RECONNAISSANCE GEOLOGY OF THE MANJAMAH QUADRANGLE, SHEET 18/41 A, KINGDOM OF SAUDI ARABIA

by

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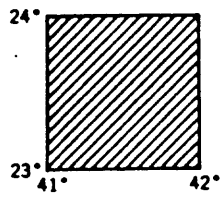
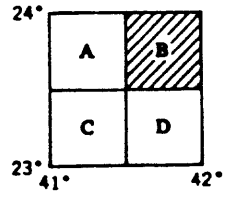


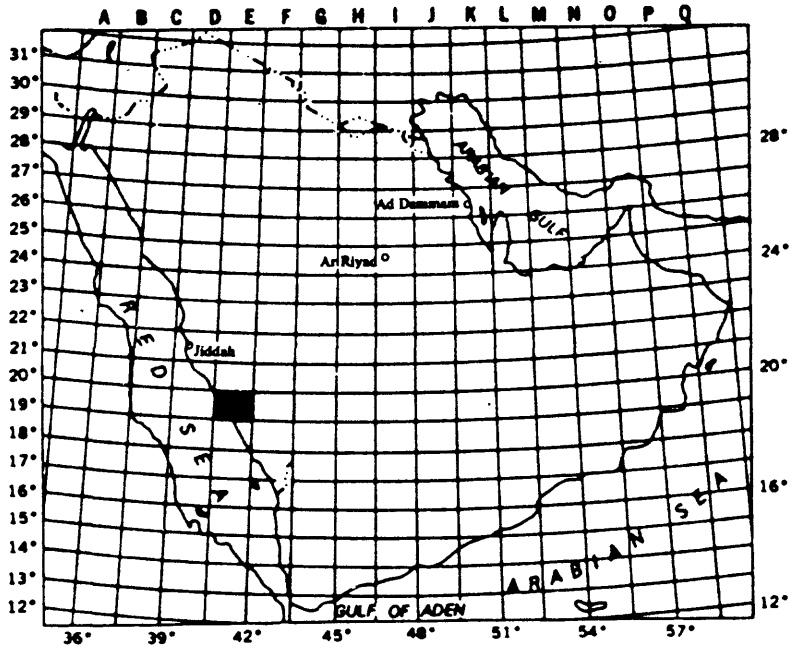
23/41

1-degree quadrangle



23/41 B

30-minute quadrangle



19E

1x1½-degree quadrangle

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ABSTRACT

The Manjamah quadrangle (sheet 18/41 A) lies between lat 18°30' and 19°00' N. and long 41°00' and 41°30' E. and encompasses an area of 2,932 km^2, of which about half is land and the remainder covered by the Red Sea. The geologic formations exposed in the quadrangle comprise Precambrian layered and intrusive rocks, Tertiary layered rocks and gabbro dikes, and Quaternary basaltic lavas, pyroclastic rocks, and surficial deposits.

The Precambrian rocks are layered metasedimentary and metavolcanic rocks that have been assigned to the Baish and Bahah groups. These rocks are cut by Precambrian biotite quartz monzonite and by Miocene gabbro dikes that were intruded during the initial stages of the opening of the Red Sea rift. Tuffaceous siltstone of the Baid formation was also deposited during the Miocene, followed in the Pliocene by the polymict conglomerate of the Bathan formation. The Quaternary rocks include basalt that was extruded during a continuation of the opening of the Red Sea rift, after uplift of the escarpment parallel with the Red Sea but before the Holocene erosional cycle.

The greater part of the land area of the quadrangle is covered by Quaternary coastal, pediment, and alluvial deposits of various kinds associated with the deltaic mouths of Wadi Hali and Wadi Yiba and their tributaries and with the development of fringing reefs and islands. The area also contains extensive Quaternary eolian deposits.

The economic potential of the quadrangle lies essentially in the agricultural value of its flood-plain deposits, which are frequently refreshed during flooding with the products of weathering and erosion of the Precambrian rocks in the valleys of Wadi Hali and Wadi Yiba; coral reefs could possibly provide raw material for use in a cement industry, if any such industry were ever required in this area.

