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SOME FEATURES OF THE GEOLOGICAL STRUCTURE, GEOMORPHOLOGY AND DEVELOPMENT OF THE PLATON MOUNTAINS (EASTERN ATLANTIC OCEAN)

Keywords: submarine mountains, Atlantic Ocean, ore formation, biological productivity.

This paper deals with some structural features of the Platon Uplift (Southern Azores Submarine Mountains, Eastern Atlantic Ocean) (Fig. 1). Investigations of the geomorphologic and structural-tectonic peculiarities, composition of solid and sedimentary rocks, lithology of bottom sediments promote the more substantiated notions about the nature of this uplift.

The basic data for this paper were collected by V. Morozenko during sea expeditions of scientific ships "Odissey" (32nd trip) and "Mikhail Lomonosov" (49th trip); also information from the Marine Geology Department (IGS NASU) and data for over 1,500 miles of precious echograms are accounted. In the margins of the Platon Uplift, sampling was carried out using pipe and bottom “Okean-50” samplers. To obtain reliable evidences about solid rocks of the region, 17 dragging were made with large cylindrical drag. Submarine investigations (V. Morozenko participated in 12 plunges) were made using “Sever-2” manned vehicle. They included visual observations, photographing, fixed sampling of coarse clastic material. 78 samples were studied in detail in laboratories of IGS and Lviv State University.

The obtained results can be used for paleotectonic reconstructions of this oceanic region as well as for recognition of higher mineralization zones and new recovery areas of biological species.

