UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Saudi Arabia Investigation Report
(IR) SA-68

A MINERAL RECONNAISSANCE OF THE JABAL SAHAH QUADRANGLE

KINGDOM OF SAUDI ARABIA

by

Jesse W. Whitlow
U. S. Geological Survey

1970

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 Also on open file in that office is a large amount of material, in the form of unpublished manuscripts, maps, field notes, drill logs, annotated aerial photographs, etc., that has resulted from other previous geologic work by Saudi Arabian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

A MINERAL RECONNAISSANCE OF THE JABAL SAHAH QUADRANGLE, KINGDOM OF SAUDI ARABIA

by

Jesse W. Whitlow

Contents

Illustrations

Abstract

A mineral reconnaissance of the Jabal Sahah quadrangle, Kingdom of Saudi Arabia, showed the presence of the anomalous elements silver, beryllium, molybdenum, niobium, tin, and tungsten and of anomalous amounts of chromium, nickel, lead, titanium, and vanadium. All anomalies are low except one for tin and one for tungsten in the granitic plug west of Jabal Sahah. Debris from this small plug contains as much as 1,000 ppm (parts per million) tin in wadi sand, and a concentrate from the sand contains as much as 40 ppm molybdenum and 1,000 ppm tungsten. The area of this small plug and the metamorphic rock around the plug should be studied in detail to learn distribution and value of tih, tungsten, niobium, and molybdenum in the rocks. Alkalic granite at Jabal Sahah contains beryllium, molybdenum, tin, niobium, tungsten, and a low anomaly of lead.

Introduction

Purpose, scope and acknowledgement.

A mineral reconnaissance of the Jabal Sahah quadrangle, Kingdom of Saudi Arabia (fig. 1), was completed in eight days of field work between June 14 and June 28, 1965. The purpose of the work was to locate areas likely to contain economic minerals, to learn the probable regional distribution of metals and to delineate areas that require additional economic geological study. A secondary purpose of the investigation was to review the existing 1:500,000 scale geologic map of the area (Jackson and others, 1963). In order to accomplish these objectives in the time available, the rocks were studied briefly, mines and prospects were looked for in reconnaissance fashion, and samples for geochemical examination were taken at 56 stations (fig. 2). This report is based on field observations and on the results of semiquantitative spectrographic and chemical analyses of the samples.

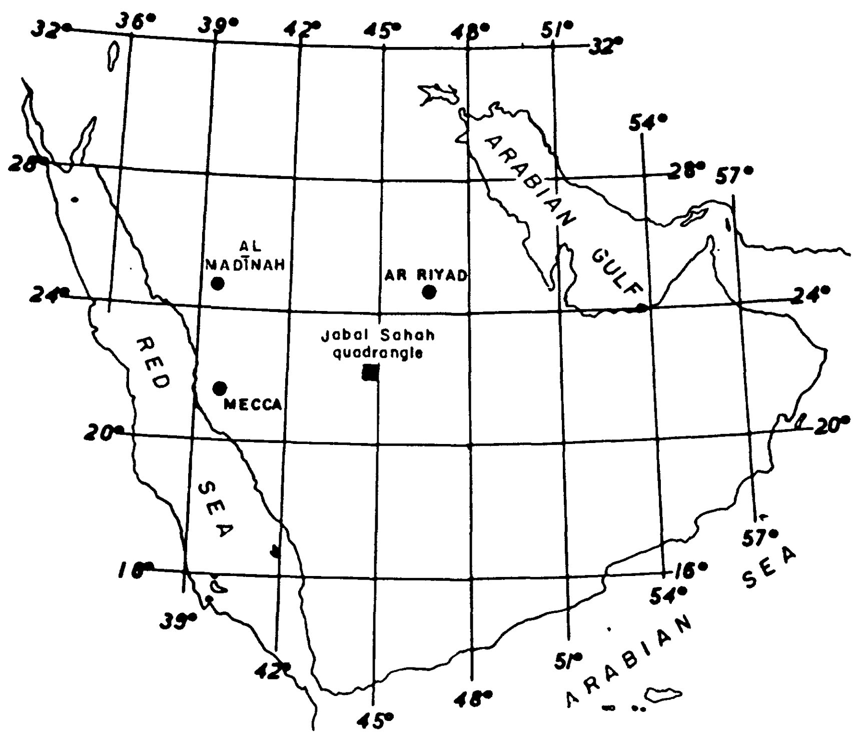

FIGURE 1. INDEX MAP OF ARABIAN PENINSULA SHOWING LOCATION OF QUADRANGLE

The work was performed by the United States Geological Survey in cooperation with the Directorate General for Mineral Resources, Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia. The Ministry furnished funds equipment, reports on mines and geologic investigations, and supporting personnel. The writer wishes to thank officials of the Ministry for their assistance in accomplishing the survey, and Misri Madak, a senior truck driver, is here commended for his help.

