DATA FROM GEOLOGIC INVESTIGATIONS IN THE YEMEN ARAB REPUBLIC DURING 1976

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Ministry of Economy, Yemen Arab Republic

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The project report series presents information resulting from various kinds of scientific, technical, or administrative studies. Reports may be preliminary in scope, provide interim results in advance of publication, or may be final documents.

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ABSTRACT

The results of semiquantitative spectrographic analyses for 31 elements in 126 specimens of rocks from the Yemen Arab Republic, collected mainly during February 1976 from the Precambrian area in the southeastern part of the country, provide background data for use in geochemical evaluation of areas potentially favorable for mineral deposits. Gold and thorium were undetected; the lower limits of determination are 10 parts per million (ppm) and 20 ppm, respectively. For the other elements, the abundances follow geochemical norms for crustal distribution: (1) Fe, Nb, and Zr in Holocene weathering products; (2) Ca and Sr in Pliocene limestone; (3) Mo in Pliocene(?) or Miocene(?) dikes; (4) Be, La, and Sn in Miocene(?) alkalic granite; (5) As, Be, and La in Tertiary and/or Cretaceous felsic tuff; (6) V in Tertiary and/or Cretaceous carbonaceous sedimentary rocks interbedded with volcanic rocks; (7) Be, La, Sn, and Zr in Tertiary and/or Cretaceous undivided volcanics; (8) Sn and W in Precambrian felsite and pegmatite; (9) Co, Cr, Ni, and Ti in Precambrian mafic rocks; (10) Mg and Sr in Precambrian marble and calc-silicate rocks; (11) Y in Precambrian schist; (12) B and Sc dispersed in rocks of many ages; and (13) Ag, Ba, Bi, Cd, Cu, Mn, Pb, Sb, Sn,

and Zn in a hydrothermal replacement deposit in Precambrian sediment. None of the rocks contained as much as 205 ppm equivalent uranium.

The highest values for Ag, Cu, Pb, Zn, and Cd were obtained on a sample of hydrothermally altered siltstone not personally collected by the writers. It was said to have come from the Ma'rib area in the eastern part of the Yemen Arab Republic. The source must be studied, because this single sample is high-grade base-metal ore.

Among the samples collected by the writers, the economically most significant are altered tuffs, ignimbrites, and felsites exposed between Jibāl Hufash and Manākhah on the road from Hudaydah to San'ā'. They are strongly anomalous for As and weakly anomalous, variously, for Hg, Mo, and Pb, which elements may constitute an epigenetic dispersion pattern from hidden sulfide deposits. Inasmuch as chalcopyrite and native copper have been reported in the vicinity of Jabal Haraz in the Manākhah area, the rocks of the Yemen Volcanics in this region should be explored for base-metal sulfide deposits.

The first results of paleontologic examinations of fossils collected during 1975 and 1976 are presented, as are a list of Landsat images covering the Yemen Arab Republic, and a selected bibliography of reports on geology and the allied sciences relating to the Yemen Arab Republic.

INTRODUCTION

Purpose of report

A study of the regional geology, mineral deposits, petrography, and paleontology of the Yemen Arab Republic was begun in 1975 as part of the Water and Mineral Survey Project of North Yemen being conducted by the U. S. Geological Survey (USGS) for the Mission to the

Yemen Arab Republic of the U. S. Agency for International Development in cooperation with the Ministries of Agriculture and of Economy. The work was sponsored by the Yemen Arab Republic (YAR) and the Agency for International Development, U. S. Department of State (USAID). The regional geology was described in a set of preliminary geologic maps (Grolier and Overstreet, 1976a-1976i), and the first results of investigations of mineral deposits were given in 1976 (Overstreet, Domenico, and others, 1976).

This report has been prepared to make available the large amount of new geologic data that was acquired during 1976 by the Water and Mineral Survey Project. It is thought appropriate to make these raw data available prior to completion of interpretation and synthesis.

Acknowledgments

The interest and assistance of the following officials is gratefully acknowledged: His Excellency, Dr. A. A. El-Eryani, formerly Chairman of the Central Planning Organization (CPO), now Minister of Education, YAR ; Hamoud Ahmid Daif Allah, President, Mineral and Petroleum Authority, Ministry of Economy, YAR; and Aldelmo Ruiz, Director, USAID Mission to the YAR. Their aid has made possible the work described below.

James W. Aubel, a U. S. Peace Corps Volunteer and geologist working on the USAID water supply project in Yemen, helped in collecting the rock samples described in this report.

SAMPLING PROGRAM

The program that provided the samples of rocks, ores, and slags related to the mineral deposits, as well as the rocks needed for petrographic description and paleontologic examination, began in June and

July 1975. This program was augmented in February 1976 when M. J. Grolier returned to the YAR to make a hydrologic interpretation of the nation (Grolier and others, unpub. data). On that later visit, many new samples of rocks were collected. Although these new samples came from localities as far apart as the shore of the Red Sea and the southeasternmost boundary of the YAR, most were taken from southeastern Yemen in the area covered by Landsat image number 1206-06504.

The geographic distribution of the analyzed samples of rock collected in the two field seasons is shown on figure 1, where the boundaries of image 1206-06504 are also defined. Separate symbols are used for the localities visited in 1975 and those reached in 1976. A numerical progression in geographic order is followed for the localities. Sample localities occupied in 1975 are numbered from the north to the south, beginning with locality 1 and ending with locality 14. They cover the region from Sa'dah to Ar Rāhidah. Sample localities visited in 1976 are plotted from west to east, thence northward. They begin with locality number 15 at Al Luhayyah on the coast and extend eastward to San'ā'. From San'ā' the localities are numbered in succession southeastward to Al Baydā', thence northward to Ma'rib, where they end at locality 51. Many localities on figure 1 represent more than one sample. Owing to the small size of this figure and to the close spacing of many samples taken in 1976, the localities in the southeastern part of Yemen are shown on a geologic map of the region covered by Landsat-image number 1206-06504 (fig. 2). (Data for interpreting the annotation block for the Landsat images are given in table 1.)

Table 1. *DATA FOR INTERPRETING THE ANNOTATION BLOCK FOR THE LANDSAT-1 IMAGES Extracted from "Earth Resources Technology Satellite Data Users Handbook," prepared by Goddard Space Flight Center, National Aeronautics and Space Administration.*

	a	b	c	d	e	f	g	h	i	
		1 2	3 4	5	6	7	8	9	1 1 0 1	
	12345678	90123456789012345	67890123456789012	345678901234	56789012345678	90123456789	0123456789	012345678	9012345678901234456	②
RBV	07JUN72	C N33-05/W115-18	N N33-04/W115-20	RBV 1 RXAI RBV 2 RBV 3	SUN EL30 AZ015	194-1234-A	1-N-P-	NASA ERTS	E-1042-16032-10 2 3	EXAMPLE

NOTES: (1) THE LETTERS "a" THROUGH "i" REFER TO PARAGRAPHS IN THIS DOCUMENT THAT EXPLAIN THE ANNOTATION BLOCK.

