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Reconnaissance geology of the Jabal Khatam quadrangle, sheet 26/39 D, Kingdom of Saudi Arabia

by

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

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[Plate is in pocket]

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ABSTRACT

The Jabal Khatam quadrangle encompasses an area of about 2,725 km^2 on the edge of the Precambrian shield in northwestern Saudi Arabia, between lat 26°00' and 26°30' N. and long 39°30' and 40°00' E. The southern one-third and northeastern corner of the area are covered by Tertiary and Quaternary basalt flows of Harrat Khaybar and Harrat Ithnayn. In one small area on its northern edge, Harrat Khaybar is composed of Tertiary rhyolitic tuff and trachyte. Most of the northern one-third and eastern part of the quadrangle are covered by Paleozoic Siq Sandstone. The remainder of the quadrangle is composed of trachyandesite flows, agglomerate, graywacke, and sparse marble of the Hulayfah group and intrusive rocks that range in composition from alkali-feldspar granite to diabase.

No deposits with economic potential were found. However, the geothermal potential of the quadrangle warrants further investigation.

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INTRODUCTION

The Jabal Khatam quadrangle (sheet 26/39 D) encompasses an area of about 2,725 km^2 on the northern border of the Precambrian shield in northwestern Saudi Arabia, between lat 26°00' and 26°30' N. and long 39°30' and 40°00' E. (fig. 1). The southern one-third and northeastern corner of the area are covered by Tertiary and Quaternary basalt flows of Harrat Khaybar and Harrat Ithnayn. Most of the northern one-third and eastern part of the quadrangle are covered by Paleozoic Siq Sandstone. The remainder of the quadrangle is composed of trachyandesite flows, agglomerate, graywacke, and sparse marble of the Hulayfah group and intrusive rocks that range in composition from alkali-feldspar granite to diabase. One small area on the northern edge of Harrat Khaybar is composed of Tertiary rhyolitic tuff and trachyte.

Previous work in the area was done by Brown and others (1963), who mapped the 1:500,000-scale Northeastern Hijaz quadrangle. The area is also part of the 1:1,000,000-scale lithostratigraphic compilation of the Arabian Shield (Johnson, 1982). Geology of the quadrangle is shown on plate 1.

This report is the result of helicopter-supported geologic mapping conducted from November 1981 to March 1982. The work on which this report is based was performed in accordance with a work agreement between the U.S. Geological Survey (USGS) and the Saudi Arabian Ministry of Petroleum and Mineral Resources.

PRECAMBRIAN ROCKS

Hulayfah group

Hulayfah group rocks (ha) crop out in the quadrangle as sparse, discontinuous outcrops of trachyandesite flows and plugs, agglomerate, coarse graywacke derived from trachyandesite, and one outcrop of black, coarsely crystalline, silicic marble (m).

The trachyandesite consists of large, broken and partially resorbed plagioclase phenocrysts in a matrix of microcrystalline potassium feldspar. Quartz phenocrysts are partially resorbed. Apatite is rare, and a trace of biotite was observed only in one thin-section. Relic amphibole phenocrysts are very sparse and are completely altered to iron oxides, chlorite, and epidote. Epidote, chlorite, and calcite are ubiquitous alteration minerals that indicate greenschist metamorphism.

