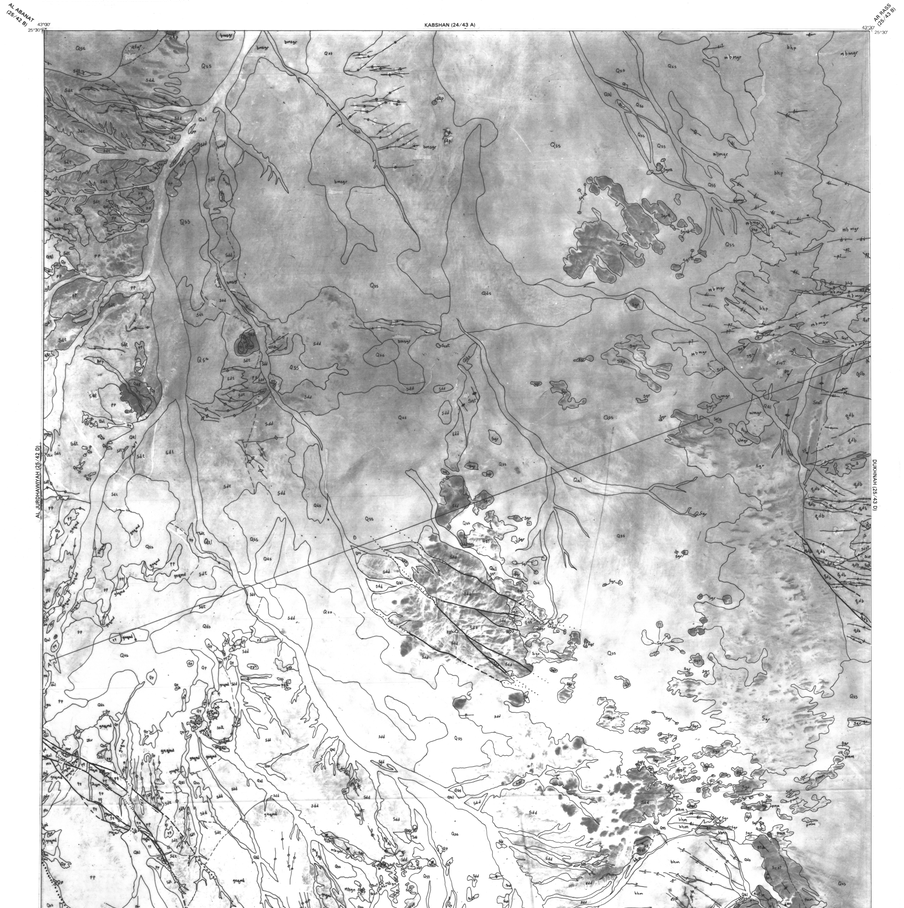
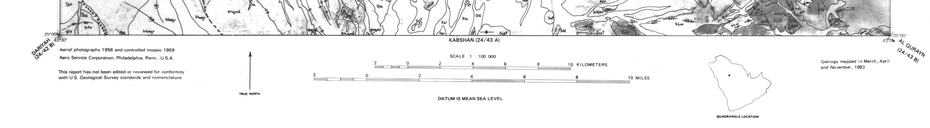
U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, PREPARED FOR
MINISTRY OF PETROLEUM AND MINERAL RESOURCES
DEPUTY MINISTRY OF MINERAL RESOURCES

OPEN-FILE REPORT USGS- 85-130
PLATE 1



ASH SHUBAYKIYAH QUADRANGLE, RECONNAISSANCE GEOLOGIC MAP OF THE SHEET 25/43 C, KINGDOM OF SAUDI ARABIA

by
Robert G. Bohannon
1985



KINGDOM OF SAUDI ARABIA

EXPLANATION

CORRELATION OF MAP UNITS

SEDIMENTS, SEDIMENTARY ROCKS, AND METAVOLCANIC ROCKS

Qal Qes Qp Qds		QUATERNARY
UNCONFORMITY		
Sgr wmgr mgr afgr		
pmm		
HIATUS?		
Sbd	dap	
HIATUS?		
Sbbd Sbbgl bha bhmgr	brp	
HIATUS?		
Sbbd	qdb Mbqzn	
HIATUS?		
Sbbd	pa	
UNCONFORMITY	pgp	PROTEROZOIC
UNCONFORMITY	pgqmd	
Sbbd	Sdd	
HIATUS		
Bcmt		

SYMBOLS

CONTACT—Dashed where approximately located. Quaternary contacts enclosed by continuous contacts

FAULT—Dashed where approximately located; dotted where concealed; arrows indicate relative reparation; arrows and U and D symbols are used only where sense of offset is provided by offset reference planes.

ANTIFORM—Showing trace of axial plane

SYNFORM—Showing trace of axial plane

STRIKE AND DIP OF BEDDING
Inclined, showing dip

STRIKE AND DIP OF FOLIATION
Inclined, showing dip

Vertical

DESCRIPTION OF MAP UNITS

Weakly metamorphosed clastic rocks classified according to the system of Folk (1968); igneous rocks classified according to the recommendations of the International Union of Geological Sciences (Streckeisen, 1976, 1979). Rock types described without regard to relative ages are listed in order of decreasing abundance.

