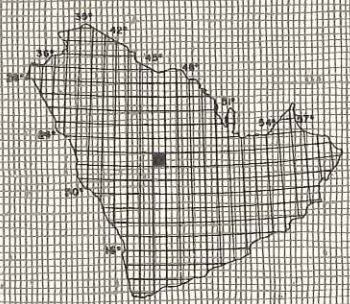
THE KINGDOM OF SAUDI ARABIA

MINISTRY OF PETROLEUM AND MINERAL RESOURCES

DIRECTORATE GENERAL OF MINERAL RESOURCES

GEOLOGY AND MINERAL EXPLORATION OF THE UMM SULAYM QUADRANGLE



Quadrangle 22/45 C

Photomosaic 131 W

BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES

SAUDI ARABIAN MISSION

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BRGM

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BY

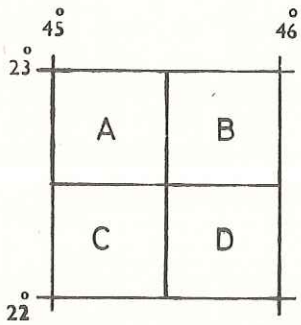
R. Brosset

(1973)

with a section on Geophysical Data by J. Maillard

QUADRANGLE 22/45 C

Photomosaic 131 W



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Jiddah, June 1974

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1. SUMMARY

The Umm Sulaym quadrangle (22/45 C) is situated at the east edge of the Precambrian Arabian Shield.

The Precambrian occupies two thirds of the quadrangle; it is represented by volcanic formations belonging to the Halaban Group, followed by volcanic and sedimentary formations of the Umm Sulaym, Murdamah and Shammar Formations. Sedimentary formations of the Paleozoic cover the eastern third of the quadrangle.

The Halaban Group is composed of:

1. Mafic and ultramafic rock cropping out in the north central part and assigned to the Ophiolitic Complex of the Halaban: gabbro, pyroxenite, peridotite, serpentinite, and sometimes associated keratophyre.

2. Alternations of andesite and andesitic tuff, with some intercalations of rhyolite, attributed to the Andesitic Halaban.

3. Rhyolitic and andesitic tuff and breccia, ignimbrite and dacite making up the Pyroclastic Halaban.

These Halaban formations have been affected by mafic and felsic intrusions, and have also, in the west of the quadrangle, been subjected to epizonal metamorphism.

A sedimentary formation, composed of marble, conglomerate, tuffite and graywacke, covers the Halaban unconformably. This formation is folded and forms a south-plunging anticlinal structure whose west flank is metamorphosed and granitized. Due to its well-marked characteristics this formation was individualized as the Umm Sulaym Formation.

The Murdamah Formation occupies the southwest part of the area, and lies in contact with the gneissic facies of the Halaban; this is partly due to fault movement (Najd Fault) and partly due to angular unconformity. The Murdamah is mainly composed of rock with sedimentary characteristics: conglomerate, 'volcanic' sandstone, feldspathic sandstone and siltstone.

In the south part of the quadrangle, at Jabal Ḍab', is the Shammar Formation, represented by rhyolite, welded rhyolitic tuff and ignimbrite.

The west part of the quadrangle is characterized by granitic intrusions cut by numerous (normally felsic) dikes, whilst the southwest corner has been affected by faults of the Najd Fault System: this fault system shows both lateral and vertical displacement with an upfaulted north side (Halaban) and a downfaulted south side (Murdamah).

A regional epizonal to mesozonal metamorphism, characterized by greenschist and amphibolite facies, is developed in the west of the area and shows increasing intensity from east to west.

The whole of the east part of the quadrangle is occupied by sedimentary Paleozoic formations represented by conglomerate and calcareous sandstone of the Wajid Sandstone and by limestone, dolomite and marl of the Khuff Formation. These two formations are usually assigned to the Permian System (?).

Quaternary formations are composed essentially of an abundance of eolian sand forming large mobile dunes, or 'nafuds', mainly in the east and southeast parts of the area.

Mineral prospecting enabled seven small groups of ancient workings to be recorded: these are localized over quartz veins in the northwest of the area. Analyses results of samples collected from the waste dumps showed some anomalous grades in gold and thus indicated that the ancient excavations were worked for gold.

Some small lenses of magnesite, closely related to the serpentinite of the Ophiolitic Complex, are localized in the north of the area at Jabal al 'Uwayjā': their size is too small to be of any economic interest.

Due to the paucity of mineral occurrences, no further work on the Umm Sulaym quadrangle is envisaged.

2. INTRODUCTION

2.1 Geographic Setting

The Umm Sulaym quadrangle, lying between latitudes 22°00' and 22°30' N., and longitudes 45°00' and 45°30 E., is situated at an altitude of 700 m to 750 m on the east edge of the Precamabrian Arabian Shield. The center of the area lies 630 km to the east of Jiddah and 300 km to the southwest of Ar Riyāḍ; access from Jiddah is by the paved Jiddah-Ar Riyāḍ road to Ẓalim, and then accross 350 km of desert in an ESE direction. A track joining Ar Riyāḍ to Bishah crosses the quadrangle in a NNE-SSW diagonal and passes between formations of the Precambrian and those of the Paleozoic. Most of the quadrangle is accessible by Land Rover, apart from areas invaded by eolian sand in the east and southeast.

