

Report on ONR Contract N00014-85-K-0583

TITLE: "TRANSFORM AND FRACTURE ZONE
MORPHOLOGY" DATE: Sep. 1985
per Randy Jacobson ONR/425GG
TELECON 3/9/90 VG

Original Objectives

Final Technical Report

The broad objectives of the research sponsored by the Office of Naval Research under contract N00014-85-K-0583 were to increase our understanding of the fundamental tectonic and petrological processes which determine the genesis and evolution of the oceanic lithosphere. In order to achieve these objectives, our research has been focused on the two main types of plate boundaries found in the ocean basins: (a) accretionary boundaries along mid-ocean ridges, and (b) transform boundaries. Both themes have been approached in two areas: (a) the central and northern Red Sea, where the earliest stages of development of an oceanic accretionary plate boundary and transform boundaries can be observed; (b) the equatorial Mid-Atlantic Ridge, where a mature system of short spreading ridge axis segments are offset by some of the largest active transforms of the entire mid-ocean ridge system. We have attempted in our research to combine as much as possible a morphotectonic with a geochemical/petrological approach, in order to achieve broader answers to our objectives.

Key words: Military Publications, Periodical
Work Accomplished

Red Sea Program - Two cruises were carried out in the central and northern Red Sea, one in 1979, one in 1983. Both cruises were with Italian research vessels, with no ship-time costs for ONR. Bathymetry, seismic reflection profiling, magnetometry, heat flow, hard rock and sediment sampling were carried out during these two cruises. Field work on the island of Zabargad, a unique uplifted body of sub-Red Sea lithosphere, was also carried out. The data obtained in the field efforts were processed and interpreted at L-DGO, where geochemical-petrological work on the samples was also carried out.

Equatorial Atlantic - Our research program in the equatorial Atlantic was based on data obtained during ONR-sponsored expeditions conducted from University of Miami vessels while the present writer was at the Rosenstiel School of Marine and Atmospheric Sciences, and during an ONR-sponsored L-DGO expedition with the R/V Conrad (Cruise RC 21-04), which operated in the Vema F.Z. area (Atlantic, 10°-11°N). Bathymetric, seismic reflection and magnetometric data from these cruises were processed and interpreted at L-DGO, where the petrology of hard rock samples was also studied. A field program which included the submersible ALVIN has been carried out at the Oceanographer F.Z. (35°N in the Atlantic).

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Results and Conclusions

The following is a brief summary of the main accomplishments of this research program. These accomplishments are reported in depth in the published papers resulting from this program, a list of which is appended to this report.

(1) It was established that the large transform/fracture zones offsetting slow-spreading ridges are the loci of intense vertical tectonic movements. These vertical tectonic motions are responsible for some of the roughest topography of the ocean basins, such as that observed in the equatorial Atlantic.

(2) Transform-related vertical crustal motions have created islands which sank below sea level about 5 my ago at the Romanche F.Z. and about 3 my ago at the Vema F.Z. Subsidence rates were one order of magnitude faster than "normal" thermal subsidence of the crust of equivalent age.

(3) A petrological study of mantle-derived peridotitic rocks from the equatorial and northern Atlantic has established that the upper mantle in this region has ~100 km wavelength heterogeneities in composition and/or thermal structure. These regional variations of mantle properties are correlated with variations of gravimetry and geoid anomalies.

(4) The study of the axial troughs of the central Red Sea led us to a model of opening of a new ocean with initial emplacement of oceanic crust, not along a continuous fracture, but in equidistant nuclei caused perhaps by upwelling of asthenospheric diapirs related to Raleigh-Taylor-type instabilities. The axial propagation from the initial nuclei would cause the formation of the initial rift. This model can be applied not only to the Red Sea and Gulf of Aden, but also to the opening of the Atlantic in the Mesozoic.

(5) We have clarified the existence in the Red Sea of transverse fracture zones, probably inherited from pre-existing continental structures. These fracture zones are of great importance in determining the geometry of initial opening and in understanding the origin of large oceanic transform faults. One of these is the Zabargad Fracture Zone, which crosses the central Red Sea in a N20°E direction.

(6) We have shed light on the geochemical and structural features of a large peridotite body derived from the upper mantle and exposed on the island of Zabargad (Figure 2). The study of this peridotitic body allowed us to determine the properties of the mantle beneath the pre-oceanic rift, and to propose a hypothesis on the evolution of the upper mantle from a sub-continental to a sub-oceanic setting.

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(7) From the study of crustal units outcropping on Zabargad we have concluded that basic magmas are intruded at the base of continental crust before and during the early stages of crustal rifting. This study led us to suggest that the thermal anomaly in the mantle preceded the process of rifting in the Red Sea. Therefore, this work suggests a hypothesis of active rather than passive rifting of the Red Sea.

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