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Subaqueous and and subareal mud volcanism at Kalang Anyar, Java, Indonesia

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The northern Java petroleum province is characterized by distributed modern and palaeo piercement structures witnessing the diffused interaction between gravitatively-unstable buoyant shales, faulting, hydrothermal activity, and hydrocarbons generation. The northeast of Java hosts at least 6 dormant mud volcanoes, several buried palaeo vents and diapirs, and the spectacular Lusi eruption site. The Watukosek fault system, originating from the Arjuno Welirang volcanic complex, extends towards the NE of the island hosting the Lusi clastic-geysering system, the Porong palaeo vent, and the Kalang Anyar, Gunung Anyar, and Pulungan mud volcanoes. Kalang Anyar extends over a surface of $\sim$6 hectares displaying dozens of scattered small seepage sites that intermittently burst oil, gas, mud and water. Geochemistry reveals that the seeping gas is methane-dominated with small portions of heavier hydrocarbons. The mixed-thermogenic origin of the methane is coupled with potential geothermal perturbation as indicated by CO_2 isotopic values. Helium isotopes also support some input of deeper sourced gas possibly migrating along the fault system. Water geochemistry indicates that brines are a mix of marine formations waters with illitization fluids.

Clasts with different lithologies are scattered throughout the area. This indicates that vigorous mud eruptions able to powerfully eject clasts from different formation occurred in the past. Well preserved shells are also common indicating that the area was once located in underwater conditions. Meter sized blocks and small carbonate ridges are present at various localities on the edges of the crater zone. These carbonate-cemented blocks contain a relatively small amount of siliciclastic sediments and abundant chemosymbiotic shells. Carbon isotope analyses of the carbonate cement reveals negative values identifying these as methanogenic chemoherms. Similar carbonate deposits are broadly documented from modern and fossil offshore seepage sites. Results indicate that Kalang Anyar mud volcano has been active since the area was submerged by the ocean and that here microbially-mediated precipitation of carbonates was ongoing during the subaqueous methane seepage at the crater site.