Topographically the area can be divided into three:

1. The east and southeast part with a flat relief corresponding to the structural platforms of the Paleozoic sedimentary formations; the different horizons of the formations are emphasized by cuestas of generally low relief (in the order of meters).

2. The middle and southwest parts characterized by Precambrian hills, whose relief may be as much as 100 m above the pediment.

3. The west part essentially characterized by a plane of granitic gravel streaked with dikes.

The quadrangle is drained by a network of very wide sand-filled wadis that flow east and southeast; eastwards the wadis generally widen out with their beds becoming less and less marked and disappearing in the eolian sand before reaching the Paleozoic sedimentary formations; otherwise they accumulate in depressions and lead to the formation of 'Sabkhats'.

2.2 Previous Work

The Umm Sulaym quadrangle is contained within the 1:500,000-scale geologic map (I-212 A) of the Southern Tuwayq quadrangle (Bramkamp et al, 1956).

In 1968 and 1969 A. Gazzaz and A. Arinan (geologists of the Directorate General of Mineral Resources) carried out a survey of the Umm Sulaym quadrangle and in 1969 J. Letalenet, (Chief Geologist of Zone II, BRGM) undertook some traverses with their collaboration.

In 1972 W.C. Overstreet and J.W. Whitlow (USGS geologists) submitted the results of their reconnaissance work carried out in 1964 on the Bi'r Ghamrah quadrangle; this work was centered mainly on the investigation of ancient mines and mineralized zones and led to the discovery of a group of ancient workings in the northwest part of the area.

Whereas the geologic data from past surveys was taken into consideration, use was also made of the preliminary interpretation by J. Maillard (BRGM geophysicist) of the 1:100,000-scale aeromagnetic and scintillometric map No. 131 as well as of a photogeologic interpretation by J.R. Villemur (BRGM geologist).

2.3 Present Work

The field work for the geology and mineral exploration of the Umm Sulaym quadrangle was carried out from the end of October 1972 to the end of January 1973 by R. Brosset (BRGM geologist).

The quadrangle covers an area of 2850 sq. km, and was studied along traverses spaced approximately 2 km apart: in the Paleozoic sedimentary formations, however, the grid was wider, whereas in contact zones, or in areas deemed to be of interest, the traverses were closer.

The following aerial photographs were used:

a) 1:100,000-scale photomosaic 131

b) 1:50,000-scale photomosaics 507 and 510

c) 1:60,000-scale aerial photographs.

A total of 740 observation points were visited from which: seven groups of ancient workings and two ferruginous areas were written up on mineral index cards; 40 thin sections were studied; 14 samples were subjected to chemical analyses; and three samples were subjected to spectrographic analyses.

3. GEOLOGY

3.1 Geologic Setting (App. 1)

With exception of the Paleozoic sedimentary formations, which cover the eastern third of the Umm Sulaym quadrangle, the geologic formations encountered in the area belong to the Precambrian of the Arabian Shield.

From NE-SW the formations crop out schematically as follows:

1. Sedimentary Formations of the Paleozoic:

   Conglomerate and sandstone of the Wajid Sandstone (PW), and limestone and dolomite of the Khuff Formation (PK).

2. Ophiolitic Complex of the Halaban (ub):

   Mafic and ultramafic rock with associated keratophyre cropping out mainly at Jabal al 'Uwayjā'.

3. Andesitic Halaban (ha):

   Alternations of andesite and andesitic tuff with some intercalations of rhyolite; the unit is locally affected by intrusions of granite and diorite.

4. Umm Sulaym Formation (us):

A formation with an exclusively sedimentary character composed of marble, conglomerate and some calcareous tuffite; this formations forms a 2-km-wide folded band that is cut into compartments by faults.

5. Pyroclastic Halaban (hp):

Pyroclastic facies of the Halaban consisting of rhyolitic tuff and breccia, ignimbrite and dacite. To the northwest this formation widens, becomes metamorphosed then progressively gives way to a granitic domain.

6. Umm Sulaym Formation (us):

The sedimentary formation mentioned previously reappears with a more complete sequence: marble and conglomerate, with tuffite and graywacke much more abundant. The formation is very folded and forms a south-plunging anticlinal structure. To the west it is metamorphosed and cut by numerous granitic intrusions (gm): like the Pyroclastic Halaban it grades into a granitic domain.

7. Granite (gm):

In the west, granite (gm) forms a plane cut by numerous dikes that are mostly felsic and more rarely mafic. Locally these granitic intrusions have superimposed a contact metamorphism on the regional metamorphism; this mainly occurs in the west part of the area.

8. Shammar Rhyolite (sr):

The Shammar Formation is represented at Jabal Ḍab', where it consists of rhyolite, ignimbrite, and rhyolitic tuff breccia.

