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Hydrocarbon Reservoirs in Azerbaijan in Relation to Faulting and Mud Volcanism

L. Merz*, A. Huseynova**, E. Babayev***, C. Hilgers*
*Strukturgeologie& Tektonik, Karlsruhe Institut für Technologie (KIT), Karlsruhe, Germany
**Oil&Gas Insitute, Azerbaijan National Academy of Sciences (ANAS), Baku, Germany
***SOCAR, Baku, Azerbaijan

Abstract

Understanding the mechanisms of mud volcanism is critical for oil and gas exploration in Azerbaijan, as well as in other countries where this natural phenomena is abundant, e.g. in Iran or Indonesia. Whereas location and geochemistry of mud volcanoes is well studied and recorded (Institute of Geology and Geophysics (ANAS) et al., 2015), geological and tectonic influences on mud volcanism are poorly studied so far. However, faults and fracture networks are crucial in understanding the migration pathways and environmental impact of mud volcanism. Such information can be used for reservoir characterization and safe well planning in hydrocarbon exploration, but also for a risk assessment in groundwater and soil use.

The WNW-trending Greater Caucasus fold- and thrust-belt with S-SSW verging folds and associated thrusts is formed by ongoing collision of the Arabian plate with Eurasia (e.g. Narimanov, 1993; Devlin et al., 1999; Saintot et al., 2006). Recent tectonic stress is oriented NNE with a movement of c. 10 mm/year (Bonini and Mazzini, 2010). It is assumed that mud volcanoes are related to structural hydrocarbon traps in anticlines formed by the thick Productive series of Neogene age, that is also the main oil and gas reservoir in Azerbaijan (e.g. Reynolds et al., 1998). Muds and associated fluids migrate from overpressured shales either through pipe systems and/or faults and fracture networks (Guliyev, 2006).

We conducted lineament mapping from remote sensing data (open source ASTER DEM30 data set with a resolution of 30m) in GIS software, and compared traced lineaments to faults shown in the geological map of Azerbaijan (1:500.000, Alizadeh et al., 2008). Fault orientations show a similar result with the majority of faults striking WNW, paralleling the Greater Caucasus. Fault lengths are significantly shorter from the mapped lineaments with an average of c. 3 m, depending on the resolution of the data base. Field observations in one study site reveal a W-E-striking thrust fault and NNW- and NE-striking normal faults. Additionally, we measured fracture orientations, spacing and few abutting relationships in a total of 18 outcrops in Neogene and Paleogene reservoir rocks (n_{total}> 1500) to deduce information on the fracture network critical for fluid flow. Fractures strike mainly N-S, W-E, NNW-SSE and NNE-SSW, WNW-ESE. Porosity and permeability measurements show that the Neogene Productive series show c. 25% porosity and c. 10 Darcy permeability. Mud volcanism at least temporarily has an impact on groundwater as shown by BTEX amounts of 0.3 to 1.2 µg/l that are not critical for human health in 3 springs.

We conclude that mud volcanoes location is associated with fault orientation. The Productive series exposes good analogues of reservoir for mud volcanism and associated hydrocarbons. Groundwater is mixed with organic components derived from mud volcanoes, and further analyses will improve our understanding of fluid pathways in the current stress field.