EGU22-11101
https://doi.org/10.5194/egusphere-egu22-11101
EGU General Assembly 2022

Characteristics and origin of macro- and mini-seepage at mud volcanoes in the Shamakhy-Gobustan region of Azerbaijan

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Azerbaijan hosts the largest concentration of mud volcanoes (MVs) on Earth. Here, high sedimentation rates and deposition of thick organic-rich series resulted in petroleum basin formation and, in turn, created the ideal setting and conditions to generate widespread sedimentary volcanism. Some of the regions hosting these piercements have been broadly studied, while others (e.g. the Shamakhy-Gobustan region) are less explored. In this seismically more active part of the country, the tectonic control plays a stronger role for the emplacement of diapirs and fluid migration.

Here we report a multidisciplinary study conducted on a set of six MVs (Kichik Maraza, Gizmeydan, Gushchu, Malikchobanly, Madrasa and Shikhzairli) located in the Gobustan-Shamakhy region and combine satellite image interpretation with field observations, gas sampling, CH_4 and CO_2 flux measurements. The studied MVs are generally hosted by anticline axes intersected by fault structures that facilitate the migration of fluids. The resulting surface morphologies include elongated (Kichik Maraza, Malikchobanly MVs) or pie-shaped (Gizmeydan, Gushchu, Shikhzairli MVs). One MV does not show an edifice and is positioned along a laterally extensive fault wall (Madrasa). Morphologies vary depending on the setting, the type of erupted mud breccia and/or the diameter of the conduit. Some of these MVs are characterized by scattered pools and gryphons where gas, water, mud and oil are released. These focused emissions are typically concentrated in the crater area (Little Kichik Maraza, Gizmeydan, Malikchobanly MVs). MVs that recently erupted can display limited or no visual gas release features (like pools or developed gryphons) since these were destroyed by erupted mud breccia flows (Big Kichik Maraza, Gushchu, Shikhzairli MVs). Copious amount of dense oil was observed at numerous gryphons of Madrasa MV. Gas analyses revealed that all the sampled seeps release methane-dominated gas that has a thermogenic origin. Molecular fractionation of this gas occurs during the vertical migration from the reservoirs. Evidence of secondary microbial methane and biodegradation is also observed at some of the seepage sites.

The conducted flux measurements were carried out over the crater and the flanks of the MVs targeting the diffused miniseepage (the invisible degassing that typically occurs over vast areas at and around MV craters) and individual seepage sites (e.g. pools or gryphons). Significant degassing was detected at all the investigated structures, also at those that did not display obvious visual seepage. Results show that these MVs release in average similar CH_4 Tg yr^{-1} like most of the other structures in Azerbaijan and one order of magnitude higher than many MV on Earth. CH_4 emissions reach up to 64 tonnes yr^{-1} (Kichik Maraza MV) and CO_2 up to 20 tonnes yr^{-1} (Gizmeydan MV).

In more seismically active Shamakhy-Gobustan region the tectonic control plays a stronger role for the resulting morphologies of MVs, fluid migration pathways and composition.