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A GEOLOGIC AND MINERAL RECONNAISSANCE OF THE ABLAH FORMATION AND THE KAMDAN ANOMALY, SOUTH AQIQ AREA, SAUDI ARABIA

by

Virgil A. Trent and Ghazi H. Sultan

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 Also on open file in that office is a large amount of material, in the form of unpublished manuscripts, maps, field notes, drill logs, annotated aerial photographs, etc., that has resulted from other previous geologic work by Saudi Arabian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

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Introduction

Geographic setting.

The Ablah formation (fig.1) lies in a narrow north-northeast-trending belt of rocks from 2 to 5 km wide, 25 km east of south Aqiq (fig. 3) in the southern Hijaz province of Saudi Arabia. Fairly open country makes access to the area good. A rough road through the area connects the village of Aqiq and the city of At Ta'if with the southern areas of the Asir region. A branch road leads to the nearby Ablah ancient mine which is located 28 km east-southeast of Aqiq at 20°10'N.x 41°55'E. Vehicle travel time from Ablah to Aqiq, east of which is a large flat area suitable for an aircraft landing strip, is about two hours.

Two large wadis, Wadi Ranyah and Wadi Shuwas, which head in the highland region to the south, join near the ancient mine. Some of the wadis in this area contain perennial streams with small fish. Wildlife in general is not plentiful, but there are many varieties of birds and large roving packs of baboons.

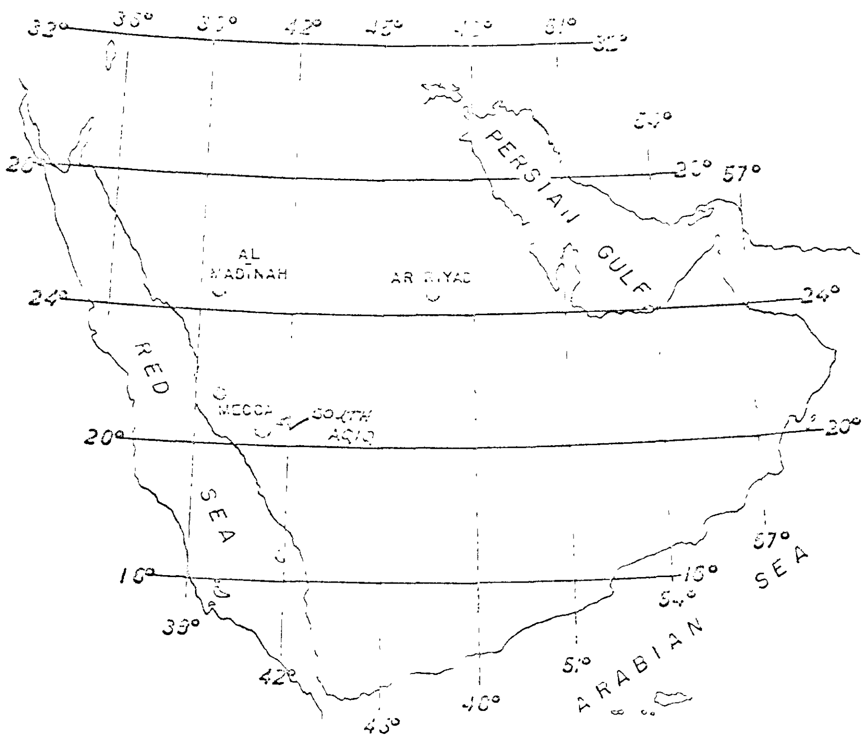
The Kamdan anomaly area (fig. 2) is 25 km west-southwest of Aqiq at 20°10'N.x 41°28'E. in rugged metamorphic terrain which was inaccessible to our vehicles. Water, outcrops, and narrow boulder-choked sections of the wadi prevented passage of vehicles beyond the base camp. The Kamdan area was reached on foot, and later by helicopter.

Structurally and topographically the grain of the country is oriented north-south and major wadis have gradual gradients to the higher, southern mountainous and plateau areas.

The climate is hot in the summer and cool in the winter with frequent afternoon and evening rains during the late summer months.

Previous investigations.

