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OCEANOLOGY

The Hubert Miller Seamount, Marie Byrd Seamounts Province, West Antarctic, Southern Ocean

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The northern mountainous province of the underwater margin of Marie Byrd Land (MBL) is named the Marie Byrd Seamounts. Until recently, the relief of this segment of the continental slope of West Antarctica was poorly known. The maps based on satellite altimetry data [1] and multibeam echo sounding survey carried out by several cruises demonstrated that this structure represents a chain of approximately 20 seamounts. It is located in the Amundsen Sea north of the MBL about 300 miles from the margin of the Pine Island Bay shelf and extends in the latitudinal direction between 68° and 70° S from 115° to 130° W (Fig. 1). One of the largest seamounts from this group, which was named after a German geophysicist, was first studied in 2001. The geological–geophysical data suggest that the Hubert Miller Seamount (HBS) formed in the course of volcanotectonic reworking of the MBL margin in response to geodynamic development of the Tasman–Antarctic gateway in the Southern Ocean (Figs. 2, 3).

The basement of the MBL continental slope has a complicated block structure, which is however smoothed by a thick sedimentary cover [2] (Fig. 4). At depths of ~3000–4000 m, the surface of the steep slope is replaced by a flat accumulative apron that envelops foothills of seamounts and grades into the abyssal plain of the Amundsen Basin at a depth of approximately 5000 m. A substantial role in the formation of this apron belongs to mudflows and deep-sea channels (see maps compiled by Heezen and Tharp [3] and GEBCO (sheets 5.15 and 5.18 [4]).

Detailed multibeam echosounding in the HMS area (69°17′ S, 121°20′ W) was first carried out in Cruise ANT-18/5a of the R/V *Polarstern*. The seamount represents a massive block elongated along the azimuth of 330° and outlined by the isobath of 3500 m. The seamount is approximately 75 km long and 55 km wide. Its transverse profile along the azimuth of 60° is asymmetrical: the northeastern slope is steep and rectilinear, while the southwestern one is gentle and undulating in shape (Figs. 2, 3).

The summit of the HMS is almost flat with a smooth gentle arch located at depths ranging from 1600 to 1200 m. The summit area contoured by the isobath 1500 m is 40 × 22 km. The summit was leveled by abrasion during its location near the sea level and in the wave agitation zone in the course of subsidence. The summit and slope surface covered by diatomaceous and foraminiferal oozes are characterized by small conical mounds (Fig. 3). These are probably parasitic volcanic cones. The minimal depth of the mount (1038 m) at 69°23′ S and 121°00′ W is confined to the summit of one such cone in the southeastern part of the summit surface.

We failed to take a drag sample on the northeastern slope of the mount. However, rock fragments were recovered by grabs and piston corers from the upper part of the western slope from a depth of 1150–1250 m. The samples cannot be interpreted unambiguously as in situ rocks, because the possibility of ice rafting is not ruled out. Nevertheless, these rock fragments are of interest due to their shape (mainly angular fragments with fresh detachment surfaces). It is assumed that they represent talus accumulated on the slope of rock exposures.

The rock fragments are composed of hornfels, arkose sandstones, quartz diorites, micaceous schists, granites, granosyenites, rhyolites, dacites, andesites, basaltic andesites, gabbro, alkaline basalts, and fresh tholeiitic olivine basalts [5]. The micaceous schists and granitoids may be considered as relict (older) proxies of the crustal granite-metamorphic complex that makes up the basement of the seamount overlain by the Mesozoic–Cenozoic volcanosedimentary complex.

According to the U–Pb zircon dating of hornfels, the ages of arkose sandstones and dioritic porphyrite are estimated at Late Jurassic (148.2 ± 7.5 Ma) and Paleocene–Eocene (47 ± 1.5 Ma), respectively [5]. Hence, acid magmatism peculiar to the island-arc development stage was replaced by the basic one, which accompanied destruction and taphrogenesis of the MBL continental margin, at the Mesozoic–Cenozoic transition (initial Paleogene).

