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ANCIENT MINES OF THE FARAH GARAN AREA, SOUTHWESTERN SAUDI ARABIA

by

C. W. Smith

with a section on

RECONNAISSANCE GEOPHYSICAL EXPLORATION

by

H. Richard Blank

PREPARED FOR
DIRECTORATE GENERAL OF MINERAL RESOURCES
MINISTRY OF PETROLEUM AND MINERAL RESOURCES
JIDDAH, SAUDI ARABIA
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ABSTRACT

Ancient miners, in quest of oxidized copper minerals, gold, silver, and possibly zinc, mined gossans to approximately 20 m depth in an area 1.1 by 0.5 km in extent at Farah Garan. The gossans, derived from sulfides, are ordinarily found at contacts between marble lenses and metavolcanic-metasedimentary rocks, but in the southern part of the mined area, gossans are also within marbles. The gossans are generally lensoidal and discontinuous along strike. The same type of metallization, in similar rocks, was found at the Hemair ancient workings, about 3 km southeast. Both deposits are thought to be of epigenetic origin, and ore deposition was controlled by shearing along marble contacts. Drilling is recommended at Farah Garan.

Al Ashyab is 4 km south of Farah Garan, and similar rocks and structures extend through both areas but there are no ancient workings at Al Ashyab. The dominant geologic feature in the area is a high, narrow, light-colored ridge consisting of intensely silicified quartz porphyry. Pyritized metavolcanic rocks envelope the silicified rock, and geochemical sampling revealed weakly anomalous, erratically spaced concentrations of copper and zinc within these rocks. No further work is recommended for the area.

Quartz-filled fractures containing gold were mapped at Al Asharfat, Lejourah, and other locations where ancient miners worked the veins. The gold-bearing quartz veins are narrow and have short strike lengths, and potential tonnages are thought to be small. The veins are in younger, more massive rocks than the enclosing metamorphic rocks and are thought to be younger than the adjacent sulfide deposits. No further work is recommended.

Pyritized zones and associated sparse copper oxides extend intermittently about 6 km south of Hemair in meta-sedimentary rocks of the Jiddah group. Similar zones, associated quartz vein swarms, and minor magnetite and gold are found in mafic metavolcanic rocks adjacent to the contact with quartz porphyry about 1 km west of Al Asharfat. Further study of these areas is recommended.

INTRODUCTION

From May, 1975 to March, 1976 the author, assisted during part of that time by A.M. Helaby, mapped and sampled in detail four ancient mines and one altered zone within the area between lats 17°37'30"N. and 17°42'00"N. and between longs 43°37'15"E. and 43°40'00"E. (fig. 1). In addition, reconnaissance mapping and sampling was done in two other areas; one is a north-striking belt of pyritized metasediments that extends from lats 17°34'15"N. to 17°40'00"N. and lies between longs 43°39'00"E. and 43°40'00"E., the other is an area of pyritized regional shear zones at lat 17°38'00"N. and long 43°38'00"E.

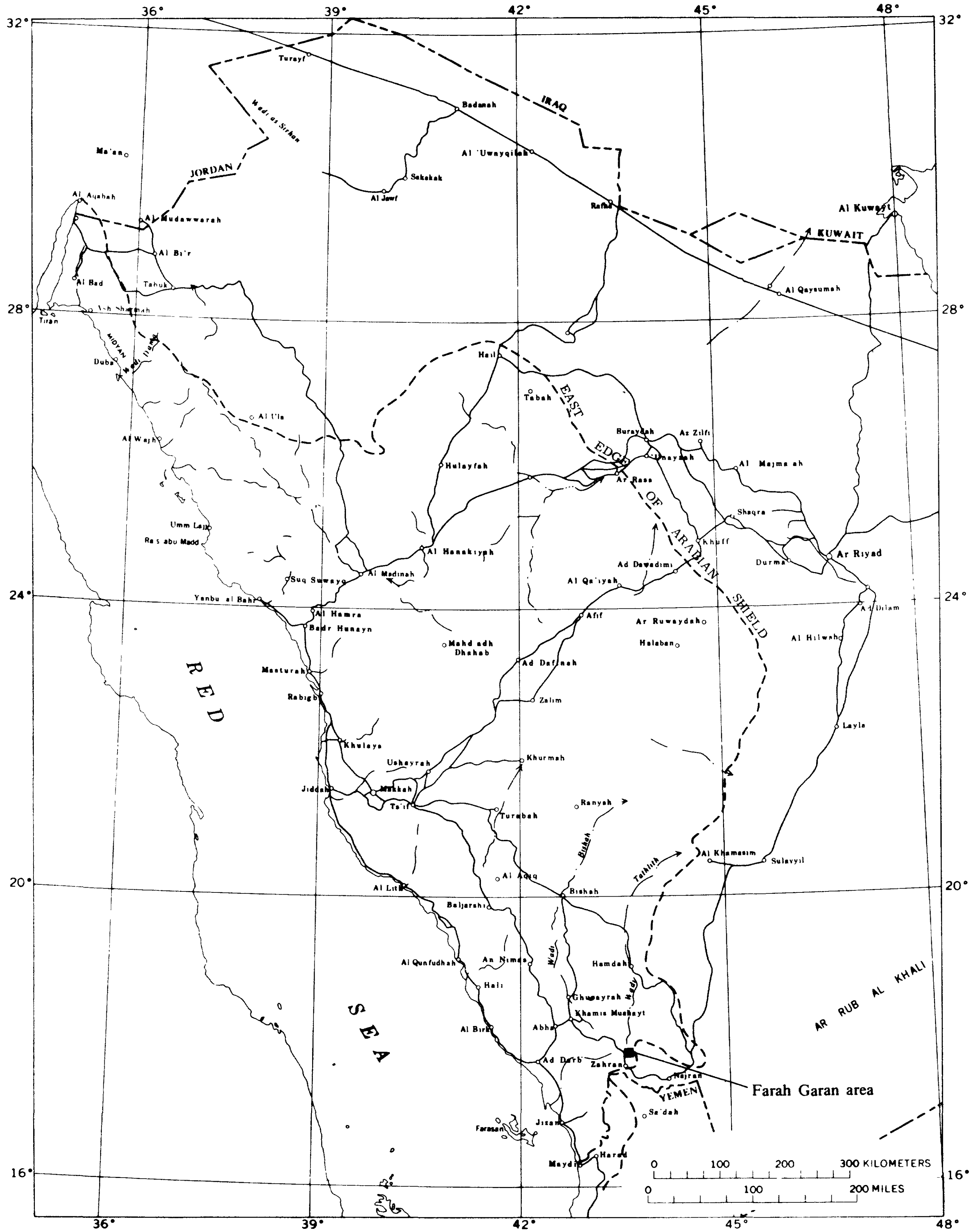


Figure 1. Index map of western Saudi Arabia showing location of the Farah Garan area.

R.E. Anderson, U.S. Geological Survey (USGS), mapped the geology of the Mayza quadrangle, including the Farah Garan area, in 1974. He re-discovered the ancient workings at Farah Garan and recognized the altered zone at Al Ashyab. In his report the Farah Garan area was given the name of Wadi Al Maslulah area (Anderson, 1978). Rock unit names assigned by Anderson have been retained for the most part in the present report, and although we are not in complete agreement on the origin of the large body of quartzose rock (qp) which covers much of the study area (fig. 2), the name of quartz porphyry has been retained for the sake of simplicity.

H.R. Blank and USGS geophysical crew conducted ground geophysical surveys, using Turam electromagnetic and self-potential methods, during the period November, 1975 to March, 1976. Their findings are reported in the section of this report covering geophysical surveys.

This investigation is one of a series of mineral deposit studies conducted by the U.S. Geological Survey, made in accordance with a work agreement with the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

REGIONAL GEOLOGIC SETTING

The layered rocks of the area, the orogenic events that affected them, and the plutonic rocks associated with or that followed orogenies, are summarized in the following hypothetical sequence of geologic events in the Farah Garan area, from oldest at the bottom to youngest at the top. Data are in part from Greenwood and others (1976).

Layered rock units	Orogenic events	Plutonic rocks
		Jiddah group rocks and weakly foliated basalt in the Lejourah region intruded by pale-red to reddish-gray quartz monzonite (qm).
	Late phase folding, faulting, and metamorphism.	Jiddah group layered rocks and medium-grained quartz diorite syntectonically intruded by coarse-grained quartz diorite (qdc) at Al Asharfat.
	Late phase folding, faulting, and metamorphism.	Jiddah group layered rocks syntectonically intruded by medium-grained quartz diorite (qd) at Al Asharfat.
Basaltic lavas (ba) laid down in Lejourah area.	Late phase folding, faulting, and metamorphism.	
Jiddah group metasedimentary and metavolcanic layered rocks. Possibly includes part of unit mapped as qp (quartz porphyry).	Aqiq orogeny-isoclinal folding, faulting, metamorphism to amphibolite facies.	First diorite series. (Radiometric age 960 million years.)

Sulfide deposition, which is considered to be epigenetic, probably took place near the end of the Aqiq orogeny, possibly earlier than the nearby deposition of gold-quartz veins in fractures within younger rocks.

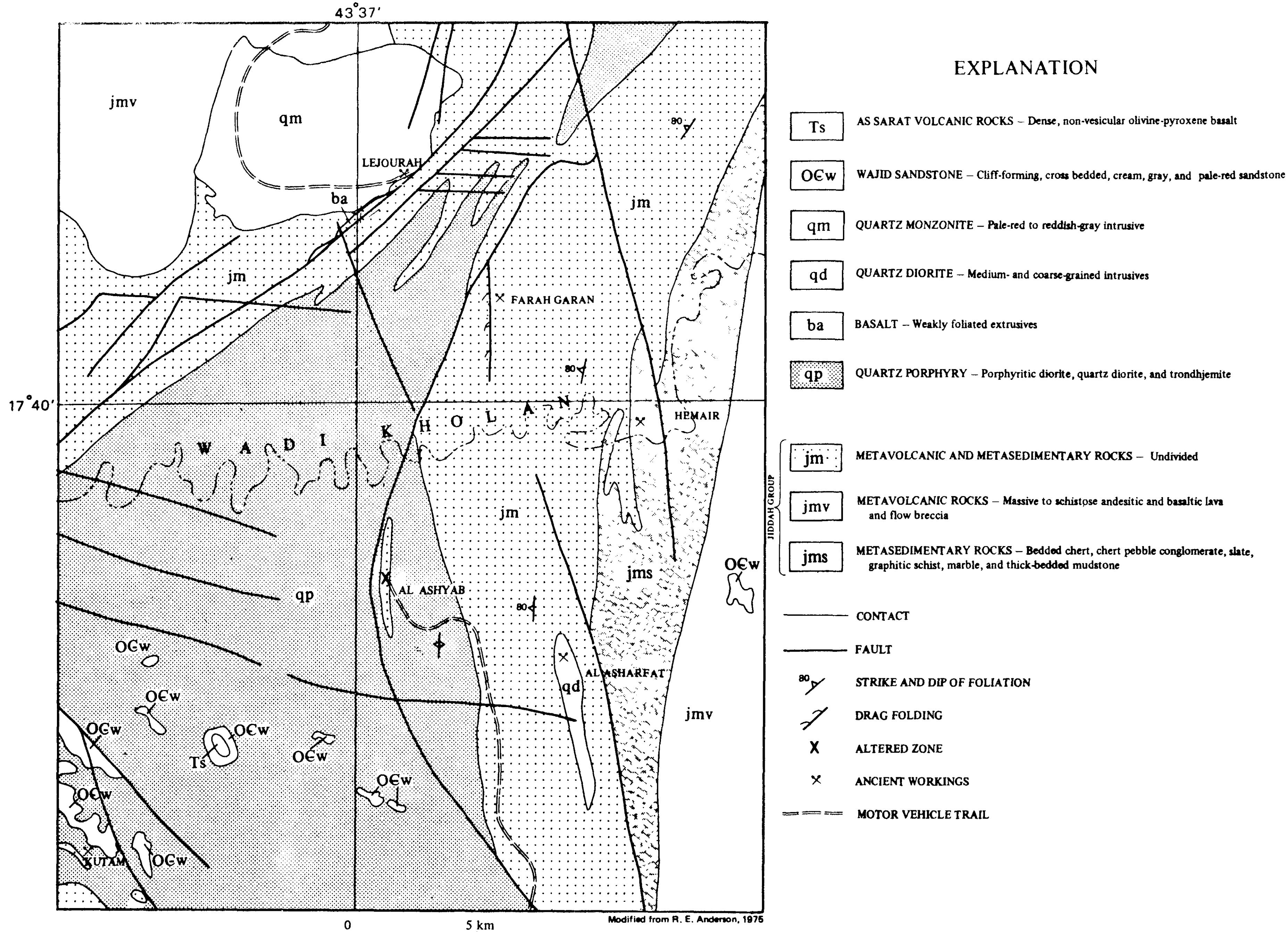


Figure 2. Geologic map of the Farah Garan-Kutam area.

FARAH GARAN MINE

Introduction

The ancient mining, milling, and smelting site of Farah Garan is at lat 17°41'00"N., long 43°38'15"W. at an elevation of about 2000 m. The ancient workings were re-discovered in 1974 by R.E. Anderson, and he and T.H. Kiilsgaard later examined the area and sampled mineralized outcrops.

Excavations by the ancient miners consisting of open cuts that average about 2 m in width extend discontinuously for 1.1 km (fig. 3). Some of the open cuts may have reached depths in excess of 20 m along ore shoots. About 5000 tons of slag is in piles near the north end of the mapped area.

The mine area is drained by two tributaries of Wadi Kholan, and local relief is as much as 100 m. The northern part is only moderately rugged and drained by a tributary that flows west. The southern part is drained by a tributary that flows south and has deeply incised the rocks of the region so that access is difficult even on foot.

In May, 1975, an area 1.1 by 0.5 km was mapped by plane table at a scale of 1:2000 by the author and A.M. Helaby. A topographic base of the same area was compiled photogrammetrically by C.M. Robins. Geochemical rock chip samples were taken at 10 m intervals on lines 50 m apart. Color photographs on a scale of about 1:12,000 and 1:20,000 aided in mapping.

Geology

The Farah Garan deposit is in metavolcanic and metasedimentary rocks of the Jiddah group. The western part of the mapped area is underlain by metavolcanic rocks of intermediate composition which contain marble lenses, whereas rocks in the eastern part are principally calcareous metasediments containing locally distributed graphitic schists (fig. 3). Metasediments are in contact with intrusive mafic volcanic rock of probable andesitic composition on the eastern edge of the mapped area.

Metavolcanic rocks are mainly green-gray quartz-chlorite schist that is interlayered with subordinate, more mafic, dark-green, feldspar-bearing schist. The quartz-chlorite schist, which is probably of dacitic composition, is characterized by clear quartz crystals as much as 3 mm in diameter, commonly shows good slaty cleavage, and is not obviously layered. The mafic, feldspar-bearing schist contains layers of volcanic breccia and massive lava, which are locally interlayered with volcanic rocks of intermediate composition and with metasedimentary rocks. Andesite dikes intrude the metasedimentary rocks near the central workings. Sills or layers of a fine-grained rock of intermediate composition containing blue-gray quartz crystals (qp, fig. 2) were noted locally on both the eastern and western edges of the deposit but were not mapped separately. These rocks are undoubtedly outliers of the large mass of quartz porphyry that crops out a few hundred meters west of the ancient workings.

Metasedimentary rocks include marble, calcareous siltstones, graywacke and graphitic schists, all of which are interlayered with metavolcanic rocks. The marble is fine grained, brown-weathering, and is in beds a few centimeters to more than 20 m thick. The layers of graphitic schist are commonly less than 5 m thick and are lensoidal. The various layers of graphite schist range from slightly graphitic to almost pure graphite.

All rocks have been metamorphosed to greenschist or amphibolite regional metamorphic facies. Chlorite and white mica form a well developed foliation that masks much of the original texture in all rocks, metasedimentary and metavolcanic alike. Typically, these rocks in thin section show strongly foliated fine-grained chlorite, epidote, white mica, and scattered ilmenite.

Structure

All rocks in the area were intensely folded isoclinally and now strike north and dip steeply west. Lenses of more competent marble were sheared only along their contacts. Later movement along a N.20°E.-striking regional fault caused local drag folding around fold axes that plunge 60° and bear S.40-60°E. Rotation and strike-slip displacement along the same fault then caused metavolcanic rocks to the west, which strike N.20°E., to be faulted against north-striking metasedimentary rocks on the east. A system of faults striking N.40-60°W. are the latest structures in the immediate area. These faults were later invaded by aplite dikes.

Mineral deposits

Mineral deposits at Farah Garan are of two types: zinc-copper sulfides and associated gold and silver along sheared contacts adjacent to marble lenses; and gold-quartz veins in shear zones not associated with marble lenses. Both types are thought to be of epigenetic origin, but age relationships between the two are not clear. The sulfide deposits are far more extensive.