Access.

Access to areas in the Jabal Sahah quadrangle is good to poor. There are few rudimentary roads and no permanent villages, which reflects the scarcity of potable water. Most wells are too salty for human use except along the east side of Jabal Sahah.

Areas underlain by granite and granodiorite (gg), gray biotite granite (gh) and alkalic granite (gm) are fairly easily traversed except locally where a large dike or a dike swarm forms a barrier. Jabal Sahah, an alkalic and peralkalic granite (gp), can be crossed at one place. Areas of considerable relief underlain by rocks of the Halaban and Murdama formations are difficult or impossible to traverse by truck, but areas of low relief are commonly passable. The narrow wadis contain either soft, wind-deposited sand or cobble to boulder-size rock debris which makes driving difficult. Suitable sites for a light airplane to land are common in the areas underlain by alkalic granite (gm) and along the Najd fault zone. They are present but not common in areas of low relief underlain by the Halaban formation and gray biotite granite. A possibly suitable place in the potentially economically important Jabal Sahah area is southeast of station 11,985.

Procedure..

Work began with a study of aerial photographs of the area to locate structural and lithologic features that should be examined in the field. A review was made of reports on mines and previous geologic investigations in the Jabal Sahah quadrangle. Field work consisted of truck traverses to study and to sample locations marked on the aerial photographs, to examine other areas, to study contact zones, and to search for abandoned mines. Location of sample stations were plotted on 1:100,000 photomosaics. Bulk samples of rock debris weighing 5 to 10 kilograms and approximately a gram of detrital magnetite were collected at each of 56 stations. A sample of granite and granodiorite for age determination was collected at station 11,995. The field work was a continuous traverse with camp set each evening at a different site.

Hand specimens, the bulk samples, and surficial debris in the camp area were scanned each evening with a short-wave-length ultra-violet light for fluorescent minerals. The bulk samples were screened to remove about 55 grams of minus 30 plus 80 mesh sand for analysis. All samples were sent to Jiddah for further processing and for semiquantative spectrographic and wet chemical analyses. In Jiddah, the minerals having a specific gravity greater than three were concentrated and recovered from the bulk samples. Magnetite was removed from the concentrate and added to the detrital magnetite collected at the sample station. The samples of screened sand, concentrate, and magnetite were submitted to the Jiddah laboratory of the Directorate General for Mineral Resources for analysis.

Geology

Geologic Units.

The geologic units granite and granodiorite (gg), Halaban formation (ha/hc), Murdama formation (mu), and alkalic and peralkalic granite (gp), of Jackson and others (1963) are used here with a few changes based on field work in 1965. The large granitic mass in the northeastern half of the quadrangle was found to intrude the metamorphosed sedimentary rock along its western and southwestern borders; therefore, the rock is here renamed alkalic granite (gm) instead of the granite and granodiorite (gn) as mapped earlier by Jackson and others (1963). This is supported by observations east of the Jabal Sahah quadrangle (W. C. Overstreet, oral communication, 1966), where contact effects were seen in metamorphosed sedimentary rocks along the southern side of the granite. Other changes from the work of Jackson and others (1963) are the identification of two bodies of gray biotite granite (gh) in the Halaban formation northwest of Jabal Sahah, the revision of the contact of the ha and hc units of the Halaban formation, and the introduction of a small body of intrusive granite (gm) into the Murdama formation near the north edge of the quadrangle. All metamorphic, sedimentary, and crystalline rocks in the quadrangle seem to be of Precambrian age.