(2) CHARACTER "POSITION" IN THE ANNOTATION BLOCK.

		1 2	3 4	5	6	7	8	9	1 1 0 1	
	12345678	90123456789012345	67890123456789012	345678901234	56789012345678	90123456789	0123456789	012345678	9012345678901234456	②
MSS	07JUN72	C N33-05/W115-18	N N33-04/W115-20	MSS 4 D MSS 5 MSS 6 MSS 7 MSS 8	SUN EL30 AZ015	194-1234-G	1-N-P-1H	NASA ERTS	E-1042-16032-4 5 6 7 8	EXAMPLE

a. **Character Positions 01-08. 07JUN72**
Day, month and year of picture exposure.

b. **Character Positions 09-25. CN33-05/W115-18**
Format Center — Latitude and longitude at the center of the RBV and MSS image format is indicated in degrees and minutes. The MSS Format Center is identical to the RBV Format Center. Format Center is defined as the geometric extension of the spacecraft yaw axis to the earth's surface.

c. **Character Positions 26-42.**
N N33-04/WII5-20
Latitude and longitude of the nadir (the intersection with the earth's surface of a perpendicular line from the spacecraft to the earth ellipsoid) is indicated in degrees and minutes. The NASA Ellipsoid is the Earth model.

d. **Character Positions 43-54. RBV 1 DXA**
The characters in this group are sensor and spectral band specific:
For RBV Images:

43-49 **Sensor and NDPF spectral band identification code. Note that the spectral identification code numbers are purposely staggered to permit identification of the spectral images used to make a color composite transparency.**

50 **"D" indicates direct transmission (real time); "R" indicates stored data played back from the satellite wideband video tape recorder.**

51-52 **RBV Shutter Duration Code**

The "XA" means the shutter for Camera 1 was set for 4.0 milliseconds, Camera 2 for 4.8 ms, and Camera 3 for 6.4 ms.

"XB" would indicate the shutter setting for Camera 1 is 5.6 ms, Camera 2 is 6.4 ms, and Camera 3 is 7.2 ms.

Alphabetic Code	Duration of Exposure Time		
	Camera 1	Camera 2	Camera 3
A	4.0	4.8	6.4
B	5.6	6.4	7.2
C	8.0	8.8	8.8
D	12.0	12.0	12.0
E	16.0	16.0	16.0

53-54 **Aperature Correction Indicator**
Ib — Aperature correction "in"
Ob — Aperature correction "out"
b — blank

For MSS images

43-51 **The sensor and NDPF spectral band identification code.**

53 Type of transmission, direct or recorded.

e. **Character Position 55-68. SUN EL30 AZ015**
Sun Angles - the sun elevation angle and sun azimuth angle measured clockwise from true North at the time of RBV exposure or midpoint of MSS frame is specified to the nearest degree.

f. Character Positions 69-79.
194-1234-A
Spacecraft heading, orbit revolution number, and ground recording station.

The "194" is spacecraft heading to the nearest degree, measured clockwise from true North. It is the orbital path plus spacecraft yaw. Heading relative to an image is always toward the image annotation block.

The "1234" is a four digit orbit revolution. Rev "0001" starts with the first ascending node (south to north equator crossing) after launch.

The "A" indicates the ground recording station. G=Goldstone, A=Alaska, N=NTTF.

g. Character positions 80-89 1-N-P-1H
The "1" means the image is full size.

The "N" means the image was processed using normal processing procedures. Abnormal processing will be indicated with "A".

The "P" means "predicted" orbit ephemeris data was used to compute image center; a "D" indicates "definitive" or best fit ephemeris was used. Normally the latter is used since it is more accurate.

The "1" indicates a linear mode, a "2" indicates a compressed mode of MSS signal processing prior to transmission from satellite to ground station.

(This applies to Bands 4, 5, and 6 only. See Appendix A)

NOTE: Compressed data will be decompressed during processing.

"H" is high gain, "L" is low gain for Bands 4 and 5 only, which have a commandable gain option.

h. Character positions 90-98 NASA ERTS

Identifies the Agency and the Project.

i. Character positions 99-114 E-1042-16032-10

Frame Identification Number—each image or frame will have a unique identifier which will contain encoded information consisting primarily of time of exposure relative to launch. Its format is E ADDD HHMMS-BCRR and is interpreted as follows:

- E — Encoded Project Identifier
- A — ERTS Mission: 1=ERTS A; 2=ERTS B
- DDD — Day number relative to launch at time of observation
- HH — Hour at time of observation
- MM — Minute at time of observation
- S — Tens of seconds at time of observation
- B — NDPF Identification Code (RBV: 1, 2, 3; MSS: 4, 5, 6, 7, 8)
- C — Blank for earth images, either 0, 1, or 2 for RBV radiometric calibration images, indicating lowest to highest exposure level respectively.
- RR — Regeneration number. This is used to indicate the re run of a video tape in the event of a malfunction in the prior run.

