J. Univ. Kuwait (Sci.) **7**, 1980

Geological and petrographical studies in the northern part of the Oman Mountains, northwest of Al-Fujairah, United Arab Emirates

MAMDOUH A. HASSAN AND JAWAD S. AL-SULAIMI

Nuclear Material Corporation, P.O. Box 98, Masaken Madinat Nasr, Nasr City, Cairo, Egypt, and Kuwait Institute for Scientific Research

ABSTRACT

Geological and petrographical studies have been carried out on ultramafic and gabbroic rocks and schists in an area covering about 100 km^2 and lying about 10 km northwest of Al-Fujairah, in the United Arab Emirates. The ultramafic rocks are composed of variously serpentinised harzburgites and dunites. Three joint sets have been described in these rocks. Dykes and veins of magnesite, pegmatitic gabbro and serpentine asbestos are abundant in them. The ultramafic rocks overlie the schists with a thrust contact. The gabbroic rocks are dominantly layered and include gabbro, eucrite, troctolite, olivine gabbro, olivine norite and uralitised gabbro. Their contacts with the schists and the ultramafic rocks are fault contacts. Two types of schists are described: green schists and quartz schists. These were originally a sedimentary succession dominated by calcareous and dolomitic sediments containing appreciable amounts of pyroclastics and cherts and with smaller amounts of sandstones with calcareous impurities. The mineral assemblages of the schists indicate that they were metamorphosed in the green schist facies at its upper limit transitional to the amphibolite facies. Correlation of the rock units of the studied area with the rock units defined by previous workers in the Oman Mountains is given.

INTRODUCTION

The Oman Mountains include one of the most extensive and well-exposed ophiolite belts in the world, known as the Oman ophiolites or the Semail ophiolites. They constitute a huge complex nappe, which was tectonically emplaced from the northeast onto the southeastern margin of the Arabian continental block during Late Cretaceous. Glennie *et al.* (1974) have classified the Semail ophiolites into six units, which conform with the complete ophiolite sequence as defined by the Penrose Conference Participants (1972). From top to bottom, these units are:

(1) Unit E: extrusive rocks, mainly spilites and basalts, associated with minor amounts of pelagic sediments.
(2) Unit D: dyke swarms of hypabyssal mafic rocks and diabase.
(3) Unit HG: a complex zone of hypabyssal gabbroid rocks, coarse-, medium- and fine-grained mafic rocks with prevalent ophitic textures.
(4) Unit G: coarsely granular mafic rocks, mainly gabbros, which are dominantly layered.
(5) Unit PG: a complex transition between P and G.

(6) Unit P: ultramafic to mafic rocks, mainly peridotites.

In limited areas of the northern part of the Oman Mountains, there is a series of metamorphic rocks at the base of the Semail nappe, known as the metamorphic sheet. Recently, copper deposits were discovered within the Semail ophiolites (Smewing *et al.* 1977; Hassan & Al-Sulaimi 1979a) which has increased interest in geological studies of the Oman Mountains. This paper presents a geological and petrographical study of the area northwest of Al-Fujairah where copper and manganese deposits were recently discovered.

GENERAL GEOLOGY

The area of the present study lies about 10 km northwest of Al-Fujairah, United Arab Emirates and embraces about 100 km^2 (Fig. 1) of rugged mountainous terrain. The