9. Gneissic Halaban (hgs):

In the southwest of the quadrangle alternations of leucocratic gneiss, gneiss with amphibole, and amphibolite are assigned to the metamorphic facies of an undifferentiated Halaban sequence; interfoliated in the gneiss there are numerous sills of mylonitized granite.

10. Murdamah Formation (mu)

The Murdamah Formation occupies the southwest edge of the area, and is composed of conglomerate, graywacke, volcanic sandstone, feldspathic sandstone and siltstone.

3.2 The Halaban Group

The Halaban Group is represented by mafic and ultramafic rock of the Ophiolitic Complex and by effusive pyroclastic facies of the Andesitic and Pyroclastic Halaban.

3.2.1 Ophiolitic Complex (ub)

The Ophiolitic Complex crops out at Jabal al 'Uwayjā', in the north of the area, and also as low hills 8 km to the west of Jabal al 'Uwayjā'. Its relationship with the surrounding country rock is hidden by Quaternary deposits; however, the nature and diversity of the rock, its special associations and the immediate proximity of Halaban volcanic rock allows it to be assigned to the Halaban Group: it forms the Ophiolitic Halaban.

This Ophiolitic Complex is composed of:

1. Gabbro: fine grained and often containing olivine, the gabbro is frequently foliated and metamorphosed: the pyroxenes are usually altered (either uralitized with the rock grading to an epidorite, or otherwise showing the beginnings of transformation to antigorite and bastite when the gabbro is serpentinized).

2. Pyroxenite: holomelanocratic rock, mainly composed of orthorhombic pyroxene (enstatite) and monoclinic pyroxene (augite, diallage).

3. Peridotite: grading frequently to serpentinite.

4. Serpentinite: black or green in color with abundant grains of magnetite, it has a mesh texture; locally it is transformed to chloritite with a bluish-gray patina and soapy to the touch. The serpentinite is often divided up by a network of rusty-brown centimeter-thick carbonate veinlets formed at the expense of the serpentinite. Some beds of rusty-colored massive marble are associated with the serpentinite, at whose expense they are formed, and frequently enclose small enclaves of serpentinized greenstone. Also frequently associated with the serpentinite are small surficial lenses of magnesite with a cauliflower-type patina: these originate from the degradation of a network of magnesite veinlets within the serpentinite. Locally there occur centimeter- to decimeter-sized veinlets of ferruginous chert with hematite giving anomalous grades in copper (Sample RB 1165, App. 2).

5. Greenstone: chloritized; sometimes with nodules of epidote; maybe derived from ancient spilite.

6. Diabase: containing bastitized pyroxene; small areas of amphibolite are found enclosed within the rock types.

7. Keratophyre: gray-green aphanitic very hard siliceous rock with a pseudo-flow-structured texture: this rock is associated with all the preceding facies.

The whole of this Ophiolitic Complex is cut by mafic and felsic intrusions:

a) Medium-grained homogeneous diorite and gabbro whose appearance is much more fresh than the mafic rock of the Ophiolitic Complex.

b) Small outcrops of calc-alkalic granite, and microgranite dikes.

To the east, at the edge of the Paleozoic formations, the border of the Ophiolitic Complex is characterized by the extensive development of brick-red colloidal and ferruginous siliceous rock; this rock, mapped as chert, takes on two distinct morphologic appearances:

a) On the one hand it appears to form an horizon covering the mafic and ultramafic rock as small outliers, with the mafic basement appearing in small windows.

b) On the other hand it forms small centimeter- to decimeter-sized veins interfoliated in the mafic basement rock.

The nature, as well as the conditions of deposition of this ferruginous siliceous rock is reminiscent of that of Jabal Ḥumayyan (Corpel, J.A., et al, 1971).

3.2.2 Andesitic Halaban (ha)

The Andesitic Halaban occupies the central part of the area, and consists of:

1. flows of dark-green aphanitic andesite, locally vesicular or with amygdales of calcite and chlorite;

2. porphyritic andesite, often epidotized, with large plagioclase laths;

3. pyroclastic facies: andesitic crystal and lapilli tuff and breccia alternating with the andesitic facies above;

4. intercalations of rhyolite and ignimbrite, gray pink to mauve in color, mainly in the west part of the formation.

The Andesitic Halaban is cut by several mafic and felsic intrusions. In its western part it is very fractured and schistosed along a N-S orientation that follows the tectonic restraints, mainly faults.

3.2.3 Pyroclastic Halaban (hp)

The Pyroclastic Halaban is the dominant formation in the northwest part of the area. The pyroclastic rock consists of:

1. rhyolitic crystal and lapilli tuff and breccia;
2. andesitic tuff and breccia, often with siliceous components in a dark-green soft cement;
3. ignimbrite or gray-pink and mauve flow-structured welded rhyolitic tuff;
4. dacite.

To the northwest the different facies have been subjected to a progressive metamorphism from east to west; there is an appearance of a foliation, with the rock being transformed gradually to chlorite and sericite schist and then to amphibole and biotite gneiss; in the patina the residual form of the lapilli still appears clearly and allows identification of ancient pyroclastic facies. Mafic and felsic intrusions cut the Pyroclastic Halaban and locally develop an aureole of contact metamorphism superimposed over the regional metamorphism.

