected in the RAE activity areas in accordance with the SCAR/COMNAP recommendations.

The studies are made by specialists of the RAE seasonal and wintering teams.

3.4.4.2. Waste collection and disposal

The RAE will continue the evaluation of the scope of work to collect the wastes of station activity and their preparation for shipping outside the Antarctic and modernizing the infrastructure of the Russian stations. The work on modernizing the stations will be continued including re-equipment of office-living buildings, diesel-electric power station and further reconstruction of the oil tanks at the stations.

The work is undertaken by a special seasonal nature protection team (AARI).

3.5. Main reporting materials

Every year after the end of the expedition and return of specialists to Russia, all primary and reporting materials of all work and research programs are submitted within 10 days for expert examination to the special Interagency Commission on receiving the materials of the Antarctic expeditions, whose membership is approved by Roshydromet.

The Interagency Commission considers the submitted materials in respect of their quality, correspondence to the work programs and adopted methods and their suitability for further storage and inclusion to the corresponding data bases or transfer to special archives. The lead institutions of the ministries and agencies supervising the specific directions of Antarctic studies are made responsible for storage and use of the materials collected by RAE.

The materials of the Russian Antarctic Expedition are state property.

3.6. Areas of activity

The activity is undertaken in compliance with the Plan-Program of scientific studies and work of the Russian Antarctic Expedition in the areas of Russian Antarctic stations and in coastal Antarctic waters along the transit routes of ships between the stations (see Figs. 3.6.1., 3.6.2.) and along the sledge-caterpillar traverses Mirny-Vostok-Mirny and Novolazarevskaya-ice barrier-Novolazarevskaya (Annex 9). Marine geophysical studies are carried out in the Cosmonauts Sea.

3.7. Calendar work plan

The seasonal RAE operations are carried out in the summertime, however, due to different causes, they are sometimes fulfilled in autumn-winter.

The most significant expedition-logistic objectives of the RAE seasonal period include:

- logistic support and rotation of personnel of wintering and seasonal stations and bases;
- aviation support for delivery and pickup of the seasonal and wintering teams of Vostok station;
- support of scientific-transport traverses to continue remote sensing studies of the subglacial Lake Vostok;
- support of a complex of nature-protection measures.

3.8. Delivery to and transportation in the Antarctic

3.8.1. Sea operations

The delivery of the expedition gear, equipment, materials, food, fuel and personnel of the seasonal and wintering teams to the Antarctic is made by the R/V "Akademik Fedorov" (except for Bellingshausen station).

The marine geological-geophysical surveys are carried out onboard the R/V "Akademik A. Karpinsky" in the area of the Cosmonauts Sea. They include remote sensing seismic, magnetic and gravimetry measurements by means of standard methods that are used by the international Antarctic community.

Both ships have necessary equipment required by the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL) and have current international certificates that are annually confirmed by the Maritime Register of Shipping of the Russian Federation:

- on prevention of pollution by oil products;
- on prevention of pollution by garbage;
- on prevention of pollution by sewage water.

The availability and periods of validity of these certificates are checked without fail by port authorities at any ports of call of vessels before they leave for sea.

The expedition cruise of the R/V "Akademik Fedorov" under the RAE framework is made in the Antarctic area within the meridians of location of Novolazarevskaya and Mirny stations.

The R/V "Akademik A. Karpinsky" operates under the RAE framework in the Cosmonauts Sea.

The tactical-technical data of RAE vessels are contained in Annex 5.

The delivery of logistics cargoes and rotation of personnel of Bellingshausen station is made by the M/S "Professor Multanovsky" en-route before and after the tourist cruises between South America and the Antarctic Peninsula.

Fig. 3.6.1. Route of the R/V "Akademik Fedorov"

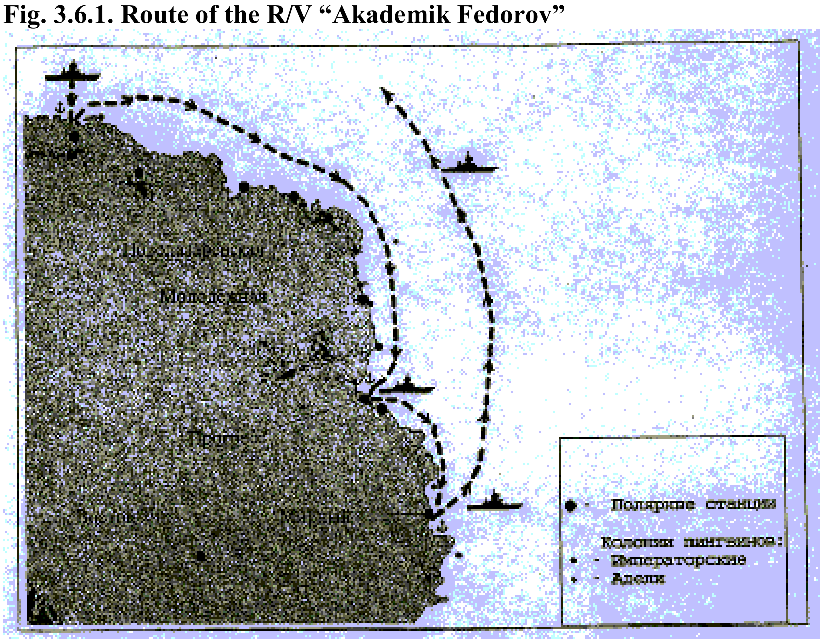
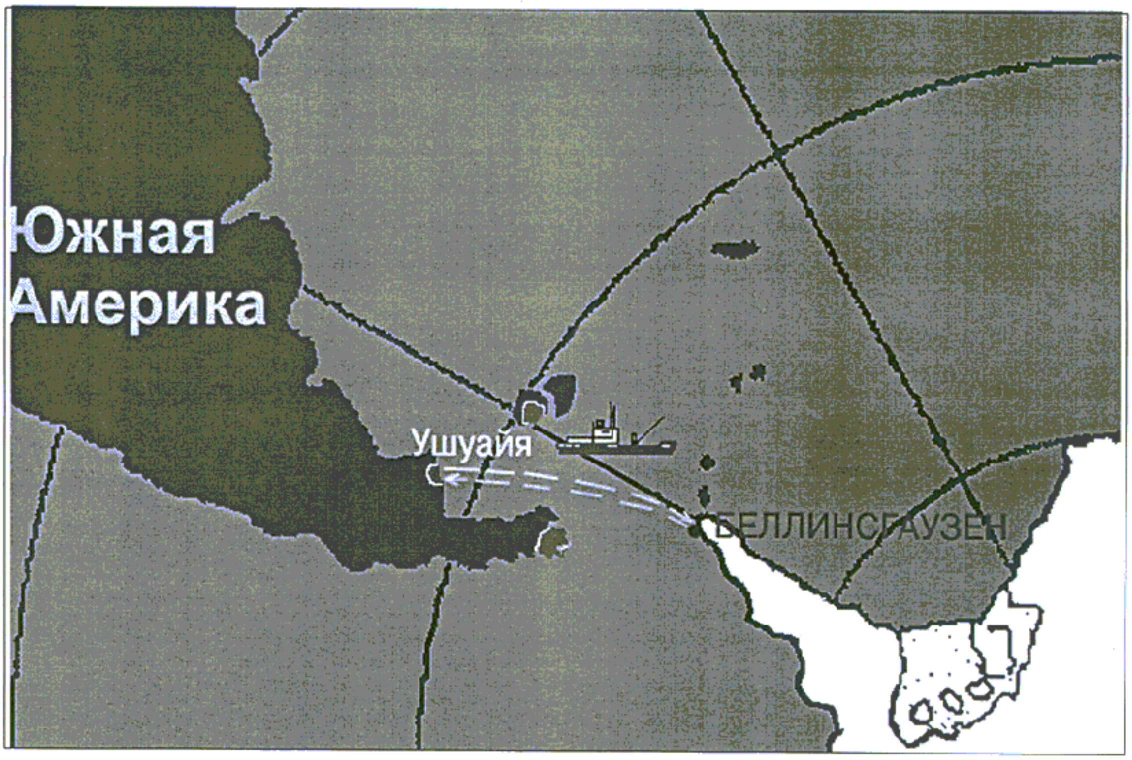


Fig. 3.6.2. Route of the M/S "Professor Multanovsky"



3.8.2. Aviation operations

The RAE aircraft operations are made for loading-unloading purpose in the area of the Antarctic coast between the ship and the stations by a flight consisting of two MI-8 helicopters basing onboard the R/V "Akademik Fedorov".

In addition, the RAE aircraft are used to land the geological groups to the mountain areas of Antarctica and pick them up after the end of work, organize field geological camps and deploy self-recording instruments (MI-8 helicopter) and airborne magnetic and radar surveys of the area of Prince Charles mountains and the Lambert and Amery ice shelves (An-2 aircraft).

All aircraft, aircraft crews and engineering-technical personnel have corresponding certificates, permits and licenses confirmed in compliance with the current regulations of the State Service of Civil Aviation of the Russian Federation. This type of helicopters uses TS-1 aviation kerosene or its western analogue JET-1A with An-2 aircraft using gasoline B-91/115.

The flights are made along the strictly specified routes in the areas of the Antarctic stations belonging to the NA or RA categories.

The seasonal team is shipped to Antarctica by aircraft from Christ Church (New Zealand) to Vostok station.

The total planned flight time of two MI-8 helicopters is 100 – 250 flight hours and of An-2 aircraft – 100 flight hours.

The technical data of aircraft are presented in Annex 6.

3.8.3. Inland transportation vehicles

The fleet of ground transport vehicles of the Russian Antarctic stations and field bases was mainly formed in the 1970-1980s. It consists of heavy caterpillar tractors (ATT, STT and MTT), caterpillar carriers (DT-30, GTT, GTS and GAZ-71), caterpillar tractors, bulldozers and skidders (T-130, T-170 and DT-75), amphibian carriers, special caterpillar machines of the BAT type, wheel tractors K-701, “Belarus”, truck cranes of K-175 type, special trucks based on “Ural-375”, “ZIL-131”, “GAZ-53”, “GAZ-66” (bowsers, water carriers, fire-engines, APA, etc.) and “Buran” type snowmobiles. Heavy caterpillars and carriers are used for inland transport traverses. Caterpillar tractors and bulldozers are employed for clearing drifting snow and for cargo transportation in the station territories. Wheel tractors are used for compacting the snow-ice runways. The truck cranes are used for loading-unloading operations at the stations and the amphibian carriers for the offshore unloading of ships at Bellingshausen station. Special trucks are used at the stations according to their functional purpose. Thus, the area of operation of ground transport vehicles is strictly limited by the territory of the Russian Antarctic stations and seasonal field bases or by the permanent transportation traverse routes. All aforementioned vehicles operate using diesel fuel or gasoline. Evidence on the distribution of ground transport vehicles is presented in Annex 7.

The sledge-caterpillar traverses for supporting operation of Vostok station are made from Mirny observatory.

3.9. Way of basing (field camps, Antarctic stations, etc.)

The RAE operations with basing on the Antarctic coast are carried out at the RAE Antarctic stations:

- Bellingshausen,
- Novolazarevskaya,
- Mirny,
- Progress,
- Vostok,
- Druzhnaya-4 field base

and the research expedition vessels:

- R/V “Akademik Fedorov”;
- R/V “Akademik A. Karpinsky”.

Evidence on RAE stations is contained in Annex 4.

3.10. Data on personnel

The activity in the Antarctic is carried out by personnel employed by RAE under the Labor Agreement (Contract) in pursuance of the Decree of the RF President and the Decisions of the RF Government on the activity of the Russian Antarctic Expedition. The number of the expedition participants are determined by the Decision of the RF Government of August 27, 1997, No. 1113. It comprises 90 persons of the wintering and 80 persons of the seasonal RAE teams without the crews of vessels and aircraft.

All expedition participants take a training course on the rules of behavior in the Antarctic.

The numbers of personnel of the seasonal and wintering teams of the specific RAE for ships, stations and field bases are determined in accordance with the approved Plan-Program of this expedition not exceeding however, the total number of the expedition personnel.

Seasonal team (a total of 80 persons):

Expedition leaders and a seasonal and marine operation team 25 - 41 persons;

- Vostok station - 13 people, including seismic, radar and microbiological groups on the study of Lake Vostok;
- Bellingshausen station – 9 people, including a nature protection engineering team;
- Progress station, Druzhnaya- 4 field base - 17 - 33 people.

Wintering team (a total of 90 persons):

- Mirny Observatory - 40 - 48 people;
- Vostok station - 13 people;
- Novolazarevskaya station - 19 - 22 people;
- Bellingshausen base - 6 people;
- Progress station – up to 12 people.

General operational-logistics and scientific-coordination management of the RAE activities is performed by the AARI RAE LC.

The responsible executor of the Plan-Program is V.V. Lukin, RAE Head.

3.11. Characteristics of cargo delivered to the Antarctic

Cargo to the RAE Antarctic stations is delivered according to the cargo-plan. In respect of weight, it can be subdivided into the main categories:

1. Food products - 65 t.
2. Fuel-lubricants - 1650 t.
3. Transport vehicles and equipment - 150 t.
4. Construction materials - 6 t.

3.12. Characteristics of auxiliary types of activity

The auxiliary types of activity during the scientific studies in the Antarctic include the logistics support in the form of transport (see above) and life support of the stations. Fulfilling the RAE programs is ensured both by the executors of the expedition work and the logistics personnel (heads of stations and expeditions, physicians, cooks, diesel electric power station mechanics, drivers-mechanics and equipment repair specialists) that determines the possibility of operating.

The logistics support, rotation of the wintering personnel and organization of seasonal activities and studies at Novolazarevskaya, Progress and Mirny stations are carried out by means of the R/V “Akademik Fedorov”. This vessel also provided support for nature protection activities at Molodezhnaya station closed in 1999.

Seasonal studies and nature protection activities at the Bellingshausen Base will be supported similar to previous years by en-route leasing the tourist vessel M/S “Professor Multanovsky” from Europe to the area of tourist marine cruises to the Argentine port Ushuaia and then to Bellingshausen station. This ship will deliver food supplies, consumables and spares, diesel fuel and RAE personnel to the station. Seasonal studies and activities as well as the replacement of the wintering team of the inland Vostok station are carried out according to an arrangement worked out for the last few year with the aviation support of the US Antarctic Program. The personnel and cargoes are shipped by regular flights from St. Petersburg to Christchurch (New Zealand) and then by special flights of the US transport aircraft to Vostok via the USA Antarctic station McMurdo.

The logistic supply of Vostok station is made using a sledge-caterpillar traverse from Mirny station during the period October to early February.

Marine geophysical surveys in the Cosmonauts Sea onboard the R/V “Akademik A. Karpinsky” are conducted along the route: St. Petersburg-Cape Town-Cosmonauts Sea-Cape Town-St. Petersburg.

The Antarctic cruise of the R/V “Akademik Fedorov” is made at the time that ensures the possibility of cargo operations in Mirny Observatory in the presence of landfast ice of new formation (before early January or not later than mid-April). With this purpose, it is planned to make the round of stations beginning from Novolazarevskaya eastward of from Mirny Observatory westward.

4. DESCRIPTION OF THE ENVIRONMENT

4.1. Environmental description of the areas of RAE shipping operations

4.1.1 Ice and hydrometeorological characteristics
Sea operations are carried out by the R/V “Akademik Fedorov” and R/V “Akademik A. Karpinsky” under the RAE programs in the area of the Lazarev, Riiser-Larsen, Cosmonauts, Commonwealth and Davis Seas. By the character of similarity of physical-geographical, hydrometeorological and ice conditions of navigation, they can be conventionally subdivided into 4 areas with meridional boundaries (Romanov A.A., 1996). By longitudinal sectors, these boundaries pass along meridians 0°, 20° E, 55° E, 82° E and 112° E being restricted from the south by the coastline and from the north by the boundary of iceberg spreading.

Four stationary low pressure centers are delineated in the study areas adjoining the Princess Martha Coast (0°) and in the Riiser-Larsen (30° E), Commonwealth (70° E) and Mawson Seas (110° E). The location of these climatic depressions and their closed character influences the formation of local ice concentration.
Active cyclonic activity both at zonal and especially at the meridional types of atmospheric processes leads to an important role of advection of air masses in the formation of the underlying surface heat balance and correspondingly, in the ice

cover. Advection achieves its maximum development during the period of the seasonal maximum ice extent.

In the Lazarev and Riiser-Larsen Seas, export flows of air and water masses predominate resulting from the activity of quasi-stationary cyclones. In the Cosmonauts, Commonwealth and Davis Seas, easterly-westerly air flows prevail along the coast and export flows in seaward areas especially along the eastern Enderby Land coast.