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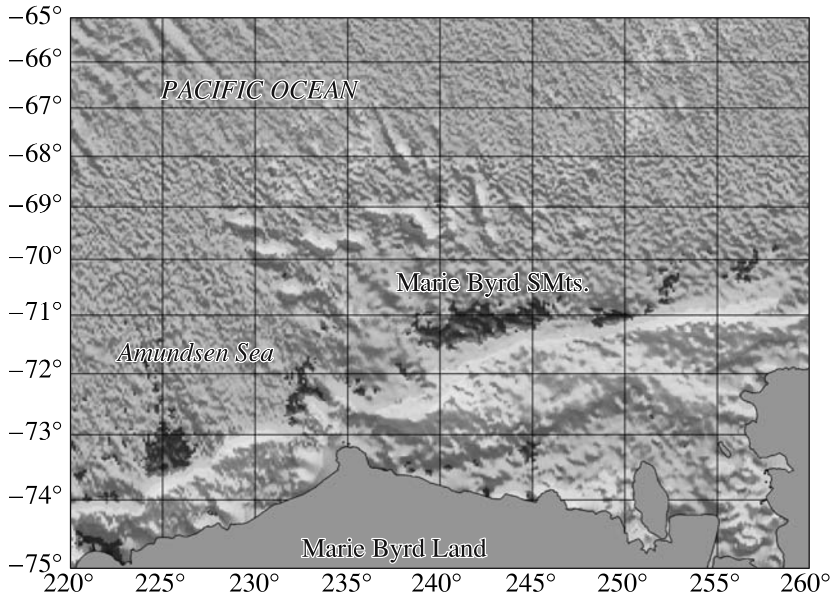

Fig. 1. Gravity field (based on satellite altimetry) reflecting the bottom topography in the Pacific sector of the Southern Ocean in the Marie Byrd Seamounts and Pine Island Bay areas [1].