Granite and granodiorite.-- The granite and granodiorite unit (gg) is a light gray to reddish-gray, biotite granitic rock that grades toward diorite and is locally porphyritic. All the granite and granodiorite (gg) in the quadrangle is southwest of the Najd fault. For that reason the letter symbol employed by Jackson and others (1963) for granite and granodiorite (gg) is used here.

The age relation of the granite and granodiorite (gg) to the Halaban formation near the southwest corner of the quadrangle is indefinite because the contact of the two rocks is covered. The contact areas of the Halaban formation and two small bodies of granite (gg) at the south edge of the quadrangle were not examined. The work of Jackson and others (1963) shows an unconformity which was not observed in 1965, between this granite and the Halaban formation (ha/hc). More detailed work in this quadrangle and in the adjoining quadrangles to the west and south is necessary to determine the age relations of the granite and granodiorite (gg) to the Halaban formation.

Halaban formation.-- The Halaban formation (ha/hc) underlies nearly half of the Jabal Sahah quadrangle and comprises metamorphosed sediments, graywacke, rhyolite, andesite, diorite and granodiorite, diorite and gabbro, greenstone, and local lenticles of marble. Epidote is common to abundant in most of the Halaban. Locally the rock has been silicified adjacent to and near rhyolite dikes, the silification is more common in the northwestern part of the quadrangle than in the southeastern part. Fairly large masses of diorite and gabbro are in the formation.

The Halaban formation northwest of Jabal Sahah is intruded by gray to reddish-gray, biotite granite (gh) which locally migmatized the metamorphic rocks of the Halaban. Numerous closely spaced andesite and rare rhyolite and granite dikes are continuous from the Halaban into and across the granite. These dikes do not appear on aerial photographs because of the similarity of color and erosional characteristics of the dikes and host rock. A divide in the Halaban formation near its contact with the granite (gh) indicates a hardening of the sedimentary rock by the metamorphosing effect of the intruding granite. The ridge is crossed by lineaments that are traceable into the granite.

The Halaban formation is shown by Jackson and others (1963) to be in fault contact with the Murdama formation (mu) in the Najd fault zone, but the present field work disclosed that the rocks on each side of the fault are the same. Too little work was done to justify revision of the geology shown by Jackson and others. In the rocks shown here, the Halaban formation (hc) generally contains more coarse graywacke and less shale and fine graywacke than the Murdama formation (mu). The metamorphic grade decreases southwestward from the schists of the biotite zone adjacent to the gray biotite granite and in and near the fault to essentially unmetamorphosed graywacke in the area labelled graywacke of the Halaban formation (hc). Wind-deposited sand covers much of the fault zone.

The Halaban formation (ha/hc) is intruded by the alkalic and peralkalic granite (gp) which truncated lineaments and metamorphosed the sedimentary rock at and near its contact. Rhyolite is common to abundant near this granite.

Gray biotite granite.-- The gray biotite granite unit (gh) is a gray to reddish gray, coarse- to medium-grained biotite granite that grades to granodiorite and diorite and locally is porphyritic. This unit which was recognized in 1965 is totally surrounded by the Halaban formation. The northern part of the granite contains more quartz than the southern part which grades to granodiorite and diorite. This granite (gh) is intruded by numerous locally closely spaced andesite and andesite-like dikes and rare rhyolite and granite dikes which are continuous into the Halaban formation. This granite (gh) intruded predominately by andesite and andesite-like dikes differs from the alkalic granite (gm) which is intruded predominately by rhyolite dikes. More detailed work is necessary to determine the age of this granite (gh) relative to the age of the alkalic granite (gm).

Murdama formation.-- The Murdama formation (mu) comprises metamorphosed shale and fine-grained graywacke. Murdama adjacent to the intrusive mass of alkalic granite (gm) in the northeastern part of the quadrangle is metamorphosed to biotite schist, or locally to biotite phyllite, near the contact. The metamorphic grade of the Murdama formation decreases away from the contact.

The relation of the Murdama formation to the small body of gray biotite granite (gm) near the north side of the quadrangle (station 27,012) was not determined. Dip of the beds south and east of the granite body is into the granite as if it is in a basin in the sediments. This granite is about in the center of a curving to circular lineament in the Murdama formation.