3.2.4 Gneissic Halaban (hgs)

The Gneissic Halaban forms a narrow band in an area affected by the Najd Fault System in the southwest of the quadrangle; here it lies in contact with the Murdamah Formation, partly due to faulting and partly due to angular unconformity. It consists of very narrow alternations of leucocratic siliceous gneiss, amphibole gneiss and amphibolite, and dips steeply and constantly to the northeast. Interstratified in the different gneiss bands are numerous sills of red mylonitized granite.

From the regularity of the alternations of gneiss of different composition, and the homogeneous grain size of their constituent parts, it is presumed that this gneiss originates from ancient well-bedded sedimentary rock belonging, maybe, to the Clastic Halaban Formation. As for the interfoliated granite in the gneiss, it seems to have been in place since (gm) granitization and may have undergone crushing and mylonitization later, at the time of the phase of post-Murdamah folding and caused by faulting of the Najd Fault System.

3.2.5 Syntectonic Intrusive Plutonic Rock

Numerous felsic and mafic intrusions belonging to a late-Halaban cycle cut the different Halaban formations just described.

The mafic intrusions are represented by gabbro, diorite and microdiorite. The gabbro is sometimes differentiated and grades either to holomelanocratic pyroxenite or to diorite and quartz diorite; this can be seen particularly in the north of the Andesitic Halaban Formation.

The felsic intrusions are represented by granodiorite and calc-alkalic granite with biotite and green amphibole: again the passage from granite to granodiorite is often gradational. The felsic intrusions are later than the mafic intrusions, and alteration and crushing of mafic rock can frequently be observed near the contact of the granitic rock; moreover, numerous granite veinlets penetrate and meander through the mafic rock at the edge of the intrusions.

These mafic and felsic bodies originate from syn- to late-tectonic intrusions of the Halaban; pebbles of them are found in the conglomeratic beds of the overlying formations. However, in the west part of the area, the Halaban is also affected by other intrusions that have been assigned to (gm) granitization.

3.3 Umm Sulaym Formation (us)

The Umm Sulaym Formation, which characterizes the central and west parts of the quadrangle, is a well individualized formation of an exclusively sedimentary character lying

a diameter in excess of 20 cm, originate from the various formations of the Halaban (granite, granodiorite, diorite, microdiorite, rhyolite, ignimbrite, rhyolitic tuff, andesite, chert); numerous marble flags originating from underlying horizons are also present.

The conglomerate also occurs as horizons interstratified in the marble.

c) The tuffite is essentially composed of detrital volcanic components surrounded by a calcareous cement; sometimes it takes on a microconglomeratic aspect.

d) The graywacke is usually fine grained with a dark-green patina and alternates frequently with fine-grained tuffite; chlorite is abundant.

e) The feldspathic sandstone has a gray or gray-green patina; showing an arenitic texture it is composed of an aggregate of small isometric and angular detrital grains of quartz and feldspar.

Westwards the different facies become metamorphosed and are subjected to the influence of granitization; the metamorphism increases from east to west but is limited to the greenschist and amphibolite facies of the epizone and mesozone. The

metamorphism is expressed by the appearance of foliation and by the development of chlorite, biotite and amphibole. The sedimentary rock types, described earlier, are transformed to metasandstone with the development of biotite, and then to leucocratic gneiss, amphibole gneiss, amphibole and skarns. In the granitized area to the west the metamorphic facies only occur as small fragments or septa.

The Umm Sulaym Formation is cut by intrusions that are attributed to (gm) granitization: hornfels and skarns with garnet and magnetite are frequently developed at the edge of these intrusions.

3.4 Murdamah Formation (mu)

The Murdamah Formation occupies the southwest part of the quadrangle, where it forms the south side of the Najd Fault, and is in abnormal contact with Gneissic Halaban; partly due to faulting and partly due to an angular unconformity. This formation has an essentially sedimentary character and is represented by conglomerate, "volcanic" sandstone, feldspathic sandstone, graywacke, and siltstone:

a) The conglomerate is polygenic, with a cement composed of calcareous sandstone and with pebbles principally of granite, and occasionally of microdiorite

and amphibolite. It is cut into low-angle (15°) wedges by the Najd Fault, and so has been subjected to dynamometamorphic deformations: the cement is very schistose and sericitic, whilst the pebbles are very drawn out and crackled, becoming pseudocylindric, with lengths sometimes greater than 50 cm (although the diameter never exceeds 10 cm).

This conglomeratic unit, which is characterized by a weathering out into "window frames", is about 150 m thick.

b) Above the conglomerate comes a monotonous detrital series: sandstone with small detrital grains of volcanic origin ("volcanic" sandstone), dark-green chloritic graywacke, feldspathic sandstone, pelite and siltstone. In the vicinity of the Najd Fault these rock types are dynamometamorphosed over a width of about 1 km, where they are mylonitized and transformed into sericitic and chloritic schist which weathers out as long needles or "pencils".

The Murdamah Formation is moderately folded, with a moderate dip generally to the southwest, and is not metamorphosed outside the area influenced by the Najd Fault.

