

COSMIC MAPPING OF ANTARCTICA

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Antarctica, the sixth continent of the Earth, is most difficult to reach and is least known territory of the planet featuring a unique environment.

Its territory amounting to about 14 mln.km² carries 87% of ice available on the Earth that includes 85% of fresh water and 60% of water available on land. If antarctic ice is uniformly distributed over the planet, the thickness of ice layer will amount to 50 m.

Our environment can be considered as an integral land-ocean-atmosphere-ice system. This system includes very complicated interrelations and the exchange of energy and water cycling is incessantly taking place. Glaciation plays a very important role in this system as a whole. Glaciation provides for geographical zonality, increases air circulation and, in many cases, dictates the structure of the atmosphere, shapes sea currents, controls the level of the World Ocean and, consequently, the size of the land available for life. Recent glaciological and geological data make it possible to make suggestions about considerable variability of glaciation of Western Antarctica. Ice cover of Western Antarctica may break down during a short period of time equal to about 100 years. In this case, the level of the Ocean will rise by 6 to 7 m that will be fatal for densely populated areas on the Earth. The problem of probable break-down of ice cover in Antarctica is closely connected with ever-growing effect of human activity on the climate. This effect, as many scientists are convinced, results in the rise of the temperature on the Earth. Monitoring of the dynamics of the ice cover and, in particular, determination of the amount of ice

are becoming very important problem facing the mankind. Remote sensing of the Earth from space and data so obtained may greatly contribute to solve these problems.

All now known geological formations are presented in Antarctica beginning with the most ancient ones and ending in comparatively new formations resulting from the processes which created the present geological appearance of the Earth.

Scientific predictions and practical investigations make it possible to assume that the sixth continent contains great amount of minerals.

The international law for mining and production of minerals of the continent is still under elaboration. The problem of development of the resources in Antarctica faces with great technical and organizational difficulties and it is very difficult to assess the effect human activity on the environment of the continent. But, ever-growing needs of the world community in minerals, particularly in fresh water, will inevitably lead in the nearest future to exploitation of the natural resources in Antarctica. This shall be preceded with investigations in the fields of geology, glaciology, ecology, and cartography.

The present status of Antarctica from the international point of view is regulated by the international treaty on Antarctica signed by 12 countries in 1959. Then, other countries have also signed the treaty. According to the treaty, the territory of Antarctica shall be exploited for the purposes of peace only and shall not be used as a field or subject of international disagreement. No country shall be denied the right to explore this continent.

The USSR is among the countries signed the treaty on Antarctica in 1959 and the Soviet Union supports the international legal rules established for development of the resources of the continent with the purpose of peace only.

The USSR takes an active part in large-scale exploration of the sixth continent by sending expeditions there.

Important is the work to map the territory of the continent. This work in the USSR shall be carried out by the Main Administration of Geodesy and Cartography. Topographic maps and photomaps at scales of 1:1,000,000 and 1:200,000 serve as a basis for making various

thematic maps and are also used in air navigation.

Topographic maps are compiled in compliance with the requirements for accuracy, detailedness, and appearance established for the USSR made topographic maps. These requirements include those worked out by a Working Group on Geodesy and cartography at the Scientific Committee on Antarctic Research (SCAR) working on the basis of the Treaty on Antarctica, 1959. Maps are made in the unified international system of coordinates, in the equal-angle transverse cylindrical Gauss projection and, to the south from 84° parallel, in the azimuthal equal-angle projection. Altitudes of objects on the terrain are determined with respect to the level of the Antarctic ocean. Land relief is shown by means of contours made every 50 m for maps of scale equal to 1:200,200. On maps^{at} scale of 1:1,000,000, contour interval is established equal to 50 m, 100 m, and 200 m, depending on altitude belts.

Traditional methods of topographic surveying in Antarctica are very cost and dangerous and consume much labour. Therefore, topographic surveys of the sixth continent at scales of 1:1,000,000 and 1:200,000 are carried out in the USSR only on the basis of materials of remote sensing with the use of the USSR "Cosmos" series satellites equipped with high-resolution cameras.

Space surveying of Antarctica is performed at two scales viz. 1:1,300,000 to 1:1,500,000 and 1:250,000 to 1:300,000. Small-scale materials are used for constructing horizontal-vertical control and stereophotogrammetric survey of the terrain. Larger scale materials are used for making photomosaics at a scale of 1:200,000 and for interpretation of objects.

Both theoretically and practically, the main problem in mapping hard-to-reach territories is obtaining of horizontal-vertical control of topographic surveys. In the USSR, this problem is solved with the help of traditional analytical phototriangulation and laws controlling the movement of earth satellites on the near-earth orbit. Elaborated are the procedure, algorithm and set of programs of bridge and block phototriangulation which make it possible to create the ground survey control without the ground and aerial surveys.

The essence of analytical phototriangulation with the use of

space data boils down to accounting for spatial-time parameters of satellite movement that can be described by means of a set of differential equations. By integration of these equations, we find the coordinates of the center of mass of the satellites as a time function that makes it possible to determine elements of exterior orientation of photos with practicable accuracy. Further on, the problem generally boils down to phototriangulation adjustment with the use of additional data irrespective of determined elements of exterior orientation including angular elements defined from photos of stars.