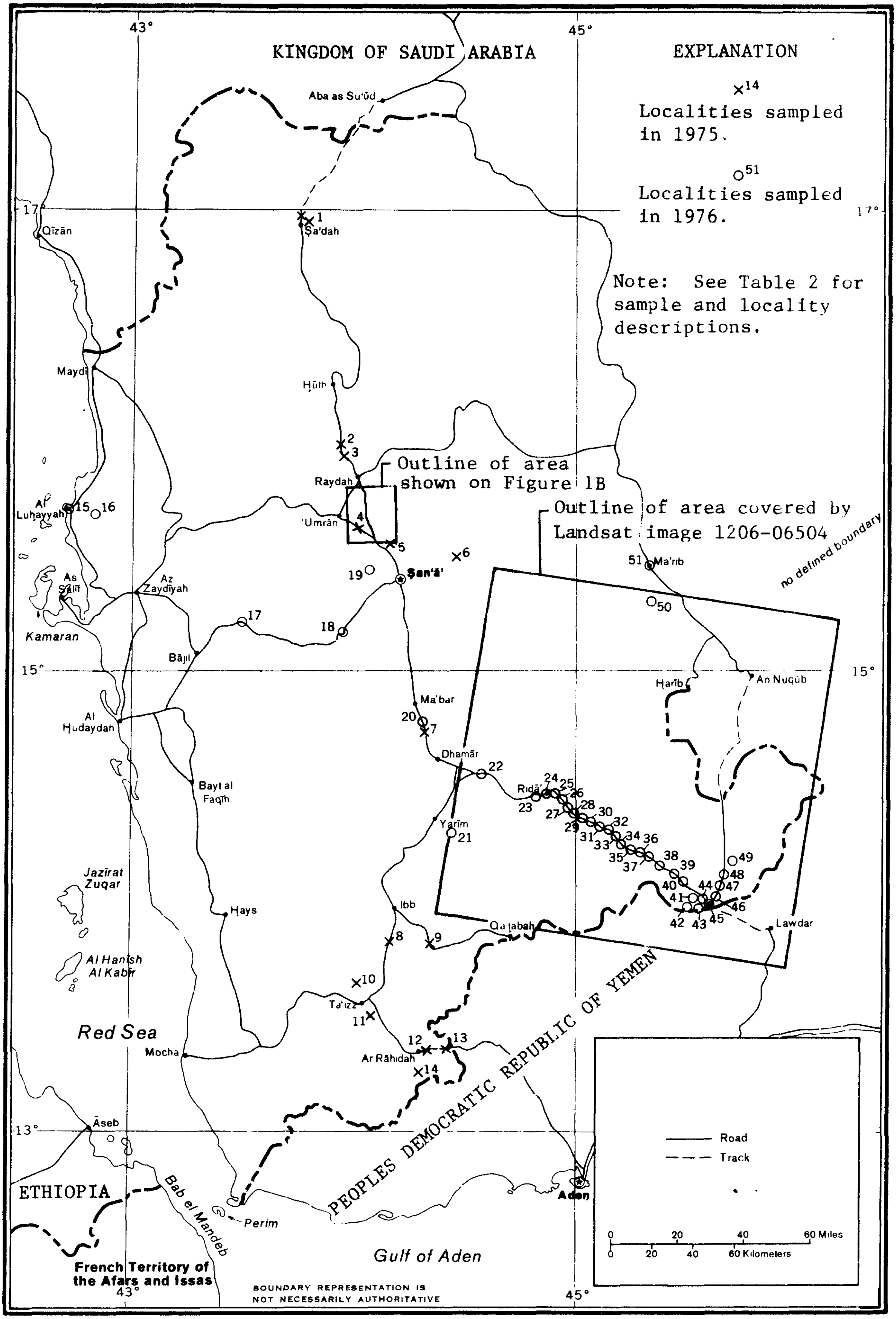

Figure 1A. Index map of the Yemen Arab Republic showing localities where rocks were sampled in June-July 1975 and February 1976.

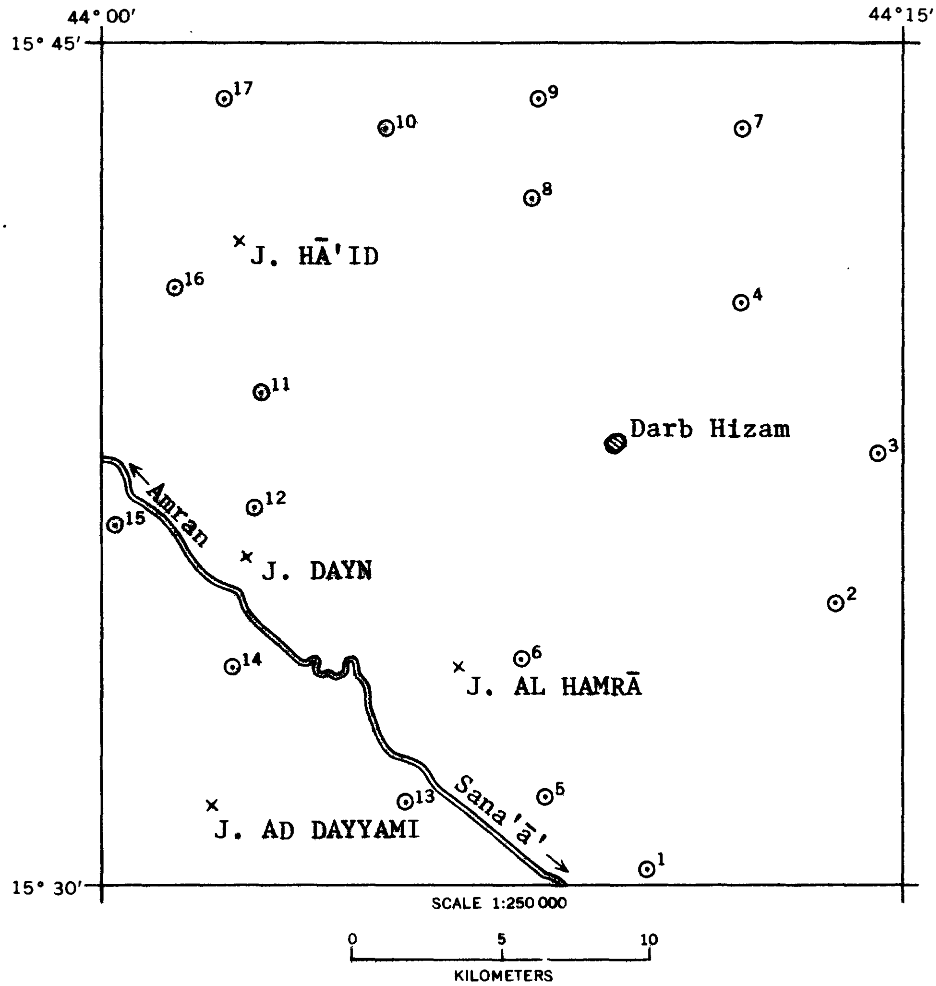

Figure 1B. Index map showing locations of 17 samples collected by Dr. Kabesh, Sana'ā' University in the Hamdan volcanic field, north of Sana'ā', Yemen Arab Republic.

The localities indicated on figure 1A show the sources of samples taken for chemical analyses made in 1975 (Overstreet, Domenico, and others, 1976) and in 1976 (this report).

The localities sampled in 1976, together with field descriptions of the rocks, are given in table 2. The geographic coordinates were scaled from localities plotted in the field on 1:250,000-scale topographic maps (Ministry of Defense, United Kingdom, 1974). Where two or more samples were taken at the same locality, the lowest sample number is used to designate the locality. Thus, at locality 10, figure 2, three samples were collected. The designation of the locality as 10 is taken from MJG-76-10, the field sample numbers MJG-76-11 and MJG-76-12 are included under locality 10 in table 2.

A study on the petrochemistry of some Quaternary basaltic rocks collected by Dr. Kabesh, San'ā' University, in the Hamdān volcanic field, 20-50 km north-northwest of San'ā' has been published (Kabesh and Ghoweba, 1976). This study is largely based on 17 rock samples collected by Dr. Kabesh, who kindly plotted the locations on figure 1B.

Table 2. *Description of localities, sampled and rocks analyzed as a result of geologic investigations in the Yemen Arab Republic during February 1976.* [Samples MJG collected by Maurice J. Grolier, U.S. Geological Survey. Other collectors include Roy O. Jackson, U.S. Geological Survey, (ROJ), and James W. Aubel, U.S. Peace Corps, (JA).]

