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THE JABAL ISHMAS-WADI TATHLITH GOLD BELT, KINGDOM OF SAUDI ARABIA

by

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ABSTRACT

The Jabal Ishmas-Wadi Tathlith gold belt is a north-south zone of numerous ancient gold mines in the southeastern Precambrian shield of Saudi Arabia, extending along long 43°30'E. between lat 18°N. and 21°30'N., a distance of about 390 km. The gold belt coincides with a major zone of faulting, shearing, and alteration. The fault zone and most of the gold mines occur within a belt of layered metavolcanic and metavolcaniclastic rocks that is situated between a continuous belt of gneissic rocks to the west and a discontinuous belt of gneissic rocks to the east. Layered rocks are slightly to highly metamorphosed andesitic to dacitic volcanic rocks intercalated with volcaniclastic sediments. Massive volcanic rocks predominate in the southern and very northern parts of the belt whereas medium- to fine-grained sedimentary rocks and volcaniclastic rocks, in part younger than the massive volcanic rocks, predominate in the central portions.

There are five geographic groups of ancient gold mines in the belt, each of which contain deposits that are probably genetically related and are typical of that group. These deposits are hydrothermal in nature and are in or next to quartz veins, quartz breccia zones, or quartz stringer zones. A few of the deposits are spatially related to felsic dikes or small bodies of gabbro but most are in quartz veins of regional systems.

In order to facilitate evaluation of individual deposits, a model was developed to determine the potential resource of each deposit. The model was developed from historical data and utilizes geologic parameters and analyses of waste dump samples to give an optimum potential resource tonnage and grade. Although these are only estimates based upon present exposures and limited analytical data, the results indicate that the deposits in the gold belt have limited economic potential. A majority of the prospects evaluated are small deposits, each estimated to contain less than 50,000 tons of gold ore. Twelve of the prospects are estimated to contain deposits ranging from 50,000 to 400,000 tons of ore at grades ranging from 7 to 32 grams per ton (g/t).

INTRODUCTION

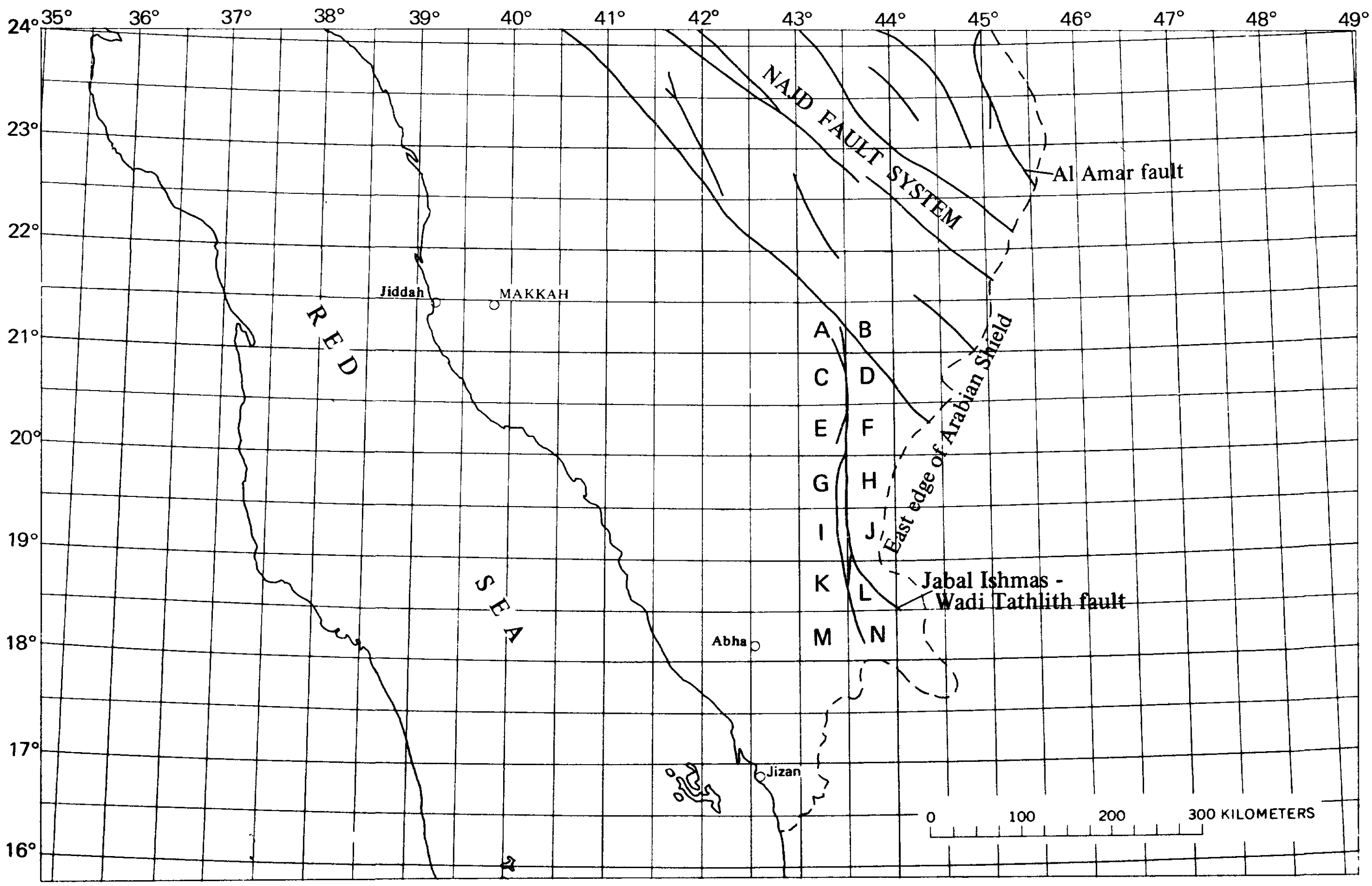
Location

Numerous ancient gold-quartz mines and barren quartz veins are found in a north-trending belt extending from lat 17°30'N. to lat 21°30'N. between long 43°E. and long 44°E. (fig. 1). Thirty-eight separate areas (pl. 1) within the belt, each containing one to several ancient mines, were studied. Access to the individual deposits is by desert tracks originating in Ranyah, Bishah, Khamis Mushayt or Najran (fig. 1). Four-wheel drive vehicles are needed to reach many of the deposits and a few in the southern part are inaccessible. Several villages are located within the southern part of the belt (south of lat 19°30'N.) but there are no permanent settlements within the northern part of the belt; however, Ranyah is only 16 km west of Jabal Sili (pl. 1, prospect 2).

Good water wells are relatively abundant in the extreme southern part of the belt and in the upper reaches of Wadis Tarib and Tathlith in the south-central part of the belt. Many are used throughout the year for irrigation as well as for domestic use and watering of livestock. Wells in the northern portion of the belt are widely scattered and provide only meager support for domestic use and livestock during part of the year. Terrain along the belt varies from rugged mountains as much as 1800 m in elevation in the very southern part to large sand covered pediments and dune fields with isolated mountain masses in the northern part.

Previous investigations

The gold belt is mapped by the 1:500,000 scale quadrangle maps of the southern Najd (Jackson and others, 1963) and Asir (Brown and Jackson, 1959). Recent mapping at a scale of 1:100,000 by geologists of the U.S. Geological Survey Saudi Arabian Mission (USGS), and the Directorate General for Mineral Resources (DGMR) has covered much of the gold belt. The location and name for each of the 14 30-minute quadrangles covering the gold belt are given in figure 1. Some of the deposits within the belt are included in the mineral locality map of the Arabian Shield (Daalhoff, 1974) and detailed studies have been done at the following localities. The Jabal Mokhyat placer deposits surrounding the Jabal Mokhyat vein deposits (no. 21, pl. 1) were recently studied and evaluated by USGS geologists (Schmidt, D. L., unpublished data). Jabal Guyan ancient mines (no. 38, pl. 1) were mapped and studied in detail by Helaby and Dodge (1977), and C. W. Smith of the USGS is currently mapping and studying an area that includes the Dhahar and Hagira ancient mines (no. 35 and no. 36, pl. 1). The Al Gariat Avala (no. 26, pl. 1), Al Lugatah (no. 25, pl. 1), Wadi Al Mushel (no. 27, pl. 1) and Hajr (no. 30a, pl. 1) ancient mines, and the mines of the



Quadrangle	Reference	
A. Jabal Dalfa 21/43 C		
B. Bir Juqjuq 21/43 D	Hadley (1976)	
C. Jabal Ishmas 20/43 A	Gonzalez (1974)	
D. Jabal Yafikh 20/43 B	Schmidt (in prep. b)	
E. Jabal Al Qarah 20/43 C	Schmidt (in prep. a)	
F. Not named 20/43 D	Not mapped	Tathlith 1° quadrangle
G. Al Hassir 19/43 A	Overstreet (1978)	Tathlith 1° quadrangle
H. Wadi Haraman 19/43 B	Overstreet (1978)	Tathlith 1° quadrangle
I. Duthur As Salam 19/43 C	Overstreet (1978)	Tathlith 1° quadrangle
J. Hamdah 19/43 D	Overstreet (1978)	Tathlith 1° quadrangle
K. Madha 18/43 A		
L. Markas 18/43 B		
M. Wadi Tarib 18/43 C		
N. Wadi Malahah 18/43 D	Greenwood (1979 b)	

Figure 1. Index map showing location of the Jabal Ishmas–Wadi Tathlith gold belt and 1:100,000–scale geologic quadrangle maps covering the area.

Jabal Mahanid group (no. 29, pl. 1) were visited and sampled by Overstreet (1978) during a regional mapping and mineral deposit investigation. Dahlat Shabab (no. 5, pl. 1), Al Gariat Avala (no. 26, pl. 1), and Al Lugatah (no. 25, pl. 1) were visited and sampled by Schaffner (1956a, b) and Bogue (1954). Gonzalez (1975, and unpub. data) investigated several of the ancient mines north of lat 20°N. (app. A) during the latter part of 1967 and early part of 1968. He was assisted by V. Tompkins, V. Flanigan, T. Kiilsgaard and C. Martin of the USGS and by Ghazz Gafer of DGMR. Samples collected during Gonzalez's study were analyzed in a mobile field laboratory by Abdu Alim.

Present investigation

Field investigations by the author took place during the spring and fall of 1976. Ghanim Jerry, prospector for the USGS, located and reconnaissance sampled many of the deposits and Marshood Mazrook and Yahia Abaduwood assisted in mapping and sampling. All samples were analyzed in the DGMR-USGS laboratory in Jiddah under the direction of Joe Curry. The Hajr mine (no. 30a, pl. 1) was mapped and sampled in detail and explored by diamond drilling during the course of the investigation, the results of which are reported by Helaby and Worl, (unpublished data).

Field work was done in part using four-wheel-drive vehicles from mobile camps and in part using helicopters from fixed camps. The ancient mines, quartz veins, sample locations, and other geological data were plotted in the field on 1:50,000 scale photo mosaics, and later transferred to a 1:500,000 scale base map prepared from Earth Resources Technology Satellite images. The larger ancient mines were mapped at a scale of 1:1,000, using a plane table and alidade, and a few of the smaller mines were mapped by pace and compass methods.

The study was done in accordance with a work agreement between the U.S. Geological Survey and the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

GEOLOGIC SETTING

Rocks underlying the southern Arabian Shield resulted from volcanic and sedimentary deposition accompanied by tectonism, metamorphism, and plutonism that occurred from about 1050 to 550 million years ago. "The volcanism was predominantly intermediate in composition; however, a shift from early tholeiitic to later calc-alkalic rocks and an increase in potassium content is observed from the oldest to the youngest deposits. The plutonic rocks show a parallel shift from early calcic to later calc-alkalic rocks and an increase in potassium content that perhaps parallel a progressive increase in thickness of a neocraton" (Greenwood and others, 1975, p. 16). A summary of the stratigraphy, orogenic events, and plutonic rocks in the southern shield is listed in table 1.

Geologic units in the gold belt consist of slightly metamorphosed to locally highly metamorphosed volcanic, volcaniclastic, and sedimentary rocks in the central and eastern portions and a band of gneissic and batholithic rocks in the western portion. Batholiths of diorite to quartz monzonite composition and stocks and plugs of gabbro and granite are found throughout the area.

Layered rocks

Layered rocks in the gold belt are divided into three map units (pl. 1) for the purposes of this report; a southern andesite-graywacke assemblage, a northern andesite-graywacke assemblage, and a metasedimentary assemblage. The relations of the southern and northern andesite-graywacke assemblages through the gold belt are not well known, in part because of the disparity of mapping from quadrangle to quadrangle and in part because of stratigraphic complexities and lateral lithofacies changes in the middle portion of the map area. In general, massive volcanic rocks and coarse sedimentary rocks dominate in the southern and northernmost parts of the belt, whereas pyroclastic volcanic rocks and finer-grained sedimentary rocks dominate in the middle portion. Rocks shown as the southern andesite-graywacke assemblage (pl. 1) seem, on the basis of reconnaissance studies, to grade laterally into and intertongue with rocks shown as the northern andesite-graywacke assemblage (pl. 1). However, intrusive relationships and degree of deformation suggest that the northern andesite-graywacke assemblage is the younger of the two, thus making it a lithofacial, but not a time equivalent of the southern andesite-graywacke assemblage. The metasedimentary assemblage is the youngest sequence of layered Precambrian rocks exposed in the gold belt. Contact relations with the other map units is unknown. Assignment of the map units used in this report to regional stratigraphic groups (Greenwood and others, 1975 and table 1) is beyond the scope of this report.

The southern andesite-graywacke assemblage includes rocks mapped as Jiddah group by Greenwood (1979a), Bayni Oshir volcanic and Harban groups by Warden, A. J. (unpub. data), Baish, Jiddah and Halaban groups by Overstreet (1978), and rocks of four unassigned metavolcanic and metasedimentary map units by Simmons (in prep.) and two unassigned metavolcanic and metasedimentary map units by Stoeser, D. B., (unpublished data).

Table 1.--*Stratigraphy, orogenic events, and plutonic rocks in the southern part of the Arabian Shield*

		UNITS	PRINCIPAL LAYERED ROCKS	OROGENIC EVENTS	PLUTONIC ROCKS
HIJAZ TECTONIC CYCLE	THIRD EPISODE	Murdama Group	Conglomerate Graywacke Andesite Rhyolite Marble	BISHAH- Folds and faults; northerly trends; greenschist metamorphism	Granite and quartz monzonite (570-550 m.y.)
		UNCONFORMITY			
	SECOND EPISODE	Halaban Group	Conglomerate Graywacke Rhyolite Dacite Andesite Marble	YAFIKH - Folds and faults; northerly trends; greenschist metamorphism	Quartz monzonite (650-600 m.y.)
		UNCONFORMITY-?			
		Ablah Group		RANYAH - Folds and faults; northerly and northeasterly trends; late transverse shears; greenschist, amphibolite, and granulite metamorphism	Injection gneiss (785 m.y.) Second dioritic series (800 m.y.)
		UNCONFORMITY			
	FIRST EPISODE	Jiddah Group Bahah Group Baish Group	Conglomerate Graywacke Dacite Andesite Basalt	AQIQ - Folds and faults; northerly trends; greenschist metamorphism	First dioritic series (960 m.y.)

Greenwood (1979) mapped two units of the Jiddah group in the Wadi Malahah quadrangle: an underlying Wassat formation consisting of metamorphosed basaltic to dacitic flows and volcanic breccia, cinder tuff, and massive to poorly bedded crystal and crystallithic tuff; and an overlying Qatan formation consisting of gray to green conglomerate to phyllite, interbedded marble, volcanic lithic graywacke, plagioclase graywacke, and interbedded carbonaceous schist. The metasediments are first-cycle deposits, derived in part from the underlying volcanic rocks, in part from dioritic plutons, and in part from contemporaneous dacitic pyroclastic and epiclastic rocks.

In the Markas quadrangle to the north, Warden (unpublished data) also recognized a dominantly volcanic lower portion and a dominantly metasedimentary upper portion to his Bayni Oshir volcanic and Harban groups. The lower volcanic unit is largely massive andesites intercalated with locally graded graywackes and subordinate dacitic to rhyolitic agglomerates. The thick upper unit is largely graywackes, siltstones, phyllites, black siliceous mudstones, limestone, and volcanic sandstones. Most of the unit is thinly bedded. To the north, in the Hamdah, Duthur Al Salam, Wadi Haraman, and Al Hassir quadrangles (fig. 1) Overstreet (1978) reports similar rocks; a lower portion of massive andesites, andesite porphyry, trachytic andesite, bedded andesitic crystal and lithic tuffs intercalated with graywackes, and an upper portion of thinly bedded graywacke, siltstone, volcanic sandstone, conglomerate and limestone. Graded bedding and ripple marks are common in the siltstones. Similar rocks are described from the Jabal Mokhyat area (no. 21, pl. 1) by Schmidt and others, (unpublished data).

The sequence of rocks from lat 18°N. to lat 20°15'N., shown as the southern andesite-graywacke assemblage (pl. 1), can be considered one unit although exposure is not continuous and degree of metamorphism varies from lower greenschist to upper amphibolite regional metamorphic grade. This assemblage is everywhere intruded by large bodies of sheared diorite and is made up of a lower metavolcanic unit and an upper metasedimentary unit. Exposures in the south are predominantly of massive volcanic rocks and coarse sedimentary rocks, whereas to the north, especially around lat 19°N., bedded pyroclastic volcanic rocks and finer-grained sedimentary rocks predominate. Although the rocks are commonly sheared in two or more directions, relict primary textures and structures are common. Isoclinal folding, characterized by highly attenuated or sheared limbs, is present but not readily recognized. Medium-sized to large boudins of competent beds and mafic dikes are common.

Massive pyritic bodies at Wadi Wassat and sulfide bodies containing anomalous amounts of nickel, copper, and zinc at

Wadi Qatan, Masane, and Kutum prospects, occur within rocks mapped as Jiddah group (Greenwood, 1979b). All of these prospects are within or just east or south of the southeasternmost corner of the map area (pl. 1). The zinc-rich sulfide body at Ash Shaib, lat 19°15'N., long 43°40'E., is also probably within this sequence of rocks, although the ore-enclosing rocks are highly deformed and metamorphosed and their identity is not definite.

The northern andesite-graywacke assemblage (pl. 1) includes rocks assigned to the Halaban group by Hadley (1976), Gonzalez (1974) and Schmidt (in prep. a,b), the Baish, Bahah, and Halaban groups by Overstreet (1978) and rocks of 4 unassigned metavolcanic and metasedimentary map units by Greene, R.C., (unpublished data).

The Halaban group in the Juqjuq quadrangle consists of two formations; an older predominantly volcanic Juqjuq formation and a younger volcanic, volcaniclastic, and conglomeratic Arfan formation (Hadley, 1976). The Juqjuq formation comprises andesite and basalt with subordinate dacitic, trachytic, and rhyodacitic flow rocks, welded ashflow tuff, crystal tuff, lapilli tuff, volcanic breccia, and agglomerate. Hadley (1976, p. 7) correlates the Juqjuq formation with the middle part of the Halaban group of the northern Shield area. The overlying Arfan formation is composed largely of medium-grained graywacke and intercalated andesite flow rock; local polymictic conglomerate, volcaniclastic graywackes, and flow rocks of dacite, basalt, and rhyolite are present in the upper part. Graded bedding and pebbly beds are common. Hadley (1976, p. 8) correlates the Arfan formation with the upper part of the Halaban group of the northern Shield area.

The Halaban group as described by Gonzalez (1975) in the Jabal Ishmas quadrangle is similar to that in the Juqjuq quadrangle except that marble is present and the metasedimentary rocks tend to be finer grained. Halaban rocks occupy a narrow synform in the center of the Tathlith 1° quadrangle. Graywacke, siltstone, shale, blue-gray marble, and intercalated andesite flow rock comprise the bulk of the section, with some conglomerate and rhyolite flow rock. Graded bedding is common and mudcracks are present in siltstones (Overstreet, 1978, p. 9). Rocks of the Halaban group are metamorphosed to lower to middle greenschist regional facies, but are not strongly sheared, foliated, or folded except along major fault zones.

The metasedimentary assemblage (pl. 1) includes rocks mapped as Murdama group by Hadley (1976), Schmidt (in prep. b) and Overstreet (1978). It includes rocks with lithology, degree and type of deformation, and intrusive relationships similar to rocks assigned to the Ablah group by Greenwood (1979a) in the Khadrah quadrangle directly to the west of the Tathlith quadrangle.

The metasedimentary assemblage crops out in a northwest-trending graben bounded by Najd faults in the northeastern part of the area (pl. 1), and between two strands of the Jabal Ishmas-Wadi Tathlith fault zone in the Al Hassir quadrangle. This assemblage is composed of calcareous graywacke, biotite schists, locally oolitic marble, polymictic conglomerate, slate, and argillite. The grade of metamorphism ranges from lower greenschist to lower amphibolite regional facies. Relict primary structures and textures are common even in the rocks of higher metamorphic grade because the rocks are generally not highly sheared, folded, or foliated except along major fault zones.

The lithologic nature of the layered rocks throughout the belt suggests two major volcanic sources or two volcanic piles. One, the source of the southern andesite-graywacke assemblage centered in the southern, or southeastern part of the map area. The second, the source of the northern andesite-graywacke assemblage, is centered north of the map area. Each would have been an extensive series of small centers that fed flows and pyroclastics to the southernmost and northernmost parts of the map area. The map area from lat 18°30'N. to lat 21°00'N. is characterized by finer-grained pyroclastics, clastics, and marine precipitates; the sources for these rocks were the developing volcanic piles to the north, or south, as well as small local sources. Rocks shown as the northern andesite-graywacke assemblage (pl. 1) distinctly lose their volcanic character, become finer grained, and contain more limestones towards the south. Rocks mapped as the southern andesite-graywacke assemblage (pl. 1) show similar, but less marked changes towards the north.

Intrusive rocks

Several stages of intrusive activity have affected the layered rocks (pl. 1) and most of the gold belt is underlain by gneissic or plutonic rocks. The areas shown as gneiss, plus some, if not all, of the diorites on plate one, are part of a complex of batholiths and gneissic domes. The complex that underlies the southwestern part of the gold belt in the Wadi Tarib quadrangle, the southwestern part of the Wadi Malahah quadrangle, and the western part of the Madha quadrangle, is part of the Wadi Tarib batholith (Greenwood, 1979b; Stoeser, in prep.). It is composed mainly of gneissic, migmatitic, foliated, and recrystallized diorite of at least two and probably several stages; it also includes gabbro and quartz-diorite. Northward along the west half of the gold belt (pl. 1) the gneissic terrain is described as biotite-granite gneiss, biotite-hornblende granodiorite gneiss, and granodiorite gneiss (Overstreet, 1978, p. 17; Gonzalez, 1975, p. 10), the granite gneiss being the youngest. Greenwood (1979b), mapped a gneiss dome in the northern part of the Wadi Malahah quadrangle that extends northward through the center of the Markas quadrangle where Warden (unpub. data) mapped it as granodiorite and granite migmatites. Another area of gneiss underlies parts of the Hamdah quadrangle. The formation of the gneiss has been placed in the Ranyah orogenic event (Greenwood and others, 1975, p. 523) and preceded deposition of the Halaban group rocks. Contacts of the batholithic complexes and gneiss are grossly concordant and harmonious with wall rocks of the southern andesite-graywacke assemblage, but in detail they are commonly disconcordant and crosscutting.

Overstreet (1978, p. 37-41) suggested that some of the gneiss of indefinite origin may represent an older basement, but there is little evidence to support this concept. In fact, in a few areas, notably the western part of the Hamdah quadrangle and the central part of the Markas quadrangle, the rocks mapped as gneiss are the higher grade metamorphic equivalents of rocks of the southern andesite-graywacke assemblage mixed with lit-par-lit intrusives and migmatites in gneiss domes.

In addition to the dioritic batholiths and gneiss domes there are two younger groups of intrusive rocks in the southern Shield; the older was emplaced during the Yafikh orogenic event, approximately 650 to 600 m.y. ago, and the younger group during the Bishah orogenic event, approximately 550 m.y. ago (Greenwood and others, 1975, p. 519). The first group is generally syn- to post-Halaban group whereas the second is generally post-Murdama group.

The intrusive rocks emplaced during the Yafikh orogenic event were gabbro and granodiorite to granite of calc-alkaline chemical trends. These include most of the larger batholiths and ring structures and many of the smaller circular plutons. Associated dikes, sills, and irregular bodies are common. The granitic rocks of this group are gray, pink, and light red; they are medium to coarse grained and porphyritic, contain large microcline or orthoclase phenocrysts, and are generally massive but locally gneissic. Lithologies mapped include rhyolite, pyroxene granophyre, granite, and quartz monzonite in the Juqjuq quadrangle (Hadley, 1976); gabbro, porphyritic biotite granite, pyroxenite, anorthosite, norite, and hornblende granodiorite in the Tathlith quadrangle

(Overstreet, 1978); and gabbro and biotite-hornblende granodiorite to quartz monzonite in the Wadi Malahah quadrangle (Greenwood, 1979b). The association of the granitic rocks and gabbro in some ring structures suggest that they are cogenetic.

The intrusive rocks emplaced during the Bishah orogenic event include gabbros to granites many of which show alkalic modal and chemical trends (Greenwood and others, 1975). Subcircular homogeneous to zoned plutons and stocks are the normal mode of occurrence for this group of rocks. Dikes and sheets in country rocks around intrusives are common. These intrusive rocks are generallly fresh and nondeformed, except along major Najd faults. Topaz and fluorite are common late interstitial minerals in granitic rocks. Tonalite is the most abundant lithologic type in the Juqjuq quadrangle and lesser amounts of gabbro, serpentinized pyroxenite, biotite granophyre (syenite to monzonite), rhyolite, granodiorite, and granite are present. Lithologies mapped in the Tathlith quadrangle include compositionally and texturally layered gabbro, norite and diorite, anorthosite, biotite granite, biotite-pyroxene granite and granite porphyry, which Overstreet assigned to a peralkaline magma series. Muscovite-quartz monzonite and quartz and potassium-feldspar porphyry were emplaced during the Bishah orogenic event in the Wadi Malahah quadrangle (Greenwood, 1979b).

Numerous metamorphosed and unmetamorphosed mafic and felsic dikes cut layered rocks of the southern andesite-graywacke assemblage and the gneissic batholithic rocks but few significant dikes intrude rocks of the northern andesite-graywacke or metasedimentary assemblage. Diabasic to dacitic dikes of three ages have been recognized (Greenwood, 1979b) in the Wadi Malahah quadrangle and the youngest dikes represented in the gold belt are mafic dikes occupying northwest-trending Najd faults. Rhyolitic and granitic dikes are mostly related to the later orogenic events and are generally not as extensive as the mafic dikes. Many of the felsic dikes are directly related to granitic bodies emplaced during the Bishah orogenic event; these dikes commonly grade along strike from graphic granite to felsite and pegmatite. Chilled margins are not common.

Structure

The major structural element (pl. 1) is the Jabal Ishmas-Wadi Tathlith fault zone, a major north- to northwest-trending zone of faulting, shearing, and alteration composed of several individual strands from .5 to 5 km in width. Each strand is marked by numerous parallel and nearly vertical fault planes, breccia zones, alteration zones, and local quartz veins. The system is a major structure that has undergone several stages of movement, most of which predated the Najd faulting. The degree of crushing, shearing, and folding is much greater in gneissic rocks and rocks of the southern andesite-graywacke assemblage than in rocks of the northern andesite-graywacke and metasedimentary assemblage. This zone probably developed originally during the older Aqiq, Ranyah, or Bishah orogenic events and was reactivated during Najd faulting. The original system was sufficiently deep to tap basic or ultramafic magma. Serpentinite bodies are common along the zone north of 19°00'N., but are not present south of this latitude. Talc, carbonate, and carbonate-rich alteration zones are also common along the northern segment. Serpentinite seems to have been emplaced during more than one period. Those serpentinites along the shear zone are highly sheared and deformed and form tectonic melanges. In the northern part of the Markas quadrangle and southern part of the Hamdah quadrangle the serpentinite is in sheet-like, generally concordant bodies and in larger masses of indeterminate shape.

The Najd system is a major system of northwest-trending left lateral faults that is extensive in the northern part of the Shield area (Brown, 1972). The Najd faults in the northeastern part of the map area (Juqjuq and Jabal Yafikh quadrangles) represent the southernmost zone of major Najd faulting, although faults of indeterminate age and northwest trend occur throughout the belt. Numerous quartz- and dike-bearing fractures with northeast and east trends, in the northern half of the belt, are probably second and third order faults of the Najd system (Hadley, 1976, p. 25).

The Jabal Ishmas-Wadi Tathlith fault zone north of lat 19° is readily traceable on the total intensity aeromagnetic maps of Andreasen and Petty (1973, 1974), as are the Najd faults. South of lat 19° the zone is not reflected on these maps; however the northwest-trending fault that bifurcates southeast at lat 19° is well marked on the aeromagnetic map and probably represents the major deep-seated system. The lack of serpentinite, talc carbonate bodies and ultramafic bodies along the south-trending segment of the zone and their presence along the southeast-trending strand also supports this interpretation.

GOLD DEPOSITS

Descriptions

The gold deposits are aligned along the Jabal Ishmas-Wadi Tathlith fault zone and all are within or close to greenstone sequences composed of greenschist facies metavolcanic, metavolcaniclastic, and metasedimentary rocks. Batholithic rocks and metamorphic rocks higher in metamorphic grade than greenschist facies contain only two small gold occurrences although quartz veins are common throughout these terrains.

Most known gold deposits of the Jabal Ishmas-Wadi Tathlith belt are within or next to quartz veins, quartz breccia zones or quartz stringer zones, thus the genetic aspects of the gold are intimately tied to that of the quartz. The veins are fracture fillings and strike of most is in the range of 335 to 40 azimuth with dips of 60-90 degrees. A few gold-bearing veins with shallow dips are connected to larger, steeply dipping veins. Only a small percentage of the quartz veins exposed in the belt contain gold; most are barren of gold or sulfides. Deposits at the Hajr mine (no. 30a, pl. 1) and Jabal Mahanid (no. 29, pl. 1) are along the altered and veined contact between an overlying serpentinite and an underlying hornblende schist. Quartz-carbonate stringers are locally present and felsic dikes occupy some, but not all, of the mineralized contacts.

The individual veins range from a single banded and brecciated vein 1± m in width and 50± m in length within a fracture, to a sheared and altered zone containing several quartz lenses, pods, breccias, and stringer zones. The largest such zone investigated was at the Al Lugatah prospect (no. 25, pl. 1), 600 m in length and 40 to 80 m in width. Most of the veins are internally brecciated and healed by younger quartz although banding, comb structure, cockade structure, and drusy vugs are common. Inclusions of wall rock fragments within the veins are common, but quartz-healed wall-rock breccias are not. Wall rock and internal vein breccias are tectonic in origin. There is no evidence of solution brecciation. Slickensided faces within and along the edge of the veins is common, and many veins have been broken and boudinaged. Veins in a few areas have been broadly folded, especially in the southern part of the belt.

Types of wall rocks at the gold deposits in the Jabal Ishmas-Wadi Tathlith gold belt are diverse: siltstone, shale, sandstone, conglomerate, quartzite, graywacke, calcareous metatuff, andesite agglomerate, andesite to dacite volcanic rock, quartz porphyry, quartz biotite schist, chlorite schist, hornblende schist, quartz monzonite gneiss, serpentinite, gabbro, diorite, quartz diorite, quartz monzonite, and biotite granite. There are no occurrences in limestone or volcanic flow rocks, both relatively abundant. The barren quartz veins occur in an even greater variety of rock types.