INTRODUCTION

The Manjamah quadrangle (sheet 18/41 A) lies between lat 18°30' and 19°00' N. and long 41°00' and 41°30' E. (fig. 1) and encompasses an area of 2,932 km^2, of which about half is land and the remainder covered by the Red Sea. The northeastern corner of the quadrangle is part of the escarpment mountains province, a rugged region between the coastal plain and the elevated Asir province of the Arabian Shield.

The area is about 360 km southeast of Jiddah and 240 km northwest of Jizan. The coastal road from Jizan swings inland near the southern edge of the quadrangle and passes through Kiyat and Bugarein on the way to Al Qunfudhah, 20 km north of Bugarein; a more direct route to the latter passes through Salamah. Branches from these roads serve the numerous small communities scattered over the wide alluvial flats of the Wadi Hali and Wadi Yiba deltas, areas which are agriculturally attractive because of water that reaches them from the frequent rainfall on the escarpment and on the mountains beyond. The soils of the delta areas have been enriched by the addition of weathering products from the Quaternary basalts of the coastal areas.

The broad geologic features of the area are shown on the 1:500,000-scale map of the Tihamat ash Sham quadrangle by Brown and Jackson (1958). The area and its surroundings are also shown on the 1:2,000,000-scale geologic map of the Arabian Peninsula (U.S. Geological Survey-Arabian American Oil Co., 1963). More detailed work and studies of mineral resources were started in 1970 and have included work on the following nearby quadrangles: Wadi Yiba, 19/41 D (Bayley, 1972); Jabal Sawdah, 18/42 C (Ratte and Andreasen, 1974); Al Qunfudhah, 19/41 C (Hadley, 1975a); Wadi Hali, 18/41 B (Hadley, 1975b); and Jabal 'Aya, 18/42 A (Prinz, 1975).

Fieldwork was done by the author in the Manjamah, Wadi Amq (1982a), Wadi Dhahaban (1982b), and Jabal Hashahish (1982c) quadrangles between mid-December 1973 and late March 1974; he was assisted in the field and office by Ghanim Jeri Alharbi, Yacob Essa Takrony, Murshid Abdo Ahmad, and Saud Muslih Ashaybani. Logistic, drafting, and laboratory support were provided by the Directorate General of Mineral Resources.

All the work on the Manjamah quadrangle was done under an agreement between the Saudi Arabian Ministry of Petroleum and Mineral Resources and the U.S. Geological Survey.