The coastal areas of the Lazarev and Riiser-Larsen Seas are located south of the Polar Circle in the area of the negative radiation balance throughout the year. The ice regime formation here is influenced here by continental Antarctic climate. On the contrary, similar areas of the Cosmonauts, Commonwealth (except for Prydz Bay) and Davis Seas are situated north of the Polar Circle, i.e., in the positive radiation balance area and the effect of sea climate on the ice cover formation and decay is especially significant.

A typical climatic feature of the area is a large amount of atmospheric precipitation (up to 300 – 400 mm/year), which governs the increased snow cover on Antarctic ice, especially on landfast ice. This fact influences significantly the peculiar structure and properties of Antarctic sea ice. Depending on the formation conditions, it can be represented by a developed layer of congelation or crystalline ice or consist of several heterogeneous or repeated layers comprised of snow-water or frazil ice.

Diatom algae whose populations are abundant in Antarctic water and ice have a large influence on sea ice structure and properties. Settling at the bottom ice surface, they spread then upward the ice strata and significantly weaken the ice both mechanically and due to intense solar radiation.

The system of surface water circulation in the area is determined by intensity of two main flows, the Coastal Antarctic Current (western water transport along the coast) and the Antarctic Circumpolar Current (strong eastern transport in the northern sea areas). The boundary area between these currents of weak unstable transport with a northern component is usually delineated as a separate zone.

The location of the drifting ice edge and formation of ice conditions are influenced significantly by zonal perturbations of the Antarctic Circumpolar Current (ACC) flow. In the areas of its southward deviation, the ice cover melting processes are more intense.

The Coastal Antarctic Current (CAC) produces a large influence on the formation of ice conditions. The latitudinal area of its spreading is very narrow, being determined by the hydrographic features (coastline meandering, presence of banks and shallows). At a specific combination of these factors, the conditions for the local ice accumulating in the coastal zone or for its free export to the open ocean areas and for the formation of polynyas are created.

The CAC speeds comprise on average, 5 - 10 cm/s, which is 3 – 5-fold less than the ACC speeds being typically less than 5 cm/s in the boundary area. .

The surface water structure in the Southern Ocean is comprised of the Antarctic surface water mass with the layer thickness of 100 – 150 m in the cyclonic gyre centers and up to 200 m south and north of them. The summer water temperature comprises 1.2 – 2.6°C and salinity about 34.0°/oo decreasing in intense melting areas to 33.0°/oo.

The storm wave zones present the main source of swell propagating from the open ocean areas to the coastal zone southeastward in accordance with the prevailing trajectories of cyclones. Swell has a significant influence on the ice regime of the coastal seas (formation and decay of landfast ice, movement of grounded icebergs, dynamics of the ice shore, etc.). The distance of swell penetration to the ice cover is estimated to be 300 – 400 km.

The influence of surges on the ice cover in the Southern Ocean is primarily in the influence on the dates of breakup and decay of landfast ice, formation of ice pressures and divergence among drifting ice, development of coastal polynyas, etc.
In general, Antarctic sea ice compared to Arctic ice is characterized by dominating first-year ice of smaller thickness, smaller horizontal size of ice features comprising it, insignificant hummock and ridge concentration and greater fracturing. The ice cover concentration is lower with a large number of polynyas and fractures observed, especially in the coastal zone.

Although the seasonal and interannual variability of the Antarctic ice characteristics is quite pronounced, it does not have a significant influence on ice performance of ships. An example is the successful winter cruises of the R/V "Akademik Fedorov" to the ice massif center in the Weddell Sea (1992) and its operations in the areas of the Russian Antarctic stations in 1994 – 1999.

In respect of iceberg danger of shipping, this is one of the most favorable area in the Antarctic.

The implementation of sea operations in the Antarctic is greatly influenced by the practical absence of the necessary marine infrastructure typical of the other World Ocean areas. There are no ports, ship repair plants, emergency-rescue service and the navigation support equipment is actually absent. The seabed relief and depths have been still insignificantly investigated with a systematic depth measurement made only in some limited areas and mostly without a reliable coordinate determination. These facts impose serious requirements to the technical state of ships navigating in these waters, their increased endurance, qualification and experience of crews and auxiliary means for ensuring safety of shipping (hydrometeorological and hydrographic support, shipborne ice helicopter reconnaissance, use of divers, own capabilities of minor and medium repair and supply with reliable navigation and communication equipment).

4.1.2. Biota characteristics
The RAE ship-based supply operations will be conducted in coastal waters of East Antarctica (from 0 to 90o E) during the period of austral summer or autumn-winter (see Fig. 3.6.1.). As a basis for biota description of the indicated areas, data of quantitative counts that were obtained in the course of the cruise of the R/V "Akademik Fedorov" in the "Druzhnaya – Novolazarevskaya" sector (45th RAE) and

of the icebreaking vessel “Kapitan Khlebnikov” (seasonal operations of the 42nd RAE) and different published sources and RAE Reports were used.

Sea birds and mammals should be considered as objects that are primarily affected during planned ship operations.

The fauna of birds and mammals of coastal waters of the study area is not rich being represented by typical Antarctic species including in the summertime migrants from the Arctic and some sub-Antarctic species.

The distribution and numbers of marine mammals of polar areas is closely connected with the character of biotopes, primarily of the ice cover. The ice conditions vary during the year and between the seasons, and the distribution of mammals here is quite of a dynamic character. All species inhabiting Antarctic waters can be clearly subdivided into groups differing in the attitude to ice. The Antarctic and Snow Petrels, Adelie and Emperor Penguins and Antarctic Tern can be can be called the real pagophilous species. Petrels are never observed far from the ice edge although they are encountered in ice-free water.

In open drifting ice, vast fractures and polynyas, the Antarctic Fulmar, Wilson’s Storm Petrel and Cape Petrel appear. These species can also be observed in open water far from ice. Albatrosses and many sub-Antarctic petrels and prions are never encountered among ice. In ice-free oceanic waters already near the drifting ice edge, the Light-mantled Albatross and soon the Black-browed Albatross appear that are most tolerant to low water temperatures. The Antarctic Giant Petrel and South Polar Skua are encountered in most diverse ice habitats.

By the number of species, the groupings of birds using the areas of close drifting ice are the least diverse. There are only 6 species with the species diversity of assemblies increasing up to 10 species in open drifting ice and in marginal habitats. In open waters north of the drifting ice edge, the number of species increases to 16 and more. The areas of increased concentrations of birds are typically confined to the increased biological productivity areas. In polar areas, these are the ice edge zone, flaw and coastal polynyas and the areas of a sharp depth increase.

The characteristics of the autumn-winter distribution of birds in the Indian sector of the Southern Ocean are given on the basis of counts in the 45th RAE. Along the transect from Cape Town to the ice edge, the species diversity in April decreased in general from 19 to 9 species a day. The species composition of sea birds changed gradually with albatrosses of G. Diomedea, petrels Oceanites spp., petrels Puffinus spp. and South Polar Skua disappearing and White-chinned Petrel, Light-mantled Albatross and Grey-faced Petrel remaining. The Cape Petrel, prions Pachyptila spp., Antarctic Petrel, Southern Fulmar and Blue Petrel appeared (from 48° to 58° S). Zones of increased species diversity and density of sea birds (15 species a day, 3.1 ind./km2) were observed north of the Antarctic convergence zone (44°01'-48°22'S/18°E). Directly south of the Antarctic convergence zone (ACZ), a sharp decrease of the species diversity was observed – up to 9 species with numbers decreasing to 0.58 ind/ km2. Crossing of the ACZ was marked by a disappearance of albatrosses of the G. Diomedea and appearance of the Cape Petrel, Grey-faced Petrel and Blue Petrel.

The next zone of increased density was noted north of the ice edge (increase of numbers from 1.3 to 3.1 ind/ km2) at the unchanged species diversity and dominance of the Southern Fulmar.

The ice transect segment was characterized by a minimum species diversity. Two species of pagophilous birds were noted – the Adelie Penguin and Snow Petrel not observed before with an absolute dominance of the Adelie Penguin (71% by numbers). The total numbers have decreased from 3.1 to 0.7 ind/km2, while the biomass has slightly increased from 1.9 to 2.1 kg/km2.

In respect of the distribution of marine mammals in the study area, only the summer distribution data are available. In is well known in general that the Crabeater seals are confined to the areas of drifting ice of medium and high concentration whereas the Weddell seals keep to the coastal zones and landfast ice. Killer whales with the largest density were observed in the marginal ice habitats, in particular in flaw polynyas and coastal ice-free zones near the ice shelves. Minke's whales are most frequent in the zones of a sharp depth increase or above the seabed rises.

In general in the study area, the Prydz Bay shelf water are characterized by increased bioproductivity. As estimated by Australian scientists, the sector adjoining the Prydz Bay (up to 60° S) is annually inhabited by up to 4.85 millions of local birds and about 2.35 millions visits this areas during migrations yielding the average densities of 3.75 ind/km2 and 1.81 ind/km2, respectively. However, during the last decades, the numbers of albatrosses, Northern giant and White-chinned Petrels were observed to decrease.

Two penguin species nest along the coast of the sector under consideration. Here, 19 colonies of the Emperor Penguins or almost half of the known in the Antarctic are located with the total numbers of about 70000 pairs. The same number of the colonies of the Adelie Penguin are known here, which comprises only about 10% with the numbers of about half a million pairs. In East Antarctica, the majority of the world population of the Antarctic Petrel is centered nesting on inland nunataks and coastal oases and islands. It is known that the distribution at sea of this species reflects in general the location of nesting colonies. Hence, a significant portion of this species is located within the study area with its total numbers estimated as 10-20 million individuals. The preferable marine habitats of the species are iceberg waters and the external ice edge zone. Along the coast, Snow, Cape and Southern Giant petrels, Antarctic Fulmars and South Polar Skuas also nest. Of Pinnipeds, in addition to the aforementioned species, Sea leopards and Ross seals and rarely Southern elephant seals inhabit here (Prydz Bay). One can encounter different cetaceans (fin back, humpback whale, etc.).

4.2. Environmental description of the RAE aircraft operation areas

The aircraft operations including ice reconnaissance and transport operations are planned at the localities of several polar stations in East Antarctica (from 0 to 90° E) during the austral autumn period.

Sea birds and mammals inhabiting the corresponding Antarctic Oases and the adjoining sea areas including landfast ice should be recognized as the objects to be primarily subjected to impact during planned aircraft operations.

The List of species observed in the area under consideration is given below in Table 4. It is necessary to take into account that most species will abandon the breeding grounds during the planned period of operations, whereas for the Emperor Penguins, the April-May months are on the contrary the pre-nesting period. In view of the fact that the period before the beginning of breeding belongs to the category of especially significant in terms of successful brood rearing and given the increased sensitivity of penguins to aviation noise, the Emperor Penguins should be recognized as the most vulnerable biota component during aircraft operations.

Table 4.2.1.

Brief information about the species of birds and mammals observed in the RAE aircraft operation areas Areas In the Oasis, on the islands At sea, on the ice

Areas	In the Oasis, on the islands	At sea, on the ice
Novolazarevskaya	Adelie Penguins, petrels	Weddell seals, Crabeater seals, Adelie Penguins
Molodezhnaya	Adelie Penguins, South Polar Skuas, Wilson's Storm Petrel	Weddell seals, Crabeater seals, Ross seals, Emperor Penguin
Progress, Druzhnaya-4	Adelie Penguins, South Polar Skuas, Snow Petrel.	Emperor Penguin, Weddell seals, Crabeater seals
Mirny	In the area of Haswell Islands – Adelie Penguins, South Polar Skuas, Snow and Antarctic Petrels and Southern Fulmars	Emperor Penguins, Weddell seals, Crabeater seals

4.3. Physical-geographical characteristics of the Novolazarevskaya station area

In scientific respect, the station is a base station in the global seismological network. Here, glaciological, hydrological, geological and aerometeorological observations and studies are carried out. The optimal numbers of the wintering team is 20 – 22 people. The ice air field existing here is of a significant interest in perspective of Antarctic air communications, since this air field is the nearest Antarctic runway to South Africa. However, the runway has not been used from 1992. The station infrastructure is represented by 23 capital and temporary structures. The design power of diesel electric power stations (DES) comprises 478 kW and the volume of oil tanks is 1040 tons. Detailed data on DES and station transportation vehicles are presented in Annexes 7,8.

Novolazarevskaya station operating from 1961, is located at the extreme southeastern tip of the Schirmacher Oasis (Queen Maud Land) in 80 km from the Lazarev Sea coast (Fig. 4.3.1.) with coordinates of 70є46' S, 11є52' E.

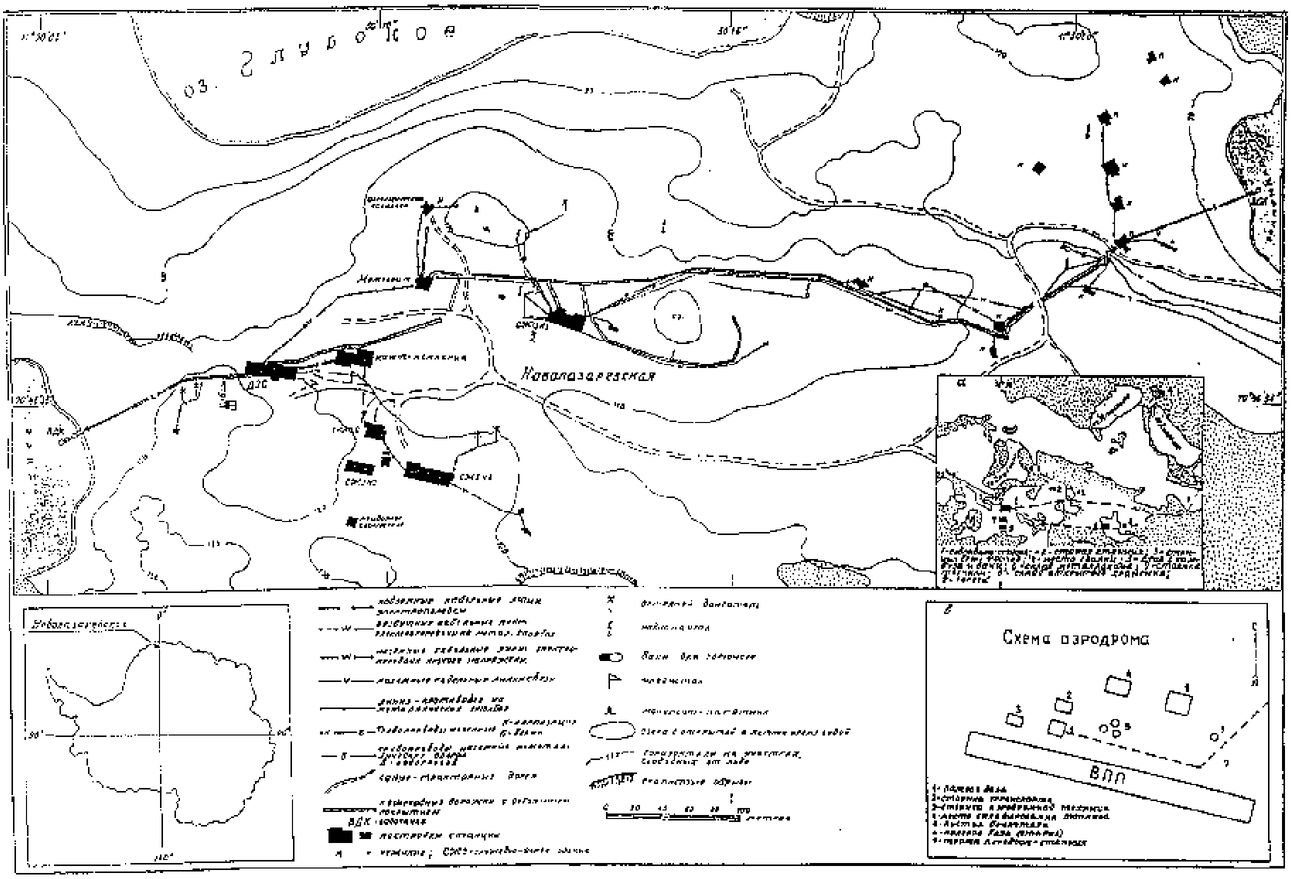
North of the station, there is an ice shelf with a slightly undulating surface ending with the Leningradsky ice dome. From the south, there is a continental ice sheet slope reaching a height of 1000 m already at a distance of 50 km. Several nunataks elevate above the ice at this slope. The Oasis presents a zone of bedrock outcropping to the surface at the boundary between the land ice sheet and the Lazarev Ice Shelf. Its area comprises 35 km2 with a length of about 17 km. It extends in a narrow band up to 3 km wide in the direction from west-northwest to east-southeast.