SEDIMENTS, SEDIMENTARY ROCKS, METASEDIMENTARY ROCKS, AND METAVOLCANIC ROCKS

SUPERFICIAL DEPOSITS (LATE CENOZOIC)

Differentiated chiefly by unique characteristics on black-and-white vertical air photographs. Slight variances in albedo, vegetation, and geomorphic expression cause individual units to appear different. All contacts are approximate and most are gradational. Units are somewhat arbitrarily defined. Thickness ranges from 0 to 10 m. Most of the deposits are poorly sorted and very poorly stratified. Sediments and sheet sand deposits include a limited amount of colluvial, alluvial, and eolian sand and gravel accumulations.

Qal ALLUVIAL DEPOSITS IN ACTIVE WADIS—Yellow-tan, light- and dark-brown silt, clay, granules, pebbles, and cobbles, with minor amounts of boulders; poorly to well sorted to very poorly sorted, in general; poorly sorted only within large hills such as Jabal Ajmah; well sorted to moderately well sorted in areas that contain a large component of reworked wind-blown sand and possibly silt; most other components are locally derived directly upgradient. In most cases, components of larger grain size are limited to vicinity of source outcrop and/or large hills. Mapped only in active wadis (Qal); well developed in wadi channels where slope is flat and in wadis where sand is abundant. Abundant in the vicinity of Abraq al Amala, common throughout western side of quadrangle, 0-3 m thick.

Qes SHEET SAND DEPOSITS—Mostly yellow brown sand and silt, also includes granules, pebbles and cobbles near some hills and on some pediment surfaces; well to moderately well sorted at most places, moderately to poorly sorted locally; unconsolidated. In thin tabular bodies, widespread over much of quadrangle. Primarily derived from eolian sand, but includes fluvial and gravity-laid deposits in small hills. 0-2 m thick.

Qp PLAYA LAKE DEPOSITS—Medium-brown, white, and light-brown silt, clay, evaporite minerals, and sand; well sorted; unconsolidated. Small, isolated deposits closely associated with alluvial deposits in active wadis (Qal); well developed in wadi channels where slope is flat and in wadis where sand is abundant. Abundant in the vicinity of Abraq al Amala, common throughout western side of quadrangle, 0-2 m thick.

Qds DUNE SAND—Light-brown to light-yellow-brown sand; very well sorted and rounded; entirely eolian transport and deposition; unconsolidated. Occurs in complex linear and fields of dunes; individual dunes as much as 10 m high. Dunes probably actively migrating in most places. Widespread in the quadrangle, but not enough to support labeling. Deposits limited to a band that stretches from the northcentral to southwestern part of the quadrangle. Includes sheet sand deposits (Qes) but separated by topographic relief of the dunes. 0-40 m thick

SEDIMENTARY ROCKS (LATE PROTEROZOIC)

The Jurdhaiyah group, originally named the Al Jurdaiyah formation by Cole (1981), is one of the most widespread units in the Precambrian of six exposed units in the adjacent Jurdhaiyah quadrangle. Only one of Cole's (1981) units, the volcanic conglomerate, occurs in Shubaykiyah quadrangle, but it is only present in two small outcrops near the central-western and southwestern border. The Murdama group was named by Cole (1981) for a thick, mostly clastic unit that is extensively exposed in the adjacent Jurdhaiyah quadrangle. Only one of Cole's (1981) units, the volcanic conglomerate, occurs in Shubaykiyah quadrangle, but it is widespread in the adjacent Jurdhaiyah quadrangle (Cole, 1981); only one Murdama unit mapped by Cole (1981); and only one unit of the Jurdhaiyah group is present. The Jurdhaiyah group is overlain by the Jubaylah group, which contains the Shayban volcanic and the Jawl diorite complex, zircon dated at 629 m.y. (Cole and Hedge (written comm., 1984), at 683 to 689 m.y. Both of these groups are intruded by granodiorite porphyry (gdp), zircon dated at 620 m.y. (Cole and Hedge (written comm., 1984). Possibly related to the younger sedimentary rocks (pmm) that occur in the plugs of the quartz-feldspar porphyry that intrudes the Murdama. It might be a sedimentary wacke and fluvial deposit derivation. Another possibility is that it is an ash-flow tuff or ash-fall tuff. Cole (1981) did not find any tuffaceous materials in the conglomerate, but tuffaceous materials are present which supports the latter supposition. If it was a widespread pyroclastic deposit, it might correlate with the basal Jurdhaiyah group which Cole (1981) describes as a fine-grained, pervolcanic sediment.

Jcv JURDHAIYAH GROUP, VOLCANIC CONGLOMERATE (Description and thickness after Cole, 1981)—Dark-green to multicolored, weakly bedded, volcanic conglomerate interlayered with andesite flow breccia; clasts are chiefly andesite and basalt, but also include rare dacite and andesite ash, and minor amounts of andesite flow rock. Conglomerate is very poorly sorted, and contains abundant angular to subrounded, boulder to pebble-sized clasts of hornblende-augite-andesite, hornblende dacite, and rare clasts of metarhyolite, basalt, and chert in a matrix of sand and silt. Andesite flow breccia common on upper surfaces of graded fine-grained sandstone, siltstone, and ash beds. Conglomerate and andesite flow breccia make up most of the limited exposures in this quadrangle; conglomerate is best exposed in several hills 5 km northwest of Abraq al Amala, total thickness from 400m to 2,000 m. The entire group thickness exceeds 3,000 m in the Jurdhaiyah quadrangle.