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-1A	18	--	15°07'50"	43°55'42"	2.7 km SW. of Al Khamīs on highway between San'ā' and Hudaydah	Tertiary, black, sheared obsidian of Yemen Volcanics; vent grading into dike, intrudes and bakes rhyolitic ignimbrite of Yemen Volcanics, undivided (TK_y). Tertiary, pink ignimbrite host for obsidian, MJG-76-1A; strong layering and collapse structure, but not strongly welded; Yemen Volcanics, undivided (TK_y).
MJG-76-1B	18	--	--	--	do.	Tertiary, pink ignimbrite host for obsidian, MJG-76-1A; strong layering and collapse structure, but not strongly welded; Yemen Volcanics, undivided (TK_y).
MJG-76-2	20	--	14°43'05"	44°21'50"	0.8 km NNE. of Risābah, about 9.7 km SSE. of Ma'bar	Tertiary, friable, weathered, gray-buff ignimbrite from Yemen Volcanics (TK_{y2}), contains mafic xenoliths, but most lithic fragments in ignimbrite are purple tuff and gray tuff; vesicles in ignimbrite are flattened and filled with glassy shards that are unwelded.
MJG-76-3	21	--	14°15'15"	44°33'15"	1.1 km SE. of Dhī Ishra' and 3.2 km NW. of Adh Dhārrah at a locality about 25 km SE. of Yarīm on the trail to Damt.	Tertiary, carbonaceous sedimentary layer 0.3 meter thick in Yemen Volcanics (TK_{y2}).
MJG-76-4	21	--	14°13'25"	44°35'15"	2.6 km SE. of Adh Dhārrah on the trail to Damt	Tertiary, indurated but pervasively weathered felsic tuff of Yemen Volcanics (TK_{y2}); scattered laths feldspar up to 4 mm long, lithic fragments up to 25 mm in diameter are round and stained brown, rare vesicles up to 3x15 mm are partially coated or filled with brown limonite; joints coated with black to dark-brown limonite; deep weathering is shown by the leaching and staining of lithic fragments and feldspars.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-5	19	--	15°12'30"	44°02'40"	8.8 km along Shībam gravel road from its juncture with the Wādī Dahr road, about 20 km from San'ā'.	Tertiary, carbonaceous siltstone interbedded with mafic lava flows of Yemen Volcanics (TK_{y3}?)
MJG-76-6	22	6	14°26'44"	44°34'37"	23.3 km east of the eastern outskirts of Dhamār.	Tertiary, vesicular glassy tuff near top of the Yemen Volcanics (TK_{y3} or younger); vesicles up to 30 mm across are coated with crusts of unidentified minerals of various colors: white, yellow, light green, red, and brown; magma probably was exceptionally rich in volatiles to cause the abundance of vesicles; this tuff is a strong cliffmaker and is a prominent horizon marker owing to the spectacular vesicles.
MJG-76-7	23	7	14°24'57"	44°46'30"	Spoil pile from well dug about 3.2 km S. 30° W. of Mallah	Tertiary, dike (?) of porphyritic epidotized, fine-grained diorite from Yemen Volcanics (TK_{y3} or T^4), contains brownish-red, altered phenocrysts of pyroxene (?) with strong longitudinal parting, and aggregates of zeolite.
MJG-76-8A	25	8	14°26'11"	44°53'50"	8.7 km SE. of Ridā' on N. side of road to Al Baydā'.	Precambrian, dark-gray quartzite with 15 percent biotite, in layers about 15 cm thick in soft biotite schist, strikes N. 10° W., dips 75° W., has a few specks of greenish-blue chrysocolla on cleavage planes, chrysocolla usually associated with bleached, quartz-rich parts of the quartzite.
MJG-76-8B	25	8	14°26'11"	44°53'50"	do.	Precambrian biotite schist interlayered with quartzite represented by MJG-76-8A; schist is composed of biotite, quartz, and feldspar.
MJG-76-9	25	8	14°26'11"	44°53'50"	115 meters SE. along road from sample MJG-76-8A	Precambrian, coarse-grained muscovite-granite gneiss (?) conformable with foliation of the thick sequence of pelitic metasediments represented by the quartzite and schist of samples MJG-76-8A and 8B, sequence contains very little carbonate; granite gneiss may be a sill.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-10	26	10	14°24'36"	44°54'53"	7.9 km SE. along road from sample MJG-76-8A; rock exposed in small pass just NW. of a cistern.	Precambrian pink quartzite interlayered with biotite-quartz schist; quartzite contains accessory feldspar and muscovite; layering strikes N. 40° E. and dips 40° W.
MJG-76-11	26	10	14°24'36"	44°54'53"	do.	Precambrian fine-grained biotite-quartz schist with felspathic layers that are coarser grained than main mass of rock; these schists are interlayered with the quartzite represented by sample MJG-76-10.
MJG-76-12	26	10	14°24'36"	44°54'53'	do.	Tertiary (?), weathered, porphyritic mafic dike, fine-grained felted mixture of feldspar and mafic minerals with hornblende phenocrysts intergrown as composite crystals with feldspar; may be a lamprophyre or diabase dike, because color and texture resemble mafic dikes seen farther north to intrude limestone of Jurassic Amran Series (Overstreet, Domenico, and others, 1976, p. 9b); at this locality the dike intrudes quartzite and schist represented by samples MJG-76-10 and 11. Dike may be part of Yemen Volcanics (TK_{y1} or TA).
MJG-76-13	27	13	14°22'46"	44°57'32"	6 km SE. along road from sample MJG-76-12 and about 2 km SE. of Abbās.	Precambrian (?) dike of pink microgranite porphyry intrusive into sheeted fine-grained granite and quartz-biotite schist of Precambrian sequence represented by MJG-76-11; amount of feldspar in schist is greater at this station than at MJG-76-11; schist strikes N. 40° E. and dips 40° NW.; dike is vertical. Possibly a late Precambrian dike, because it closely resembles Precambrian rhyolite dikes in Saudi Arabia (Overstreet and Rossman, 1970).
MJG-76-14	27	13	14°22'46"	44°57'32"	do.	Precambrian, fine-grained, sheeted, pink granite at MJF-76-13, scattered small phenocrysts of feldspar up to 5 mm across; granite contains about 2 percent of biotite and sparse, rounded, felsic cognate inclusions of finer grain than main mass of granite; despite the field aspect of a sheeted rock, the hand specimen is massive with a faint parallelism of biotite-rich layers that suggests primary flow banding. Possibly this granite is equivalent to the late Precambrian peralkaline granite mapped in Saudi Arabia (U.S.Geol. Survey and the Arabian American Oil Company, 1963, map).

