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The Geology of the Jabal Al-Qunnah Area, Saudi Arabia

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ABSTRACT. This paper describes the field geology of the area to the north of the Al-Jibub which is bounded by 41° 05′ E-41° 10′ E longitude and 21° 00′ N – 21° 05′ N latitude. The Jabal Al-Qunnah is an elliptical body measuring 10 by 6 km with its major axis trending 032°. The area has been studied topographically using aerial photographs, spot heights and contour lines, and has been divided into four land form categories. The highest point is 1620 m while the lowest elevation is 1400 m above sea level. This area broadly consists of hills of moderate relief cut by narrow and broad wadis (mostly fault controlled) in which the more common sediments are generally coarse gravels with some sand. Wind blown sand forms local small dunes. Sand and gravels derived from the local outcrops occur in the nearby wadis and samples from the alluvium wadi deposits have been studied geochemically.

The solid geology consists of Bahah group metamorphics which are intruded by a large gabbro and peripheral ring granites. There are also numerous dykes, some of which are possibly of Tertiary age. To the west is a large granitic pluton that makes relatively low ground with a sand and gravel blanket through which small masses of weathered rocks arise. This granite cuts the gabbro and has a shear margin against it. The gabbro has been altered along shear zones and faults, and generally has developed a patchy greenschist facies metamorphic assemblage.

The gabbroic body shows relict layering on various scales including megalayers some 300 m thick. The structure of this layered, inverted cone intrusion has been studied in detail by making several traverses, as a result of which, the igneous pluton has been petrographically divided into six different lithological units, clinopyroxene gabbro An_{65}, hornblende-clinopyroxene gabbro An_{55}, hornblende gabbro (with kaersutite and An_{48-52}), olivine gabbro, leucogabbro An_{55}, and gabbro pegmatite with dark prismatic amphibole. There is a general reduction in colour index upward within each layer and from layer to another. the igneous rocks are probably of late Precambrian age and the metamorphics were formed about 1100 m.y. age.

A development model has been postulated for the Al-Taif region which is applicable to the present area.

The Al-Jibub area is located in the west central part of the Arabian Shield. The area studied measures about 10 by 6 km and consists of igneous rocks of varied types and origins: volcanic, unmetamorphosed sedimentary and pyroclastic rocks, and highly to weakly metamorphosed igneous and sedimentary rocks (Fig. 1). The Jabal Al-Qunnah and Adad intrusions occur in the area with the peripheral ring granitic dykes and the western Qazayel calc-alkaline granite in addition to the metamorphic sequence (French and Sindi 1979).

The Jabal Al-Qunnah intrusion has been divided into six main units: clinopyroxene gabbro (An_{65} greenish amphibole), hornblende clinopyroxene gabbro (An_{55} and is wholly amphipolitized), hornblende gabbro (An_{48-52}, kaersutite and is the freshest type of gabbro in the area), olivine gabbro, leucogabbro (An_{55}), and gabbro pegmatite and pyroxenite bodies.

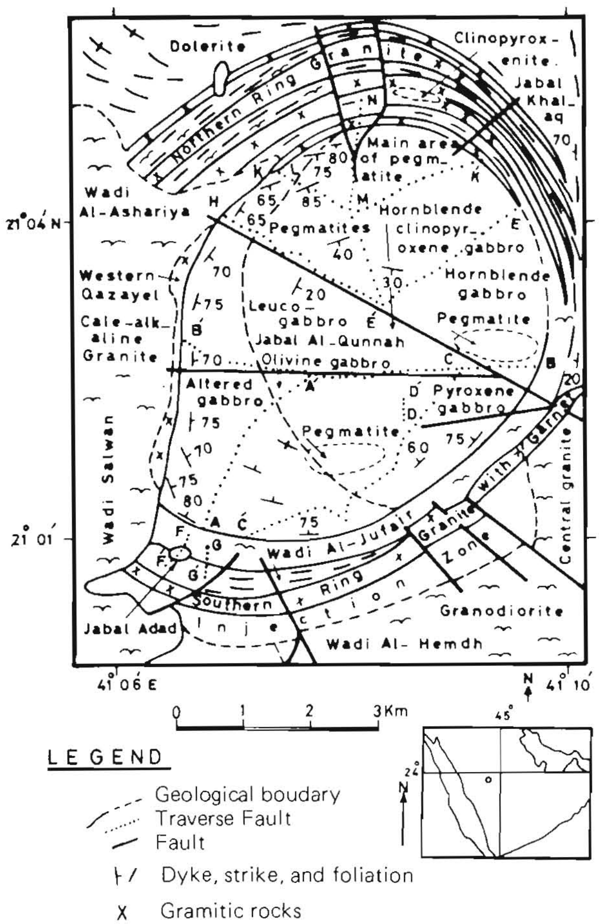

Fig. 1. Types of the gabbroic rocks, direction and location of the studied traverses along the Jabal Al-Qunnah layered intrusion.

These units form in concentric layers to give the shape of the oval body of the Jabal Al-Qunnah outcrop. The dip of these layers is inwards and varies from 80° at the margins to 15° at the centre to give the structure of an inverted cone.

The country rocks follow the regional N-S trend, but deflected trends round the igneous intrusion occur in some places of the north-eastern part of the region.

Weathering processes are active in producing rounded granite surfaces, exfoliation, spheroidal outcrops, scale weathering, pits, caves, tors and pillers. This is in addition to the dendritic and radial drainage pattern, low-lying and controlled wadis.

The area, in general, is extremely arid. Humidity is very low, rain is rare and there are no reservoirs. Temperature varies from 15° to 20°C during winter, and from 25 to 35°C during summer. The area is rocky with no oases and only trivial vegetation. There are only three water-wells in the Jabal Al-Qunnah region, but some small gardens, fields and pumped water-wells are present in the greater Al-Jibub area. Most of the wadis in this area are small and young (*e.g.*, Wadi Al-Hemdh), and feed into other larger more mature wadis in the region (*e.g.*, Wadis Al-Ashariya and Turabah).

Fresh rock samples and minerals have been studied in addition to others from the weathered surface, soils and wadi deposits. No mining takes place in the area, but gold, silver and lead extracted nearby at the Ma'milah area, where there is an ancient gold mine, outside the mapped area of Fig. 1 and is located at latitude 21° 03′ N and longitude 41° 18′ E. Two diamond bore-holes drilled in 1972 and 1973 by the U.S.G.S. indicated that this mine is not rich enough to be worked at the present time (kiilsgaard 1976). A geochemical survey of the region is at present being carried out by the author.

Techniques used

The area has been mapped and studied over a period of more than 30 weeks of field survey and 5 weeks of office work using aerial photographs (1:60,000) taken in 1956 by the U.S.G.S. and D.G.M.R. Ortho-aerial photographs (1:50,000) taken in 1971 by the British Fairey's Survey and the Saudi Arabian Survey were also studied. The topographical map that was made at this stage is produced as Fig. 2.

700 rock samples were collected, of which 82 have been geochemically analysed by X-ray flourescence and atomic absorption methods. 210 mineral analyses have been made using a Hitachi S450 SEM equipped with the 800 EDS analyser. Five soil samples have been collected and geochemically studied in a later stage by atomic absorption spectrometry and wet chemical analysis techniques.