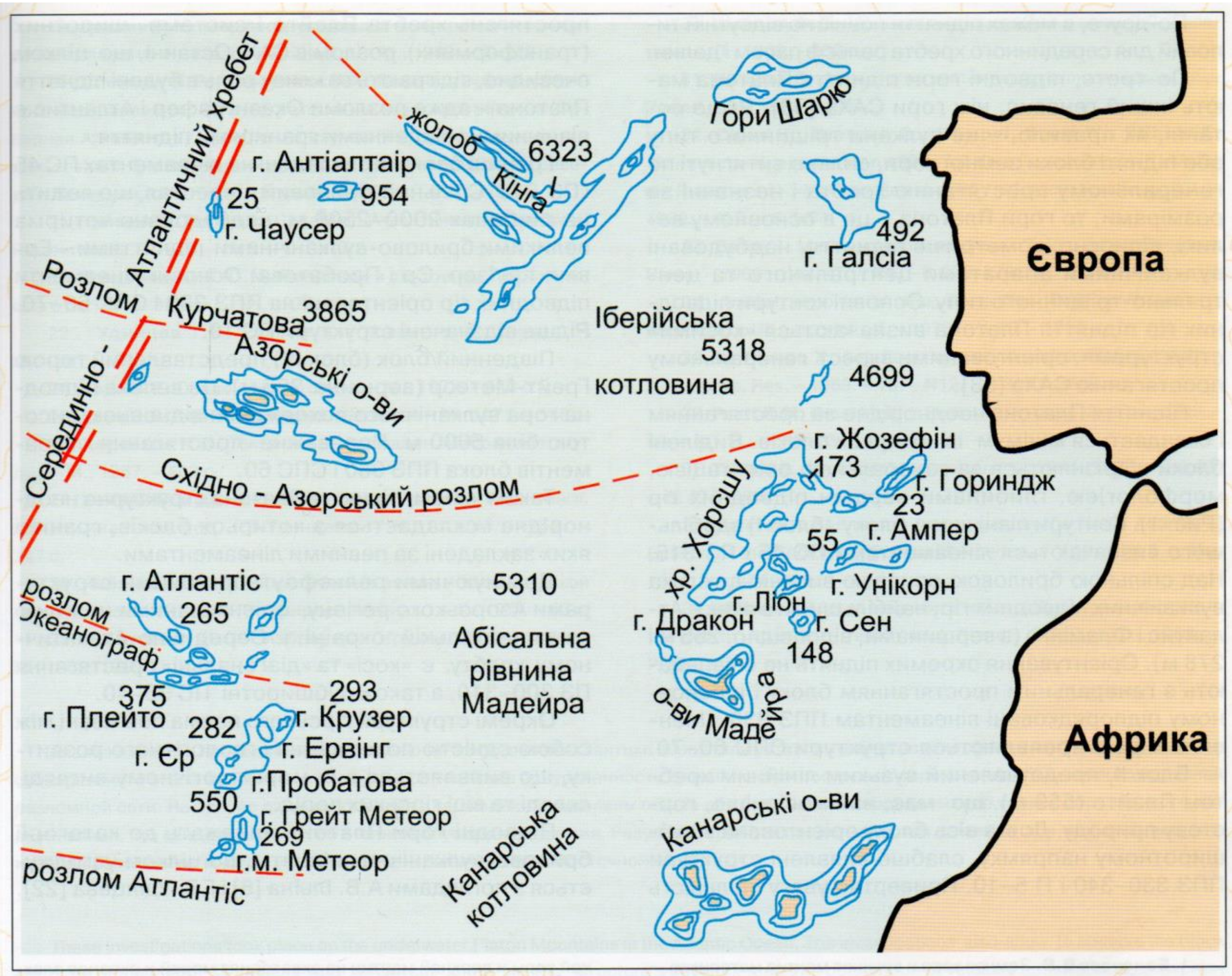

Fig.1 – **Map-scheme of Azorean Region(Western Atlantic)**

Investigation history

In geological aspect, the investigation history of the Platon Mountains is directly tied with geological study of the whole Atlantic Ocean. The earth crust of the Central Atlantic Ocean demonstrates manifestations of unique geological processes without which understanding it is impossible to reconstruct the complete sequence of geological development.

The modern notions about origin and development of oceanic bottom are mostly based on the theory of lithospheric plates. But in 1980-1990s the concept of intraplate tectonics appears as well as a number of other ones, which spread the idea of the uniformity of tectonic processes on the oceanic bottom [11, 5].

Therefore, investigations of transitional type structures during their interim development obtain a special importance. The aseismic ridges and uplifts belong to those structures; they structurally and genetically differ from seismically active riftogenous mid-ocean ridges [3, 4] including also the Platon Uplift.

First studies of the bottom relief in the Central Atlantic Ocean were made else in late 1800s by American expeditions on ships “Challenger” and “Albatros”. In the first decades of XX Cnt., the US Hydrographic Service had discovered numerous submarine mountains including mountains of so-called Southern Azores Mountains and Uplifts – Platon Mountains. By they were studied only in general. A special interest to investigation of the open ocean’s part appeared after WW II. The Lamont Geological Observatory carried out seismic profiling of the region for the study of sedimentary cover.

In 1965, the Scripps Oceanographic Institute, Lamont Geological Observatory and other geological institutions of the USA developed the Deep-Sea Drilling Project (DSDP). Till 1972, the special drilling ship “Glomar Challenger” had drilled the Central sector of the Eastern Atlantic Ocean. The boreholes penetrated the whole sedimentary sequence and taped the basement in the Canary Caldron near Canary, Madeira, Azores, Azores-Gibraltar Zone (b/h 136, 137, 138).

B/h 414 was drilled in 49th trip of “Glomar Challenger” (1976) directly in the central part of the PlatonUplift, in the location of Arwing and Cruiser submarine mountains [10].

The section did not permit to obtain a clearer pattern of the uplift’s geological structure due to restricted possibilities.

In the late 1970s-1980s, accounting a principal importance of those investigations, native scientists passed a geological-geophysical geotraverse in the Central Atlantic Ocean. The participants of these works were the production associations “Sevmorgeologia” and “Yuzhmorgeologia” (Ministry of Geology of USSR) and Institute of Physics of the Earth (Academy of Sciences of USSR). Those works proceeded from the results of preceding surveys: magnetic, gravimetric, seismometric. The main purpose was to elucidate the deep structure of the aquatory’s bottom. It was solved by PA “Okeangeologia” (leaders E. M. Litvinov, I.S. Gramberg), Active participants were geophysicians of the Moscow State University (A. G. Gaynanov), Institute of Oceanology, AS of USSR (V.M. Litvin).

In 1985, accordingly to plans in the frames of projects “Sediment” (under scientific leadership by P.P. Timofeev, Correspondent Member of AS of USSR) and “Lithos” (Academician Yu.M. Pushcharovsky), the first trip of scientific ship “Academician Nikolay Strakhov” was carried out [2].

The main scientific aim of that trip was to made a number of geological, geophysical, lithological, lithological, petrographic, geochemical investigations of recent deposits, sedimentary and volcanic rocks in some regions of the eastern sector in the Central Atlantic Ocean including Atlantis Uplift (Platon Mountain). To raise objectivity of further conclusions, the investigations were carried out in the regional frames – one class of oceanic structures was examined.