Field sample number	Locality numbers: Figure 1	Locality numbers: Figure 2	Coordinates: North latitude	Coordinates: East longitude	Locality description	Field description of rock
MJG-76-15	28	15	14°21'36"	44°59'43"	4.8 km SE. along road from sample MJG-76-13.	Precambrian, pink, fine-to medium-grained, massive biotite granite with gneissic banding at contacts; may be equivalent to the late Precambrian peralkaline granite mapped in Saudi Arabia (see MJG-76-14).
MJG-76-16	29	16	14°21'25"	45°01'30"	4.8 km E. along road from sample MJG-76-15.	Precambrian, feldspathic biotite gneiss, medium-grained, strongly layered, probably granodiorite gneiss.
MJG-76-17	30	17	14°21'03"	45°03'07"	4.8 km E. along road from sample MJG-76-16.	Precambrian, fine-grained biotite schist intruded by two pegmatite dikes of Precambrian age.
MJG-76-18A	30	17	14°21'03"	45°03'07"	do.	Upper of two pegmatite dikes at this locality; consists mainly of white to pink potassium feldspar with 20 percent of quartz and 2 to 3 percent of biotite weathered), a trace of muscovite on the cleavage surfaces of the feldspar; this body of pegmatite tends to conform to the foliation of the wall-rock biotite schist.
MJG-76-18B	30	17	14°21'03"	45°03'07"	do.	Lower of two pegmatite dikes at this locality; consists mostly of pink potassium feldspar with about 10 percent of quartz and a trace of biotite.
MJG-76-19A	31	19	14°21'05"	45°05'04"	About 5 km E. along road from sample MJG-76-17.	Precambrian, pink to white fine-grained granite gneiss; sample is pink phase, it contains very little biotite, but the biotite lies in the foliation plane and helps define it.
MJG-76-19B	31	19	14°21'05"	45°05'04"	do.	Precambrian, white, fine-grained, granite gneiss, white phase is quartz rich and contains no more than 1 percent of biotite, but the biotite is well oriented in the gneissic layering; about 1.6 km to the SE., the granite gneiss is in contact with biotite schist.
MJG-76-20A	31	20	14°20'55"	45°05'47"	2.6 km SE. along road from sample MJG-76-19.	Precambrian, quartz vein with pegmatitic pods strikes N. 40° E., dips vertically parallel to foliation of biotite schist host; sample consists of white, massive quartz free from visible sulfide minerals or gold.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-20B	31	20	14°20'55"	45°05'47"	2.6 km SE. along road from sample MJG-76-19.	Pegmatitic phase of quartz vein, consists mainly of pink to white potassium feldspar with sparse quartz, and a trace of muscovite.
MJG-76-21	31	21	14°20'06"	45°06'45"	4.8 km SE. along road from sample MJG-76-20.	Precambrian, pink, fine-grained, granite gneiss with gneiss with septa of biotite schist; strikes N. 40° E. and dips 65° W. May be equivalent of the older calc-alkaline granite mapped in Saudi Arabia (U.S. Geol. Survey and Arabian American Oil Company, 1963, map).
MJG-76-22	32	22	14°19'50"	45°08'33"	4.8 km SE. along road from sample MJG-76-21.	Precambrian, black, medium-grained, biotite schist; consists of about 80 percent biotite with quartz and feldspar; resembles biotite schist produced by retrogressive metamorphism of gabbro or other mafic rock and forming envelopes around cores of gabbro or pyroxenite, but no mafic rocks observed.
MJG-76-23	32	23	14°19'30"	45°10'53"	4.8 km SE. along road from sample MJG-76-22.	Precambrian, feldspathic quartz-biotite schist; strikes E., dips 55° N.; much less biotite than sample MJG-76-22; metasediment.
MJG-76-24	32	23	14°19'30"	45°10'53"	do.	Precambrian, quartz monzonite dike, contains 5 to 8 percent biotite, strikes N. and dips vertically in quartz-biotite schist at this locality.
MJG-76-25	33	25	14°18'08"	45°13'07"	4.8 km SSE. along road from sample MJG-76-23.	Precambrian coarse-grained, feldspathic biotite gneiss very similar to MJG-76-16; strongly developed feldspathic layers up to 7 mm thick alternate with biotitic layers from 0.5 to 4 mm thick; scattered porphyroblasts of feldspar up to 12 by 20 mm, possibly a porphyroblastic granodiorite gneiss; foliation strikes N. 40° W. and dips vertically.
MJG-76-26A	34	26	14°16'30"	45°15'17"	3.9 km SSE. along road from As Sawādiyah	Precambrian biotite gneiss; lacks inclusions, may be septum of metagraywacke of middle amphibolite grade included in intrusive granodiorite gneiss.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-26B	34	26	14°16'30"	45°15'17"	3.9 km SSE. along road from As Sawādiyah	Precambrian, light pink fine-grained biotite granite dike intrusive into biotite gneiss represented by sample MJG-76-26A; this granite has a faint parallel arrangement of biotite flakes with a few flakes across the grain of the rock, may be a weak primary flow banding; dike resembles late Precambrian peralkaline granite mapped in Saudi Arabia (see MJG-76-14).
MJG-76-27A	35	27	14°16'33"	45°17'56"	4.8 km E. along road from sample MJG-76-26A	Precambrian, coarse-grained feldspathic biotite gneiss with sheared metacrysts of feldspar; interpreted to be a coarse-grained phase of gneiss represented by sample MJG-76-16 and thought to be polymetamorphosed granodiorite.
MJG-76-27B	35	27	14°16'33"	45°17'56"	do.	Precambrian, coarse-grained schistose biotite gneiss similar to sample MJG-27A but more strongly foliated and somewhat finer grained than that specimen; feldspar porphyroblasts up to 10 mm across; foliation strikes N. 25° E. and dips vertically.
MJG-76-28A	35	28	14°15'36"	45°20'03"	4.8 km SE. along road from sample MJG-76-27A.	Precambrian coarse-grained biotite gneiss that is a coarse, feldspathic pahse of MJG-76-27A; coarse-grained layers of pink feldspar are segregated from fine-grained biotite layers, virtually a pegmatitic phase of granodiorite gneiss; intrudes biotite schist and contains septa of biotite schist as inclusions.
MJG-76-28B	35	28	14°15'36"	45°20'03"	do.	Precambrian, fine-grained biotite schist that forms septum in gneiss represented by sample MJG-76-28A; septum is about 1 meter wide, 100 meters long,

