DEPARTMENT OF THE INTERIOR
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Hamdah Ancient Gold Mines, Kingdom of Saudi Arabia

with a section on Ground Electromagnetic Geophysical Surveys
By Maher A. Bassari

by

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HAMDAH ANCIENT GOLD MINES, KINGDOM OF SAUDI ARABIA

A PROGRESS REPORT ON PROSPECT EVALUATION, GEOLOGY, DRILLING, AND GEOCHEMISTRY

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with a section on

GROUND ELECTROMAGNETIC GEOPHYSICAL SURVEYS

By
MAHER A. BAZZARI

ABSTRACT

The Hamdah prospect is a 1.5-km^2 area that includes ancient mine workings 15 km southeast of Hamdah in the southern Arabian Shield. The workings cluster at a gently dipping thrust contact between serpentinite (above) and hornblende schist (below) exposed in a window within the serpentinite. Aplite sills intrude the contact, and gold concentrations occur just above or below it.

The ancient mine dumps cover >100,000 m^2 of the prospect and are estimated to be 1.5 to 1.8 m thick. They contain nearly 181,000 metric tons of material at an average grade of 4.5 g/t gold, thus having an estimated total gold content of 831 kg, or 26,726 Troy oz. Almost 100 percent of the contained gold is recoverable by cyanide acid leaching.

Eleven new diamond-drill holes were completed to supplement information from 12 drill holes completed during an earlier drilling program, in order to enable more detailed evaluation of the prospect. The drill holes are grouped in the northeast, southeast, southwest, and west quadrants of the prospect. In the northeast quadrant, where 9 drill holes intersect gold at shallow (<27 m) depths, the quadrant is calculated to contain nearly 242,300 metric tons of gold-bearing material. The calculations show: (1) 19,144 metric tons high-grade material grading 21.4 g/t Au at 5 g/t cutoff; (2) 39,884 metric tons of material grading 8.5 g/t Au at 5 g/t cutoff; (3) 71,617 metric tons of material grading 3.9 g/t Au at 1 g/t cutoff; and (4) 111,641 metric tons low-grade material grading 2.0 g/t Au at 1 g/t cutoff. Total gold content of this selected block is 1,251 kg gold, or 40,234 Troy oz. The mineralized zone in

the northeast quadrant is open to the northeast, east, and southeast. Drill data are insufficient in detail to allow grade or tonnage estimates for the southeast, southwest, and west quadrants of the prospect. Gold is concentrated in surface alluvium in the southeast and southwest of the prospect, in amounts that are of possible economic significance.

Ground geophysical surveys (CEM and VLF) revealed the presence of electrical conductors at shallow depths, some of which correlate with possible disseminated sulfide minerals, and others with the thrust contact.

It is recommended that the thickness of the dumps be more accurately determined, and that the gold leachability of bulk dump material be tested. Shallow reverse-circulation drilling is recommended on 25-m centers in the northeast quadrant, and diamond drilling is recommended elsewhere at the prospect. Geophysical surveys are required to help establish depths to the serpentinite/schist contact on the northeastern, southern, and western margins of the prospect. Detailed mapping should be undertaken at the prospect, and a mineral-belt type of mapping program should be completed over the larger Hamdah region.

INTRODUCTION

The Hamdah prospect is in the southeastern part of the Arabian Shield in southern Saudi Arabia (fig. 1). It is a 1.5-km^2 site marked by a large number of vertical to inclined shafts, pits, trenches, and waste dumps from ancient gold-mining activity. These excavations are adjacent to a cluster of ruined buildings that presumably identifies the village occupied by the mining personnel, and overall constitute the largest group of ancient workings in the southern Arabian Shield (Helaby and Worl, 1980). On three occasions during the past three decades, the prospect and surrounding region have been explored for gold, asbestos, chromite, and nickel by geologists of the Directorate General for Mineral Resources (DGMR), the U.S. Geological Survey (USGS), and other agencies.

The present report documents the progress of a fourth, current phase of exploration that was initiated by the USGS in January 1989 to test three types of targets: (1) gold associated with aplite and a thrust contact between hornblende schist (below) and the Hamdah serpentinite (above); (2) gold concentrated in the zone of weathered bedrock and colluvium at the surface; and (3) gold contained in waste material from earlier mining activity, which forms the dumps that are a conspicuous feature of the mine workings.

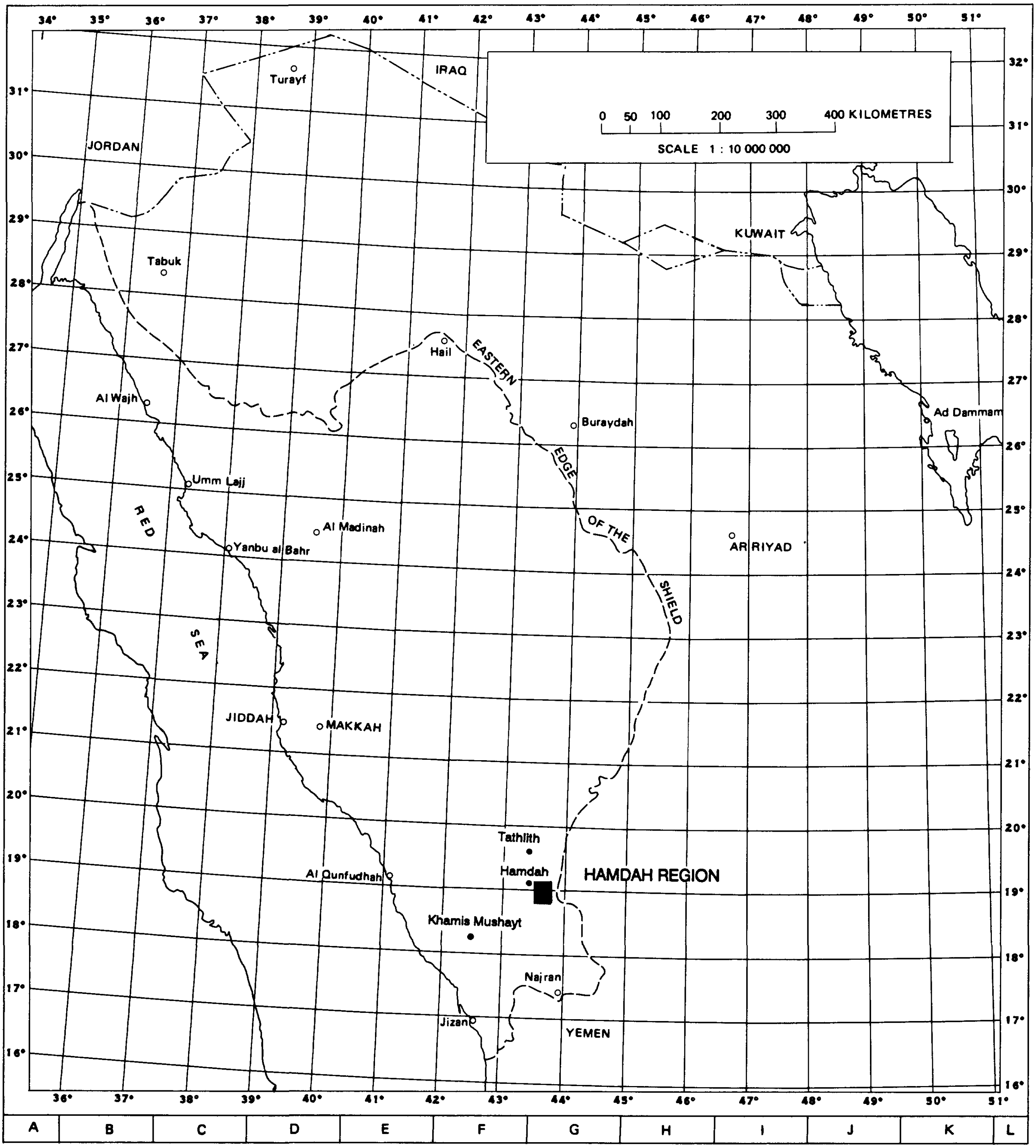

Figure 1.--Index map of the Arabian Shield showing the location of the Hamdah region.

Specific objectives of the current phase of exploration include the following:

(1) **A confirmation of the high, although erratic, gold values reported by earlier workers, which are as much as 63 grams per ton (g/t) gold, although more common grades are between 3 and 5 g/t;**

(2) **An examination by further drilling of the apparent simple structural control on the distribution of gold represented by the serpentinite/schist thrust contact; and**

(3) **An evaluation of the gold contents of the ancient mine dumps.**

Additional purposes of the project are to establish the wider Hamdah region as a gold target, to develop a gold-mineralization model for the region, and to provide justification for an on-going exploration program in the area.

The ancient workings at the Hamdah prospect were first mentioned by Schaffner (1957) using the place name "Higera." Helaby and Worl (1980) subsequently appended the name "Hamdah" and referred to the ancient workings as "Hajrah-Hamdah," in order to avoid confusion with other sites in Saudi Arabia named "Hajrah." In this report, the term "Hajrah" is dropped and the prospect is referred to as "Hamdah" on instruction from the DGMR: the MODS number of the prospect (0619) is unchanged from that of the Hajrah-Hamdah occurrence. Collectively, the Hamdah prospect and adjacent ancient workings (Bi'r Hamadan, MODS 1434; Hajr Gharb, MODS 1441; Jabal Hajr, MODS 1463) are referred to as the Hamdah group of mines (fig. 2; table 1); four other gold prospects 15 km to the north are referred to as the Jabal Mahanid group of mines (Wells, 1982).

Table 1.--Ancient gold mines in the Hamdah area.

MODS number and name	MODS location degree minute second	Chief references
HAMDAH GROUP OF MINES		
0619 Hamdah (Haj'r Mine)	18 54 48N; 43 40 30E	a, b, c, e, f
1434 Bi'r Hamadan (Jabal al Ge'at)	18 54 18N; 43 38 00E	a, b, c, e, f
1441 Hajr Gharb	18 55 12N; 43 37 20E	a, b, c, e, f
1463 Jabal Hajr	18 55 18N; 43 40 00E	a, b, c, e, f
JABAL MAHANID GROUP OF MINES		
0623 Jabal Ibn Hassan	19 03 00N; 43 41 25E	d, e, f
0624 Al Halamiya	19 02 35N; 43 40 15E	d, e, f
1430 Riah	19 04 00N; 43 41 40E	d, e, f

References:

a	This report
b	Hariri (1986)
c	Helaby and Worl (1980)
d	Wells (1982)
e	Worl (1981)
f	Worl and Elsass (1980)

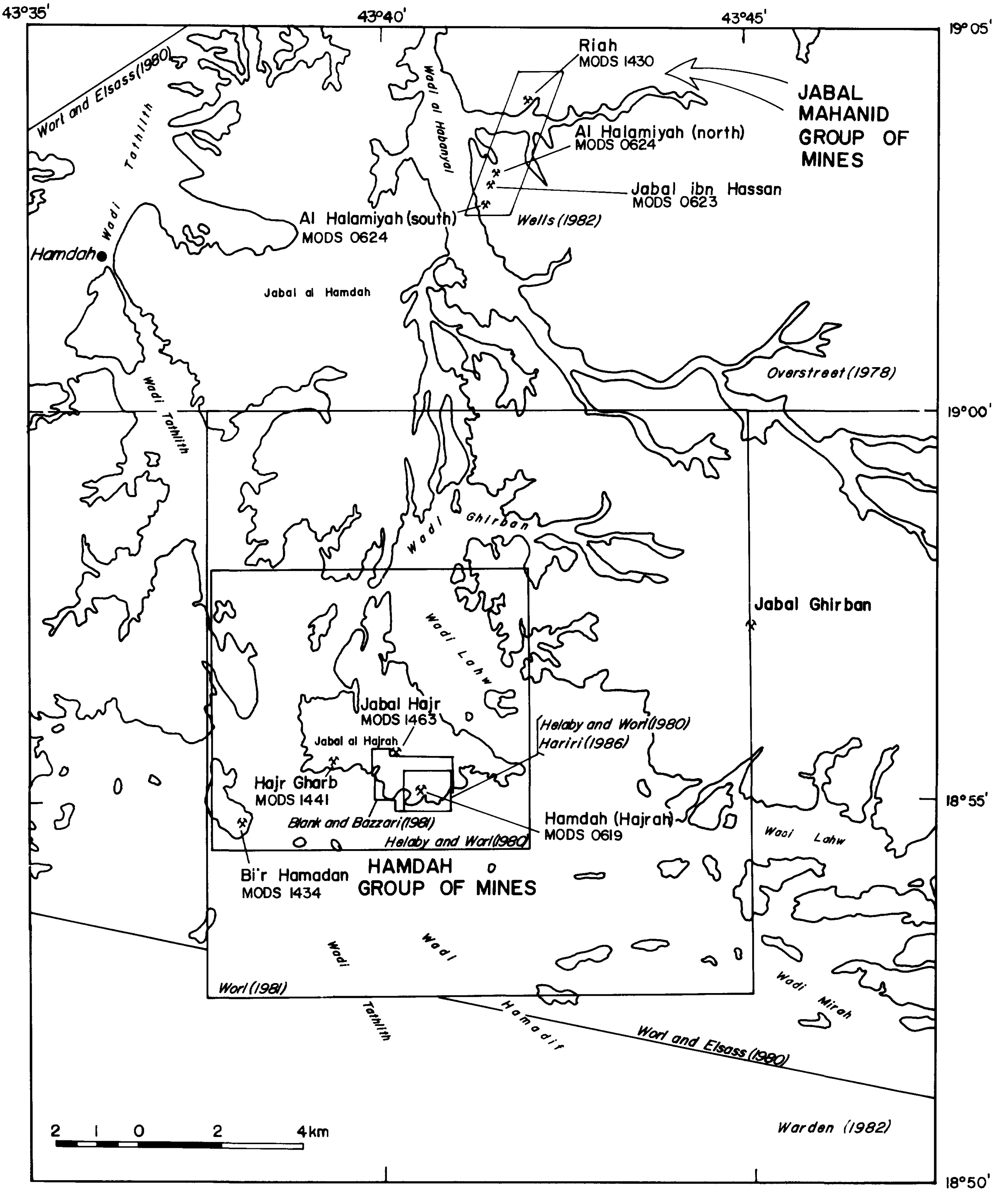

Figure 2.--Map showing location of geologic-mapping and geophysical-surveying projects in the Hamdah region.

LOCATION AND PHYSIOGRAPHY

The Hamdah prospect (MODS 0619) is located at lat 18° 55' N., long 43° 41' E. The site is approximately 15 km southeast of Hamdah and 180 km north of Najran, and is accessible by desert tracks leading about 50 km east from the Khamis Mushayt-Tathlith highway. The ancient workings are situated in the valleys and on the flanks of low hills in an area of moderate relief (30 m) along the southern margin of a triangular-shaped hill that rises to 1,444 m above sea level at Jabal al Hajrah (fig. 2). Outwash from the mine site merges southward with alluvium in Wadi Tathlith and Wadi Hamadif to form a large apron of surficial material that covers the southern part of the study area. Wadi Lahw and Wadi Ghirban, east and northeast of the prospect, drain around the northern flank of Jabal al Hajrah and join Wadi Tathlith to drain northwest through a constricted valley toward the village of Hamdah.

PREVIOUS WORK AND PRESENT INVESTIGATIONS

In the 1950s and 1960s, geologists of the DGMR and USGS were attracted to the area by the asbestos potential of the Hamdah serpentinite (Ahmad, 1957; Schaffner, 1957; Kareh and others, 1962; Overstreet, 1966). The first mention of gold in the region was made by Schaffner (1957), who referred to extensive ancient workings at the Hamdah prospect and reported an assay of 0.04 oz./t Au and 0.17 oz./t Ag from a sample of "fine [grained] ancient tailings."

In the mid-1950s, Brown and Jackson (1959) mapped the region in connection with compilation of the 1:500,000-scale Asir quadrangle. Warden (1969; 1982) subsequently mapped the area south of lat 19° N. at 1:100,000 scale (Markas quadrangle, sheet 18/43B). Airborne magnetometer and scintillation-counter surveys of the area were made in 1965-66 and 1966-67 (Consortium Members, 1967).

USGS geologists returned to the Hamdah area in 1976 in connection with a comprehensive exploration of the Jabal Ishmas-Wadi Tathlith gold belt (Worl, 1979). Overstreet (1978) incorporated field data first acquired during reconnaissance exploration by the USGS in 1965 in a geologic map of the area north of 19° N. (Tathlith one-degree quadrangle) (fig. 2). The map by Overstreet (1978) includes the northern part of the Hamdah region and is an illustration in an account of asbestos and gold mineralization in the region. In 1976, the Hamdah group of mines was mapped at 1:10,000 scale and the Hamdah prospect was mapped at 1:2,000 scale (Helaby and Worl, 1980). Concurrently, the Hamdah and Jabal Hajr prospects were surveyed by ground magnetometry (Blank and Bazzari, 1981). Toward the end of 1976 the area was tested for gold by 14 vertical diamond drill holes (12 at the Hamdah prospect, 1 at the Hajr Gharb prospect, and 1 at an alteration zone 6 km southeast of the Hamdah prospect) (Helaby and Worl, 1980). On the basis of the geologic mapping and the 1976-drill hole results, it was concluded that "gold at the [Hamdah prospect] is widely disseminated along the contact between an overlying serpentinite and underlying hornblende schist," whereas "gold at the Jabal al Hajrah, Hajr Gharb, and Bi'r al Hamdan ancient mines sites is in close proximity to aplite and granite dikes" and is associated with "quartz stringer zones, and along the footwall of shallow-dipping aplite and granite dikes." At Hamdah, Helaby and Worl (1980) described the gold as erratic in distribution and reported average gold values of 3-5 g/t, and locally as much as 10 g/t. Erratic, generally low grades were also reported from the adjacent prospects. Helaby and Worl (1980) drew attention to the gold resource represented by the waste dumps at the Hamdah prospect, which they estimated to contain 200,000 metric tons (t) of material at an average grade of 3.8 g/t gold. They concluded their work by recommending limited follow-up to investigate the possibility of locating gold-bearing zones in a northwest and southeast direction along extensions of the principal trend of the ancient workings.

Concurrent with exploration for gold at the Hamdah prospect, Worl and Elsass (1980) studied the petrology, and the gold, chromium, and nickel contents of the serpentinite in the larger region; Worl (1981) completed a geologic map of the Jabal al Hajrah quadrangle; and Rooney and Al-Koulak (1978) investigated asbestos localities. Four years later, to round-out the USGS exploration program, Wells (1982) mapped the Jabal Mahanid group of mines, 15 km to the north.

The Hamdah prospect was subsequently geochemically surveyed by rock-chip sampling (Hariri, 1986). This study showed a maximum gold content of 18 g/t and an average grade of 1.34 g/t in serpentinite from an inclined shaft, and a nine-hole drilling program was recommended to test the contact between the serpentinite and underlying hornblende schist.

The current phase of exploration began in 1989. This report is an account of field work performed between January and April 1989 and of office work through September 1989. The field work included geophysical surveys, diamond drilling, and a detailed geochemical survey of surface dumps by trenching and channel sampling.

The geophysical surveys utilized CRONE (shoot-back) (CEM) and WADI very low frequency (VLF) electromagnetic methods. The drilling program consisted of 11 diamond-drill holes totaling 1,034.4-m depth. The core was logged and sampled at the Hamdah field camp, and samples were analyzed at the DGMR/USGS Laboratory, Jiddah. The ancient mine dumps were surveyed by channel-sampling trenches and pits excavated in the dumps. A total of 54 trenches (87 m in overall length) were dug across the four largest dumps, and continuous channel samples were collected from within 1-m-square sample areas. The analytical results formed the basis of an estimate of the value of leachable gold contained in dump material. All phases of the exploration program at the prospect site were tied to a surveyed grid consisting of 100-m line spacings that are flagged every 50 m by station markers. The total area covered by the grid is 850 m (N-S) by 750 m (E-W). The orientation of the grid lines (N. 30° E.) is referred to as "grid north," and grid stations are identified by coordinates based on the number of meters from the origin, for example 550N. 50E.

Because of time constraints, the authors undertook little new geologic mapping, and the geology shown in plate 1 is chiefly based on work by Helaby and Worl (1980).

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REGIONAL GEOLOGY

OVERVIEW

The Hamdah region is underlain by an assemblage of late Proterozoic metavolcanic and metasedimentary rocks, serpentinite, and serpentinite melange intruded by diorite, granite, and gabbro. These rocks are exposed in a triangular-shaped expanse of outcrops (fig. 3) that is separated from schist and gneiss of the Ash Sha'ib mineral district to the north by a northeast-trending fault, is bounded on the south by the northwest-trending Al Mulha fault zone, and is overstepped on the east by the Cambrian-Ordovician Wajid Sandstone. The southern part of the Nabitah fault zone and rocks of the associated Jabal Ishmas-Wadi Tathlith gold belt are immediately west of the Hamdah region. Internally, the region is cut by numerous faults, and the serpentinite and metamorphosed layered rocks are folded into gently plunging anticlines and synclines.

The serpentinite and metavolcanic rocks of the Hamdah region are expressed on magnetic-anomaly maps of the area by clusters of east-trending, high-amplitude, short-wavelength magnetic anomalies (fig. 4). Diorite-granite and granite plutons have flat magnetic signatures, and faults are expressed by magnetic lineaments and smooth magnetic boundaries.

The Hamdah prospect is located a few kilometers southwest of a large diorite-granite pluton that occupies the core of the Hamdah region (fig. 3). The prospect is separated from the pluton by a north-trending fault (termed here the Wadi Lahw

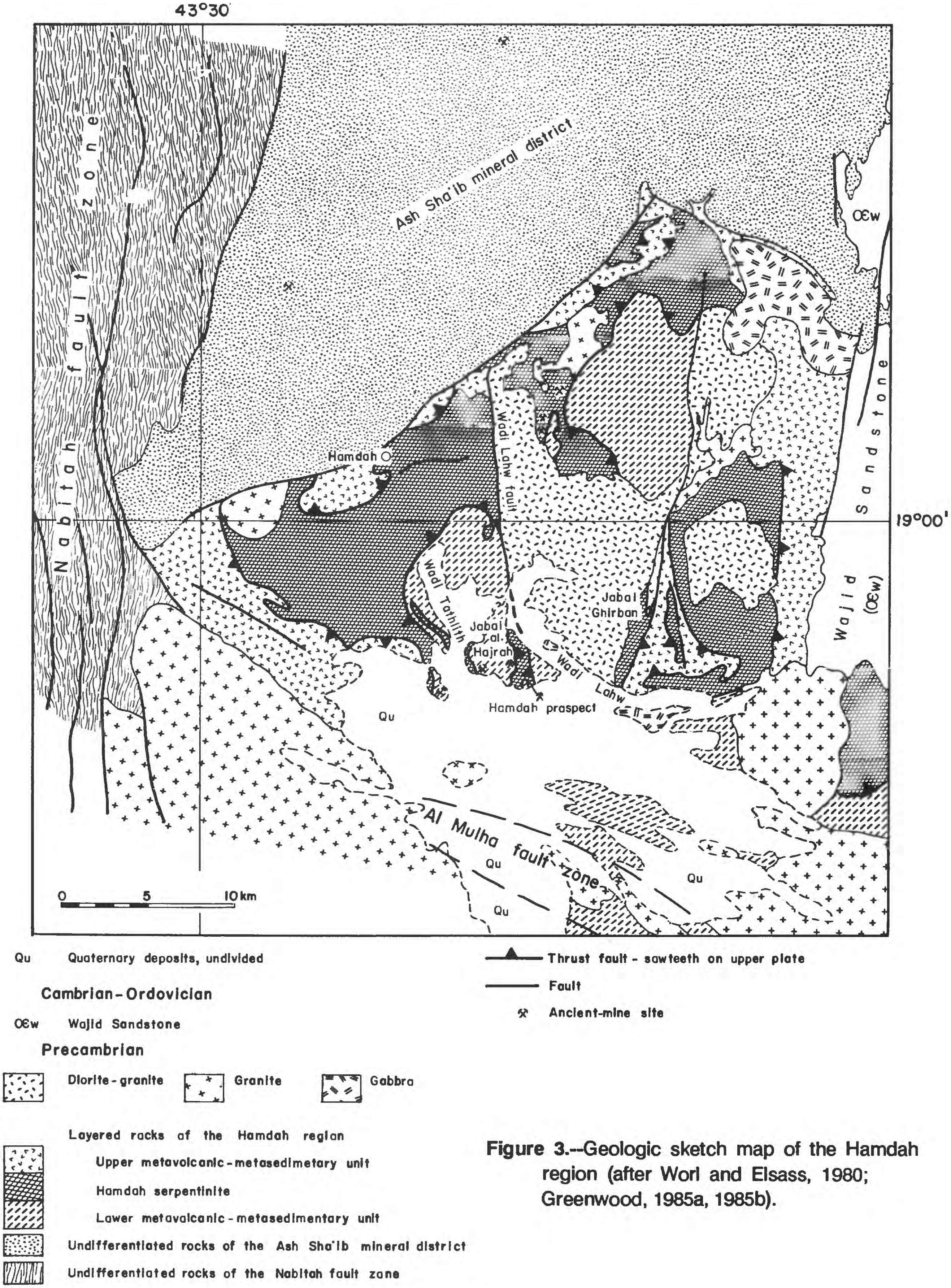
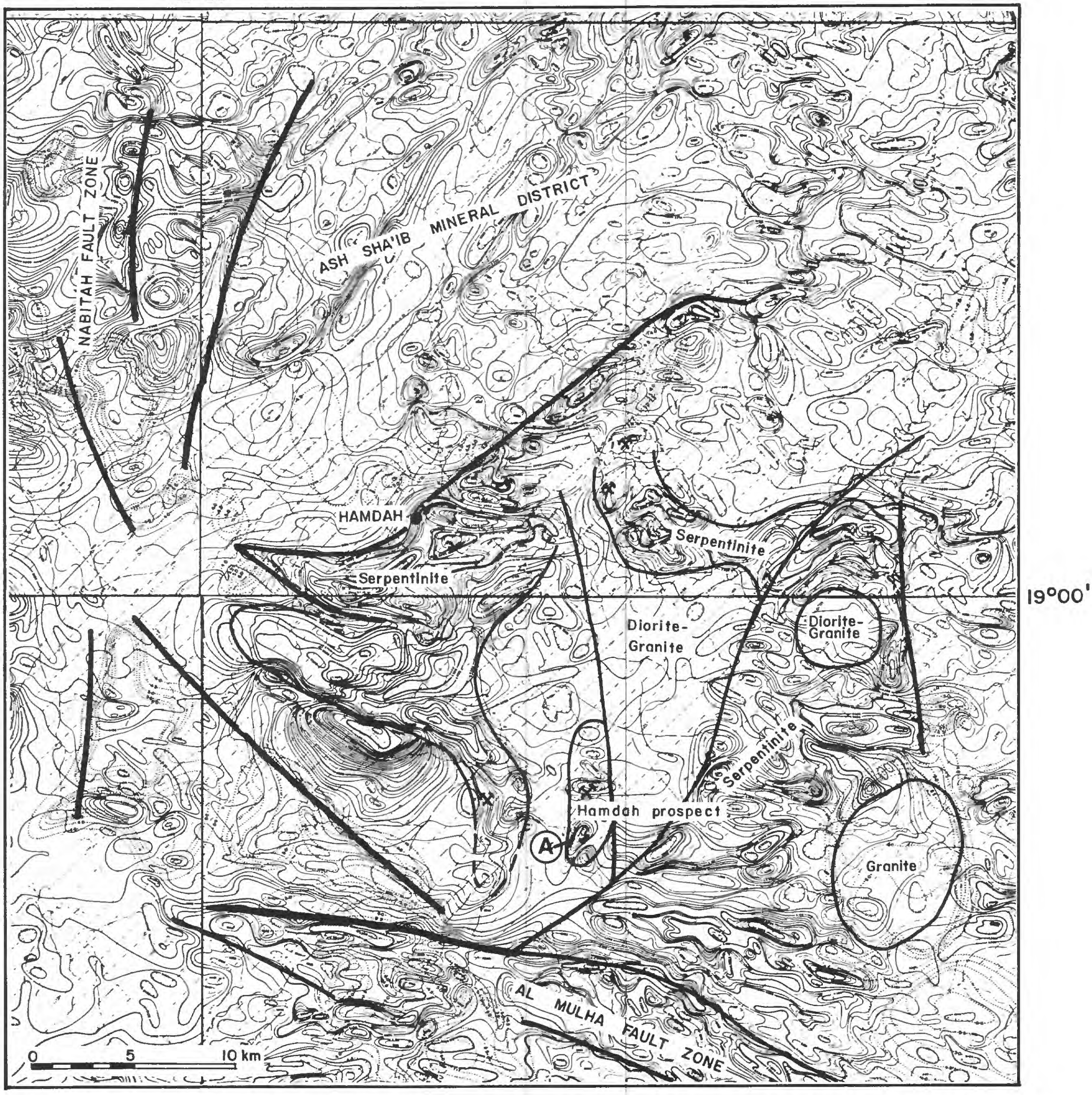


Figure 3.--Geologic sketch map of the Hamdah region (after Worl and Elsass, 1980; Greenwood, 1985a, 1985b).



Ⓐ Area of magnetically defined boundary beneath alluvium in Wadi Tathlith

Figure 4.--Map showing location of magnetic and scintillation-counter anomalies in the Hamdah region (after Consortium Members, 1967), annotated to identify some of the principal features of the magnetic data.

fault) and is apparently associated with an isolated lens-shaped mass of serpentinite southeast of Jabal al Hajrah. The present authors infer that the Wadi Lahw fault is downthrown to the west and that the rocks exposed in the vicinity of the Hamdah prospect originally formed a roof zone to the pluton. Diorite and aplite dikes west of the fault presumably represent intrusions in the roof zone of the pluton, and the concentrations of dikes that occur in the vicinity of the Hamdah and other gold prospects in the region (fig. 5) probably reflect local centers of magmatic and hydrothermal activity in the roof zone.

Ar-Rehaili and Warden (1980) and Warden (1982) envisaged that the Hamdah serpentinite was emplaced during regional folding and metamorphism as a plastic diapiric mass in the cores of north-trending folds. By contrast, Worl and Elsass (1980) and Greenwood (1985a, 1985b) interpreted the serpentinite as a relatively flat-lying sheet-like body that was thrust over an underlying (autochthonous ?) unit of metavolcanic and metasedimentary rocks and was overthrust by (and partly intruded into) an overlying allochthonous metavolcanic and metasedimentary unit.

The structural interpretation of Worl and Elsass (1980) and Greenwood (1985a, 1985b) is adopted as a tectonic model for the region in this report, and the resulting tripartite layered-rock stratigraphy of serpentinite-metavolcanic-metasedimentary rocks is utilized in the description of the geology of the prospect.

The original relationship of the layered rocks, their probable correlatives elsewhere in the southern Arabian Shield, and their paleogeographic/tectonic significance are not known. However, because such issues of regional extent have limited relevance to the immediate objectives of exploration for gold at the Hamdah prospect, they are not further discussed. (For more information on the tectonic setting of the region see Schmidt and others, 1978; Overstreet, 1978; Greenwood and others, 1982; Johnson and Vranas, 1984; Greenwood, 1985a, 1985b; Stoeser and Camp, 1985; Bookstrom and others, 1989).

LITHOLOGY

Layered Rocks of the Hamdah Region

The **lower metavolcanic-metasedimentary unit** (fig. 3) is an assemblage of hornblende schist, quartz-biotite schist, carbonaceous schist, and chlorite-epidote schist that represents volcanic and sedimentary rocks regionally metamorphosed to amphibolite facies (Worl and Elsass, 1980). The assemblage is exposed in windows in the core of the Hamdah region, structurally beneath the Hamdah serpentinite. Possibly coeval rocks occur (at higher metamorphic grade) along the Al Mulha fault zone to the south (Warden, 1982).

The **Hamdah serpentinite** crops out as sheared, discontinuous slabs of altered dunite, peridotite, and pyroxenite (Al-Rehaili and Warden, 1980; Worl and Elsass, 1980). These have been inferred (Greenwood, 1985a) to be remnants of a once-continuous sheet of ultramafic rocks that is broadly to isoclinally folded about shallowly plunging north- and east-trending axes.

The lithologically heterogeneous and structurally complex **upper metavolcanic-metasedimentary unit** overlies the Hamdah serpentinite. It includes rocks that are coherently layered and others that are disrupted and chaotic, and consists of basalt, andesite, chlorite-epidote schist, pyritic-carbonaceous schist, brown marble, and serpentinite melange composed of disrupted amphibolite, lenses and slabs of serpentinite, tremolite-talc-carbonate schist, and chlorite-tremolite schist (Worl and Elsass, 1980; Greenwood, 1985a).

Intrusive Rocks of the Hamdah Region

Intrusive rocks in the Hamdah region intrude (and are younger than) the layered rocks.

Diorite-granite--The oldest intrusive rocks occur as a diorite-granite complex north and east of the Wadi Lahw fault. Several intrusive phases are present (Worl, 1981), among which diorite is one of the oldest (664 ± 12 Ma; U-Pb zircon method: Cooper and others, 1979). The diorite is medium to coarse grained, metamorphosed, and foliated. It crops out in the large pluton that forms the core of the Hamdah region (fig. 3), and is present elsewhere as small, irregular pods and dikes. Serpentinite and schist inclusions are common in the larger dike-like bodies of diorite. Other components of the diorite-granite complex include granodiorite and biotite monzogranite (Greenwood, 1985a; Worl, 1981). They are slightly foliated and coarse grained, and contain a distinctive red garnet.

Granite--The granite plutons shown in figure 3 are composed of biotite monzogranite west of Hamdah village, and biotite-hornblende syenogranite east-southeast of Hamdah prospect and at the southern end of the Nabitah fault zone. Granite situated along the Al Mulha fault zone (southeastern corner of figure 3), is strongly deformed and has a gneissic texture.

Gabbro--Two generations of gabbro are present in the Hamdah region (Worl and Elsass, 1980), but they are not differentiated in figure 3. The older generation is medium to coarse grained and foliated; the younger, which is well exposed in the northeastern part of the region, is fine grained, and layered.

Dike rocks--Many types of dike rock are mapped in the region. The oldest dikes are diorite, and probably related to the diorite component of the diorite-granite complex. Such dikes are particularly common at Jabal Ghirban, 7.5 km east of the Hamdah prospect, where diorite constitutes 40-90 percent of the exposure. Mafic dikes, possibly also of diorite composition, locally occur in outcrop and drill core at the Hamdah prospect.

Dikes of granitic composition are related to the granodiorite and granite components of the diorite-granite complex east of the Wadi Lahw fault. The dikes chiefly consist of granite but grade along strike into graphic granite, pegmatite, aplite, and rhyolite. Aplite is particularly common in the vicinity of the Hamdah prospect at the contact between the Hamdah serpentinite and the underlying hornblende schist, and along northeast- and northwest-trending faults. Elsewhere in the southern Hamdah region, dikes of porphyritic granodiorite and younger equigranular granite are abundant, representing a dike swarm in the layered rocks that formed the roof zone to the diorite-granite complex. At the contacts of many of the felsic dikes, the layered rocks in the Hamdah region are retrogressively metamorphosed to greenschist facies.

PROSPECT GEOLOGY

The ancient workings of the Hamdah prospect are located at the center of a north-trending anticline of Hamdah serpentinite, and cluster at the thrust contact between the serpentinite and the underlying hornblende schist that forms part of the lower metavolcanic-metasedimentary unit (fig. 5). The anticline extends beyond the limits of figure 5 as far as the Wadi Lahw fault, 2.5 km north of the prospect, and as far as a magnetically defined boundary beneath Quaternary alluvium in Wadi Tathlith, 2.5 km south of the prospect (A, fig. 4). The schistose rocks are exposed in windows in the center of the anticline and on the flanks of the anticline to the east and west. The windows consist of anticlinal domes, as much as 300 m wide, and up-faulted blocks. As shown in figure 5, the largest dome plunges southwest at its southern end and northwest at its northern end.

At the current stage of exploration, the gold mineralization is believed to be genetically associated with the aplite sills and dikes emplaced along the thrust contact between the Hamdah serpentinite and hornblende schist of the underlying lower metavolcanic-metasedimentary unit. The sills and dikes are part of the region-wide dike swarms mapped by Helaby and Worl (1980) and Worl (1981) that are coeval with the diorite-granite complex north and east of the Wadi Lahw fault. These dikes are interpreted to be part of a heat source for a gold-mineralizing hydrothermal system in the Hamdah area. Gold-bearing fluids are envisaged to have infiltrated fractured rock along the thrust contact and to have precipitated gold beneath the serpentinite caprock. A similar gold-deposition environment exists in northern California (J.E. Quick, oral commun., 1989). In the Klamath Mountains, north California, much gold-mining activity centered on areas that are adjacent to thrust faults in and east of the Trinity complex (Hotz, 1971).

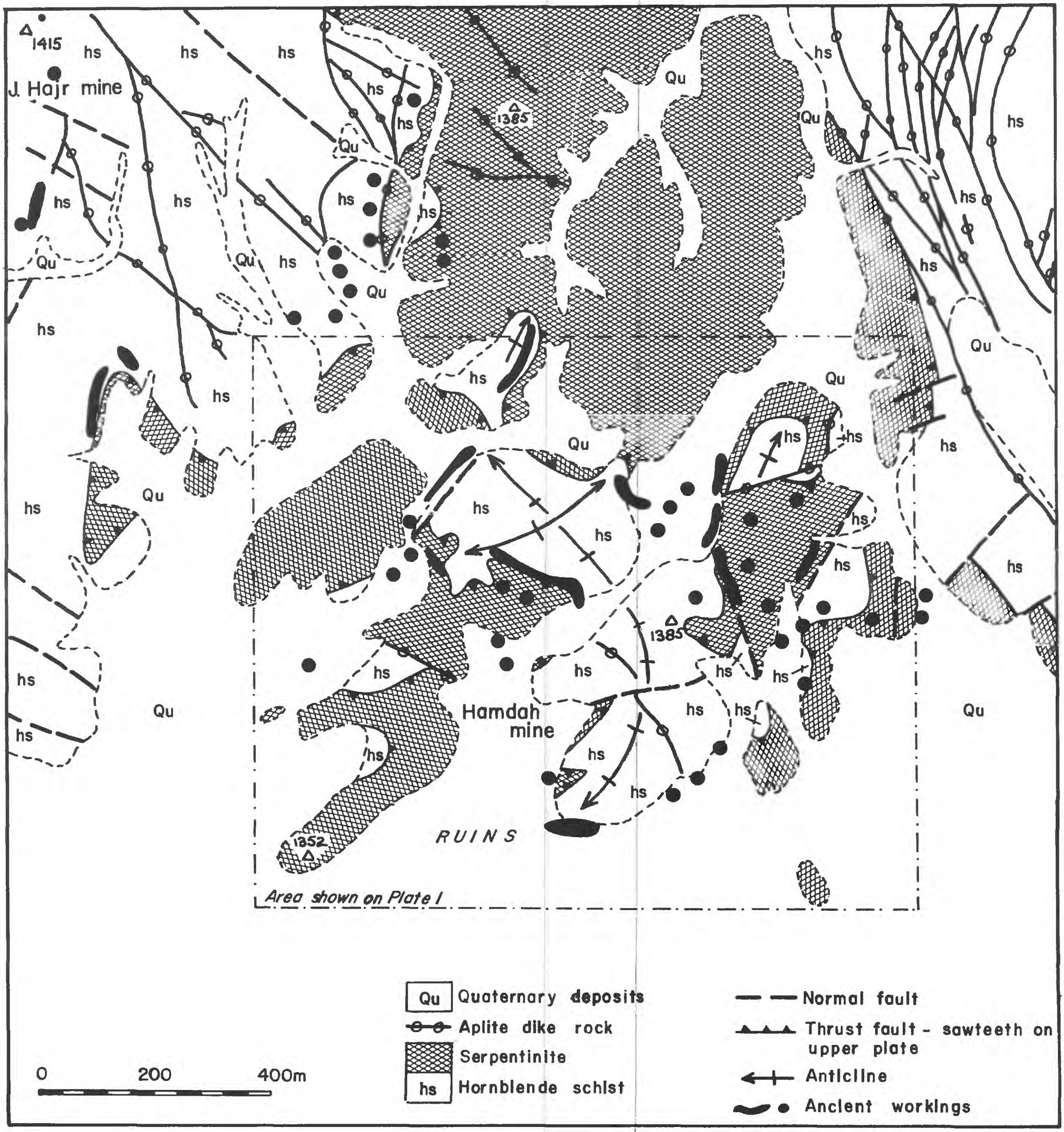


Figure 5.--Geologic sketch map of the Hamdah prospect and vicinity (after Helaby and Worl, 1980).

LITHOLOGY

Hornblende Schist

At the Hamdah prospect, the metamorphic rocks beneath the Hamdah serpentinite are predominantly hornblende schist (Worl and Elsass, 1980; Worl, 1981). Outside the prospect area, thick units of additional rock types occur, including quartz-biotite schist, biotite schist, chlorite schist, sericite schist, and grey marble. Intercalations of such rocks types were observed in drill core from the prospect, but are relatively thin and are minor components of the assemblage in comparison to the predominant hornblende schist.

The hornblende schist (hs, pl. 1) is fine to medium grained and pale to dark brownish green. Foliation is defined by mineral alignment parallel to lithologic layering. Mineral assemblages include hornblende, plagioclase, epidote, actinolite, and chlorite, and represent the amphibolite grade of regional metamorphism. Biotite, diopside, and quartz are minor constituents. The fine grain size of the biotite, the presence of actinolite, and the abundance of epidote in association with carbonate suggest that the hornblende schist is hornfelsed in the prospect area, possibly reflecting a local heat source. Massive units in the hornblende schist are mottled and contain irregularly shaped pale green epidote-rich zones and dark-green hornblende-rich zones. Relict depositional textures suggest that the protolith of the unit included lapilli and lithic tuffs and volcaniclastic graywacke. Trachytic textures are reported from some massive rock units, and some very fine grained massive rocks may represent later dikes.

Adjacent to major faults, the hornblende schist is altered to chlorite and sericite schist, and includes calcite and epidote that form veinlets and replace patches of the groundmass. Cataclastic textures and mylonite are present along thrust fault zones at Jabal al Hajra west of the Hamdah prospect. Blocks of quartz-veined hornblende schist and fragments of quartz, presumably from quartz veins, are common as waste material on the ancient mine dumps; but little quartz veining was observed in outcrop in the immediate study area.

Serpentinite

The most comprehensive descriptions of the Hamdah serpentinite (s, pl. 1) were given by Worl and Elsass (1980) and Al-Rehaili and Warden (1980), from which the following notes have been compiled. The original rocks included dunite, metamorphic peridotite, and a cumulate complex of peridotite and minor pyroxenite. These rocks were thoroughly serpentinized and were affected by shearing, low grade metamorphism, and hydrothermal alteration with the results that the appearance and color of the rock in outcrop is highly variable. Primary dunite altered to form reddish-brown serpentinite whereas primary pyroxenite produced greenish-gray serpentinite, and subsequent talc-, tremolite-, carbonate-, magnesite-alteration produced a mottled rock. The texture ranges from massive and coarse grained to massive and fine grained, or sheared and foliated.

The chief relict primary minerals are chromite and magnetite, and rare olivine and pyroxene. Chromite and magnetite occur as trains that show intricate rheid flow layering or as millimeter-thick bands in shear planes. The serpentine minerals are chrysotile and lizardite. These are associated with talc and minor amphibolite, chlorite, and calcite. Serpentinization and later alteration produced abundant secondary magnetite. In combination, the primary and secondary magnetite (as much as 5 and 25 percent of the rock, respectively) cause the high-intensity magnetic anomalies that characterize the serpentinite. Tremolite and talc schist are located along shear zones.

The serpentinite was hydrothermally altered at the margins of felsic dikes and along fractures, producing a reddish-tan carbonate-rich friable rock, and a very dense silicified rock. Swarms of boudinaged spilitized dolerite dikes are common at the margins of the serpentinite bodies in the region, and dikes of younger pyroxenite cut across the serpentinite and country rock.

Intrusive Rocks

Intrusive rocks in the prospect area include aplite sills along the thrust contact between the Hamdah serpentinite and the hornblende schist, aplite dikes along northeast- and northwest-trending faults, and mafic dikes and sills.

Quaternary Deposits

Alluvium, reworked eolian silt, and outwash fans or pediment regolith are mapped in figure 3 and on plate 1 as undivided Quaternary deposits. Alluvium consists of poorly sorted, locally stratified unconsolidated sand and gravel. It fills the broad wadi channels that drain the low hills of the prospect area and covers much of the plain to the south. North, south, and west of Jabal al Hajrah, the Quaternary alluvium is underlain by a section of tan to light-gray silt 50 cm to 10 m thick. A similar deposit is found in the constricted part of Wadi Tathlith upstream from Hamdah. According to Overstreet (1978), some silt was also deposited in historic times upstream from weirs or constrictions made elsewhere in the wadi system for irrigated agricultural purposes. On the basis of a study of their mineralogy, texture, and structure, G.O. Bachman (written commun., 1978; cited in Worl, 1981) suggested such silt deposits are mostly eolian material (loess) that has been reworked by water. The presence of reworked loess in the prospect area needs to be checked by further work.

Pediment regolith occurs on surfaces one to several meters above the present wadi levels. The regolith consists of rounded pebbles derived from nearby bedrock sources that are coated by desert varnish and rest on, and partially in, a grus derived from the underlying bedrock. The regolith is as much as 50 cm thick. Depending on its location in the prospect area, it grades into wadi alluvium or into weathered bedrock, and is locally mixed with dump material.