Jss SANDSTONE ASSOCIATED WITH ABRAQ AL AMALA PLUGS—Light-yellow-brown and light-brown, fine-grained, quartz sandstone containing between 10 and 20 percent very fine (intraclastic) sand-size grains of dark-brown fine-grained plagioclase matrix. Thickness and bedding characteristics could not be determined. Possibly related to collapse of caldera associated with plugs of Abraq al Amala, because unit is sparsely and locally found within small areas near outcrops of the quartz-feldspar porphyry (pmm). Another possibility is that it is a sedimentary rock derived from the pmm. If it is related to the pmm, it might be a sedimentary wacke and fluvial deposit. Another possibility is that it is an ash-flow tuff or ash-fall tuff. Cole (1981) did not find any tuffaceous materials in the conglomerate, but tuffaceous materials are present which supports the latter supposition. If it was a widespread pyroclastic deposit, it might correlate with the basal Jurdhaiyah group which Cole (1981) describes as a fine-grained, pervolcanic sediment.

Jsa SANDSTONE AND CONGLOMERATE—Light-gray to light-brown, fine- to medium-grained, quartz sandstone and pebble conglomerate; contains between 10 and 20 percent very fine (intraclastic) sand-size grains of dark-brown fine-grained plagioclase matrix. Thickness and bedding characteristics could not be determined. Possibly related to collapse of caldera associated with plugs of Abraq al Amala, because unit is sparsely and locally found within small areas near outcrops of the quartz-feldspar porphyry (pmm). Another possibility is that it is a sedimentary wacke and fluvial deposit. If it is related to the pmm, it might be a sedimentary wacke and fluvial deposit derivation. Another possibility is that it is an ash-flow tuff or ash-fall tuff. Cole (1981) did not find any tuffaceous materials in the conglomerate, but tuffaceous materials are present which supports the latter supposition. If it was a widespread pyroclastic deposit, it might correlate with the basal Jurdhaiyah group which Cole (1981) describes as a fine-grained, pervolcanic sediment.

Ms MURDAMA GROUP, METALLITSTONE, AND METASANDSTONE (Description after Cole, 1981)—Brownish-green to olive, thinly bedded, slightly fractured, contorted, immature feldspathic volcanic arenite and rare pebble-conglomeratic metasandstone; locally phyllitic; very fine grained to medium grained. Conglomeratic metasandstone contains clasts of andesite, basalt, dacite, rhyolite, quartz-feldspar porphyritic rhyolite, coarse granophyric microcline granite, very fine-grained trachytic andesite, monocrystalline quartz and feldspars and minor amounts of siltstone, phyllite and polycrystalline quartz. Metasiltstone, the only rock type present in this quadrangle, is exposed in several hills 5 km northwest of Abraq al Amala, in southwest corner of the quadrangle. The thickness of the Murdama, although not determinant in this quadrangle, is estimated to be about 2700 m regionally (Letalenet, 1974)

METASEDIMENTARY AND METAVOLCANIC ROCKS (LATE PROTEROZOIC)

Schist in Shubaykiyah quadrangle is part of a widespread, moderately high-grade metamorphic terrane that includes the Ash schist, Hali schist, and Dukhnah gneiss. Ash schist is a term that is commonly applied in a collective sense for all of the schistose rocks of the region. However, in the nearby Dukhnah quadrangle (25/43 D), Beurrier and Villey (1982) restrict the term Ash schist to a sequence of well layered carbonate, clayey silt, graywacke, and volcanic beds. They used the term Hali schist for similar rocks lacking carbonate beds and the term Dukhnah gneiss apparently for similar rocks of slightly coarser, or more pronounced, compositional layering. Schist of the Shubaykiyah quadrangle is intermediate in many of the features of their descriptions. The schist and gneiss are intruded by the oldest dated igneous rocks (the 683-689 m.y. old Dyke) dated; and are the only rocks with a regional penetrative metamorphic fabric. Thus, they probably are the oldest lithologic terrane in the region.