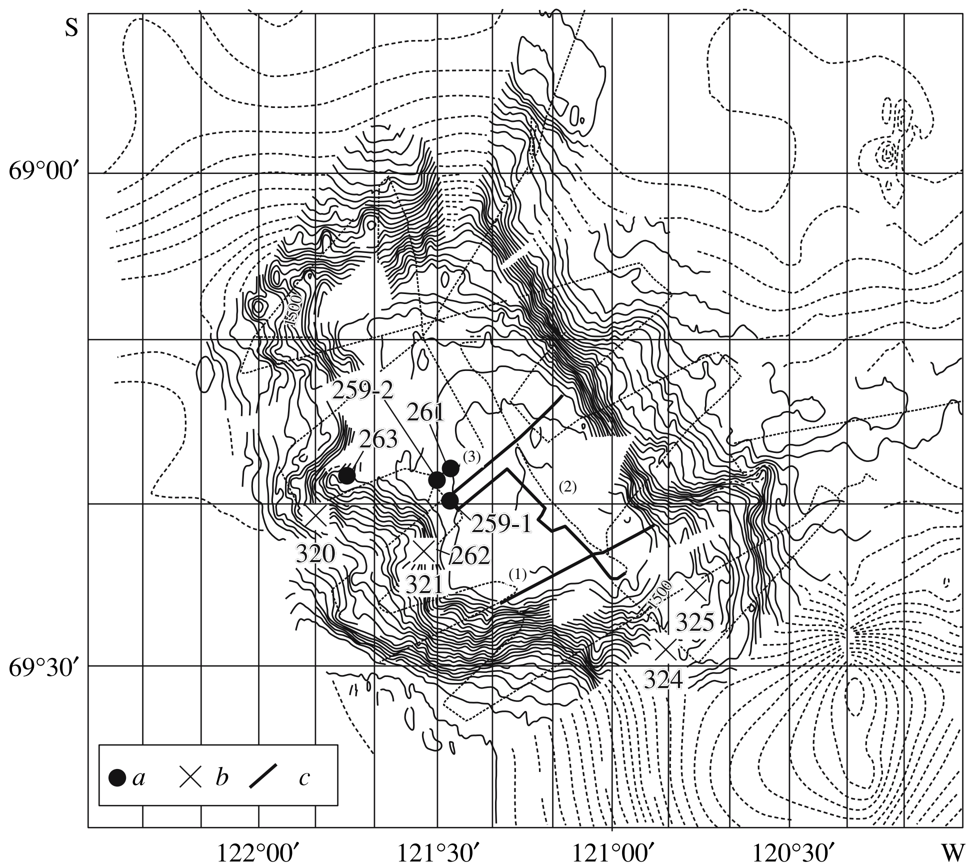

Fig. 2. Relief of the HMS mapped in Cruise ANT-18/5a of the R/V *Polarstern* and rock sampling sites in cruises ANT-18/5a and ANT-23/4 of the R/V *Polarstern.* (*a, b*) Geological stations of cruises ANT-18/5a and ANT-23/4, respectively; (*c*) profiles of the high-frequency profiling in Cruise ANT-18/5a (Fig. 3).

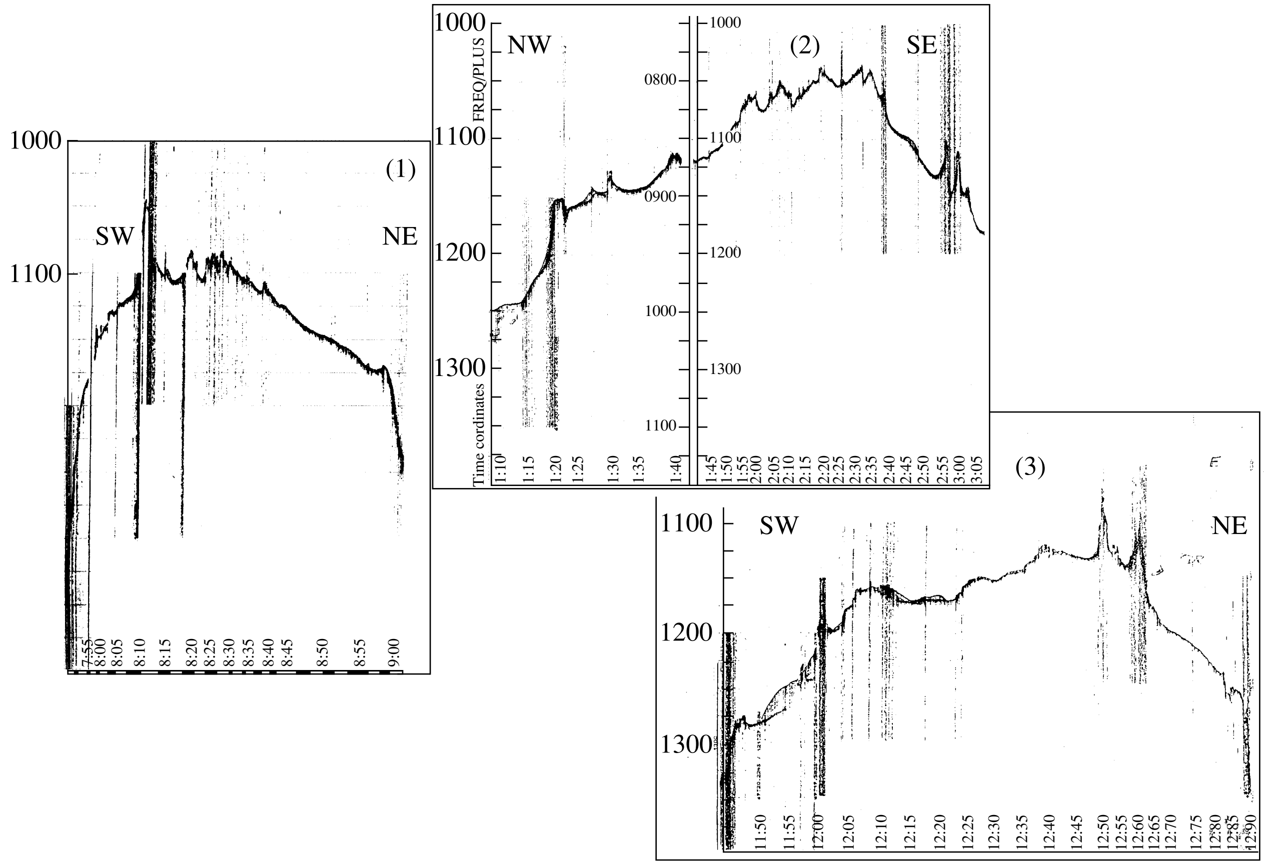

Fig. 3. Profiles of the high-frequency profiling in the HMS area during Cruise ANT-18/5a of the R/V *Polarstern.*