Alkalic granite.-- The alkalic unit (gm) in the Jabal Sahah quadrangle is a gray and reddish-gray, coarse- to medium-grained, biotite granite that locally is porphyritic. This granite was mapped by Jackson and others (1963) as granite and granodiorite unit (gn), which they regarded as being older than the Murdama formation (mu). Work in the area in 1965 shows that this granite is intrusive into the Murdama formation and the granite contains inclusions of the Murdama. The same relationship is reported in the adjoining quadrangle to the east (W. C. Overstreet, oral communication, June 1966).

The alkalic granite (gm) is intruded by many rhyolite and rare andesite dikes probably in faults and along joints. This is the only granite mass in the quadrangle intruded by predominately rhyolite dikes. Evidence of faults in the granite near stations 11,970 and 27,013 shows that the north side moved westward relative to the south side.

Alkalic and peralkalic granite.-- The alkalic and peralkalic granite unit (gp) is a reddish to reddish-gray, coarse- to medium-grained, biotite granite that is intrusive into the Halaban formation (ha/hc). Jabal Sahah and a small plug west of Jabal Sahah are of this granite. Dikes are not present in the alkalic and peralkalic granite, but many rhyolite dikes are in the surrounding rock of the Halaban formation.

The distribution of trace elements in samples from these two bodies is almost identical except for differences in concentration. Samples from the small plug contain more tin, beryllium, and tungsten than samples from Jabal Sahah.

Dikes and silicified zones:-- The dikes in the Jabal Sahah quadrangle consist of andesite (A), rhyolite (R), breccia-andesite (B-A), and andesite-like rocks (A?). Dikes are in all rock units except the alkalic and peralkalic granite (gp).

The two gray biotite granite (gh) bodies northwest of Jabal Sahah are intruded by many andesite (A) and andesite-like dikes (A?) that are continuous from the granite into the Halaban formation (ha). This indicates a post-Halaban age for the dikes. The swarms of andesite and andesite-like dikes are more numerous in the andesitic and extrusive phase of the Halaban formation (ha) than in the graywackd and shaly phase (hc), but they are common in all of the Halaban. Reaction of the dikes on the host rock is at most a thin hardened zone adjacent to the dike; commonly there is no reaction with the host rock.

Rhyolite dikes are mumerous in the southern half of the alkalic granite (gm) and locally in the Halaban formation (hc). These dikes are as much as 15 meters thick in the alkalic granite and probably were intruded along faults in the granite. The rhyolite commonly reacted with the granite. Feldspars in the granite are reddened as much as two meters from the dikes. Rhyolite in the Halaban formation (ha/hc) commonly forms ridges of red rock that vary in width from a few meters to as much as 10 meters. Generally the rhyolite dikes in the sedimentary rock are parallel to prominent lineaments observed on aerial photographs.

One breccia dike (B-A) was examined in the quadrangle at sample station 11,972. The breccia is along an andesite dike which locally is silicified enough to be difficult to identify. The host granite (gm) is altered for several meters from the dike as shown by red to reddish feldspar. No mineralized area was associated with the dike.

Silicified areas are common in the Halaban formation (ha/hc) near Jabal Sahah and near the northwest corner of the quadrangle. The silicification is associated with rhyolite dikes. No mineralization was seen in the dikes or in the host rocks along the silicified areas.

Structure.

Observed structures in the Jabal Sahah quadrangle are faults, lineaments, trend lines, and possibly the trough of a syncline. The faults were mapped by Jackson and others (1963) except for faults shown by dashed lines in the alkalic granite (gm). A long fault mapped by Jackson and others (1963) in the Halaban was changed here to a lineament for lack of field evidence for a fault. Also, field evidence is lacking for the north-trending faults shown by a dashed line in the Murdama. Well-developed lineation, cataclastic cleavage, local pencil structures, and small tectonic slices of granite in the metasediments are evidence of faulting in the Najd fault zone. However, the displacement was not determined. The faults in the alkalic granite (gm) are based on observations in and east of this quadrangle. Faults of little displacement probably control the location of the rhyolite dikes in the alkalic granite. The north-trending dikes end near the fault shown from the east side of the quadrangle westward to station 11,970; dikes north of this fault trend eastward sub-parallel to the fault. Relative movement along most of the fault is difficult to determine, but the evidence shown on the map is that the north side moved westward at station 11,970, and near station 27,013. A small fault of similar displacement is probably present just south of station 11,971.