All deposits listed were mined by ancients prior to 1000 A.D. Most of the gold mined was from along the selvage zones of larger quartz veins, or within quartz stringer zones in shear zones, areas where quartz was not abundant. Workings are generally shallow pits and trenches confined to the near-surface weathered zone. Underground workings are not common; shafts are shallow and at the intersections of the mineralized structure and crosscutting faults. Deep shafts with drifts leading off for unknown distances are found at Al Lugatah (no. 25, pl. 1), Al Gariat Avala (no. 26, pl. 1), Hajr mine (no. 30a, pl. 1), Shasrah (no. 37, pl. 1), and Jabal Guyan (no. 38, pl. 1). Circular to trough-shaped grinding stones can be found at most prospects but slag is not common. Ancient stone dwellings are common and at Jabal Umm Matirah (no. 1, pl. 1), Dahlat Shabab (no. 5, pl. 1), Bir Jarbuah (no. 11, pl. 1), Al Gariat Avala and the Hajr mine there are ruins of large villages next to the ancient mines. Fine- to medium-grained tailings in and next to the village sites suggest that the villages were occupied during the mining operations.

Geologic descriptions, physical descriptions, exploration methods, summarized analytical data, and estimated potential resources for each occurrence or prospect are given in appendix A.

Igneous associations

A genetic relationship between the gold-quartz veins and felsic or gabbro intrusive bodies can be inferred at several areas. At the Umm Shat group (no. 7, pl. 1), Jabal Kattab (no. 15, pl. 1), Wadi Al Mushel (no. 27, pl. 1), Al Hasbat (no. 28, pl. 1), Jabal Shaybah (no. 22, pl. 1), Jabal Dalfa (no. 3, pl. 1), Jabal Mahanid (no. 29, pl. 1), and Hijrah-Hamdah (no. 30, pl. 1) prospects, quartz monzonite and aplite dikes were the source of the quartz-forming solutions. At these locations quartz occurs as stringers and pods along the contacts of the dikes, in some places for distances of several meters into altered wall rock, as stringers and veins within the dikes, and extending beyond the dikes along the same structure. In the Jabal Mahanid area all of the deposits are along a contact between serpentinite and hornblende schist that has been intruded by felsic dikes. The associated gold mineralization, quartz veining, aplite dikes, and pegmatites can be traced to a small granite stock at the northern end of a belt of occurrences. A similar situation exists at the Higera-Hamdah prospects where gold is found along the contact between serpentinite and hornblende schist that has been invaded by felsic dikes. Gold is also found here in small conformable quartz-stringers and breccias extending outward from quartz-monzonite dikes into quartz-biotite schist. Veins at Avala, Wadi Miflih (no. 32, pl. 1), and Ishmas Junub (no. 8, pl. 1) are within small gabbro bodies and some of the veins at

Shaybah and Al Baythat (no. 31, pl. 1) are within gabbro. Most of these occurrences are numerous and discontinuous small quartz veins close to the edge of the enclosing body and are probably late differentiates of their respective stocks. The veins at Avala, however, transect most of the gabbro body and are part of a regional system.

Mineralogy and alteration

Mineralogy of the veins is simple, with white to light-gray massive quartz being the main constituent; pods and stringers of dark-gray quartz are rare. Chalcedonic quartz is present in the veins in the northern part of the belt and is the major constituent in a few veins. Calcite pods and stringers are locally abundant. Pyrite, minor chalcopyrite, and sphalerite occur sporadically. Galena is locally abundant in the Wadi Al Mushel and Al Hasbat veins and arsenopyrite is present in the altered and mineralized zone at the Hajr mine. Flakes of graphite within quartz were noted at Jabal Shaybah and Bir Jarbuah and minor rhodochrosite is found as scattered crystals at Bir Jarbuah. Chlorite is a common constituent in most veins, as scattered clots and as distinct bands. Pink potassium feldspar clots and pegmatitic zones are found within the vein systems at Jabal Dalfa, Najeeb (no. 16, pl. 1), Wadi Al Mushel, and Jabal Mahanid. Gold is found as descrete scattered flakes within the quartz, as a fine film along fractures in quartz, as flakes in small irregular vugs, and as small specks next to or within chlorite, pyrite, or chalcopyrite. Gold is also found in the selvage zones within stringers, pods, and masses of hematite or limonite. The nature of the gold in the unweathered portions of the selvage zone is not known. At the Hajr mine, descrete isolated grains of gold were found in altered serpentinite close to aplite dikes.

Hydrothermal alteration of the wall rocks is common and extends along many non-quartz, as well as quartz, vein-bearing fractures. Propylitization is very common and extends tens of meters away from the vein or fracture as shown by carbonate and pyrite in the wall rock, but it is often difficult to distinguish the deposits in similar-appearing greenschists. Most of the deposits have more intense alteration close to the vein or fracture. This alteration consists of carbonate- and sericite-rich rock that has a distinct red hue and contrasts sharply with the green of the propylitized greenschists. In some areas, especially Jabal Mahanid and Hijrah-Hamdah, the carbonate-sericite altered rock has been intensely silicified.

Centers of metallization

Although the gold deposits are aligned along the Jabal Ishmas-Wadi Tathlith fault zone, they are centered in five distinct geographic groups (pl. 1). Deposits within each group are generally of a similar type.

Group I (no. 1-21, pl. 1) takes up most of the northern part of the belt and contains approximately half of the known deposits within the belt. The ancient gold mines are in quartz and quartz-rich breccia veins that trend northeast or slightly west of north and are cut by later north- and northwest-trending barren quartz veins. Calcite and chalcedonic quartz are common vein minerals and sulfides are minor constituents. At three of the deposits, quartz veins are intimately associated with felsic dikes, but generally the deposits are in quartz veins of a regional system that show no relationship to intrusive igneous activity. The veins of group I are at the intersection of major faults of the Najd system with the Jabal Ishmas-Wadi Tathlith fault zone. Most of the gold-bearing veins are cut by Najd faults and barren quartz veins along Najd faults and thus predate Najd faulting. However, a few of the gold-bearing veins may be along third order faults of the Najd system. Ancient placer workings are common in the large wadis and flats surrounding several of the deposits in this group (Schmidt and others, unpublished data).

Group II deposits include the two with the highest potential for future development, Al Lugatah and Al Gariat Avala. Al Lugatah is in a large lens of altered and sheared quartz porphyry that contains abundant pods and stringers of quartz, whereas Al Gariat Avala is in major regional quartz veins that cut gabbro and greenstone. The rest of the deposits in this group are in short discontinuous veins and pods in and around gabbro bodies. This group of deposits is aligned east-west across the intersection of the Jabal Ishmas-Wadi Tathlith fault zone and a northwest-trending system of faults.

Deposits in group III (pl. 1) are associated with felsic dikes, and most occur beneath flat-lying bodies of serpentinite. Much of the mineralization is along a veined and altered contact between an overlying serpentinite and an underlying hornblende schist, but some is along or extends out from felsic dikes several tens of meters below this contact. Sulfides of lead, zinc, and iron are found locally. The felsic dikes are related to the late intrusive phase of a major granodiorite to granite late-syntectonic to post-tectonic stock, dated by zircon methods using thorium-lead, uranium-lead, and lead-lead data at 660 ± 12 m.y. (Cooper, and others, 1979).

Deposits in group IV are small discontinuous pods and veins of quartz along faults, or scattered within or next to a gabbro body. Only a small percentage of the quartz veins contain gold or sulfide minerals. The deposits are along the Jabal Ishmas-Wadi Tathlith fault zone, but all are in second or third order faults rather than the main fault segments.

Deposits in group V are along shear zones in quartz veins, quartz pods, and stockworks of quartz stringers that show no spatial relationship to intrusive igneous rocks. Copper, zinc, and iron sulfides are locally abundant constituents of the gold deposits, and pyrite is common throughout the shear zones. Two of the deposits, Dhahar (no. 35, pl. 1) and Hagira (no. 36, pl. 1), are in zones that at present are exploration targets for massive sulfide deposits of copper and zinc.

GEOCHEMISTRY

Methods of study

Three types of samples were collected for geochemical analyses; composite dump, channel, and grab. The dump samples consisted of approximately 3 kg of material taken from holes dug at least 30 cm deep into the dump. Very fine material was avoided when possible and fragments larger than 5 cm were discarded. Channel samples consisted of from 1 to 3 kg, depending upon sample length, of 2 - 5 cm-sized chips taken from outcrop along a continuous strip. Grab samples consisted of approximately 2 kg of 5 cm or larger fragments taken from a mine dump or from scattered outcrop locations. Sample locations are given in appendix A and on figures 2 through 16. The amount and type of samples taken in each area depended upon the exposure, extent of waste dumps, composition of the dumps, and access to the ancient workings.

All analyses were performed by the DGMR-USGS laboratory in Jeddah under the direction of Joe Curry. Each sample was analyzed by semiquantitative spectrographic methods and by atomic absorption methods for gold and silver. Samples for determination of gold by atomic absorption were prepared by digesting a 10 gm sample split, first in HCl, then in HNO_3; adding HBr and Methyl Iso Buthyl Ketone (M.I.B.K.) to the washed and centrifuged solution; washing the resultant organic layer in a weak HCL, HBr, and water solution to remove interfering elements; and collecting the organic layer in a test tube sealed with a polyethylene stopper. (Joe Curry, written commun., 1978). Selected samples were further analyzed by atomic absorption or chemical methods for Cu, Pb, Zn, Co, Ni, Cr, Mo, and W. A complete listing of all analytical results are on permanent file with the USGS Mission, Jiddah, Saudi Arabia.

The complete data set of 605 samples was divided into 15 subsets (table 2) to facilitate interpretation of the geochemical data by statistical methods using a computer. Subsets of felsic plutonic rocks and mafic rocks were tested also, but neither contained samples with gold values greater than the detection limit. Subsets 3 (felsic dikes), 4 (ultramafic igneous rocks), 5 (greenschist), and 6 (intermediate igneous rocks), include channel samples taken from the wall of the ancient mine workings or as close as feasible, or grab samples taken from waste dumps. Samples comprising subsets 9 through 13 are of all three types (dump, channel, and grab), and each subset contains all samples that were taken from the deposits defining the subset. Frequency tables and histograms of gold values in all geochemical data subsets are given in appendix B.

The element of primary concern in this evaluation was gold--its abundance and distribution. The other elements are important only in their relationship to gold, as none are of economic interest. Most of the frequency distributions of gold values are "censored", that is, a certain fraction of the values fall below the lower analytical detection limit. Only the distribution of gold values in the dump samples approached a normal distribution (app. B) because 91 percent of the samples contained gold in greater abundance than the limit of detection of 0.01 ppm. Since the frequency distributions for gold generally show moderate to strong positive skewness, as do the distributions for most of the metals, the data were transformed to common logarithms and from these the geometric mean and deviation were determined. The geometric mean is the antilogarithm of the arithmetic mean of the data after transformation to common logarithms. The geometric deviation is the antilogarithm of the standard deviation of the data after transformation to logarithms. Cohen's method (see Miesch, 1967) was used to adjust the geometric mean of frequency distributions that were censored. Cohen's method calculates a new mean and standard deviation based upon an ideal normal (in this case lognormal) distribution that hypothetically would be seen if the data values in the censored part of the distribution could be detected. If more than 50 percent of the data is censored then the adjusted mean is less than detection limit value.

The geometric mean is a suitable estimate of relative abundance for comparison purposes, but it is not the best estimate of true abundance. Because of a negative bias it gives values less than true abundance. The best estimate of true abundance for a lognormal frequency distribution is Sichels t- estimator. This method gives a value close to the arithmetic mean, but generally lower because it is not so strongly influenced by a relatively few high values. A program for

Table 2.--*Geochemical data subsets*

Subset number	Number of samples	Data set description
1	605	Total of all samples from the gold belt study
2	235	All dump samples
3	69	Felsic dikes
4	14	Ultramafic igneous rocks
5	57	Greenschist
6	11	Intermediate igneous rocks
7	21	Gossan
8	126	Quartz
9	150	Deposits 1-21 (pl. 1)
10	138	Deposits 22-26 (pl. 1)
11	177	Deposits 27-30 (pl. 1)
12	18	Deposits 31-33 (pl. 1)
13	32	Deposits 34-38 (pl. 1)
14	183	Samples containing greater than 1 g/t gold
15	28	Samples containing greater than 10 g/t gold

computing Sichels t- estimator is not available in Jiddah at present. Appendix C lists the minimum value, maximum value, geometric mean, geometric deviation, and Cohen's mean and deviation for each significant element of each data set. Arithmetic means determined from the raw data for gold and silver are given in tables 3 and 4, along with the gold/silver ratios determined from the arithmetic means. The arithmetic means and not the geometric means, or Cohen's means, should be used as the estimator of true abundance for gold and silver, but they must be considered as slightly high, especially for the strongly censored distributions. Arithmetic means are not given for the other elements because true abundance is not important for them and the geometric mean is a far better estimator for relative abundance.

Correlation coeficients were calculated for each pair of significant elements by computer using the log-transformed data. These are given in appendix D. Confidence limits could not be determined for the coefficients because a program to do so is not available in Jiddah. Therefore, the lowest value that constitutes a significant correlation must be estimated for each individual case.

Discussion of results

The summaries of geochemical data (app. C, tables 3, 4) provide a reasonable estimate of the geochemical nature of each individual subset. Comparisons between certain subsets must be made with caution because of the disparity of sample types and number. Comparisons within two groups of subsets, the six different rock types, and the five geographic areas may be valid, although the statistical significance has not been determined for any comparisons. The data for each of the six rock-type subsets (3-8) is similar, because the samples were of a single rock type and either a channel or a grab sample. Comparisons between subsets of this group would probably be statistically valid. The data for the geographic subsets (9-13) comes from a variety of sample and rock types and the summaries represent a geochemical approximation of the mineralized areas within a geographic unit. The summary of the total samples subset (table 3 and 4, no. 1), could be considered to be a geochemical approximation of the mineralized areas within the gold belt. Comparison among the 5 geographic subsets and the total sample subset would be geologically permissible but perhaps not statistically valid. The summary of the dump samples subset (table 3 and 4, no. 2), can be considered to be the geochemical average of all ore zones within the gold belt; keeping in mind that the analytical gold value represents only a fraction of the hypogene gold concentration, the bulk having been removed by the mining operations. The greater than 1 g/t gold and greater than

Table 3.--*Summary of gold analytical data for all geochemical data subsets. All values are in g/t.*

Subset	Samples containing gold (percent)	Minimum value	Maximum value	Geo-metric mean	Cohen's mean	Arithmetic mean	Gold/silver
1. All samples	67	0.01	325.0	0.83	0.06	2.85	1.60
2. Dump samples	91	0.05	325.0	1.51	0.98	4.79	1.66
3. Felsic dikes	45	0.02	5.5	0.18	0.003	0.26	0.54
4. Ultramafic igneous rocks	64	0.04	5.5	0.61	0.04	1.09	0.73
5. Greenschist	66	0.05	7.7	0.40	0.04	0.62	0.52
6. Intermediate igneous rocks	36	0.08	0.9	0.23	0.001	0.14	0.13
7. Gossan samples	71	0.04	63.0	0.70	0.08	4.01	1.28
8. Quartz	61	0.02	184.0	0.58	0.02	1.84	1.92
9. Deposits 1-21 (pl. 1)	65	0.04	184.0	0.92	0.05	3.22	1.96
10. Deposits 22-26 (pl. 1)	86	0.04	325.0	1.30	0.46	5.46	2.11
11. Deposits 27-30 (pl. 1)	81	0.01	63.0	0.49	0.15	1.65	0.95
12. Deposits 31-33 (pl. 1)	100	0.07	13.3	1.10	1.10	3.09	1.76
13. Deposits 34-38 (pl. 1)	44	0.11	37.5	2.91	0.002	3.65	1.73
14. Samples greater than 1.0 g/t gold	100	1.10	325.0	4.01	4.01	8.92	2.37
15. Samples greater than 10 g/t gold	100	11.50	325.0	23.43	23.43	39.00	5.10

Table 4.--*Summary of silver analytical data for all geochemical subsets. All values are in g/t.* [*Leaders (--) indicate not calculated*].

Subset	Samples containing silver (percent)	Minimum value	Maximum value	Geo-metric mean	Cohen's mean	Arithmetic mean
1. All samples	82	0.10	104.0	1.07	--	1.78
2. Dump samples	93	0.20	104.0	2.69	1.20	2.88
3. Felsic dikes	55	0.10	3.6	0.54	--	0.48
4. Ultramafic igneous rocks	100	0.30	2.7	1.28	1.28	1.50
5. Schist	86	0.30	3.3	1.15	0.87	1.19
6. Intermediate igneous rocks	91	0.20	3.5	0.78	0.65	1.08
7. Gossan samples	86	0.90	25.0	2.25	1.44	3.13
8. Quartz	73	0.10	18.6	0.82	--	0.96
9. Deposits 1-21 (pl. 1)	84	0.20	53.5	0.91	0.63	1.64
10. Deposits 22-26 (pl. 1)	95	0.20	50.5	1.46	1.28	2.59
11. Deposits 27-30 (pl. 1)	69	0.20	104.0	1.17	--	1.74
12. Deposits 31-33 (pl. 1)	89	0.10	6.3	1.43	0.82	1.76
13. Deposits 34-38 (pl. 1)	97	0.10	7.2	1.43	--	2.11
14. Samples greater than 1.0 g/t gold	97	0.20	104.0	1.78	1.50	3.77
15. Samples greater than 10 g/t gold	100	0.20	50.5	4.01	4.01	7.65

10 g/t gold subsets (14 and 15) represent approximations of the mineralized and higher grade ore zones. These are biased because of the amount of contamination in the dump samples.

Because 67 percent of all samples collected contained detectable gold and averaged 2.85 g/t, the area can be considered anomalous in gold--a gold belt. The fact that 91 percent of the dump samples contained detectable gold, suggests that the ancient miners were competent in recognizing valuable deposits because few, if any, of the pits and trenches were dug on barren quartz veins. Gold is the only metal found in concentrations sufficient for extraction, even in the weathered zones. The metal concentration of the dump samples compared to the total data set differs only in a slight enrichment of Fe, Ni, Au, and possibly Pb, in the dump samples.

Ultramafic rocks (subset 4) and greenschists (subset 5) seem to be the best host rocks. A larger percentage of samples from these two sets contained gold and the average abundance was greater as compared to felsic dikes (subset 3), felsic plutonic rocks (not summarized), intermediate igneous rocks (subset 6), and mafic igneous rocks (not summarized). The element concentrations of ultramafic rocks and greenschists are generally higher in Fe, Mg, Ca, Cr, Ni, Sr, Au, and Ag than felsic dikes, felsic plutonic rocks, intermediate igneous rocks, and mafic igneous rocks. The ultramafics contained more Cr, Ni, and Mg, whereas the schists contained more V, Zr, and Ti. The high As content of the greenschist (subset 5), reflects an arsenopyrite-bearing altered zone at the Hajr mine.

Gossan samples are enriched in Ag, Fe, Ni, and possibly Pb, as compared to dump samples (subset 2), and to the total sample (subset 1). They are also depleted in Ba compared to the total sample subset and in Ti, Ba, Cr, and Zr as compared to the dump samples. The percentage of gossan samples containing gold and the average gold concentration are not significantly different from the total sample subset, but are lower than that of the dump samples. This suggests that gold is not concentrated in the gossan zones, although silver and possible lead are. The gold content of quartz (subset 8) is significantly lower than that of gossans (subset 7), dump samples,and total sample subset but is higher than any of the host rock subsets. This lack of a gold concentration in the quartz suggests that the major gold metallization is in the selvage zones or in veinlets in the wallrock next to the veins, rather than within the massive quartz veins.

In comparing the subsets of geographic areas (subsets 9 through 13) it is obvious that deposits 22-26 (subset 10) are prime targets for exploration. Deposits 31-33 (subset 12) have a higher percentage of samples that contain detectable gold and an average gold concentration that is relatively high, however, only 18 samples represent this subset and the maximum gold value recorded is low. The average gold concentration of samples from deposits 34-38 (subset 13) is high, but only 44 percent of the samples contained detectable gold. A high percentage of samples from deposits 27-30 (subset 11) contained detectable gold, but the average concentration is low. Samples from deposits 1-21 (subset 9) contained a relatively high concentration of gold and 65 percent of the samples contained detectable gold, making it the second best group of deposits.

Deposits 22-26 (subset 10) have slightly higher concentrations of Fe and Zr than any of the other four groups and higher Pb and Ti concentrations of all but deposits 31-33 (subset 12). Deposits 27-30 (subset 11) have higher concentrations of Cr and Ni, reflecting the abundance of serpentinite in this geographic area. Deposits 34-38 (subset 13) and deposits 31-33 (subset 12) have higher average concentrations of Cu, reflecting the association of the gold with base metal sulfides in deposits 35 and 36.

Spearman's rank correlation coefficients were calculated by computer for each pair of elements, using the log-transformed data. A coefficient of 1.0 represents the maximum positive correlation, 0.0 signifies complete lack of correlation and -1.0 represents the maximum negative correlation. As can be seen by the correlation matrices (app. D) there is a complete range from 0.0 to coefficients approaching 1.0 or -1.0. Whether or not any one coefficient is significant depends upon the number of data pairs compared and the level of confidence desired. As the number of data pairs increases, the smallest coefficient that is significant at a given statistical level of confidence becomes smaller. The numerical value of a coefficient is important only if it is large enough to indicate a significant degree of positive or negative correlation. Statistical levels of confidence provide arbitrary but objectively defined limits for deciding which coefficients are large enough to be considered geologically important. A program is not available in Jiddah at this time, to subject each coefficient to a significance test. Therefore, an arbitrary set of criteria based upon empirical knowledge was devised to evaluate the coefficients.

The significant correlation coefficients between Au and other elements are listed in table 5. Coefficients with Pb, Zn, Cu, determined by atomic absorption methods, were not considered because usually not enough samples were analyzed by these methods. Silver correlates with gold in all but three of the subsets, greenschists (subset 5), gossans (subset 7), and deposits 34-38 (subset 13). No other element approaches this consistency, suggesting that only silver would satisfy

Table 5.--*Significant correlation coefficients between gold and other elements for all geochemical data subsets*

Subset

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fe			/		−/						X				
Mg			X												
Ca			/												
Ti											/				
Mn				−/											
Ba															
Cr			X			X					/				
Cu			/		−/						/		X		
Ni			X			X									
Pb	/	/								X			X		
Sr		−/							−X						
V	/										/				
Y															
Zr			/												
Ag	X	X	/	−X		−X		X	X	X	X	/		X	X

(blank) Correlation coefficient probably not significant at the 95 percent confidence level

/ Positive correlation coefficient probably significant at the 95 percent confidence level

X Positive correlation coefficient probably significant at the 99 percent confidence level

−/ Negative correlation coefficient probably significant at the 95 percent confidence level

−X Negative correlation coefficient probably significant at the 99 percent confidence level as a pathfinder element for gold. The element association of deposits 27-30 (subset 11) reflects the association of gold with magnetite in altered serpentinite and that of deposits 34-38 (subset 13) reflects the association with massive sulfide deposits. It should be noted that gossans, quartz veins, samples greater than 1 g/t gold and samples greater than 10 g/t gold, did not show a significant correlation with any element other than silver, pointing out the independent geochemical nature of gold.

RESOURCE ANALYSIS

A major goal of this study was to evaluate the potential of the individual ancient mines within the gold belt. In order to facilitate the evaluation, a means of utilizing the limited and variable types of data from the individual prospects was needed. A model was developed based upon historical data for gold-lode deposits (Simons and Prinz, 1973), and specific data for the African, Canadian and Australian shield and greenstone gold belts (U.S. Bureau of Mines, 1971-1975; Emmons, 1937; Anhaeusser, 1976). Data from the Mahd adh Dhahab gold mine (Roberts and others, 1978; Worl, 1978) was also included. The first step was to outline the limiting conditions or expectations. In other words, under similar geologic conditions in other Precambrian shield areas what are the parameters of the known prospects and developed ore bodies. These parameters are listed in table 6. In summary, the great majority of the prospects are small, low grade, and have limited or no potential.

The second step was to develop a means of evaluating each prospect. The tonnage of a prospect can be estimated from length and width of the mineralized structure. Length is the total continuous exposed distance of the mineralized structure, or a segment of the structure (table 7). Width is set at 1 m for small structures and 1.5 m for large structures and total depth at 100 m for small structures and 150 m for large structures. These figures were based upon reasonable required mining widths and historical data. A value of 2.7 for the specific gravity was assigned based upon studies of drill core at the Mahd adh Dhahab mine (Worl, 1978). Since only approximately 75 percent of the linear structure in this type of deposit contains ore, the tonnage calculations were adjusted accordingly.

The dump sample is preferred as an estimate of potential grade. Many of the deposits are poorly exposed and the waste dumps are the only source of samples as the veins and ancient workings are covered by alluvial and eolian sands. Exposures

Table 6.--*Characteristics of Precambrian greenstone belt gold-ore bodies.*

I. Ore body dimensions:

	Length	Width	Depth
Large structure	100 m	1.5 m	150 m
Small structure	60 m	1.0 m	100 m

II. Tonnage:

<100,000 tons in a majority of the deposits
>500,000 tons in very few of the deposits

III. Grade:

1-5 g/t for a majority of total prospects
5-20 g/t for a majority of mines
>20 g/t for a very few mines

IV. Percentage of prospects with potential

46 percent of the prospects have no potential
36 to 45 percent of the prospects have limited potential
7 to 16 percent have potential resources
<1 percent have significant potential resources

V. Occurrence:

Gold metalization occurs in several localized ore shoots of variable grade.

Table 7.--*Empirial model for determination of potential resources of gold deposits in the Jabal Ishmas-Wadi Tathlith gold belt.*

I. Tonnage

Length x width x depth x sp gr x .75 percent = tonnage m

Large structure:

Length x 1.5 m x 150 m x 2.7 x .75 percent = tonnage m

Small structure:

Length x 1.0 m x 100 m x 2.7 x .75 percent = tonnage m

Length is the total continuous exposed distance of mineralized structure. This may be all of or a segment of a vein.

II. Grade

1. Average grade of dump samples is equivalent to from 25 to 35 percent of grade of best minable width.

2. Channel and selected chip samples indicate presence of gold only and high values represent reasonable estimates of grade of higher-grade ore zones.

are so limited that channel sampling across the mineralized zones was difficult, if not impossible, and results of those samples obtained are probably not representative. The mine dump itself is a bulk representative sample of the prospect, and composite sampling of the dump is the best method, short of diamond drilling, to estimate the potential grade at any one prospect. It was inferred that the average Au value of dump samples is equivalent to 25 - 35 percent of the potential ore grade. Although this figure is somewhat arbitrary, it was based upon comparisons of dump sample values and epigenetic ore values at the Mahd adh Dhahab mine and the Hajr mine (Helaby and Worl, unpublished data).

This method of analysis is applicable only to the ancient vein mines of the Jabal Ishmas-Wadi Tathlith gold belt; not to veins that were not mined by ancients, ancient placer mines, or to ancient mines in other areas. Quartz veins not mined by the ancients were tested by grab, channel, and gravel samples. None were found to contain gold. For consideration as a potential resource, an ancient mine must show geologic or physical evidence of mineralization, such as trenches, pits, shafts, or analyses for a reasonable length (continuous for 100 m along one vein, or an aggregate 300 m along several parallel or en echelon veins). Only those segments that show evidence of somewhat continuous mineralization were included in the resource analysis. The model gives an estimate of the potential resource tonnage and grade of a prospect, which is the maximum expected if the assumptions of length, width, depth, and grade are met. The evaluations are based upon exposure only and no inference was made to extensions under cover. The resulting potential resources for each mine area are listed in appendix A. The results as summarized in table 8 are not encouraging for future exploration work along this belt of ancient mines. Only three ancient mines are considered worthy of further investigations, Al Lugatah (no. 25, pl. 1), Al Gariat Avala (no. 26, pl. 1), and Jabal Guyan (no. 38, pl. 1). Others of interest, but of low priority include Jabal Umm Matirah (no. 1, pl. 1), Ishmas Kabir (no. 6a, pl. 1), Jabal Dalfa (no. 3, pl. 1), and Nufud Almistajed (no. 17, pl. 1). The mines in the Jabal Mahanid (no. 29, pl. 1), and Hijrah-Hamdah (no. 30, pl. 1) areas are a special case and are worthy of further work because of the potential for finding a source bed for the gold in the near vicinity.

Table 8.--*Summary of potential resources of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt.*

Number of deposits	Potential ore tonnage	Area number (pl. 1)	Potential grade (g/t)
34	Less than 50,000		Less than 7 g/t
4	50,000 to 100,000	6b 32 33 34	12-17 17-24 23-32 40-55
2	100,000 to 200,000	4 11	9-12 7-10
2	200,000 to 300,000	1 6a	10-16 14-20
4	300,000 to 400,000	3 25 26 38	15-21 9-12 13-18 12-16
1	15 to 20 million	25	2.5

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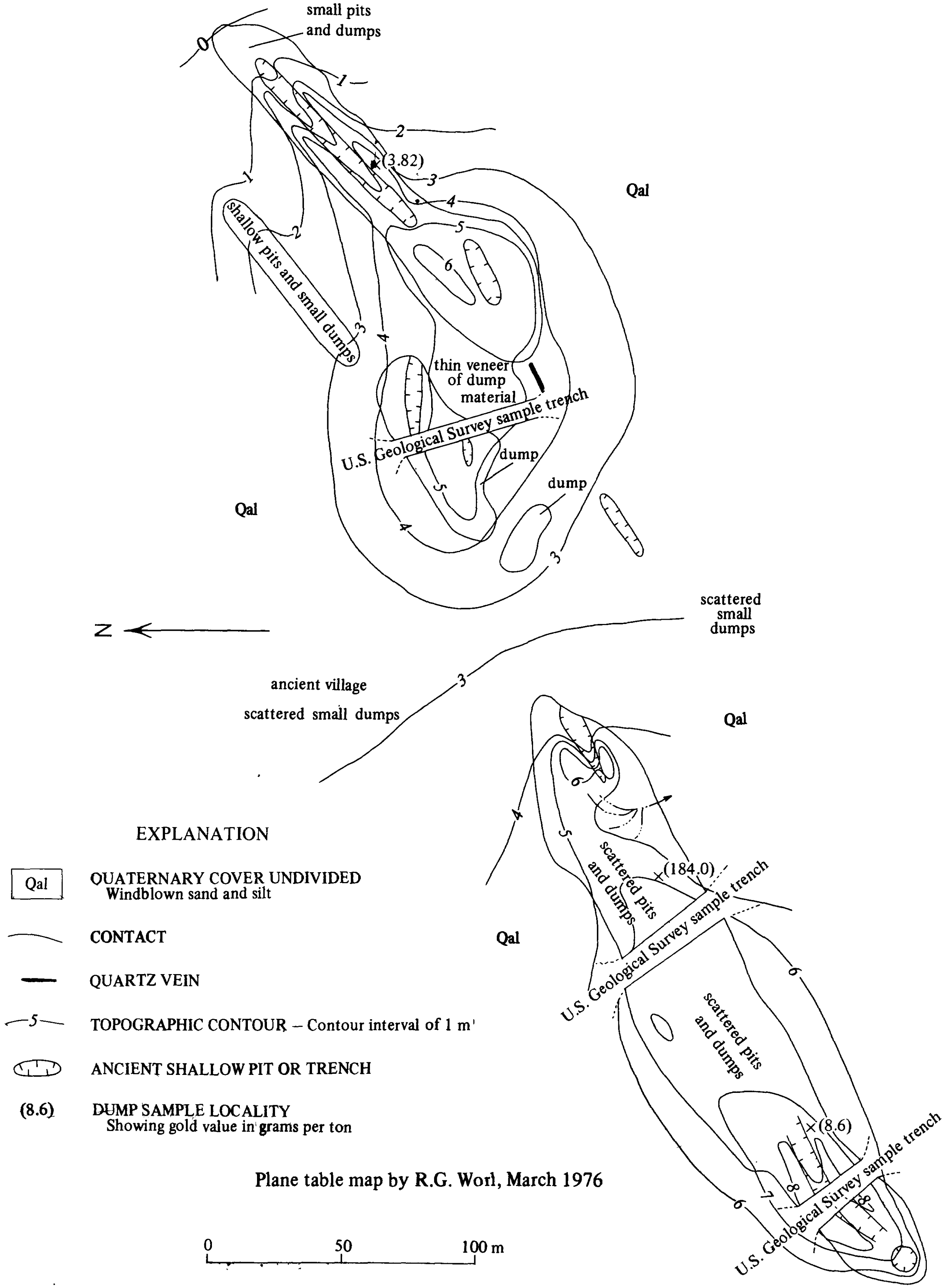

Figure 3. Geology of the Ishmas Kabir ancient gold mine (no. 6a, pl. 1).