Field-sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
						strikes N. and dips vertically; schist is composed of biotite, quartz, and small, equant feldspars; schist has pronounced rodding that is made more evident by weathering, sample is weathered and biotite is hydrated and has a color resembling that of brass.
MJG-76-28C	35	28	14°15'36"	45°20'03"	4.8 km SE. along road from sample MJG-76-27A	Precambrian, pink felsite dike grading along strike into pegmatitic quartz vein; felsite, represented by sample MJG-76-28C, consists of pink potassium feldspar and quartz; felsite dike intrudes biotite gneiss.
MJG-76-28D	35	28	14°15'36"	45°20'03"	do.	Sample is gray, greasy-appearing quartz from the pegmatitic quartz vein from MJG-76-28C.
MJG-76-29A	36	29	14°15'16"	45°21'45"	4.8 km SE. along road from sample MJG-76-28A	Precambrian, fine-grained pink granite that contains sparse amphibole; granite forms a sill in fine- to medium-grained biotite diorite gneiss, and granite is weakly foliated parallel to contacts striking N. 10° E. and dipping 75° W., granite is weathered with pervasive limonite replacing amphibole and pyrite (?).
MJG-76-29B	36	29	14°15'16"	45°21'45"	do.	Precambrian, hornblende-biotite schist with equant, essentially interstitial plagioclase; seen in both schistose and gneissic phases, may be metadiorite; host for granite sill.
MJG-76-30	37	30	14°13'46"	45°22'09"	4.8 km SE. along road from sample MJG-76-29A	Precambrian, coarse-grained biotite gneiss that closely resembles MJG-76-16, MJG-76-27A, and MJG-76-27B; probably gneissic granodiorite; foliation strikes N. 35° E. and dips vertically.
MJG-76-31	37	31	14°12'38"	45°22'29"	4.8 km SE. along road from sample MJG-76-30.	Precambrian, gray, fine-grained, well-foliated biotite gneiss composed of biotite, feldspar, and quartz with a trace of accessory garnet and, in the more feldspathic layers, specks of red-brown allanite; rock is interpreted to be a metasediment of lower amphibolite facies.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-32A	38	32	14°10'31"	45°23'46"	5 km SE. along road from sample MJG-76-31	Precambrian, gray, fine-grained, massive biotite granite which is sheeted parallel to the foliation of the host rock; granite resembles the late Precambrian peralkaline granite mapped in Saudi Arabia (see MJG-76-14).
MJG-76-32B	38	32	14°10'31"	45°23'46"	do.	Precambrian, medium- to coarse-grained metadiorite that is host for granite; metadiorite is similar to that in specimen MJG-76-29B, except that MJG-76-32B is coarser grained, has more amphibole and less biotite; thin granitic stringers cut across the foliation of the metadiorite, and these stringers are, in turn, intersected by epidote-bearing veinlets that extend both across and parallel to the foliation of the metadiorite.
MJG-76-32C	38	32	14°10'31"	45°23'46"	do.	Precambrian, epidote-rich, lenticular inclusion in fine-grained biotite granite represented by sample MJG-76-32A.
MJG-76-33A	38	33	14°09'08"	45°25'30"	4.7 km SE. along road from sample MJG-76-32A	Precambrian, pink, fine-grained granite gneiss; gneissic structure strongly marked by thin layers of fine-grained biotite.
MJG-76-33B	38	33	14°09'08"	45°25'30"	do.	Precambrian, gray to pink, very fine grained, biotite granite gneiss with small porphyroclasts (?) of pink feldspar; rock may be a mylonitic phase of granite represented by sample MJG-76-33A.
MJG-76-34	39	34	14°06'26"	45°26'50"	4.8 km SSE. along road from sample MJG-76-32A and 30.1 km NW. of Al Baydā'.	Precambrian, gray, fine- to medium-grained feldspathic biotite gneiss; aggregates of epidote are concentrated in the biotitic layers; paragneiss of low amphibolite facies; resembles rocks represented by samples MJG-76-23 and MJG-76-26A.
MJG-76-35A	46	35	13°59'00"	45°37'13"	4.8 km by road ENE. of Al Baydā'.	Precambrian, massive greenstone with tiny gash veins filled with epidote and quartz.
MJG-76-35B	46	35	13°59'00"	45°37'13"	do.	Precambrian, dark green, chloritized and feldspathized massive metadiorite; relicts of pyroxene and biotite in a chloritic matrix, porphyroblasts of pink to white feldspar, and veinlets of red feldspar in rock.

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-35C	46	35	13°59'00"	45°37'13"	4.8 km by road ENE. of Al Baydā'	Precambrian, coarse-grained chloritized hornblende granodiorite gneiss; dull greenish chloritized hornblende grains up to 20 mm across, pink and white feldspars up to 10 mm across; poorly defined gneissic banding owing to large size of main minerals composing rock.
MJG-76-36A	47	36	13°59'31'	45°39'43"	4.8 km by road ENE. of sample MJG-76-35A.	Precambrian, gray to pink fine-grained, biotite granite dike that intersects metadiorite with granitic layers; dike resemble peralkaline granite mapped in Saudi Arabia (see sample no. MJG-76-14).
MJG-76-36B	47	36	13°59'31"	45°39'43"	do.	Precambrian, fine-grained metadiorite or coarse-grained meta-andesite, has abundant fine-grained biotite in a felted matrix of feldspar with sparse quartz; intruded by granite dike.
MJG-76-36C	47	36	13°59'31"	45°39'43"	do.	Precambrian, little metamorphosed, mafic dike, possibly diabase, intrudes metadiorite and may be intruded by granite dike represented by sample MJG-76-36A.
MJG-76-37A	47	37	14°00'32"	45°40'43"	4.8 km by road NE of sample MJG-76-36A	Precambrian, fine-grained, feldspathized metadiorite; traversed by veinlets of epidote; resembles rock represented by sample MJG-76-35B.
MJG-76-37B	47	37	14°00'32"	45°40'43"	do.	Precambrian, porphyroblastic granitic gneiss occurs as layers in metadiorite; strong planar structure in gneiss is composed of quartz-feldspathic layers up to 10 mm thick alternating with biotitic layers less than 1 mm thick.
MJG-76-37C	47	37	14°00'32"	45°40'43"	do.	Precambrian, feldspathic segregation zone in metadiorite represented by sample MJG-76-37A; segregation consists of massive red feldspar with minor chloritized amphibole and biotite; it resembles the small zones of feldspar porphyroblasts present in the metadiorite except that this segregation zone is 10 cm thick whereas the small zones tend to be 5 to 12 mm thick.

Field-sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-38A	47	38	$14^{o}01'25''$	$45^{o}41'56''$	4.8 km by road NE. of sample MJG-76-37A; for northeasterly 1.6 km the road is on a light-colored granite, possibly equivalent to the older calc-alkaline granite mapped in Saudi Arabia (see MJG-76-21).	Precambrian, gneissic alaskite that is parallel to the foliation and bedding of calc-silicate rocks in a sequence of metamorphosed sedimentary and volcanic rocks that strikes about N., gneissic structure in the alaskite is defined by rare flakes of biotite.
MJG-76-38B	47	38	$14^{o}01'25''$	$45^{o}41'56''$	do.	Precambrian, pale green to white calc-silicate rock that forms layers 0.9 to 1.2 meters thick in gneiss and greenstone; small veins of tremolite up to 10 mm thick are in the calc-silicate rock, and some joints in the calc-silicate are coated with selvages of muscovite in flakes up to 6 mm across but only 3 to 4 mm thick.
MJG-76-38C	47	38	$14^{o}01'25''$	$45^{o}41'56''$	Same locality, but in exposures on N. side of road whereas the two previous samples are from the S. side.	Precambrian (?), pyroxenite dike, consists mainly of pyroxene with 5 percent of feldspar, little altered; intrudes augen gneiss that was not sampled.
MJG-76-39A	48	39	$14^{o}02'43''$	$45^{o}42'58''$	2.9 km by road NE. of sample MJG-76-38A.	Precambrian, pink, massive, quartz-rich granite from E. wall of pluton; massive granite grades into primary gneiss of wall zone which is banded and contains inclusions of wall rock oriented parallel to contact; this massive granite varies in size of grain from coarse to fine; sample MJG-76-39A is of the coarse-grained phase; rock resembles the late Precambrian peralkaline granite mapped in Saudi Arabia (see sample MJG-76-14).
MJG-76-39B	48	39	$14^{o}02'43''$	$45^{o}42'58''$	do.	Precambrian, pink, fine-grained granite from same pluton as sample MJG-76-39A.