Lineaments are erosional features that form an alinement on aerial photographs and commonly are observed in the field, but other evidence of faulting was not seen along them. The prominent lineaments are shown on the map.

Trend lines depict the trace of bedding, foliation, cleavage, joints, repeated lithologic changes, or other planar features observed on aerial photographs.

Trend lines in this quadrangle are probably bedding and cleavage. The trend in the Murdama around the granite (gm) at station 27,012 indicates that this is either a basin or the end of a syncline plunging northward.

Distribution of selected elements

Semiquantative analyses of 56 samples of sand from Jabal Sahah quadrangle were made for 27 elements by C. E. Thompson, U.S.G.S., in the Jiddah laboratory of the Directorate General for Mineral Resources. Chemical analyses were performed by J. Goldsmith, L. Al Dugaither, and I. Baradja for copper, zinc, molybdenum, and tungsten in concentrates and for copper, zinc, and molybdenum in magnetite.

Results of the analyses give the approximate distribution of the elements in the Jabal Sahah quadrangle; however, only 13 elements are depicted on the map and discussed in the text. Spectrographic analyses showed barium, boron, chromium, cobalt, copper, gallium, lead, manganese, nickel, scandium, strontium, titanium, vanadium, yttrium, and zirconium in 80 percent or more of the samples. Chemical analyses of concentrates and magnetite disclosed zinc in all samples, molybdenum in 55 of the 56 samples of magnetite, and tungsten in 14 samples of concentrates. The remaining elements, beryllium, lanthanum, niobium, silver, and tin are in less than 30 percent of the samples. Four elements were below the limits of spectrographic detection in samples from the quadrangle.

Chemical data on the map and discussed below are:

(1) results of spectrographic analyses for copper, zinc, and molybdenum;
(2) positive anomalies for nine slected elements; and
(3) the chemical analyses for tungsten.

Special symbols are used for copper, zinc, molybdenum, and tungsten, and their abundances in ppm (parts per million) are given. The symbol for copper also shows the location of the sample station. Other elements are shown by chemical symbol and content in ppm.

Positive anomalies for the selected elements discussed in the text were determined by comparing the content of each element in approximately 1200 samples from the area of the Southern Najd Quadrangle (Jackson and others, 1963). Industrial demand was considered in choosing the selected elements. The minimum parts per million detected spectrographically and chemically and the minimum parts per million for a positive anomaly of selected elements are:

Element	Spectrographic analyses: Minimum parts per million detected	Spectrographic analyses: Minimum parts per million for positive anomaly	Chemical analyses: Minimum parts per million detected
Beryllium	2	2	
Chromium	5	200	
Copper	10	100	10
Lead	10	30	
Molybdenum	2	2	5
Nickel	5	100	
Niobium	50	50	
Silver	1	1	
Tin	10	10	
Titanium	20	10,000	
Tungsten	50	20	20
Vanadium	20	100	
Zinc	100	500	25

The presence of detectable beryllium, niobium, silver, and/or tin is a positive anomaly in the area of the Jabal Sahah quadrangle.

The short-wave-length ultra-violet light showed scheelite (calcium tungstate) in three samples, powellite (calcium molybdate) in six samples. Locations of scheelite and/or powellite are shown on the map. Most of the concentrates in which tungsten was detected by chemical analysis were barren of scheelite or powellite; therefore, other tungsten and molybdenum minerals are present in the area.

Copper, zinc, molybdenum and tungsten.

Spectrographic analyses detected copper in 47 of the 56 samples of sand from the quadrangle. Chemical analyses show copper in 40 of the concentrates and in 52 of the samples of magnetite. Generally, less copper is in samples from granitic rocks than is in samples from metamorphosed sedimentary rocks. The concentrates usually contain more copper than sand or magnetite. An exception occurs at station 27,000, where wadi sand contains 100 ppm copper, but the concentrate and magnetite respectively contain only 40 ppm and 30 ppm copper. There are no significant concentrations of copper in the quadrangle.

