# RECONNAISSANCE INVESTIGATIONS OF ANCIENT GOLD MINES IN THE NORTHWESTERN PART OF THE AL AQIQ QUADRANGLE, KINGDOM OF SAUDI ARABIA

by

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# RECONNAISSANCE INVESTIGATIONS OF ANCIENT GOLD MINES IN THE NORTHWESTERN PART OF THE AL AQIQ QUADRANGLE, SHEET 20/41 D, KINGDOM OF SAUDI ARABIA

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## ABSTRACT

Four groups of ancient gold mines were investigated in the northwestern part of the Al Aqiq quadrangle, sheet 20/41 D, Kingdom of Saudi Arabia. Those in the Aqiq Ghamid area are the largest and the most numerous. The other three groups each consist of a few small workings.

All of the ancient mines are along quartz veins, many of which are associated with crosscutting felsic dikes. Most of the ancient mines of the Aqiq Ghamid area are in a zone of quartz veins, altered rocks, and felsic dikes in a quartz diorite phase of an elongate north-trending diorite intrusion of Precambrian age. In all areas, sulfides are rare and the silver contents are low.

Further exploration is suggested in three areas: the zone containing the Wadi Kara ancient mines, the northern part of the Aqiq Ghamid area, and the Aqiq Ghamid mine, which has an untested potential of 400,000 metric tons of 17 to 24 g/t gold ore.

## INTRODUCTION

In the northwestern part of the Al Aqiq quadrangle, sheet 20/41 D, Kingdom of Saudi Arabia, there are four groups of ancient gold mines including numerous individual workings in the Aqiq Ghamid area, a few small workings at As Sadeeh and Wadi Kara sites, and several small workings at Ar Raduh site (figs. 1 and 2; table 1). Most of these mines are mentioned by Goldsmith (1971) and Greenwood (1975), but only one, the Aqiq Ghamid ancient gold mine, has previously been mapped and sampled (Smith and Kouther, 1967). Some small workings in the Aqiq Ghamid area that are mentioned by Smith and Kouther (1967) were not found.

[1]/U.S. Geological Survey, Denver, Colorado

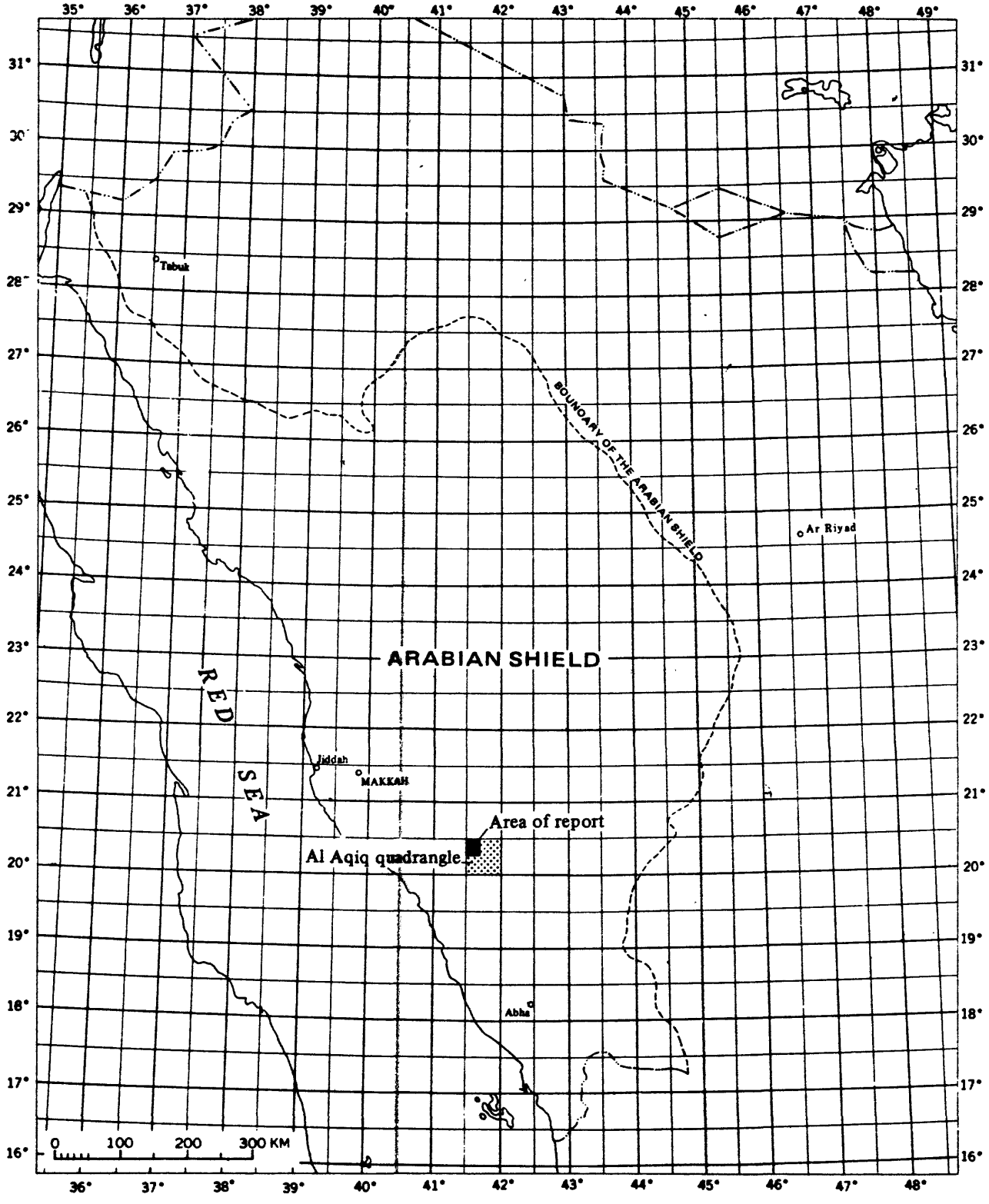



Figure 1.–Index map of western Saudi Arabia showing location of area of report in the northwestern part of the Al Aqiq quadrangle.

