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RECONNAISSANCE GEOLOGY OF THE MUSAYLIM QUADRANGLE, SHEET 19/40 B, KINGDOM OF SAUDI ARABIA

by

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The work on which this report is based was performed in accordance with a cooperative agreement between the U. S. Geological Survey and the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

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RECONNAISSANCE GEOLOGY OF THE MUSAYLIM QUADRANGLE, SHEET 19/40 B, KINGDOM OF SAUDI ARABIA

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ABSTRACT

The Musaylim quadrangle (19/40 B) encompasses an area of about 2,908 km^2 along the Red Sea coastal plain (Tihamat ash Sham) between lats 19°30' and 20°00'N. and longs 40°30' and 41°00'E. The southeast corner of the quadrangle is located about 40 km NNW of the coastal village of Al Qunfudhah. Several small agricultural communities, including Musaylim, are found in the area, and are situated along the three major wadis that drain the quadrangle. They are connected by a network of unsurfaced roads that serve the area locally. A new paved road parallels the Red Sea coast.

The southwestern 40 percent (approximately) of the quadrangle is covered by water of the Red Sea. Of the remaining area, the extreme northeastern part is underlain by a Precambrian batholith and Miocene gabbro dikes. A very small outcrop of Precambrian Bahah group metasedimentary rocks juts into the north-central part of the area. The rest of the quadrangle (80-90 percent of the exposed land surface), is covered by alluvium, eolian sand, and sabkhah deposits, except for two small areas of Tertiary sedimentary rocks and granite in the east-central part. Elevations range from sea level to 1,098 m at Jabal Nakhirah.

The Bahah group was deformed, metamorphosed, and synchronously intruded by the granodiorite and granite batholith during the Tihama orogeny. The Tertiary rocks were deposited, tilted, and emplaced during the Miocene and Pliocene.

Wadi sand and gravel constitute the only deposits having economic potential.

INTRODUCTION

The Musaylim quadrangle (19/40 B) encompasses an area of about 2,908 km^2 along the Tihamat ash Sham portion of the Red Sea coastal plain between lats 19°30' and 20°00'N. and longs 40°30' and 41°00'E. (fig. 1). The quadrangle is about 40 km north-northwest of the Red Sea village of Al Qunfudhah and 210 km southeast of Jiddah. The southwestern part of the quadrangle (about 40 percent) is covered by water of the Red Sea. The

