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Microbiology and geochemistry of hydrocarbon-rich sediments erupted from the deep geothermal Lusi site, Indonesia

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The Lusi eruption represents one of the largest ongoing sedimentary hosted geothermal systems, which started in 2006 following an earthquake on Java Island. Since then it has been producing hot and hydrocarbon rich mud from a central crater with peaks reaching 180.000 m3 per day. Numerous investigations focused on the study of offshore microbial colonies that commonly thrive at offshore methane and oil seeps and mud volcanoes, however very little has been done for onshore seeping structures. Lusi represents a unique opportunity to complete a comprehensive study of onshore microbial communities fed by the seepage of CH4 as well as of heavier liquid hydrocarbons originating from one or more km below the surface.

While the source of the methane at Lusi is clear (Mazzini et al., 2012), the origin of the seeping oil, either form the deep mature Eocene Ngimbang (type II kerogen) or from the less mature Pleistocene Upper Kalibeng Fm. (type III kerogen), is still discussed. In the framework of the Lusi Lab project (ERC grant n° 308126) we analysed an oil film and found that carbon preference indices among n-alkanes, sterane and hopane isomers (C29-steranes: 20S/(20S+20R) and α,β-C32 Hopanes (S/(S+R), respectively) are indicative of a low thermal maturity of the oil source rock ($\sim$0.5 to 0.6 % vitrinite reflectance equivalents = early oil window maturity). Furthermore, sterane distributions, the pristane to phytane ratio and a relatively high oleanane index, which is an indication of an angiosperm input, demonstrate a strong terrestrial component in the organic matter. Together, hydrocarbons suggest that the source of the oil film is predominantly terrestrial organic matter. Both, source and maturity estimates from biomarkers, are in favor of a type III organic matter source and are therefore suggestive of a mostly Pleistocene Upper Kalibeng Fm. origin.

We also conducted a sampling campaign at the Lusi site collecting samples of fresh mud close to the erupting crater, using a remotely controlled drone as well as older, weathered samples for comparison. In all samples large numbers of active microorganisms were present. Rates for aerobic methane oxidation were high, as was the potential of the microbial communities to degrade hydrocarbons (oils, alkanes, BTEX tested). The data suggests a transition of microbial populations from an anaerobic, hydrocarbon-driven metabolism in fresher samples from center or from small seeps to more generalistic, aerobic microbial communities in older, more consolidated sediments. Ongoing microbial activity in crater sediment samples under high temperatures (80-95C) indicate a deep origin of the involved microorganisms (deep biosphere). First results of molecular analyses of the microbial community compositions confirm the above findings. This study represents an initial step to better understand onshore seepage systems and provides an ideal analogue for comparison with the better investigated offshore structures.