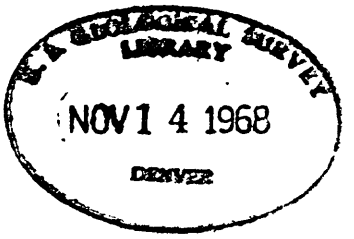
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Saudi Arabia Investigation Report
(IR) SA-45



MINERAL RECONNAISSANCE OF THE WADI AL 'AYS QUADRANGLE

by

Robert F. Johnson and Virgil A. Trent

1968

MINERAL RECONNAISSANCE OF THE WADI AL 'AYS QUADRANGLE

by

Robert F. Johnson and Virgil A. Trent

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 Also on open file in that office is a large amount of material, in the form of unpublished manuscripts, maps, field notes, drill logs, annotated aerial photographs, etc., that has resulted from other previous geologic work by Saudi Arabian government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.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Saudi Arabian Mineral
Exploration - 45

MINERAL RECONNAISSANCE OF THE WADI AL 'AYS QUADRANGLE

by

Robert F. Johnson* & Virgil A. Trent*

Introduction

The Wadi al 'Ays quadrangle was examined for mineral occurrences in 1965 under the terms of an agreement between the Ministry of Petroleum and Mineral Resources and the U. S. Geological Survey. A total of 27 man-days were spent in the area. Other than small chromite bodies of doubtful economic value no evidence was found for the existence of economic mineral deposits.

The Wadi al 'Ays quadrangle lies between 25° and 25°30'N. latitude, and between 38° and 38°30'E. longitude. The quadrangle is on the north side of the drainage divide that separates Wadi al Far'ah and its tributaries, and Wadi al Hamd; nearly the entire quadrangle drains into Wadi al Hamd.

The topography in much of the quadrangle is subdued and access is good for 4-wheel drive vehicles. The terrain is more rugged at the southern edge of the quadrangle and along the divide between Wadi al 'Ays and Wadi al Tura'ah. The northern contact of the ultramafic complex is also difficult of access.

Al 'Ayn, the only settlement in the area, has several hundred inhabitants. Water for the town and the surrounding date gardens is obtained from shallow wells. Water can also be obtained from wells in the larger wadis and a spring issues from a cave in serpentinite near the western edge of the quadrangle.

An unpaved road connects Al 'Ayn with Yanbu al Bahr to the south. The road has been graded for about half of the distance of 160 kilometers. The road continues

northward down Wadi al 'Ays to Wadi al Hamd where it joins a road that follows the old railroad from Medina to Al 'Ula. About 10 kilometers north of Al 'Ayn a road branches off to the northwest and continues to Al Wajh on the Red Sea coast. Car tracks made by woodcutters follow most of the larger wadis.

The ultramafic rocks of the Wadi al 'Ays quadrangle have been of interest for many years because of the common association of serpentinite with chromite and chrysotile asbestos. Ahmed Fakhry (written communication) reported the presence of serpentinite in 1938 and later, during a prospecting trip in 1941, he reported an occurrence of asbestos near a spring at Lahaja, 32 kilometers northwest of Al 'Ayn.

Kahr (1961) investigated the ultramafic rocks and the surrounding area. Some of the rock units shown on our map within the ultramafic complex were mapped by Dr. Kahr (scale 1:50,000), whose work in that area was more detailed than ours. The chromite-bearing areas were also located by Dr. Kahr.

The HUNTING Survey Corporation made an airborne geophysical survey of the ultramafic rocks and the surrounding area in 1962. Part of our work was to make ground examinations of magnetic anomalies found in the course of the survey.

A geologic map of the Northwestern Hijaz (scale 1:500,000) prepared by Brown and others (1963) includes the Wadi al 'Ays quadrangle.

The purpose of the present investigation was to examine as much of the quadrangle as possible, within the time available, in a search for minerals of economic value. The sample localities shown on the accompanying map give an indication of the area examined. Samples of wadi sediments were analyzed spectrographically for 27 elements. It was hoped that areas of higher than normal metal content could be blocked out for more detailed study.