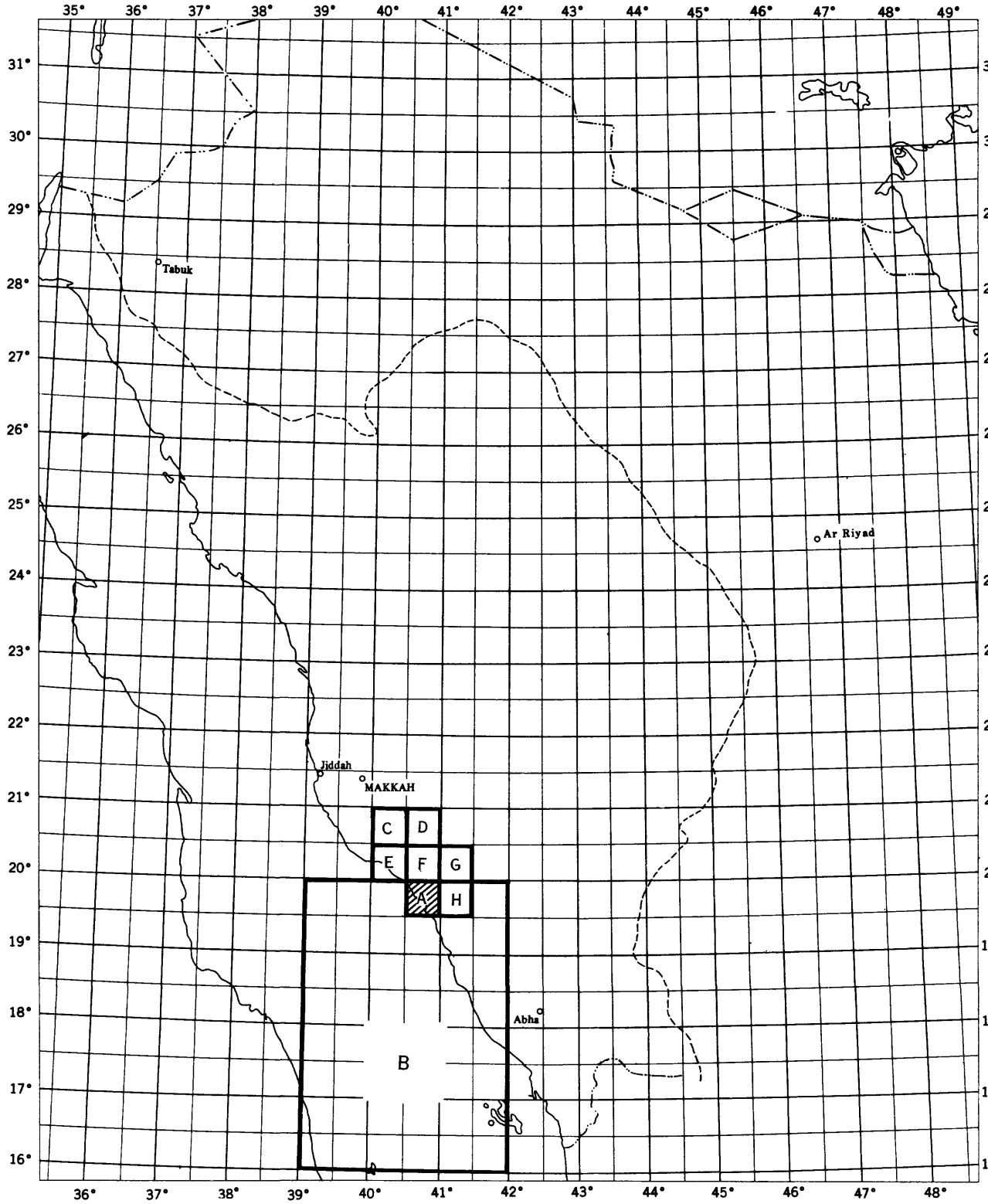

Figure 1.–Index map showing location of the Musaylim quadrangle, A, and nearby quadrangles referred to in this report: B, Tihamat ash Sham; C, Wadi Sadiyah; D, Wadi Salibah; E, Al Lith; F, Jabal Afaf; G, Jabal Ibrahim; and H, Jabal Shada.

remainder of the area is underlain by Precambrian and Tertiary rocks or is covered by several types of surficial deposits.

Several small agricultural communities, including Musaylim, are located in the area and are found along the three major wadis that drain the quadrangle. They are connected by a network of unsurfaced roads that serve the area locally. A new paved road, which will eventually connect Jizan with Mecca, crosses the quadrangle along the Red Sea coast. Elevations in the quadrangle range from sea level to 1,098 m at Jabal Nakhirah.

The area was first mapped by Brown and Jackson (1958) at a scale of 1:500,000 (fig. 1). No further work was done in the quadrangle until the present study was made, but previous mapping was done at a scale of 1:100,000 in adjoining (Jabal Shada, Greenwood, 1975a; Jabal Ibrahim, Greenwood, 1975b) and nearby (Wadi Sadiyah, Wier and Hadley, 1975; Wadi Salibah, Cater, 1977) quadrangles; two adjoining quadrangles were mapped at the same time as Musaylim (Al Lith, Hadley and Fleck, 1979a; Jabal Afaf, Hadley and Fleck, 1979b).