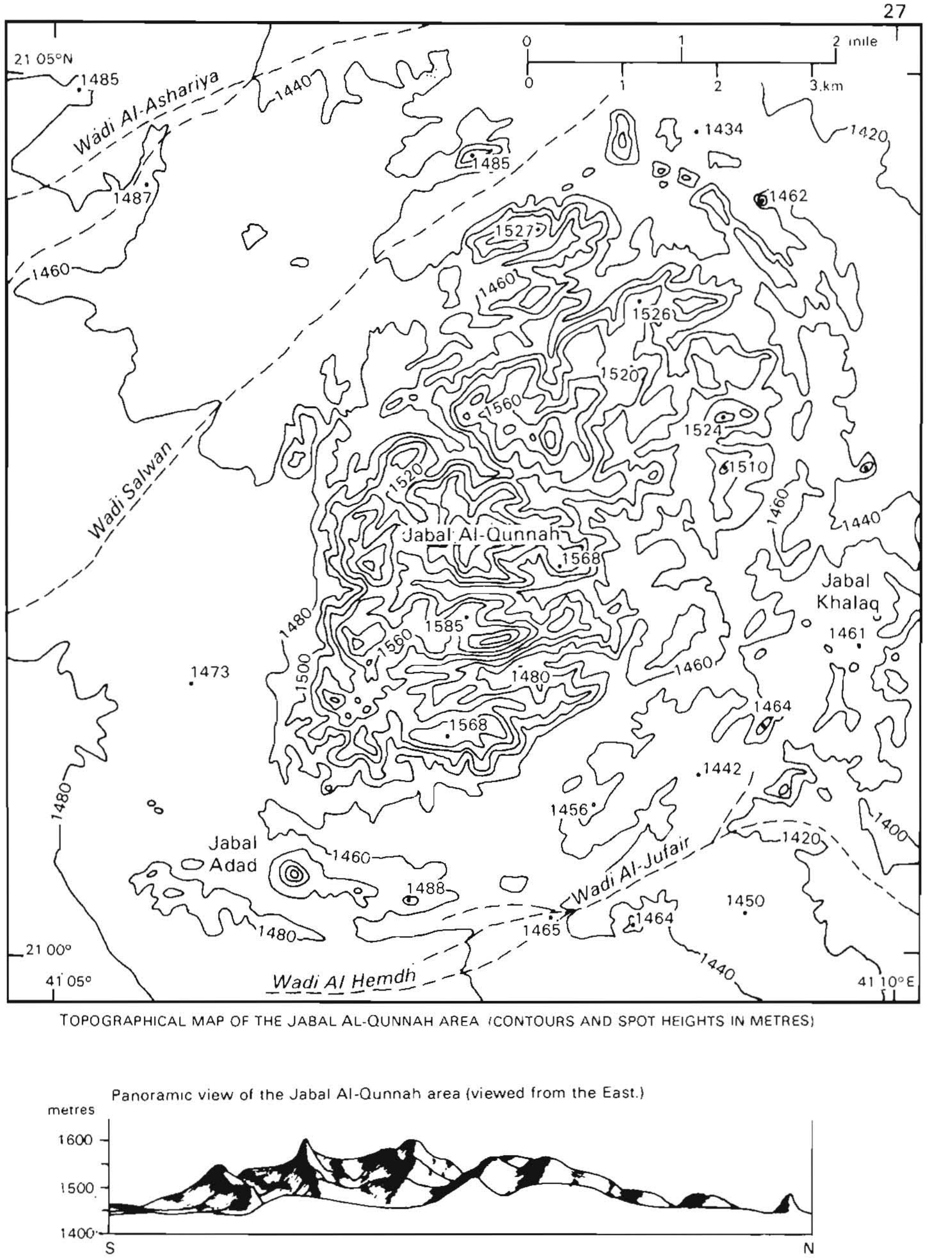

Fig. 2. Topographical map of the Jabal Al-Qunnah area (contours and spot heights in metres).

Topography, Geomorphology and Geology of the Jabal Al-Qunnah

The main direction of the wind in the greater At-Taif area is from the west. The average temperature, from 1966 to 1984, was 14.8°C during winter (January) and 28.3°C during summer (June). The average precipitation was 156.4 mm and the mean humidity 59% in January and 21% in June during the last 18 years. Most of the vegetated areas are on the wadi banks. The surface water that is taken from natural springs and in wells dug in alluvial deposits is enough for domestic uses and normal irrigation (Sindi 1983).

The low ground in this area – occupied by the broad wadis and lower parts of the tributary wadis – lies between 1400 and 1460 m (Fig. 2). Above this level, the main hard rocks rise as steep hills with more solid rocks exposed. The rock types of the gabbro mostly reflect the case of the weathering. There are, for example, broad areas of low relief. Between 1460 and 1520 m the rocks are cataclased and contain much chlorite and epidote. Above this area, there are hills of strong gabbro which tend to reach heights of about 1560 m, while in the centre of the pluton between 1560 m and 1620 m there are strong anorthosite. All these rocks are weathered to various extents and show to the physical and chemical alteration in response to weathering, so that it is difficult to obtain fresh samples.

A panoramic view has been drawn for the area with the topographical map to illustrate the ridge hills and variation in the elevation of the area. A geomorphological model (Fig. 3) has been postulated for the development of the greater At-Taif region in which the area under investigation is included.

The pluton has been affected by tectonic movements, and several faults are present, most of which trend NE-SW and E-W. Erosion along these faults has produced deep valleys and wide wadis. There is also a semblance of a radial drainage pattern over the Jabal Al-Qunnah as a result of the heterogenity of the intrusion, the different types of weathering and the differing resistance of the layered rock types which form these rugged hills.

The roof rocks of the intrusion have been removed completely and many of the contacts lie beneath the wadi deposits. The western part of the layered intrusion is cut by the younger, western Qazayel calc-alkaline granite. This granite is coarse-grained, brittle and highly weathered, and has been eroded to form a low-lying basin covered by the alluvium deposits of Wadi Al-Ashariya.

Wadi Deposits

Poorly sorted gravels derived from the local outcrop, cover most of the wadis in the area. These wadi blankets contain alternating layers of coarse and medium grains and large pebbles. The sand is probably of eolian origin reworked and redeposited by sheet flow of water. Trace element analyses of selected samples

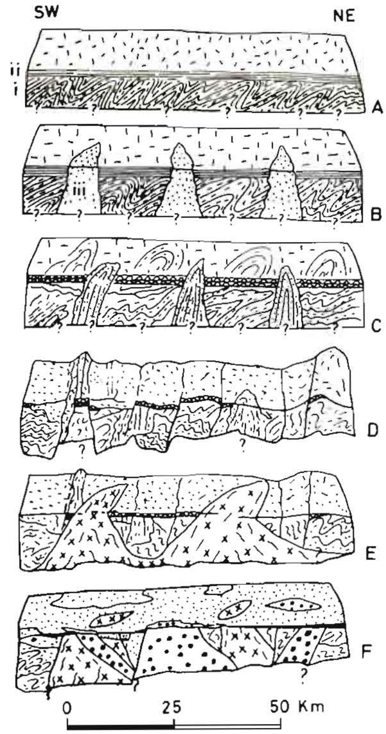

Fig. 3. Postulated schematic geological history for the greater Al-Taif region during the late Precambrian times.

Diagram A: i) The oldest complex, including the oceanic sedimentary rocks and most of the metamorphic rocks of the Arabian Shield folded and metamorphosed in the late Precambrian time but before group (ii).

ii) Other sedimentary rocks including greywacke, arenaceous and volcanic sediments. All of these rocks have been deformed and metamorphosed to form the meta-sedimentary and greenstone rock types in the late Precambrian.

Diagram B: iii) The groups of figure A predate the injection of alkaline acidic magma that eventually formed, orthogneisses batholiths and lit-par-lit structures within the late protero zones of greenstone.

Diagram C: These rocks are more subsequent the metamorphism to form amphibolites, schists and gneisses.

Diagram D: These rocks have been folded and faulted in several tectonic events accompanied polyphases of metamorphism.

Diagram E: Intrusion of granitic rocks (c. 1000 m.y) that took place mainly with late deformation to give them gneissic structure.