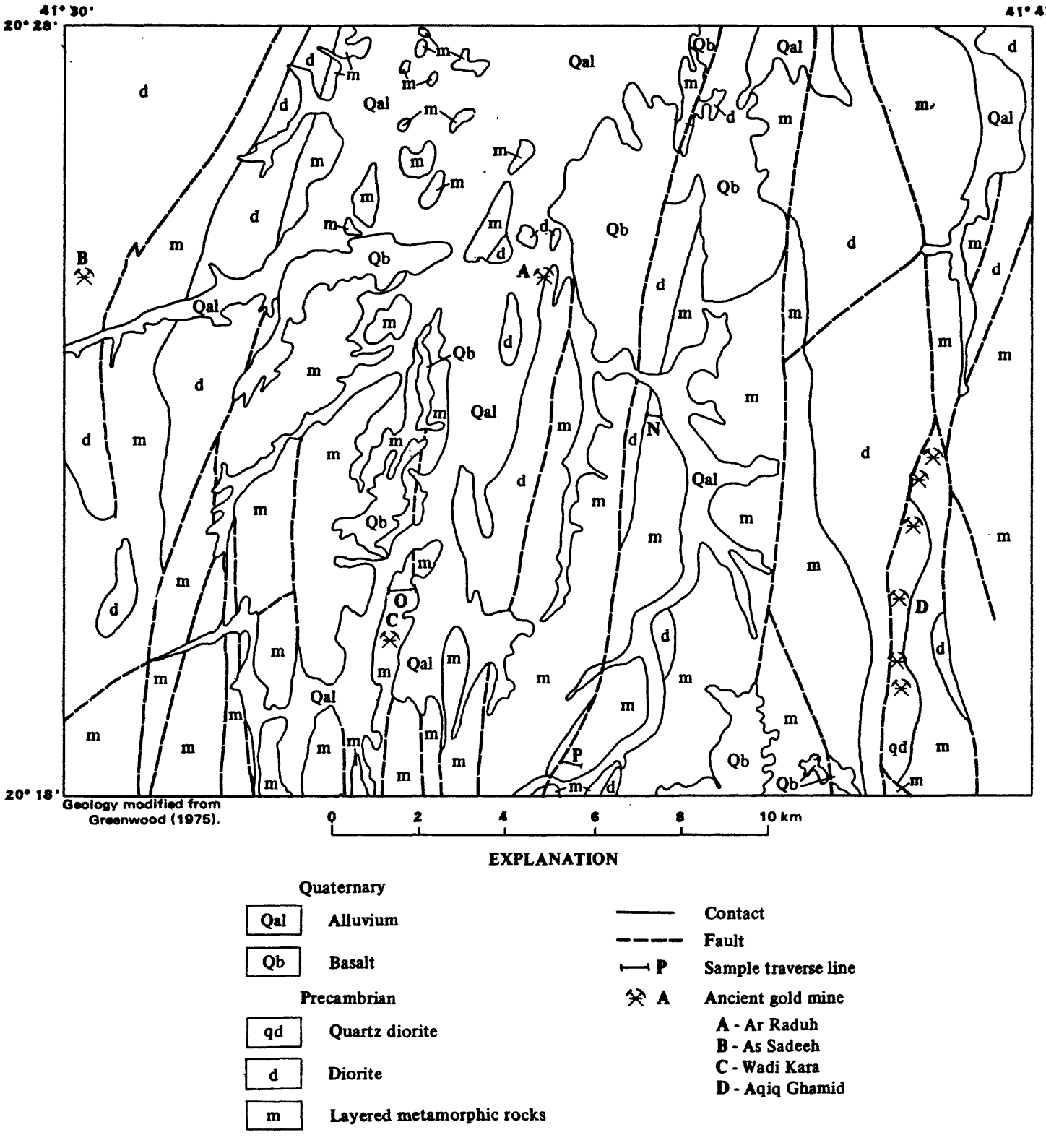



Figure 2.–Geologic map of the northwestern part of the Al Aqiq quadrangle showing location of ancient gold mines and selected sample traverse lines.

Table 1.--*Description of ancient mine sites in the Aqiq Ghamid area*

| Mine site | Latitude (north) | Longitude (east) | Description |
|---|---|---|---|
| 1 | 20°20'05" | 41°41'03" | Two partially filled, open cuts in quartz diorite: a) the western cut is 17 m long, 3 m wide, and 2 m or more deep and is located at the intersection of a fracture and vein system that trends 65° and a shear zone that trends 20° (dump sample 160084, channel sample 160890); b) the eastern cut is an irregularly shaped pit along a fracture and quartz veinlet zone that trends from 55° to 65°. The open pit is 25 m in length, from 2 to 4 m wide, and 1 m or more deep (dump sample 160085, channel samples 160888 and 889) |
| 2 | 20°20'21" | 41°41'11" | Shallow filled pit, 20 m long and 3 m wide, along 50-cm-wide quartz vein that trends 100° in greenschist (dump sample 160086) |
| 3 | 20°20'24" | 41°41'06" | Shallow, filled pit, 17 m long and 3 m wide, along a general 60° trend. Other small pits along strike to the northeast. Country rock is quartz diorite, and there is gray quartz on the dump (dump sample 160087) |
| 4 | 20°20'38" | 41°41'06" | Shallow, filled pit, 10 m by 10 m in an area of no exposed rock. There is gray quartz and altered quartz diorite on the dump (dump sample 160088) |
| 5 | 20°20'46" | 41°41'10" | Aqiq Ghamid mine (fig. 3). Numerous ancient workings along three northwest-trending vein systems. Several of the workings are more than 50 m long and locally more than 10 m deep, although most are now filled with sand and silt. Country rock is altered quartz diorite with inclusions of greenschist (dump samples 134091 to 097 and 160089 and 90; channel samples 160583 to 612) |
| 6 | 20°21'01" | 41°41'00" | Two filled, open cuts at the intersection of two vein systems: a) the northern cut is 80 m long and 3 m wide, along a 30- to 70-cm-wide brecciated quartz vein that trends 90° and is in altered quartz diorite (dump sample 160061 from southeastern part of wast dump, 062 from south-central part, and 063 from southwestern part); b) the southern cut is 42 m long and 2 m wide, along quartz veinlets that trend 55° (dump sample 160064) |
| 7 | 20°21'21" | 41°41'13" | Open cut 30 m long, 1-3 m wide, and 1-2 m deep, along a quartz-stringer zone that trends 30°. Country rock is a granite pod that contains abundant, large quartz phenocrysts (dump sample 160066 from northwestern end of dump and 067 from southeastern end; 160065 is sample of blue quartz chips from veinlets southwest of open pit; channel samples 160734 to 737) |