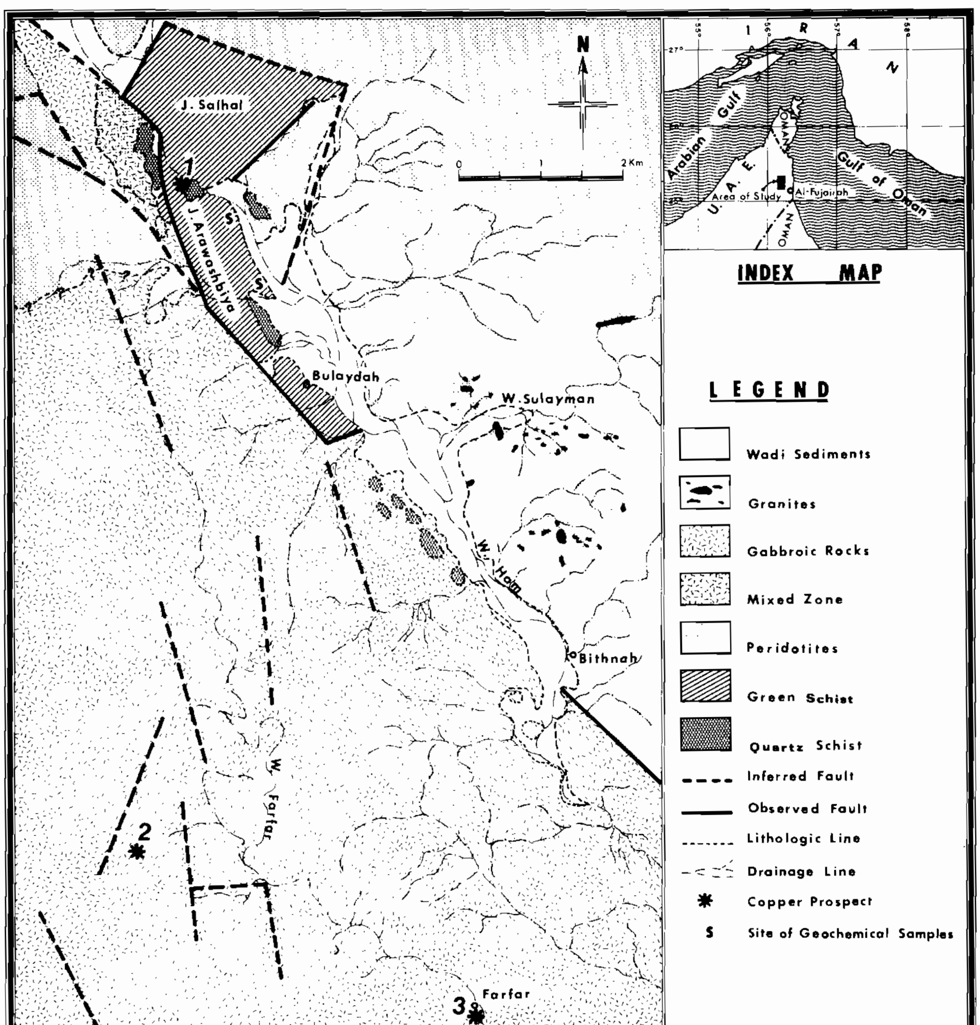

Fig. 1. Geologic map of the study area.

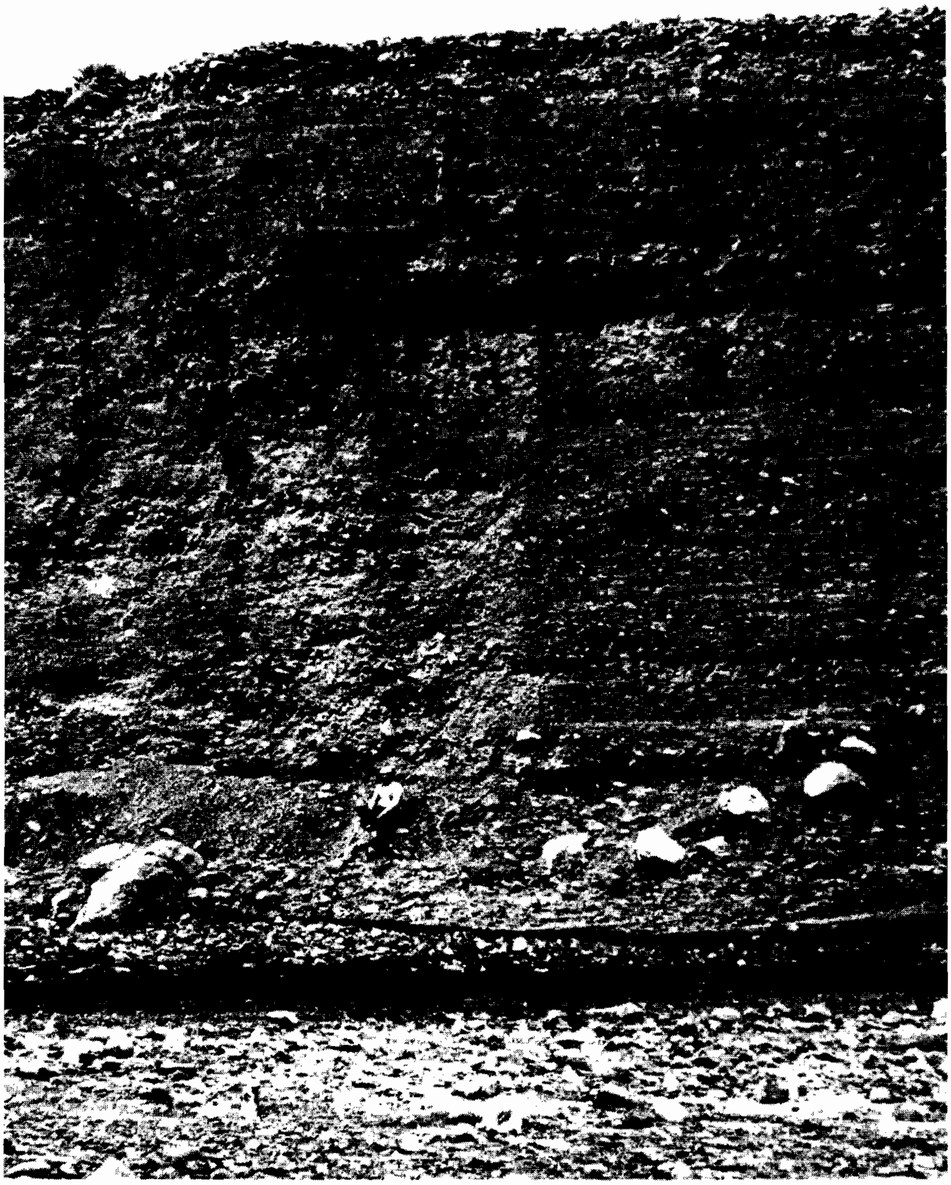

Fig. 2. A raised terrace of consolidated gravel, northeastern side of Wadi Ham, about 15 km northwest of Al-Fujairah.

area is drained towards the southeast to the Gulf of Oman through Wadi Ham. The drainage lines (wadis) show distinctive features due to their rejuvenation by recent uplift. Raised terraces about 5 m high are common in these wadis. Raised terraces 10–15 m high on both sides of Wadi Ham are also common (Fig. 2).