mcst SCHIST—Mostly gray to greenish gray amphibolite grade biotite, hornblende-plagioclase schist and muscovite-biotite-quartz-plagioclase schist; minor amounts of marble and quartzofeldspathic gneiss with compositional layering. Minor amounts of metadacite, metarhyolite, metagabbro, amphibolite, and staurolite and staurolite-garnet schist occur at some locations. Well-developed penetrative fabric ubiquitous; texture mostly granoblastic to granoblastic, but poikiloblastic and porphyroblastic textures also occur; dips of schistosity and layering are commonly steep, but range from 0 to 90 degrees. Thickness and bedding characteristics could not be determined (present at several localities and might be common) observed only in best exposures. Present in southeast corner, east-central part, central to northwest part, and south-central part of the quadrangle. In southeast, prograde to the Ad Dawadimi batholith, grouped with the Dukhnah gneiss, biotite, hornblende, and muscovite; fine-grained muscovite, biotite, and chlorite form retrograde phase replacing coarser prograde minerals. Protolith in southeast part of quadrangle, chiefly graywacke, feldspathic sandstone, shale, and minor amounts of pebble conglomerate with volcanic clasts; in south-central part of and mile also suggested by presence of amphibolite and rare relict igneous textures. Original sedimentary structures rarely preserved; compositional layering ranges from 0.05 to 1m thick; normally grades into schistosity, but locally layering present locally; schistosity intersects bedding (compositional layering) commonly at a 5-15 degree angle. Contact metamorphism of quadrangle, schist is in large triangular-shaped screen between plutons and the Ad Dawadimi batholith, and between a biotite quartz diorite pluton (bhmgr) and lithologically and structurally similar rocks to southeast, but presence of abundant muscovite-biotite-quartz-plagioclase schist and gneiss; fine-grained muscovite, biotite, and chlorite form retrograde phase replacing coarser prograde minerals. Protolith in northeast part of quadrangle, chiefly graywacke, feldspathic sandstone, shale, and minor amounts of pebble conglomerate with volcanic clasts; in south-central part of and mile also suggested by presence of amphibolite and rare relict igneous textures. Original sedimentary structures rarely preserved; compositional layering ranges from 0.05 to 1m thick; normally grades into schistosity, but locally layering present locally; schistosity intersects bedding (compositional layering) commonly at a 5-15 degree angle. Contact metamorphism of quadrangle, schist is in large triangular-shaped screen between plutons and the Ad Dawadimi batholith, and between a biotite quartz diorite pluton (bhmgr) and lithologically and structurally similar rocks to southeast, but presence of abundant muscovite-biotite-quartz-plagioclase schist and gneiss; fine-grained muscovite, biotite, and chlorite form retrograde phase replacing coarser prograde minerals. Protolith in northeast part of quadrangle, chiefly graywacke, feldspathic sandstone, shale, and minor amounts of pebble conglomerate with volcanic clasts; in south-central part of quadrangle, quartzo-feldspathic gneiss with thinner layering and more schistose, and better-defined compositional layering; slightly abundant; a greater percentage of coarser-grained, massive to crudely layered gneiss than in the Ash schist. Original sedimentary thickness of schist could not be known, because base of section not observed

INTRUSIVE ROCKS

YOUNGER COARSE-GRAINED GRANITOID (LATE PROTEROZOIC)

These rocks commonly form elliptical plutons or large stocks throughout the western part of the Arabian shield (Stuckless and others, 1982). Where dated, they average about 580 m.y. old (Brown and others, 1979; Fleck and others, 1980) and are thought to represent the last major plutonic event of the Arabian shield

Sgr SHUBAYBIYAH GRANITE—SBG—Pinkish-gray, brown-gray, and light-gray biotite and muscovite-biotite syenogranite and min amounts of monzogranite; texture variable from hypidiomorphic granular to allotriomorphic granular; perthite, myrmekite, antiperthite, and dig graphic textures commonly nonfoliated; medium grained and slightly porphyritic to coarse grained and porphyritic; rare pegmatitic and coarse grained and porphyritic in center. Common accessory minerals include fluorite, zircon, sphene, allanite, and opaque minerals; rare chlorite and tourmaline locally; plagioclase commonly altered to sericite and saussurite; biotite commonly altered to chlorite and epidote; occur in veins. Intrudes Jabal Aswad, in coarse-grained, inequigranular to porphyritic, fluorite-bearing syenogranite that could possibly be a separate unit. Contains abundant inclusions of older rocks and is commonly intruded by younger rocks. Outcrops in northwest corner of pluton (—g—) and one protoclastically sheared granitic dike occurs along eastern margin of quadrangle. Forms pluton with adjacent quartz diorite (qdb). Figure 1B is plot of percentage quartz, potassium feldspar, and plagioclase (ORP) in Shubaykiyah samples. Forms a peneplain upon which large, isolated, rounded hills crop out

wmgr WHITE MONZOGRANITE—White biotite and muscovite-biotite monzogranite; quartz about 28 percent, potassium feldspar about 33 percent, plagioclase about 35 percent, and mafic minerals about 5 percent of rock; hypidiomorphic equigranular, nonfoliated; perthitic texture common; myrmekite, antiperthite, and dig graphic textures commonly nonfoliated; medium grained and slightly porphyritic to coarse grained and porphyritic; rare pegmatitic and coarse grained and porphyritic in center. Common accessory minerals include fluorite, zircon, sphene, allanite, and opaque minerals; rare chlorite and tourmaline locally; plagioclase commonly altered to sericite and saussurite; biotite commonly altered to chlorite and epidote; occur in veins. Intrudes Jabal Aswad, in coarse-grained, inequigranular to porphyritic, fluorite-bearing syenogranite that could possibly be a separate unit. Contains abundant inclusions of older rocks and is commonly intruded by younger rocks. Outcrops in northwest corner of pluton (—g—) and one protoclastically sheared granitic dike occurs along eastern margin of quadrangle. Forms pluton with adjacent quartz diorite (qdb). Figure 1B is plot of percentage quartz, potassium feldspar, and plagioclase (ORP) in Shubaykiyah samples. Forms a peneplain upon which large, isolated, rounded hills crop out