STRUCTURE

Serpentinite/Hornblende-Schist Thrust Contact

The contact between the Hamdah serpentinite and the underlying hornblende schist (herein referred to as the serpentinite/schist contact) is locally exposed in natural outcrop at the prospect, is more completely exposed in ancient mine excavations, and is especially well illustrated in core from the 20 drill holes that penetrate the contact. The contact is gently dipping (between 10° and 30°), is relatively sharp, and is conformable to foliation and layering in the schist. Rocks at the contact are commonly altered and in many places are intruded by aplite and quartz stringers. Pods of serpentinite locally occur within the hornblende schist, but hornblende-schist xenoliths do not occur in the serpentinite.

The contact of the Hamdah serpentinite and the overlying metavolcanic and metasedimentary rock unit is more complex and gradational. Much of the contact is altered, sheared, and filled by mafic dikes, and the contact appears to be discordant with respect to structures in the layered rock unit. Pods, lenses, and dikes of serpentinite are locally abundant in the overlying unit, and suggest that the serpentinite intruded this rock unit.

Normal Faults and Shears

Three episodes of faulting are recognized at the prospect that postdate the thrust at the serpentinite/schist contact. The oldest is represented by subvertical northeast-trending faults (designated "a," "b," "c" and "d" on pl. 1) that cut the Hamdah serpentinite and the underlying schist and downthrown to the west. They may reflect an episode of Nabitah-age faulting.

These faults are cut by a shear zone (designated "e" on pl. 1) that trends north-northwest through the eastern part of the prospect area. The sense of displacement of the fault is left lateral. In part of the prospect, where the shear zones coincides with the outcrop of the serpentinite/schist contact, ancient workings are common. The depth to intersection of sheared rock in drill hole HR-4 suggests that the shear zone dips steeply to the southwest.

The third phase of post-thrust faulting consists of a poorly exposed, steeply dipping, east-northeast-trending fault in the northern part of the prospect (fault "f" on pl. 1). Motion on this fault appears to have involved a component of left-lateral slip. Its orientation and relatively young age are consistent with a fault that formed as a riedal shear associated with the Nadj fault system (Moore, 1979; Schmidt and others, 1978).

DRILLING RESULTS

The Hamdah prospect has been tested by 23 diamond-drill holes for a cumulative depth of 1,997.40 m (table. 2). Twelve holes (HR-1 to HR-12) were drilled in 1976 by the Arabian Drilling Company (Helaby and Worl, 1980); the remaining 11 (HR-89-1 to HR-89-11) were drilled in spring 1989 by BRGM. All holes except HR-89-4 were vertical. HR-89-4 was designed to have a bearing of 300° and a plunge of -60°; a Tro-Pari survey revealed a small amount of drift from bearing 300° to 299° and from plunge -60° to -61°.

Table 2.--Summary of diamond drilling at Hamdah prospect. [All holes vertical, except HR-89-4, which is inclined 60° on a bearing of 300°. Depths for HR-1 to HR-12 are from Helaby and Worl (1980); depths for HR-89-1 to HR-89-11 are from this report.]

Drill hole no.	Depth drilled (in meters)	Drill hole no.	Depth drilled (in meters)
HR-1	104.50	HR 89-1	50.35
HR-2	85.45	HR 89-2	55.60
HR-3	64.60	HR 89-3	145.80
HR-4	119.40	HR 89-4	98.80
HR-5	60.75	HR 89-5	82.35
HR-6	115.15	HR 89-6	163.35
HR-7	51.10	HR 89-7	81.00
HR-8	50.00	HR 89-8	80.00
HR-9	116.55	HR 89-9	57.70
HR-10	67.30	HR 89-10	115.80
HR-11	63.85	HR 89-11	103.65
HR-12	64.35		
Subtotal	963.00	Subtotal	1034.40
	TOTAL	1997.40	

For details of 1989 drilling, see Appendix 1.

The positions of the 1976 and 1989 drill holes are shown on plate 2. It should be noted that the positions of some 1976 drill holes on this plate differ slightly from the positions shown on plate 2 of the original report by Helaby and Worl (1980). This is because the drill hole positions shown on plate 2 of Helaby and Worl (1980) were plotted prior to drilling and were not confirmed by topographic survey measurements in 1976 (S.M. Liban, oral commun., 1989). When the 1976 drill hole pyramids were surveyed for the present study, it was found necessary to shift the position of several, particularly HR-3 and HR-10, in order to accurately tie them to the new (1989) grid. The positions of the 1989 drill holes were surveyed at the time of drilling and plotted on the prospect map (pl. 2), but their coordinates were not noted. Grid coordinates of 1989 drill holes mentioned in this report have been determined by measurement from the prospect map and may be inaccurate by 1 or 2 m.

In general, the objective of the 1989 drilling program was to fill gaps between holes drilled in 1976 and provide samples for geochemical analysis, in hope of confirming the 1976 results and establishing the Hamdah prospect as a gold target justifying further investigation. Nine holes were drilled to intercept the serpentinite/schist contact, and two holes (HR-89-6 and HR-89-11) were drilled to intercept significant geophysical anomalies.

Drill-bit size data for the 1976 drilling program are not available. In all 1989 holes, PQ-size drill bits were used to penetrate the near-surface alteration zone; below that depth the bit size was reduced to HQ, and in some cases it was reduced further to NQ to achieve greater depth. Cores from seven of the 1989 drill holes were measured and logged at the Hamdah field camp; the cores from the remaining four holes were logged in Jiddah. Continuous splits of core for sampling were prepared by diamond saw. Because of time constraints, and the large sample volume that would ensue, lithologic breaks were not used to define sample intervals. Instead, most core was systematically sampled at 1-m intervals, except in the vicinity of hypothesized concentrations of gold such as at the serpentinite/schist contact, sulfide-bearing intercepts, and the margins of aplite dikes, in which cases the sample interval was reduced to 0.5 m or less. The samples were analyzed for gold, silver, arsenic, and copper by atomic-absorption spectroscopy at the DGMR/USGS Laboratory, Jiddah.

Summary analytical results and summary graphic logs of the 1989 drill core are presented in Appendix 1. Full details of the analytical results and copies of the complete drill logs are contained in data file USGS-DF-10-7. Core from the 1976 drilling program was briefly examined by the present authors prior to starting the 1989 drilling program in order to gain familiarity with the expected drill-core rock types. Further details about the 1976 drilling results were provided by Helaby and Worl (1980).

For the purpose of this report, the prospect is divided into four "quadrants"---the "northeast," "southeast," "southwest," and "west," respectively---as shown on plate 2. The reader should note however, that these descriptors refer to relative areas within the prospect area, and are not absolute with reference to any grid lines shown on plate 2. The first three "quadrants" represent subareas of the eastern part of the prospect, for which relatively detailed information is available; the "west quadrant" represents the western part of the prospect area, and may be further subdivided at a later date as information warrants. Table 2 gives the depth of each drill hole; table 3 presents information about the length and weighted average grade of gold intercepts in the drill core and, together with figure 6 and 7, gives information about the lithology of the intercepts that contain the greatest gold concentrations. Table 4 (see p. 32) gives an estimate of the value of gold for the northeast quadrant of the prospect, where most drilling was carried out. In these tables and figures, and elsewhere in this report, reference to a concentration of gold or to a zone of mineralization is a reference to samples that yield concentrations greater than 1 g/t gold, and the term "gold intercept" is a reference to drill hole intercepts that have a weighted average grade greater than 1 g/t based on a 1 g/t cutoff for individual samples.

Table 3.–Summary of lithologies and gold-rich intercepts (based on 1 g/t Au cutoff; weighted average grade reported in g/t Au) in drill-holes from the Hamdah prospect.

Drill-hole #	Gold inter-cepts from-to(m)	Thick-ness (m)	Weighted average (g/t Au)	Lithology of gold-rich intercept
NORTHEAST QUADRANT				
HR-1	11.0-11.5	0.5	1.65	Talc & limonite altered zone in serpentinite, 4.85 m above aplite at serpentinite/schist contact.
HR-2	71.5-73.0	1.5	1.50	Base of serpentinite: spans serpentinite/schist contact.
HR-3	26.5-27.0	1.5	1.60	Within serpentinite.
	34.5-36.0	1.5	1.52*	Basal 1.5 m of serpentinite; disseminated pyrite.
	37.0-39.5	2.5	4.87	Immediately below serpentinite/schist contact; (disseminated pyrite).
	42.5-43.5	1.0	3.40	Within hornblende schist (trace pyrite).
HR-10	0.0-2.0	2.0	2.25	In sand and colluvium.
	2.0-4.0	2.0	1.10	Within aplite.
HR-11	16.0-18.0	2.0	8.50	Basal 0.3 m of serpentinite (top of sericite-biotite-chlorite schist).
	20.0-21.0	1.0	1.20	
HR-89-1	No gold intercepts greater than 1 g/t Au; drill hole collared below serpentinite/schist contact.			
HR-89-2	23.3-23.4	0.1	1.75	Basal 1 m of aplite dike emplaced along serpentinite/schist contact.
	24.2-24.5	0.3	1.77	
	49.0-50.0	1.0	3.01	Hematite and sericite rich bands in hornblende-biotite schist.
HR-89-3	0.0-2.0	2.0	1.96	In grus and weathered serpentinite.
	3.0-3.9	0.9	2.30	Weathered serpentinite.
	5.9-8.6	2.7	3.89	Within aplite emplaced along serpentinite/schist contact.
HR-89-4	15.9-18.3	2.4	21.42**	In chlorite schist below aplite emplaced along contact.
HR-89-5	9.9-11.7	1.8	1.75	In chlorite schist below serpentinite & above aplite.
HR-89-6	0.0-1.0	1.0	2.00	In dump material.
	3.0-4.0	1.0	2.40	In weathered serpentinite.
	161.2-161.6	0.4	1.10	Sericite-altered in chlorite schist.

Table 3.--Summary of lithologies and gold-rich intercepts--(continued)

Drill-hole #	Inter-cepts from-to(m)	Thick-ness (m)	Weighted average (g/t Au)	Lithology of gold-rich intercept
SOUTHEAST QUADRANT				
HR-8	No intercepts greater than 1 g/t Au.			
	[18.5-27.5			Minor gold enrichment (0.1-0.4 g/t Au) in schist immediately below serpentinite/schist contact].
HR-9	No intercepts greater than 1 g/t Au.			
	[36.5-38.5			Minor gold enrichment (0.1-0.18 g/t Au) in serpentinite immediately above serpentinite/schist contact].
HR-89-11	1.0-2.0	1.0	1.37	Colluvium [entire colluvium section (0.0-3.0 m) gold-rich].
	69.5-70.5	1.0	1.17	Carbonate-altered chlorite schist.
SOUTHWEST QUADRANT				
HR-6	No gold intercepts greater than 1 g/t Au.			
HR-7	23.0-31.5	8.5	3.02	In muscovite-chlorite & biotite-chlorite schist 3 m below serpentinite/schist contact.
HR-89-7	0.0-0.3	0.3	4.60	In surface mud.
	31.4-32.1	0.7	1.26	Chlorite schist adjacent old shaft (5m below serpentinite/schist contact).
HR-89-8	0.0-1.0	1.0	2.34	In weathered serpentinite & colluvium.
HR-89-10	0.0-1.25	1.25	4.17	In weathered serpentinite at surface.
	[14-16			Slight gold enrichment (0.5 g/t Au) in aplite].
	103.1-103.6	0.50	1.09	Epidote-alteration & thin quartz vein in chlorite schist.
WEST QUADRANT				
HR-4	No gold intercepts greater than 1 g/t Au.			
HR-5	26.5-27.5	1.0	1.37	Carbonate-altered chlorite schist 5.5m below serpentinite/schist contact & 2.5 m below quartz-vein zone.
HR-12	No gold intercepts greater than 1 g/t Au.			
HR-89-9	[0.00-1.0	1.0	0.67	Minor gold-rich zone in serpentinite].
	20.0-22.0	2.0	1.35***	Carbonate-altered biotite schist above fault zone

Note * = includes one sample (35.0-35.5m) grading 0.96 g/t Au.
** = inclined hole: intercept is calculated vertical thickness.
*** = includes two samples less than 1.0 g/t Au.

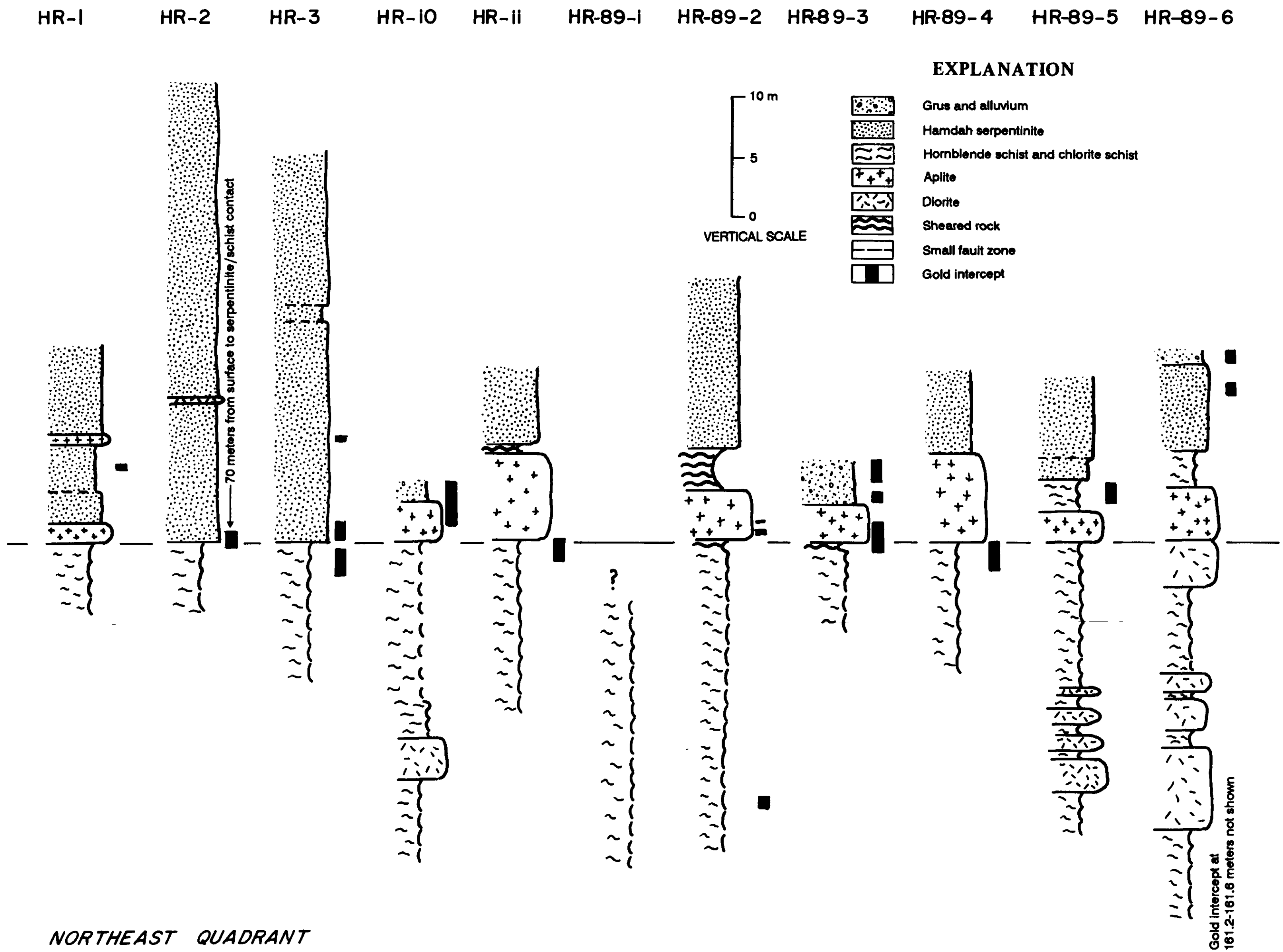


Figure 6.--Diagram showing gold intercepts (>1.0g/t Au) in diamond-drill holes in the northeast quadrant, Hamdah prospect, relative to the base of the Hamdah serpentinite and/or base of aplite sill at the serpentinite/schist contact.

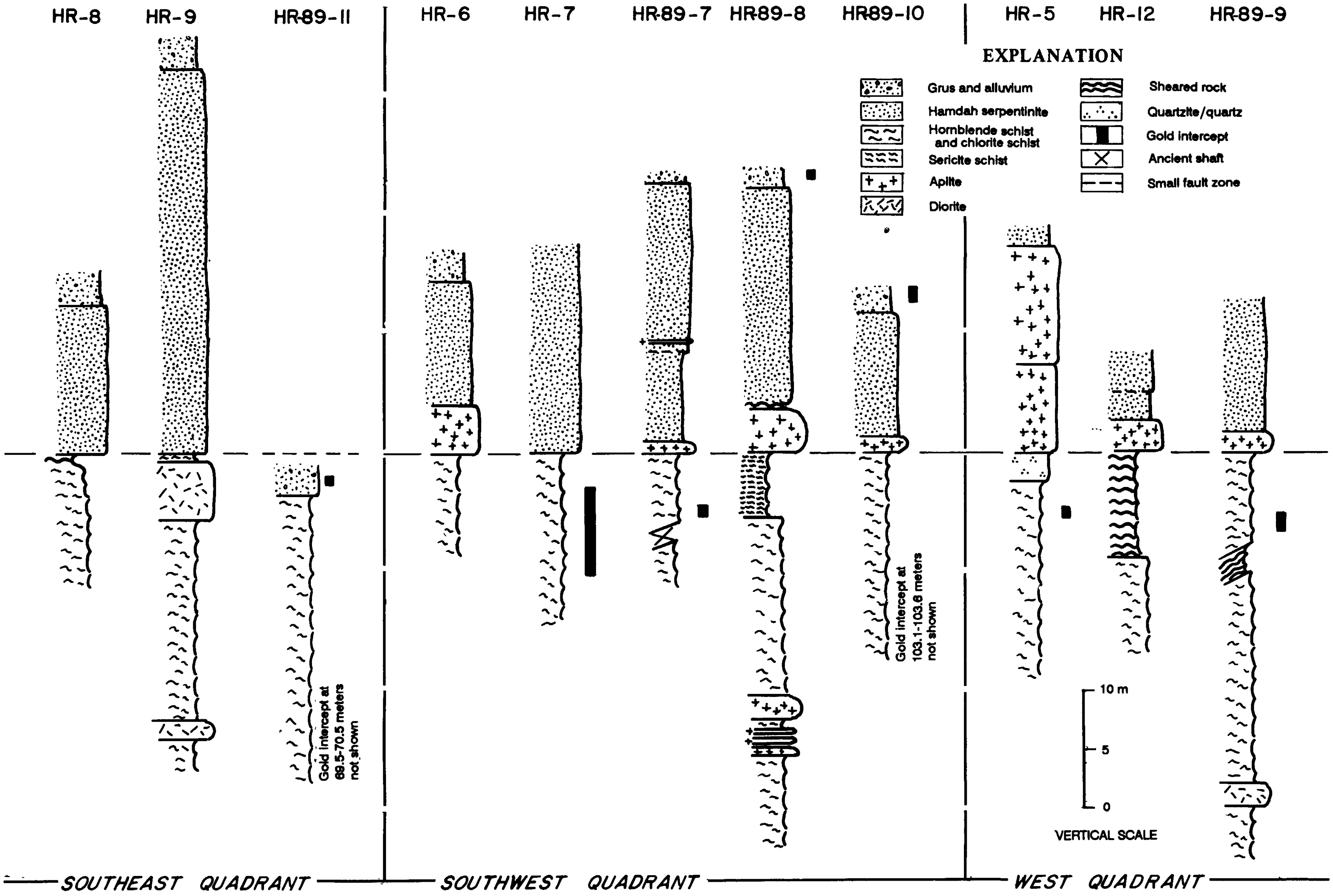


Figure 7.--Diagram showing gold intercepts (>1.0 g/t Au) in diamond-drill holes in the southeast, southwest, and west quadrants, Hamdah prospect, relative to the base of the Hamdah serpentinite and/or base of aplite sill at the serpentinite/schist contact.

NORTHEAST QUADRANT

Drill Holes

Drill holes HR-2, HR-3, HR-10, and HR-11 (pl. 2) were stepped-back between 100 to 180 m from the ancient workings so as to intersect the serpentinite/schist contact at projected depths of between 20 and 50 m. Drill hole HR-1 was stepped back only approximately 20 m from the ancient workings.

HR-1 (grid coordinates 856N. 430E.) intersected gold concentrations between depths of 11.0 and 11.5 m (table 3) in talc-and limonite-altered serpentinite close to the base of the Hamdah serpentinite (fig. 6). HR-2 (876N. 376E.) intersected gold concentrations between depths of 71.5 and 73.0 m at the serpentinite/schist contact, and HR-3 (886N. 295E.) intersected gold above and below the serpentinite/schist contact at 26.5-27.0 m, 34.5-36.0 m, 37.0-39.5 m, and 42.5-43.5 m. HR-10 (698N. 690E.) encountered gold in the top 4 m; and HR-11 (734N. 542E.), at 16.0-18.0 m and 20.0-21.0 m, immediately beneath a thick aplite sill that occupies the serpentinite-schist contact.

Drill holes HR-89-1, HR-89-2, HR-89-3, HR-89-4, HR-89-5, and HR-89-6 were completed in 1989. HR-89-1 (702N. 280E.) was collared in hornblende schist immediately below the serpentinite/schist contact. Although close to ancient workings, no gold concentrations or other evidence of mineralization were intersected in this hole. In HR-89-2 (800N. 370E.), very narrow gold-rich intersections were made between depths of 23.3 and 24.5 m, at the base of an aplite sill at the serpentinite/schist contact, and a thicker intersection was made at 49.0-50.0 m, within hornblende schist. In drill hole HR-89-3 (750N. 408E.) gold values are reported from the 4-m thick surface alluvium (0.0-2.0 m and 3.0-3.9 m) and from aplite at a depth of 5.9-8.6 m. At greater depth in HR-89-3 (125.5-127.0 m), slightly enhanced gold values (0.14, 0.11, and 0.15 g/t Au) are obtained from three samples collected beneath a near-horizontal shear zone located at 120.3-m depth. These intercepts do not show in table 3 or figure 6 because they are below the 1 g/t Au cutoff.

Drill holes HR-89-4 and HR-89-5 were collared at approximate grid coordinates 784N. 570E. and 842N. 598E. The holes intersected gold concentrations at 15.9-18.3 m in chlorite schist below an aplite sill, and at 9.9-11.7 m in chlorite schist immediately below the Hamdah serpentinite, respectively. Gold concentrations in drill hole HR-89-6 (720N. 660E.) were obtained from alluvium and weathered rock at the surface, from serpentinite at a depth of 3.0-4.0 m, and from a thin quartz vein in chlorite schist at a depth of 161.2-161.6 m. Drill hole HR-89-6 was primarily sited to intercept a strong Crone electromagnetic (CEM) anomaly. A section of sulfide-rich rocks and 0.5-cm-thick graphite seams in fault breccia (but no gold concentrations) were penetrated at a depth of 110.3-112.4 m. Graphite, in combination with sulfides, forms an excellent conductor, and in this instance is a possible cause of the electromagnetic anomaly.

Longitudinal and Cross Sections

Interpretations of the geologic relations and of the distribution of mineralization at Hamdah are shown on longitudinal and cross sections (pl. 3) and a fence diagram (pl. 4). (See plate 2 for locations of sections). In the northeast quadrant of the prospect, longitudinal sections A-A', B-B', C-C', and D-D' are laid out along lines 300E., 400E., 425E., and 575E.; cross sections AA-AA', BB-BB', and CC-CC' are laid out along lines 850N., 800N., and 725N., respectively.

The drill hole information indicates that the serpentinite/ schist contact dips gently (10° -30°) northeast and southwest off the flanks of the dome of hornblende schist that trends through the prospect (see section A-A'). The steepening of the dip and the relatively great depth (72.85 m) of the contact in drill hole HR-2 (section B-B') is caused by a fold (the syncline shown in section AA-AA') and a fault (fault "b" shown on section AA-AA' and on plate 1, which has approximately 40 m offset, down to the northwest) (same as cross-section A-A' in Helaby and Worl, 1980).

Observations made during the present phase of exploration suggest that a shear zone trends northwest through the northeast quadrant of the prospect. As indicated in the original drill log, sheared rock was intersected in drill hole HR-4 at a depth of 42.0-51.3 m. From this intersection, the shear is inferred to dip steeply to the southwest, and corresponds to the shear shown on sections B-B', C-C', D-D', AA-AA', BB-BB', and CC-CC'. In the vicinity of HR-11, the outcrop of the shear zone coincides with the outcrop of the serpentinite/schist contact and also with a zone of ancient workings. North of HR-11 the shear zone and serpentinite/schist contact diverge. Between HR-3 and HR-4, the shear zone is offset by a left lateral fault. The sense of displacement of the three faults "b", "c", and "d" across the shear implies that it has left-lateral movement.

The inferred continuity of aplite intersections between drill holes HR-11, HR-89-4, HR-89-5, and HR-89-6, and between drill holes HR-1, HR-89-2, and HR-89-3, and possibly HR-2 and HR-3, implies that the aplite is sill-like in geometry. The sill (or sills) are located at the serpentinite/schist contact (fig. 6) or are emplaced in the schist unit within 3 m of the contact. At greater depths, sills of diorite are intercepted in drill holes HR-10, HR-89-5, and HR-89-6.

SOUTHEAST QUADRANT

Drill Holes

Drill holes HR-8 (138N. 580E.) and HR-9 (390N. 888E.) intersected no gold concentrations above the 1-g/t cutoff adopted here. HR-89-11 is the only 1989 drill hole in the southeast quadrant. It was designed to test a strong CEM anomaly centered approximately at 360N. 600E. (pl. 8), although due to a lack of surveying equipment at the time the hole was sited, the hole was collared approximately 100 m south of the anomaly. Gold values in the drill hole were obtained from samples of weathered serpentinite and colluvium in the topmost 4 m of the hole (perhaps close to the stratigraphic position of the now-weathered serpentinite/schist contact) and from samples of chlorite schist at a depth of 70 m (table 3).

Cross Section

The geologic relations in the southeast quadrant of the prospect are illustrated in cross-section FF-FF' along line 300N. Information from drill holes HR-9 and HR-89-11 is projected onto the section. HR-8 and HR-9 intersected the serpentinite/schist contact at depths of 17.5 and 39.2 m, respectively. The contact is inferred to dip gently to the southeast, and is marked in the drill core by carbonate and talc alteration of the serpentinite and by fault gouge. The projection of fault "d", a normal fault (pl. 1), is shown on cross-section FF-FF' as downthrown 5 m to the northwest. Diorite sills are present at the serpentinite/schist contact instead of aplite, and sills or dikes of diorite are also present at deeper levels within the schist succession (HR-89-11). It is conceivable that the absence of aplite from drill core in the southeast quadrant may explain the apparent lack of a significant gold-bearing horizon at the serpentinite/hornblende schist contact in this part of the prospect.

SOUTHWEST QUADRANT

Drill Holes

No gold concentrations are reported from drill hole HR-6 (254N. 032E.), but drill hole HR-7 (407N. 268E.) yielded the thickest gold intersection (8.5 m) of any drill hole in the Hamdah exploration program (Table 3). The intercept is from 23.0 to 31.5 m in talc-altered, muscovite-chlorite and biotite schist, between 3 and 12 m below the serpentinite/schist contact.

Drill holes HR-89-7, HR-89-8, and HR-89-10 were collared at approximate grid coordinates 364N. 192E., 450N. 300E., and 309N. 392E., respectively. Significant gold values are reported from alluvium and weathered serpentinite at the top of all three holes, from chlorite schist at a depth of 32 m on the edge of an ancient shaft in drill hole HR-89-7, and from chlorite schist at a depth of 103 m in drill hole HR-89-10 (Table 3). Slight enrichment of gold (as much as 0.5 g/t Au) is reported in samples of aplite between depths of 14 and 16 m at the serpentinite/schist contact in drill hole HR-89-10.

Longitudinal and Cross Sections

Cross section DD-DD' on line 370N. and the southern part of longitudinal section A-A' on line 300E. show the geology of the quadrant. The contact between the Hamdah serpentinite and underlying schistose rocks is gently dipping to flat-lying, and is located at depths between 20 and 30 m. The contact is marked by talc alteration in drill holes HR-7, HR-89-8 and HR-89-10. Aplite (fig. 7) is present at the contact in holes HR-6, HR-89-7, HR-89-8, and HR-89-10, and at several deeper levels in HR-89-8. The schist succession consists of interbedded chlorite-biotite schist, biotite schist, and hornblende schist. Sericite schist is locally present (in hole HR-89-8 immediately beneath the aplite that marks the thrust contact). A normal fault with offset of over 30 m is downthrown to the northwest (fault "b", pl. 1) on cross section DD-DD'.

WEST QUADRANT

Drill Holes

In the west quadrant, gold intercepts are reported from drill holes HR-5 and HR-89-9. In drill hole HR-5 (723N. 092W.) a 1-m intercept of gold (1.37 g/t Au) occurs at a depth of 27 m in carbonate-altered chlorite schist, 5 m below a thick aplite sill emplaced at the serpentinite/schist contact. Drill hole HR-89-9 (553N. 051E.) was sited to test the gold potential of the region immediately west of the ancient workings aligned northeast along fault "a" (pl. 1). It intersected a slight gold enrichment (0.67 g/t Au) in weathered serpentinite in the topmost 1 m of the drill hole, and a stronger concentration (1.35 g/t Au) through a 2-m thickness of biotite schist starting at a depth of 20 m, 5.5 m below the aplite sill. The third drill hole completed in the west quadrant, HR-12, was collared at 385N. 140W.; it intersected no gold concentrations.

Cross Section

A single cross section (EE-EE') shows the geology in the west quadrant. A southwest-trending normal fault cuts the plane of the cross section (fault "a," pl. 1) and is downthrown over 20 m to the west. An aplite dike occurs along the fault 180 m southwest of the line of the cross section. West of the fault, the serpentinite/schist contact is relatively flat lying and is the inferred locus of intrusion of an aplite sill. A great thickness of sheared rock was intersected at the serpentinite/schist contact between 10.15 and 18.20 m in drill hole HR-12 (fig. 7); elsewhere at the prospect, shearing at the serpentinite/schist contact is less conspicuous.

DISTRIBUTION OF GOLD AND ROCK-TYPE ASSOCIATIONS

Table 3 and figures 6 and 7 summarize information about the distribution of gold intercepts in the 1976 and 1989 drill holes at the Hamdah prospect, and about the rock-types that contain the gold.

At the end of the 1976 drilling program, Helaby and Worl (1980) concluded that the serpentinite/schist contact is the favorable location for the gold mineralization. The 1989 drilling results confirm this conclusion, particularly for the northeast quadrant of the prospect, and emphasize the probable significant control on mineralization of aplite sills at the serpentinite/ schist contact. In addition, the 1989 drilling results reveal the local presence of gold concentrations in zones of weathered serpentinite and colluvium at the surface. The origin of such surface concentrations---whether derived from in situ weathering of serpentinite and schist or, more likely, by outwash from adjacent workings---and their potential significance requires further investigation.

BEDROCK CONCENTRATIONS

In the northeast quadrant, significant concentrations of gold were noted in core from 10 out of the 11 holes drilled; only HR-89-1 did not yield gold values above the 1-g/t Au cut off used in this report. Among the 10 gold-bearing drill holes, eight intercepted gold within 5 m of the serpentinite/schist thrust-fault contact and(or) the aplite sill emplaced along the contact (HR-2, HR-3, HR-10, HR-11, HR-89-2, HR-89-3, HR-89-4, and HR 89-5). In four of these holes (HR-11, HR-89-2, HR-89-3, and HR 89-4), the gold is concentrated in the bottom section of, or immediately below, the aplite sill; in HR-10 it is in the upper section of the sill; and in HR-89-5 the gold is above the sill. In drill holes HR-1 and HR-89-6, gold intercepts occur in serpentinite 6-7 m above the serpentinite/schist contact; and in drill hole HR-3, gold occurs in serpentinite 10 m above the contact as well as at the contact. In drill hole HR-89-2, gold mineralization also occurs in hornblende schist approximately 25 m below the base of the aplite at the serpentinite/schist contact in a zone of local deformation (folding), and in hole HR-89-6, a 0.4-m-thick gold intersection occurs at greater depth (161.2-161.6 m) within the schist succession. With the exception of the last mentioned deep intersection in HR-89-6, and the downfolded intersection in HR-2, the effect of the varied stratigraphic positions of the gold concentrations in these drill holes is that the level of the gold-bearing zone in the northeast quadrant is at an approximately constant depth below the present-day land surface, as shown in section D-D'.

In the other quadrants of the Hamdah prospect, significant gold values have been obtained from solid bedrock in six out of 11 drill holes. However, among these drill holes the correlation between high gold values and the serpentinite/ schist/aplite-sill contact is not as pronounced as in the northeast quadrant. In drill holes HR-7 and HR-89-7 (southwest quadrant), the gold concentrations are located as much as 10 m below the contact. In drill holes HR-5 and HR-89-9 (west quadrant), the intercepts are located approximately 8 m below an aplite sill emplaced at the serpentinite/schist contact. The only drill holes in the southeast, southwest, and west quadrants that contain enhanced gold values at the serpentinite/schist contact are HR-89-10 in aplite (southwest quadrant) and HR-8 and HR-9 (southeast quadrant), although the amount of concentration of gold at this contact in these holes is slight; 0.5 g/t Au (above a background value elsewhere in the drill hole of <0.1 g/t) in HR-89-10, and 0.1-0.4 g/t in HR-8 and HR-9 (Helaby and Worl, 1980). Such amounts of enrichment do not show in the figures and tables in this report because the grades fall below the 1 g/t Au cutoff used to determine gold intercepts. Nevertheless, they are of interest as indicators of a structural/stratigraphic control on the process of gold mineralization at the Hamdah prospect rather than as indicators of specific targets for further work.

Deep intersects outside the northeast quadrant were obtained in drill holes HR-89-10 (103.1-103.6 m) and HR-89-11 (69.5-70.5 m), in the southwest and southeast quadrants, respectively.

SURFACE CONCENTRATIONS

Concentrations of gold in weathered bedrock and(or) colluvium at the Hamdah prospect occur in drill holes HR-10 (2.25 g/t), HR-89-3 (1.96 g/t), and HR-89-6 (2.00 g/t) in the northeast quadrant, and in HR-89-7 (4.6 g/t), HR-89-8 (2.34 g/t), HR-89-10 (4.17 g/t), and HR-89-11 (1.37 g/t) elsewhere. A concentration of 0.67 g/t (below the cutoff) is reported from the topmost 1 m of drill hole HR-89-9. In assessing the significance of these results, the results of geochemical sampling of wadi sediment around the Hamdah prospect should also be considered (Helaby and Worl, 1980). Concentrations of gold have been obtained from samples of sediment in wadis that drain the south-central part of the prospect, in the area between HR-89-8 and HR-8 (pl. 1). These results, in conjunction with the drilling results described herein, outline areas of anomalous surface gold.

GOLD, ALTERATION, AND SULFIDE MINERALS

According to Helaby and Worl (1980), the mineralization at Hamdah is mineralogically simple, consisting of gold disseminations along selvages of aplite sills, in or along quartz-carbonate veins, and in hydrothermally altered serpentinite, hornblende schist, and quartz-biotite schist. Hydrothermal alteration at the prospect resulted in (1) the precipitation of carbonate, talc, chlorite, and magnetite in fractures in serpentinite or at the contact between serpentinite and hornblende schist (commonly in association with aplite and quartz-carbonate veining), and (2) silicification of quartz-biotite schist.

Sulfide minerals are not common at the prospect. Arsenopyrite in fractures, pyrite in quartz-carbonate veins, and fine disseminations of pyrite in altered and silicified quartz-biotite schist were reported by Helaby and Worl (1980).

During the 1989 drilling program, a gold-rich interval of sulfide-bearing schist was noted between depths of 49 and 50 m in drill hole HR-89-2. The schist is metamorphosed siltstone and shale interleaved with 1- to 2-cm-thick layers of green hornblende and black biotite, and contains hematite-sericite-chlorite alteration. Small (0.1 mm) sulfide grains are disseminated evenly along the foliation planes of the hornblende schist in this intersection. Preliminary observations suggested that sulfides were more common in fine-grained (0.1 mm) rock than in massive rock. The sulfide minerals consist of pyrite, pyrrhotite, small amounts of arsenopyrite ($FeAsS_2$) and loellingite (FeAs), and local trace amounts of chalcopyrite. Pyrite grains range in size from <0.005 to 0.5 mm. Arsenopyrite and chalcopyrite form smaller grains, typically from 0.005 to 0.1 mm across, and occur as isolated grains. Pyrite, pyrrhotite, and arsenopyrite are intergrown with albite, potassium feldspar, epidote, chlorite, and quartz. These intergrowths fill interstices between lithic and mineral clasts. Petrographic and electron-microbeam investigations to date have not revealed free gold or gold inclusions in sulfide minerals, possibly because the gold grain size is extremely small and the grains are difficult to detect. The source of the gold in the intercept is currently unknown.

The depth of oxidation at the Hamdah prospect ranges from 16 to 35 m in the 1989 drill holes. In the oxidation zone, serpentinite is leached and exhibits a yellow or red hue not seen in surface outcrops; it also contains light-green veins of asbestos and off-white veins of magnesite. The presence of gold concentrations within 35 m of the surface should facilitate the extraction of gold from oxidized rock by heap-leach methods.

Only a cursory study of veining was undertaken for this report, utilizing observations of core from drill hole HR-89-2. In this drill hole, small, 0.1- to 1.5-cm-thick quartz veins are associated with the aplite intrusion located along the thrust contact, and with the gold-bearing sulfide zone underlying it. Sericitic or chloritic envelopes surround the veins, which are oriented parallel to the layering of the schist. In the sulfide-bearing zone, thin (<2 mm), sulfide-rich stringers (>50 percent sulfide minerals) that parallel the foliation are present close to the quartz vein. However, no gold was detected in any of the quartz veins and the relationship, if any, of the quartz veins to the gold-forming event is not known at this time.

THICKNESS AND GRADE OF GOLD INTERCEPTS

Northeast Quadrant

Significant gold values were noted in samples of drill core collected at or close to the serpentinite/schist/aplite-sill contact in the eight gold-bearing drill holes in the northeast quadrant; these values range from 1.40 to 57.33 g/t Au (see gold assays reported for individual samples in Appendix 1). When the individual samples are grouped into gold-bearing intercepts (on the basis of a cut-off grade of 1 g/t Au), the weighted average grades of the resulting intercepts range from 1.2 to 21.42 g/t (table 3) over thicknesses of 0.5 to 4.0 m. One drill hole (HR-89-1) did not intersect gold concentrations greater than the cut off value.

As shown on cross section CC-CC' (pl. 3) gold is present at the surface, in the topmost few meters of drill holes HR-10 and HR-89-6 (2.25 to 2.40 g/t Au over 1 to 4 m) in the eastern part of the northeast quadrant, and in drill hole HR-89-3 (1.96 g/t Au over 2 m) in the western part. The gold is concentrated in weathered serpentinite and(or) dump material. Drill hole HR-89-3 also intersects a 2.7-m thick concentration of gold grading 3.89 g/t Au at a depth of 5.9 m (such depths are to the top of the gold-bearing intercepts). Section AA-AA' indicates that the gold-bearing horizon intersected by drill holes HR-89-3 in the west and HR-89-6 in the east continues to the north. Drill hole HR-1, in the western part of the quadrant, intersects a 0.5-m-thick section of rock grading 1.65 g/t Au at a depth of 11.5 m, and drill hole HR-89-5 intersects a 1.82-m-thick concentration of gold grading 1.91 g/t Au at a depth of 9.9 m. In the central part of the northeast quadrant, drill hole HR-11 (section CC-CC') intersects a 2-m-thick concentration of gold grading 8.50 g/t Au at a depth of 16 m. Farther north, drill hole HR-89-4 intersects a 2.4-m-thick concentration of gold grading 21.42 g/t Au at a depth of 15.9 m (the richest gold intercept in the quadrant). Drill hole intercepts in this central part of the northeast quadrant are the most consistent in thickness and the highest in grade of all intercepts in the prospect.

Southeast Quadrant

Gold was intersected in only one drill hole (HR-89-11) in the southeast quadrant. The gold is present in alluvium in a 1-m thick intersection grading 1.37 g/t Au and situated 1 m below the present-day surface. No other significant gold occurrences were encountered in the quadrant (table 3; Appendix 1).

Southwest Quadrant

Gold was detected at the surface in three out of four drill holes in the southwest quadrant: HR-89-7, HR-89-8, and HR-89-10 (table 3). In these drill holes the gold was found in drill-core samples of weathered serpentinite 0.3-, 1.0-, and 1.25-m thick, respectively. Weighted average gold contents are 4.6 g/t Au in drill hole HR-89-7, 2.34 g/t Au in HR-89-8, and 4.17 g/t Au in HR-89-10. Shorter, subsurface intercepts of gold concentrations were obtained from drill holes HR-89-7 and HR-89-10 at depths of 31.4 m and 103.1 m, respectively. These intercepts are of 1.26 g/t Au through a 0.7-m thickness in drill hole HR-89-7, and 1.09 g/t Au through a 0.5-m thickness in drill hole HR-89-10. Such thin and deep intercepts are of no apparent economic interest. However, drill hole HR-7 is interesting because it contains the thickest section of gold-bearing rock intercepted to date in the Hamdah exploration program: 3.02 g/t Au through a thickness of 8.5 m at a depth of 23 m.

West Quadrant

Less information is available for the west quadrant than for any other quadrant. Nevertheless, two holes, HR-5 and HR-89-9, intersected gold concentrations: 1.37 g/t Au through a 1-m thickness at a depth of 26.5 m in HR-5, and 1.35 g/t Au through a 2-m thickness at a depth of 20.0 m in drill hole HR-89-9 (table 3). The third drill hole in the quadrant, HR-12, intersected no significant gold values.

ESTIMATED VALUE OF GOLD IN NORTHEAST QUADRANT

On the basis of the relative large number of drill holes in the northeast quadrant of the Hamdah prospect, an estimate has been made of the value of gold in a block southeast of HR-2 (pl. 2; table 4). Over much of this area the gold-bearing zone lies within 20 m of the surface. In the vicinity of drill hole HR-2 the zone is locally deeper (71-73 m) as a result of folding and normal faulting, and this is the reason for excluding HR-2 from the evaluation.

Table 4.--Estimated grade and tonnage of gold at Hamdah prospect, northeast quadrant.

Column #1	#2	#3	#4	#5	#6	#7
Grade based on drill hole intercepts	Average thickness (meters)	Area m^2	Volume m^3	Metric tons*	Grade (g/t Au)	Contained gold (grams)
Highest grade	2.4	3,068	7,363	19,144	21.4	409,688
2d highest grade	2.0	7,670	15,340	39,884	8.5	339,014
3d highest grade	2.7	10,202	27,545	71,618	3.9	279,310
Lowest grade	1.8	23,855	42,939	111,641	2.0	223,282
Totals		44,795	93,187	242,287		1,251,294
						or 40,235 Troy oz.

Note: * = calculated on the basis of 2.6 t/m^3
All figures and weights for area rounded to nearest whole number.

The preliminary grade and tonnage estimates are based on selected intercepts in seven drill holes. These, and their thicknesses, are as follows:

HR-1, weighted average grade 1.6 g/t Au, 0.5 m
HR-10, weighted average grade 1.1 g/t Au, 2.0 m
HR-11, weighted average grade 8.5 g/t Au, 2.0 m
HR-89-3, weighted average grade 3.9 g/t Au, 2.7 m
HR-89-4, weighted average grade 21.4 g/t Au, 2.4 m
HR-89-5, weighted average grade 1.75 g/t Au, 1.8 m.
HR-89-6, weighted average grade 2.4 g/t Au, 1.0 m

For the purpose of the grade-and-tonnage estimate, these intercepts are grouped into four categories (table 4): 1) highest grade (21.4 g/t Au); 2) two intermediate grades (8.5 g/t Au and 3.9 g/t Au); and 3) lowest grade (2.0 g/t Au). The boundaries of each grade block are shown on plate 2; their areas were determined with a computer, by digitizing the boundaries, and the results are given in table 4, column 3. The boundaries of the low-grade area are delineated on the basis of data from drill holes HR-1, HR-10, HR-89-5, and HR-89-6. Higher grade area boundaries were determined by projecting the area of influence of intercepts halfway between adjacent drill holes. Thicknesses for each grade category are the average thicknesses of the intercepts from the respective drill holes within each grade area. The specific gravity was taken to be 2.6, which represents an intermediate value taken from the range of densities for serpentinite (from 2.44 to 2.80) and for schist (from 2.73 to 3.19) published in the literature (Olhoeft and Johnson, 1989).

The estimated gold content of each of the grade categories is:

Highest grade: just under 410 kg gold (409,688 grams contained in 19,144 metric tons of rock grading 21.4 g/t Au at 5 g/t cutoff);

Second highest grade: about 340 kg gold (339,014 grams contained in 39,884 metric tons of rock grading 8.5 g/t Au at 5 g/t cutoff);

Third highest grade: nearly 280 kg gold (279,310 grams contained in 71,618 metric tons of rock grading 3.9 g/t Au at 1 g/t cutoff); and

Lowest grade: just over 220 kg gold (223,282 grams contained in 111,641 metric tons of rock grading 2.0 g/t Au at 1 g/t cutoff).

These sums make the total gold content of all four grade categories approximately 1,250 kg (40,230 troy oz.).

