Impact of organic matter degradation on rheological behavior of fine-grained sediment

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Abstract

In this study, the influence of organic matter degradation on the rheological properties of mud samples, having similar densities, is examined. The mud samples were collected from four different locations of Port of Hamburg, Germany, to have varying organic matter content. The rheological analysis of fresh and degraded mud samples was performed with the help of several tests including shear stress ramp-up tests, amplitude sweep tests, frequency sweep tests, thixotropic tests and structural recovery tests.

Introduction

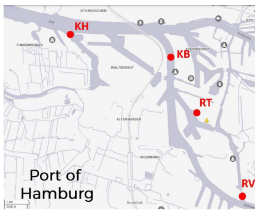
Muddy sediments usually exhibit a complex rheological fingerprint – which is a combination of yield stress, thixotropy or viscoelasticity – due to the presence of hard clay particles and organic matter (i.e., clay-organic flocs).

Marine sediment composition

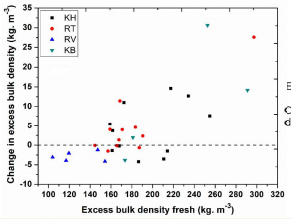
Under anaerobic conditions, the microbial degradation of organic matter typically results in the formation of carbon dioxide (CO_2) and methane (CH_4). These trapped gas bubbles in the mud sample are supposed to decrease the rheological properties and density of mud along with the delayed consolidation. As already known that the rheological properties of mud are strongly dependent on the existence of organic matter, its degradation can also significantly effect the rheological fingerprint of mud.

Methodology

The "undisturbed" mud samples were collected from four different locations of Port of Hamburg (Germany) using one meter core sampler. The bulk density of the sediments was determined by the oven drying method. For anaerobic degradation, fresh mud samples were placed into 500 ml air tight glass bottles. The headspace above mud sample was flushed with N_2 and incubated at 36°C in the absence of light to maintain anaerobic conditions for 250 days.

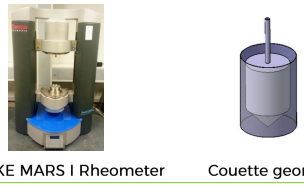


Frahmlot



Excess bulk density = $\rho - \rho_w$

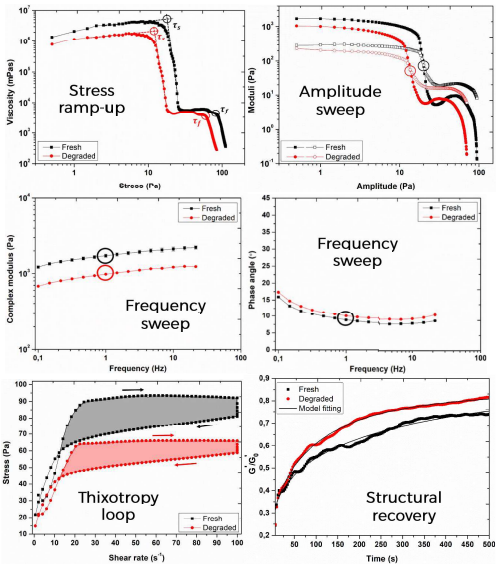
Change in properties = degraded – fresh



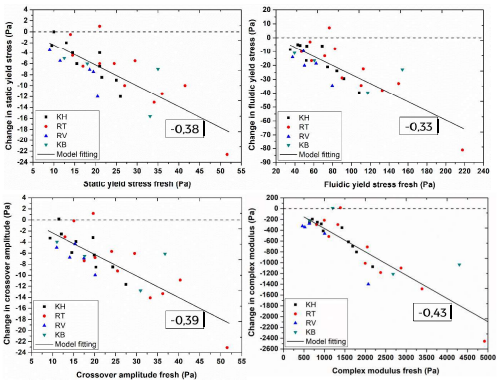
HAAKE MARS I Rheometer

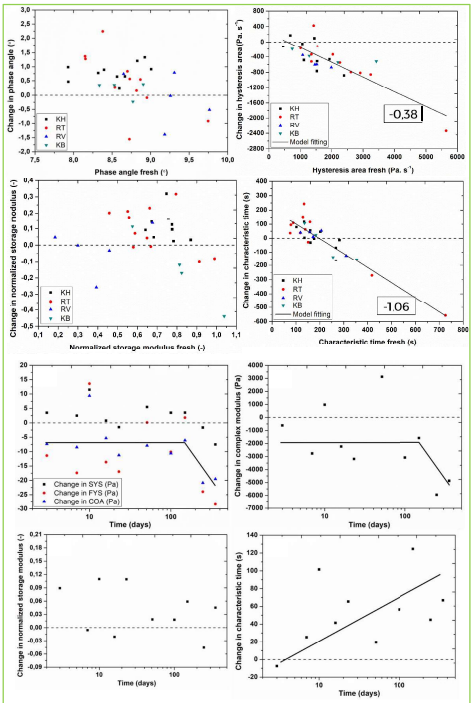
Couette geometry

Results



The results showed a significant decrease in rheological properties including yield stresses (static and fluidic), crossover amplitude, complex modulus and thixotropic hysteresis area for degraded mud samples as compared to the fresh mud samples.





Initially, after 3 days of degradation, a significant decrease in rheological properties was observed, which became more or less constant till 150 days, and after that a further decrease in rheological properties was evident.

Conclusion

The influence of organic matter degradation on the rheological properties of mud is examined. The results showed a significant decrease in rheological properties for degraded mud as compared to the fresh mud. The slope of the line, correlating the change in rheological properties as a function of the same property of fresh mud, was quite similar and varies within the range of -0.33 to -0.43. The effect of degradation time on the rheological properties of mud showed two critical time periods (3 days and 150 days) after which a significant change in rheological properties of mud was observed.

References

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