The oldest rocks in the area include Precambrian granodiorite and granite, and a small outcrop of Bahah group metasedimentary rocks. Greenschist facies metamorphism and a strong foliated and schistose fabric developed during an early Arabian Shield tectonic event (Tihama orogeny) characterize these rocks. Tertiary rocks include tuffaceous and sedimentary rocks of the Miocene Baid formation, Miocene granite, Miocene gabbro dikes, and conglomerate and sandstone of the Pliocene Bathan formation. The Tertiary rocks are part of the Red Sea structural setting and were deposited during opening of the Red Sea and the associated tectonic events. Quaternary deposits, including coral reef, pediment, alluvium, sabkhah, and eolian sand, cover most of the quadrangle.

Field work for this report was done by helicopter during October, 1973. Logistical and personnel support were generously provided by the Directorate General of Mineral Resources. I wish to thank Ghanim Jeri Alharbi, Yacob Essa Takrony, and Saud Muslih Ashaybani for assistance in the field and office. This work was done under a cooperative agreement between the Ministry of Petroleum and Mineral Resources of the Saudi Arabian Government and the U.S. Geological Survey.

PRECAMBRIAN ROCKS

Granodiorite, granite and subordinate quartz monzonite, and metasedimentary rocks of the Bahah group constitute the Precambrian rocks in the quadrangle.

Layered rocks

Bahah group

The Bahah group is exposed in two small areas along and near the east side of Wadi ash Shaqah al Yamaniyah at the north-central border of the quadrangle. It is the southern extension of a belt of Bahah metasedimentary rocks that are well exposed in the southeast quadrant of the Jabal Afaf quadrangle.

The rock consists of medium- to dark-brown, fine-grained biotite schist. In places, bedding is well preserved, but generally the rock is moderately to strongly schistose and primary sedimentary features are obliterated. It is composed of quartz, plagioclase, biotite, minor epidote, opaque minerals, and accessory minerals.

Intrusive rocks

Granodiorite and granite

An intrusion composed primarily of granodiorite and granite underlies Jabal Nakhirah in the extreme northeast corner of the mapped area. It is part of a large batholith that extends into the adjoining Jabal Afaf and Jabal Shada quadrangles and is considered to be equivalent in age and composition to the granodiorite and granite batholith underlying Jabal Afaf.

The intrusion is composed of granodiorite, granite, and subordinate quartz monzonite. The rock is light to medium gray, medium to coarse grained, and porphyritic. Biotite and minor hornblende and chlorite make up from 5 to 10 percent of the rock. The intrusion is strongly foliated and schistose, and is cut by numerous faults. Cobble-sized mafic inclusions are common throughout the body. Late-stage aplite and pegmatite dikes cut the rock and are similar to those in the analogous Jabal Tharban and Jabal Baqaratayn granites (Bayley, 1972; Hadley, 1975).

TERTIARY ROCKS

Tertiary rocks in the quadrangle include the Baid formation, gabbroic dikes, granite, and the Bathan formation.

Baid formation

The Baid formation (Brown and Jackson, 1959) crops out in a small area in the east-central part of the quadrangle. It is almost completely eroded down to a maximum relief of 2 m in the

exposed area. It consists of a lower part of maroon-to-reddish ash fall and lithic tuff, and an upper part of cream, thin- to medium-bedded (3-15cm) tuffaceous siltstone and thin-bedded gray limestone (Hadley and others, unpublished data).

Miocene gabbro dikes

Miocene gabbro dikes intrude the granodiorite and granite pluton in the Jabal Nakhirah area. The dikes trend northwest, and are exposed in two areas, but they can be traced in the subsurface, well beyond their outcrop areas, using aeromagnetic methods (Andreasen and Petty, 1974).

The dikes are as much as 100 m wide, have chilled fine-grained margins, and the coarse-grained central portions have been eroded to U-shaped troughs.