Sulfide deposits

No sulfides were seen during the examination, except for minor pyrite found in quartz. All sulfides near the surface have been oxidized to form geothite, hematite, manganese oxides, copper carbonate, and zinc silicate within siliceous, cellular gossans along sheared contacts of marble lenses. In places, sulfides locally replaced marble and have undergone oxidation to form finely cellular, slightly siliceous medium-brown to maroon gossans composed mainly of iron oxides. Some small areas of gossan are heavily stained by copper oxides. Zinc minerals are ordinarily not visible in the field but assays of gossans indicate that zinc is ubiquitous. Microscopic and X-ray diffraction studies of gossans, made by the USGS laboratories in Jiddah, have detected hemimorphite ($H_2Zn_2SiO_5$). Appreciable gold and silver were found in some of the gossan samples but the mineral form or association of these metals is not known. Lead minerals were not observed, even though some samples contained moderate amounts of lead.

Ancient workings in sulfide gossans are grouped in three zones, mainly the northern, central, and southern part of the area (fig. 3).

North workings.--Pits and open stopes have been sunk on gossans to depths as much as 20 m on both contacts of a marble lens that extends about 600 m N.20°E. and dips 65°W. The stopes average about 2 m in width and follow gossans averaging 0.4 m in width. In some stopes, two or more gossans lie parallel, but the average width of mineralized rock on either contact probably does not exceed 2.0 m. Small workings within the marble lens reveal locally gossanized zones along fractures.

The central part of the marble lens has undergone fracturing, cavity filling, and partial replacement by milky quartz and calcite, and large parts of the lens are composed of these minerals. Quartz and calcite contain very minor amounts of cubic pyrite and no gold or silver. At least some of the quartz and calcite was deposited prior to the sulfides, as is revealed by the cross-cutting relationship of sulfide gossans to quartz.

The marble lens pinches and becomes discontinuous to the southwest and is accompanied by other lenses not exceeding 2 m in width.

Central workings.--The largest stope in the central workings is 60 m long, 6 m wide, and 5 m deep, and reveals several discontinuous gossans in sheared metasedimentary rocks at the west contact of a marble lens. Other shallower, rubble-filled stopes on strike to the north indicate a sulfide zone, which possibly extends 250 m in that direction. The marble lens pinches about 50 m south of the large stope, but quartz-filled shears continue south to an inclined shaft that shows copper-stained quartz. The entire sulfide zone is thus about 450 m long. Parallel marble lenses that have sheared, gossanized contacts indicate possible sulfide metallization intermittently across a 100 m width in this area.

South workings.--The south workings consist of marble lenses honeycombed with irregular shafts, trenches, open cuts, and adits along a distance of 250 m. These workings are on gossans developed where sulfides locally replace marble. Two small marble lenses and minor gossans were mapped south of the workings, but obvious zinc-copper metallization terminates in this area.

Gold-quartz veins

Gold-quartz veins were worked by the ancients in the extreme north and central parts of the mapped area (fig. 3). The quartz is milky- to medium-gray and contains very sparse cubic pyrite. Free gold was not seen. Veins average about 0.3 m in width but range up to 1.5 m wide, and are discontinuous and lenticular along strike. The quartz veins were deposited in shears not associated with marble lenses.

Sampling of gossans and veins

Thirty-six chip and grab samples were taken across mineral gossans in place and from waste dumps. In addition, Kiilsgaard and Anderson sampled at 28 localities, but information of sample widths is lacking for some of their sampling (fig. 4).

All samples were assayed for gold, silver, copper, lead, and zinc by both atomic absorption and semi-quantitative spectrographic methods. Spectrographic analyses also gave semi-quantitative data for 25 additional elements (table 1). This work was done in the Directorate General of Mineral Resources (DGMR) laboratories in Jiddah.

Sulfide deposits.--Forty-two chip samples from gossans gave the following average width and grades:

Width (meters)	Au grams/ton(g/t)	Ag g/t	Cu percent(pct)	Pb pct	Zn pct
0.56	2.22	19.40	0.77	0.25	5.33

Ranges of widths and grades are as follows:

Width (m)	Au g/t	Ag g/t	Cu pct	Pb pct	Zn pct
12.0-0.05	44.8-0.03	130.0-0.75	2.05-0.04	2.15-0.004	23.60-0.03

A weighted average from six continuous chip samples across the south end of the central workings gave the following width and grade:

Width (m)	Au g/t	Ag g/t	Cu pct	Pb pct	Zn pct
2.85	0.47	10.30	1.14	0.09	5.64

Gold-quartz veins.--The average content of gold and silver in 11 chip and dump samples is as follows:

Au g/t	Ag g/t
2.31	0.58

Average vein width where sampled in place is 1.2 m. Ranges of vein widths and content of gold and silver are as follows:

Width (m)	Au g/t	Ag g/t
1.5-0.3	10.64-Trace	1.16-0.004

Table 1.--Semi-quantitative spectrographic analyses of samples from Farah Garan ancient mine. Lower limit of detectability shown in parentheses. Data in parts per million, except for Fe, Ti, Ca, and Mg, which are in percent. N, element was looked for but not found; symbol < preceding a number indicates an amount less than the number was found; symbol > preceding a number indicates an amount greater than the number was found. Samples 96159 through 96171 were assayed at a time when detectability limits were higher than at present.

Sample Number	(.05) Fe%	(.02) Mg%	(.05) Ca%	(.002) Ti%	(10) Mn	(200) As	(10) B	(20) Ba	(1) Be	(10) Bi	(20) Cd	(5) Co	(10) Cr	(20) La	(5) Mo	(20) Nb	(5) Ni	(100) Sb	(5) Sc	(10) Sn	(100) Sr	(10) V	(50) W	(10) Y	(10) Zr
106907	3	1	15	0.15	3000	N	N	300	N	N	N	5	700	N	<5	N	70	N	30	N	<100	70	N	10	20
106908	0.7	0.3	3	0.005	200	N	N	<20	N	N	N	<5	200	N	<5	N	<5	N	<5	N	<100	10	N	<10	<10
106909	0.5	0.02	0.15	0.01	20	N	N	<20	N	N	N	<5	100	N	<5	N	<5	N	<5	N	<100	10	N	<10	<10
106910	0.7	0.02	0.15	0.03	100	N	N	20	N	N	N	<5	100	N	<5	N	5	N	<5	N	<100	30	N	<10	<10
106911	0.5	0.02	0.07	0.005	70	N	N	<20	N	N	N	<5	100	N	<5	N	<5	N	<5	N	<100	10	N	<10	<10
106912	0.7	0.02	1.5	0.007	70	N	N	<20	N	N	N	<5	100	N	<5	N	5	N	<5	N	<100	10	N	<10	<10
106913	0.3	0.02	0.05	0.005	50	N	N	<20	N	N	N	<5	150	N	<5	N	<5	N	<5	N	<100	10	N	<10	<10
106914	0.7	0.02	0.15	0.03	200	N	N	50	N	N	N	<5	100	N	<5	N	5	N	<5	N	<100	30	N	<10	<10
106915	1.5	0.7	5	0.07	300	N	N	300	N	N	N	<5	500	N	<5	N	30	N	5	N	<100	70	N	<10	<10
106916	0.5	0.15	1.5	0.007	200	N	N	30	N	N	N	<5	100	N	<5	N	5	N	<5	N	<100	10	N	<10	<10
106917	3	3	10	0.1	3000	N	N	30	N	N	N	<5	300	N	<5	N	5	N	<5	N	<100	30	N	<10	10
106918	7	3	5	0.01	>5000	N	N	20	N	N	N	<5	100	N	<5	N	<5	N	<5	N	<100	10	N	<10	20
106919	3	0.5	0.7	0.3	2000	N	N	200	N	N	N	<5	150	N	<5	N	7	N	15	N	<100	70	N	10	50
106920	7	5	10	0.005	>5000	N	N	30	N	N	200	5	100	N	30	N	7	N	<5	N	<100	20	N	<10	<10
106921	7	3	5	0.03	5000	N	70	200	N	30	100	5	10	N	<5	N	5	N	7	N	<100	30	N	<10	<10
106922	7	3	7	0.01	5000	N	50	50	N	20	200	10	100	N	<5	N	5	N	<5	N	<100	30	N	<10	<10
106923	7	5	10	0.03	3000	N	N	70	N	N	500	10	100	N	<5	N	5	300	7	N	<100	30	N	<10	<10
106924	3	0.5	1.5	0.05	1000	N	N	500	N	N	N	5	100	N	<5	N	5	N	15	N	<100	70	N	<10	<10
106925	7	1	0.5	0.1	1000	1000	N	500	N	N	N	7	150	N	<5	N	10	N	20	N	<100	100	N	<10	<10
106926	10	1	1	0.5	>5000	1500	N	1500	N	N	150	5	70	N	<5	N	20	3000	15	N	<100	200	N	20	50
106927	5	0.3	5	0.03	>5000	300	N	1500	N	10	100	<5	50	N	<5	N	7	300	<5	N	<100	50	N	<10	<10
106928	5	3	1	0.1	3000	N	N	1500	N	N	N	10	10	N	<5	N	<5	N	10	N	<100	15	N	10	20
106929	10	1	10	0.03	5000	N	N	70	N	10	20	10	20	N	<5	N	<5	<100	<5	N	<100	20	N	<10	<10
106930	5	0.07	1.5	0.01	200	N	N	<20	N	N	N	<5	200	N	<5	N	7	N	<5	N	<100	10	N	<10	<10
106931	5	0.1	2	0.02	300	N	N	<20	N	N	N	<5	100	N	<5	N	7	N	<5	N	<100	15	N	<10	<10
106932	5	0.03	0.2	0.01	500	N	N	<20	N	N	N	<5	200	N	<5	N	5	N	<5	N	<100	20	N	<10	<10
106933	10	0.07	0.1	0.03	1000	N	N	100	N	N	N	<5	10	N	<5	N	<5	N	<5	N	<100	10	N	10	<10
106934	7	0.15	0.7	0.01	3000	N	N	20	N	N	N	5	70	N	<5	N	<5	N	<5	N	<100	10	N	<10	<10
106935	5	0.1	0.3	0.01	1500	N	N	50	N	N	70	<5	70	N	<5	N	70	300	5	N	<100	50	N	10	<10
106936	1	0.15	0.1	0.03	1500	N	N	30	N	N	N	<5	200	N	<5	N	10	<100	<5	N	<100	30	N	<10	<10
106937	1	0.05	0.2	0.05	100	3000	N	1500	N	10	70	<5	150	N	<5	N	30	700	<5	N	100	30	N	10	<10
106938	7	1	0.5	0.03	>5000	N	N	500	N	20	30	100	150	N	<5	N	70	N	<5	N	<100	100	N	<10	<10
106939	>20	1.5	3	0.07	300	N	N	70	N	N	30	<5	150	N	70	N	<5	N	5	N	<100	20	N	20	10
106940	5	10	0.7	0.003	>5000	200	N	<20	N	N	50	10	50	N	<5	N	10	N	< 5	N	<100	70	N	<10	<10
106941	10	7	0.3	0.08	3000	300	N	<20	N	N	50	<5	50	N	<5	N	5	N	< 5	N	<100	150	N	<10	<10
106942	1.5	10	10	0.007	>5000	200	30	20	N	30	200	10	50	N	<5	N	20	100	< 5	N	150	30	N	<10	<10
96159	3	3	1	0.1	1000	<500	<50	200	<5	<20	<100	20	50	<100	50	<20	20	<200	15	<20	<200	30	<100	20	30
96160	5	0.7	0.5	0.5	1000	<500	<50	300	<5	<20	<100	20	100	<100	<10	<20	30	<200	20	<20	<200	150	<100	20	70
96161	5	0.7	0.7	0.07	1000	<500	500	50	<5	<20	<100	<20	70	<100	<10	<20	20	<200	10	<20	<200	30	<100	<20	20
96162	3	0.7	1.5	0.01	700	<500	70	<50	<5	20	<100	<20	20	<100	<10	<20	<20	<200	<10	<20	<200	20	<100	<20	<20
96163	1.5	5	7	0.003	700	<500	<50	<50	<5	<20	<100	<20	50	<100	<10	<20	<20	<200	<10	<20	<200	20	<100	<20	<20
96164	5	0.5	2	0.5	2000	<500	<50	1000	<5	<20	<100	20	30	<100	15	<20	50	300	20	<20	<200	100	<100	30	50
96165	7	0.7	0.5	0.2	700	700	<50	200	<5	<20	<100	20	150	<100	10	<20	50	<200	30	<20	<200	100	<100	<20	30
96166	1.5	3	10	0.01	3000	<500	<50	<50	<5	<20	<100	<20	30	<100	<10	<20	30	<200	<10	<20	<200	30	<100	<20	<20
96167	5	0.5	0.2	0.03	100	2000	<50	3000	<5	50	<100	<20	100	<100	50	<20	50	1000	<10	<20	<200	100	<100	<20	<20
96168	1.5	0.05	0.1	0.003	100	1000	<50	3000	<5	<20	<100	<20	70	<100	<10	<20	30	300	<10	<20	<200	20	<100	<20	<20
96169	3	3	0.05	0.15	300	<500	100	5000	<5	<20	<100	<20	50	<100	<10	<20	50	<200	<10	<20	<200	50	<100	<20	50
96170	10	1	0.3	0.005	700	1500	<50	<50	<5	150	<100	<20	70	<100	20	<20	70	500	<10	<20	<200	70	<100	<20	20
96171	10	1.5	0.1	0.1	2000	<500	<50	150	<5	<20	<100	30	50	<100	50	<20	50	<200	<10	<20	<200	30	<100	<20	50

Rock sampling for trace metal analysis

Four hundred rock chip samples were gathered for geochemical analyses along east-west lines across mineralized zones within an area of 1.1 by 0.5 km. Atomic absorption and semi-quantitative spectrographic analyses were made on all samples. The two analytical methods gave similar results for Au, Ag, Cu, Pb, and Zn. Copper and zinc analyses were evaluated statistically, grouped into four frequency distributions, and plotted on figures 5 and 6.

Generally, anomalous copper and zinc contents are confined to marble lenses and associated shear zones that have visible gossans (figs. 5, 6). Only a few scattered anomalous samples were found elsewhere. Although the metasedimentary and metavolcanic rocks are locally pyritized, they rarely contain anomalous amounts of copper or zinc. Likewise, the white quartz veins along marble lenses and along the trace of the Farah Garan fault are also barren.

Conclusions and recommendations

Zinc-copper-lead-gold-silver metallization is distributed intermittently throughout an area of 1.1 by 0.5 km at Farah Garan. Epigenetic sulfide minerals, accompanied by gold and silver, were deposited along sheared contacts of marble lenses and partly replaced the marbles. In addition, gold was deposited in quartz veins perhaps independently and in more restricted areas.

It is recommended that both types of metallization be tested by four diamond drill holes (figs. 3, 7).

Drill hole FG-1 is planned to intersect the downward projection of gossans exposed in the large central workings. In addition the hole will explore at depth a zone 100 m wide where other gossans were mapped at contacts with marble lenses; samples of these rocks contain anomalous amounts of zinc and copper, and geophysical studies found a 400 millivolt, negative, self-potential anomaly. Proposed length of the drill hole is 200 m.

FG-2 is planned to intersect the downward projection of copper-zinc metallization found at the south workings and also to explore the continuation at depth of other gossans associated with marble lenses across a zone 100 m wide. The south extension of the self-potential anomaly would also be explored. In addition, this drill hole may provide information concerning the shape and plunge of folded marble lenses and their effect on sulfide deposition. Its proposed depth is 200 m.

FG-3 is laid out to intersect drag-folded marble lenses locally replaced by sulfide. In addition, it would explore the projection of other thin marble lenses and a gold-quartz vein worked by the ancients. Geophysical studies outlined a negative self-potential anomaly trending along the hanging wall of the Farah Garan fault. The drill hole would intersect this anomalous zone and penetrate the Farah Garan fault. If continued to 350-400 m depth, it would also explore metallization projected 250 m below the surface at the central workings.