GEOCHEMICAL SURVEY RESULTS

The Hamdah prospect has been geochemically surveyed three times: in 1976 by Helaby and Worl (1980); in 1986 by Hariri (1986); and in 1989 by the authors of this report. The results of these surveys are shown on plates 5 and 6.

1976 SURVEY

Helaby and Worl (1980) collected dump, channel, exploration-pit, and rock-chip or gravel samples, and analyzed the samples by semiquantitative methods for gold and silver. The locations and the gold contents (in g/t Au) of these samples are shown on plate 5.

The dumps, estimated by Helaby and Worl (1980) to contain 200,000 t of material, were tested by 48 samples, 20 of which were collected from the northeasternmost dump ("dump one" on pl. 6). The samples consisted of approximately 3 kg of rock chips 1-5 cm in diameter from the top 20 cm of the dumps at sites approximately 3 m in diameter. The samples yielded values ranging from 0.01 to 74.0 g/t Au, and a "rough estimate" average of 3.8 g/t Au. No attempt was made to sample the variation in gold concentrations on vertical sections through the dumps, which were estimated to be between 1 and 2 m thick.

Sixty-five channel samples were taken from continuous strips across the altered, veined, and in places, gold-bearing serpentinite/schist contact. The samples included altered serpentinite, hornblende schist, and aplite. The sampled strips ranged between 50 cm to 1 m in length and yielded samples 1-3 kg in weight composed of rock chips 2-5 cm in diameter. The average gold content of the channel samples was 1.25 g/t Au (range 0.0-12.8 g/t Au).

Helaby and Worl (1980) dug 10 exploration pits to bedrock at the serpentinite/schist contact; eight were excavated in ancient workings, one on the contact where there were no workings, and one in a wadi. Twenty-four samples collected from these pits tested zones 10-50 cm wide that had been mined by the ancients. The samples averaged 3.31 g/t Au (range 0.02-40.0 g/t Au).

One hundred and twenty-five rock chip samples were collected from two traverses that intersected in the middle of the prospect area; one traverse ran north-south, the other east-west (pl. 5). The purpose of sampling these traverses was to obtain systematic information about the distribution of gold in the prospect area and to determine gold values for all rock types in the area and for wadi sediment and dump material. Samples weighed 2-3 kg and consisted of rock chips (or gravel in areas of no outcrop) collected along intervals of 10 or 20 m. These samples averaged 1.67 g/t Au (range 0.05-87 g/t Au); samples of dump material, wadi sediment downstream from dumps, and chips from ancient workings yielded the highest values. The results of the survey outlined a notable zone of gold concentration in wadi sediment in the western part of the prospect area (1.70-38.4 g/t Au), which helped decide the location of drill hole HR-89-9.

1986 SURVEY

Hariri (1986) collected 100 chip samples across contact zones between serpentinite and schist, and other samples from shafts, pits, and trenches dug by the ancient miners (pl. 5). Samples were analyzed by atomic-absorption spectroscopy for gold, tellurium, silver, copper, lead, zinc, arsenic, tin, bismuth, and molybdenum. Spectroscopic methods were used to determine chromium and nickel content. The results yielded average gold concentrations in serpentinite, aplite, and hornblende schist of 1.34 g/t Au, 0.153 g/t Au, and 0.148 g/t Au, respectively. A maximum gold value of 18 g/t Au was detected in sheared carbonate-altered serpentinite exposed in an ancient shaft.

1989 SURVEY

The 1989 sampling program concentrated on the ancient mine dumps (pl. 6). The dumps, covering just over 100,000 m^2, are between 1.5 and 1.8 m thick. They are estimated to contain nearly 181,000 t of material grading between 3.3 and 6.7 g/t gold and, as explained below, are estimated to have a total content of about 831 kg leachable gold (table 5). This estimate was obtained in the following manner (using Dump 1 as an example): the cumulative thickness of dump material (DU-1-TR) exposed in trenches that reached bedrock area is 8.3 m (table 5, col. 2); the cumulative thickness of dump material exposed in trenches that did not reach bedrock is estimated to be 13.7 m (col. 3) (for details see the footnote #1, following page). The number of trenches (col. 4) is 13, which yields an average dump thickness of 1.7 m (col. 5.) The area (col. 6) was determined by digitizing plate 5 and using computer routines. The volume (col. 7) was obtained by multiplying column 6 by the average thickness. The tonnage (col. 8) was obtained by multiplying the volume by 1.18, the specific gravity of typical placer deposits (Bureau of Land Management, no date). The average grade of material from dump DU-1-TR was taken to be 3.7 g/t gold (col. 9), a figure which represents the average amount of leachable gold extracted from samples from dump one, excluding erratic values greater than 16 g/t Au (see Appendix 2, table 2-1, col. 17). Column 10 of table 5 indicates the resulting amount of contained leachable gold. The total amount, 181,000 t, is comparable to the 200,000 t of dump material whose average grade is 3.8 g/t Au, estimated by Helaby and Worl (1980).

For the purpose of estimating the amount of leachable gold contained by the ancient mine dumps, large samples of dump material were collected from trenches between 1 and 2 m deep and 2 m long. The trenches were excavated by backhoe; nearly half (48 percent) of the trenches reached bedrock. Composite rock-chip samples were collected from channels along diagonal lines joining the corners of 1-m squares drawn on the walls of the trenches. The squares were drawn starting at the bottom of each trench. If <0.5 m of trench wall remained (on the vertical) after the bottom square was drawn, rock fragments from the remaining part of the wall were added to the bottom sample; if >0.5m remained, a separate sample was established. Each sample was a composite of material ranging in size from sand to fragments about 30 cm across, collected from a square on one trench wall and from its counterpart on the opposite wall. The ends of trenches were not sampled because of the risk of contamination by spoil that had fallen back into the trenches. Further details of the sampling are contained in the Data File. The locations of the trenches are shown on plate 6. The number and the depth of each trench are the first and second numbers plotted alongside the trench locations; the third number is the average gold value (g/t Au) of all the trench samples (DGMR analytical results: for further details, see Appendix 2). The area of each dump sampled by trenching is designated by alpha-numeric number (for example, DU-1-TR for "dump one trenched"); the area not sampled by trenching designated DU-1-NTR (for "dump one not trenched"). For comparative purposes, plate 5 shows assay results for samples that were obtained by Helaby and Worl (1980) from areas of the dumps not included in the current trench-sampling program.

Table 5.--Estimated amount of leachable gold in ancient mine dumps at Hamdah prospect.

Column #1	#2	#3	#4	#5	#6	#7	#8	#9	#10
DU-1-TR	8.3	13.7	13	1.7	5,033	8,556	10,096	3.7	37,356
DU-1-NTR	0	3	2	1.5	26,609	39,913	47,098	4.5	211,941
DU-2-TR	1	15.6	9	1.8	4,929	8,872	10,469	6.7	70,144
DU-2-NTR	0	3	2	1.5	3,897	5,846	6,898	4.5	31,040
DU-3-TR	8.1	9.4	12	1.5	10,607	15,911	18,774	6.3	118,279
DU-3-NTR	0	3	2	1.5	13,988	20,982	24,759	4.5	111,414
DU-4-TR	10.9	16.2	18	1.5	14,324	21,486	25,353	3.3	83,666
DU-4-NTR	0	3	2	1.5	17,705	26,557	31,338	4.5	141,020
DU-5-NTR	0	3	2	1.5	3,303	4,955	5,846	4.5	26,308
TOTALS					100,395	153,078	180,631		831,168
							or 26,726 troy oz.		

Column	#1	Dump number
	#2	Cumulative depth of trenches in each dump that reach bedrock
	#3	Cumulative depth of trenches in each dump that do not reach bedrock + 0.5 m per trench (see footnote [1] on p. 37)
	#4	Number of trenches per dump (2 hypothetical trenches used for DU-1-NTR and untrenched parts of other dumps)
	#5	Average dump thickness
	#6	Area of dump, in m^2
	#7	Volume of dump, in m^3
	#8	Size of dump, in metric tons (assuming density of 1.18 t/m^3)
	#9	Average grade of leachable gold per dump (g/t Au) excluding samples greater than 16 g/t Au (for further details see Appendix 2, table 2-1, column 17)
	#10	Contained leachable gold (in grams)

Footnote [1]: For the purposes of determining the cumulative depth of trenches that did not reach bedrock (table 5, col. 3), 0.5 m was added to each trench depth to allow for the assumed extra depth necessary to reach bedrock. Thus the figure of 13.7 m in dump one (table 7; col. 3) is obtained by adding 0.5 m to each of the relevant depths shown in Appendix 2, table 2-1, col. 5:

Trench	Trench depth + 0.5 m extra
TR 1	2.0 + 0.5 m
TR 2	1.0 + 0.5 m
TR 9	2.0 + 0.5 m
TR10	1.6 + 0.5 m
TR11	1.2 + 0.5 m
TR12	1.1 + 0.5 m
TR13	1.3 + 0.5 m
average	13.7 m

NOTE: the estimate of the amount of gold in the remaining part of dump one (DU-1-NTR) is based on an inferred dump thickness of 1.5 m (the average of two hypothetical trenches—thus the number 2 shown for DU-1-NTR in table 5, col. 4—0 m and 3 m thick), and a grade of 4.5 g/t gold, the average grade of leachable gold, excluding erratic values of >16 g/t, obtained from all dump samples (see Appendix 2).

The dump samples were crushed and prepared for analysis at the DGMR/USGS Laboratory, Jiddah. A split of each sample was analyzed by graphite-furnace spectroscopy at the DGMR/USGS Laboratory. A duplicate split was sent to Skyline Labs, Inc., Denver, Colorado, for analysis by atomic-absorption spectroscopy and cyanide leach. The analytical results are given in Appendix 2.

A range of possible monetary values represented by the gold contained in the dumps is given in table 6, which, for summary purposes, uses global average grade figures, and three different prices of gold. (The total tonnage in table 6--181,000--differs from the figure in table 5 because of the rounding of decimal places).

Table 6.--Range of estimates, value of total gold in Hamdah mine dumps.

Estimated Averages	Average Total Au g/Ton	Total Tons	Grams Au	Troy oz Au	Estimated Value $300 oz Au	Estimated Value $350 oz Au	Estimated Value $400 oz Au
Avg cut >10	4.2	181,000	764,000	25,000	$7,500,000	$8,750,000	$10,000,000
Avg cut >16	4.5	181,000	808,000	26,000	$7,800,000	$9,100,000	$10,400,000
Avg uncut	6.0	181,000	1,090,000	35,000	$10,500,000	$12,250,000	$14,000,000

Dump One

Dump one is located in the northeastern part of the prospect (pl. 6). It was sampled in 13 trenches and is estimated to contain, in its trenched and untrenched parts, more than 249 kg leachable gold (table 5).

Dump Two

Dump two was tested by nine trenches. Samples from these trenches yielded the highest average grade of all sampled dump material (6.7 g/t). The trenched part of dump two contains about 70 kg leachable gold and the untrenched part is estimated to contain 31 kg. The total estimate for the dump is 101 kg leachable gold.

Dump Three

Dump three was sampled in 14 trenches, and the results for the trenched part and the estimate for the untrenched part indicate nearly 230 kg of contained leachable gold.

Dump Four

Samples from 18 trenches in dump four yielded the lowest average grade of gold (3.3 g/t). However, because of its large size (at nearly 57,000 t, it is the largest

Hamdah dump), the dump contains a significant amount of leachable gold (approximately 225 kg, or 27 percent of the total).

Dump Five

Dump five is the smallest dump in the prospect area. It was not examined by trenching, but on the basis of averages obtained from the other dumps it is estimated to contain about 26 kg of leachable gold.

GROUND ELECTROMAGNETIC GEOPHYSICAL SURVEYS

by

Maher A. Bazzari

In conjunction with geochemical sampling and diamond drilling in 1989, the Hamdah prospect was surveyed by CRONE (CEM) (Crone, 1966) and WADI very low frequency (VLF) electromagnetic methods, two of a number of standard geophysical methods utilized in mineral exploration programs to locate subsurface conductive bodies. CRONE, WADI, and all other types of electromagnetic exploration techniques are based on the fact that a primary alternating electric field will induce a secondary current and thereby a secondary electric field in a conductive body. The secondary field opposes the primary field, and together they create a resultant electric field with an amplitude and phase different from those of the primary and secondary fields. These differences in phase are detected and measured and, after suitable interpretation, are used to locate the conductive body.

The electrical conductivity of rock units is affected by a number of different factors. The preeminent factor, from the point of view of the explorationist, is the presence of sulfide minerals. However, electrically conductive bodies may also be caused in certain environments by the electrolytic effect of pore water in regions of enhanced porosity and water saturation, and by the presence of clays (as in alteration zones) or graphite in alteration haloes and shear zones. Such environments exists in the Arabian Shield. The successful detection of geologic features by geophysical instruments depends upon their conductivities, their depth of burial and configuration, and the frequency of the primary signal and configuration of the transmitter and receiver coils employed during the electromagnetic survey. The lower the signal frequency and the greater the coil spacing, the greater (within limits) is the depth of detection of the conductive body.

To facilitate the geophysical and geochemical surveys of the Hamdah prospect, and to control the location of drill sites, a grid was surveyed by theodolite comprising grid lines 100 m apart and stations 50 m apart. The 950-m-long base line was oriented N. 30^{o} E. from true north, a bearing referred to in this report as "grid north". The base line was established along a ridge of three hornblende-schist hills through the center of the prospect, and the orientation was chosen so as to be perpendicular to the general northwest-trending long axis of the zones of ancient workings mapped by Helaby and Worl (1980). The point of origin of the grid is on the level plain southwest of the Hamdah ancient mine prospect and is at the position corresponding to 000N. 000E.

CRONE ELECTROMAGNETIC SURVEY

The CRONE electromagnetic equipment used in the survey of the Hamdah prospect consisted of two coils that are capable of both transmitting and receiving alternating magnetic fields of three fixed frequencies (390 kHz, 1830 kHz, and 5,010 kHz). The two coils are not connected by hard line. When the horizontally held transmitting coil is energized, the vertically held receiving coil is rotated about a horizontal axis until a null signal is observed on the field-strength meter. The amount of rotation from the vertical, which theoretically could reach 90°, constitutes the "tilt angle," and is measured on the instrument as degrees positive (+) or degrees negative (-) depending on which way the coil is rotated. A second measurement is taken when the former transmitting coil becomes the receiver and vise versa. The two tilt angles recorded at each station in this manner are averaged, and the averaged resultant tilt angle is recorded and plotted at the midpoint between coils. This averaging procedure, which is called the horizontal shootback method, tends to negate the effect of any elevation or positional difference between the coils.

Crone (1972) ran model experiments to measure the effect of differently shaped bodies having various conductivities. His models indicated that if the earth medium is homogeneous, the dip angle should be zero. Measurements along a profile perpendicular to a buried narrow vertical conductor, such as is created in many parts of the Shield by sulfide minerals embedded in steeply dipping Proterozoic rocks, exhibit positive tilt angles over the conductor and negative tilt angles over the flanks of the conductor, in situations where the depth to the conductive body is less than the width of the anomaly. In contrast, a near-surface conductive body that is wider than the coil spacing might produce negative dip angles above the conductor, and positive tilt angles on its flanks. This latter case seems to prevail at the Hamdah prospect.

In the present survey, measurements were taken on eight lines, using coil spacings of 50 m and 100 m at station intervals of 50 m and a relatively high transmission frequency (5,010 kHz). The resulting CEM data for the entire survey are shown in this report as tilt-angle contour maps (pls. 7, 8), and data for two profiles are shown in figure 8, which is used to ascertain the coil-spacing response of subsurface conductive materials in the region.

Results of 50-m Coil-Spacing CEM Measurements

Three anomalous zones (A, B and C) are clearly shown on the contour map (pl. 7) that was constructed from the 50-m coil-spacing data.

Zone A is an east-trending low-amplitude anomaly consisting of -5° to -30° tilt angles that extend between lines 700N. and 900N. from line 150E. to east of line 750E. It correlates in a general manner with ancient workings and with the inferred down-dip extension of the mineralized zone in the northeast quadrant of the prospect area, but the 50-m CEM data neither reflect the northwest-trending shear zone in the northeast quadrant of the prospect nor the zone of mineralization that extends southeast from drill hole HR-11.

Zone B (-5° to -10° tilt angle) occupies the western part of the survey area, between lines 450N. and 550N. from lines 50E. to 435E. It correlates with an area of ancient workings and with dump three (pl. 6). Zone C, in the southern part of the survey area, does not correlate with ancient workings but, significantly, is open to the south where bedrock is concealed by Quaternary alluvium.

Results of 100-m Coil-spacing CEM Measurements

Plate 8 shows a tilt-angle contour map constructed from 100-m coil-spacing data. This map shows three anomalous conductive zones (A', B', and C'), which are comparable in general to the three 50-m coil-spacing anomalies shown on plate 7, although their sizes and locations differ in detail.

The anomalies in zone A' are most intense (-20° tilt angle) in the western part of the survey area, in the area between drill holes HR-89-1 and HR-89-9. Farther east the anomalies are between -5 and -15°. The axis of the anomalies trends northwest through the area tested by drill holes HR-89-4 and HR-89-6. The anomalies do not reflect the northwest-trending shear zone mapped along the line of the northeasternmost zone of ancient workings, although an isolated anomaly of -20° is situated at the intersection of the shear zone and fault "d" (pl. 1; 600N. 750E.).

The relatively low values of the tilt-angle anomalies that compose anomaly A for the 50-m and A' for the 100-m coil-spacing data are interpreted to mean that the source of the anomalies consists of weakly conductive material at relatively shallow depths (20-40 m). Such material is probably along the contact between the Hamdah serpentinite and hornblende schist.

Drill hole HR-89-2, at approximately 800N. 350E., is on the axis of anomaly A' in the western part of the survey area; it intersected mineralized rock (1.77 g/t Au) at the sheared contact between the Hamdah serpentinite and hornblende schist at a depth of nearly 25 m. Farther east, HR-89-6 was sited at 720N. 660E. to intercept the eastern end of anomaly A'. A section of sulfide-rich rocks and 0.5-cm-thick graphite seams in fault breccia were penetrated at a depth of 110.3 m. Graphite, in combination with sulfides, forms an excellent conductor, and in this instance it is a possible cause of the anomaly.

Zone B on plate 8 is a medium to strong tilt-angle anomaly of -30° to -35°. Ancient workings are present in the eastern part of the zone (centered on 500N. 300E.); the western extremity of the anomaly coincides with fault "a". The CEM data of zone B are interpreted as reflecting a zone of conductive material present from near surface to a depth of 50 m or more.

In zone C, the tilt-angle anomalies have amplitudes as great as -40°. The measurements constitute a series of discontinuous lows that in part coincide with ancient workings. Like the anomaly defined by the 50-m coil-spacing data, the anomaly zone is open to the south. Drill hole HR-89-11 was intended to test the anomaly centered at 360N. 600E., but due to a topographic oversight it was sited south of the anomaly. To date, therefore, the anomaly, and other anomalies in zone C, are untested, unexplained geophysical targets from an exploration point of view.

CRONE Electromagnetic Profile 350E.

Figure 8 shows the results of the CEM tilt-angle survey for 50-m and 100-m coil spacings along profile 350E. Negative anomalies in the 50-m coil-spacing data indicate the presence of conductive bodies at 500N. and at about 715N.; the 100-m coil-spacing data show a coincident anomaly at 500N., an anomaly at 800N. (shifted north with respect to the 50-m data), and an anomaly at 300N. that is unrepresented in the 50-m coil-spacing profile.

The negative anomalies are not of great amplitude, which means that the inferred conductors weakly respond to the applied CEM field. Comparison of the curves plotted in figure 8 with the model curves published by Crone (1972) suggests that the conductors are at a shallow depth of about 30 m. The strongest negative anomaly is defined by the -40° 100-m coil-spacing tilt-angle measurement at 300N. (fig. 8A). The absence of a corresponding anomaly in the 50-m coil-spacing data suggests that the source of this anomaly is located at a depth of more than 50 m.

CRONE Electromagnetic Profile 550E.

The 50-m and 100-m coil-spacing tilt-angle anomalies along profile 550E. (fig. 8B) can be divided into northern and southern groups. North of 500N. the 50-m and 100-m anomalies are in phase and are characterized by amplitudes of +5° to -15°. The values and the shapes of the curves of these anomalies indicate the presence of conductive bodies at shallow depths of less than 30 m.

South of 500N. the 50-m and 100-m coil-spacing data are out of phase. A sharp negative anomaly of nearly -30° is shown on the profile for the 100-m coil-spacing

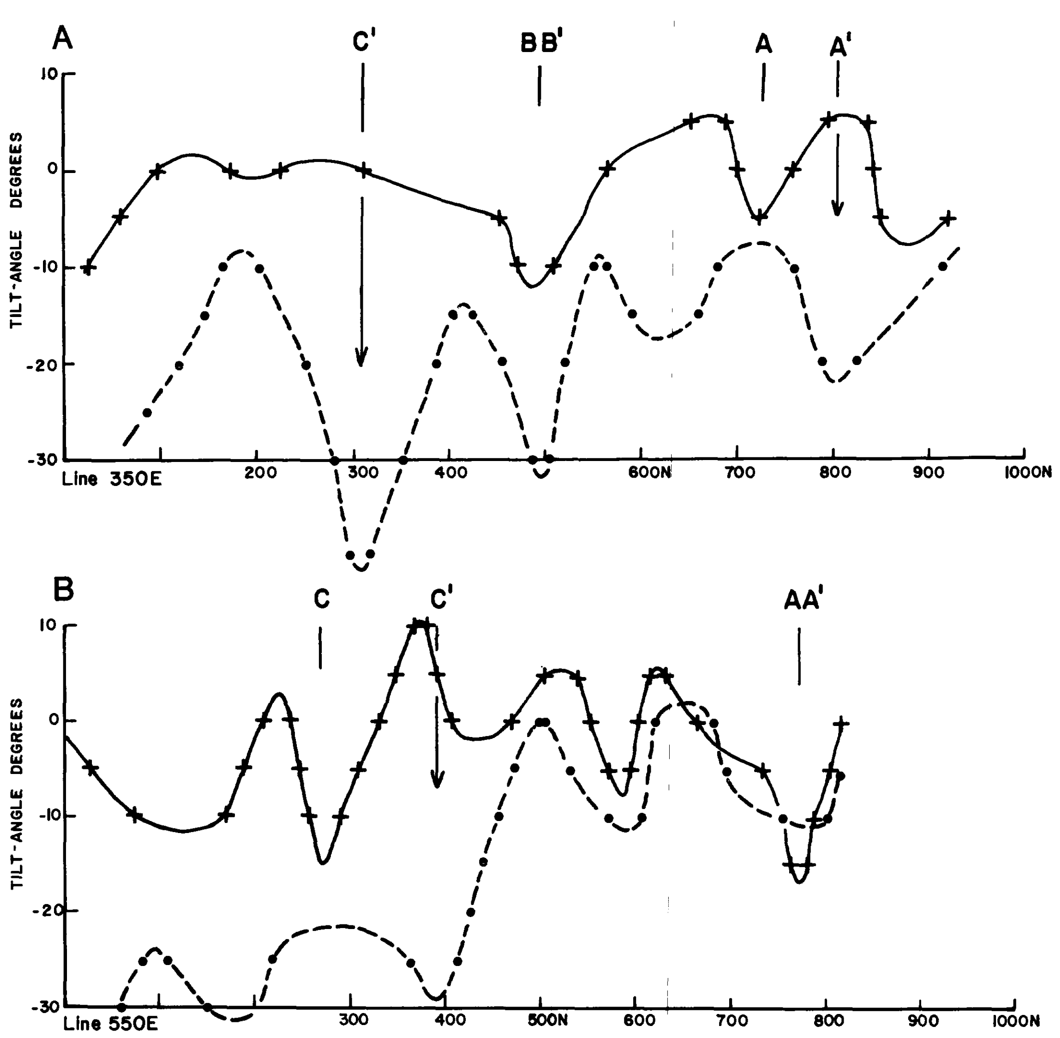


Figure 8.—CRONE electromagnetic survey profiles for lines 350E **A** and 550E **B**, Hamdah prospect, showing tilt-angle measurements for 50-m coil spacing (crosses) and 100-m coil spacing (dots). Letter symbols (A, A', etc.) indicate the locations of negative tilt-angle anomalies shown on plates 7 and 8, where A=50-m coil-spacing anomalies, and A'=100-m coil-spacing anomalies.

data at 390N. (anomaly C'), but the comparable 50-m coil-spacing anomaly is about 100 m farther south.

VERY LOW FREQUENCY SURVEY

The very low frequency (VLF) geophysical method consists of measuring a secondary electromagnetic field that is induced by high-power electromagnetic signals from transmitters usually thousands of kilometers from the site. Commonly the transmitters are radio stations used for communication with submarines---hence the low frequency of the radio signals transmitted, usually in the range of 15 to 30 kHz, so as to effectively pass through water.

The magnetic component of the primary electromagnetic field forms concentric circles about the transmitting VLF antennae and induces currents in the earth that flow relatively near surface throughout the world. Conductive bodies at shallow depths in the Earth's crust will distort these currents as well as the secondary magnetic field created by the currents. The VLF equipment detects the locations of such bodies by measuring the vertical and horizontal components of the in-phase ("real") and out-of-phase ("imaginary") secondary electromagnetic fields.

WADI Very Low Frequency Survey

The WADI VLF developed by Atlas Copco ABEM AB was used in this survey. The apparatus consists of controller, measuring units, and antenna units that are mounted on a belt worn by the operator. It is customary at the start of a survey to use the equipment to determine the directions and signal strengths of VLF stations transmitting in the range of 15-30 kHz in order to select a transmitter appropriate for the needs of the survey. For the Hamdah survey, the most useful VLF transmitting station was the one situated at Bordeaux, France (FUD 15.1 kHz-500 kw).

Measurements were taken at intervals of 25 m along the survey grid lines, at the same points used for the CEM survey so as to allow comparison of the CEM and VLF results. The field data were transferred from the WADI memory to an International Business Machine (model PS2) computer for processing, and the amplitude and phase of the real and imaginary components of both the original and the filtered data were plotted. Although the objective of the field work was to acquire sufficient data for a detailed and reliable interpretation, shortage of time, and poor reception of the VLF transmission on many occasions from noon until evening, led to cessation of the survey and prevented the acquisition of data needed to fill in lines. Because of this, only two VLF profiles, along 350E. and 550E., were prepared (figs. 9 and 10). The original data are shown in the upper, "A" part of each figure; the "B" part of each figure shows the filtered data. Filtering has the effect of smoothing and phase-shifting the anomalies, as if they represented responses from sources at depths of 50 m.

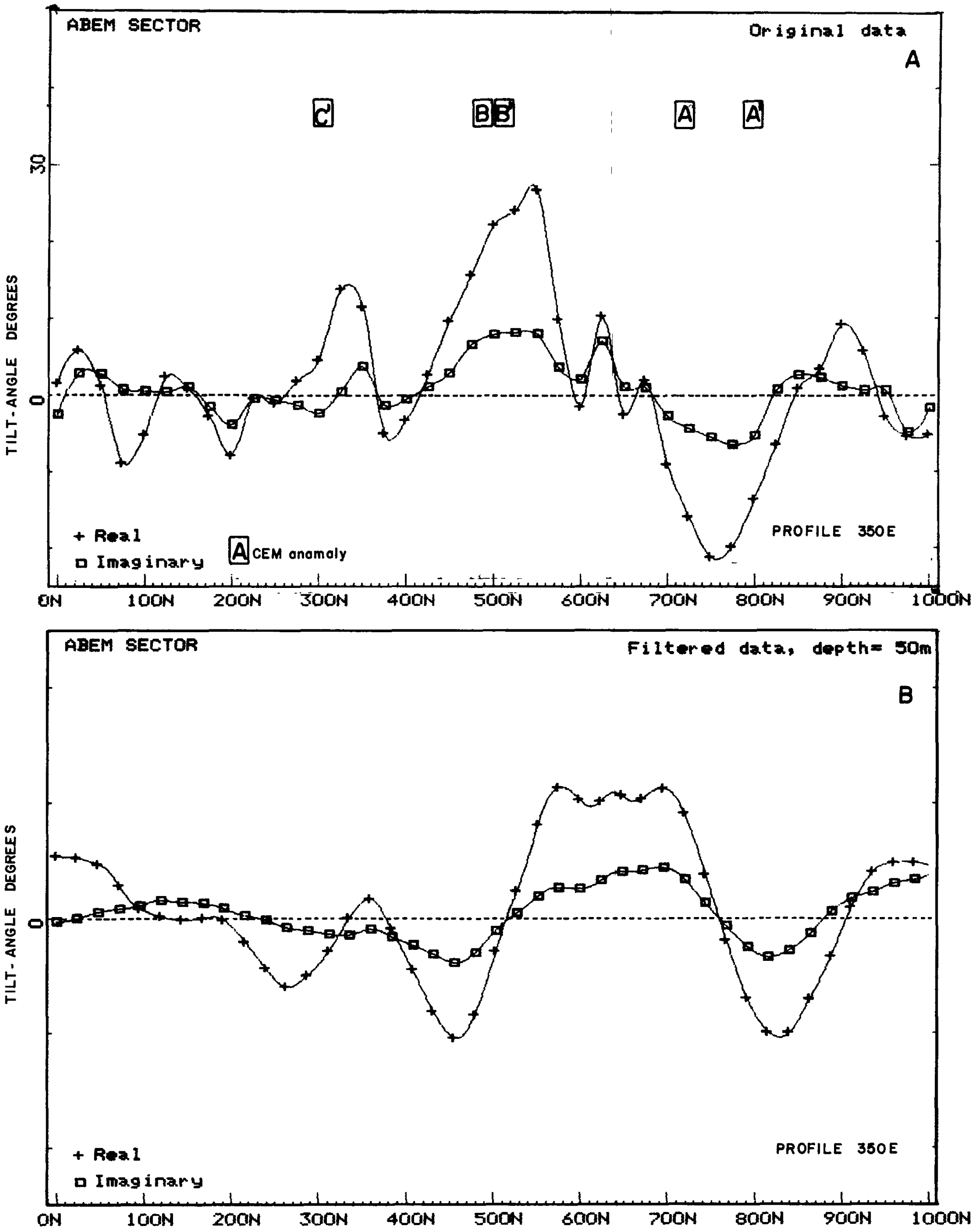


Figure 9.--VLF profile 350E, showing real and imaginary components of (A) original data and (B) data filtered to represent a depth of 50 m. Boxed letter symbols (A, A', etc.) indicate the locations of CRONE electromagnetic negative tilt-angle anomalies shown on plates 7 and 8, where A=50-m coil-spacing anomalies, and A'=100-m coil-spacing anomalies.

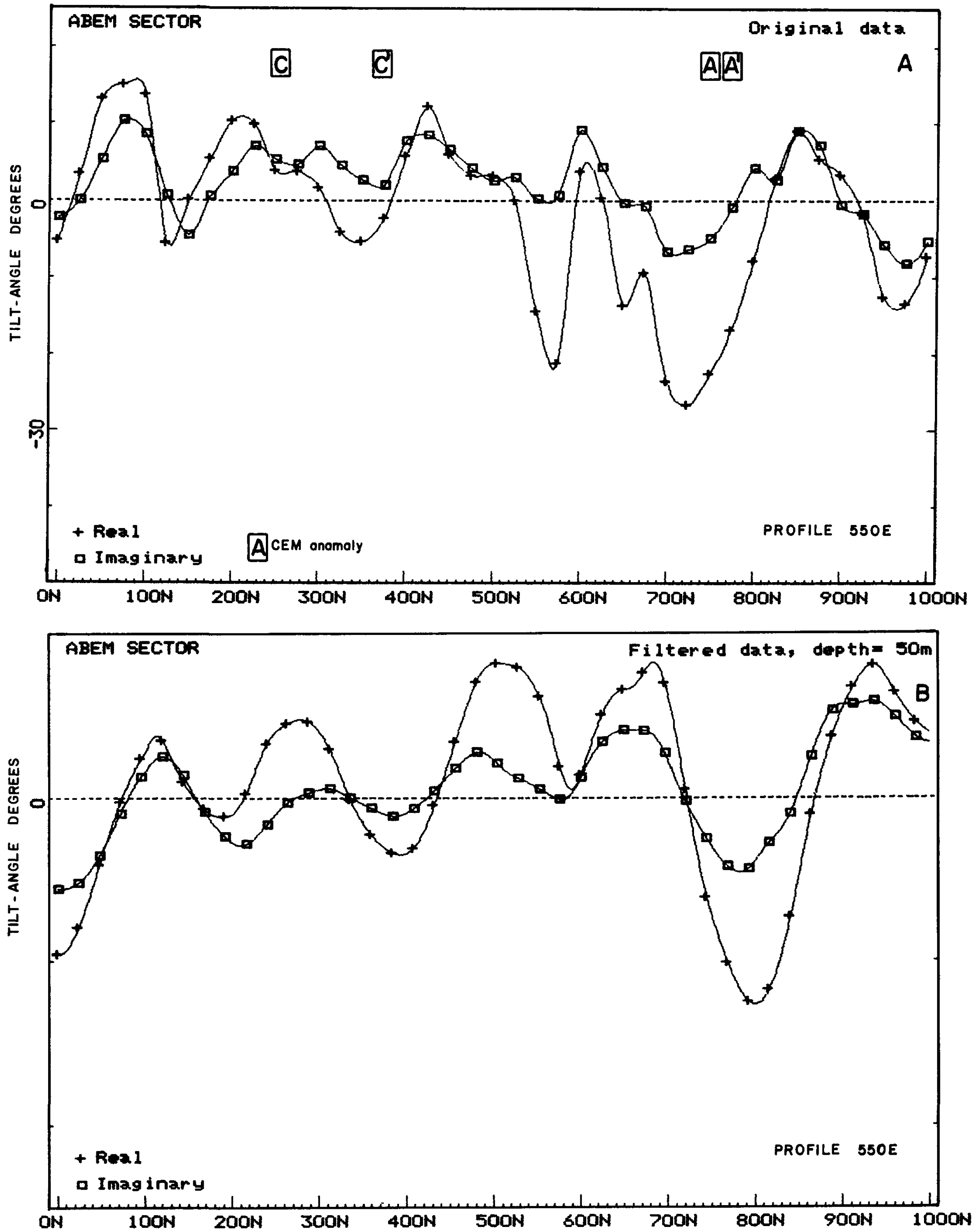


Figure 10.--VLF profile 550E, showing real and imaginary components of (A) original data and (B) data filtered to represent a depth of 50 m. Boxed letter symbols (A, A', etc.) indicate the locations of CRONE electromagnetic negative tilt-angle anomalies shown on plates 7 and 8, where A=50-m coil-spacing anomalies and A'=100-m coil-spacing anomalies.

VLF Profile 350E.

The effects of filtering the VLF data are clearly shown in figure 9. The anomalies are smoothed and are phase-shifted about 100 m to the north, and the resulting profiles are comparable in shape to the profiles of CEM data from the same grid line. This comparison is particularly evident for the VLF 50-m filtered and CEM 50-m coil-spacing data sets.

The trough on the filtered VLF data at 825N. is close to the location of drill hole HR-89-2, which intersected gouged, sheared, and mineralized rock (1.77 g/t Au) at a depth of nearly 25 m at the contact between the Hamdah serpentinite and hornblende schist. The trough at about 450N. correlates with fault "b." The wide peak between the troughs coincides with the exposures of hornblende schist in the core of the prospect area, and the steep gradient between 700N. and 800N. coincides with a zone of ancient workings and the surface and near-surface extent of the serpentinite/schist contact.

VLF Profile 550E.

Figure 10 shows VLF data along profile 550E. Prominent troughs in the real and imaginary components of the filtered data correlate with several significant geologic features. The most conspicuous trough, at approximately 800N., is close to the site of drill hole HR-89-4, which intersected very rich mineralization (as much as 57 g/t Au) at a depth of 16 m in a 2-m thick chlorite schist unit at the base of the aplite sill that marks the serpentinite/schist contact in this part of the prospect. The cross-over point at 730N. is close to the northwest-trending shear zone; the small troughs at 620N. and 200N. correlate with ancient workings. The cause of the broad trough at 400N. is unknown; it overlies the central part of the hornblende schist dome in the core of the prospect.

SUMMARY AND RECOMMENDATIONS

Based on a consideration of the results of exploration-in-progress presented in this report, the following recommendations are made.

GRID

At present, the Hamdah-prospect grid consists of lines 950 m long that are oriented N. 30° E. to be perpendicular to the general trend of the mineralized zones as known at the start of the current phase of exploration. It is recommended that the grid be extended north and south to cover likely future survey areas.

DUMPS

The examined dumps at Hamdah contain an estimated 831 kg of leachable gold. The results of sampling by Skyline Labs, Inc. (Denver, Colorado) indicate that shake leaching extracts nearly 100 percent of the gold contained in pulverized samples. It is recommended that leach-column experiments be performed on unpulverized bulk material taken from dumps to determine the feasibility of extracting gold from uncrushed material. It is also recommended that experimental sieving and analysis of dump material be undertaken to establish whether crushing significantly enhances the efficiency of gold recovery by leaching.

Additional trenching, in areas not presently accessible by back-hoe, is desirable, and a reverse-circulation drilling program would help to more precisely delineate dump sizes and depths. In this context, it is strongly recommended that an accurate topographic map of the dumps be prepared, and that a hammer-seismic survey be carried out to determine the thickness of the dumps and the topography below the dumps. Hammer-seismic traverses should also be conducted across wadis draining the prospect in order to determine the thickness of possible gold-bearing alluvium and to detect possible bedrock placer traps.

GEOPHYSICS

The ground geophysical survey indicates that contacts between the Hamdah serpentinite and underlying schist, and in places the ancient workings, are zones of higher conductance than other parts of the prospect area. Three conductive zones at relatively shallow depths (from 20 to 40 m) are outlined by moderate CEM tilt-angle anomalies of -10° to -15° at both 50- and 100-m coil spacings. These correlate, in general, with the thrust contact and with some of the ancient workings. In the southern part of the surveyed area, stronger negative anomalies (-40° are possibly caused by conductors at greater depths (>50 m). The CEM anomalies are open at all margins of the surveyed grid. Additional CEM work should be carried out, particularly in the area of Quaternary cover located just south of the prospect; and several core drill holes at least 70 m deep should be sited to test the anomalies.

The preliminary results of the VLF survey show that conductive bodies are present in the survey area at shallow depths. However, very little of the survey area is covered by existing VLF data; additional profiles at 50-m line and 25-m station spacing are recommended. The objective of the VLF work would be to estimate depths to the serpentinite/schist contact, especially to the northeast and to the west of the prospect.

MAPPING

Due to time constraints, no geologic mapping was carried out during the 1989 field season. Detailed mapping of the prospect is required to help interpret geophysical data and to site drill holes outside the northeast quadrant of the prospect.

DRILLING

Drilling results to date indicate the presence of an estimated 1,250 kg of gold in the northeast quadrant of the Hamdah prospect. However, more detailed systematic drilling is needed to investigate the region to the northeast and east of the present drill holes where the quadrant is still open. Reverse-circulation drilling of a large number of shallow holes to test the gold concentrations of the near-surface thrust contact in the northeast quadrant is recommended. In the southeast quadrant, this type of drilling could be used to delineate the extent of gold-bearing alluvium north and south of drill hole HR-89-11. Additional core drilling is recommended for the southwest and west quadrants where the possibility for deeper intercepts of gold-bearing mineralization is relatively untested.

HAMDAH REGION

Many ancient gold workings are known in the area that extends from Jabal Mahanid in the north to the Hamdah prospect in the south, a distance of approximately 12 km. A mineral-belt-scale mapping and sampling program is strongly recommended for the area, with the objectives of revealing the geologic controls to mineralization, identifying areas containing schist metamorphosed to hornfels, and delineating areas for future ground geophysical surveys and possible drilling.

DATA STORAGE

DATA FILE

All field and laboratory data for this report, including maps, assay results, thin sections, and drill logs for the Hamdah prospect, are stored in Data File USGS-DF-10-7 in the Jiddah office of the U.S. Geological Survey Saudi Arabian Mission.

MINERAL OCCURRENCE DOCUMENTATION SYSTEM (MODS)

The MODS file for Hamdah (0619) has been updated by the addition of this report number. No new MODS files were established.

REFERENCES CITED

Ahmad, M.I., 1957, Report on the reconnaissance survey of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Open-File Report 69, 138 p.

Al-Rehaili, M.H., and Warden, A.J., 1980, Comparison of the Bir Umq and Hamdah ultrabasic complexes, Saudi Arabia, in Al-Shanti, A.M.S., convenor, Evolution and mineralization of the Arabian-Nubian Shield: Jiddah, King Abdulaziz University, I.A.G. Bulletin, v. 3, 143-156 p.

Blank, H.R., and Bazzari, M.A., 1981, Magnetic surveys in the Hajrah-Hamdah area, including a ground survey of the Hajr ancient mine, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Record 15, 12 p.

Bookstrom, A.A., Vennum, W.R., and Doebrich, J.L., 1989, Geology and mineral resources of the Farah Garan-Kutam mineral belt, Kingdom of Saudi Arabia: Saudi Arabian Directorate General of Mineral Resources Technical Record USGS-TR-10-3 (in prep.).

Brown G.F., and Jackson, R.O., 1959, Geologic map of the Asir quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-217A, scale 1:500,000.

Bureau of Land Management, (no date), Placer examination--Principles and practice: U.S. Department of the Interior, Bureau of Land Management Technical Bulletin 4, 209 p.

Cooper, J.A., Stacey, J.S., Stoeser, D.B., and Fleck, R.J., 1979, An evaluation of the zircon method of isotopic dating in the southern Arabian craton, Kingdom of Saudi Arabia: Contributions to Mineralogy and Petrology, v. 68, p. 429-439.

Crone, J. D., 1966, The development of a new ground EM method for use as a reconnaissance tool: Society of Exploration Geophysicist's Mining Geophysics Case Histories, v. 1, p. 150-156.

----------- 1972, Model test studies with shootback electromagnetic method: Crone Geophysics, Ltd., Canada, 20 p.

Consortium Members, 1967, Airborne magnetic-scintillation counter survey 1966-67, sheets 162 and 165, 1:100.000 scale. (Aero Service Corporation, Hunting Geology and Geophysics Ltd., Arabian Geophysical And Surveying Company, Lockwood Survey Corp., Ltd., under the supervision of Bureau de Recherches Geologiques et Minieres.

Greenwood, W.R., 1985a, Geologic map of the Bi'r Idamah quadrangle, Sheet 18G, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Geoscience Map GM-79, 1:250,000 scale, with explanatory notes, 30 p.

---------------- 1985b, Geologic map of the Jibal al Qahr quadrangle, Sheet 19G, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Geoscience Map GM-76, 1:250,000 scale, with explanatory notes, 17 p.

Greenwood, W.R., Stoeser, D.B., Fleck, R.J., and Stacey, J.S., 1982, Late Proterozoic island-arc complexes and tectonic belts in the southern part of the Arabian Shield, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Open-File Report USGS-OF-02-8, 46 p. U.S. Geological Survey Open-File Report 83-296.

Hariri, M.M., 1986, Gold mineralization at the ancient Hajr mine: Saudi Arabian Deputy Ministry for Mineral Resources Open-File Report DGMR-OF-06-36, 25 p.

Helaby, A.M., and Worl, R.G., 1980, Exploration and evaluation of the Hajrah-Hamdah group of ancient gold mines, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Record 3, 52 p. U.S. Geological Survey Open-File Report 81-445.

Hotz, P.E., 1971, Geology of lode gold districts in the Klamath Mountains, California and Oregon: U.S. Geological Survey Bulletin 1290, 91 p.

Johnson, P.R., and Vranas, G.J., 1984, The origin and development of late Proterozoic rocks of the Arabian Shield: Saudi Arabian Deputy Ministry for Mineral Resources Open-File Report RF-OF-04-32, 96 p.

Kareh, R.P., Keller, F., and Kahr, V.P., 1962, A geological-geophysical reconnaissance of the Muhawiyah and Tathlith areas: Saudi Arabian Directorate General of Mineral Resources Open-File Report 164, 8 p.

Moore, J.M., 1979, Tectonics of the Najd transcurrent fault system, Saudi Arabia: Journal Geological Society London, v. 136, p. 441-454.

Olhoeft, G.R., and Johnson, G. R., 1989, Densities of rocks and minerals, <u>in</u> Carmichael, R.S., ed., CRC practical handbook of physical properties of rocks and minerals: Boca Raton, Florida, CRC Press, Inc., pp. 139-176.

Overstreet, W.C., 1966, Mineral exploration between Bi'r Idimah and Wadi Haraman, Asir quadrangle, Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Project Report 39, 70 p. U.S. Geological Survey Open-File Report (IR)SA-39.

Overstreet, W.C., 1978, A geological and geochemical reconnaissance of the Tathlith one-degree quadrangle, sheet 19/43, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Project Report 230, 132 p. U.S. Geological Survey Open-File Report 78-1072.

Rooney, L.F., and Al-Koulak, Z.H., 1978, Asbestos occurrences in serpentinites of the Hamdah area, Kingdom of Saudi Arabia: U. S. Geological Survey Saudi Arabian Mission Project Report 239, 22 p. U.S. Geological Survey Open-File Report 78-360

Schaffner, D. F., 1957, Preliminary report on Higera asbestos deposit: Saudi Arabian Directorate General of Mineral Resources Open-File Report 77, 3 p.

Schmidt, D.L., Hadley, D.G., and Stoeser, D.B., 1978, Late Proterozoic crustal history of the Arabian Shield, Southern Najd Province, Kingdom of Saudi Arabia, in Evolution and mineralization of the Arabian-Nubian Shield: King Abdulaziz University, Institute for Applied Geology, I.A.G. Bulletin 3, v. 2, p. 41-58.