Diagram F: In the latest Precambrian time (700-500 m.y.) several injections of young basic, intermediate and acidic intrusions have occurred in the area. These batholihs have also caused some deformation to the pre-existing rocks.

Table 1. Trace element analyses of some selected soil samples (ppm).

Element	1	2	3	4	5
Ba	750	765	416	325	218
Co	90	70	85	18	20
Cr	150	217	319	120	450
Cu	570	320	118	320	425
Ga	5	7	9	3	2
Mn	100	160	120	230	350
Mo	5	4	2	3	1
Ni	60	50	30	20	80
Pb	35	25	20	10	30
Sr	120	20	300	70	315
Ti	3500	3400	3050	2980	3200
V	67	55	44	30	90
Y	10	15	8	20	10
Zn	50	40	20	30	10
Zr	35	40	75	25	82

from the wadi deposits (Table 1) show variable concentrations of elements. Most of the sand is from acidic sources that may be from the local granites, but the basic and intermediate source make significant contributions to these deposits, as the chemical analyses show. Mo, Sc, Ti, V, Y, Zr and Ca are relatively constant, which of indicate their equal distribution in the local rocks. Ga, Mo, Sc, Y and Zr are very low in these deposits that also may indicate their low concentration in the surrounding rocks.

Structure

The metamorphic rocks follow the regional N-S trend and have a westward regional dip of 55-90°, but the emplacement of the Jabal Al-Qunnah intrusion forced the foliation into a synformal shape around the pluton, and parallel to its margin (Sindi and French 1983). The area has suffered several tectonic movements as a result of which steeply inclined E-W, NE-SW, N-S and NW-SE faults, joints and minor folds (chevron and Z types) are present at several localities of the metamorphic country rocks.

Two stages of tectonic movements have been recognized in the pluton. The first movement produced an older set of E-W and NW-SE faults, while the second stage caused the younger NE-SW and N-S set.

The Jabal Al-Qunnah body was intruded with steep contacts into the Bahah group and early metagabbroic rocks, and at a later stage several vertical, ring shaped granitic sheets intruded into the layered gabbroic intrusion and conform with its margins. On the northern side of Jabal Al-Qunnah, the contact between the acidic ring sheets and the gabbroic pluton is sharp and clear and several gabbroic masses appear as rafts within these acidic intrusion.

The Jabal Al-Qunnah gabbroic body is layered in a concentric pattern in which the outer layers dip steeply inwards at 50-70° and progressively more gentle dips follow towards the central layers, that dip less than 20° (Fig. 1, 4 and 5). The strike of layering swings round to give a generally elliptical inverted cone shape, but local distortions due to dyke intrusions and tectonic movements are present. The layers are alternatively of melanocratic and leucocratic materials. Slump structures, drag folded layers and crystal settling structures are present, mainly in the southern and southeastern part of the pluton. Rhythmic layers and gravity stratification range in thickness from 1 cm to about 60 m.

The lamination of the minerals is parallel to the layering. Morever, density grading occurs in the rhythmic layers, with pyroxene concentrations at the base grading upwards to the leucocratic minerals which in some places are sharply superseded by another dark layer. The rhythmic layers grade towards the centre

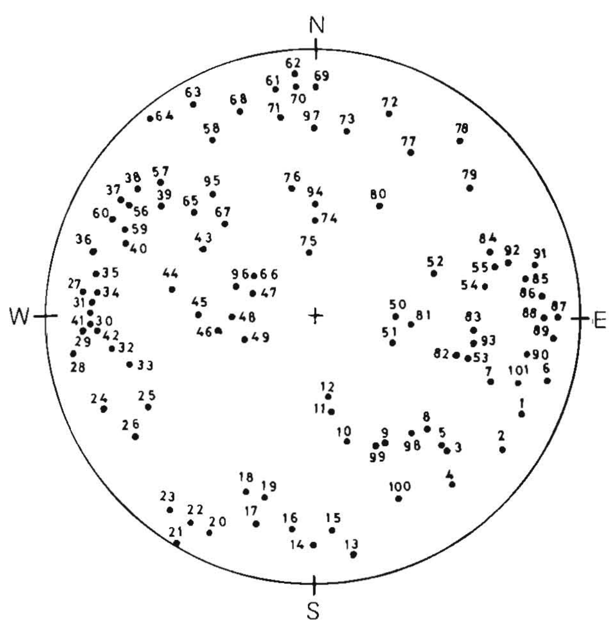

Fig. 4. Lower hemisphere stereogram of poles to the layering in the gabbros of the Jabal Al-Qunnah. The numbers relate to samples taken from the measured outcrops of the traverses.

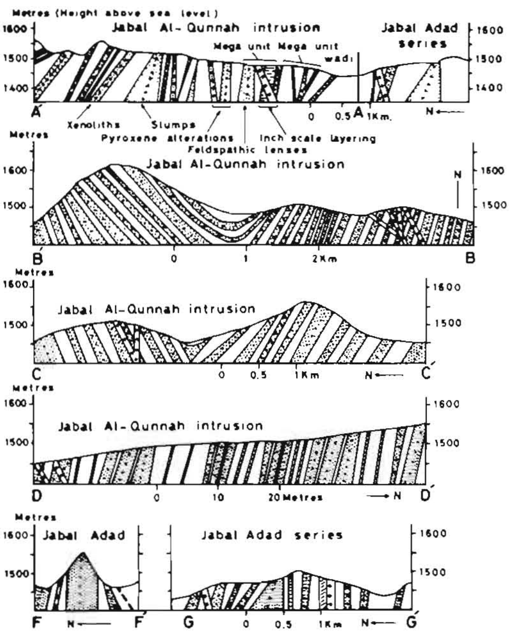

Fig. 5. The different traverses of the Jabal Al-Qunnah and Jabal Adad intrusions.

into a uniform composition and grain size, giving massive, non-layered, plagiocla-se-clinopyroxene gabbro with colour index ranging from 35 to 90 in the mafic layers and from 15 to 30 in the feldspathic layers. Massive, fresh gabbros, hypabys-sal intrusives and several acidic dykes of assorted composition and wide age range are present in several localities of the pluton. Veins of plagioclase-rich gabbro cut the central layered gabbros of the pluton in various directions.

Detailed Field Relations of the Jabal Al-Qunnah intrusion

The gabbroic rocks of the Jabal Al-Qunnah layered intrusion have been divided into six units, but there is no systematic variation of these types with stratigraphic position or level.

a) Clinopyroxene gabbro forms the bulk of the outcrop with colour index 40-80, plagioclas An_{65}, and some evidence of cryptic layering.

b) Hornblende-clinopyroxene gabbro occurs in different places in the southern half of the intrusion, with a colour index of 60-85. Corona textures are present, and plagioclase composition is An_{55}. This rock type is almost wholly amphibolitized.

c) Hornblende gabbro is the freshest gabbro in the area and occurs mainly in the northeast of the pluton with colour index 40-60, dark brown 10 × 8 × 8 mm hornblende (kaersutite) and plagioclase composition of An_{48-52}.

d) Olivine gabbro occurs mainly in the west-central part of the oval body. It occurs as sheets within the main mega layers. No boundary can be drawn around the zone where this type of gabbro occurs.

e) Leucogabbro occurs mainly in the centre and towards the top of the Jabal Al-Qunnah intrusion with colour index 15-25 and plagioclase composition of An_{55}.

f) Gabbro pegmatite occurs as elliptical discrete pockets, lenses or pods parallel to the layered structure, and has dark-green prismatic amphiboles up to 10 cm long.

In the far north and north-east of the area, there are pyroxenite masses measuring about 30 m by 50 m and several such small masses (30 m × 10 m) are found in other parts of the pluton.