Table 1.--*Description of ancient mine sites in the Aqiq Ghamid area* --Continued

| Mine site | Latitude (north) | Longitude (east) | Description |
|---|---|---|---|
| 8 | 20°21'56" | 41°41'10" | Irregularly shaped waste dump composed of gray quartz in an area of no exposure (dump sample 160068) |
| 9 | 20°22'02" | 41°41'15" | Shallow, filled pit, 30 m long and 10 m wide, along veinlets that trend 30° in granite (dump sample 160069 south side of dump and 070 north side) |
| 10 | 20°22'13" | 41°41'13" | Shallow, filled pit, 40 m long and 5 m wide, along a quartz-stringer zone that trends 45° in granite pod (dump sample 160071 south side of dump and 072 north side) |
| 11 | 20°22'33" | 41°41'08" | Two shallow pits, about 50 m apart, along the edge of a granite pod: a) southwestern pit is 15 m long and 2 m wide and aligned along a 55° trend (dump sample 160073); b) northeastern pit is 30 m long and 2 m wide and aligned along a 48° trend (dump sample 160074) |
| 12 | 20°22'36" | 41°41'21" | Shallow pit, 36 m long and 2 m wide, along quartz veinlets that trend 55° in a granitic pod that cuts diorite; in an area of poor exposure (dump sample 160075) |
| 13 | 20°22'50" | 41°41'25" | Several shallow pits, lengths 25 m, 20 m, 13 m, 10 m, and smaller, from 1 to 3 m wide, and locally as much as 2 m deep. Pits trend 40° in an area of poor exposure. General area has numerous granite pods cutting diorite (dump samples 160076 south side of dump and 077 north side) |
| 14 | 20°22'58" | 41°41'29" | Two sets of open pits: a) the southwestern pit is a shallow trench 60 m long and 2-3 m wide in a zone of granitic dikes that trend 45° and cut diorite and greenschist inclusions. Quartz stringers are in and along the dikes (dump samples 160078 southwestern dump, 079 south-central and 080 northeastern); b) the northeastern set includes several irregularly shaped, open cuts, 10-25 m long and as much as 2 m deep, in a zone of granite dikes that trend 40° (dump samples 160081 southwestern dump, 082 south-central, and 083 northeastern) |

The ancient mine sites are acessible by good desert tracks from the major village of Al Aqiq, which is a few kilometers south of the Aqiq Ghamid area (area D, fig. 2). As Sadeeh is the only mine site that cannot be directly reached by vehicle; the nearest track ends a few hundred meters south of the site in Wadi Khaniqah.

The area was visited for 5 days during April 1980, and the ancient mine sites and other areas were sampled. Waiss K. Essa was in charge of sample collection. The work on which this report is based was performed in accordance with a cooperative agreement between the U.S. Geological Survey and the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

The Al Aqiq quadrangle has been mapped at a scale of 1:100,000 (Greenwood, 1975). In the area of the ancient mines the bedrock consists of a Precambrian greenstone sequence that has been intruded by diorite, felsic dikes, and quartz veins and is overlain by Quaternary basalt (fig. 2). The greenstone sequence includes dark-gray-green, fine- to medium-grained, arkosic graywacke with locally abundant tuffaceous chert, carbonaceous schist, blue marble, quartzite, metabasalt, volcanic breccia, and bedded tuff. The greenstones have been intruded by a series of elongate, north-trending lenses of hornblende-plagioclase diorite, which in most places are metamorphosed to greenschist facies. All of these rocks are sheared and foliated along generally north trends. Most of the felsic dikes also trend north. In the vicinity of the Aqiq Ghamid mine the diorite is quartz rich and in places hydrothermally altered. This alteration may be associated with later, crosscutting felsic dikes. The diorite is strongly cataclasized, with mylonite and cataclastic layering in evidence. The diorite is the oldest intrusive unit in the quadrangle, and the greenstones are part of the Precambrian Baish and Bahah groups, which are the oldest sequence of rocks exposed in the southern Arabian Shield (Greenwood, 1975).

## SAMPLING PLAN

Three types of samples were collected for geochemical analysis: dump samples, channel samples, and rock-chip or gravel samples collected along traverses. The samples were all analyzed at the DGMR-USGS laboratory in Jiddah under the direction of K. J. Curry using semiquantitative spectrographic and atomic absorption methods for gold, silver, tungsten, and molybdenum. Samples analyzed by atomic absorption for gold were prepared by digesting a 10-g sample split, first in HCl, then in $HNO_3$; adding HBr and Methyl Iso Butyl Ketone

(MIBK) to the washed and centrifuged solution; washing the resultant organic layer in a weak HCl-HBr-$H_2O$ solution to remove interfering elements; and then collecting the organic layer in a test tube sealed with a polyethylene stopper (K. J. Curry, written commun., 1978). Results of all analyses are recorded in the U.S. Geological Survey Saudi Arabian Mission Rock Analysis Storage System (RASS) computerized data base, Jiddah, Saudi Arabia. Because tungsten and molybdenum were not detected, only gold and silver analytical values for dump and channel samples are presented in tables 2 and 3, respectively.

Dump samples each consist of approximately 3 kg of rock chips, from 1 to 5 cm in diameter, collected from ancient waste dumps. Each sample is a composite collected from the top 20 cm of material at several locations on the dump. Channel samples were collected across or along altered, veined, and mineralized zones. Each sample consists of from 1 to 3 kg of chips, from 2 to 5 cm in diameter, collected along a continuous strip of outcrop. The channel length is variable and is included with the sample description in table 3. Traverse samples each consist of from 2 to 3 kg of chips, from 2 to 5 cm in diameter, collected along a 25-m-long traverse line. A continuous series of samples was collected along the traverse line. Traverse directions and a summary of gold values for the traverse samples are listed in table 4. Most traverse samples (lines A through M) are from areas of known mineralization. Three traverse lines (N, O, P; fig. 2) are across areas with no known mineralization. Traverse line O is across the same quartz vein-felsic dike zone that contains the Wadi Kara ancient mines and is approximately 2 km north of the mine area. Traverse lines P and N are across zones of cherty metasedimentary and metavolcanic rocks. None of the samples from these three traverses contain detectable amounts of gold.

## DESCRIPTIONS OF ANCIENT MINES AND SAMPLING SITES

### Aqiq Ghamid area

In the Aqiq Ghamid area (fig. 2, area D) there are several ancient mines along the southeastern boundary of one of the large diorite lenses. Rocks in this area are locally quartz rich and are mapped as quartz diorite by Greenwood (1975). Their relationship to the main diorite intrusion seems to be gradational. Within the quartz diorite are numerous quartz veins; zones of propylitic, argillic, and carbonate alteration; felsic dikes; and inclusions of greenschists. In the center of the Aqiq Ghamid area is an intensely altered zone, but