Stoeser, D.B., and Camp. V.E., 1985, Pan-African microplate accretion of the Arabian Shield: Geological Society of America Bulletin, v. 96, p. 817-826.

Warden, A.J., 1969, Interim report of the geology of the Markas area (Asir Province): Saudi Arabian Directorate General of Mineral Resources Open-File Report 350, 147 p.

Warden, A.J., 1982, Reconnaissance Geology of the Markas quadrangle, sheet 18/43 B, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Open-File Report USGS-OF-02-41, 58 p. Obtain copy from Saudi Arabian Deputy Ministry for Mineral Resources.

Wells, J.D., 1982, Geology of the Jabal Riah area, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Open-File Report USGS-OF-02-69, 23 p. U.S. Geological Survey Open-File Rept 82-1049.

Worl, R.G., 1979, The Jabal Ishmas-Wadi Tathlith gold belt, Kingdom of Saudi Arabia: U. S. Geological Survey Saudi Arabian Mission Project Report 264, 108 p. U.S. Geological Survey Open-File Report 79-1519.

---------- 1981, Reconnaissance Geology of the Jabal al Hajrah 7 1/2-minute quadrangle, Kingdom of Saudi Arabia: Saudi Arabian Deputy Ministry for Mineral Resources Technical Record 2, 21 p.

Worl, R.G., and Elsass, F.R., 1980, Evaluation of mineralization in serpentinite and enclosing rocks in the Hamdah area, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Project Report 276, 33 p. U.S. Geologial Survey Open-File Report 81-446.

(PAGE 53 FOLLOWS)

APPENDIX 1

EXPLANATION FOR SUMMARY DRILL LOGS,
1989 DRILLING PROGRAM

░	APLITE
░	ALLUVIUM
▨	BIOTITE SCHIST
▤	META TUFF
▤	CHLORITE SCHIST
▩	DIORITE
▨	HORNBLENDE SCHIST
▧	SERICITE SCHIST
▨	SERPENTINITE

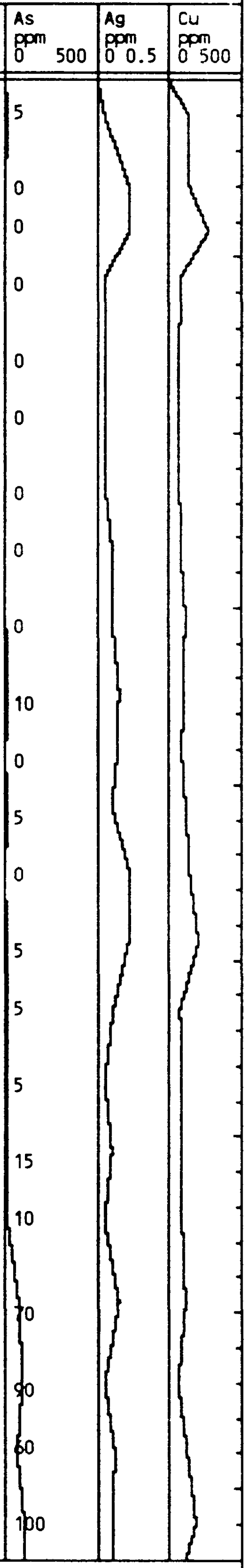
Drill Hole No.: HR 89-1

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 1/29/1989 1/30/1989

Depth Metres	Veins & Alteration	Lithology	Legend
	Alteration: argillitic and sericitic. Ore Min.: Hematite stain; limonite, hematite, and also talc and epidote along fractures. Alteration: argillitic; hematitic. Ore Min.: tr. of pyrite	0.00 - 2.00 meters. Hornblende schist: Altered, muddy, soft, and friable.	▨
		2 - 4 meters. Hornblende schist.	▨
5.00	3.50-4.40: hematite stain; 4.40-4.60: talc. 4.60-5.00: hematite. 5.60-5.90: hematite along fractures. Alteration: Hematitic. Sericitic. Limonitic. Ore Min.:	4 - 6 meters. Hornblende schist: argillitic.	▨
	6.80-6.90: Shear zone. Hematite stain. Alteration: chloritic. Ore Min.:	6 - 8 meters. hornblende schist: 6.10;6.90: bands of chlorite, and sericite.	▨
10.00	8.70-9.30: Sericitised. 9.40-9.50: Shear zone. Calcite veinlets present. . 9.80: quartz veinlet at 40 CA. Alteration: chloritic. Ore Min.:	8 - 10 meters. Hornblende schist: 8.10: bands of biot and minor chlorite & sericite. 9.80: Chloritized.	▨
	Series of quartz and calcite veinlets around 0.5cm thick. Hematite along fractures. Alteration: Ore Min.:	10 - 13 meters. Hornblende schist: 10.80: Biotite schist bands. 12.70: Chlorite schist bands. The rock is massive.	▨
15.00	13.20; 14.80; 15.90: hematite along fractures Alteration: chloritic Ore Min.:	13 - 17 meters. Biotite accumulation incrs. dwnward to 16.25, in bands 2cm thick, at 60 CA.	▨
20.00	19.00: calcite veinlet. Alteration: chloritic Ore Min.:	17 - 24 meters. Hornblende schist: 18.00: biotite interbeds with chlorite. Downward, biot. decrs. & chlor. incrs.	▨

Au ppm 0 5	As ppm 0 500
0.02	5
0.01	0
0.01	0
0.01	0
0.01	0
0.01	0
0.01	0
0.01	0
0.01	0
0.01	10
0.01	0
0.01	5
0.01	0
0.01	5
0.01	5
0.01	5
0.01	15
0.01	10
0.02	70
0.05	90
0.03	60
0.05	100



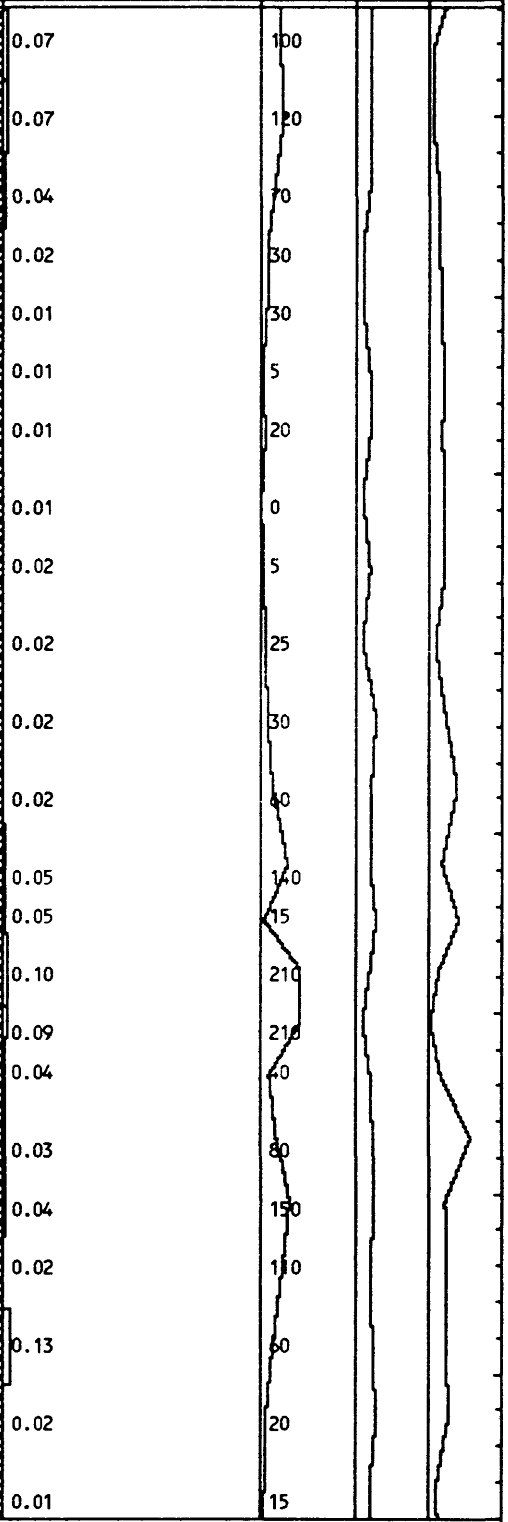
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-1

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 1/29/1989 1/30/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
			▨	0.07 0.07 0.04	100 120 70		
25.00	26.10: 7cm qtz vein 26.90: 8cm calcite 28.70: 1cm calcite veinlet. Hematite and limonite stain present. Alteration: chloritic Ore Min.:	24 - 29 meters. Chlorite enrichment decreases downwards to 24.60; sparse narrow bands of biotite. Epidote present. 27.30: biotite and chlorite bands.	▨	0.02 0.01 0.01 0.01 0.01 0.02	30 30 5 20 0 5		
30.00	29.35: 1cm calcite veinlet. Alteration: chloritic Ore Min.:	29 - 33 meters. 29.35-: Chlorite and hbl bands interbed w/ minor biot bands; chlorite decrs dwnwrd.	▨	0.02 0.02 0.02	25 30 40		
35.00	Alteration: chloritic Ore Min.:	33 - 36 meters. 33.35-33.90: biotite bands interbedded w/ hornblende. Chlorite increases downwards.	▨	0.05 0.05 0.10 0.09 0.04	140 15 210 210 40		
	36.40:Calcite veinlet 1cm thick. 37.75:-series of 0.4cm to 1.5cm calcite veinlets. Alteration: chloritic Ore Min.:	36 - 40 meters. Hbl schist intrbd w/ biot schist. Biot schist > hbl schist.	▨	0.03 0.04 0.02 0.13	80 150 110 60		
40.00	44.50: Calcite veinlet, 1cm thick. Alteration: Ore Min.:	40 - 45 meters. Hornblende schist: pale green; weak foliation. Epidote is present.	▨	0.02 0.01	20 15		



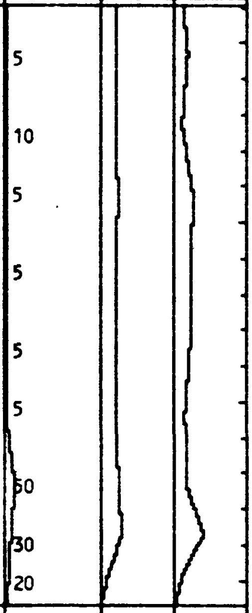
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-1

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 1/29/1989 1/30/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
			▨	0.01	5		
			▨	0.01	10		
			▨	0.02	5		
45.00	49.00: series of 0.5cm to 5cm qtz veinlets. 49.50: series of 0.5cm to 5cm calcite veinlets. 49.00-49.50: Sheared Alteration: chloritic Ore Min.: disseminated pyrite (fine)	45 - 50.35 meters. Biot-qtz-hbl schist, w/ minor chlorite. 49.5-50.35: hornblende schist; massive to weak foliation.	▨	0.01	5		
			▨	0.01	5		
			▨	0.01	5		
			▨	0.02	50		
			▨	0.01	30		
50.00	End of hole at 50.35 metres.		▨	0.01	20		
55.00							
60.00							



U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-2

Project : Hamdah drilling 1989

Logged by: P.Bosch Drilled: 1/25/1989 - 1/27/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
	Alteration: argillitic Ore Min.:	0.00 - 2 meters. Argillitically altered serpentinite.	▨	0.04 0.07	5 5		
	Asbestos veinlets: 2.4: 0.3cm, @ 50 CA; 0.5cm, @ 90 CA. 2.6-7.2: 0.7cm, @ 0 CA. Alteration: hematitic Ore Min.:	2 - 3 meters. Dk grn serpentinite: fractured, filled w/ hematite & limonite.	▨	0.02	5		
	4-4.6: Asbestos veinlets bounding magnesite. Alteration: hematitic Ore Min.:	3 - 5 meters. Serpentinite: asbestos veinlets incrs dwnwrd. 7.20: asbestos zone.	▨	0.02 0.01	5 5		
5.00	Green asbestos veinlets, continue further down to 7.7; Short fiber asbestos Alteration: hematitic Ore Min.:	5 - 9 meters. Serpentinite: dk. grn and massive; asbestos rich zone, w/ white and lt grn asbestos surrounding dk. grn asbestos vein. 8.20-8.40: hematite alteration.	▨	0.01 0.02 0.04 0.06	20 25 30 30		
10.00	9.45:Three generations of asbestos veins: lt, & dk.green, & white. 1.5cm asbestos is cut and surrounded by white asbest vein Alteration: hematitic Ore Min.:	9 - 12 meters. serpentinite: highly fractured. Dk grn & lt grn asbestos flanked by hematite. Fractures coated by hematite. 11.85: end of fracture zone.	▨	0.07 0.03 0.05	30 20 25		
15.00	13.0: 0.3cm carbnt veinlet. 12.8: qtz veinlet. . 14.35: 30cm qtz vein @ 60 CA. Alteration: hematitic Ore Min.:	12 - 16 meters. Serpentinite: dk to lt grn, interbedded w/ hem. beds @ 50 to 60 CA. 13.2:light green asbestos.	▨	0.03 0.02 0.04 0.03	20 25 30 25		
20.00	16.10-16.90: Shear zone. 19.0: alt.asbestos vein @ 60 CA. 19.3: qtz vein. 19.7-20.1: shear zone. Alteration: limonitic Ore Min.:	16 - 20.1 meters. Friable, soft, in shear zones. 16.6: Yellow-brown limonitic alteration. 19.7: upper contact @ 50 CA. 20.1: lower contact @ 60 CA.	▨	0.05 0.06 0.05 0.06	90 45 60 20		
	22.6;22.85: Hematite rich bands @ 75 CA.	20.1 - 23 meters. Aplite: fractured at	⁘	0.03	20		

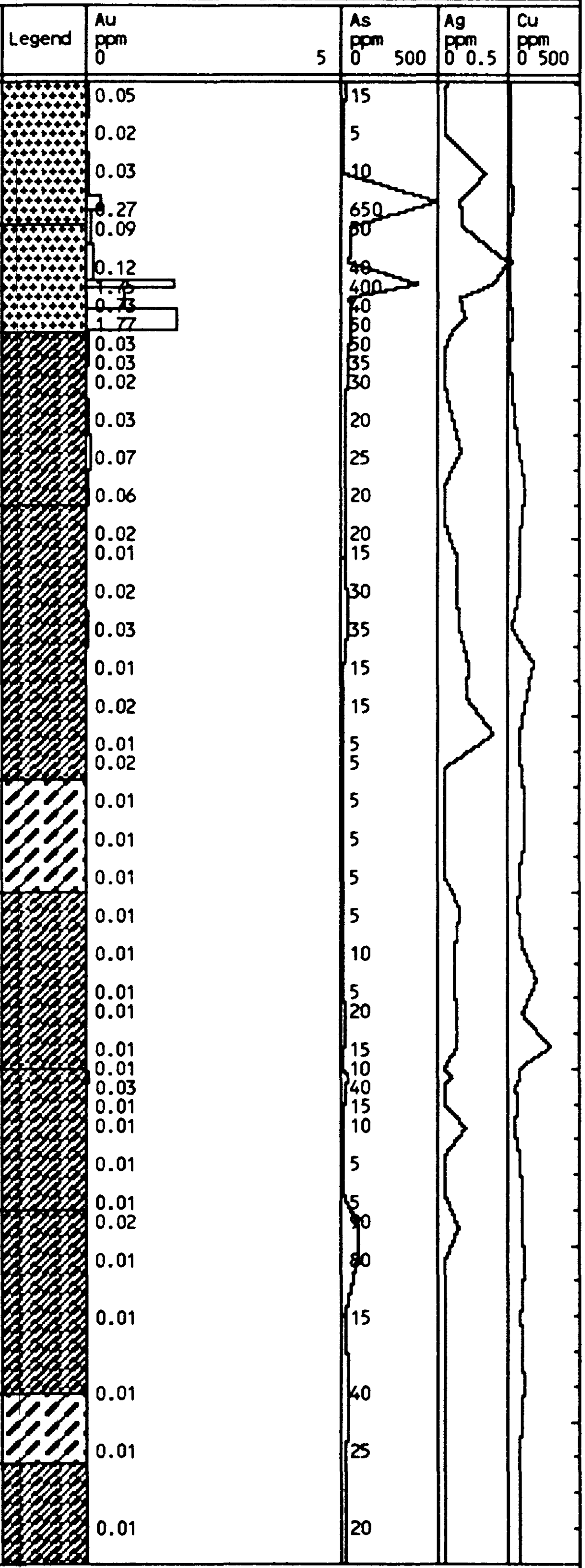
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-2

Project : Hamdah drilling 1989

Logged by: P.Bosch Drilled: 1/25/1989 - 1/27/1989

Depth Metres	Veins & Alteration	Lithology
	Alteration: hematitic. Ore Min.: traces of pyrite.	contact. 20.1: contact between serp and aplite.
	24.55: shear zone along contact w/ hbl schist at 40 CA. Alteration: Ore Min.:	23 - 24.55 meters. 23.85: 11cm hematite. 24.55: clay gouge.
25.00	25.8: 45cm qtz vein at 15 CA. Alteration: hematitic Ore Min.: remnant of pyrite	24.55 - 27 meters. Hornblende schist: Lt to dk. green: fracture zone is coated with limonite and hematite. Veinlets, filled or replaced by hematite are common.
30.00	27.25: 1cm zone of hematite - epidote; hematite common on fractures. 28.65: 2cm zone of epidotized biotite schist. Alteration: Ore Min.:	27 - 30.9 meters. Small bands of biot. schist interbedded w/ hbl.schist, incrs. downward. 30.9: contact w/ biot schist.
	31.4: Chlorite & sericite bands at 80 CA. Alteration: Ore Min.:	30.9 - 32.50 meters. Biotite schist: dk. green, to black. Minor chlorite & epidote along fract.
	34.7:Au in Fe stain along w/ chlorite. Fracture 15 CA.; some talc; 34.9: 10cm Aplite dike at 60 CA. 35.2: 7cm Aplite dk Alteration: chloritic Ore Min.:	32.5 - 35 meters. Hornblende schist: Biot. schist interbed continue downwards, w/ chlorite alteration
35.00	7 cm aplite dike, at 60 CA., cut by hem. bands parallel to CA which is flanked by chlorite schist, w/ Py along contact. Alteration: Ore Min.: trace pyrite	35 - 37 meters. Two types of schist beds: massive, & speckled; either biot or hbl schist due to narrow bands of biot or hbl intrbd. at 70 CA. as between 35.7 & 35.95
	Alteration: Ore Min.:	37 - 39.6 meters. 37.8-38.1: speckled bed, at 70 CA 38.5-38.6: speckled bed, at 70 CA.
40.00	Alteration: Ore Min.:	39.6 - 40.6 meters. 39.6-40.6: Biotite schist.
	Alteration: Ore Min.:	40.6 - 42 meters. Hornblende biotite schist. 40.6-41.2: speckled



Au ppm	As ppm
0.05	15
0.02	5
0.03	10
0.27	650
0.09	60
0.12	40
[illegible]	400
0.73	40
1.77	60
0.03	50
0.03	35
0.02	30
0.03	20
0.07	25
0.06	20
0.02	20
0.01	15
0.02	30
0.03	35
0.01	15
0.02	15
0.01	5
0.02	5
0.01	5
0.01	5
0.01	5
0.01	5
0.01	10
0.01	5
0.01	20
0.01	15
0.01	10
0.03	40
0.01	15
0.01	10
0.01	5
0.01	5
0.02	90
0.01	80
0.01	15
0.01	40
0.01	25
0.01	20

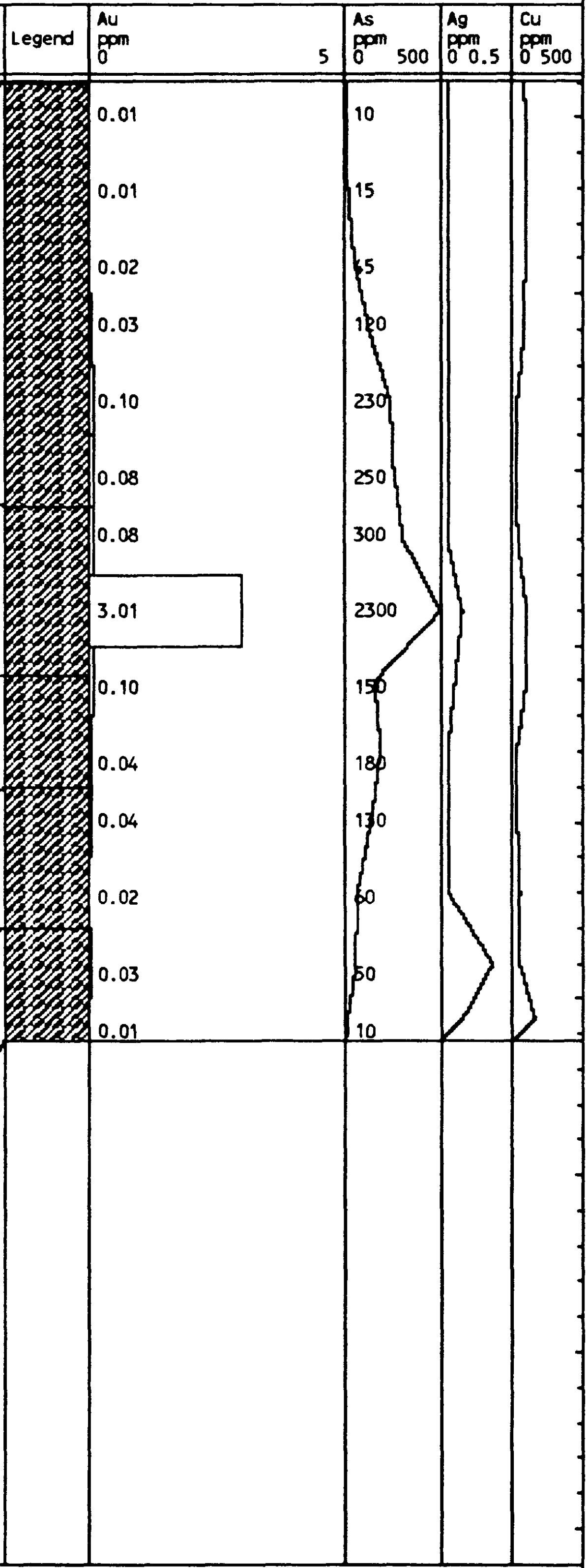
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-2

Project : Hamdah drilling 1989

Logged by: P.Bosch Drilled: 1/25/1989 - 1/27/1989

Depth Metres	Veins & Alteration	Lithology
		bed, @ 70 CA.
45.00	42.5:Limonitic, hematitic bands and talc; hematite within talc; sericite along edges. 46.9:Sericite band. Alteration: hematitic. chloritic. Ore Min.:	42 - 48 meters. Hornblende schist, w/ chloritic alteration.
50.00	hematite band cut by chlorite band parallel to CA. w/ chlorite along edges of hematite. Fold structure. Alteration: Ore Min.:	48 - 50.4 meters. 48.9-49.1: Biot. schist bed at 80 CA. 49.1-50.4: hornblende & biot.schist intrbd. Bands of 1 to 2cm hematite w/ sericite along edges. Fold zone(?)
	Alteration: Ore Min.: 52.8: 20cm hematite band along w/ sericite, at 50 CA. 54.5: 12cm Hematite band with sericite at 50 CA. Alteration: haematitic. chloritic. Ore Min.:	50.4 - 52 meters. 50.4-51.3: Rock less deformed; hematite at 60 CA. 51.3-53.95: chloritized zone.
		52 - 54 meters. 51.3-53.95: chloritized zone. 53.95-54.25: hbl schist w/ hematite band @ 70 CA.
55.00	54.4: Sericite band, 70 CA., cut by other sericite band, 40 CA 54.5: 12cm hematite band w/ sericite, at 50 CA. Alteration: Ore Min.:	54 - 55.60 meters. 54.25-to end of hole: Hbl schist interbeds w/ biot. bands; 60 CA Deformation incrs. Sericite between bands of hbl & biot. compacted together.
	End of hole at 55.60 metres.	
60.00		



Au ppm	As ppm
0.01	10
0.01	15
0.02	65
0.03	120
0.10	230
0.08	250
0.08	300
3.01	2300
0.10	150
0.04	180
0.04	130
0.02	60
0.03	50
0.01	10

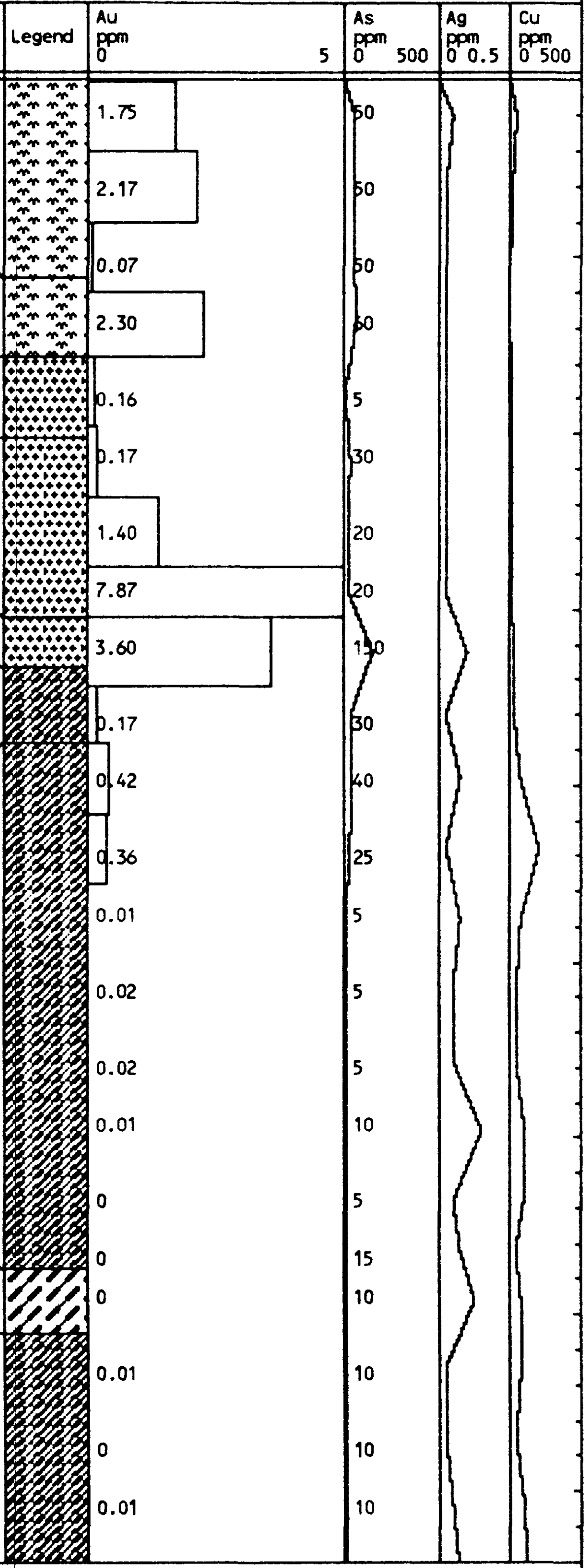
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89

Depth Metres	Veins & Alteration	Lithology
	2.80: Shear zone start. Alteration: Limonitic. Ore Min.:	0.00 - 2.8 meters. Highly altered rock: Muddy, yellow to brown, limonitic alteration, soft and friable.
	2.80-3.90: Shear zone. Alteration: argillitic. sericitic. Ore Min.:	2.8 - 3.9 meters. Altered rock, (serpentinite ???): Broken/& gouged; Argillitic & sericitic alteration.
5.00	Alteration: Limonitic Ore Min.: minor traces of pyrite	3.9 - 5.05 meters. Lt.grey to red stain of limonite after pyrite
	5.05-5.35: Shear zone. Alteration: Ore Min.:	5.05 - 7.60 meters. Aplite: (Fractured from 5.05 to 5.35)
	7.60-8.30: Shear zone Alteration: Ore Min.:	7.6 - 8.30 meters. Gouged rock (aplite). Broken.
	Alteration: sericitic Ore Min.:	8.3 - 9.40 meters. Hornblende chlorite schist; with sericite and epidote alteration.
10.00 15.00	10.50: 0.3 calcite veinlet. Hematite stains; 11.55: malachite and hematite stain along fracture. Alteration: chloritic. sericitic. Ore Min.: Traces of pyrite.	9.4 - 16.85 meters. Hornblende schist with some chlorite, talc, and also hematite stain.
	Bands of biotite oriented at 80 cla. Alteration: Ore Min.:	16.85 - 17.75 meters. Biotite-hornblende schist.
20.00	Alteration: chloritic. Ore Min.:	17.75 - 21.80 meters. Hornblende schist with minor chlorite and bands of biotite.



U.S.G.S. Jeddah Mission SCALE: 1:100

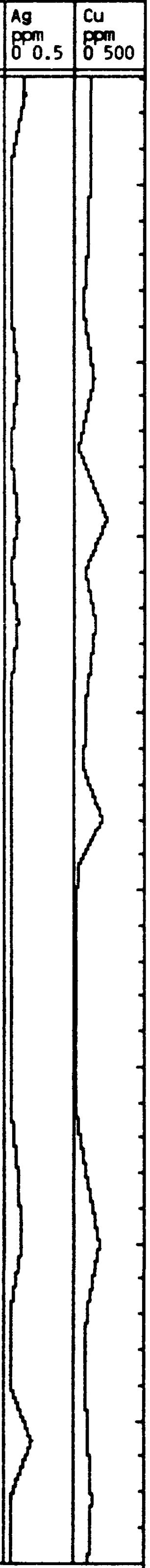
Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89

Depth Metres	Veins & Alteration	Lithology
	Bands of biotite orientation is 75 CA. Alteration: sericitic Ore Min.:	21.8 - 28.20 meters. Hornblende biotite schist with chlorite decreasing downward; Bands of biotite are narrow. Talc is present.
25.00		
	31.35: Fracture filled by calcite. Pyrite along fracture. 32.60-33.10: Qtz vein (45 CA) flanked by calcite veins. Alteration: sericitic Ore Min.: Dissaminated pyrite (fine)	28.2 - 35.95 meters. Weakly foliated hornblende schist, with thin bands of chlorite, getting less abundant downward.
30.00		
35.00		
	Alteration: sericitic. chloritic. Ore Min.:	35.95 - 48.55 meters. Hornblende biotite schist. Biotite interbeds with hornblende. Foliation 75 CA. Thin bands of sericite with minor chlorite.
40.00		

Au ppm 0 – 5	As ppm 0 – 500
0	5
0.01	15
0.01	15
0	15
0.01	30
0.01	25
0	10
0.01	55
0.01	65
0	30
0.01	60
0.05	120
0.07	180
0.02	70
0.07	170
0.05	110
0.04	160
0.01	100
0.02	60
0.05	50
0.01	20
0	5
0	0



U.S.G.S. Jeddah Mission

SCALE: 1:100

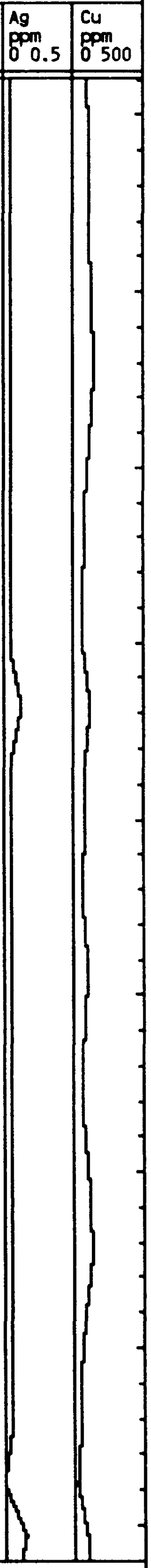
Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89

Depth Metres	Veins & Alteration	Lithology	Legend
45.00			▨
50.00	49.80: 2cm thick quartz vein, @ 10 CA., extending down for 25cm. Alteration: sericitic Ore Min.:	48.55 - 51.25 meters. Chlorite schist: weakly foliated; minor sericite; no hbl or biotite. 49.60:about 20 cm shear zone.	----
	Alteration: chloritic Ore Min.:	51.25 - 53 meters. Hbl schist with biot. and chlorite alteration. Foliation @ 70 CA.	▨
	Alteration: Ore Min.:	53 - 55.25 meters. Hbl. schist w/ fine quartz and biotite; foliation @ 70 CA.	▨
55.00	Alteration: Ore Min.:	55.25 - 59.70 meters. Hbl schist with chl. schist interbed, and has narrow bands of biot. Foliation @ 85 CA.	▨
60.00	Alteration: Ore Min.:	59.7 - 62.15 meters. Hbl schist with minor chlorite increasing downward. Weakly foliated.	▨
	Alteration: Ore Min.:	62.15 - 69.65 meters. Hbl schist with biot.	▨

Depth Metres	Au ppm 0 5	As ppm 0 500
	0	5
	0	0
	0	0
45.00	0	5
	0	0
	0	0
	0	10
	0.02	35
50.00	0.03	50
	0.01	20
	0	15
	0	5
	0	5
55.00	0.01	15
	0.01	65
	0.01	100
	0.02	15
	0	0
	0.01	5
60.00	0	5
	0.02	130
	0.02	130
	0	60

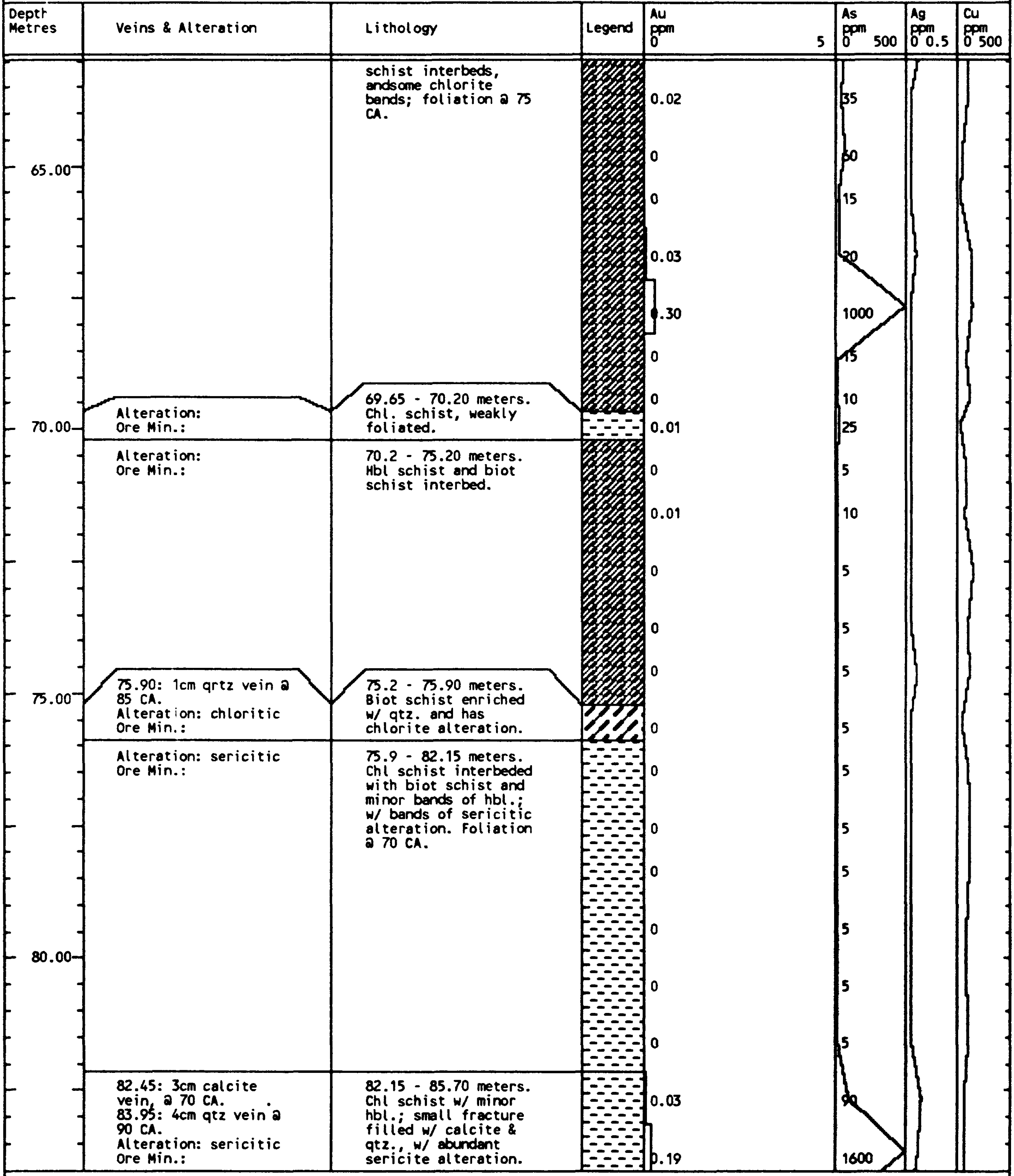


U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89



Depth Metres	Veins & Alteration	Lithology
		schist interbeds, andsome chlorite bands; foliation @ 75 CA.
69.65 - 70.20	Alteration: Ore Min.:	69.65 - 70.20 meters. Chl. schist, weakly foliated.
70.2 - 75.20	Alteration: Ore Min.:	70.2 - 75.20 meters. Hbl schist and biot schist interbed.
75.2 - 75.90	75.90: 1cm qrtz vein @ 85 CA. Alteration: chloritic Ore Min.:	75.2 - 75.90 meters. Biot schist enriched w/ qtz. and has chlorite alteration.
75.9 - 82.15	Alteration: sericitic Ore Min.:	75.9 - 82.15 meters. Chl schist interbeded with biot schist and minor bands of hbl.; w/ bands of sericitic alteration. Foliation @ 70 CA.
82.15 - 85.70	82.45: 3cm calcite vein, @ 70 CA. 83.95: 4cm qtz vein @ 90 CA. Alteration: sericitic Ore Min.:	82.15 - 85.70 meters. Chl schist w/ minor hbl.; small fracture filled w/ calcite & qtz., w/ abundant sericite alteration.

Au ppm	As ppm
0.02	35
0	60
0	15
0.03	20
0.30	1000
0	15
0	10
0.01	25
0	5
0.01	10
0	5
0	5
0	5
0	5
0	5
0	5
0	5
0	5
0	5
0	5
0.03	90
0.19	1600

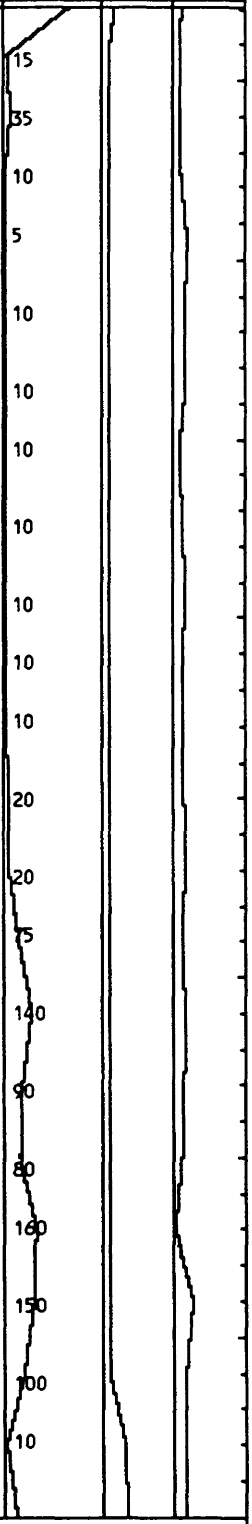
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
		Py presents along qtz & calcite vein.	▤				
				0	15		
85.00							
				0	35		
	Alteration: Ore Min.:	85.7 - 93.4 meters. Hbl schist interbeds w/ biotite schist; abundance of chlorite bands. Foliation @ 70 CA.	▨	0	10		
				0	5		
				0	10		
				0	10		
90.00				0	10		
				0	10		
				0	10		
				0	10		
	Alteration: sericitic Ore Min.:	93.4 - 96.50 meters. Chl schist interbeds w/ biot schist; foliation @ 80 CA.	▤	0	10		
95.00				0	20		
				0	20		
	Alteration: Ore Min.:	96.5 - 103.35 meters. Hbl schist interbeds w/ biot schist. 101.35-102.0: chl bed increases. Foliation @ 75 CA. Calcite & sericite fill small fractures.	▨	0.04	75		
				0.04	140		
				0.02	90		
100.00				0.02	80		
				0.04	160		
				0.07	150		
				0.09	100		
	Alteration: Ore Min.:	103.35 - 106.50 meters. Biot schist w/ some qtz phenocryst. Minor Sericite band.	▨	0.02	10		



U.S.G.S. Jeddah Mission SCALE: 1:100

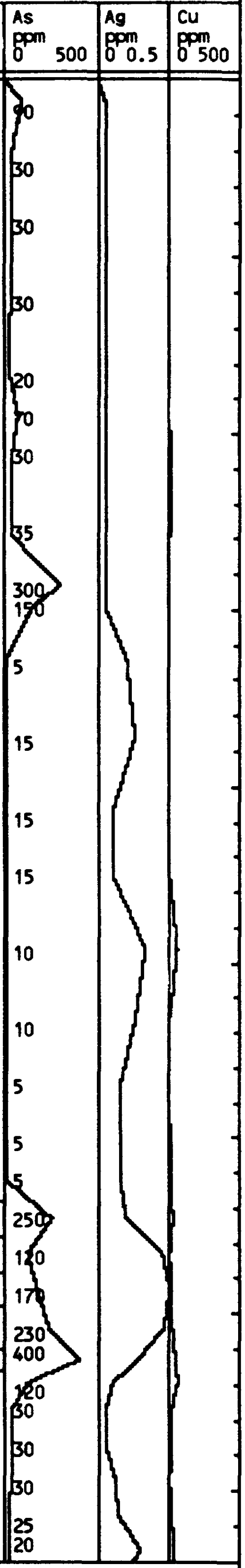
Drill Hole No.: HR 89-4

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 1/30/1989 2/02/1989

Depth Metres	Veins & Alteration	Lithology	Legend
	Mm size asbestos veinlets; @ 15 CA. 2.6-3.4: Shear zone. 3.6: 0.5 cm asbestos veinlet @ 80 CA. Alteration: argillitic limonitic Ore Min.:	0.00 - 5.00 meters. Altered serpentinite. argillite & limonite down to 4.90. Soft, & friable.	▨
5.00	7.00: Shear zone. Alteration: hematitic Ore Min.:	5 - 7.20 meters. Fractured, altered, & weathered serpentinite Serpentinite intermixed w/ biotite chlorite schist.	▨
	7.3-7.6: Shear zone. 7.6: Contact with aplite dike. Alteration: Ore Min.: pyrite xtal	7.2 - 7.6 meters. Serpentinite; Sheared(?) and fractured. Limonite and epidote along fractures.	▨
10.00 15.00	8.35: 3 cm sericite band 90 CA., with py xtals, cut by chl. band @ 20 CA. 14.9-15.0: black hem (magnetite) zone; hem along contact. Alteration: limonitic Ore Min.: pyrite	7.6 - 15.9 meters. Aplite. Sericite and epidote along fractures. Grey/white xtalline rock. Small fracture 15 CA. coated with limonite.	⁘
	Alteration: hematitic Ore Min.:	15.9 - 18.3 meters. Chlorite schist 70 CA; interbedded with hematite at 60 CA. 30 cm hematite along contact (18.0-18.30).	┄
20.00	18.5: 0.3 cm calcite veinlet with hematite @ 30 CA; edged w/ Ag(?). Alteration: limonitic Ore Min.:	18.3 - 22.15 meters. Contact interbedded w/ chlorite-hbl.shst. @ 70-80 CA. Light to dk hbl schist. Chl. on fract 20.05: carb.,limonite & epidote along frac.	▩
	22.15-23.36: Intermix		

Au ppm 0 5	As ppm 0 500
0.04	90
0.03	30
0.04	30
0.04	30
0.02	20
0.01	70
0.02	30
0.01	35
0.06	300
0.02	150
0.01	5
0.01	15
0.01	15
0.04	15
0.01	10
0.02	10
0.03	5
0.04	5
0.02	5
6.27	250
21.00	120
57.33	170
12.67	230
5.03	400
0.10	120
0.04	30
0.07	30
0.06	30
0.03	25
0.04	20



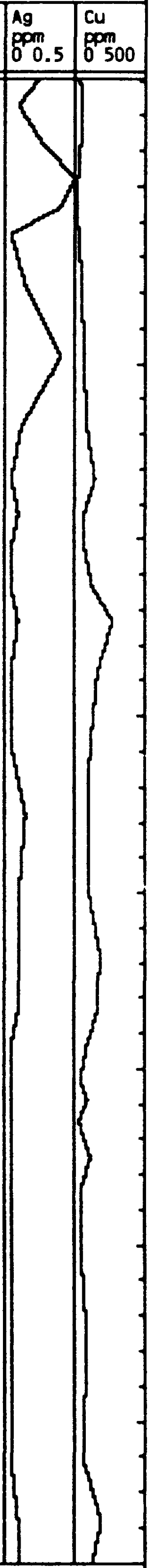
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-4