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-40	48	39	14°02'43"	45°42'58"	Same location as sample MJG-76-39A near east side of pluton.	Precambrian skarn from contact between granite pluton and wall rocks that consist of greenstone or fine-grained metadiorite; the skarn is a fine-grained, felted mixture of feldspar and mafic silicate minerals weathered to a gray-brown massive rock.
MJG-76-41A	48	41	14°03'11"	45°43'32"	4.8 km NE. by road from sample MJG-76-39A.	Precambrian layered mafic rocks ranging in texture and composition from fine-grained gabbro and diabase to medium-grained diorite; sample MJG-76-41A is fine-grained gabbro or coarse-grained diabase.
MJG-76-41B	48	41	14°03'11"	45°43'32"	do.	Precambrian, massive, fine- to medium-grained diorite; unmetamorphosed.
MJG-76-41C	48	41	14°03'11"	45°43'32"	do.	Precambrian, dark, massive diorite with a trace of biotite and quartz.
MJG-76-42A	48	42	14°03'42"	45°45'50"	4.8 km ENE. by road from sample MJG-76-41A	Precambrian, massive, layered, medium-grained, epidotized metadiorite country rock.
MJG-76-42B	48	42	14°03'42"	45°45'50"	do.	Precambrian, pink, gneissic granite with gneissic structure defined by strung-out grains of quartz in plane of foliation; gneissic granite occurs as sills parallel to layering in metadiorite.
MJG-76-42C	48	42	14°03'42"	45°45'50"	do.	Precambrian, greenstone dike in gneissic granite.
MJG-76-43	49	43	14°04'49"	45°48'15"	4.7 km NE. by road from sample MJG-76-42A and at outskirts of As Sawma'ah.	Precambrian, green, gneissic metadiorite, partly chloritized, contains some epidote; thin quartz-feldspar stringers transect foliation; the metadiorite is the country rock in this area.
MJG-76-44	48	44	14°02'00"	42°42'40"	10.6 km by road from Madhwaqayn	Precambrian, pink, fine-grained, gneissic biotite granite; biotite is sparse.
MJG-76-45A	41	45	14°01'04"	45°29'46"	Mica deposit at Sha'ib Al Garlikah in Wadi Nabah.	Precambrian, zoned, sheet-muscovite-bearing pegmatite intrusive into porphyritic, biotite granite gneiss; This pegmatite forms a dike 20-24 meters wide and 60 meters long that strikes N. 70° E. and dips about vertically; the pegmatite dike may be genetically associated with a granitic stock exposed to the SW.

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
						at Jabāl Saudah; other sheet-muscovite-bearing pegmatite dikes are exposed upstream in Sha'ib Al Garlikah, in Wādī Nabah, in Wadi Al Thoaier, and in Wadi Khabid; sample MJG-76-45A is potassium feldspar from feldspar-rich zone in basal part of exposure.
MJG-76-45B	41	45	14°01'04"	45°29'46"	do.	Precambrian white quartz associated with potassium feldspar in basal part of exposed pegmatite dike; sample MJG-76-45B is pure white quartz.
MJG-76-45C	41	45	14°01'04"	45°29'46"	do.	Precambrian, wall zone of pegmatite dike near contact with porphyritic biotite granite gneiss; sample MJG-76-45C consists of dominant potassium feldspar, 15 percent of red-brown garnet, and less than 10 percent of quartz.
MJG-76-45D	41	45	14°01'04"	45°29'46"	do.	Precambrian wall zone of pegmatite higher in exposure than sample MJG-76-45C; wall zone of pegmatite represented by specimen MJG-76-45D consists of dominant potassium feldspar with 5 percent of muscovite, 2 percent of garnet, and 1 percent of quartz.
MJG-76-45E	41	45	14°01'04"	45°29'46"	do.	Precambrian core of pegmatite near top of exposure, consists of muscovite-garnet-rich zone containing 90 percent of muscovite, 4 percent of garnet and 10 percent of quartz; muscovite in small books up to 15 mm across, A-structure common, books badly warped.
MJG-76-45F	41	45	14°01'04"	45°29'46"	do.	Precambrian, muscovite-garnet selvage from pegmatite; consists of 5 percent garnet, 1 percent quartz, remainder is muscovite.
MJG-76-45G	41	45	14°01'04"	45°29'46"	do.	Precambrian, feldspar-muscovite selvage from pegmatite at contact with gneiss.

Field-sample number	Locality numbers Figure 1	Figure 1	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-45H	41	45	14°01'04"	45°29'46"	Mica deposit at Sha'ib Al Garlikah in Wādī Nabah.	Precambrian books of muscovite up to 75 mm across, strong A-structure, books are warped, smoky color.
MJG-76-45I	41	45	14°01'04"	45°29'46"	do.	Precambrian, porphyritic biotite granite gneiss from contact on N. side of pegmatite dike; strongly weathered.
MJG-76-46	41	46	14°00'35"	45°30'25"	Bed of Wādī Nabah about 0.8 km downstream from sample MJG-76-45A.	Precambrian ferruginous breccia layer in granite gneiss exposed in N. side of bed of wadi, breccia is about 5-10 cm thick, cemented by limonite developed by weathering of siderite; age of siderite may be considerably younger than the Precambrian gneiss.
MJG-76-47	42	47	13°57'18"	45°27'07"	0.2 km E. of Al Zahair	Precambrian greenish gray slaty argillite, cleavage strikes N. 75° E. and dips 75° S.
MJG-76-48A	43	48	13°57'50"	45°29'45"	5 km by road E. of Al Zahair.	Precambrian, dark gray, banded, quartz-rich, biotite-quartz gneiss with thin biotite-feldspar layers; layering strikes N. 40° E. and dips 75° to 80° S.
MJG-76-48B	43	48	13°57'50"	45°29'45"	do.	Precambrian, gray-green, fine-grained granitoid layer parallel to foliation of biotite-quartz gneiss.
MJG-76-49A	43	49	13°57'42"	45°32'22"	Exposure on N. side of road at E. end of air-field runway at Al Baydā'.	Precambrian gray-green sericite schist, limonite stain; metasediment.
MJG-76-49B	43	49	13°57'42"	45°32'22"	do.	Precambrian, white to light gray sericite schist; silky luster, more quartzose than rock represented by sample MJG-76-49A; metasediment.
MJG-76-49C	43	49	13°57'42"	45°32'22"	do.	Precambrian green calc-silicate rock with red-brown garnets, forms layers parallel to the bedding of the sericite schist; metasediment.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-49D	43	49	13°57'42"	45°32'22"	Exposure on N. side of road at E. end of airfield runway at Al Baydā'	Precambrian, red to dark green feldspathic gneiss, possibly feldspathized metadiorite similar to sample MJG-76-37C.
MJG-76-50	45	50	13°58'50"	45°34'43"	Exposure just N. of Al Baydā' high school at N. entrance to town.	Precambrian, light gray, coarse-grained, massive granite intrusive into sericite schist of area; may be equivalent to the peralkaline granite mapped in Saudi Arabia (see sample MJG-76-14); the town of Al Baydā' is built on this granite.
MJG-76-51A	45	51	13°59'12"	45°34'32"	0.8 km by road NW. of sample MJG-76-50 and 2.4 km from the center of Al Baydā'.	Precambrian, gray-green chloritic sericite schist containing a layer siliceous marble; sample MJG-75-51A is of the schist; metasediment.
MJG-76-51B	45	51	13°59'12"	45°34'32"	do.	Precambrian, sample of siliceous marble.
MJG-76-52A	44	52	14°01'13"	45°34'02"	4.7 km by road NNW. of sample MJG-76-51A.	Precambrian, gray-green meta-andesite interlayered with metadiorite and gneissic granite; the meta-andesite, represented by sample MJG-76-52A, consists of a felted aggregate of feldspar grains less than 0.5 mm across set in a chloritic matrix; sequence strikes N. 45° E. and dips vertically.
MJG-76-52B	44	52	14°01'13"	45°34'02"	do.	Precambrian dark gray, medium-grained metadiorite interlayered with meta-andesite; metadiorite, represented by specimen MJG-76-52B, is parallel to the layering of the meta-andesite and is transected by stringers composed of epidote and feldspar.
MJG-76-52C	44	52	14°01'13"	45°34'02"	do.	Precambrian, pink, coarse-grained gneissic feldspar; has scarce augen of pink potassium feldspar, and greatly elongated blades of quartz the shape of which suggests response to regional deformation.
MJG-76-53A	40	53	14°02'55"	45°32'17"	4.8 km by road NW. of sample MJG-76-52A.	Precambrian, gray, medium-grained, epidote-bearing feldspathic biotite gneiss; strongly segregated quartz feldspathic layers alternate with micaceous layers, each several millimeters thick; the presence of small porphyroclasts of quartz is interpreted to indicate cataclastic origin of gneiss; strikes N. 30° E., dips vertically; metagraywacke (?).