In 2006, study of the HMS was continued and its morphology was examined in more detail during Cruise ANT-23/4 of the R/V *Polarstern*. Additional volcano-shaped cones were discovered, and rocks were dredged at six stations. At four stations including one small volcanic cone, rock material was unambiguously taken in situ. According to preliminary data, the material includes basalts of two different age types: (a) young subalkaline variety (stations 320, 321) with the elevated LILE and REE contents formed in extension settings; (b) older (Jurassic–Cretaceous) greenstone-facies basaltic porphyrites (stations 324, 325) of the island-arc type formed during volcanotectonic activation in geodynamic settings of compression and continental crust accretion along the margin of the West Antarctica craton.

The dredged basalt fragments are similar to rocks obtained previously by gravity corers and grabs in Cruise ANT-18/5a. This fact supports an earlier assumption, according to which the fragments represent talus material transported from exposed slopes of the rigid basement.

At Station 317-1 (69°10.315′ S, 121°25.456′ W, water depth 1983–1584 m) located on the southern slope of Haxby Seamount west of the HMS, fragments of basaltic breccia with carbonate cement were dredged in Cruise ANT-23/4 of the R/V *Polarstern.* The cement yielded six-rayed corals belonging to the order Scleractinia (identification by M.R. Gekker, Paleontological Institute, Russian Academy of Sciences), echinoderm (spines of sea urchins have been identified reliably), and algae remains. According to paleontological data, the host rocks are of the Cretaceous–Cenozoic age.

In available publications, the Marie Byrd Seamounts are considered as volcanoes formed in the extension zone during detachment of the MBL from the NW-drifting Campbell Plateau [6, 7] or separation of the Bellingshausen and MBL lithospheric plates [8]. Summarization of original data on the HMS morphology, gravity field structure, and basement petrology suggests the following ideas concerning the origin of this seamount.

Numerous parasitic volcanic cones discovered in the region and in situ basalt fragments recovered here testify to volcanic origin of the seamount. This assumption is supported by the analysis of the anomalous gravity field by D.E. Teterin. The mount is marked by a positive anomaly (160 mGal), which is similar in shape to the mount and conjugated at the foothill with a negative minimum of 5–25 mGal typical of isostatically compensated crustal blocks. The density model of the NE–SW profile across the seamount shows that the positive

