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The formation of deep basins in High Arctic from metamorphism in continental crust

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In the East Barents and North Chukchi basins, 16-20 km deep, the crystalline crust is attenuated to 12-18 km (reference profiles 2-AR, 4-AR and 5-AR). P-wave velocities and densities in this layer are characteristic of the oceanic crust. However, the subsidence history in the basins is quite different from that typical of the oceanic crust. In both basins the subsidence continued for several hundred million years and one half of the deposits or more was formed long after the start of the subsidence when cooling of the oceanic plate would be already over. Moreover, the basins are 4-5 km deeper than it could be expected according to the thickness of the crystalline crust above the Moho boundary. In the absence of large free-air gravity anomalies, joint analysis of the gravity and seismic data indicates the existence under the Moho of thick layers of high-density and high-velocity eclogites. As can be seen in high resolution seismic profiles, the intensity of crustal stretching did not exceed 10% in the basins, and their formation can be predominantly attributed to a high-grade metamorphism in the mafic lower part of continental crust. At some episodes, strong increase in the rate of subsidence occurred in the basins. This indicates acceleration of metamorphism catalyzed by infiltration of mantle fluids.

A set of the above features, abnormally large depth, long subsidence history with its acceleration at the late stages, and episodes of pronounced acceleration of the subsidence represent characteristic features of some other large hydrocarbon basins, e.g., of the North and South Caspian basins. These features can be used for prospecting new prolific provinces on the Arctic shelf.

The Lomonosov ridge, Mendeleev high and the Makarov basin pertain to the same structural type. In the Oligocene they underwent erosion near to sea level with the formation of pronounced unconformity. Then at the end of Oligocene deep-water basins were formed in these regions. Rapid crustal subsidence after a long period of relative stability is atypical of oceanic crust. It can be produced either by intense stretching of continental crust or by a density increase due to metamorphism in this layer. Recent seismic reflection profiles demonstrate only minor stretching of the crystalline basement in the regions. Then metamorphism should be the main cause of formation of deep basins in these regions. This can explain attenuation of crystalline crust and an increase in P-wave velocities in this layer that are typical for many deep basins formed due to intense metamorphism in continental crust.