ISSN 1028-334X, Doklady Earth Sciences, 2006, Vol. 411, No. 8, pp. 1336–1338. © Pleiades Publishing, Inc., 2006.
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OCEANOLOGY

A New Astrobleme in the Pacific Ocean[1]

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Received May 10, 2006

DOI: 10.1134/S1028334X06080381

Recent decades have been characterized by great interest in study of ring structures formed as a result of falling cosmic bodies [1]. Of all similar structures, astroblemes found on the ocean floor are of special interest. The small number of them is explained by the difficulty of finding them and poor study of the ocean. Generally, such structures are revealed by chance as not corresponding to the general tectonic plan.

The ring structure in the Northwestern Pacific was discovered by Sakhalin researchers during the sea expedition carried out by the Institute of Marine Geology and Geophysics (Yuzhno-Sakhalinsk) on cruise 38 of the R/V *Morskoy Geofizik* in 1991. Preliminary information and possible versions of the depression nature (endogenic or cosmic) were discussed earlier as a preliminary analysis [2].

During the cruise, the structure was studied by the continuous seismic profiling (CSP) method from a system of short profiles at the test site sufficient for its confident contouring (Fig. 1). Several profiles were run in order to find such depressions in the direction parallel to the strike of transform faults, which have not revealed similar variations in the cover and basement structure.

The studied astrobleme "Sakhalinka," which was so named by the expedition participants, is prominent in the bottom and basement relief (Fig. 2). The depression diameter along isobath 5900 m is 12 km. The depression depth in the basement relief is 700 m. The coordinates of the structure center are 30°15′ N and 170°03′ E. The acoustic basement is exposed on the southeastern slope and, partially, on the northern slope, where the slope has the form of a scarp. The depression is filled with acoustically transparent sediments 400 m thick. On the flanks, the thickness of poorly transparent deposits characterized by short irregular reflections of average intensity varies from 0 m to 100 m (Fig. 3). The relationship between the crater depth and its diameter (*h*/*d*) for the acoustic basement is 0.04, which agrees well with the generally accepted data for craters of similar sizes (0.05–0.02) [3].

Thus, the isolated position of the structure, as well as its form and sizes, allows us to refer the studied ring structure to impact craters or astroblemes. It should be noted that the process of crater formation by falling cosmic bodies into the ocean is poorly studied. The relationships obtained by investigation of continental craters on the Earth and the results of modeling are used for assessment of underwater crater parameters. When we calculate the parameters of the crater formed by a meteorite falling into the water medium, first of all, we take into account the water depth, the size of the impact, and the density of the target material. Known underwater craters, such as Chiksulub (Mexico), M'olnir (Barents Sea) and Lokne (Sweden), have different sizes and (*h*/*d*), and they were formed at depths of 200–400 m.

We assessed the conditions of the Sakhalinka astrobleme formation. The calculations of the relationship between the transition crater radius and meteorite diameter with the meteorite velocity of 20 km/s are given in [4]. We understand the transition crater as the crater existing at the moment after the elastic recoil, but prior to the beginning of the sliding of material formed

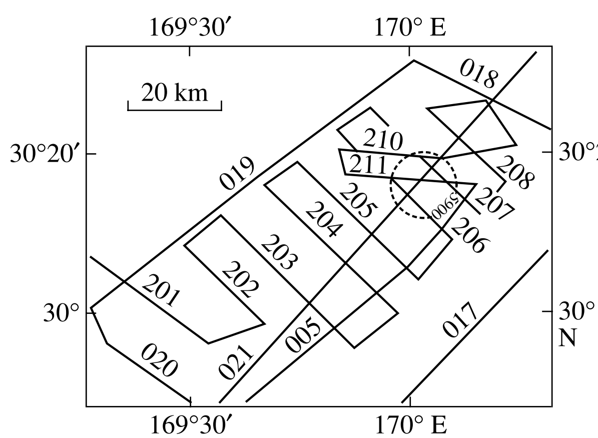

Fig. 1. Scheme of CSP profiles at the test site. Dashed line shows the 5900-m isobath.

[1] This article was translated by the authors.

