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Ukrainian Antarctic Research for 2006-2007 summer season

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Geological-geophysical research

The geology and geophysics of Antarctica is a special research topic. Complex navy investigations include gravimetrical and magnitometrical survey, echo-sounding, vertical electromagnetic sounding, floor sampling. New materials on morphological-morphometrical peculiarities of relief, break-tectonics, Earth core structure etc were obtained. The results of these works allow creation of spatial-time model of Earth core and upper mantle formation of West part of Antarctic Peninsula.

The trends of geological-geophysical investigations in Antarctica are connected to scientific works in near-Antarctic water area of World Ocean, and first of all – in shelf zone for mineral-raw materials and hydrocarbonates exploration.

Magnetic observatory "Argentine Islands" (Akademik Vernadsky station) is equipped with modern magnitometric apparatus, included in the INTERMAGNET and used for investigations of time-spatial structure of geomagnetic field in Antarctica. This observatory has the longest time series of Earth magnetic field records in Western Antarctic, starting from 1954. Maps of Antarctic magnetic field components and also maps of components secular variations are made.

Biological research

The efforts of leading biologists of Ukraine are directed to structure-functional analysis of Antarctic biocenosis of different hierarchical levels. Ukraine also holds continuous biological monitoring.

One of the main problems of such monitoring is a search of biochemical indicators for estimation of population state. The investigations of biochemical (including oxidative processes) characteristics and element compound of blood carried out by Ukrainian scientists showed that Antarctic species of fish are significantly different from others. This phenomenon is due to adaptation of fish to Antarctic conditions. The survey allowed to determine the peculiarities of macro and micro elements distribution in blood and liver of Antarctic fish depending on species.

By 2006 the inventory of avifauna of Argentine islands, Piterman island, adjacent land and water areas of West shore of Grahams Land near Vernadsky Station. The species composition, number, peculiarities of nested biology, habit of life and propagation of all navy birds species populating the region. A monography "Birds of Argentine Islands and Piterman island" is prepared, summarizing all the ornithological research up to the present day. A detailed description of all 26 birds species of the region was given.

The further plans are more detailed investigations of nested biology of background species, mechanisms of propagation of some species (gentoo and Antarctic penguin, snowy sheathbill, Antarctic skua) to the south of contemporary southern edge of their natural habitat. Some more fundamental research topics are considered.

In 2006 mammal-fauna investigations of the region were started. The species compound, number and habit of life peculiarities of mammals investigation is planned. The investigation of pinniped and cetacean role in Antarctic ecosystem is also suggested. The undertakings for preservation of rare species are planned.

In 2003 at Galindez island, near Vernadsky Station a bio-geographical polygon was positioned of unique Antarctic landscape oasis of glacier, fields of lichen and moss, soils, cascade lakes. An exact topographic map of the polygon was created. All the landscape peculiarities, birds nest and etc are positioned.

The complex approach to Antarctic cenosis investigation allowed secure of microscopic hybrid-producer of anti-cancer melamine. Absolutely new data on phytoviruses and on soil microbiological cenosis was obtained.

For the first time in Antarctic plants (*D. antarctica*) and mosses antigens of viruses of tobacco mosaic, cucumber mosaic and etc were defined. This is evidence on high diversity of antigen determinants of Antarctic plants viruses.

Soil microorganisms were found to be resistant to high concentration of toxic metal such as cuprum, chrome, cadmium, mercury. For the majority of microorganisms these metals are highly toxic at concentration of 1 to 5 mg/l. But Antarctic microorganisms increase at 50-70 mg/l of chrome, cadmium and mercury and at 500-4000 mg/l of cuprum.

For waste treatment on Vernadsky station a technology of microbe metabolism control is effectively used for 4 years.

The terms of Madrid Protocol require utilization of organic waste. The same protocol forbids introduction to Antarctica any microorganisms, including destructors of food waste. This problem is solved by new biotechnology based on microbe metabolism control i.e. introduction of non-toxic elements that direct microorganisms for quick fermentation of food waste. The weight reduction of about 20 times is obtained for 7 to 10 days forming non-toxic gas – nitrogen and carbonic acid. The solid waste is dried out and pressed with plastic for removal from station. The microorganisms' metabolism control technology allows complete utilization of ecologically-hazardous waste from Akademik Vernadsky Station.

The final goal for biological research is determined as creation of theoretical basis for prognosis of pelagian ecosystem state of Atlantic part of the Antarctica, including Antarctic krill and fish stock and development of recommendations for use of these commercial resources. Such task represents both national interests and interests of other countries participating in International Convention of 1980 on preservation and rational use of navy resources of Antarctic region. The methodological basis for this research is complex monitoring of the region ecosystem.

