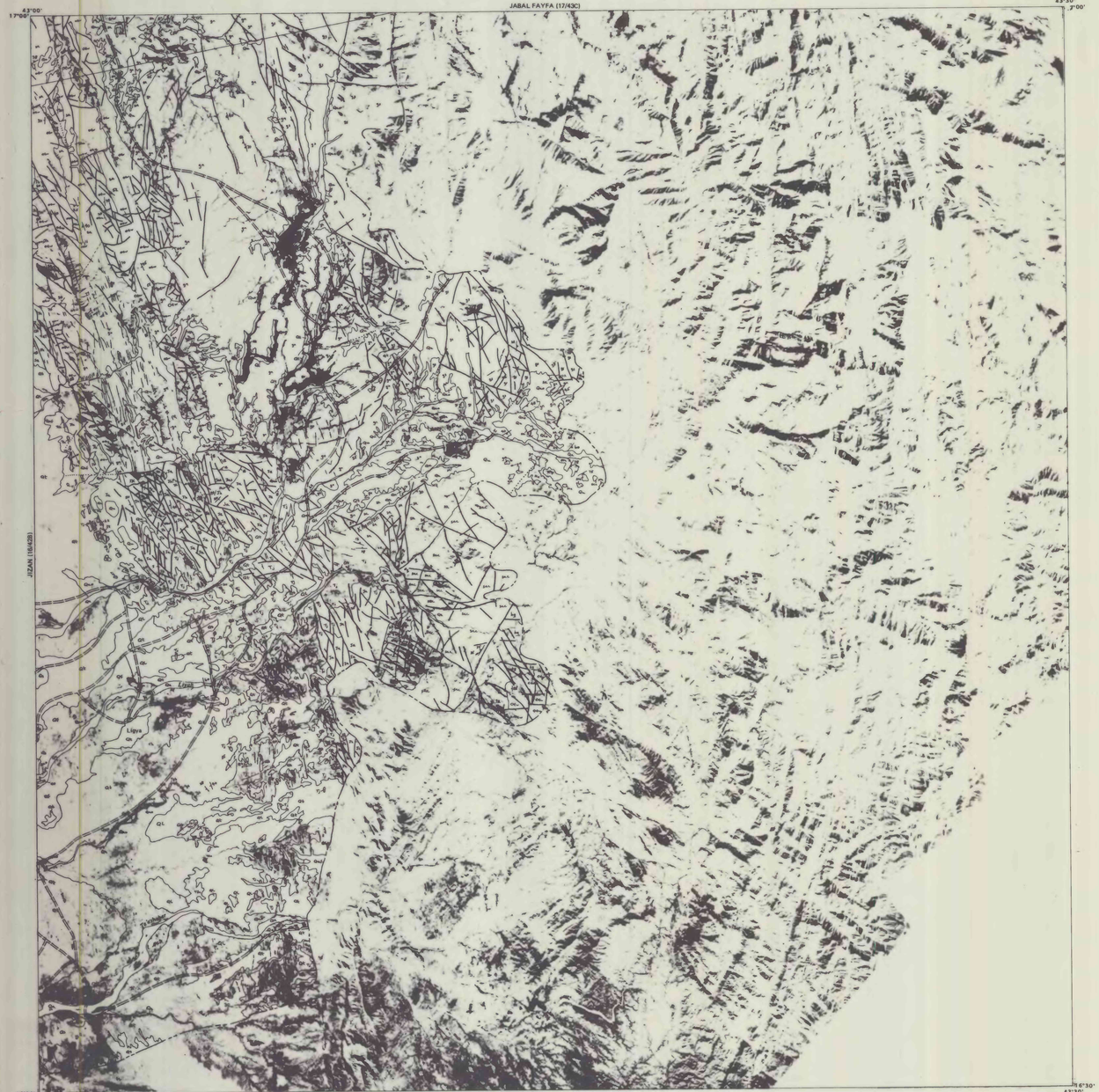
U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, PREPARED FOR