Table 2.--*Gold and silver analyses of dump samples*

[Results in grams per metric ton. Leader indicates not detected; N.D. indicates not determined. Samples S-1 to S-26, results from Smith and Kouther, 1967]

| Sample number | Gold | Silver |
|---|---|---|
| A. Aqiq Ghamid ancient mine | | |
| 134091 | 5.30 | 0.7 |
| 134092 | 13.60 | 1.0 |
| 134093 | 13.60 | .8 |
| 134094 | 1.20 | .5 |
| 134095 | 1.70 | --- |
| S-1 | 9.90 | N.D. |
| S-2 | 4.40 | N.D. |
| S-3 | 6.50 | N.D. |
| S-4 | 4.40 | N.D. |
| S-5 | 5.40 | N.D. |
| S-6 | 15.30 | N.D. |
| S-7 | 0.30 | N.D. |
| S-8 | 5.80 | N.D. |
| S-9 | 1.90 | N.D. |
| S-10 | 4.10 | N.D. |
| S-11 | 11.60 | N.D. |
| S-12 | 3.70 | N.D. |
| S-13 | .70 | N.D. |
| 134096 | 0.30 | --- |
| 134097 | .70 | --- |
| 160089 | .60 | --- |
| 160090 | .90 | --- |
| S-14 | .70 | N.D. |
| S-15 | 22.10 | N.D. |
| S-16 | 1.40 | N.D. |
| S-17 | 1.40 | N.D. |
| S-18 | 2.70 | N.D. |
| S-19 | 1.40 | N.D. |
| S-20 | 2.00 | N.D. |
| S-21 | 9.20 | N.D. |
| S-22 | 1.40 | N.D. |
| S-23 | 3.70 | N.D. |
| S-24 | 3.70 | N.D. |
| S-25 | 2.00 | N.D. |
| S-26 | 3.40 | N.D. |

Table 2.--*Gold and silver analyses of dump samples*--Continued

| Sample number | Mine site[1] | Gold | Silver |
|---|---|---|---|
| B. Ancient mines in the Aqiq Ghamid area | | | |
| 160061 | 6 | 0.66 | 0.5 |
| 160062 | 6 | 1.96 | .9 |
| 160063 | 6 | 22.10 | .9 |
| 160064 | 6 | 4.24 | 1.6 |
| 160065 | 7 | .08 | .8 |
| 160066 | 7 | 4.10 | --- |
| 160067 | 7 | .10 | .7 |
| 160068 | 8 | .84 | --- |
| 160069 | 9 | 8.40 | --- |
| 160070 | 9 | 1.52 | .7 |
| 160071 | 10 | 13.20 | .8 |
| 160072 | 10 | 4.98 | --- |
| 160073 | 11 | 1.52 | .6 |
| 160074 | 11 | 13.20 | .8 |
| 160075 | 12 | 1.68 | 1.5 |
| 160076 | 13 | 1.74 | .5 |
| 160077 | 13 | 7.76 | --- |
| 160078 | 14 | .68 | .7 |
| 160079 | 14 | 28.80 | --- |
| 160080 | 14 | .94 | 1.8 |
| 160081 | 14 | .58 | --- |
| 160082 | 14 | .88 | .7 |
| 160083 | 14 | 4.24 | .5 |
| 160084 | 1 | 12.80 | --- |
| 160085 | 1 | 3.46 | .7 |
| 160086 | 2 | 2.18 | .7 |
| 160087 | 3 | 2.16 | .9 |
| 160088 | 4 | 1.38 | --- |

[1]Site number as on fig. 3 and table 1

Table 2.--*Gold and silver analyses of dump samples*--Continued

| Sample number | Mine site[1] | Gold | Silver |
|---|---|---|---|
| C. As Sadeeh ancient mine (fig. 5) | | | |
| 160036 | B | 0.96 | 0.5 |
| 160037 | B | 1.38 | --- |
| 160038 | B | 4.98 | .7 |
| 160039 | B | 1.66 | .5 |
| 160040 | B | 3.20 | .7 |
| D. Wadi Kara ancient mine (fig. 2) | | | |
| 134098 | C | 13.60 | 1.7 |
| 134099 | C | 13.60 | 1.2 |
| 134100 | C | 1.18 | --- |
| E. Ar Raduh ancient mine (fig. 2) | | | |
| 160092 | A | --- | --- |

[1](fig. 2)

Table 3.--*Gold and silver analyses and descriptions of channel samples*

[Results in grams per metric ton. Leader indicates not detected; N.D. indicates not determined. Samples K-1 to K-11, results from Smith and Kouther, 1967]

| Sample number | Description | Gold | Silver |
|---|---|---|---|
| A. Aqiq Ghamid ancient mine | | | |
| 160583 | 3 m north from main vein zone, quartz stockwork | 1.42 | --- |
| 160584 | 3 m south from main vein zone, altered quartz diorite | 0.48 | --- |
| 160585 | 3 m north from main vein zone | 1.04 | 1.1 |
| 160586 | 3 m south from main vein zone | .46 | --- |
| 160587 | 40 cm across main vein zone | 1.04 | --- |
| 160588 | 3 m north from main vein zone | .36 | --- |
| 160589 | 3 m south from main vein zone | 1.04 | --- |
| 160590 | 130 cm across main vein zone, includes 20-cm-wide zone of blue quartz | .36 | --- |
| 160591 | 3 m east from main vein zone | .40 | 0.5 |
| 160592 | 3 m west from main vein zone | .06 | --- |
| 160593 | 3 m northwest, parallel to vein system | .06 | --- |
| 160594 | 3 m northwest, parallel to vein system | .06 | --- |
| 160595 | 3 m northeast across vein system | .12 | --- |
| 160596 | 3 m northeast from main vein system; quartz veinlet stockwork | .06 | --- |
| 160597 | 3 m northeast from main vein system | .06 | --- |
| 160598 | 3 m southwest from main vein system | .38 | --- |
| 160599 | 3 m northeast across main vein system | .36 | .6 |
| 160600 | 3 m northwest, parallel to vein system, quartz pods | 1.04 | --- |
| 160601 | 3 m northeast across vein system | --- | --- |
| 160602 | 3 m northeast from main vein zone, altered quartz diorite | .80 | --- |

Table 3.--*Gold and silver analyses and descriptions of channel samples*--Continued

| Sample number | Description | Gold | Silver |
|---|---|---|---|
| A. Aqiq Ghamid ancient mine (continued) | | | |
| 160603 | 3 m north from main vein zone, quartz veinlets | 0.80 | --- |
| 160604 | 150 cm across main vein zone, includes 40 cm of blue quartz | .12 | --- |
| 160605 | 3 m south from main vein zone, blue quartz pods | 1.42 | --- |
| 160606 | 3 m south from main vein zone | --- | 1.1 |
| 160607 | 3 m north from main vein zone | --- | --- |
| 160608 | 3 m northeast from main vein zone, minor quartz veinlets | .22 | --- |
| 160609 | 3 m across iron oxide-bearing, altered quartz diorite | --- | 0.5 |
| 160610 | 3 m north, across quartz veinlet zone | .34 | --- |
| 160611 | 3 m north, across quartz veinlet zone | --- | --- |
| 160612 | 3 m north, across quartz veinlet zone | .12 | --- |
| K-1 | | 2.0 | N.D. |
| K-2 | | 2.0 | N.D. |
| K-3 | | 2.0 | N.D. |
| K-4 | | 13.0 | N.D. |
| K-5 | | 1.0 | N.D. |
| K-6 | | 1.0 | N.D. |
| K-7 | | .7 | N.D. |
| K-8 | | 1.4 | N.D. |
| K-9 | | .7 | N.D. |
| K-10 | | 1.0 | N.D. |
| K-11 | | 1.0 | N.D. |