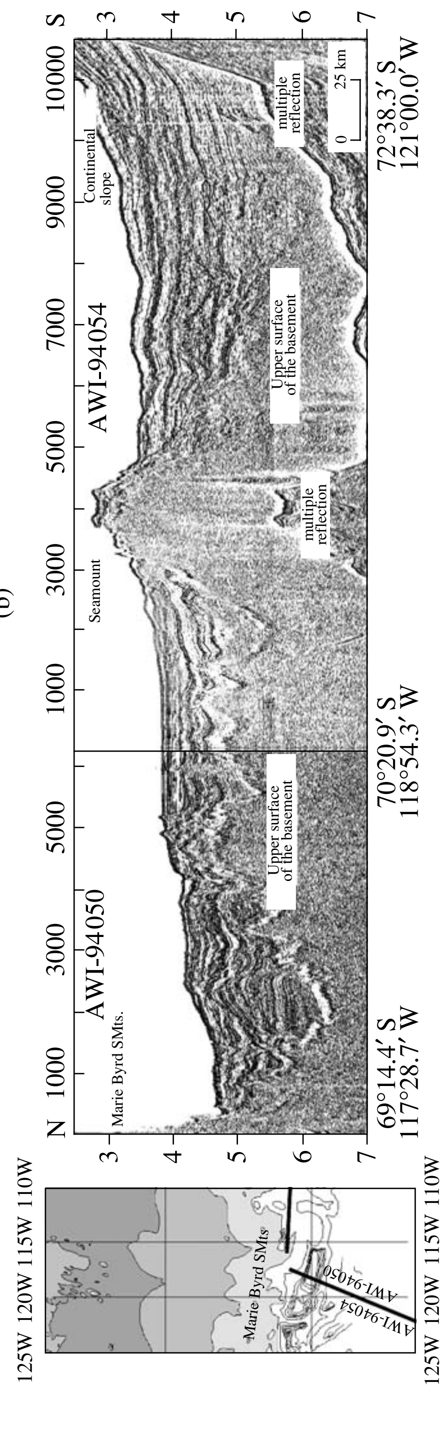

Fig. 4. Deep seismic sounding profiles AWI-94050 and AWI-94054 in cruises of the R/V *Polarstern* [2]. (a) Position of profiles; (b) profiles.

anomaly is induced by a lenslike body located at the dipping surface of the crustal layer with a density of 2.63 g/cm^3 compensated by subsidence of the Moho discontinuity. The central part of this body hosts a vertical isometric block approximately 10 km across with a rock density of 2.8 g/cm^3. Such a structure is typical of underwater volcanoes composed of alkaline basalts. Hence, the volcanic origin of the HMS may be caused by the northward advancement of the MBL volcanic province in response to activation of the mantle plume approximately 30 Ma ago and tectonic uplift of this structure [9].

As is known, geological interpretations of gravimetric data and geochronology of fragments of linear magnetic anomalies used for kinematic reconstructions of the Campbell Plateau, Bellingshausen, and MBL lithospheric plates are ambiguous. Nevertheless, the available data suggest that alternative ideas proposed by Kurentsova and Udintsev in [5] seem sufficiently valid.

Similarly to the majority of other seamounts in the MBL province, the HMS is characterized by block morphology. The volcanic rocks dredged from this mount may be related to the relatively early (typically island-arc) volcanic activity in the basement, its lava cover, or the activity of parasitic volcanoes on the tectonic block in the case of young basalts. Similar parasitic volcanic cones are characteristic, for example, of the Iceland block and Amsterdam Island block (flank of the southeastern branch of the Mid-Indian Ridge). Such tectonic blocks complicated by volcanism can form in response to the uplift of a spacious mantle plume, tectonomagmatic activation, and tectonic destruction of the ancient MBL-line continuation of the Andean island-arc system.

Such a scenario is consistent with variations in volcanics of the HMS. They belong to calc-alkaline (basalts, basaltic andesites, andesites, dacites, and rhyolites), subalkaline, and tholeiitic genetic series. The calc-alkaline volcanism reflects the early phase of uplift of a thick continental crust and its tectonomagmatic activation. This phase predated subsidence of the crust at the early stage of taphrogenesis. Such volcanism is typical of subaerial environments under geodynamic compression in the island-arc system of the West Antarctic continuation of the Andean orocline [10]. The subalkaline series (olivine alkaline basalt) marks the later stage associated with initial subsidence of the continental crust along the newly formed flexure of the retreating continental slope, local extension, fracturing in fluid-saturated settings (above the mantle plume), and formation of the basaltic cover of the continental flexure and its block uplifts. The tholeiitic series (vesicular olivine basalts of the E-MORB type) marks the youngest stage developed in local extension zones during taphrogenesis and formation of parasitic cones in the tectonic block. In terms of chemical composition, distribution of minor elements, and isotopic composition, volcanics from the HMS area are close to their counterparts from the Mesozoic–Cenozoic Andean mobile foldbelt.

This margin of the MBL was probably heated by a large mantle uplift (plume) in the Jurassic–Cretaceous with the formation of basalts and insignificant subsidences. In the Oligocene–Miocene, subsidence in the central part of the present-day Amundsen and Bellingshausen seas reached oceanic depths. This was accompanied by the formation of crust of the transitional continental/oceanic type as is assumed for the periphery of the continental margins of East Antarctica [11, 12] and southern Australia [13].

Unfortunately, the origin of the HMS and similar seamounts of the MBS group cannot be elucidated unambiguously without deep-sea drilling.

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