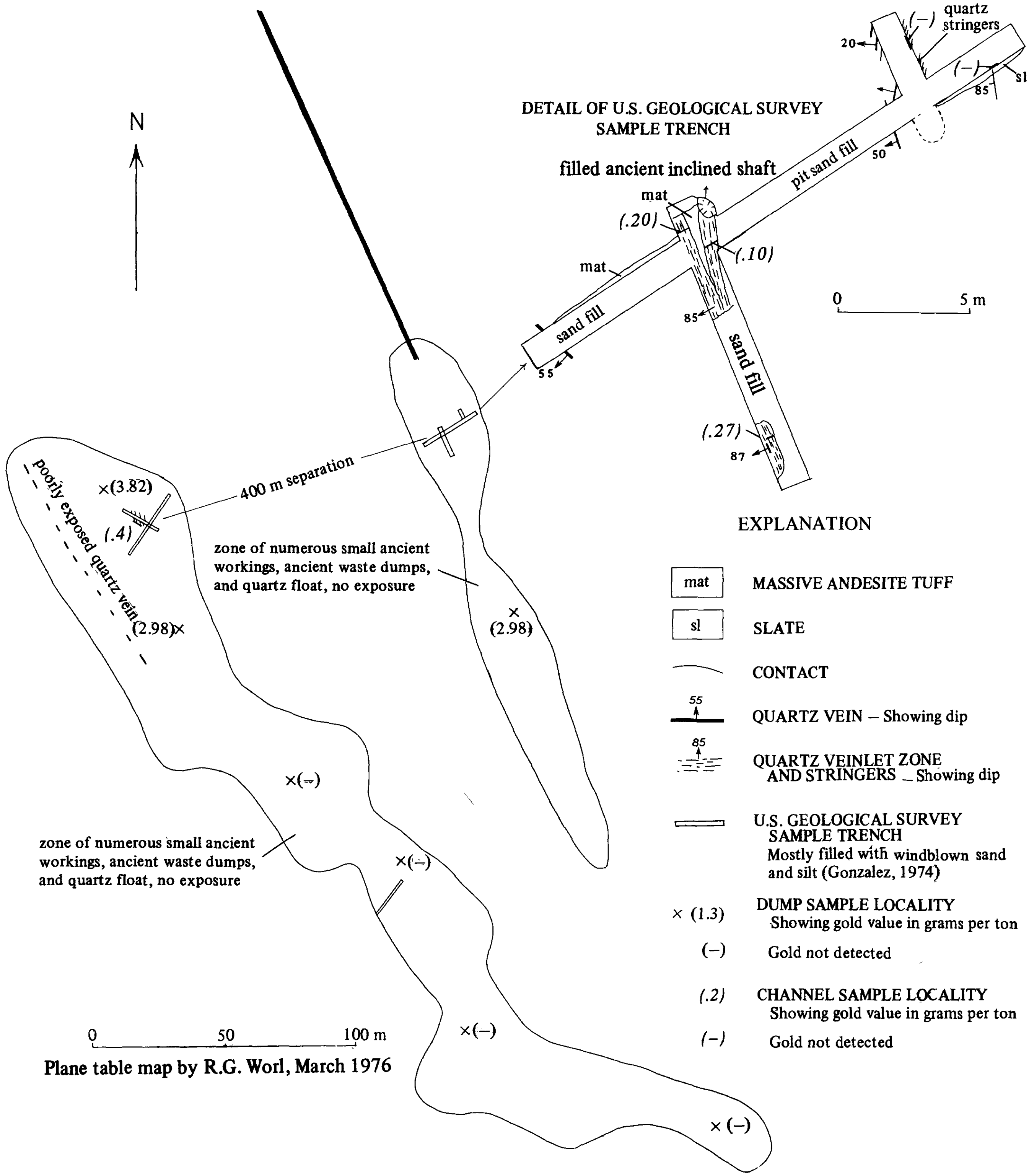

Figure 4. Geology of the Gharb ancient gold mine, Umm Shat group (no. 7a, pl. 1).

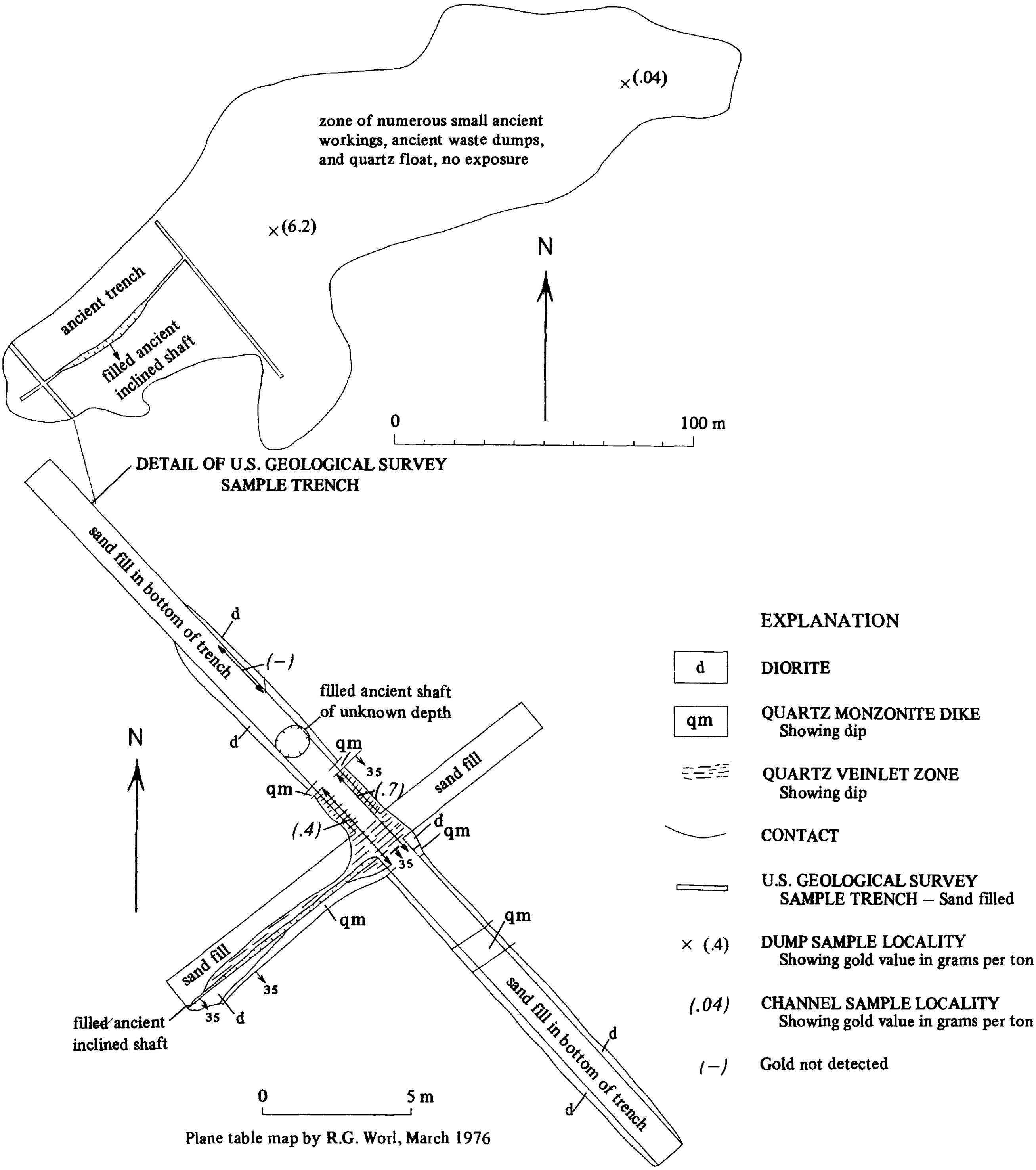

Figure 5. Geology of the Sharg **ancient gold mine**, Umm Shat group (no. 7b, pl. 1).

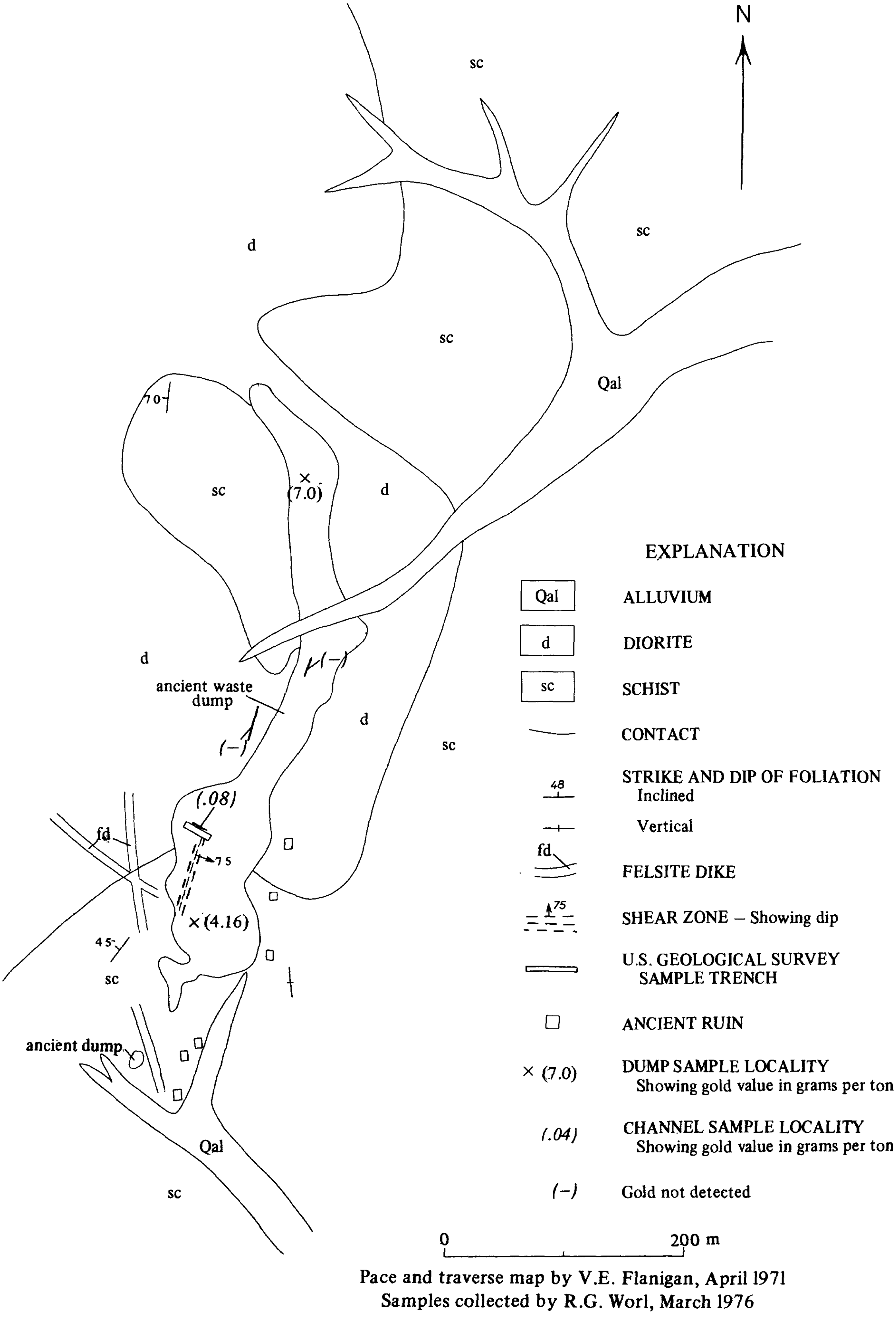

Figure 6. Geology of the Bir Jarbuah ancient gold mine (no. 11, pl. 1).

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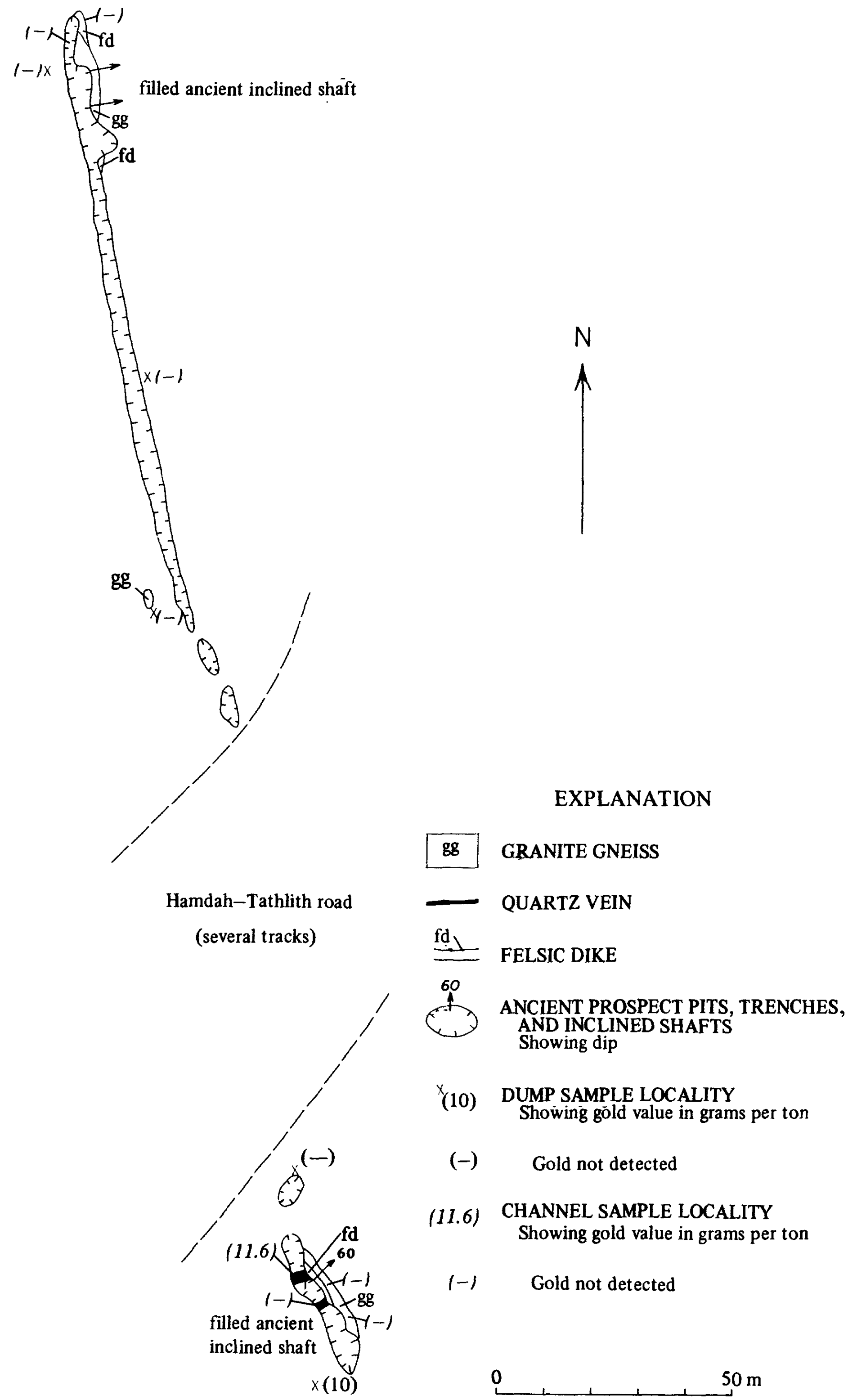


Figure 9. Geology of the Al Hasbat ancient gold mine (no. 28, pl. 1).

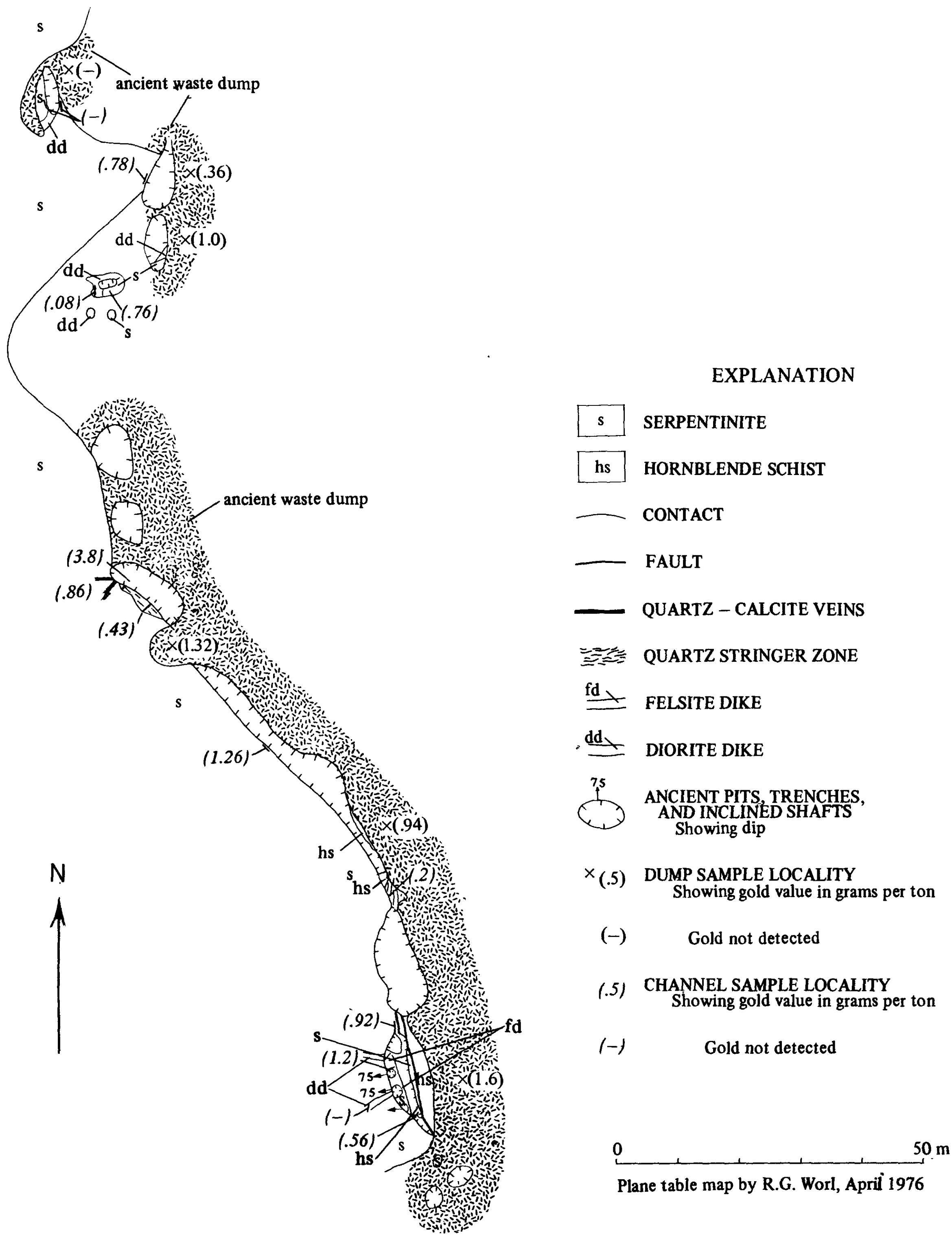


Figure 10. Geology of the Al Hlamiya south ancient gold mine, Jabal Mahanid group (no. 29a, pl. 1)

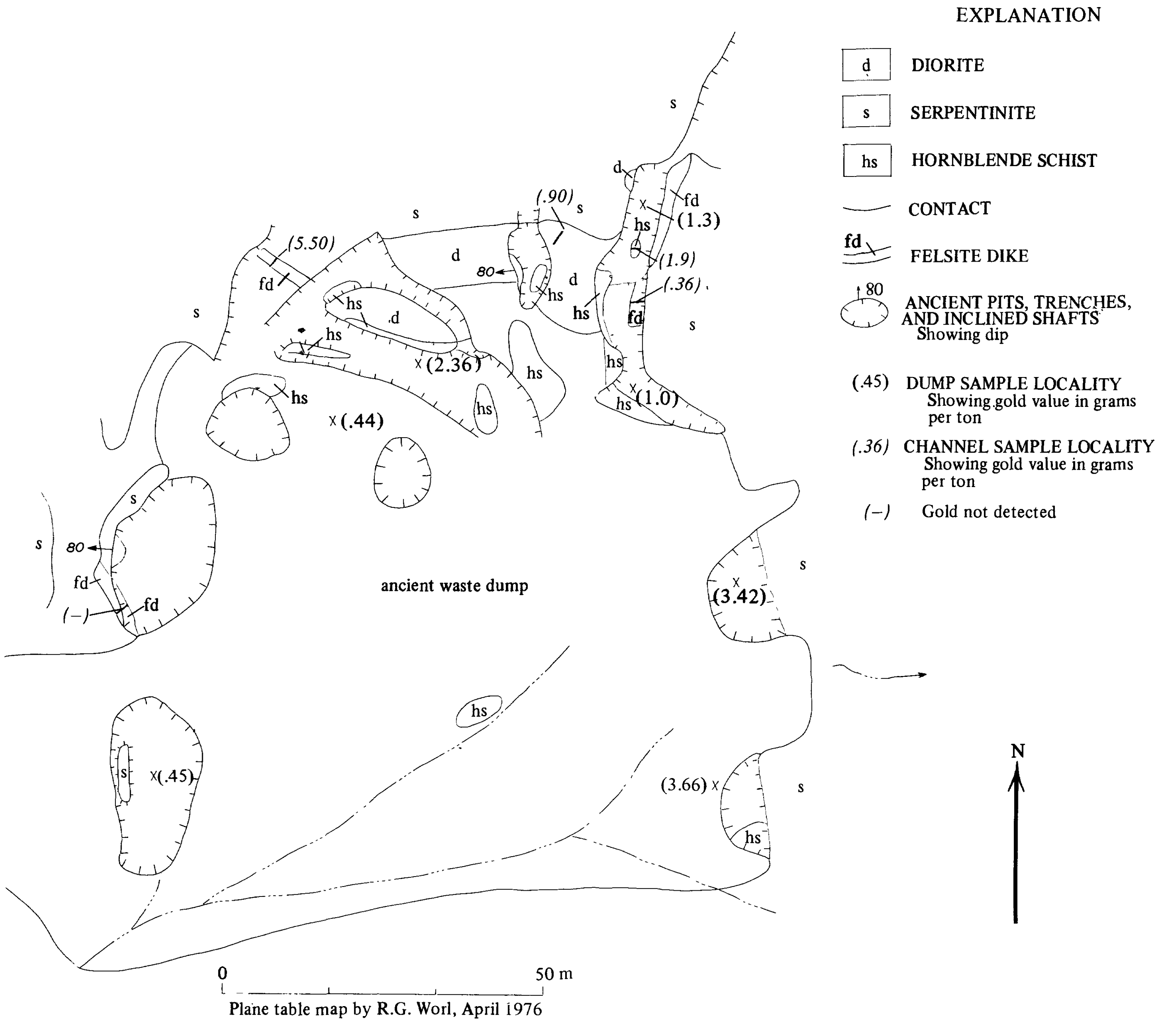
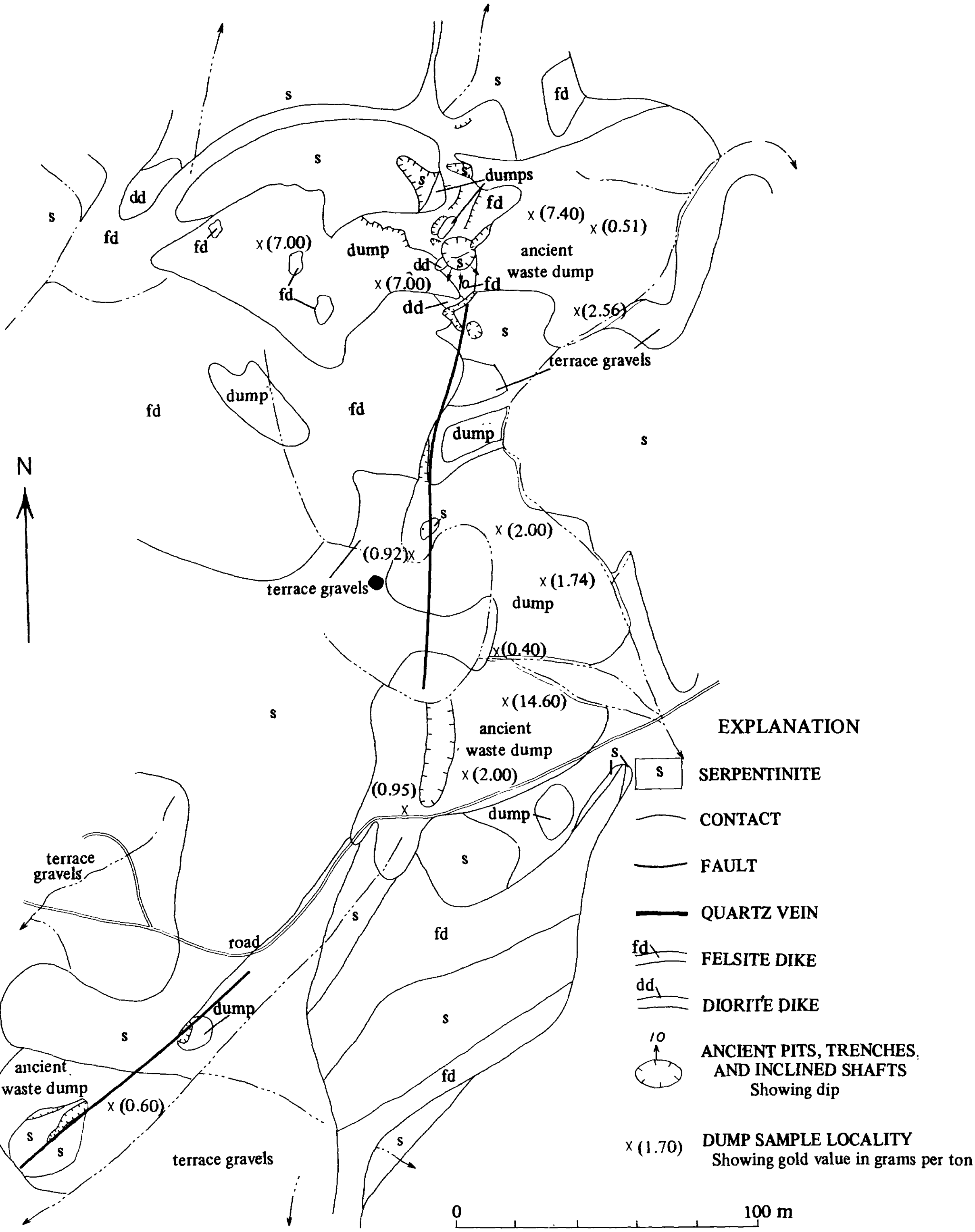


Figure 11. Geology of the Jabal Ibn Hassun ancient gold mine, Jabal Mahanid group (no. 29b, pl. 1)



Plane table map by R.G. Worl, June 1976

Figure 12. Geology of the Riah ancient gold mine, Jabal Mahanid group (no. 29c, pl. 1).

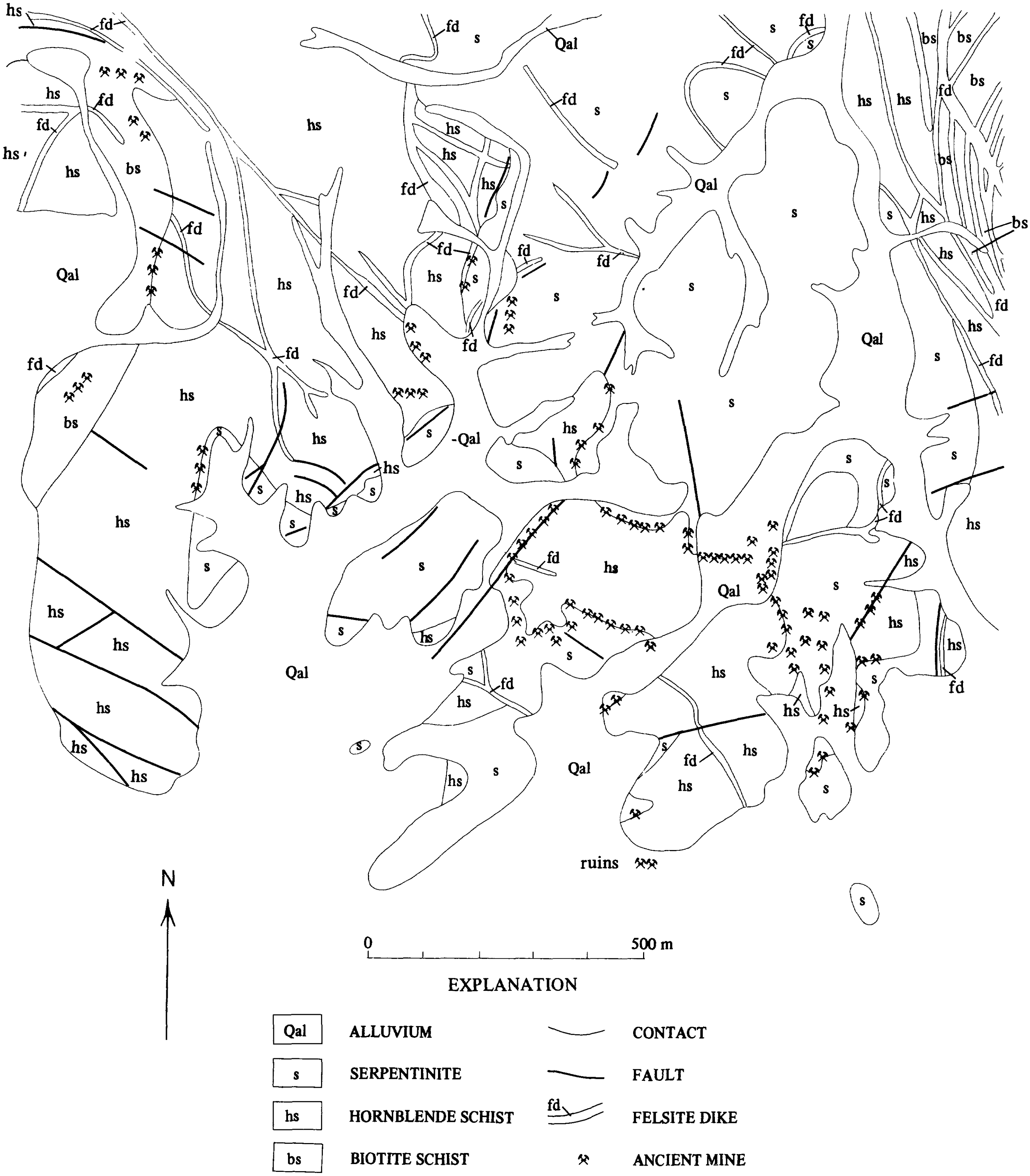


Figure 13. Geology of the Hajr ancient gold mine area (no. 30a, pl. 1) (after Helaby and Worl, in prep.)