Since 1980s, Yu. Bogdanovich and N. Lisitsin [1] used the submarine vehicle (SV) "Pisces" for geological researches of the Plato Uplift and other submarine mountain in that region. Scientific ships "Ikhtiandr" and "Odissey" (Sevastopol Experimental Design Bureau) maintained a number of plunges down to 2,000 m using SV "Sever-2" (North-2"). V.R. Morozenko participated these works. Tops and slopes of submarine mountains were investigated; the route submarine geological survey was made.

Geological and geomorphologic investigations

The obtained data enabled to recognize structure features of the submarine mountains in discussion, formulate a new approach to the region development history and to outline the main tectonic evolution stages. Detailed geological and geomorphologic studies using SVs demonstrated that each of submarine mountains at the Platon Uplift has characteristic individual features of morphology and structure. The structural non-uniformity of the uplift is clearly manifested in the peculiarities of the morphology and structure of each of for recognized blocks [8,9].

We know that thick (up to 1,700 m) caps of Miocene reefogenous limestones overbuild the highest submarine mountains in the region under investigation. The sedimentary sequences are based over basalt conglomerates (depth 1.9-2.0 km) containing pebbles of alkaline basalts and trachyandesites. This enables their comparison with volcanic formations of the Azores [2].

Reefogenous limestones are broken by some fracture systems. Submarine observations demonstrated that directions of fracture zones are substantially changed upward in the section that is probably related to the changing directions of tectonic dispositions in the time where reefogenous structures formed. The fracture systems N-NW 330° and E-NE 60-70° are of regional importance and traced at the all investigated submarine mountains. Local manifestations are observed for the dislocation systems N10°, E 90°, N-NE 30°. The sequence of the upward changes of fracture directions is individual for each submarine mountain.

Iron-manganese ore shows are related to the tectonic dislocations. The ore matter is often concentrated directly in the fracture zones. In this connection, they have a sharp difference in colour relatively light grey enclosing limestones.

We have recognized that the majority of submarine mountains passed the development stage of normal atolls; planation of their tops became a result of abrasional-erosional processes during the subaerial development stage that was recognized directly from the "Sever-2" SV. Fig.2. Differences of the depths, where the tops of guyots occur, are probably a result of differentiated tectonic movements. It manifests in the better planation of the tops of higher guyots (Arwing –225m, Great Meteor – 256 m) in comparison with relatively low ones (Atlantis –278 m, Yer –280m). A less clear trend to subsidence of Arwing and Meteor mountains determined a more duration of the subaerial stage and, as a consequence, more complete planation of their tops.

The uneven subsidence of different submarine mountains is especially clear manifests in the margins of block III. Mountains Criuser (293 m), Yer (280 m), Probatova (550 m) are situated at the block periphery, their tops are somewhat deeper and planarion is worse than at Arwing Mountain, which occupies the central position. Evidently, subsidence process was manifested most intensively in the marginal parts of the block. It was accompanied by tectonic fragmentation of the volcanic base of the mountains and reef structures, which crown them, and also by forming of cuesta-type structures (Yer Mountain). The top of this mountain has a clear inclination towards SE due to uneven subsidence of distal areas of its base.

As compared with other mountains in block III, the Arwing Mountain is a relatively stable location with less expressed trend to subsidence. It is a typical volcano overbuilt by a thick cap of reefogenous limestones. Processes of relief tectonic rebuilding are easily manifested there.

The similar regularity – rising amplitudes of uplift tectonic movements and their higher differentiation from the center towards periphery – is observed also in the margins of block I. The top of Atlantis Mountain is deeper situated and less planated than Flamingo Mountain top.

Generalizing these evidences it is possible to note the main directions in the tectonic evolution of the region. The feature of the geological history of the Plato Uplift is the stadial character of tectonic activation, changes of relief-forming dislocations strikes in the time. May be, the structures determining base contours of elevated blocks I, III, IV are oldest: NW 315°, NE 45°, E 90°. Just then the individuality of blocks appeared; their further development passed individually.

The next stage of tectonic-magmatic activation of the region was forming of large volcanoes of central and central-fracture types. Powerful lava outflows resulted in the appearance of volcanic structures of mountains Atlantis, Flamingo, Arwing, Cruiser, Meteor. During this stage, the main relief-forming inportance passes to the structures N-NW 330°, E-NE 60-70°. The earth crust on which the submarine mountains were built is dated as not earlier than Oligocene [7,11].

