



REGIONAL SEAS

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***A Review of the Geology of Coral Reefs
in the Red Sea***

UNEP Regional Seas Reports and Studies No. 152

Prepared in co-operation with



PERSGA

P R E F A C E

The Regional Seas Programme was initiated by UNEP in 1974. At present it includes twelve regions¹ and has some 140 coastal states participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to controlling environmental problems through integrated management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities^{2,3}.

The Regional Seas Programme has always been recognized as a global programme implemented through regional components. Interregional co-operation among the various sea areas on common problems is an important element in assuming the compatibility of the different regional components.

The substantive aspect of any regional programme is outlined in an "action plan" which is formally adopted by an intergovernmental meeting of the Governments of a particular region before the programme enters an operational phase. In the preparatory phase leading to the adoption of the action plan, Governments are consulted through a series of meetings and missions about the scope and substance of an action plan suitable for their region. In addition, with the co-operation of appropriate global and regional organizations, reviews on the specific environmental problems of the region are prepared in order to assist the Governments in identifying the most urgent problems in the region and the corresponding priorities to be assigned to the various activities outlined in the action plan. UNEP co-ordinates directly, or in some regions indirectly through existing regional organizations, the preparations leading to the adoption of the action plan. All action plans are structured in a similar way, although the specific activities for any region are dependent upon the needs and priorities of that region.

The Regional Conference of Plenipotentiaries on the Conservation of the Marine Environment and Coastal Areas in the Red Sea and Gulf of Aden was convened in the City of Jeddah, 13-14 February 1982, at the invitation of the Government of the Kingdom of Saudi Arabia by the Arab League Educational, Cultural and Scientific Organization (ALECSO). The Conference adopted the Action Plan for the Conservation of the Marine Environment and Coastal Areas in the Red Sea and Gulf of Aden together with the following two legal agreements:

- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment; and,⁴
- Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency.⁴

This document is one of a series of UNEP/Regional Seas Programme publications relevant specifically to the Red Sea and Gulf of Aden Regions^{5,6,7} and which comes as a first publication of a new series of joint UNEP/PERSGA publications (see Forward).

¹ Mediterranean Region, Kuwait Action Plan Region, West and Central African Region, Wider Caribbean Region, East Asian Seas Region, South-East Pacific Region, South-West Pacific Region, Red Sea and Gulf of Aden Region, Eastern African Region, South Asian Region, Black Sea Region and North-West Pacific Region.

² UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. UNEP Regional Seas Reports and Studies No.1, UNEP, 1982.

³ UNEP: UNEP-sponsored programme for the protection of oceans and coastal areas. UNEP Regional Seas Reports and Studies No. 135. UNEP, 1991.

⁴ Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment; Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency, UNEP, 1983.

⁵ IUCN/UNEP: Management and conservation of renewable marine resources in the Red Sea and Gulf of Aden region. UNEP Regional Seas Reports and Studies No. 64. UNEP, 1985.

⁶ UNEP: Action Plan for the conservation of the marine environment and coastal areas of the Red Sea and Gulf of Aden. UNEP Regional Seas Reports and Studies No. 81. UNEP, 1986.

⁷ HALIM, Y. et al: Regional Review on the State of the Marine Environment in the Red Sea and Gulf of Aden, UNEP, 1989 (Draft)

FORWARD

Since its initiation in 1974, the Red Sea and Gulf of Aden Environment Programme (PERSGA) has been working in close co-operation with related international organizations including UNEP which has supported the activities leading to the convening of the Jeddah Conference of Plenipotentiaries in February 1982, and continues to act in an advisory capacity on matters related to environmental assessment and management in the region.

Within the framework of this long-standing co-operation, and under an agreement between UNEP and PERSGA Secretariat, several projects were completed by institutions and individual scientists in the region in the context of the Red Sea and Gulf of Aden Action Plan.

The present publication is one of the products of these completed projects, supported by PERSGA and UNEP, and is published as a joint UNEP/PERSGA publication. Other similar documents are now being prepared as joint publications to appear in the near future.

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1. INTRODUCTION

1.1 OBJECTIVES

This review has been written in response to the rapid expansion of work on Red Sea reefs over the last two decades, and is an attempt to summarise our present-day knowledge about the kinds of reefs known in the Red Sea, and of their foundations and origins. This review cannot present the detail which is available in the source literature, but is intended to highlight the important literature and provide a useful starting point. One of the main problems of coral reef science in this region has been duplication of work caused by inadequate knowledge of the literature, and it is hoped that provision of such material in this single, summary document can also help to avoid this time-consuming and wasteful practice.

There has been some revision of knowledge in this area within the last two decades, and reviews (mostly biological in emphasis rather than geological) have examined this. Where such reviews exist, these are used as the source material here rather than the body of sometimes much earlier literature. One object of any review is to draw a new "starting line" for its subject matter; in the rapidly expanding scientific knowledge of the Red Sea today, any primary source literature over about 15 years old is likely already to have been assimilated into the body of understanding (or abandoned in many cases), and rarely is there much need to cite volumes of much older references.

