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Ejected Sedimentary Rocks of Mud Volcanoes as Indicators of Depositional Environments and of Hydrocarbon Generation within the South Caspian Basin, Azerbaijan

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Mud volcanoes are prominent geological features of the South Caspian Basin of Azerbaijan, one of the oldest oil producing regions worldwide. The basin is characterized by extreme sedimentation rates, which lead to the accumulation of large volumes of Mesozoic and Cenozoic sediments. These mostly unconsolidated strata reach thicknesses of up to 20 km and overlay a continental basement in the onshore part. Tectonic forces control the occurrences of mud volcanoes in regions with over-pressured subsurface sediments as mud volcanoes are closely linked to fault systems. The mud volcanoes of Azerbaijan are a surface expression of vertical hydrocarbon migration and offer the chance to investigate the subsurface by means of ejected rocks transported to the surface. These rocks of Mesozoic and Cenozoic sedimentary sequences are potential indicators of the regional hydrocarbon generation. The mud of nineteen volcano cones contained numerous ejected rock fragments, which we use to identify environmental and depositional parameters of the sediments of the Caspian Basin. We also intended to estimate the depth range from which the mud was transported to the surface using organic geochemical parameters.

Mircopalaeontological investigations (calcareous nannoplankton) have been performed on selected samples. These analyses suggest that the investigated sediments are of Late Cretaceous to Palaeogene ages and relate to the stratigraphic interval during which the main hydrocarbon source rocks of Azerbaijan have been deposited.

Organic geochemical, organic petrographical and mircopalaeontological investigations have been performed on selected samples of nineteen mud volcanoes. Analyses total organic carbon and total sulphur were performed on an elemental analyzer. These analyses suggest that the sediments can be classified as anoxic marine deposits whereas only few are sediments of a lacustrine environment. Bulk source rock information were obtained from RockEval pyrolysis. Resulting Hydrogen and oxygen indices indicate that the organic matter of the sediments consist mostly of mixtures of aquatic and terrestrial organic matter.

The hydrocarbons of the sediments were extracted and subsequently fractionated into aliphatic, aromatic and hetero-compound groups. The amounts of extractable hydrocarbons in relation to organic carbon contents indicate that most of the ejected sedimentary rocks contain migrated hydrocarbons. All extracted hydrocarbons have been affected by secondary alterations which most likely involved biodegradation the chromatographic analyses of the aliphatic fraction indicate elevated ratios of pristane/n-C17 and phytane/n-C18 and the chromatograms generally show that the normal alkanes have been removed to a large extend.

Despite of biodegardation, environmental and maturity indicative biomarkers could be identified, and C27- to C29-sterane isomers suggest a dominant imprint of aquatic organic matter on the extracted hydrocarbons. An influence of diatoms on the sterane distribution seems plausible, but an admixture of land plant material is highly likely. Homohopane isomerization ratios as well as the ratio of trisnorneohopane over trisnorhopane suggest that the extracted hydrocarbons come from a coalification range which spreads from immature to mature although, maximum maturity does not reach the peak of oil generation. C29-sterane isomerisation ratios support this finding. Vitrinite reflectance measurements on the ejected rocks indicate a similar range of maturities as suggested from biomarker analyses. However, the data indicate again that most of the investigated rocks have been impregnated by allochthonous hydrocarbons as biomarker maturities may slightly depart from the measured reflectance values. We estimated from maturity/depth conversion that the mud volcanoes along a SSW-NNE transect from the Kura Basin to the Apsheron Peninsula produce their mud from a depth range between 4000 and 5500 m corresponding

to a maturity range of 0.5 to 0.65% vitrinite reflectance, although, no specific regional maturity/depth trend could be identified. However, the biomarker data indicate changes of depositional environments as well as changes of the types of the organo-facies, which is in good accordance with the stratigraphic information based on the calcareous nannoplankton.