Table 3.--*Gold and silver analyses and descriptions of channel samples*--Continued

| Sample number | Description | Gold | Silver |
|---|---|---|---|
| B. Ancient mines in the Aqiq Ghamid area[1] | | | |
| 160734 | 25 m along northwest edge of ancient workings number 7 | 0.26 | --- |
| 160735 | 25 m west from main vein zone, ancient workings number 7 | .28 | --- |
| 160736 | 25 m along southeast edge of ancient workings number 7 | .22 | 0.7 |
| 160737 | 25 m west from main vein zone, ancient workings number 7 | .22 | --- |
| 160888 | 25 m along southeast edge of east pit of ancient workings number 1 | .24 | .80 |
| 160889 | 25 m along northwest edge of east pit of ancient workings number 1 | .16 | --- |
| 160890 | 25 m along south side of west pit of ancient workings number 1 | .08 | .50 |
| C. As Sadeeh ancient mine[2] | | | |
| 160571 | | --- | 1.1 |
| 160572 | | 0.42 | 1.3 |
| 160573 | | .24 | 1.2 |
| 160574 | | .10 | 1.5 |
| 160575 | | 18.20 | 1.5 |
| 160576 | | .28 | 1.2 |
| 160577 | | 1.16 | 1.1 |
| 160578 | | .46 | 1.5 |
| 160579 | | .22 | 1.9 |
| 160580 | | .12 | 1.4 |
| 160581 | | .16 | 1.6 |
| 160582 | | .10 | 1.4 |

[1](Fig. 3 and table 1)
[2](fig. 5; all samples are 8 m in length across the mineralized quartz-vein zones)

Table 3.--*Gold and silver analyses and descriptions of channel samples*--Continued

| Sample number | Description | Gold | Silver |
|---|---|---|---|
| D. Wadi Kara ancient mine (fig. 2) | | | |
| 160910 | 25 m across vein zone 50 m south of workings | 1.70 | 1.30 |
| 160911 | 25 m across vein zone 25 m south of workings | 0.08 | 0.50 |
| 160912 | 25 m across south end of workings | 6.20 | 1.8 |
| 160913 | 25 m across north end of workings | 3.00 | 1.4 |
| 160914 | 25 m across vein zone 25 m north of workings | .50 | 1.0 |
| E. Ar Raduh ancient mine (fig. 2) | | | |
| 160919 | 25 m across north end of workings | --- | .70 |
| 160920 | 25 m across south end of workings | --- | .80 |

Table 4.--*Traverse sample numbers and summary of gold analyses*
[Results in grams per metric ton; only values greater than 0.10 g/t noted]

| Traverse | Figure | Sample number | Traverse direction | Summary of gold results |
|---|---|---|---|---|
| A | 3 | 160702-706 | W to E | --- |
| B | 3 | 160707-716 | W to E | 707-0.36 |
| C | 3 | 160717-723 | W to E | 721-0.22 |
| D | 3 | 160724-728 | W to E | --- |
| E | 3 | 160729-737 | W to E | --- |
| F | 3 | 160738-742 | W to E | 738-0.18 |
| G | 3 | 160743-747 | W to E | --- |
| H | 3 | 160748-753 | W to E | --- |
| I | 3 | 160754-770 | W to E | 760 to 763 0.1 to 0.2 |
| J | 3 | 160771-816 | S to N | 777-0.58; 778-3.6; 779-0.12; 791-0.12; 793-0.18; 795-0.12; 813-0.16; 815-0.18 |
| K | 3 | 160817-822 | NW to SE | 820-0.18 |
| L | 3 | 160823-826 | NW to SE | --- |
| M | 3 | 160827-890 | N to S | 829-0.40; 830-0.44; 832-0.18; 833-0.16; 838-0.24; 846-0.80; 858-0.12; 889-0.24; 890-0.16 |
| N | 2 | 160891-905 | W to E | --- |
| O | 2 | 160906-909 | W to E | --- |
| P | 2 | 160915-920 | W to E | --- |

exposures in this zone are poor (fig. 3). All of the felsic dikes, most of the ancient mines, and some of the quartz veins fall in this zone. All of the ancient workings are along quartz veins and stringers, many of which are in or along felsic dikes, but not all of the quartz-vein systems are mineralized. Vein systems composed of gray to blue-gray quartz are mineralized, but apparently later formed systems of milky-white quartz are not.

Individual mine sites (fig. 3) are described in table 1. The Aqiq Ghamid mine (mine site 5, fig. 3 and table 1; fig. 4) is discussed separately in the next section. Gold and silver analyses of dump and channel samples are listed in tables 2 and 3, respectively. Traverse sample numbers and a summary of gold analyses are in table 4. Tungsten, lead, and molybdenum were not detected, and copper was generally less than 100 ppm. The average gold content of all 36 dump samples from this zone was 4.80 g/t, and the average gold content of the 27 dump samples exclusive of the Aqiq Ghamid mine was 4.96 g/t. Gold contents ranged from 0.30 to 28.80 g/t. Most silver contents ranged from 0.5 to 1.5 g/t, even in samples with high gold contents. Arsenic contents in the range from 500 to 2,000 ppm were detected in several dump samples from the Aqiq Ghamid area.

A few channel samples (table 3) were collected at the ancient workings in the Aqiq Ghamid area and contained traces of gold (less than 1 g/t). These samples were from 25-m-long channels, both along and away from the workings. They were collected, in part, to provide background information to help interpret the 25-m traverse samples. Several traverse samples (table 4) contained trace amounts of gold (less than 1 g/t). If one considers the length of the sample, these must be considered very anomalous. One traverse sample (160778) collected near ancient mine 9 (fig. 3) contained 3.6 g/t gold.