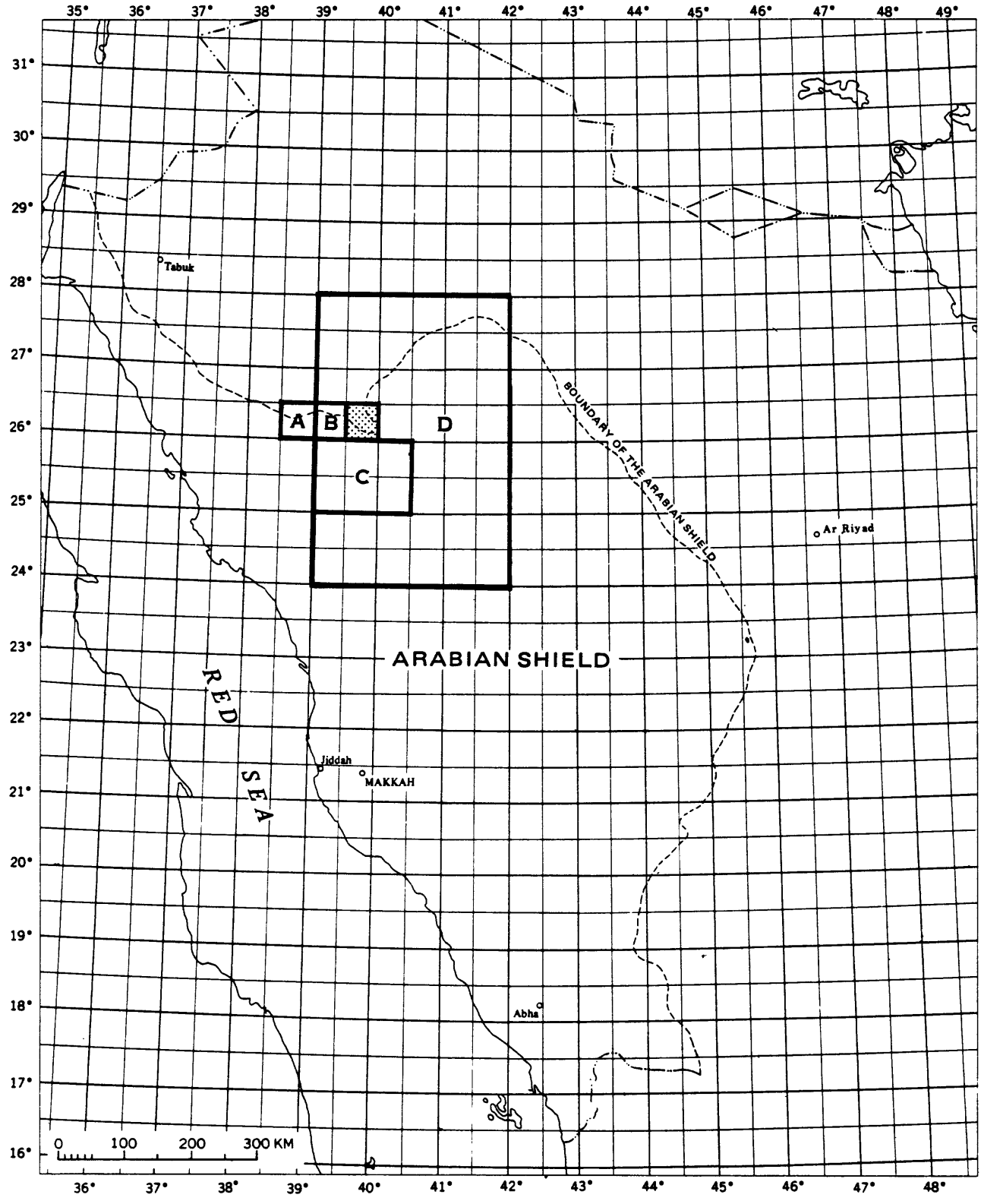

Figure 1.--Index map of western Saudi Arabia showing location of Jabal Khatam quadrangle (shaded) and other quadrangles referred to in this report: A, Qal'at as Sawrah (Hadley, 1975); B, Ishash (Fairer, unpub. data); C, Khaybar (Dhellemmes and Delfour, 1980); D, Northeastern Hijaz (Brown and others, 1963).

Agglomerate crops out at one locality in the east-central part of the quadrangle beneath the Siq Sandstone. This rock is composed of cobbles of trachyandesite separated by smaller fragments of andesitic material. Small, discontinuous, thin lenses of graywacke are intercalated with the trachyandesite flows. One outcrop of black, coarse-grained, massive marble was found. The presence of these metasedimentary rocks associated with the trachyandesite indicates that the Hulayfah group rocks are the result of subaqueous eruptions.

There is no evidence in the quadrangle on which the relative stratigraphic placement of these rocks can be based. Brown and others (1963) assigned these rocks to the Halaban group. In the adjoining Ishash quadrangle to the west (Fairer, [illegible]), these rocks are overlain by andesitic graywacke, siliceous marble, and argillite as well as andesite flows that are in turn overlain by rhyolite flows and tuffs. The extension of an upper tuff unit to the south into the Khaybar quadrangle, designated as Hulayfah group (Dhellemmes and Delfour, 1980), has been dated by the rubidium-strontium (Rb-Sr) method as 708 and 705 Ma (Vialette, 1979, in Dhellemmes and Delfour, 1980). These dates and lithologies make it reasonable to assign these rocks to the Hulayfah group, the type locality of which is 130 km to the east. The Hulayfah group has been broadly correlated with the Halaban group which ranges in age from 760 to 680 Ma (Schmidt and others, 1979; Greenwood and others, 1982/1983).