Linear elements of exterior orientation of photos, i.e. the coordinates of the centre of projection, are determined by solving six differential equations describing satellite movement and accounting for the disturbances of satellite orbital movement caused by irregular distribution of the Earth mass and air drag at the altitude of flight. Other disturbing factors, attraction by the Moon, Sun, other stars, sun light pressure, aerodynamic and electromagnetic forces do not noticeable affect the geometry of satellite orbit at altitudes of flight between 200 and 300 km.

As observations performed during many years show the effect of disturbing factors on the evolution of a satellite orbit result in deviation of the assumed parameters of the orbit during a complete turn (over 40,000 km) equal to about 1.5 to 3 km. along the orbit and 50 to 150 m in altitude and lateral direction. Practically, the accuracy of coordinates of centers of projection depends on the errors in parameters of initial conditions of integration of the differential equations of movement and errors in measurement of planimetric coordinates judging from photos. If it is possible to determine the initial conditions of integration by base stations whose coordinates are known, the accuracy of linear elements of exterior orientation will depend on errors in measurement of coordinates judging from photos and errors in coordinates of initial stations.

Angular elements of exterior orientation are determined as functions of coordinates of the centers of protection and elements of relative orientation. The angular elements of orientation can

also be defined from photos of star background.

The technique of analytical phototriangulation with the use of space photos depends on functioning of independent programs for solving the sets of differential equations of satellite movement by means of numerical integration using the Runge-Kutt and Adams methods, modifies mathematical model of phototriangulation with the use of conditions of colinearity and laws of satellite movement and the stochastic model of accounting for different additional information including the analysis of the quality of source data required for determining the parameters of initial conditions.

The algorithm for solving a large set of equations uses the peculiarities of a tape matrix of coefficients of sets of equations that makes it possible to greatly reduce machine time.

In case of stereophotogrammetric survey of the relief with the use of space photos, it is necessary to take into consideration the effect of the curvature of the earth surface. In this case, it is advisable to use high-accuracy, stereophotogrammetric instruments of an analytical type. Such instruments automatically take into account the said effect alongside high accuracy of measurements.

When analog-type instruments are used, stereotopographic survey with the use of space photos is possible within the amount of effect of earth curvature is smaller than measurement errors.

Analog-type instruments are less efficient than analytical-type ones and their accuracy is worse.

Interpretation of objects is accomplished by means of photos made at a scale of 1:200,000. The limited number of objects to interpreted and relative similarity of landscapes in Antarctica have made it possible to work out the procedure oriented only to office interpretation technology with the use of standards tested during the work of the Soviet expeditions of Antarctica.

The procedure contains recommendations on interpretation of basic topographic objects in Antarctica including description of their interpretation features and is accompanied with the album of standards for interpretation of space photos of typical landscapes.

Originals of stereotopographic surveys are, usually, made on the basis of photomosaics compiled by traditional methods with the use of rectifying instruments or analytically. Photomosaics are

used also for making photomaps in polygraphic presentation.

Practically, air navigation work performed in Antarctica widely uses single photos with a coordinate grid which are rectified to a specified projection. These photos are obtained by means of digital technique with the use of a computer and image input/output units.

In summary, it may be said that the technology of mapping with the use of space photos is highly efficient from the economic point of view and can be used for studying hard-to-reach areas. High rates of scientific and technical progress in the field of remote sensing from space provide favourable conditions for increasing the number of applications of the technology of mapping with the use of space photos since such approach makes it possible to change over to large-scale mapping.

For processing space photos, use shall be made of precision equipment for measuring coordinates, rectifying space photos, and interpreting these photos. As practice shows, very good are the equipment manufactured by VEB "Carl Zeiss" (GDR). This equipment includes a stereocomparator, type "Stecometer", for measuring coordinates, rectifying instrument, type "Rectimat"; interpreting instrument, type "Interpretoscope".

If rectification is accomplished by means of digital technique use is also made of image input/output units, type ФЕАГ-200 interfaced with the USSR made computer CM1420 and computer EC-1055M manufactured by the VEB "Robotron", GDR.

Materials Presented on Exhibition Boards

Base material of boards - pressboard, 50x50 cm, lined with white paper.

Board No.1.

1. Stereoscopic pairs, 18x18 cm, scale 1:1,300,000.
2. Digital photo, scale 1:1,000,000, grid format 25x25 cm.

Board No.2.

1. Topographic map, scale 1:200,000.

Board No.3.

1. Photomap, scale 1:200,000 (polygraphic reproduction)

Board No.4.

1. Enlarged photo, size about 42x42 cm, scale 1:200,000 (taken at scale of 1:250,000 to 1:280,000) covering a part of a map.

Board No.5.

1. Photos, size 18x18 cm, describing dynamics of coastal zone.

Board No.6.

1. Several landscapes pictures taken by means of a photographic camera.