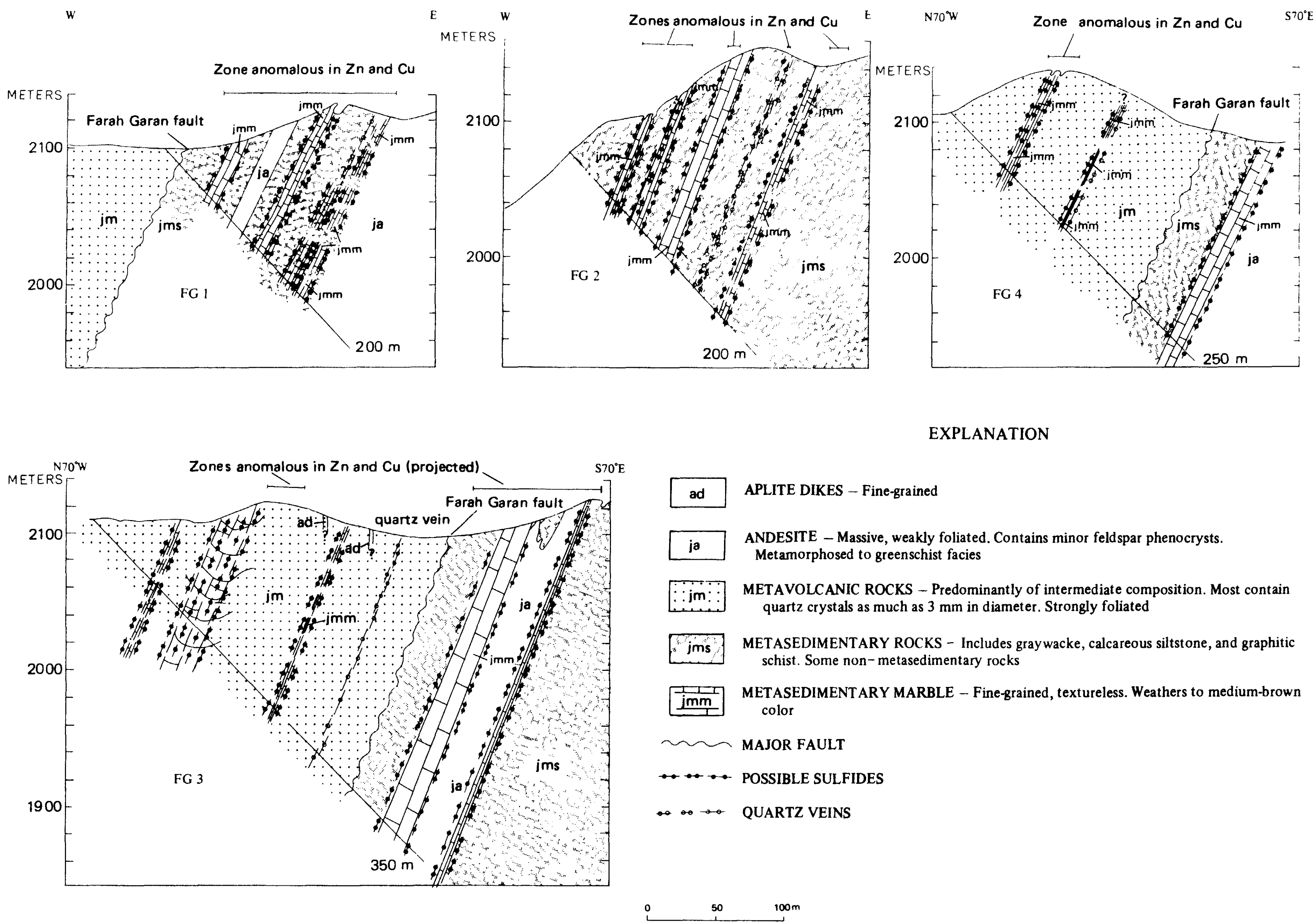


Figure 7. Vertical sections along proposed drill hole FG 1, 2, 3, and 4, Farah Garan ancient mine.

FG-4 is planned to intersect the downward projection of metallization found at the north workings and also to further test the self-potential anomaly trending parallel to the hanging wall of the Farah Garan fault. It would also explore the northerly projection of metallization found along sheared contacts of marble lenses at the central workings. The hole is estimated to be 250 m in length.

The four proposed drill holes would aggregate about 1050 m in length and would adequately test metallization at depth. Depending upon results, the drilling program could be expanded if desirable.

AL ASHYAB

Introduction

Al Ashyab was recognized as having possible mineral potential by R.E. Anderson during his mapping of the Mayza quadrangle. An inspection of the area was later made by T.H. Kiilsgaard and Anderson. The area of interest is at lat 17°30'13"N. and long 43°37'11"E. and is accessible by 4-wheel drive vehicle via a Bedouin truck-trail leading from the Najran-Khamis Mushayt highway (fig. 2).

Work in the area by the author during November 1975, and February 1976, assisted by A.M. Helaby, consisted of laying out a base line, rock chip sampling on a 25 and 50 m grid, and geologic mapping on an aerial photographic base at a scale of 1:5000.

Al Ashyab is named from a prominent north-south ridge rising 120 m from the valley floor. There are no ancient workings in the area.

Geology

The oldest rocks at Al Ashyab are interbedded metasedimentary and metavolcanic rocks of the Jiddah group (figs. 2, 8). Metasedimentary rocks are sparse and consist of shaly, calcareous rocks in lenses as much as 4 m wide interlayered with silicic to intermediate tuffs and flows that contain quartz crystals to 3 mm in diameter and with dark-green mafic volcanics, which in places contain feldspar phenocrysts. All rocks have been metamorphosed to the greenschist or amphibolite facies.

In thin section the intermediate metavolcanic rocks are quartz-sericite schist and the mafic metavolcanics are chlorite-epidote-quartz schist that contain finely scattered ilmenite. The shaly-calcareous metasedimentary rocks display fluffy chlorite on fresh surfaces, and in thin section are fine-grained chlorite-epidote-quartz schist containing a little coarse-grained ilmenite. The rocks are similar to those mapped at Farah Garan, 4 km north. They occupy the valley floors at Al Ashyab.

Metasedimentary and metavolcanic rocks of the Jiddah group were syntectonically intruded by quartz porphyry in thin sills and probably are interlayered with flows and tuffs of the same rocks. The quartz porphyry is part of a large mass that extends south to Kutam and well north of Farah Garan (fig. 2). It contains blue-gray quartz phenocrysts as much as 1 cm in diameter in a fine-grained groundmass of garnet-bearing sericite-quartz-chlorite schist. Evidence for intrusive origin consists of dikes and thin sills of quartz porphyry within the

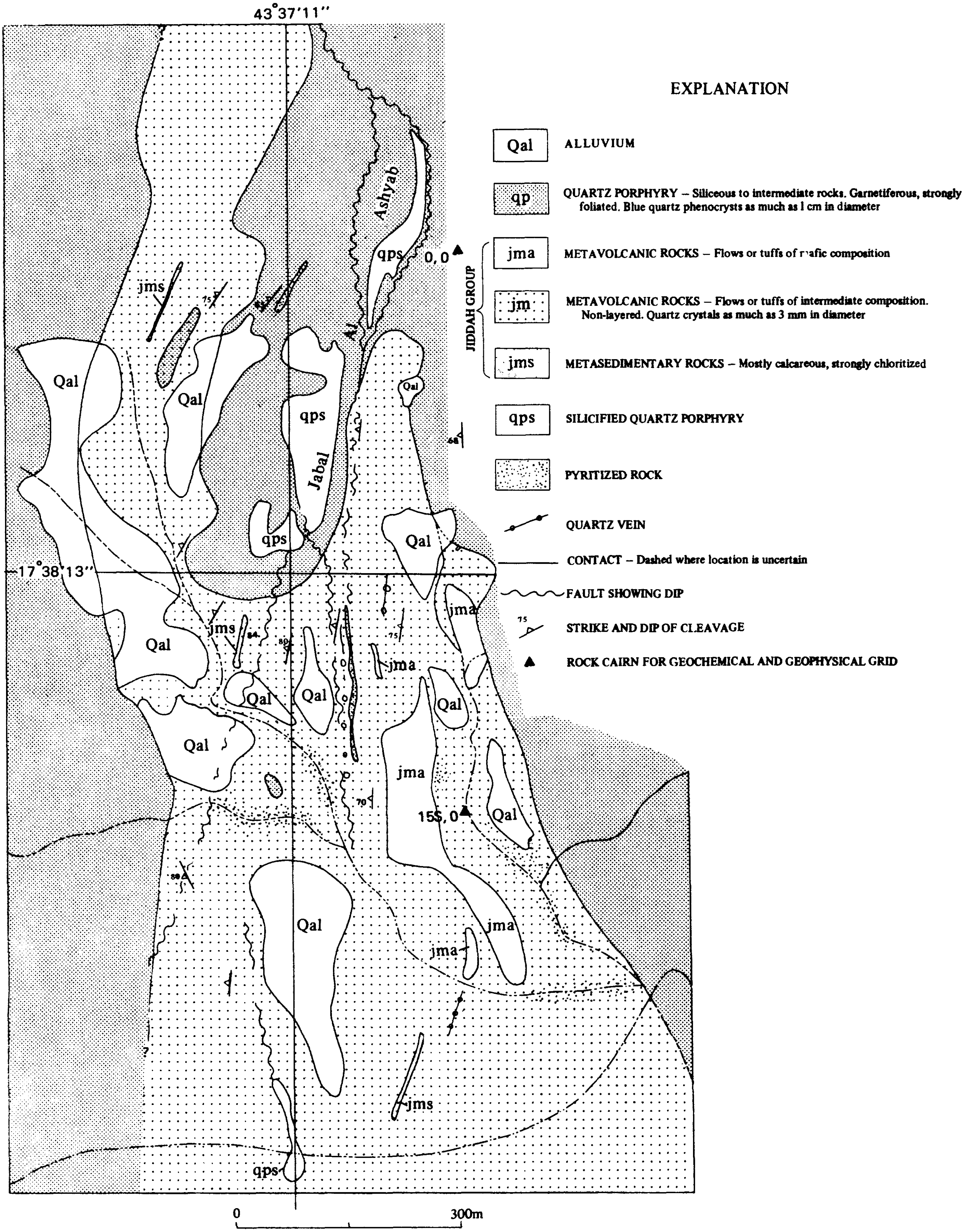


Figure 8. Geologic map of Al Ashyab area.

same rock type. Some outcrops show evidence of extrusive origin, however, and quartz porphyry appears to lie in conformable contact with layered metavolcanic rocks. The quartz porphyry occupies the high valley walls and the central ridge within the mapped area.

Structure

All rocks were isoclinally folded and sheared. Layering and strong foliation strike north and dip steeply west. Regional shears extend north and south outside of the mapped area and diverge around a large silicified mass of quartz porphyry at Jabal Al Ashyab, indicating that at least part of the shearing is post-silicification.

Some of the silicified rocks are sheared, although little horizontal displacement has taken place. In the south-central part of the mapped area, a major north-south shear zone has been intruded by quartz porphyry, indicating that some of the shearing is pre-quartz porphyry, and was later silicified. Consequently, the regional shears are thought to have been active over a long time period.

Complimentary east-trending faults of little displacement are reflected by drainage systems. They are younger than the northerly shearing and in places are intruded by fine-grained mafic dikes.

Alteration

In the northern part of the mapped area, quartz porphyry has been almost totally silicified along the general northerly shear direction for a distance of approximately 600 m, forming a high, narrow ridge (fig. 8). Quartz phenocrysts are visible within the silicified zone, indicating that the original rock was quartz porphyry. In thin section the rock exhibits granular quartz and relicts of muscovite and epidote from an earlier generation of alteration minerals. Very fine pyrite is sparsely disseminated throughout the quartz.

A zone of quartz-sericite alteration extends out from the silicified mass at least 200 m to the west and north, but only a few meters to the east and south. Limits of the quartz-sericite mass are not shown on figure 8 because of the difficulty in mapping gradational boundaries. In thin section the rock is fine-grained quartz-sericite-chlorite schist that contains very fine-grained pyrite crosscutting foliation.

Metallization

Two types of metallization were recognized in the south-central part of the Al Ashyab area: prominent pyritization within metavolcanic rocks and quartz veins containing minute copper stains.

Pyritized metavolcanics are best exposed in the wadi bottoms (fig. 8). Within these areas, disseminated cubic pyrite as much as 0.5 cm across is weathered to hematite. The greatest concentrations of pyrite appear to be along major shear zones, especially along the north-northeast striking shear in the southwest part of the area. Drainages crosscutting this zone display intensely pyritized metavolcanic rocks. One chips sample from this area contained 0.26 percent zinc. No other indication of metallization was seen.

A north-striking quartz-carbonate vein was mapped in the south-central part of the area. The vein is as much as 3 m wide and consists mainly of milky quartz and lesser brown-weathering calcite. The quartz contains very sparse cubic pyrite, and vein selvages show very weak copper staining. Chip samples from the vein indicate low concentrations of all metals.

Rock sampling for trace metal analysis

Rock chip samples were taken at 556 sites on a grid whose spacing was 25 m in the south and 50 m in the north and that covered an area of 1 km by 0.5 km (figs. 9, 10). Samples were analyzed for gold, silver, copper, lead, and zinc by both atomic absorption and semi-quantitative methods. Analytical data for copper and zinc were grouped statistically and their frequency distribution determined.

Copper

Copper content below 41 ppm is considered to be background, and amounts greater than 325 ppm are considered to be anomalous.

The quartz porphyry, including the silicified ridge, is generally low in copper. A poorly defined, weakly anomalous zone coincides with pyritized metavolcanics south and east of the silicified ridge, but anomalous values are scattered. A pyritized shear zone sampled at the extreme south contains no anomalous copper.

Zinc

Zinc content of less than 49 ppm is considered to be background, and amounts greater than 480 ppm are anomalous.

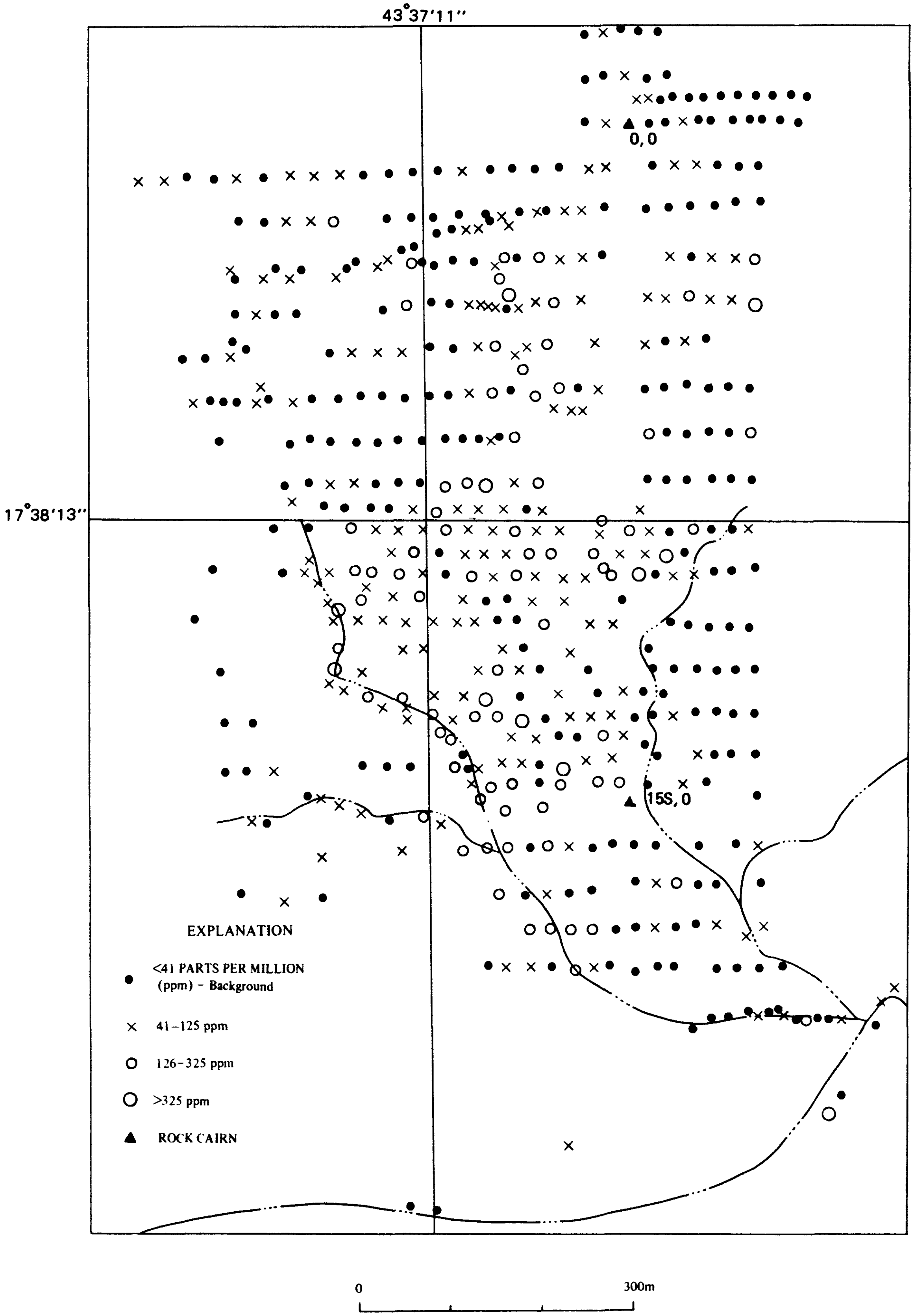


Figure 9. Copper content of rock samples, Al Ashyab.

