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Study of Conrad and Shaban deep brines, Red Sea, using bathymetric, parasound and seismic surveys

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ABSTRACT

Red Sea was formed where African and Arabian plates are moving apart. Each year the plates drift about 2.5 cm farther apart, so that the Red Sea is slowly but steadily growing hence known as the next coming ocean simply an embryonic ocean. It is characterized by the presence of many deep fractures, located almost exactly along the middle of the Sea from northwest to southeast. Theses fractures have steep sides, rough bottom and brines coming up form on the bottom. Brine deposits are the result of subsurface magmatic activity. They are formed in graben structure as shown by the bathymetric, parasound and seismic studies in the investigated area.

1. Introduction

Narrow marginal shelves and coastal plains are the main morphological features of the Red Sea. The main trough of the Red Sea is broad with depth about 400–1100 m. The main trough of the southern Red Sea is bisected by ~60 km wide axial trough, about 2000 m deep. The early Red Sea was formed about 30 Ma ago where African and Arabian plates were close forming one plate before moving apart (Roeser, 1975; Girdler and Southern, 1987). The axial trough of the Red Sea between15°N to 19°30′N was occupied by the well-developed magnetic anomalies of the seafloor spreading center (Roeser, 1975 and Cochran, 1983). North and south of the Red Sea spreading was prevailed from this center (Roeser, 1975 and Cochran, 1983). At the north of 19°30′N; the bottom of the Red Sea is divided into rough topography reflecting high and low zones. These zones reflect NE-SW short faults nearly 5 km in length (Cochran, 1983). The Red Sea deeps are isolated by broader and shallower inter-trough zones. These zones covered by Miocene evaporites and post-Miocene sediments (Izzeldin, 1989).

The northern 500 km of the Red Sea has bathymetrically surveyed stepping down to an axis of deep water. Sediments in this region are faulted and deformed (Cochran and Martinez, 1988). Small deeps are generally associated with large dipolar magnetic anomalies which they spaced along the axial depression (Pautot et al., 1986; Cochran et al., 1986). The deeps of the central Red Sea transition zone are much larger than the deeps accompanied with dipolar magnetic anomalies. The small deeps, e.g. Shaban Deep, have sediments in the bottom which are intruded by igneous rocks (Pautot et al., 1984).

The purpose of this paper is to present new detailed bathymetric maps to the elongated deeps which are called Conrad and Shaban Deeps (Fig. 1). These deeps are studied with seismic and parasound surveys. The present data are worked out by a Cruise Meteor M44/3 in 1999 and processed in the laboratories of Bremen University, Germany. The results of this work were amended by previous published works in the conclusion of present study.

2. Methodology

The data used in the Conrad Deep studies have been acquired in 1999 during the Meteor Cruise 44/3. The survey by Hydrosweep and Parasound sediments echosounders are continuously operated to study the morphology, depositional processes and sediment structures of the seafloor. Multichannel seismic reflection survey is also used. The acquired data are digitally recorded in the present study.

The general objective of the multibeam Hydrosweep echosounder system is to survey the seafloor topographic features. A sector beam of 90° is covered by a fan of 59 pre-formed beams.

