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Subduction zone earthquake probably triggered submarine hydrocarbon seepage offshore Pakistan

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Seepage of methane-dominated hydrocarbons is heterogeneous in space and time, and trigger mechanisms of episodic seep events are not well constrained. It is generally found that free hydrocarbon gas entering the local gas hydrate stability field in marine sediments is sequestered in gas hydrates. In this manner, gas hydrates can act as a buffer for carbon transport from the sediment into the ocean. However, the efficiency of gas hydrate-bearing sediments for retaining hydrocarbons may be corrupted: Hypothesized mechanisms include critical gas/fluid pressures beneath gas hydrate-bearing sediments, implying that these are susceptible to mechanical failure and subsequent gas release. Although gas hydrates often occur in seismically active regions, e.g., subduction zones, the role of earthquakes as potential triggers of hydrocarbon transport through gas hydrate-bearing sediments has hardly been explored.

Based on a recent publication (Fischer et al., 2013), we present geochemical and transport/reaction-modelling data suggesting a substantial increase in upward gas flux and hydrocarbon emission into the water column following a major earthquake that occurred near the study sites in 1945. Calculating the formation time of authigenic barite enrichments identified in two sediment cores obtained from an anticlinal structure called “Nascent Ridge”, we find they formed 38-91 years before sampling, which corresponds well to the time elapsed since the earthquake (62 years). Furthermore, applying a numerical model, we show that the local sulfate/methane transition zone shifted upward by several meters due to the increased methane flux and simulated sulfate profiles very closely match measured ones in a comparable time frame of 50-70 years. We thus propose a causal relation between the earthquake and the amplified gas flux and present reflection seismic data supporting our hypothesis that co-seismic ground shaking induced mechanical fracturing of gas hydrate-bearing sediments creating pathways for free gas to migrate from a shallow reservoir within the gas hydrate stability zone into the water column. Our results imply that free hydrocarbon gas trapped beneath a local gas hydrate seal was mobilized through earthquake-induced mechanical failure and in that way circumvented carbon sequestration within the sediment. These findings lead to conclude that hydrocarbon seepage triggered by earthquakes can play a role for carbon budgets at other seismically active continental margins. The newly identified process presented in our study is conceivable to help interpret data from similar sites.

Reference:
Fischer, D., Mogollon, J.M., Strasser, M., Pape, T., Bohrmann, G., Fekete, N., Spieß, V. and Kasten, S., 2013. Subduction zone earthquake as potential trigger of submarine hydrocarbon seepage. Nature Geoscience 6: 647-651.