To the south-west of the pluton, there is a small intrusion of weakly layered, coarse-grained, melanocratic, amphibolitized-clinopyroxene gabbro isolated from the rest of the main gabbro outcrop. It forms a hill called Jabal Adad. This rock is slightly metamorphosed, the pyroxene altered to green amphibole and the plagioclase (An_{50}) is highly sericitized. The collected samples are very similar to those from the southern part of the Jabal Al-Qunnah. They have sieve, poikilitic, ophitic and subophitic textures.

The layers of the pluton are not at their original angle of repose, and the oval Jabal Al-Qunnah outcrop has been faulted and deformed at different stages since consolidation. The layered gabbroic rocks include clinopyroxene, calcic plagioclase (An_{45-80}), olivine, apatite, brown and green amphibole and opaque phases as the main igneous minerals. Olivine forms large crystals and may be enclosed within even larger clinopyroxenes. The rocks are altered by cataclasis with the formation of epidote and chlorite, and calcite occurs as a replacive and uniform phase. The more widespread alteration includes the development of additional epidote and colourless to pale-green actinolitic amphibole. Quartz also occurs secondarily and in thin veins. Brown amphibole forms rims, resistant to alteration, around clinopyroxenes or around opaque phases, and occasionally forms large single prismatic crystals. Ophitic (or relict ophitic) texture is sometimes seen, but most often the feldspars are interstitial to the mafic minerals. Alteration is capriciously distributed and in some reactions pyroxenes have been converted to fibrous uralitic pseudomorphs, while feldspars are sausuritised. In thin sections, fresh zoned feldspar may be found along with only slightly altered pyroxenes.

The rocks are extremely diverse and for the sake of brevity only representatives of each of the main rock type of the selected traverses are described in detail.

A net of twelve traverses have been made in various directions to study this inverted cone intrusion. Of these, representative traverses have been selected for description in this paper. The most distinctive area of the rhythmically layered intrusion is the southern part where there is a clear continuous sequence of layering for a distance across strike of up to 3 km, comprising some 30 units. The major units vary in thickness from 5 m to 160 m.

i) *Traverse A-A'*

This traverse crosses the body from the south-west to the centre and consists of several major units. The first of which is only partially exposed because of erosion, so that the base is not seen. The basal layer is overlain by an altered leucocratic pyroxene gabbro. This layer strikes at about 100° and its dip is steeply northwards at about 70° and extends to about 115 m in thickness. Some contorted layers have folds steeply plunging to the southeast.

A) *Mega layer one* is the first layer in this traverse, from which five samples have been collected. It has a colour index of about 50 and a layered structure even at the scale of the single thin section. The melanocratic thin layers, 10 mm thick, are mainly green to colourless amphibole, clinopyroxene, epidote and patches of opaques. The thin leucocratic layers, 25-30 mm thick, are mainly plagioclase An_{57} with $2v_{\gamma} = 85°$ and crystal size 1-4 mm across with corroded edges, but green material and material impregnated with opaque dust are also present. Large single opaque crystals 4 mm long occur sporadically in the green material of the melanocratic layer. These crystals are mantled by a thin zone of dark amphibole and sometimes sphene.

The size of the amphibolitized-clinopyroxene crystals is about 4 mm across, but some are 0.5-2 mm across. Other clinopyroxene crystals are up to 10 mm across and show pleochroism from pale-reddish brown to pale-purple colour. Some of the brownish clinopyroxene (titaniferous diopside) crystals are corroded on the surfaces while others have a peripherial reaction rim. These crystals are 1-4 mm across with $2v_{\gamma} = 60°$ and $Z \wedge C = 40°$ and occur mostly in subhedral rectangular shape elongated parallel to the layering.

The green amphibole, actinolite, is in aggregates of small grains each up to 0.5 mm long by 0.1-0.2 mm across and interpenetrated. There are occasional larger grains up to 7.0 mm long by 0.1-0.5 mm across. The value of $2v_{\gamma}$ is 80° and $Z \wedge C = 17°$. Amphibole sometimes fills rectangular areas which may represent former pyroxenes and some of the larger amphibole crystals and aggregates enclose clinopyroxene grains.

Epidote-clinozoisite measures 1.0-2.5 mm long and 0.5-1.5 mm across with $2v_{\gamma} = 80°$ and $Z \wedge C = 5°$. A few thin zones of epidote (200 μm) cross the sample. Long intergrown, lath-like chlorite grains (penninite) each 0.5-0.7 mm long by 0.1-0.3 mm occurs with $2v_{\gamma} = 20°$ occurs with weak pleochroism of pale-green to pale-brown, but some have anomalous blue birefringence and are up to 1.00 mm long and 0.1 mm across. Minor amounts of white mica and also of brown biotite in tiny flakes are present. Apatite makes 0.5-3.5% of the layer, measures 0.5 by 1.5 mm and occurs within the zone of epidote and iron oxide dust that impregnates the amphibole. Quartz, 0.1-1.00 m, occurs as interstitial grains and fills fractures and joints. Thin seams of carbonate (100 μm) occurs in these samples.

The mesocratic gabbros retain the banded structure of the layered gabbro, but with rather poorer definition than in the first lower part of the mega layer. Veins of prehnite occur, but they have been produced secondarily as extremely fine needles. Both cataclasis and hydrothermal metamorphism are clear in this part of the intrusion.

B) *Mega layer two* has a base marked by dark rock (25 m thick) containing blocks and Pebble-like inclusions of coarse, layered, leucocratic material. It has a conglomeratic appearance and may have derived from the layer immediately beneath. The mega layer is more altered and contains much more radiating and sub-radiating aggregates of green amphibole than the layer beneath. The plagioclase (An_{58}) is more altered to sericite and epidote. About 9% apatite is present as large crystals and in aggregates. The melanocratic layer has some luster-mottled pyroxene about 4 cm in grain size and is overlain by a 59 m leucocratic layer that has 65% feldspar (An_{55}) and some melanocratic lenses parallel to the layering.

C) *Mega layer three* lacks apatite and has traces of original brown amphibole and opaques. The melanocratic and leucocratic alternations vary from 5 mm to units of about 2 m thick that may contain many alternations of various thicknesses. Xenoliths and enclaves of leucocratic materials can be found sporadically through the next 5 m of this layer which can be traced laterally for tens of meters. This melanocratic layer grades in composition upwards into the next leucocratic layer where the feldspar makes up as much as 70% of the rock.

D) *Mega layer four* has granular amphibole rather than the radial habit of the previous layers. Opaques mark a separate layer and are converted superficially to sphene. Original brownish clinopyroxene occurs, but there is no sign of brown amphibole. Some of the pyroxene crystals have schiller structure. Apatite is of low abundance. Most of the green amphibole contain dendritic opaques which may be inherited from original pyroxene. The dip of this layer is inwards at about 50° and the strike is 085°. Fine-scale repetition of various subordinate layer is super-imposed on the darker layered unit. The top (upper) surface of this mega unit is sharply defined and overlain by the dark base of altered ultrabasic rocks of the next layer which again contains various sizes of 'pebble' xenoliths. The leucocratic layers have some melanocratic lenses which are arranged parallel to the layering. The length of these lenses is typically 5 cm and the length to thickness ratio varies from 2 to 5.

E) *Mega layer 5 to 10* have granular epidote and are rich in opaques. Apatite is moderate in quantity and plagioclase is An_{60-65} with corroded edges. Some of the plagioclase is altered to epidote and white mica with bending and displacement of the twin lamella. Small flakes of biotite occur with sphene and brown amphibole. Opaques have thin selvedges of sphene in this mega layer. Pale-green amphibole form coarse felted crystals.