The geologic map of the Southern Hijaz quadrangle (scale 1:500,000) by Brown, and others,(1962) represents the first regional synthesis of geologic data in this part of Arabia and includes the Kamdan and Ablah areas. This map is a product of



INDEX MAP OF ARABIAN PENINSULA
SHOWING LOCATION OF QUADRANGLE

FIGURE 3.

a collation and compilation of data gathered on field trips within the quadrangle area and of photogeologic interpretation.

During 1963 V. P. Kahr and F. Ronner, Senior Geologists of the Directorate General for Mineral Resources, conducted regional geological and mineral examinations in the Ablah-Biljurshi areas mapping at a scale of 1:50,000. Their preliminary report (Kahr and Ronner, 1963) provided us with a guide and reference during our work. Included in the report is a preliminary geologic-tectonic map covering the area between 19°45' and 20°15'N., and from 41°30' to 42°00'E. Areas of mineralized rock and ancient mines are located on the map.

To our knowledge, there have been no previous field examinations in the Kamdan anomaly area.

Present work.

This report summarizes the results of studies which included 13 work-days in the Ablah formation and 3 work-days in the Kamdan area during two field trips in June and July 1964. The purposes and objectives of this work were previously outlined (Trent, 1966). Two brief examinations of the Kamdan anomaly source rock were made by Trent (July 29, 1965) and Rex V. Allen, U.S.G.S., (August 20, 1965) using helicopter transport.

Results of analyses of wadi sand and rock samples located on a geologic sketch map of each area with recommendations is included in this report.

New data gathered in July-August 1965 has led to different conclusions from the inferences expressed in the preliminary report (Trent, 1966). It is the purpose of this text to present these new interpretations of the Ablah and Kamdan areas.

Acknowledgements.

We thank the many officials and employees of the Directorate General for Mineral Resources, Ministry of Petroleum and Mineral Resources, whose assistance and cooperation made this work possible. Mr. Faisel Sadek, geological student, accompanied us during our second field trip to the Ablah area.

The hospitality and assistance offered to us by the Emir of Al Aqiq was much appreciated.

Kamdan anomaly

The Kamdan aeromagnetic anomaly area (fig.2) is located about 25 km west-southwest of Al Aqiq in a topographically rugged area underlain by metamorphic rocks.

Aeromagnetic and scintillation surveys of the Al Mahawiyah area (Hunting Survey Corporation Limited, 1962) include the Kamdan area. D. R. Maby, U.S.G.S., analysed the data gathered in this survey and found the largest single anomaly (total relief 600 ÷ gammas) appeared to be produced by a small body of granite mapped at this location, 42°11'N.x 41°28'E. on the geologic map by Brown and others (1962). Maby, in lieu of more geologic information, suspected the anomaly was produced by the granite (gr) but there was some question about the positional correlation of the anomaly with the granite (written communication, D. R. Maby, 1964, p.11).

It was our task to locate the source of the anomaly, to collect wadi sand and rock samples for geochemical examination, to prospect for minerals, and to check the local geology. Prior to the field work studies of both black and white (W.S.A., 1:60,000 and K.L.M., 1:12,500 scales) and colored (K.L.M., 1:12,500 scale) aerial photographs were completed in Jiddah. To do the field work we drove, as far as possible, up a main wadi west of Aqiq and set a base camp. Here, we rented a camel and packed into the Kamdan area where a fly camp was set.

Geology.

The country rock in the Kamdan area is chlorite schist (gs) as shown by Brown and others (1962). From the base camp to our fly camp these rocks show prominent north-south trend lines. Southwest of the fly camp the structural fabric of the metamorphic rocks assumes a lobate appearance. Local zones of iron oxides in the schist, for example localities 10083, 10085, and 10071, are inferred to be derived from concentrations of pyrite crystals, which are common in this unit.

The small body of massive dark rock, mapped as granite (gr) by Brown and others, (1962) proved to be greenstone and is devoid of anomalous amounts of magnetite. Likewise, the large body of rock north of the fly camp mapped by Brown and others (1962) as granite (gr) is also greenstone. These rocks are in the greenschist facies. A thin section shows this rock is albite-epidote-calcite-chlorite schist in which sericitized and recrystallized plagioclase is set in a matrix of epidote, and calcite with some anhedral quartz crystals in small stringers or veinlets. Clear epidote is abundant. The greenschist is probably a metamorphosed volcanic rock.