The further monitoring of Antarctic region will allow both direction of ecosystem change and global climatic processes determination.

Medical-physiological research

Medico-biological investigations in Antarctic are made for the following National Program research topics:

- Modernization of medical election of candidates to the expedition.
- Study of peculiarities of human adaptation in Antarctic conditions.
- Investigation of Antarctic conditions influence on human health.
- Development of facilities for prophylaxis and rehabilitation of polar explorers.

It was shown that adaptation of winterers on the station consists of several phases: acute adaptation, functional stress, relative stabilization and depressive phase.

The phase of acute adaptation (Antarctic autumn) is characterized by disorders of normal circadian architectonics of psychical-physiological and visceral functions.

The phase of functional stress (Antarctic winter) becomes evident as a result of complex influence of biorhythmological factors, deprivation, hypodynamics and is characterized by so-called "Antarctic syndrome" and final formation of relations in winterers community.

During relative stabilization phase (Antarctic spring) close relationships are formed in the collective, biorhythms are stabilized.

The final depressive phase (Antarctic summer) is characterized by high anxiety, emotional instability, desynchronization disorders. After return from the expedition evidences of latent hypoxia are found for the winterers.

The obtained data on phases of human adaptation in Antarctica show the importance of further improvement of psychical-physiological accompaniment of expeditions and rehabilitation methods. It is also important to deeper the investigations of extreme Antarctic factors influence on human body.

Physics of atmosphere and near space

Ukrainian station holds continuous monitoring of man-caused radio emission due to conception of anthropogenic influence on "electromagnetic Earth climate". Akademik Vernadsky Antarctic Station has the most sensitive and wide-band electromagnetic receivers (of Ukrainian design) in the world.

Methodical investigations of global thunderstorm activity are also undertaken, having information on climate change around the globe.

One more important and original investigations topics is energetic connection between neutral atmosphere (troposphere) and its ionized part – ionosphere and magnetosphere. The Vernadsky Station first allowed testing a hypothesis of powerful near-surface perturbations (atmospheric fronts influence on electrodynamical parameters of geospace).

Nuclear-physical research of Earth interior and atmosphere

During last years on the basis of experimental investigations held on Vernadsky Station astrogeophysical investigations are conducted by the following major research topics:

1. Investigations of radon emanation and its connection to Earth core tectonics.

Statistical investigations of radon emanation from the Earth core in seismic and aseismic conditions are based on conception of the earthquake as self-organized criticality. Therefore continuous measurements of radon emission on Akademik Vernadsky Antarctic Station are held from 2003. It was shown that spectral density of radon distribution function contains information on time and magnitude of further earthquakes.

2. Investigation of impulse electromagnetic Earth emission (Dicke superradiance) and its correlation with other geophysical fields connected to tectonic phenomenon. Glaciers, Earth core and upper mantle investigation are made by Dicke superradiance geopolariton sounding.

Geopolariton sounding has quiet a long history before finding its application in geological survey. Dicke superradiance geopolaritons bear information on strain state of Earth core allowing investigations of seismic and tectonic phenomenon. Preliminary results of geopolariton measurements showed the possibility of glacier, Earth core and upper mantle structure restoration. Process of year-round data from geopolariton monitoring on Vernadsky station also showed that geopolariton signal carries information on earthquake preparation.

3. Atmospheric aerosol properties investigations and its influence on measurement of ozone quantity in the atmosphere.

With the help of neutron-activation analysis element compound of aerosol in different Earth regions – Ukraine, Slovenia, Antarctica was made. The analysis of measurement result showed that there is a strict correlation between aerosol compounds in all the Earth regions.

Elements not kept within correlation dependency define man-caused pollution of the region.

This correlation dependency allows introduction of 'clean air standard' for the Earth region.

Aerosol particles are multifractal and their size distribution is determined by log-normal distribution. Multifractal light scattering is significantly different from Rayleigh scattering.

The results obtained allow estimate of atmospheric aerosol influence on global climate on the basis of astrogeophysical energy-balance climate theory developed in National Antarctic Scientific Center of Ukraine. Furthermore it is possible to estimate influence of atmospheric aerosol on measured ozone content in the atmosphere, particularly in near-polar regions.

Based on the results obtained, Ukraine plans starting net measurements of radon, aerosols and ozone in different Earth regions.

4. Investigation of possibility of detecting of cosmic rays of ultra high energy from their interaction with Antarctic glaciers.