The present work was made possible through the cooperation of officials of the Directorate General of Mineral Resources, Ministry of Petroleum and Mineral Resources, who helped obtain personnel and field equipment for the work. Mr. Ghazi Sultan, Chief Geologist of the Directorate General of Mineral Resources, accompanied the writers on the first field trip into the area and arranged for the cooperation of the Emir at Al 'Ayn.

Geologic setting

Rocks of Precambrian age underlie the Wadi Al 'Ays quadrangle except for two areas in the southwest corner covered by basalt flows of Tertiary or Quaternary age. The layered rocks of Precambrian age are shown as two units on the map. An older slightly metamorphosed volcanic sequence, called the Halaban andesite, is overlain by argillite and other slightly metamorphosed sedimentary rocks of the Hadiyah formation. The layered rocks have been intruded by granite, granodiorite, diorite, and mafic and ultramafic intrusions; the ultramafic rocks are now largely serpentinite. The layered rocks are strongly folded with northerly-trending fold axes predominating in most of the area. North to northeast-striking faults are common.

Halaban meta-andesite crops out in the western part of the quadrangle and in a folded belt in the central part. A narrow belt of meta-andesite is exposed along the west side of Wadi At Tura'ah. Dark green or greenish brown flows and pyroclastic rocks predominate in the Halaban andesite. Graywacke and other clastic rocks are interbedded with the volcanic rocks and make up a minor part of the volcanic section. Ferromagnesian minerals in the volcanic rocks are largely altered to chlorite and the plagioclase is clouded but the volcanic origin of the rocks is clear. Most of the material appears to be andesitic in composition. Light-colored felsitic rocks occur sparingly in the volcanic section. They are most abundant on the eastern margin of the ultramafic complex where Kahr (1961) mapped them as felsite (?). We show these rocks as Halaban(?) as they appear to be part of the volcanic section and to be similar to light-colored metavolcanic rocks in the Halaban to the south in the adjoining Jabal Radwa quadrangle.

Rocks that we are showing as Halaban andesite were mapped as greenstone (gd) or schist (sc) by Brown and others (1963). We were able to divide Brown's (sc) unit into metavolcanic and metasedimentary rocks as they are not highly schistose in this area. The metavolcanic rocks are similar to rocks Brown mapped as Halaban andesite east of the Wadi Al 'Ays quadrangle and they are in a similar stratigraphic position beneath the metasedimentary rocks of the Hadiyah formation.

The eastern and northern parts of the mapped area are underlain by slightly metamorphosed rocks of the Hadiyah formation and a broad belt of Hadiyah extends south to the southwest corner of the quadrangle. Red and green argillite and siltstone are the most abundant rock types but conglomerate and sandstone are widespread and partly recrystallized limestone is locally present. The rocks are very slightly metamorphosed except near intrusions where they may be converted to hornfels. A little sericite has developed on bedding planes in the argillite and slaty cleavage is locally present; there is little visible change in the coarser clastic rocks.

An unconformable relationship is commonly seen between the Hadiyah formation and the underlying Halaban andesite. Whether this represents a period of uplift and erosion of the Halaban or merely the deposition of the sedimentary beds against flow rocks with varying degrees of initial dip is not known.

The Hadiyah formation is the youngest bedded Precambrian rock in the mapped area. Basalt flows of Tertiary or Quaternary age have flowed down valleys of the present erosion cycle in the southwest corner of the quadrangle. At least two ages of flows can be recongized. The youngest are fresh black scoriaceous lavas that are unaffected by erosion and could well have been erupted in historic time.

The Precambrian layered rocks have been intruded by numerous bodies of plutonic rocks that range in composition from a highly siliceous rock to peridotite. Granite is rare in the quadrangle. Biotite granite crops out at the south edge of the mapped area and small intrusions of porphyritic biotite granite cut rocks of the Hadiyah formation 10 kilometers north of Al 'Ayn. Hornblende-biotite granite underlies a basin at the west edge of the quadrangle about 16 kilometers northwest of Al 'Ayn.