3.5 Late- and Posttectonic Plutonic Rock (gm)

Late- and posttectonic intrusions affect mainly the west part of the area, where they are generally eroded and form a natural gravel (granular rock) covered plane. They mostly crop out in the form of pavement areas, or next to the walls of the numerous dikes which protect them from erosion. The intrusions are composed of later diorite and gabbro, granite and granodiorite, and have been assigned to (gm) granitization.

3.5.1 Gabbro and Diorite (gb, d)

Gabbro and diorite with an hypidiomorphic-granular texture crop out in the west of the quadrangle as small hills within the granitic rock. They mainly cut the Umm Sulaym Formation, but also form small outcrops within the granite (gm) and so are interpreted as representing a differentiation facies of granite (gm); they could have formed at the edge of the intrusions when these cut mafic rock.

3.5.2 Granodiorite and Granite (gd, g)

The granite is gray or pink in color, medium grained, usually with biotite and sometimes with green amphibole; it is alkalic to calc-alkalic with orthoclase, albite and oligoclase, and at the edge of the intrusions it sometimes grades

to a granodiorite. The rock is criss-crossed by numerous dikes and often enough contains septa of metamorphic rock belonging to the Umm Sulaym Formation.

To the southwest, in the area influenced by the Najd Fault, the granite is red, mylonitized and poor in ferromagnesian minerals; here it either forms small hills in a narrow band attached to the metamorphosed Murdamah and to the Gneissic Halaban, or small hills interfoliated in the Halaban gneiss.

3.6 Shammar Formation (sr)

The Shammar Formation crops out in the south of the quadrangle at Jabal Ḍab': a pseudo-tabular hill, elongate in an ESE-WNW direction and rising to about 100 m above the pediment. It is composed essentially of gray-pink to brick-red flows of rhyolite and ignimbrite, cinder-gray welded rhyolitic tuff, rhyolitic breccia and locally pyromeride.

In the east part of the massif the rhyolite is characterized by a microgranular groundmass and is similar in appearance to a microgranite.

In the breccia facies of the north of the massif rare spots of violet fluorite have been observed.

The outcrop is surrounded by Quaternary deposits and the relationships with the enclosing rock are hidden; however, through analogy of facies, this exclusively rhyolitic formation has been assigned to the Shammar Formation.

3.7 Dikes

In the west part of the quadrangle the granitic plane is criss-crossed by numerous dikes that are usually felsic, and more rarely mafic.

The dikes which cut the granite and granodiorite (gm) are composed of gray and brick-red alkalic to calc-alkalic microgranite, and their mineralogic composition appears identical to that of the granite (gm); it could represent a late phase of (gm) granitization. The microgranular structure is either homogeneous and fine grained, or porphyritic: in the latter case the felsitic groundmass surrounds large hypidiomorphic phenocrysts of globular quartz and of alkali feldspar.

In the center of the area a network of microgranite dikes forms large hills whose morphology corresponds to the structure of the country rock. The dikes consist of an alkalic microgranite with a porphyritic texture composed mainly of quartz and alkali feldspars with very few ferromagnesian minerals (rare biotite). This microgranite cuts the sedimentary

facies of the Umm Sulaym Formation and has developed a narrow aureole of contact metamorphism over several tens of meters: the marble and calcareous tuffite are transformed to skarns with magnetite and small garnets, whilst the graywacke and feldspathic sandstone acquire a microgranular texture giving the rock a microdioritic aspect. These microgranite dikes can be interpreted either as satellites of the (gm) granitization or as Shammar manifestations; the relationships are not visible in the field.

3.8 Paleozoic Sedimentary Formations

The Paleozoic formations, which crop out over the whole of east part of the quadrangle, are represented by two formations attributed to the Permian (Powers, et al, 1966): the Wajid Sandstone and the Khuff Formation.

3.8.1 Wajid Sandstone (PW)

The Wajid Sandstone lies unconformably on the Precambrian Shield, and is composed of conglomerate and sandstone. More often than not it only crops out in the form of small, relatively thin outlier fragments covering basement outcrops.

The conglomerate is monogenetic with a cement composed of brownish- to rusty-colored calcareous sandstone, and pebbles entirely of rounded, oval or spherical quartz whose size

rarely is greater than 5 cm. Some chips of hematite, that are found dispersed over these formations, could originate from thin ferruginous horizons interstratified in the conglomerate.

The sandstone is rusty to brown in color, partly cemented and friable, and is composed mainly of small contiguous grains of quartz; the cement, which is not very abundant, is calcareous.

Locally the conglomerate and sandstone are characterized by bedding structures. Their assignment to the Wajid Sandstone is only presumed, for it is possible that this formation, which is not very thick and which is fairly poorly represented in the quadrangle, is only the base of the Khuff Formation.

3.8.2 Khuff Formation (PK)

The Khuff Formation constitutes the dominant component of the Paleozoic formations. It lies on the Wajid Sandstone, but the observations were too localized and restricted to know whether or not there is an unconformity between the two formations: the indication within the quadrangle tends towards conformity.