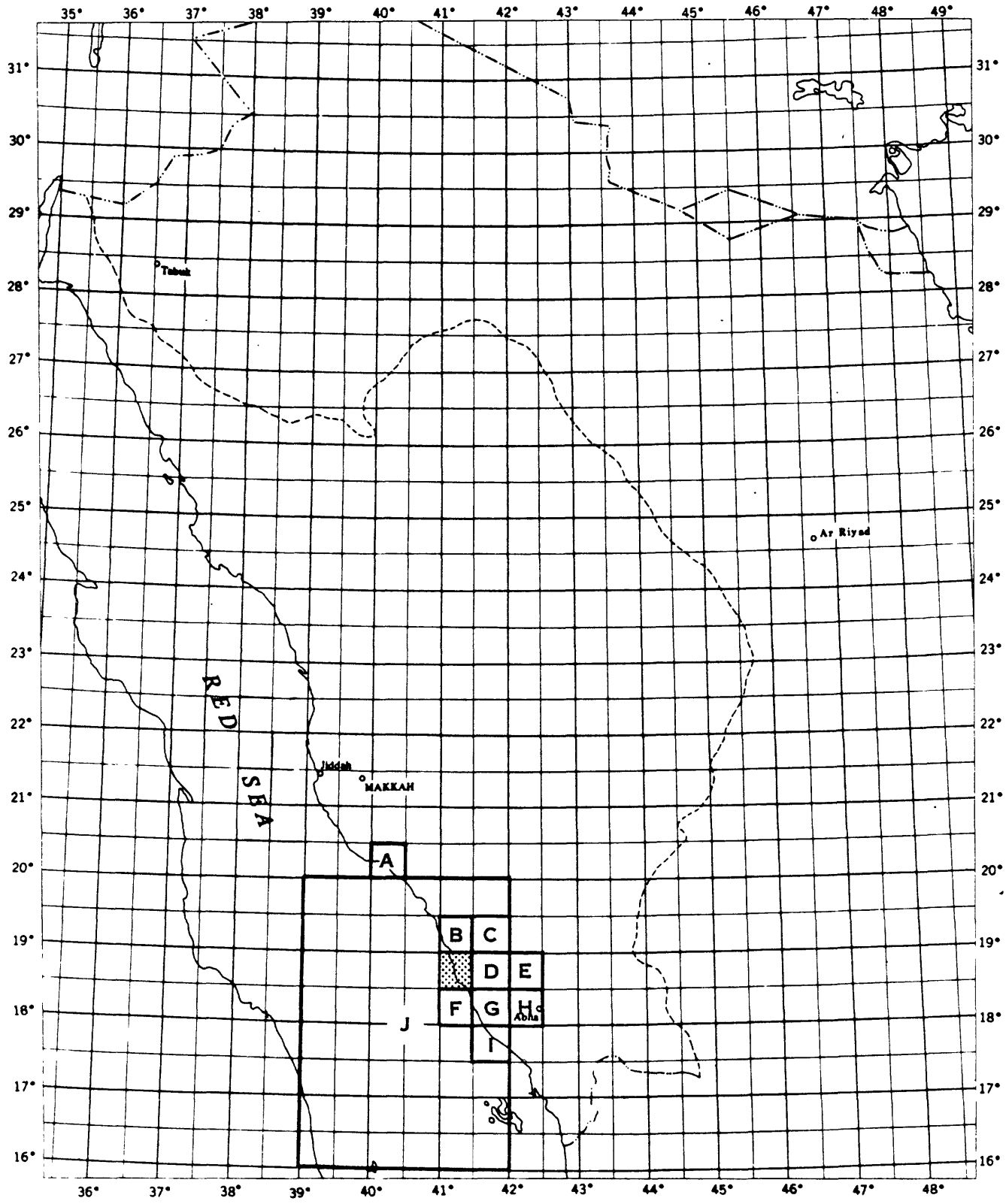

Figure 1.–Index map of western Saudi Arabia showing the location of the Manjamah quadrangle (shaded) and other quadrangles cited in this report: A, Al Lith (Hadley and Fleck, 1980); B, Al Qunfudhah (Hadley, 1975a); C, Wadi Yiba (Bayley, 1972); D, Wadi Hali (Hadley, 1975b); E, Jabal 'Aya (Prinz, 1975); F, Wadi Amq (Hadley, 1982a); G, Wadi Dhahaban (Hadley, 1982b); H, Jabal Sawdah (Ratte and Andreasen, 1974); I, Jabal Hashahish (Hadley, 1982c); J, Tihamat ash Sham (Brown and Jackson, 1958).

PRECAMBRIAN ROCKS

Layered rocks

The Precambrian layered rocks of the Manjamah quadrangle are assigned to the Baish and Bahah groups. Those assigned to the Baish group comprise mafic to intermediate volcanic rocks and sedimentary rocks that include some chert; those assigned to the Bahah group are all of sedimentary origin and include some marble. These layered rocks have been metamorphosed to greenschist facies and strongly affected by faults with north- to north-northwest trends, parallel with the Miocene gabbro dikes, the escarpment bordering the Precambrian rocks, and the trend of the Red Sea rift.