The Oasis is mainly comprised of the pre-Cambrian age strata consisting of acidous gneiss and crystalline slates with intrusions of gabbro-norites, gabbro-diorites and pegmatite veins. On the pre-Cambrian rocks, loose quaternary deposits bed non-uniformly by area, their thickness rarely comprising 15-25 m being not greater typically than several meters.

The Oasis relief is hillocky with the absolute marks of up to 228 m. Much of the Oasis is characterized by alternation of coniform hills and depressions separating them that are elongated in the sublatitudinal direction, which corresponds to the strike of geological structures and the largest tectonic disjunctive dislocations. This relief feature is broken in the northern part of the Oasis. Here, chaotically scattered troughs and semi-closed depressions of former cirques and nivation niches predominate. Along with the depressions (valleys) extended in the sub-latitudinal direction, there are some valleys oriented in the direction close to meridional. Relative elevations of the tops of coniferous hills over the surrounding depressions vary between 10 to 100 m (20-30 m, on average). Gouging traces of the ice sheet glaciation are observed everywhere being preserved in the form of individual spurs, “sheep-back rocks” and glacial striation at the surface of cliffs, etc. indicating that in the past, the glacier covered the Oasis. Weak development of the weathering forms on the rock surfaces and fresh traces of glacial impact indicate recent ice disappearance.

The depressions between the coniferous hills deepened by glacial gouging are partly occupied by the lakes whose total number is about 180. Many lakes are interconnected by the channels of temporary water flows appearing in the summer months. The depth of channel entrenchment is different comprising 8-10 m in the break segments. In mid-summer during the period of intense melting of snow fields and the glacial slope adjoining the Schirmacher Oasis, the area of some lakes significantly increases. Numerous small lakes appear with an area of up to several tens of square meters. By genesis, the lakes of glacial origin dominate. There are many relict lakes-lagoons located at the boundary between the Oasis and the ice shelf. Both shallow (3-5 m) and deep lakes (20 to 120 m) are encountered. The latter include Lake Glubokoye located in 300 m from the Novolazarevskaya station (with the water table area of about 70 thousand m2 and the maximum depth of 32 m). In the years with rapid snow melting, the water level in the lake rises by 3—4 m. At this time, water breaks a channel under the snowfield and its excess is discharged to Lagerny Bay. Water in the lake has very low mineralizing and small hardness. The level of carbonates in most lakes is 0.02-0.04 ‰.

Fig. 4.3.1. Map-scheme of Novolazarevskaya station



Climate of the Oasis with dominating continental character indications is formed at low temperatures predominantly by the intensity of solar radiation. The weather forms depending on the type of winds determining the character of clouds and air temperature. The dominating most intense cyclonic easterly and southeasterly winds result in the temperature increase in winter and decrease in summer in the Oasis, which is accompanied by significant cloudiness, snow storms, snowfalls and storm winds. The catabatic south-southeasterly wind causes sometimes a sharp air temperature and wind speed differences being combined with clear weather and air humidity decrease to 30-40%. Much of the Oasis is characterized by the absence of continuous snow cover not only in summer when strong melting and evaporation are observed, but also in winter when strong southeasterly winds blow away the fallen snow over a considerable area. In the summertime, the surface of the Oasis due to strong solar energy absorption by the dark surface of rocks and insignificant albedo receives solar heat 3-fold greater than the ambient snow-ice surface. The rock surface of the Oasis is sometimes heated up to 26? C and the air temperature in the surface layer increases to 5? C. The relative air humidity on average for a year is not greater than 52%. Under such conditions, strong evaporation and melting of snow occurs, which is probably, one of the decisive factors ensuring the existence of the Oasis under the current climatic conditions.

Averages characterizing climate of Novolazarevskaya:

Direct annual radiation ……..….43.9 kcal/cm2
Total annual radiation …………………..…...…93.8 kcal/cm2
Absorbed annual radiation..……………...…...….69.6 kcal/cm2
Annual radiation balance…………………………23.9 kcal/cm2
Average annual temperature ………………...………...-11°C
Mean annual atmospheric pressure at sea level ..988.0 mb;
Mean annual wind speed ...………………………....10.2 m/s
Prevailing wind direction …………………… …ESE;
Mean annual relative air humidity…… ..52%
Annual precipitation quantity…..........………………..……309 mm;
Number of days with snow storms for a year..…………88
Mean annual absolute air humidity …..…0.07 hPa;
Mean annual total cloudiness ……………..….5.8 points

The Oasis flora is distinguished by exceptional depletion. The terrestrial vegetation is represented by the individual rare patches of lichen on a rocky substrate and by moss concentrations on silt. The vegetation coverage of the Oasis does not exceed several percents. A total of 21 species of lichen were observed in the Oasis. The most widespread are Rhizocarpon flavum, Acarospora petalina, Gasparrinia clegans, G.murorum, Buellia pycnogonoides, Lecidia rupicida, Lecanora polutrota, Lecidea auriculata.

Waters of lakes of the oases are populated by diatom algae. The algoflora of lakes in the Schirmacher Oasis where 45 taxa were detected has been comparatively well studied. Most of them belong to widespread cosmopolitan species with many of them being algae-ubiquists.

Of birds, the Snow Petrels, Wilson’s Storm Petrel and the South Polar Skua are not numerous at nesting. The Adelie Penguins are sometimes observed.

4.4. Physical-geographical characteristics of the Molodezhny Oasis area

The Molodezhnaya station operating from 1962 developed quite intensely for a long time as the main SAE base, center of hydrometeorological studies and processing of hydrometeorological information, including rocket sounding of the upper atmospheric layers and geophysical and seismic studies. It was also the major snow-ice airfield to receive heavy aircraft. For the last few years, most research programs at the station were cut down. The station personnel decreased by more than 5-fold during these years. The created station infrastructure (with a total power of diesel-electric stations (DES) exceeding 1500 kW, more than 70 structures at the station and the oil tank capacity of 14150 t) remains to a great extent unused. Detailed information on DES and the station transport vehicles is presented in Annexes 7,8.

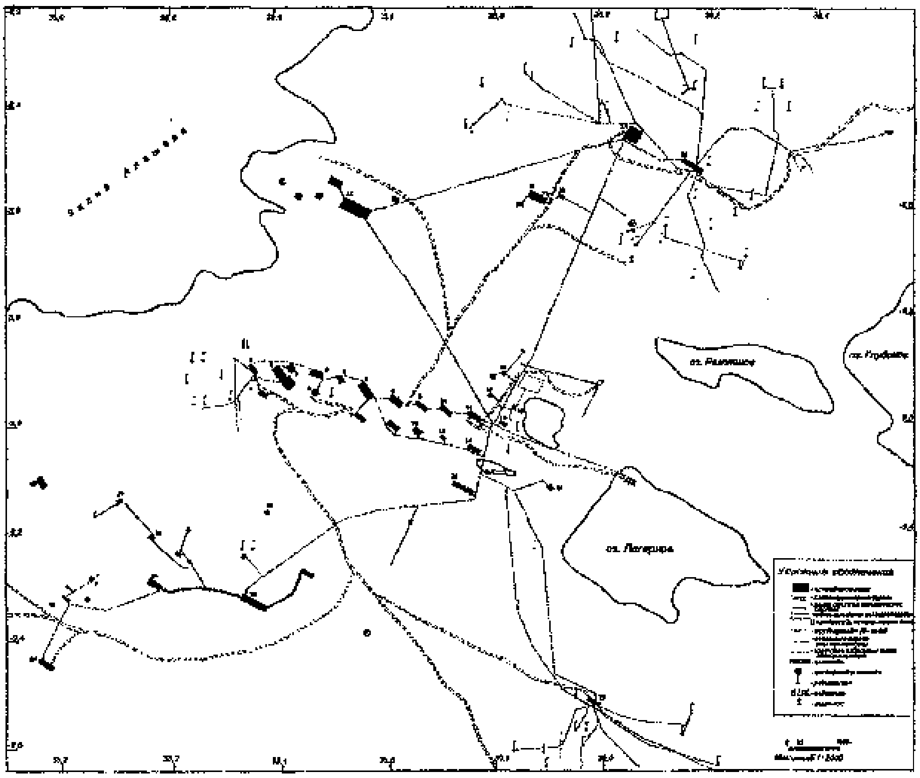
According to the transfer of RAE activities to the regime of minimum permissible parameters (Decision of the RF Government of August 28, 1997, No. 1113 “On the activity of the Russian Antarctic Expedition”), the Molodezhnaya station was closed on June 8, 1999. Beginning from 1998, the work to establish a self-contained structure ("small" Molodezhnaya) was undertaken at the station in order to be able to dismantle the buildings and clean the territory.

The Molodezhnaya station is located in the Molodezhny Oasis (Thala Hills) in the western area of the Enderby Land on the shore of Alasheyev Bay (Cosmonauts Sea) (Fig. 4.4.1.). The Oasis extends over 8.3 km, its largest width comprising 2.7 km. The largest height reaches 110 m. Coordinates: 67°40' S, 45°51'E.
The main part of the Oasis is comprised of geo-complexes located around Lake Glubokoye. In addition, the tracts at Cape Gaudisa and southeast of it and the geo-complexes adjoining Cape Bliznetsov and Steregushiy are referred to the Oasis. The Oasis also includes Zarya and Voskhod Bays. The area of the Oasis comprises 41 km2, the area of snowfields – 6.5 km2 and the area of lakes - 0.5 km2.

The relief of lithogenic geo-complexes of the Oasis belongs by its type to the exaration rocky hillocky area. Its ridges are elongated close to the northwestern direction. The length of ridges is up to 1 km at a width of up to 150 m while the depressions between them are mainly occupied by small glaciers, snowfields and lakes. The relative height of the ridges is about 10-40 m with the absolute height increasing southeastward comprising slightly more than 100 m near the boundary of the Oasis in 3.5 km from the ocean shore. The northeastern slopes of ridges are steep and short and scarps are encountered. The opposite slopes are gentle with some of them being 200 m in length. This is a manifestation of the cuesta relief character. The detrital material forms a thin and discontinuous mantle of alluvial-deluvial and morainic origin. Gneiss, enderbites, crystalline slate and intrusives of granitoid composition are the predominant mountain rocks.

South of the Molodezhny Oasis, there is a gradually elevating ice sheet slope of Antarctica. In 10 km from the Oasis it reaches a height of 500 m and in 70 km - 1000 m. The sub-ice (bedrock) relief in this region is strongly dissected. This is indicated from the west by the outlet Campbell and from the east Hays glaciers flowing along the sub-ice valleys with a rate of 180 m/year and 1400 m/year, respectively and by the zones of cracks located within 10 km from the ocean shore. Most of the area is comprised of alternating in the section bands of brownish hypersthenic gneiss and grey, pinkish-grey granitized biotite gneiss. Individual bands of comparatively uniform gneiss up to 200 m thick are observed in the strike over 1-1.5 km. However, in most places, the strata turns out to be very diverse by composition with a rapid change of discontinuous interlayers and bands with a thickness of up to 3-5 m observed in the strike only over 20-25 m. In general, hypersthenic gneiss mainly comprises the southeastern portion of the area being gradually replaced by biotite gneiss in the northwestern direction. The seabed relief of the coastal zone of Alasheyev Bay is a continuation of the structural features of the coastal Molodezhny Oasis. Its forms as ridges and valley-like depressions extend northwestward.

Fig. 4.4.1. Map-scheme of Molodezhnaya station



The formation of bottom sediments occurs due to terrigenous detrital material (bedrock destruction products) exported from the continent by glaciers, melt glacial water and wind and as a result of washout of some seabed shallows by underwater currents and due to biogenic components of the remains of plankton and benthic organisms depositing from the water column. The seabed of Alasheyev Bay is covered by different types of bottom products. The mineralogical composition of bottom sediments corresponds to that of bedrock comprising the shores of the water area. The levels of heavy minerals in bottom sediments varies between 6-8 to 20% comprising more rarely 32% and greater (coastal part of Alasheyev Bay). This is related to the washout of bedrock that is directly exposed on the shores of the Bay. The prevailing heavy fraction minerals are amphiboles, black ore garnet and pyroxenes (80-90%).

In the vicinity of Molodezhny Oasis, more than 40 temporary and permanent lakes were discovered. Their surface area varies between 0.5 to more than 400 ha with depths from several centimeters to slightly more than 36 m. The field studies have revealed three types of lakes:

1) almost annually overfilled lakes with pronounced water flow beds;
2) overfilling or drying lakes due to a periodic drainage;
3) lakes with an equilibrium balance of water inflow and sublimation evaporation.

The thickness of the winter ice cover at these lakes changes from 2-2.5 to 3-4 m and more depending on the maximum summer temperature, volume and depth of the lake basin, thermal properties of surrounding soils and bedrock composition.

The largest lakes in the Molodezhny Oasis – Lakes Glubokoye and Lagernoye are ice-covered the year-round with only a narrow zone between the shore and the ice becoming ice-free in summer. Lakes 1 and 2 become completely ice-free by mid-summer with large open water zones between the shore and the ice typically already in mid-November. They freeze from mid-to-late February.

The peculiarities of the atmospheric circulation in the western area of the Enderby Land are determined by interaction of air pressure systems dominating at temperate and high latitudes of the Southern Hemisphere. This is the Antarctic continental High, a ring belt of low atmospheric pressure covering the southern half of the Southern Ocean. Above the Enderby Land, a spur of the Antarctic continental High persists with an axis located approximately along 50° E. The radiation regime features in the Oasis are determined by its location behind the Polar Circle, character of the underlying surface, duration of sunshine and the atmospheric state. The annual air temperature variations here are typical of Antarctica with one maximum in summer (January) and one minimum in winter (July). In winter, the temperatures gradually decrease from April to July with a difference of averages of adjoining months between 2.8 to 2.1°, and then increase very slowly with a difference of similar values of 0.2-0.7°. Thus, the mean monthly air temperature from April to June decreases by 7.3°, and then increases from July to September by 0.9°. The second half of winter (July-September) is the coldest with almost all absolute minimum temperatures (they are always below -30°) recorded in these months.

The east-northeasterly and south-southeasterly winds prevail in the Oasis, their frequency of occurrence for a year comprising 85.7%. They include winds of the main types: cyclonic (east-northeasterly and easterly), anticyclonic or catabatic (south southeasterly) and transient (east-southeasterly and southeasterly). During the year, the catabatic winds predominate from March to July and the cyclonic winds from August to January. Calm weather is not typical, the largest frequency of occurrence of calms observed in July-January while in April, it comprises only 0.2%. Calms are typically recorded during the short periods of change of the main weather types.

Some understanding of climate can be obtained from the following data

Direct radiation...45.0 kcal/cm2
Total radiation..100.6 kcal/cm2
Radiation balance.......................................…..30.5 kcal/cm2
Absorbed radiation......................................70.5 kcal/cm2
Mean air temperature (annual)............ …..-11.0°
Mean annual atmospheric pressure............... ..988.00 cm
Mean wind speed... 10.6 m/s
Prevailing wind direction ....… …….E, SE
Mean annual relative air humidity.... .68%
Annual amount of cloudiness (total)........... …..6.6 points
Annual amount of precipitation............... …………..270 mm Number of days with a snow storm a year…………………190 days

The soils in the Oasis are quite fragmentary and are referred to the initial cryogenic-structural type. They contain little humus, which is mainly concentrated in the upper layer. Thus in the Molodezhny Oasis, the sample from horizon 0-10 cm contained 3.62% of humus and the sample from horizon 10-30 cm – 1.39%. In general, the humus content in the surface horizon of soils very poor in humus, is less than 1%. The organic substances of animal origin (guano, feathers, tissue and bones of birds and other animals) also enrich the soils with nitrogen and phosphorus contributing to the initial soil formation.

Vegetation of pereglacial complexes is represented by lichen, algae and mosses; there are also bacteria and microscopic fungi. Almost a constant low humidity, low air temperature and strong winds producing desiccating and corrasion impact on soil and plants create very unfavorable conditions for plant organisms. However, where there are conditions for a constant sufficient moistening of soils, vegetation is most noticeable compared to dry places. The plants of one or several species settle separately in single individuals or form small curtains with an area of several centimeters to several decimeters or more rarely of several meters.