F) *Mega layers 11 and 12* are thinly banded (millimeter scale) and have a total thickness of 122 m each. They have green and brown amphibole and plagioclase (An_{70}), and are cut by doleritic dykes. Quartz veins occur between the melanocratic and leucocratic parts of the layers. Thin seam of carbonate crosses the minerals of these layers. Apatite is 8%, but decreases towards the top of layer 12.

G) *Mega layer 13* has pegmatitic crystals of mottled green amphibole, and has large and abundant opaques and apatite which reaches up to 12%.

H) *Mega layers 14 to 17* are rich in clinopyroxene and opaques and have much higher degree of alteration of clinopyroxene in which the alteration and the thickness of the leucocratic layers increase towards the centre of the intrusion. The plagioclase composition is An_{70}. Thin seams of quartz, carbonate and prehnite pass through the rocks.

I) *Other layers of Traverse A-A'* extend to the centre of the pluton. The base of the next layer is marked by dark 'conglomeratic' rock which contains blocks and pebble-like inclusions of coarse, layered, leucocratic material that may have derived from the layer immediately beneath. Plagioclase tends to become more calcic. Fresh hornblende gabbros have been collected from two small outcrops which appear within some of the layers. The differences between units are mainly in the overall proportions of mafics and felsics. The layers grade in colour index towards the centre to become more leucocratic, massive, equigranular and highly altered. Such alteration is indicated by mechanical cataclastic degradation of the igneous minerals. Generally, these layers are more highly amphibolitized in the southern part of the traverse than in the northern section.

ii) *Traverse B-B'*

This traverse crosses the pluton in an east-west direction. It crosses several major layers and shows the overall symmetry of the layered intrusion. At both ends of this traverse, the strike of the layers is about 030° and the dip is steeply inwards at about 70° at the edges, but it progressively decreases to become less than 20° at the centre of the intrusion. The rocks of the eastern part are much less altered than in the western and south-western regions of the intrusion. At the eastern side, the rocks are homogeneous, mottled, and coarse-grained, and the pyroxenites have ophitic and subophitic textures. The contact with the Bahah country rocks is easily defined to within a few meters. At the western side, the pluton is faulted and sharply bounded by the coarse-grained, highly weathered western Qazayel calc-alkaline granite that is occupied by the deposits of Wadis Al-Ashariya and Salwan.

A) *Mega layer one* is exposed at the eastern end of this traverse. The lower part is slightly metamorphosed, melanocratic, layered and has a colour index of about 80. It has some leucocratic patches which measure up to 10 mm long by 6 mm across and consist mainly of feldspar crystals. The average size of most of the crystals is about 1.5 mm in diameter, but smaller interstitial grains about 0.4-1.0 mm across are present. Luster-mottled pyroxenes are also present in some rocks. The small scale layering is present even on the scale of the thin sections. Colourless fibrous aggregates of chlorite (may be clinochlore) with $2v_\gamma = 10°$ and $Z \wedge C = 2°$ are present to fill the spaces between the crystals, but penninite with anomalous blue birefringence is also present. A few colourless apatite crystals (0.1 mm in diameter) are present, but their abundance is more in the western side of this traverse than in the eastern region of the intrusion. There are a few thin zones of secondary alteration involving 200 μm seams of prehnite and epidote, and others of carbonate (100 μm) cross the rocks, passing through the secondary amphibole as well as the feldspars and pyroxenes. Quartz veins, pegmatites and basic dykes cut this layer in several localities. The green areas of the rocks are dominated by brown and green amphibole, clinopyroxene, epidote, sericitised plagioclase and some opaques (ilmenite and magnetite) in order of decreasing abundance. Some of the clinopyroxene is mantled with brown amphibole. The high TiO_2 of the samples and the strong brown colour of the amphibole in addition to other optical properties suggests that the brown amphibole approaches kaersutite. Amphiboles make up 60% of the rock while relict patches of clinopyroxene make about 10%. Augite has $2v_\gamma = 60°$ and $Z \wedge C = 45°$.

The ultrabasic layer is overlain by a coarse-grained leucogabbro layer in which the feldspar (An_{50}) composes about 60%, has corroded edges and is patchily altered to epidote and sericite. Apatite makes up about 20% in some areas, but does not have a uniform distribution. For the rest of the unit, the rocks become more leucocratic towards the top and the layering is more regular, with thin mafic seams (5-15 mm) marking out the layering. These seams become thinner and further a part untill near the top of the unit where they are virtually absent. The topmost part of the unit has been dragfolded, with folds of half metre amplitude plunging to the southeast. The remaining samples from this first half of this traverse show essentially the same minerals as the first mega unit.

B) *Mega layers 2 to 21* have brown amphibole (kaersutite) and clinopyroxene. Some of the latter has brown amphibole rims in while both these rims and the remaining amphibole crystals tend to have been changed to a later, diffuse green amphibole. The pleochroism of the clinopyroxene is from pale-reddish brown to pale-purple with $2v_\gamma = 60°$ and $Z \wedge C = 40°$. Colourless aggregates of small subhedral, brown and green amphibole (actinolite) about 0.5×0.1 mm have $2v_\gamma = 80°$ and $Z \wedge C = 15°$-$17°$. Some large anhedral and granoblastic fresh brown amphibole occurs in rows and strings cross the main layer. This phenomena may suggest a secondary subsolidus recrystalization of the brown amphibole from the original coarse-grained hornblende gabbro in which the original brown amphibole has been replaced by a similar brown phase. The clinopyroxene is completely altered to green amphibole in layer 13 upwards where the brown amphibole is almost absent. Olivine crystals about 5 mm in diameter with thin amphibole rims make up about 20% of the rocks in mega layer 15. They are present between the clinopyroxene crystals and have $2v_\gamma = 80°$. Plagioclase (An_{54}) increases in quantity towards the top of the intrusion, and equigranular (An_{70}) anorthositic gabbro with massive uniform composition is found at the centre of the pluton. The dip in layer 21 is about 20°. The contact between the gabbro pegmatite patches and the ultramafic rocks is diffused. Plagioclase, apatite, clinopyroxene, olivine and opaques in addition to some of the kaersutite crystals are preserved from the original igneous rocks in the gabbroic layers of the Jabal Al-Qunnah intrusion.

In the hornblende-rich layers, there are some large central grains of amphibole which merge into finer grained areas of granular amphibole with inclusions of clinopyroxene. Some of these rocks are cut by thin dykes which are mineralogically and texturally similar to the layered gabbroic rocks of this intrusion.

C) *Mega layers 22 to 40* are similar in structure, texture, occurrence, alteration and mineralogy to the leucocratic and amphibolitized gabbro of the southern region which is represented by Traverse A-A′, but they lack apatite and have higher abundance of brown amphibole (kaersutite) and clinopyroxene. In some layers, the brown-amphiboles are granular and form triple junctions between grains, although the aggregate form of the amphibole remains prismatic. Plagioclase composition (An_{65}) tends to be constant. Reaction rims of epidote, chlorite, hornblende and skeletal magnetite are present round some of the feldspar crystals. Large anhedral crystals of magnetite are present in these samples. Some of the clinopyroxene crystals are surrounding by the brown hornblende, and this in turn is surrounded and mantled by green material which may be uralite.

The topographic relief on the western sector is higher than those in the rest of the intrusion. These layers are in reverse order (*i.e.* the basel unit is at the western side of the intrusion and they dip eastwards). The first unit towards the west and adjacent to the western Qazayel calc-alkaline granite represents the top of a major unit which is about 80 m thick, while the next complete layer is 100 m in thickness and begins with amphibolitized-clinopyroxene gabbro with plagioclase of An_{53-55} composition.