Within the Red Sea (Figure 1), some areas have been much better documented than others. The Gulf of Aqaba in particular has been well studied, and to a lesser degree the areas around Jeddah and Port Sudan have been the focus of a reasonable amount of attention. Next, Yanbu in the central region, the Dhalak Archipelago in the far south, and the southern coast of the Arabian peninsula from south of Jeddah to Aden have also been surveyed to various degrees, although sometimes these surveys have been biological rather than geological. Together these add up to a fairly extensive area, but they are by no means comprehensive, and extensive parts of the Red Sea remain almost completely unexplored scientifically. The Gulf of Aden is less well documented, although the reefs of Djibouti have been the subject of some study.

The Red Sea is highly regarded above all else perhaps, for its fringing reefs. However, some of the literature has been misleading in respect to their distribution. Even some fairly recent summaries have remarked that fringing reefs line the entire banks of both sides, but this is incorrect. Fringing reefs are best developed in the northern half of the Red Sea proper and Gulf of Aqaba only, and while they do exist sporadically in the southern half, they are by no means continuous and are commonly weakly developed. The persistent, erroneous impressions derived from the fact that most visits to the region took place north of Jeddah, particularly in the Gulf of Aqaba, and extrapolation to the whole Red Sea was tempting and so perhaps inevitable until much better documentation became available (Sheppard and Wells 1988).

It is now known that the southern half is much more of a sedimentary basin, with gentle bathymetric gradients, seagrasses and mangroves, and is entirely dissimilar to the reef-fringed northern and central parts with their steep bathymetric profiles.

In the mid-1980's, a substantial barrier reef complex in the central section was documented, as were a series of remarkable algal reefs in the southern part, and also at this time the geology of the Dhalak Archipelago was documented in another series of studies. In the last 10 years, the region has emerged, in a marine geological sense, from a condition where more basic surveys were needed to one where a certain amount of synthesis is possible, and it is hoped that this document will help to provide a starting point for this phase.

1.2 IMPORTANCE OF RED SEA REEFS

Coastal coral reef formations of the Red Sea have long been used for recreation sites, sources of food and sources of material for building and crafts. In these respects they have been valuable to small local populations for at least 3,000 years. At the same time, they became known with much less favour to the increasing number of seafaring traders who navigated these reef-strewn waters. As the sea developed into an increasingly important trading and pilgrimage route, problems of unintended encounters with reefs increased too, so that from very early days, reefs of the Red Sea were well known, if not always appreciated. Horton (1987) reviews the human settlement of the Red Sea, and illustrates the importance of coral reef material, for example, in the construction of Port Suakin.