Lichens are widespread. They settle not only in shelters, but also in the windward parts of rocky cliffs sometimes near the ice. In this case, at the blowing snow, the plants are covered with a protective ice cork that protects them from the corrasion impact. The rocks, loose soil and also other plants (mosses and algae) present a substrate for lichen. Crustose lichens are most widespread in the oases. They are observed at the surface of rocks in the form of individual patches comprising sometimes several meters. Due to the dominance of southeasterly winds in the oases, lichens are typically encountered at the slopes of the northern and northwestern exposition in wind-protected places. Lichens here grow on moss, but they are most abundant on the rocky substrate. Most typical are the bushy species of G. Neuropogon and Alectoria, leaf-like Gurophora and crustose Buellia with Lecanora being more rare. At the surface of cliffs, crustose Gasparrinia elegans, Buellia fregida, Xantoria condelaria f. antarctica, Biatora flava are very often observed. At the moss-free sand surface, Lepraria neglecta, as well as Phuscia caesioides, Caloplaca elegans and Biatora flava often develop.

Mosses prefer the places with a permanent sufficient moistening. They are also observed at the bottom of some freshwater lakes not freezing to the bottom in the wintertime. At present, 14 moss species are known in the oases.

The main components of the lake flora in Antarctic oases are bacteria, blue-green and diatom algae. The diatoms are mainly observed in the near-bottom zone in organic crust formed by bacteria and blue-green algae. Fifteen species of diatom algae were detected in the studied water bodies. Neither of these species belongs to the Antarctic endemics. Not all species are equally observed over the entire study area, and only some of them can be considered typical of all water bodies of the Oasis. These species include Navicula seminulum Grun., Achnanthes marginulata Grun., Pinnularia gibba var.parna (Ehr.) Grun. and Pinnularia sp. The largest numbers of the diatom cells in general were detected in Lake Glubokoye and in water body 5 with the largest number of species in the latter. Lake Gluboloye is situated among the Thala Hills. Its length with the bay, which it forms in the west, comprises 1300 m, its width is 500 m and the largest depth is 36 m.

There are few terrestrial animals. They include mites Petrozetis oblongus and probably, Maudheima vilsoni.

At the slopes of the Oasis and on nearby islands, small colonies of Adelie penguins are observed (Vechernyaya Mt. Oasis, the Myall and Mcmahon Islands). The Wilson's Storm Petrel and South Polar Skua nest in insignificant numbers. Antarctic Petrels fly in and Emperor penguins call occasionally.

Of mammals, the Weddell seals and sometimes Ross seals breed in the station area; one observes sometimes sea leopards. Near the coast of Alasheyev Bay, one can observe little picked whale and killer whale.

Of fish, the families of Nototheniidae, Harpagiferidac and Bathydraconidae are most frequent in the bay. The most widespread family of Nototheniidae is represented by two Genuses. On rocky soils (in 10-30 m depth), a grouping of red algae Phyllophora antarctica, Echinoidea Sterechinus neumayeri and small gasteropods of the Cingula type was detected. Of algae, brown and diatom algae are also noted. In total in Alasheyev Bay, not less than 10 species of different macro-algae were sampled. On soft soils at a depth of 100 m, the leading forms are Nemertini, Polychaeta, Amphipoda and Echinodermata. In depths of less than 100 m that were surveyed only in Alasheyev Bay, the feeding forms of Polychaeta, Nemertini, Amphipoda and Echinodermata are predominant on sandy soils. In depths of 10-30 m, a grouping of red algae, Echinoidea Sterechinus neumayer and small gasteropods of the Cingula type as in Olav-Prydz Bay were observed.

4.5. Physical-geographical characteristics of the area of studies undertaken using the Druzhnaya-4 seasonal base

The seasonal Druzhnaya-4 Base is a regional field center that organizes field geological studies in the IGY valley. The base infrastructure consists of temporary panel huts. The power of diesel electric station (DES) is 78 kW and the oil storage tank capacity is 120 t.

The seasonal Druzhnaya-4 Base is located at nunatak Landing in Sandefjord inlet of Prydz Bay in 2 km from the barrier whose height is about 6 m and the sea depth reaches 100 m. The coordinates are: 69°45' S, 73°43' E (Fig. 4.5.1).

The Base is a logistics center of seasonal geological-geophysical studies in the East Antarctica region including McRobertson and Princess Elisabeth Lands with the Prince Charles Mountains and mountain oases of the Ingrid Christensen Coast. The region covers a coastal part of the Antarctic continent between 60°-78° E extending inland from 68° to 75° S. A unique character of this territory is that it is one of the most exposed at the continent with the mountain outcrops extending over 600 km inland providing a rare opportunity of investigating the middle portion of the Antarctic continent. The geological structure of the territory is quite diverse and most informative both at the regional and continental scales. These factors determined the interest of geologists in this region whose regular study has been carried out since 1971.

The study area belongs to the pre-Cambrian East Antarctic craton (platform), the largest structural component of the polar continent. Three ancient tectonic provinces are outstripped within its bounds:

a) Archean Westphalian protocraton;
b) Archean-Early Proterozoic Rukersky granite - greenstone area; and
c) vast Proterozoic Wegener-Mawson mobile belt dividing and "jointing" the first two blocks.

The Phanerozoic platform mantle includes the late Paleozoic continental sediments Cenozoic trachybasalts and water-glacial deposits. The intrusive formations are represented by practically the entire substance and age scale of rocks. There are Archean granites and metabasites, Proterozoic charnockites, ultrabasites and laminated gabbroids, Paleozoic lamproites and dolerites, Mesozoic alkaline picrites and kimberlites. In the modern structural plan, the region presents a mountain setting of the largest at the continent rift graben of the Mesozoic initial stage used by a system of Lambert-Amery Ice Shelves. A submeridional rift structure extends inland over 600-650 km dissecting the ancient structures of the crystalline basement oriented in the sub-latitudinal direction. Thus, the Meso-Cenozoic rift forming processes so typical of the Antarctic also occur here. Simultaneously, in the metallogenic respect, it is one of the most perspective regions on the Antarctic continent. The shows of minerals include ferruginous quartzites, coal, uranium-bearing sandstones, gold-quartz shows, single findings of diamonds in diatreme alkaline picrites, etc.; potentially perspective for the elevated levels of non-ferrous and precious metals are laminated meta-gabbroids and ultrabasites; there is a high possibility of discovering new, probably diamond-bearing, kimberlite and lamproite formations.
It can also be noted that a marine continuation of the territory (Prydz Bay, the Commonwealth Sea) presents a large modern sedimentary basin potentially perspective for oil and gas.

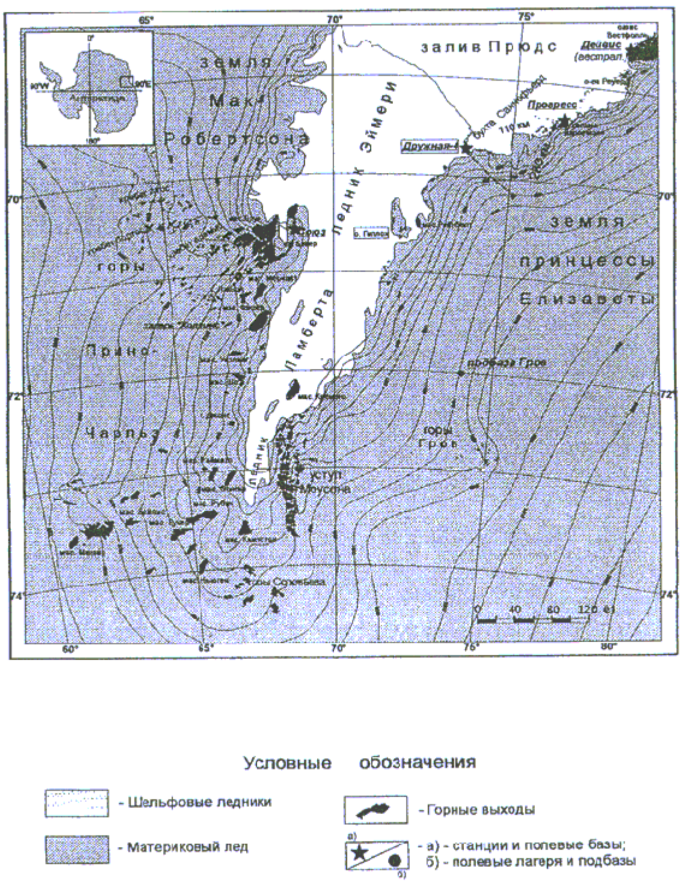


Fig. 4.5.1. Review schemaic of the area of Prince Charles mountains

Legend
Mountain outcrops
Land ice
a) stations and field bases;
b) field camps and sub-bases.

No special floristic and faunistic studies were carried out except for the Larsemann Hills Oasis.

On the islands and in the coastal ice-free territories in the Druzhnaya-4 Base area, one encounters small (up to 100 individuals) groups of Adelie penguins.

The most detailed description of the observed living nature species is given for the Vestfold Oasis and the Larsemann Hills, Progress station (see section 4.6.).

4.6. Physical-geographical characteristics of the Progress station area

The Progress station constructed as a promising basic year-round station for geological-geophysical studies was then transferred to a rank of seasonal bases due to a sharp decrease of funding. The station area is one of the most promising areas in East Antarctica in terms of mineral and hydrocarbon raw materials. This is confirmed by the fact that after the Progress station was established here, a Chinese Zhong-Shan station and an Australian Law station were constructed in the Larsemann Hills Oasis. The station area allows us to consider it as a perspective station in respect of creating here the RAE transport-logistics center with an airfield for intercontinental flights. It is planned that the airdrome built at this location will be optimal for the flights of IL-76 aircraft along the route Russia – Africa – Antarctica (Progress) – Australia.

The station infrastructure is represented by 3 capital and temporary structures with the DES power of 285 kW and oil storage tank of 500 tons. Detailed information on DES and station transport vehicles is contained in Annexes 7,8.

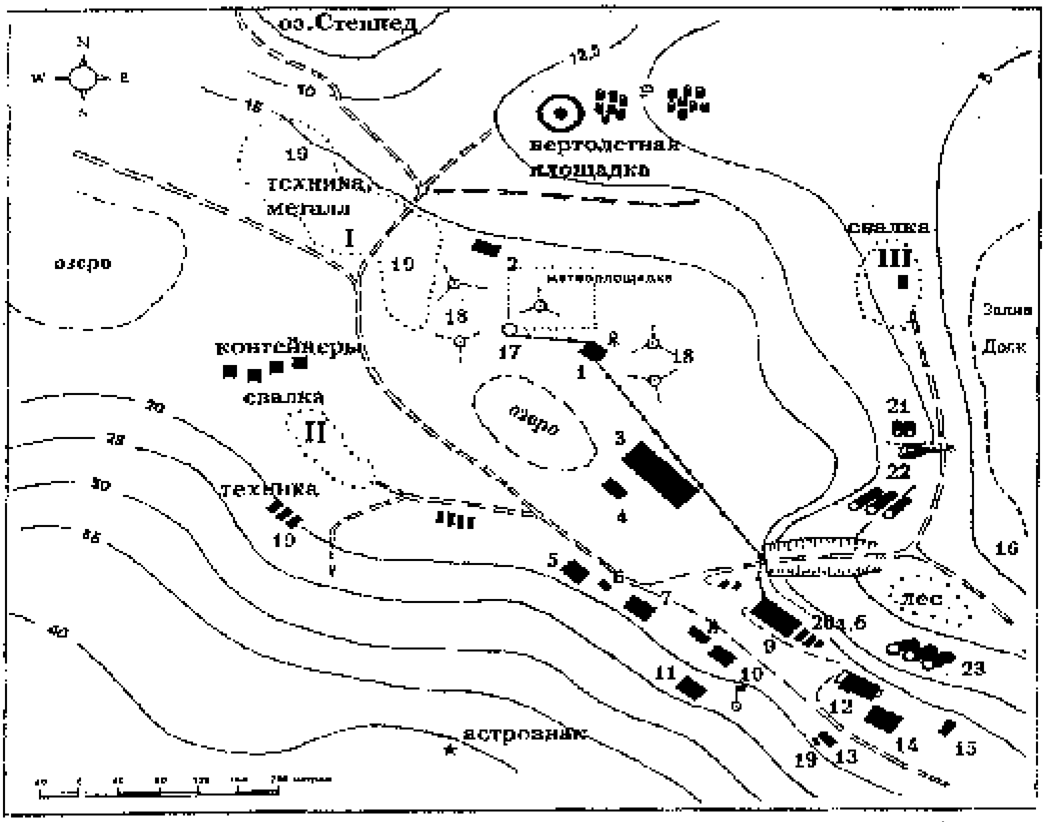
The Progress station is located in the Larsemann Hills Oasis at the Ingrid Christensen Coast (Fig. 4.6.1.). Coordinates 69°22' S, 76°23' E.

The Oasis presents a large group of islands and peninsulas projecting from the Antarctic Shield. The total area of the oasis with the islands is around 50 km2.
The surface of the Oasis is strongly dissected with the maximum heights of about 150 m above the ocean level. Along with the slopes whose sloping angles comprise 45o and more up to steep borts of clefts, there are relatively large leveled surfaces in the Oasis. These surfaces are related to marine transgressions and mostly have the heights close to 50-60 m and to 10 m. The formation of some surfaces with insignificant sloping angles (up to 5o) is also due to glacial scouring. The horizontal surfaces governed by bedrock bedding are actually absent. In the territory of the Oasis, there are ravine-shaped relief features confined to the tectonic fractures.

Loose deposits are mainly represented by eluvium and colluvium. The thickness of loose deposits is insignificant up to the first meters. Most of the territory represents bedrock exposures practically without loose deposits. In the north of the Mirror Peninsula as well as in small numerous bays, beach deposits are widespread elevating at some locations up to 10 m above the sea level. The morainic material is observed at different orographic levels.

From the Larsemann Hills inland, there is a gentle slope of the ice sheet almost perennially snow-covered. Ice in this area has a tendency to move towards the valley of the Dalk Glacier, which results in the formation of cracks covering the eastern part of the hills.

Fig. 4.6.1. Map-diagram of the Progress station facilities



The main peculiarities of the meteorological regime of the area were characterized from data of the Zhong-Shan station (CHINARE Date Report No 7, 1994) for October – March. From October to March, the maximum wind gust recorded by the weather station is less than 32 m/s. The wind speed directions at the plateau of the dome are strongly subjected to mesoscale fluctuations of local topography.

Climatic information on air temperature and wind direction and speed

1989-1992 averages	October	November	December	January	February	March
Air temperature, °C, at 9 a.m.	-11.3	-5.7	-0.7	0.5	-2.2	-8.3
Daily maximum air temperature, °C	-4.0	-2.5	3.2	3.3	0.1	-5.6
Highest temperature, °C	-3.2	3.3	6.9	6.7	4.7	-0.1
Prevailing wind direction	B	B	B	B	B	B
Daily mean wind speed (m/s)	7.3	6.6	6.0	5.3	7.1	7.3
Maximum wind gust (m/s)	31.9	29.1	31.8	27.2	26.0	30.3

Due to relief features, insignificant thickness of loose deposits and poor drainage of permafrost, more than one hundred of lakes are observed over a small area of the Oasis. Most of these lakes are described in the Australian Catalogue. The materials were obtained prior to 1990 and can thus be initial in the determination of the baseline state of lakes. The largest lakes in the station impact zone are Lake Progress (with a watershed area of 39.1 ha, water table area of 10.5 ha and the maximum depth of 34 m), Lake Mir (with a watershed area of 82 ha, water table area of 12.5 ha and the maximum depth of 0.7 m) and Lake Stepped (with a watershed area of 57.8 ha, water table area of 5.0 ha and the maximum depth f 4.5 m). In Lakes Progress and Nella, cyano-bacterial mats were detected. Thus, these lakes are of special interest in scientific respect.

Large streams are absent in the territory of the Oasis. Short water flows are observed only during the active melting period. The largest streams flow to and from Lake Stepped in the northern part of the Peninsula between the Bazovaya Mountain and the dike located near the Progress-2 station and from a nameless lake (No. 73 in the Australian catalogue) to Lake Mir. Short water streams flow from Lake Progress to Lake Nella and then to the sea.

The terrestrial vegetation is very poor. The local flora in the Oasis similar to the Entire East Antarctica is represented only by a-vascular plants: algae, lichen, microscopic fingi and moss. The flora of cormophyte and moss-like plants is represented by 6 species and lichen flora by 13 species. Only in the most favorable habitats, lichen and moss form small curtains whose total projective cover is not greater than 1%. The maximum development of the moss sod – a curtain with an area of up to 10 m2, was observed near the boundary of Progress-2 station, whereas in other places, the size of curtains is not greater than several tens of cm2.