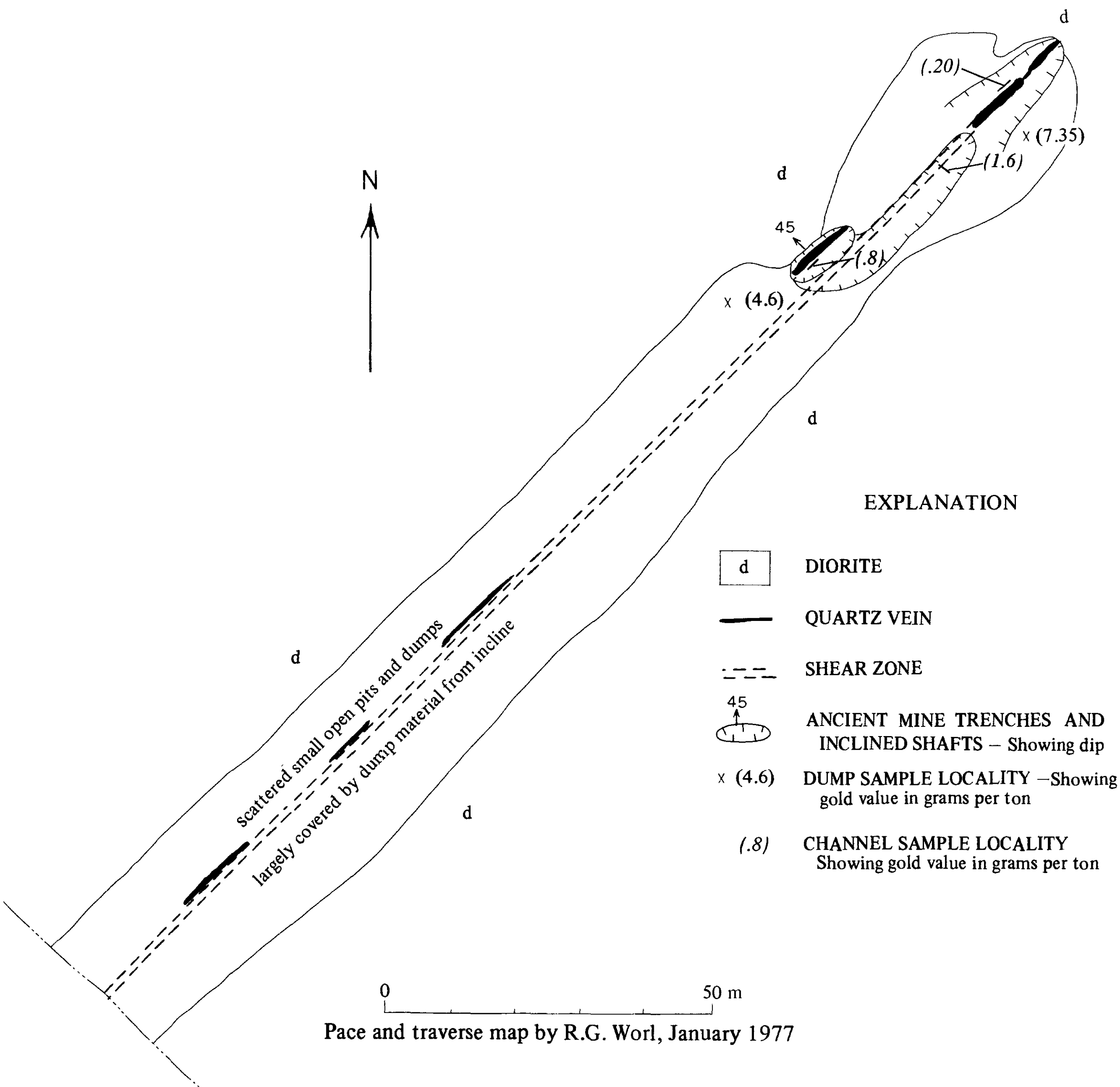
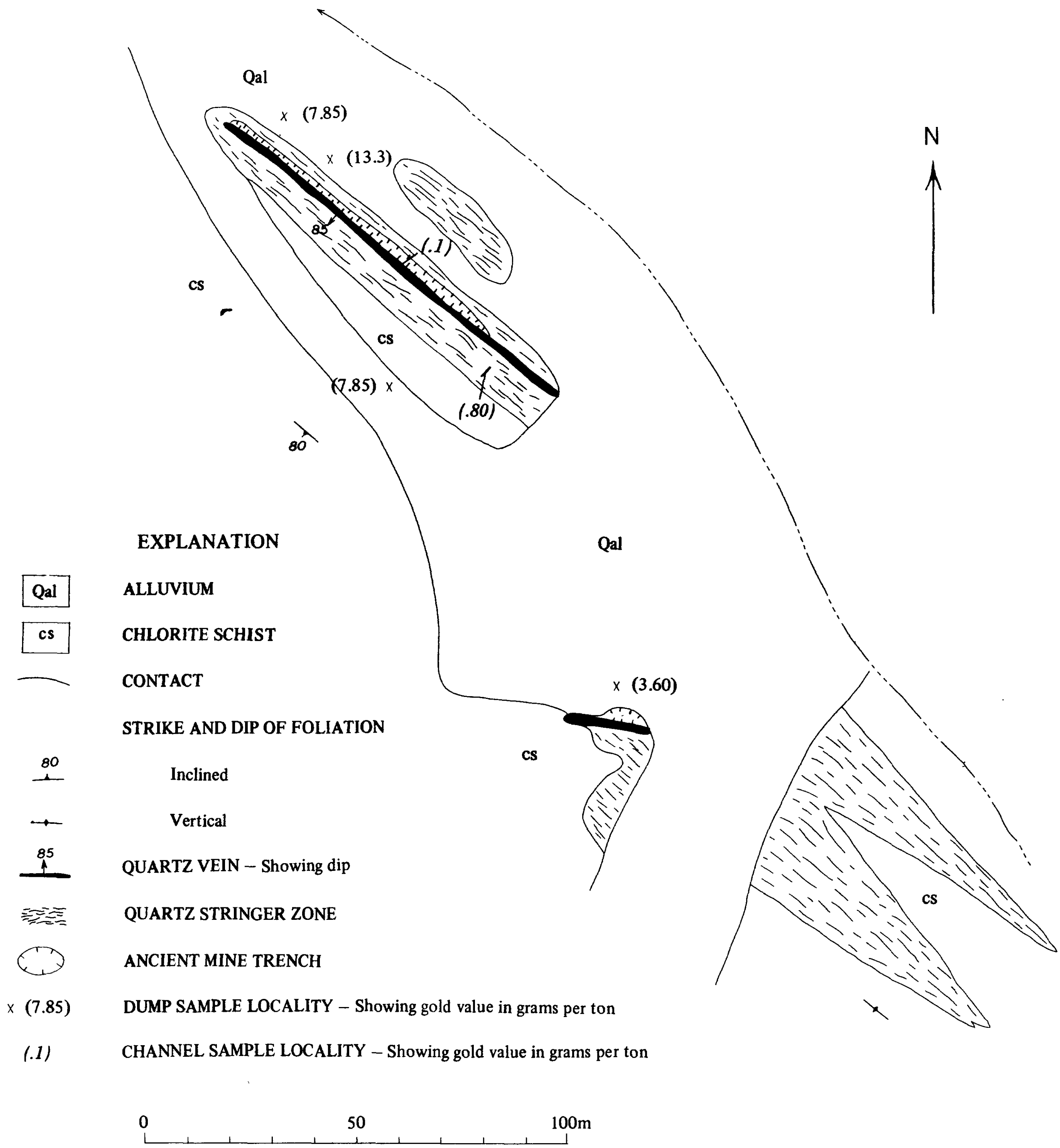


Figure 14. Geology of the Wadi Miflih ancient gold mine (no. 32, pl. 1)



Pace and compass map by R.G. Worl, 1977

Figure 15. Geology of the Wadi Gharaba ancient gold mine (no. 33, pl.1)

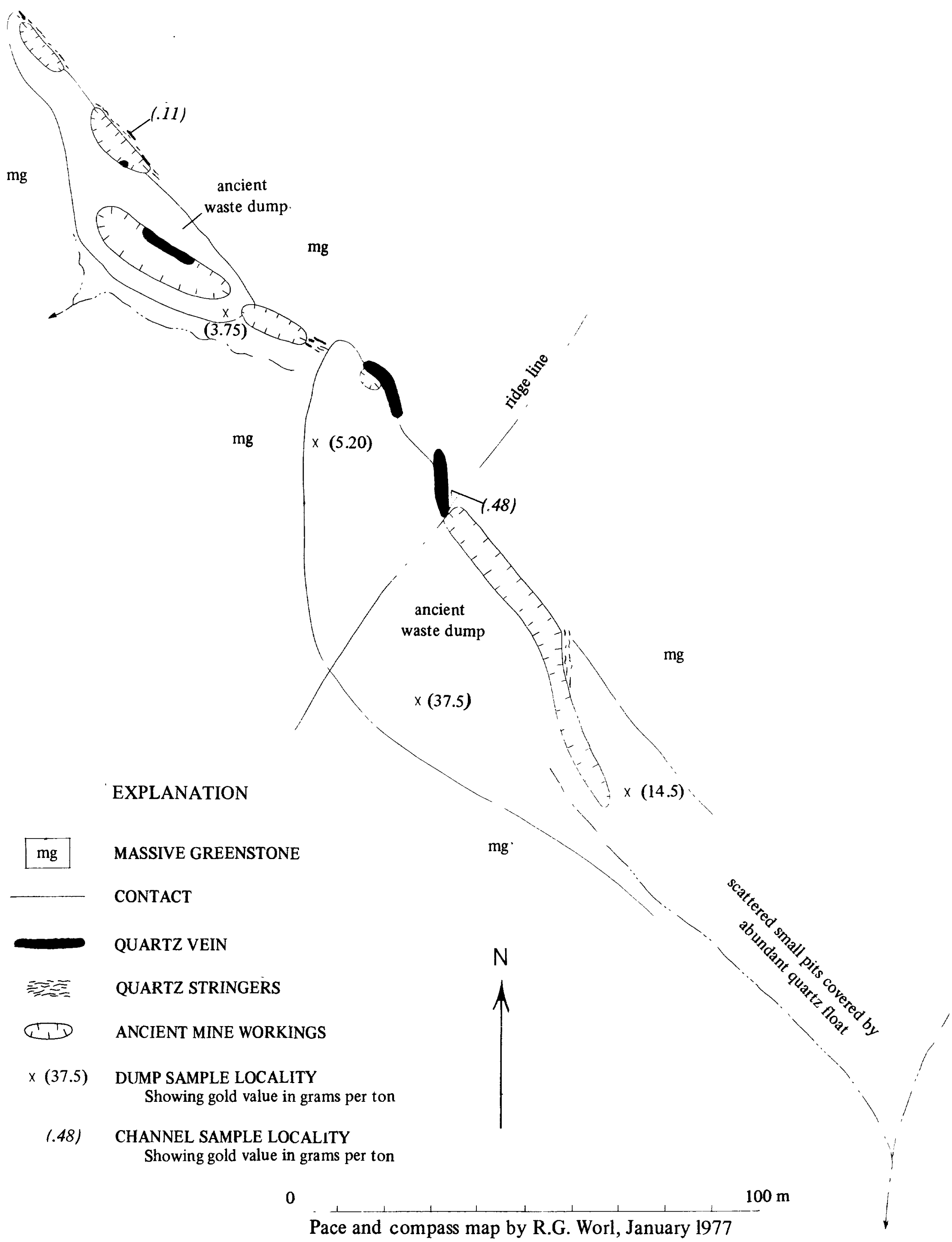


Figure 16. Geology of the Masagha ancient gold mine (no. 34, pl. 1)

CONCLUSIONS

Discussion

The Jabal Ishmas-Wadi Tathlith gold belt coincides with a major north-south fault system and a belt of metavolcanic and metasedimentary rocks. The gold-bearing quartz veins are largely confined to greenschist grade metavolcanics and metasedimentary rocks and are spatially related to the main fault zone, the Jabal Ishmas-Wadi Tathlith fault zone. This association is found in other Precambrian shield areas of the world (Anhaeusser, 1976, p. 30; Goodwin and Ridler, 1977, p. 154). The gold deposits are spatially related to the fault system but are probably only indirectly related to it genetically. Movement along the fault system developed the tensional (dilational) second- and third-order fractures that were the loci for deposition of gold and quartz from hydrothermal solutions.

The fact that all known deposits (app. A) in the gold belt are classified as hydrothermal and epigenetic and occur within greenschist grade rocks is an important exploration guide. However, the possibility exists for other, mainly syngenetic, types of deposits to be present. The source of the gold that was transported and deposited in the hydrothermal systems may have been from such deposits. It has been suggested that the conditions of middle or upper greenschist facies of regional metamorphism constitute an optimum thermal zone wherein gold tends to concentrate preferentially (Anhaeusser, 1976, p. 32). According to this concept, gold from various sources would tend to migrate to the regime of greenschist metamorphism and to be concentrated and deposited there. The source of the gold may have been outside the present boundaries of the greenschist belts. Possible sources might be zones of higher metamorphic grade such as anatectic zones, gneiss domes, and mobile tectonic belts. Perhaps, however, the gold was derived from source beds within the rocks that were themselves undergoing greenschist facies metamorphism. Such gold deposits would have stratigraphic relationships similar to those of the gold-bearing deposits in the Abitibi Orogenic belt in the Canadian Shield (Goodwin and Ridler, 1977, p. 155): the gold in the quartz veins in those deposits is thought to have been slightly remobilized from a local source bed. Possible types of source rocks are massive sulfide bodies, ironstones, quartzitic clastic rocks, and porphyritic subvolcanic intrusives and flows of felsic composition. Examples of all these are present in the Jabal Ishmas-Wadi Tathlith gold belt, but are untested as possible sources of the gold.

Each of the five geographic groups of deposits in the gold belt (pl. 1) contain deposits that are typical of that group and are probably related genetically. Intergroup comparison of the characteristics of the gold deposits suggest that there are many significant differences in the genesis and ages of deposits between the groups. Some deposits in group I are in rocks of the metasedimentary assemblage (pl. 1) and some seem to be related to mafic dikes emplaced in Najd faults and are thus younger than 550 m.y. old. Deposits in group III can be related to a 660 ± 12 m.y. intrusive event, but those in groups II, IV, and V are not dated.

Deposits in group I seem to be largely related to regional quartz veins, probably of metamorphic origin, although at three of the deposits, including one of the larger, the gold was transported by and deposited from hydrothermal solutions of quartz monzonitic to granitic derivation. Source of the gold is unknown. Group II deposits may be the result of a gold-bearing zone where gold was remobilized and transported by any system that generated heat and fluids, such as felsic igneous activity, mafic igneous activity, or regional metamorphism. Samples collected from this group have higher concentrations of Fe, Zr, Pb, and Ti as compared to the other groups, and gold shows a positive correlation to Pb. The element concentrations and associations may be reflecting the association of many of the veins with gabbros in this group. Group III deposits may be the result of gold being transported by and deposited from hydrothermal solutions related to the emplacement of granodiorite stocks. The serpentinite may have been an impervious cap that dammed gold-bearing solutions, or it may have acted as a chemical reactant or catalyst that promoted deposition of the gold. The source of the gold for this group could have been the ultramafic bodies, now serpentinite, or the relatively abundant black shales, both of which were in contact with the magma and ore-forming solutions. The greater abundance of Cr and Ni in samples from this group, and the correlation of Au with Fe and Ti, reflects the association of gold with magnetite in the altered serpentinite. Gold in group V deposits is probably related to massive sulfide deposits present in the area, the quartz veins representing material remobilized along shear zones during regional metamorphism. The greater abundance of Pb and Cu in samples from this group, and the positive correlation of gold with the same two elements, supports the concept that the gold is associated with the base-metal sulfide deposits. Group IV deposits may have a similar origin, but sulfide-rich beds are not known in this area and the ultimate source of the gold is unknown. The greater abundance of copper in samples from this group suggests an association of gold with base metal sulfides although there is no obvious correlation of gold with the base metals.

Recommendations

Potential gold resources in the gold belt are of three types: gold-bearing quartz veins, placer deposits (not covered in this report), and gold-bearing bedded syngenetic deposits (not covered in this report). The gold-bearing quartz veins have limited potential. Three of the deposits, Al Lugatah (no. 25, pl. 1), Al Gariat Avala (no. 26, pl. 1), and Jabal Guyan (no. 38, pl. 1) are considered worthy of further exploration by diamond core drilling. Several others should be investigated further by field studies. These include Jabal Umm Matirah (no. 1, pl. 1), Ishmas Kabir (no. 6a, pl. 1); Jabal Dalfa (no. 3, pl. 1), and Nufud Almistajed (no. 17, pl. 1).

Although only hydrothermal gold quartz vein deposits are known from the gold belt, an unevaluated potential exists for gold in other types of environments. Massive sulfide deposits, volcanic ironstones, quartzitic clastic rocks, and porphyritic subvolcanic intrusives and flows of felsic composition are all present within the belt and are all favorable exploration targets for gold deposits. Any exploration for massive sulfide or stratiform sulfide bodies in the vicinity of the group IV deposits should include gold as a potential resource. The area of the group III deposits should be investigated for a local gold-bearing source bed for the hydrothermal deposits.

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APPENDIX A

Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas–Wadi Tathlith gold belt
[The numbers used in this listing for the individual mines correspond to those on plate 1.
Each ancient mine is given the status of prospect or occurrence based upon size of the deposit and the amount of geologic exploration.]

Mine No.	Name and location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples; RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
1	Jabal Umm Matirah 21°23'30"N. 43°29'30"E.	Prospect (2000x1000)	Detailed mapping 1:1000 scale (fig. 2) Sampling Du, Ch 115018-021 115129-154	Shallow open pits along veins, 1-3 m deep, now sand filled. Minor slag; village with tailings. Small placer mines in same general area. (110,4) (60,5) (30,2) (60,5) (numerous small)	Series of en echelon quartz veins cutting metagraywacke of the Halaban formation. Veins are composed entirely of milky, vuggy, hematite-stained quartz. Visible gold, but no sulfides. Attitude of veins: strike 20° dip 90°	12 dump samples .05 to 22, avg. 3.54 g/t 3 channel samples 4.2 to 16, avg. 11 g/t 1/ 8 grab samples .6 to 16.0, avg. 6.64 g/t	164,025 91,125	10-14 11-16
2	Jabal Silli 21°14'30"N. 43°18'00"E.	Occurrence (100x10)	Visited Sampling Gr 115052-053	Small, widely scattered open pits on poorly exposed quartz veins. All less than 20 m in length.	Small, widely scattered quartz veins.	2 grab samples, no gold detected		
3	Jabal Dalfa Group 21°10'00"N. 41°11'00"E.	Prospect (6000x5000)	Sampling Du, Gr 115023-032 115058-061 115106-111	Numerous small open pits along quartz veins, most 100 m or less in length.	Numerous quartz veins related to monzo-granite intrusives. All veins are in or next to felsic dikes or plugs. Country rocks include gabbro, biotite schist and chlorite schist. Red carbonate alteration is common along the edges of the veins. Veins composed of quartz breccia and calcite with locally abundant hematite- and jarosite-staining. Local visible gold, but few sulfides. Attitude of veins: strike 45° to 80°	12 dump samples .16 to 26, avg. 5.3 g/t	303,750 22,275 44,550	15-21 15-21 15-21
4	Chaim 21°04'15"N. 43°46'30"E.	Prospect (750x100)	Visited Sampling Du, Gr, Ch 2/ Sample trench across ancient working to depth of 3 m 115048-051	Scattered open cuts and one vertical shaft along a 1 km long zone, now sand filled (100,7) (80,5)	Quartz veins, veinlets and breccia cement in 5 m wide breccia zone; attitude: strike 35°, dip 50°W. Vein composed of milky quartz with pyrite, galena, hematite, and malachite. Country rock calcareous metatuff.	3 dump samples 1.52, 1.52 and 7.90 g/t 2/ 2 dump samples 2.2 and 2.2 g/t 2/ 2 channel samples 23 and .9 g/t	120,000 8,000 (ancient dump)	9-12 3.07

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples; RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
5	Dahlat Shabab 21°04'15"N. 43°46'30"E.	Prospect (2500x1500)	Visited Sampling, Gr 1/ Sampling, Ch, Gr 4/ Sampling and trenching 110983-985	Many open pits and trenches along five quartz veins, most small. Small village, no slag. (150,2) (100,2) (65,1) (30,1)	Quartz breccia veins, strike 30° to 45° and dip 50° to 75° NW, cut andesitic agglomerate of the Halaban Group. The veins are composed of massive white quartz with local hematite and malachite staining. Pyrite, chalcopyrite, and sphalerite are rare. Wallrocks are altered over a large area, and intensely silicified next to the veins.	2 quartz grab samples 12.5 and 14.5 g/t. 4/ 32 channel samples avg. 12.6 g/t 4/64 quartz grab samples avg. 11.9 g/t 1/ 3 channel samples .04, .11 and .11 g/t 1/ 3 grab samples 4.2, 3.0 and 44.0 g/t	210,000 (aggregate)	12-18
6	Jabal Ishmas Group							
6a	Ishmas Kabir 20°51'45"N. 43°13'30"E.	Prospect (530x50)	Detailed mapping 1:1000 scale (fig.3) Sampling, Du, Gr 5/ Three sample trenches across ancient workings. 115011-013	Large dumps, now largely covered by sand, along two parallel veins. Open cuts of unknown depth (125,3)(65,3) (35,1)(35,2), minor slag, small village.	Parallel quartz breccia veins, 20 cm to one m wide, with ankerite ?, limonite, and malachite; minor pyrite, chalcopyrite and visible gold. Attitude: strike 50°, dip 70°NW. Country rocks are quartz diorite and quartz biotite schist. Poorly exposed.	2 dump samples 3.82 and 8.6 g/t 1 selected chip sample 185 g/t 5/ Several dump samples	202,000 18,700 (ancient dump)	14-20 5.11
6b	Abu Tal 20°52'30"N. 43°16'20"E.	Occurrence	Visited Sampling, Du, Gr 115003-006	Series of sand filled pits along two or three small quartz veins (35,1)(90,3)(60,1)	Parallel, en echelon, quartz veins in calcareous metatuff of the Halaban group. Attitude: strike 50°, dip 80°NW. Milky quartz breccia, no sulfides or visible gold. Vein is not exposed.	3 dump samples 2.5 to 7.2 avg. 4.2 g/t 1 quartz grab sample nil	95,681	12-17
6c	Ishmas 20°52'50"N. 43°16'40"E.	Occurrence	Visited Sampling, Du, Gr 110997-999 115000-001	Series of small sand filled pits along edges of large quartz vein, (50,3) (30,2)	Large, 2 to 3 m wide, quartz breccia vein, 350° trend, cutting diorite and calcareous metatuff of the Halaban group. Milky-vuggy quartz, locally hematite stained, with minor pyrite.	3 dump samples 1.0, nil, and 1.5 g/t 5/ Several dump samples, avg. 1.3 g/t		

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples; RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
7	Umm Shat Group (5500x1200)							
7a	Gharb 20°57'20"N. 41°18'00"E.	Prospect (600x25)	Detailed mapping (fig. 4) 1:1000 scale Sampling Du, Gr, Ch 5/ Five sample trenches across ancient workings. 115008 115033-047	Numerous small sand filled pits, shafts and inclines along several small veins. Judging from the amount of dump material, some of the pits, shafts and inclines must be deep.	Several quartz veins and and quartz-healed breccia zones; attitude: strike 335°, dip 85°SW. The major zones are approximately 1 m wide with 50 cm to 1 m of alteration on each side. Parallel felsic dikes. Country rocks are siltstones, sandstones, and calcareous metatuff of the Halaban group. Veins composed mainly of milky quartz with hematite stain and local malachite and limonite. Pyrite, chalcopyrite, sphalerite, and visible gold within limonite occur in minor amounts.	7 dump samples 3.0 to 3.8 avg. 3.48 g/t 5 channel samples .1 to 1.0 avg. .5 g/t 5/ Several dump samples avg. 2.6 g/t 5/ Several channel samples avg. 3.0 g/t	45,560 91,125 (inferred under alluvial cover)	10-14 ?
7b	Sharg 20°58'10"N. 41°20'30"E.	Prospect (270x70)	Detailed mapping (fig. 5) 1:1000 scale Sampling Du, Gr, Ch 5/ Three sample trenches across ancient workings	Numerous small sand filled pits, shafts, and inclines along vein zone.	Quartz stringers along shear zone in quartz-monzonite. Attitude: strike 50°, dip 35°SE. Parallel felsic dikes. Zone of shearing, quartz veinlets, disseminated pyrite, and alteration is extensive, but gold metallization is confined to narrow zone.	3 dump samples .04 to 6.2 avg. 2.8 g/t 2 channel samples .6 and .4 g/t 5/ 20 channel samples one contained Au 6.8 g/t 5/ Several dump samples avg. 2.6 g/t	52,650	8-11
8	Jabal Ishmas Junub 20°48'00"N. 43°20'30"E.	Occurrence (400x100)	Visited Sampling, Du, Gr 115068-073	Shallow sand-filled pits along three parallel quartz veins. (170,2) (190,2) (30,1)	Three discontinuous 20 to 50 cm wide quartz veins cutting gabbro and graywacke. Veins composed of vuggy, hematite-stained quartz, no sulfide minerals.	Dump sample .8 g/t 3 grab samples 5.5, 8.0 and 2.1 g/t		

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
9	Jabal Nabitah 20°52'30"N. to 20°56'00"N. 43°21'30"E. to 43°23'00"E.	Occurrence (5000x3000)	Visited Sampling, Du, Gr 110989-996 115081-086	Numerous small (<30 m length) filled pits along quartz veins.	Numerous quartz veins in and along the Nabitah fault zone. Earlier veins of 30° trend and later larger veins of 350° trend. Most workings along the earlier vein systems. Both composed of milky, vuggy, locally hematite-stained quartz, no sulfides. Country rocks are diorites and graywackes of the Halaban group. Minor seams of limonite gossan on edges of some veins.	3 dump samples .15, .10 and .01 g/t 5 grab samples .05 to 2.0 avg. .48 g/t		
10	Ishghab Gharb 20°56'30"N. 43°30'40"E.	Occurrence (1000x300)	Visited Sampling, Du, Gr 115157-159	Several small (<20 m length) sand-filled pits along quartz veins and quartz float.	Small stringy quartz veins, of 5° trend cutting quartz-biotite schist. No sulfides.	Dump sample 1.1 g/t Grab sample quartz .2 g/t		
11	Bir Jarbuah 20°52'00"N. 43°35'00"E.	Prospect (7000x1500)	Reconnaissance mapping 1:5000 (fig. 6) Sampling Du, Gr, Ch 110964-973	Several small sand-filled pits along quartz veins. Main area has ancient village, minor slag, tailings dump, and extensive pits and shafts along one vein. (500,5) (65,2)	Several short stringy quartz veins cutting diorite and quartz-biotite and chlorite schists; most individual veins trend 350° but zone has 60° trend. Main area has banded quartz, chalcedonic quartz, calcite vein cutting diorite and schist. Vein is in small shear zone, attitude: strike 15°, dip 75°SE. Vein material is hematite stained and rhodochrosite and graphite blebs are minor constituents.	2 dump samples 4.2 and 7.0 g/t	136,000	7-10
12	Jabal Ishghab 20°56'30"N. 43°40'10"E.	Occurrence (1500x200)	Visited Sampling, Gr 110974-976 110986-988	Very small diggings along quartz veins	Series of quartz stringers, pods, and veins along contact of overlying conglomerate and underlying graywacke. Contains minor pyrite, chalcopyrite, and galena.	1 dump sample .5 g/t 6 grab samples nil to .26 g/t avg. .05		

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)(grams per ton)
13	Jabal Al Minrag 20°51'00"N. 43°44'30"E.	Occurrence (1200x200)	Visited Sampling, Gr, Du 110977-981	Numerous small pits along quartz float zone.	No exposure, workings are along quartz float, and pyrite-bearing siltstone zones. Quartz in float is dark gray with ribbon texture.	1 quartz grab sample .66 g/t 2 dump samples, nil and .06 g/t	
14	Al Ghabiyah 20°48'45"N. 43°47'30"E.	Occurrence (1000x200)	Visited Sampling, Du, Gr 115119-123	A few small, now completely silt-filled pits along quartz float. Small village.	No exposure, quartz float only.	1 dump sample, nil 4 grab samples, all nil 2/ Several dump samples avg. 2.0 g/t	
15	Jabal Kattab 20°39'00"N. 43°10'30"E.	Occurrence (300x25)	Visited Sampling, Gr 115062-065	Small sand-filled pits.	Poor exposure. Brecciated and sheared quartz-calcite veins next to or within felsic dike. Workings, trend 345° and 50°. Small village, very minor slag.	4 grab samples, all nil	
16	Najeeb 20°34'30"N. 43°29'00"E.	Occurrence (3000x700)	Visited Sampling, Gr 110957-960	Small random dumps on quartz float, and scattered small placer mines.	Poor exposure, lenses or pods of quartz cutting diorite and calcareous siltstone. Gray quartz lenses within white massive quartz. Veins seem to be related to felsic dikes.	2 quartz grab samples, nil and .22 g/t 2/ 3 dump samples avg. 2.0 g/t Grab sample 3.6 g/t	
17	Nufud Almistajed 20°37'30"N. 43°35'10"E.	Occurrence (4000x800)	Visited Sampling, Gr 110961-962	Small pits along poorly exposed quartz vein. No slag or village.	Large, 1-3 m wide, veins in granite. Poorly exposed for length of 4 km. Attitude: strike 15° dip 50°E. Banded stringy veins composed of quartz, milky to light gray, vuggy, and hematite-stained. Visible gold is common; in one instance occurring as flakes within vug. Very minor sulfides.	1 channel sample 26.2 g/t	Insufficient data
18	Bir Almistajed 20°39'30"N. 43°47'20"E.	Occurrence (7000x1500)	Visited Sampling, Gr 110963	Numerous small pits along quartz veins and pods and along quartz float, many are placer workings in small wadis.	Numerous small stringy quartz and calcite veins cutting sandstone and shale of the Murdama formation. Poorly exposed.	1 grab sample nil	

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	Potential resource (grams per ton)
19	Bani Qutman 20°20'00"N. 43°25'40"E.	Occurrence (3500x600)	Visited Sampling, Gr, Du 110941-956	Numerous small open pits and trenches, now filled with sand. Small village. (150,1) (80,1) (60,1)	Several discontinuous 15° trending quartz veins cutting graywackes and carbonate tuffs. Larger veins as much as 2 m wide, composed of milky brecciated quartz, locally banded and generally vuggy and hematite stained. Alteration consists of 50 cm to 2 m wide zones of silicification and propylitizations along edge of vein. Minor sulfides.	6 dump samples nil to 3.54 avg. 1.29 g/t 5 quartz grab samples all nil	60,750	6-9
20	Wadi Jabyan 20°28'00"N. 43°37'10"E.	Occurrence (8000x3000)	Visited Sampling, Du, Gr 115094-102	Several small sand-filled pits along quartz veins, all less than 30 m in length.	Extensive zone of small discontinuous quartz veins, most less than 50 cm in width. Hematite-stained, brecciated milky quartz, locally banded with dark gray quartz, or chalcedonic quartz. Very minor sulfides. Veins seem to occur in same structure as diorite dikes. Country rocks are quartzites and chlorite schist.	2 dump samples, both nil 3 quartz grab samples .04, .09, and .40 g/t		
21	Jabal Mokhyat 20°12'00"N. 43°28'00"E.	Occurrence (7500x5000)	Visited Sampling, Du, Gr 110938-940 115089-094	Shallow to moderately deep trenches along quartz veins and stringers (210,3) (60,2) (35,1). Numerous small placer mines in area (Schmidt and others, in prep.)	Numerous quartz veins widely scattered over large area. Diverse attitudes, major trend 350°. Veins range from 5 cm stringers to more than 1 m wide breccia veins of massive quartz with cockscomb texture. Country rocks are sandstones, quartzites, graywackes, and andesite. Veins locally contain malachite and limonitic gossan.	4 grab samples nil to 6.4 avg. 2.7 g/t 1 dump sample 4.24 g/t 2/ 1 vein gossan sample 17.0 g/t 2/ 1 grab sample 10.0 g/t		
22	Jabal Shaybah 19°49'30"N. 43°21'00"E.	Occurrence (500x50)	Visited Sampling, Gr 110490-498	Several small pits along veins, all less than 20 m in length.	Quartz veinlet stockworks and stringer zones on footwall of diorite dike, cutting gabbro. Part of an en echelon series of dikes. Also several discontinuous veins and pods of quartz in gabbro, 5 km to the west. Attitude of dike and veins; strike 20° dip 70°E. Stockwork zone contains locally abundant sphalerite and graphite flakes.	6 grab samples .06 to 1.3, avg. .58 g/t		