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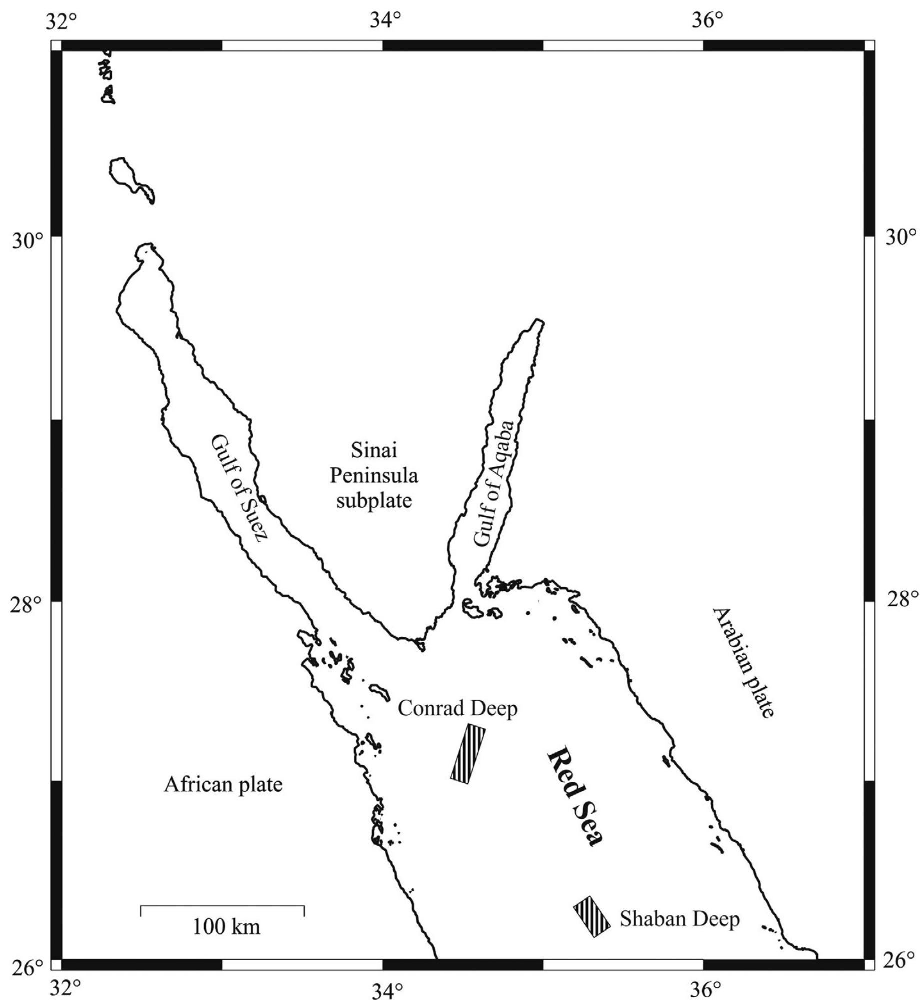

Fig. 1. Overview map of the study area (Conrad and Shaban Deeps). Location of detailed investigated area is shown by the above two boxes.

Consequently, a bar with the width of two times the water depth, perpendicular to the ship track, is mapped. Multibeam-system (mb-system) software package was used to process the data. This package consists of more than 20 programs. This mb-system software manipulate, translate, process, list, and display swath-mapped sonar data (Caress and Chayes, 1996). The data were finally were gridded with 70 m grid-size and displayed by the software of the Generic Mapping Tools (Wessel and Smith, 1999).

The uppermost seafloor sedimentary layers were surveyed with echo-sounder Parasound system. A very high vertical resolution is attained due to the narrow beam angle of 4°, the high signal frequency of 4 kHz, the short signal length of two sinoid pulses. The resolution of small horizontal changes is detected by an optimized succession generation of signals. The Parasond system data are analog which were converted to digital data. These data were stored on 9-track tapes or hard disks in a format of SEG-Y such as format with ParaDigma system (Spieß, 1993).

Multichannel seismic reflection measurements were accomplished with the instrumentation of the Marine and Environments Research Institute, Bremen University. Two seismic sources of different volumes were used, in an exchanging mode for some profiles. The first seismic source is the water gun (SODERA Inc. S-15) with a frequency range 200–2000 Hz gives information of the upper 100–300 m of the sediment succession. The second seismic source is the air gun (Generator-Injector Gun; SODERA Inc.). It has signal energy up to 350 Hz admits seismic imaging of sedimentary layers 1500 m, down seafloor depth.

3. Results and discussion

The Conrad deep area (Fig. 2) is bounded by latitude 34°38′ E–34°48′E and longitude 26°54′N–27°09′N and comprise an area about 30 km × 15 km. Conrad basin has an oval shape with longitudinal axis oriented approximately NE-SW, i.e. the same trend of the Gulf of Aqaba. The deepest part in Conrad area is 1550 m occupying about 10 km^2 in a total of 450 km^2. The depth decreases in the out direction to reach about 1000 m.

The Shaban area (Fig. 3) is approximately 25 km × 15 km (latitude 35°14′E–35°22′E and longitude 26°06′N–26°19′N) and comprises the second basin (Shaban basin). It was surveyed also using a multibeam "Hydrosweep".

Shaban basin has extension (NW-SE, i.e. the same direction of the Gulf of Suez. The deepest part in Shaban area is 1600 m occupying about 40 km^2 in a total 375 km^2. The depth decreases in the out direction to reach about 950 m.

The bathymetric and the Parasound profiles show that the axial depression of the northern Red Sea becomes visible as a fault bounded graben. Extension of the northern Red Sea has reached a point at which the magma starts to erupt. The magma ascends along the faults bounding the axial depression.