Although the actual contact with the western Qazayel calc-alkaline granite is difficult to see in the field because of erosion and the Wadis Al-Ashariya and Salwan deposits that cover it, it is possible to define the contact to within a few meters. Dyke-like sheets from the western Qazayel calc-alkaline granite cut the western side of the intrusion in various places. Many of these sheets have N-S direction, but some are broadly E-W. Pegmatitic gabbro and basic dykes are rarely found at this end of the traverse. At the northeastern side and north-western part of the Jabal Al-Qunnah layered intrusion and within this traverse, there are later gabbroic intrusives which may relate to the emplacement of this large gabbroic body or may possibly have a Tertiary age. Doleritic dykes and mylonitic rocks cut the intrusion in several directions. Quartz veins with suture textures are present in which some of the quartz shows undulose extinction. Some other silica patches represent a late stage of silica metasomatism or silica segregation. Small cavities filled with minute silica aggregates are also present. Late secondary calcite veins and grains are present between the feldspar crystals. There are some vesicular areas (0.8 mm in diameter) in some of the layers of the centre of the intrusion.

iii) *Traverse C-C′*

It occurs in the south eastern part of the intrusion, where the layering is less clearly marked and the mineral proportions and grain sizes tend to be mergent between the different layers, and the grains are less coarse than in the pyroxenic gabbros. Syenite and hybrid, metasomatic, quartz diorite are produced as a modification of the original gabbroic rocks due to the effect of the quartz veins and acidic (granitic) sheets that penetrated the eastern region of the Jabal Al-Qunnah layered gabbroic mass. These minor intrusions also caused diffusion of the boundary between the melanocratic and leucocratic layers, although the fine scale alternating layering is clear.

The plagioclase is An_{55} and chlorite partly replaces feldspars. Amphiboles may approach kaersutite in composition. The apatite crystals measure 1.0×0.8 mm and are free from inclusions. Large (7×1 mm) clinopyroxene crystals with a substantial amount of iron oxide exsolution are present.

Alteration of the feldspars to chlorite and epidote, along with sericite, and the growth of green amphibole in these samples are due to hydrothermal alteration. Alteration was accompanied by mechanical degradation of the igneous minerals. Metamorphism caused exsolution of the clinopyroxene and wavy extinction of feldspars. These alterations place the metamorphism of these gabbroic rocks to be between the amphibolite and greenschist facies.

iv) *The Northern Part of the Oval Shaped Jabal Al-Qunnah Intrusion*

This part of the intrusion has layering less obvious than that in the southern sector. Hornblende gabbro is the freshest lithology in the pluton and occurs in the north-eastern part of the gabbroic body. It has a colour index about 50-70 where the hornblende crystals are generally dark-brown and their average size is about 10×8 mm. The clinopyroxene (probably diopside) is also altered to brown and green amphibole, but to a lesser extent than in the rest of the samples of this layered body. Its average measurement is about 4 mm across, but some crystals can be up to 10 mm across. The plagioclase (An_{48-62}) is patchily sericitized.

v) *Pegmatite*

There are two types of gabbro pegmatite in the area. Pyroxene-rich gabbro pegmatite occurs in the central and western regions of the pluton and is cut by veins of the younger plagioclase-rich gabbro pegmatite that occurs mainly near the centre of the Jabal Al-Qunnah intrusion. In some areas, slightly rotated xenoliths of the layered gabbro have been seen in the gabbro pegmatites, with no clear sharp contacts or edges with their host. In other places, elliptical discrete pockets, lenses and pods of the gabbro pegmatite are present parallel to the layered structure. The pegmatites have close affinities with the main gabbroic intrusion in having mergent margins and similar compositions. The two types of pegmatite may have been emplaced one after the other into the still hot gabbroic body. The pegmatite is almost wholly pyroxene and plagioclase. Each of the dark green amphiboles, pyroxenes and plagioclase crystals of these gabbro pegmatites measures 2-10 cm across.

A large mass, about 70 m across, of gabbro pegmatite is found to the north of Traverse B-B′. The boundary between this gabbro pegmatite and the fresh hornblende gabbro of this region is difficult to define. Further towards the north a coarse massive pyroxenite body (500 m by 300 m) has also been found. At the north east of the pluton, there is a pyroxenite mass (30 × 10 m) which is cut by a fine-grained hornblende-gabbro dyke trending 070°. Several such masses are also found in other parts of the pluton. There is no other clear relation between the pyroxenites and any of the other rocks in the area, but it is reasonable to link them with the main gabbroic body.

vi) *Jabal Adad Intrusion*

A separate small hill of coarse-grained gabbroic body is present between the southwest of the Jabal Al-Qunnah pluton and the north of the southern Al-Qunnah ring dyke. This is called the Jabal Adad intrusion, and is isolated from the previous gabbroic and granitic batholiths by deep, fault-defined wadis. It is faulted in the NE-SW direction and makes a steep feature rising about 100 m. Its outcrop is about 800 by 500 m and has sharp contacts with the old foliated layered metagabbro, amphibolites and Dhurah gneisses and the other metamorphic rocks. The intrusion is less obviously metamorphosed and more weakly layered than the southern part of the main Al-Qunnah gabbroic body. The Jabal Adad amphibolitized gabbroic rocks (Traverse F-F′) have typically gabbroic texture, coarse-grained and have dark grey colour with lustre mottled pyroxene in places. The pyroxene is partly altered to amphibole and the feldspar has been sericitized. The strike of the layering is east-west and the dip is almost vertical. Some of the melanocratic and leucocratic layers gradually merge into each other, but some of the felsic layers are sharply overlain by the mafic bands. The basic layers are much thicker than the upper felsic units and the whole of the central part of the Jabal Adad consists of only one basic layer about 500 m thick. The intrusion has been cut by andesitic and granitic dykes and by acid pegmatite intrusions.

East of the Jabal Adad, another Traverse G-G′ has been made to examine the relations between the Adad gabbro and the strongly foliated and metamorphosed metagabbro of the country rock (Sindi and French 1983). The schistosity strikes 085° and the dip is almost vertical. The pyroxene in the metagabbroic bands has been replaced by amphibole, and the plagioclase crystals are sericitized. Screens of the Bahah rocks are present between the metagabbroic bands. Basic and acidic dykes, trending East-West, cut these metagabbros, Both metagabbros and the altered rocks have relict layering much like that of the pluton. Nevertheless, the presence of fold structures and gneissosity can usually be picked out.

Mineralogy and Geochemistry

A summary of the modal analyses of representative samples from the different traverses through the layered Jabal Al-Qunnah gabbroic body and the Jabal Adad intrusion are presented in Table 2. These samples represent a full sequence from highly altered to unaltered rocks. The variation in the quantity and type of minerals depends not only on the alteration process, but also on the layered sequence and the rock type.

Some brownish green amphibole partly replaces the clinopyroxene. Generally, the green amphibole occurs in fine-grained prisms while the brown phase occurs in rims round the clinopyroxenes and opaques. Fresh kaersutite and olivine crystals have been found in the eastern and central parts of the pluton. The chlorite is corundophilite and most of the opaques are ilmenite.

Eighty two whole rock samples have been analysed for major oxides and trace elements on both highly altered surface and least altered samples. Averages, arithmetic mean and standard deviation are present in Table 3. SiO_2 and K_2O are relatively low while Al_2O_3 and CaO are high that reflect the high abundance of the plagioclase and epidote in the pyroxenic gabbro when compared with world-wide gabbroic and pyroxinite rocks (Sindi 1981). The total alkalis is $< 4\%$ and total Fe is > Mg. Al_2O_3, TiO_2, CaO, MgO, MnO, total Fe and H_2O are highly variable.