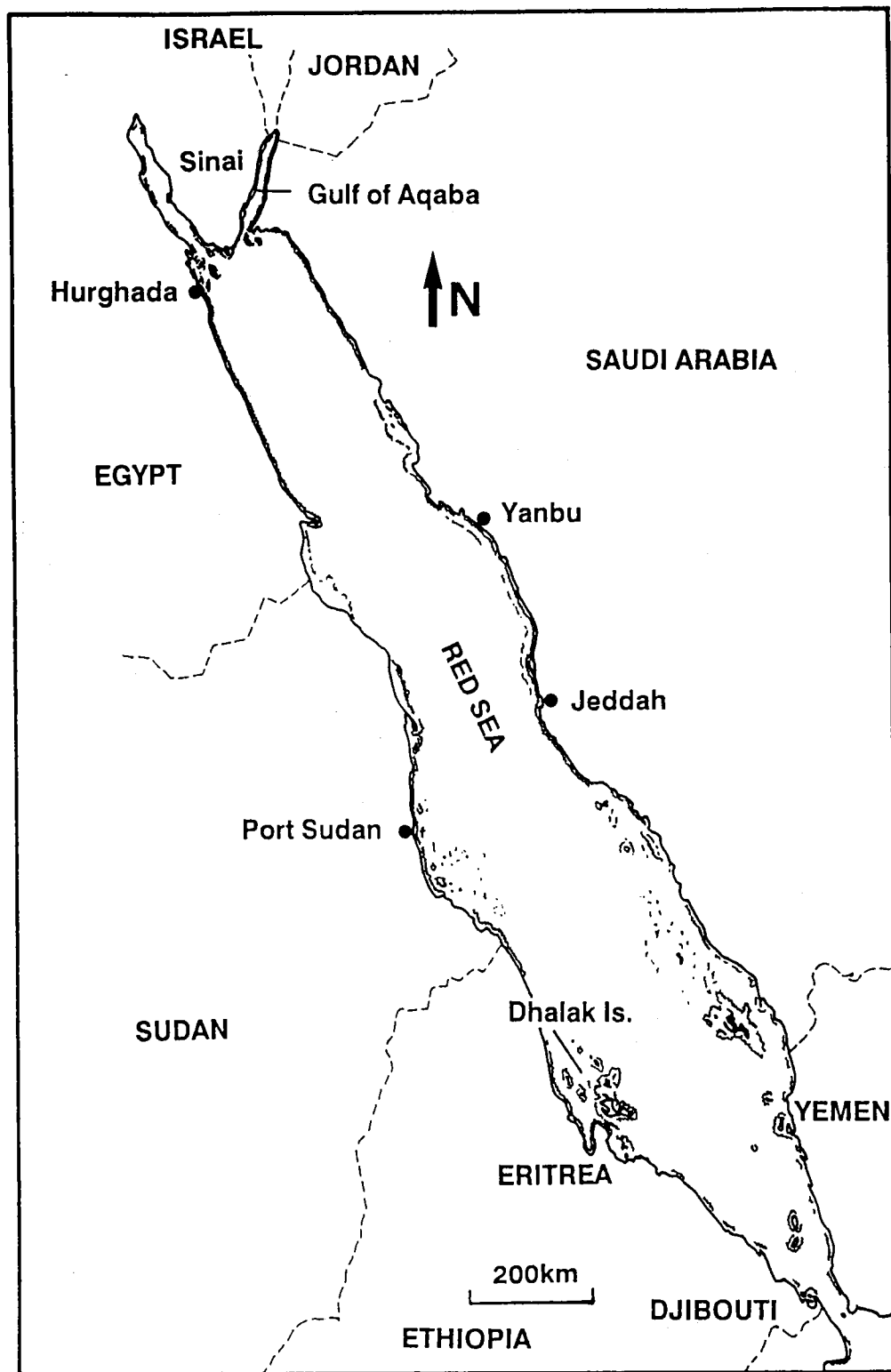


Figure 1: Red Sea and Gulf of Aden, showing major locations of reefs. Hatching indicates most studied areas.

For hundreds of years, reef resources of the Red Sea were used sustainably. There was nothing intrinsically different about the earlier cultures which allowed use to be sustainable, rather it came about from the low density of the populations living along the coasts. In the last few decades, increased population and the resultant increase of activities in the coastal areas, such as urbanization, industrialization and a growing tourist industry, have caused the damage of coral formations in many areas of the world, and the Red Sea is no exception, particularly near its major urban areas. Accordingly, the protection of coral reefs is becoming increasingly difficult, particularly of reefs near human settlements (Stoddart and Johannes, 1978).

New pressures also arise with shifts in human demands. The Red Sea is a major oil tanker route and coral reefs have been threatened by oil spills. Untreated sewage from urban areas, and unrestricted collection of shallow water marine life all add their deleterious effects. Landfill, which selectively encroaches onto reef flats and other shallow water areas, is a greater and still increasing problem. Corniche development along reef flats, landfill which extends municipal and private property, and shallow excavations associated with ports and more importantly perhaps, the provision of landfill material, all destroy reefs more or less permanently.

Despite the strategic setting of the Red Sea, being a link between the east and west, perhaps the main resources of the Red Sea are the coral reefs themselves. As expressed by Bemert and Ormond (1982) the coral reefs of the Red Sea provide a most valuable natural laboratory in which to further our understanding of life on earth. They are also especially beautiful, with highly diverse ecosystems. Their biological diversity, in fact, probably considerably exceeds that of the adjacent lands in an interesting inversion of the usual situation. With proper management, Red Sea reefs promise to be a source of great beauty and pleasure for generations to come.

The economic importance of reefs, where fossil coral reefs serve as reservoirs for petroleum, has been known since the beginning of the petroleum industry in the region. Much of the Middle East is a carbonate province with important hydrocarbon deposits. Reef complexes occur extensively from the Cretaceous and Tertiary, and some of these are coral reefs. For example, the Kirkuk field, Iraq, is a regressive Tertiary reef, with fore reef and a back reef facies; it extends for over 250 miles, ranging in age from Middle Eocene to Miocene.

The Red Sea itself has attracted reef researchers for many years. Many parts of it contain favourite sites for studying the growth of corals and formation of reefs. The Red Sea is characterised by markedly changing environmental conditions which span the entire range, from those which can support vigorously growing corals to those where environmental stresses exceed the tolerances of coral or reef growth. The Red Sea's varied bathymetry also provides excellent opportunities for researching modern carbonate reefal sedimentation.

Comprehensive reviews on ecological research on coral reefs of the Red Sea are given in Mergner (1984), Head (1987a) and Sheppard *et al* (1992). A chapter in the latter reviews available geological knowledge, though this is done mainly to provide a geological background to what is essentially a biological account. Braithwaite (1987) provides a valuable geological overview. Even so, geological aspects of this region have received less attention to date than biological aspects. Other reef geological reviews important to this region, though not necessarily concerned with reefs of the Red Sea specifically, are contained in Hopley (1982), Friedman and Krumbein (1985) and Schroeder and Purser (1986).

2. GEOLOGICAL OVERVIEW OF THE RED SEA

2.1 EARLY FORMATION

Today the Arabian peninsula occupies, more or less, its own tectonic plate (Figure 2), which appears to be a relatively newly separated fragment of the very large African plate. The separation zone is marked by the area of sea floor spreading which passes down the Gulf of Aden and Red Sea, through the Gulf of Aqaba and into the

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