The approximate limits of our work during June 1964 are indicated by the locations of samples of wadi sand. With the aid of helicopters in July and August 1965 brief examinations were made of an area of dark-colored rock 2 km southwest of the small body of greenstone mapped south of the fly camp. The dark rock is an intrusive mass of diorite and amphibolite containing quite enough magnetite to account for the 600 gamma aeromagnetic anomaly in this area (oral communication, W.E. Davis and R. V. Allen, U.S.G.S., July 1965). The outcrop area south of the diorite and amphibolite is probably greenstone, but cropping out within schist (gs?) between the magnetic intrusive and the small greenstone mass is a band of quartzite.

There is a large structural discontinuity between the greenstone areas north and south of the camp. The northern greenstone unit has low angle saucer-shaped bedding as viewed from high hills to the south. Schist to the south of the camp strikes northwestward and dips steeply to the southwest. This is inferred to indicate a fault along the wadi.

Economic geology.

Mineral deposits:-- One ancient mine was located in this area from slag heaps observed while examining the diorite and amphibolite by helicopter in July 1965. Later R. V. Allen examined the area of slag and reported (oral communication, R. V. Allen, August 1965) a pit 4 m long by 2 m wide by 2-1/2 m deep on the side of a hill near the slag. Some copper mineralization was seen by Allen in and around the pit and in the adjacent rock.

Geochemical reconnaissance:— Seven samples of wadi sand were collected (fig.2) and processed by a mechanical concentrator in the field. The product was analysed spectrographically for 27 elements by C. E. Thompson, U.S.G.S., in the laboratories of the Directorate General for Mineral Resources, Ministry of Petroleum and Mineral

Resources, Jiddah, Saudi Arabia. The amount of copper, zinc, and molybdenum in parts per million found by Thompson is shown in the table on figure 2. In addition, wet chemical analyses of heavy-mineral and magnetite fractions of the concentrate were completed by Thompson; however, this data is not presented here.

The background value for copper in wadi sand is about 100 ppm in this southeastern corner of the Southern Hijaz quadrangle (oral communication: R. Goldsmith, U.S.G.S. May 1966). Inasmuch as these samples were concentrated prior to analysis the values recorded in the table are not considered anomalous.

No ore-grade concentration of magnetite was found in the small area of diorite and amphibolite examined.

Recommendations.

In view of the results of the field reconnaissance and analysis of samples we do not feel further investigations of a first priority order are warranted in the Kamdan area.

It is quite likely that additional regional reconnaissance work will be persued in the Wadi Bida area; therefore we recommend: (a) examination of the contact of the diorite and amphibolite with adjacent rock, (b) a study of the surface of the diorite and amphibolite, (c) some additional geochemical exploration around the diorite, particularly along its western margin, (d) the ancient mine and area nearby should be examined and sampled, and (e) the general area should be scouted for other intrusive rock masses, and possible associated mineralization. These recommendations are of a low priority but they should be completed in conjunction with further work in this area. Work should be from helicopter.

The 600 gamma aeromagnetic anomaly is due to a magnetite-rich intrusive mass of diorite and amphibolite 3-1/2 km long and 2 km wide. The maximum and minimum points of magnetic intensity are shown on the map.

If geophysicists in the future need a type aeromagnetic anomaly with the magnetic rock unit well defined, for calibration or testing of instruments, or for studies of magnetic properties of rocks, the Kamdan anomaly is particularly suitable. Perhaps it should be marked with paint to increase its visibility from the air to improve its usefulness as a test site.

Ablah formation

The purpose of the next phase of our work was to examine the young Precambrian rocks of the Ablah formation and trace them south into the Tihamet Ash Sham quadrangle (Brown and Jackson, 1958). Brown regards this information as necessary to a clear knowledge of the stratigraphy and mineralization of the region (oral communication: G. F. Brown, 1964).

