# MUD VOLCANOES OF THE SOUTH CASPIAN BASIN

**Warner Matthew John Charles (1), Turner Joshua Creviere (2), Bentham Peter (1), Buddin Tim (3), Piggott Neil (1), Riley Greg (1)**

*1 BP Exploration Operating Co. Sunbury on Thames, Middx, TW16 7LN. United Kingdom,*

*2 BP America, Houston, Texas, United States,*

*3 Midland Valley, Denver, Colorado, United States.*

E-mail: warnm3@bp.com

The South Caspian Basin (SCB) represents an ideal natural laboratory in which to study mud volcanoes. Over 400 mud volcanoes have been recognised in the region, with active examples identified both onshore and offshore, and dormant examples observed buried within the subsurface.

For BP these mud volcanoes are important from both a shallow hazards perspective and as an influence on seismic data quality. Through investment in regional 2D seismic data and PSA-scale 3D seismic volumes BP has a built a 1st class dataset covering the Azeri offshore sector. Recent analysis of these data using modern geophysical techniques has allowed a more detailed definition of subsurface mud volcano geometry, including the identification of palaeo-mudflows. In addition, this analysis has facilitated the following observations:

- Many mud volcanoes in the offshore Azeri sector of the SCB are situated over palaeo-structural highs. These structures were created during the Late Miocene, Early Arabian compressional event, co-eval with deposition of the Maykop source interval, and pre-date deposition of the Productive Series interval. The deep-seated palaeo-structures in the north of the offshore Azeri sector comprise an imbricate stack/incipient accretionary complex.
- SCB mud volcanoes are principally sourced from the deeply buried (up to 12km below mud-line) Oligo-Miocene Maykop Formation. This interval forms the primary hydrocarbon source interval for the SCB, and mud volcanoes in the region frequently vent gas and seep oil.
- Many of the mud volcanoes exhibit a multi-pulse kinematic evolution, with three key stages:
- Mobilisation of the source interval and the creation of 1st generation mud volcanoes during the Surakhany - co-incident with hydrocarbon maturation in the source interval and the very earliest stages of box fold formation during the onset of Late Arabian deformation.
- Kinematic hiatus and burial of the 1st generation mud volcanoes.
- Re-mobilsation, deflation of the buried 1st generation palaeo-volcanoes, deformation of the surrounding strata, and creation of a 2nd generation of mud volcanoes at the surface during the Apsheronian
- This remobilisation created associated collapsed calderas, which can serve to significantly reduce the seismic image beneath the intense deformation.

The detailed analysis of subsurface mud volcano geometry has enabled BP to:

- Identify and classify shallow hazards, and thus build lower risk drilling plans
- Build Improved velocity models, and generate higher quality seismic images

In addition, these observations can be placed in its worldwide context. Whilst the detailed evolutionary mechanisms by which mud volcanoes in the South Caspian Basin grow are not clearly understood, the observations made in the SCB are similar to those made in other mud volcano provinces, and confirm a number of general points:

- Mud volcanoes are created through the mobilisation of buried clastic material (*clasto-kinesis?).* The source interval becomes mobile when the effective vertical stress and its internal co-efficient of friction is reduced by overpressure. In contrast to salt, this fluidisation process can cut across lithological boundaries, and can interact with younger intervals and fluid sources.
- Mud volcanoes are commonly associated with hydrocarbons,
- Mud volcanoes are often associated with accretionary wedges (Makran, Pakistan; Barbados; Mediterranean Ridge); thrust belts; and submarine fans.

In addition, these features are often geologically young, associated with subsurface structures such as faults, and are commonly found in areas of earthquake activity.