The low TiO_2, K_2O, K/Na and Fe_2O_3/FeO indicate a sub-alkaline nature according to the definition of Nockolds (1954), while Peacock's (1931) alkali-lime index is 54.5, placing the suite in the alkali-calcic range. These samples are in the mildly alkaline field of MacDonald and Katsura (1964), while they are close to the boundary between alkaline and subalkaline fields of Wenrich-Verbeek (1979). These variation among the different fields are due to the layered nature and therefore varied composition in the rocks. A plot of the chemical analyses of these layered rocks provides compositions belonging to all major petrographic suites (Sindi 1981).

The chemical analyses show that the alterations are due to chemical factors involving hydrothermal process. The alteration diagram (H_2O vs. total Fe) shows a wide scatter of these samples.

Table 2. Summary of selected modal analyses of the main types of the layered gabbroic rocks from the Jabal Al-Qunnah and Adad intrusions at the Al-Jibub area.

Selected samples from traverse A–A′

Sample No. and location / Minerals	241 dark	241 light	247	255	264 A	264 B	265	266	267	268	273	274	281	283	288
Quartz	–	–	–	–	–	–	32	20	15	10	–	–	–	–	–
Plagioclase	12	70	29	7	40	24	18	18	16	12	36	13	59	24	39
Clino-pyroxene	6	2	4	25	1	1	1	8	3	1	1	38	8	9	22
Brown-amphibole	–	–	–	–	–	–	–	–	–	–	1	3	1	13	2
Green-amphibole	42	10	30	33	32	29	28	39	48	43	32	24	19	23	26
Colourless-amphibole	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Opaques	10	5	7	18	8	13	4	3	6	5	10	18	7	4	7
Epidote	18	5	20	4	8	6	5	3	5	10	3	1	1	13	–
Chlorite	8	3	6	7	6	23	8	3	3	11	2	–	1	7	–
Apatite	1	3	2	7	3	3	1	4	1	2	12	1	1	1	1
Calcite	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Others	3	2	2	2	2	1	3	2	3	6	3	2	3	6	3
Colour Index	80	20	60	80	50	45	45	70	65	63	50	70	33	65	43

Selected samples from Traverse B–B′

Sample No. and location / Minerals	384	386	387	390 C	393 1	399 dark	399 light	404	417	421	422	424*	429	439	444	455
Quartz	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Plagioclase	28	19	28	79	30	29	69	8	67	35	29	48	44	21	15	8
Clino-pyroxene	3	4	–	–	40	8	5	4	6	25	3	24	19	–	–	4
Brown-amphibole	29	48	1	4	40	15	5	6	2	13	7	6	10	7	19	1
Green-amphibole	15	12	6	6	10	20	5	49	4	22	19	3	5	12	59	49
Colourless-amphibole	2	1	–	1	1	1	1	1	–	1	1	–	5	2	–	–
Opaques	5	3	10	3	5	12	7	15	4	2	6	4	1	8	2	6
Epidote	7	4	7	2	2	1	1	6	4	1	8	–	9	25	2	13
Chlorite	5	1	35	1	1	1	1	6	9	1	16	1	2	21	–	12
Apatite	1	3	2	1	1	6	1	1	1	–	–	1	1	1	1	–
Calcite	1	1	8	1	1	4	2	3	2	–	9	–	2	1	1	1
Others	4	4	3	2	4	3	3	1	1	–	1	1	2	2	1	1
Colour Index	75	73	60	28	70	60	30	80	15	55	40	50	50	70	85	80

Table 2. Continued.

Sample No. and location	Selected samples from Traverse C–C′										Selected random samples from the Jabal Al–Qunnah												Selected samples from Adad intrusion			
Minerals	219	221	223	368	370	371	373	382	405	408	19	21	23	26	44	50	57	175*	177	179	180	480	10	171	234	236
Quartz	–	–	–	23	10	20	33	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–
Plagioclase	4	14	10	64	42	51	41	62	15	9	12	49	29	2	31	23	63	40	48	45	8	64	5	9	33	3
Clino-pyroxene	1	6	10	1	35	3	–	10	4	5	1	9	15	1	–	37	6	15	17	–	5	10	1	5	1	1
Brown-amphibole	13	6	5	1	1	–	–	3	8	57	1	5	15	1	39	16	9	25	10	–	3	7	3	14	2	1
Green-amphibole	48	59	39	5	5	13	9	8	49	23	58	28	15	42	8	11	8	1	14	39	67	7	78	44	54	65
Colourless-amphibole	–	–	–	–	1	–	–	1	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Opaques	9	5	16	2	1	1	›–	7	7	2	6	1	19	4	3	5	6	2	4	3	6	5	4	10	1	5
Epidote	12	5	10	–	1	1	–	1	3	2	12	2	8	32	9	6	5	–	1	5	1	4	5	9	5	15
Chlorite	8	2	5	–	–	–	–	–	1	1	5	1	5	12	5	1	2	–	1	6	2	2	2	5	2	5
Apatite	3	1	3	–	–	–	–	6	3	–	3	1	1	3	2	–	–	–	1	–	–	–	–	2	–	3
Mica	–	–	–	2	1	2	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Calcite	1	1	1	1	2	8	5	–	2	–	1	1	1	1	1	–	–	–	2	1	1	–	1	1	1	1
Others	1	1	1	1	1	1	2	2	3	1	1	3	2	2	2	1	1	2	2	1	1	1	1	1	1	1
Colour Index	80	75	75	33	35	40	28	30	70	80	80	38	45	43	45	60	30	60	40	45	70	35	70	70	60	60

Others = Other minerals not tabulated above (e.g. quartz, colourless amphibole, mica, prehnite, sphene and zircon).
* = Sample includes olivine not less than 12%.

Table 3. Statistical means, averages and standard deviation for the chemical analyses of the Jabal Al-Qunnah Gabbros.

E \ G. Anal.	A	B	C	Standard Deviation
SiO_2	41.62	42.15	42.00	3.45
TiO_2	2.96	2.62	2.76	1.30
Al_2O_3	15.68	17.88	17.19	4.14
Fe_2O_3	3.38	3.44	3.13	1.57
FeO	8.56	6.53	7.53	2.85
MnO	0.17	0.13	0.15	0.05
MgO	8.80	7.23	8.16	3.58
CaO	11.96	13.45	12.81	2.11
Na_2O	2.56	2.36	2.42	0.79
K_2O	0.54	0.45	0.48	0.32
H_2O^+	2.34	1.78	2.07	0.85
H_2O^-	0.07	0.06	0.07	0.05
P_2O_5	0.46	0.20	0.31	0.94
CO_2	0.95	1.07	1.03	1.01
Ba	135	108	114	98.12
Ce	37	18	25	25.20
Cl	99	88	93	69.07
Co	49	49	51	19.04
Cr	72	49	74	100.74
Cu	287	311	278	234.73
La	28	22	25	12.54
Li@	10	14	14	9.02
Nb	15	25	20	9.74
Ni	50	39	49	46.76
Pb	38	29	33	15.68
Rb	10	8	9	16.51
S	281	251	296	364.37
Sr	786	914	973	577.08
V	394	371	377	182.17
Y	59	18	36	65.53
Zn	71	44	58	28.66
Zr	253	246	248	103.60
Diff. Index	21.78	18.81	19.86	8.22

@ = The Li calculation is for 31 samples.

A = Average of 35 amphibole-rich gabbros, clinopyroxene (≤13%), plagioclase (8-45%), opaque (≤13%) and colour index is 35-85.

B = Average of 41 clinopyroxene-rich gabbros, amphibole (≤25%), opaque (≤10%) and colour index is 15-50.

C = Statiscal mean of the 82 gabbroic samples from the Jabal Al-Qunnah area.