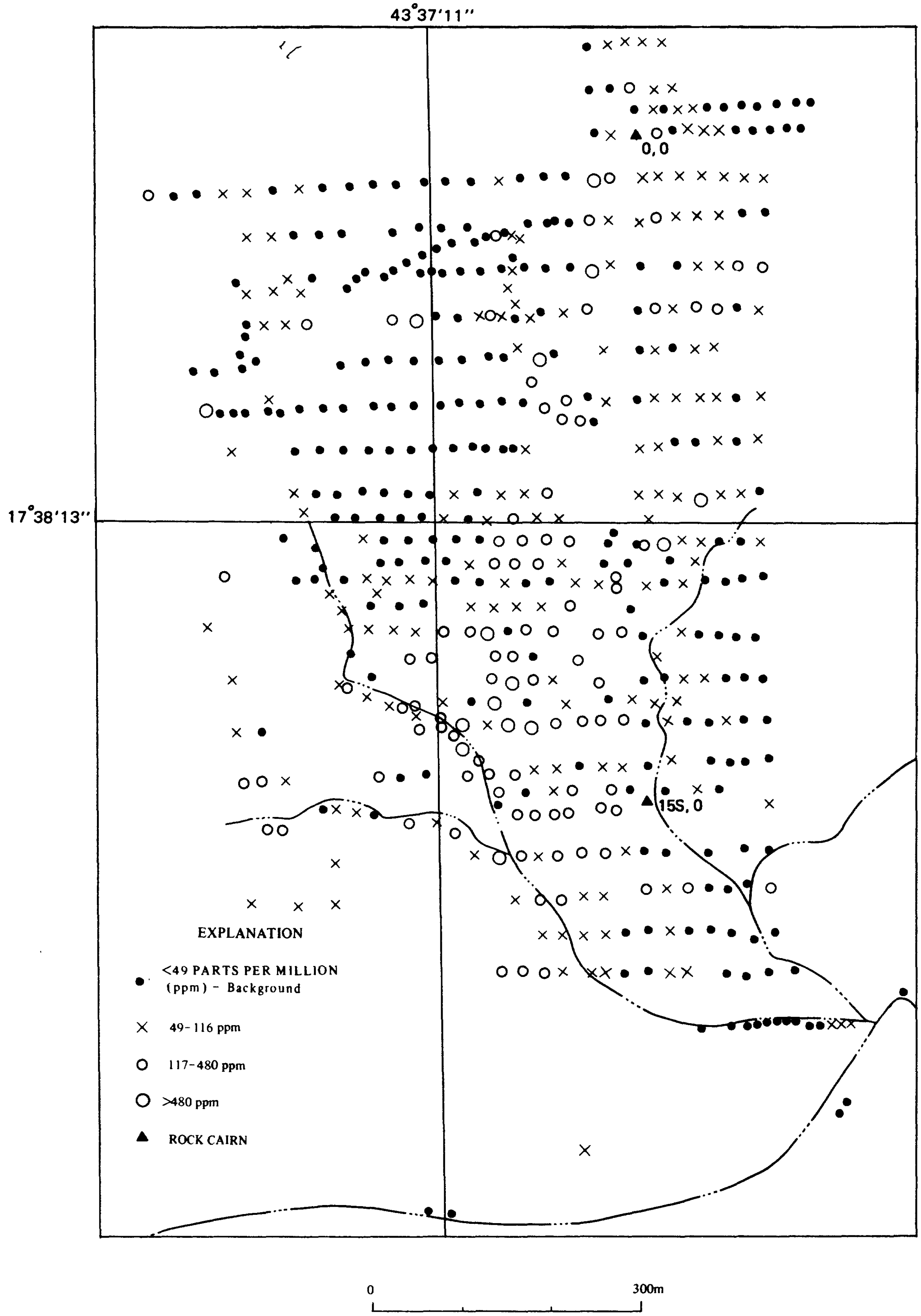


Figure 10. Zinc content of rock samples, Al Ashyab.

Most of the quartz porphyry, including the silicified ridge, does not contain anomalous zinc. However, anomalous zinc samples are more numerous and more closely grouped than are those anomalous in copper. Samples with higher zinc contents are concentrated within the pyritized shear zone south of the ridge, as are those of high copper content.

Other anomalous samples are widely scattered and do not appear to be significant.

Conclusions and recommendations

Al Ashyab is 4 km south of Farah Garan and similar rocks extend through the two areas, except that the marble lenses mapped at Farah Garan are less common at Al Ashyab. Folds, faults, and quartz veins strike north and dip steeply west in both areas. Identical metavolcanic rocks are altered to quartz-sericite-chlorite schist and are pyritized within shear zones at both places. Strongly silicified quartz porphyry occurs only at Al Ashyab.

At Farah Garan, visible copper- and zinc-bearing minerals are confined to sheared, gossanized contacts with marble lenses, and geochemical studies confirm this relationship. Pyritized quartz-sericite alteration zones contain no anomalous amounts of copper or zinc. At Al Ashyab, the metavolcanic rocks affected by quartz-sericite-pyrite alteration are strongly anomalous in copper and zinc in closely confined areas, whereas weakly anomalous zones are broader and poorly defined. The silicified quartz porphyry is not anomalous in either metal.

Metallization in both areas is believed to be epigenetic and related to shears within metavolcanic rocks but at Al Ashyab, visible zinc-copper metallization is lacking, and the erratically spaced, moderately anomalous mineralized zones encountered in geochemical studies suggest that economic mineral deposits probably are not present at depth.

No further work is recommended for the area.

AL ASHARFAT

Introduction

The Al Asharfat ancient workings are at lat 17°37'00"N., long 43°39'00"E. and are accessible via a Bedouin truck-trail (fig. 2). They consist of 10 shallow workings along a distance of approximately 1.5 km. The largest working is 50 m long and 8 m deep at the deepest part. A sorting area with a few grinding stones is adjacent to the largest workings. Most of the workings are partly filled with mine waste.

The author, assisted by A.M. Helaby, sampled veins and dumps and mapped the area using aerial photographs during February 1976.

Geology and structure

Rocks of the Jiddah group here are isoclinally folded, faulted, and strongly foliated, and are intruded by two syntectonic phases of quartz diorite. All rocks are cut by faults which strike N.10°E. and dip steeply west. The latest faults, which strike N.50°W., are filled by fine-grained mafic dikes (fig. 11).

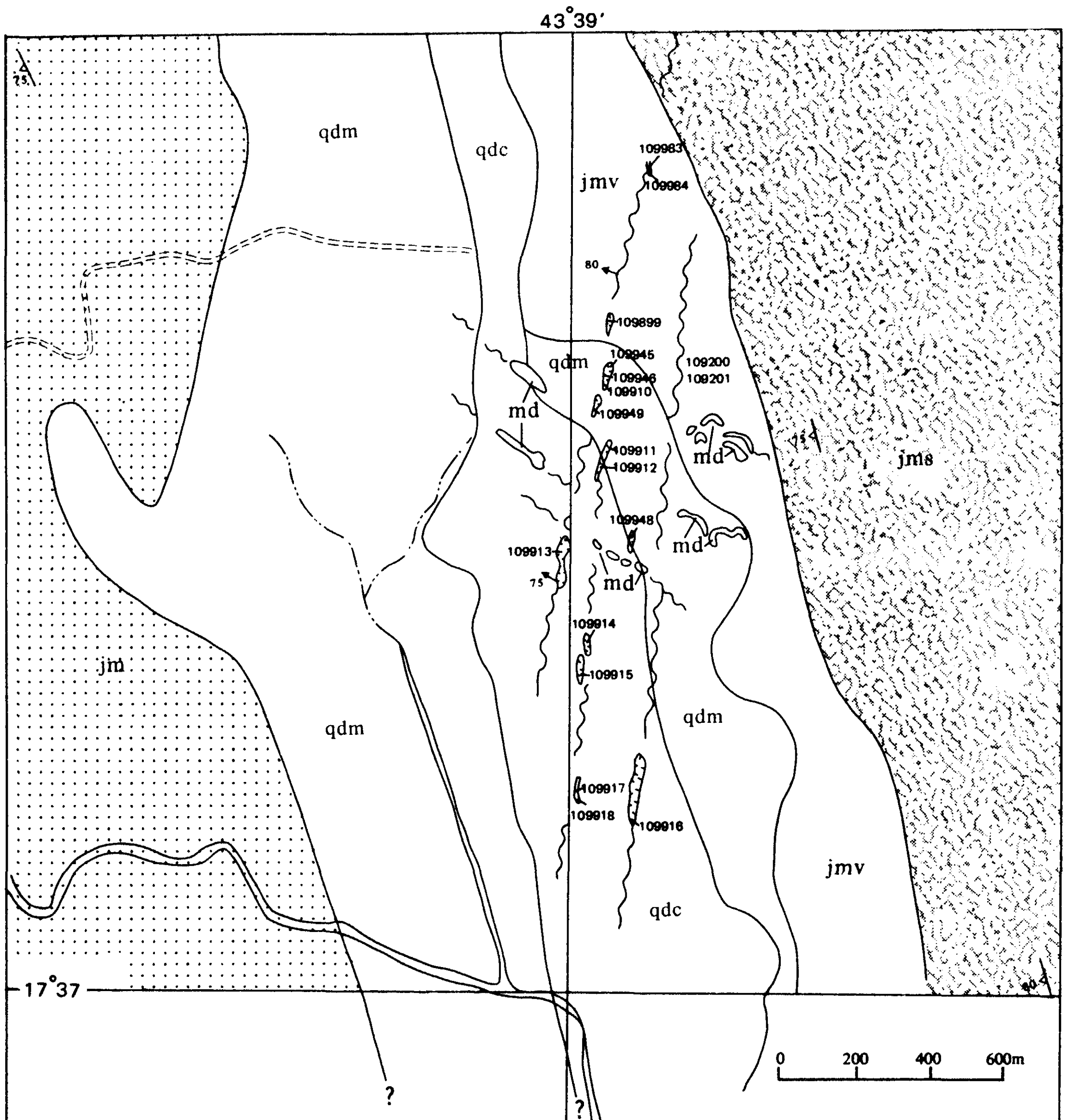


Figure 11. Geologic and sample map of Al Asharfat.

ANALYTICAL DATA

Sample number	Description	Width (m)	Au g/ton	Ag g/ton	Cu %	Pb %	Zn %
109200	Quartz, with iron oxide, cubic pyrite	Grab	0.07	1.3	0.010	--	0.008
109201	Quartz, with iron oxide, cubic pyrite	Grab	0.08	0.8	0.010	--	--
109899	Quartz, clear, white	Grab	0.25	--	0.001	--	--
109910	Pillar in workings--fault	0.05	38.80	4.0	0.009	--	0.004
109911	Schist, pyritic, sericitic		0.90	0.3	0.004	--	0.004
109912	Minor quartz, iron oxide	Grab	0.23	0.5	0.007	--	0.006
109913	Siliceous, iron-stained	Grab	3.44	0.3	0.006	--	0.004
109914	On shear, siliceous, iron-stained	0.15	6.86	0.8	0.030	0.003	0.003
109915	Shear, silicified	0.05	1.70	4.3	0.008	0.001	0.007
109916	Shear, weakly silicified	0.40	0.07	0.2	0.002	--	0.005
109917	Sparse iron oxide	0.30	0.35	0.6	0.030	--	0.004
109918	Weak copper stain in fault	0.30	2.60	1.8	0.750	0.003	0.030
109945	Quartz with manganese oxide	0.05	0.18	0.6	0.002	0.001	0.007
109946	Dump, selected, siliceous	Grab	1.40	2.4	0.010	0.005	0.006
109948	" " "	Grab	22.00	1.5	--	--	0.001
109949	Shear in fresh quartz diorite	0.20	0.10	0.8	0.007	0.001	0.007
109983	Quartz with manganese oxide	0.10	0.15	--	--	--	--
109984	Shear, sparse iron oxide	0.10	0.48	0.9	0.007	0.001	0.010

EXPLANATION

md — MAFIC DIKES – Fine-grained

qdc — QUARTZ DIORITE – Syntectonic, massive, coarse-grained. Contains blue-gray quartz

qdm — QUARTZ DIORITE – Syntectonic, massive, medium-grained. Contains blue-gray quartz

JIDDAH GROUP

jm — METAVOLCANIC AND METASEDIMENTARY ROCKS – Interbedded

jmv — METAVOLCANIC ROCKS – Schistose andesitic and basaltic lavas

jms — METASEDIMENTARY ROCKS – Interbedded marble, graphitic schist, cherty conglomerate, and intermediate volcanic rocks

CONTACT – Dashed where location is uncertain

80 FAULT SHOWING DIP

75 STRIKE AND DIP OF FOLIATION

ANCIENT WORKINGS

MOTOR VEHICLE TRAIL

109200 SAMPLE LOCALITY AND NUMBER

The intrusive rocks are massive and less foliated than the enclosing metavolcanics. Both phases of quartz diorite contain subhedral, blue-gray quartz intergrown with plagioclase, amphibole, fine-grained biotite, and scattered ilmenite. The later phase, which intrudes the earlier, is petrographically similar but coarser grained.

Metallization

Trenches along the N.10°E. fault system expose narrow fractures along which wall rocks are silicified and locally stained by hematite derived from cubic pyrite. The width of silicified wall rock does not exceed 0.5 m. In places the fractures contain narrow stringers of milky pyritic quartz. Dump material from a trench at the south end of the area studied contained minor copper stain but none was seen in place. The silicified wall rock apparently was the material sought by ancient miners and probably contains free gold, but none was seen by the author.

Assay results

Assay results and sample locations are shown on figure 11. Silicified fault zones exposed in workings were sampled at 18 localities and two grab samples were gathered from dumps.

The highest gold assay was 38.8 grams per ton, in a sample across 0.05 m of silicified, faulted material in the deepest workings. A sample of selected siliceous rock from the dump of the same workings contained 22.0 grams gold per ton. Samples cut across narrow silicified fault zones in other workings assayed as much as 6.86 grams gold per ton. No significant amounts of silver, copper, lead, or zinc were found in the samples.

Conclusions and recommendations

Ancient miners worked gold deposits to shallow depths in the Al Asharfat region, where gold occurs in narrow, silicified zones bordering faults. Potential gold reserves of the area are small and no further study is recommended.

LEJOURAH

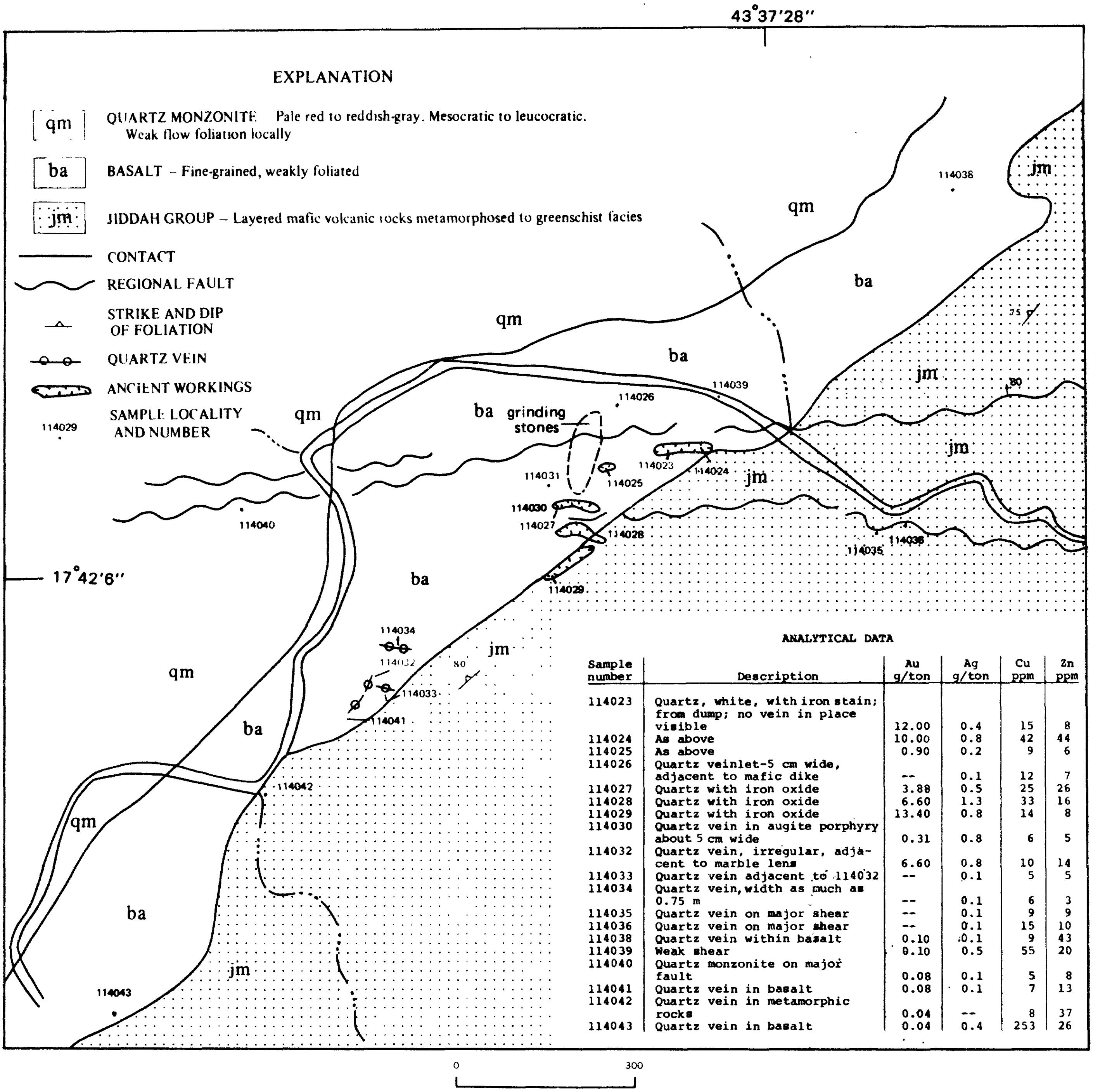
Introduction

Lejourah is accessible by motor vehicle via a Bedouin truck trail that passes through the village of Talhah and joins the Khamis Mushayt-Najran highway nearby (fig. 2). Five ancient workings within a small area are at lat 17°42'6"N., long 43°37'28"E. in relatively flat terrain. They are filled with mine waste, and no bedrock is exposed in them. A great number of grinding stones and sorting piles are near the workings.