The rock units of the area include peridotites (variously serpentinised) with a mixed zone composed of ultramafic and gabbroic rocks, layered gabbroic rocks, two types of schists (green schists and quartz schists), small granitic intrusions and wadi sediments.

DESCRIPTION OF THE ROCK UNITS

1. PERIDOTITES

They are mainly composed of harzburgites and dunites which are variously serpentinised. Relics of olivine and enstatite crystals reach up to 8 mm in length. The peridotites show wide variation in colour (various shades of green, brown, grey and black).

The harzburgite is composed of about 60% of variously serpentinised olivine, about 30% of enstatite showing clear schiller structure and about 10% of augite and chlorite. Dunite is composed of more than 90% of variously serpentinised olivine with accessory enstatite, augite and chlorite. Mesh textures due to serpentinisation are common in both rocks.

The peridotites are cut by numerous joints which give them a layered appearance at a distance. Three joint sets were distinguished (J_1, J_2 and J_3 respectively). They are best exposed in an area about 3 km northwest of Bithnah, where their attitudes were measured (Fig. 3). In other parts of the studied area, intense fracturing and brecciation of peridotites make it difficult to measure the attitudes of the joint sets.

Joint sets J_1 and J_2 are shear joints and were probably formed simultaneously. They define slip surfaces in the peridotite where stresses have transformed the rock into black-coloured bands of aphanitic serpentine minerals. On the aerial photographs, these joint sets appear to be circularly distributed around a centre at a point about 2 km northeast of Bulaydah, making a semicircular structure in the peridotites. This structure may be interpreted as the fracture pattern associated with a varying stress field affecting the peridotites. The third joint set (J_3) comprises tension joints and has less distribution than the first two sets. It forms open planar fractures with smooth surfaces which are commonly filled with carbonates. It cuts and displaces joints J_1 and J_2. Similar tension joints or fractures occur in various other attitudes, but they do not form recognisable sets. All these tension joints may have formed due to the release of load pressure during the uplift of the peridotites.

The peridotites (especially the more serpentinised varieties) are also very commonly fractured and intensely sheared in many parts, with magnesite and other carbonates filling the fractures. These fractures and shear zones were formed due to the numerous faults cutting the peridotites in various directions and the consequent development of extensive shear effects.

Dykes and veins in the peridotites

A large number of dykes and veins of various types, sizes and attitudes cut the peridotites. In order of abundance, these are magnesite veins, pegmatitic gabbro and gabbro dykes and veins, and serpentine–asbestos veins.