One day was spent examining the mine area at Ablah and a nearby belt of meta-sedimentary rocks and paraschists (gs) to the west. The camp was then moved to a central location along the road within the Ablah formation (fig. 1). A section of the Ablah formation was described in detail in the vicinity of our camp, where we mapped the rocks north and south of the camp as well as along the road. We collected rock and wadi sand samples and checked areas that had previously been noted on black and white (WSA, 1:60,000 scale and KLM, 1:12,500 scale) and color (KLM, 1:12,500 scale) aerial photographs.

Geology.

Rock types:— The Ablah formation is one of the youngest Precambrian units mapped in the Southern Hijaz quadrangle (Brown, and others, 1962). It consists largely of coarse clastic rocks with interbedded shale, limestone, and dolomitic limestone. Volcanic flow rocks ranging in composition from rhyolite to basalt are interbedded in the Ablah formation, and they are sulfide-bearing locally. The Ablah formation is bounded on the west and partly bounded on the east by major faults. Bedding dips generally eastward. Sills of peralkalic granite (gp) in the Ablah formation commonly dip east at low angles and are concordant with the bedding. Some thin bodies of peralkalic granite cut across the bedding and thus are dikes.

The Ablah formation is unmetamorphosed in the northern two-thirds of the map area, but just to the north of the large lava flow lying across the formation the rocks are strongly deformed, and recrystallized in part. Metamorphic rank of these rocks increases southward from this point into the Tihamet Ash Sham quadrangle.

Clastic rocks:— Dark red, medium-to coarse-grained, crossbedded sandstone, volcanic wacke, pebble conglomerate and conglomerate are interspersed with red and green shales. The shales crop out commonly adjacent to limestone strata. Detrital constituents grade from angular in the conglomerate to poorly rounded in the sandstone with most of the wackes having angular to sub-angular grains. Carbonate, frequently, is the cementing agent in these clastic rocks. Most of the feldspars and other detrital grains are either coated with limonite or are sericitized.

Conglomerate along the western margin of the formation contains abundant fragments of andesite and rhyolite probably derived from the andesite and rhyolite that crops out over a wide area west of and adjacent to the Ablah formation.

Cross-bedding is very common in the sandstone and conglomerate and indicates the beds have not been overturned throughout most of northern two-thirds of the map area. Generally these beds dip from 25° to 50° east.

Limestone, dolomitic limestone, and marble:— Dark-to light-gray limestone beds are best exposed in a narrow discontinuous belt along both sides of the long, western fault, but limestone also occurs sporadically along the western margin of the large granite intrusive body in the central part of the formation and near the eastern contact with schist (gs). Further south, just north and south of the large transverse lava flow, dolomitic limestone and marble strata are interbedded with layers of green, buff, and minor black shale, and thin concordant granitic sills or dikes. Here, much of the marble has a crenulated structure and, as seen in thin section, is recrystallized and veined. The veins are largely calcite, but they also contain quartz and feldspar.

Intrusive peralkaline granite and syenite:— Concordant, peralkalic, fluorite-bearing granite and syenite sills and dikes are common in the Ablah formation in this area. Abundant transverse faulting has produced a herringbone outcrop pattern of flatirons of granite and syenite from small sills. They usually cap dark red sandstone or conglomerate which dips at generally low angles to the east. A large body of peralkaline granite and syenite crops out in several, high, mountainous blocks in the central part of the Ablah formation and is possibly a sill. Usually these sills and dikes have chilled contacts and the clastic rocks may show variable effects of metamorphism over a short distance from the contact. The sills and dikes dip at low angles toward the interior of the large plug of peralkalic granite near Ablah. We thought these structures might be cone sheets, but there is no evidence of an arcuate pattern of joints and sills in the older rocks to the east that would indicate a cone sheet structure.

Several thin sections of the rock were examined and the only significant difference between these sills and the mass of peralkaline granite at Ablah is the common graphic granite texture in these hypabyssal rocks. The sills consist of subhedral to anhedral crystals of sericitized potash and plagioclase feldspar with a variable small amount of quartz. On the basis of percentage of quartz some sills are granite and some are syenite. Magnetite is a common accessory mineral, but fluorite was not seen in thin section.