Hornblende granodiorite occurs in three intrusions, one east of the granite at the south edge of the area, another crops out about 12 kilometers northeast of Al 'Ayn on the margins of the large basin in Wadi Al 'Ays and in isolated hills within the basin. The third intrusion lies on the flanks of Jabal al Qasm and in the basin to the south. The other bodies shown as "dg" on the map are hornblende diorite except for two bodies of light-colored biotite diorite in the ultramafic complex near the southwest corner of the quadrangle.

A small stock of quartz syenite intrudes the Hadiyah formation at the eastern edge of the quadrangle. The Hadiyah formation has been converted to hornfels and now forms a crater-like rim around the uneroded remnants of the intrusion enclosing a basin about six kilometers in diameter. Except for some hills of quartz syenite, the floor of the basin is a sand covered plain. Syenitic rocks probably underlie the basin as they crop out around the margin for more than half the circumference. Massive magnetite float was seen in the basin and possibly small bodies of magnetite-rich rock occur near the margin of the syenite as they do in a similar stock 30 kilometers to the south.

The largest area of plutonic rocks is the complex of diorite, gabbro, and serpentinized peridotite in the western part of the quadrangle. Kahr (1961) mapped the complex in some detail and the outline of rock units within the complex are largely taken from his map. He considers the rocks as a group to be an ophiolite complex.

The metamorphic effects of the ultramafic intrusion on the surrounding rocks are slight. Some silica-carbonate rock occurs along the contact but adjacent rocks are tilted and only slightly altered. The complex may have reached its present position as a cold intrusion, a rather common type of serpentinite intrusion in fold belts in other parts of the world, (Turner and Verhoogen, 1960. p.311).

The structure of the area is complex and not well understood. Small folds are common in the Hadiyah formation and the outcrop pattern of the Halaban andesite in the central part of the quadrangle is indicative of tight folding on a larger scale.

Faults are common throughout the area; only the more prominent faults are shown on the map. Many faults strike northerly and northeasterly but east-striking faults are present in the southern and northwestern parts of the quadrangle.

Mineral deposits

Evidence of ancient mining activity is scanty in the Wadi al 'Ays quadrangle. Fakhry (written communication) sampled three ancient workings that may lie within the quadrangle, the deposits are only vaguely located and are described as follows:

The Tiraa deposit is a small working on a hill 43 kilometers north of Muraighib (an ancient gold mine 40 kilometers southwest of Al 'Ayn). Fakhry mentions ruins and numberous pits in the wadi near the hill.

The Nighaira deposit is 74 kilometers north of Muraighib. The workings consist of a stope 75 meters long and 9 meters deep. Ruins were found as well.

Jabal Zabiyah is described as 80 kilometers north of Muraighib and 32 kilometers north of Al Ees (possibly Al 'Ayn on our map). Ruins are mentioned as well as 5 pits in serpentine on black quartz veinlets.

We did not see any of the above deposits but did examine an ancient working 16 kilometers N.23° E. from Al 'Ayn at our sample locality numbered 4486. A stope about 20 meters long and 6 meters deep follows the footwall of a steeply-dipping quartz vein. Most of the vein was left in place and two parallel veins were not mined. Ruins of three buildings are in the wadi below the east end of the vein. The veins are in indurated rocks of the Hadiyah formation near their contact with serpentinite. Secondary copper minerals occur in silicified rock below the west end of the workings.

Kahr (1961) describes two chromite lenses each of which he estimates to contain about 5,000 tons of chromite. He also describes small asbestos deposits of poor quality slip-fiber chrysotile. Kahr outlined three chromite-bearing areas that he recommended for further study; these areas are shown on our map. We saw small lenses of chromite in these and other areas but saw no large lenses other than one described by Kahr north of Jabal al Wask.

Small amounts of secondary copper minerals occur within and on the contact of the ultramafic complex but no deposits seemed to be large enough to be of economic interest.