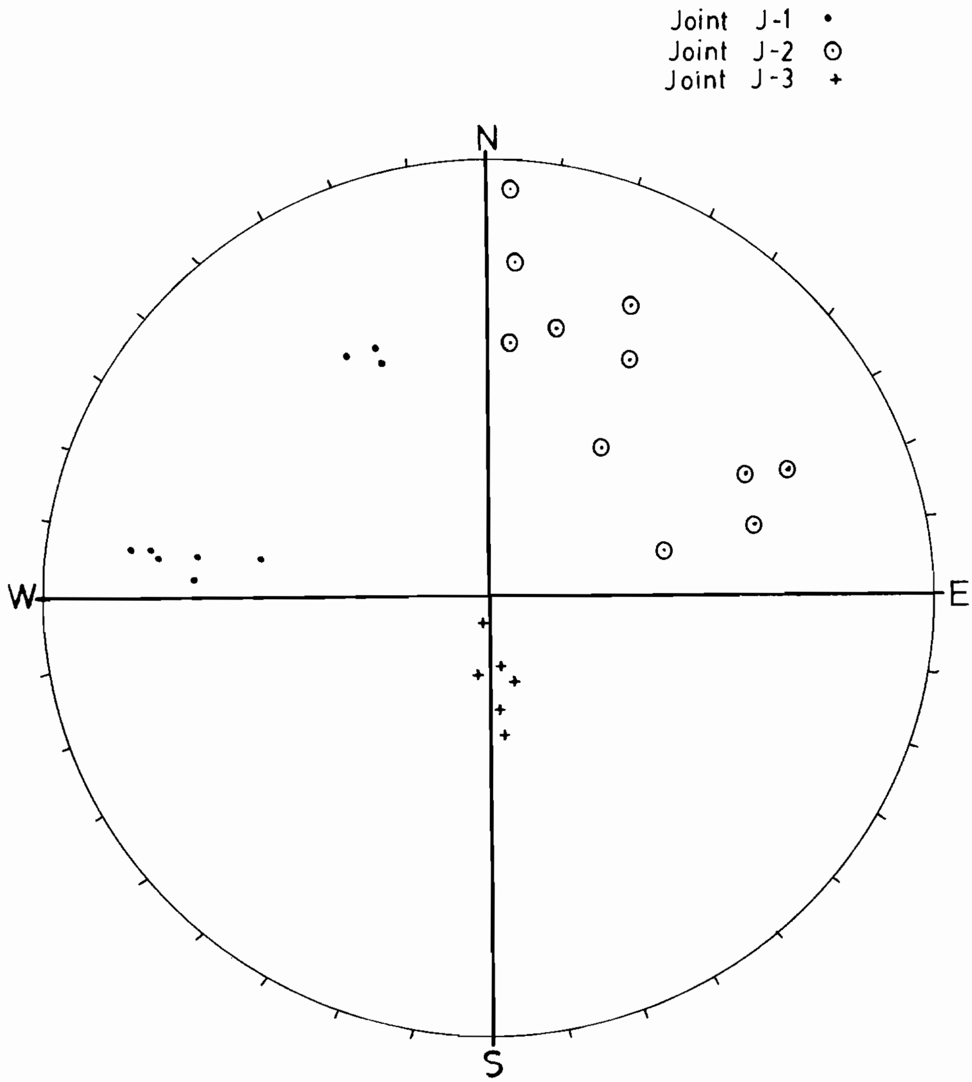

Fig. 3. Steriographic projection of the poles of the joint sets in serpentinised peridotites in an area about 3 km northwest of Bithnah.

The magnesite veins are characterised by their amorphous milky colour. They are widely distributed in the peridotites. They range in thickness from a few millimetres to tens of centimetres with variable attitudes. The largest vein occurs about 3 km southeast of Bithnah. It is a composite vein of magnesite and chalcedony with a northeast strike and vertical dip. Its thickness is about 30 cm and extends about 30 m along the strike. In sheared peridotite, small and intersecting veins of magnesite are common in joints and fractures. The magnesite probably originated during the serpentinisation process. Small, thin veins of other carbonates also occur in the peridotites.

The pegmatitic gabbro and gabbro dykes and veins are common in the peridotites, especially in the area near Bithnah. They vary in thickness from a few centimetres to tens of centimetres and in length from several tens of centimetres to 15 m without any preferred trend. They have sharp contacts with the enclosing peridotites. They are composed of augite, calcic plagioclase, and subordinate hornblende. They were intruded after the serpentinisation of the peridotites because their pyroxene is not serpentinised.

The serpentine–asbestos occurs as masses and veinlets of wide distribution in the peridotites, occupying joints and fractures with thicknesses up to 5 cm. It occurs as short, brittle fibres which are light-green to grey in colour. The asbestos is believed to have formed during deformation and shearing of the serpentinised peridotites, where stresses along shear joints and in shear zones caused the transformation of various serpentine minerals into asbestos.

Chromite float

Careful search for chromite concentrations within the peridotites failed to locate any. However, chromite float was found in a small wadi southeast of Bithnah. It was probably derived from boulders in the alluvium which were transported for large distances.

Peridotite–schist contact

The peridotites are in contact with the schists only in the northwestern part of the area, around Jabal Salhal (Fig. 1). All along the contact, the peridotites appear to overlie the schist with a gently dipping contact surface. Therefore, it is believed that the peridotites are thrust over the schists with a thrust plane almost dipping at variable angles to the southeast. In some places, it lies flat.

2. GABBROIC ROCKS

The gabbroic rocks are the most abundant rock types in the area of study. They include gabbro, eucrite, troctolite, olivine gabbro, olivine norite and uralitised gabbro. Other rock types present in minor amounts are quartz anorthosite, wehrlite, dunite and amphibolite.

The gabbroic rocks in the studied area show well-developed layering (Fig. 4) except where they are sheared. This layering was studied in detail by Hassan & Al-Sulaimi (1979b). Numerous dykes and veins cut the gabbroic rocks. In order of abundance these are: pegmatitic gabbro dykes similar to those in the peridotites, quartz anorthosite dykes, quartz veins, and intrusive magmatic breccia (Fig. 5). The gabbroic rocks are cut by many faults and fracture zones and are highly sheared in many places. The sheared areas are light coloured due to bleaching and hydrothermal alteration (Fig. 6).

Gabbro–peridotite contact

The gabbroic rocks and peridotites almost always occur in fault contact in the area of study. A major southeast–northwest-trending fault separates the main masses of gabbroic rocks and peridotites. This fault is covered by Wadi Ham throughout most of the area, except in the southeastern part, southeast of Bithnah, where it crops out. Here

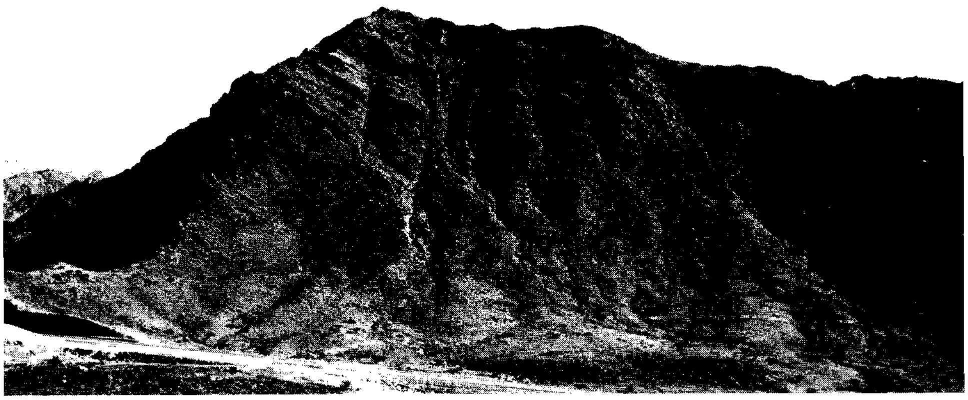

Fig. 4. A distant view of layered gabbroic rocks, about 12 km northwest of Al-Fujairah.