Interaction of cosmic rays of ultra high energy (>10^{20}eV) with Antarctic glacier leads to formation of a powerful radio-impulse from ice that after reflection from ionosphere may be registered by Akademik Vernadsky Station apparatus. Preliminary process of 2005 year measurements confirms possibility of existence of such particles.

Investigations of "cosmic" neutrons were also held with the help of solid track detectors, processed at Joseph Stephan Institute in Lubliana for energy spectrum of cosmic rays in a wide energy interval determination.

Hydrometeorological investigations

Continuous series of standard meteorological survey at Vernadsky Station is one of the longest in Antarctica starting from 1947. During 10 years of Ukrainian Antarctic expeditions a complex of hydro-meteorological investigations was significantly widened and improved, particularly with oceanographic survey (temperature, saltiness) and glaciers survey.

According to Vernadsky Base temperature data, one of the most significant increases of year average temperature is by 2 degrees for the last 25 years. The warming trend is typical for other stations of Antarctic Peninsula.

The mass balance measurements of "Domestic" glacier (Galindez island) are made weekly for definition of year-to-year variations of mass. It was shown that it has a slow trend to decrease.

Ukrainian and German scientists first in the world identified over 200 volatile organic and inorganic elements at Galindez Island. Time trends for 4 000 years were defined for 26 of these elements. It was found that freons and their substitute accessed the glacier from man-caused sources, while sulfur, bromine, iodine and some chlorine-carbonates were generated by biochemical reactions of micro-alga, phytoplankton and also by photolysis reaction and redox-reactions of organic elements in snow and ice cover of the glacier.

Design of GIS system of Antarctic Peninsula

Topographical-geodesic works are made on the islands and adjacent water areas of Argentine Islands Archipelago using modern GPS system including:

- Definition of accurate geodesic coordinates of stable reference point by long-time GPS observations for estimate of regional lithosphere motions.
- Repeated GPS observations on British triangulation points and widening of geodesic net on Argentine Archipelago Islands.
- Large-scale mapping of topographic peculiarities and ice dome on Galindez Island.
- Ensuring accurate positioning of different measurement points for the Islands, Antarctic Peninsula or sea floor investigations.

According to geodesic GPS observations a local network from over 200 points on Argentine Archipelago was created.

Development and introduction of new technologies

The apparatus of Akademik Vernadsky Station is continuously improved, first of all by Ukrainian devices. New highly accurate devices for geomagnetic field and ionosphere perturbations monitoring were installed that correspond to the characteristics of devices used in INTERMAGNET. The last original device from Lviv center Institute for cosmic research – handheld meteomagnetic stations.

Participation in III IPY

16 Ukrainian projects were submitted to IPY Programme. All these projects were successfully joined to IPY endorsed Projects

1. Investigations of the Earth's inner structure and development of Antarctic electron atlas on the basis of gravimetric tomography method (Endorsed project # 185).
2. West Antarctic lithosphere structure by geologic-geophysical data complex (Endorsed project # 185).
3. Geoelectric model of the Antarctic Peninsula and attached regions (Endorsed project # 185).
4. Population of krill and other pelagic community components of Atlantic part of Antarctica and evaluation of connection between these changes and Earth' global changes (Endorsed project # 131).
5. Monitoring of seismoacoustic, geopolaritonic, geomagnetic fields of radon emanation for earthquakes forecasting and investigation of the nature of energetic processes in the Earth' core, mantle, and crust (Endorsed projects # 185, #77).
6. Development of energobalance model of the Earth' global climate on the basis of monitoring of Antarctic atmosphere parameters (aerosol, ozone), cosmic rays (Endorsed projects # 459, # 217)
7. Search for the most effective melanin producer in Antarctica and investigations of its functional peculiarities (Endorsed projects # 142, # 137).
8. Structural-functional characteristics of microbe senosis in Antarctica. Investigations of microorganisms' role in biochemical elements cycles (Endorsed project # 137).
9. Complex investigation of Antarctic biota (Endorsed project # 137).
10. Ozone layer dynamics and climate changes (Endorsed project # 99).
11. Development of new medical and psycho-physiological technologies of health and efficiency preservation of Antarctic expedition participants (Endorsed project # 341).
12. Development and introduction of new nature protecting biotechnologies in Antarctica (Endorsed project # 454).
13. Creation of geo-information system of west Antarctic region (Endorsed project # 185).
14. Creation of scientific investigations data base in Antarctica (Endorsed project # 49).
15. Investigations of polar geo-spheres with the help of aerospace facilities (Endorsed project # 185).
16. Analysis of transformation of large-scale processes in the South hemisphere troposphere as a result of global climate warming for development of physic-statistical methods of weather forecasting at the Antarctic Peninsula (Endorsed project # 180).