Dump samples are thought to be the best indicator of the potential grade of mineralized rocks at ancient mine sites in the Precambrian Shield (Worl, 1979). Many of these deposits are poorly exposed, and because the veins and ancient workings are covered by alluvial and eolian sands, the waste dumps are the only source of samples. Channel sampling across the mineralized zones is difficult, if not impossible, and results obtained from that sampling are probably not representative. The mine dump itself is a bulk representative sample of the prospect, and composite sampling of the dump is the best method, short of diamond drilling, to estimate the

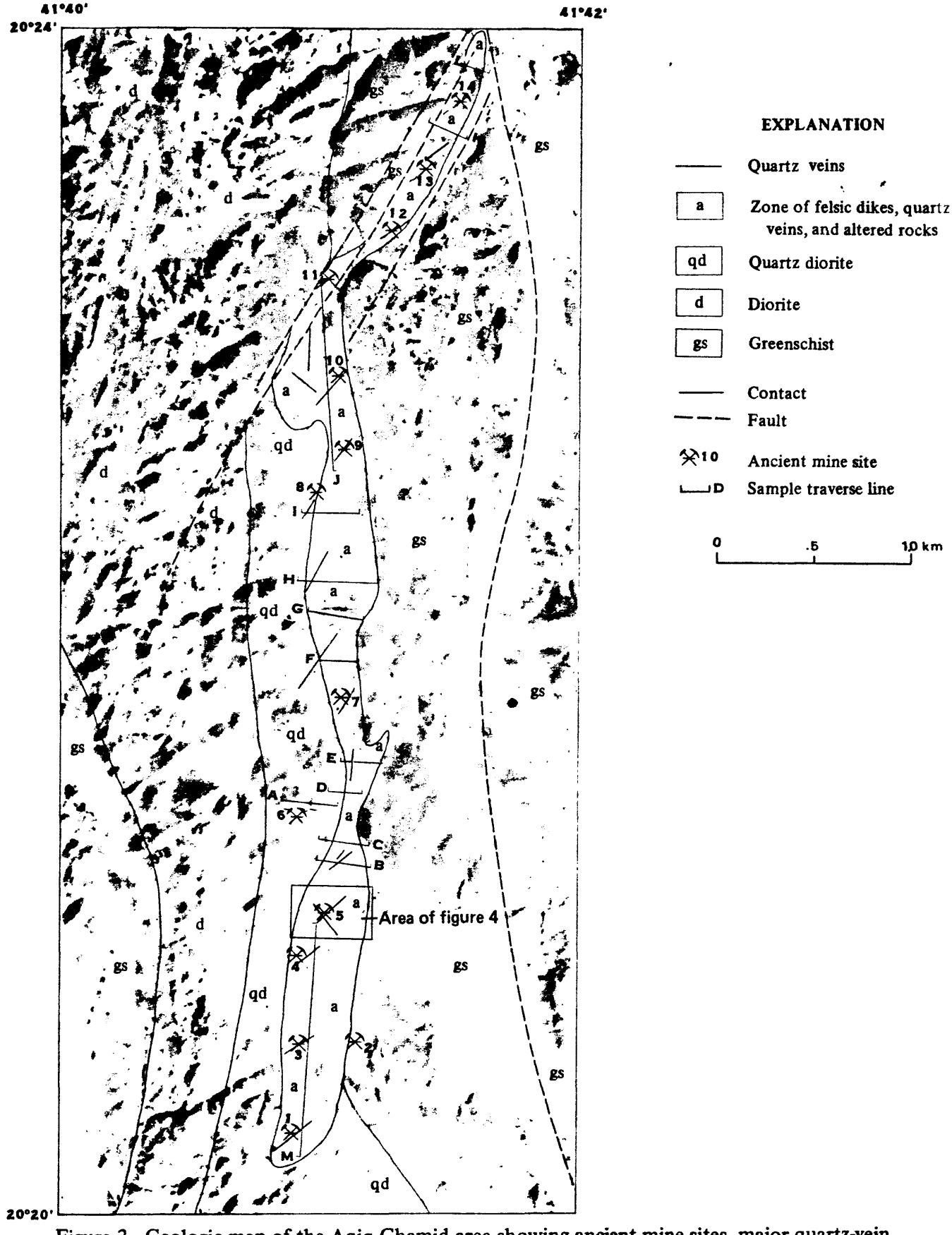
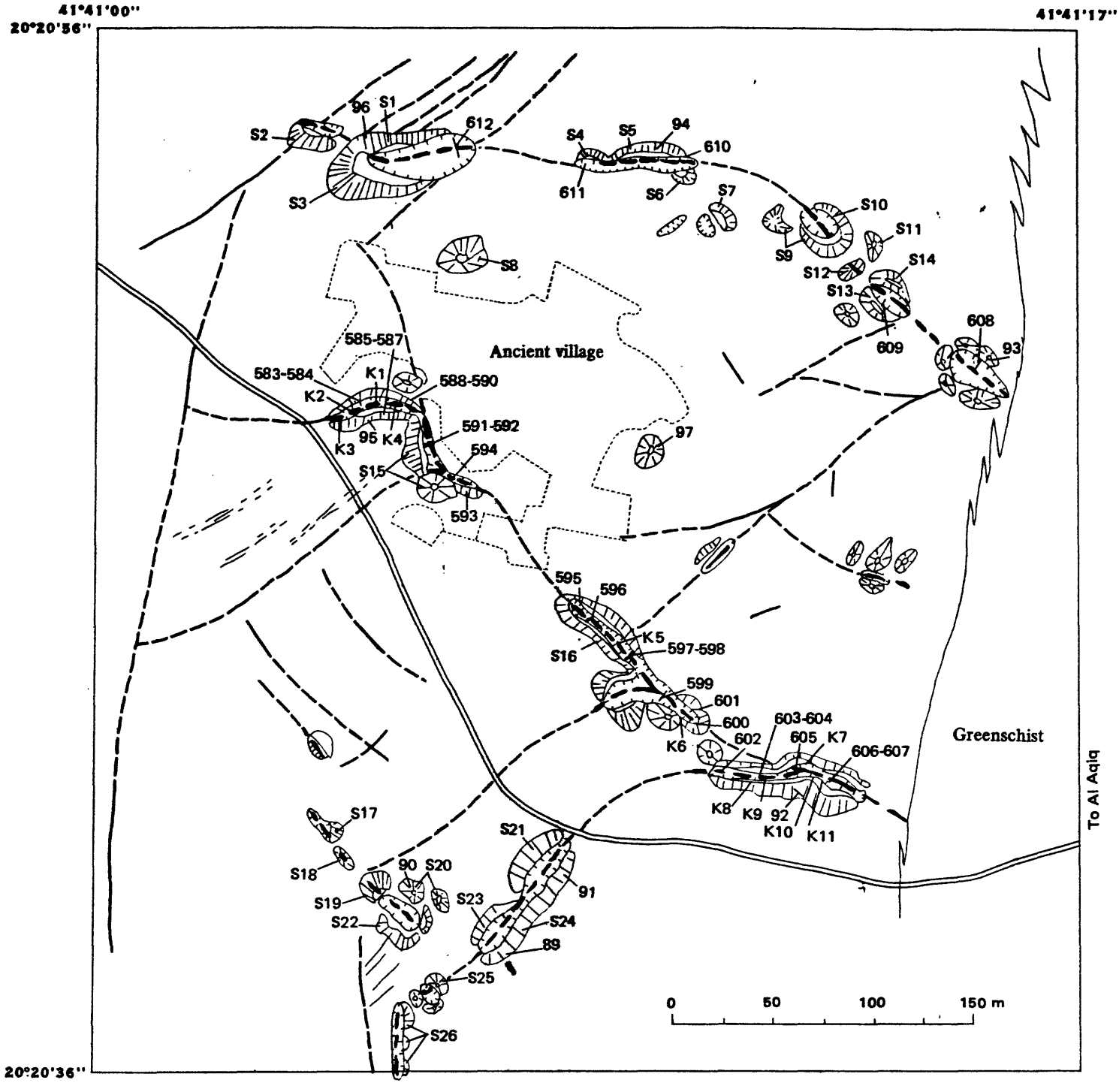



Figure 3.–Geologic map of the Aqiq Ghamid area showing ancient mine sites, major quartz-vein zones, and sample traverse lines.