MINISTRY OF PETROLEUM AND MINERAL RESOURCES
DEPUTY MINISTRY FOR MINERAL RESOURCES

KINGDOM OF SAUDI ARABIA

OPEN-FILE REPORT USGS-OF 85-720
PLATE 1



Aerial photography and controlled mosaic 1861-1963.
Aero Service Corporation, Philadelphia, Penn. USA.
Lambert conformal conic projection, standard parallels 17° and 35°

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

Geology mapped in 1977, 1979, and 1984
The position of the international boundary on this map is not to be taken as definitive

SCALE 1 : 100 000

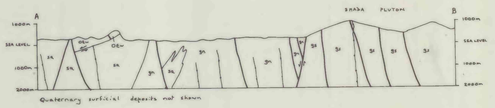
2 0 2 4 6 8 10 KILOMETERS

2 0 2 4 6 8 10 MILES

DATUM IS MEAN SEA LEVEL

TRUE NORTH

QUADRANGLE LOCATION



RECONNAISSANCE GEOLOGIC MAP OF THE WADI KHULAB QUADRANGLE, SHEET 16/43A, KINGDOM OF SAUDI ARABIA

By

H. Richard Blank, Jr. and Mark E. Gettings

1985

CORRELATION OF MAP UNITS

PLUTONIC AND HYPABYSSAL ROCKS	SEDIMENTARY, VOLCANIC, AND METAMORPHIC ROCKS	
	Qa Qf Qt Qao Qf Qaf	Pleistocene to Holocene — QUATERNARY
	UNCONFORMITY	
Tgb Tdc	Tj Ti	Oligocene to Miocene — TERTIARY
	UNCONFORMITY	
	K1	CRETACEOUS TO LOWER TERTIARY
	UNCONFORMITY	
	Ja Jk	JURASSIC
	UNCONFORMITY	
	OE/Jk OEw	CAMBRIAN TO ORDOVICIAN
	UNCONFORMITY	
gr gn bg	ss ssc	PROTEROZOIC

DESCRIPTION OF MAP UNITS

QUATERNARY SURFICIAL DEPOSITS

HOT SPRINGS--Identified by the letters "HS" and a small circle. Several springs occur in the bed of Wadi Khulab. The emerging water ranges in temperature from 50° to 75°C (Barbut and others, 1983)

Qu — QUATERNARY DEPOSITS UNDIVIDED--Mostly loessic silt forming graded surfaces about 20-30 m above the present active drainage system

Qs — EOLIAN SAND--Consists of linear and barchan dunes, and an extensive veneer of sand, overlying old flood plain and loessic deposits. Occurs mostly in the southwest part of the quadrangle

Qa — ALLUVIUM--Sand, gravel, and silt of modern active drainage system.

Qao — OLDER ALLUVIUM--Forms terraces within and on the flanks of active channels

Qf — FLOOD-PLAIN DEPOSITS--Deposits of silt, sand and gravel, locally interlayered with boulders, between the main channels of the modern drainage system. Correlates north with alluvial terrace deposits of the Sabya quadrangle, and thought to be of Pleistocene and Holocene age (Fairer, 1983)

Qt — REWORKED LOESS--Deposits of reworked loessic silt and sand, forming a surface at slightly higher elevations than the flood-plain deposits. Located at the contact between outcropping bedrock and the coastal plain

Qt/Qaf — LOESS AND INTERSTRATIFIED SAND AND GRAVEL--Deposits (Qt) cover much of the western part of the quadrangle, and form graded surfaces of low relief on the interfluves between the main stream channels. Much of the coarse component appears to have originated by sheet flow; upslope, material coalesces with alluvial fans and debris from possible mud flows (Qaf)

PHANEROZOIC INTRUSIVE ROCKS

TIHAMAT ASIR COMPLEX--The unit is an intrusive complex of probable mantle derivation believed by some authors to represent oceanic material emplaced in extensional structures at the boundary between the Arabian craton and the Red Sea (Coleman and others, 1979). Potassium-argon dating indicates a later Oligocene to early Miocene age (23.3±1, 23.0±2, and 20.6±.06 Ma; Coleman and others, 1972)