Interbedded volcanic rock:--- Local, thin flows of amygduloidal rhyolite, andesite and basalt contain small quantities of sulfides and malachite and azurite which occur in the Ablah formation. Calcite commonly fills the amygdules. In the southern part of the map area rhyolite flows predominate.

Structure.

The rocks are not strongly folded in the northern two-thirds of the map area where the Ablah formation generally dips eastward from 20° to 50°. Further south it is locally tightly folded and the dips steepen to high angles. At the south end of the map area interbedded rhyolite lavas and sedimentary rocks dip at higher and higher angles southward and are truncated by the large north-trending fault on the eastern side of the formation.

Transverse faults are common and are evident in offsets of limestone and sills. The largest transverse fault in the area displaces a large southern block of peralkalic granite and syenite to the southwest. Further north in chlorite schist near sample locality

10112 another transverse fault has the same relative movement of south block to the west.

The Ablah formation lies between two major north-trending faults. Along the east boundary of the formation a large fault separates rocks of the Ablah formation from the chlorite schist unit (gs) of Brown and others (1962) and red, alkalic, biotite granite (gr) further south. To the west unmetamorphosed andesitic lavas are in fault contact with the Ablah formation along a prominent north-trending lineament. Beds of limestone and marble occur along the margin and, locally, east and west of the fault and suggest that the surface of unconformity occupies a sinuous trace either along the fault plane or locally within the lavas (oral communication: V. P. Kahr, 1966).

R. Goldsmith, U.S.G.S., and V. Kahr, Dir. Gen. Mineral Resources, located by helicopter a large exposure of Ablah rock 5 km west of the Wadi Qirshah-road junction (along the granite and lava fault contact mapped by Brown and others) which is possibly a down-dropped block, in lava (oral communication: R. Goldsmith, U.S.G.S., May 1966).

Economic geology.

Ancient mine:— The Ablah ancient mine is located on the north edge of a large, peralkaline, fluorite-bearing, granite plug (gp) about 13 km long from north to south and 5 km wide. At the mine a medium-sized, coarsely crystalline, pegmatite pipe crops out in a high, white, cone-shaped hill. The bulk of this pegmatite is plagioclase feldspar, calcite, and quartz, with some florite, and a little galena and primary and secondary copper minerals. The enclosing peralkaline granite, gp, has abundant albite-and pericline-twinned microcline (resulting in a grid structure in thin section) with minor plagioclase feldspar, quartz, and amphibole.

Located near the mine are many slag piles and the ruins of a large ancient village. The volume of slag indicates that the Ablah mine was used primarily as a source of flux for the reduction of ores transported here (written communication: P. K. Theobald, Jr., U.S.G.S., 1965).

Mineralized rock:— Fluorite, pyrite, and other sulfide minerals have been found in parts of the granite, the Ablah formation, and the andesite and rhyolite (ha?).

Sills and dikes of peralkaline granite and syenite:— At sample locality 10,098 two granitic sills about 3 m thick dip 50° east with red sandstone, wacke, and pebble conglomerate exposed between them. The granite is graphic textured in thin section with quartz phenocrysts common. All the feldspars are sericitized. Along the base of these sills at the contact with sandstone small amounts of fluorite and pyrite are present. Fluorite occurs similarly in other sills and dikes of peralkalic granite and syenite and within the large central sill(?) at locality 10,039. The sulfide minerals associated with pink granite, aplite, pegmatite, and rhyolite dikes in the Ablah area were interpreted by Kahr and Ronner (1963, p.3) to have been formed during a late period of hydrothermal activity in the area.

A small amount of radioactivity was detected at locality 10,098, but the mineral giving rise to it was not found.

Interbedded volcanic rocks:— Small quantities of sulfide minerals occur in rhyolite flows in the southern part of the mapped area. Spectrographic analysis of sample 10,151 shows 100 ppm copper, 100 ppm lead, and 150 ppm molybdenum. Locally, thin andesite and basalt flows within the Ablah formation contain small amounts of malachite, azurite, and chrysocolla.

