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## Geochemical and geophysical characterization of Kalang Anyar mud volcano, Java, Indonesia

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The northeast sector of Java, Indonesia, is a sedimentary basin hosting several petroleum provinces. This region is characterized by distributed modern and paleo piercement structures, diffused hydrothermal systems, degassing sites and mud volcanoes. Sedimentary volcanism includes the Kalang Anyar mud volcano, one of the active piercements located along the NE-striking Watukosek fault system. This fault system extends from the volcanic arc through the sedimentary basin in the north of the island.

Kalang Anyar covers an area of approximately 1.5 km<sup>2</sup> and displays several small seeps scattered over the crater. These seeps discharge mud water, oil, and gas. Several expeditions conducted at the site allowed the acquisition of a multidisciplinary dataset including geochemical, geological and geophysical data. Seismic data highlight the occurrence of drumbeat signals marked by high central frequencies, similar to those found in other mud volcanoes.

Laboratory analyses carried out on the gas released from the seeps show a methane-dominated content with lower quantities of heavier hydrocarbons and CO<sub>2</sub>, and a marked thermogenic origin. Moreover, CO<sub>2</sub> and helium isotopes suggest the presence of mantle-derived fluids that presumably migrate along the Watukosek fault system for tens of kilometers within the sedimentary basin. Water geochemistry indicates that brines are a mix of marine formations waters that interacted with illitized units.

Carbonate blocks located on the outskirts of the crater zone have been mapped and analysed. These result to be methanogenic carbonates (carbonate cement  $\delta^{13}\text{C}$  as low as -48.8) that formed during the microbially-mediated methane oxidation and carbonate precipitation during the offshore activity of the mud volcano. Dating of these blocks indicate that the mud volcano was recently active in sub-aqueous conditions. Kalang Anyar represents a rare example of onshore mud volcanism witnessing the offshore activity and associated precipitation of authigenic carbonates.

Dozens of new settlements have been recently constructed on the flanks and around the crater of Kalang Anyar. This exponentially growing edification represents a common example that may pose in severe danger to the settlements and the residents in case of sudden eruptive activity. The uncontrolled development of the constructions is a geo-hazard that shall not be underestimated.