Baish group

The Baish group (Schmidt and others, 1973) is represented in the Manjamah quadrangle by basalt and andesite and related volcanic rocks, volcaniclastic rocks, graywacke, slate, argillite, and chert. These rocks are moderately to strongly schistose, especially near fault zones. The lava flows are 5 to 20 m thick and are composed of green to dark-green rocks, commonly amygdaloidal and porphyritic, with phenocrysts 0.2 to 2 cm long in a fine-grained chloritic matrix; glomeroporphyritic textures are common in the andesite flows. The volcaniclastic rocks include gray, green, reddish, or tan tuffs and agglomerate. They are fine to medium grained except for the agglomerates. Most bedding in these rocks and sedimentary structures in the graywackes, slates, and argillites have been obliterated by shearing.

Bahah group

The Bahah group (Schmidt and others, 1973) in the Manjamah quadrangle includes graywacke, siltstone, argillite, and marble and lacks the lavas and tuffs that are present in the nearby Wadi Dhahaban quadrangle. The marble is white, gray, or buff and forms a distinct layer between rocks of the Baish group and the other sedimentary rocks of the Bahah group. The lack of interbedded clastic rocks in the marble unit distinguishes it from the Bahah marble unit of the Wadi Dhahaban quadrangle, which contains about 70 percent of such rocks.

Intrusive rocks

Biotite quartz monzonite

Biotite quartz monzonite crops out in the extreme southeastern corner of the quadrangle in the bottom of two small wadis that extend into the area from the Wadi Hali quadrangle.

The rock is reddish orange, medium grained, and generally equigranular, although porphyritic phases are present in some areas of the outcrop. The primary minerals include oligoclase (40-50 percent), orthoclase (25-35 percent), and quartz (15-25 percent). Other minerals include biotite (2-8 percent) and 1-2 percent each chlorite, muscovite, epidote, magnetite, sphene, and zircon.

The exact age of the intrusion is not known but its nontectonized character and general composition compared with similar intrusive bodies in the Wadi Hali quadrangle suggests that the rock is late Precambrian in age.

TERTIARY ROCKS

Layered rocks

The Tertiary layered rocks in the Manjamah quadrangle include the Baid and Bathan formations, which are probably of Miocene and Pliocene age, respectively. These rocks occupy small areas in the northern half of the quadrangle 25 to 30 km from the coastline.

Baid formation

The Baid formation (Brown and Jackson, 1958) consists in the Manjamah quadrangle of cream-colored, uniformly bedded, tuffaceous siltstone composed of sericitic argillaceous material enclosing sparse embayed fragments of volcanic glass, plagioclase, and magnetite. The beds range in thickness from 3 to 15 cm, and individual beds can be traced without appreciable change in thickness over their exposed strike lengths.

In the neighboring Al Qunfudhah quadrangle (sheet 19/41 C) the formation consists of conglomerate, sandstone, limestone, marly argillite, chert, and basalt (Hadley, 1975a). Most of the formation dips 20 to 60° SW.; toward its base, beds are vertical to slightly overturned where they are in fault contact with Precambrian rocks. The fact that the formation is unfossiliferous suggests the possibility that it was deposited in fresh water. The formation is interpreted as early to middle Tertiary in age; it was deformed possibly when the Miocene gabbro dikes were intruded into attenuated zones of the crust along the Red Sea margin.

Bathan formation

The Bathan formation is named after Wadi Bathan in the Al Lith quadrangle (sheet 20/40 C, Hadley and Fleck, 1980), where it consists of a terrigenous clastic sequence of boulder conglomerate, pebble conglomerate, and sparse beds of

coarse-grained sandstone. It was assigned by Hadley and Fleck to the Pliocene for the following reasons: it bears no relationship to the Holocene drainage system; it is strongly indurated; it is tilted at a moderate angle; and it dips toward the Red Sea escarpment.

In the Manjamah quadrangle, the Bathan formation is represented by a polymict conglomerate containing subangular to subrounded clasts of metavolcanic and metasedimentary rocks, and sparse plutonic rocks. It has been eroded to a flat surface and is poorly exposed, but has given rise to a lag-pebble and cobble plain located approximately 4 km east of Kidwat al Ghawanimah.