Andesitic lavas:— The andesite and rhyolite west of the Ablah formation locally display sulfides. Sample 10,100 collected from andesitic lava near the junction of Wadi Qirshah and the road contains a little chalcocite. Spectrographic analysis disclosed 2,000 ppm copper, the highest for the area. Andesitic rock represented by samples 10,128 through 10,130 has 70 ppm, 30 ppm, and 70 ppm copper respectively with sample 10,129 containing 100 ppm zinc.

Geochemical reconnaissance

Fourteen samples of wadi sand were collected, screened at the sample site to the -30 +80 size fraction, and sent to the laboratories of the Directorate General for Mineral Resources, Ministry of Petroleum and Mineral Resources, Jiddah, Saudi Arabia. The samples were then split using a Jones splitter. One half provided material for spectrographic analysis and the other half supplied magnetite for wet chemical and spectrographic analysis. The latter data are not presented here. C. E. Thompson, U.S.G.S., performed the spectrographic and wet chemical analyses with the exception of rock samples 10,105 through 10,130 which were analysed spectrographically by K. H. Shabwan, Directorate General for Mineral Resources, Ministry of Petroleum and Mineral Resources. Ten rock samples were submitted for semi-quantitative spectrographic analysis using the modified method employed by the U. S. Geological Survey.

In general, the wadi sand samples were collected to test a particular structure, rock type, or drainage basin. No significant anomalies for copper, zinc, and molybdenum were located. The one sample containing the most copper is 10,133 (50 ppm) located on the fault contact of the andesitic lava and the Ablah formation

Sample 10,117 contains 1000 ppm chromium, 150 ppm nickel, 15 ppm lead, and 70 ppm each of lanthanum and niobium. In this area, as in others, the trace content of chromium and nickel increases along faults.

Results of the wadi sand and rock spectrographic analysis are shown for copper, zinc, and molybdenum on figure 1.

Conclusions

Basal clastic rocks of the Ablah formation contain abundant volcanic debris, mostly fragments of andesitic to rhyolitic rock derived from adjacent, older, volcanic rocks. These lavas are unmetamorphosed, typically andesitic in composition, and much like rocks mapped as younger than the Halaban formation in other parts of the Southern Hijaz quadrangle (oral communication: R. Goldsmith, 1966). In this context we classify these rocks as Halaban or younger.

The interbedded lavas of variable composition in the Ablah formation may represent a continuing of the Halaban or younger volcanic activity or an independant, younger volcanic period. Inasmuch as these rocks occur sporadically and sparingly in the Ablah section and resemble the andesite and rhyolite mapped as Halaban formation or younger we infer that they represent a continuance of the same volcanic period into the Ablah episode of sedimentation.

The Ablah formation is interpreted here to have formed in a deltaic-estuarine and shallow marine depositional environment in largely volcanic-granitic terrain. Areally abrupt, rapid changes in the lithology of these beds coupled with a rhythmic oscillation between shallow marine deposits and a whole range of moderately well sorted clastic rocks best fit this type of environment.

At some time following deposition of the Ablah formation the peralkalic granite (gp) and its genetically related sills and dike were intruded. The accompanying fluorite-sulfide hydrothermal activity is the youngest mineralizing event in the area.

There are, therefore, two types of sulfide-bearing rock in this area: a) primary copper and other sulfide minerals which occur within the andesite and rhyolite lavas (ha?) and in the interbedded rhyolite, andesite, and basalt flows as well; and b) the later fluorite-sulfide hydrothermal activity associated with the intrusion of the peralkaline granite (gp).

Geochemical data gathered by P. K. Theobald Jr. in this same area indicate the regional variation in copper, zinc, and molybdenum trace element content of the Ablah rocks relate primarily to three igneous rocks in the predominently sedimentary sequence. The large, central, granite and syenite sill (?) contributes most of the zinc. The small granite and syenite sills contribute most of the molybdenum and dark-colored andesite and basalt flows near the top of the section contribute most of the copper (written communication: P. K. Theobald Jr., December, 1964).