In addition to local plants, alien species of vascular plants were detected in 1995 in the territory of Progress-2 station. These are Alopecurus geniculatus, Puccinellia distans, Rumex pulcher sp., Stellaria media and Chenopodium rubrum.
During the seasonal studies of the 36th RAE, the microbiological studies of the surface soil layer were carried out. The largest and the smallest numbers of viable bacteria were revealed in the territory of Progress station. The highest numbers of microorganisms were detected on the segments with pronounced biological contamination such as soil under the medical block or a fecal tank comprising 802.0 and 761.0 thousand microbial bodies/g. In the areas with pronounced biological contamination at Progress-2 station and Law Base, alien bacteria were revealed, but their numbers were negligibly small compared to natural microflora and comprised not more than 0.3 %-0.7% of the total microbial background, respectively. No cells capable of vegetation were detected in the samples collected from roads, Progress-2 station and in its vicinity. A distinguishing feature of the microbial community revealed in soil from the Law Base territory was the detection of intestinal group bacteria in some samples (direct evidence of man presence). Their numbers were obviously negligible (about 100 microbial bodies/g), but their presence itself can indicate a possibility of survival of these bacterial forms under the severe conditions of high latitudes.

Based on the data obtained for the nearby Vestfold Oasis and general information on the fauna of free living invertebrates of continental Antarctica, the species of mites Acarina, tardigrades Tardigrada and nematodes Nematoda are obviously encountered in the territory under consideration.

The ornithological fauna of the area is poor in respect of the species composition, the population of birds in not numerous. Five species were recorded in the territory of the Oasis.

Adelie Penguin – molts, breeds on the nearest islands;
Emperor Penguin, calls ocasionally;
South Polar Skua - breeds;
Snow Petrel - breeds;
Wilson's Storm Petrel - breeds.

Of mammals, the Weddell seal is common on landfast ice breeding here.

Active practical and scientific activities began in the Larsemann Hills area during the season of 1985/1986. At this time, the "Progress 1" base was established in the south of the Mirror peninsula. In 1988, slightly northward of it, the "Progress 2" station was built. In 1989, the "Progress 1" station was closed and partly dismantled. During the same season, in one kilometer northwestward of "Progress 2", a Chinese Zhong Shan station was constructed. As a result, almost 250 ha (about 180 ha of "Progress 1" and "Progress 2" stations and about 70 ha of "Zhong Shan) were under the anthropogenic load. In addition to these large stations, a seasonal Australian base is located in the territory of the Oasis that operates only during the warm period with a limited personnel (during the season of 1997/1998, there were only two people. The territory of the road with the adjoining watersheds (about 3.5 km long) was also under the impact of practical activity.

The expected development of the infrastructure in this territory envisages the increase of practical activities. In particular, one of the important factors will be a construction of the runway with all necessary construction and engineering facilities and the use of "Progress 2" as a supply base for the Vostok station. There will be an inevitable movement of heavy vehicles between the "Progress 2" and the glacier along the route to "Progress 1" and further to the glacier towards the runway. Under the conditions of unstable equilibrium of the ecosystems of Antarctica, such activity may result in the significant changes both in the biotic and abiotic components of the ecosystems in the Oasis.

4.7. Physical-geographical characteristics of the Mirny Observatory area

The Mirny Observatory was opened in 1956 with a status of the observatory. It is a station with the longest national series of observations of the main climatic and geophysical parameters and the major transportation base for supporting the inland traverses, including traverses to Vostok station.

The station infrastructure is represented by 3 two-storied module buildings, DES building with a total power of 1320 kW, garage for repair of heavy transport vehicles, "baseline" station building, work shops and some supporting objects. The total number of capital and temporary structures is 37. The oil storage tank capacity is 8000 t. Detailed information on DES and the station transport vehicles is presented in Annexes 7, 8.

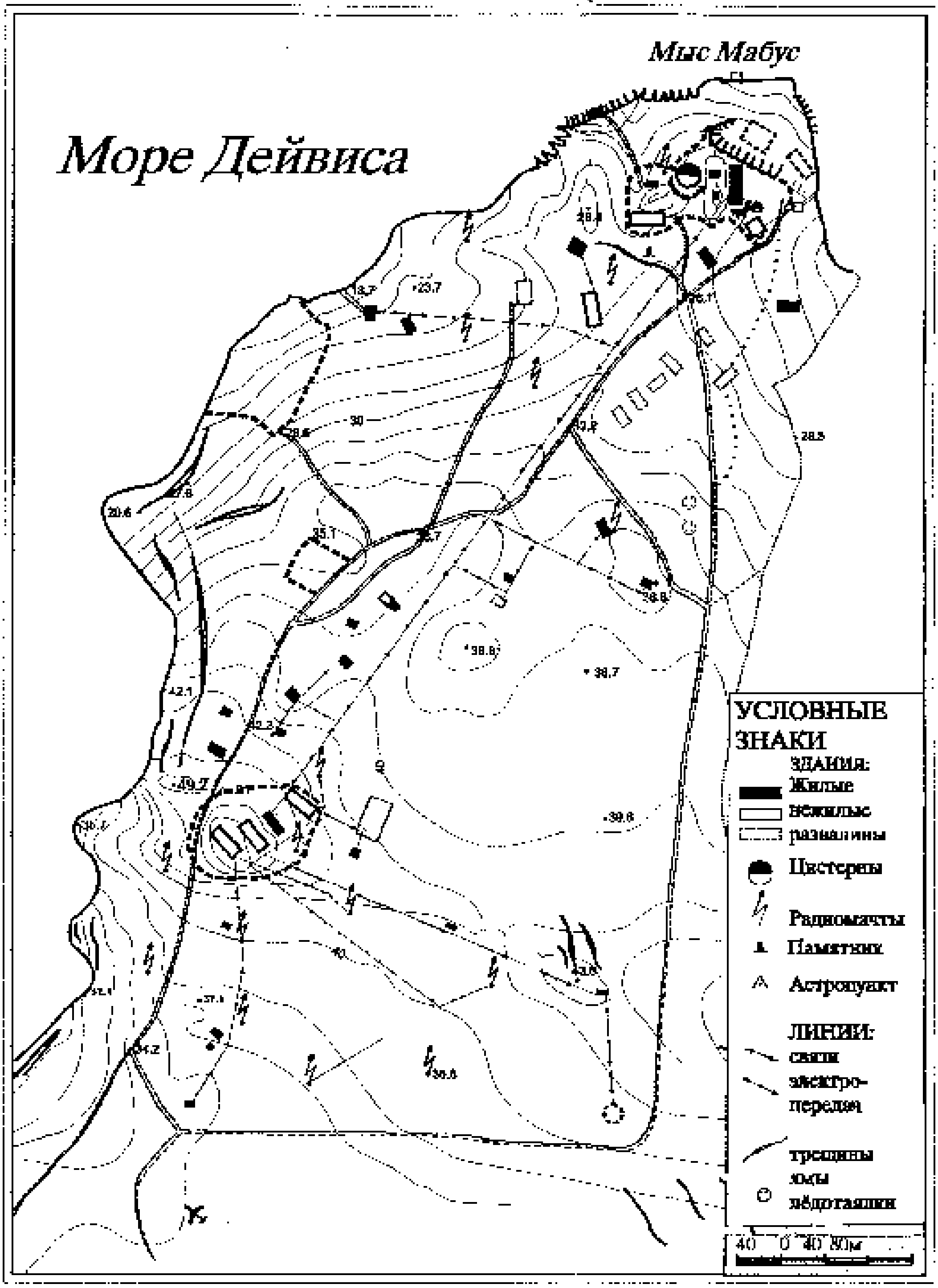
The Mirny Observatory is situated on the Davis Sea shore (Indian sector of the Southern Ocean) at a small bench that has received the name of Mirny Peninsula (Fig. 4.7.1.). The coordinates are 66°33'S, 93°01'E and the height above sea level is 39.9 m.

The station facilities are located at four rock outcrops: Komsomolskaya, Radio, Morennaya and Vetrov Hills elevating above the ice sheet at the very shore.
In the territory of the research settlement between the hills, the ice thickness comprises 80-100 m. South of the station, it gradually increases comprising more than 1.5 km at a distance of 100 km from Mirny. The coastal ice sheet band 50 km in width is covered with cracks.

Participants of the 1st SAE have found a safe passage in this zone and marked it by stakes. The sledge-caterpillar traverses leave Mirny inland along this corridor. East and west of the Observatory, the marginal part of the ice sheet is also covered with cracks presenting piles of broken ice. West of Mirny, an outlet Annenkov glacier descends to the McDonald Bay and in 30 km eastward, an outlet Helen glacier. The ice sheet in the vicinity of Mirny flows slowly encountering significant obstacles in the form of bedrock outcrops. Thus, the structures located at the glacier between the hills move to the west-northwest with a rate of 0.2-0.3 m/year and have a maximum displacement of about 7 m for a decade. In 250-300 m southeast of the settlement, the entire glacier moves to the north-northeast with the flow rate rapidly increasing with increasing distance becoming maximum at the outlet Helen glacier (600 m/year). In the area of the Brown Mountain, the glacier moves to the northeast with low rates between 0.1 to 1.2 m/year and in the area of the Gaussberg mountain to the north-northwest with a rate of 2.5-9.0 m/year.

The four known hills with the bedrock outcrops on which the settlement is located present the isolated islands. The rocky bed of the glacier between them has depths not greater than 20-60 m. Approximately in 1 km south of this group of islands, there is a 100 m isobath, which is then sharply bends to the southeast and goes along the Mirny-Pionerskaya Route. East of it along the route, there are several troughs with marks of 200 to 370 m. West of the route in 5-7 km from Mirny, the rocks elevate 30-120 m above the sea level. The length of this elevation in the southeastern direction is about 6 km. In the southwestern direction, it extends in the form of individual hills separated by shallow depressions.

Fig. 4.7.1. Map-scheme of Mirny Observatory



The geological structure of Mirny is comprised of Pre-Cambrian crystalline rocks with three complexes identified between them: magmatized crystalline slate, gabbro-dolerites and charnockites.

The shore of the continent presents a snow-ice barrier with a height of 15-20 m above the sea level cut in places by nunataks. Snow slides are possible. The seabed relief is characterized as follows. At the traverse of Mabus Point and east of it, the depth less than 10 m predominates. A 10-m isobath passes at a distance of 15-20 m from the coastline. The seabed is rocky with a sharp slope to the sea and abundant underwater boulders that make the approach to the shore dangerous even for ships with a small draft. West and seaward of Mabus Point, the depths gradually increase approaching 100 m and the bottom becomes even.

Several islands and cliffs project to the Davis Sea north of Mirny, the Haswell Island being the largest of them (94 m above the sea level).

The sea in the Mirny area is covered with landfast ice much of the year whose width at the end of winter achieves 30-40 km. The landfast ice breakup occurs from December 17 to March 9 at an average date of February 3. It is established from March 18 to May 5 at an average date of April 6. The ice-free period probability near Mirny with duration of more than one month comprises 85 %, more than two months - 45 % and more than three months - 25 %. There are always many icebergs frozen to the ice at the Mirny roadstead. In the summertime when the sea is cleared of landfast ice, they drift along the shore from east to west. Seawater is characterized by constant below zero temperatures with salinity comprising 34.4 ‰, on average. The tides in the vicinity of Mirny have an irregular diurnal character. The maximum current speeds near the coast reach 1.5 knots and the minimum are not greater than 0.1-0.3 knots.

The Mirny Observatory is located in the climatic area of the glacial slope foot. Local climate is strongly influenced by the close proximity of the ocean resulting in unstable sharply changing weather as the oceanic cyclones closely approach the Antarctic coast and often persist near it. The cyclones are observed both at the Antarctic and the temperate latitude front. Some dominance of the cyclonic activity at the Antarctic front is observed in the summer and during the transient periods. The cyclones of temperate latitudes predominate in winter. The latter are more active and typically determine the storm and hurricane winds. The second factor determining the weather character is strong catabatic winds that bring dry and adiabatically heated air. The regime of catabatic winds at the coast has pronounced annual variations. The catabatic wind is stronger in winter than in summer. In summer, when the coastal slopes receive much heat the catabatic winds attenuate and their frequency of occurrence decreases. The catabatic winds typically have a speed of about 15 m/s and the southeast direction. In the rear of cyclones, the wind increases to 20-25 m/s attaining southern direction. During the year, there are 204 days on average when the wind speed is greater than 15 m/s. With storm cyclones from temperate latitudes approaching the Antarctic coast, which mainly occurs in winter, hurricane easterly winds occur with a speed of up to 50-60 m/s. Calms are extremely rare being recorded in 1 % of the observation cases. The coast in the Mirny area is characterized by the below zero air temperatures almost the year-round. The total duration of the period with the above zero temperatures comprises 16 days, on average. Summer begins in December with the warmest period being the second half of December and January when the maximum temperatures comprise +6 to 9°C and the minimum –10 to -12. The most frequent are the temperatures from -5 to + 3°C. The autumn period is March-April; early winter is May and June; the real winter months are July, August and September. At this time, the air temperature is on average between -15 to -26°C. During the anomalous cold years, the temperature drops to minus 35-45°C. The sum of degree-days of frost varies from year-to-year within 3.500-4.500.

The total cloudiness for a year is 5.5-7 points. The lower cloudiness is about 3 points. Annual variations of cloudiness have a maximum in summer and a minimum in winter. The frequency of occurrence of clear sky by the total cloudiness is equal to 25-35%, on average for a year and of overcast sky to 45-65%. Throughout the year, 400-600 mm of precipitation is recorded, sometimes liquid precipitation is observed. The strong winds are usually accompanied with snow storms. The average number of days with a snow storm for a year is about 200 days. The snow storms cause drifting snow piling up in the territory of the station. The maximum annual snow accumulation in the Mirny area is 900-950 mm of the water column. It was noted that the major snow accumulation occurs during the snow storms at the wind speed of not greater than 20-25 m/s. At large speeds, no snow accumulation occurs while at a speed of more than 40 m/s, the earlier accumulated snow is blown away. The largest snow accumulation around the structures occurs at easterly winds, usually at attenuating blizzard. In November, December and January, the snow surface becomes lower. Snow settles as a result of compacting and intense evaporation and melting. During this period, a large amount of water is discharged from the continent to the sea that freshens the sea near the coast. Freshwater is discharged due to the streams flowing from the barrier in summer, melting of underwater barrier portions and icebergs staying near the coast and snow blown by wind from the continent. For each linear meter of the coastline in the Mirny area there is roughly, 50000 m3 of melt water.

The convenience of weather conditions in the Mirny area changes from 5.1 in winter to 6.3 points in summer comprising 5.6 points on average, for a year.

The Mirny Observatory is located precisely at the Polar Circle, hence, there is no 24 h polar night here. During the polar day in December, the Sun does not descend even at midnight due to refraction. This is however, observed only for several days.

The average values characterizing climate of Mirny are presented below:

Direct radiation 48.6 kcal/cm2
Total radiation....................…………………… 97.8 kcal/cm2
Radiation balance..............……………………..... 4.5 kcal/cm22
Absorbed radiation……………………………..…..18.7 kcal/cm2
Mean temperature (annual)………………...………...-11.4°C
Mean maximum air temperature .………. ..-8.1°C
Mean minimum air temperature…………..... -14.6°C
Absolute maximum air temperature……….. ….6.8°C
Absolute minimum air temperature……….. ….-40.3°C
Mean annual atmospheric pressure……..……… ..…987.8 mb
Mean wind speed…………………………...…… ..11.2 m/s
Prevailing wind direction………………… ……ESE
Mean annual relative air humidity …….70%
Annual amount of precipitation…………………… 624 mm

The hills where Mirny is located and the rocky small islands near the coast are almost devoid of the vegetation cover. Only lichen, moss and algae are observed in small numbers.

The hydrobiological studies during the period 1965 to 1972 (11, 13, 16 SAE) of the sublittoral of the Davis Sea at the Mirny roadstead and in the vicinity of Haswell Island has revealed the main features of marine flora and fauna. Phytobenthos in the Mirny area was significantly more depleted than in other coastal areas of Antarctica, which is obviously related to a large steepness of shores.

