

# Traces of sediment origin in rheological behaviour of mud samples taken from the North-Western Persian Gulf

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## Introduction

The Persian Gulf is the text book example of sediments which have directly precipitated from the water. The north-western part of this important body of water is covered with mud deposits which were believed to be mainly originating from the Arvand River catchment area. However, recent findings show that precipitated aragonite needle mud forms a considerable portion of fine sediments in the mentioned area. This study aims to correlate sediment origin, mineralogy and physical properties to the general rheological behaviour of mud deposits in the study area.

## Sediment origin in the North-West Persian Gulf

Mud deposits up to 20 metres thickness are observed at the very shallow coasts extending from Shah-Abdollah and Hendijan Fishery Ports in the east towards the Arvand River mouth and surrounding area of Kuwait Bay in the west. Aragonite needles and oolites are found in certain locations in the north-western part of the Persian Gulf. Oolites are a chemically-precipitated type of sediment, getting their name from the fact that they are well-rounded and resemble little eggs ("ooids"). True aragonite needle muds are another chemically-precipitated type of sediment whose aggregation may result in oolite formation through a complicated process. These types of sediments are found in warm, shallow, saline, agitated water, usually where strong currents exist. They are chemically-precipitated from water that becomes oversaturated with CaCO<sub>3</sub>. The solubility of carbonate in warm water is already low, and wave agitation blows off more CO<sub>2</sub>. This leads to an increase in pH. Small particles are picked up from the bottom, and carried up into surface waters of high pH. Carbonate precipitates around these particles as coatings of aragonite. Tidal deltas in warm waters provide ideal environments in which a grain can be moved periodically and still stay within the same depositional setting for a sufficiently long period of time to develop a thick oolitic coating. Typical habitats for oolites and aragonite needle muds in the modern oceans are the Bahamas, Shark Bay, and the Persian Gulf. There is very limited information on the rate of accumulation of these sediments, but the shoals of the Bahama Banks are presently accreting at the rate of 1mm/year (or 1m/1,000 years). Little has been published on the carbonate mud and oolites of the Iranian coastline.

The true aragonite needle muds are too fine grained to be studied with a light microscope. Hence, Fig. 1 shows photographs of mud samples from nearshore and offshore Hendijan Port taken by a scanning electron microscope (SEM). As it is obvious, the sediment texture consists of ordinary clay flakes together with a considerable amount of aragonite needle mud. Here the aragonite appears as needles with a length/breadth ratio of 5/1 to 8/1. The dimension of the figured needles vary from 0.1 × 0.5μ to 0.2 × 1.7μ. The aragonite fraction in the sediment constituents is estimated to be 40 and 60 percent in the nearshore and offshore samples, while the water content ratio of sediment mixture is measured 100 and 80 percent, respectively. Primary zeta potential measurements show incipient instability in the sediment suspension and high potential of aggregation and flocculation.

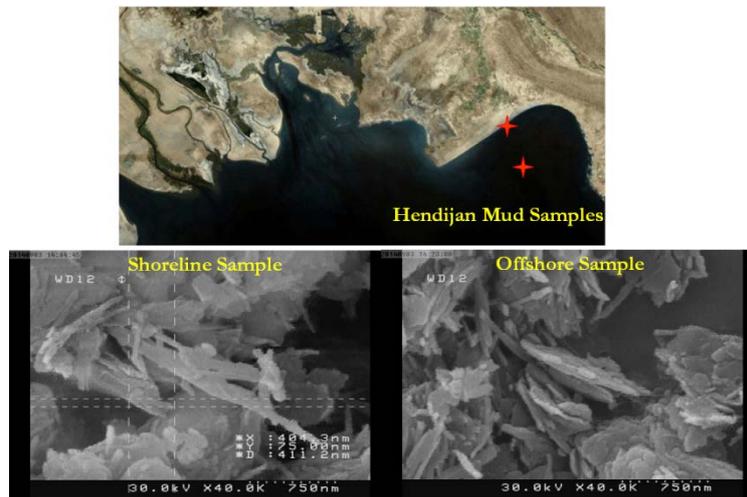


Fig. 1. SEM photographs of mud samples from nearshore and offshore Hendijan Port.

### Rheometry investigations

The selected samples from the Hendijan Coast of the Persian Gulf were analysed using an Anton Paar Physica MCR300 rheometer capable of performing oscillatory tests. Concentric cylinder geometries were used as the measuring system at a constant temperature of 25 °C. The oscillatory tests can be operated in terms of controlled shear deformation (CSD) or controlled shear stress (CSS) in the form of sinusoidal functions. To determine the flow stress from the oscillatory tests, the amplitude sweeps tests (keeping the frequency at a constant value; usually the angular frequency sets as 10rad/s) were performed in controlled-strain deformation ramp mode with a strain range of 0.01 to 100 (%). The measured results are storage modulus  $G'$  and loss modulus  $G''$ . At low stress amplitudes both  $G'$  and  $G''$  have nearly constant values and almost parallel straight lines (linear viscoelastic zone). We note that  $G' > G''$  implies a gel-like character of the mud in the respective stress amplitude range. After the crossover point at  $G' = G''$ , in the stress range in which  $G'' > G'$  the behaviour is that of a liquid (Mehta *et al.*, 2014). The flow stress point (Metzger, 2006). Fig. 2 shows sample results of the natural Hendijan mud with two different water contents, relevant to nearshore and offshore samples.

tf is the stress

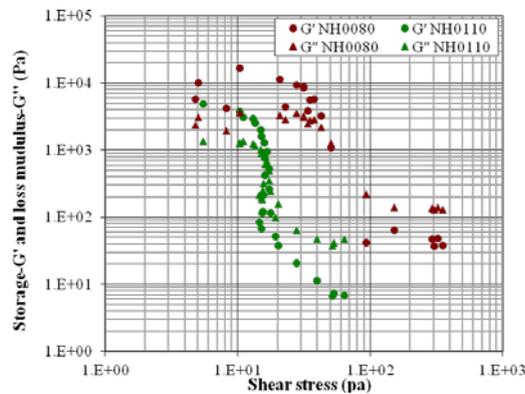


Fig. 2. Sample measured results from oscillatory test.

### Summary

A considerable amount of precipitated aragonite needle mud is observed in sediment constituents over the shallow coasts of the North-Western Persian Gulf. This carbonate fraction seems to play an important role in mud rheological behaviour, something which is tried to be investigated in this study.

### References

- Mehta A., F. Samsami, Y. Khare and C. Sahin. 2014. Fluid mud properties in nautical depth estimation. *J. Waterway, Port, Coastal, Ocean Eng.* 140(2):210–222.
- Metzger T.G. 2006. *The rheology handbook: for users of rotational and oscillatory rheometers.* Vincentz network GmbH & Co. KG, Hannover, Germany.