Texturally, the rock is diabasic, gabbroic, and ophitic. It is composed of 40-60 percent saussuritized labradorite, 5-10 percent serpentinized olivine, and a few percent magnetite, chlorite, apatite, epidote, and sphene. The chlorite is a result of sea-floor hydrothermal metamorphism (Donato and Coleman, 1976).

The dikes are part of the normally and reversely polarized dike swarm that parallels the Red Sea and extends from Ad Darb to the Gulf of Aqaba (Brown, 1972; Blank, 1978; Coleman and others, 1977); they have been dated, using potassium-argon methods, at 19-27 m.y. old (Brown, 1972).

Miocene granite

Granite intrudes the Baid formation in two separate bodies. It is leucocratic, light gray, medium to coarse grained, and is eroded to a flat surface. It represents the only known coarse-grained hypidiomorphic-textured Tertiary granite intrusion in Saudi Arabia related to the opening of the Red Sea. The only other intrusive rock of similar composition and age is the Jabal at Tirf granophyre (Coleman and others, 1977).

Bathan formation

The Bathan formation crops out along the north side of Wadi ad Duqah near the east-central edge of the quadrangle. It forms a northwest-trending elongate outcrop consisting of a low ridge 2-5 m high along the northwest side, and is exposed as several small outcrops scattered elsewhere in the mapped area. The formation is composed of boulder conglomerate (with clasts as much as 0.5 m in diameter) and coarse-grained, tabular-bedded, fine- to medium-grained lithic sandstone.

QUATERNARY DEPOSITS

The extensive Quaternary deposits in the Musaylim quadrangle consist of shallow banks and coral reefs, carbonate island sand deposits, pediment and plain sand, gravel, and silt, alluvial sand and gravel, wadi flood-plain silt deposits, sabkhahs, eolian sand-dune fields, and eolian linear sand ridges.

Shallow banks and coral reef

Shallow bank and coral reef deposits are found along most of the coastal margin and around the near-shore islands. The banks are a mixture of calcareous and terrigenous muds, the latter dominating the coastal margin banks. Water depth over the banks and reef ranges from 0.5 to 5 m.

Carbonate island sand deposits

Several islands are found within 1-10 km of the main shoreline and are as much as 3.5 km long and 0.7 km wide. Sediment on the islands consists of fine- to coarse-grained calcareous sand composed of broken shell and coral fragments. Holocene coral reef fringes the islands at distances of from less than 100 m to 1.5 km. Several kinds of salt-tolerant grasses grow on the islands.

Pediment and plain sand, gravel, and silt deposits

Most of the coastal plain is covered by terrigenous sediment. The sediment is very flat as a rule, slopes away from the outcrop areas, is dissected by the major and minor wadis, and is covered by the eolian sand fields and linear sand ridges. The deposits are hummocky where sand is mounded around desert shrubs, are dotted by sparse acacia trees, and are composed of poorly sorted fine- to coarse-grained sand and gravel and, near outcrop areas, clasts as much as 300 mm or larger in diameter.

Alluvial sand and gravel

Sand and gravel blankets all of the wadis and their tributaries in the area. It is composed of tan to brown sand, gravel, minor silt, and cobble-sized material that ranges from massive to well stratified. Sediment-filled channels and crossbedding are structures commonly observed in erosional faces. Maximum thickness of the alluvial material does not appear to exceed 3 m in the quadrangle.

Wadi flood-plain silt

Within and marginal to the major wadis are extensive flood-plain deposits composed principally of silt and minor fine-grained sand and clay. The material is tan, ranges from massive to well stratified, and is as much as 3 m thick where dammed. The material was deposited during intermittent flooding stages in the low-energy over-bank environment comprising high ground within wadis and on wadi margins.

Sabkhah deposits

Sabkhah deposits extend along the entire coastal length of the quadrangle, broken only by deltaic fingers of alluvial material. The deposits stretch inland as far as 3 km from the coastline and consist of brown to white flat-lying salt-impregnated silt. The surface of the sabkhah, in most places, is a crust 1-3 cm thick. Maximum depth of the sabkhah sediment is unknown but as much as 20 cm were measured. The chemical and mineralogical composition of the sabkhah salts were not determined.