The area was mapped in February 1976 on color photographs at a scale of approximately 1:12,600, and dumps, sorting piles, and a few unmined quartz veins were sampled.

Geology

Volcanic rocks of the Jiddah group, principally interlayered basalt and andesite, are isoclinally folded, sheared, strongly foliated, and metamorphosed to greenschist facies in the mine area (fig. 12). Foliation and layering strike N.45°E. and dip steeply northwest. Later basalt flows are massive, weakly foliated, and cut by quartz veinlets that contain associated



ANALYTICAL DATA

Sample number	Description	Au g/ton	Ag g/ton	Cu ppm	Zn ppm
114023	Quartz, white, with iron stain; from dump; no vein in place visible	12.00	0.4	15	8
114024	As above	10.00	0.8	42	44
114025	As above	0.90	0.2	9	6
114026	Quartz veinlet-5 cm wide, adjacent to mafic dike	--	0.1	12	7
114027	Quartz with iron oxide	3.88	0.5	25	26
114028	Quartz with iron oxide	6.60	1.3	33	16
114029	Quartz with iron oxide	13.40	0.8	14	8
114030	Quartz vein in augite porphyry about 5 cm wide	0.31	0.8	6	5
114032	Quartz vein, irregular, adjacent to marble lens	6.60	0.8	10	14
114033	Quartz vein adjacent to 114032	--	0.1	5	5
114034	Quartz vein, width as much as 0.75 m	--	0.1	6	3
114035	Quartz vein on major shear	--	0.1	9	9
114036	Quartz vein on major shear	--	0.1	15	10
114038	Quartz vein within basalt	0.10	0.1	9	43
114039	Weak shear	0.10	0.5	55	20
114040	Quartz monzonite on major fault	0.08	0.1	5	8
114041	Quartz vein in basalt	0.08	0.1	7	13
114042	Quartz vein in metamorphic rocks	0.04	--	8	37
114043	Quartz vein in basalt	0.04	0.4	253	26

Figure 12. Geologic and sample map of Lejourah.

ilmenite. The youngest rock is a pale-pink to gray, medium- to coarse-grained quartz monzonite pluton that intrudes the basalt to the northwest.

Structure and metallization

Regional faults that strike slightly north of east and dip steeply north transect all rocks. Ancient workings are within basalt along the trace of fault zones and on the contact between basalt and metavolcanic rocks. The open cuts are small, and the orebodies worked apparently had short strike lengths. Piles of sorted quartz on waste dumps must represent the material the ancients were mining. The quartz is milky and iron stained, and contains sparsely scattered free gold in grains as much as 0.5 mm across. The gold occurs typically in small clusters of chloritic material. Cubic pyrite is also disseminated sparsely within the quartz.

Unmined quartz veins deposited as fracture fillings in basalt were mapped about 250 m southwest of the workings. The veins average 0.4 m in width and have strike lengths of only a few meters.

Assay results

Sample locations, descriptions, and analyses are shown on figure 12. Among vein samples only sample 114032, cut across an irregular quartz vein, contained gold in significant amounts, 6.60 grams per ton. Samples from other quartz veins and faulted zones contained only negligible gold. Of six samples collected from sorting piles, the richest contained 13.40 grams per ton and the poorest 0.90 grams per ton. The average grade of these six samples is 7.80 grams gold per ton. No other metals were found in significant amounts.

Conclusions and recommendations

Ancient miners at Lejourah worked gold-bearing veins in small open cuts within an area 150 by 500 m. Quartz from sorting piles near the open cuts bears visible free gold. The numerous grinding stones confined to a small area adjacent to the ancient workings indicate that the gold veins were intensively worked.

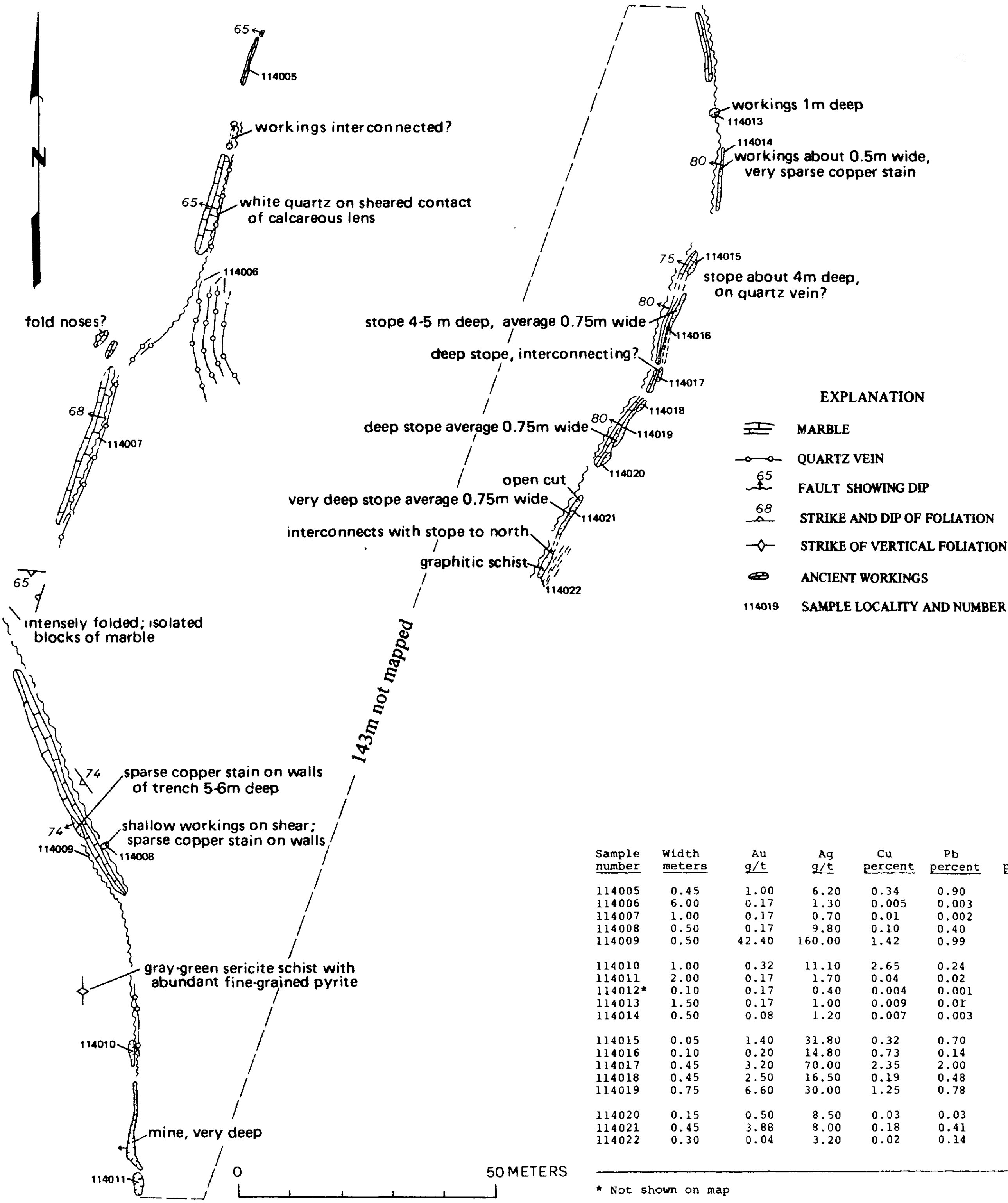
Geologic mapping and sampling of the ancient mine sites indicate that the possibility of finding extensions of the gold-bearing quartz veins is remote. Even though free gold was found in quartz on dumps, and significant gold was found in sampling, the potential tonnage of ore is too small to merit further consideration.

HEMAIR

Introduction

The Hemair ancient mining site is on the steep valley walls of Wadi Kholan at lat 17°40'00"N., long 43°39'00"E., where a line of workings trends nearly due south and extends intermittently more than 500 m. The workings are very narrow, averaging less than a meter in width, but some are extremely deep where ancient miners evidently followed ore shoots. Mine dumps have been completely eroded away.

The nearest approach to Hemair via land vehicle is from Al Ashyab, about 5 km southwest (fig. 2). The area was reached by helicopter in February 1976, at which time mineral outcrops were mapped by use of Brunton and tape and were sampled.



Sample number	Width meters	Au g/t	Ag g/t	Cu percent	Pb percent	Zn percent
114005	0.45	1.00	6.20	0.34	0.90	3.75
114006	6.00	0.17	1.30	0.005	0.003	0.02
114007	1.00	0.17	0.70	0.01	0.002	0.004
114008	0.50	0.17	9.80	0.10	0.40	0.08
114009	0.50	42.40	160.00	1.42	0.99	1.85
114010	1.00	0.32	11.10	2.65	0.24	0.60
114011	2.00	0.17	1.70	0.04	0.02	0.09
114012*	0.10	0.17	0.40	0.004	0.001	0.001
114013	1.50	0.17	1.00	0.009	0.01	0.004
114014	0.50	0.08	1.20	0.007	0.003	0.009
114015	0.05	1.40	31.80	0.32	0.70	0.51
114016	0.10	0.20	14.80	0.73	0.14	0.14
114017	0.45	3.20	70.00	2.35	2.00	1.50
114018	0.45	2.50	16.50	0.19	0.48	0.36
114019	0.75	6.60	30.00	1.25	0.78	0.94
114020	0.15	0.50	8.50	0.03	0.03	0.09
114021	0.45	3.88	8.00	0.18	0.41	0.20
114022	0.30	0.04	3.20	0.02	0.14	0.09

* Not shown on map

Figure 13. Sketch geologic and sample map of Hemair.

Geology

Metasedimentary and metavolcanic rocks of intermediate composition and assigned to the Jiddah group were isoclinally folded, faulted, and metamorphosed to greenschist facies within the Hemair region. Metasedimentary rocks consist of fine-grained, nonbedded, brown-weathering marble, graphitic schist, and calcareous siltstone. These rocks are interbedded with massive metavolcanics containing crystals of clear quartz as much as 3 mm in diameter. The metavolcanics are part of the same rock unit as that mapped at Farah Garan and Al Ashyab.

Structure, metallization, and alteration

Foliation and layering of the metasedimentary rocks strike north and dip steeply west. The rocks, particularly the marble-graphite contacts, were sheared by a regional fault along bedding planes. The shear zone was then weakly silicified and the enclosing metavolcanic rocks were pyritized. Copper, lead, and zinc sulfides with accompanying gold and silver were then deposited. Milky quartz was later deposited within the main shear zone and along subordinate shears. Slight post-silicification movement along the major fault weakly brecciated the silicified zones (fig. 13).

Sheared, silicified, and metallized rock along the fault averages less than one meter in width and is absent in the center of the mapped area where the fault is expressed only by thin fractures. Gossans are best developed on sheared contacts of marble, where they are sparsely copper stained. Silicification is stronger at the south end of the area, where black, flinty, fine-grained, siliceous material may be silicified graphitic rock.

Assay results

Eighteen continuous chip samples were cut across the metallized fault and their positions are indicated on figure 13. Analyses of gold, silver, copper, lead, and zinc indicate that metal is erratically distributed along the fault zone. Ranges of metal contents and sample widths are as follows:

Width (m)	Au g/t	Ag g/t	Cu pct	Pb pct	Zn pct
5.0-0.05	42.40-Trace	70.00-0.40	2.65-0.004	2.00-0.001	3.75-0.001

Average width and assays are as follows:

Width (m)	Au g/t	Ag g/t	Cu pct	Pb pct	Zn pct
0.82	3.50	20.9	0.54	0.40	0.57

Conclusions and recommendations

Rock formations, structure, content of sulfides and precious metals, and ore contacts at the Hemair deposit are in many respects similar to those of Farah Garan, 3 km northwest, and these deposits are probably genetically related. The Hemair deposits themselves are small and merit no further investigation, but the general area contains rocks and structures favorable for ore deposition and warrants additional study.

PRELIMINARY STUDIES OF THE HEMAIR-AL ASHARFAT REGION

Introduction

During January and February of 1976 the author mapped and sampled by reconnaissance methods a belt of metasediments extending south from Hemair, as well as shear zones parallel to the contact between quartz porphyry and mafic metavolcanics (fig. 2). Several small ancient workings were found and examined. Mapping was done on low-level, color aerial photographs.

The Hemair-Ethel region

Geology

A belt of metasedimentary rocks of the Jiddah group extends south through Hemair and passes under Wajid Sandstone near the Ethel mine (fig. 14). The rocks include black to brown, massive, fine-grained marble, cherty conglomerate, graywacke, calcareous mudstone, and graphitic sediments. The sedimentary rocks are interbedded with layered quartz crystal tuffs, massive unlayered quartz crystal metavolcanic lavas, and metavolcanic flow breccias. Many of the metasedimentary rocks contain graphite and associated cubic pyrite. The metasediments strike north and dip steeply west. They are in contact with thick-bedded andesitic to basaltic metavolcanics on the east and with mafic metavolcanic flows and interbedded thin metasedimentary rocks on the west.

Metallization and alteration

Quartz crystal metavolcanics and calcareous metasediments are pyritized, sericitized, and weakly silicified in broad zones along the belt of metasedimentary rocks. Fine-grained cubic pyrite is heavily disseminated in some zones and is probably not genetically related to the more coarse-grained pyrite associated with graphitic rocks. The pyrite is generally found in strongly sheared zones. Weathered pyritized rocks are unevenly stained by iron oxide.

A small ancient workings named Degarth is adjacent to a marble lens about 1 km east of Al Asharfat (fig. 14). The open cut is 9 m long, 4 m wide and 4 m deep and is on sheared and pyritized metavolcanic rock containing copper carbonates and copper pitch. Pyritization extends at least 1 km north of the open cut, and within the pyritized rock, sparse copper carbonates were noted along thin fractures and small amounts of copper-stained float rock were found in wadis. Strongly pyritized rocks extend at least 1 km south of Degarth, and small amounts of chalcopyrite were found in sparsely copper stained, calcareous rock. Farther south, rocks are pyritized locally but no copper minerals were found.

Rock sampling for trace metal analysis

Preliminary rock chip sampling for geochemical study was done at 35 locations along a length of about 6 km of the belt of metasedimentary rocks. Locations were chosen to represent all rock types; however, pyritized shear zones were especially tested. Sample localities and their respective descriptions and grades are shown on figure 14.

Three samples anomalous in copper and zinc were taken from sites where copper minerals were locally visible. Samples from north of Degarth, where copper minerals also are locally visible, contained copper and zinc in amounts just above background. Samples from the region south of Degarth contained moderately anomalous amounts of copper and zinc in two samples each.

Unnamed workings

At lat 17°36'15"N., long 43°40'20"E. (fig. 14), veins and veinlets of milky quartz in mafic metavolcanic rocks strike north, dip steeply west, and are about 5 m wide. Shallow ancient workings on the east contact of the quartz veins are about 200 m apart, but quartz is discontinuous between the two workings.

Three samples taken across the quartz vein in workings contained no significant amounts of metals.

Ethel workings

Massive veins and narrow stringers of milky quartz were worked in shallow open cuts by ancient miners at lat 17°33'50"N., long 43°40'10"E. (fig. 14). The vein system strikes north, dips steeply west, and ranges from massive quartz as much as 4 m wide to a series of narrow stringers along a strike distance of about 200 m. The quartz is unevenly stained by iron oxides derived from pyrite. Workings are along selvages of massive quartz within swarms of quartz veinlets.