Tgb — Gabbro--Consists of clinopyroxene gabbro, syenogabbro, syenite, and monzonite. The extent of the gabbro is obscured by the alluvial cover although, on the basis of aeromagnetic data, the outcrops are interpreted as part of a circular intrusion some 5 to 8 km in diameter (Blank and others, in press). The unit is isolated from other rocks by Quaternary deposits, but because of its petrologic character and unaltered appearance it is considered to be part of the Tihamat Asir complex. The unit is poorly exposed in Wadi Mighlayan in the southwest part of the quadrangle

Dike rocks--Consists of mafic and felsic dikes of uncertain age, but probably forming part of the Tihamat Asir complex

Tdc — Sheeted dike complex--Consists of mafic and felsic dikes which crop out from the Yemen border southeast of the quadrangle to Ad Darb, over 100 km to the north-west: the most widespread component of the Tihamat Asir complex in the region. Dikes are particularly abundant in the northwestern part of the Wadi Khulab quadrangle where they form a sheeted dike complex. The complex consists of diabase, basalt, and gabbro dikes between 0.5 and 18 m thick, subordinate rhyolite and dacite dikes, and screens of mainly Tertiary volcanic country rock. Where the dikes are most abundant, the complex is composed of dike-on-dike intrusive rocks

PHANEROZOIC LAYERED ROCKS

Tj — JIZAN GROUP:

Mafic to felsic volcanic rocks--Of probable late Oligocene to early Miocene age (Schmidt and others, 1982) interbedded with subordinate sedimentary rocks. Unconformably overlie the Tawilah formation and are covered at the top by Quaternary surficial deposits. The volcanic rocks include basaltic and andesitic massive porphyritic lavas, pillow lavas, vasicular lavas, tuff flows, palagonite tuff, and subaqueous tuff. The felsic rocks include rhyolitic welded to nonwelded vitric and crystal tuff, porphyritic flows, and a few dacitic tuffs. The interbedded sedimentary rocks consist of laharic breccia, conglomerate, sandstone, mudstone, siltstone, and shale

Ti — Intermediate to felsic rocks--A distinct unit that occurs in the southern part of the quadrangle. Composed of soda-rich latite andesite, latite porphyry, quartz andesite, and diorite. Whether these rocks are volcanic or, more likely, hypabyssal intrusions, is not certain

Kt — TAWILAH FORMATION--A sequence of sandstone and rhyolitic tuff about 10 to 30 m thick. Unconformably overlies the Amran formation and is overlain by the Jizan group. The formation is therefore of inferred Cretaceous to early Tertiary age. The lower part consists of crossbedded sandstone and subordinate pebble conglomerate. The upper part consists of rhyolite tuff and tuffaceous siltstones. The upper few meters of the formation is strongly silicified and iron-stained forming concretions of hematite and fragments of chert in mottled, silicified groundmass. The mottled zone is interpreted as a paleoweathering horizon (Blank and others, in press). The formation represents a fluvial environments passing up into an emergent environment

Ja / Jas — AMRAN FORMATION--An assemblage of dolomitized limestone, calcarenite, and micrite overlain by interbedded argillaceous limestone, micrite, biosparite, biomicrite, sandy limestone, marl, and subordinate intraformational conglomerate, shale, siltstone, and sandstone. Fossils are abundant, indicating a middle to late Jurassic age (Callovian to Oxfordian) for the lower part of the succession and an upper Jurassic age (Oxfordian to Kimmeridgian) for the upper part. Locally the formation contain abundant sandstone (Jas). The formation conformably overlies the Khums formation, and unconformably overlain by the Tawilah formation. The limestones accumulated in a shallow-marine environment representing a transgressive episode between the Khums formation and the Tawilah formation

Jk — KHUMS FORMATION--An assemblage of interbedded sandstone, silty sandstone, siltstone, shale, and rare conglomerate, 20-130 m thick, overlain by massive to crossbedded, medium- to coarse-grained sandstone as much as 290 m thick. The unit disconformably overlies the Wajid Sandstone although in most places the contact is faulted; it is overlain by the Amran formation. The formation is probably early Jurassic in age (Anderson, 1979). Sandstone in the Khums formation consists of quartz arenite, subarkose, and immature subarkose. The detrital grains texturally more mature, and suthigenic silica cement more abundant than in the Wajid Sandstone. The formation was deposited in a fluvial environment and was probably derived from a northerly source