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)(grams per ton)
23	Bir Ghatana 19°45'35"N. 43°18'00"E.	Occurrence (300x200)	Visited Sampling, Du, Gr 110499-502	Small workings along vein.	Large quartz vein on contact of diorite and graywacke(?); attitude: strike 305° dip 40°E. Hematite-stained milky quartz, locally brecciated, cockscomb texture common.	Dump sample 4.2 g/t Grab sample .42 g/t	
24	Jabal Hobuyet 19°45'50"N. 43°31'15"E.	Occurrence (3000x200)	Visited Sampling, Gr 110479-485	Several short pits and shallow inclines along foot and hanging walls of large veins.	Several large, 1-2 m wide quartz pods and veins. Attitude: strike 40° dip 40°E. Massive Fe-stained quartz, vuggy, with gossanny selvage zones.	2 vein grab samples 2.0 and 7.4 g/t 3 grab samples of selvage. Do not contain detectable gold.	
25	Al Lugatah (Wadi Thafin) 19°38'30"N. 43°26'30"E.	Prospect (600x80)	Detailed mapping 1:1000 scale (fig. 7) Sampling Du, Gr 110439-446 110824-879	Several deep shafts, inclines, and open pits along quartz pods. Small village, minor slag.	Pod-like body of altered and veined quartz porphyry approximately 600 m in length and 40 to 80 m in width. The body is highly sheared and filled with quartz veinlet stockwork and locally contains folded and broken quartz pods and veins as much as 2 m in width. Vein material is Fe-stained, vuggy, and locally banded quartz. Attitude of the sheared quartz porphyry body and the individual quartz pods within is strike 5° dip 55°W. Gold metallization occurs in the selvage zones of the larger pods.	47 dump samples .08 to 16.3 avg. 2.51 g/t 4 grab samples nil to 58.0, avg. 15.4 g/t 6/ 2 dump samples, 7.7 and 5.25 g/t 6/ 3 grab samples, nil, .35 and 1 g/t 6/ 8 channel samples .7 to 8.0, avg. 3.5 g/t	19 million tons potentially metallized 2.5 145,800 9-12 16,200 x 2 7-10 182,250 8-11
26	Al Gariat Avala 19°41'00"N. 43°40'30"E.	Prospect (1200x400)	Detailed mapping (fig. 8) 1:1000 scale Sampling Du, Gr 110880-937 110419-437	Several deep shafts, inclines, and trenches along quartz veins. Small village, minor slag. Extensive dump and tailings piles. (120,3)(95,2)(90,1) (55,6)(55,5)(22,2) (20,5)(12,8)(12,5) (10,4)	Quartz breccia veins cutting gabbro are 50 cm to 2 m in width, and composed of milky quartz with minor amounts of pyrite and visible gold. Wall rock inclusions and carbonate-rich alteration next to the vein are common. Northwest-trending felsic dikes also cut gabbro. Attitude of quartz veins: strike 20° dip 50°E and strike 45° dip 55°SE.	48 dump samples .06 to 28.8, avg. 4.9 g/t 7 grab samples .04 to 21.5, avg. 5.4 g/t 6/ 4 dump samples 7.7 to 10.5 avg. 9.2 g/t 6/ 3 channel samples nil, nil, 1.8 g/t 6/ 9 grab samples, nil to 16.5 avg. 3.7 g/t 3/ 4 dump samples, 7.7 to 10.5, avg. 9.2 g/t 3/ 8 grab samples, nil to 16.4, avg. 5.3 g/t	864,000 (total potentially metalized) 4.6 60,750 13-18 872,000 (total potentially metalized) 6.5 162,000 18-26 137,000 7-10

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
27	Wadi Al Mushel 19°12'45"N. 43°36'30"E.	Occurrence (800x50)	Visited Sampling, Gr 110461-463 110781-785	Small shallow pits along quartz breccia veins. (40,2)	Poorly exposed quartz-potassium-feldspar veins and pods cutting granite gneiss. The veins are all less than 100 m in length and are 20 to 50 cm in width. Fe staining and vugs are common, and pyrite is a minor constituent. These veins are part of a north- to northeast- and northwest-trending series of veins that extend for several km north and south of this occurrence. Only this occurrence and number 28 described below contain ancient mines.	8 grab samples; only 1 contained gold, 21 g/t 6/ 1 grab sample, 7.7 g/t		
28	Al Hasbat 19°10'10"N. 43°32'45"E.	Occurrence (1000x50)	Mapped 1:1000 scale (fig. 9) Sampling Du, Gr, Ch 110464-475 110774-776	Sand-filled pits and inclines along quartz vein. (130,2)(30,4)	One meter wide, gossany, locally galena-rich quartz vein cutting granite gneiss. Attitude: strike 345° dip 60°E. Vein is parallel to granite dike. This occurrence is in the southern part of a series of quartz veins that extend many kms to the north.	5 dump samples, only one contained gold, 10 g/t 5 channel and grab samples, only one contained gold, 11.6 g/t		
29	Jabal Mahanid Group	Prospect (4000x600)	110400-405 110447-450					
29a	Al Hlamiya South 19°02'35"N. 43°40'15"E.	(200x40)	Detailed mapping 1:500 scale (fig. 10) Sampling Du, Ch 110790-809	Several pits, trenches, inclines, and shafts along a contact between hornblende schist and serpentinite. (65,3)(14,2, 5?)(33x3)	Gold metallization occurs along contact zone of underlying hornblende schist and overlying serpentinite. The sheared and altered contact contains felsic dikes and quartz-calcite stringers and veinlets. Most gold metallization is apparently along edge of felsic dikes. Sulfides are minor constituents of veinlets. Attitude of contact: strike 340° dip 75°W.	6 dump samples, nil to 1.6, avg. .8 g/t 11 channel samples, .08 to 3.8, avg. 1.0 g/t 6/ 1 grab sample 2.10 g/t	113,900	4-5

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
29b	Jabal Ibn Hassun 19°03'00"N. 43°41'25"E.	Prospect (300x80)	Detailed mapping (fig. 11) 1:500 scale Sampling, Du, Ch 110810-821	Several pits and inclines along a serpentinite and hornblende schist contact. (15,9,5)(16,8) (25,3)(4,4,10?) (20,3)(25,2)(28,2)	Gold metallization occurs along contact of overlying serpentinite and hornblende schist. Northern continuation of Al Hlamiya, except here contact is folded.	6 dump samples .44 to 3.7, avg. 1.9 g/t 5 channel samples nil to 5.5, avg. 1.7 g/t 6/ 1 dump sample 3.85 g/t	115,425	8-11
29c	Riah 19°04'00"N. 43°41'40"E.	Prospect (44x100)	Detailed mapping (fig. 12) 1:1000 scale Sampling, Du, Gr 110410-412 115184-190 117316-318	Several pits and adits along felsite dike and serpentinite contact, and along altered shears in serpentinite. (20,2,3)(12,12,3) (40,8) (18,2,1) (20,1.5)(18,1)(15,1) 4(10,1) 2(5,1)	Area of numerous felsic dikes cutting serpentinite. Quartz stringers and pods with gold metallization occur along footwall contact of flat dipping dikes and along altered shears in serpentinite.	11 dump samples .4 to 14.6, avg. 4.19 g/t 6/ 1 grab sample 1.40 g/t		
30	Hijrah-Hamdah							
30a	Hajr 18°54'48"N. 43°40'30"E.	Prospect (1000x700)	Detailed mapping (fig. 13) 1:2000 scale Sampling, Du, Gr, Ch Diamond drilling 12 holes 964.5 m Ground magnetic survey 100400-419 100465-500 110657-719 110390-399 110651-654	Very extensive ancient workings; trenches, inclines, and shafts, large village, minor slag. All trenches are 1 to 2 m wide and 1 to 3 m deep. Trenches (approximate) Length m — Number 10 — 46 20 — 11 30 — 7 40 — 6 60 — 2 90 — 1 120 — 1 160 — 1 18 shafts and inclines from 1 m to unknown but deep depths.	Gold metallization occurs along the altered contact zone of overlying serpentinite and underlying hornblende schist. Felsic dikes intrude portions of the contact. Fine- to medium-grained gold occurs in quartz-calcite stringers, sheared and altered selvage zones along contacts of the aplite dikes or disseminated through altered serpentinite close to the contact.	48 dump samples, .02 to 74.00, avg. 3.80 g/t 65 channel samples nil to 12.80, avg. 1.25 g/t 24 exploration pit samples .02 to 40.00, avg. 3.31 g/t		

APPENDIX A. Descriptions and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)(grams per ton)
30b	Jabal Hajr 18°55'18"N. 43°40'00"E.	Occurrence (55x100)	Mapping 1:10,000 scale Sampling Du, Ch 117017-026	Numerous small pits, adits, and inclines, all less than 20 m in length.	Gold metallization apparently occurs in quartz-calcite seams, pods, and stringers within foliation of quartz-biotite schist. Local pyrite and galena occur within larger veins. All workings, and presumably metallization, are close to large felsic dikes.	6 channel samples .02 to 2.3 avg. .78 g/t 2 dump samples 1.26 and 1.16 g/t	
30c	Hajr Gharb 18°55'12"N. 43°37'26"E.	Prospect (650x350)	Mapping 1:10,000 scale Sampling Du, Ch Diamond drilling 1 hole 154.35 m 117041-068	Numerous pits, adits, and inclines, most less than 10 m in length. (25,1,10)(2,2,8) (15,1,15?)(30,4,2) (35,1,5) Abundant fine-grained tailings.	Numerous felsic dikes cutting highly foliated quartz-biotite schist. Gold occurs in foliation of schist, apparently in pods and stringers of quartz and calcite close to felsic dikes, or along selvage of larger conformable quartz veins. Foliation strikes 45° and dip 20°NW.	9 dump samples .05 to 15.00, avg. 2.04 g/t 20 grab samples .02 to 63.00, avg. 3.83 g/t	
30d	Bir Al Hamadan (Jabal Al Ge'at) 18°54'18"N. 43°38'00"E.	Occurrence (600x50)	Mapping 1:10,000 scale Sampling Du, Ch 110562-564 110759	Several sand-filled trenches along one zone. (50,2)(70,2)	Gold metallization occurs in quartz pods, stringers, and veinlets within a 1 m wide conformable zone in quartz-biotite schist. Attitude of foliation and mineralized zone: strike 20°, dip 65°W.	2 channel samples, nil and nil 1 dump sample nil	
31	Al Baythat 18°51'50"N. 43°21'40"E.	Occurrence (4000x500)	Visited Sampling, Du, Gr 117216-222	Numerous sand-filled trenches along widely scattered quartz veins. (76,1)(34,1)(77,2)	Scattered quartz veins in gabbro and biotite-granite, only a few of which have ancient workings. Attitude of most veins: strike 80° dip 90°.	5 dump samples .07 to 3.75, avg. 1.5 g/t 1 grab sample .09 g/t	

APPENDIX A. Description and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
32	Wadi Miflih 18°48'45"N. 43°23'15"E.	Occurrence (300x20)	Visited Mapping, pace and compass 1:1000 scale (fig. 14) Sampling, Du, Gr 117210-215	Trench and deep incline along quartz vein. (20,3)(32,2)(15,10)	Quartz vein along shear zone in diorite. Attitude: strike 35° dip 45°W.	3 channel samples .80, 1.55 and .20 g/t 2 dump samples 4.60 and 7.35 g/t	68,343	17-24
33	Wadi Gharaba 18°35'30"N. 43°56'40"E.	Occurrence (1000x500)	Visited Mapping, pace and compass 1:1000 scale (fig. 15) Sampling, Du, Ch 117184-190	Trench and inclines along footwall of large quartz vein. Small village, grindstones. (80,2,3)(15,3,1)	Scattered small quartz pods and veins in shear zone cutting highly foliated greenschists. Several veins have small pits along edge, largest has inclines along footwall of 1 m wide vein. Gold apparently in gossany selvage on footwall of vein. Attitude of vein: strike 310° dips 80°W.	4 dump samples 3.60 to 13.30, avg. 8.15 g/t 2 channel samples .09 to .80 g/t	50,118	23-32
34	Masana Al Masagha 18°25'30"N. 43°36'00"E.	Prospect (2000x500)	Visited Mapping, pace and compass 1:1000 scale (fig. 16) Sampling, Du, Ch 117223-234	Extensive trenches and waste dumps along edges of large quartz veins and along quartz stringer zones. Small village, very minor slag.	Scattered quartz veins, stringers and pods along shear zones in diorite and greenschist. Largest vein 160 m long and 6 m wide. Attitude of most veins is: strike 320° dip 85°W.	2 channel samples .38 and .11 g/t 7 dump samples 3.50 to 37.5, avg. 13.89 g/t	68,343 41,000	40-55 40-55
35	Dhahar 18°13'15"N. 43°44'00"E.	Prospect (1000x700)	Visited Sampling, Ch, Gr 110548-555	Several small, less than 20 m long, open pits along edges of quartz veins and along quartz stringer zones. Village with minor slag.	Scattered quartz veins, stringers and pods along altered shear zones in quartz porphyry and greenschist. Pyrite and malachite common constituents of veins. Attitude of veins: strike 345° dip 90°.	6 channel samples nil to 11.5, avg. 3.45 g/t 7/ 3 channel samples nil, .25, and 1.15 g/t		
36	Hagira 18°11'00"N. 43°43'30"E.	Occurrence (2500x500)	Visited Sampling, Ch, Gr 110535-547	Several small open pits and one shaft along sheared and altered zones.	Scattered quartz veins, breccias, stringers, and pods along shear zones in quartz porphyry and greenschist. Pyrite, chalcopyrite, and malachite local constituents of veins.	8 channel samples all nil 7/ 3 channel samples all nil		

APPENDIX A. Description and potential resource estimates of ancient gold mines in the Jabal Ishmas-Wadi Tathlith gold belt (continued)

Mine No.	Name and Location	Status (size in meters)	Exploration (Du-dump, Gr-grab, and Ch-channel samples: RASS sample numbers)	Workings (length, width in meters)	Geologic descriptions	Analytical data (gold in grams per ton)	Potential resource (Metric tons)	(grams per ton)
37	Shasrah 18°13'30"N. 43°50'00"E.	Occurrence (600x50)	Visited Sampling, Ch 110556-559	Several trenches along shear zone, and deep shafts and inclines at intersection of north-trending shear zone and east-trending quartz veins.	Highly sheared zone along contact between massive cobble-boulder conglomerate to east and finer-grained metasediments to the west. Numerous quartz stringers in shear zone and larger quartz veins with east-trend. Visible gold in hematite-limonite boxworks.	4 channel samples all nil		
38	Jabal Guyan 18°10'00"N. 43°55'00"E.	Prospect (2000x1000)	8/ Detailed mapping 1:1000 scale Sampling, Du, Gr, Ch	Extensive workings, total of 30 ranging from small shallow pits to deep trenches and shafts. Numerous grindstones, village.	Gold occurs in quarts veins and associated altered metavolcanic country rocks. The veins, as much as 4 m in width, occupy north-west trending faults. Later barren quartz heals breccia in the gold-quartz veins and also occurs in northeast trending veins. Pyrite is minor constituent of veins.	8/ 52 dump samples >.04 to 40, avg. 4.10 g/t 8/ 58 grab samples >.40 to 27.2, avg. 2.46 g/t 8/ 113 channel samples >.04 to 10.7 avg. .78 g/t	227,812 136,687 21,600 21,600	12-16 12-16 12-16 12-16

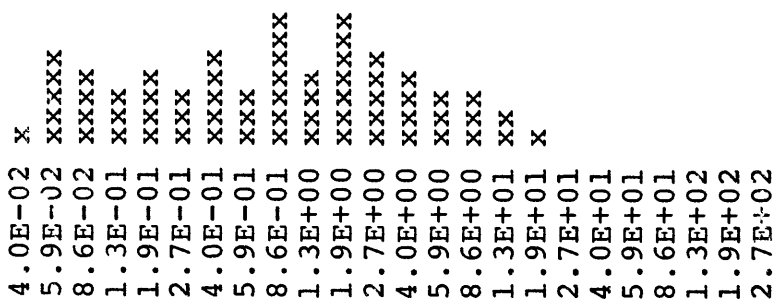
1/ Hadley (1976)
2/ Gonzalez, unpub. data, 1974
3/ Schaffner (1956a)
4/ Bogue (1954)
5/ Gonzalez (1974)
6/ Overstreet (1978)
7/ Greenwood (1979b)
8/ Helaby and Dodge (1976)

APPENDIX B. Frequency tables and histograms of gold values in all geochemical data subsets

Geochemical data subset 1, all samples from the gold belt study.

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
3.3E-03 - 4.8E-03	0	0	0.00	0.00
4.8E-03 - 7.1E-03	0	0	0.00	0.00
7.1E-03 - 1.0E-02	1	1	0.17	0.17
1.0E-02 - 1.5E-02	0	1	0.00	0.17
1.5E-02 - 2.2E-02	2	3	0.33	0.50
2.2E-02 - 3.3E-02	1	4	0.17	0.66
3.3E-02 - 4.8E-02	8	12	1.33	1.99
4.8E-02 - 7.1E-02	30	42	4.98	6.97
7.1E-02 - 1.0E-01	26	68	4.31	11.28
1.0E-01 - 1.5E-01	19	87	3.15	14.43
1.5E-01 - 2.2E-01	23	110	3.81	18.24
2.2E-01 - 3.3E-01	20	130	3.32	21.56
3.3E-01 - 4.8E-01	29	159	4.81	26.37
4.8E-01 - 7.1E-01	21	180	3.48	29.85
7.1E-01 - 1.0E+00	42	222	6.97	36.82
1.0E+00 - 1.5E+00	22	244	3.65	40.46
1.5E+00 - 2.2E+00	41	285	6.80	47.26
2.2E+00 - 3.3E+00	31	316	5.14	52.40
3.3E+00 - 4.8E+00	23	339	3.81	56.22
4.8E+00 - 7.1E+00	21	360	3.48	59.70
7.1E+00 - 1.0E+01	17	377	2.82	62.52
1.0E+01 - 1.5E+01	12	389	1.99	64.51
1.5E+01 - 2.2E+01	7	396	1.16	65.67
2.2E+01 - 3.3E+01	3	399	0.50	66.17
3.3E+01 - 4.8E+01	1	400	0.17	66.33
4.8E+01 - 7.1E+01	3	403	0.50	66.83
7.1E+01 - 1.0E+02	0	403	0.00	66.83
1.0E+02 - 1.5E+02	0	403	0.00	66.83
1.5E+02 - 2.2E+02	1	404	0.17	67.00
2.2E+02 - 3.3E+02	1	405	0.17	67.16

Histogram

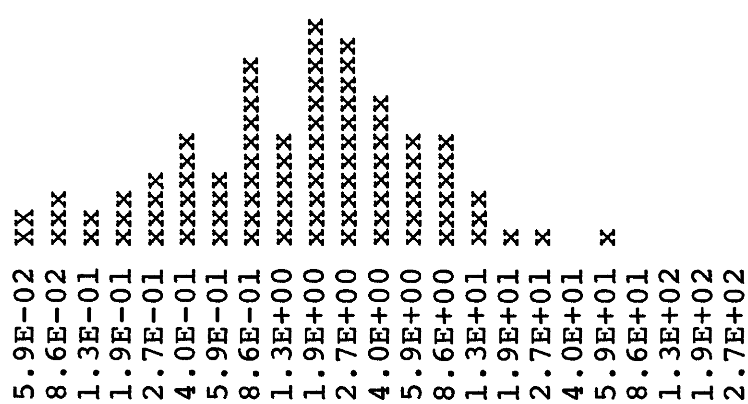


APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 2, all dump samples.

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
3.3E-02 - 4.8E-02	0	0	0.00	0.00
4.8E-02 - 7.1E-02	4	4	1.70	1.70
7.1E-02 - 1.0E-01	8	12	3.40	5.11
1.0E-01 - 1.5E-01	5	17	2.13	7.23
1.5E-01 - 2.2E-01	8	25	3.40	10.64
2.2E-01 - 3.3E-01	9	34	3.83	14.47
3.3E-01 - 4.8E-01	15	49	6.38	20.85
4.8E-01 - 7.1E-01	10	59	4.26	25.11
7.1E-01 - 1.0E+00	23	82	9.79	34.89
1.0E+00 - 1.5E+00	15	97	6.38	41.28
1.5E+00 - 2.2E+00	28	125	11.91	53.19
2.2E+00 - 3.3E+00	25	150	10.64	63.83
3.3E+00 - 4.8E+00	18	168	7.66	71.49
4.8E+00 - 7.1E+00	15	183	6.38	77.87
7.1E+00 - 1.0E+01	14	197	5.96	83.83
1.0E+01 - 1.5E+01	7	204	2.98	86.81
1.5E+01 - 2.2E+01	3	207	1.28	88.09
2.2E+01 - 3.3E+01	2	209	0.85	88.94
3.3E+01 - 4.8E+01	1	210	0.43	89.36
4.8E+01 - 7.1E+01	2	212	0.85	90.21
7.1E+01 - 1.0E+02	0	212	0.00	90.21
1.0E+02 - 1.5E+02	0	212	0.00	90.21
1.5E+02 - 2.2E+02	0	212	0.00	90.21
2.2E+02 - 3.3E+02	1	213	0.43	90.64

Histogram

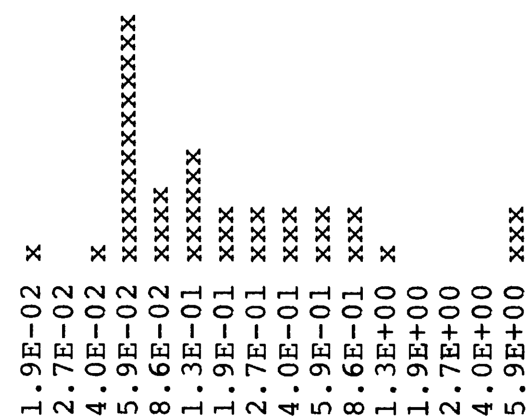


APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 3, felsic dikes.

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
1.0E-02 - 1.5E-02	0	0	0.00	0.00
1.5E-02 - 2.2E-02	1	1	1.47	1.47
2.2E-02 - 3.3E-02	0	1	0.00	1.47
3.3E-02 - 4.8E-02	1	2	1.47	2.94
4.8E-02 - 7.1E-02	9	11	13.24	16.18
7.1E-02 - 1.0E-01	3	14	4.41	20.59
1.0E-01 - 1.5E-01	4	18	5.88	26.47
1.5E-01 - 2.2E-01	2	20	2.94	29.41
2.2E-01 - 3.3E-01	2	22	2.94	32.35
3.3E-01 - 4.8E-01	2	24	2.94	35.29
4.8E-01 - 7.1E-01	2	26	2.94	38.24
7.1E-01 - 1.0E+00	2	28	2.94	41.18
1.0E+00 - 1.5E+00	1	29	1.47	42.65
1.5E+00 - 2.2E+00	0	29	0.00	42.65
2.2E+00 - 3.3E+00	0	29	0.00	42.65
3.3E+00 - 4.8E+00	0	29	0.00	42.65
4.8E+00 - 7.1E+00	2	31	2.94	45.59

Histogram



APPENDIX B. Frequency tables and histograms (continued)

Geochemical data Subset 4, ultramafic igneous rocks

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
2.2E-02 - 3.3E-02	0	0	0.00	0.00
3.3E-02 - 4.8E-02	1	1	7.14	7.14
4.8E-02 - 7.1E-02	0	1	0.00	7.14
7.1E-02 - 1.0E-01	0	1	0.00	7.14
1.0E-01 - 1.5E-01	0	1	0.00	7.14
1.5E-01 - 2.2E-01	1	2	7.14	14.29
2.2E-01 - 3.3E-01	1	3	7.14	21.43
3.3E-01 - 4.8E-01	1	4	7.14	28.57
4.8E-01 - 7.1E-01	1	5	7.14	35.71
7.1E-01 - 1.0E+00	1	6	7.14	42.86
1.0E+00 - 1.5E+00	1	7	7.14	50.00
1.5E+00 - 2.2E+00	0	7	0.00	50.00
2.2E+00 - 3.3E+00	0	7	0.00	50.00
3.3E+00 - 4.8E+00	1	8	7.14	57.14
4.8E+00 - 7.1E+00	1	9	7.14	64.29

Histogram

4.0E-02	xxxxxxx
5.9E-02	
5.6E-02	
1.3E-01	
1.9E-01	xxxxxxx
2.7E-01	xxxxxxx
4.0E-01	xxxxxxx
5.9E-01	xxxxxxx
8.6E-01	xxxxxxx
1.3E+00	xxxxxxx
1.9E+00	
2.7E+00	
4.0E+00	xxxxxxx
5.9E+00	xxxxxxx

APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 5, greenschist

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
3.3E-02 - 4.8E-02	0	0	0.00	0.00
4.8E-02 - 7.1E-02	4	4	7.14	7.14
7.1E-02 - 1.0E-01	5	9	8.93	16.07
1.0E-01 - 1.5E-01	2	11	3.57	19.64
1.5E-01 - 2.2E-01	3	14	5.36	25.00
2.2E-01 - 3.3E-01	2	16	3.57	28.57
3.3E-01 - 4.8E-01	5	21	8.93	37.50
4.8E-01 - 7.1E-01	4	25	7.14	44.64
7.1E-01 - 1.0E+00	4	29	7.14	51.79
1.0E+00 - 1.5E+00	1	30	1.79	53.57
1.5E+00 - 2.2E+00	5	35	8.93	62.50
2.2E+00 - 3.3E+00	1	36	1.79	64.29
3.3E+00 - 4.8E+00	1	37	1.79	66.07
4.8E+00 - 7.1E+00	0	37	0.00	66.07
7.1E+00 - 1.0E+01	1	38	1.79	67.86

Histogram

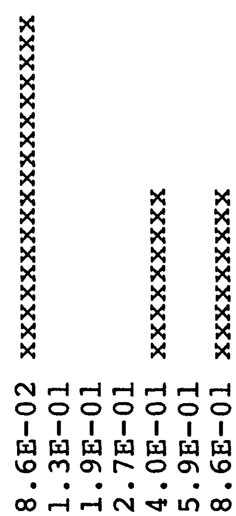
```
5.9E-02 XXXXXXXX
8.6E-02 XXXXXXXXXX
1.3E-01 XXXX
1.9E-01 XXXXXX
2.7E-01 XXXX
4.0E-01 XXXXXXXXXX
5.9E-01 XXXXXXXX
8.6E-01 XXXXXXXX
1.3E+00 XX
1.9E+00 XXXXXXXXXX
2.7E+00 XX
4.0E+00 XX
5.9E+00
8.6E+00 XX
```

APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 6, intermediate igneous rocks.

