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SEDIMENTATION IN THE PERSIAN GULF*

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ABSTRACT

As part of the International Indian Ocean Expedition the German research ship "Meteor' visited the Persian Gulf from 14th of March to 23rd of April 1965. Geological studies constituted the main part of the program and were carried out by personnel of the Geological-Paleontological Institute of Kiel University with the support of the German Research Society. The paper embodies information on the hydrology of the Persian Gulf in organic sedimentation, Biogenic sedimentation, and Pleistocene Relic Sediment of the Persian Gulf.

The relationships described in this paper should not only serve as a model for adjacent seas in arid climates and for marine marl deposition, but also give impetus for the study of recent sedimentaton on the open shelf of the Indian Ocean.

INTRODUCTION

As part of the International Indian Ocean Expedition the German research ship "Meteor" visited the Persian Gulf from 14th of March to 23rd of April 1965. Geological studies constituted the main part of the program and were carried out by personnel of the Geological-Paleontological Institute of Kiel University with the support of the German Research Society.

Those parts of the investigations which have been completed have been published in detail with bibliographies and English abstracts in:

a) G. DIETRICH; KRAUSE, G; SEIBOLD, E. & VOLLBRECHT, K. Reisebericht der Indischen Ozean Expedition mit dem Forschungsschiff "Meteor" 1964-1965—"Meteor"—Forschungsergebnisse, A, 1, 1-52, Berlin 1966.

b) E. SEIBOLD und K. VOLLBRECHT. Die Bodengestalt des Persischen Golfs—"Meteor" Forschungsergebnisse, C, 2, 29-56, Berlin-Stuttgart 1969.

c) M. HARTMANN; LANGE, H; SEIBOLD, E. & WALGER, E. Oberflächensedimente im Persischen Golf und Golf von Oman. I. Geologisch-hydrologischer Rahmen und erste sedimentologisch Ergebnisse — "Meteor"-Forschungsergebnisse, C, 4, (Im Druck), Berlin—Stuttgart 1971.

d) M. SARNTHEIN: Ds. II. Quantitative Komponenten-Analyse der Grobfraktion - "Meteor" - Forschungsergebnisse, C, 5 (Im Druck), Berlin Stuttgart 1971.

A comparison of this adjacent sea in an arid climate with other adjacent seas has been made in E. SEIBOLD: Nebenmeere in humiden and ariden Klimabereich-Geolog. Rundschau 60, 1, (Im Druck), Stuttgart 1970.

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1. *The Sedimentation Framework*

Morphology: A simplified bathymetric chart of the Persian Gulf is shown in Fig. 1. The Gulf's surface area (to the dashed line in the east) of 226,000 Km^2 and it's median water depth of 35 m yield a volume of 7,827 km^3.

The Iranian Coast is steep as a result of the Zagros Mountain folding; in contrast, the Arabian Coast is flat. This asymmetry is reflected in the isobaths of the Gulf, *i.e.* the depth axis is displaced toward the NE.

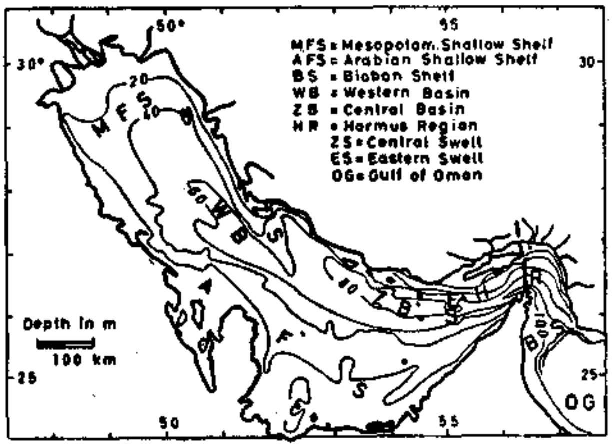

Fig. 1. Divisions of the Persian Gulf.

The Central and Eastern swells divide the Gulf into 3 basins along its long axis: the West Basins, which ends in the NW on the Mesopotamian Shallow Shelf; the Central Basin bordered on the SW by the Arabian Shallow Shelf and in the east by the Hormus Region. The Hormus Region grades (without any distinct swell) into the Biaban Shelf. This shelf extends to the continental slope in the Gulf of Oman.

The islands on the Iranian side of the Gulf are anticlinal features. In the Central part islands and shallows are the result of salt domes.

Maximum depths found in the West Basin reach 73 m, in the Central Basin 105 m and in the Hormus Region a depth of 192 m has been recorded in a salt dome related rim syncline south of Tunb Island. The Masandam Channel reaches a depth of 302 m as it curves around the spur of Oman.