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 1/30/1989 2/02/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500
	zone. 22.95:contact with hematitic band @ 60 CA. 23.20-23.36: chlorite zone. Alteration: Ore Min.:	22.15 - 23.36 meters. Chlorite schist and sericite schist intermixed.		0.02 0.02 0.01 0	15 15 15 40
25.00	Alteration: Ore Min.:	23.36 - 26.20 meters. Pale green Hornblende schist, w/ beds of biot.schist. Schist varies from massive to fine-grained beds.		0 0.01 0.01 0.01	100 30 20 5
	Alteration: limonitic Ore Min.:	26.2 - 28.35 meters. Altered hornblende schist: limonite & chlorite along fractures.		0 0 0 0	15 15 5 15
30.00	Limonitic alteration along fractures. Alteration: limonitic Ore Min.:	28.35 - 32.75 meters. Biot.schist, with numerous sericite bands 0.1-1.0cm thick at 45 CA. Sericite decreases downwards and increases again between 31.05-31.35m.		0 0 0 0 0	5 5 5 5 10
	34.5: 1 cm sericite/ hem. band at 75 CA.. 34.6: 2cm sericite band at 75 CA. Alteration: Ore Min.:	32.75 - 34.7 meters. Hornblende schist: contact 60 CA., massive, with small bands of biot.schist 50 CA. "Speckled". 34.5-34.7: 4 sericite bands 1-2 cm wide.		0 0 0.01	5 10 30
35.00	35.4-35.5: Aplite dike; contact @ 75 CA. Alteration: hematitic Ore Min.:	34.7 - 35.85 meters. Chlorite schist: hematite alteration along fracture below aplite.		0 0 0	5 5 5
	Alteration: chloritic Ore Min.:	35.85 - 39.8 meters. Hornblende schist intermixed w/ narrow biotite bands. Chlorite alteration along fractures.		0 0.03 0.10 0.06 0.03	5 70 170 120 70
40.00	40.06: 20cm zone of sericite, hematite, alt. band, @ 75 CA. 40.95: 15cm zone of sericitte. 41.8 & 42.2: 10cm bands of hematite.	39.8 - 42.55 meters. Sericite schist: sericite bands associated w/ hem. along fracture. Py along bands of hem at 39.8 and 41.8		0.06 0.02	130 60



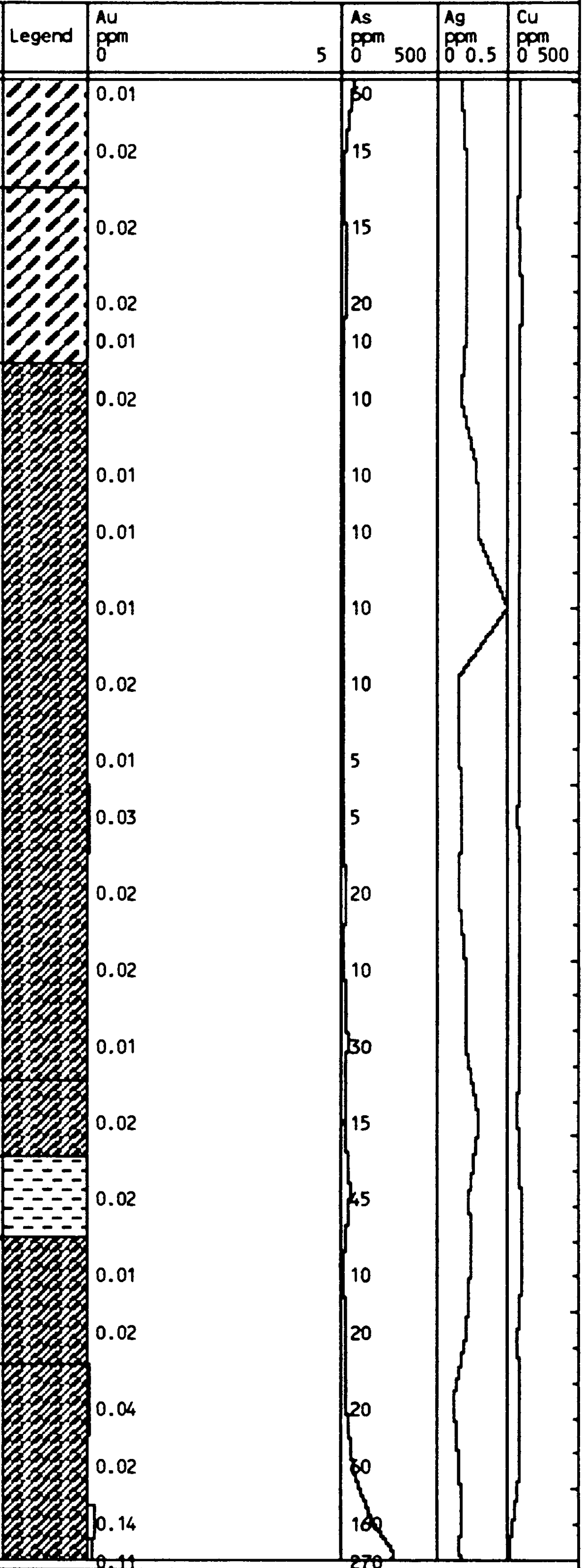
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89

Depth Metres	Veins & Alteration	Lithology	Au ppm 0 5	As ppm 0 500
105.00		Foliation @ 80 CA.	0.01	60
			0.02	15
	106.50-110.50: series of 0.5-1cm qtz vein, @ 85-90 CA. Alteration: Ore Min.:	106.5 - 109.0 meters. Biot schist w/ incr of qtz content, @ abundance of qtz. veinlets. Foliation @ 70 CA. Minor hbl.	0.02	15
			0.02	20
			0.01	10
	115.00: 3cm qtz vein @ 80 CA. alongwith tr of Py. Alteration: Ore Min.: Tr. pyrite	109 - 119.20 meters. Hbl schist and biot schist interbedded, Weak foliation. Minor chlorite & sericite. Biotite decreases downward.	0.02	10
110.00				
			0.01	10
			0.01	10
			0.01	10
			0.02	10
			0.01	5
115.00				
			0.03	5
			0.02	20
			0.02	10
			0.01	30
	Alteration: Ore Min.:	119.2 - 120.30 meters. Hbl schist: Foliation @ 90 CA.	0.02	15
120.00				
	Shear zone(?) Alteration: sericitic Ore Min.:	120.3 - 121.45 meters. Chl schist w/ sericite schist. Broken and altered	0.02	45
	Alteration: Ore Min.:	121.45 - 123.25 meters. Hbl schist interbed w/ biot schist. Foliation shows "microfolding".	0.01	10
			0.02	20
	125.70: 35cm qtz vein, @ 85-90 CA., flanked by py on both edges. . 132.65: about 2cm calcite vein. Alteration: sericitic Ore Min.: Pyrite	123.25 - 133.70 meters. Hbl & chl schist interbed, w/ biot, @ 70 CA foliation. Small bands of sericite alteration.	0.04	20
			0.02	60
125.00				
			0.14	160
			0.11	270

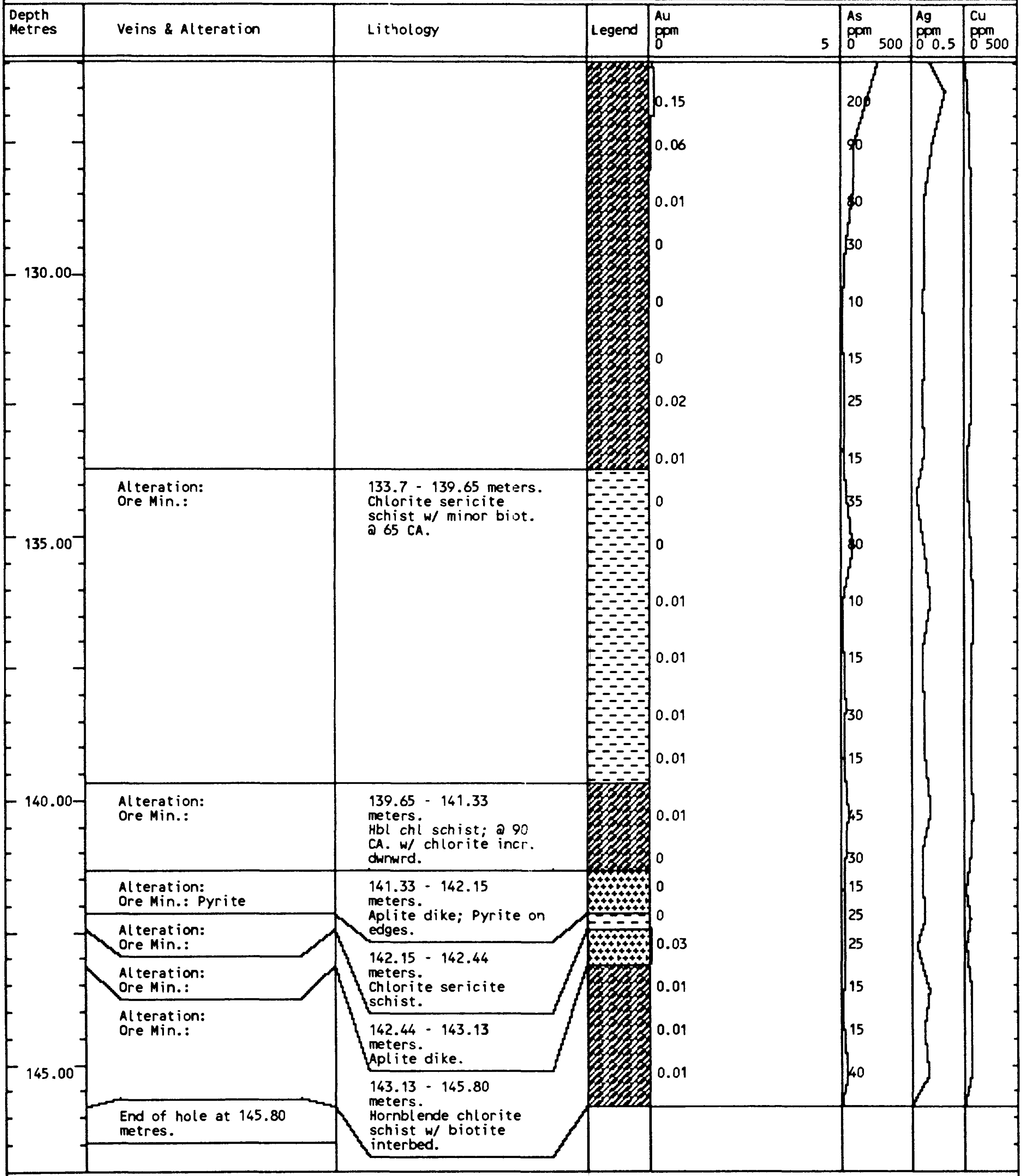


U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-3

Project : Hamdah Drilling 1989.

Logged by: Eyad Jannadi Drilled: 1/28/89 & 2/11/89



Veins & Alteration	Lithology
Alteration: Ore Min.:	133.7 - 139.65 meters. Chlorite sericite schist w/ minor biot. @ 65 CA.
Alteration: Ore Min.:	139.65 - 141.33 meters. Hbl chl schist; @ 90 CA. w/ chlorite incr. dwnwrd.
Alteration: Ore Min.: Pyrite	141.33 - 142.15 meters. Aplite dike; Pyrite on edges.
Alteration: Ore Min.:	142.15 - 142.44 meters. Chlorite sericite schist.
Alteration: Ore Min.:	142.44 - 143.13 meters. Aplite dike.
Alteration: Ore Min.:	143.13 - 145.80 meters. Hornblende chlorite schist w/ biotite interbed.
End of hole at 145.80 metres.	

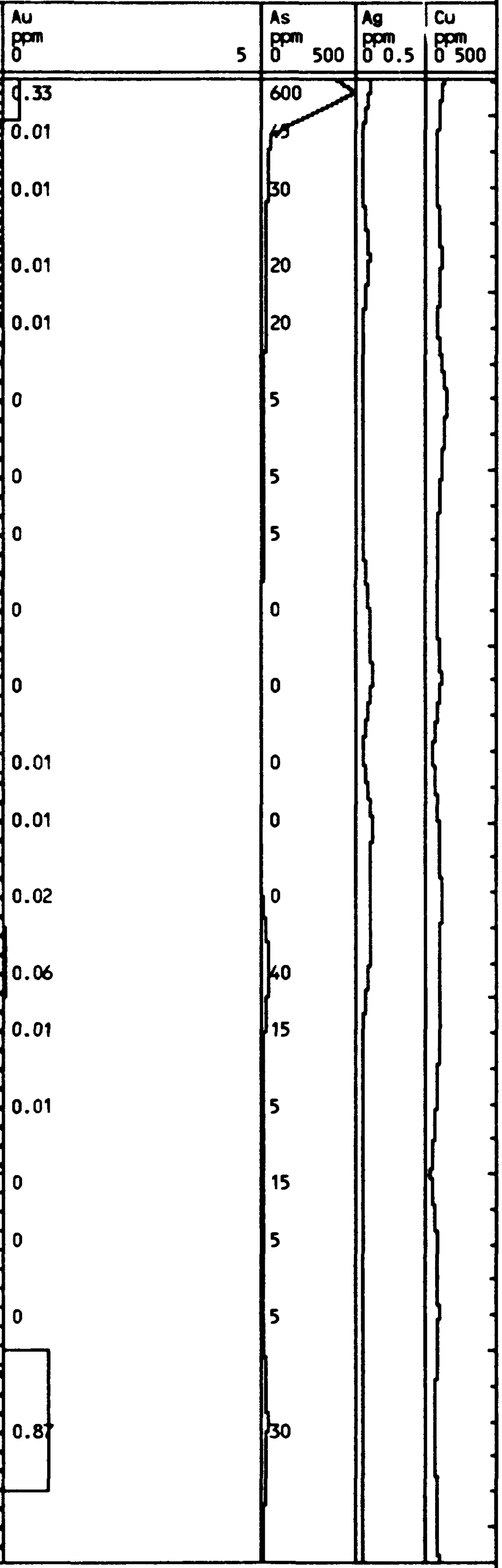
Au ppm	As ppm
0.15	200
0.06	90
0.01	80
0	30
0	10
0	15
0.02	25
0.01	15
0	35
0	40
0.01	10
0.01	15
0.01	30
0.01	15
0.01	45
0	30
0	15
0	25
0.03	25
0.01	15
0.01	15
0.01	40

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-4

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 1/30/1989 2/02/1989



Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm	As ppm
	Alteration: hematitic Ore Min.: pyrite	42.35. Minor calcite.	▧	.33	600
45.00	Small sericite bands parallel to CA. Alteration: Ore Min.:	42.55 - 45.4 meters. Hornblende schist: Fine-grained and massive. 42.8-43.1:sericite still common, then decreases below 43.1	▩	0.01 0.01 0.01	45 30 20
50.00	47.4: Small shear zone; fragmented rock 10 cm wide, 50 CA. Alteration: Ore Min.: pyrite	45.4 - 50.2 meters. Thick sequence of biot.schist interbeds w/ chlorite schist. Thin band(0.1mm) pyrite along bedding, 40 CA., (between biotite & chlorite beds).	▨	0.01 0 0 0 0	20 5 5 5 0
	Alteration: Ore Min.: pyrite	50.2 - 51.8 meters. Chlorite schist w/ minor pyrite along contact and fractures.	┅	0 0.01	0 0
55.00	Alteration: Ore Min.:	51.8 - 57.5 meters. Biotite schist.	▨	0.01 0.02 0.06 0.01 0.01	0 0 40 15 5
60.00	Alteration: Ore Min.:	57.5 - 60.3 meters. Chlorite schist.	┅	0 0 0	15 5 5
	60.3: 15cm qtz vein, @ 80 CA., pyrite along the edges. . 63.6:about 2cm sericite band. Alteration: Ore Min.: disseminated pyrite	60.3 - 65 meters. Sericite alteration below qtz.vein; Biot. schist: black, massive to fine grained, interbedded w/ chlorite schist and occasional sericite schist band	▨	0.87	30

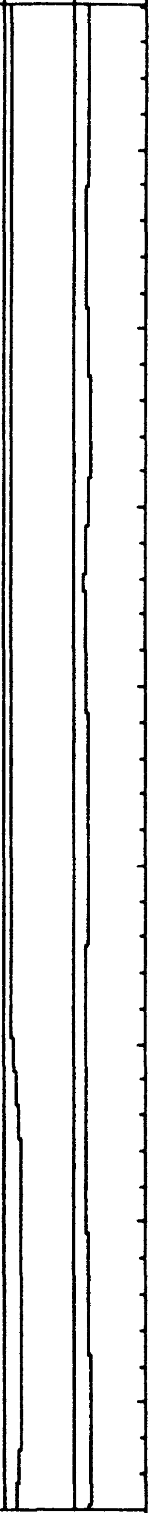
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-4

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 1/30/1989 2/02/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
			▨	0.01	5		
65.00	65.25: 3cm sericite schist, @ 80 CA. 66.05:about 1.5cm sericite band, @ 90 CA. Pyrite coating along fractures. Alteration: Ore Min.: pyrite	65 - 98.8 meters. Biotite schist inter-bedded w/ chlorite schist to the end oof hole. Some bands are thick, while others are thin.	▨	0	5		
			▨	0.03	5		
			▨	0	5		
70.00			▨				
			▨	0.01	0		
			▨	0	0		
75.00			▨	0	0		
			▨	0	0		
			▨	0	0		
80.00			▨				
			▨	0	5		
			▨	0	5		

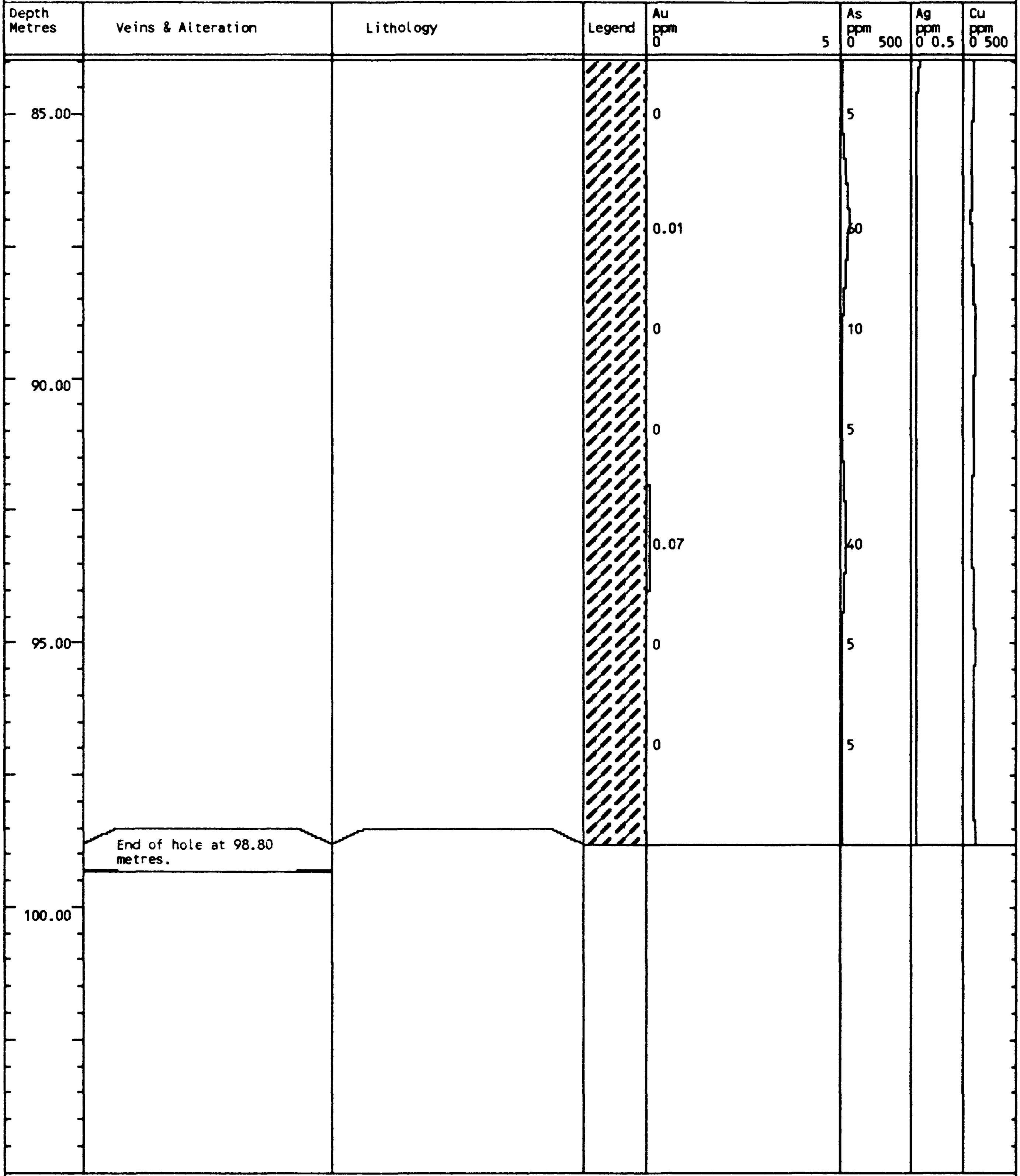


U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-4

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 1/30/1989 2/02/1989



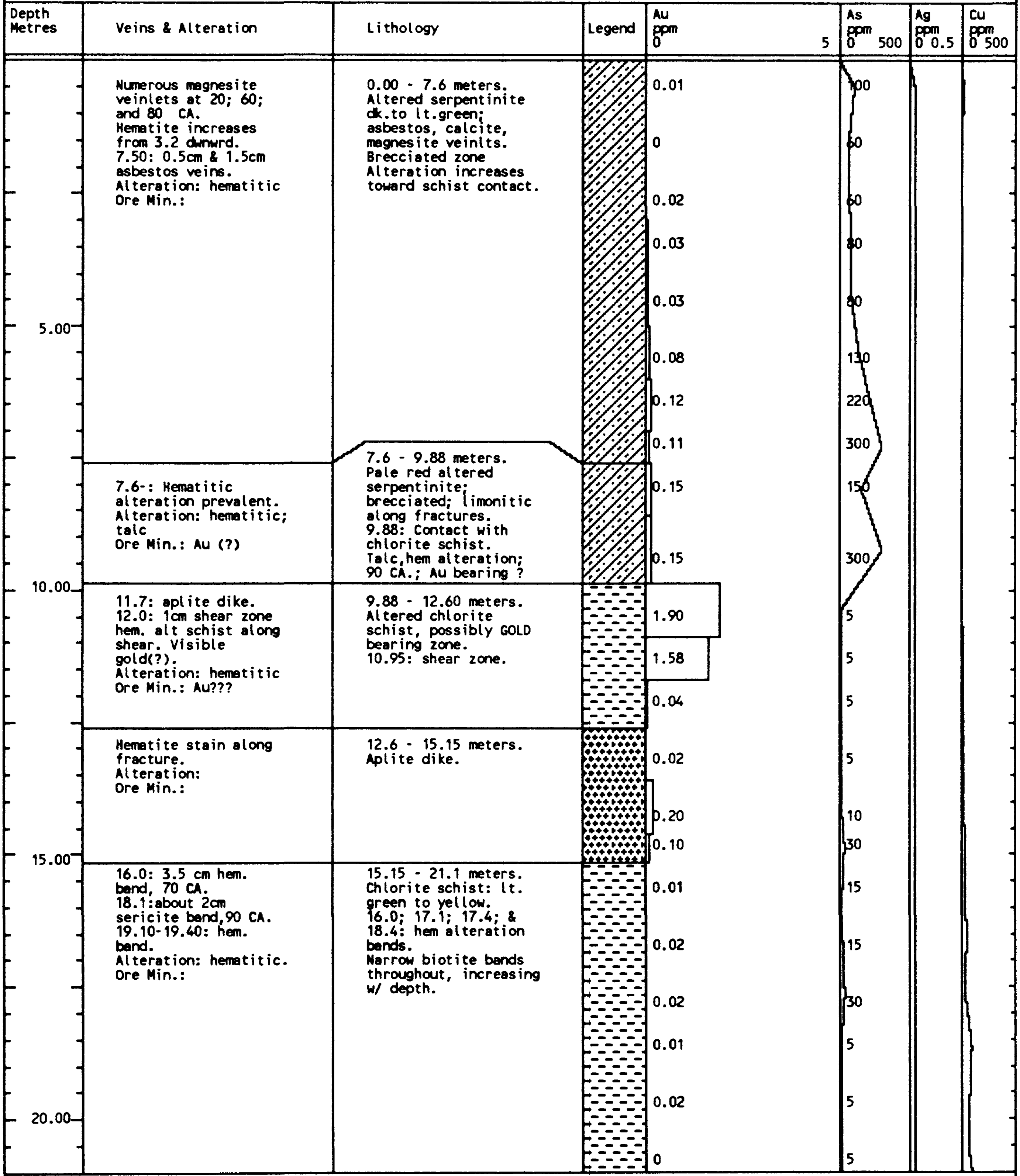
End of hole at 98.80 metres.

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-5

Project : Hamdah Drilling 1989

Logged by: P.Bosch & E.Jannadi Drilled: 2/02/1989 - 2/11/1989



Veins & Alteration	Lithology
Numerous magnesite veinlets at 20; 60; and 80 CA. Hematite increases from 3.2 dwnwrd. 7.50: 0.5cm & 1.5cm asbestos veins. Alteration: hematitic Ore Min.:	0.00 - 7.6 meters. Altered serpentinite dk.to lt.green; asbestos, calcite, magnesite veinlts. Brecciated zone Alteration increases toward schist contact.
7.6-: Hematitic alteration prevalent. Alteration: hematitic; talc Ore Min.: Au (?)	7.6 - 9.88 meters. Pale red altered serpentinite; brecciated; limonitic along fractures. 9.88: Contact with chlorite schist. Talc,hem alteration; 90 CA.; Au bearing ?
11.7: aplite dike. 12.0: 1cm shear zone hem. alt schist along shear. Visible gold(?). Alteration: hematitic Ore Min.: Au???	9.88 - 12.60 meters. Altered chlorite schist, possibly GOLD bearing zone. 10.95: shear zone.
Hematite stain along fracture. Alteration: Ore Min.:	12.6 - 15.15 meters. Aplite dike.
16.0: 3.5 cm hem. band, 70 CA. 18.1:about 2cm sericite band,90 CA. 19.10-19.40: hem. band. Alteration: hematitic. Ore Min.:	15.15 - 21.1 meters. Chlorite schist: lt. green to yellow. 16.0; 17.1; 17.4; & 18.4: hem alteration bands. Narrow biotite bands throughout, increasing w/ depth.

U.S.G.S. Jeddah Mission

SCALE: 1:100

Drill Hole No.: HR 89-5

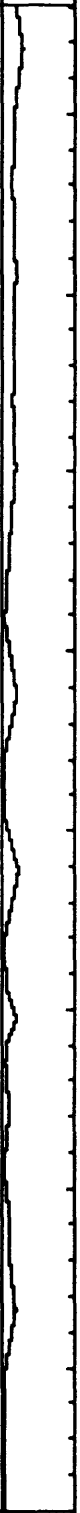
Project : Hamdah Drilling 1989

Logged by: P.Bosch & E.Jannadi Drilled: 2/02/1989 - 2/11/1989

Veins & Alteration	Lithology	Legend
Alteration: Ore Min.:	21.1 - 26.1 meters. Black to dk.green Biotite schist: 21.6-21.9: hem. band. 23.5: 10cm chlorite schist band. 24.55-24.65: sericite band.	▨
26.9-27.0;27.5-27.6; aplite dikes. 27.80: 10cm aplite dike. Alteration: Ore Min.:	26.1 - 29 meters. Lt.yellow - green chlorite schist: lim. alteration along fractures. Broken.	▤
Alteration: Ore Min.:	29 - 30.2 meters. Quartz diorite infiltrated w/ biotite schist. Hornblende - rich diorite.	▩
Alteration: Ore Min.:	30.2 - 31 meters. Biotite schist.	▨
Alteration: Ore Min.:	31 - 32.6 meters. Diorite.	▩
33.4: 0.8 cm aplite dike; bottom contact @ 70 CA w/ sericite/ hematite bands. Alteration: Ore Min.:	32.6 - 33.5 meters. Biotite schist.	▨
Alteration: Ore Min.:	33.5 - 34.9 meters. Quartz diorite, hornblende rich.	▩
35.0: quartz vein. Alteration: Ore Min.:	34.9 - 35.35 meters. Chlorite schist.	▤
35.8: 5cm quartz vein @ 90 CA. Alteration: Ore Min.:	35.35 - 38.7 meters. Quartz diorite with chlorite bands at: 35.6-35.9;37.55-37.85	▩
Alteration: Ore Min.:	38.7 - 39.7 meters. Chlorite schist.	▤
Alteration: Ore Min.:	39.7 - 40.7 meters. Quartz biotite schist rich in hornblende, foliated @ 60 CA.	▨
Alteration: Chloritic Ore Min.:	40.7 - 44 meters. Metavolcanic tuff, massive, fine grained,	▤

Depth Metres	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5
	0	5	
	0	5	
	0	5	
	0.01	5	
25.00			
	0.01	5	
	0	5	
	0	5	
	0	5	
	0	0	
30.00			
	0.03	35	
	0.03	0	
	0.03	5	
	0.03	5	
	0.03	0	
	0.03	5	
35.00			
	0.01	0	
	0	5	
	0	30	
	0	5	
	0	5	
	0	20	
	0	0	
	0.02	70	
40.00			
	0	5	
	0.01	30	

Cu ppm 0 500

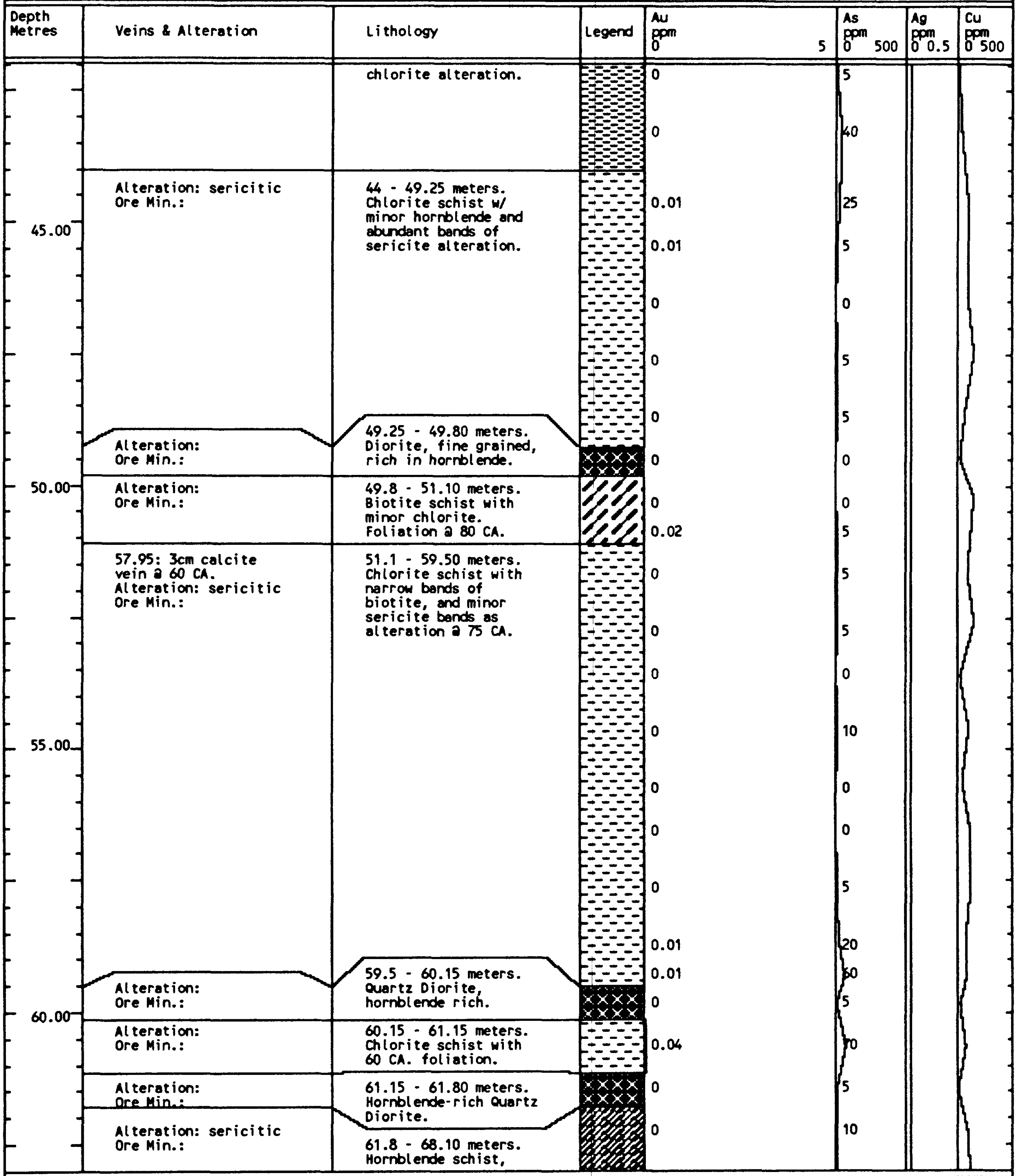


U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-5

Project : Hamdah Drilling 1989

Logged by: P.Bosch & E.Jannadi Drilled: 2/02/1989 - 2/11/1989



Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
		chlorite alteration.		0 0	5 40		
45.00	Alteration: sericitic Ore Min.:	44 - 49.25 meters. Chlorite schist w/ minor hornblende and abundant bands of sericite alteration.		0.01 0.01 0 0 0	25 5 0 5 5		
	Alteration: Ore Min.:	49.25 - 49.80 meters. Diorite, fine grained, rich in hornblende.		0	0		
50.00	Alteration: Ore Min.:	49.8 - 51.10 meters. Biotite schist with minor chlorite. Foliation @ 80 CA.		0 0.02	0 5		
55.00	57.95: 3cm calcite vein @ 60 CA. Alteration: sericitic Ore Min.:	51.1 - 59.50 meters. Chlorite schist with narrow bands of biotite, and minor sericite bands as alteration @ 75 CA.		0 0 0 0 0 0 0 0.01 0.01	5 5 0 10 0 0 5 20 60		
60.00	Alteration: Ore Min.:	59.5 - 60.15 meters. Quartz Diorite, hornblende rich.		0	5		
	Alteration: Ore Min.:	60.15 - 61.15 meters. Chlorite schist with 60 CA. foliation.		0.04	70		
	Alteration: Ore Min.:	61.15 - 61.80 meters. Hornblende-rich Quartz Diorite.		0	5		
	Alteration: sericitic Ore Min.:	61.8 - 68.10 meters. Hornblende schist,		0	10		

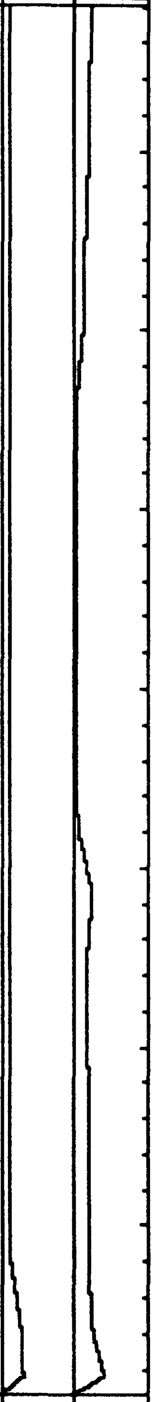
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-5

Project : Hamdah Drilling 1989

Logged by: P.Bosch & E.Jannadi Drilled: 2/02/1989 - 2/11/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
		interbedded w/ chlorite schist bands; abundant sericite bands alteration. Foliation @ 70 CA.	▨	0.01	5		
			▨	0	5		
65.00			▨				
			▨	0	5		
			▨	0	5		
			▨	0	15		
	Fine grained disseminated pyrite along and with quartz bands. Alteration: sericitic Ore Min.: fn.grn. diss. pyrite	68.1 - 74.85 meters. Qtz rich hornblende schist, fine grained, qtz bands; minor chlorite; abundant sericite bands alteration.	▨	0	5		
			▨	0	5		
70.00			▨				
			▨	0	0		
			▨	0	5		
			▨	0	5		
			▨	0	5		
			▨	0	5		
75.00	Very fine, disseminated pyrite along both sides of aplite dikes. 81.15: 2cm quartz vein with 40 CA. Alteration: chloritic Ore Min.: fine grn. pyrite	74.85 - 82.35 meters. Hornblende-chlorite schist; interbedding of chlorite and hornblende with abundant biotite bands; 1-3 cm aplite dikes throughout the unit.	▨	0	5		
			▨	0	5		
			▨	0	5		
			▨	0	5		
			▨	0	5		
80.00			▨				
			▨	0.01	5		
			▨	0.04	5		
			▨	0.23	5		
	End of hole at 82.35 metres.						

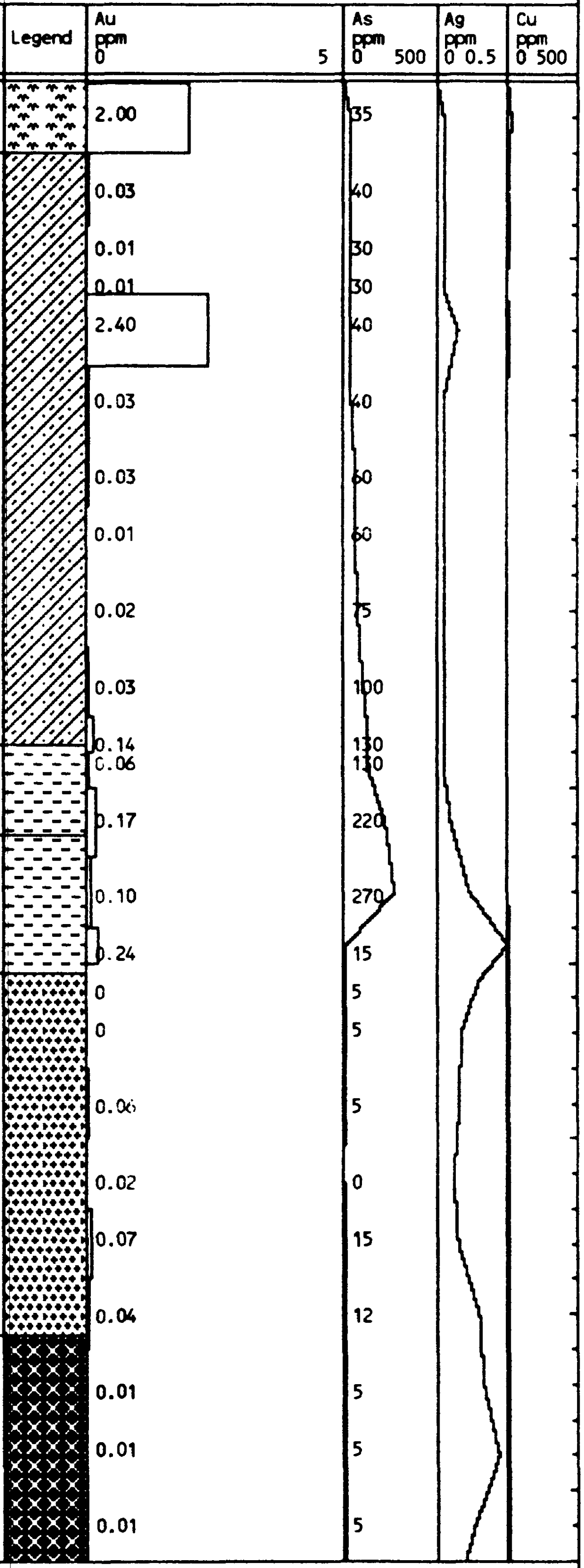


Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89

Depth Metres	Veins & Alteration	Lithology
	Alteration: Ore Min.:	0.00 - 1.00 meters. Mud: brown
5.00	3.00-3.40: Sheared zone. 8.90: Limonite alteration. Alteration: asbestos; hematitic, & limonitic. Ore Min.:	1 - 9.4 meters. Serpentinite: w/ asbestos alteration. Hematite along fractures.
10.00	9.4-9.7:sheared. Alteration: Ore Min.:	9.4 - 10.7 meters. Chl. schist, sheared along contact.
	Alteration: Ore Min.:	10.7 - 12.65 meters. chl. schist, sheared, fractured, and intermixed w/ serpentinite.
15.00	Alteration: hematitic, & limonitic. Ore Min.:	12.65 - 17.8 meters. Aplite, w/ hem stain along fractures.
20.00	Contact between aplite & diorite at 17.80, @ 70 CA. And small shear zone at 20.0. Alteration: hematitic Ore Min.:	17.8 - 22 meters. Diorite: with hbl,& chl matrix. Hematite alteration along fractures.



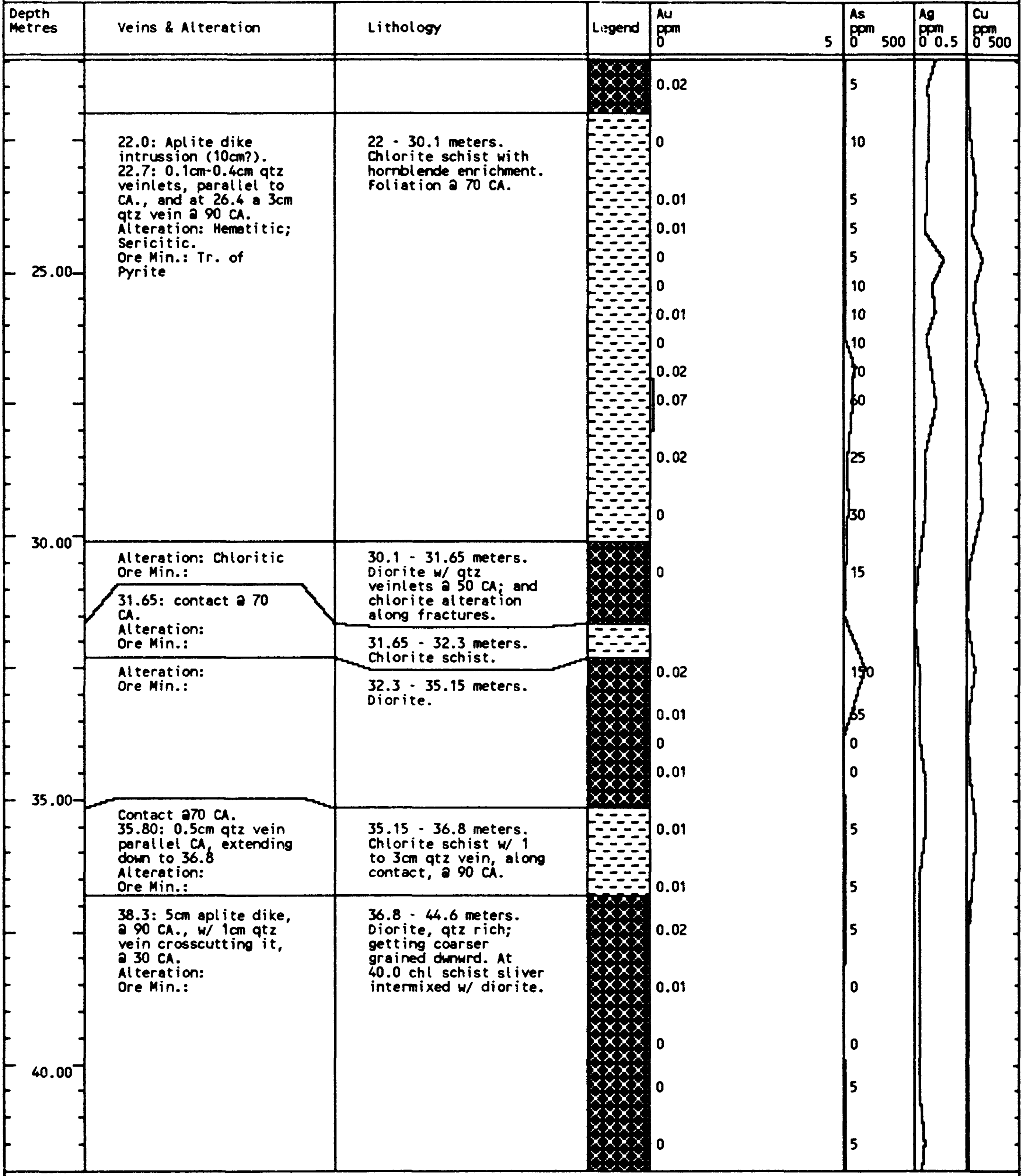
Au ppm	As ppm
2.00	35
0.03	40
0.01	30
0.01	30
2.40	40
0.03	40
0.03	60
0.01	60
0.02	75
0.03	100
0.14	130
0.06	130
0.17	220
0.10	270
0.24	15
0	5
0	5
0.06	5
0.02	0
0.07	15
0.04	12
0.01	5
0.01	5
0.01	5

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89



Veins & Alteration	Lithology
22.0: Aplite dike intrussion (10cm?). 22.7: 0.1cm-0.4cm qtz veinlets, parallel to CA., and at 26.4 a 3cm qtz vein ä 90 CA. Alteration: Hematitic; Sericitic. Ore Min.: Tr. of Pyrite	22 - 30.1 meters. Chlorite schist with hornblende enrichment. Foliation ä 70 CA.
Alteration: Chloritic Ore Min.:	30.1 - 31.65 meters. Diorite w/ qtz veinlets ä 50 CA; and chlorite alteration along fractures.
31.65: contact ä 70 CA. Alteration: Ore Min.:	31.65 - 32.3 meters. Chlorite schist.
Alteration: Ore Min.:	32.3 - 35.15 meters. Diorite.
Contact ä70 CA. 35.80: 0.5cm qtz vein parallel CA, extending down to 36.8 Alteration: Ore Min.:	35.15 - 36.8 meters. Chlorite schist w/ 1 to 3cm qtz vein, along contact, ä 90 CA.
38.3: 5cm aplite dike, ä 90 CA., w/ 1cm qtz vein crosscutting it, ä 30 CA. Alteration: Ore Min.:	36.8 - 44.6 meters. Diorite, qtz rich; getting coarser grained dwnwrd. At 40.0 chl schist sliver intermixed w/ diorite.