Sampling

About 50 samples of wadi sediment were taken for trace-element analysis during the mineral reconnaissance. The samples were screened to a size range from 0.175 to 0.495 millimeters at the sample site and later were analyzed spectrographically for trace amounts of 27 elements in the laboratories of the Directorate General for Mineral Resources in Jiddah. Charles Thompson, U. S. Geological Survey, analyzed the samples.

The copper content of the samples is shown on the map. The percentage of samples with anomalous copper content is greater in the Wadi al 'Ays quadrangle than in the other quadrangles that we have sampled. Anomalous samples from wadi sands in the Hadiyah formation contain more copper on the average, 50 to 70 ppm (parts per million), than do samples from sand in the Halaban andesite which commonly contain 30 to 50 ppm. Background for copper is about 15 ppm. The two highest copper analyses came from wadi

sand in the ultramafic complex. A sample from a wadi that drains a gabbroic intrusion near the south end of the complex contains 150 ppm of copper, 3 ppm of molybdenum, and anomalous amounts of cobalt, manganese, titanium, and vanadium. A sample from the north edge of a diorite intrusion at the north edge of the complex contains 100 ppm of copper.

Only a few samples contain anomalous amounts of other elements. A wadi sample from a small granite intrusion in the Hadiyah formation about 10 kilometers north of Al 'Ayn contains 30 ppm of molybdenum or more than 15 times background. Numerous quartz veins that contain scattered pyrite and tourmaline occur in the vicinity.

Samples taken in areas underlain by ultramafic rock are high in chromium and nickel as would be expected. Most wadi samples from areas of Hadiyah formation contains 100 ppm or more of chromium whereas most samples from areas underlain by Halaban andesite contain 50 ppm or less. More sampling is needed to confirm this but it could be a useful aid in stratigraphic work.

One of the objectives of the mineral reconnaissance was to make ground checks of aeromagnetic anomalies found by the HUNTING survey in 1962. Don R. Mabey of the U. S. Geological Survey (written communication) recommended the investigation of three anomalies in the quadrangle.

An anomaly at the south edge of the granodiorite at Jabal Al Qasm. The anomaly is about on the contact of the granodiorite with rocks of the Halaban andesite. No surface concentration of magnetite was seen.

An anomaly at the southern border of the ultramafic complex near the west edge of the map at 25°14'N. Serpentinite in this area is intruded by felsitic bodies but no magnetite was seen.

Northwest-trending linear magnetic anomalies. Mabey thought that these anomalies may represent buried ultramafic rocks intruded along fault zones. Serpentinite crops out south of sample locality 4486 adjacent to one of the linear anomalies. Wadis with a preferred northwest trend, coincident with the linear anomalies, occur northwest of the ultramafic mass. This is suggestive of faulting but no other evidence of faulting or of the presence of ultramafic dikes was seen.

Recommendations

Other than a search for chromite and asbestos as recommended by Kahr (1961) there

are no specific areas that appear to warrant a more detailed study. We are more pessimistic than Dr. Kahr with regard to the chromite deposits and it seems doubtful if enough ore could be developed to be competitive in world markets. With the growth of a steel industry in Saudi Arabia an internal market for chromite may develop.

Copper minerals occur and the rocks contain higher than normal amounts of copper as shown by the trace-element content of wadi sands. Careful prospecting may result in the location of minable deposits but we saw no indication of the presence of large copper deposits.

References

Brown, G. F., Jackson, R. O., Bogue, R. G., and Elberg, E. L., Jr., 1963, Geology of the Northwestern Hijaz quadrangle, Kingdom of Saudi Arabia: U. S. Geol. Survey - Ministry of Petroleum and Mineral Resources, Misc. Geol. Inv. Map I-204A.

Kahr, Victor P., 1961, Geology north of Yanbu Al Bahr: Saudi Arabia Ministry of Petroleum and Mineral Resources, Dir. Gen. of Min. Resources, Jiddah, Unpublished report.

Turner, F. J., and Verhoogen, John, 1960, Igneous and metamorphic petrology; New York, McGraw-Hill, 694 p.