mgr MIRYA GRANITE—Pinkish-gray, muscovite-biotite syenogranite; coarse grained, hypidiomorphic equigranular, nonfoliated. Quartz about 32 percent, slightly perthitic potassium feldspar about 46 percent, and plagioclase about 17 percent of rock; mafic minerals 5 percent or less. Exposed on Jabal Mirya, in southern part of quadrangle; forms a large, rounded, and resistant hill. Contains several coarse-grained porphyritic dikes (p), whose overall composition is similar to that of Mirya granite and may be genetically related to it; cuts other units. Although no large dikes are present, there are many east-northeast trending quartz veins (not mapped)

pmm PORPHYRITIC MUSCOVITE-BEARING MONZOGRANITE—White, very light gray and pale-pinkish-gray muscovite-biotite monzogranite with minor amounts of muscovite-biotite syenogranite; hypidiomorphic granular, porphyritic texture with very coarse grained (2 cm) perthitic potassium feldspar phenocrysts set in a coarse-grained, equigranular, groundmass. Quartz between 25 and 30 percent, potassium feldspar between 40 and 50 percent, plagioclase between 20 and 25 percent of rock; sericite and saussurite common; slight chlorite alteration of biotite; pleochroic halos common in biotite. Long axes of phenocrysts roughly parallel to pluton margins

GRANITOIDS OF THE AD DAWADIMI BATHOLITH (LATE PROTEROZOIC)

This term is used informally (Cole, 1981) to delineate a variety of plutons ranging from dark quartz diorite to alkali-feldspar granite in composition. The conterminous batholith consists of those plutons that are east of the Ad Dawadimi fault in the southern part of the quadrangle and regionally, but isolated plutons and stocks of similar rocks are sprinkled here and there within the Suwaj terrane. Age relations of plutons making up the batholith are poorly understood. Circular to elliptical diorite and granodiorite plutons, the largest intruded by and enclosed by the Ad Dawadimi batholith, are found in the southeast and another similar plug that is partially enclosed by the cover rocks in quadrangle 26/43 C, have been dated at 615 and 614 m.y., respectively (Cole and Hedge, written comm., 1984). However, the majority of the rocks in the batholith are more granitic in composition; they form a discontinuous, irregular, and elongate belt of rocks. Nonetheless, the dated plutons argue for their youth relative to many of the surrounding, irregularly shaped granitic plutons. Because contact relations between an elliptical hornblende diorite pluton (qdb) and granitic rocks to its north (mbmgr) suggest that the diorite is younger, the granitic rocks are shown to postdate the diorite and ones in this quadrangle.

bhp BIOTITE-HORNBLENDE QUARTZ MONZONITE PORPHYRY—Medium- to dark-gray, biotite-hornblende quartz monzonite porphyry; coarse to very coarse grained, hypidiomorphic granular porphyritic texture with plagioclase phenocrysts set in a hypidiomorphic granular, nonfoliated, medium- to fine-grained groundmass. Quartz between 15 and 20 percent, potassium feldspar 45 percent, plagioclase 34 percent, and mafic minerals 12 percent of the rock. Sericite and saussurite common alteration products of plagioclase; muscovite possibly altered to sericite, and muscovite; potassium feldspar phenocrysts contain graphic intergrowths of quartz. Groundmass rich in myrmekitic quartz-plagioclase intergrowths. Hornblende euhedral to subhedral, rarely anhedral, and commonly altered to chlorite; accessory minerals include the muscovite-biotite monzogranite (mbmgr) and therefore considered to be the youngest of the Ad Dawadimi batholith. Forms pluton with adjacent diabase dikes (—d—)

dap DIORITE AND ANDESITE PORPHYRY PLUGS AND DIKES—Dark-gray, hornblende diorite, quartz diorite, tonalite, and andesite; flow banded; medium grained. In small plugs intruding biotite muscovite syenogranite (bmsgr) in north-central part of quadrangle and the Ad Dawadimi batholith in southeast part of quadrangle. Quartz diorite and tonalite dikes (—•—) intrude dikes

mbmgr MUSCOVITE-BIOTITE MONZOGRANITE—Light gray to medium gray, muscovite-biotite monzogranite and minor amounts of muscovite-biotite syenogranite; hypidiomorphic granular, porphyritic texture; perthitic potassium feldspar phenocrysts in hypidiomorphic equigranular to very slightly porphyritic; coarse-grained (0.5) phenocrysts of subedral potassium feldspar crystals make up less than 1 percent of rock; nonfoliated. Some potassium feldspar crystals are rapakivi texture. Quartz about 30 percent, potassium feldspar as shown composition on ORP (quartz, potassium feldspar, plagioclase) ternary diagram; mafic minerals range from 1.5 to 5.5 percent of rock. Zircon, allanite, sphene, fluorite, and apatite common accessories; rare chloritic alteration of biotite. Intrudes the Ad Dawadimi batholith, exceeding porphyry dikes (p) in the first part of pluton and by east-northwest trending quartz-olite dikes (—Q—) in northern part