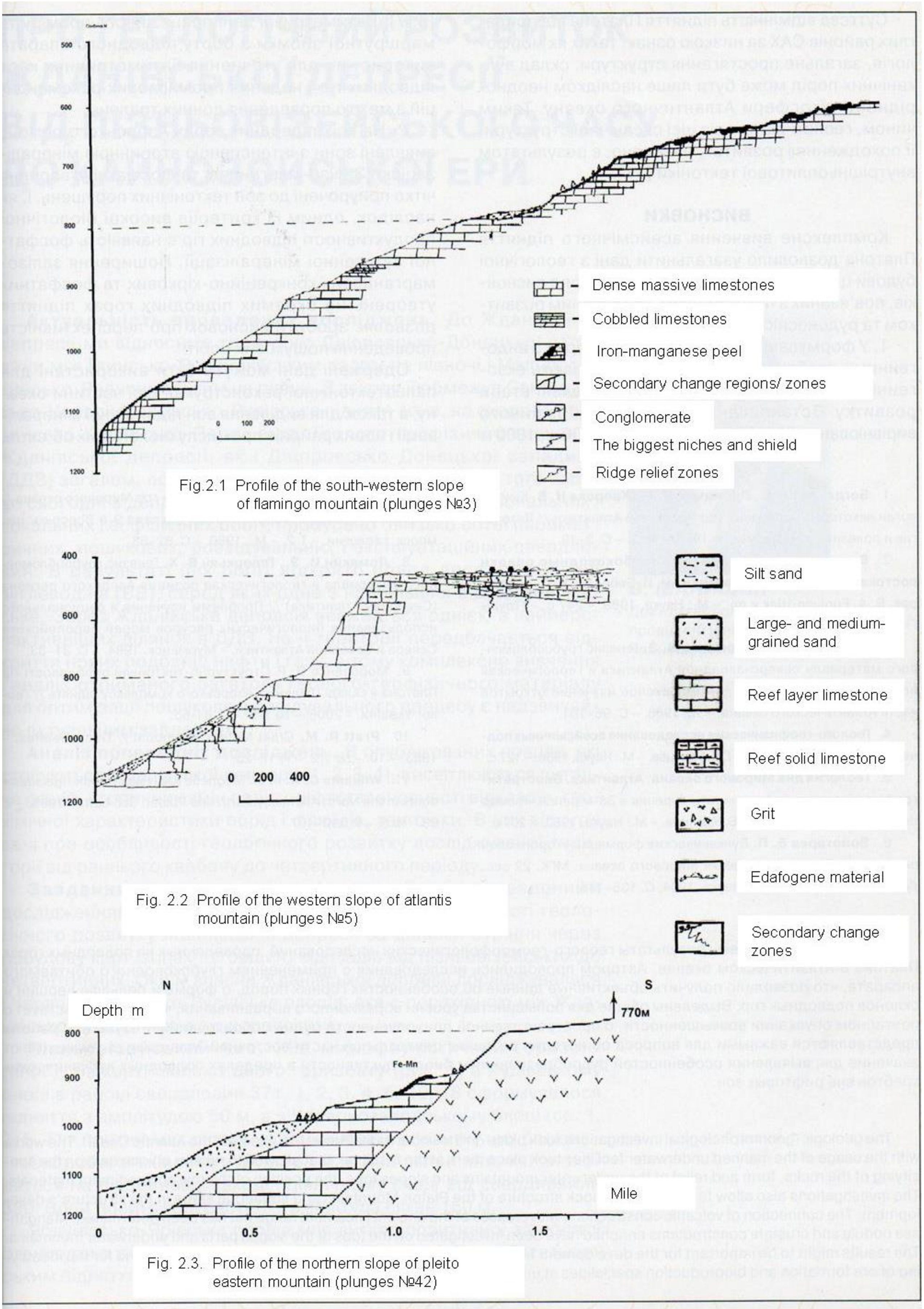

Fig.2.1 Profile of the south-western slope of flamingo mountain (plunges №3)

Fig. 2.2 Profile of the western slope of atlantis mountain (plunges №5)

Fig. 2.3. Profile of the northern slope of pleito eastern mountain (plunges №42)

At the dawn of the Miocene, third stages began – an intense subsidence of these blocks of the Plato Uplift that caused the formation of thick sequences of reefogenous limestones (up to 1,700 m). The subsidence was preceded by the washing out of volcanites; the limestone sections were accumulated over basal conglomerates [2, 8].

The total subsidence was accompanied by differentially directed tectonic movements that resulted in the appearance of several systems of tectonic dislocations. It caused the development of fracture zones in the sedimentary sequence. As previously, the faults N-NW 330° and E-NE 60-70° had the regional importance. Therefore, the direction of active structures did not change substantially since the second stage.