The Khuff Formation is composed of horizons of beige, gray-blue and red-violet limestone, gray-blue dolomite that is often porous and cavernous with solution features, and marl or shale interbedded in the limestone and dolomite.

Topographically the relief is flat and corresponds to the structural platforms of the different stratigraphic horizons that are only emphasized by the formation of successive low (meter-sized) cuestas.

3.9 Surficial Formations

The surficial formations are represented by deposits of sand, gravel and eluvium between the hills; by sand of granitic origin in the granitic planes to the west; by eolian sand.

Eolian sand is very abundant and is the predominant surficial formation: mobile sand which occurs over most of the quadrangle, although it particularly invades the east part, in the form of large NE-SW trending dune ridges (Nafūd).

In places the accumulation of wadi water in depressions has led to the formation of 'Sabkhats' which generally mark the end of the wadis.

3.10 Lithostratigraphy

From a lithostratigraphic point of view the formations encountered in the Umm Sulaym quadrangle show the following succession from the base upwards:

1. Halaban Group
2. Umm Sulaym Formation
3. Murdamah Formation
4. Shammar Formation
5. Paleozoic Formation.

The Halaban Group consists of:

a) the Ophiolitic Halaban, which contains the oldest rock and represents the base of the Halaban: it is composed of mafic and ultramafic rock with associated keratophyre, and is frequently altered to serpentinite and greenstone.

b) the Andesitic Halaban, composed essentially of alternations of andesite and andesitic tuff.

c) the Pyroclastic Halaban with rhyolitic and andesitic tuff and breccia, ignimbrite and dacite.

The Halaban formations were folded and cut by mafic and felsic syn- and late-tectonic intrusions. Erosion followed with components of the volcanic and intrusive formations of the Halaban supplying the younger sedimentary formations.

In the northwest part of the area the pyroclastic facies were subjected to a progressive east to west metamorphism with epizonal and mesozonal characters; these metamorphic facies are of the greenschist and amphibolite facies. In this region the area is very granitized and it is not excluded that a local metamorphism caused by the intrusions is superimposed on the regional metamorphism.

The Umm Sulaym Formation is an exclusively sedimentary formation, intermediate between the Halaban Group and the Murdamah Formation, which lies unconformably on the Halaban formations. At the base it is represented by thick horizons of marble above which comes conglomerate composed of components derived from the Halaban formations. The conglomerate beds are covered sometimes by further horizons of marble or by tuffite and graywacke. The Umm Sulaym Formation is strongly folded and cut by posttectonic intrusions belonging to the granite (gm). A progressive east to west metamorphism, limited to the greenschist and amphibolite facies, affected the west part of this formation.

The Murdamah Formation, which is mainly sedimentary, incorporates components derived from erosion of earlier formations in the form of conglomerate, "volcanic" sandstone and feldspathic sandstone. It is in contact with the Halaban Group partly through fault movement and partly through angular unconformity.

The Murdamah Formation is moderately folded and is cut by granitic (gm) intrusions; it was not subjected to regional metamorphism, although a weak metamorphic aureole developed around the granitic intrusions. Dynamometamorphic effects brought on by faulting affect this formation over a width of approximately 1 km in the vicinity of the Najd Fault.

After the (gm) intrusions a Shammar rhyolitic volcanism occurred; it is possible that this volcanism was brought on by the Najd Fault System.

Paleozoic sedimentary formations covered the Precambrian formations unconformably and have been assigned to the Permian System.

4. GEOPHYSICAL DATA (by J. Maillard) (App. 5)

4.1 Aeromagnetic and Scintillometric Map No. 131

The west half of Sheet 131 (equivalent to the Umm Sulaym quadrangle), covering the Precambrian formations and part of the Permian Khuff Formation, was surveyed by the Consortium members in 1966.

A preliminary qualitative magnetic interpretation showed several linear magnetic features (faults or abnormal contacts) and delineated zones with different magnetic behaviour corresponding to different geologic formations: because of the existence of overburden in places, these features do not appear on the corresponding photomosaic.

4.1.1 Linear Magnetic Features

The linear magnetic features are mainly oriented NNW and NW, and are often outlined by elongate magnetic anomalies: these features may correspond sometimes to faults filled with more mafic material (see Fault 5, App. 5).

Some NNE-trending faults can be seen near the edge of the outcropping Khuff Formation.

4.1.2 Magnetic Zones

The magnetic relief is generally rather flat with weak-intensity magnetic anomalies having no gradients: there are, however, some zones with greater magnetic relief (Sectors II, IV, V, VI).

To the east of Sector I, which probably corresponds to a granitic area, Sector II shows magnetic anomalies (often elongated along a NW trend) with strong gradients but of medium intensity (500 to 600 γ). The shape of these anomalies indicates surficial causes, and few faults affect this area. According to the 1:500,000-scale USGS geologic map (Bramkamp, et al, 1956) most of this sector may correspond to amphibolite schist or to a contact metamorphic zone.

Sector IV and most of Sector V are well delineated by the existence of several unshaped magnetic anomalies, whose origin is surficial (intrusions of mafic rock, such as gabbro ?).