Zinc was detected spectrographically in two samples of wadi sand, 27,047 and 27,048; both contain 100 ppm. Zinc is present in all the concentrates and samples of magnetite which were analyzed chemically. Zinc ranges from 25 ppm to 150 ppm in the concentrates and from 100 ppm to 600 ppm in the magnetite. The highest zinc content is in samples from Jabal Sahah and station27,018 which contain 25 to 150 ppm in concentrates and 300 to 600 ppm in magnetite samples. Samples from stations 11,970 through 11,978 near the contact between alkalic granite and Murdama formation and in alkalic granite average less zinc in concentrates and magnetites than any group in the quadrangle.

Molybdenum was detected in three samples of wadi sand, a sabkah, 30 concentrates, and 55 samples of magnetite. Molybdenum ranges in abundance from 2 ppm to 10 ppm in sand, 5 ppm to 60 ppm in concentrates, and 5 ppm to 30 ppm in samples of magnetite. The granitic rocks generally contain more molybdenum than the metamorphosed sedimentary rocks except for samples from stations 11,970 through 11,976 which contain only 5 ppm or less molybdenum. Jabal Sahah, stations 11,981 through 11,985, contains above average molybdenum in concentrate and magnetite samples. The greatest abundance of molybdenum in wadi sand is 10 ppm at station 11,989, in concentrate is 60 ppm at station 27,019, and in magnetite is 30 ppm at station 11,983. There are no significant concentrations of molybdenum in the quadrangle.

Chemical analyses detected tungsten in 14 concentrates. The amount of tungsten ranges from 20 ppm to 1,000 ppm. Six of the 14 concentrates are from or associated with alkalic and peralkalic granite (gp) in Jabal Sahah and the small plug to the west. The concentrate from station 11,988, which contains 160 ppm tungsten, and the concentrate from station 11,989, which contains 1,000 ppm tungsten, are from wadi sand derived from alkalic and peralkalic granite (gp) and rocks associated with the small plug. Concentrate from station 27,018 contains as much as 240 ppm tungsten and is from alkalic granite (gm), which is also the source rock of tungsten-containing concentrates from stations 11,974, 11,975, and 27,019. Samples of tungsten-containing concentrates are from areas underlain by Halaban unit (ha) and alkalic and peralkaic granite (gp) at station 11,987, Halaban unit (ha) at station 11,991, Halaban unit (hc) at station 27,009, and Murdama formation intruded by granite dikes at station 27,013. Area of stations 11,988 and 11,989, and area of station 27,018 should be studied in more detail to identify the tungsten minerals and to evaluate the tungsten in the area.

Silver, beryllium, niobium, and tin.

Silver was detected (1 ppm) in wadi sand from station 11,992 which is from rhyolite, metamorphosed sedimentary rocks, and minor red granite. This area is not a source for silver.

Beryllium was detected in seven samples of wadi sand in abundances ranging from 2 ppm to 10 ppm. Six of the samples 11,981 through 11,985 and 11,988 are from Jabal Sahah and the small alkalic and peralkalic (gp) plug to the west which contains as much as 10 ppm beryllium, the highest tenor in the quadrangle. Sand from alkalic granite (gm) at station 27,019 contains only 2 ppm beryllium.

Niobium was detected in samples of wadi sand from Jabal Sahah collected at stations 11,981 through 11,985, and from west of Jabal Sahah station 11,988.

The six samples contained 50 ppm niobium and are from alkalic and peralkalic granite (gp) or the contact area of the alkalic granite and adjacent metamorphic rock.

Tin was detected in seven samples of wadi sand collected in the quadrangle. Four samples from Jabal Sahah contain 10 ppm and one contains 50 ppm (station 11,982). Two tin-containing samples are from the small plug of alkalic and peralkalic granite west of Jabal Sahah. Wadi sand from station 11,988 contains 1,000 ppm tin and sand from station 11,989 contains 10 ppm tin. Concentrates from these localities were not analyzed for tin, but they were shown above to be relatively rich in tungsten. The concentration of these elements in the area of the alkalic and peralkalic granite (gp) plug should be studied to learn the distribution and value of tin, tungsten, and niobium in the rock.

Chromium, lead, nickel, titanium and vanadium.

Anomalous chromium was found in five samples of wadi sand, and the maximum was 700 ppm. Sand at station 11,979 is from Halaban formation unit (hc) southwest of the Najd fault and contains 200 ppm chromium. Sand at station 11,986 contains 700 ppm chromium, and is from the contact are of alkalic and peralkalic granite (gp) and the Halaban formation unit (ha) along the southwest side of Jabal Sahah. Samples of sand that contain 200 ppm chromium were collected at stations 11,987, 11,998, and 27,002 from areas underlain by Halaban formation unit (ha). The histogram (fig. 3) for chromium shows concentration in the quadrangle.