Phytoplankton is represented almost exclusively by diatom algae (Pleurosigma sp., Fragilariopsis antarctica, Thalossiosica sp., Nitschia stellata, etc.). In addition to them, only one species of red alga Phyllophora antarctica was noted in the upper sublittoral zone. The most rapid development of diatoms occurs in September being connected by time with the formation of frazil ice crystals. The daily photosynthesis production value obtained on the basis of measurements and calculations comprises about 36.7 gC/m2, i.e., almost the entire annual phytoplankton production is generated in spring under the ice.

The cryopelagic fauna is represented by fry of trematomus, Calanus, Copepoda and Amphipoda.

The seabed fauna of coastal waters in the Mirny area was much richer than for example, similar fauna in the vicinity of Molodezhnaya station numbering several hundreds of species. In many cases, the biomass of animals achieves several kilograms per 1 m2 of seabed. The vertical zonality in the distribution of benthos depends on the character of seabed and snow cover extent on landfast ice. As in general at the Antarctic shelf, a significant portion of benthic biomass is comprised of non-feeding organisms and primarily of sponges. One should note the presence of siliceous sponges usually typical of large depths. Different pearlweeds, ascidians, coelenterates (Hydroidea, Alcyonaria, Actiniaria), etc. are numerous. The fauna of Echinodermata numbers about 40 species. Most numerous of them are sea hedgehogs Sterechinus neumayeri, stars Odontaster validus, feather stars Promachoczinus kerguelensis and different sea cucumbers. Polychaeta are represented by diverse species; Polychaetes of the Genus Eulagisca were detected. Large carnivorous Nemertinea Lineus spp. are observed. Among the mollusks, most noticeable are nudibranchiate species. The most mass form among gastropods is Rissoidae.
Of fish, different Trematomus species are especially typical of the Davis Sea coastal water in the Mirny area: Trematomus borchgrevinki; Trematomus newnesi; Trematomus nicolai; Gymnodraco acuticeps, etc. More rare are the Antarctic toothfish Dissostichus mawsoni and the Antarctic smooth-tongue Pleuragramma antarcticum. An abundant food base and the availability of suitable grounds for nesting create favorable conditions for the existence of a large number of sea birds. A total of 11 bird species were recorded in the vicinity of Mirny:

Adelie Penguin - breeding;
Emperor Penguin - breeding;
Macaroni Penguin – single call;
Antarctic Giant Petrel – occasional migrations
Cape Petrel - breeding;

Snow Petrel - breeding;
Antarctic Petrel - breeding;
Wilson's Storm Petrel - breeding;
South Polar Skua - breeding;
Kelp Gulf - migratory.

The Adelie penguins are encountered almost in all land areas emerging to sea. They appear at the coast of Antarctica on approximately October 20; egg laying begins about November 10; in mid-December – hatching of chicks; in late February-early March – end of molting and the birds leave for sea. The Emperor Penguins arrive to the coast in early April and by the end of April, they form a colony on sea ice east of Haswell Island. The coordinates of this colony are 66°32' S, 93°02'E. A small colony was observed in the vicinity of the Gaussberg Mountain. In early May, there is egg laying; chicks hatch from the middle of July; they come out from the pouch-like skin fold of parents to the ice around August 20; molting begins in early December; from the middle of December, the colony begins to break up with only some individuals left in late January.

Pinnipeds are typical fauna representatives at the coast. The Weddell seal is most widespread on the coastal ice breeding here. Single individuals of the sea elephant and the Ross Seal are encountered in the Mirny area. The Crabeater seal and the Sea leopard keep to the drifting ice. Minke's whales approach frequently the Mirny area. The area of the Haswell archipelago is in the List of Antarctic specially protected areas: category of Sites of special scientific interest SSSI No.7. The area was proposed for protection as a site of high biological diversity and as nesting grounds of 5 species of petrels, skuas and one species of penguins. The area provides a unique opportunity for scientific research and requires protection since it is located in direct proximity to the station.

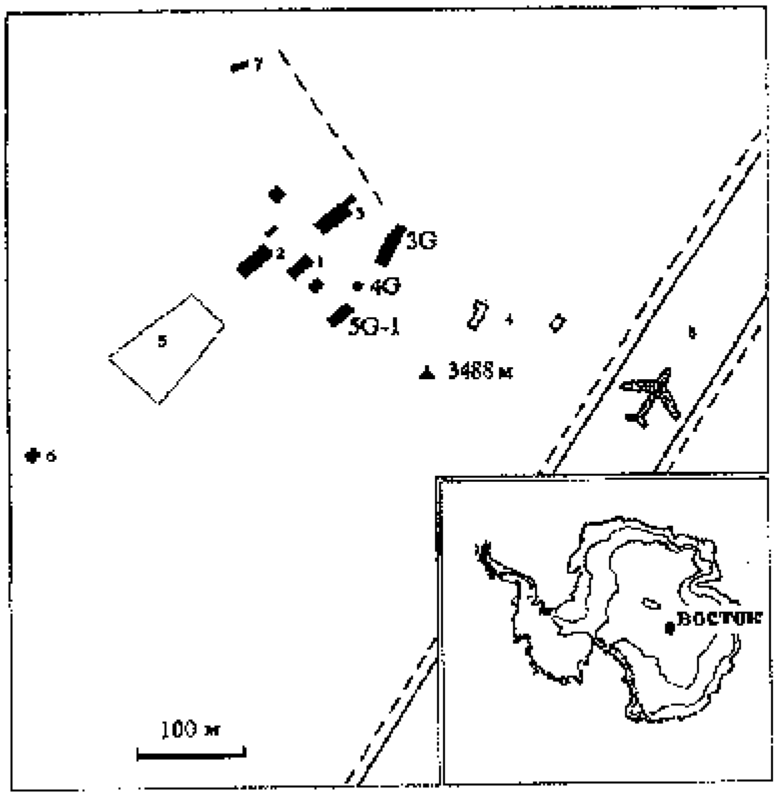
4.8. Physical-geographical characteristics of the Vostok station area

The Vostok station is the only one unique scientific inland station located at the Pole of Cold and at the South geophysical Pole of the globe (Fig. 4.8.1.). Coordinates are 78є28' S 106є50' E, height above sea level is 3488 m.

After completing the largest project on deep drilling, the significance of the station will be determined by the fulfillment of climatic, geomagnetic and ionospheric programs as well as by the perspective studies on subglacial Lake Vostok. The station needs improvement of its infrastructure, especially in respect of searching alternative energy-efficient technologies. The station infrastructure is represented by 4 capital structures with the design DES power of 270 kW and the oil tank capacity of 200 tons. The life activity at the station fully depends on the annual sledge-caterpillar traverses from Mirny station. Detailed information on DES and station transport vehicles are presented in Annexes 7,8. Due to the decreased RAE funding beginning from 1994, only one traverse instead of two a year are arranged, leading to the need of reducing energy consumption, in particular, termination of the power-consuming program on upper-air sounding of the atmosphere. Beginning from 1994, for logistics supply of the stations, the aviation support of the US Antarctic Program is also used under the framework of joint work.

The station is located at the plain snow surface of the East Antarctic glacial Plateau. The least distance from the coast is 1260 km, from Mirny station - 1420 km and from the South Pole - 1253 km. The ice cover thickness in this area comprises 3700 m with the thickness of the snow-firn strata of about 120 m. The ice sheet bed under the station is at a mark of approximately 200 m below the sea level. There are no natural water bodies in the station area. The outcrops of bedrock are absent. The ice sheet is perennially snow-covered that never melts. The landscapes of this area are distinguished by a significant monotony and natural elements by uniformity.

Fig. 4.8.1. Plan of Vostok station (43 RAE)



1 - mess-room; radio-house; 3 – DES; 4 – old station; 5 – meteo-site; 6 – microbiological laboratory; 7 – upper-air complex; 8 – runway. Points with symbols 3G, 4G, 5G-1 denote the locations of boreholes.

The mountain part of the shield with marks of more than 2000-3000 m belongs to the climatic area of Central Antarctica. The geographical location of the station, features of the underlying surface, solar radiation regime and atmospheric circulation govern the general climate severity.

High transparency and dryness, as well as a smaller atmospheric mass above the ice sheet compared to the coastal areas of Antarctica result in a large total solar radiation flux incoming to the glacial surface. It equals 1.26 GJ/m2 in December and is 80% comprised by direct radiation. The annual radiation balance at the surface of the station is equal to 0.08 GJ/m2. Intense air cooling occurs above the Antarctic Plateau with strong surface temperature inversion developed during the entire year. The

natural seasons in Central Antarctica are defined conventionally, by the character of the change of temperature and illumination. Winter continues for 6 months (April-September), summer for two months (December-January) with transient seasons lasting also for two months (spring – October and November and autumn – February and March). A typical feature is winters without the pronounced cold centers, which is due to the development of active meridional atmospheric circulation.
In spite of steady air temperature variations in general in winter, the coldest month is August (with an average multiyear temperature of August close to -70C), when cooling of the atmosphere lasting for the entire polar nigh approaches its limit at the end of it. In spring, especially with the onset of polar day, there is a steady and large air temperature increase by absolute values. From September to October, the mean monthly air temperature increases two-fold.

In general in spring, the temperature is quite low, its average comprising -50C. The temperature is the highest in the middle of the polar day in summer (December-January), never dropping below -36C, on average, for a month although not exceeding -30C. The highest temperature is observed in the third 10-day period of December and in the first 10-days of January indicating a direct relation to the Sun's height above the horizon. The average temperature of the autumn months is low (-50.8C) being equal to the temperature of spring months. The average annual air temperature from year-to-year varies compared to multiyear temperature between 2.1 to –1.4C. The annual amplitude during the time of observations is equal to 35.7, with the absolute amplitude comprising 75.60. The diurnal temperature variations are usual on average for a year with the maximum in the daytime and minimum at night. In winter, the diurnal variations are practically absent. A large number of observations clearly show a regular feature, namely, the decrease of temperature with decreasing pressure whereas its increase is accompanied with increasing atmospheric pressure.
At Vostok station, due to its location at a large height, the pressure is very low. The annual variations have a maximum in the summer and the minimum in late winter (September). Climate is also distinguished by extremely low air humidity. The water vapor pressure in summer comprises only 0.29 hPa, and on average for a year it equals 0.07 hPa. An insignificant amount of moisture in the atmosphere is attributed to negligible evaporation from the glacial cover due to the absence of free moisture supply at the surface and low air temperature. In the annual variations of absolute humidity, the maximum is observed in summer and the minimum in winter.
There are evident variations of the frequency of occurrence of clear and overcast sky at Vostok. The frequency of occurrence of clear sky is the highest in winter (60%) and the lowest in summer (30-40%). The cloudiness is weak.

The wind regime is characterized by weak catabatic west-southwesterly winds. The annual speed variations have two maximums – in September-October and in March. There is a direct relation between the catabatic wind direction and the ice sheet sloping direction.
The frequency of occurrence of catabatic winds during a year comprises 60-80%. Cyclones (obviously very weak) sometimes penetrate the station area both from the Indian and the Pacific sectors of the Antarctic. In the event of the cyclone arriving from the Ross Sea, the cyclonic winds coincide with the westerlies prevailing at the station while at the south-southwesterly winds, the cyclonic weather features are pronounced. The probability of storm winds (with a speed > 15 m/s) is small. The maximum speeds recorded in the gusts comprises 23 m/s in summer, 23 m/s in

autumn, 27 m/s in winter and 32 m/s in spring. The frequency of occurrence of calms is less than 1%.

The frontal cloudiness carrying precipitation penetrates very rarely. The annual sum of atmospheric precipitation falling out only in the solid form is about 25-50 mm. The main amount of snow is accumulated during the cold time of the year from May to October. Up to 98% of the entire mass of precipitation fallout here is comprised of columnar ice crystals. The precipitation of such ice crystals was recorded at Vostok station for 247 days on average for a year. Ice crystals also form fog and haze typical of the central areas of Antarctica. The ice transparent fog occurs at a weak wind and quite often simultaneously with the fallout of ice needles from the atmosphere. There are about 35 days with ice fog on average for a year, such days in summer being few. The ice-crystal haze is also observed with the intense fallout of ice needles being observed more frequently than fog up to 150 days a year. The snow storms in the station area are rare due to weak winds, their frequency of occurrence with drifting snow comprising not more than 15% for a year. In summer when the snow surface is covered with the radiation crust, even the wind with a speed of 10 m/s does not cause the snow transport.

Average values characterizing climate of Vostok are presented below:

Annual radiation balance……………………… -0.08 GJ/m2;
Average temperature (annual)………………...…… -.4°C
Absolute maximum air temperature ………..….-13.6є?;
Absolute minimum air temperature ………..… .-89.2°C
Mean annual atmospheric pressure…..………..……624.2 mb
Absolute maximum air pressure………………... 666.1 mb
Average annual wind speed …………………………..5.4 m/s
Prevailing wind direction…………………… … WSW;
Average annual relative air humidity……. .71%;
Average annual absolute air humidity ……… 0.07 hPa;
Average annual cloudiness…………………………….3.4 points

At the surface of the snow cover, space microparticles deposit with different intensity and periodicity. Air flows bring microparticles (volcanic dust, spores and pollen of plants, microorganisms, chemical compounds and microelements) as well as anthropogenic particles (compounds of sulfur, nitrogen, carbon, decay products of thermonuclear explosions, etc.) from the other continents and the oceans.
Different optical phenomena such as halos, crowns and columns and optical illusions are typical of the atmosphere in the Vostok station area. The polar night lasts for almost four months from April 24 to August 20.

4.9. Physical-geographical characteristics of the Bellingshausen Base area

The Bellingshausen Base carries out hydrometeorological observations and biological, glaciological and environmental surveys. The optimal personnel of the station during the wintering period number 26 people.

Subantarctic marine climate produces an extremely aggressive action on metal structures and equipment at the station. As a result, the station is in acute need of comprehensive nature protection measures including a significant reconstruction of infrastructure. The station infrastructure is represented by 12 capital and temporary structures. The design DES power is 1000 kW and the oil storage tank capacity is 9290 tons. Detailed data on DES and station transport vehicles are presented in Annexes 7,8.

The Bellingshausen Base is located at the center of the Fildes Peninsula (southwestern tip of King George Island (Vaterloo) in the group of South Shetland Islands) where station and bases of 11 states are situated (Fig. 4.9.1.). Coordinates are 62°11' S, 58°58' W.

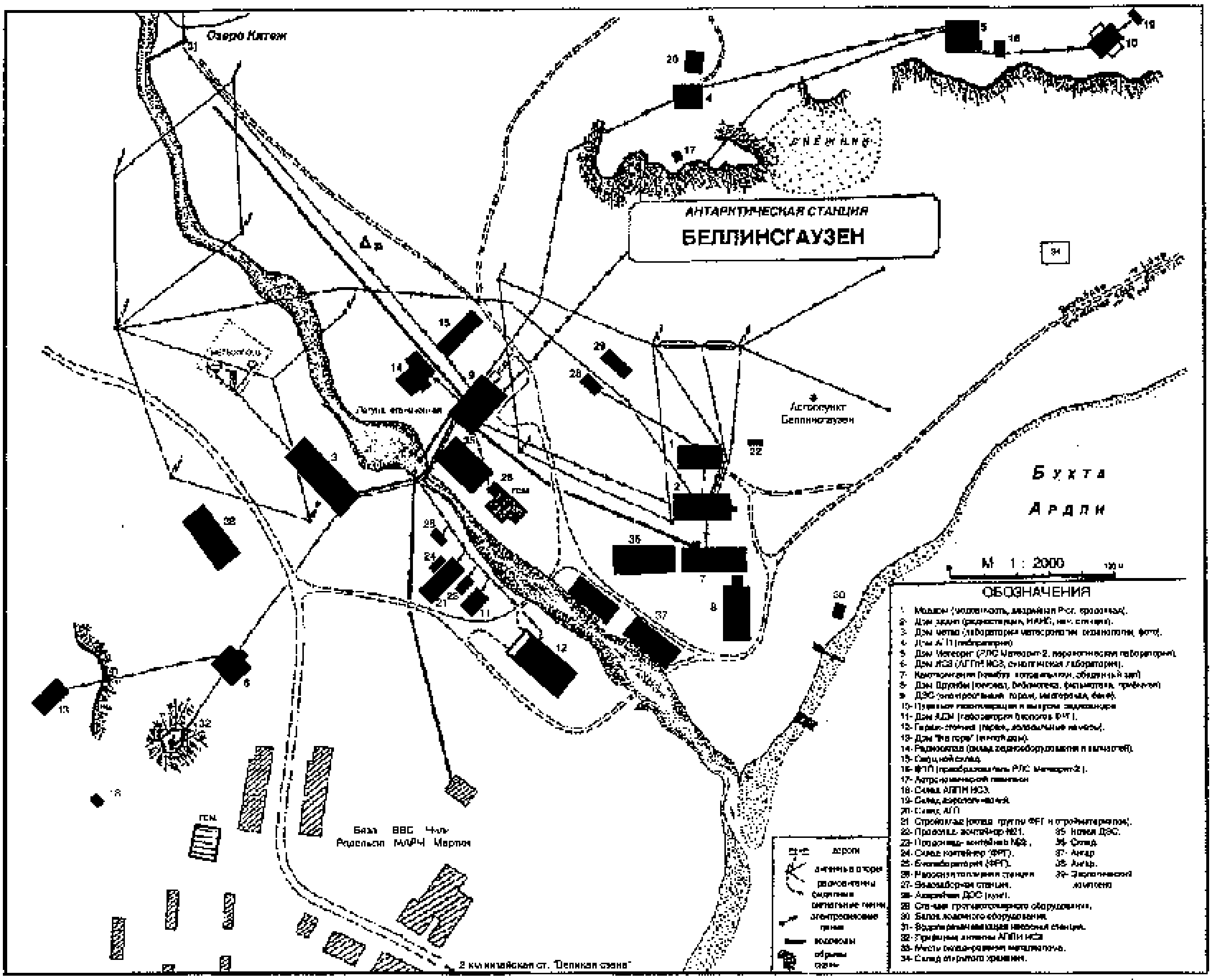
King George Island is one of the largest islands of the archipelago (with a length of about 80 km, a width of 30 km and an area of 1338 km2). Almost the entire island is ice-covered. The Fildes Peninsula presents the largest ice-free area (with a length of about 10 km, a width of up to 2.5 – 3 km and an area of about 30 km2). The peninsula is elongated in the southwest –northeast direction. The coastline is jagged by numerous bays and capes the largest of them being the Ardley Peninsula at the eastern coast. The northwest shore of the Fildes peninsula is washed by waters of the Drake Passage and the southeast shore is closed by Guardia-Nacional Bay. From the south, the peninsula is separated by a narrow Fildes Strait from Nelson Island (Leipzig). The peninsula is comprised of volcanic rocks predominantly by Paleogene and Neogene andesites, basalts and different tuffs. The eruptions of both fissure and central type probably occurred at the time of their formation.