G. Anal.= Group analyses.

E = Elements

Two hundred and ten microprobe mineral analyses have been carried out on number of thin sections from selected rocks from this intrusion, covers most of the rock types of the Jabal Al-Qunnah intrusion and traverses sections.

The feldspars are mainly Ca-rich and the anorthite content varies between 33% and 79%. It is much altered to sericite and in some places to epidote. Most of the clinopyroxenes are altered to pale green amphibole and sieved with opaque crystals and they are Ti-rich (2%). The clinopyroxene falls in the alkaline and peralkaline fields of Le Bas (1962) and spread into the augite field, although some are salite and endiopside.

The layers show no iron enrichment towards the centre of the pluton. Orthopyroxene has not been seen. Although ortho-amphibole (anthophyllite) has been found and analysed, it is a product of metamorphism or metasomatic processes, clinoamphibole being the main amphibole in these rocks. Two main types of these clinoamphiboles have been identified, one with high Al_2O_3 (13.5%) and moderate MgO (11.8%), the other with lower Al_2O_3 (10.8%) and higher MgO (13.2%). Strong brown kaersutites are TiO_2 (7.3%) and Al-rich mineral in which Al_2O_3 is about 14.6%. Magnetite, hematite, ilmenite and pyrite minerals have been identified. Apatite has also been found and has an average of 0.1% Cl. Epidote ranges in composition from epidote$_{77}$-clinozoisite$_{23}$ to epidote$_{92}$-clinozoisite$_8$. Chlorite is in the corundophilite field. Brown biotite and muscovite have also been found in small flakes. Calcite grains are present in veins and as inclusions and interstitial crystals. Fresh colourless olivine crystals ($2v_\gamma = 90°$) have been analysed and they are Ca-poor and Na-rich, they may be hyalosiderite (Fe_{66}).

Summary and Conclusion

The inverted cone of the elliptical Jabal Al-Qunnah layered gabbroic batholith does not have dykes or homogeneous marginal rocks to indicate its source magma. It consists of leucocratic gabbro, amphibolitized gabbro, clinopyroxene gabbro, hornblende gabbro, hornblende-clinopyroxene gabbro, olivine gabbro and gabbro pegmatite. Inch-scale and rhythmic layering with regular mineralogical composition and occurrence are present among the pluton. The grain size tends to increase slightly towards the centre. The abundance of the feldspar increases towards the centre of the pluton and so gives rise to some rocks of anorthositic composition.

The alignment or the tabular minerals, prismatic amphibole, plagioclase laths, apatite and some opaque ores, indicate the features of cumulate igneous lamination. The plagioclase shows, in places, recrystallization to a granular texture in addition to injection by the quartz veins. The area is slightly metamorphosed, which has caused the exsolution of the iron from the clinopyroxene. The recrystallization of brown amphibole to green amphibole is common. The amphibole forms in rows and connected strings. Some of the clinopyroxene crystals are altered to green amphibole and occur in poikilitic textures. They contain short opaque rods of iron ore with regular orientation along cleavages. This amphibolitization has affected the intrusion after the solidification and caused partial replacement of pyroxene, while later metamorphism caused some of the mineral alignment and the metamorphic features in the pluton. The high Ca content of the clinopyroxene together with their restricted Fe-enrichment could therefore be indicative of metamorphic re-equilibration from a formerly alkaline nature. The absence of orthopyroxene and the presence of the titaniferous clinopyroxene and kaersutite suggests an affinity with alkaline-olivine basalt magma. The pressure and temperature for the crystallization of the feldspars is about P_{H_2O} of 5 kbs at 1100°C, but the absence of olivine from most of these gabbroic rocks may indicate lower temperatures, which fits with the co-existence of ilmenite and magnetite in one sample.

The size of the pluton suggests that there would be an overburden of several kilometers. Also, the emplacement of the huge western Qazayel calc-alkaline granitic batholith may indicate that there were several kilometers of rocks above the gabbros. The metamorphic conditions and igneous crystallization put this intrusion deeper than 9 km. Since the mafic minerals are more abundant at the bottom of the main layers, the crystals may accumulated by sinking under gravity in which the structure could be the result of emplacement through a central conduit to a level at which cone sheet like fractures developed and the general structure formed *via* pulses of magma. Each pulse developed a layered structure partly by flow and partly deriving from nucleation and progressive crystallization of the sheets of magma to increasing viscosity, the early pulses becoming immobile before later pulses were emplaced.

The association of the layered gabbros with later calc-alkaline plutons and their emplacement in old polymetamorphic gneisses suggests derivation of the melt from the mantle above a subduction zone.

The evolution of the Jabal Al-Qunnah complex fits with the hypothesis of the Josephine ophiolite (layered gabbro) of California (Harper 1984) and with the model for the origin of the Troodos massif in Cyprus (Moores *et al.* 1984).

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جيولوجية منطقة جبل القنة ، المملكة العربية السعودية

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ص. ب **٢٤٥٥** *الرياض* **١١٤٥١** *المملكة العربية السعودية*

يصف هذا البحث الجيولوجيا الحقلية لمنطقة تقع شمال قرية الجبوب والمحدودة بخطي طول **٤١° ٠٥¯** شـرقا، **٤١° ١٠¯** شـرقـا وخطى عرض **٢١° ٠٠¯** شمالا، **٢١° ٠٥¯** شمالا. جبل القنة عبارة عن جسم بيضاوى حوالى ١٠ × ٦ كم واتجاه محوره الأكبر، **٣٢°**. درست المنطقة من الناحية الطبوغرافية باستخـدام الصـور الجـوية ونقـاط الارتفـاعـات وخـطوط المنـاسيب لتقسم إلى أربع فئات فكان ارتقاع أعلى قمه هو **١٦٢٠**م بينما أدنى مستوى فى المنطقة هو **١٤٠٠**م فوق سطح البحر. تتكون المنطقة بشكل عام من تلال ذات تضاريس متـــوسـطة قطعت بأودية عريضـة أو ضيقـة متبعـة خطوط الصدوع بحيث تكون رسوبياتها من جلاميد وحصى وبعض الـرمال التى تُكوّن برخانات صغيرة وقباب رملية بسيطة. هذه الرسوبيات تكونت من الصخور المجاورة لهذه الأودية فى المنطقة. والتى جمعت منها بعض العينات ودرست جيوكيميائيا.

تتكـون جيولوجية المنطقة من مجموعة صخور الباحة المتحـولة والتى تداخل فيها جابرو جبل القنة مع الصفائح الجـرانيتية المـلاصقـة له والقواطع العديدة والتى قد يرجع

عمرها إلى العصر الثلاثى . يظهر إلى الغرب جسم جرانيتى ذو أرضية منخفضة مغطاة برمل وجلاميد يبرز من خلالها كتل من الجرانيت المُمَعَرَّي والذى يقطع الجابرو ويكوِّن حافة احتراق. يتعرى الجابرو على طول مناطق الضعف والصدوع حيث يتبع سِخْنات الشيست الأخضر المتحول .

يُظهر جسم الجابرو طبقات ذات مقاسات مختلفة تشتمل على طبقات كبيرة بسماكة حوالى ٣٠٠ متر . درس تركيب هذه الصخيقة المتطبقة ذات القمع المقلوب بتفصيل أكثر وذلك بعمل عدة قطاعات مساحية ، ونتيجة لذلك فقد قسمت هذه الصخيقة إلى ست وحدات صخرية على أساس التركيب المعدنى والمعامل اللونى . تكونت هذه الصخور النارية فى عصر ما قبل الكمبرى المتأخر بينما تكونت الصخور المتحولة قبل حوالى ١١٠٠ مليون سنة .

وضع نموذج لتطور منطقة الطائف والذى يمكن تطبيقه على المنطقة المدروسة .