The distribution of lead in samples of sand is shown on figure 3, where it can be seen that the observed anomalies are low. Anomalous lead is in samples from stations 11,981, through 11,985, 11,988, 11989 and 27,019. The five samples from Jabal Sahah and the two samples from the small alkalic and peralkalic (gp) plug to the west contain 50 ppm lead. Sand at station 27,019, from alkalic granite (gm), contains 30 ppm lead.

The histogram in figure 3 shows four anomalous concentrations of nickel in

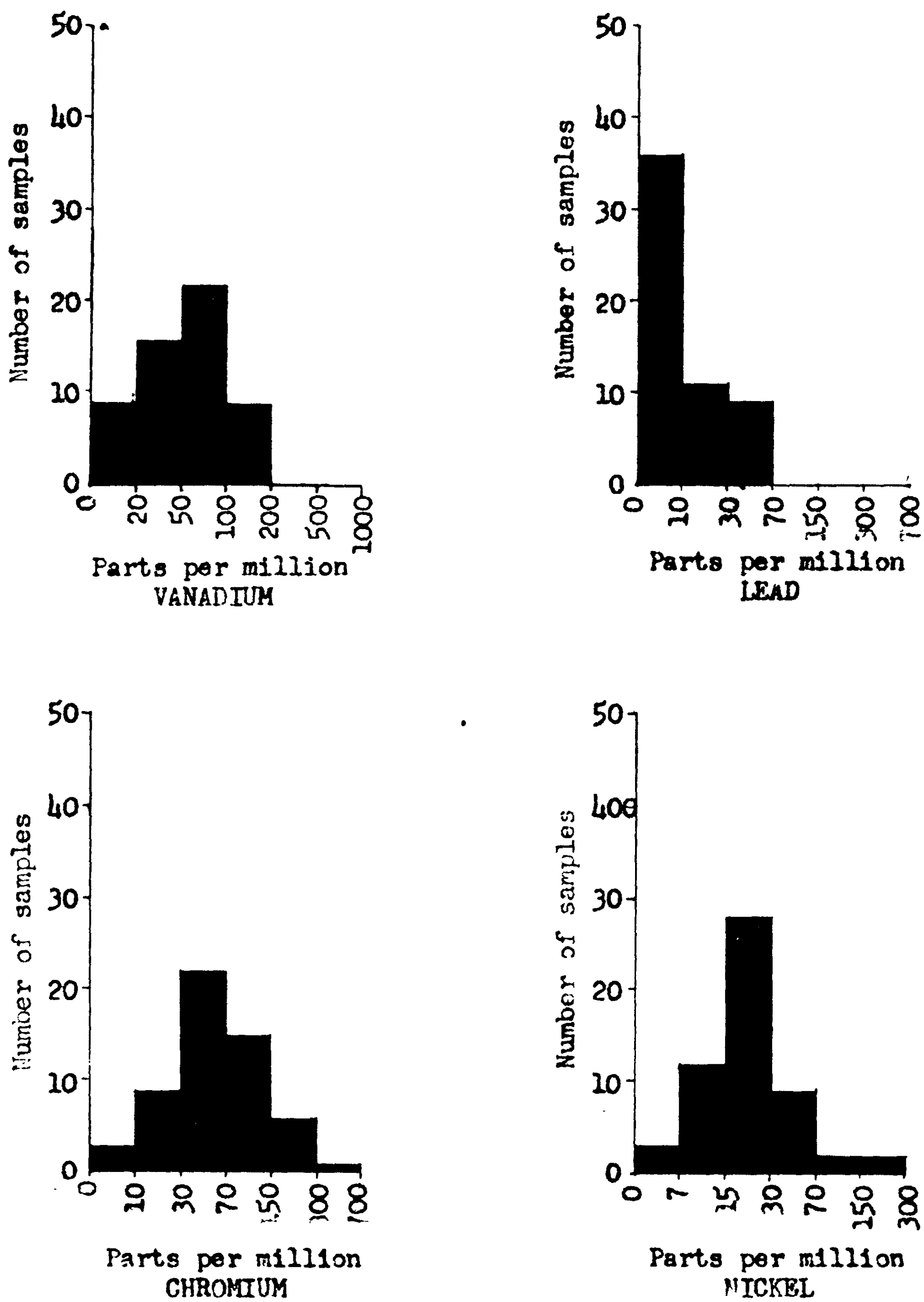

Figure 3. Histograms showing concentrations of vanadium, lead, chromium, and nickel in -30 +80 mesh sand in the Jabal Sahah quadrangle, Kingdom of Saudi Arabia