Fig. 5. Magmatic breccia, Wadi Farfar. Fragments of amphibolite (grey) are set in a matrix of granitic material (white). The amphibolite fragments are reworked in the younger granitic material with fine granitic veinlets crossing them.

Fig. 6. Zone of kaolinisation in layered gabbro in Wadi Farfar.

the width of the fault zone varies from 400–500 m. Tectonically emplaced huge blocks of highly brecciated and mixed peridotites and gabbroic rocks as well as reddish brown quartz schists are exposed in the fault zone. Silicification of the brecciated rocks in the fault zone is widespread, producing resistant ridges parallel to the trend of the fault.

Two features indicate dexteral strike–slip movement on the fault. Firstly, several small outcrops of schists between Bulaydah and Bithnah are interpreted as detached blocks from the main mass of Jabal Arawashbiya (Fig. 1). Secondly, the pattern of the feather-like fractures on both sides of the fault. This strike–slip movement is at least several kilometres. Furthermore, there must have been a vertical component of movement of at least several kilometres which brought up the gabbroic rocks in juxtaposition with the peridotites on both sides of the fault zone.

3. SCHISTS

The schists crop out in the northern part of the studied area and include two types: green schists and quartz schists respectively. The green schists are characterised by greenish to greyish and whitish overall colours of their outcrops. They are well foliated and in many places well laminated. Three groups of assemblages are included in the green schists: calcareous, basic and siliceous assemblages. Massive laminae and beds of manganese minerals (dominantly braunite) occur interlayered with calcareous and siliceous assemblages in the southwestern part of Jabal Salhal (Figs 7 and 8). It is believed that these manganese concentrations could be of commercial value.

Fig. 7. Massive manganese bands in the schists of Jabal Salhal.

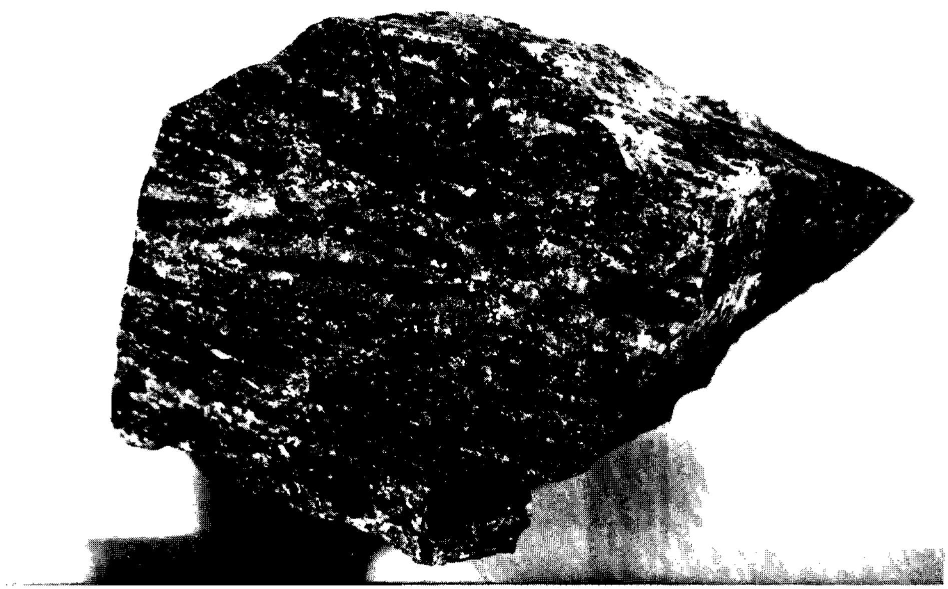

Fig. 8. A hand specimen of thin folded manganese bands interlayered with chert from Jabal Salhal.

The quartz schists are characterised by their overall brownish and reddish colours due to extensive ferrogenation. They occur as few scattered outcrops in the area between Jabal Salhal and Jabal Arawashbiya and in the area between Bithnah and Bulayda. Intense fracturing is characteristic of all outcrops of the quartz schists which are believed to be fault blocks detached from an original mass which does not crop out within the area. Similar blocks, but of much smaller sizes (not shown in Fig. 1) commonly occur in the fault zone of Wadi Ham south of Bithnah and west of Jabal Arawashbiya.

Schists–gabbro contact

The only place in which schists come into contact with the gabbroic rocks is in the northwestern part of the area. The contact between the schists of Jabal Arawashbiya and the surrounding gabbroic rocks is a fault contact. It is part of the main fault of Wadi Ham. The width of the fault zone is about 30 m and it extends for about 3 km. The schists and gabbroic rocks are highly fractured and mylonitised. Blocks of serpentinites, quartz schists and gabbroic rocks occur as horses in the fault zone. Copper mineralisation was recently discovered in the schists of this area by Hassan & Al-Sulaimi (1979a).

4. GRANITIC INTRUSIONS

Small granitic intrusions are very abundant in the peridotites between Bithnah and Wadi Sulayman. They vary in shape, with lensoid and tabular bodies being most common. The petrography and geochemistry of these granitic intrusions will be the subject of a forthcoming publication.

