

Tectonic control of modern fluid discharge at the bottom of Lake Baikal: the Class@Baikal Project data report

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ABSTRACT. Lake Baikal is a part of large intracontinental rift zone. Baikal sedimentary infill is more than 7 km thick and was developed under predominantly extensional tectonics. Large number of faults of different geometry is imaged by several seismic surveys carried out in the region. The fault systems serve as fluid discharge pathways from deep sources to surface. A number of active seepage structures were mapped and studied during the Class@Baikal expeditions along the major fault system of the Central Baikal basin, which extends in SE-NW direction over 40 km and was named recently as the Gydratny Fault. Irregular distribution of these seeps, differences in their morphology and activity rate imply a variable permeability of the fault and different characteristics of migration pathways along its segments.

Keywords: Baikal rift zone, the Gydratny Fault, gas discharge zones, gas hydrate.

1. Introduction.

Lake Baikal is located in the Central segment of the Baikal rift system. It is a zone of deep crustal faults in the continental Eurasia with length of about 1,500 km and has a direction from the southwest to the northeast. As for any rift system, the Lake Baikal depression is characterized by a large number of faults and complex structure. In deep layers of sedimentary infill of the basin liquid and gaseous hydrocarbons are generated and migrate along faults to the bottom surface. In places where fluids reach the surface, we find areas of focused gas and oil discharge (mud volcanoes, seeps). Numerous structures of focused hydrocarbon gas discharge and near-surface gas hydrates accumulations are associated with the Gydratny fault, i.e. Gydratny as «gas hydrates bearing» (Khlystov, 2018). The Gydratny fault is a listric normal fault with predominantly Northern and North-Western Direction. The study area can be divided in two main blocks (hanging wall and footwall, separated by the Gydratny fault). The first block (footwall, block 1) is bounded on the North-West by the Obruchev (Olkhon) fault and on the South-East by the Gydratny fault. This large block is essentially undisturbed by faulting and is elevated relative to the block 2. The lowered block is characterized by the presence of secondary multiple small faults on the hanging wall (Solovyeva et al., 2020). One of the tasks of the Class Baikal expedition was to study this fault.

2. Material and methods.

Six geochemical profiles were carried out crossing the Gydratny Fault. At each profile, 10 bottom sampling stations were selected. Sampling for gas geochemistry was performed from each core. All sediments collected during the Class@Baikal expeditions were obtained using a 3 or 5 m long gravity corer. Subsampling for hydrocarbon gases analysis was subsequently performed taking into consideration the lithology of the recovered sediments. The degassing was accomplished according to the Headspace technique. The molecular composition of HCG in the C1 through C5 range, including alkenes (ethene, propene and butene) and alkanes with isomeric molecular structure (iC4, iC5 and SiC6) were determined in the laboratory of RV "G.Yu. Vereshchagin" using a portable gas chromatograph (Hromatek Kristall 2000) equipped with a TC detector. The carbon isotope ratios from C1 to C5 hydrocarbon gases and CO₂ were measured on a Finnigan Delta V Advantage mass spectrometer.

3. Results and discussion

Methane was detected in sediments along the whole fault extend in high concentrations that exceeds 2-10 times background values, suggesting that the fault plane acts as regional fluid migration path. The highest methane content (> 275 ml/l) and the presence

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of its homologues were observed at several local sites situated along the fault and associated with mud volcanoes and gas hydrate bearing seeps. The methane concentration in block 2 is higher than in block 1. The Gydratny master fault is accompanied by numerous subsidiary faults developed within hanging wall while the footwall is less faulted. The associated faults are believed to enhance the main fluid migration system. The carbon isotopic composition varies from -72 to -57‰ VPDB for methane and from -21 to -31 ‰ VPDB for ethane, suggesting that these are thermogenic gases that migrate from deep layers of sedimentary infill of the basin.

4. Conclusions.

The molecular and carbon isotopic composition of hydrocarbon gases suggests that thermogenic gases

migrates through a fault from deep layers of sedimentary infill of the basin.

The concentration of methane and its homologues varies along the fault. Seismic data show a well-established segmented nature of the Gydratny Fault system, which is believed to control the observed variations of fluid discharge rates.

References

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