Alkali-feldspar granite

A large pluton of hypersolvus alkali-feldspar granite (ag) crops out in the southwestern corner and along the western boundary of the quadrangle. This pluton is composed of coarse-grained, pink, grussy weathering granite that has intruded trachyandesite of the Hulayfah group.

In thin section the granite is composed predominately of strained perthite with strained quartz and accessory biotite, sphene, magnetite, and rare zircon and apatite. Alteration minerals are sparse and consist of sericite, chlorite, and hematite, mostly located along microfractures. The texture is hypidiomorphic granular and the maximum grain size is approximately 6 mm. Strain is readily apparent on a microscopic and megascopic scale. All of the minerals in thin section show strain extinctions and kinking or bending of crystal lamellae. On a megascopic scale the pluton has a very conspicuous joint pattern.

Near the southwestern corner of the quadrangle are several steptoes composed of alkali-feldspar granite that has been intruded by thick, subhorizontal sheets of quartz diabase.

This alkali-feldspar granite is similar to the granite described above except that part of the perthite has been replaced by very late stage plagioclase crystals. In its outermost exposures, the granite is very fine grained, has a quenched or hypabyssal texture, and contains tridymite, hollow plagioclase, and graphic intergrowths of quartz and feldspar.

The quartz diabase is fine grained and is composed of laths of plagioclase, which ranges in composition from labradorite to rare bytownite, quartz, ophitic hornblende, subophitic augite, reddish-brown biotite, sphene, and magnetite. Quench-textures occur at the margins of the sills. Greenschist facies alteration minerals, chlorite, epidote, and calcite, are sparse. Similar rocks in the northern shield were emplaced during the Ar Rimah orogenic phase from 600 to 535 Ma (Dhellemmes and Delfour, 1980).

PALEOZOIC ROCKS

Siq Sandstone

The Cambrian Siq Sandstone (Cs) (Bramkamp and others, 1963; Powers and others, 1966) rests unconformably on Precambrian rocks throughout the northern and eastern parts of the quadrangle. The underlying erosional surface generally has little relief, but locally deep cobble-filled channels are present.

The Siq Sandstone exposed in the quadrangle consists of dark-red, reddish-brown, and buff, friable, medium-grained to conglomeratic, thickly-bedded and strongly crossbedded quartz sandstone. The basal 10 m, exposed in the east-central part of the quadrangle, consists of cobble to boulder conglomerate that contains thin septa of dark-red siltstone to fine sandstone. Cobbles and boulders, derived from the underlying Precambrian rocks, consist of andesitic, granitic, and gneissic material. Above the boulder layer the Siq Sandstone grades into a strongly crossbedded, sparse quartz-pebble conglomerate. The quartz pebbles are gray, white, and brown, well-rounded, and polished. Matrix material of the conglomerate and the nonconglomeratic beds of the Siq Sandstone consist of well sorted, subangular to rounded grains of arkosic minerals cemented by quartz and calcite.

The Siq Sandstone has long been recognized (for example, Bramkamp and others, 1963) as having been deposited during an extensive early Cambrian marine transgression. In the Qal'at as Sawrah quadrangle to the west (Hadley, 1975), fossil trilobite burrows and gastropod tracks found in mud-cracked sandstone indicate deposition of the Siq Sandstone in shallow water.

CENOZOIC ROCKS

Differentiated volcanic rocks

Near the northern edge of Harrat Khaybar in the western part of the quadrangle are differentiated volcanic rocks in necks and associated flows and tuffs (Ttr) that range in composition from trachyte to rhyolite. These rocks are thought to correlate with similar rocks that crop out at Jabal al Abyad to the south in the Khaybar quadrangle (Dhellemmes and Delfour, 1980).

The trachyte is composed of oligoclase, augite, and altered olivine and biotite phenocrysts in a trachytic matrix of potassium feldspar, sanidine, sphene, apatite, and sparse late quartz and tridymite. Olivine is locally altered to bowlingsite and iddingsite. Biotite is altered to granular iron, epidote (locally piemontite), and chlorite. Other common alteration minerals are calcite, epidote, hematite, and chlorite. Phenocrysts tend to be euhedral but broken. Flow orientation of the matrix is common. One highly altered, completely recrystallized xenolith of marble was found. This marble may have been the source of CO_2 for the pervasive carbonatization seen in these rocks.