Eolian sand-dune fields

One very large and several small eolian dune fields are found in the quadrangle. The largest of these slopes away from Jabal Nakhirah in the northeastern part of the quadrangle, has maximum dimensions of 12 by 20 km, and is covered by numerous eolian sand ridges. The fields consist of tan fine- to medium-grained sand in continuous hills that merge together to areas covered by closely associated but isolated dunes separated by wind-deflated barren ground. Dune height is as much as 5 m.

Eolian linear sand ridge

Eolian sand ridges (Bramkamp and others, 1963) overlie pediment and plains deposits and eolian dune fields in the northern half of the quadrangle and in the area south and east of Musaylim. They consist of linear ridges composed of fine- to medium-grained sand, and range from 20 to 100 m in width and 300 m to 6.5 km in length. The greatest concentration of linear ridges in the quadrangle is atop the dune field near Jabal Nakhirah, where the dune field provides a source of abundant sand for the ridges overlying it. The eolian ridges in the area are identical to those in north Africa and result from bimodal wind directions; one is inland normal to the Red Sea coastline; the second, northwestward parallel to the Red Sea, plays the dominant role in maintaining the linear integrity of the ridges.

STRUCTURE

The Bahah group schist is moderately to strongly foliated and dips steeply northwest immediately north of the exposed area in the Jabal Afaf quadrangle. As indicated by structure in the Jabal Afaf quadrangle, the schist is part of the east limb of a northeast-plunging synform, initially folded during the Tihama orogeny (Schmidt and others, 1973).

The granodiorite and granite at Jabal Nakhirah is strongly foliated and is intensely sheared along northwest-trending fault planes. Because of shearing, the rock is mylonitic. The composition and structural character of the intrusion is similar to the Wadi Baqarah orthogneiss of the Wadi Hali and Jabal Aya quadrangles (Hadley, 1975; Prinz, 1975), which was emplaced 763 ± 48 m.y. ago, as determined by whole rock Rb-Sr methods (Fleck and others, in press).

The Baid formation is monoclinally tilted toward the Red Sea. Its deformation is a result of tectonic events associated with and following initial opening of the Red Sea (Coleman, 1974; Coleman and others, 1977; Hadley and others, unpublished data).

Granite intruding the Baid formation is probably about the same age as the Red Sea Miocene gabbro dikes and may represent an advanced differentiated product of the tholeiitic parent magma of the dikes.

Structure of the Bathan formation could not be determined, but its geomorphic pattern suggests a northwest strike. Based on its structure in the Al Lith quadrangle (Hadley and Fleck, 1979a), it may dip northeast toward the Red Sea escarpment. On the other hand, judging from the style of folding and deformation of the Shumaysi formation in the Jiddah area (Al-Shanti, 1966), the Bathan may be tilted toward the Red Sea like the Baid. The Bathan formation is considered to have been folded during Pliocene faulting and uplift related to development of the Red Sea escarpment (Hadley and Fleck, 1979a).

METAMORPHISM

The Bahah group is metamorphosed to the amphibolite facies and contains a metamorphic mineral assemblage of biotite, minor hornblende, quartz, plagioclase, epidote, and sphene. The granodiorite and granite is not appreciably metamorphosed, and is primarily responsible for metamorphism of the Bahah group. The Tertiary sedimentary and granitic rocks are not metamorphosed, but the gabbro dikes show substantial propylitic alteration and hydrothermal greenschist metamorphism (Donato and Coleman, 1977).

ECONOMIC GEOLOGY

No metal mineralization was seen in the quadrangle. The only material having economic potential is alluvial sand and gravel deposits in wadis, and these could be exploited only for local consumption, of which there is none at present.

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