Assay results

Six samples were cut across massive quartz and quartz veins within workings. One sample from a selvage of a massive quartz vein contained 1.64 grams of gold per ton. The remaining samples contained negligible amounts of valuable metals.

Conclusions and recommendations

Sparsely copper-stained, pyritized shear zones within interbedded metavolcanic and metasedimentary rocks occur in an area about 3 km south of the Hemair deposit. The intervening area has not been studied. It is recommended that more detailed studies be made of the metasedimentary and interbedded metavolcanic rocks and of their genetic relation to sulfide deposits in the area. The small quartz veins merit no further study.

The East Al Ashyab area

Geology

About 1.5 km southeast of Al Ashyab at lat 17°38'00"N., long 43°38'00"E., a series of lensoidal, weakly folded quartz veins strike north and dip steeply west. They are within strongly foliated mafic metavolcanic rocks of the Jiddah group near the contact with quartz porphyry (fig. 14). The entire vein swarm is about 0.5 km wide by 2 km long, but the veins are discontinuous along strike. The quartz veins locally contain specular hematite, in places contain sparse copper staining in vein selvages, and are barren of sulfides. Strongly sheared metavolcanic rocks are pyritized in parallel zones. Bands of magnetite as much as 0.1 m wide and a few meters long are parallel to foliation within metavolcanics near the contact with quartz porphyry at a point 0.5 km south of the vein swarm. About 2 km farther south, a small, deep ancient working on the contact between metavolcanics and quartz porphyry exposes a blue to gray quartz vein as much as 0.45 m wide. The vein contains sparse crystalline pyrite and a little gold.

Assay results

Quartz veins were sampled thoroughly to test for precious metal content. Assays indicate no significant amounts of either gold or silver in the quartz vein swarm. Some samples of pyritized sericite schist in the same area have high contents of copper and zinc (fig. 14). Two samples of quartz vein from ancient workings contained 14.0 grams of gold and 1.3 grams of silver per ton, and 22.0 grams of gold and 1.0 gram of silver per ton, respectively.

Conclusions and recommendations

The area studied is a very small part of an extensive contact zone between mafic metavolcanic rocks of the Jiddah group and a large body of quartz porphyry. Although many of the sampling data are negative, positive factors include:

1. Sparse copper staining in vein selvages.
2. Scattered anomalous copper-zinc contents in samples from pyritized shear zones.
3. Magnetite in thin bands along foliation.
4. Significant gold analyses in quartz from ancient workings.

The large quartz porphyry mass was interpreted by Anderson as being intrusive into rocks of the Jiddah group (Anderson, in prep.), but the present author believes that much of it is interlayered with the Jiddah group and is extrusive, in part perhaps tuff. It is obvious that the origin of the quartz porphyry is important in respect to the genesis of sulfide deposits in the area and to a logical approach to exploring for them. Therefore, it is recommended that this and other contact zones of quartz porphyry be studied in detail in order to clarify contact relationships if possible; gathering of further data on metallization could be done concurrently with such a study.

RECONNAISSANCE GEOPHYSICAL EXPLORATION

by

H. Richard Blank

Introduction

In late 1975 and early 1976 a limited program of geophysical work was carried out at Al Ashyab and Farah Garan by the combined USGS/DGMR Geophysics section, in support of base metal exploration by C.W. Smith. The work consisted of approximately 35.2 line-km of self-potential (SP) surveys and 9.0 line-km of Turam electromagnetic surveys. Altogether about one crew-month was spent in the field, about two-thirds of which time was at Al Ashyab. Production at both locations was hampered to some extent by the ruggedness of the terrain.

The geophysical surveys were essentially reconnaissance in scope and aimed at identifying the gross electrical characteristics of the altered zones. It was intended to follow up this work at a later time with additional surveys to delineate specific drilling targets if warranted by the combined results of the integrated exploration program. To date, however, the work reported here remains the only geophysical prospection in either area.

Al Ashyab surveys

Self-potential

The Jabal Al Ashyab altered zone was the first target surveyed. Smith's camp immediately south of the Jabal served as a base of operations for the field party. The SP survey was made during November 1975 under conditions of high surface aridity (there had been no rains in the recent past). Readings were taken at 50-m intervals along east-west traverse lines laid out by tape and compass normal to Smith's surveyed base line.

Initially the three-pot (leapfrog) method was used, but because of the need for greater accuracy it was decided to switch to the two-pot (fixed pot, moving pot) method, keeping one pot stationary on the base line. Traverse lines were then tied together by surveying the base line with one pot fixed at station (0,0). To facilitate the measurements an auxillary base line 0.5 km long was established west of Jabal Al Ashyab and exactly 0.5 km west of Smith's line. The measuring device used was a BRGM model RUE electronic millivoltmeter. Although this type of instrument has a very high input impedance, and differences of potential can be read with an accuracy of $\pm$ 0.2 millivolt in all operating environments, line-closure errors were in some cases as high as 20 millivolts. Pot potentials were compared several times each day and pot polarization drifts can account for at most a few millivolts--generally less than 1 millivolt--of uncertainty at any time during the survey. Excessive closure errors occurred with both the two-pot and three-pot methods, and their origin has not been unequivocally determined. It seems likely to be related to rapid dessication of the immediate electrode environment, which was watered some hours prior to each traverse and then charged with saturated copper sulfate solution just prior to the actual measurement.

Results.--The SP data were eventually reduced to an assumed datum of zero millivolts at station (15S,OE) on the Smith base line, and contoured to produce the equipotential map of figure 15. This map contains, in addition to errors described above, spatial distortions associated with the lack of slope corrections in the tape-and-compass station locations, which have been plotted as a rectilinear grid. Such distortions are generally negligible but may amount to as much as half a grid interval in the vicinity of the cliffs of Jabal Al Ashyab.

The total SP relief of the surveyed area is 115 millivolts. Equipotential contours show virtually no relation to mapped geological structures (fig. 8). The central part of the surveyed area, a zone of silicified and in some places pyritized metasedimentary and metavolcanic rocks of the Jiddah group, is mostly a relative SP high. Quartz porphyry terrane east of the Smith base line is characterized by low average SP values, whereas quartz porphyry terrane in the western part of the area has generally lower SP values than the central part but contains strong high and low SP anomalies.

The dominant SP anomaly grain does not trend north, following the strike of geological units, but nearly east. This is the direction of the SP traverse lines and therefore could be accounted for by datum offsets between stations on the base line. However, it is doubtful that the easterly direction of anomaly trend is an artifact of the survey. Very pronounced easterly SP, IP (induced polarization), and ground magnetic trends have been delineated in the vicinity of the Kutam mine, 7 km to the southwest of Al Ashyab, notwithstanding the absence of such geologic trends in that area (Blank and others, unpublished data). Moreover, the regional aeromagnetic pattern throughout much of the southern Arabian Shield is characterized by nearly east-west anomalies that seem to transect first-order geologic structures.

A system of topographic lineaments that have trends a few degrees south of east is clearly distinguishable on aerial photographs of the Kutam - Al Ashyab region and suggests control by a set of fractures trending nearly east. At Al Ashyab the strongest linear SP anomaly, a sharply bounded low of almost 90 mv amplitude, trends slightly south of east and more or less follows the principal alluviated wadi. Several lesser SP trends are also roughly aligned with wadis. The drainage and associated anomalies may reflect the existence of a shear system that influences ground water disposition and hence potential gradients. No evidence was found relating SP anomalies to superficial indications of mineralization.

From the point of view of the explorationist the SP results are not encouraging; no negative SP anomaly appears to be associated with the Al Ashyab alteration zone. In the light of experience with the SP method elsewhere in the southern shield this must be regarded as contra-indicative of base metals at shallow depths.

Turam

The electromagnetic survey at Al Ashyab was carried out in December 1976 using a newly delivered ABEM TS-4 type 5280 system operating at 660 Hz and 220 Hz. A linear current cable was laid out oriented north approximately along the line of stations 8E, about 400 m east of Smith's base line. Its south end was grounded in sandy soil on the left bank of the main wadi, where the wadi bends sharply to the east, about 250 m south of the southernmost SP traverse (line 24S), and the north end was grounded in a rock gully about 150 m north of line 0S. Traverses were made at 100 m intervals starting with line 5S and extending to line 19S; receiver staffs normally separated by 40 m were positioned midway between SP stations and moved in 50 m increments.

Planned traverses along lines 21S and 23S had to be abandoned due to carburetion problems with the 3.2 Kv JLO motor-generators.

Results.--Reduced-amplitude equiratio maps and equiphase maps for each frequency have been prepared from profiles along the eight traverses and are presented in figures 16-19. Reduced ratios are obtained by correcting the observed ratios for the different distance of each receiver from the source cable, which is assumed to be of infinite length; phase angles represent the phase lead of the signal induced in the far receiver over the received in the near receiver.[1/] Over a uniform half-space the reduced ratio would be 1:0 and the phase angle zero degrees.

[1/] Because phase anomalies obtained in the Al Ashyab and Farah Garan surveys are positive rather than negative, as is usual with the procedures followed, it is possible that the new Turam equipment is wired for the opposite convention.

In contrast to the SP results, the Turam anomaly map pattern for the Al Ashyab area strongly mirrors the generally north-trending structural grain. No east-trending anomalies were detected. Results at 660 Hz and 220 Hz are quite similar, an indication that surficial conductivities do not contribute substantially to the Turam response.

Two main linear anomalies appear to be present in the area covered, each of which is within or at the margin of the belt of rocks of the Jiddah group. The stronger of the two, with a maximum reduced ratio of 1.65 at 220 Hz and 1.73 at 660 Hz, follows the western boundary of the Jiddah rocks closely at 220 Hz and somewhat less closely at the higher frequency. At 220 Hz the ratio anomaly is remarkably uniform along strike and sharply asymmetrical perpendicular to the strike, due to the primary cable. The anomalous source is probably steeply dipping or vertical. Moderately high ratio values are accompanied by fairly large phase angle differences (maximum of + 8.5° at 220 Hz and + 14.7° at 660 Hz), thus implying a source of moderate conductivity. The depth to the top of the induced current system is probably no greater than the depth to the water table (about 20 m). Because neither base metal mineralization nor graphitic rocks were seen in the vicinity of the Jiddah group-quartz porphyry contact, whereas minor pyrite and considerable cataclasis can be seen, the source is inferred to be a pyritized, wet shear zone.

The second and slightly weaker anomaly reaches a peak ratio of 1.60 at 220 Hz and 1.70 at 660 Hz and has a maximum phase anomaly of +4.3° at 220 Hz and +12.4° at 660 Hz. Its maximum coincides rather closely with the eastern border of the Jiddah group. This anomaly lacks the continuity of the western anomaly, however, and is not present north of the southern tip of Jabal Al Ashyab. The Jiddah rocks are pyritized where the anomaly is most intense.

Typical Turam profiles are shown in figure 20, in which values of amplitude ratio (increasing toward the top of the page) and phase angle (increasing toward the bottom of the page) at 660 Hz and 220 Hz are plotted for line 17S. The location of both principal anomalies can be seen in relation to the quartz porphyry contacts. The asymmetry of the western anomaly is less distinct here than on profiles farther north. Smaller anomalies situated between the two flank anomalies have larger amplitudes north and south of the profile chosen. These and other anomalies within the central part of the surveyed area are probably also related to localization of conductive solutions along shears rather than to conductive bedrock. However, the central part of the area appears to be the area of maximum Cu-Zn enrichment (see figs. 9 and 10), and it is possible that the associated Turam anomalies in part reflect the presence of sulfides.

Conclusions

Geophysical reconnaissance at Jabal Ashyab has demonstrated that no substantial SP effect is associated with the generally north-trending lithologic belts in the zone of alteration. The highly silicified quartz porphyry of the Jabal proper seems to produce a positive SP anomaly. Easterly trends of anomalies with amplitudes up to 90 mv that traverse the target area across the structural grain are as yet unexplained, but are consistent with a similar SP anomaly pattern at the nearby Kutam ancient mine; both may reflect an east-trending shear set. Turam surveys show the existence of linear conductive zones that seem to be produced by north-trending shear zones within and especially near the margins of the central belt of metamorphic rocks. The principal Turam anomalies are open to the south and require further field work for complete delineation. The possibility exists that the Turam anomalies are due to base metal mineralization, but geochemical support for such an interpretation is weak at best. Further geophysical work might consist of additional Turam traverses in the southern part of the target, accompanied by reconnaissance induced polarization profiles.

Farah Garan surveys

Self-potential

The base of operations for Farah Garan surveys was the USGS camp at Kutam. Field work was carried out with the aid of a helicopter for the commute across Wadi Kohlan (Wadi Maslulah), and a spike camp was set up for overnight storage of equipment. The SP survey was made in January 1976, when surface conditions were similar to those prevailing at Al Ashyab. Measurements were again made along east-west lines surveyed by tape and compass in 50 m increments from a north-south base line established by Smith, but at Farah Garan the traverse spacing was increased to 100 m. The two-pot (fixed pot, moving pot) method was used exclusively, and the instrument was the same as before. On this occasion the SP readings appeared to be quite stable: no difficulties were encountered in making ties and repeats. All values were subsequently reduced to an assumed datum of zero millivolts at station (ION,O) on the base line.

Results.--SP results at Farah Garan are shown as an equipotential contour map in figure 21. Once again, spatial distortion is present due to lack of slope corrections, particularly along the several southernmost profiles (lines 2, 4, 6, 8, and 10S), where the topographic relief is extreme, but the maximum distortion is less than at Jabal Al Ashyab. Figure 21 also shows the location of six Turam profiles.

The relative self-potential values range from +171 to -520 millivolts, and the maximum difference of potential, nearly 0.7 v, is the largest we have yet measured. Most of this difference is embodied in an extensive SP low that trends north-northeast across the prospect area, more or less parallel to the trend of the trunk wadi draining the flattish area of old high-level alluvium. The close association of the SP low with an area of low topographic relief suggests a genetic relationship. However, such a relationship is probably secondary; both SP low and low topographic relief are associated with the belt of predominantly metasedimentary rocks of the Jiddah group containing the central and south ancient mine workings (fig. 3). A very steep gradient bounding the SP low on the northwest lies just northwest of and parallel to the Farah Garan fault, a shear zone interposed between the predominantly metasedimentary formation and a predominantly metavolcanic formation also belonging to the Jiddah group. The gradient lies wholly within the metavolcanics. A weaker gradient bounds the southeast side of the SP low and lies largely within meta-andesites, roughly following the eastern contact of the metasedimentary formation.

These relations do not obtain in the southern part of the map area, where the geologically inferred trace of the Farah Garan fault and the SP gradient trends diverge, and the SP anomaly contours transect the metasedimentary-metaandesite contact at a high angle.

Ancient mine workings are disposed within, on the flanks of, and outside the SP anomaly but the anomaly itself is not directly associated with any known distribution of mineralization, and probably results instead from oxidation of graphitic members of the metasedimentary formation, and only in relatively minor part from oxidation of ore. Within this formation the potential is more or less uniformly low. Where no graphite is present (that is, in the metavolcanic formations), the potential increases to values that are more or less uniformly high: the metasedimentary rocks seem to behave as a single, negatively charged electrode. However, the graphite content of the metasedimentary unit must drop off sharply at the southern end of the SP anomaly.

Inspection of the SP map shows that there are in fact a number of discrete minima within the principal low. In most cases the shapes of these minima are not well represented by the contours because of the wide traverse spacing (100 m), and therefore their geologic association is difficult to judge. Some or all may result from oxidation of local concentrations of sulfides. However, it is equally likely that they too are produced by graphite.

Two sets of northerly SP trends seen on the equipotential map may reflect the influence of secondary structural elements auxillary to the Farah Garan fault. The more westerly of the two extends south from Smith's base line and is closely associated with the central and south ancient workings. The more easterly set is not associated with any known mineralization but extends into an area not yet mapped. It may coincide in part with a strong Turam anomaly found on the traverse of line A, although the validity of the latter anomaly is suspect (see next section). In any case the area covered by both sets of northerly SP trends should probably be thoroughly prospected.

Turam

The six reconnaissance Turam lines labelled A-F in figure 21 were surveyed in February 1976 as a test of the Farah Garan shear zone. A source cable 2.3 km in length was laid out on a bearing of 023°, about 100 m offset from the first station on the traverse lines. The Turam system was again the new ABEM TS-4. Grounding at the southwest end was accomplished easily in wet sands of a rock-walled wadi tributary to Wadi Kohlan, and the north-northeast electrode was buried with much more difficulty in a rocky gully. In spite of the relatively short length of the traverse lines, it was not possible to obtain an accurate null in all cases at their eastern extremities due to loss of signal strength.

