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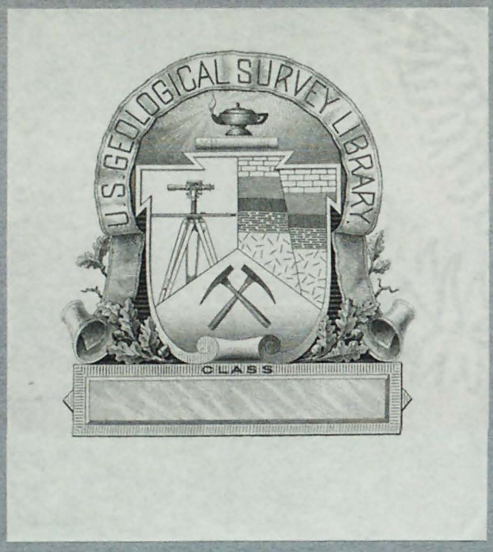
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PRELIMINARY TECTONIC MAP OF THE ARABIAN PENINSULA

by

Glen F. Brown
U. S. Geological Survey

1971

PREFACE

In 1963, in response to a request from the Ministry of Petroleum and Mineral Resources, the Saudi Arabian Government and the U. S. Geological Survey, U. S. Department of the Interior, with the approval of the U. S. Department of State, undertook a joint and cooperative effort to map and evaluate the mineral potential of central and western Saudi Arabia. The results of this program are being released in USGS open files in the United States and are also available in the Library of the Ministry of Petroleum and Mineral Resources. Also on open file in that office is a large amount of material, in the form of unpublished manuscripts, maps, field notes, drill logs, annotated aerial photographs, etc., that has resulted from other previous geologic work by Saudi Arabian government agencies. The Government of Saudi Arabia makes this information available to interested persons, and has set up a liberal mining code which is included in "Mineral Resources of Saudi Arabia, a Guide for Investment and Development," published in 1965 as Bulletin 1 of the Ministry of Petroleum and Mineral Resources, Directorate General of Mineral Resources, Jiddah, Saudi Arabia.

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The tectonic map of the Arabian peninsula, scale 1:10,000,000, is intended for incorporation in the world tectonic map being prepared by the Tectonic Subcommission of the International Geological Congress, It is a preliminary draft synthesis, skeletonized from a working scale map (1:4,000,000) being prepared from all available geological, geophysical, and structural information of the peninsula and adjacent coastal waters. Both maps are being compiled for the Ministry of Petroleum and Mineral Resources of the Kingdom of Saudi Arabia.

Currently, ideas about tectonics are being radically revised. These revisions will have economic as well as scientific importance. This is a first attempt to introduce these ideas into the structural picture of the peninsula. Applications to ore search, to structure of the Precambrian shield, and to the geophysics of the Red Sea are of immediate concern. The principal sources of information were the U.S. Geological Survey geological map of the Arabian peninsula (Brown et al, 1963) and the topographic and physiographic map of the Arabian peninsula (Brown and others, unpub. data).

The Ministry of Petroleum and Mineral Resources of the Kingdom of Saudi Arabia has financed the preparation of the map,

supplied the elevations of formation tops in oil exploration test holes, and extended many other courtesies. The Ministry of Agriculture and Water has supplied information from borings drilled for water to depths of 2000 meters or less. Besides the prime support of the Directorate of Mineral Resources of the Ministry of Petroleum and Mineral Resources, the geological missions of France and Japan have freely made their work available. Much of the information from coastal waters and adjacent land has come from oil companies exploring for petroleum and natural gas.

Various members of the U.S. Geological Survey team in Arabia helped with many aspects of the compilation. Field geophysical surveys and interpretation with computerized programing and contour plotting were accomplished by V. Flanigan, G.E. Andreasen, and A.J. Petty. R.O. Jackson, R.G. Coleman, R.L. Moravetz, A. Griscom and J.A. Reinemund reviewed the preliminary proof.

The Continental Oil Company kindly furnished the elevation of some formation tops in the Dofar. Air borne magnetic profiles made for the Central Planning Organization across the Jordan-Arabia basin through Al Jauf and profiles across the northeastern flank of the Arabian platform near Anaiza served as a preliminary guide to depth to basement. This information was supplemented by a gravity survey in northwest Arabia near the Jordanian boundary which included a gravity profile from the exposures of crystalline rocks near the

northern edge of the shield. These depth estimates based on geophysical data along with depths from exploratory borings in Jordan (Bender, 1968) were used in this area. As structures in eastern Arabia are attributed to Pliocene epirogenic warpings associated with basement faulting and salt flowage (Falcon, 1967), the outlines of concessions were assumed to represent highs on the basement around which the contours are bent.