sand samples. Anomalous nickel is in samples from stations 11,973, 11,986, 11,987, and 27,012. Sand at station 11,973 contains 200 ppm nickel and is from a roof pendant of metamorphic rock in light gray biotite granite. Sand at station 11,986 contains 300 ppm nickel and is from an area underlain by mixed alkalic and peralkalic granite (gp) and metamorphic rock of the Halaban formation. The sample of wadi sand from station 11,987 is from a similar environment and contains 200 ppm nickel. Sand at station 27,012, which is from alkalic granite (gm) and the Murdama formation, contains 100 ppm nickel.

Anomalous titanium is in samples of sand from seven stations. Samples from stations 11,986 and 11,987 are from an area underlain by mixed alkalic and peralkalic granite (gp) and metamorphic rock of the Halaban formation. The sample from station 11,999 is from Halaban rocks, and samples from stations 27,001, 27002, and 27,048 are from areas underlain by Halaban formation intruded by many andesite dikes. The sample from station 27,045 is from area underlain by Halaban formation (ha) and gray biotite granite (gh).

Abundances of vanadium found in samples of sand are shown in the histogram (fig. 3). Seventeen samples from the Jabal Sahah quadrangle contain small anomalous quantities of vanadium. Sand sampled at station 11,977 is from the Najd fault zone near alkalic granite .

Samples from stations 11,986 and 11,987 are from Jabal Sahah and from Halaban metamorphosed by the granite intrusive (gp). Ten of the 17 samples are from the mafic unit (ha) of the Halaban formation and contain as much as 200 ppm vanadium. The sample at station 27,012 is from an area underlain by alkalic granite (gm) and Murdama formation. Samples at stations 27,009 and 27,010 contain 100 ppm vanadium and are from areas underlain by the sedimentary unit (hc) of the Halaban formation near the Najd fault zone. The sample from station 27,049 contains 150 ppm vanadium and is from gray biotite granite (gh) where it is dioritic in composition.

The anomalies for chromium, lead, nickel, titanium, and vanadium are low, and no concentrations of these elements were observed at the places examined.

However, the positive anomalies for titanium near Jabal Sahah adds to the interest of that granitic body as a potential source for tin, tungsten, and niobium.

Summary

The geologic units of Jackson and others (1963) are used here, but field work in 1965 showed that some boundaries should be changed and a few bodies of rock renamed. Boundary for the unit (hc) of the Halaban formation was changed, two bodies of gray biotite granite (gh) were identified northwest of Jabal Sahah, and the granite in the northeastern part of the quadrangle, which is intrusive into the Murdama formation, was renamed the alkalic granite (gm). Also, the rock type on each side of the Najd fault is similar, but the metamorphic grade decreases southwestward. Age relations of the rock units, except the alkalic and peralkalic granite, need detailed work for understanding.

Jabal Sahah and the small alkalic and peralkalic (gp) plug to the west are economically interesting because of their mineralogy and trace elements. The two areas contain the same elements, but the small plug contains more tin, tungsten and beryllium. The area of the small alkalic and peralkalic plug (gp) and the area in the metamorphic rock around the plug should be studied in detail to learn the distribution and concentration of tin, tungsten, beryllium and niobium in the rocks. Jabal Sahah should be examined in greater detail to learn the distribution and quantity of the source minerals of tin, niobium, beryllium, and tungsten in the rock.

Reference cited

Jackson, Roy., Bogue, R. F., Brown, G. F., and Gierhart, R. D.; 1963, Geologic map of the Southern Najd quadrangle, Kingdom of Saudi Arsbia: U. S. Geol. Survey, Misc. Geo. Inv. Map I-211A.