Rhyolite flows, ash-flows, and ash-fall tuffs surround the trachyte plugs, and one rhyolite dike was found nearby. The rhyolite of this unit is underlain by the older basalt flows and is underlain by the younger basalt flows. The rhyolite tends to be glomeroporphyritic, containing phenocrysts of oligoclase to andesine, deeply eroded and embayed quartz, and perthite in a matrix composed of shards and saussuritized potassium feldspar. Tridymite and sanidine are sparse. Other minerals include sparse, altered biotite, rutile in quartz, magnetite, sphene, and apatite. Alteration minerals include chlorite, sericite, epidote, calcite, and hematite. Xenoliths of trachyte are present in some of the fragmental flows. One ash-fall tuff is composed of shards, quartz, calcite, and hematite in a matrix of devitrified glass that contains much chlorite.

Basalt

The basalt (QTb) of Harrat Ithnayn is the northern extension of Harrat Khaybar, and thus is part of the largest basalt plateau in Saudi Arabia (Brown and others, 1963; Coleman and others, unpub. data). The oldest basalt of Harrat Khaybar is basanite and crops out in the Khaybar quadrangle to the south (Dhellemmes and Delfour, 1980; Coleman and others, unpub. data). This rock has been dated by potassium-argon (K-Ar) analysis as 9.1 Ma (Brown, 1970). Outcrops of this

rock are dark-gray to black flows of aa and pahoehoe that contain more than 60 percent olivine. A complete petrographic and chemical description of these and younger basalts described below was made by Coleman and others (1983).

The younger basalts (QTbv), which occur in this quadrangle and in the Khaybar quadrangle, are alkali-olivine basalt, hawaiite, and mugearite (Coleman and others, 1983). They are lighter gray in color than the basanite, tend to be more viscous and vesicular, and contain from less than 5 percent to 20 percent olivine. Relative ages of the basalt flows and cinder cones from youngest to oldest are shown on plate 1 by roman numerals I to III, respectively.

The youngest cinder cone of Harrat Ithnayn, located at point A' on the cross-section, and associated fresh, black alkali-olivine basalt flows (Qb) erupted during historic times, about 1800 A.D. (1220 A.H.) (Simkin and others, 1981; Coleman and others, 1983). This basalt is characterized by the presence of 10 to 20 percent olivine, 20 to 25 percent diopside, 50 to 60 percent plagioclase of a composition more calcic than An_{50}, 5 to 10 percent magnetite-ilmenite, and small amounts of nepheline and potassium feldspar (Coleman and others, 1983).

Eolian sand

The central portion of the quadrangle is covered by a large, complex dune field composed of pale-reddish-brown to pale-orange sand (Qes). The sand of this dune field presumably was derived from the massif of alkali-feldspar granite located immediately to the north and not from the disintegration of the Siq Sandstone whose particles are buff to white.

Sabkah deposits

A white sabkah deposit (Qsb) comprising salt-saturated mud and fine sand lies immediately to the east of the alkali-feldspar granite massif near the southwestern corner of the quadrangle. Other smaller areas are scattered throughout the quadrangle wherever water is impounded following infrequent rains.

Surficial deposits, undivided

All of the valleys and other depressions in the quadrangle are covered by pediment, eolian sand, colluvium, alluvial sand, and gravel and cobble deposits (Qu). The material in these deposits was derived from the surrounding outcrops.

STRUCTURE

Structural features of the Jabal Khatam quadrangle are limited to contraction jointing of the plutonic rocks modified by small-scale fault movement during the Nadj event (Brown and others, 1963) that affected most of the northern shield. Small-scale faulting also affected the Siq Sandstone at this time. Because of sparse discontinuous outcrops, no evidence was observed that indicated the structure of the Hulayfah group rocks.

ECONOMIC GEOLOGY

No deposits of economic importance were found. However, because of the recent volcanic activity in Harrat Ithnayn and Harrat Khaybar, the geothermal potential of the area deserves further evaluation, as proposed by Coleman and others (1983).

DATA STORAGE

No information was added to the Mineral Occurrence Documentation System (MODS) data bank and no data files were created in the preparation of this report.

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