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
4.8E-02 - 7.1E-02	0	0	0.00	0.00
7.1E-02 - 1.0E-01	2	2	18.18	18.18
1.0E-01 - 1.5E-01	0	2	0.00	18.18
1.5E-01 - 2.2E-01	0	2	0.00	18.18
2.2E-01 - 3.3E-01	0	2	0.00	18.18
3.3E-01 - 4.8E-01	1	3	9.09	27.27
4.8E-01 - 7.1E-01	0	3	0.00	27.27
7.1E-01 - 1.0E+00	1	4	9.09	36.36

Histogram

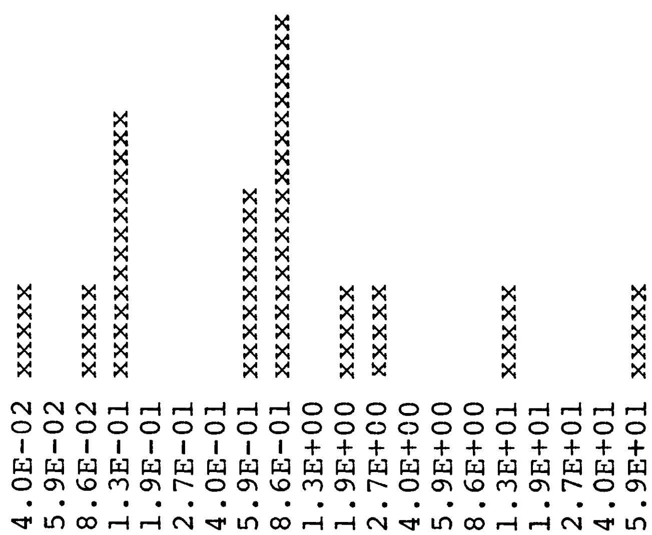


APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 7, gossan

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
2.2E-02 - 3.3E-02	0	0	0.00	0.00
3.3E-02 - 4.8E-02	1	1	4.76	4.76
4.8E-02 - 7.1E-02	0	1	0.00	4.76
7.1E-02 - 1.0E-01	1	2	4.76	9.52
1.0E-01 - 1.5E-01	3	5	14.29	23.81
1.5E-01 - 2.2E-01	0	5	0.00	23.81
2.2E-01 - 3.3E-01	0	5	0.00	23.81
3.3E-01 - 4.8E-01	0	5	0.00	23.81
4.8E-01 - 7.1E-01	2	7	9.52	33.33
7.1E-01 - 1.0E+00	4	11	19.05	52.38
1.0E+00 - 1.5E+00	0	11	0.00	52.38
1.5E+00 - 2.2E+00	1	12	4.76	57.14
2.2E+00 - 3.3E+00	1	13	4.76	61.90
3.3E+00 - 4.8E+00	0	13	0.00	61.90
4.8E+00 - 7.1E+00	0	13	0.00	61.90
7.1E+00 - 1.0E+01	0	13	0.00	61.90
1.0E+01 - 1.5E+01	1	14	4.76	66.67
1.5E+01 - 2.2E+01	0	14	0.00	66.67
2.2E+01 - 3.3E+01	0	14	0.00	66.67
3.3E+01 - 4.8E+01	0	14	0.00	66.67
4.8E+01 - 7.1E+01	1	15	4.76	71.43

Histogram



APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 8, quartz

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
1.0E-02 - 1.5E-02	0	0	0.00	0.00
1.5E-02 - 2.2E-02	1	1	0.79	0.79
2.2E-02 - 3.3E-02	1	2	0.79	1.57
3.3E-02 - 4.8E-02	5	7	3.94	5.51
4.8E-02 - 7.1E-02	12	19	9.45	14.96
7.1E-02 - 1.0E-01	4	23	3.15	18.11
1.0E-01 - 1.5E-01	4	27	3.15	21.26
1.5E-01 - 2.2E-01	6	33	4.72	25.98
2.2E-01 - 3.3E-01	4	37	3.15	29.13
3.3E-01 - 4.8E-01	4	41	3.15	32.28
4.8E-01 - 7.1E-01	1	42	0.79	33.07
7.1E-01 - 1.0E+00	5	47	3.94	37.01
1.0E+00 - 1.5E+00	4	51	3.15	40.16
1.5E+00 - 2.2E+00	6	57	4.72	44.88
2.2E+00 - 3.3E+00	2	59	1.57	46.46
3.3E+00 - 4.8E+00	3	62	2.36	48.82
4.8E+00 - 7.1E+00	2	64	1.57	50.39
7.1E+00 - 1.0E+01	2	66	1.57	51.97
1.0E+01 - 1.5E+01	4	70	3.15	55.12
1.5E+01 - 2.2E+01	5	75	3.94	59.06
2.2E+01 - 3.3E+01	1	76	0.79	59.84
3.3E+01 - 4.8E+01	0	76	0.00	59.84
4.8E+01 - 7.1E+01	0	76	0.00	59.84
7.1E+01 - 1.0E+02	0	76	0.00	59.84
1.0E+02 - 1.5E+02	0	76	0.00	59.84
1.5E+02 - 2.2E+02	1	77	0.79	60.63

Histogram

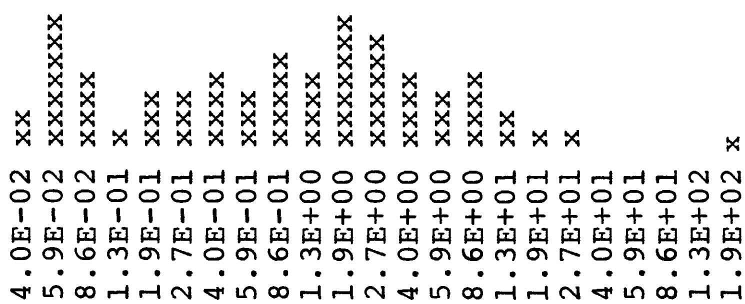
1.9E-02	x
2.7E-02	x
4.0E-02	xxxx
5.9E-02	xxxxxxxxx
8.6E-02	xxx
1.3E-01	xxx
1.9E-01	xxxxx
2.7E-01	xxx
4.0E-01	xxx
5.9E-01	x
8.6E-01	xxxx
1.3E+00	xxx
1.9E+00	xxxxx
2.7E+00	xx
4.0E+00	xx
5.9E+00	xx
8.6E+00	xx
1.3E+01	xxx
1.9E+01	xxxx
2.7E+01	x
4.0E+01	
5.9E+01	
8.6E+01	
1.3E+02	
1.9E+02	x

APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 9, deposits 1-21 (pl. 1)

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
2.2E-02 - 3.3E-02	0	0	0.00	0.00
3.3E-02 - 4.8E-02	3	3	2.00	2.00
4.8E-02 - 7.1E-02	10	13	6.67	8.67
7.1E-02 - 1.0E-01	6	19	4.00	12.67
1.0E-01 - 1.5E-01	2	21	1.33	14.00
1.5E-01 - 2.2E-01	5	26	3.33	17.33
2.2E-01 - 3.3E-01	5	31	3.33	20.67
3.3E-01 - 4.8E-01	6	37	4.00	24.67
4.8E-01 - 7.1E-01	4	41	2.67	27.33
7.1E-01 - 1.0E+00	7	48	4.67	32.00
1.0E+00 - 1.5E+00	6	54	4.00	36.00
1.5E+00 - 2.2E+00	10	64	6.67	42.67
2.2E+00 - 3.3E+00	9	73	6.00	48.67
3.3E+00 - 4.8E+00	6	79	4.00	52.67
4.8E+00 - 7.1E+00	5	84	3.33	56.00
7.1E+00 - 1.0E+01	6	90	4.00	60.00
1.0E+01 - 1.5E+01	3	93	2.00	62.00
1.5E+01 - 2.2E+01	2	95	1.33	63.33
2.2E+01 - 3.3E+01	2	97	1.33	64.67
3.3E+01 - 4.8E+01	0	97	0.00	64.67
4.8E+01 - 7.1E+01	0	97	0.00	64.67
7.1E+01 - 1.0E+02	0	97	0.00	64.67
1.0E+02 - 1.5E+02	0	97	0.00	64.67
1.5E+02 - 2.2E+02	1	98	0.67	65.33

Histogram

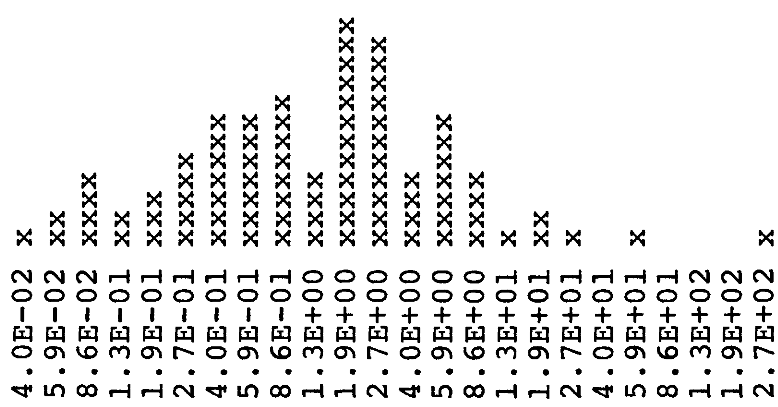


APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 10, deposits 22-26 (pl. 1)

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
2.2E-02 - 3.3E-02	0	0	0.00	0.00
3.3E-02 - 4.8E-02	1	1	0.72	0.72
4.8E-02 - 7.1E-02	3	4	2.17	2.90
7.1E-02 - 1.0E-01	5	9	3.62	6.52
1.0E-01 - 1.5E-01	3	12	2.17	8.70
1.5E-01 - 2.2E-01	4	16	2.90	11.59
2.2E-01 - 3.3E-01	7	23	5.07	16.67
3.3E-01 - 4.8E-01	9	32	6.52	23.19
4.8E-01 - 7.1E-01	9	41	6.52	29.71
7.1E-01 - 1.0E+00	11	52	7.97	37.68
1.0E+00 - 1.5E+00	6	58	4.35	42.03
1.5E+00 - 2.2E+00	16	74	11.59	53.62
2.2E+00 - 3.3E+00	15	89	10.87	64.49
3.3E+00 - 4.8E+00	6	95	4.35	68.84
4.8E+00 - 7.1E+00	9	104	6.52	75.36
7.1E+00 - 1.0E+01	6	110	4.35	79.71
1.0E+01 - 1.5E+01	1	111	0.72	80.43
1.5E+01 - 2.2E+01	3	114	2.17	82.61
2.2E+01 - 3.3E+01	1	115	0.72	83.33
3.3E+01 - 4.8E+01	0	115	0.00	83.33
4.8E+01 - 7.1E+01	2	117	1.45	84.78
7.1E+01 - 1.0E+02	0	117	0.00	84.78
1.0E+02 - 1.5E+02	0	117	0.00	84.78
1.5E+02 - 2.2E+02	0	117	0.00	84.78
2.2E+02 - 3.3E+02	1	118	0.72	85.51

Histogram

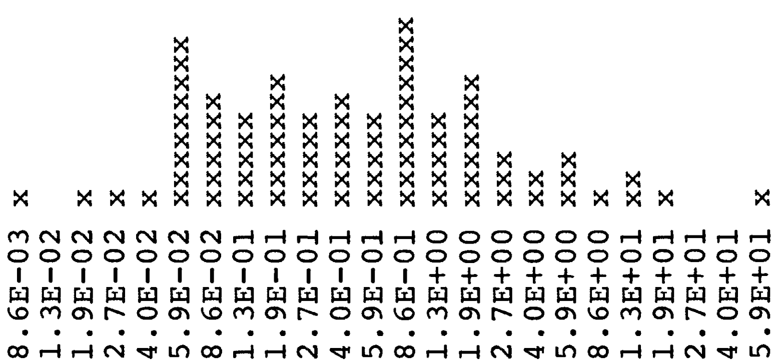


APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 11, deposits 27-30 (pl. 1)

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
3.3E-03 - 4.8E-03	0	0	0.00	0.00
4.8E-03 - 7.1E-03	0	0	0.00	0.00
7.1E-03 - 1.0E-02	1	1	0.57	0.57
1.0E-42 - 1.5E-02	0	1	0.00	0.57
1.5E-02 - 2.2E-02	2	3	1.14	1.70
2.2E-02 - 3.3E-02	1	4	0.57	2.27
3.3E-02 - 4.8E-02	2	6	1.14	3.41
4.8E-02 - 7.1E-02	16	22	9.09	12.50
7.1E-02 - 1.0E-01	10	32	5.68	18.18
1.0E-01 - 1.5E-01	9	41	5.11	23.30
1.5E-01 - 2.2E-01	12	53	6.82	30.11
2.2E-01 - 3.3E-01	8	61	4.55	34.66
3.3E-01 - 4.8E-01	11	72	6.25	40.91
4.8E-01 - 7.1E-01	8	80	4.55	45.45
7.1E-01 - 1.0E+00	18	98	10.23	55.68
1.0E+00 - 1.5E+00	9	107	5.11	60.80
1.5E+00 - 2.2E+00	13	120	7.39	68.18
2.2E+00 - 3.3E+00	6	126	3.41	71.59
3.3E+00 - 4.8E+00	4	130	2.27	73.86
4.8E+00 - 7.1E+00	6	136	3.41	77.27
7.1E+00 - 1.0E+01	2	138	1.14	78.41
1.0E+-1 - 1.5E+01	4	142	2.27	80.68
1.5E+01 - 2.2E+01	1	143	0.57	81.25
2.2E+01 - 3.3E+01	0	143	0.00	81.25
3.3E+01 - 4.8E+01	0	143	0.00	81.25
4.8E+01 - 7.1E+01	1	144	0.57	81.82

Histogram

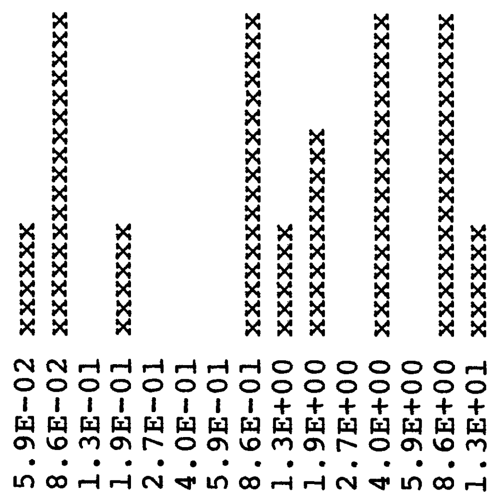


APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 12, deposits 31-33 (pl. 1)

Limits Lower	-	Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
3.3E-02	-	4.8E-02	0	0	0.00	0.00
4.8E-02	-	7.1E-02	1	1	5.56	5.56
7.1E-02	-	1.0E-01	3	4	16.67	22.22
1.0E-01	-	1.5E-01	0	4	0.00	22.22
1.5E-01	-	2.2E-01	1	5	5.56	27.78
2.2E-01	-	3.3E-01	0	5	0.00	27.78
3.3E-01	-	4.8E-01	0	5	0.00	27.78
4.8E-01	-	7.1E-01	0	5	0.00	27.78
7.1E-01	-	1.0E+00	3	8	16.67	44.44
1.0E+00	-	1.5E+00	1	9	5.56	50.00
1.5E+00	-	2.2E+00	2	11	11.11	61.11
2.2E+00	-	3.3E+00	0	11	0.00	61.11
3.3E+00	-	4.8E+00	3	14	16.67	77.78
4.8E+00	-	7.1E+00	0	14	0.00	77.78
7.1E+00	-	1.0E+01	3	17	16.67	94.44
1.0E+01	-	1.5E+01	1	18	5.56	100.00

Histogram



APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 13, deposits 34-38 (pl. 1)

Limits Lower - Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
7.1E-02 - 1.0E-01	0	0	0.00	0.00
1.0E-01 - 1.5E-01	2	2	6.25	6.25
1.5E-01 - 2.2E-01	0	2	0.00	6.25
2.2E-01 - 3.3E-01	0	2	0.00	6.25
3.3E-01 - 4.8E-01	1	3	3.12	9.37
4.8E-01 - 7.1E-01	0	3	0.00	9.37
7.1E-01 - 1.0E+00	2	5	6.25	15.62
1.0E+00 - 1.5E+00	0	5	0.00	15.62
1.5E+00 - 2.2E+00	0	5	0.00	15.62
2.2E+00 - 3.3E+00	0	5	0.00	15.62
3.3E+00 - 4.8E+00	3	8	9.37	25.00
4.8E+00 - 7.1E+00	1	9	3.12	28.12
7.1E+00 - 1.0E+01	0	9	0.00	28.12
1.0E+01 - 1.5E+01	3	12	9.37	37.50
1.5E+01 - 2.2E+01	1	13	3.12	40.62
2.2E+01 - 3.3E+01	0	13	0.00	40.62
3.3E+01 - 4.8E+01	1	14	3.12	43.75

Histogram

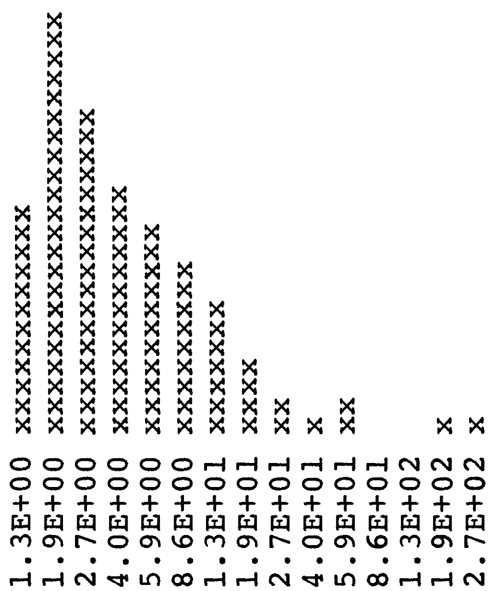
```
1.3E-01 XXXXXX
1.9E-01
2.7E-01
4.0E-01 XXX
5.9E-01
8.6E-01 XXXXXX
1.3E+00
1.9E+00
2.7E+00
4.0E+00 XXXXXXXXX
5.9E+00 XXX
8.6E+00
1.3E+01 XXXXXXXXX
1.9E+01 XXX
2.7E+01
4.0E+01 XXX
```

APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 14, samples containing greater than 1 g/t gold.

Limits Lower	-	Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
7.1E-01	-	1.0E+00	0	0	0.00	0.00
1.0E+00	-	1.5E+00	22	22	12.02	12.02
1.5E+00	-	2.2E+00	41	63	22.40	34.43
2.2E+00	-	3.3E+00	31	94	16.94	51.37
3.3E+00	-	4.8E+00	23	117	12.57	63.93
4.8E+00	-	7.1E+00	21	138	11.48	75.41
7.1E+00	-	1.0E+01	17	155	9.29	84.70
1.0E+01	-	1.5E+01	12	167	6.56	91.26
1.5E+01	-	2.2E+01	7	174	3.83	95.08
2.2E+01	-	3.3E+01	3	177	1.64	96.72
3.3E+01	-	4.8E+01	1	178	0.55	97.27
4.8E+01	-	7.1E+01	3	181	1.64	98.91
7.1E+01	-	1.0E+02	0	181	0.00	98.91
1.0E+02	-	1.5E+02	0	181	0.00	98.91
1.5E+02	-	2.2E+02	1	182	0.55	99.45
2.2E+02	-	3.3E+02	1	183	0.55	100.00

Histogram



APPENDIX B. Frequency tables and histograms (continued)

Geochemical data subset 15, samples containing greater than 10 g/t gold.

Limits Lower	-	Upper	Frequency	Cummulate Frequency	Frequency Percent	Cummulate Frequency Percent
7.1E+00	-	1.0E+01	0	0	0.00	0.00
1.0E+01	-	1.5E+01	12	12	42.86	42.86
1.5E+01	-	2.2E+01	7	19	25.00	67.86
2.2E+01	-	3.3E+01	3	22	10.71	78.57
3.3E+01	-	4.8E+01	1	23	3.57	82.14
4.8E+01	-	7.1E+01	3	26	10.71	92.86
7.1E+01	-	1.0E+02	0	26	0.00	92.86
1.0E+02	-	1.5E+02	0	26	0.00	92.86
1.5E+02	-	2.2E+02	1	27	3.57	96.43
2.2E+02	-	3.3E+02	1	28	3.57	100.00

Histogram

```
1.3E+01 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
1.9E+01 xxxxxxxxxxxxxxxxxxxxxxxxxx
2.7E+01 xxxxxxxxxxx
4.0E+01 xxxx
5.9E+01 xxxxxxxxxxx
8.6E+01
1.3E+02
1.9E+02 xxxx
2.7E+02 xxxx
```

APPENDIX C. Summaries of analytical results of geochemical samples from each geochemical data subset [Values are in ppm except where an asterisk (*) indicates values in percent. Analyses were made by semiquantitative methods except where an apostrophe (') indicates atomic absorption methods. Leaders (---) indicate no values determined; dots (...) indicate interference].

Subset 1.--Summary of analytical results of all 605 samples from the Jabal Ishmas-Wadi Tathlith gold belt.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.10	20.0	1.66	3.19	605	---	---	.19
Mg*	0.10	12.6	0.60	5.89	590	...	...	.11
Ca*	0.05	25.0	1.30	4.05	605	---	---	.07
Ti*	0.002	1.25	0.08	6.06	600	0.08	6.29	.27
Mn	0.50	5000.0	279.15	4.68	604	---	---	.13
As	200.00	10000.0	619.8	2.98	64	6.55	13.75	.22
B	10.00	2000.0	15.36	2.58	122	...	...	.18
Ba	20.00	3000.0	192.91	2.60	499	111.91	4.42	.04
Be	1.00	20.0	1.87	1.94	156	0.36	3.78	.06
Co	5.00	200.00	14.19	2.19	318	4.51	4.28	.11
Cr	5.00	5000.00	188.71	2.84	605	---	---	.16
Cu	5.00	3000.00	20.59	3.56	504	13.45	4.60	.21
Mo	5.00	70.00	8.08	1.56	52	---	---	.15
Ni	5.00	2000.00	2.65	5.41	586	24.28	5.69	.15
Pb	10.00	20000.0	34.82	4.20	357	10.56	6.99	.30
Sc	5.00	100.00	10.68	1.85	344	4.89	2.95	.14
Sr	100.00	1500.00	165.23	1.71	352	96.32	2.26	.06
V	10.00	1000.0	45.70	3.07	600	44.88	3.11	.32
Y	10.00	100.0	1.63	1.51	348	9.80	2.05	.05
Zn	200.00	5000.0	365.8	2.25	46	---	---	.03
Zr	10.0	7000.0	61.10	2.65	446	28.88	4.79	.10
Cu'	5.0	4375.0	24.99	4.70	145[1]	18.30	5.61	.15
Pb'	10.0	13126.0	39.15	4.58	123[1]	19.60	6.42	.13
Zn'	4.0	8000.0	33.01	3.65	153[1]	---	---	.19
Ni'	10.00	800.0	118.15	4.80	23[2]	14.91	22.00	.11
Au'	0.01	325.0	0.83	5.87	408	0.06	56.43	1.00
Ag'	0.10	104.0	1.07	2.80	495	---	---	.47
Cr'	50.0	1875.0	237.70	3.80	37[2]	---	---	.11

[1]164 samples analyzed
[2]37 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 2.--Summary of analytical results of 235 dump samples.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.10	15.00	2.67	2.31	235	---	---	.02
Mg*	0.02	12.50	1.04	3.90	228	0.93	4.61	.04
Ca*	0.05	10.00	1.71	2.72	235	---	---	.05
Ti*	0.002	1.00	0.23	3.52	235	---	---	.07
Mn	10.00	5000.00	484.25	3.18	234	475.28	3.29	---
As	200.00	10000.00	568.06	2.79	35	14.76	9.98	.08
B	10.00	150.00	12.70	1.69	72	---	---	.05
Ba	20.00	1000.00	226.82	2.07	221	191.18	2.67	.11
Be	1.00	15.00	1.98	2.00	75	0.44	3.82	.03
Co	5.00	100.00	12.01	2.05	168	7.21	2.86	.10
Cr	15.00	200.00	174.89	2.45	235	---	---	.21
Cu	5.00	1000.00	27.46	2.95	225	24.71	3.24	.18
Mo	5.00	50.00	9.48	2.10	19	---	---	.18
Ni	5.00	2000.00	28.93	3.93	234	28.60	3.97	.06
Pb	10.00	20000.00	55.97	4.59	174	24.63	7.18	.29
Sc	5.00	30.00	10.29	1.65	193	8.08	2.02	.04
Sr	100.00	700.00	150.16	1.46	181	122.15	1.68	.30
V	10.00	1000.00	88.52	2.15	235	---	---	.13
Y	10.00	30.00	16.20	1.43	191	13.59	1.65	.03
Zn	200.00	1000.00	290.00	1.54	26	49.84	2.79	.20
Zr	10.00	500.00	84.03	2.11	213	65.07	2.93	.05
Cu'	10.00	735.00	94.58	3.26	22[1]	---	---	.24
Pb'	25.00	13126.00	259.96	5.31	15[1]	39.92	20.94	.20
Zn'	18.00	650.00	99.70	2.98	22[1]	---	---	.23
Ni'	13.00	800.00	278.06	3.21	13[2]	101.25	10.86	.07
Au'	0.05	325.00	1.51	4.43	213	0.98	7.15	1.00
Ag'	0.20	104.00	1.42	2.69	219	1.20	3.18	.48
Cr'	90.00	1875.00	721.36	3.21	16[2]	---	---	.06

[1] 22 samples analyzed
[2] 16 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 3.--Summary of analytical results of 69 samples of felsic dikes.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.1	7.0	0.86	2.6	69	---	---	.31
Mg*	0.05	12.5	0.39	4.92	69	---	---	.56
Ca*	0.07	10.0	1.03	3.22	69	---	---	.32
Ti*	0.002	0.3	0.037	3.40	69	---	---	.02
Mn	20.00	3000.0	193.20	3.27	69	---	---	.28
As	---	---	---	---	---	---	---	.34
B	10.0	50.0	19.74	2.02	5	---	---	.25
Ba	20.0	2000.0	158.60	2.98	62	119.41	3.84	.27
Be	1.0	20.0	2.04	2.03	26	0.54	3.66	.12
Co	5.0	50.0	1.42	2.36	20	1.33	7.05	.48
Cr	30.0	3000.0	167.13	3.19	69	---	---	.51
Cu	5.0	1000.0	10.35	2.69	55	7.31	3.16	.36
Mo	5.0	10.0	6.14	1.35	5	---	---	.20
Ni	5.0	2000.0	25.25	7.09	61	---	---	.56
Pb	10.0	1000.0	18.94	2.44	44	---	---	.03
Sc	5.0	30.0	8.27	1.83	21	2.09	3.29	.34
Sr	100.0	1000.0	153.3	1.71	38	88.34	2.21	.02
V	10.0	70.0	15.77	1.79	67	15.34	1.82	.24
Y	10.0	50.0	16.12	1.56	37	9.03	2.15	.14
Zn	---	---	---	---	---	---	---	---
Zr	10.0	500.0	56.01	2.31	56	34.59	3.58	.34
Cu'	50.0	955.0	12.32	3.45	23[1]	...	...	.32
Pb'	10.0	740.0	19.57	2.96	15[1]	...	...	.36
Zn'	5.0	55.0	14.69	1.82	26[1]	---	---	.44
Ni'	---	---	---	---	---	---	---	---
Au'	0.02	5.5	0.18	3.91	31	0.003	68.74	1.0
Ag'	0.10	3.6	0.54	2.61	38	---	---	.37
Cr'	50.0	80.0	68.79	1.25	4[2]	---	---	.05

[1]26 samples analyzed
[2]4 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 4.--Summary of analytical results of 14 samples of ultramafic rock.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	1.0	10.9	3.91	2.21	14	---	---	.17
Mg*	2.0	12.50	6.46	1.96	14	---	---	.03
Ca*	0.10	10.0	2.13	4.53	14	---	---	.13
Ti*	0.002	0.70	0.004	8.41	13	0.03	10.38	.19
Mn	100.00	3000.0	481.94	2.76	14	---	---	.48
As	---	---	---	---	---	---	---	---
B	---	---	---	---	---	---	---	---
Ba	20.0	500.0	111.18	3.04	7	19.55	8.18	.03
Be	---	---	---	---	---	---	---	---
Co	5.0	50.0	21.27	2.14	13	18.32	2.49	.08
Cr	50.0	5000.0	650.55	4.76	14	---	---	.29
Cu	5.0	30.0	15.52	1.99	10	8.58	3.13	.07
Mo	---	---	---	---	---	---	---	---
Ni	30.0	1500.0	361.0	3.94	14	---	---	.29
Pb	10.0	20.0	12.60	1.49	3	4.40	2.18	.37
Sc	5.0	30.0	10.46	2.13	9	5.60	2.99	.21
Sr	100.0	500.0	160.95	1.85	8	98.42	2.31	.15
V	10.0	300.0	30.03	3.09	14	---	---	.13
Y	10.0	20.0	12.60	1.49	3	4.39	2.18	.17
Zn	---	---	---	---	---	---	---	---
Zr	10.0	70.0	12.75	1.99	8	...	...	.17
Cu'	5.0	19.0	9.34	1.74	4[1]	5.76	2.36	.65
Pb'	23.0	46.0	31.96	1.31	6[1]	---	---	.65
Zn'	9.0	55.0	21.43	1.90	6[1]	---	---	.68
Ni'	---	---	---	---	---	---	---	---
Au'	0.04	5.6	0.62	4.62	9	0.038	60.21	1.0
Ag'	0.30	2.7	1.28	1.96	14	---	---	.60
Cr'	---	---	---	---	---	---	---	---

[1]6 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 5.--Summary of analytical results of 57 samples of schist.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.30	15.0	3.31	2.33	57	---	---	.32
Mg*	0.03	12.50	1.54	3.72	56	1.41	4.27	.25
Ca*	0.10	20.0	3.37	3.81	57	---	---	.05
Ti*	0.003	1.25	0.17	3.53	57	---	---	.09
Mn	20.0	3000.0	760.37	2.42	57	---	---	.22
As	200.0	10000.0	1399.37	4.51	8	2.21	51.75	.34
B	10.0	500.0	20.95	3.53	13	---	---	.16
Ba	30.0	2000.0	244.14	2.33	49	155.45	3.97	.16
Be	1.0	5.0	1.65	1.70	20	0.56	2.76	.11
Co	5.0	50.0	18.45	2.04	47	12.77	2.84	.10
Cr	50.0	2000.0	293.9	3.37	57	---	---	---
Cu	5.0	3000.0	26.67	4.46	51	---	---	.33
Mo	5.0	15.0	6.25	1.53	8	1.23	2.67	.14
Ni	5.0	2000.0	79.23	6.33	56	74.05	6.68	.05
Pb	10.0	150.0	16.26	2.25	27	---	---	.08
Sc	5.0	50.0	13.37	2.02	50	10.88	2.38	.21
Sr	100.0	1500.0	203.39	1.91	40	130.80	2.47	.15
V	10.0	300.0	73.89	2.74	57	---	---	.25
Y	10.0	100.0	16.86	1.74	40	11.79	2.12	.04
Zn	200.0	1500.0	322.15	2.14	7	---	---	.14
Zr	10.0	300.0	44.86	2.65	49	32.42	3.40	.06
Cu'	10.0	4375.0	80.52	5.33	13[1]	60.96	6.75	.36
Pb'	11.0	45.0	22.59	1.62	13[1]	20.67	1.75	.36
Zn'	9.0	405.0	47.34	3.31	14[1]	---	---	.30
Ni'	64.0	88.0	---	---	3[2]	...	...	.03
Au'	0.05	7.74	0.40	3.83	38	0.044	33.78	1.0
Ag'	0.30	3.30	1.15	1.83	49	0.87	2.58	.04
Cr'	10.0	40.0	15.87	2.23	3[2]	86.75	1.56	.05

[1] 14 samples analyzed
[2] 5 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 6.--Summary of analytical results of 11 samples of intermediate igneous rocks.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	10.0	20.0	3.27	2.35	11	---	---	.17
Mg*	0.15	10.0	1.40	4.44	11	---	---	.11
Ca*	0.15	5.0	1.34	3.21	11	---	---	.29
Ti*	0.002	0.50	0.08	7.43	11	---	---	.31
Mn	300.0	1500.0	487.81	1.64	11	---	---	.26
As	---	---	---	---	---	---	---	---
B	---	---	---	---	---	---	---	---
Ba	150.0	700.0	370.41	1.62	8	123.55	6.61	.04
Be	1.0	7.0	2.41	2.68	3	0.26	6.25	.40
Co	5.0	30.0	9.12	1.84	7	5.29	2.51	.70
Cr	20.0	3000.0	121.26	3.84	11	---	---	.67
Cu	5.0	1500.0	30.91	8.36	9	...	...	---
Mo	20.0	30.0	---	---	2	---	---	---
Ni	5.0	1500.0	14.05	5.43	11	---	---	.67
Pb	10.0	300.0	30.80	4.97	4	...	...	.32
Sc	5.0	20.0	8.39	1.58	8	6.06	1.97	.27
Sr	100.0	1000.0	234.04	2.22	8	146.7	2.88	.24
V	10.0	150.0	43.15	2.76	11	---	---	.46
Y	10.0	30.0	15.11	1.55	7	10.32	1.91	.11
Zn	300.0	5000.0	1046.13	4.24	3	30.18	17.57	.27
Zr	50.0	150.0	89.0	1.54	8	37.53	4.47	.34
Cu'	13.0	1500.0	102.3	8.07	5[1]	---	---	.30
Pb'	13.0	220.0	26.16	3.31	5[1]	---	---	.31
Zn'	46.0	8000.0	308.78	7.99	5[1]	---	---	.27
Ni'	---	---	---	---	---	---	---	---
Au'	0.08	0.90	0.23	3.33	4	0.0009	---	1.0
Ag'	0.20	3.50	0.78	2.60	10	0.65	2.97	.67
Cr'	---	---	---	---	---	---	---	---

[1] 5 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 7.--Summary of analytical results of 21 gossan samples

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.50	15.0	3.83	2.34	21	---	---	.34
Mg*	0.05	12.50	0.82	5.38	21	---	---	.38
Ca*	0.10	25.0	2.43	4.66	21	---	---	.34
Ti*	0.002	1.0	0.08	5.86	21	---	---	.10
Mn	10.0	3000.0	440.78	3.69	21	---	---	.22
As	300.0	3000.0	1051.0	2.54	6	45.04	12.71	.31
B	10.0	2000.0	21.54	5.93	9	---	---	.23
Ba	20.0	500.0	1.76	2.45	16	83.29	4.89	.15
Be	1.0	3000.0	1.25	1.63	5	---	---	.08
Co	5.0	50.0	19.58	2.01	14	8.60	3.87	.58
Cr	30.0	3000.0	242.80	3.89	21	---	---	.05
Cu	5.0	300.0	38.41	3.10	21	---	---	.09
Mo	5.0	10.0	---	---	2	---	---	.25
Ni	5.0	1500.0	37.84	7.04	19	27.25	8.46	.22
Pb	10.0	7000.0	54.97	11.55	10	---	---	.01
Sc	5.0	30.0	13.85	1.95	14	7.09	3.14	.25
Sr	100.0	300.0	130.0	1.51	13	93.64	1.76	.21
V	20.0	500.0	83.89	2.76	21	---	---	.36
Y	10.0	30.0	18.25	1.46	10	8.38	2.40	.23
Zn	---	---	---	---	---	---	---	.33
Zr	10.0	150.0	31.31	2.19	15	17.41	3.26	.14
Cu'	5.0	175.0	26.17	2.81	9[1]	---	---	.39
Pb'	10.0	5838.0	118.31	11.91	8[1]	74.10	15.15	.14
Zn'	17.0	213.0	64.76	2.36	9[1]	---	---	.25
Ni'	15.0	20.0	---	---	2[2]	---	---	.38
Au'	0.04	63.0	0.70	6.94	15	0.08	50.18	1.00
Ag'	0.90	25.0	2.25	2.28	18	1.44	3.84	.20
Cr'	70.0	200.0	120.10	1.65	5[2]	---	---	.36