Spectrographic analyses of wadi sand and rock samples show that higher than average trace element content of copper, zinc, and molybdenum occurs within the volcanic and igneous rocks, rather than in sedimentary strata, in the Ablah formation. All the sulfide-bearing rocks located in the Ablah formation are either volcanic or igneous rather than sedimentary. The geochemical data and our brief field examinations indicate to us a definite lack of evidence of stratiform deposits carrying economic minerals in the Ablah formation.

One of the primary objectives of this trip was to determine if the Ablah formation crops out further south in the Tihamet Ash Sham quadrangle (Brown and Jackson, 1958). Red and green shales and sandstones occur at the head of Wadi Haffian, Map I-216A. Patches of marble and metasedimentary beds of the Ablah formation are exposed along strike at numerous localities in the Tihamet Ash Sham quadrangle as seen and checked by helicopter in company with J. W. Mytton, U.S.G.S., July 16, 1965.

Recommendations

Additional examinations in the andesite and rhyolite rocks west of the Ablah formation should be carried out. One hand sample, 10100, contains visible chalcocite in dark-colored vesicular andesite. Spectrographic analysis disclosed 2000 ppm in this sample. In our opinion additional prospecting in this area should be concentrated in: a) the belt of andesitic and rhyolitic lavas west of and adjacent to the Ablah formation and b) along both sides of the fault contact or unconformity between these rocks and the Ablah formation. Access to the belt of andesitic lavas is good along wadis with several tributaries of Wadi Qirshah crossing the unit. Reconnaissance geochemical sampling and rock examinations within the andesite and rhyolite and along the major fault to the east would take one geologist approximately one man-month to complete.

A considerable length of the area of outcrops of the Ablah formation remains to be examined north of Wadi Qirshah. Because both primary sulfides and introduced sulfides and fluorite occur in the Ablah formation a reconnaissance survey is warranted.

Reconnaissance geological and geochemical studies of the Ablah formation and its faulted contacts north of Wadi Qirshah would take one geologist about one man-month.

Some of the interbedded rhyolitic lavas in the Ablah formation at the south end of the mapped area contain sulfides, such as sample 10,151. This area would be worthy of one or two days' examination. The terrain is mountainous further south and helicopters would be a help.

All together there are two man-months of work in the Ablah area which we would classify as third order priority in the mineral exploration program.

This work should be coordinated with recommendations which will be made by P. K. Theobald Jr., U.S.G.S., concerning future exploration in the Ablah area.

