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"Slab graveyards" beneath axial rift of the Mid-Atlantic Ridge?: Evidence from SHRIMP-II dating of zircon in gabbroids from the Markov Deep, 6oN

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Unusually ancient (ranging from ˜100 to 300 and even 2230 Ma [5, 6, etc.) and young (˜1.2-2 Ma [1] zircons were discovered in the axial Mid-Atlantic Ridge (MAR) zone using U-Pb dating. At first glance, finds of ancient zircons are inconsistent with the general accepted plate tectonics model which suggests the formation of new oceanic crust in the spreading zone of the World Ocean. However, they can be explained by features of the oceanic mantle structure.
We have dated 150 grains of zircon by U-Pb SIMS SHRIMP technique, which identified both ancient and young zircons in the same samples of MAR gabbroids from Sierra Leone testing area, Markov Deep, 6oN, dredged during Cruise 10 of R/V "Akademik Ioffe" (2001-2002) and Cruise 22 of R/V "Professor Logachev" (2003) [2]. Zircons were separated from gabbroids in the Markov Deep from depths 3600-3240 and 3900-3600 m. All complexes of the oceanic lithosphere occur on it's slopes: mantle residual ultramafites (harzburgites, lherzolites, and dunites), diverse gabbroids, granodiorites, plagiogranites, dolerites and basalts, including fresh pillow lavas (with chilled glassy margins), and deformed and hydrothermally altered rocks with sulfide mineralization.
Studied samples are represented by cataclased and altered leucogabbronorites and one sample of fresh non-cataclased troctolite. Based on SHRIMP U–Pb dating, zircons can be subdivided into two groups: "young" zircon (less than ˜2.3 Ma) and "old" zircon (older than ˜87 Ma). The young zircon often form subhedral crystals with thin oscillatory zoning and a sectorial structure. It has low U and Th contents (up to 100 μg/g) and extremely low radiogenic lead. Its 238U/206Pb age varied from 0.76 ± 0.04 Ma to 2.28 ± 0.18 Ma. Zircons from nearby plagiogranites define an intermediate age of ˜1.2-1.4 Ma [1]. The magmatic nature of young zircon suggests that its age defines the crystallization age of the host magmatic rocks.
Ancient zircons define U/Pb ages between the Paleozoic and the Mesoarchean. They are most abundant in the troctolite I1069/19. Their age varies from 87 Ma to 657 Ma, and even 3126 Ma. The ages of ancient zircon in gabbronorite I1028 is 1439 Ma; four grains from L1097 yield ages of 991, 1355, 1852, and 2875 Ma. All grains of the ancient zircon are rimmed by thin selvedge of newly-formed zircon, which too thin for the age determination.
So, two groups of zircons with ages of 2.3-0.7 and 87-3117 Ma were identified in samples from the modern oceanic lithosphere formed in the spreading zone of the MAR. The age of young zircon evidently reflects the formation age of gabbroids, while ancient grains are presumably xenogenic. It is important that many samples contain zircons of the both groups, which evidently were contained in the same portions of the basaltic melt. Their origin could be related to the partial capture of materials of different ages from the "graveyard of slabs" by the material of mantle plume ascending from the core-mantle boundary. They presumably contain different in age and origin rocks that were involved in subduction. The detailed study of rocks from exhumed slabs, which are represented by ultrahigh-pressure complexes of Kazakhstan, China, and others formed at P > 2.8-4 GPa (possibly, up to 8.5 GPa) and T = 600-900°C, showed that zircon can be preserved in a metastable status even under such conditions [3].
According to [4], ascending mantle plumes partially entrap material from the ambient mantle, including burial slabs. During ascent, the plume material and incorporated slab fragments were in the solid state. They melted when the plume head reached its buoyancy level and began to spread in oceanic lithosphere. Zircon, as the highest temperature mineral, was last to melt. Therefore, its relicts can preserved in the melt. This model is supported by

the existence of a mantle plume beneath the Sierra Leone testing area [7, 8].

The presented data indicate that zircon can be used as an important (and, possibly, sole) source of information on the composition of deep-seated mantle beneath modern oceans, and about presence in it "slab graveyards" even beneath their axial rifts.

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