Faults on the peninsula and in adjacent Africa are mapped from surface outcrops (Brown et al., 1963; Bender, 1968; Dannert et al., 1970; Wiesner, 1970; Gillman, 1968), whereas those in the Red Sea and Gulf of Aden follow submarine scarps or are interpreted from geophysical data and are shown with hatchures.

The large transverse faults crossing the Arabian shield have now been mapped in sufficient detail to measure horizontal displacement ranging from 5 to 20 kilometers, the distance depending on the age of the rocks faulted. They are shown on the map with barbed symbols. The submarine scarps are those shown on the bathymetric charts of the British National Institute of Oceanography prepared by Laughton et al., (Falcon et al., 1970). These charts were also used as sources for the bathymetry shown on the tectonic map.

Currently some geologists envisage the Oman mountains to be overthrust blocks of oceanic crust (McKenzie, 1970, and Coleman, 1971). This interpretation seems reasonable according to the geology

as described by Wilson (1967), Reinhardt (1969), and Greenwood and Loney (1968). Analysis of the seismic data also seems to support this interpretation. There is good evidence that Arabia has drifted against Asia with obduction of ocean crust-mantle slabs onto Arabia during the Alpine orogeny, perhaps with a somewhat earlier inception. Perhaps a majority of published opinions consider that the Gulf of Aden and the central deep in the Red Sea are also underlain with oceanic igneous material and tectonically displaced mantle rock but the bulk of the Red Sea trough is a Miocene salt basin. In the Gulf of Aden the oceanic crust seems to have been generated in the mid-gulf ridge during and subsequent to Miocene rifting (Laughton, A.S., Whitmarsh, R.B., and Jones, M.T., and Gass, I.G., in Falcon et al., 1970).

The oceanic tholeiitic basalts in the median trough of the Red Sea (Gass in Falcon et al., 1970) are most likely of Pliocene age and younger. Similar basalts from volcanoes in rift faults with massive olivine phenocrysts along the coastal plain in Saudi Arabia are dated at 4 m.y. (K40-Ar total rock) and appear to represent mantle material, strengthening the hypothesis that there is a younger accelerated rift movement with inception from late Pliocene to Pleistocene which is of oceanic type whereas the earlier Miocene Red Sea rift was developed in sialic crust.

Another older salt basin, dating from late Precambrian to Cambrian underlies the eastern portion of the peninsula (Falcon, 1967, and Meyerhoff, 1970) and salt plugs of late Jurassic age have been described on the east side of the Arabian shield in southwest Arabia (Beydoun, 1966).

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MINISTRY OF PETROLEUM AND MINERAL RESOURCES
DIRECTORATE GENERAL OF MINERAL RESOURCES

KINGDOM OF SAUDI ARABIA

PRELIMINARY TECTONIC MAP OF THE ARABIAN PENINSULA

Compiled by Glen F. Brown,
U.S. Geological Survey, Jiddah, Saudi Arabia,
on behalf of the
Ministry of Petroleum and Mineral Resources

SCALE 1 : 10 000 000

100 0 100 200 300 400 500 km.

1971

30° 40° 50° 60° 20°

Al Jauf · Kuwait · Anaiza · Ar Riyadh · Dubai · Muscat · Al Wajh · Jiddah · Makkah · Bishah · Port Sudan · Massawa · San'a · Al Hudaydah · Al Mukalla · Aden · SOCOTRA

GULF OF SUEZ · GULF OF AQABA · RED SEA · ARABIAN GULF · GULF OF OMAN · OMAN · DOFAR · ARABIAN SEA · GULF OF ADEN · EAST EDGE OF SHIELD

LEGEND

TECTONIC EPOCHS AND THEIR CLOSING FOLDINGS

I. FOLDED AREAS AND FOLDED PLATFORM BASEMENT

ALPINE EPOCH
- Ophiolite

LATEST PRE-PALEOZOIC EPOCH
- Granitoids and migmatites

II. COVERS OF PLATFORMS AND MEDIAN MASSES
Deeply subsided parts of ancient platforms. (with basement reworked by Baikalian and Paleozoic foldings, including areas with basement of unknown age)

DEPTH OF BASEMENT RELATIVE TO SEA LEVEL
- Above mean sea level
- From 0 to – 500 m
- From – 500 to – 1000
- From – 1000 to – 1500
- From – 1500 to – 2000
- From – 2000 to – 3000
- From – 3000 to – 4000
- Below – 4000

TECTONIC STRUCTURES
- Salt anticlines and domes
- Boundaries of salt tectonic areas
- Volcanoes, terrestrial and submarine, active or erupting in historical time
- Normal and reversed faults
- Low-angle overthrusts and nappes
- Transverse faults
- Outlines of oceanic type crust within intracontinental seas
- Anticlines
- Synclines

VOLCANIC ROCKS (VOLCANOGENE)
- Neogene-Quaternary effusions
- Trap rocks, flood basalts

SEA-BOTTOM RELIEF IN METERS
- 200