bmsgr BIOTITE MONZOGRANITE AND SYENOGRANITE—Light-gray to light-pinkish-gray biotite monzogranite, muscovite-biotite monzogranite, and biotite-muscovite syenogranite; very fine to medium grained, mostly hypidiomorphic equigranular and nonfoliated, slightly porphyritic locally; is allotriomorphic granular and slightly porphyritic locally; rare pegmatitic and coarse grained and slightly perthitic; rare myrmekite present. Figure 1C depicts composition on QKP ternary diagram; mafic minerals from 1 to 10 percent of rock. Primary biotite ubiquitous, muscovite is not common except at location of foliation in northern part of pluton. Common accessories include fluorite, zircon, sphene, apatite, and allanite common accessories; chlorite alteration of biotite and saussuritization of plagioclase core common. Contains xenoliths of coarse- to medium- grained hornblende-biotite monzogranite and dikes of the bmsgr. An elliptical pluton intruding schist and Suwaj terrane north of Jabal Miraa in southeast part of quadrangle; although not part of conterminous Ad Dawadimi batholith, grouped with those rocks because of similar composition, morphology, dike geometry, and trend of dikes. Forms pluton with adjacent biotite quartz monzonite; east-west-trending dikes (—d—) intrude pluton; rhyodacite to monzogranite dikes (—r—); dacite/diabase dikes (—dd—) and diabase dikes (—d—)

bhmgr BIOTITE-HORNBLENDE MONZOGRANITE TO SYENOGRANITE—Pinkish-gray biotite-hornblende monzogranite, hornblende-biotite monzogranite, and biotite monzogranite; hypidiomorphic granular, porphyritic texture; coarse grained, hypidiomorphic equigranular, and nonfoliated; mafic constituents commonly occur in clusters. At margins texture inequigranular to porphyritic with coarser to medium grained subedral plagioclase and medium-grained hornblende and biotite phenocrysts set in a fine grained groundmass. Contact with Ad Aqiq and Ad Dawadimi batholith gradational; is allotriomorphic granular; contains potassium feldspar, and plagioclase. Sericite, saussurite, and chlorite alteration of biotite and saussuritization of plagioclase common. North part of pluton exposed on Jabal Ajmah, Jabal Aswad, and Jabal Miraa; is in contact with and is transitional to boundary of larger plagioclase grains quartz commonly finer grained in the zones of shearing; alteration of biotite and hornblende to chlorite in inequigranular nearly complete in these zones. Little alteration present in porphyritic monzogranite. Contains abundant inclusions of older rocks and is commonly intruded by younger rocks. Contact with schist, QKP composition depicted on figure 1D; mafic minerals commonly form between 5 and 36 percent of the rock. Apatite, sphene, and allanite common accessories; chlorite alteration of biotite and saussuritization of plagioclase common. Forms pluton with adjacent biotite monzogranite; east-central quadrangle borders part of conterminous Ad Dawadimi batholith. Dikes of bhmgr are rare; the presence of abundant composition to diorite in the Dukhnah quadrangle dated at 615 m.y. old (Cole and Hedge (written comm., 1984) and the presence of the last major pulse of the batholith, which is thought to differentiate on mag. intruded by northwest-trending biotite- and hornblende-bearing monzodiorite dikes (—m—); dacite to east to northeast-trending hornblende quartz diorite dikes (—h—) and rare diabase dikes (—d—). Dacite and granitoid dikes commonly protoclastically or cataclastically sheared

mbqzn MUSCOVITE-BIOTITE GRANODIORITE—Light-gray, muscovite-biotite granodiorite with minor amounts of muscovite-biotite monzogranite; medium grained, hypidiomorphic granular, non-foliated. QKP composition is depicted on figure 1D; mafic minerals commonly form between 5 and 15 percent of the rock. Apatite, sphene, allanite, and zircon common accessories; prehnite and epidote replace biotite and plagioclase altered to sericite and saussurite. Forms irregular-shaped, low-relief pluton on southcentral border of quadrangle, isolated from Ad Dawadimi batholith and not dated, but grouped possibly with younger rocks because of its composition. Contains source of diabase dikes (—d—) that intrude older rocks

gdp BIOTITE-HORNBLENDE GRANODIORITE PORPHYRY—White and medium-gray biotite-hornblende granodiorite; slightly porphyritic with coarse grained subedral plagioclase phenocrysts set in a medium-grained, equigranular, non-foliated groundmass. QKP ratios are quartz 9 percent, potassium feldspar 42 percent, and plagioclase 24 percent; mafic constituents form 25 percent of the rock. Forms large elliptical, low-relief pluton of which only the southeastern part is exposed in quadrangle. Is isolated from Ad Dawadimi batholith and very poorly exposed in the quadrangle. In adjacent Dukhnah quadrangle,zircon dated at 620 m.y. by Cole and Hedge (written comm., 1984). Texture, age, shape, relief, composition and proximity to Ad Dawadimi batholith suggest that it is genetically related to the batholith and, with, and intruded by, hornblende dacite porphyry dikes (—a—)