Results.--The Turam data are shown as combined contour maps of reduced amplitude ratio and relative phase angle in figures 22-25. Plot points on the traverses are very approximate owing both to lack of slope correction, which particularly affects position on lines E and F where the terrane falls off quite rapidly towards Wadi Kohlan, and to the fact that the line was oriented by hand-held Brunton compass as the receivers were advanced from station to station by the length of the standard 40 m connecting cable. Also the rendering of contour lines from widely spaced traverse data is hazardous. Nevertheless, the inductive response of the target area can be qualitively evaluated.

The anomaly at the eastern end of line A is the strongest recorded but because of the weakness of the signal received it is possibly in error, as stated previously. This aside, two major Turam anomalies were delineated. The more intense anomaly appears on both lines A and B, and opens to the north, whereas the weaker of the two is apparently centered on line D. These anomalies are colinear but discrete. The current concentrations are located on or just east of the Farah Garan fault; the northern anomaly and perhaps both anomalies, are directly associated with layers of graphitic schist in the metasedimentary formation. For line A the association was established by successively halving the receiver separation, until it was revealed that the anomaly source coincides with a near-vertical bed of graphitic schist 5-10 m thick with surface outcrops. Therefore the anomaly is caused either by the graphite or by concealed sulfides in the graphitic zone--its source could be no deeper than about 20 m or approximately the depth to the base of the zone of oxidation (or water table).

Rocks traversed in the vicinity of the ancient workings did not produce any appreciable disturbance of the Turam field. Metavolcanic rocks west of the Farah Garan fault produce almost no reponse even where mineralized.

Conclusions.--The combination of highly conductive graphite beds and sulfide mineralization is a particularly difficult challenge for geophysical investigations, and on the basis of work to date, the possibility of sulfide contributions to either the Turam or the SP anomalies cannot be ruled out entirely. On the other hand the outlook is not favorable. It must be considered likely that both effects are produced by the graphite schist component of the predominantly metasedimentary formation of the Jiddah group.

A Turam survey at closer traverse spacing might provide better evidence on the relation of inductive anomalies to geochemical anomalies and to mappable graphitic units. If preliminary drilling results are encouraging, consideration should be given to completing the Turam or another electromagnetic survey, and to carrying out a *mise-à-la-masse* IP (induced polarization) survey.

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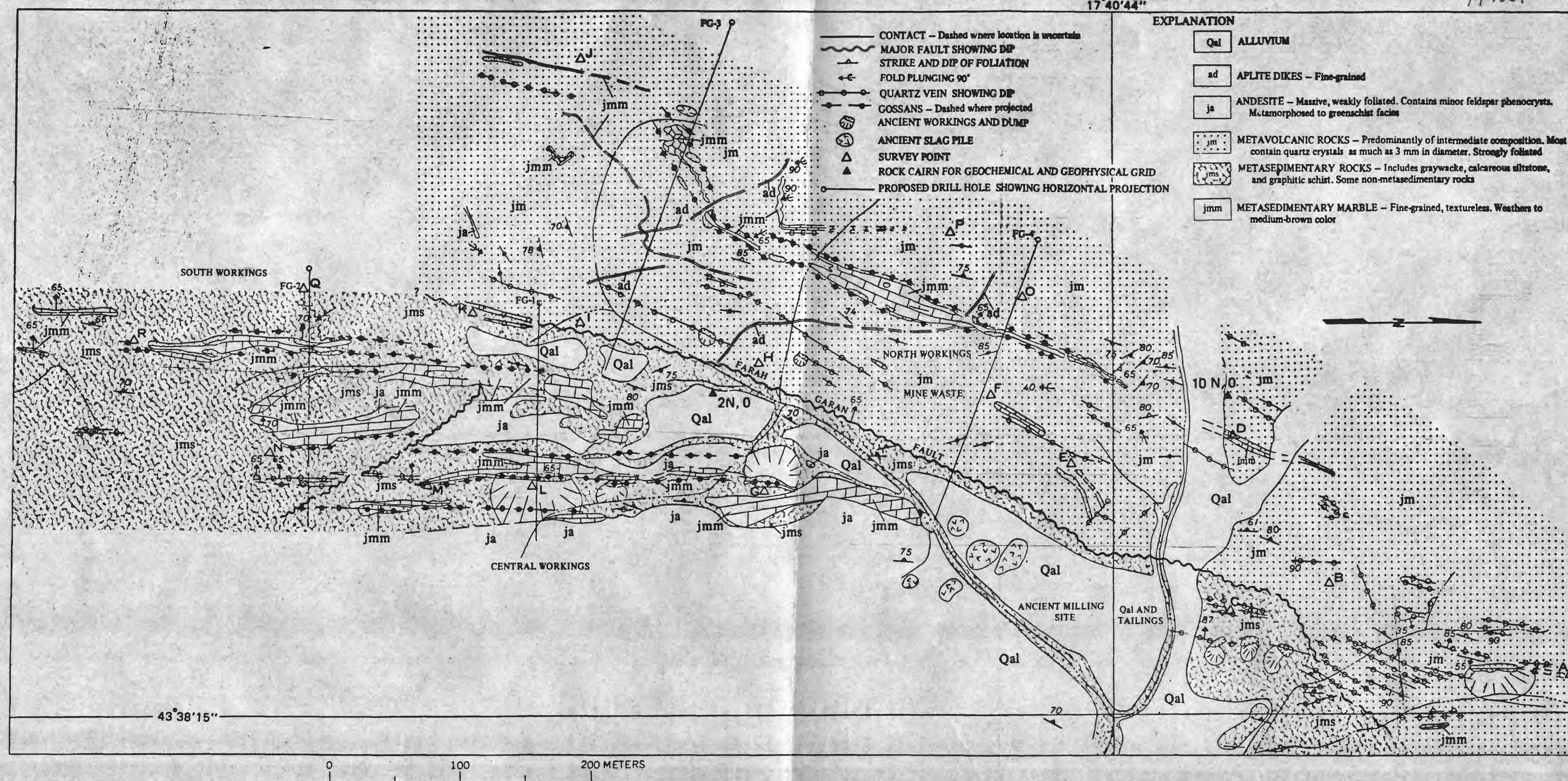


Figure 3. Geologic map of the Farah Garan ancient mine.

Sample number	Width m	Au g/t	Ag g/t	Cu pct	Pb pct	Zn pct
95332	-	0.04	1.50	0.02	0.006	0.03
333	-	0.33	0.70	0.12	0.05	0.21
334	-	0.07	30.00	0.17	0.15	0.20
335	-	0.04	2.50	0.02	0.01	0.17
336	-	0.05	3.00	0.07	0.007	0.32
95396-	2.85	0.47	10.30	1.14	0.08	5.64
402	1.0	0.10	2.60	0.03	0.004	0.05
403	5.0	0.04	1.30	0.09	0.01	0.06
404	5.0	0.04	1.50	0.04	0.01	0.16
405	5.0	0.04	3.30	0.04	0.01	0.03
96159	0.4	0.15	0.80	0.12	0.004	0.04
160	1.5	0.04	1.00	0.11	0.01	0.00
161	1.0	0.49	13.00	0.05	0.12	2.46
162	1.2	1.32	6.30	0.13	0.17	4.90
163	12.8	0.14	2.20	0.03	0.02	0.07
164	0.4	5.68	20.80	8.58	0.98	16.00
165	0.4	0.74	130.8	2.05	0.30	1.94
166	1.0	0.28	6.50	8.40	0.006	0.40
167	0.7	0.04	35.60	0.90	0.35	1.35
168	0.7	0.04	60.40	0.17	0.13	0.93
169	-	0.24	15.20	0.59	0.08	0.50
170	8.6	1.32	26.00	1.12	0.02	1.85
171	-	0.22	2.40	1.37	0.19	2.70
106907	1.5	9.68	0.42	0.000	0.03	0.02
908	-	0.88	0.50	0.002	0.01	8.005
909	-	1.14	0.30	0.004	0.003	0.008
910	1.5	0.34	0.80	0.004	0.003	0.008
911	-	6.08	0.42	0.004	0.002	0.006
912	1.2	Tr.	1.16	0.005	0.008	0.007
913	-	10.64	0.42	0.005	0.003	0.03
914	8.6	0.06	0.50	0.02	0.007	0.04
915	0.3	0.53	0.22	0.01	0.01	0.02
916	-	0.18	0.42	0.01	0.006	0.007
917	12.8	0.33	3.44	0.15	0.07	0.33
918	1.5	1.80	18.40	0.11	0.15	3.50
919	0.3	0.10	0.94	0.08	0.01	0.08
920	0.3	0.38	48.00	0.08	0.06	1.16
921	0.3	2.24	3.50	0.60	0.52	13.00
922	0.4	0.36	19.00	0.32	0.67	8.50
923	0.2	0.22	13.30	0.37	0.04	3.55
924	0.6	0.03	9.00	0.97	0.16	1.53
925	0.6	0.22	59.00	1.15	0.28	1.30
926	0.3	44.80	32.50	2.05	2.15	21.80
927	0.7	23.00	40.00	1.00	1.42	23.60
928	0.3	0.49	8.40	0.82	0.08	1.22
929	0.5	0.43	7.00	1.25	0.63	8.00
930	-	1.32	0.90	0.002	0.003	0.008
931	-	4.28	0.75	0.002	0.008	0.005
933	0.4	0.10	5.00	0.45	0.10	0.98
934	0.1	0.34	2.50	0.65	0.02	2.37
935	0.8	0.06	6.50	1.02	0.08	1.05
936	0.6	0.22	16.00	1.12	0.04	0.37
937	0.5	0.06	63.50	2.05	0.30	1.62
938	8.8	0.06	36.50	1.90	0.16	2.37
939	0.4	0.15	3.00	0.26	0.04	0.52
940	0.3	4.00	11.40	0.60	0.30	18.50
941	0.05	0.05	16.30	0.65	0.03	2.95
942	0.3	1.56	12.70	0.57	0.16	21.50

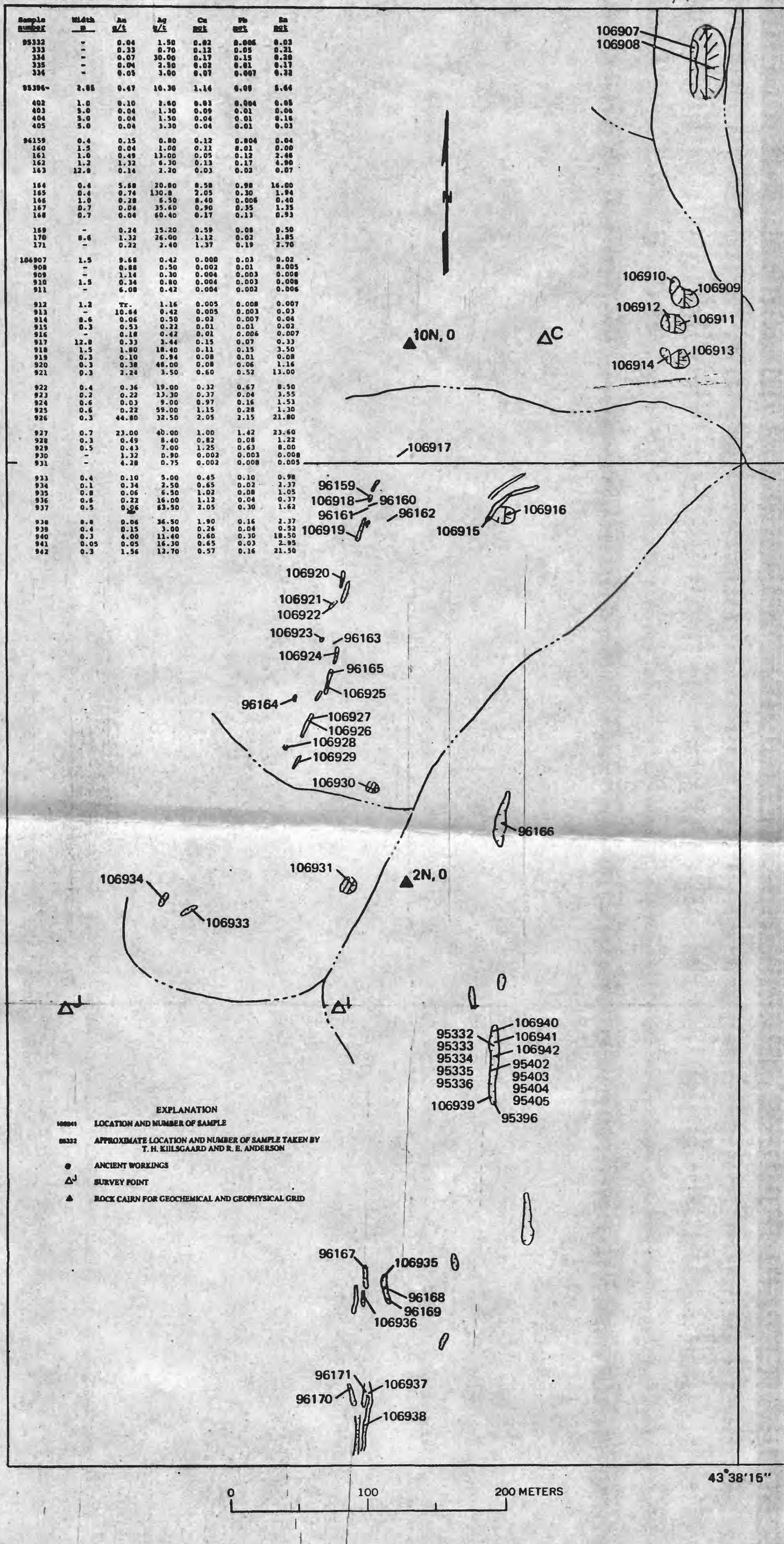


Figure 4. Sample locality map, Farah Garan ancient mine.

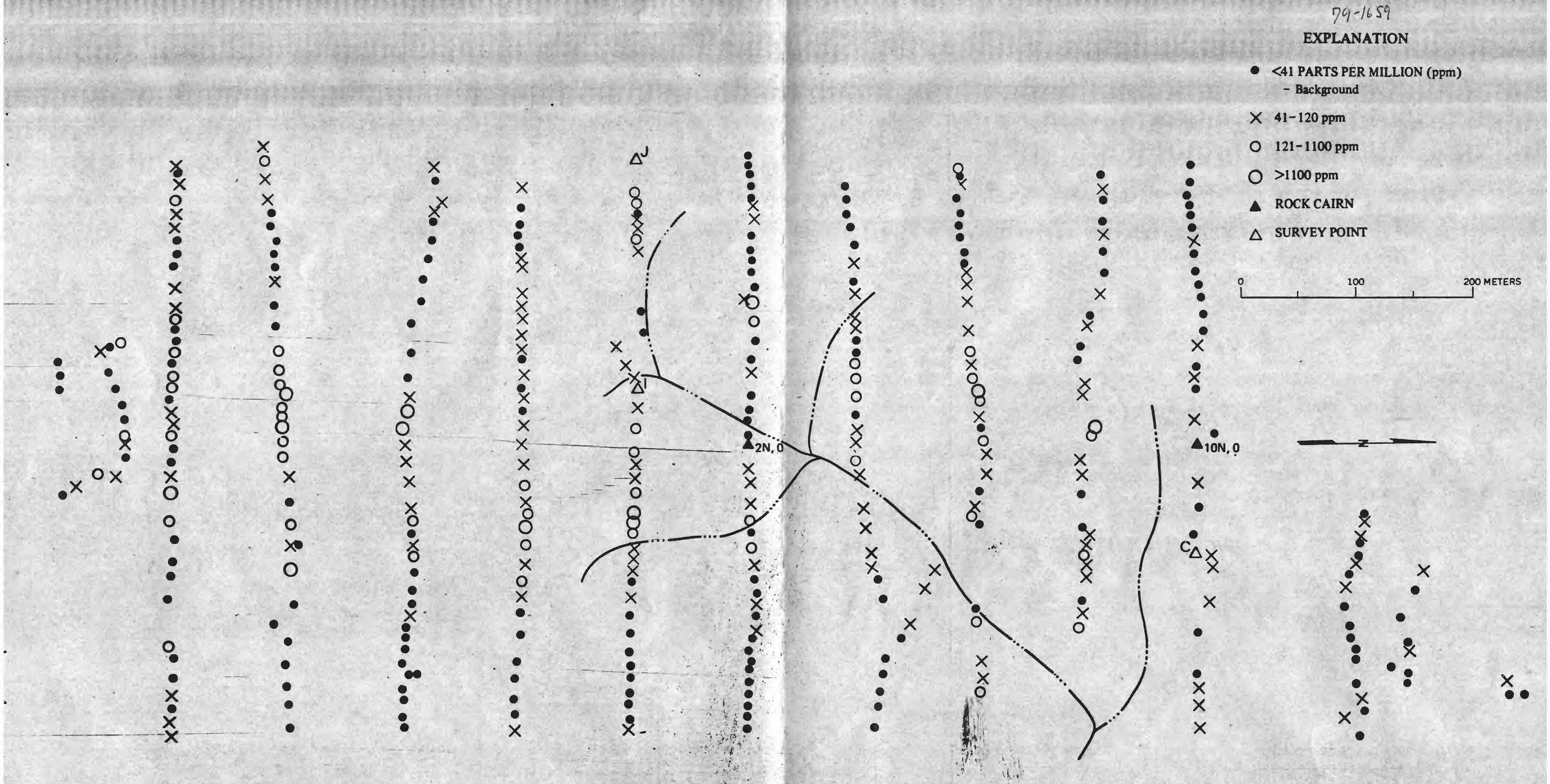


Figure 5. Copper content of rock samples, Farah Garan ancient mine.