To the east, Sector VI, with medium-intensity (300 to 500 γ) magnetic anomalies, may correspond to a strip of more mafic rock. It seems that the contours of this Sector are well delineated in the magnetic map as scattered outcrops can be seen on the corresponding photomosaic.

In the southwest of the sheet (south of the Fault 3) the area with a very flat magnetic relief corresponds to the Murdamah Formation.

In the east part of the area surveyed, which corresponds to the Khuff Formation, very weak magnetic anomalies appear to have a deeper origin.

The structure A, in the southeast corner, is a magnetic anomaly of about 500 gammas intensity and may be explained by the presence of a cylindrical magnetic body at shallow depth probably dipping to the southwest (intrusion ?).

It would appear that the thickness of the sedimentary cover in this eastern area is not large.

5. STRUCTURE

5.1 Folding

With the exception of the tabular formations of the Paleozoic all the formations in the Umm Sulaym quadrangle are folded.

A first phase of folding occurred before the Murdamah and affected the volcanic and sedimentary Halaban and Umm Sulaym Formations. The main structural element of the phase is represented by a SSE-plunging anticlinorium clearly shown by the stratified Umm Sulaym facies: seven kilometers to the southwest of Bi'r Umm Sulaym an anticlinal closure is clearly visible, whilst at Jabal Qutaynnah a synclinal closure was interpreted. The flanks of the anticline are very steep, and the N 20° W-trending axis plunging 60° SSE. is emphasized by the lineations: the west flank is metamorphosed and has been affected by granitic (gm) intrusions. The heart of the anticline, which is visible at the anticline closure to the southwest of Bi'r Umm Sulaym, is characterized by Halaban intrusions of diorite and microdiorite cutting the Pyroclastic Halaban and by intrusions of granite (gm) cutting the diorite and microdiorite.

A later, post-Murdamah, phase of folding steepened the already-folded pre-Murdamah formations and formed structures of generally moderate dip in the Murdamah Formation. In the southwest part of the area variations in direction and intensity of dip between the formations of the Halaban and of the Murdamah are particularly noticeable.

5.2 Faulting

The main faulting in the Umm Sulaym quadrangle is the Najd Fault System, in the southwest of the area. This fault network affects a region about 2 km wide. The strike of the principal faults is N 40-50° W., and the tensions brought about by these faults are expressed by multiple complementary faults with a general E-W direction. The strike of these complementary faults, as well as the strikes and dips of the lineations, indicate an oblique lateral movement: the north side of the main fault being raised up and displaced to the west, and the south side being downthrown and displaced to the east. The dynamometamorphism brought about by this Najd Fault led to mylonitization and schistosity of the nearby rock.

The Najd Fault System is pre-Paleozoic in age, and it is possible that it was the cause of the Shammar volcanism.

The Precambrian formations were also affected by faulting prior to the Najd Fault System: these have a NNW strike and in several places have caused formations of the Halaban to be in contact with the sedimentary Umm Sulaym Formation.

Other faults are post-Paleozoic, with a general NW-SE strike and these have influenced the Paleozoic formations in the east of the quadrangle.

6. MINERAL EXPLORATION

6.1 Generalities

The abundance of eolian sand throughout the area hindered the use of classic methods of indirect prospecting: alluvial and geochemical prospecting. Direct prospecting was mainly centered on the search for altered zones, gossans and ancient workings, and several chemical and spectrographic analyses were carried out on samples collected from favorable zones. This direct prospecting led to the discovery of some ancient workings on quartz veins and of a few areas of mineralization associated with ultramafic rock.

6.2 Ancient Workings (Apps. 2 & 3)

Seven groups of ancient workings, all located in the northwest of the area, were listed. These workings, on quartz veins related to intrusions of diorite and granite in the Halaban formations, are all small in size, and generally consist of trenches or pseudo-circular excavations filled with sand.

6.2.1 Occurrence 131 A-RB 9m (App. 3-3)

This occurrence consists of a group of four workings on quartz veins cutting an intrusion of alkalic granite: they extend over an area of 300 m x 100 m:

a) a north trench (30 m long, 3 m wide, 1 m deep) on a N 20° E.-trending quartz vein;

b) a southwest trench (15 m long, 1 m wide, 1 m deep) on a N 50° W.-trending quartz vein;

c) ancient workings of the southeast consisting of a circular excavation (3 m diameter, 1 m deep) on a vein network of quartz with a general orientation of N 40° W.

d) a south trench (30 m long, 1 m wide, 1 m deep) on an E-W.-trending quartz vein.

Everywhere the quartz is milky and contains geodes of pyramid quartz. Locally it is coated with hematite and sometimes contains a small amount of chrysocolla, malachite, rare stains of galena and some oxidized pyrite.

Analyses results of ferruginous quartz collected from the waste material yielded anomalous grades in gold reaching 10 g/t, and some anomalous grades in copper, lead, zinc.

6.2.2 Occurrence 131 A-RB 10m (App. 3-4)

This occurrence consists of two small trenches, lying 100 m apart, on quartz veins cutting diorite and microdiorite intrusive in the Andesitic Halaban.

a) The northernmost trench (15 m long, 2 m wide, 0.5 m deep) is on an E-W trending quartz vein.

b) the other trench, to the south, (6 m long, 1 m wide, 0.2 m deep) is on a N-S oriented quartz vein.

