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The Paleozoic Pull-Apart Basin of Eastern Slope of Southern Ural, Russia

A. Andreev

State Resources Enterprise "Aerogeologia", Moscow, Russia (andrey@mineral.ru / Fax: +7 495 936-18-78)

For the first time the pull-apart basin was discovered in Paleozoic volcanic-sedimentary rock sequences of the Magnitogorsk Megasynclinorium. The basin under consideration bears structural, morphological, and facies features typical of rhomb-shaped pull-apart basins.

The Kizil–Urtazym lithology-structural zone, which is located on the western slope of the Magnitogorsk Megasynclinorium, comprises a series of meridional en-echelon synclines. The largest one is known as the Khudolazovo. The Zilair flysch Formation and Ulutau tephroid-siliceous Formation are occurs in syncline core. In the east, the syncline is limited by the Kizil Fault and Bakruzyak Anticline composed of basalts of the Karamalytash Formation. The similar Sibai, and Uldashevo anticlines are situated on the southern and northern centreclinal closures of the syncline. The well-known volcanogenic massive sulfide deposits are localized in the Sibai and Bakruzyak anticlines. Coarse-clastic mixtite rock sequences with large olistoliths and abundant volcanogenic materials are typical of the structure under study.

The study of sections, along with geological, structural, and paleovolcanological maps of various scales and satellite images, suggested that the Khudolazovo Syncline is a typical pull-apart basin, was formed as a result of displacements along the large sinistral strike-slip fault. Initially, the S-shaped extension fracture was generated, and then a rhomb-shaped basin started to open. Its morphology is clearly expressed in topography and structure.

The palinspastic reconstruction yielded a common volcanic center of the Karamalytash time. The Sibai and Bakruzyak deposits previously represented a common ore field. The proposed model of the Khudolazovo Syncline formation explains the discrete localization of copper massive sulfide deposits in the present-day structure. The size of the Khudolazovo Basin fits the statistical range of known modern and ancient pull-apart basins. The length/width ratio in such structures remains constant at 3 : 1. The extent of pull-apart basins reaches to 20–50 km, on average. The length and pull-apart displacement magnitude of the Khudolazovo structure is 40 km. It was a marine basin as indicated by a thick turbidite rock sequence with units and interlayers of siliceous rocks with abundant radiolaria, sponges, and conodonts. The basin probably developed as a compensated trough. The total thickness of the Ulutau and Zilair rocks in the Khudolazovo Syncline is 2.5 km. The basin was most likely not deep, because the silty and cherty beds commonly bear abundant remains of land plant stems and leaves on bed surfaces, and sandstones contain a carbonate admixture. The oolitic limestone interlayers, the gypsum admixture and the shallow-water conglomerates with perfectly rounded pebbles mark the coastal-marine sedimentation conditions at the basin periphery. The existence of the Khudolazovo Basin is supported by the directions of clastic material removal from the margins to the axial zone.

The basin most likely started to form after the deposition of the Karamalytash basalt–chert Formation and related copper massive sulfide mineralization. It cannot be ruled out that the eruption of Karamalytash basalts, which bear the geochemical signature of back-arc spreading, registers the onset of the Khudolazovo strike-slip and pull-apart basin development. The structure of the modern Andaman Sea provided a similar model.

As indicated by the condensed siliceous units, the Khudolazovo Basin evolved for a long time in a stepwise manner. Such units clearly outline (in plan) the contours of a rhomb-shaped basin and mark breaks in the pull-apart motion. It seems likely that the siliceous sediments were deposited at slope flexures controlled by normal faults. In addition to sedimentary cherts, the hydrothermal quartz–hematite metasomatites were formed along permeable extension zones at basin margins. The topography controlled by normal faults is typical of modern basins, which develop near strike-slip faults. The development of stepwise normal faults at moving-apart walls of the Khudolazovo basin might have served as a driving force for the formation of chaotic mixtite complexes. Avalanches, stonefalls, slumps, and debris flows provided the deposition of unsorted coarse-clastic sediments. The seismic activity induced the displacement of large blocks several meters and even kilometers in dimension. The abundant volcanogenic clastic material, especially the pyroclastic material in the mixtite matrix and sandstones, points to volcanic explosions during sedimentation. The northwestern corner of the Khudolazovo Basin incorporated a volcano that supplied the explosive and effusive materials. The redstone alteration of volcanics, vesicular scoria and clinker in lavas, and opacitization of dark-colored minerals indicate that the volcanic eruptions occurred in a shallow-water and subaerial environment. Serpentinite typical of regional strike-slip systems are also noticed in the Khudolazovo structure. Serpentinite fragments are always present in the Zilair sandstone of the Khudolazovo Syncline, indicating the synsedimentary character of faulting.

Several analogous rhomb-shaped basins are registered in the strike-slip zone to the north and south of the Khudolazovo Syncline. Their size gradually decreases to the north and south, demonstrating the waning of strike-slip and pull-apart displacements at terminations of the common zone. This pattern is typical of regional strike-slip systems.