5. WADI SEDIMENTS

The alluvial deposits of the wadis and the raised terraces consist of consolidated and non-consolidated sediments composed mainly of boulders, gravel, sand and silt. Most of the clasts are rounded to subrounded. Stratification is lacking in these sediments, which constitute a good reservoir for rain water. There are several springs in Wadi Ham and Wadi Farfar issuing from these sediments.

PETROGRAPHY

The petrography of the rock units in the studied area is described under the following headings: 1. Ultramafic rocks; 2. Gabbroic rocks; 3. Schists; 4. Dykes and veins. The mafic and ultramafic rock types will be named according to the system given by Streckeisen (1976).

1. ULTRAMAFIC ROCKS

The ultramafic rocks are mainly composed of peridotites and their serpentinised derivatives. The types represented in the area of study are:

Harzburgite: composed of olivine and enstatite. Accessory minerals include augite, chromite, magnetite, picotite, chlorite and calcite.

Dunite: composed almost totally of olivine. Accessory minerals include plagioclase, enstatite, chromite, magnetite, picotite, chlorite and calcite.

Wehrlite: composed of olivine and augite. Accessory minerals include plagioclase, enstatite, chromite, magnetite and hornblende.

Harzburgite is the most abundant peridotite in the area of study. Together with dunite, it forms the outcrops of the ultramafic rocks in the area. Wehrlite occurs only as bands within the gabbroic rocks. Fresh peridotites are rare; they are commonly variously serpentinised.

Texture

Weakly serpentinised peridotites are coarse grained, equigranular hypidiomorphic to xenomorphic. The length of the grains varies from 1·5–5 mm. Some orthorhombic pyroxene crystals form phenocrysts more than 7 mm in length and about 4 mm in width. Near the fault zone of Wadi Ham, most of the grains decrease in size to less than 0·5 mm due to mylonitisation.

Mineral composition

Olivine. This is the main constituent of the ultramafic rocks. Commonly, it forms equidimensional anhedral grains. Serpentinisation is present along borders of olivine grains, as well as along fractures crossing them, producing mesh textures. The serpentine collars around olivine as well as veins crossing it range in thickness up to 3 mm. These collars and veins are composed of cross-fibre serpentine and have wavy extinction because of changes in orientation along the curved borders of the mesh. Magnetite dust is frequently concentrated in the serpentine collars of the mesh where it occurs along the centre of the vein. It is likely that this magnetite was formed due to liberation of iron during the serpentinisation of olivine crystals. Some small serpentinised and mesh-textured olivine crystals occur as inclusions in enstatite.

Enstatite. This occurs as euhedral and subhedral prismatic crystals, with a strong parting parallel to (100). Enstatite has a weak birefringence and an average 2V of about 75° +ve. Partly serpentinised enstatite crystals are common in harzburgite.

Augite. This occurs in the form of subhedral crystals which have been altered in the rims into a green amphibole. It has an average 2V of about 60° +ve. Commonly, it shows simple twinning. It occurs in wehrlite as a major constituent (up to 30%), whereas in harzburgite and dunite it occurs as an accessory mineral (less than 10%). Glennie *et al.* (1974) indicated that the chemical composition of clinopyroxene in the peridotites of the Oman Mountains is that of a rather pure diopside. However, diopside was not observed in the peridotites of the studied area.

Opaque minerals. They are represented by magnetite, chromite and picotite. They occur either as small, irregular, solitary grains sparsely distributed in the rocks or as aggregated dust-like particles. Some of these grains are fractured and the cracks are filled with fibrous serpentine in a pull-apart structure. Picotite commonly shows effects of resorption and embayments. Other minerals are plagioclase which is always intensely altered, calcite which occurs as veinlets, and chlorite which is an alteration product. No serpentinites (rocks dominantly composed of serpentine minerals) were found in the area of study. In all the thin sections studied, serpentine minerals never exceeded 30% by volume. In Jabal Faiyah, about 40 km southwest of the study area, serpentinites occur. They were described by Al-Khamees (1972).

2. GABBROIC ROCKS

They are the most abundant rocks in the area of study, where they form a layered complex. They include the following types, listed in order of abundance:

Gabbro:	composed mainly of plagioclase and monoclinic pyroxene, with accessory amounts of olivine (less than 10%).
Eucrite:	composed essentially of plagioclase and equal amounts of monoclinic and orthorhombic pyroxenes.
Troctolite:	composed mainly of plagioclase and olivine.
Olivine gabbro:	composed mainly of plagioclase, monoclinic pyroxene and olivine.
Olivine norite:	composed mainly of sodic plagioclase and secondary hornblende. It is the result of alteration of other types of gabbroic rocks.

Texture

The gabbroic rocks are coarse grained, equigranular and xenomorphic to hypidiomorphic. They are characterised by primary and secondary textures. The most characteristic primary (magmatic) texture occurs in olivine norite, where olivine crystals are partly or totally enclosed by both plagioclase and pyroxene crystals; some of these olivine crystals are corroded and rounded. This texture was probably formed during early magmatic crystallisation of the minerals, where corrosion of early formed olivine by the magma began at the time of crystallisation of calcic plagioclase and orthorhombic pyroxene. Also some plagioclase inclusions are present in pyroxene crystals; in other cases some pyroxene and olivine crystals are partly included in plagioclase.