Much of the coastline presents a steep, precipitous and even pendent in some places abrasion scarp. Its height is 40 – 50 m. The action of abrasion is especially noticeable at the western coast of the Fildes Peninsula where a shallow water area extends over 2 km from the shore covered with small islands and cliffs presenting a current abrasion platform. The eastern coast is not so strongly dissected. There are several bays here with pebble beaches inside.

The relief of the peninsula presents a typical low hillocky area with the absolute heights of up to 150 m. The contours of large relief forms are probably determined by fractures and tectonically relaxed zones. The hills along them form into several elongated chains of sublatitudinal direction being separated by through depressions of the same strike crossing the entire peninsula. The tops of the hills have a relic character. Their shape changes depending on the composition of rocks. Some tops present massive towers with almost precipitate slopes. The slopes of hills are mainly clearly differentiated into two parts – the upper steep comprised of bedrock and lower gentle comprised of the weathering products.

The origin of the modern relief is primarily related to glacial scouring. The leading current relief-forming processes are physical weathering and partly solifluction. Current marine deposits are represented by beaches with a series of pronounced accumulation and accumulation-abrasion terraces extending along the eastern and western coasts of the island. The height of marine terraces varies between 2 to 3 m above the sea level. They are comprised of well sorted by size polymict fine and medium (rarer large) pebble-beds and sands. In the composition of pebble-beds, rocks of local origin sharply predominate, but alien rocks are also observed including metamorphic slates similar to those comprising the east coast of Clarence (Shishkova) Island most likely brought here by floating ice.

Fig. 4.9.1. Antarctic Bellingshausen station



In addition to stratified features, volcanic necks and dikes are numerous on Fildes Island. Round six volcanic necks were recorded in the coastal zone. Dikes are morphologically expressed by clear crests or peak-like ledges up to 5-7 m high. The north and the south of the peninsula is abundant in disjunctive disturbances. A system of sublatitudinal faults along which the valleys of the largest streams occur in the current relief are especially clear.

Climate of the Fildes Peninsula is of marine type with small seasonal temperature variations. The sub-Antarctic warm sea air is the prevailing air mass determining the weather in this area.

The synoptic processes are distinguished by intense cyclonic activity. Due to the frequent cyclones, the weather conditions at the Bellingshausen station are unstable. Wet, gloomy weather predominates (with the number of days without the Sun of about 200). Short periods of clear weather are observed only with the development of high pressure crests in the rear of coming cyclones.

Due to prevailing cloudy weather, the number of solar radiation measurements in the absence of clouds and haze is extremely small. The low values of direct solar radiation are attributed to a large water vapor pressure, which is approximately 2-3-fold greater than at the stations located in the Antarctic oases or at the coast of Antarctica. In spite of this, it should be noted that in summer, the direct radiation intensity values are quite significant. Thus, in December-January, it reaches 1.45–1.49 kcal/cm2. Scattered radiation makes the largest contribution (up to 80%) to the total heat influx during the year. The total radiation values from March to December are close to data of other coastal Antarctic stations while in January, the total radiation is half as large due to the dominance of lower clouds. The total sum of absorbed radiation comprises 48% of the entire incoming radiation.

The mean annual air temperature comprises –2.8°C. The temperature in January-February, is typically above zero (0.7 – 0.8°C), being below zero in all other months. The coldest month is June (the mean monthly temperature is minus 7.2°C). There are no sharp oscillations in mean daily temperature.

The prevailing cyclonic type of weather is characterized by low stratified and stratified cumulus clouds with average annual lower cloudiness of 7.7 points, relative humidity of 86% and the number of days with precipitation in each month varying from 22 to 30. Liquid precipitation is sometimes observed at below zero air temperatures (up to –7°C). The fogs are frequent (about 76 days a year).
The prevailing wind is ESE with a speed of 9.3 m/s. The period from August to December is characterized by the wind with the northern component. The strongest winds are easterly winds (up to 28 m/s), typically with gusts. They are often related to the cyclones exiting along the South American trajectory. The maximum gust speeds achieve 48 m/s. At the winds from the Antarctic Peninsula, snow storms are almost always observed in winter (the number of cases with a snow storm for a year is 98). The snowfalls also occur in the summer, however, the forming snow cover disappears during several days. The constant snow cover is established approximately by the middle of May.

In the summer months (January-April), the Oasis is completely snow-free except for quite numerous snowfields. Glaze ice plays a large role in the snow cover development. At the slopes of northwestern exposition, the thickness of ice crusts comprises sometimes several centimeters. The formation of zastrugi is not typical, their height rarely exceeding 20 – 30 cm. The average density of the snow cover is quite high (about 0.40 g/cm3), which is mainly explained by the presence of a large number of ice crusts in the snow strata. From the second half of October, the snow thickness gradually decreases. Extensive areas become snow-free in late November – early December with snow disappearing completely by the middle of December. Glaze ice, hoarfrost and rime often lead to a failure of sensors of different instruments operating in the open air. The thickness of glaze ice on antennas comprised 20 cm in diameter in some years resulting in the break of antennas, deformation and damage of steel radio-masts.

Average values characterizing climate of the Bellingshausen Base area:

Direct solar radiation..…………………………..…13.4 kcal/cm2
Scattered annual radiation ..……………..…..……..56.5 kcal/cm2
Total annual radiation …………………..…...… 70.0 kcal/cm2
Annual radiation balance……………………… ….15 kcal/cm2
Duration of sunshine a year…… ……564.7 h
Number of days without the sun……… …about 200
Mean annual temperature ……………...……….. -2.8°C
Mean annual wind speed ..………………………... 7.1 m/s
Prevailing wind direction………………… ……ESE;
Mean annual relative air humidity…….. 86%
Annual amount of precipitation......………………..……729 mm;
Mean annual total cloudiness…………..……… 9 points

Sea ice forms only for several winter months. Ice formation in the vicinity of the station typically begins in April, however, this process is unstable and is easily interrupted due to the wind, wave and air temperature increase. Steady ice formation begins in the first half of May. In the middle of May, landfast ice is usually established, its thickness achieving 50 cm at the end of May. The maximum landfast ice thickness is recorded in September (80 – 100 cm). Guardia-Nacional Bay is cleared from drifting ice in September-October. The dates of the final landfast ice breakup vary over a wide range from October to December.

In the Drake Passage, only drifting ice cake is observed near the shores until July with the young landfast ice being established in early July, whose thickness comprises only 5 cm over the entire shallow zone of the strait. Landfast ice remains stable for a short period breaking up in early October after achieving a thickness of 50 cm and is exported from the shallow zone adjoining the coast to the strait.

As shown by observations, the landfast ice in the vicinity of the station breaks up at its maximum thickness almost without the traces of melting. Its decay occurs exclusively under the influence of dynamic factors. Waves and tidal phenomena play a decisive role at this.

Current land glaciation presents a typical ice sheet, which consists of several elevated domes connected by low bridges-saddles and of some short outlet glaciers. The ice sheet jointing except for the zone of outlet glaciers is insignificant. The flow rate of the non-dissected ice sheet margin is not greater than 5-5.5 m/year. The observations in the Admiralty Bay indicate a retreat of the glaciers and a decrease of the ice sheet over the last decades. In all bore pits made on the island for the purpose of stratigraphy of the snow-firn strata of glaciers, interlayers of volcanic ash were also noted.

The hydrographic network is very poorly developed in general. Due to slow and uniform snow melting and the character of loose deposits, much of moisture does not go to the water flows but saturates instead the concentrations of weathering products. The streams are small, their bed being entrenched only over several tens of centimeters. The low places are filled with melt water forming dozens of shallow small lakes and pools with a depth of up to 2 m and several quite deep (up to 16 m) lakes that are confined to the bottom depressions of through valleys. There are around 60 lakes on Fildes Island.

Among the lakes, one observes lagoon, glacial and tectonic-scouring lakes. The lagoon lakes are located near the coastline in heights between 3 to 20 m. They are separated from the sea by a series of marine terraces. The lake basins of tectonic origin tend to tectonic fractures and faults (Kitezh, Dlinnoye and Slalomnoye). The glacial lake basins are the shallowest up to 3 m deep. One can frequently see a cascade of lakes at different hypsometric levels connected by a series of water flows. The lakes are covered by ice up to 1 m thick much of the year. The ice-free period lasts for not more than 3 months (from January to March). The specific feature of the thermal regime of lakes is in the dominance of comparatively cold water masses the year round (0.5 – 3.0 oC). Water in lakes is fresh containing up to 1.5 ‰ of sea salts transported by winds with snow and rain.

Permafrost is spread everywhere. The measured depth of seasonal melting on the Fildes Peninsula comprises 0.3 m under the sod of lichens and more than 1 m in coarse-grained sea deposits. Primitive cryogenic-structural soils with an insignificant humus content are typical.

The continuous soil-vegetation cover is absent. Soils are observed under the moss-lichen sod or algal crust. Lichens are represented by more than 100 species. Moss grows in moistened habitats, the patches of moss covering sometimes tens and hundreds of square meters. Unlike the mainland Antarctica, two species of flowering plants are observed here, Deshampsia Antarctica and Colobantus.

The lakes are relatively rich in phyto- and zooplankton. In spring, copepods are numerous.

Birds comprise the basis of the fauna of vertebrates.
Emperor penguin – regular runs.
Gentoo penguin – breeding, non-breeding individuals are observed the year-round.
Antarctic penguin - breeding.
Adelie penguin – breeding, rare in winter.
Antarctic Giant Petrel - breeding.
Antarctic Fulmar – migratory.
Antarctic Petrel - migrations.
Cape Petrel – breeding, observed the year-round.
Snow Petrel – migrations.
Wilson's Storm Petrel - breeding.
Black-bellied Storm Petrel – breeding.
Blue-eyed shag – the year-round, breeding (on small islands in the Drake Passage).
Cattle egret - migrations.
Snowy Plover - single migration.
Baird Sandpiper - occasional migrations.
Snowy Sheathbill – wintering, breeding.
South Polar Skua and Brown Skua – breeding.
Kelp Gull – breeding, wintering.

Antarctic tern – breeding, wintering

The most vulnerable to the anthropogenic impact is the Antarctic Giant Petrel. During the study period (1996-1998), 7 colonies of the Antarctic Giant Petrel were recorded on the peninsula. During the last decade, a decrease in the numbers of nesting birds is observed in the areas directly adjoining the stations. An extremely low breeding success of the species was also recorded. For example, in 1996/1997, it comprised only 9.7% for the colonies on the Fildes Peninsula and Ardley Island (10 chicks left 103 nests), which is a record low indicator for this species. One of the factors influencing a low breeding success of the Antarctic Giant Petrel is am anxiety factor from the Chilean aviation (helicopter flights at an altitude lower than 50 m). The second factor is the increased concentration of skuas in the area of polar stations as a result of a long-term additional feeding of birds, especially at Bellingshausen station (Russia), Frei Base (Chile) and Great Wall station (China).

Five species of Pinnipeds were observed on the Peninsula. These are the Weddell Seal, Crabeater Seal, Sea Leopard, South Fur Sea and Southern Sea Elephant. Fur Seals reconstruct their numbers in recent years, their breeding and beginning of formation of harem groups is observed. In coastal waters, cetaceans are observed, namely, little picked and humpback whales.

5. ANALYSIS OF THE ENVIRONMENTAL IMPACT OF RAE ACTIVITY

In order to perform an analysis of the environmental impact of the expedition activity, it is necessary to identify the impact sources by the main agents of impact and assess the impact significance for impact objects (environmental values and elements).

5.1. Identification of impact sources

The identification of the environmental impact sources is undertaken for all types of the RAE activity in the Antarctic.

The main types (agents) of anthropogenic impact are typically subdivided into:

- Physical (noise, thermal pollution, mechanical and other disturbance of different media);
- Chemical (connected with pollution of different media with chemical substances, communal waste, atmospheric emissions and life activity products);
- Biological (connected with incorporation by man of alien flora and fauna and microbes resulting in the increased mortality in the populations of local animals and disturbance of natural structure and webs in the ecosystems).

The Protocol prohibits using the biological impact sources in the Antarctic without a special permit. Since the studies or operations that have a biological environmental impact are absent in the RAE activity, this type of anthropogenic impact is not considered in the present EIA.

To perform the analysis, all RAE scientific-expedition activities are conventionally subdivided into three groups:

- Logistics operations. They include four types of activity (probable impact sources) – ship, air and ground transport operations and activity at the station (Table 5.1.1.)
- Scientific-research activity. As possible impact sources, the annually repeated routine scientific studies and standard long-term observations (monitoring) are considered as separate types of activities (Table 5.1.2-4).
- Environmental protection. As possible impact sources, the work on the preservation and reconstruction of damaged environmental compartments is considered, namely, flora and fauna observations, collection of garbage and waste disposal (Table 5.1.5.)

We note that for a subsequent determination of the impact significance, it is necessary to take into account the environmental state of the impact area, i.e., to determine whether the activity is undertaken in the station areas – non-recoverable areas (NA) or in the areas of field work or logistics operations – recoverable areas (RA) or in the Antarctic virgin territory – conventionally intact areas (IA).

Identification of the impact areas is based on the descriptions of activities and the environment of the areas where they are to be undertaken.

For the analysis of the environmental impact of RAE activities, the methods employed earlier for the EIA both in the Antarctic and the Arctic were used, in particular, a matrix evaluation method. The matrices are presented below in the form of Tables 5.1.1-5 on all types of all directions of the RAE activity.

The cross in the table cell (X) denotes that the type of activity under consideration is identified as an impact source, as it produces a corresponding agent of impact on the environment of the impact area. It is important to note that one impact source may have several agents of impact. In addition, one and the same agent of impact can be caused by different impact sources, which is necessary to take into account during a subsequent determination of the impact significance in case of coincidence of one and the same impact area.

As can be seen from the tables, most types of activity do not produce the presented agent of impact, i.e. they are not the impact sources and do not participate in further analysis.

