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Controls on the effect of organic matter decay on sediment rheological properties

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Introduction: Organic matter can significantly change the rheological behavior of river sediments and decrease yield points and viscosity [1, 2]. Therefore, it is assumed that decay of sediment organic matter (SOM), i.e. a change in content and nature of organic matter, impacts sediment properties. This study focuses on the effects of the microbial decay of SOM on rheological properties. Next to the decrease in the content of SOM, the prevailing redox potential and therefore the pathway of degradation also impacts sediment properties: aerobic SOM degradation (i.e., in the presence of oxygen) releases carbon dioxide which easily dissolves in the pore water, while under anaerobic conditions, also methane is released [3]. Due to its low solubility, methane is entrapped in gas bubbles which can decrease mud density and strength.

Methods: Fine grained sediment samples were collected from different locations in the Port of Hamburg, Germany, using a one meter core sampler. Four different sediment layers were distinguished (suspended particulate matter, fluid mud, pre-consolidated and consolidated sediment) based on visual and on-board characterization. The physical properties (e.g., density, particle size distribution, organic matter content) of the mud samples were determined and long-term (>250 days) release of CO_2-C and CH_4-C aerobic and anaerobic degradation of SOM performed using the methodology reported in [3]. Rheological analyses including stress ramp-up tests, amplitude sweep tests, frequency sweep tests and thixotropic tests were performed using the HAAKE MARS I rheometer (Thermo Scientific, Germany) with concentric cylinder (Couette) geometry [1].

Results: Decay of organic matter reduced both the static and the fluidic yield stress in all samples (i.e. negative delta, shown for static yield stress in Fig. 1). Decrease in static yield stress due to SOM degradation on average amounted to 62% of the fresh samples' value. Also, a linear relationship was found between the yield stress of the fresh sample and the absolute magnitude of loss in yield stress by SOM degradation. The largest delta of the yield stresses before and after incubation had been seen for more dense, i.e. more consolidated sediments. Also, density had a great impact on the yield stress correlation, i.e. the highest multiple correlation coefficients were seen between yield stress and the two parameters density and SOM decay rate.

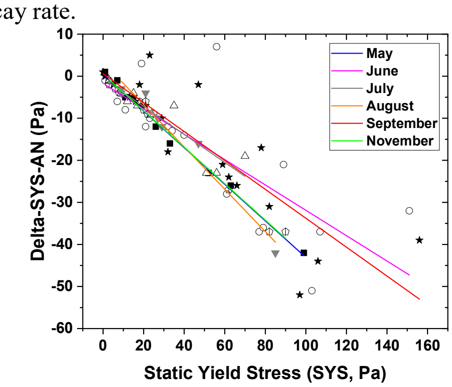

Fig. 1: Relationship between the static yield stress of fresh samples and the difference (delta) between fresh and degraded samples. Symbols = different seasons

Interestingly, samples from nine different locations and four different layers, covering a wide range of yield stresses, followed the same linear regression for individual sampling campaigns, with slopes clearly differing at other points in time. It is therefore concluded that the rheological properties are influenced by seasonal changes of SOM conditions as affected by in-situ decay, dredging, input of fresh SOM and degree of consolidation, reflected by sediment density .

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