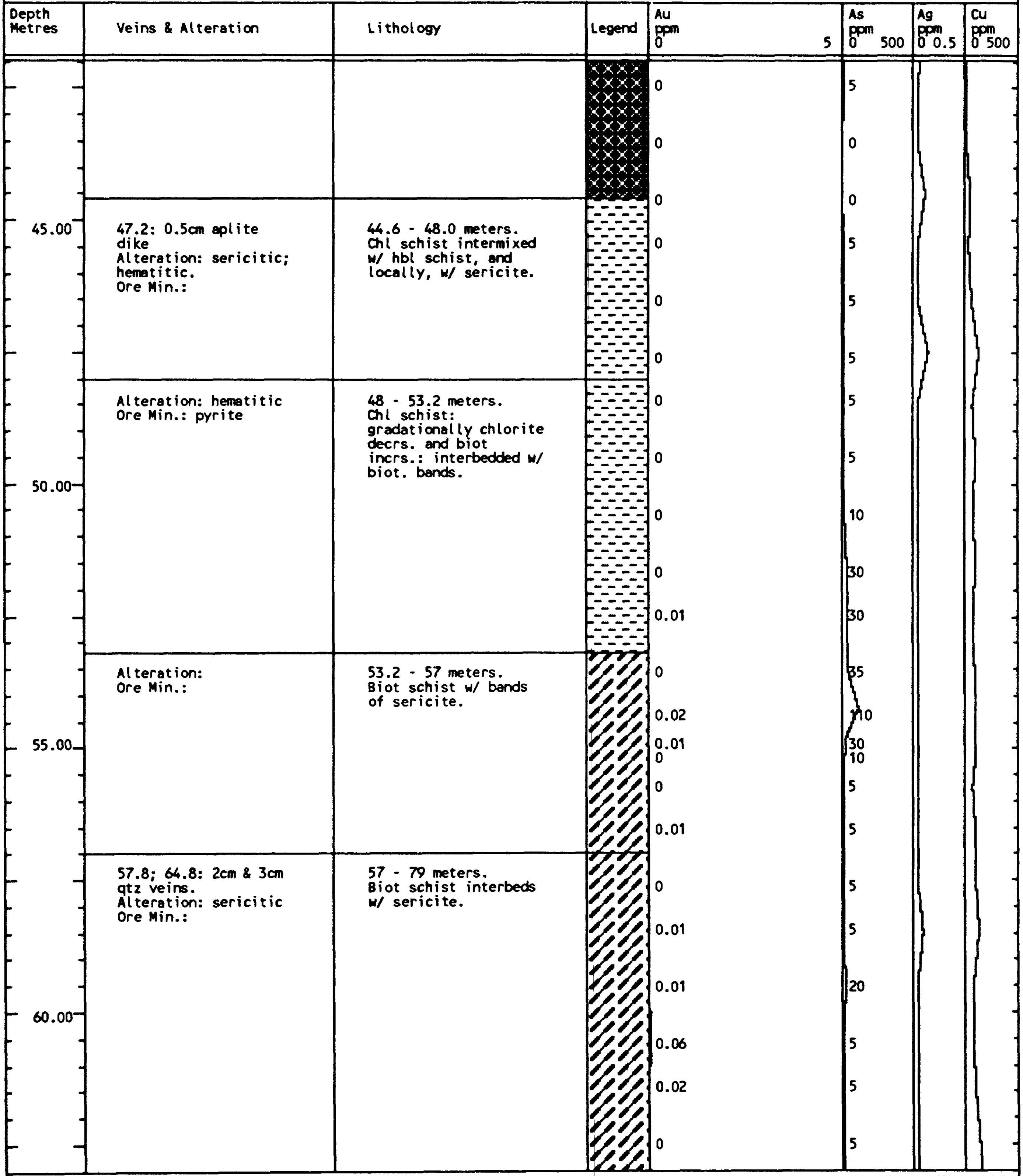
Au ppm	As ppm
0.02	5
0	10
0.01	5
0.01	5
0	5
0	10
0.01	10
0	10
0.02	70
0.07	60
0.02	25
0	30
0	15
0.02	150
0.01	65
0	0
0.01	0
0.01	5
0.01	5
0.02	5
0.01	0
0	0
0	5
0	5

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89



Veins & Alteration	Lithology
47.2: 0.5cm aplite dike Alteration: sericitic; hematitic. Ore Min.:	44.6 - 48.0 meters. Chl schist intermixed w/ hbl schist, and locally, w/ sericite.
Alteration: hematitic Ore Min.: pyrite	48 - 53.2 meters. Chl schist: gradationally chlorite decrs. and biot incrs.: interbedded w/ biot. bands.
Alteration: Ore Min.:	53.2 - 57 meters. Biot schist w/ bands of sericite.
57.8; 64.8: 2cm & 3cm qtz veins. Alteration: sericitic Ore Min.:	57 - 79 meters. Biot schist interbeds w/ sericite.

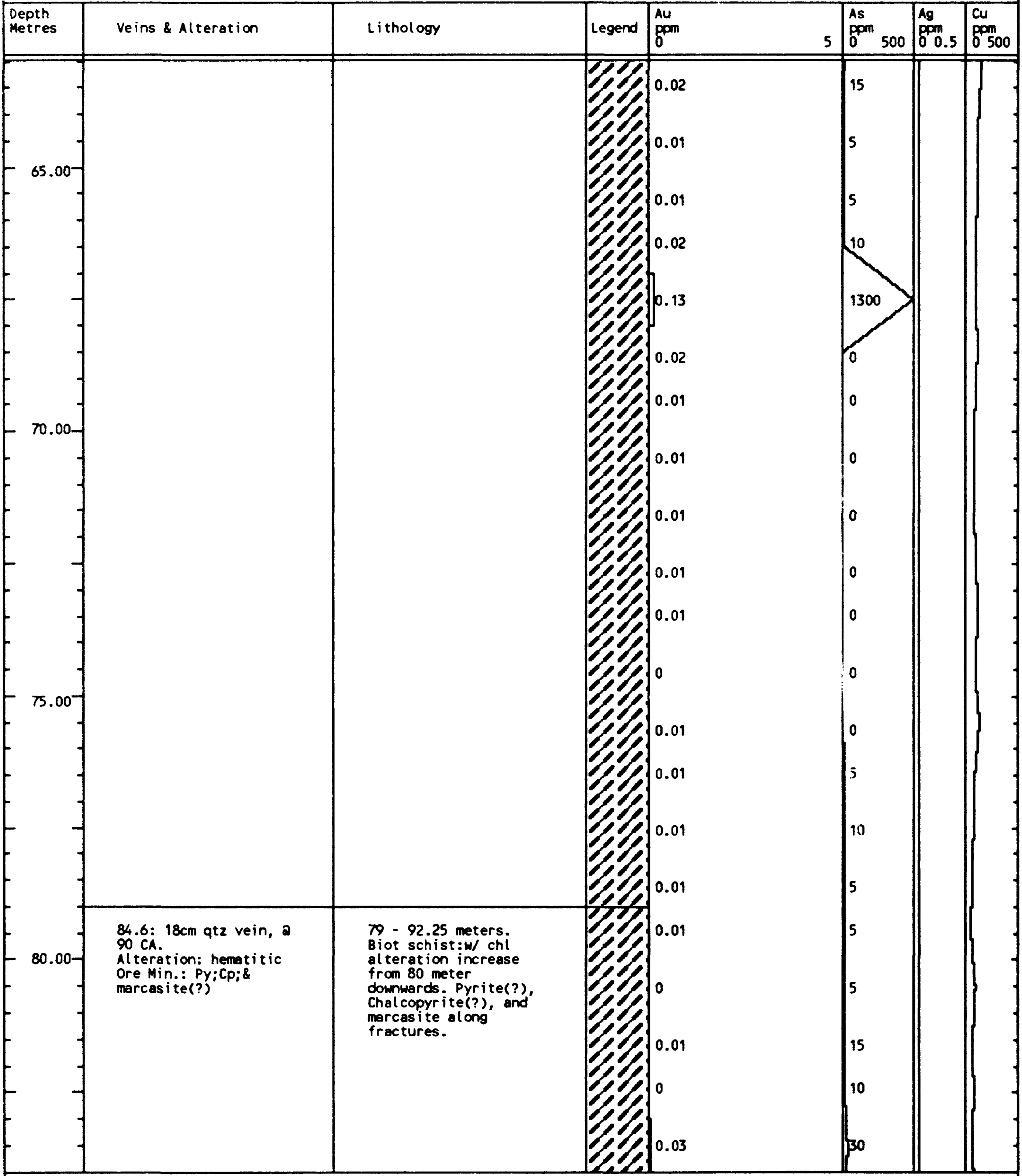
Au ppm	As ppm
0	5
0	0
0	0
0	5
0	5
0	5
0	5
0	5
0	10
0	30
0.01	30
0	35
0.02	110
0.01	30
0	10
0	5
0.01	5
0	5
0.01	5
0.01	20
0.06	5
0.02	5
0	5

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89



84.6: 18cm qtz vein, @ 90 CA.
Alteration: hematitic
Ore Min.: Py;Cp;& marcasite(?)

79 - 92.25 meters. Biot schist:w/ chl alteration increase from 80 meter downwards. Pyrite(?), Chalcopyrite(?), and marcasite along fractures.

Au ppm	As ppm
0.02	15
0.01	5
0.01	5
0.02	10
0.13	1300
0.02	0
0.01	0
0.01	0
0.01	0
0.01	0
0.01	0
0	0
0.01	0
0.01	5
0.01	10
0.01	5
0.01	5
0	5
0.01	15
0	10
0.03	30

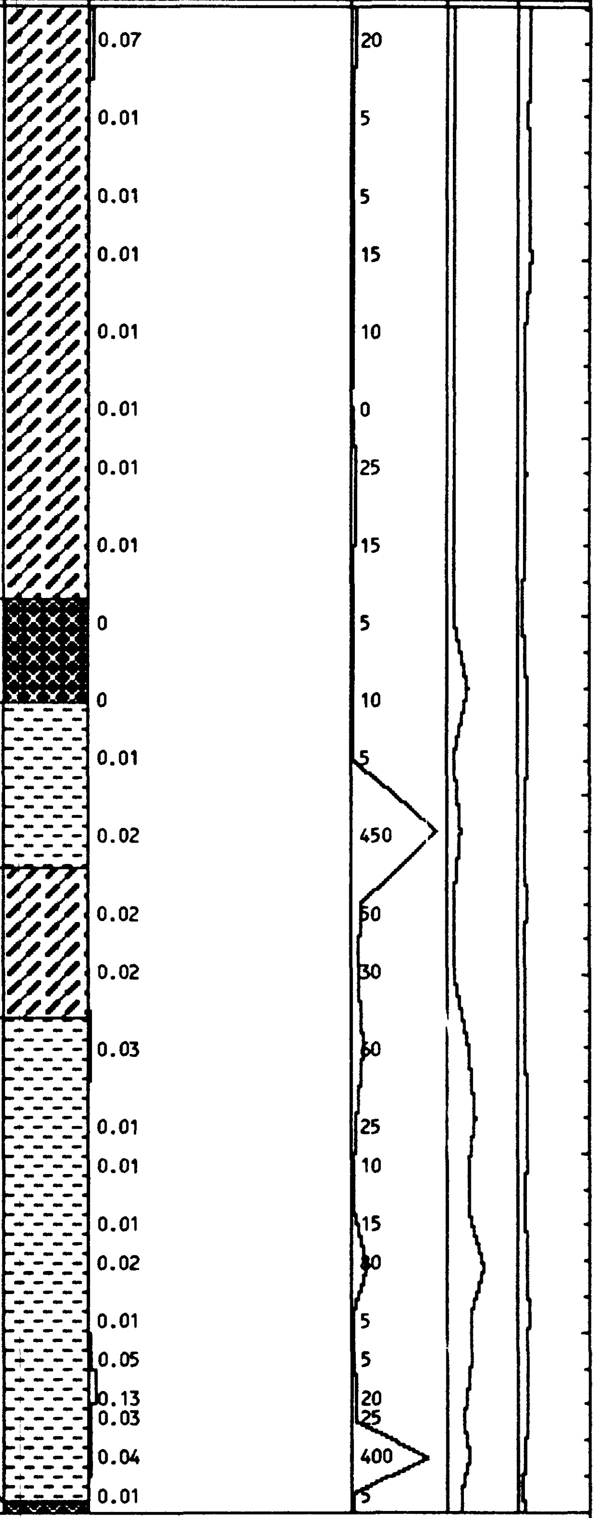
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89

Depth Metres	Veins & Alteration	Lithology
85.00		
90.00		
	Alteration: Ore Min.:	92.25 - 93.7 meters. Diorite; qtz rich, fine grained, becomes coaser around 93.m
95.00	95.30; 95.70: 5cm & 10 cm qtz vein @ 80 & 60 CA. Alteration: Ore Min.: pyrite	93.7 - 96 meters. Chl schist w/ py along edges of qtz veins.
	Alteration: Ore Min.:	96 - 98.12 meters. Biotite schist.
100.00	100.05-101.3: Fold structure deformation. 104.40: 8cm qtz vein @ 80 CA. Alteration: Ore Min.: py,bornite(-?) marcasite(?)	98.12 - 104.85 meters. Chl schist w/ biot schist, and scattered dissemination of Py, bornite (?), & marcasite (?).
	Alteration: Ore Min.:	104.85 - 105.1 meters. Diorite, qtz rich



Au ppm	As ppm
0.07	20
0.01	5
0.01	5
0.01	15
0.01	10
0.01	0
0.01	25
0.01	15
0	5
0	10
0.01	5
0.02	450
0.02	50
0.02	30
0.03	60
0.01	25
0.01	10
0.01	15
0.02	40
0.01	5
0.05	5
0.13	20
0.03	25
0.04	400
0.01	5

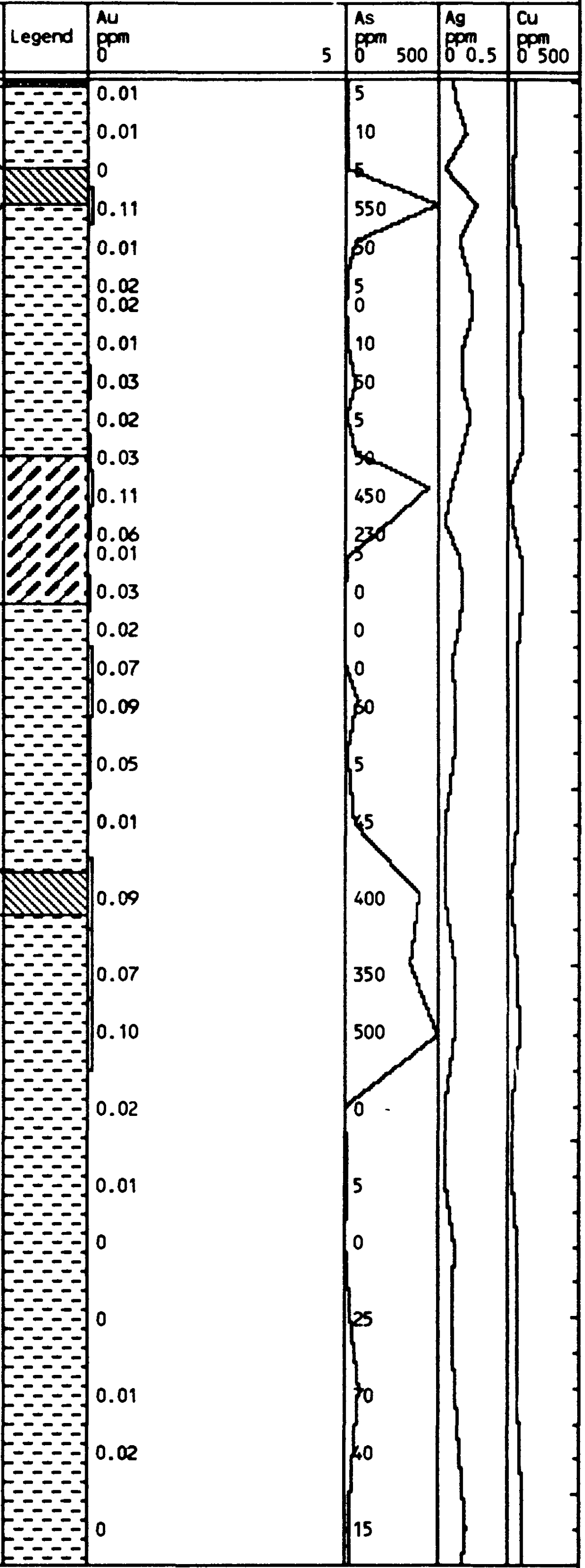
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89

Depth Metres	Veins & Alteration	Lithology
105.00	Alteration: Ore Min.: pyrite	105.1 - 106.25 meters. Chlorite schist
	Alteration: Ore Min.: pyrite	106.25 - 106.75 meters. Sericite schist, light green.
110.00	Alteration: Ore Min.: pyrite	106.75 - 110.3 meters. Chlorite schist.
	Fault zone Alteration: Ore Min.: pyrite, & chalcopyrite.	110.3 - 112.4 meters. Highly broken & fragmented, biotite schist. Py, Cp and 0.5cm graphite are present.
115.00	112.95-113.20 & 114.45-114.65 : qtz diorite dikes, @ 20 & 70 CA. 113.95: 1cm qtz vein @ 80 CA; contains pyrite. Alteration: sericitic. Ore Min.: pyrite	112.4 - 116.2 meters. Chlorite schist: has epidote alt and sericite.
	Alteration: Ore Min.: pyrite	116.2 - 116.8 meters. Sericite schist w/ 50 CA at contact.
120.00 125.00	118.9: Fold deformation structr. 120.2: 1-6cm qtz veins @ 75 CA. 127.3-127.5: aplite dike @ 60 CA. Alteration: sericitic Ore Min.: pyrite	116.8 - 132.4 meters. Chlorite schist contains disseminated pyrite



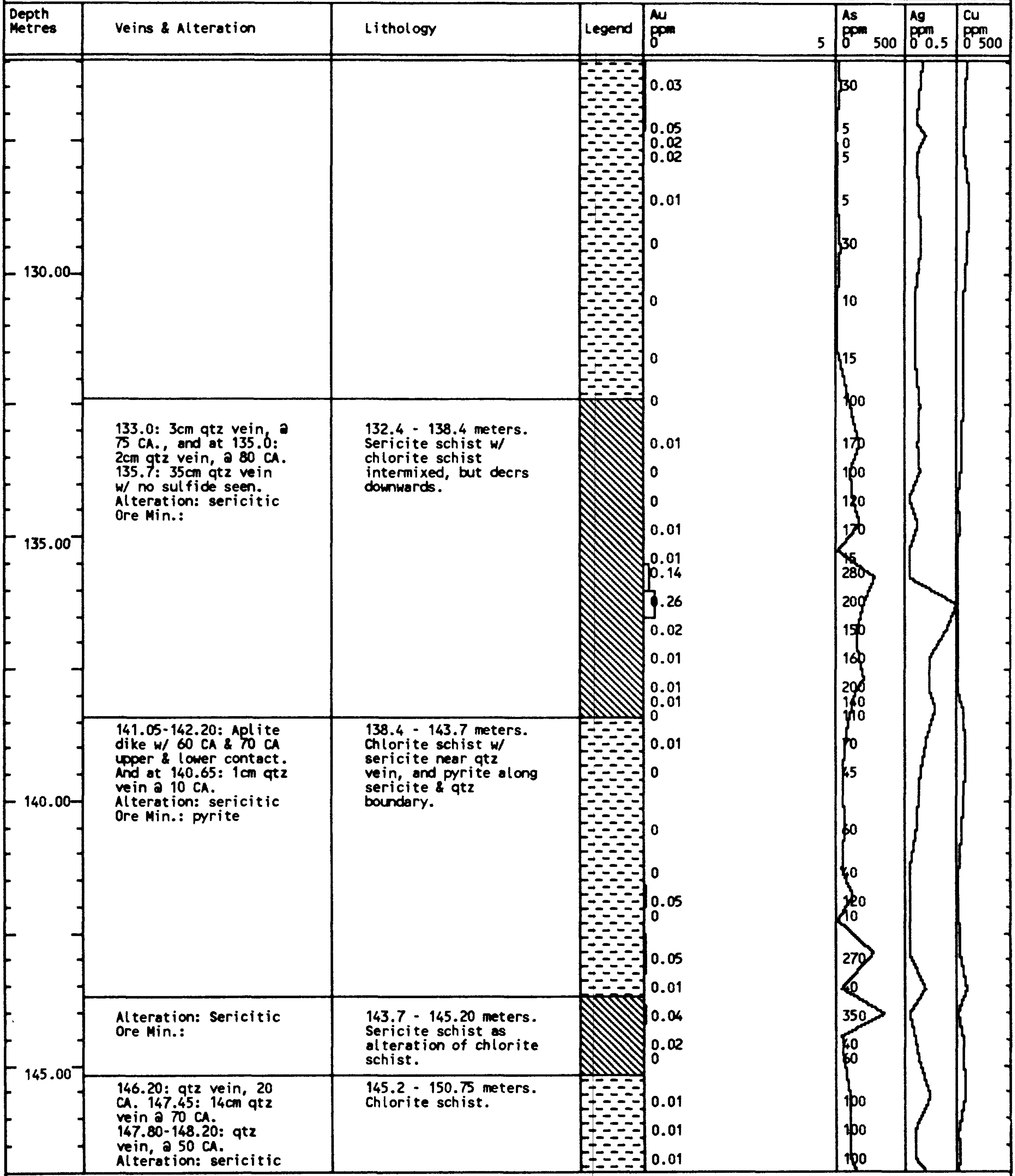
Au ppm	As ppm
0.01	5
0.01	10
0	5
0.11	550
0.01	50
0.02	5
0.02	0
0.01	10
0.03	50
0.02	5
0.03	50
0.11	450
0.06	230
0.01	5
0.03	0
0.02	0
0.07	0
0.09	60
0.05	5
0.01	45
0.09	400
0.07	350
0.10	500
0.02	0
0.01	5
0	0
0	25
0.01	70
0.02	40
0	15

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89



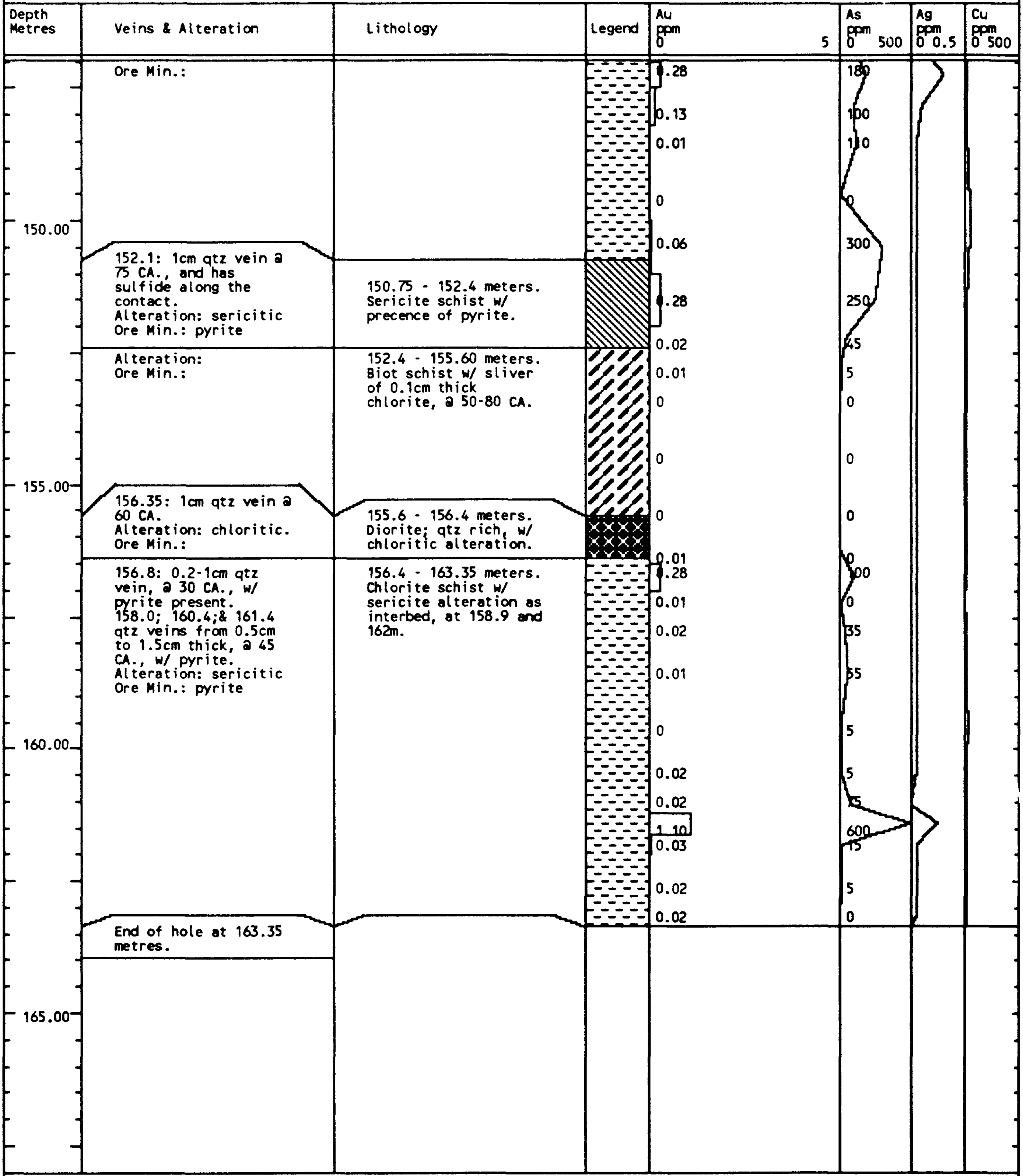
Veins & Alteration	Lithology
133.0: 3cm qtz vein, @ 75 CA., and at 135.0: 2cm qtz vein, @ 80 CA. 135.7: 35cm qtz vein w/ no sulfide seen. Alteration: sericitic Ore Min.:	132.4 - 138.4 meters. Sericite schist w/ chlorite schist intermixed, but decrs downwards.
141.05-142.20: Aplite dike w/ 60 CA & 70 CA upper & lower contact. And at 140.65: 1cm qtz vein @ 10 CA. Alteration: sericitic Ore Min.: pyrite	138.4 - 143.7 meters. Chlorite schist w/ sericite near qtz vein, and pyrite along sericite & qtz boundary.
Alteration: Sericitic Ore Min.:	143.7 - 145.20 meters. Sericite schist as alteration of chlorite schist.
146.20: qtz vein, 20 CA. 147.45: 14cm qtz vein @ 70 CA. 147.80-148.20: qtz vein, @ 50 CA. Alteration: sericitic	145.2 - 150.75 meters. Chlorite schist.

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-6

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/13/89 - 2/18/89



Ore Min.:

152.1: 1cm qtz vein @ 75 CA., and has sulfide along the contact.
Alteration: sericitic
Ore Min.: pyrite

150.75 - 152.4 meters. Sericite schist w/ precence of pyrite.

Alteration:
Ore Min.:

152.4 - 155.60 meters. Biot schist w/ sliver of 0.1cm thick chlorite, @ 50-80 CA.

156.35: 1cm qtz vein @ 60 CA.
Alteration: chloritic.
Ore Min.:

155.6 - 156.4 meters. Diorite; qtz rich, w/ chloritic alteration.

156.8: 0.2-1cm qtz vein, @ 30 CA., w/ pyrite present. 158.0; 160.4;& 161.4 qtz veins from 0.5cm to 1.5cm thick, @ 45 CA., w/ pyrite.
Alteration: sericitic
Ore Min.: pyrite

156.4 - 163.35 meters. Chlorite schist w/ sericite alteration as interbed, at 158.9 and 162m.

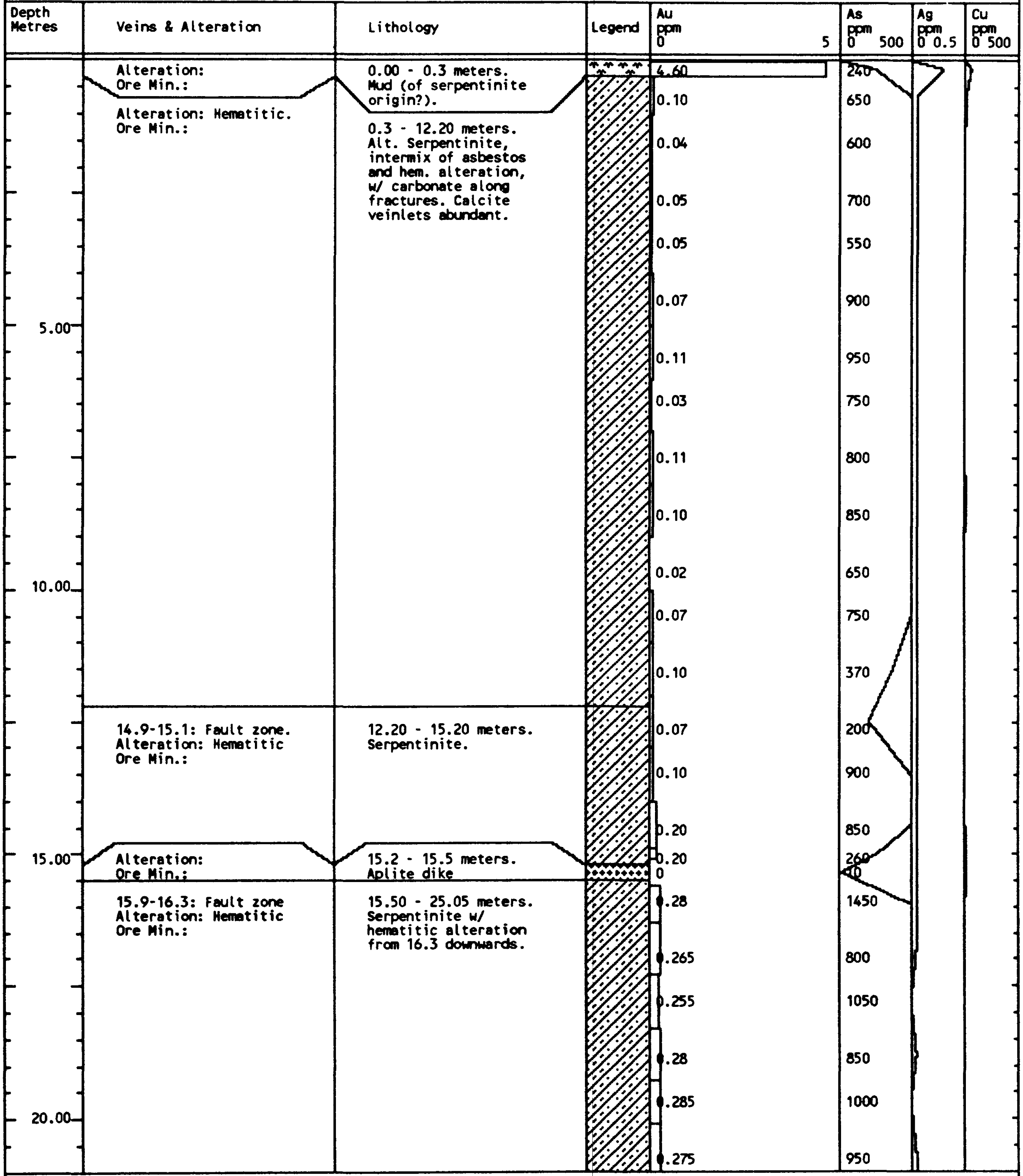
End of hole at 163.35 metres.

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-7

Project : Hamdah Drilling 1989

Logged by: Paul Bosch Drilled: 2/18/89 - 2/20/89



Alteration:
Ore Min.:

0.00 - 0.3 meters.
Mud (of serpentinite origin?).

Alteration: Hematitic.
Ore Min.:

0.3 - 12.20 meters.
Alt. Serpentinite, intermix of asbestos and hem. alteration, w/ carbonate along fractures. Calcite veinlets abundant.

14.9-15.1: Fault zone.
Alteration: Hematitic
Ore Min.:

12.20 - 15.20 meters.
Serpentinite.

Alteration:
Ore Min.:

15.2 - 15.5 meters.
Aplite dike

15.9-16.3: Fault zone
Alteration: Hematitic
Ore Min.:

15.50 - 25.05 meters.
Serpentinite w/ hematitic alteration from 16.3 downwards.

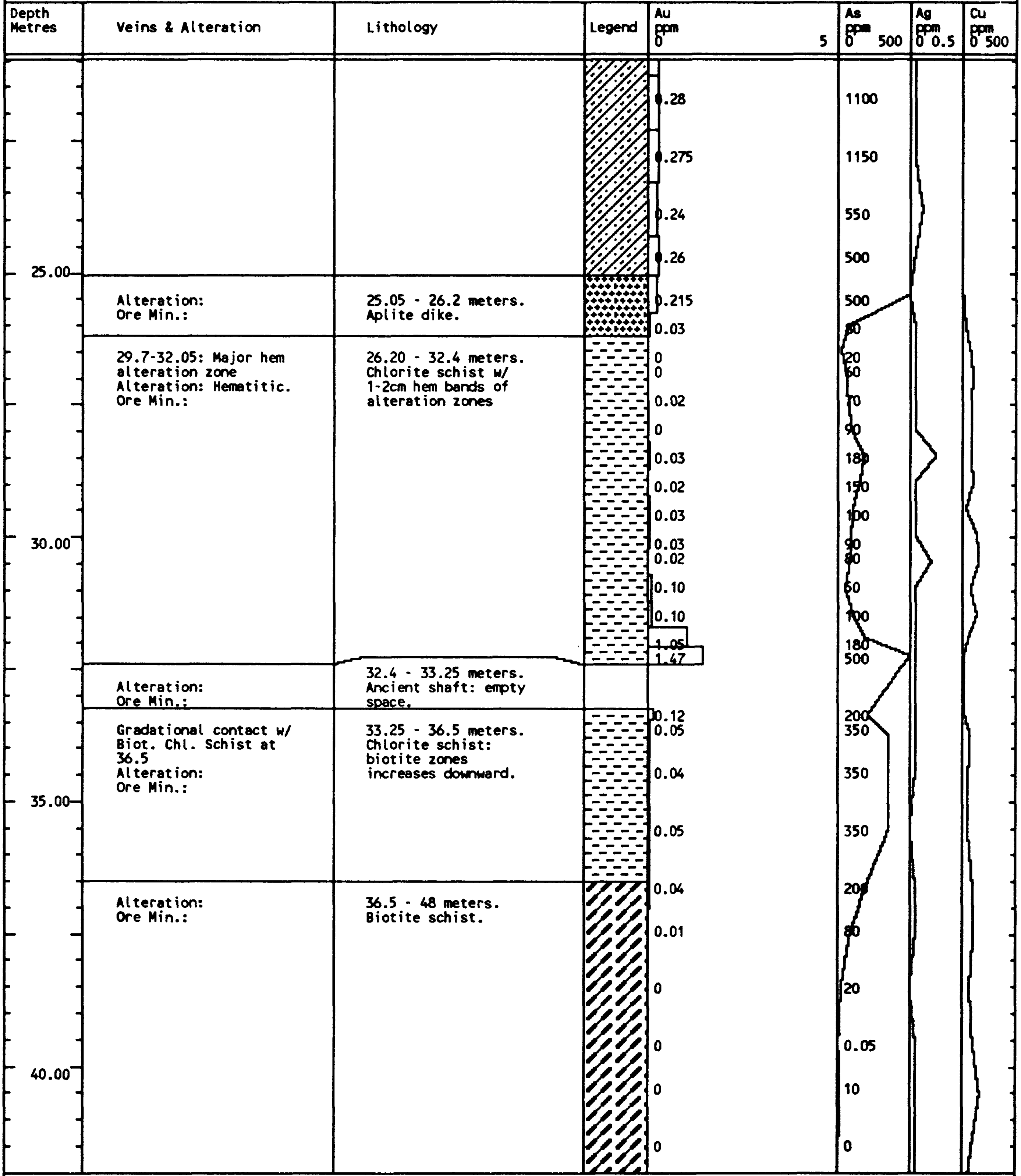
Au ppm	As ppm
4.60	240
0.10	650
0.04	600
0.05	700
0.05	550
0.07	900
0.11	950
0.03	750
0.11	800
0.10	850
0.02	650
0.07	750
0.10	370
0.07	200
0.10	900
.20	850
0.20	260
0	40
.28	1450
.265	800
.255	1050
.28	850
.285	1000
.275	950

U..S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-7

Project : Hamdah Drilling 1989

Logged by: Paul Bosch   **Drilled:** 2/18/89 - 2/20/89



Veins & Alteration	Lithology
Alteration: Ore Min.:	25.05 - 26.2 meters. Aplite dike.
29.7-32.05: Major hem alteration zone Alteration: Hematitic. Ore Min.:	26.20 - 32.4 meters. Chlorite schist w/ 1-2cm hem bands of alteration zones
Alteration: Ore Min.:	32.4 - 33.25 meters. Ancient shaft: empty space.
Gradational contact w/ Biot. Chl. Schist at 36.5 Alteration: Ore Min.:	33.25 - 36.5 meters. Chlorite schist: biotite zones increases downward.
Alteration: Ore Min.:	36.5 - 48 meters. Biotite schist.

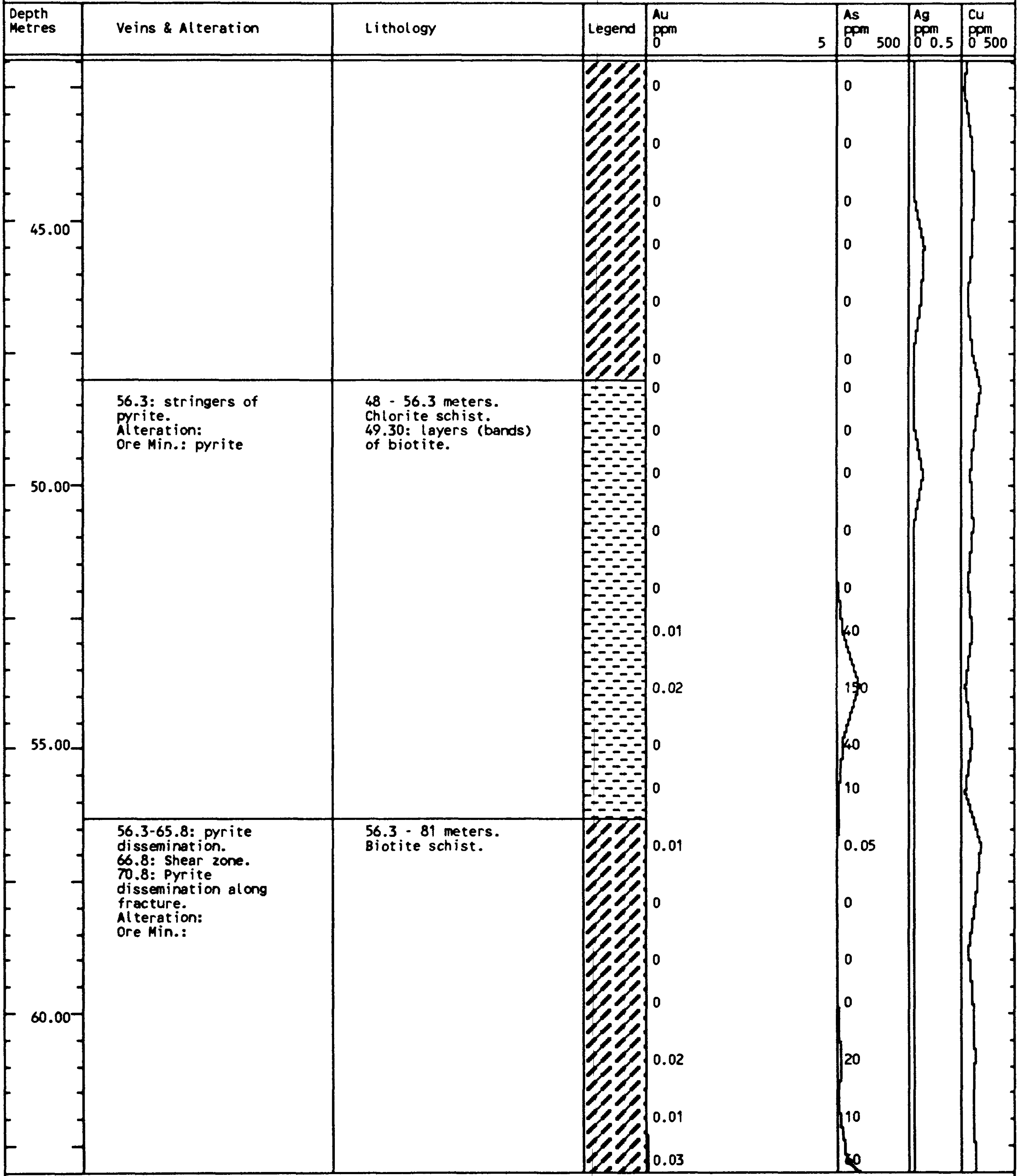
Au ppm	As ppm
.28	1100
.275	1150
.24	550
.26	500
.215	500
0.03	80
0	20
0	60
0.02	70
0	90
0.03	180
0.02	150
0.03	100
0.03	90
0.02	80
0.10	60
0.10	100
1.05	180
1.47	500
0.12	200
0.05	350
0.04	350
0.05	350
0.04	200
0.01	80
0	20
0	0.05
0	10
0	0

U..S.G.S. Jeddah Mission   SCALE: 1:100

Drill Hole No.: HR 89-7

Project : Hamdah Drilling 1989

Logged by: Paul Bosch Drilled: 2/18/89 - 2/20/89



56.3: stringers of pyrite.
Alteration:
Ore Min.: pyrite

48 - 56.3 meters.
Chlorite schist.
49.30: layers (bands) of biotite.

56.3-65.8: pyrite dissemination.
66.8: Shear zone.
70.8: Pyrite dissemination along fracture.
Alteration:
Ore Min.:

56.3 - 81 meters.
Biotite schist.

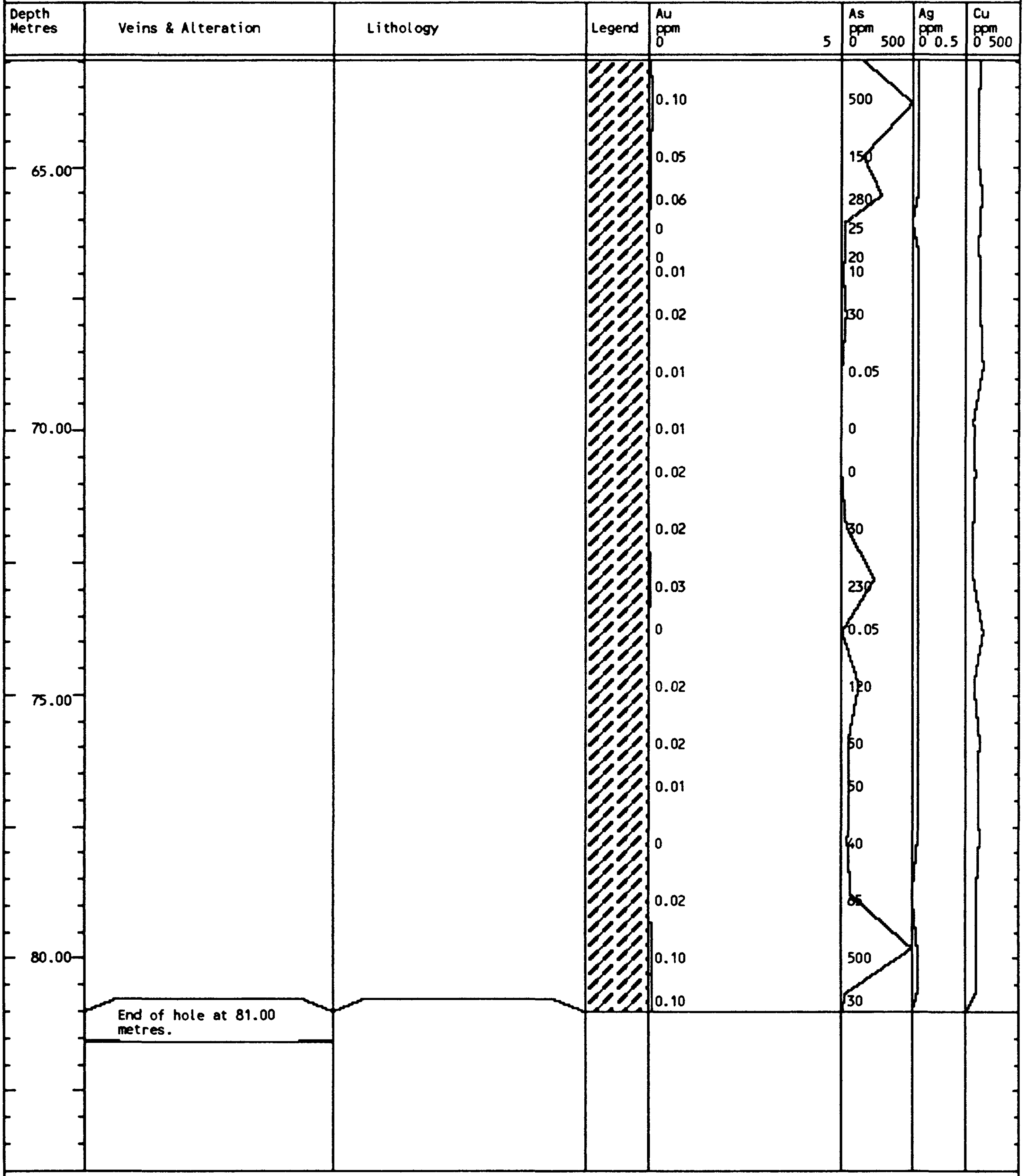
Au ppm	As ppm
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0.01	40
0.02	150
0	40
0	10
0.01	0.05
0	0
0	0
0	0
0.02	20
0.01	10
0.03	[illegible]0

U..S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-7

Project : Hamdah Drilling 1989

Logged by: Paul Bosch Drilled: 2/18/89 - 2/20/89



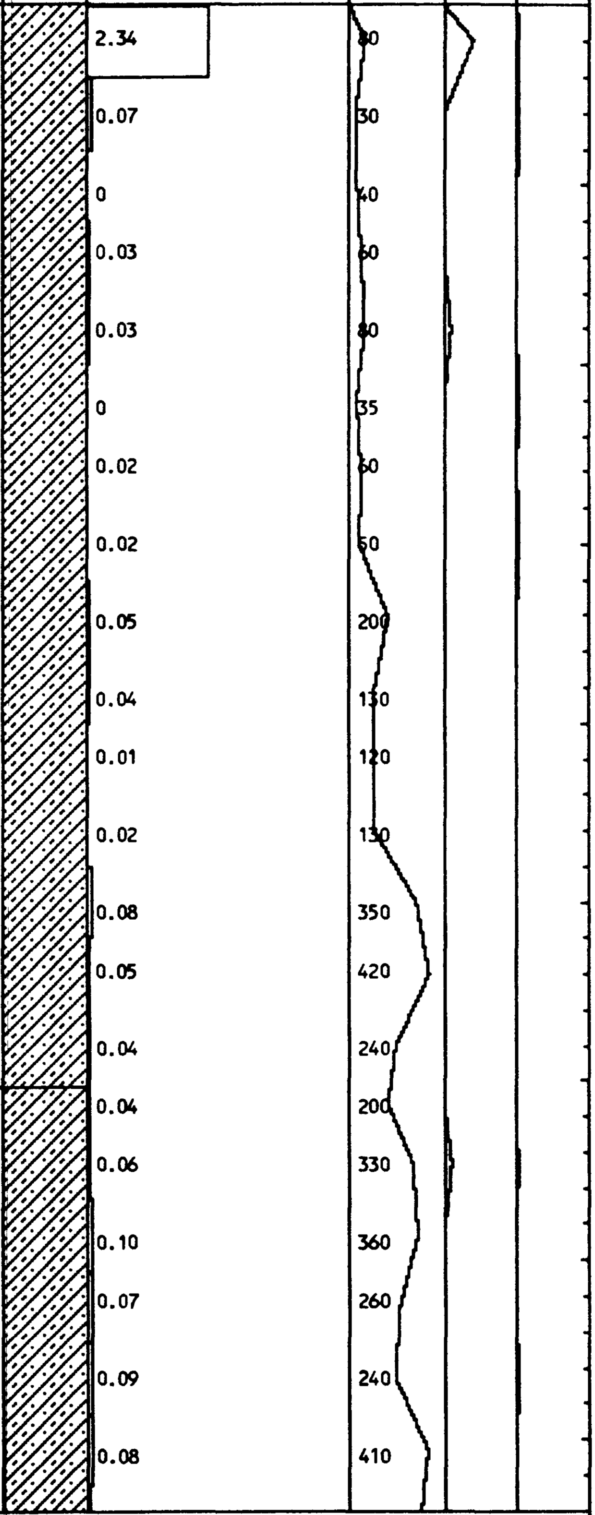
U..S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-8

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/20/1989 2/22/1989.