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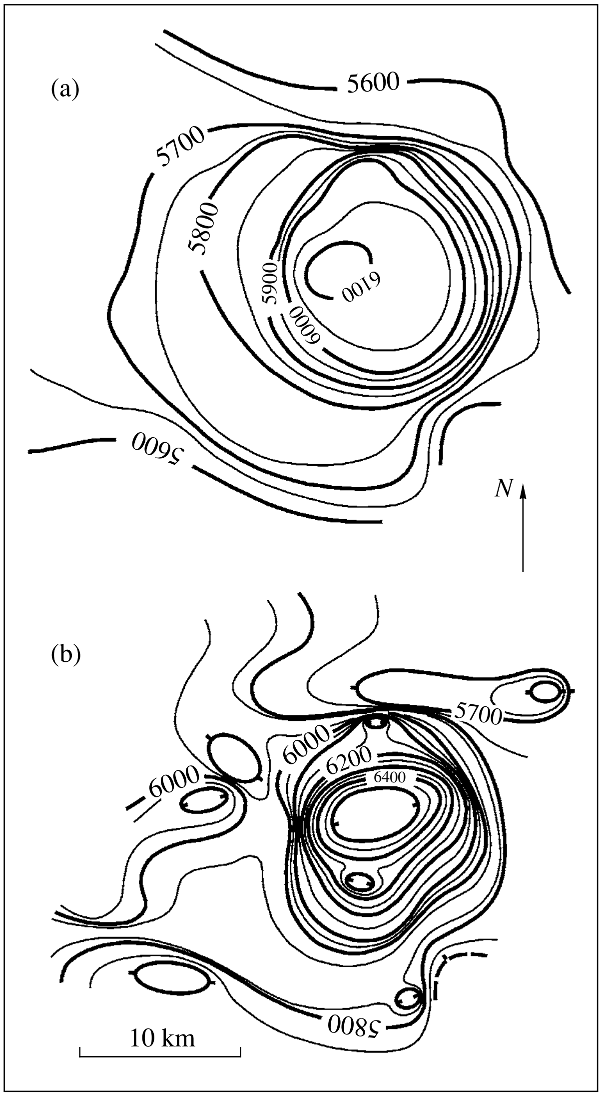

Fig. 2. (a) Bottom relief and (b) acoustic basement.

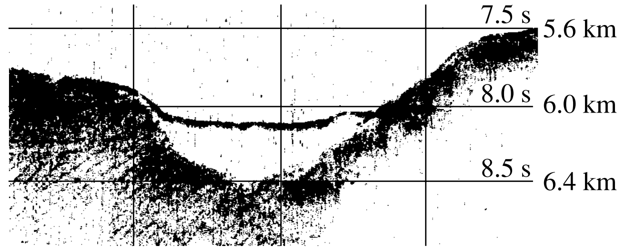

Fig. 3. Seismic profile 206 across the astrobleme showing the time of acoustic signal propagation (s) and depth from the Pacific level (km).

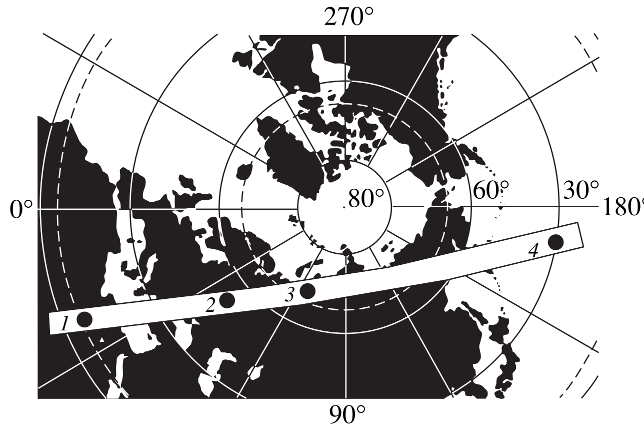

Fig. 4. The Euro-African crater belt. Craters: (*1*) Oasis, (*2*) Kamennyi, (*3*) Karskii, (*4*) Sakhalinka.

by the explosion. The calculation results showed that for a crater with a diameter of 12 km well-pronounced in the bottom relief, the initial cavity must be 20 km in diameter and 7 km in depth. Structures of such sizes can be formed by a meteorite impact of 500-m radius. According to statistics [5, 6], objects with a radius of ~500 m reach the Earth approximately once every 100 000 yr. Falling of such meteorites into the ocean results in tsunami generation with a wave height >10 m at a distance of 1000 km from the point of falling.

Let us assess the time and conditions for crater formation on the ocean floor. Investigations of a single deep-sea impact structure Eltanin [7] allowed us to conclude that, when a meteorite of 500-m radius falls into the ocean with a thickness of the water mass of more than 4 km, craters are not formed on the floor. Hence, astrobleme Sakhalinka was formed when the ocean was much shallower than the present depth. Paleoceanological conditions can be reconstructed on the basis of the lithological composition of sedimentary deposits and the sequence of major seismostratigraphic complexes. The plate sedimentary cover was formed during Berriasian–Holocene [8]. Since the Berriasian–Campanian interval was mainly characterized by the accumulation of carbonate sediments, which formed the lower seismic complex, the ocean level in the Cretaceous period was 2 km lower than the present depth.

The siliceous deposits filling the structure were formed under more abyssal conditions. Hence, the crater was, most probably, formed at the Cretaceous–Paleogene boundary. In this connection, the well-known hypothesis on the Earth's collision with a giant meteorite at the Cretaceous–Paleogene boundary (approximately 65 Ma ago) is of interest. While flying around almost the entire globe from southwest to northeast, the meteorite split into smaller meteorites, formed a belt of craters, and fell down hypothetically somewhere in the ocean, since the Karskaya astrobleme is considered its last trace on land [9]. Taking into account plate migration in the Cenozoic [10], we think that the Sakhalinka astrobleme blends well with the Euro-African belt of craters (Fig. 4), being formed either by one of the fragments of this meteoritic swarm or by the meteorite itself.

ACKNOWLEDGMENTS

The authors are grateful to V.V. Adushkin and N.P. Yushkin for the presented materials and inspiring discussions.

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