OEw / OE/Jk — WAJID SANCSTONE--Medium- to coarse-grained sandstone, interbedded with subordinate pebble conglomerate and iron-stained siltstone. Of probable Cambrian to Ordovician age. Sandstone was deposited in a fluvial environment on weathered and peneplained rocks of the Arabian Shield, and was derived from a southerly source. During the Tertiary, widespread gravity sliding at the basal contact produced a thin breccia horizon. The sandstone conspicuously cross-bedded, in tabular, torrential cross-sets ranging from 0.5 to 4 m in thickness. The rock moderately to well sorted and consists of quartz arenite, sub-arkose, and immature subarkose. Conglomerate composed of vein quartz, minor schists, granite, and diabase pebbles. In places the Wajid sandstone resembles the Khums formation; where its identity is uncertain, it is symbolized OE/Jk

PROTEROZOIC INTRUSIVE ROCKS

QUARTZ VEINS--Cropping out in the Proterozoic rocks, these rocks are of inferred late Proterozoic age

GRANITOID ROCKS OF THE SHADA PLUTON:

gr — Biotite granite--Moderately to well-foliated leucocratic biotite granite and subordinate muscovite granite, biotite granodiorite, and quartz-rich granitoids; contains abundant inclusions of amphibolite, biotite schist, quartz-muscovite schist, and tonalite gneiss. The unit forms the core of the Shada pluton and represents a synkinematic intrusion emplaced in the Sabya Formation

gn — Granite and granodiorite--Foliated to gneissic, leucocratic biotite or biotite-muscovite granite and granodiorite; contains abundant inclusions and large pendants of the Sabya formation. The unit forms the outer part of the Shada pluton and represents a synkinematic intrusion emplaced in the Sabya formation penecontemporaneously with intrusion of the biotite granite unit

bg — Migmatite--A varied unit composed of schist, paragneiss, and granite. The granite gneiss resembles sections of the granite and granodiorite unit of the Shada pluton, and formation of the migmatite probably genetically related to intrusion of the pluton. Occurs in the southern part of the mapped area

PROTEROZOIC LAYERED ROCKS

ss / ssc — SABYA FORMATION--An assemblage of sericite-quartz schist and chlorite-sericite-quartz schist interbedded with subordinate muscovite-quartz schist, chlorite-muscovite-quartz schist, quartz-carbonate-sericite schist, greenstone, greenschist, and amphibolite-feldspar-quartz schist (ss). The southern exposure contain abundant quartz-carbonate-sericite schist and meta-andesite tuff, interbedded with minor quartzite and marble (ssc). The formation extends south from the Sabya quadrangle (Fairer, 1983) where it represents a flyschlike succession of mainly continental derivation

EXPLANATION

- CONTACT
- FAULT--Dotted where concealed
- STRIKE AND DIP OF BEDS
  - 30 — Inclined
- STRIKE AND DIP OF FOLIATION
  - 60 — Inclined
  - Vertical
- ANTICLINE--Showing trade of crest and direction of plunge
- LINEATION--Showing direction and amount of plunge
- DIRT TRACK
- INTERNATIONAL BOUNDARY--Approximately located

INTRODUCTION

The Wadi Khulab quadrangle, bounded by lat 16°30' and 17°00' N. and long 42°00' and 43°30' E, is one of the southernmost quadrangle of the Kingdom of Saudi Arabia. It is named after Wadi Khulab which flows westward across the central part of the area. Approximately one-third of the quadrangle, comprising the mapped area, lies within Saudi Arabia; the remainder lies within the Yemen Arab Republic. Delineation of the international boundary should not be considered definitive.

From west to east, the physiography of the mapped area consists of a portion of the Tihamat Asir, or coastal plain, extending from the Jizan quadrangle to the west (Blank and Gettings, 1984); a northwest-trending hill range close to the western border of the quadrangle; a pediplain; and the foothills of the Red Sea escarpment. The top of the escarpment is about 50 km east of the mapped area, in the Yemen Arab Republic. Within Saudi Arabia, the highest elevation in the quadrangle about 770 m above sea level, is found at Tirf in the western range of hills.