ABRAQ AL AMALA INTRUSIVE CENTER (LATE PROTEROZOIC)

Small group of plugs and dikes defining localized, ring- shaped center, Age not known; includes dikes that locally fill overal with plagioclase-bearing porphyry (pp) that formed contemporaneously with the eruption of Jurdhaiyah group (Cole, 1981); intrudes the Suwaj terrane to plagioclase porphyry

pa PLUGS—Medium gray-green hornblende dacite to andesite porphyry; medium-grained phenocrysts include plagioclase, hornblende, and quartz; quartz and albite groundmass fine grained. Alteration of plagioclase to calcite or saussurite ubiquitous, and chlorite alteration of hornblende common. Forms plugs and dikes consisting of hornblende dacite porphyry, commonly with plutonastic to trachytic texture, that form ring dike complex (—a—)

INTRUSIVE ROCKS ASSOCIATED WITH JURDHAIYAH SEDIMENTATION

Cole (1981) describes these rocks as being local to the area of Al Jurdhaiyah group sedimentary and volcanic rocks. He also states that they are probably broadly coeval with the Jurdhaiyah sedimentation in, the Jurdhaiyah basin. In Shubaykiyah quadrangle they occur in the northeastern boundaryof the Qowr Matlubah, several small stocks and plugs along the west border of the map, small plugs on the eastern side of Jabal Miraa and Alawwaysa, and many dikes throughout western side of map.

pp PLAGIOCLASE-BEARING ANDESITE PORPHYRY—Medium- to dark-greenish-gray, and light-greenish-gray hornblende andesite porphyry that commonly contains lesser amounts of biotite, garnet, and/or augite; also, uncommon dacite porphyry with either clear recrystallized to very fine grained, holocrystalline, felted to granofelsic feldspar and quartz or entirely plagioclase laths less than 0.5 mm in length. Phenocryst content varies between 20 and 65 percent of rock. Intense saussuritization of plagioclase laths common in thin sections of porphyritic samples, as is sericitization and sericitic alteration of plagioclase phenocrysts. Alteration of hornblende common; associated with abundant opaque minerals (—) that range in composition and character from porphyry identical to the pluton by fine-grained dark quartz diorite. Large, irregular trending, fine-grained, yellow-brown muscovite quartz monzonite dike in southeast corner of quadrangle and dikes presumed to be late stage differentiates associated with porphyry

GRANITOIDS OF THE SUWAJ SUITE

The Suwaj suite are the oldest intrusive rocks in the region. U-Pb zircon dates by Cole and Hedge (written comm., 1984) indicate these rocks are 683-689 Ma old; sample from north end of Jabal Suwaj dated at 689 m.y., sample from Jabal Aswad dated at 683 m.y., sample dated at 685 Ma. Intrudes throughout western side of quadrangle; eastern limit runs diagonally through quadrangle approximately from northwest to southeast corners. Original eastern limit not known because younger Ad Dawadimi batholith occurs to east. Both the Suwaj suite and the Ad Dawadimi batholith are part of the Suwaj terrane. Although schist is pervasive in pendants and septa throughout the Ad Dawadimi batholith, the Suwaj suite is not preserved there. Therefore, it seems likely that the present east limit of the Suwaj suite is not its original east limit. Contacts between units differentiated within the Suwaj suite are commonly gradational, but locally intrusive; contacts between Suwaj suite and younger rocks are commonly intrusive. Locally, zones of plutonic contacts. Mapped boundaries simply enclose areas typified by a particular lithology; variations within the units are commonly great. It is evident that the more mafic variables, such as diorite, are concentrated in the Jabal Suwaj and Mathanit area, the more quartz-rich varieties such as tonalite are common in the northwest, and the more quartz and K-spar rich varieties occur in the southeast.

pgh PEGMATITE GRANOPHYRE—Orangish-pink to light tan biotite-hornblende syenogranite; myrmekite and graphic intergrowths of quartz and potassium feldspar common; equigranular primary medium grained, hypidiomorphic inequigranular to porphyritic texture. Occurs in small bodies at scattered localities within the batholith and Jabal Mabbel in central part of quadrangle. Probably a late-stage differentiate of more widespread and more mafic older intrusions

pgqmd GRANODIORITE AND QUARTZ MONZODIORITE—Mostly light-blueish-gray, light-gray, medium-bluish-gray, white, and light- pink-gray biotite-hornblende, or hornblende quartz monzodiorite. Lesser amounts of biotite-hornblende, biotite, or hornblende granodiorite also present and rare biotite- hornblende quartz diorite and tonalite. Hypidiomorphic granular, porphyritic texture; is hypidiomorphic equigranular to slightly inequigranular and nonfoliated at all observed localities except one, 6 km east of the power station, where slight foliation, consisting of alignment of plagioclase and hornblende crystals, occurs; foliation is defined by the alignment of hornblende crystals by larger quartz crystals common. QKP compositions of samples shown on figure 1E; mafic constituents form between 6.5 and 15.5 percent of rock. Sphene abundant; zircon, allanite, and apatite common, plus various opaques minerals. Plagioclase ubiquitously altered to saussurite, sericite, and muscovite; replacement of plagioclase by calcite also occurs; chlorite and prehnite alteration of biotite very common. Present in two large bodies within the Suwaj diorite terrane in southwestern part of quadrangle.