The secondary textures resulted from alteration of the primary minerals. A special alteration texture was observed in some gabbros. Where the uralite masses after pyroxene come in contact with plagioclase, a thin film of fibrous serpentine and/or chlorite is developed. Mesh texture is common especially in troctolite. Cracks in plagioclase crystals due to expansion of olivine during serpentinisation is also common. Small serpentine veins also cut plagioclase and pyroxene. In some uralitised gabbros, poikilitic texture is common, where small tabular plagioclase crystals are included within large plates of green secondary hornblende.

Mineral composition

Plagioclase. It is the most abundant mineral in the gabbroic rocks where it may amount to more than 50% by volume. It occurs as subhedral to anhedral grains with a tabular habit. In shear zones, plagioclase shows granulation due to crushing with the development of secondary deformational twins. Kaolinisation and saussuritisation is also common in plagioclase.

Orthopyroxenes. They are represented by hypersthene and less commonly by enstatite. They are commonly altered to hornblende in the rims. Uralitisation occurs in the core of some hypersthene crystals, in some eucrite and olivine norite samples. Serpentinisation in orthopyroxenes is rare and never forms bastite.

Monoclinic pyroxenes. Both augite and diallage occur in most of the gabbroic rocks. In diallage (100) parting is very common; (001) parting is also present but much less common. Simple twinning is very common in the monoclinic pyroxenes. They are also commonly altered into green hornblende and tremolite, into serpentine minerals or less commonly into chlorite.

Olivine. Euhedral olivine crystals occur in olivine norite; in other gabbroic rocks it forms equidimensional grains. It also occurs as inclusions in pyroxene crystals.

Secondary hornblende. Green hornblende is pseudomorphous after pyroxenes and it frequently contains relics of them. In uralitised gabbro, it forms large poikilitic plates which enclose other minerals.

Opaque minerals. They include chromite, picotite, magnetite and sulphides.

Alteration products. These include actinolite, tremolite, chlorite, prehnite, bowlingite and serpentine minerals.

3. SCHISTS

The green schists include three groups of assemblages. The calcareous assemblage is largely composed of calcite marbles with thin laminae of one or more of the following minerals: diopside, epidote, tremolite, quartz, plagioclase and sphene. The basic assemblage is composed largely of tremolite, actinolite and plagioclase, with minor amounts of diopside, zoisite, epidote, calcite, quartz, sphene and opaque minerals. Relic augite is common in this assemblage. The siliceous assemblage is largely composed of quartz and albite with minor amounts of epidote, actinolite, diopside, biotite, apatite, piedmontite and opaque minerals.

The quartz schists are composed largely of quartz and albite with minor amounts of chlorite, muscovite and biotite. Relic plagioclase and relic clastic textures are commonly observed in the quartz schists.

4. SMALL DYKES AND VEINS

Pegmatitic gabbro, quartz–anorthosite and amphibolite dykes and veins cut the ultramafic and gabbroic rocks. The pegmatitic gabbro is a very coarse equigranular rock with a hypidiomorphic texture. It is composed of augite, calcic plagioclase and hornblende with accessory iron oxides. The quartz anorthosite dykes occur only in the gabbroic rocks. This rock is an equigranular, coarse grained rock, with a hypidiomorphic texture. It is composed of calcic plagioclase and quartz (up to 20%). The amphibolite is composed of hornblende, plagioclase and quartz. Accessory minerals include augite, diopside, epidote, and iron oxides. The hornblende usually forms poikilitic texture.

CORRELATION OF THE ROCK UNITS

The rock units described in this paper correlate nicely with the rock units described by earlier authors in other parts of the Oman Mountains. Glennie *et al.* (1974) indicated that the main mass of peridotites of the Semail nappe (excluding ultramafic layers within the layered gabbroic sequences) are typical representatives of the earth's upper mantle which, by partial melting, produced basaltic liquids. Upon crystallisation, these liquids produced the other units of the Semail nappe. Therefore, the peridotites are interpreted as the refractory residues which recrystallised at great depths and were brought to the surface in a solid state. Near the top of this unit, a horizon containing abundant chromite lenses marks the transition from the refractory residues to the rocks formed by crystallisation of the basaltic liquids. In the area of the present study, the absence of any chromite lenses in the peridotites indicates that they are part of the refractory peridotites (unit P of Glennie *et al.* 1974). Their geochemical characteristics (Al_2O_3 < 1%, CaO 0·66–1·29%, Na_2O < 0·05%, near absence of K_2O and TiO_2) (Hassan *et al.* 1979) support this view. The gabbroic rocks are clearly cumulates produced by crystallisation of the basaltic liquids.

The schists in the area studied were originally a sedimentary succession dominated by calcareous and dolomitic sediments containing appreciable amounts of pyroclastics and cherts and smaller amounts of sandstones with minor calcareous impurities. This succession is very similar to the rock assemblages of the Hawasina complex (Allemann & Peters 1972; Glennie *et al.* 1974). According to the mineral assemblages of these schists, it is clear that they were metamorphosed in the green schist facies at its upper limit transitional to the amphibolite facies (Turner 1968). The cause of the metamorphism may have been the deep burial under the ophiolite sequence during nappe emplacement, aided by frictional forces during that movement.