EXPLANATION

Ancient workings

Contact, irregular

Fault, dashed where inferred

Quartz veins

Channel samples: 583-612, 160,000 series; K1-K11 (Smith and Kouther, 1967)

Dump samples: 91-96, 160,000 series; 89-90, 134,000 series; S1-S26 (Smith and Kouther, 1967)

Figure 4.–Sample location map of the Aqiq Ghamid ancient mine site (after Smith and Kouther, 1967). The rocks in the map area are altered quartz diorite except in the eastern part of the map area, where greenschists are present.

potential grade of a prospect. It is inferred that the average gold value of dump samples is equivalent to from 25 to 35 percent of the potential ore grade. Although this figure is somewhat arbitrary, it is based upon comparisons of dump sample contents and epigenetic ore values at mines in the Kingdom (Worl, 1979).

Using this method, the average epigenetic ore grade at the ancient mine sites in the Aqiq Ghamid area, exclusive of the Aqiq Ghamid mine, ranges from 14 to 20 g/t. The high gold contents (greater than 5 g/t) are distributed throughout the zone of alteration and veining, and exposures are such that estimates of size, except at the Aqiq Ghamid mine, cannot be made. Most mine sites are small, but two areas are worthy of further investigation: the vicinity of ancient mines 9 and 10, and the zone extending northeast from ancient mine 11 to ancient mine 14 (fig. 3).

## Aqiq Ghamid ancient mine

Aqiq Ghamid (fig. 4) is the major ancient mine in this region and has one of the largest associated ruins in Arabia. The mine area was mapped by Smith and Kouther (1967), who also collected a series of dump and vein samples. The ancient workings consist of numerous open pits, some as long as 50 m. Most of the workings are filled with sand and silt, but just south of the ancient village they are open to a depth of 13 m. It appears that shafts and declines may have gone to greater depths.

The mineralized rocks are mostly along two northwest-trending quartz-vein zones, and mineralization may be most intense where these veins intersect northeast- and east-trending veins. Because the veins pinch and swell considerably, their width varies from a feather edge to 130 cm. The mineralized veins consist of gray quartz, much of it in stringers, that contains only trace amounts of pyrite and arsenopyrite. The quartz diorite wall rock ranges from unaltered to moderately altered. In some zones numerous quartz stringers extend out from the veins for undeterminable distances.

Gold and silver analyses are listed in tables 2 and 3 and include gold analyses for dump and vein samples as reported by Smith and Kouther (1967). The average gold content for all dump samples from the Aqiq Ghamid mine was 4.80 g/t, a figure very close to the average value of dump samples from the rest of the Aqiq Ghamid area. The gold contents for the two major northwest-trending vein systems (fig. 4) were higher, the average gold contents for these dump samples being 5.88 g/t. If this

figure is assumed to be 25 to 35 percent of the epigenetic ore grade as discussed in the previous section, the epigenetic ore grade in these two veins is estimated at from 17 to 25 g/t. Using a method developed to estimate the potential tonnage of prospects in the Jabal Ishmas-Wadi Tathlith gold belt (Worl, 1979), it is estimated that there are 190,000 metric tons of ore in the northern vein system and 180,000 metric tons in the southern vein system to a depth of 150 m. This estimate agrees well with the estimate of Smith and Kouther (1967) of 1,000,000 tons in the two systems to a depth of approximately 400 m.

Most channel samples collected along or away from the ancient workings contained trace amounts of gold, that is, from 0.06 to 1.42 g/t. Samples from the vein system collected by Smith and Kouther (1967) had higher gold contents, that is, from 0.7 to 13.0 g/t.

### As Sadeeh ancient mine

The As Sadeeh ancient mine (lat 20°24'46" N., long 41°30'39" E.) consists of a series of small workings a few hundred meters north of Wadi Khaniqah near the western boundary of the Al Aqiq quadrangle (fig. 2, area B). The prospect is mentioned but not described by Goldsmith (1971). The ancient workings consist of several short open cuts that are from 2 to 3 m deep and several deep shafts and declines.

The prospect is in diorite along 20- to 40-cm-wide quartz veins and attendant alteration zones (fig. 5). Most of the veins and alteration zones are along fractures trending 315° but the ancient workings are aligned along quartz stringers and alteration zones in north-trending fractures, where the fractures intersect those trending 315°. The veins are composed of white quartz with minor iron staining, local vugs, and some carbonate. Propylitic and carbonate alteration are present along both fracture systems and the quartz pods.

Five dump samples (table 2, 160036 to 040) had an average gold content of 2.44 g/t. Twelve channel samples, each 8 m long, were collected across the mineralized zone (fig. 4). One sample contained 1.16 g/t gold and another 18.2 g/t. The remainder contained trace amounts of gold (less than 1 g/t). Silver contents were between 1 and 2 g/t.

### Wadi Kara ancient mines

The Wadi Kara ancient mines (lat 20°19'56" N., long 41°34'26" E.) (fig. 2, area C) consist of a series of