Sdt TONALITE—Light-gray, light-blueish-gray, and white, mottled with 10 to 40 percent dark-green, gray to black mafic minerals; hypidiomorphic equigranular, holocrystalline, and mostly tonalite to quartz diorite. Includes lesser amounts of biotite-hornblende granodiorite, and hornblende diorite, all of about the same general color and appearance. Mostly coarse grained, rarely medium grained, hypidiomorphic equigranular, holocrystalline, and nonfoliated; rare pegmatitic and coarse grained and porphyritic in some tonalite and granodiorite samples quartz poikilitically surrounds smaller plagioclase phenocrysts; one foliated sample has cataclastic texture with secondary biotite, probably after pyroxene, in shear zones surrounding abraded plagioclase phenocrysts. Contains xenoliths of coarse- to medium- grained hornblende-biotite monzogranite and dikes of the Sdt. Sericite after plagioclase, and calcite after plagioclase are nearly ubiquitous alteration reactions; QKP compositions are plotted on figure 1E; mafic minerals form between 8 and 42 percent of the rock.

Sdd DIORITE AND QUARTZ DIORITE—Mottled black and light blue-gray or white to almost totally black. Includes hornblende, biotite-hornblende, and augite-hornblende diorite; biotite-hornblende and augite-biotite-hornblende quartz diorite; and hornblende, biotite, and augite-biotite quartz monzodiorite. Hypidiomorphic granular, porphyritic to inequigranular; rare hornblende monzodiorite, and rare black to dark-gray augite-hypersthene-hornblende norite also present. Medium coarse to coarse grained, hypidiomorphic equigranular, holocrystalline, and mostly non-foliated, except in the southeast part of Jabal Makhamil where foliation is pronounced. Contact with Ad Dawadimi batholith to, intrusive contact with schist. Coarse-grained apatite and sphene ubiquitous accessories; monazite and zircon less common accessories. Plagioclase commonly altered to saussurite and sericite; biotite altered in nearly every case to chlorite, epidote, and opaque minerals; hornblende altered to chlorite. QKP compositional plots are shown on figure 1E; mafic minerals form between 12 and 66 percent of most diorites and quartz diorites and as much as 90 percent of amphibolites

REFERENCES

Beurrier, M., and Villey, M., 1982a, Reconnaissance geology and mineral exploration of the Dukhnah quadrangle, 25/43 D: Saudi Arabian Deputy Ministry for Mineral Resources Technical Record DMMR-TR-82-6, 29p., 3 plates.

Beurrier, M., and Villey, M., 1982b, Reconnaissance geology and mineral exploration of the Al Jurdhaiyah quadrangle, 25/42 C: Saudi Arabian Deputy Ministry for Mineral Resources Technical Record DMMR-TR-82-6, 16p., 3 plates.

Brambamy, R.A., Ramirez, L.F., Brown, G.F., and Pocock, A.R., 1963, Geologic map of the Wadi Ar Rimah quadrangle, Kingdom of Saudi Arabia: U. S. Geological Survey Miscellaneous Geologic Investigations Map I-206 A.

Brown, G. F., and Jackson, R. O., 1960, The Arabian Shield: International Geological Congress, 21st, Copenhagen, 1960, Proceedings, Sec, 9, p. 69-77

Brown, G. F., Hedge, Carl, and Marvin Richard, 1979, Tabulation of Rb-Sr and Pb-alpha ages of rocks in the Arabian Shield: U. S. Geological Survey Open-File Report 79-79, [18,32A-Z,33].

Cole, J. C., 1981, Reconnaissance geology of the Al Jurdhaiyah quadrangle, sheet 25/42 C, Kingdom of Saudi Arabia: U. S. Geological Survey Saudi Arabian Mission Miscellaneous Map 44, 2 plates.

Delfour, Jacques, 1981, Geologic map of the Al Risaz quadrangle, sheet 24 H, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Geologic Map GM-58 A.

Greene, R. C., 1983, Stratigraphy of the Murdama Formation between Afif, Halaban, and As Sawdah, Kingdom of Saudi Arabia: U. S. Geological Survey (Saudi Arabian Mission) Open-File Report DM-OF-83-235 p.

Letalenet, J., 1974, Geology and mineral exploration of the Jabal al Mardamah quadrangle, 25/43 A: Bureau de Recherches Geologiques et Minieres (Saudi Arabian Mission) Report 74-2ED-10, 35 p.

Muller, Y., 1975, Geology and mineral exploration of the Al Jurdhaiyah area quadrangle sheet 25/42: Bureau de Recherches Geologiques et Minieres (Saudi Arabian Mission) Report 75- 2ED-21, 48 p.

Stacey, J. S., Doe, B. R., Roberts, R. J., Delevaux, M. H., and Gramlich, J.W., 1980, A lead isotope study of mineralization in the Saudi Arabian Shield: Contributions to Mineralogy and Petrology, V. 74, p. 175-188.

Streckeisen, A., 1976, To each plutonic rocks its proper name: Earth-Science Reviews, Vol. 12