Gabbro dikes

Gabbro dikes intruded into the Precambrian layered rocks in the northeastern corner of the Manjamah quadrangle are a small part of a system that extends from Ad Darb to the Gulf of Aqaba and has yielded potassium-argon (K/Ar) whole-rock dates ranging from 19 to 27 million years (m.y.) ago, averaging 22 m.y. (Brown, 1972; Blank, 1977). These Miocene dikes were formed toward the close of the initial opening of the Red Sea rift. They trend north-northwest and are coarse grained toward their centers but were chilled and are consequently fine grained and resistant to weathering and erosion on their margins; as a result their outcrops commonly have U-shaped profiles.

QUATERNARY ROCKS

Volcanic rocks

Quaternary basalts extend from the Wadi Hali quadrangle into the southern half of the Manjamah quadrangle and form three isolated outcrops in the northeastern part of the quadrangle. The outcrops consist of columnar vesicular basalt, underlain in places by loosely consolidated, well-bedded, black tephra. The surfaces of the basalt outcrops are composed of angular blocks of lava as much as 40 cm in diameter. Flows radiate out from a cinder cone in the largest of the isolated outcrops; otherwise they extend consistently toward the sea. The basalt is unaltered and its mineralogy consists, in order of abundance, of twinned labradorite laths, clinopyroxene, olivine, magnetite, iddingsite, and apatite; some of its very abundant vesicles are partly filled with white calcite. The rocks are believed to be 0.5 m.y. old and younger (Ghent and others, 1979).

Surficial deposits

Shallow bank and coral reef deposits

Shallow banks of sediments and reefs of coral are present along most of the coastline in the Manjamah quadrangle and in two small islands off the mouth of Wadi Hali. Most of the banks consist of terrigenous mud, with some admixture of calcareous mud. The reefs consist of many kinds of coral, gastropods, brachiopods, and pelecypods, and are still being built by living organisms on cemented accumulations of the skeletons and shells of former generations. The water depth above the banks and the crests of the coral reefs is from 0.5 to 10 m.

Carbonate sand deposits

The islands off the mouth of Wadi Hali consist of fine- to coarse-grained carbonate sand deposits composed of broken shells, coral fragments, and subordinate amounts of eolian silt.

Pediment and plains deposits

Pediment and surficial deposits extend across the coastal plain for as much as 25 km from the outcrops of Precambrian rocks. They consist of boulder- to cobble-sized material near the Precambrian outcrops, and of gravel, sand, and silt elsewhere. The are dissected by the major wadis and overlain by eolian sand ridges between Wadi Hali and Wadi Yiba. The surfaces of the flatter areas are undulating and hummocky where the sediment has been mounded around grass clumps and desert shrubs.

Alluvial sand and gravel deposits

Sand and gravel deposits form the floors of all the main wadis and their tributaries and consist of tan to brown, subangular to well-rounded, unstratified to well-stratified material that is commonly crossbedded and fills channels.

Wadi flood-plain deposits

Extensive flood plains have formed along the main wadis and consist of silt with subordinate amounts of fine-grained sand and clay. New material is deposited during periods of intermittent flooding in the low-energy environments of high ground within the wadis and marginal to the main channels.

Sabkhah deposits

Sabkhah deposits as much as 3 km wide extend along most of the coast. Most are separated from the sea by narrow strips of coral reefs and shallow banks. They are flats composed of brown and white saline silt, partly covered by indurated crusts 1 to 3 cm thick.

Eolian sand deposits

Eolian sand deposits form dune fields behind the coastal deposits, along Wadi Shiah, and overlying pediment and plains deposits to the north of Wadi Shiah. They consist of continuous hills of fine- to medium-grained, tan sand. The hills merge in areas covered by closely associated but isolated dunes as much as 7 m high, separated from each other by wind-deflated barren ground. The smaller fields are elongate or oval in shape; the larger fields are irregular in shape.