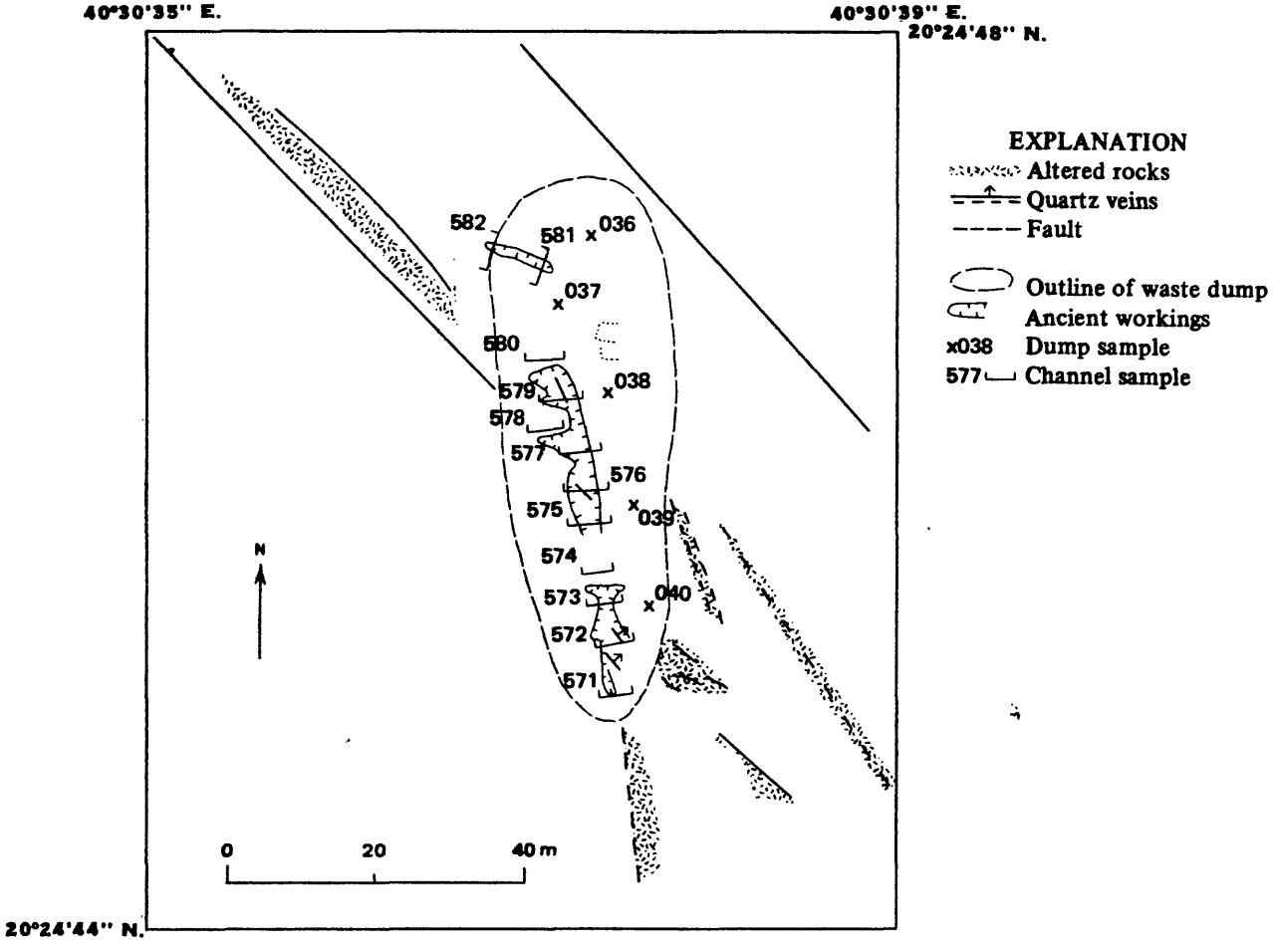



Figure 5.–Sample location and geologic sketch map of the As Sadeeh ancient mine site. Rocks in map area are diorite.

small workings in a zone of shearing, quartz veins, and felsic, mostly aplitic, dikes. Most of the country rock is quartz-sericite schist, but pyritic tuffaceous cherts, graywackes, and calcareous tuffs are also present. The ruins of an ancient village are associated with these workings.

The southernmost workings are approximately 40 m long and follow a quartz-stockwork zone on the edge of a large quartz vein trending 340°. Several small workings are scattered along strike to the north. The quartz vein dips west, and the workings are deep declines along the hanging wall of the quartz-stockwork zone.

Three dump samples (table 2) from the southernmost workings had gold contents of 13.6, 13.6, and 1.2 g/t. Five channel samples (table 3), each 25 m long, were collected across the vein and dike zone. Two of the samples contained less than 1 g/t gold. The other three contained 1.7, 6.2, and 3.0 g/t gold, amounts which are significant for samples of this length.

### Ar Raduh ancient mine

Goldsmith (1971) mentions this ancient mine (lat 20°25'25" N., long 41°36'31" E.; fig. 2, area A) but gives no description other than to mention pink quartz on the dump and about 50 buildings in associated ruins. The workings, which may not be the same as those reported by Goldsmith (1971, p. 33), consist of two shallow pits, each approximately 25 m long. One pit is along a zone of north-trending altered shears, and the other is along the edge of a quartz vein trending 83° ENE. Country rock is altered diorite. A dump sample (table 2, 160092) contained only a trace amount of gold. Two channel samples (table 3) collected across the workings contained no detectable gold.

## DISCUSSION AND RECOMMENDATIONS

All ancient gold mines in the northwestern part of the Al Aqiq quadrangle are associated with quartz veins. Most are in diorite or quartz diorite bedrock that includes some of the oldest intrusive rocks in this part of the Shield. The gold-bearing quartz veins are associated with zones of hydrothermal alteration and commonly with felsic, mainly aplitic, dikes. The deposits consist of quartz and presumably free gold. Sulfides are rare, with minor pyrite and arsenopyrite. The silver contents of all types of samples were generally low, at or just above background values. No other trace elements were found in anomalous amounts.

Two areas are worthy of further investigations: the Aqiq Ghamid area, especially the Aqiq Ghamid mine, and the zone of dikes, veins, and alteration that contains the Wadi Kara ancient workings. The Aqiq Ghamid area (fig. 3) of quartz veins, alteration, and felsic dikes contains most of the ancient workings in the study area. The diorite in this area contains abundant quartz, commonly in clusters and pods. Two areas within the Aqiq Ghamid area are of special interest: the northern part of the area from ancient mine sites 9 through 14 (fig. 3) and the area of the Aqiq Ghamid mine (fig. 4).

In the northern area, the degree of alteration is higher and the felsic dikes are more numerous. The gold contents of dump samples averaged 5.2 g/t gold, which are high relative to those in samples from the rest of the area. This northern area is poorly exposed, and exploration should include both detailed sampling of existing outcrops and trenching, where needed.

The Aqiq Ghamid mine was one of the major producers of gold in the Arabian Peninsula during ancient times. The area has the potential, to a depth of 150 m, of approximately 400,000 metric tons of from 17 to 24 g/t gold ore. The traces of the two major vein systems are exposed, although in part only by partially filled pits and dumps. These vein systems should be sampled directly by diamond drilling. Most of the mine area is poorly exposed but should be sampled and evaluated through a series of trenches.

The Wadi Kara ancient workings (fig. 2) are in a zone of shears, quartz veins, and felsic dikes. The workings are small, but the gold contents in both dump and channel samples are high. The entire zone should be sampled; the sampling should include detailed work around the ancient mines to check for extensions of high-grade mineralization.

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