[1]9 samples analyzed
[2]5 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 8.--Summary of analytical results of 126 quartz samples.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.10	10.0	0.57	2.81	126	---	---	.09
Mg*	0.015	12.5	0.11	4.95	120	---	---	.16
Ca*	0.05	25.0	0.44	4.74	126	---	---	.04
Ti*	0.002	0.5	0.017	5.15	123	0.016	5.40	.17
Mn	0.50	3000.0	69.15	5.47	126	---	---	.17
As	200.0	2000.0	470.8	2.30	11	...	...	.26
B	10.0	2000.0	25.47	5.23	17	...	...	.10
Ba	20.0	1500.0	108.0	2.96	79	35.05	5.99	.06
Be	1.0	5.0	1.93	1.68	14	0.11	5.16	.04
Co	5.0	70.0	13.55	2.51	21	0.38	10.09	.12
Cr	30.0	2000.0	173.40	1.92	126	---	---	---
Cu	5.0	2000.0	15.63	4.55	83	---	---	.07
Mo	5.0	70.0	7.03	2.04	15	---	---	---
Ni	5.0	1500.0	10.44	3.36	122	---	---	.04
Pb	10.0	2000.0	30.49	4.18	52	---	---	.13
Sc	5.0	50.0	10.16	1.99	23	0.79	5.59	.03
Sr	100.0	1500.0	194.64	2.35	19	12.37	5.80	.18
V	10.0	500.0	23.79	2.76	125	23.49	2.78	.07
Y	10.0	30.0	14.08	1.47	24	3.62	2.54	.10
Zn	200.0	5000.0	686.26	3.19	9	---	---	.13
Zr	10.0	500.0	25.95	2.68	47	4.76	5.51	.03
Cu'	5.0	2725.0	22.49	4.50	42[1]	17.86	5.12	.06
Pb'	10.0	2650.0	44.54	4.66	34[1]	19.64	6.94	.04
Zn'	4.0	525.0	23.81	3.84	46[1]	---	---	.05
Ni'	10.0	640.0	51.77	5.68	5[2]	27.55	8.66	---
Au'	0.02	184.0	0.58	8.71	77	0.022	---	1.0
Ag'	0.10	18.6	0.82	3.06	92	---	---	.47
Cr'	50.0	930.0	157.16	2.66	6[2]	157.16	2.66	.02

[1] 46 samples analyzed
[2] 6 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 9.--Summary of analytical results of 150 samples from deposits 1 through 21 (pl. 1)

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.10	15.0	1.08	3.57	150	---	---	---
Mg*	0.015	5.0	0.24	5.93	136	---	---	.12
Ca*	0.05	20.0	0.98	4.39	150	---	---	.05
Ti*	0.002	1.25	0.06	7.54	149	0.06	7.74	.05
Mn	0.50	3000.0	162.80	6.62	149	---	---	.09
As	200.0	10000.0	687.37	3.22	35	30.45	10.63	.30
B	10.0	100.0	14.60	1.72	50	5.42	2.53	.16
Ba	20.0	2000.0	203.8	2.82	111	83.20	6.08	.11
Be	1.0	5.0	1.31	1.57	18	0.25	2.65	.22
Co	5.0	100.0	9.73	2.01	60	2.79	3.62	.04
Cr	5.0	700.0	124.51	1.98	150	---	---	.25
Cu	5.0	300.0	15.56	2.86	114	9.12	3.90	.02
Mo	5.0	10.0	5.69	1.32	16	1.42	2.21	.14
Ni	5.0	160.0	11.48	2.89	142	10.48	3.03	.02
Pb	10.0	500.0	19.37	2.47	61	---	---	.27
Sc	5.0	30.0	9.41	1.65	65	3.36	2.96	.14
Sr	100.0	1500.0	175.98	1.80	67	71.84	2.76	.40
V	10.0	500.0	42.90	3.42	150	42.90	3.42	.13
Y	10.0	50.0	14.48	1.48	68	7.69	2.03	.14
Zn	---	---	---	---	---	---	---	---
Zr	10.0	500.0	54.77	2.72	96	18.33	5.77	.18
Cu'	---	---	---	---	---	---	---	---
Pb'	---	---	---	---	---	---	---	---
Zn'	---	---	---	---	---	---	---	---
Ni'	---	---	---	---	---	---	---	---
Au'	0.04	184.00	0.92	6.46	98	0.05	85.20	1.0
Ag'	0.20	53.50	0.91	2.72	126	0.63	3.56	.43
Cr'	---	---	---	---	---	---	---	---

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 10.--Summary of analytical results of 138 samples from deposits 22 through 26 (pl. 1)

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.15	15.0	2.70	2.49	138	---	---	.04
Mg*	0.02	12.50	0.95	3.49	137	0.92	3.60	---
Ca*	0.05	7.0	1.45	2.88	138	---	---	.02
Ti*	0.002	1.0	0.21	4.28	136	0.19	4.82	.26
Mn	10.0	5000.0	444.50	3.71	138	---	---	.02
As	200.0	5000.0	568.0	2.65	11	...	...	.13
B	10.0	50.0	10.99	1.37	39	...	...	.04
Ba	20.0	700.0	254.12	2.15	127	199.24	3.04	.07
Be	1.0	20.0	2.70	2.14	55	0.58	4.71	---
Co	5.0	50.0	9.53	1.80	94	5.95	2.42	.19
Cr	50.0	2000.0	127.45	1.86	138	---	---	.05
Cu	5.0	700.0	25.10	3.29	135	23.81	3.42	.18
Mo	5.0	30.0	9.31	2.33	4	---	---	.02
Ni	5.0	2000.0	20.60	2.86	138	---	---	.12
Pb	10.0	2000.0	76.66	4.12	122	53.64	5.33	.61
Sc	5.0	30.0	9.47	1.67	109	7.21	2.05	.02
Sr	100.0	500.0	137.0	1.42	101	110.49	1.62	.12
V	10.0	500.0	82.89	2.44	138	---	---	.22
Y	1.0	50.0	17.13	1.42	117	14.79	1.61	.12
Zn	200.0	1000.0	264.49	1.45	25	87.05	2.14	.20
Zr	10.0	500.0	110.08	1.95	120	75.21	3.31	.20
Cu'	6.0	438.0	22.62	3.29	34[1]	---	---	.22
Pb'	10.0	740.0	47.95	3.95	32[1]	41.39	4.32	.14
Zn'	5.0	413.0	43.23	3.40	34[1]	---	---	.27
Ni'	---	---	---	---	---	---	---	---
Au'	0.04	325.0	1.30	4.92	118	0.46	19.38	1.0
Ag'	0.20	50.50	1.46	2.73	131	1.28	3.10	.56
Cr'	---	---	---	---	---	---	---	---

[1] 34 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 11.--Summary of analytical results of 177 samples from deposits 27 through 30 (pl. 1)

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.10	15.00	1.90	3.10	177	---	---	.41
Mg*	0.02	12.50	1.16	6.28	177	---	---	.27
Ca*	0.07	15.00	1.79	3.86	177	---	---	.20
Ti*	0.002	1.00	0.06	5.30	176	0.06	5.43	.35
Mn	10.00	5000.00	354.50	3.74	177	---	---	.26
As	200.00	5000.00	566.50	2.80	17	---	---	.26
B	10.00	2000.00	32.40	5.78	24	---	---	.07
Ba	20.00	3000.00	152.19	2.42	143	88.10	4.05	.07
Be	1.00	10.00	1.77	1.71	63	0.56	2.93	.03
Co	5.00	10.00	22.57	1.91	105	7.15	4.80	.28
Cr	15.00	3000.00	379.41	3.42	177	---	---	.31
Cu	5.00	1000.00	17.35	2.95	152	12.71	3.60	.30
Mo	5.00	50.00	8.35	1.87	14	0.92	0.07	.21
Ni	5.00	2000.00	100.42	7.05	169	83.04	8.22	.27
Pb	10.00	20000.00	24.17	4.40	103	1.38	0.41	.01
Sc	5.00	30.00	10.95	1.82	109	5.58	2.81	.22
Sr	100.00	1500.00	174.72	1.73	112	108.07	2.25	.14
V	10.00	1000.00	36.80	2.79	172	34.79	2.91	.34
Y	10.00	100.00	15.99	1.60	94	8.84	2.19	.11
Zn	200.00	5000.00	479.91	2.98	9	---	---	.06
Zr	10.00	500.00	44.49	2.34	132	23.93	3.78	.07
Cu'	5.00	48.00	2.08	9.23	14[1]	---	---	.24
Pb'	10.00	13126.00	149.70	14.64	14[1]	---	---	.07
Zn'	6.00	463.00	28.37	3.97	14[1]	---	---	.18
Ni'	10.00	800.00	130.61	4.61	22[2]	14.58	23.89	.22
Au'	0.01	63.00	0.49	5.33	144	0.15	18.79	1.00
Ag'	0.20	104.00	1.17	2.43	122	0.20	17.67	.40
Cr'	50.00	1875.00	248.21	3.78	36[2]	---	---	.22

[1]14 samples analyzed
[2]36 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 12.--Summary of analytical results of 18 samples from deposits 31 through 33 (pl. 1)

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.70	5.0	2.01	1.71	18	---	---	---
Mg*	0.07	1.0	0.53	2.54	18	---	---	---
Ca*	0.10	15.0	1.17	4.29	18	---	---	---
Ti*	0.03	0.7	0.20	2.51	18	---	---	---
Mn	100.00	2000.0	4.63	2.44	18	---	---	---
As	---	---	---	---	---	---	---	---
B	---	---	---	---	---	---	---	---
Ba	20.00	1000.0	24.12	2.53	18	---	---	---
Be	---	---	---	---	---	---	---	---
Co	5.00	30.0	17.18	1.62	11	6.97	3.52	---
Cr	70.00	500.0	191.17	1.66	18	---	---	---
Cu	15.00	1000.0	87.42	3.73	18	---	---	---
Mo	5.00	30.0	8.34	2.40	7	...	...	---
Ni	5.00	30.0	14.79	2.02	18	---	---	---
Pb	15.00	300.0	81.02	2.60	15	49.32	4.19	---
Sc	5.00	30.0	1.97	1.87	14	12.06	2.98	---
Sr	10.00	700.0	175.82	2.06	12	99.10	2.66	---
V	30.00	200.0	89.46	1.84	18	---	---	---
Y	10.00	30.0	2.13	1.53	12	13.17	2.22	---
Zn	300.00	700.0	446.05	1.40	6	40.00	7.72	---
Zr	10.00	100.0	40.60	1.90	17	36.58	2.14	---
Cu'	8.00	735.0	85.29	3.59	18	---	---	---
Pb'	30.00	270.0	101.47	2.30	14	48.51	4.93	---
Zn'	24.00	650.0	138.33	3.10	18	---	---	---
Ni'	---	---	---	---	---	---	---	---
Au'	0.07	13.3	1.10	5.79	18	---	---	---
Ag'	0.10	6.3	1.44	2.59	16	0.82	6.29	---
Cr'	---	---	---	---	---	---	---	---

Subset 13.--Summary of analytical results of 32 samples from deposits 34 through 38 (pl. 1)

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.20	20.0	2.0	3.11	32	---	---	.16
Mg*	0.02	10.0	0.87	4.40	32	---	---	.24
Ca*	0.07	25.0	1.42	5.88	32	---	---	.11
Ti*	0.002	0.70	0.06	5.00	32	---	---	.28
Mn	30.0	3000.0	526.87	2.85	32	---	---	.19
As	---	---	---	---	---	---	---	---
B	10.0	15.0	---	---	4	---	---	---
Ba	50.0	1000.0	167.92	2.05	26	98.07	3.72	---
Be	1.0	3.0	1.22	1.50	9	...	...	.03
Co	10.0	70.0	24.62	1.74	19	7.56	4.87	.02
Cr	20.0	1500.0	236.76	3.01	32	---	---	.02
Cu	5.0	3000.0	81.46	5.92	30	63.64	7.23	.02
Mo	7.0	70.0	16.32	2.31	7	0.65	10.17	---
Ni	5.0	500.0	22.68	3.62	32	---	---	.04
Pb	10.0	500.0	29.70	4.55	9	---	---	.03
Sc	5.0	50.0	14.60	1.98	23	8.34	3.02	.01
Sr	100.0	1000.0	202.62	1.86	16	84.28	2.95	.04
V	10.0	500.0	70.82	2.44	32	---	---	.03
Y	10.0	30.0	15.94	1.44	15	8.10	2.14	---
Zn	200.0	5000.0	---	---	4	4.84	20.97	---
Zr	10.0	70.0	28.18	23.20	19	13.00	3.62	.01
Cu'	5.0	4375.0	90.50	5.62	32	---	---	---
Pb'	10.0	600.0	28.79	2.66	20	12.39	4.13	.02
Zn'	6.0	8000.0	51.33	4.12	32	---	---	---
Ni'	---	---	---	---	---	---	---	---
Au'	0.11	37.50	2.91	6.47	14	0.002	...	1.0
Ag'	0.10	7.20	1.43	2.71	31	...	...	.43
Cr'	---	---	---	---	---	---	---	---

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 14.--Summary of analytical results of 183 samples containing greater than 1.0 g/t gold.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.15	15.0	2.16	2.62	183	---	---	.20
Mg*	0.02	12.5	0.68	6.03	180	0.63	6.66	.16
Ca*	0.05	10.0	1.29	3.34	183	---	---	.16
Ti*	0.002	1.00	0.15	4.28	182	0.14	4.45	.07
Mn	0.50	3000.00	322.20	4.18	183	---	---	.15
As	200.00	10000.00	680.13	2.91	39	27.44	10.32	.03
B	10.00	2000.00	15.18	2.52	51	...	...	.07
Ba	20.00	3000.00	192.47	2.41	161	135.30	3.56	.09
Be	1.00	10.00	2.12	1.93	48	0.32	4.44	.05
Co	5.00	100.00	13.22	2.11	114	6.03	3.44	.09
Cr	50.00	3000.00	216.95	2.55	183	---	---	.06
Cu	5.00	1000.00	24.64	3.41	172	21.21	3.81	.01
Mo	5.00	70.00	10.14	2.34	19	0.29	7.74	.09
Ni	5.00	2000.00	28.09	4.86	181	27.26	4.95	.17
Pb	10.00	20000.00	74.77	5.06	127	24.36	9.57	.01
Sc	5.00	50.00	10.22	1.77	129	6.53	2.40	.01
Sr	100.00	300.00	142.11	1.44	117	101.93	1.75	.06
V	10.00	1000.00	72.12	2.59	183	72.12	2.59	.11
Y	10.00	50.00	15.60	1.48	120	10.91	1.85	.01
Zn	20.00	1000.00	299.23	1.53	25	6.76	9.50	.14
Zr	10.00	50.00	62.30	2.52	151	39.42	3.80	.14
Cu'	5.00	735.00	51.13	4.30	33[1]	---	---	.19
Pb'	10.00	13126.00	149.79	6.09	26[1]	53.83	12.13	.22
Zn'	6.00	650.00	76.57	4.18	33[1]	---	---	.19
Ni'	10.00	800.00	179.08	5.38	11[2]	58.13	14.51	.01
Au'	1.10	325.00	4.01	2.67	183	---	---	1.00
Ag'	0.20	104.00	1.78	2.92	177	1.50	3.96	.46
Cr'	60.00	1875.00	504.56	4.16	14[2]	---	---	.02

[1]33 samples analyzed
[2]14 samples analyzed

APPENDIX C. Summaries of analytical results of geochemical samples (continued)

Subset 15.--Summary of analytical results of 28 samples containing greater than 10 g/t gold.

	Minimum	Maximum	Geometric mean	Geometric deviation	Number of values	Cohen mean	Cohen deviation	Correlation with gold
Fe*	0.15	10.0	1.33	3.0	28	---	---	.07
Mg*	0.02	7.0	0.26	6.9	28	---	---	.19
Ca*	0.05	5.0	0.67	4.0	28	---	---	.23
Ti*	0.002	0.5	0.10	4.7	27	0.08	5.78	.12
Mn	0.50	2000.0	164.87	6.51	28	---	---	.03
As	200.0	3000.0	708.07	2.89	6	26.93	10.75	.28
B	10.0	20.0	11.22	1.33	6	5.25	1.75	.14
Ba	20.0	500.0	129.83	2.68	24	89.28	3.69	.10
Be	1.0	2.0	1.41	1.45	8	0.52	2.27	.17
Co	5.0	30.0	12.16	2.03	15	4.55	3.60	.11
Cr	70.0	150.0	202.48	2.21	28	---	---	.12
Cu	5.0	200.0	19.04	3.23	24	13.60	3.99	.16
Mo	5.0	15.0	8.22	1.62	5	1.11	3.77	.02
Ni	5.0	500.0	15.83	3.71	27	14.67	3.86	.05
Pb	10.0	7000.0	101.85	6.54	16	13.71	18.66	---
Sc	5.0	30.0	11.94	1.66	14	4.29	3.29	.02
Sr	100.0	300.0	165.46	1.43	14	87.26	2.13	.36
V	10.0	150.0	47.86	2.48	28	---	---	.02
Y	10.0	30.0	15.37	1.49	16	9.55	1.96	---
Zn	200.0	500.0	305.33	1.34	6	91.29	2.36	.06
Zr	10.0	200.0	45.11	2.59	20	23.40	4.15	.06
Cu'	5.0	300.0	34.34	4.27	11[1]	---	---	.14
Pb'	10.0	5838.0	176.32	8.37	8[1]	46.59	18.74	.18
Zn'	6.0	535.0	49.63	3.94	11[1]	---	---	.21
Ni'	---	---	---	---	---	---	---	---
Au'	11.50	325.0	23.43	2.27	28	---	---	1.0
Ag'	0.20	50.50	4.01	3.51	28	---	---	.56
Cr'	70.0	1625.0	---	---	2[2]	---	---	---

[1] 11 samples analyzed
[2] 2 samples analyzed

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset. [Analyses were made by semiquantitative methods except where an apostrophe (') indicates atomic absorption methods. Leaders (--) indicate no values determined].

Subset 1.--Correlation coefficients of significant elements for the complete data set of 605 samples, Jabal Ishmas-Wadi Tathlith gold belt.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.73	.58	.68	.76	.45	.19	.50	.49	.16	.21	.74	.35	.41	.04	.01	.04	.19	.46	Fe
	1.00	.70	.48	.76	.22	.43	.31	.75	.02	.24	.45	.22	.26	.03	.12	.05	.11	.31	Mg
		1.00	.46	.74	.33	.26	.20	.53	.05	.30	.41	.21	.24	.12	.17	.11	.07	.32	Ca
			1.00	.62	.69	.14	.42	.12	.16	.27	.76	.44	.69	.00	.09	.00	.27	.31	Ti
				1.00	.46	.16	.38	.47	.03	.26	.59	.34	.38	.03	.08	.03	.11	.34	Mn
					1.00	.29	.23	.09	.20	.28	.47	.38	.71	.02	.00	.07	.04	.11	Ba
						1.00	.01	.75	.16	.08	.06	.14	.29	.02	.02	.04	.16	.14	Cr
							1.00	.18	.31	.08	.56	.27	.20	.36	.16	.23	.21	.41	Cu
								1.00	.07	.08	.20	.04	.04	.13	.14	.15	.15	.25	Ni
									1.00	.09	.25	.51	.22	.05	.25	.07	.30	.34	Pb
										1.00	.19	.17	.21	.02	.07	--	.06	.08	Sr
											1.00	.33	.39	.08	.01	.04	.32	.50	V
												1.00	.52	.01	.06	.00	.05	.09	Y
													1.00	.11	.12	.06	.10	.10	Zr
														1.00	.79	.92	.15	.12	Cu'
															1.00	.87	.13	.18	Pb'
																1.00	.19	.12	Zn'
																	1.00	.47	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 2.--Correlation coefficients of significant elements for 235 dump samples.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.71	.54	.73	.76	.58	.09	.29	.49	.15	.29	.71	.42	.57	.14	.09	.14	.02	.21	Fe
	1.00	.69	.78	.77	.46	.38	.14	.71	.06	.37	.42	.36	.55	.12	.17	.11	.04	.05	Mg
		1.00	.61	.69	.49	.18	.03	.47	.10	.31	.30	.32	.39	.24	.27	.22	.05	.08	Ca
			1.00	.78	.73	.01	.21	.37	.11	.30	.64	.44	.73	.04	.11	.03	.07	.20	Ti
				1.00	.60	.09	.12	.45	--	.30	.59	.39	.58	.10	.13	.07	--	.12	Mn
					1.00	.24	.18	.49	.18	.32	.56	.42	.70	.06	.12	.06	.11	.10	Ba
						1.00	.16	.71	.29	.14	.09	--	.19	.12	.06	.12	.21	.19	Cr
							1.00	.28	.37	.04	.31	.25	.21	.36	.30	.30	.18	.32	Cu
								1.00	.22	.32	.19	.23	.20	.05	.08	.05	.06	.17	Ni
									1.00	.22	.24	.06	.22	.05	.27	.07	.29	.44	Pb
										1.00	.09	.23	.26	.04	--	.05	.31	.01	Sr
											1.00	.36	.44	.05	.07	.04	.13	.38	V
												1.00	.55	.03	.07	.02	.02	.08	Y
													1.00	.12	.18	.11	.05	.08	Zr
														1.00	.80	.95	.24	.17	Cu'
															1.00	.84	.20	.28	Pb'
																1.00	.23	.19	Zn'
																	1.00	.48	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 3.--Correlation coefficients of significant elements for 69 samples of felsic dikes.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.59	.37	.34	.46	.15	.47	.47	.44	.02	.16	.46	.09	.09	.20	.07	.07	.31	.57	Fe
	1.00	.74	.04	.51	.35	.66	.36	.84	--	.22	.29	.13	.35	.15	.28	.30	.56	.50	Mg
		1.00	--	.46	.24	.52	.16	.66	.08	.22	.19	.14	.33	.19	.29	.27	.32	.50	Ca
			1.00	.05	.40	.27	.39	.32	.08	.17	.45	.16	.53	.35	.21	.25	.02	.09	Ti
				1.00	.30	.48	.25	.46	.08	.02	.18	.17	.37	.08	.26	.23	.28	.15	Mn
					1.00	.31	.08	.43	.11	.10	.10	.05	.59	.01	.08	.07	.27	.16	Ba
						1.00	.07	.82	.01	.08	.06	.12	.49	.27	.22	.25	.51	.50	Cr
							1.00	.12	.15	--	.45	.13	.07	.49	.18	.20	.36	.33	Cu
								1.00	.12	.03	.12	.27	.55	.33	.32	.36	.56	.52	Ni
									1.00	.10	.02	.23	.15	.08	.25	.10	.03	.09	Pb
										1.00	.18	.03	.24	.10	.08	.10	.02	.08	Sr
											1.00	.04	.04	.14	.03	.03	.24	.16	V
												1.00	.17	.13	.04	.03	.14	.16	Y
													1.00	.15	.15	.13	.34	.17	Zr
														1.00	.84	.91	.32	.13	Cu'
															1.00	.91	.36	.07	Pb'
																1.00	.44	.07	Zn'
																	1.00	.37	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 4.--Correlation coefficients of significant elements for 14 samples of ultramafic rocks.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.48	.12	.36	.78	.41	.21	.15	.17	.32	--	.50	.34	.34	.61	.66	.65	.17	.13	Fe
	1.00	.21	.43	.21	.32	.62	.56	.68	.04	.32	.34	.11	.11	.20	.24	.21	.03	.45	Mg
		1.00	.25	.36	.44	.19	.63	.30	.59	.29	.23	.23	.23	.25	.27	.26	.13	.17	Ca
			1.00	.34	.61	.79	.78	.70	.33	.55	.86	.40	.40	.06	.06	.02	.19	.07	Ti
				1.00	.50	.44	.34	.46	.24	.28	.60	.52	.52	.80	.81	.83	.48	.04	Mn
					1.00	.59	.67	.71	.23	.43	.55	.58	.58	.25	.26	.29	.03	.13	Ba
						1.00	.74	.94	.05	.60	.83	.41	.41	.18	.16	.21	.29	.43	Cr
							1.00	.73	.34	.50	.64	.36	.36	.08	.09	.11	.07	.13	Cu
								1.00	--	.53	.80	.42	.42	.22	.22	.25	.29	.35	Ni
									1.00	--	.21	.05	.05	.15	.16	.15	.37	.31	Pb
										1.00	.50	.34	.34	--	.07	.04	.16	.06	Sr
											1.00	.31	.31	.22	.21	.24	.13	.13	V
												1.00	1.00	.32	.38	.40	.17	.19	Y
													1.00	.32	.38	.40	.17	.19	Zr
														1.00	.96	.99	.66	.30	Cu'
															1.00	.98	.65	.34	Pb'
																1.00	.69	.32	Zn'
																	1.00	.60	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 5.--Correlation coefficients of significant elements for 57 samples of schist.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.41	.15	.56	.48	.23	.12	.45	.28	.09	.26	.72	.17	.22	.16	.13	.14	.32	.07	Fe
	1.00	.53	.08	.31	.33	.57	.12	.68	.12	.08	.13	.12	.18	.08	.11	.06	.25	.10	Mg
		1.00	.03	.49	--	.33	.21	.31	.21	.26	.12	.09	.08	.02	.18	.06	.05	.35	Ca
			1.00	.13	.39	.28	.25	.13	.06	.03	.54	.16	.51	.04	.10	.01	.09	--	Ti
				1.00	.55	.41	.32	.24	.39	.66	.57	.31	.34	.12	.10	.12	.22	.05	Mn
					1.00	.14	.34	.26	.38	.55	.54	.43	.73	.03	--	.05	.16	.08	Ba
						1.00	.10	.84	.33	.29	.14	.06	.12	--	.06	--	--	.04	Cr
							1.00	.04	.01	.17	.58	.39	.21	.55	.34	.43	.33	.05	Cu
								1.00	.22	.11	.24	.05	.15	.08	.01	.10	.05	.20	Ni
									1.00	.20	.14	.14	.30	.05	.06	.04	.08	.03	Pb
										1.00	.42	.47	.45	.01	.05	--	.15	.02	Sr
											1.00	.39	.45	.23	.21	.23	.25	.18	V
												1.00	.51	.03	.06	.03	.03	.14	Y
													1.00	.19	.19	.13	.06	.15	Zr
														1.00	.90	.94	.37	.05	Cu'
															1.00	.95	.36	.20	Pb'
																1.00	.30	.10	Zn'
																	1.00	.03	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 6.--Correlation coefficients of significant elements for 11 samples of intermediate igneous rocks.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.80	.03	.11	.07	.48	.17	.77	.05	.11	.21	.59	.09	.33	.34	.16	.22	.17	.47	Fe
	1.00	.01	.31	.18	.75	.14	.69	.44	.29	.08	.36	.18	.74	.24	.10	.14	.11	.05	Mg
		1.00	.15	.13	.25	.76	.37	.64	.82	.64	.07	.20	--	.89	.89	.91	.29	.56	Ca
			1.00	.50	.69	.13	.13	.35	.32	.58	.66	.48	.75	.28	.12	.21	.31	.22	Ti
				1.00	.17	.08	.25	.19	.10	.50	.49	.42	.34	.16	.08	.14	.26	.21	Mn
					1.00	--	.69	.32	.56	.39	.07	.52	.91	.45	.29	.35	.04	.08	Ba
						1.00	.36	.93	.53	.37	.28	.07	.36	.64	.56	.61	.67	.73	Cr
							1.00	.12	.51	.02	.60	.11	.41	.63	.51	.53	.37	.66	Cu
								1.00	.31	.26	.27	.15	.65	.47	.48	.48	.67	.70	Ni
									1.00	.65	.03	.26	.38	.76	.76	.75	.32	.34	Pb
										1.00	.48	.39	.31	.57	.57	.59	.24	.15	Sr
											1.00	.45	.28	.21	.24	.19	.46	.61	V
												1.00	.53	.19	.05	.13	.11	.11	Y
													1.00	.18	.06	.11	.34	.27	Zr
														1.00	.95	.99	.30	.73	Cu'
															1.00	.99	.31	.69	Pb'
																1.00	.28	.70	Zn'
																	1.00	.67	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 7.--Correlation coefficients of significant elements for 21 gossan samples.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.12	.12	.23	.01	.39	.24	.49	.06	.46	.02	.67	.34	.43	.20	.29	.27	.34	.27	Fe
	1.00	.57	.41	.41	.61	.61	.29	.80	.36	.23	.26	.12	.36	.05	.37	.11	.38	.48	Mg
		1.00	.16	.33	.29	.21	.31	.38	.52	.17	.20	.14	.06	.20	.50	.38	.34	.25	Ca
			1.00	.49	.82	.86	.21	.80	.06	.07	.73	.67	.75	.44	.18	.38	.10	.06	Ti
				1.00	.22	.26	.03	.10	.50	.58	.32	.49	.20	.41	.20	.29	.22	.40	Mn
					1.00	.83	.38	.83	.09	.02	.69	.58	.78	.21	.16	.24	.15	.10	Ba
						1.00	.31	.86	.06	.03	.59	.64	.70	.04	.04	.08	.05	.18	Cr
							1.00	.27	.26	.29	.51	.15	.20	.11	.07	.19	.10	.06	Cu
								1.00	.07	.12	.45	.40	.58	.22	.26	.25	.22	.23	Ni
									1.00	.34	.25	.20	--	.07	.70	.33	.01	.68	Pb
										1.00	.10	.19	.17	.04	.39	.01	.21	.16	Sr
											1.00	.60	.71	.55	.31	.52	.36	.19	V
												1.00	.80	.15	.13	.08	.23	.14	Y
													1.00	.16	--	.08	.14	.02	Zr
														1.00	.62	.93	.39	.59	Cu'
															1.00	.81	.14	.59	Pb'
																1.00	.25	.31	Zn'
																	1.00	.20	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 8. Correlation coefficients of significant elements for 126 quartz samples.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.66	.53	.72	.66	.65	.18	.55	.60	.18	.01	.75	.25	.38	.33	.21	.35	.09	.37	Fe
	1.00	.62	.51	.68	.40	.13	.44	.61	.06	.04	.41	.07	.23	.32	.16	.32	.17	.21	Mg
		1.00	.48	.72	.48	.01	.23	.47	.02	.18	.42	.15	.26	.08	--	.13	.04	.26	Ca
			1.00	.47	.56	.03	.37	.32	.06	.12	.66	.14	.39	.20	.08	.22	.17	.21	Ti
				1.00	.64	.25	.52	.57	.06	.22	.57	.35	.32	.32	.16	.33	.17	.24	Mn
					1.00	.18	.41	.44	.23	.28	.71	.43	.50	.33	.24	.37	.07	.11	Ba
						1.00	.25	.47	.14	.30	.22	.32	.11	.13	.04	.07	.01	.01	Cr
							1.00	.35	.32	.07	.54	.29	.23	.57	.30	.40	.07	.31	Cu
								1.00	.13	.15	.44	.27	.42	.06	.02	.06	.05	.20	Ni
									1.00	.20	.32	.15	.18	.31	.57	.38	.13	.34	Pb
										1.00	.21	.41	.16	.07	.06	.09	.18	.02	Sr
											1.00	.46	.41	.34	.29	.38	.07	.27	V
												1.00	.51	.19	.19	.23	.10	--	Y
													1.00	.04	.07	.08	.03	.06	Zr
														1.00	.76	.90	.06	.31	Cu'
															1.00	.86	.04	.36	Pb'
																1.00	.05	.33	Zn'
																	1.00	.47	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 9.--Correlation coefficients of significant elements for 150 samples from deposits 1 through 21, (pl. 1).