Short-term uplifts or eustatic fluctuations of the oceanic level were the cause of abrasional-erosional transformations of the top relief of reef structures. The most complete planation took place in the central parts of blocks I and III (mountains Flamingo and Arwing) as well as on the Great Meteor Mountain. The periphery parts of the blocks subsided more intensively therefore tops of the mountains Atlantis, Yer, Probatova, Cruiser were planated worse.

There, in the marginal parts of the blocks differentiated tectonic movements ("key tectonics") manifested. These processes resulted in the tectonic fragmentation of volcanic and reefogenous structures, formation of chop cliffs, cuestas. The recent differences in the depth of submarine mountains at the Platon Uplift, probably, also is a result of earth crust differentiated movements. In spite of that, parts of the ridge developed in the single rhythm as a whole.

Substantial differences between the Platon Mountain and adjacent regions of the Mid-Atlantic Ridge in some features (morphology, general strike, composition of volcanic rocks) can be only a consequence of the non-uniformity of lithosphere in the Atlantic Ocean. Therefore, the geological history of this oceanic structure, its origin and development, evidently, is a result of intraplate tectonics [11].

The integral study of the aseismic Platon Uplift enabled to generalize data on the geological structure of this region and to formulate a number of conclusions related to its origin, geological development and ore presence.

Conclusion

The relief of the uplift was formed not only by the endogenous processes but also with especially important role of exogenous ones during the numerous subaerial stages of development. The common levels of abrasional planation: 30-500; 800-900; 1,200; 1,800 m [6,7]. Precision bathymetric data and route survey from the submarine vehicle enabled to specify bathymetric maps of the submarine mountains and give recommendations for bottom dragging.

Zones of intense secondary mineralization are known at all submarine mountains of the Azores Region. Iron-manganese and phosphatic accumulations are clearly related to the tectonic dislocation zones. As a result, the presence of phosphatic authigenic formation is amongst the criteria of high biological productivity of submarine mountains.

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Морозенко В. Р. **Особливості геологічної будови, геморфології та розвитку гір Платона (Східна Атлантика).** В роботі наведені результати геолого-геоморфологічних досліджень, що проводились на підводних горах Платона в Атлантичному океані. Виконані спостереження та відбір зразків з борту глибоководного апарату «Сєвєр-2». Отримано об'єктивні дані щодо особливостей гірських порід, форми і рельєфу вершин та схилів підводних гір, виділені загальні рівні абразійного вирівнювання, що свідчить про етапне занурення піднять та закономірності розташування рудоносних утворень. Результати роботи мають суттєве значення для рішення питань історії розвитку центральної частини Східної Атлантики, а також для виявлення особливостей рудоутворення і біопродуктивності в районах підводних вулканічних хребтів за межами рифтових зон.

Ключові слова: підводні гори, Атлантичний океан, глибоководний апарат, рудоутворення і біопродуктивність.

Morozenko V. R. **Some features of the geological structure, geomorphology and development of the Platonn Mountains (Eastern Atlantic Ocean).** The results of geologic and geomorphologic studies carried out using submarine manned vehicles are discussed in the paper. That investigation involved the submarine Platon Mountains, Atlantic Ocean. Those studies enabled to obtain quite objective data of rock features, forms and relief of the tops and slopes of submarine mountains. The general levels of abrasional planation were recognised those testified to the stadial subsidence of the uplift and spatial relations of ore accumulations. The results are considered as important for solving the problems of the Central Atlantic Ocean's development and recognition of features of the ore formation and higher biological productivity areas within the submarine volcanic ridges off the rift zones.

Keywords: submarine mountains, Atlantic Ocean, ore formation, biological productivity.

Морозенко В. Р. **Особенности геологического строения, геоморфологии и развития гор Платона (Восточная Атлантика).** В работе приводятся результаты геолого-геоморфологических исследований, проведенных на подводных горах Платона в Атлантическом океане. Исследования проводились с борта глубоководного обитаемого аппарата «Север-2», что позволило получить объективные данные об особенностях горных пород, о форме и рельефе вершин и склонов подводных гор. Выделены общие уровни абразионного выравнивания, что свидетельствует об этапном опускании поднятия, о пространственной приуроченности рудных образований. Результаты работы представляются важными для решения вопросов истории развития центральной части восточной Атлантики, а также имеют значение для выявления особенностей рудообразования и биопродуктивности в пределах подводных вулканических хребтов вне рифтовых зон.

Ключевые слова: подводные горы, Атлантический океан, глубоководный обитаемый аппарат, рудообразования и биопродуктивность.

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