Allemann & Peters (1972) subdivided the metamorphic rocks in the northern part of the Oman Mountains into monometamorphic and polymetamorphic series. The polymetamorphic series suffered an early metamorphism in the amphibolite facies and a later one in the green schist facies (retrogressive metamorphism). The monometamorphic series was affected by the later metamorphism only. The same authors also stated that between the two metamorphic phases, granitic and quartz veins were intruded. The metamorphic rocks of the study area were included in the polymetamorphic series by Allemann & Peters (1972).

Glennie *et al.* (1974) agreed with Allemann & Peters (1972) as to the subdivision of the metamorphic rocks and the retrogressive metamorphism of the polymetamorphic series. However, retrogressive metamorphism could not be detected in the present study. Furthermore, relic textures preserved from the premetamorphic conditions are common in both the green schists and the quartz schists of the present study.

Two small blocks (not *in situ*) of calc–silicate rocks were found in the fault zone of Wadi Ham, in an area about 1·5 km northwest of Bulaydah. These are believed to be tectonic inclusions brought into their present position by the fault. These blocks contain the following mineral assemblages:

(1) calcite–diopside–grossularite(–plagioclase–epidote) with interlayered bands of quartz–diopside.
(2) diopside–wollastonite–grossularite(–plagioclase–microcline–sphene) with quartz and calcite pockets.
(3) diopside–wollastonite–quartz(–plagioclase–sphene) with quartz bands which contain rolled diopside crystals.

These assemblages present a higher grade of metamorphism than is common in the schists and belong to the higher ranges of the amphibolite facies (Turner 1968). They may represent the earlier higher metamorphism of Allemann & Peters (1972). However, no signs of retrogressive metamorphism were recognised in the thin sections studied.

ACKNOWLEDGEMENTS

Support of this work by the Geology Department, Kuwait University and the Kuwait Institute for Scientific Research is greatly appreciated. The generosity and hospitality of the Amiri Dewan (Office) of Al-Fujairah Emirate, of which the authors were guests during part of the field work, are also acknowledged.

REFERENCES

Al-Kahmees, A.H. 1972. Geological studies on the serpentinites of the Oman Mountains, Trucial States. M.Sc. thesis, Kuwait University.

Allemann, F. & Peters, T. 1972. The ophiolite–radiolarite belt of the North-Oman Mountains. Ecol. Geol. Helv. **3:** 657–97.

Glennie, K.W., Boeuf, M.G.A., Hughes Clarke, M.W., Moody-Staurt, M., Pilaar, W.F.H. & Reinhardt, B.M. 1974. Geology of the Oman Mountains. Konink. Nederlands. Geol. Mijnbouwkundig Genootschap Verh. **31:** 423 pp.

Hassan, M.A. & Al-Sulaimi, J.S. 1979a. Copper mineralisation in the northern part of the Oman Mountains near Al-Fujairah, United Arab Emirates. Econ. Geol. **74:** 919–24.

Hassan, M.A. & Al-Sulaimi, J.S. 1979b. Cumulus layering in gabbroic rocks of the Oman ophiolites, United Arab Emirates. J. Univ. Kuwait (Sci.) **6:** 261–71.

Hassan, M.A., Essawy, M.A. and Al-Sulaimi, J.S. 1979. Geochemistry of some ultramafic and gabbroic rocks from the northern Oman Mountains, United Arab Emirates. J. Univ. Kuwait (Sci.) **6:** 243–60.

Penrose Conference Participants, 1972. Ophiolites. Geotimes **17/12:** 24–5.

Smewing, J.D., Simonian, K.O., Elboushi, I.M. & Gass, I.G. 1977. Mineralized fault zone parallel to the Oman ophiolite spreading axis. Geology **5:** 534–8.

Streckeisen, A. 1976. To each plutonic rock its proper name. Earth-Science Review **12:** 1–13.

Turner, F.J. 1968. Metamorphic petrology, mineralogical and field aspects. McGraw Hill, New York: 403 pp.

(Received 6 January 1979)

دراسات جيولوجية وبتروجرافية في الجزء الشمالي
من جبال عمان ، شمال غرب الفجيرة ،
الامارات العربية المتحدة

ممدوح عبد الغفور حسن
هيئة المواد النووية
ص.ب ٩٨ ، مساكن مدينة نصر ،
القاهرة ، ج . م . ع .

جواد صادق السليمي
معهد الكويت للأبحاث العلمية ،
الكويت

خلاصة

يقدم هذا البحث دراسات جيولوجية وبتروجرافية للصخور فوق المافية والجابروية وصخور الشست في منطقة تبلغ مساحتها حوالي ١٠٠ كم^{٢} وتقع شمال غرب مدينة الفجيرة بحوالي ١٠ كم . وقد أدت الدراسات الحقلية إلى التعرف على العلاقات بين الوحدات الصخرية بالمنطقة وكذلك التراكيب الجيولوجية بها ، وأدت الدراسات المجهرية إلى التعرف على نوعية الصخور التي تشملها كل وحدة من هذه الوحدات . وأشار البحث في النهاية إلى الارتباط بين الوحدات الصخرية بالمنطقة المدروسة والوحدات الصخرية في جبال عمان بصفة عامة .