Hydrology: The water of the Gulf is characterized by high surface temperatures in the summer. Even the central Gulf attains temperatures up to 36°C. In the winter, however, the water cools down to 21°C and less. Measurements made in April 1965 show the salt content increasing from 36.6‰ at the entrance to 40.6‰ off Schatt el Atab due to the high evaporation rate (yearly average 144 cm). For this reason in the winter average density values are reached which belong to the highest of the world's oceans (Sigma t up to 3000). This heavier water sinks to the bottom in the northwestern Gulf, and probably also on the Arabian shelf, and flows as bottom water out of the Gulf. An apposing flow of surface water entering from the Gulf of Oman is deflected toward the Iranian coast through the Coriolis effect.

Complex tidal currents are present which run mainly parallel to the Gulf's long axis. Maximum current velocities, at times of longer duration, often exceed 0.5 m/sec even when measured 0 - 4m from the bottom.

These hydrologic conditions allow oxygen to reach the bottom in all parts of the Gulf with the result that oxygen concentrations of less than 60 % saturation are not found. For the same reasons the pH values are always over 8.0 and, with the exception of mixing zones in the Hormus Region, nutrient contents (phosphate, silicate) are low.

2. *Inorganic Sedimentation*

On the Iranian side terrigenous material is delivered almost exclusively through rivers entering the Gulf from the Zagros Mountains. This material consists in the finest fractions of (approximate of decreasing abundance) calcite, quartz, dolomite, feldspar, chlorite, illite, palygorskite, swelling minerals and a small amount of kaolinite. Some of these minerals, along with the red colouring of the finest grains, can be directly related to the geology of the hinterland.

In the West Basin this fluviatile material has built up a young Holocene blanket of fine-grained sediment extending 20 to 30 km into the Gulf. This means that a sedimentation rate of up to several metres prox. 1000 years is present. The wind transported sediment, amounting to several centimetres prox. 1000 years, is insignificant in comparison here.

The previously mentioned tidal currents, working in combination with wind generated waves and currents (Shamal winds mainly from the NW), tend to transport this material parallel to the coast. The dominant transport direction is southeast ward which explains why the Central Swell has been built into the Gulf to a height ranging from 10 to 40 metres. Our data indicates that the sediment brought in by the Schatt el Arab is insignificant on the Iranian side of the Gulf. Its importance to sedimentation on the western Mesopotanian shelf is still an open question.

In the Central Basin the coastal-parallel sediment transport is interrupted by the presence of islands and the steep bottom slope. Here, the fluviatile material is carried directly into deeper water.

In Hormus Bay the finest fluviatile sediment accumulates in the inner bay or in areas protected by Islands.

On the shallow Arabian Shelf present day fluviatile material is insignificant. For this reason inorganically precipitated and biogenic carbonate form the dominant shelf sediment.

3. *Biogenic Sedimentation*

The high water temperatures of the Persian Gulf favour biogenic carbonate production. The carbonate content of the sediment is usually over 50%. Most of the recent sediment, particularly on the Iranian side, can therefore be classified as marl. The carbonate content in the sediment increases as the grain size increases. This is partially due to detrital sediment, but for the most part biogenic components are responsible. For this reason the aragonite content also increases from Iran toward the axis of the Gulf.

Because these biogenic components are usually larger than the terrigenous sediment found far away from the coast, they are not easily transported and give the sediment an autochthonous character.

The low nutrient content of the Gulf's water plus the addition of terrigenous material account for the low values of organically bound carbon in the sediments (mostly 0.5 - 1.0% Corg., maximum 2%). The nitrogen content is similarly low (under 0.3%).

4. *Pleistocene Relic Sediment*

Presently there is very little terrigenous material being brought into the central Persian Gulf. As a result the dominating biogenic sediment with its high aragonite content is being mixed with the underlying fossil sediment through bioturbation. This bioturbate mixing has been seen to extend up to 2.5 m into the overlying Holocene sediment. The fossil material comes from the Late Pleistocene and Early Holocene and consists of inorganic and biogenic very shallow water carbonates (mostly aragonite), glauconite and in the West Basin fluviatile or dune sands. With the help of these relic sediments, 3 standstill periods in the transgression could be defined: -64 to -61 m, -53 to -41 m and -30 to -25 m. The Late Pleistocene climate was quite certainly drier than the present day climate.

The relationships described in this paper should not only serve as a model for adjacent seas in arid climates and for marine marl deposition, but also give impetus for the study of recent sedimentation on the open shelf of the Indian Ocean.