PREVIOUS AND PRESENT WORK

The first geologic map of the Saudi Arabian portion of the Wadi Khulab quadrangle was produced as a portion of the 1:500,000-scale geologic map of the Asir quadrangle (Brown and Jackson, 1959). Gillman (1968) subsequently described the Phanerozoic stratigraphy of the area. Most previous work in the quadrangle concerned the petrology, genesis, and tectonic significance of a Tertiary dike swarm and gabbro intrusion at the western margin of the map (Coleman and others, 1972; Blank, 1977; Coleman and others, 1977; Gettings, 1977); Coleman and others, 1979; Kellogg and Blank, 1982). Tertiary volcanic and sedimentary rocks of the Jizan group have been described in detail by Schmidt and others (1982) and Schmidt and Hadley (1984).

The limestones potential of the area has been investigated by Bhutta (1968), Laurent (1974), Basse Sambre-E.R.I. (1977), and Cheeseman and Binda (1981). Berthier and others (1981), and Barbut and others (1983) discussed the geothermal resources of the area.

The present geological map is based on mapping by the authors in 1977 and 1979, aided by photogeologic interpretation, and by a brief reconnaissance by consultants to the U.S. Geological Survey (Johnson and Vranas, 1984). A 1:250,000-scale geologic map of the Jizan quadrangle, incorporating the present map, has recently been compiled (Blank and others, in press).

GEOLOGIC SETTING

The Wadi Khulab quadrangle includes Proterozoic metasedimentary rocks of the Sabya formation and synkinematic granitoids rocks of the Shada pluton, a succession of Phanerozoic sedimentary and volcanic rocks, and Tertiary dikes and gabbros of the Tihamat Asir complex.

The Proterozoic rocks belong to the Arabian Shield, a large area stretching east and north of the Wadi Khulab quadrangle. The Shield is composed of metamorphosed and deformed volcanic and sedimentary plutonic rocks. In the quadrangle, the Sabya formation is a southerly extension of one of these more widespread metamorphosed and deformed units of layered rocks, and the Shada pluton is an example of an early granite intrusion in the Shield.

Following the close of the Precambrian, the Wajid Sandstone of Cambrian to Ordovician age was deposited by northward-flowing streams on weathered and peneplained rocks of the Arabian Shield. The Wajid Sandstone occurs through much of southern Arabia and represents the lowest of several units of Phanerozoic sedimentary rocks overlying the Shield. These rocks were deposited in environments controlled by epeirogenic movements in the Precambrian basement. Emergence and nondeposition during much of the Paleozoic resulted in the gap in the Phanerozoic record above the Wajid Sandstone until sedimentation resumed during the Mesozoic. In response to fluctuations in the position of the shore line and variations in depths of water from the Jurassic to the early Tertiary, the Khums formation of fluvial sandstone and siltstone, marine limestones of the Amran formation, and sandstone and felsic tuffs of the Tawilah formation, were successively deposited. The Tawilah formation represents a regressive environment and the top of the formation is marked by a paleo-weathering zone.

Younger rocks in the quadrangle are predominantly magmatic in origin. They include mafic and felsic volcanic rocks of the Jizan group, and intrusive rocks of the Tihamat Asir complex. These rocks reflect the onset of upper mantle upwelling and crustal attenuation in the region of the proto-Red Sea. The Jizan group was deposited in an intracontinental rift (Schmidt and others, 1982) prior to the formation of the Red Sea itself, and the Tihamat Asir complex was emplaced in extensional structures during the subsequent initial separation of Arabia from Africa (Coleman and others, 1979).

Most of the quadrangle is underlain by crust of average continental thickness and density, but westwards there is a transition to a denser and thinner crust (Healy and others, 1982). It is generally agreed that the transition is related to crustal attenuation at the margins of the Red Sea although the mechanism of attenuation and the extent to which the denser crust represents new oceanic material is debated (Lowell and Genik, 1972; Gettings, 1977; Coleman and others, 1979; Kellogg and Blank, 1982; Schmidt and others, 1982; Cochran, 1983).

DATA STORAGE

No entries or updates have been made to the Mineral Occurrence Documentation System (MODS) data bank. Field and petrographic data in support of this map have been store as part of base data file USGS-DF-04-36.

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