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	An'	Au'	Ag'	
1.00	.78	.65	.86	.82	.77	.22	.62	.61	.05	.39	.86	.50	.67	--	--	--	--	.42	Fe
	1.00	.73	.85	.83	.74	.09	.44	.71	.08	.48	.70	.42	.71	--	--	--	.12	.29	Mg
		1.00	.69	.83	.65	.10	.42	.54	.13	.42	.60	.33	.49	--	--	--	.05	.39	Ca
			1.00	.81	.85	.19	.45	.57	.08	.36	.82	.47	.74	--	--	--	.05	.35	Ti
				1.00	.77	.16	.47	.61	.45	.47	.73	.45	.66	--	--	--	.09	.40	Mn
					1.00	.32	.35	.42	.02	.42	.65	.54	.84	--	--	--	.12	.21	Ba
						1.00	.07	.26	.10	.18	.21	.29	.34	--	--	--	.25	.05	Cr
							1.00	.54	.21	.23	.63	.32	.26	--	--	--	.02	.40	Cu
								1.00	.04	.35	.59	.20	.36	--	--	--	.02	.33	Ni
									1.00	.14	.18	.03	.03	--	--	--	.27	.28	Pb
										1.00	.27	.26	.38	--	--	--	.41	.13	Sr
											1.00	.39	.53	--	--	--	.13	.47	V
												1.00	.66	--	--	--	.15	.10	Y
													1.00	--	--	--	.18	.10	Zr
														--	--	--	--	--	Cu'
															--	--	--	--	Pb'
																			Zn'
																	1.00	.43	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 10.--Correlation coefficients of significant elements for 138 samples from deposits 22 through 26 (pl. 1).

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.83	.68	.73	.82	.70	.04	.28	.39	.12	.35	.71	.42	.49	.28	.40	.29	.04	.08	Fe
	1.00	.71	.52	.82	.51	.09	.17	.57	.08	.32	.43	.26	.32	.36	.41	.30	.01	.03	Mg
		1.00	.60	.75	.59	.08	.21	.37	.09	.38	.42	.26	.39	.38	.45	.32	.23	.09	Ca
			1.00	.63	.84	.46	.43	.04	.32	.37	.80	.53	.77	.34	.45	.37	.26	.15	Ti
				1.00	.61	.10	.21	.39	.06	.30	.59	.39	.42	.31	.38	.21	.02	.04	Mn
					1.00	.37	.32	.02	.25	.34	.71	.45	.71	.28	.40	.30	.08	.08	Ba
						1.00	.08	.49	.06	.21	.33	.36	.45	.15	.17	.15	.05	.03	Cr
							1.00	.11	.47	.02	.41	.32	.38	.10	--	.01	.18	.25	Cu
								1.00	.08	.16	.06	.10	.02	.16	.12	.11	.12	.03	Ni
									1.00	.07	.30	--	.36	.23	.16	.28	.61	.42	Pb
										1.00	.20	.31	.24	.16	.16	.13	.13	.11	Sr
											1.00	.38	.49	.16	.25	.21	.22	.21	V
												1.00	.57	.18	.25	.19	.12	.08	Y
													1.00	.41	.49	.49	.20	.04	Zr
														1.00	.90	.90	.22	.06	Cu'
															1.00	.92	.14	.10	Pb'
																1.00	.27	.04	Zn'
																	1.00	.56	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 11.--Correlation coefficients of significant elements for 177 samples from deposits 27 through 30 (pl. 1).

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.58	.43	.56	.59	.08	.51	.53	.54	.07	.19	.72	.23	.20	.03	.06	--	.41	.60	Fe
	1.00	.76	.26	.65	.18	.75	.13	.87	.22	.25	.26	.11	.01	.31	.36	.32	.27	.37	Mg
		1.00	.25	.71	.02	.55	.09	.61	.22	.27	.19	.13	.08	.30	.34	.30	.20	.34	Ca
			1.00	.43	.50	.06	.47	.13	.09	.21	.74	.34	.63	.06	.09	.05	.35	.26	Ti
				1.00	.14	.46	.26	.51	.18	.28	.41	.22	.18	.24	.25	.22	.26	.34	Mn
					1.00	.30	.24	.24	.17	.22	.30	.35	.69	.11	.06	.12	.07	.03	Ba
						1.00	.13	.83	.09	.02	.22	.01	.19	.22	.21	.21	.31	.40	Cr
							1.00	.17	.13	.14	.63	.33	.33	.02	.10	.03	.30	.47	Cu
								1.00	.04	.08	.25	.04	.07	.28	.28	.27	.27	.42	Ni
									1.00	.09	.08	.12	.03	.44	.69	.50	.01	.33	Pb
										1.00	.18	.24	.19	.08	.14	.06	.14	.09	Sr
											1.00	.31	.41	.02	.10	.04	.34	.52	V
												1.00	.38	.24	.17	.23	.11	.04	Y
													1.00	.09	.11	.09	.07	--	Zr
														1.00	.80	.97	.24	.09	Cu'
															1.00	.84	.07	.28	Pb'
																1.00	.18	.14	Zn'
																	1.00	.40	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 12.--Correlation coefficients of significant elements for 18 samples from deposits 31 through 33 (pl. 1).

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.80	.21	.75	.27	.12	.25	.49	.77	.13	.24	.74	.76	.44	.56	.55	.33	.30	.46	Fe
	1.00	.43	.70	.70	.34	.21	.06	.80	.06	.39	.74	.77	.35	.16	.52	.53	.32	.51	Mg
		1.00	.31	.75	.11	.22	.23	.06	.35	.05	.45	.61	.13	.24	.23	.05	.20	.16	Ca
			1.00	.47	.20	.11	.11	.53	.21	.21	.78	.84	.62	.13	.52	.66	.35	.83	Ti
				1.00	.33	.14	.33	.30	.06	.32	.54	.62	.04	.26	.11	.41	.13	.45	Mn
					1.00	.27	.19	.37	.05	.83	.23	.26	--	.10	.32	.26	.28	.38	Ba
						1.00	.26	.52	.20	.24	.15	.08	.20	.25	.22	.18	.11	.18	Cr
							1.00	.15	.38	.20	.32	.08	--	.96	.26	.12	.02	.07	Cu
								1.00	.21	.34	.60	.50	.39	.28	.59	.35	.43	.46	Ni
									1.00	.35	.30	.11	.42	.34	.50	.45	.48	.43	Pb
										1.00	.36	.30	.07	.26	.38	.35	.32	.34	Sr
											1.00	.77	.24	.32	.37	.35	.14	.54	V
												1.00	.40	.10	.25	.38	.08	.58	Y
													1.00	.03	.49	.66	.48	.68	Zr
														1.00	.39	.02	.21	.01	Cu'
															1.00	.68	.80	.63	Pb'
																1.00	.69	.76	Zn'
																	1.00	.54	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 13.--Correlation coefficients of significant elements for 32 samples from deposits 34 through 38 (pl. 1).

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.73	.34	.39	.64	.23	.25	.57	.46	.20	.09	.69	.18	.25	.52	.36	.60	.16	.20	Fe
	1.00	.18	.49	.58	.09	.04	.62	.42	.13	.29	.49	.15	.34	.63	.40	.71	.24	.20	Mg
		1.00	.33	.50	.54	.04	.24	.60	.30	.50	.51	.25	.33	.28	.12	.15	.12	.38	Ca
			1.00	.57	.27	.26	.19	.52	.34	.27	.67	.48	.72	.21	.08	.26	.28	.08	Ti
				1.00	.38	.10	.51	.45	.06	.14	.48	.33	.40	.50	.23	.48	.19	.15	Mn
					1.00	.12	.14	.44	.26	.16	.45	.12	.14	.21	.10	.19	.16	.11	Ba
						1.00	.35	.57	.56	.36	.86	.05	.10	.29	.15	.31	.34	.03	Cr
							1.00	.15	.50	.35	.21	.06	.06	.97	.30	.71	.40	.12	Cu
								1.00	.37	.61	.64	.22	.41	.15	.13	--	.24	.30	Ni
									1.00	.23	.04	.40	.50	.47	.54	.43	.55	.06	Pb
										1.00	.25	.16	.25	.31	.03	.18	.08	.36	Sr
											1.00	.25	.41	.20	.39	.38	.24	.35	V
												1.00	.68	--	.27	.03	.45	.20	Y
													1.00	.03	.10	.14	.44	.13	Zr
														1.00	.33	.72	.34	.11	Cu'
															1.00	.57	.27	.27	Pb'
																1.00	.17	.19	Zn'
																	1.00	.33	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 14.--Correlation coefficients of significant elements for 183 samples containing greater than 1.0 g/t gold.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.66	.56	.67	.71	.53	.11	.41	.46	.19	.29	.69	.33	.50	.13	.10	.10	.20	.05	Fe
	1.00	.77	.66	.80	.38	.44	.17	.76	.04	.30	.37	.35	.49	.14	.25	.13	.16	.11	Mg
		1.00	.66	.74	.50	.19	.14	.50	.06	.29	.34	.36	.50	.25	.34	.23	.16	.10	Ca
			1.00	.73	.71	.08	.33	.24	.15	.28	.69	.44	.74	.05	.19	.05	.07	.08	Ti
				1.00	.57	.14	.23	.46	.03	.31	.56	.37	.60	.08	.15	.04	.15	.01	Mn
					1.00	.29	.32	--	.25	.32	.58	.38	.72	.04	.13	.05	.10	--	Ba
						1.00	--	.77	.40	.09	.17	.10	.27	.08	.02	.06	.07	.23	Cr
							1.00	.14	.40	.15	.47	.21	.33	.38	.32	.32	.01	.32	Cu
								1.00	.26	.25	.07	.15	.10	.09	.15	.09	.17	.22	Ni
									1.00	.10	.27	.06	.29	.01	.27	.07	.01	.40	Pb
										1.00	.10	.23	.28	.02	.05	--	.06	.03	Sr
											1.00	.29	.50	.09	.07	.10	.11	.26	V
												1.00	.54	.01	.06	.01	.01	.03	Y
													1.00	.10	.21	.12	.14	.04	Zr
														1.00	.78	.91	.19	.16	Cu'
															1.00	.86	.22	.32	Pb'
																1.00	.19	.21	Zn'
																	1.00	.46	Au'
																		1.00	Ag'

APPENDIX D. Correlation coefficients for each pair of significant elements for each geochemical data subset (continued)

Subset 15.--Correlation coefficients of significant elements for 28 samples containing greater than 10 g/t gold.

Fe	Mg	Ca	Ti	Mn	Ba	Cr	Cu	Ni	Pb	Sr	V	Y	Zr	Cu'	Pb'	Zn'	Au'	Ag'	
1.00	.67	.62	.77	.70	.82	.07	.51	.43	.27	.61	.77	.33	.64	.02	.01	.12	.07	.17	Fe
	1.00	.83	.75	.82	.61	.36	.35	.79	.15	.45	.59	.52	.72	.03	.30	.04	.19	.29	Mg
		1.00	.85	.75	.73	.10	.12	.58	.19	.27	.50	.41	.68	.25	.53	.30	.23	.07	Ca
			1.00	.68	.79	--	.32	.44	.10	.38	.76	.38	.78	.08	.35	.12	.12	.02	Ti
				1.00	.69	.25	.30	.59	.23	.47	.51	.48	.62	.04	.18	.06	.03	.14	Mn
					1.00	.09	.34	.23	.16	.32	.73	.28	.71	.17	.21	.07	.10	.08	Ba
						1.00	.19	.72	.36	.30	.01	.05	.17	.27	.10	.25	.12	.06	Cr
							1.00	.27	.38	.50	.53	.31	.29	.56	.48	.60	.16	.27	Cu
								1.00	.21	.50	.27	.43	.33	.07	.13	.07	.05	.11	Ni
									1.00	.03	.24	.22	.02	.03	.52	.18	--	.45	Pb
										1.00	.39	.45	.35	.19	.14	.30	.33	.10	Sr
											1.00	.30	.63	.22	.06	.17	.02	.19	V
												1.00	.51	.36	.07	.29	--	.09	Y
													1.00	.03	.28	.05	.06	.17	Zr
														1.00	.65	.87	.14	.16	Cu'
															1.00	.83	.18	.37	Pb'
																1.00	.21	.25	Zn'
																	1.00	.56	Au'
																		1.00	Ag'

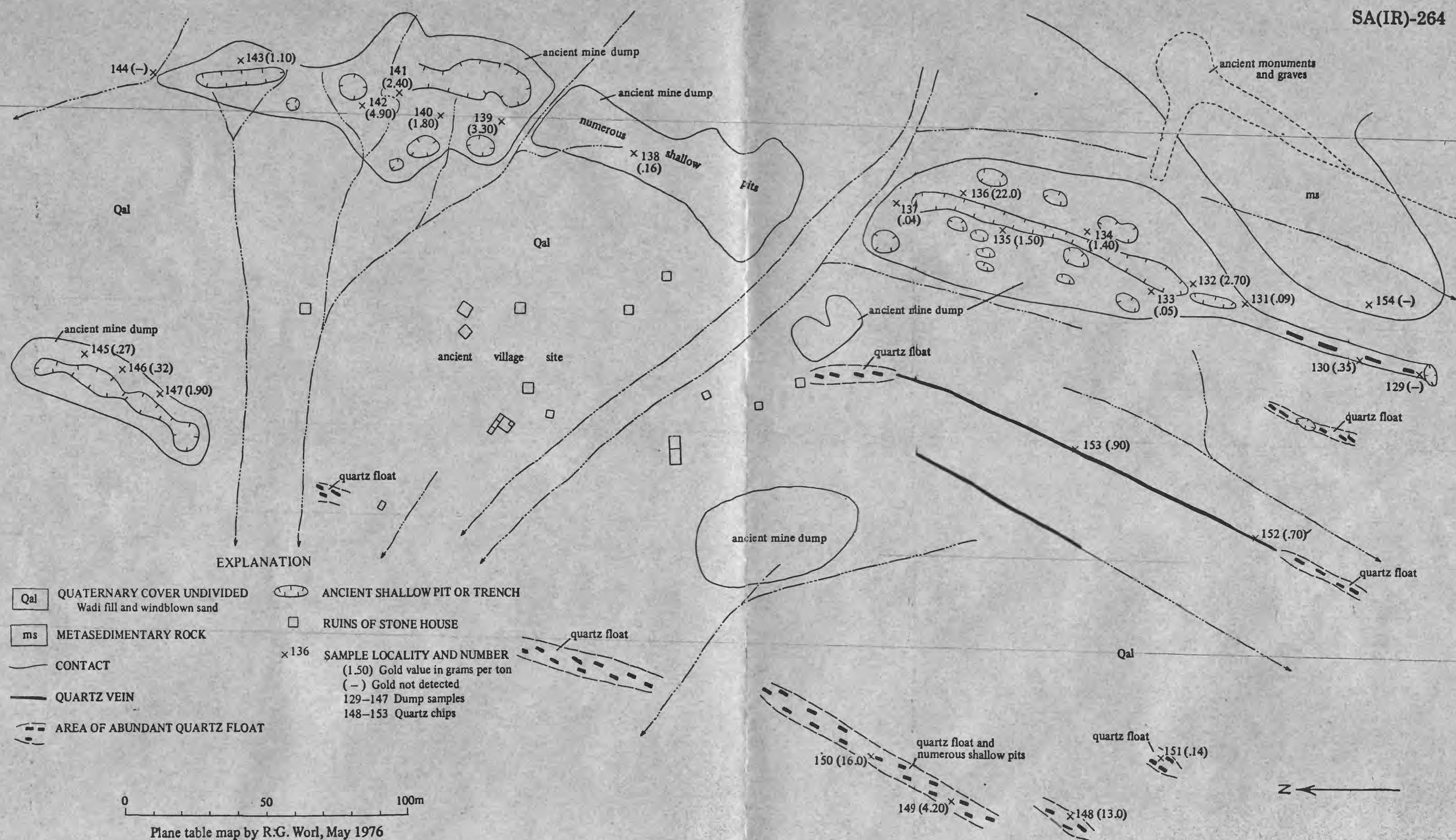
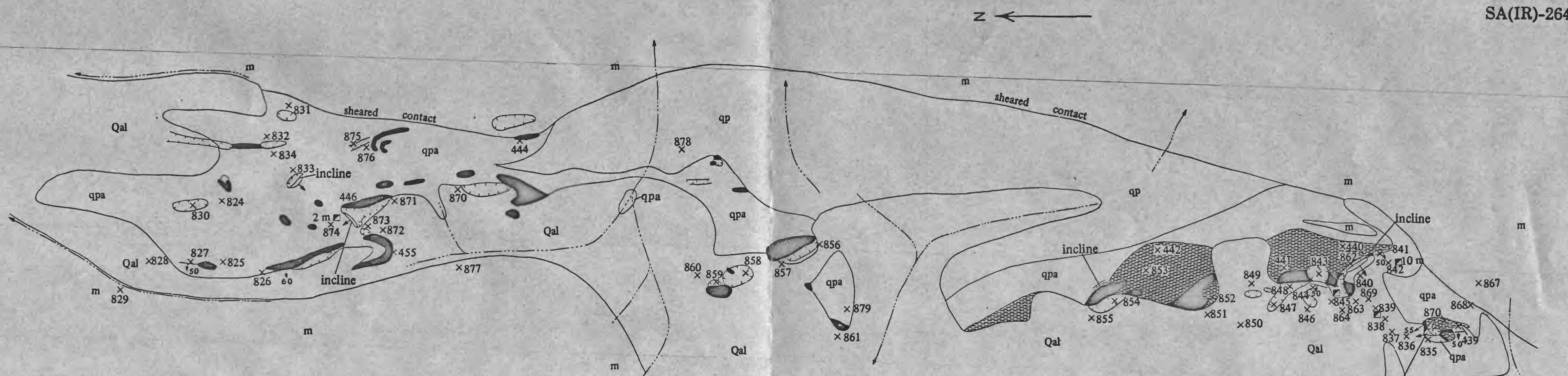


Figure 2. Geology of the Jabal Umm Matirah ancient gold mine (no. 1, pl. 1).

79-1519



EXPLANATION

Qal	ALLUVIUM
qpa	ALTERED AND VEINED QUARTZ PORPHYRY
qp	QUARTZ PORPHYRY
m	METAVOLCANIC
	CONTACT
	QUARTZ VEIN – Showing dip
	QUARTZ VEIN STOCKWORK

ANCIENT MINE WORKINGS

3 m	Shaft, showing depth
	Open pit
× 869	SAMPLE LOCALITY AND NUMBER
(3.2)	DUMP SAMPLE Showing gold value in grams per ton
(3.2)	CHANNEL SAMPLE Showing gold value in grams per ton
(–)	Gold not detected

Sample location	Gold value	Sample location	Gold value	Sample location	Gold value
439	*(–)*	837	(6.24)	854	(2.4)
441	*(.54)*	838	(.38)	855	(16.3)
444	*(3.2)*	839	(1.0)	856	(2.4)
446	*(.58)*	840	(.94)	857	(2.36)
824	(1.54)	841	(2.36)	858	(.32)
825	(.08)	842	(.62)	860	(.8)
826	(.11)	843	(.20)	861	(8.0)
827	(6.60)	844	(1.64)	862	(.50)
828	(.58)	845	(7.30)	863	(.46)
829	(.58)	846	(.08)	864	(2.0)
830	(5.2)	847	(.28)	870	(4.40)
831	(1.26)	848	(.28)	871	(1.70)
832	(2.82)	849	(2.8)	872	(.28)
833	(3.88)	850	(4.6)	873	(3.26)
834	(2.21)	851	(6.0)	874	(.50)
835	(2.0)	852	(.60)	875	(4.0)
836	(.36)				

0 20 40 m

Plane table map by R.G. Worl, April 1976

Figure 7. Geology of the Al Lugatah (Wadi Thafin) ancient gold mine (no. 25, pl. 1)

79-1519

Sample location	Gold value	Sample location	Gold value	Sample location	Gold value	Sample location	Gold value
419	*(–)*	882	(8.7)	897	(3.74)	915	(49.0)
420	*(1.5)*	883	(.73)	898	(.76)	917	(.66)
425	*(–)*	884	(2.0)	899	(.48)	918	(1.56)
426	*(–)*	885	(2.64)	900	(2.90)	919	(2.05)
427	(.04)	886	(.08)	901	(1.64)	920	(.28)
430	*(.06)*	887	(.06)	902	(3.15)	921	(325.00)
431	*(–)*	888	(.9)	907	(8.15)	922	(1.8)
432	*(21.5)*	889	(2.4)	908	(.15)	923	(2.5)
433	(7.10)	890	(2.0)	909	(.48)	924	(.42)
434	*(1.3)*	891	(.08)	910	(4.49)	925	(1.50)
435	(19.0)	892	(.76)	911	*(.17)*	929	(2.02)
436	(6.0)	894	(.20)	912	(5.0)	930	(.10)
880	(7.2)	895	(.28)	913	(1.45)	931	(1.8)
881	(28.8)	896	(1.70)	914	(13.0)	932	(2.27)

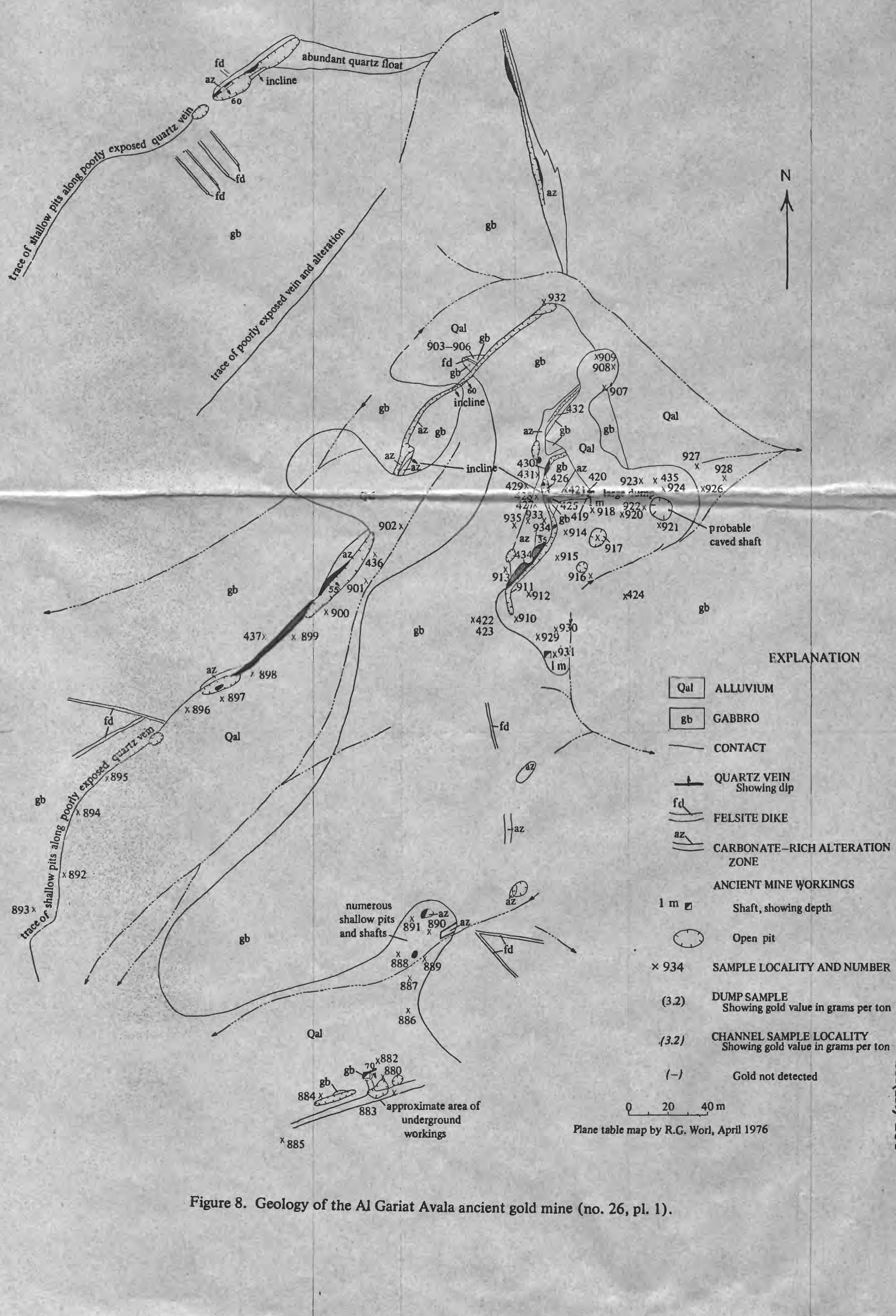
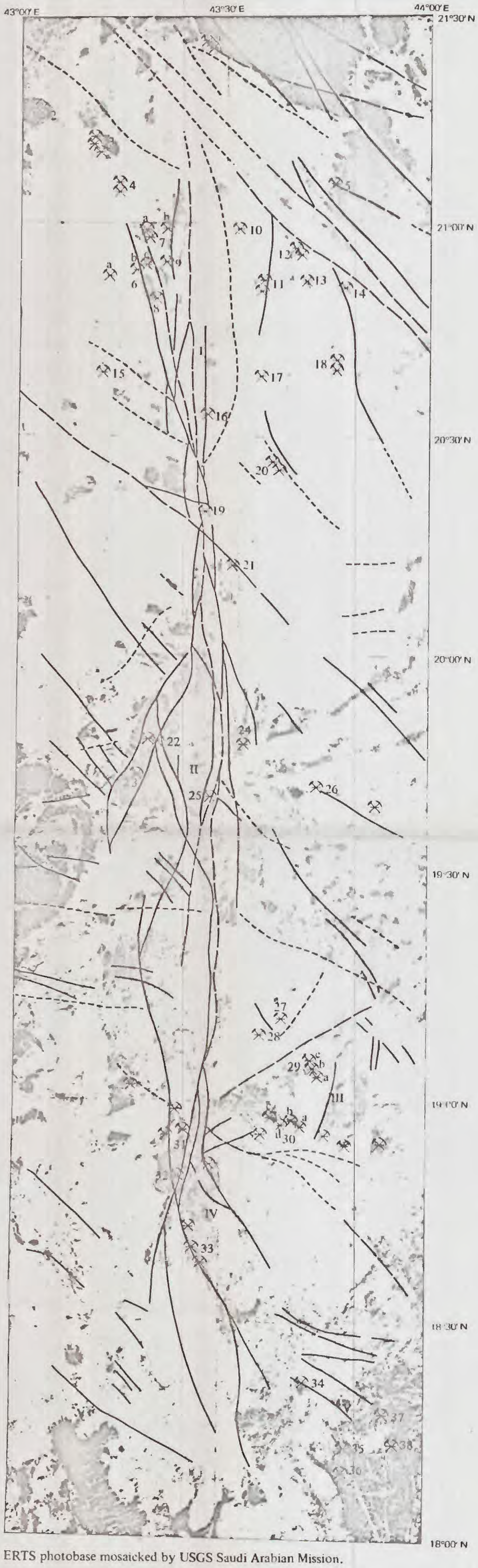


Figure 8. Geology of the Al Gariat Avala ancient gold mine (no. 26, pl. 1).

U.S. GEOLOGICAL SURVEY
SAUDI ARABIAN PROJECT

KINGDOM OF SAUDI ARABIA
MINISTRY OF PETROLEUM AND MINERAL RESOURCES

SA(IR)-264
PLATE 1



ERTS photobase mosaicked by USGS Saudi Arabian Mission.

EXPLANATION

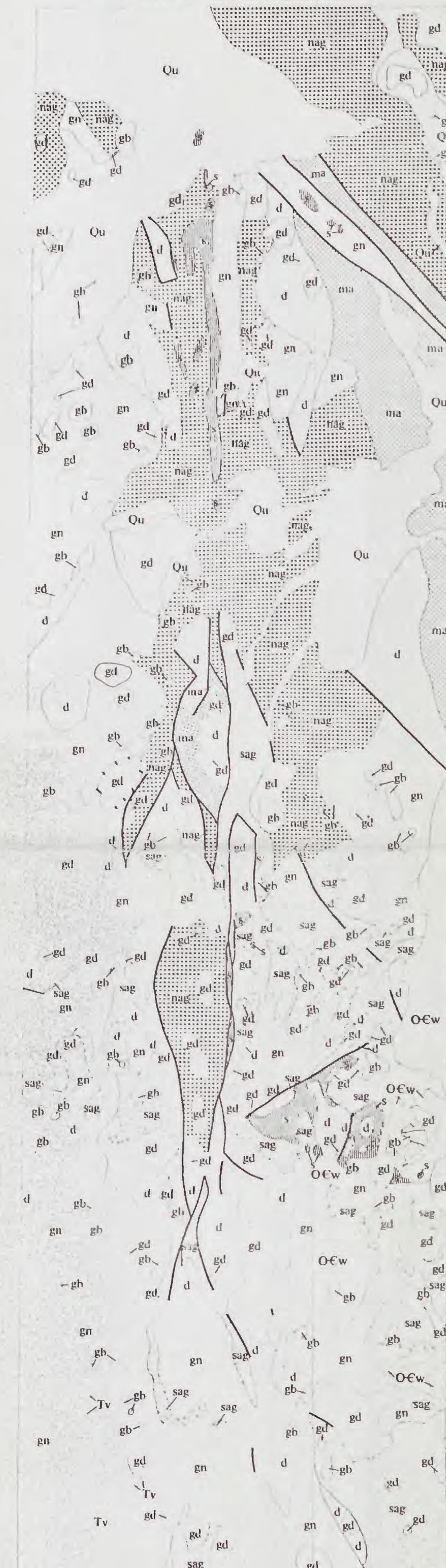
Qu	QUATERNARY COVER, UNDIVIDED
Tv	TERTIARY VOLCANIC ROCKS
O€w	PALEOZOIC WAJID SANDSTONE
	PRECAMBRIAN
gd	GRANODIORITE TO GRANITE
gb	GABBRO
gn	GNEISS, MOSTLY QUARTZ MONZONITE
d	DIORITE
s	SERPENTINITE
ma	METASEDIMENTARY ASSEMBLAGE
nag	NORTHERN ANDESITE-GRAYWACKE ASSEMBLAGE
sag	SOUTHERN ANDESITE-GRAYWACKE ASSEMBLAGE
	CONTACT
	FAULT
	FAULT WITH AEROMAGNETIC ANOMALY
	AEROMAGNETIC ANOMALY LINEAMENT
⚒	ANCIENT MINE SITE
IV	GROUP OF ANCIENT GOLD MINES

ANCIENT MINE SITE

Number	Area name
1	Jabal Umm Matirah
2	Jabal Silli
3	Jabal Dalfa Group
4	Chaim
5	Dahlat Shabab
6	Jabal Ishmas Group
a	Ishmas Kabir
b	Abu Tal
c	Ishmas
7	Umm Shat Group
a	Gharb
b	Sharg
8	Jabal Ishmas Junub
9	Jabal Nabitah
10	Ishghab Gharb
11	Bir Jarbuah
12	Jabal Ishghab
13	Jabal Al Minrag
14	Al Ghabiyah
15	Jabal Kartab
16	Najeeh
17	Nufud Almistajed
18	Bir Almistajed
19	Bani Qutman
20	Wadi Jabyan
21	Jabal Mokhyat
22	Jabal Shayban
23	Bir Ghatana
24	Jabal Hobuyet
25	Al Lugatah (Wadi Thafin)
26	Al Gariat Avala
27	Wadi Al Mushel
28	Al Hasbat
29	Jabal Mahauid Group
a	Al Hamiya South
b	Jabal ibn Hassun
c	Riah
30	Hijrah Hamdah
a	Hajr
b	Jabal Hajr
c	Hajr Gharb
d	Bir Al Hamadan (Jabal al Ge'at)
31	Al Basthat
32	Wadi Siflih
33	Wadi Gharaba
34	Masana Al Masagha
35	Dhahar
36	Hagira
37	Shasrah
38	Jabal Guyan

Approximate scale 1:1,000,000

0 50 100 KM



Geology modified after Jackson and others, 1963; Brown and Jackson, 1959; Hadley, 1976; Gonzalez, 1974; Schmidt (in prep. a and b); Overstreet, 1978; Simmons (in prep.); Warden, (in prep.); Stoeser (in prep.); and Greenwood (in prep. a and b).

GEOLOGY OF THE JABAL ISHMAS-WADI TATHLITH GOLD BELT, KINGDOM OF SAUDI ARABIA

By
Ronald G. Worl

1979