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
5.00 10.00	0-1.90: Mud & argillite. Alteration: argillitic. Limonitic Ore Min.:	0.00 - 15.10 meters. Altered and oxidized serpentinite w/ mud near surface. Argillite, Asbestos & limonite plus talc are present.	▨	2.34 0.07 0 0.03 0.03 0 0.02 0.02 0.05 0.04 0.01 0.02 0.08 0.05 0.04	80 30 40 60 80 35 60 50 200 130 120 130 350 420 240		
15.00 20.00	22.30-22.75: Sheared zone at contact w/ aplite Alteration: Hematitic Ore Min.:	15.1 - 22.75 meters. Oxidized serpentinite w/ hematite alteration, minor talc present.	▨	0.04 0.06 0.10 0.07 0.09 0.08	200 330 360 260 240 410		



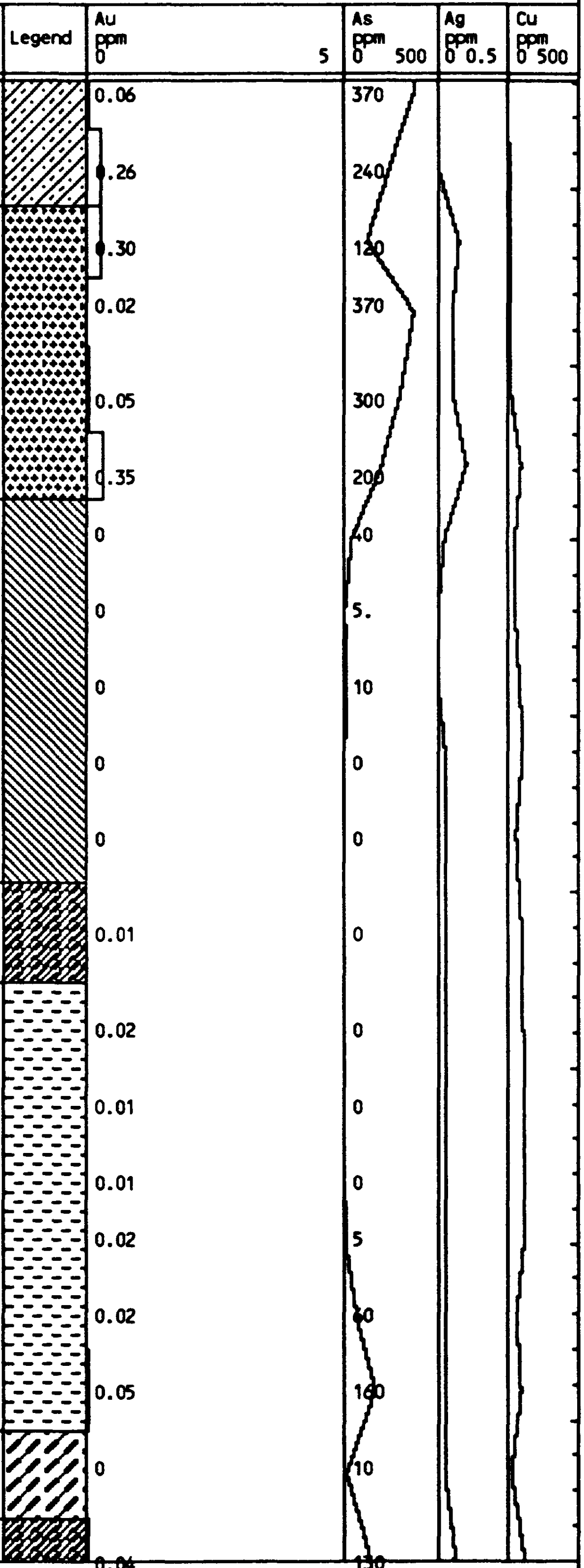
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-8

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/20/1989 2/22/1989.

Depth Metres	Veins & Alteration	Lithology
25.00	22.75-25.95: Aplite has serpentinite & hem. 25.95 downward contains serp & hbl schist. Alteration: Hematitic Ore Min.:	22.75 - 26.90 meters. Aplite dike.
30.00	29.80: 10cm Qtz vein @ 70 CA. Alteration: Chloritic. Ore Min.:	26.9 - 32.35 meters. Sericite schist interbedded w/ hbl schist; w/ foliation @ 80 CA.
	Alteration: Chloritic & sericitic. Ore Min.:	32.35 - 33.80 meters. Hbl schist w/ 80 CA. foliation; abundant chlorite, epidote, & sericite.
35.00	Alteration: Ore Min.:	33.8 - 40.15 meters. Chlorite biotite schist, w/ chlorite & biotite bands interbedding. Epidote is present.
40.00	Alteration: sericitic Ore Min.:	40.15 - 41.40 meters. Biotite schist w/ minor chlorite.
	Alteration: sericitic	41.4 - 49.60 meters.



Au ppm	As ppm
0.06	370
.26	240
.30	120
0.02	370
0.05	300
.35	200
0	40
0	5.
0	10
0	0
0	0
0.01	0
0.02	0
0.01	0
0.01	0
0.02	5
0.02	60
0.05	160
0	10
0.04	130

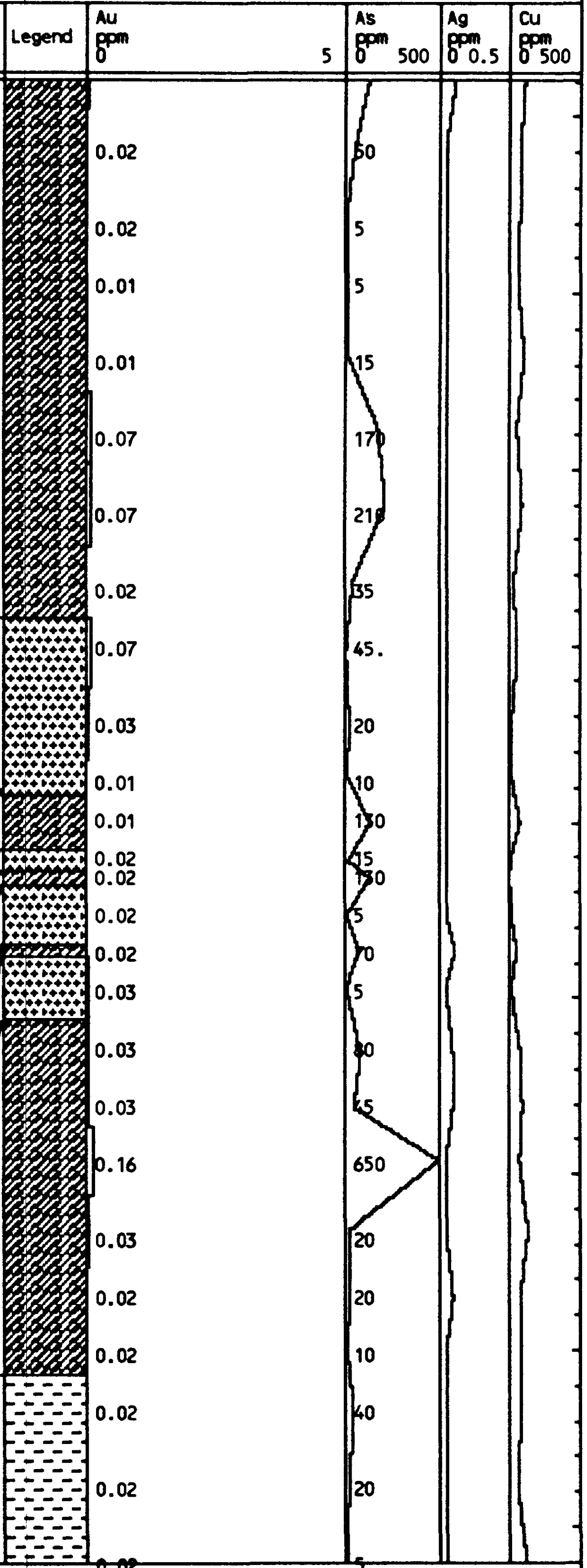
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-8

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi   Drilled: 2/20/1989 2/22/1989.

Depth Metres	Veins & Alteration	Lithology
	Ore Min.:	Hornblende biot schist w/ 85 CA foliation. Chlorite, sericite & epidote are present.
45.00		
50.00	50.0: 0.5-1.5cm Qtz vein @ 85 CA.w/ sericite alongside & disseminated pyrrhotite Alteration: Ore Min.: Pyrrhotite	49.6 - 52.10 meters. Pink Aplite, w/ Kspar and qtz phenocryst, & hornblende.
	Alteration: Ore Min.:	52.1 - 52.9 meters. Hornblende schist; epidotized. Chlorite abundant. Foliation @ 80 CA.
	Alteration: Ore Min.:	52.9 - 53.20 meters. Aplite dike
	Alteration: Ore Min.:	53.2 - 53.4 meters. Hornblende schist; epidotized.
55.00	Alteration: Ore Min.:	53.4 - 54.25 meters. Aplite dike.
	Alteration: Ore Min.:	54.25 - 54.4 meters. Hornblende schist.
	Alteration: Ore Min.:	54.4 - 55.3 meters. Aplite dike.
	Alteration: Ore Min.: Dissem. Py & pyrrhotite	55.3 - 60.35 meters. Hornblende chlorite schist, w/ minor biotite bands. Foliation @ 65 CA.
60.00	62.0: 10cm Epidote band Alteration: Ore Min.:	60.35 - 63.55 meters. Chlorite biotite schist. Foliation @ 80 CA.



Au ppm	As ppm
0.02	50
0.02	5
0.01	5
0.01	15
0.07	170
0.07	210
0.02	35
0.07	45.
0.03	20
0.01	10
0.01	130
0.02	15
0.02	150
0.02	5
0.02	70
0.03	5
0.03	80
0.03	45
0.16	650
0.03	20
0.02	20
0.02	10
0.02	40
0.02	20
0.02	5

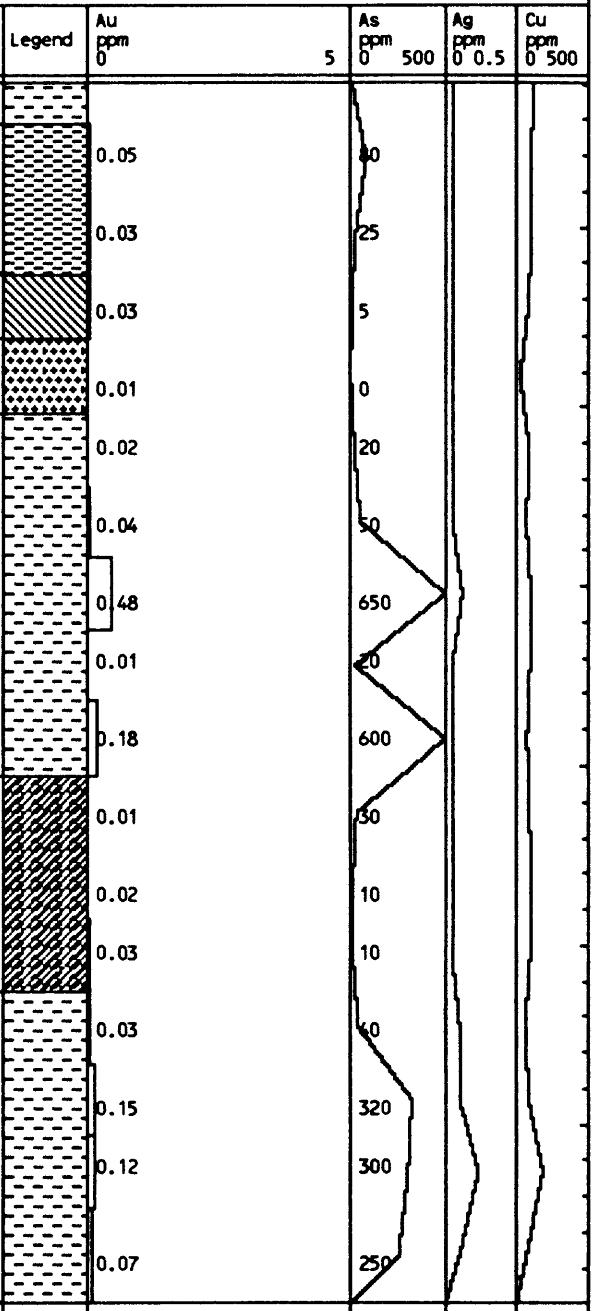
U.S.G.S. Jeddah Mission   SCALE: 1:100

Drill Hole No.: HR 89-8

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/20/1989 2/22/1989.

Depth Metres	Veins & Alteration	Lithology
	Alteration: chloritic Ore Min.:	63.55 - 65.65 meters. Meta-tuff, fine grained, massive, w/ minor chlorite and sericite are present.
65.00	Alteration: Ore Min.: Pyrrhotite & pyrite dissem	65.65 - 66.55 meters. Sericite biotite schist; foliation @ 70 CA.
	Alteration: Ore Min.:	66.55 - 67.60 meters. Aplite dike.
70.00	Alteration: Sericitic Ore Min.:	67.6 - 72.65 meters. Chlorite biotite schist.Chlorite and biot bands interbedded, w/ abundance of sericite.
	Alteration: Ore Min.:	72.65 - 75.65 meters. Hornblende schist w/ abundant sericite; @ 85 CA. Biotite is present & increases downwards.
75.00	Alteration: Ore Min.:	75.65 - 80.0 meters. Chlorite biotite schist & abundance of sericite; foliation @75 CA.
80.00	End of hole at 80.00 metres.	



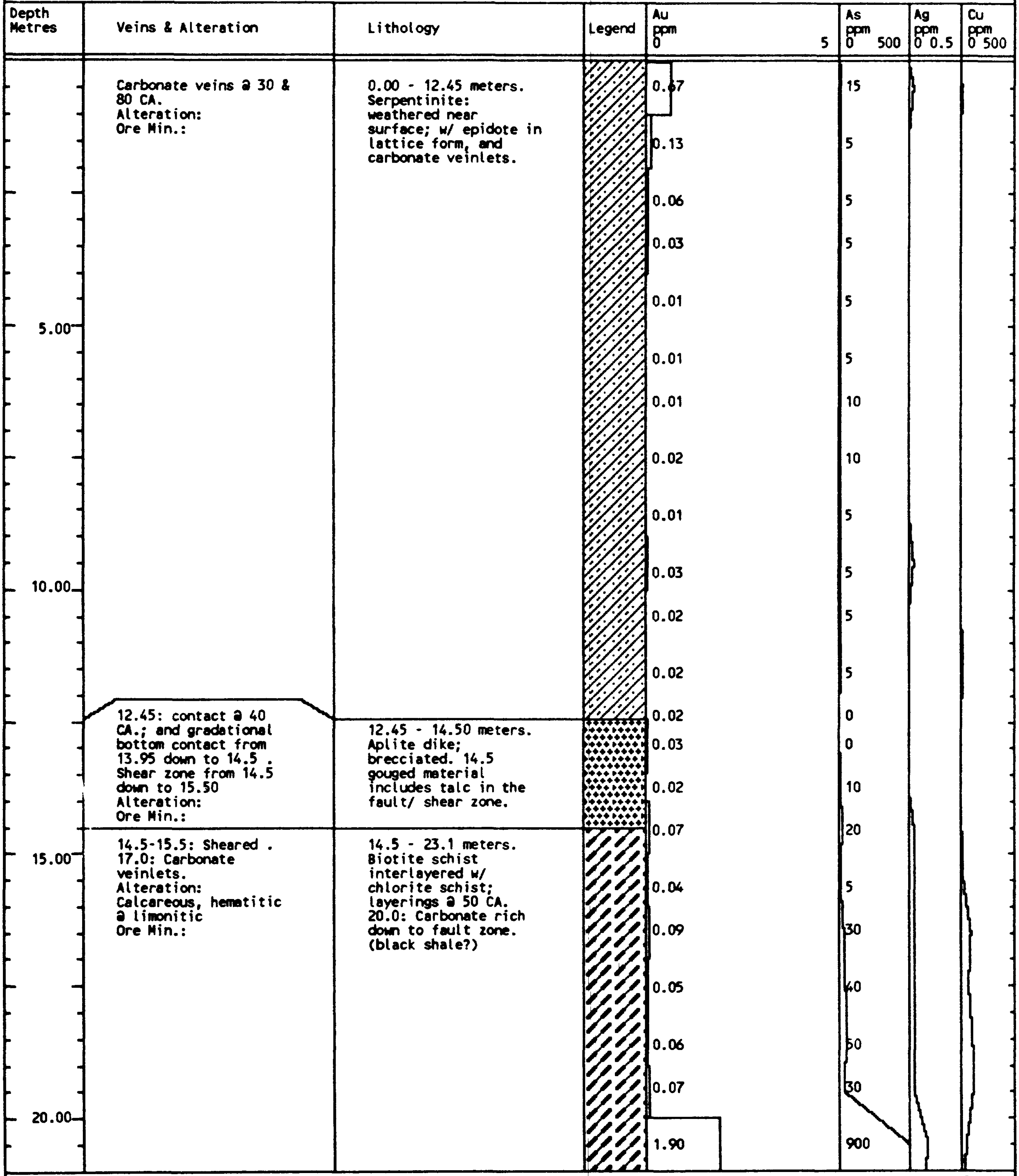
Au ppm	As ppm
0.05	40
0.03	25
0.03	5
0.01	0
0.02	20
0.04	50
0.48	650
0.01	20
0.18	600
0.01	30
0.02	10
0.03	10
0.03	40
0.15	320
0.12	300
0.07	250

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-9

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/25/1989 - 2/26/1989



Veins & Alteration	Lithology
Carbonate veins @ 30 & 80 CA. Alteration: Ore Min.:	0.00 - 12.45 meters. Serpentinite: weathered near surface; w/ epidote in lattice form, and carbonate veinlets.
12.45: contact @ 40 CA.; and gradational bottom contact from 13.95 down to 14.5 . Shear zone from 14.5 down to 15.50 Alteration: Ore Min.:	12.45 - 14.50 meters. Aplite dike; brecciated. 14.5 gouged material includes talc in the fault/ shear zone.
14.5-15.5: Sheared . 17.0: Carbonate veinlets. Alteration: Calcareous, hematitic @ limonitic Ore Min.:	14.5 - 23.1 meters. Biotite schist interlayered w/ chlorite schist; layerings @ 50 CA. 20.0: Carbonate rich down to fault zone. (black shale?)

Au ppm	As ppm
0.67	15
0.13	5
0.06	5
0.03	5
0.01	5
0.01	5
0.01	10
0.02	10
0.01	5
0.03	5
0.02	5
0.02	5
0.02	0
0.03	0
0.02	10
0.07	20
0.04	5
0.09	30
0.05	40
0.06	50
0.07	30
1.90	900

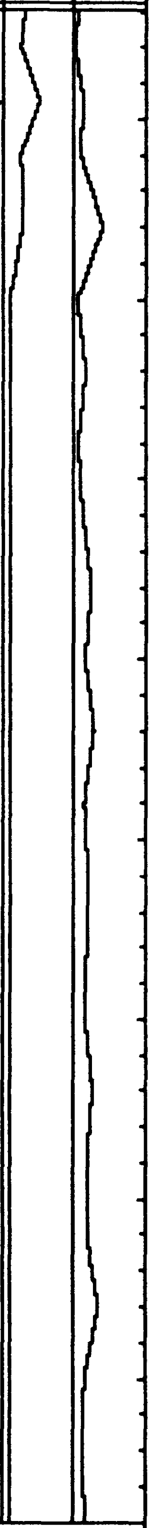
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-9

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/25/1989 - 2/26/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
			▨	0.99	600		
			▨	0.93	500		
			▨	0.06	40		
	Fault zone Alteration: Ore Min.:	23.1 - 25.6 meters. Highly broken and fragmented biotite schist within fault zone.	▨	0.17	140		
25.00			▨	0.03	20		
	28.05: 2cm aplite dikelets @90 CA., cut by Carbonate veinlets @ 40 CA. Alteration: chloritic Ore Min.:	25.6 - 45.75 meters. Biotite schist with local thin layers of chlorite alteration.	▨	0.04	50		
			▨	0.04	130		
			▨	0	5		
			▨	0	0		
30.00			▨	0.01	0		
			▨	0	5		
			▨	0.01	5		
			▨	0.01	0		
			▨	0.01	0		
35.00			▨	0.01	0		
			▨	0.01	0		
			▨	0.01	0		
			▨	0.01	0		
			▨	0.01	5		
40.00			▨	0.02	10		
			▨	0.01	5		
			▨	0.01	10		



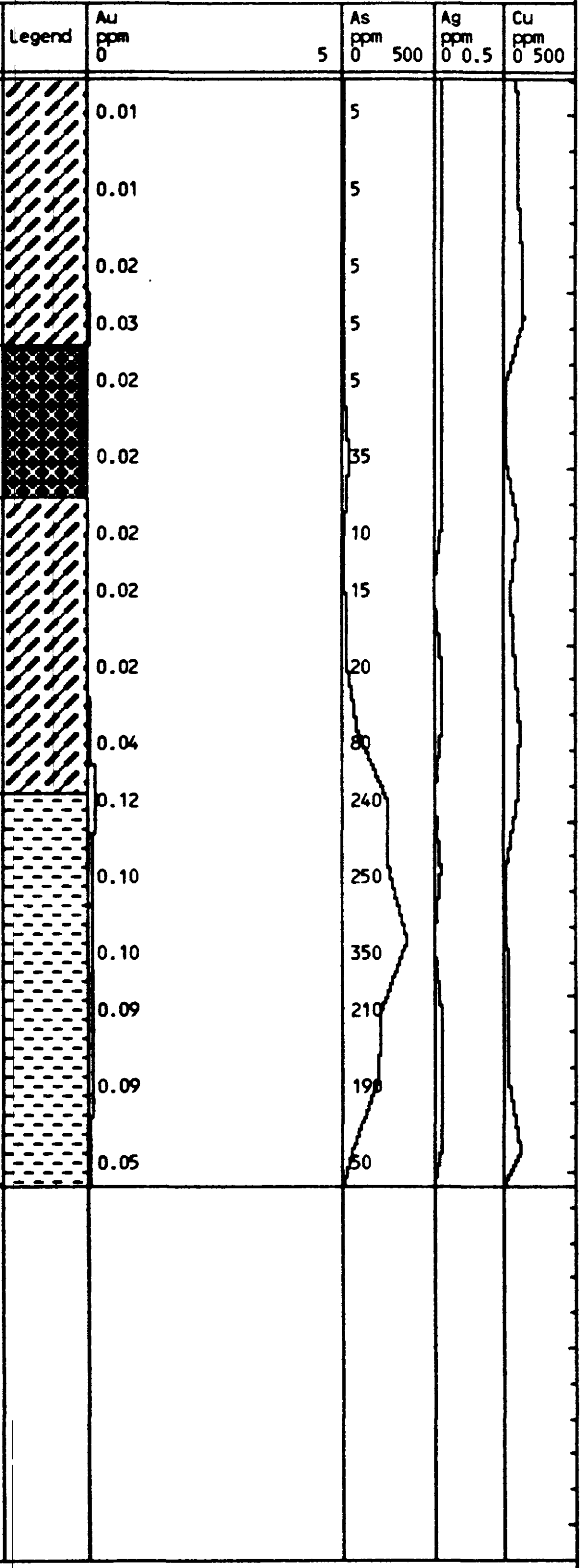
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-9

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/25/1989 - 2/26/1989

Depth Metres	Veins & Alteration	Lithology
45.00		
	47.3-47.45: Sliver of biotite schist . 47.9:Contact w/biot schist @ 85 CA. Alteration: Ore Min.:	45.75 - 47.9 meters. Granodiorite dike, pink-brown, coarse grained.
50.00	Alteration: Ore Min.:	47.9 - 52.1 meters. Biotite schist interbedded w/ carbonate rich layers.
55.00	layering deformed toward the bottom of hole. Alteration: Ore Min.:	52.1 - 57.70 meters. Chlorite schist.
	End of hole at 57.70 metres.	
60.00		



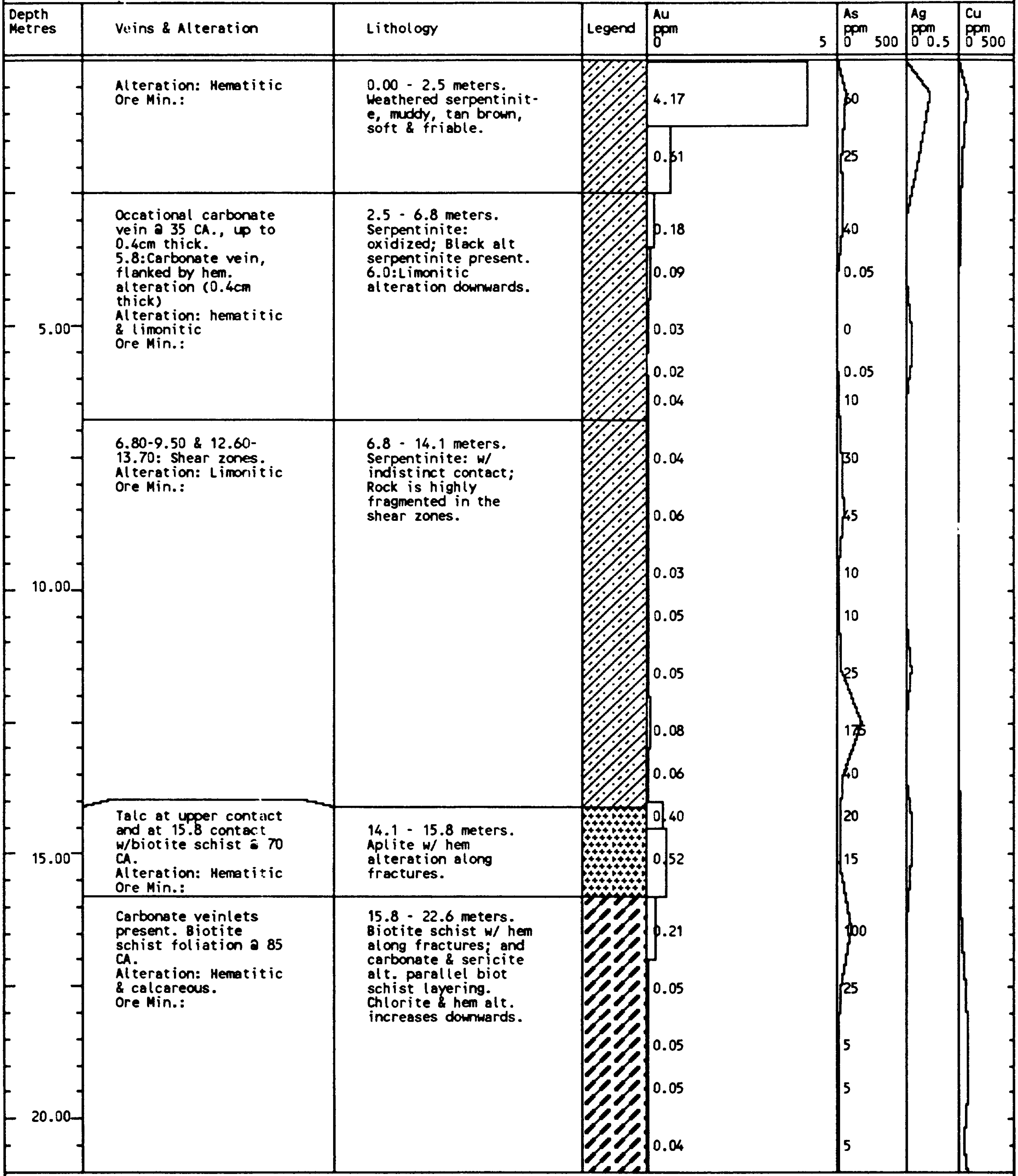
Au ppm	As ppm
0.01	5
0.01	5
0.02	5
0.03	5
0.02	5
0.02	35
0.02	10
0.02	15
0.02	20
0.04	80
0.12	240
0.10	250
0.10	350
0.09	210
0.09	190
0.05	50

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-10

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/22/1989 - 2/25/1989



Veins & Alteration	Lithology
Alteration: Hematitic Ore Min.:	0.00 - 2.5 meters. Weathered serpentinite, muddy, tan brown, soft & friable.
Occational carbonate vein @ 35 CA., up to 0.4cm thick. 5.8:Carbonate vein, flanked by hem. alteration (0.4cm thick) Alteration: hematitic & limonitic Ore Min.:	2.5 - 6.8 meters. Serpentinite: oxidized; Black alt serpentinite present. 6.0:Limonitic alteration downwards.
6.80-9.50 & 12.60-13.70: Shear zones. Alteration: Limonitic Ore Min.:	6.8 - 14.1 meters. Serpentinite: w/ indistinct contact; Rock is highly fragmented in the shear zones.
Talc at upper contact and at 15.8 contact w/biotite schist @ 70 CA. Alteration: Hematitic Ore Min.:	14.1 - 15.8 meters. Aplite w/ hem alteration along fractures.
Carbonate veinlets present. Biotite schist foliation @ 85 CA. Alteration: Hematitic & calcareous. Ore Min.:	15.8 - 22.6 meters. Biotite schist w/ hem along fractures; and carbonate & sericite alt. parallel biot schist layering. Chlorite & hem alt. increases downwards.

U.S.G.S. Jeddah Mission SCALE: 1:100

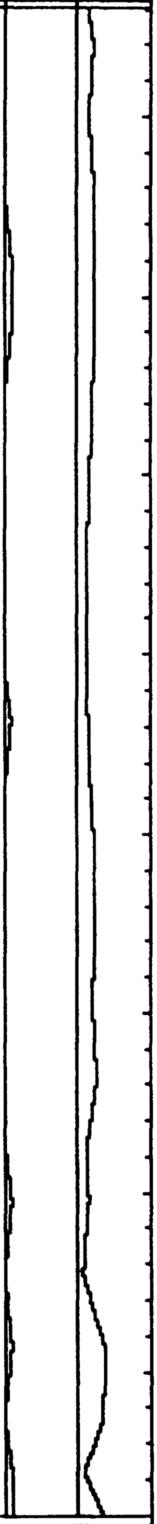
Drill Hole No.: HR 89-10

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/22/1989 - 2/25/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500
			▨	0.03 0.04	5 0
	Alteration: hematitic Ore Min.:	22.6 - 23.9 meters. Chlorite schist w/ hem alteration increase.	- - -	0.03	0
25.00	Alteration: hematitic Ore Min.:	23.9 - 25.5 meters. Sericite schist; hem alteration decreases.	▧	0.03	0
	25.8: 0.5cm Qtz vein @ 90 CA. Alteration: Ore Min.:	25.5 - 27.7 meters. Hornblende schist: Fine grained, dk grey to black.	▩	0.03 0.03 0.03	0 0 0
30.00	Alteration: Ore Min.:	27.7 - 30.5 meters. Chlorite schist: grey green, and relatively coarser grained than the unit above it.	- - -	0.03 0.02 0.03	0 5 0
35.00	30.5:0.2cm Cabonate veinlet w/ sericite bleb inside;@ 50 CA. 33.8P:0.8cm Carbonate vein flanked by sericite Alteration: Sericitic Ore Min.:	30.5 - 37.10 meters. Biotite schist, fine grained,dk grey to black, interlayered w/ chlorite altered zones. Sericite layerings increases between 33.10-33.20	▨	0.02 0.04 0.03 0.03 0.03 0.02 0.03	0 0 0 0 0 0 5
40.00	37.8: nomerous cabonate veins, @ 90 CA., cut by magnetite(?) stringers @ 85 & 40 CA. Alteration: Ore Min.:	37.1 - 41.6 meters. Hornblende schist: Upper contact @ 85 CA. w/ biotite schist.	▩	0.05 0.05 0.05 0.05 0.08	85 130 60 40 200

Ag ppm 0 0.5 | Cu ppm 0 500



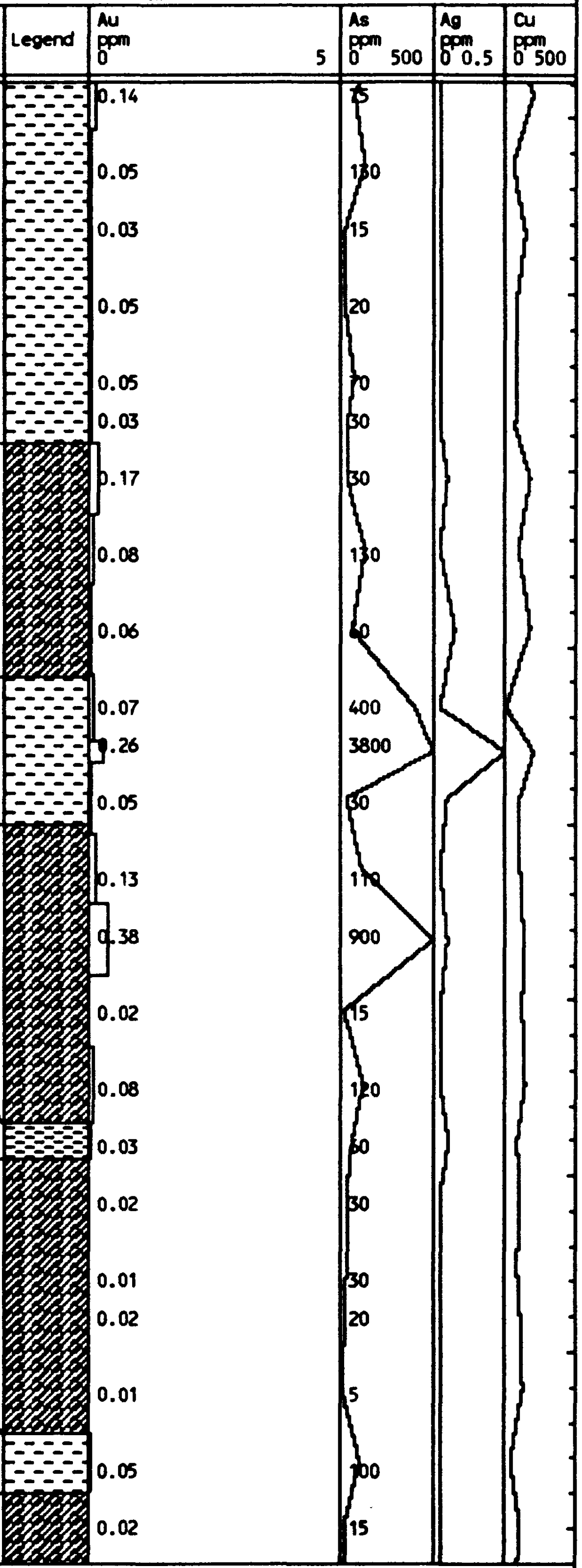
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-10

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/22/1989 - 2/25/1989

Depth Metres	Veins & Alteration	Lithology
45.00	Sericite alteration along both upper and lower contact. 44.65:Isolated pyrite crystals. Alteration: Ore Min.: Pyrite	41.6 - 47.10 meters. Chlorite schist w/ interlayers of biotite.
50.00	Contact @ 85 CA. 49.0-49.1: Small shear zone @ 45 CA.. 50.50:2cm carbonate vein @ 90 CA. Alteration: sericitic Ore Min.:	47.1 - 50.4 meters. Hornblende schist interlayered w/ sericite schist.
	50.4: Chlorite interlayed w/ sericite schist. 51.20:Sericite schist. 51.33-51.63:Qtz vein Alteration: Ore Min.: Py along qtz vein	50.4 - 52.5 meters. Chlorite schist.
55.00	Alteration: Ore Min.:	52.5 - 56.75 meters. Hornblende schist w/ layering range between 1-20cm.
	56.75 0.5cm sericite band along contact . Contact @ 85 CA. Alteration: Ore Min.:	56.75 - 57.25 meters. Meta Tuff: light grey -green, medium grained.
60.00	Alteration: Ore Min.:	57.25 - 61.15 meters. Hornblende schist interlayered w/ sericite schist.
	61.2: 1cm qtz vein Alteration: Ore Min.:	61.15 - 62.0 meters. Chlorite schist, argillitized & epidotized.
	Alteration: Ore Min.:	62 - 67.05 meters. Hornblende schist, dark green to black

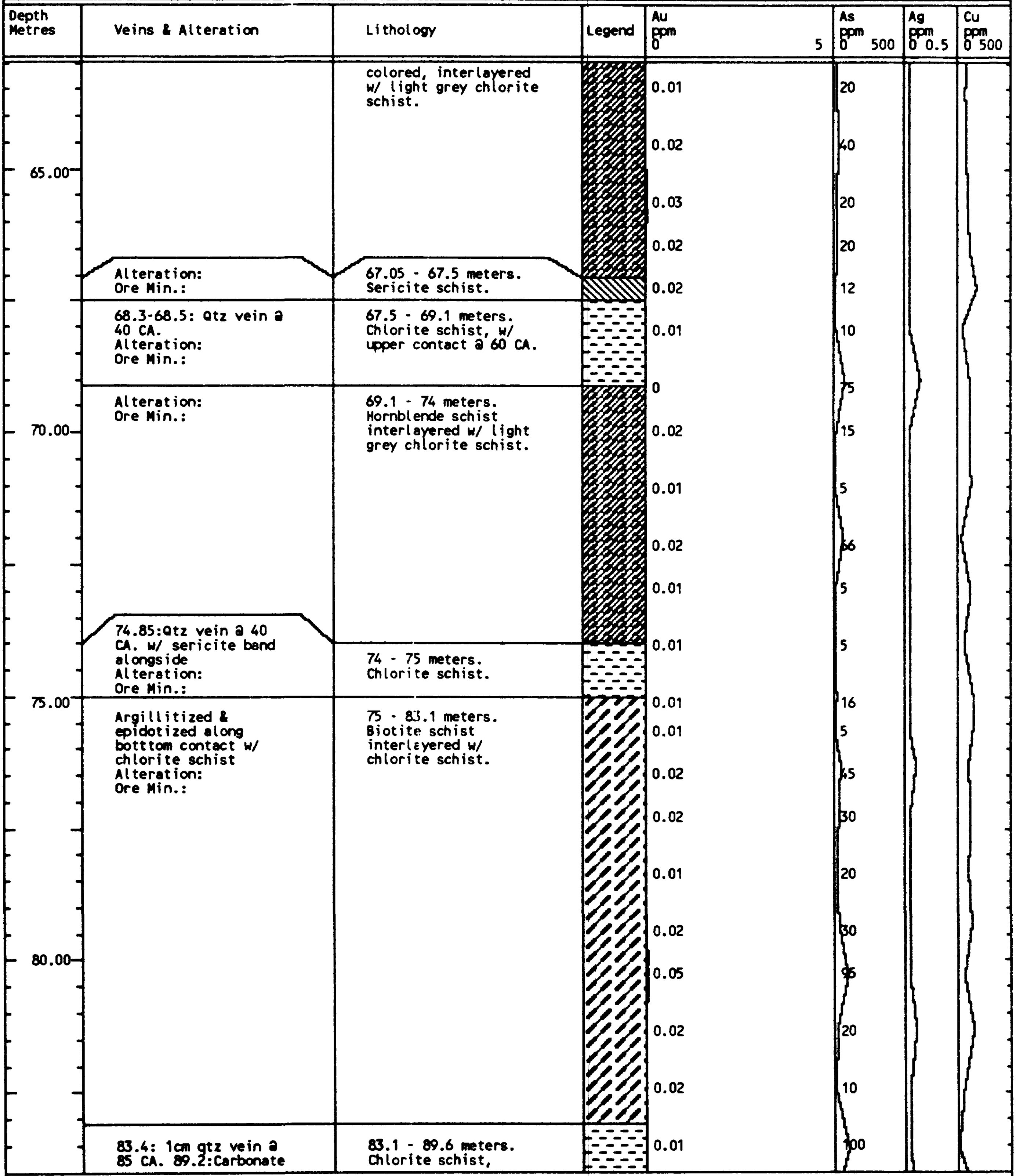


U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-10

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/22/1989 - 2/25/1989



Veins & Alteration	Lithology
	colored, interlayered w/ light grey chlorite schist.
Alteration: Ore Min.:	67.05 - 67.5 meters. Sericite schist.
68.3-68.5: Qtz vein @ 40 CA. Alteration: Ore Min.:	67.5 - 69.1 meters. Chlorite schist, w/ upper contact @ 60 CA.
Alteration: Ore Min.:	69.1 - 74 meters. Hornblende schist interlayered w/ light grey chlorite schist.
74.85:Qtz vein @ 40 CA. w/ sericite band alongside Alteration: Ore Min.:	74 - 75 meters. Chlorite schist.
Argillitized & epidotized along botttom contact w/ chlorite schist Alteration: Ore Min.:	75 - 83.1 meters. Biotite schist interlayered w/ chlorite schist.
83.4: 1cm qtz vein @ 85 CA. 89.2:Carbonate	83.1 - 89.6 meters. Chlorite schist,

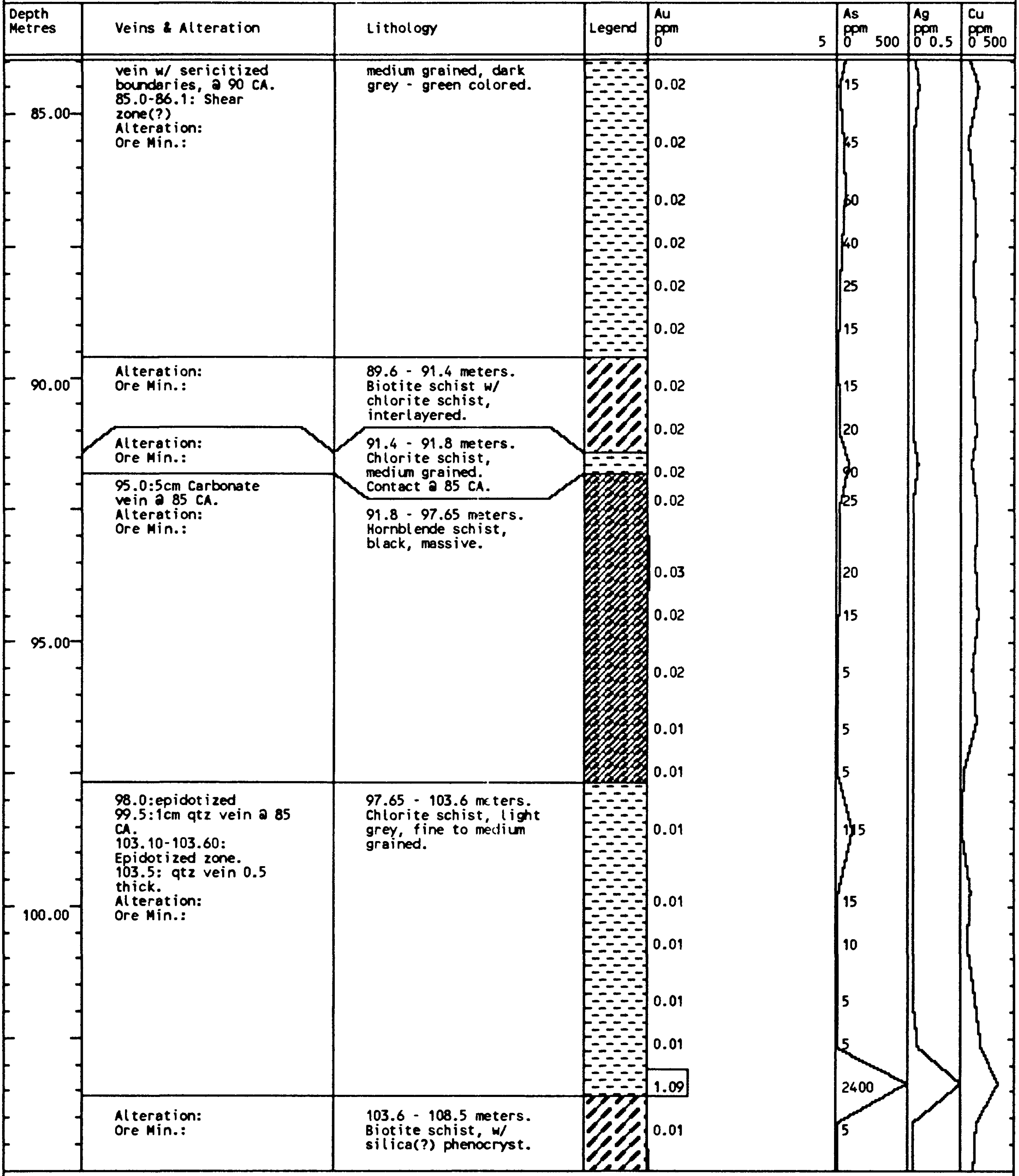
Au ppm	As ppm
0.01	20
0.02	40
0.03	20
0.02	20
0.02	12
0.01	10
0	75
0.02	15
0.01	5
0.02	66
0.01	5
0.01	5
0.01	16
0.01	5
0.02	45
0.02	30
0.01	20
0.02	30
0.05	95
0.02	20
0.02	10
0.01	100

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-10

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/22/1989 - 2/25/1989



Veins & Alteration	Lithology
vein w/ sericitized boundaries, @ 90 CA. 85.0-86.1: Shear zone(?) Alteration: Ore Min.:	medium grained, dark grey - green colored.
Alteration: Ore Min.:	89.6 - 91.4 meters. Biotite schist w/ chlorite schist, interlayered.
Alteration: Ore Min.:	91.4 - 91.8 meters. Chlorite schist, medium grained. Contact @ 85 CA.
95.0:5cm Carbonate vein @ 85 CA. Alteration: Ore Min.:	91.8 - 97.65 meters. Hornblende schist, black, massive.
98.0:epidotized 99.5:1cm qtz vein @ 85 CA. 103.10-103.60: Epidotized zone. 103.5: qtz vein 0.5 thick. Alteration: Ore Min.:	97.65 - 103.6 meters. Chlorite schist, light grey, fine to medium grained.
Alteration: Ore Min.:	103.6 - 108.5 meters. Biotite schist, w/ silica(?) phenocryst.