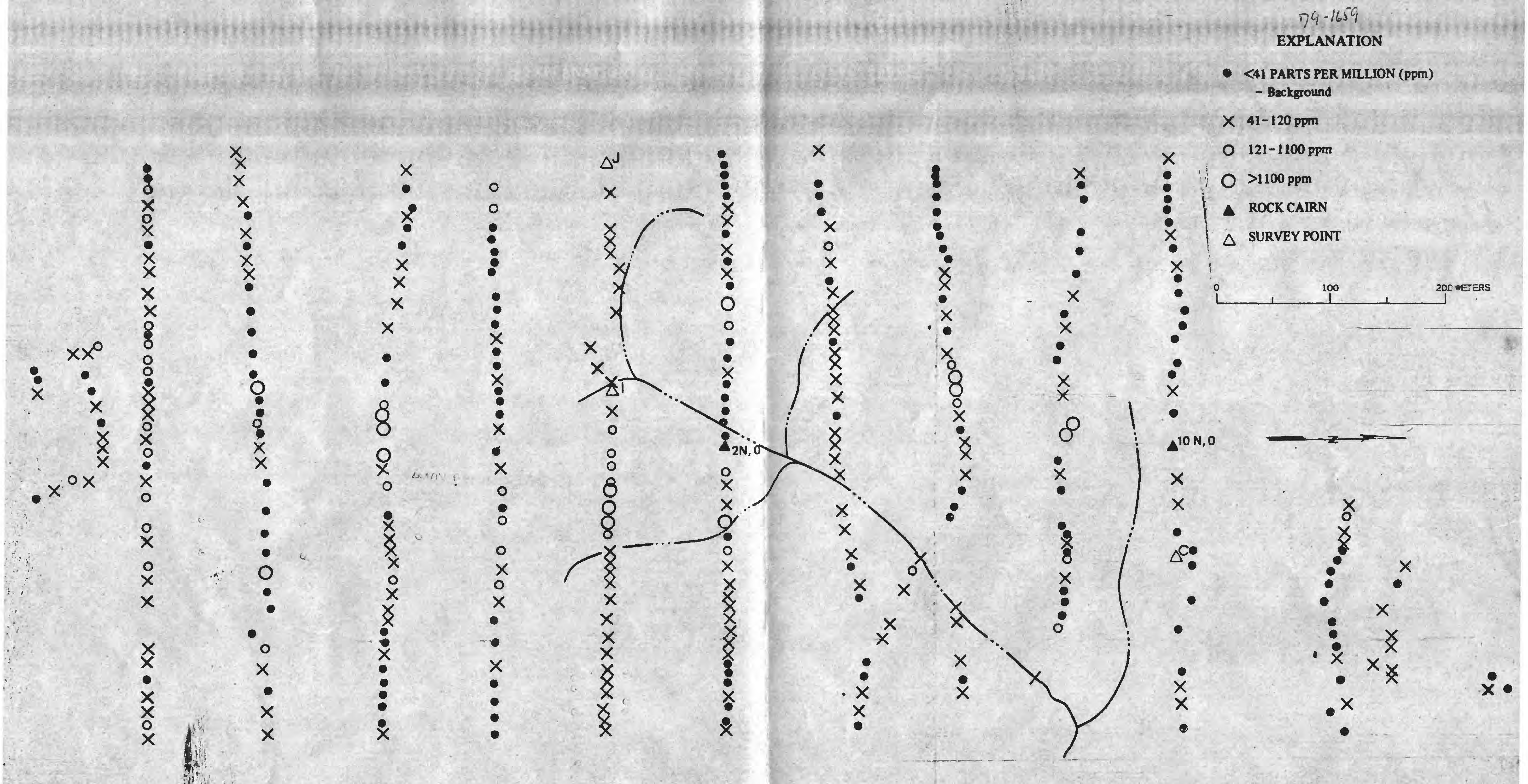
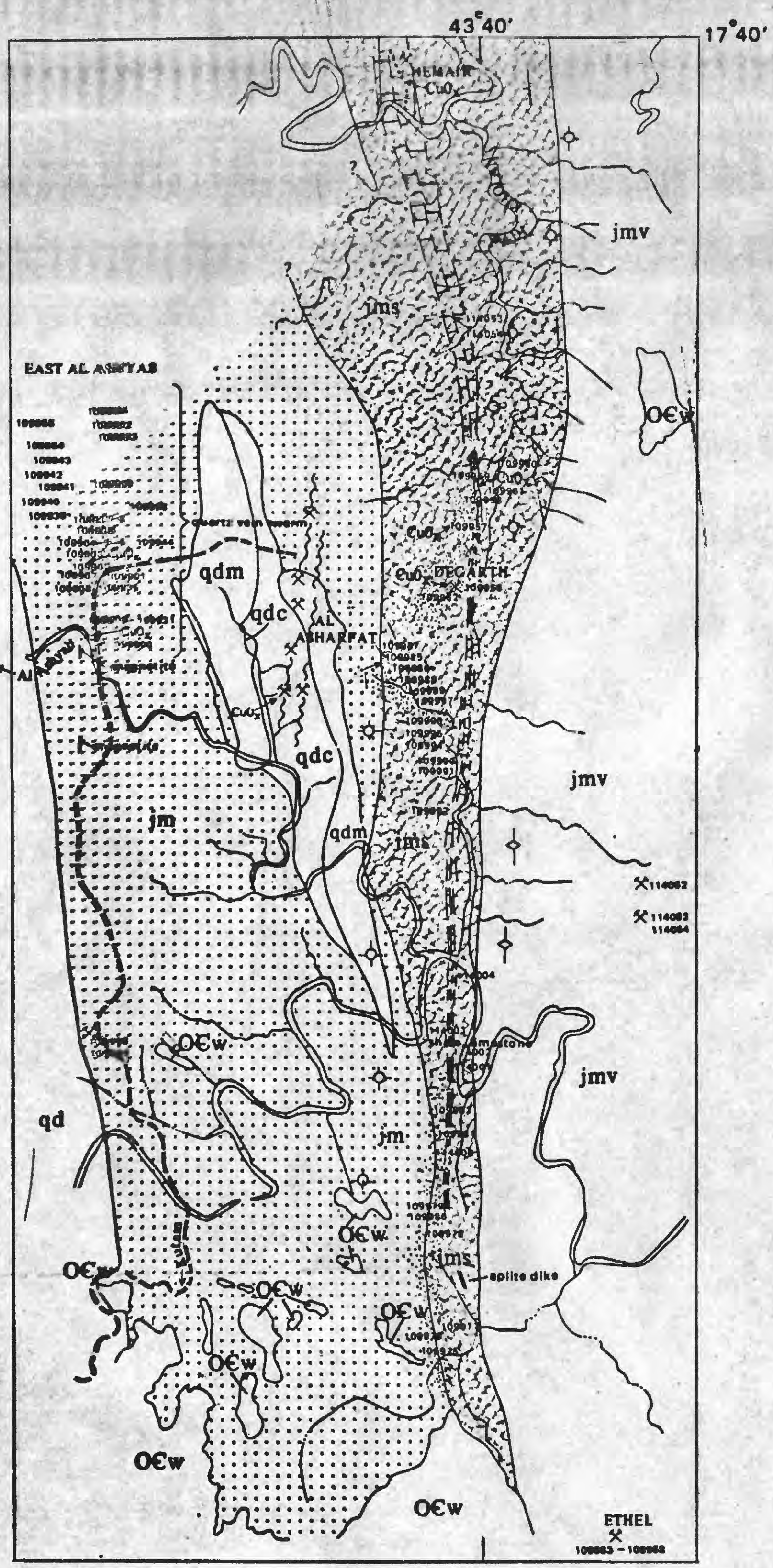


Figure 6. Zinc content of rock samples, Farah Garan ancient mine.



EXPLANATION

- OЄw — WAJID SANDSTONE
- qdc — QUARTZ DIORITE – Syntectonic, massive, coarse-grained. Contains blue-gray quartz
- qdm — QUARTZ PORPHYRY – Siliceous to intermediate rocks of quartz dioritic composition. Characterized by blue-gray quartz phenocrysts
- qp — QUARTZ PORPHYRY – Siliceous to intermediate rocks of quartz diorite composition. Characterized by blue-gray quartz phenocrysts

JIDDAH GROUP

- jm — METAVOLCANIC AND METASEDIMENTARY ROCKS – Undivided
- jmv — METAVOLCANIC ROCKS – Massive to schistose andesite and basalt lava and flow breccia. Minor interbedded sedimentary rocks
- METASEDIMENTARY ROCKS – Chert pebble conglomerate, calcareous mudstone, graphitic schist. Interbedded with metavolcanic rocks of intermediate composition
- METASEDIMENTARY ROCKS – Mostly calcareous

- CONTACT – Dashed where location is uncertain
- STRIKE AND DIP OF FOLIATION
- STRIKE AND DIP OF BEDDING
- PYRITIZED ZONE
- CuO_x COPPER STAIN
- ANCIENT MINING SITE
- 109923 SAMPLE LOCALITY AND NUMBER
- MOTOR VEHICLE TRAIL
- FOCAL CENTER OF PHOTOGRAPH

0 1000m

79-1659

ANALYTICAL DATA.

Sample number	Description	Au g/ton	Ag g/ton	Cu ppm	Pb ppm	Zn ppm
109898	Milky quartz about 1 m wide	0.10	--	9	11	9
109900	Sericite schist, pyritized, brown iron oxids	0.10	0.2	169	--	178
109901	Quartz vein, 5 cm wide	0.08	0.6	543	--	318
109902	Quartz vein, sparse copper carbonate in selvage	0.08	0.2	38	--	34
109903	Quartz vein, 15 cm wide	0.05	0.2	33	10	28
109904	Quartz vein, 10 cm wide	0.10	0.8	56	12	95
109905	Quartz carbonate veinlets	0.04	0.9	116	13	54
109906	Quartz carbonate veinlets across 3 m	0.08	1.0	45	13	44
109907	Quartz sericite schist, pyritized	0.05	0.6	48	11	5
109908	Quartz sericite schist, pyritized	0.07	0.2	22	--	13
109909	Quartz sericite schist, pyritized	0.11	0.2	57	--	145
109919	Quartz-carbonate vein, to 40 cm wide	0.07	0.3	27	--	15
109920	Quartz-carbonate stringers across 5 m	0.04	0.3	16	11	17
109921	Milky quartz, contains moderate iron oxids	0.10	0.3	30	--	20
109922	Milky quartz, folded, contains manganese oxide	0.08	--	80	10	20
109923	Sericite schist, pyritized	0.09	2.0	200	29	27
109924	Zone of quartz veinlets, 2 m wide	--	--	46	--	10
109925	Zone of quartz veinlets, 1.5 m wide	0.04	0.5	30	--	10
109926	Zone of quartz veinlets, copper oxide in selvages	0.07	1.2	550	18	67
109927	Quartz veinlets in sericite schist	--	1.0	888	14	178
109928	Quartz veinlets, 2 m wide	--	0.4	60	17	30
109929	Quartz sericite, pyritized	--	0.1	60	--	5
109930	Quartz veinlets in sericite schist	0.10	0.3	20	--	32
109931	Quartz veinlets in sericite schist	0.10	0.2	13	--	26
109932	Quartz sericite, strongly pyritic	0.10	0.5	22	--	66
109933	Quartz sericite, strongly pyritic	0.10	0.4	50	--	138
109934	Quartz sericite, strongly pyritic	0.10	0.6	87	10	263
109935	Quartz stringers in sericite schist	0.10	0.6	131	--	480
109936	Quartz with hematite (after magnetite?)	0.10	1.2	903	42	338
109937	Quartz vein, 20 cm wide, copper oxide in selvage	0.10	2.1	6400	14	130
109938	Quartz vein, 30 cm wide	0.10	0.6	200	11	66
109939	Quartz vein, 30 cm wide	0.10	0.2	27	--	18
109940	Quartz porphyry, silicified	0.10	0.7	43	--	12
109941	Quartz-carbonate veinlets, 1 m wide	0.10	1.7	18	29	55
109942	Quartz with tremolite, 20 cm wide	0.10	0.3	10	--	20
109943	Quartz-carbonate veinlets	0.10	0.7	16	15	10
109944	Quartz in marble lens	0.10	0.7	37	11	30
109954	Quartz-carbonate veinlets	0.10	2.2	38	25	14
109955	Quartz-carbonate veinlets	0.13	0.8	19	14	16
109956	Copper carbonate in sericite schist	0.13	11.4	15800	22	1500
109957	Quartz schist, pyritized, sericite	0.13	1.1	34	--	31
109958	Quartz schist, pyritized, sericite	0.14	0.4	44	--	25
109959	Metavolcanic rocks, silicified	0.14	0.6	35	--	65
109960	Graphitic schist containing cubic pyrite	0.14	0.9	109	18	69
109961	Marble, copper stained	0.15	1.5	68	27	45
109962	Sericite quartz schist containing pyrite	0.18	0.6	58	--	53
109963	Milky quartz, 30 cm wide	0.14	--	5	--	10
109964	Milky quartz, 60 cm wide	0.15	--	12	--	25
109965	Milky quartz, 4 cm wide	1.64	0.6	20	--	4
109966	Milky quartz, 2.5 m wide	0.14	--	5	--	46
109967	Milky quartz, 3.0 m wide	0.14	1.1	30	16	5
109968	Quartz stringer zone, 2 m wide	0.14	--	7	--	8
109975	Metavolcanic rocks, weakly pyritized	0.13	--	9	--	59
109976	Metavolcanic rocks, weakly pyritized	0.13	0.6	67	15	34
109977	Contact metavolcanic rocks, graphitic schist	0.13	2.0	92	23	31
109978	Contact metavolcanic rocks, graphitic schist	0.13	0.5	21	24	7
109979	Graphitic schist, pyritiferous	0.13	0.4	15	11	37
109980	Marble, dark-gray to black	0.13	1.6	12	38	37
109981	Graphitic schist, calcareous	0.14	1.3	29	25	50
109982	Graphitic schist, calcareous	0.36	1.7	218	22	75
109985	Mudstone, calcareous, containing chalcopyrite	0.64	10.9	7800	32	5600
109986	Mudstone, calcareous, containing chalcopyrite	0.20	5.1	4110	22	1680
109987	Quartz sericite schist, pyritiferous	0.15	0.5	46	--	43
109988	Quartz sericite schist, pyritiferous	0.15	1.1	168	19	53
109989	Quartz sericite schist, pyritiferous	0.13	1.0	30	14	59
109990	Siliceous, calcareous, black, mottled	0.15	0.4	36	24	133
109991	Cherty conglomerate	0.15	0.6	55	21	83
109992	Graphitic schist, containing coarse cubic pyrite	0.15	1.5	42	23	27
109994	Sericite schist, containing iron oxide stain	0.10	0.3	26	13	250
109995	Metavolcanic rocks, containing calcareous lenses, cubic pyrite	0.14	0.7	112	10	65
109996	Sericite schist, weakly pyritiferous	0.14	0.4	77	10	44
109997	Sericite schist, weakly pyritiferous	0.17	0.6	10	12	47
109998	Quartz-carbonate vein in workings, 45 cm wide	14.00	1.3	64	19	42
109999	Quartz, gray-blue with pyrite, 20 cm wide	22.00	1.0	105	27	57
114000	Quartz-sericite schist, pyritiferous	0.24	0.5	99	--	36
114001	Quartz-carbonate in schist	0.14	0.9	363	--	92
114002	Quartz veinlets in tightly folded schist	0.17	0.5	30	--	46
114003	Metasedimentary rocks, calcareous	0.17	1.0	33	21	99
114004	Metasedimentary rocks, calcareous adjacent to graphite	0.17	1.0	54	30	43
114053	Marble, medium gray-brown with quartz stringers	--	0.1	99	25	78
114054	Marble, medium gray-brown	--	--	6	10	7
114062	Quartz vein swarm	--	--	8	--	4
114063	Quartz vein swarm, 0.5 m wide in deep workings	0.08	0.9	28	--	15
114064	Quartz, iron-stained grab sample from dump	--	--	11	--	3

Figure 14. Geologic and sample map of the Hemair-Asharfat region.