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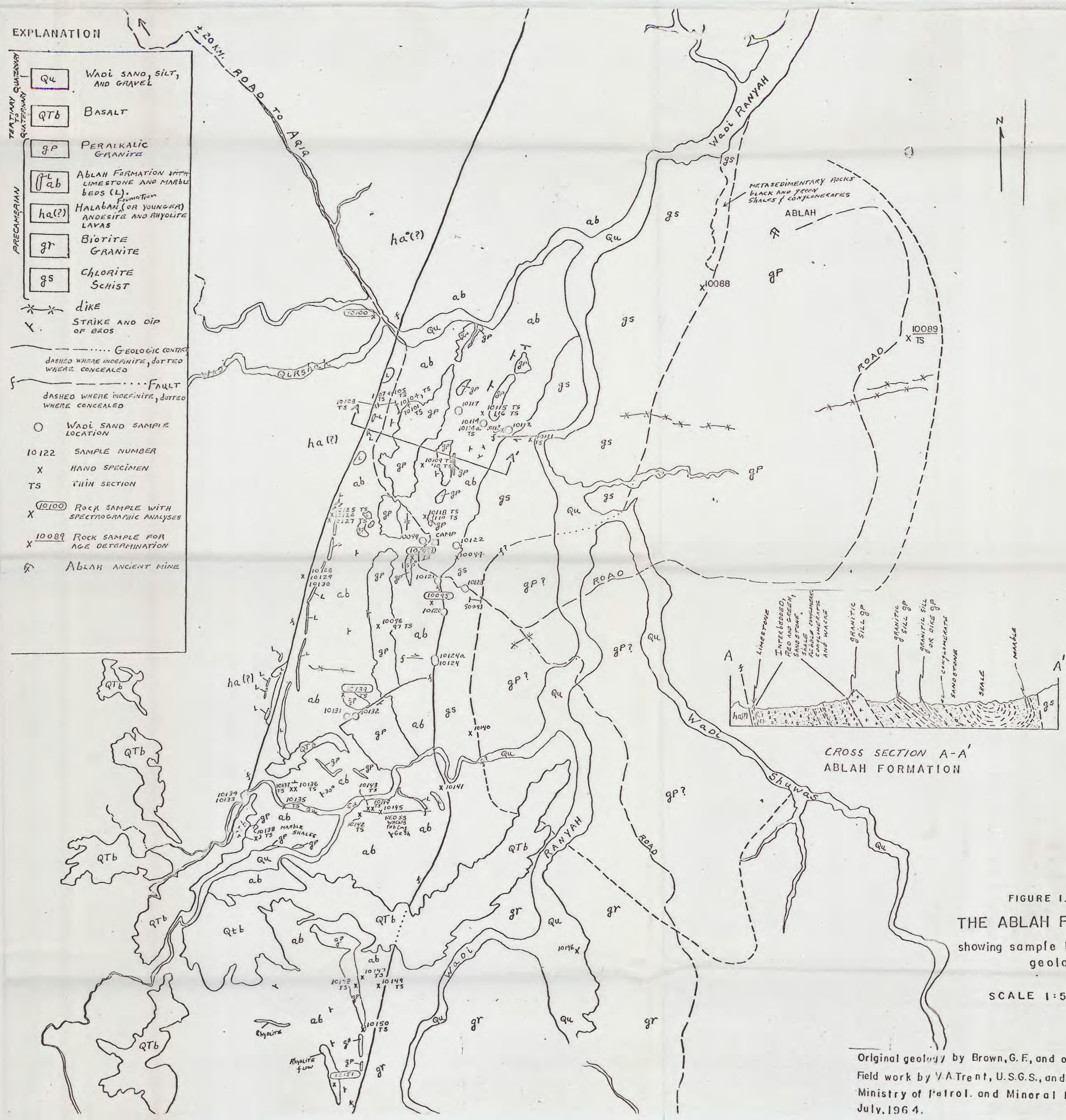

Spectrographic Analysis of wadi sand samples (-30+80 fraction)

Sample Number	Copper PPM	Zinc PPM	Molybdenum PPM
10,099			
10,112	30	—	—
10,114	30	—	—
10,117	20	—	2
10,120	10	—	—
10,121	20	—	—
10,122	30	—	2
10,123	20	—	—
10,124	15	—	—
10,124a	15	—	—
10,131	20	—	—
10,132	20	—	—
10,133	30	—	—
10,134	50	—	—

PPM (PARTS PER MILLION)

Spectrographic Analysis of Rock samples

Sample Number	Copper PPM	Zinc PPM	Molybdenum PPM
10,095	10	—	7
10,098	30	—	5
10,100	2000	—	—
10,105	15	—	—
Conglamerate	10	—	—
10,128	70	—	—
10,129	30	100	—
10,130	70	—	—
10,139	<10	—	—
10,151	100	—	150

Analyst: C.E. Thompson, U.S.G.S.

NOTE: Rock samples 10105 through 10130 analysed by K.H. Shabwan, Ministry Petrol. and Mineral Resources, Dir. Gen. Mineral Resources.

FIGURE I.

THE ABLAH FORMATION

showing sample locations and geology

SCALE 1:50,000

Original geology by Brown, G.F., and others, 1962.
Field work by V.A. Trent, U.S.G.S., and G.H. Sultan, Ministry of Petrol. and Mineral Resources, June-July, 1964.

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FIGURE 2.

KAMDAN AEROMAGNETIC ANOMALY AREA

showing wadi sand samples, hand specimens, and rock types

Spectrographic Analyses of wadi sand concentrate samples (-30+80 fraction).

SAMPLE NUMBER	COPPER PPM (PARTS PER MILLION)	ZINC PPM	MOLYBDENUM PPM
10,072	70	<100	2
10,073	100	100	2
10,074	70	100	2
10,075	100	--	2
10,078	50	—	—
10,079	70	—	—
10,082			

NOTE: WADI SAND SAMPLES PROCESSED by MECHANICAL CONCENTRATOR.