Table 5.1.1.
Logistics operations

Agent of impact / Type of activity	Atmospheric emissions (including dust)	Domestic waste	Noise	Fuel spills	Mechanical disturbance	Heat	Impact area
Ship operations	x	-	x	-	x	x	Ship route, location of stay in the areas of Antarctic stations (ITA and RTA)
Air operations	x	-	x	-	-	x	Areas of Antarctic stations, “Station-ship” routes (ITA)
Ground operations	x	-	x	x	x	x	Areas of Antarctic stations and “Mirny-Vostok”, Novolazarevskaya – Coast” routes (ITA and RTA)
Station activity	x	x	x	x	x	x	Current work within the areas of Antarctic stations, practical activity, operation of diesel electrical stations (ITA)

Table 5.1.2.
Basic scientific research in the Southern Polar Area

Agent of impact / Type of activity	Atmospheric emissions (including dust)	Domestic waste	Noise	Fuel spills	Mechanical disturbance	Heat	Impact area
Studies of the atmosphere	-	-	-	-	-	-	Stations (ITA), Area of ship operations
Studies of the cryosphere	x	-	x	-	x	x	Ice sheet area above the lake (RTA)
Studies of the hydrosphere	-	-	-	-	-	-	Area of ship operations
Studies of the lithosphere	-	-	x	-	x	-	Cosmonauts Sea, R/V "Akademik A. Karpinsky" (RTA)
Biological studies	-	-	-	-	-	-	Stations (ITA), Area of ship operations

Table 5.1.3.
Monitoring of natural media of the Antarctic

Agent of impact / Type of activity	Atmospheric emissions (including dust)	Domestic waste	Noise	Fuel spills	Mechanical disturbance	Heat	Impact area
Monitoring of the atmosphere	-	-	-	-	-	-	Stations (ITA)
Monitoring of land and sea ice	-	-	-	-	-	-	Stations (ITA), Area of ship operations
Monitoring of coastal waters and sea level oscillations of the Southern Ocean	-	-	-	-	-	-	Stations (ITA), Area of ship operations
Monitoring of the state of magnetosphere and ionosphere	-	-	-	-	-	-	Stations (ITA)
Seismic monitoring of the Southern Polar Area	-	-	-	-	-	-	Stations (ITA)

Table 5.1.4.
Scientific-applied studies and developments

Agent of impact / Type of activity	Atmospheric emissions (including dust)	Domestic waste	Noise	Fuel spills	Mechanical disturbance	Heat	Impact area
Hydrometeorological services to national activity in the Antarctic	-	-	-	-	-	-	Stations (ITA), Area of ship operations
Navigation-hydrographic activity	-	-	-	-	-	-	Area of ship operations (RTA)
Mapping of ice shores from satellite data with GPS positioning	-	-	-	-	-	-	Area of ship operations (TRA)
Justification and generation of electronic plans of Antarctic stations	-	-	-	-	-	-	Bellingshausen Base (ITA)

Table 5.1.5.
Environmental protection

Agent of impact / Type of activity	Atmospheric emissions (including dust)	Domestic waste	Noise	Fuel spills	Mechanical disturbance	Heat	Impact area
Data acquisition to assess the current environmental status of the areas of Antarctic stations	-	-	-	-	X	-	Station areas (ITA)
Waste collection and disposal	x	x	x	x	X	x	Station areas (ITA)

5.2. Analysis of significance of the expected environmental impact

The analysis of determining the impact significance from undertaking the types of activity identified as an impact source was also performed using a matrix method. The cross in the cells of matrices presented below in the form of Tables 5.2.1-7 denotes those impact objects (environmental values and elements) that are subjected to the corresponding agent of impact from the corresponding impact source (type of activity). The cross absence indicates that the agent of impact under consideration does not have any influence on the impact object.

The impact significance is determined given the types of impacts and the environmental state of the RAE activity areas that are mainly defined as non-recoverable areas (NA). The assessment criterion is a “a minor or transitory impact”. In the event, the impact is assessed as less than a minor or transitory, the activity can be undertaken without additional EIA procedures.

Table 5.2.1.
Ship operations (RTA, ITA)

Impact object / Agent of impact	Flora	Fauna	Sea ice	Air	Impact significance
Atmospheric emissions (including dust)	-	-	-	x	Less than a minor or transitory impact
Noise	-	x	-	-	Less than a minor or transitory impact
Mechanical disturbance	-	-	x	-	Less than a minor or transitory impact
Heat	-	-	-	x	Less than a minor or transitory impact

Table 5.2.2.
Air operations (ITA)

Impact object / Agent of impact	Flora	Fauna	Ice	Snow	Lakes	Soil	Air	Impact significance
Atmospheric emissions (including dust)	-	-	-	x	-	-	x	Less than a minor or transitory impact
Noise	-	x	-	-	-	-	-	Less than a minor or transitory impact
Heat	-	-	-	-	-	-	x	Less than a minor or transitory impact

Table 5.2.3.
Ground transport operations at the stations (ITA) and along the “Mirny–Vostok” and “Novolazarevskaya – Coast” (RTA) routes

Impact object / Agent of impact	Flora	Fauna	Ice	Snow	Lakes	Soil	Air	Impact significance
Atmospheric emissions (including dust)	x	-	-	-	-	-	x	Less than a minor or transitory impact
Noise	-	x	-	-	-	-	-	Less than a minor or transitory impact
Fuel spills	-	-	X	x	-	x	-	Less than a minor or transitory impact
Mechanical disturbance	-	-	X	-	-	x	-	Less than a minor or transitory impact
Heat	-	-	-	-	-	-	x	Less than a minor or transitory impact

Table 5.2.4.
Station activity (permanent long-term activity within the ITA)

Impact object Agent of impact	Flora	Fauna	Ice	Snow	Lakes	Soil	Air	Impact significance
Atmospheric emissions (including dust)	x	-	X	-	x	-	x	Impact from the station activity is within the existing impact scale being not beyond the limits of the present changes of the ITA environmental parameters
Domestic waste	-	-	-	-	x	x	-	
Noise	-	x	-	-	-	-	-	
Fuel spills	-	-	-	-	x	x	-	
Mechanical disturbance	-	-	X	-	-	x	-	
Heat	-	-	-	-	-	-	x	

Table 5.2.5.
Study of the cryosphere (Vostok station, ITA, RTA)

Impact object Agent of impact	Flora	Fauna	Ice	Snow	Lakes	Soil	Air	Impact significance
Atmospheric emissions (including dust)	-	-	x	x	-	-	X	Less than a minor or transitory impact
Noise	-	-	-	-	-	-	-	No impact
Mechanical disturbance	-	-	x	x	-	-	-	Less than a minor or transitory impact
Heat	-	-	-	-	-	-	x	Less than a minor or transitory impact

Table 5.2.6.
Study of the lithosphere (RTA)

Impact object Agent of impact	Flora	Fauna	Ice	Snow	Lakes	Soil	Air	Impact significance
Noise	-	x	-	-	-	-	-	Less than a minor or transitory impact
Mechanical disturbance	-	-	-	-	x	-	-	Less than a minor or transitory impact

Table 5.2.7.
Environmental protection (ITA)

Impact object / Agent of impact	Flora	Fauna	Ice	Snow	Lakes	Soil	Air	Impact significance
Atmospheric emissions (including dust)	x	-	-	x	x	-	x	Less than a minor or transitory impact
Domestic waste	-	-	-	x	x	x	-	Less than a minor or transitory impact
Noise	-	x	-	-	-	-	-	Less than a minor or transitory impact
Fuel spills	x	-	X	x	-	x	-	Less than a minor or transitory impact
Mechanical disturbance	-	-	X	x	-	x	-	Less than a minor or transitory impact
Heat	-	-	-	-	-	-	x	Less than a minor or transitory impact

5.3. The most significant of the expected environmental impacts

Based on the matrix analysis made, the most significant impact by the number of sources will result from the activity of waste disposal at the stations where a secondary pollution of the environment is possible by garbage, dust and accidental spills of used fuel stored in old corroded containers. However, these impacts will occur within the limits of the stations, namely in non-recoverable areas (NA), i.e. within the existing changes of environmental parameters.

5.4. Possible total impact of proposed activity in combination with other types of activity

The RAE activity at the Bellingshausen station will be carried out in the area where other Antarctic national programs and operators work (in particular, tourist operators). In this case, a summation of the environmental impact from their joint activity occurs. However, the Fildes Peninsula area belongs to the category of in non-recoverable areas (NA), in respect of which there should be a special approach to management and assessment (see section 2). Thus, even in the event of a joint activity of RAE and other operators in the indicated areas, the expected impact will not be greater than a minor or transitory impact.

5.5 Coordination with management plans of the areas

RAE operates in the framework of the administration-practical activity of the stations and bases of the Russian Antarctic Expeditions.

5.6. Compatibility with other types of activity in these areas

The RAE activity was agreed upon in the framework of research programs and was considered compatible with the other types of activity in the corresponding areas.

5.7. Alternative types of activity (compared with the proposed activity by the extent of environmental impact)

There are none.

5.8 Proposals to mitigate the environmental impact
A document was prepared on planning waste disposal at the Russian Antarctic stations and ships. At present, garbage disposal at the stations and ships is carried out in strict compliance with the existing instructions that temporarily substitute the Waste Disposal Plans.

5.9. Specific conditions for implementation of activity
The RAE activity is carried out under the conditions of untimely and insufficient funding during the non-optimal time frame for the seasonal logistics operations.

5.10 Personnel responsible for observing nature protection requirements
During the period of seasonal operations onboard a ship – Head of the next seasonal RAE. At the stations – Heads of the stations.

6. CONCLUSIONS

The preliminary EIA stage has revealed that all types of activity under consideration undertaken by the Russian Antarctic Expedition in the Antarctic, have a less than minor or transitory impact on the environment.
The RAE activity in the framework of the terms considered and types of activity presented can be carried out without additional EIA procedures.

7. ORGANIZATION UNDERTAKING THE ENVIRONMENTAL IMPACT ASSESSMENT OF THE ACTIVITY PLANNED IN THE ANTARCTIC

JSC "Institute of Geoecology"
109017 Moscow, Staromonetny per., 29
License G 187404
Registration No. M 97/0808/020/L of 27.01.1998.
Responsible executor - Gavrilo Maria V.;
((812) 1646818, maria@yai.usr.pu.ru)

8. REFERENCES

1. Protocol on Environmental Protection: Adopted in Madrid in 1991.
2. Guidelines for Environmental Impact Assessment in Antarctica: XXIII ATCM/WP (Lima, Peru, May 1999).
3. List of data to be included to the information on environmental impact assessment of the activity planned in the Antarctic Treaty area: adopted by the order of Roshydromet No. 139 of December 12, 1999.
4. On the activity of the Russian Antarctic Expedition: Decision of the Russian Federation Government of August 27, 1997, No. 1113.
5. On ensuring the implementation of the Protocol on Environmental Protection to the Antarctic Treaty: Decision of the RF Government of December 18, 1997, No. 1580.

6. On the adoption of the Procedure for consideration and issuance of permits for the activities of Russian individual persons and legal entities in the Antarctic Treaty Area: Decision of the RF Government of December 11, 1998 No. 1476.
7. Developing and understanding of Minor or Transitory: XX ATCM/IP 2 (Utrecht, Holland, April-May 1996).
8. Further understanding of the term Minor of Transitory: XXI ATCM/WP 35 (Christchurch, New Zealand, May 1997).
9. Elementos para la Interpretacion de los Procedimientos de Evaluacion de Impacto Ambiental contenidos en el Anexo I del Protocolo de Madrid: XXI ATCM/IP 55 (Christchurch, New Zealand, May 1997).
10. Application of the "minor or transitory impacts" criterion of EIA in different regions of Antarctica: XXII ATCM/IP 66 (Tromse, Norway, May-June 1998).
11. Environmental Impact Assessment. The role of EIA Guidelines in understanding "Minor or Transitory": XXII ATCM/WP 19 (Tromse, Norway, May-June 1998).
12. On measures to ensure interests of Russia in the Antarctic: Decision of the RF Government of September 9, 1999 No. 1027.
13. Sub-program "Study and Research of the Antarctic": Federal Program "World Ocean" (Federal Service of Russia for Hydrometeorology and Environmental Monitoring), Moscow, 1997.-66p, Ann.
14. Romanov A.A. Ice navigation conditions in the Southern Ocean: Report No. 35 Marine meteorology and related oceanographic activities // WMO/TD-No. 783 – 1996 – 117p.

ANNEXES

ANNEX 1
Protocol on Environmental Protection to the Antarctic Treaty

ANNEX 4
Main evidence on the Russian Antarctic stations and seasonal field bases used in RAE

Name	Coordinates Latitude Longitude	Height above sea level	Date of opening	Numbers of RAE personnel	Number of permanent and temporary structures	Oil storage volume (k t)	Transported RAE fuel
				wintering	season	total	
Mirny	66є33' S 93є01' E	35	13.02.1956	50	-	50	378.0001.000
Novolazarevskaya	70є46' S 11є50' E	102	18.02.1961	22	-	22	231.0400.400
Vostok	78є28' S 106є48' E	3488	16.12.1957	13	13	26	40.3770.200
Progress	69є23' S 76є23' E	64	26.02.1961	-	-	-	30.5000.200
Bellingshausen	62є12' S 58є58' E	16	22.02.1968	-	15	15	129.2900.095
Druzhnaya-4	69є45' S 730є42' E		18.01.87	-	50	50	140.63-

ANNEX 5
TACTICAL-TECHNICAL DATA OF RAE SHIPS

Vessel	Size	Class	Crew	Machinery	Supplies
1. "Akademik A. Karpinsky". Built 1984-04 USSR	Tonnage: 430 t. Main particulars: Length 104.50 m 96.40 m Breadth 16.03 m 10.20 m 5.9 m Height 5.9 m Deadweight 1959 t Displacement 5715 t Speed 14.7 knots	KM L2	Crew 65 persons Including scientific-technical personnel	Power plants - diesel Power 2 (2573 h.p.)	Fuel 1596 т.б.
2. "Akademik Fedorov" Built 1987-09 Finland	Tonnage: 12660 t Main particulars: Length 141.10 m 133.97 m Breadth 23.50 m 13.30 m 8.30 m Height 8.30 m Deadweight 7200 t Displacement 16336 t Speed 16.0 knots	KM ULA2A2	Expedition team 160 people Crew 80 people	Power plants diesel-electric 2 (6000 h.p.) 2 (2250 h.p.)	Fuel 3850 т.б.

ANNEX 6
TACTICAL-TECHNICAL DATA OF AIRCRAFT PARTICIPATING IN RAE AVIATION SUPPORT

Type	Design weight (t)	Max takeoff weight (t)	Fuel	Fuel consumption (kg/h)	Maximum loading (kg)	Suspended weight (kg)	Cruising speed (km/h)	Full refueling (kg)	Flight range (km)	Undercarriage type
MI-8T	7.5	12.0	TS-1	620	4000	Up to 3000	190	2700	750	Wheel
An-2	3.2	5.5	B-91	130	1500	-	180	900	900	Ski

ANNEX 7
Main evidence on diesel electric power stations (DES) at the stations and seasonal field bases used in RAE

Station or base	Purpose of DES	Type of generator	Power, kW
Mirny	Main	AS-806R AS-814R	320 500
	Emergency	AS-816A	500
Novolazarevskaya	Main	AD-200 DGMA-100M1 DGMA-75M1	200 95 75
	Emergency	DGA-48 DES-60P	48 60
Vostok	Main	DGMA-100M1 TM3-DE-104	95 100
	Emergency	DGMA-75M1	75
Progress	Main	DGMA-75M1 AD-60-CAT/400 AD-60-CAT/400	75 60 60
	Emergency	AD-60 AD-30	60 30
Bellingshausen	Main	DGMA-100M1 DGMA-100M1 DGMA-100M1	100 100 100
	Emergency	DGMA-24	24
Druzhnaya-4	Main	DGMA-24 DGMA-30	24 30

ANNEX 8
TRANSPORT VEHICLES AT THE RAE STATIONS AND SEASONAL FIELD BASES

Transport units	Mirny	Novolazarevskaya	Vostok	Progress	Bellingshausen	Drzhnaya-4	Total
Heavy caterpillar tractors ATT, CTT, MTT, DT-30	19	10	1	-	-	2	20
Carriers GTT, GTS, GAZ	2	3	-	4	2	3	11
Crawler tractors Bulldozers	6	2	2	2	1	1	13
Wheel tractors	-	3	-	2	1	-	6
Truck cranes	1	1	1	1	1	-	5
Road-laying machine BAT	1	1	-	-	-	-	2
Special truck-based machinery	1	3	-	1	2	-	7
Amphibian carriers	-	-	-	-	1	-	1
Snowmobiles “Buran”	-	1	1	-	-	-	2
Skidders	-	-	-	1	-	-	1
Excavator	-	-	-	1	-	-	1
TOTAL	**30**	**24**	**5**	**12**	**8**	**6**	**79**