Eolian linear sand ridge deposits

Eolian linear sand ridge deposits form dunes 40 to 130 m wide and as much as 9 km long on the pediment and plains deposits between Wadi Hali and Wadi Yiba. They extend over the wadi flood-plain deposits in one area. These dunes are parallel with each other and normal to the Red Sea coast. They have resulted from bimodal wind directions, one blowing inland normal to the Red Sea coast, and the other, which plays the dominant role in maintaining the linear integrity of the ridges, blowing north-northwestward parallel with the Red Sea coast.

ECONOMIC GEOLOGY

The effect of the geologic evolution of the Manjamah quadrangle on its economic potential lies essentially in the agricultural value of its flood-plain deposits, which are refreshed frequently with the products of weathering and erosion of the Precambrian rocks in the valleys of Wadi Hali and Wadi Yiba, and also possibly enriched by derivatives from the Quaternary volcanic rocks. The coral reefs could possibly provide raw material for use in a cement industry, if any such industry were ever required in this area.

REFERENCES CITED

Bayley, R. W., 1972, Geologic map and section of the Wadi Yiba quadrangle, Tihamat ash Sham area, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Geologic Map GM-1, 6 p., scale 1:100,000.

Blank, H. R., Jr., 1977, Aeromagnetic and geologic study of Tertiary dikes and related structures on the Arabian margin of the Red Sea in Red Sea research 1970-1975: Saudi Arabian Directorate General of Mineral Resources Bulletin 22, p. G1-G18.

Brown, G. F., 1972, Tectonic map of the Arabian Peninsula: Saudi Arabian Directorate General of Mineral Resources Arabian Peninsula Map AP-2, scale 1:4,000,000.

Brown, G. F., and Jackson, R. O., 1958, Geologic map of the Tihamat ash Sham quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-216 A, scale 1:500,000.

Ghent, E. D., Coleman, R. G., and Hadley, D. G., 1979, Ultramafic inclusions and host alkali olivine basalt of the southern coastal plain of the Red Sea, Kingdom of Saudi Arabia: (abs.), EOS, Transactions, American Geophysical Union, v. 57, no. 12, p. 1025.

Hadley, D. G., 1975a, Geology of the Al Qunfudhah quadrangle, sheet 19/41 C, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Geologic Map GM-19, 11 p., scale 1:100,000.

_____ 1975b, Geology of the Wadi Hali quadrangle, sheet 18/41 B, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Geologic Map GM-21, 19 p., scale 1:100,000.

_____ 1982a, Reconnaissance geology of the Wadi Amq quadrangle, sheet 18/41 C, Kingdom of Saudi Arabia: U.S. Geological Survey Open-File Report 82-287, scale 1:100,000.

_____ 1982b, Reconnaissance geology of the Wadi Dhahaban quadrangle, sheet 18/41 D, Kingdom of Saudi Arabia: U.S. Geological Survey Open-File Report 82-283, scale 1:100,000.

_____ 1982c, Reconnaissance geology of the Jabal Hashahish quadrangle, sheet 17/41 B, Kingdom of Saudi Arabia: U.S. Geological Survey Open-File Report 82-286, scale 1:100,000.

Hadley, D. G., and Fleck, R. J., 1980, Reconnaissance geology of the Al Lith quadrangle, sheet 20/40 C, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Geologic Map GM-32, 10 p., scale 1:100,000.

Prinz, W. C., 1975, Reconnaissance geology of the Jabal 'Aya quadrangle, sheet 18/42 A, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Geologic Map GM-17, 9 p., scale 1:100,000.

Ratte, J. C., and Andreasen, G. E., 1974, Reconnaissance geology and magnetic intensity map of the Jabal Sawdah quadrangle, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Geologic Map GM-16, 8 p., scale 1:100,000.

U.S. Geological Survey and Arabian American Oil Company, 1963, Geologic map of the Arabian Peninsula: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-270 A, scale 1:2,000,000.