Au ppm 0 5	As ppm 0 500
0.02	15
0.02	45
0.02	60
0.02	40
0.02	25
0.02	15
0.02	15
0.02	20
0.02	90
0.02	25
0.03	20
0.02	15
0.02	5
0.01	5
0.01	5
0.01	115
0.01	15
0.01	10
0.01	5
0.01	5
1.09	2400
0.01	5

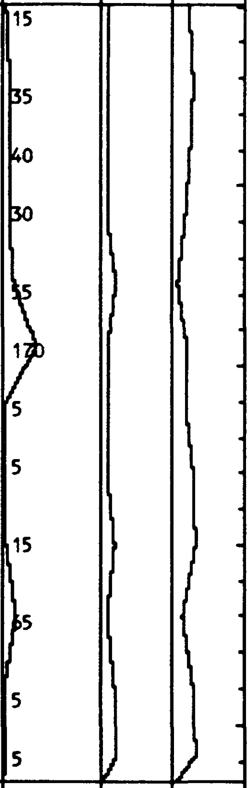
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-10

Project : Hamdah Drilling 1989

Logged by: P.Bosch Drilled: 2/22/1989 - 2/25/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
105.00			▨	0.03	15		
			▨	0.02	35		
			▨	0.02	40		
			▨	0.02	30		
	Alteration: Ore Min.:	108.5 - 110.6 meters. Chlorite schist, w/ epidote alteration.	┄	0.02	55		
110.00			┄	0.03	170		
	113.0: 1cm qtz vein @ 85 CA. Alteration: Ore Min.:	110.6 - 115.8 meters. Biotite schist w/ epidotized zone between 112.85 & 113.3; carbonate veins present.	▨	0.02	5		
			▨	0.02	5		
			▨	0.02	15		
			▨	0.02	65		
115.00			▨	0.02	5		
			▨	0.02	5		
	End of hole at 115.80 metres.						
120.00							
125.00							

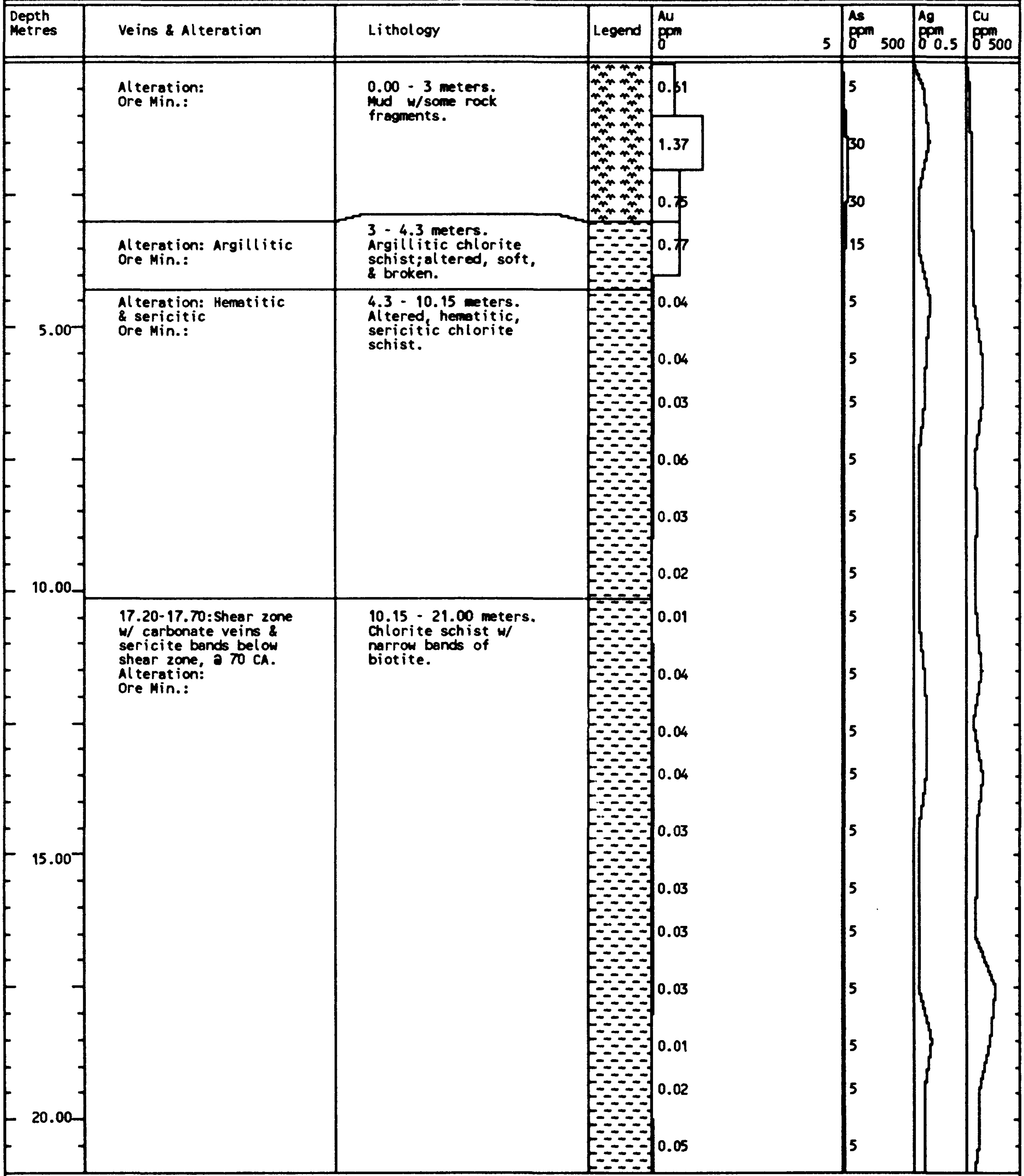


U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-11

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/26/1989 - 2/28/1989



Veins & Alteration	Lithology
Alteration: Ore Min.:	0.00 - 3 meters. Mud w/some rock fragments.
Alteration: Argillitic Ore Min.:	3 - 4.3 meters. Argillitic chlorite schist;altered, soft, & broken.
Alteration: Hematitic & sericitic Ore Min.:	4.3 - 10.15 meters. Altered, hematitic, sericitic chlorite schist.
17.20-17.70:Shear zone w/ carbonate veins & sericite bands below shear zone, @ 70 CA. Alteration: Ore Min.:	10.15 - 21.00 meters. Chlorite schist w/ narrow bands of biotite.

Au ppm	As ppm
0.61	5
1.37	30
0.75	30
0.77	15
0.04	5
0.04	5
0.03	5
0.06	5
0.03	5
0.02	5
0.01	5
0.04	5
0.04	5
0.04	5
0.03	5
0.03	5
0.03	5
0.03	5
0.01	5
0.02	5
0.05	5

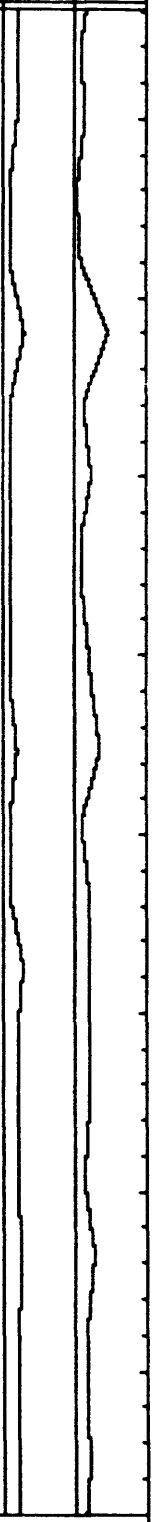
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-11

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/26/1989 - 2/28/1989

Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
	Alteration: Sericitic Ore Min.:	21 - 25.6 meters. Chlorite & biotite schist interbed one another, w/ foliation @ 70 CA. Minor sericite present.		0.04	15		
				0.03	35		
				0.03	5		
				0.02	10		
25.00				0.03	5		
	Alteration: Sericitic Ore Min.:	25.6 - 27 meters. Hornblende chlorite schist, weak foliation @ 75 CA.	▨	0.02	5		
	34.85-35.20: Shear zone. 36.65:Carbonate vein, 0.5cm thick, @ 70-80 CA. Alteration: Ore Min.:	27 - 36.2 meters. Chlorite schist interbeded w/ biot schist, @ 75 CA. foliation.		0.03	5		
				0.03	0		
				0.03	5		
30.00				0.02	5		
				0.04	0		
				0.02	0		
				0.03	5		
				0.03	10		
35.00				0.03	5		
	Alteration: Ore Min.:	36.2 - 42.45 meters. Chlorite schist, w/ minor hornblende and biotite, @ 75 CA.		0.03	20		
				0.04	15		
				0.03	5		
				0.03	5		
40.00				0.04	20		
				0.04	20		



SCALE: 1:100

Drill Hole No.: HR 89-11

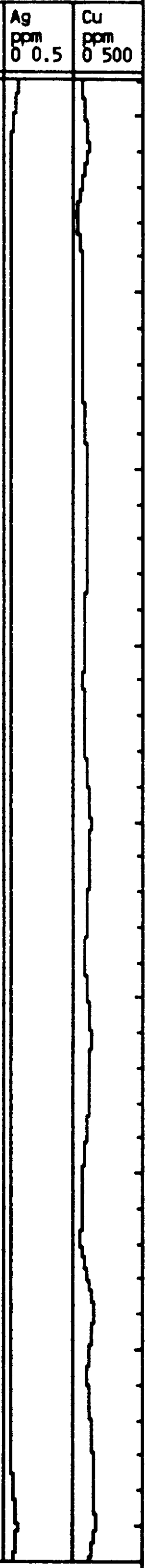
Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/26/1989 - 2/28/1989

Veins & Alteration	Lithology	Legend
		▤
Alteration: Ore Min.:	42.45 - 44.35 meters. Chlorite & bitotite schist, @ 75 CA.	▤
Alteration: Ore Min.:	44.35 - 44.95 meters. Diorite dike.	▩
45.85; 56.10; 57.35: Carbonate veins, 0.5 cm, 1cm, & 1cm thick @ 75, 85, & 75 CA., respectively. 56.25:Qtz vein, @ 90 CA., 0.4cm thick. Alteration: Ore Min.:	44.95 - 59.85 meters. Chlorite schist interbedded w/ biotite schist.	▤
Alteration: Ore Min.:	59.85 - 60.90 meters. Hornblende schist w/ chlorite schist, w/ foliation @ 75 CA.	▧
62.10: series of calcite veinlets, @ 75 CA., 0.3cm thick. Alteration: Ore Min.:	60.9 - 62.10 meters. Chlorite schist interbedded w/ biotite schist, @ 75 CA.	▤
Series of Qtz vein at 65.8; 66.2; 66.25 @	62.1 - 66.7 meters. Chlorite schist	▤

Depth Metres
45.00
50.00
55.00
60.00

Au ppm 0 5	As ppm 0 500
0.03	5
0.03	5
0.03	25
0.03	5
0.03	5
0.04	5
0.03	5
0.03	0
0.03	5
0.03	5
0.02	0
	5
0.01	5
0.01	5
0	5
0	5
0.01	5
0	5
0.01	5
0.01	40
0.01	15
0	30



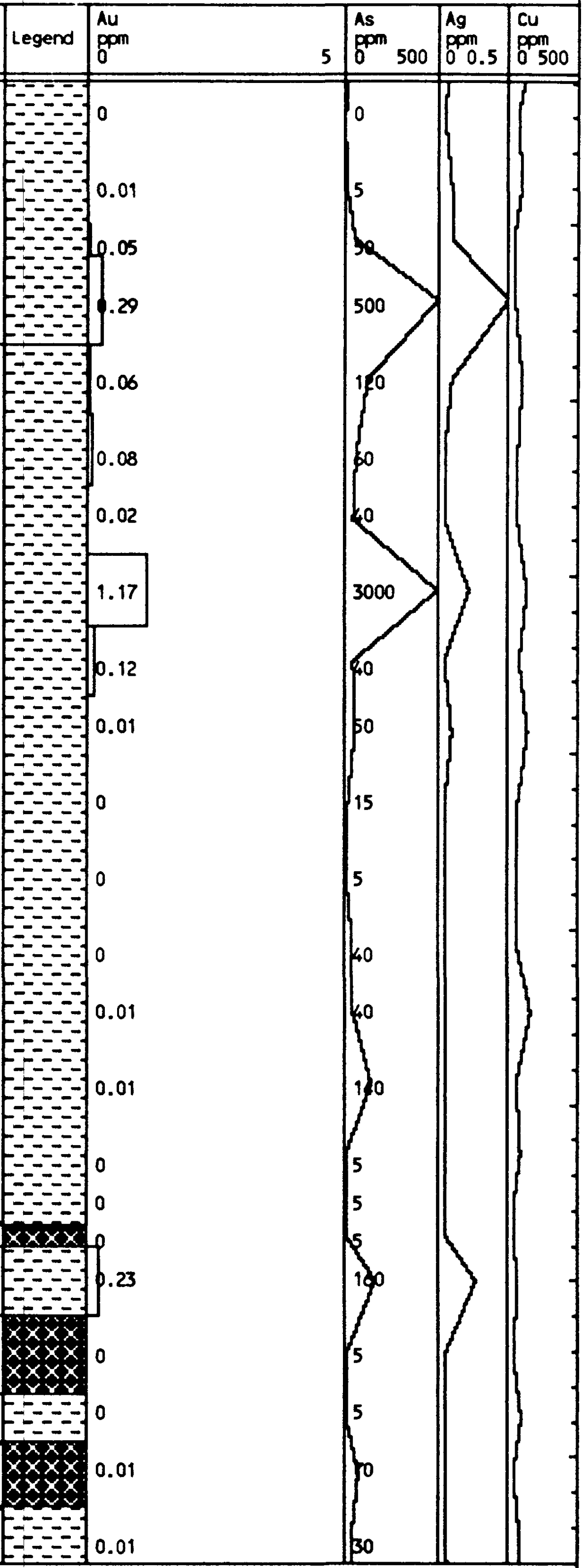
U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-11

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/26/1989 - 2/28/1989

Depth Metres	Veins & Alteration	Lithology
65.00	65; 55; 85 CA., w/ 2cm, 1.1cm, & 2.5cm thick. Alteration: Ore Min.:	interbedded w/ Hornblende schist, w/ weak foliation @ 90 CA. Epidotized zone at 65.45 m.
70.00 75.00	66.7: Zone of series of calcite veins @ 75 CA. in the thickness range of 0.6cm. 74.30:Aplite dike 5cm thick. Alteration: Ore Min.:	66.7 - 79.2 meters. Chlorite schist interbedded w/ biotite schist, and abundant fractures filled w/ calcite.
	Alteration: Ore Min.:	79.2 - 79.5 meters. Diorite dike.
80.00	Alteration: Ore Min.:	79.5 - 80.50 meters. Chlorite & Biotite schist.
	Alteration: Ore Min.:	80.5 - 81.60 meters. Diorite, medium grained.
	Alteration: Ore Min.:	81.6 - 82.30 meters. Chlorite schist interbedded w/ biotite schist.
	Alteration: Ore Min.:	
	Alteration: Ore Min.:	82.3 - 83.2 meters. Diorite, fine to medium grained.



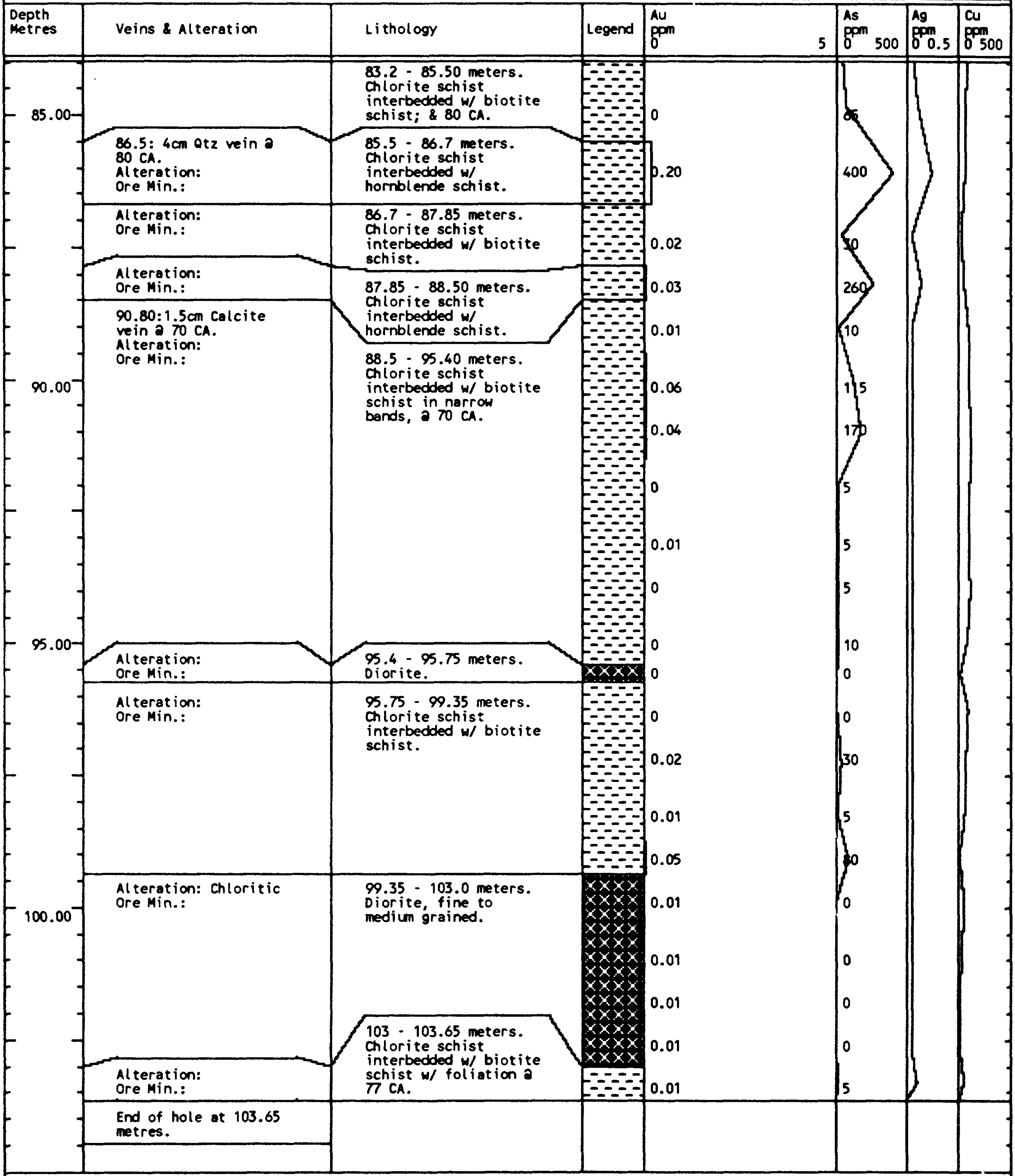
Au ppm	As ppm
0	0
0.01	5
0.05	50
0.29	500
0.06	120
0.08	60
0.02	40
1.17	3000
0.12	40
0.01	50
0	15
0	5
0	40
0.01	40
0.01	120
0	5
0	5
0	5
0.23	160
0	5
0	5
0.01	70
0.01	30

U.S.G.S. Jeddah Mission SCALE: 1:100

Drill Hole No.: HR 89-11

Project : Hamdah Drilling 1989

Logged by: Eyad Jannadi Drilled: 2/26/1989 - 2/28/1989



Depth Metres	Veins & Alteration	Lithology	Legend	Au ppm 0 5	As ppm 0 500	Ag ppm 0 0.5	Cu ppm 0 500
85.00		83.2 - 85.50 meters. Chlorite schist interbedded w/ biotite schist; & 80 CA.		0	65		
	86.5: 4cm Qtz vein @ 80 CA. Alteration: Ore Min.:	85.5 - 86.7 meters. Chlorite schist interbedded w/ hornblende schist.		0.20	400		
	Alteration: Ore Min.:	86.7 - 87.85 meters. Chlorite schist interbedded w/ biotite schist.		0.02	30		
	Alteration: Ore Min.:	87.85 - 88.50 meters. Chlorite schist interbedded w/ hornblende schist.		0.03	260		
	90.80:1.5cm Calcite vein @ 70 CA. Alteration: Ore Min.:			0.01	10		
90.00		88.5 - 95.40 meters. Chlorite schist interbedded w/ biotite schist in narrow bands, @ 70 CA.		0.06	115		
				0.04	170		
				0	5		
				0.01	5		
				0	5		
95.00				0	10		
	Alteration: Ore Min.:	95.4 - 95.75 meters. Diorite.		0	0		
	Alteration: Ore Min.:	95.75 - 99.35 meters. Chlorite schist interbedded w/ biotite schist.		0	0		
				0.02	30		
				0.01	5		
				0.05	80		
	Alteration: Chloritic Ore Min.:	99.35 - 103.0 meters. Diorite, fine to medium grained.		0.01	0		
100.00				0.01	0		
				0.01	0		
				0.01	0		
	Alteration: Ore Min.:	103 - 103.65 meters. Chlorite schist interbedded w/ biotite schist w/ foliation @ 77 CA.		0.01	5		
	End of hole at 103.65 metres.						

(PAGE 107 FOLLOWS)

APPENDIX 2, Table 2-I

Gold Assays of Hamdah Mine Dump Samples

Sample Number Column # 1	DUMP (DU) 2	TRENCH (TR) 3	SAMPLE (S) 4	meters to bdrk in TR 5	ppm Au avg/TR 6	ppm Au DGMR AA 7	ppm Au DGMR AA 8	ppm Au DGMR AA 9	ppm Au DGMR AA 10	ppm Au Skyline LT10AA GT10FA 11	ppm Au uncut avg 12	ppm Au cut >16 13	ppm Au cut >10 14	ppm Ag DGMR AA 15	ppm Au Skyline shake leach 16	ppm Au Skyline shake leach cut >16	ppm Au Skyline shake leach cut >10
246501	1	1	1			3.0	3.3	3.7		2.3	3.1	3.1	3.1	0.10	2.8	2.8	2.8
246502	1	1	2			2.3	4.2	3.5		2.6	3.2	3.2	3.2	0.14	3.3	3.3	3.3
246503	1	1	3			2.5	3.1	3.0		2.9	2.9	2.9	2.9	0.14	2.8	2.8	2.8
246504	1	1	4			2.8	5.0	4.0		3.1	3.7	3.7	3.7	0.10	4.6	4.6	4.6
246505 grab	1	1	5	2.0 +	3.7	4.0	7.0	7.1		4.2	5.6	5.6	5.6	0.10	6.2	6.2	6.2
246506	1	2	1			3.0	5.0	5.0		3.7	3.3	3.3	3.3	0.10	4.8	4.8	4.8
246507	1	2	2	1.0 +	3.7	3.1	4.6	5.3		3.3	4.1	4.1	4.1	0.14	4.7	4.7	4.7
246508	1	3	1			1.1	1.4	1.3		1.1	1.2	1.2	1.2	0.05	1.3	1.3	1.3
246509	1	3	2	1.5	2.8	3.7	4.8	5.8		3.5	4.5	4.5	4.5	0.17	5.3	5.3	5.3
246510	1	4	1	0.3	0.1	0.1	0.1	0.1		0.2	0.1	0.1	0.1	0.05	---	---	---
246511	1	5	1	1.3	2.4	1.2	2.0	2.0		4.4	2.4	2.4	2.4	0.05	1.4	1.4	1.4
246512	1	6	1			1.6	1.8	1.4		1.1	1.5	1.5	1.5	0.05	1.1	1.1	1.1
246513	1	6	2			1.3	1.8	2.1		1.2	1.6	1.6	1.6	0.05	1.7	1.7	1.7
246514	1	6	3			1.5	1.7	2.1		1.8	1.8	1.8	1.8	0.05	1.8	1.8	1.8
246515	1	6	4	2.0	1.9	2.6	3.2	3.2		2.1	2.8	2.8	2.8	0.05	2.9	2.9	2.9
246516	1	7	1	1.4	6.4	2.4	3.1	22.0	2.3	2.2	6.4	6.4	6.4	0.05	2.9	2.9	2.9
246517	1	8	1			1.1	2.0	2.0		1.4	1.6	1.6	1.6	0.05	1.7	1.7	1.7
246518	1	8	2	1.8	2.5	2.6	3.3	5.0		2.4	3.3	3.3	3.3	0.05	3.3	3.3	3.3
246519	1	9	1			0.9	1.1	1.4		1.0	1.1	1.1	1.1	0.05	---	---	---
246520	1	9	2			3.0	4.8	5.3		3.2	4.1	4.1	4.1	0.10	4.5	4.5	4.5
246521	1	9	3			4.3	3.8	4.0		2.7	3.7	3.7	3.7	0.10	4.2	4.2	4.2
246522	1	9	4			4.8	21.0	6.9	6.0	6.8	9.1	9.1	9.1	0.20	6.8	6.8	6.8
246523 grab	1	9	5			4.1	7.0	5.8		2.5	4.9	4.9	4.9	0.44	6.8	6.8	6.8
246524 dup 1	1	9	6			7.5	17.0	17.0		13.0	13.6	13.6	10.0	0.75	12.0	12.0	10.0
246525 dup 2	1	9	7	2.0 +	6.1	4.6	8.2	7.0		4.9	6.2	6.2	6.2	0.52	9.1	9.1	9.1
246526	1	10	1			2.4	2.8	4.0		2.1	2.8	2.8	2.8	0.10	3.1	3.1	3.1

Gold Assays of Hamdah Mine Dump Samples

Sample Number	DUMP (DU)	TRENCH (TR)	SAMPLE (S)	meters to bdrk in TR	ppm Au avg/TR	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au Skyline LT10AA GT10FA	ppm Au uncut avg	ppm Au cut >16	ppm Au cut >10	ppm Ag DGMR AA	ppm Au Skyline shake leach	ppm Au Skyline shake leach cut >16	ppm Au Skyline shake leach cut >10
246527	1	10	2			1.9	2.3	3.8		2.3	2.6	2.6	2.6	0.14	2.8	2.8	2.8
246528 grab	1	10	3	1.6 +	2.7	1.7	2.4	4.0		2.4	2.6	2.6	2.6	0.05	2.0	2.0	2.0
246529	1	11	1			2.9	4.0	4.6		2.7	3.6	3.6	3.6	0.05	4.6	4.6	4.6
246530	1	11	2			5.1	2.8	4.2		1.4	3.4	3.4	3.4	0.05	1.3	1.3	1.3
246531	1	11	3	1.2 +	3.6	3.0	5.0	4.0		3.7	3.9	3.9	3.9	0.17	3.8	3.8	3.8
246532	1	12	1			1.5	1.7	1.7		1.4	1.6	1.6	1.6	0.05	1.7	1.7	1.7
246533	1	12	2	1.1 +	2.9	2.9	6.5	4.0		3.3	4.2	4.2	4.2	0.10	4.1	4.1	4.1
246534	1	13	1			3.5	8.0	4.0		3.8	4.8	4.8	4.8	0.10	5.4	5.4	5.4
246535	1	13	2	1.3 +	4.4	3.3	5.0	4.2		3.3	4.0	4.0	4.0	0.18	4.8	4.8	4.8
	Dump Average			1.4 +							3.7	3.7	3.6		3.7	3.7	3.6
246536	2	1	1			2.0	2.9	2.6	2.2	1.5	2.2	2.2	2.2	0.22	2.6	2.6	2.6
246537	2	1	2	1.0	6.9	48.0	3.0	2.6	2.7	1.5	11.6	11.6	10.0	0.23	2.9	2.9	2.9
246538	2	2	1			5.0	9.1	6.0		8.2	7.1	7.1	7.1	0.54	7.6	7.6	7.6
246539	2	2	2	2.0 +	6.3	4.8	7.4	5.3		4.8	5.6	5.6	5.6	0.60	6.6	6.6	6.6
246540	2	3	1			5.7	13.0	7.3	7.0	11.0	8.8	8.8	8.8	0.60	8.9	8.9	8.9
246541	2	3	2	2.0 +	8.0	5.2	7.5	6.7		9.1	7.1	7.1	7.1	0.60	9.2	9.2	9.2
246542	2	4	1	1.2 +	5.9	4.2	6.0	6.8		6.4	5.9	5.9	5.9	0.46	7.5	7.5	7.5
246543	2	5	1			4.8	9.6	6.0	6.5	9.1	7.2	7.2	7.2	0.42	7.2	7.2	7.2
246544	2	5	2			4.3	6.0	5.0		3.7	4.8	4.8	4.8	0.40	6.8	6.8	6.8
246545	2	5	3			6.9	19.0	7.7	10.0	13.8	11.5	11.5	10.0	0.70	11.0	11.0	10.0
246546 grab	2	5	4	1.7 +	7.9	5.4	12.0	7.3	7.0	8.7	8.1	8.1	8.1	0.57	8.8	8.8	8.8
256547	2	6	1			1.1	2.0	1.5		0.9	1.4	1.4	1.4	0.14	---	---	---
246548	2	6	2	1.3 +	1.7	1.6	2.4	2.6		1.2	2.0	2.0	2.0	0.22	2.1	2.1	2.1
246549	2	7	1			5.0	9.5	7.0		4.6	6.5	6.5	6.5	0.40	6.7	6.7	6.7

Gold Assays of Hamdah Mine Dump Samples

Sample Number	DUMP (DU)	TRENCH (TR)	SAMPLE (S)	meters to bdrk in TR	ppm Au avg/TR	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au Skyline LT10AA GT10FA	ppm Au uncut avg	ppm Au cut >16	ppm Au cut >10	ppm Ag DGMR AA	ppm Au Skyline shake leach	ppm Au Skyline shake leach cut >16	ppm Au Skyline shake leach cut >10
246550	2	7	2	1.2 +	5.4	4.3	6.0	4.4		2.0	4.2	4.2	4.2	0.35	4.1	4.1	4.1
246551	2	8	1	0.7 +	9.9	8.0	11.0	9.2		11.5	9.9	9.9	10.0	0.70	10.0	10.0	10.0
246552	2	9	1			8.4	11.5	18.0		11.4	12.3	12.3	10.0	0.62	12.0	12.0	10.0
246553	2	9	2	1.5 +	9.6	6.1	5.5	8.5		7.6	6.9	6.9	6.9	0.60	7.4	7.4	7.4
	Dump Average			1.4 +							6.8	6.8	6.5		6.7	6.7	6.6
246554 grab	3	1	1	---	3.4	3.0	3.4	4.4		2.6	3.4	3.4	3.4	0.20	3.9	3.9	3.9
246555	3	2	1			5.3	6.8	6.8		9.0	7.0	7.0	7.0	0.45	8.5	8.5	8.5
246556 grab	3	2	2	1.1	6.0	4.7	5.8	5.6		4.1	5.1	5.1	5.1	0.30	6.1	6.1	6.1
246557	3	3	1			8.0	9.5	12.0		12.7	10.6	10.6	10.0	0.45	10.0	10.0	10.0
246558	3	3	2	1.0 +	9.8	7.7	8.6	9.0		10.8	9.0	9.0	9.0	0.35	9.7	9.7	9.7
246559	3	4	1			6.7	5.6	6.4		7.6	6.6	6.6	6.6	0.45	7.5	7.5	7.5
246560	3	4	2	2.0 +	7.0	7.3	6.0	7.5		8.8	7.4	7.4	7.4	0.24	6.3	6.3	6.3
246561	3	5	1			3.3	4.0	3.3		3.0	3.4	3.4	3.4	0.20	3.7	3.7	3.7
246562	3	5	2			9.6	19.0	12.5		15.1	14.1	14.1	10.0	0.10	9.1	9.1	9.1
246563	3	5	3			3.8	4.0	4.0		2.8	3.7	3.7	3.7	0.20	4.2	4.2	4.2
246564	3	5	4			7.3	6.0	6.3		7.7	7.0	7.0	7.0	0.30	7.4	7.4	7.4
246565	3	5	5			3.3	4.2	4.0		3.1	3.7	3.7	3.7	0.20	4.6	4.6	4.6
246566	3	5	6	1.7 +	5.9	2.7	4.8	4.0		2.8	3.6	3.6	3.6	0.17	3.9	3.9	3.9
246567	3	6	1			8.2	2.7	2.7	10.0	15.8	7.9	7.9	7.9	0.42	13.0	13.0	10.0
246568	3	6	2	1.3 +	6.5	4.7	4.0	3.5		8.1	5.1	5.1	5.1	0.65	7.9	7.9	7.9
246569	3	7	1			3.8	5.0	5.0		3.0	4.2	4.2	4.2	0.20	5.1	5.1	5.1
246571 grab	3	7	3	1.2	4.0	2.0	5.4	5.5		1.9	3.7	3.7	3.7	0.13	2.4	2.4	2.4
246572	3	8	1			3.0	3.7	3.8		3.1	3.4	3.4	3.4	0.25	4.1	4.1	4.1
246573	3	8	2	1.2	3.8	4.1	4.2	5.0		3.3	4.2	4.2	4.2	0.25	5.9	5.9	5.9

Gold Assays of Hamdah Mine Dump Samples

Sample Number	DUMP (DU)	TRENCH (TR)	SAMPLE (S)	meters to bdrk in TR	ppm Au avg/TR	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au DGMR AA	ppm Au Skyline LT10AA GT10FA	ppm Au uncut avg	ppm Au cut >16	ppm Au cut >10	ppm Ag DGMR AA	ppm Au Skyline shake leach	ppm Au Skyline shake leach cut >16	ppm Au Skyline shake leach cut >10
246574	3	9	1			5.3	5.2	6.0		3.8	5.1	5.1	5.1	0.30	6.7	6.7	6.7
246575	3	9	2			5.3	5.2	5.3		4.4	5.1	5.1	5.1	0.25	7.3	7.3	7.3
246576 dup 1	3	9	3	1.4	7.1	9.7	10.0	9.2		15.3	11.1	11.1	10.0	0.45	10.0	10.0	10.0
246577	3	10	1			180.0	210.0	150.0		227.0	191.8	16.0	10.0	9.00	165.0	16.0	10.0
246578	3	10	2			2.6	3.0	2.5		1.7	2.5	2.5	2.5	0.15	4.1	4.1	4.1
246579 dup 1	3	10	3	1.1	66.1	3.9	4.6	3.5		4.3	4.1	4.1	4.1	0.22	6.2	6.2	6.2
246580	3	11	1			6.1	8.4	5.5		8.7	7.2	7.2	7.2	0.33	7.4	7.4	7.4
246581	3	11	2	1.0 +	4.1	1.4	1.1	1.5		1.1	1.0	1.0	1.0	0.10	1.4	1.4	1.4
246583	3	13	1			5.5	9.0	3.7	5.3	3.3	5.4	5.4	5.4	0.20	6.8	6.8	6.8
246584	3	13	2			2.2	2.6	2.0		1.8	2.2	2.2	2.2	0.12	2.6	2.6	2.6
246585 dup 1	3	13	3	1.3	3.5	4.0	3.5	2.4		2.5	3.1	3.1	3.1	0.10	3.0	3.0	3.0
246586	3	14	1			2.2	3.5	2.0		1.8	2.4	2.4	2.4	0.05	2.9	2.9	2.9
246587	3	14	2	0.8	3.2	4.3	4.8	3.3		3.7	4.0	4.0	4.0	0.10	4.8	4.8	4.8
	Dump Average			1.3 +							11.2	5.7	5.3		11.0	6.3	6.0
246588	4	1	1			1.2	1.6	1.0		1.3	1.3	1.3	1.3	0.05	1.1	1.1	1.1
246589	4	1	2			0.9	1.2	1.4		0.9	1.1	1.1	1.1	0.05	---	---	---
246590 dup 1	4	1	3	1.2 +	1.2	1.5	1.4	1.0		1.2	1.3	1.3	1.3	0.05	1.3	1.3	1.3
246591	4	2	1			1.4	1.7	1.3		1.4	1.5	1.5	1.5	0.05	1.1	1.1	1.1
246592	4	2	2	0.6	2.0	2.5	2.0	1.7		1.1	1.8	1.8	1.8	0.05	1.2	1.2	1.2
246594	4	3	1			3.0	4.7	2.6		2.9	3.3	3.3	3.3	0.10	3.6	3.6	3.6
246595	4	3	2			4.3	8.4	4.7	5.2	4.2	5.4	5.4	5.4	0.12	4.3	4.3	4.3
246596 dup 1	4	3	3	1.0 +	3.7	2.5	3.2	2.4		2.2	2.6	2.6	2.6	0.05	2.5	2.5	2.5
246597	4	4	1			3.5	3.7	2.8		2.7	3.2	3.2	3.2	0.12	2.8	2.8	2.8
246598	4	4	2	0.6	3.7	6.3	4.0	4.1		2.7	4.3	4.3	4.3	0.15	3.6	3.6	3.6

Gold Assays of Hamdah Mine Dump Samples

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246600	4	5	1			1.7	2.3	1.9		1.6	1.9	1.9	1.9	0.05	1.8	1.8	1.8
246601	4	5	2			1.3	1.4	1.2		3.4	1.8	1.8	1.8	0.05	3.1	3.1	3.1
246602	4	5	3			1.6	1.7	1.2	3.6	1.9	2.0	2.0	2.0	0.05	2.6	2.6	2.6
246603	4	5	4	1.7	2.1	2.3	2.8	2.6		2.9	2.7	2.7	2.7	0.05	3.1	3.1	3.1
246604	4	6	1			1.5	1.6	1.4		1.7	1.6	1.6	1.6	0.05	1.9	1.9	1.9
246605	4	6	2	0.6	2.3	3.2	3.2	3.2		2.9	3.1	3.1	3.1	0.05	3.8	3.8	3.8
246607	4	7	1			15.0	17.5	17.0	15.0	14.8	15.9	15.9	10.0	0.11	4.8	4.8	4.8
246608	4	7	2			13.0	3.4	3.7	4.3	4.6	5.8	5.8	5.8	0.05	4.5	4.5	4.5
246609 dup1	4	7	3			3.2	2.4	2.3	2.5	2.5	2.6	2.6	2.6	0.05	4.0	4.0	4.0
246610	4	7	4	0.9	6.3	0.5	1.3	0.7	1.3	1.0	1.0	1.0	1.0	0.05	1.8	1.8	1.8
246611	4	8	1			5.5	3.7	6.0	7.8	5.8	5.8	5.8	5.8	0.05	3.1	3.1	3.1
246612	4	8	2	0.9	4.4	2.7	2.5	2.0		4.6	3.0	3.0	3.0	0.05	2.7	2.7	2.7
246613	4	9	1			1.3	1.6	1.0		1.3	1.3	1.3	1.3	0.05	2.1	2.1	2.1
246614	4	9	2			3.8	2.3	1.7	2.3	2.9	2.6	2.6	2.6	0.05	3.0	3.0	3.0
246615	4	9	3			3.8	3.3	3.8		3.8	3.7	3.7	3.7	0.12	4.2	4.2	4.2
246616	4	9	4	1.6	2.8	3.7	3.3	3.8		3.9	3.7	3.7	3.7	0.05	4.1	4.1	4.1
246617	4	10	1			3.7	2.9	6.0	3.7	3.6	4.0	4.0	4.0	0.05	4.7	4.7	4.7
246618	4	10	2	1.3 +	3.9	5.0	3.0	4.0		3.1	3.8	3.8	3.8	0.05	5.2	5.2	5.2
246619	4	11	1			2.6	2.2	2.8		2.1	2.4	2.4	2.4	0.05	3.3	3.3	3.3
246620	4	11	2	1.8 +	2.3	2.3	2.1	2.7		1.9	2.3	2.3	2.3	0.05	2.9	2.9	2.9
246621	4	12	1	1.2 +	3.4	5.5	4.0	2.4	3.3	1.8	3.4	3.4	3.4	0.05	3.7	3.7	3.7
246623	4	13	2	1.4	7.8	17.0	4.1	6.3	5.6	6.2	7.8	7.8	7.8	0.12	5.0	5.0	5.0
246624	4	14	1			1.4	1.7	1.8		1.4	1.6	1.6	1.6	0.05	2.1	2.1	2.1
246625	4	14	2	1.9 +	4.0	3.0	1.7	20.0	4.3	2.7	6.3	6.3	6.3	0.05	3.2	3.2	3.2
246627	4	15	2	1.0	5.5	10.5	3.9	4.3	5.0	3.8	5.5	5.5	5.5	0.10	4.1	4.1	4.1
246628	4	16	1			5.0	4.0	4.4		4.9	4.6	4.6	4.6	0.10	4.0	4.0	4.0

Gold Assays of Hamdah Mine Dump Samples

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246629	4	16	2	2.0 +	27.5	54.0	38.0	38.0	70.0	51.9	50.4	16.0	10.0	1.00	35.0	16.0	10.0
246630	4	17	1			2.0	1.2	1.7	2.0	1.8	1.7	1.7	1.7	0.05	1.9	1.9	1.9
246631	4	17	2			8.0	3.8	4.4	4.8	6.5	5.5	5.5	5.5	0.05	3.8	3.8	3.8
246632 grab	4	17	3	1.8 +	3.7	6.4	3.3	3.1	3.2	3.6	3.9	3.9	3.9	0.05	2.9	2.9	2.9
246633	4	18	1			6.5	3.6	4.7	4.6	4.7	4.8	4.8	4.8	0.10	4.7	4.7	4.7
246634	4	18	2			7.0	5.5	4.6	6.3	6.0	5.9	5.9	5.9	0.05	5.4	5.4	5.4
246635	4	18	3			0.2	0.3	0.2		0.2	0.2	0.2	0.2	0.05	---	---	---
246636	4	18	4	1.6	3.4	2.6	2.2	2.7		2.6	2.5	2.5	2.5	0.05	2.3	2.3	2.3
		Dump Average		1.3 +							4.6	3.8	3.5		3.8	3.3	3.2
Total avg						5.9	6.4	5.8	5.8	6.0	6.0	4.5	4.2	0.25	5.7	4.5	4.3
Maximum Au (ppm)						180.0	210.0	150.0	70.0	227.0	191.8	16.0	10.0	9.00	165.0	16.0	10.0
Minimum Au (ppm)						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
Total standard deviation						16.3	18.2	13.3	11.2	19.8	16.6	3.3	2.7	0.8	14.1	3.1	2.7
N						129.0	129.0	129.0	29.0	129.0	129	129	129	129	124	124	124