The quartz is frequently pyramided and encloses a very small amount of hematite.

6.2.3 Occurrence 131 A-RB 11m (App. 3-5)

This occurrence consists of a trench (20 m long, 1 m wide, 0.5 m deep) on a quartz vein striking N 10° E.

6.2.4 Occurrence 131 A-RB 12m (App. 3-6)

This occurrence is a trench (20 m long, 1-3 m wide, 0.5 m deep) on a N 30° E.-trending quartz vein cutting microdioritic rock of the Halaban. The quartz contains a small amount of chrysocolla.

Analyses results of the quartz coming from the waste material gave a gold grade of 1 g/t.

6.2.5 Occurrence 131 A-RB 13m (App. 3-7)

These are two occurrences lying 50 m apart on quartz veins oriented E-W and N 40° W. and cutting Halaban andesite; they are each 30 m long and 0.5 m wide and are almost completely filled with eolian sand. Analyses results of quartz coming from the waste dump gave a gold grade of 3 g/t.

6.2.6 Occurrence 131 A-RB 14m (App. 3-8)

Two groups of ancient workings lying 250 m apart are formed mainly of small circular excavations (about 25) with diameters of 2-5 m and depths of 1 m. These workings were carried out on a vein bed of quartz locally mineralized with malachite, chrysocolla and oligist.

Analyses results gave a gold grade of 3 g/t and some anomalous values in copper (860 ppm) and lead (300 ppm).

6.2.7 Occurrence 131 A-RB 15m (App. 3-9)

This occurrence consists of a trench on a quartz vein oriented N 20° E.; it is 15 m long, 1 m wide and 0.5 m deep. The quartz is milky, locally ferruginous and poorly mineralized in chrysocolla. Diorite and microdiorite make up the country rock.

Analyses results of quartz coming from the waste dumps gave grades of 2 g/t in gold and 500 ppm in copper.

6.3 Mineralization Associated with Ultramafic Rock

This mineralization consists essentially of lenses of magnesite and veinlets of hematite within the serpentinite and peridotite of Jabal al 'Uwayjā' in the north of the quadrangle.

The magnesite is frequently present and forms small residual surficial concentrations within the serpentinite and peridotite from which it is derived: the largest lens is approximately 100 m x 50 m, and contains fine-grained concentrations which impart a cauliflower-type patina.

Some veinlets of hematite, often associated with brown carbonate, are localized in the serpentinite and very occasionally contain a small amount of chrysocolla and malachite. An analysis of hematite, that showed no mineralization to the naked eye, gave an anomalous grade in copper of 650 ppm (App. 3-2).

6.4 Conclusions

The presence of grains of magnetite and small garnets in the skarns developed at the edge of the intrusions, as well as the presence of rare spots of violet fluorite in the rhyolitic breccia of the Shammar Formation at Jabal Ḍab' should be noted for the sake of completeness.

Analyses results of samples from the ancient workings all yielded anomalous values in gold; thus it is probable that these ancient excavations were made for the discovery and mining of gold. This mineralization related to small quartz veins is of a hydrothermal type, and is too poor to be of economic interest.

The residual concentrations of magnesite found in the serpentinite massifs are both very dispersed and very limited in size: they are of no economic interest.

7. CONCLUSIONS

From a geologic point of view the lithologic units encountered in the Umm Sulaym quadrangle are very varied and give a glimpse of the geologic evolution from the Precambrian to the Paleozoic.

The Precambrian is well represented by:

a) the Halaban Group, consisting of the Ophiolitic Complex and of volcanic formations of the Andesitic and Pyroclastic Halaban.

b) sedimentary formations of the Umm Sulaym and Murdamah Formations and by the Shammar Rhyolitic Formation.

Both during and at the end of the Halaban period, intrusions occurred within the various Halaban formations; the whole was then eroded with the detritus supplying the components of the Umm Sulaym Formation which could mark the end of the Halaban cycle. The Halaban and Umm Sulaym Formations were folded, locally metamorphosed and cut by various intrusions: the main structure of this phase is a south-plunging anticlinorium.

Another period of erosion affected all these formations with the new phase of sedimentation beginning the deposition of the Murdamah Formation: the Murdamah Formation was later moderately folded and then affected by the Najd Fault System. The final Precambrian episode is represented by the Shammar volcanism which may have been brought on by movement of the Najd Fault System.

The Paleozoic is represented by tabular formations attributed to the Permian System: these are sandy formations of the Wajid Sandstone and the predominantly calcaro-dolomitic formations of the Khuff Formation.

Mineral prospecting yielded no encouraging results. Several ancient workings (for gold) were discovered in quartz veins cutting the Halaban formations but their sizes are small and do not justify additional investigation.

Also discovered were several lenses of magnesite, but these are only small residual concentrations formed within serpentinite massifs and offer no economic interest.

In conclusion, therefore, no further prospecting is recommended in the Umm Sulaym quadrangle.

8. REFERENCES

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