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-53B	40	53	14°02'55"	45°32'17"	4.8 km by road NW. of sample MJG-76-52A.	Precambrian, dark gray, metadiorite with the texture and composition of biotite-hornblende gneiss in which hornblende is dominant; interlayered with feldspathic biotite gneiss represented by sample MJG-76-53A.
MJG-76-53C	40	53	14°02'55"	45°32'17"	do.	Precambrian, pink to white, medium-to coarse-grained gneissic biotite granite in layers parallel to the gneissic structure of the biotite gneiss and metadiorite.
MJG-76-54A	40	54	14°03'07"	45°31'23"	2.3 km NW. along road from sample MJG-76-53A.	Precambrian, gray to dark gray, massive, granodiorite with sparse, scattered porphyroblasts of pink potassium feldspar; contacts covered, but the granodiorite appears to intrude metamorphosed sedimentary rocks.
MJG-76-54B	40	54B	14°03'01"	45°31'50"	1.8 km by road NW. of sample MJG-76-54A.	Precambrian, grayish white quartzite; exposed surfaces of quartzite, where joints intersect bedding, show selective erosion of layers 2 to 3 mm to 6 to 8 mm thick with the thicker layers being more deeply eroded and stained light brown; may indicate that the more readily eroded layers contain a little carbonate; sample MJG-76-54B represents the largest body of quartzite observed on this traverse in southeastern Yemen: the body of quartzite is at least 800 meters thick and 5 km long and supports two ranges of hills.
MJG-76-55A	40	55	14°03'35"	45°31'03"	4.8 km by road NNW. of sample MJG-76-53A	Precambrian, gray, slaty argillite with extremely fine grained sericite on cleavage surfaces; strikes N. 65° E. and dips 85° S.
MJG-76-55B	40	55	14°03'35"	45°31'03"	do.	Precambrian, grayish green, lustrous, chloritic sericite-chloritoid schist exposed 10 meters along road to NW. of sample MJG-76-56A; chloritoid porphyroblasts in schist are up to 2 mm by 5 mm in size; about 3 km farther toward the NW. is the contact between the metasedimentary rocks represented by samples MJG-76-55A and 55B, and a pluton of intrusive granite.

Field sample number	Locality numbers Figure 1	Figure 2	Coordinates North latitude	East longitude	Locality description	Field description of rock
MJG-76-56A	40	56	14°04'01"	45°29'46"	4.8 km by road NW. of sample MJG-76-55A.	Precambrian (?), massive coarse-grained, hornblende granite that forms a small pluton about 3.5 km across and intrusive into metasedimentary rocks; sample MJG-76-56A is of massive granite from central part of pluton, but the walls of the pluton show flow banding, compositional layering, and inclusions oriented parallel to the contacts; although the pluton resembles megascopically the late Precambrian peralkaline granite mapped in Saudi Arabia (see sample MJG-76-14), the granite in this small pluton also resembles the Tertiary granites sampled in Yemen at Jibāl Sabir (Overstreet, Domenico, and others, 1976, table 1) and Jibāl Hufash (this report, sample MJG-76-72B.
MJG-76-56B	40	56	14°04'01"	45°29'46"	do.	Precambrian (?), quartz-tourmaline-feldspar vein in hornblende granite; these veins are 25-50 mm wide and occupy joints in the granite; locally the feldspar in the veins is replaced by epidote; the tourmaline is black and forms rosettes up to 20 mm across.
MJG-76-57A	39	57	14°05'33"	45°27'34"	5 km by road NW. of sample MJG-76-56A.	Precambrian quartz-sericite-actinolite schist exposed to the NW. of the pluton of granite represented by sample MJG-76-56A; actionolite gives a strong lineation in the plane of foliation of the schist, and joints normal to the lineation are filled with brown-stained quartz stringers up to 5 mm thick, stain may come from the weathering of siderite or pyrite; lenticular masses of calc-silicate rocks are present in this sequence of metasedimentary rocks; sample MJG-76-57A represents the quartz-sericite-actinolite schist.
MJG-76-57A1	39	57	14°05'33"	45 27'34"	do.	Precambrian, calc-silicate rock.

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-57B	39	57	$14^{o}05'33''$	$45^{o}27'34''$	5 km by road NW. of sample MJG-76-56A.	Precambrian (?), black, manganese-stained, chalcedonic matrix cementing white quartz vein with subparallel fractures following the walls of the vein; cubes of limonite pseudomorphic after pyrite and boxwork structures after carbonate minerals are present in chalcedony.
MJG-76-58	37	58	$14^{o}12'00''$	$45^{o}22'45''$	4.8 km by road NW. of Dhī Nā'im.	Precambrian, equigranular, epidote-rich, garnetiferous, biotite-plagioclase gneiss; veins of pink feldspar are associated with parts of gneiss where epidote replaces plagioclase; garnet is red-brown.
MJG-76-59A	37	59	$14^{o}14'02''$	$45^{o}23'25''$	3.6 km by road NNW. of Al Qā.	Precambrian, white to pale yellow, coarse-grained marble; strikes N. 10^{o} E. and dips 75^{o} SW.; 12 meters thick, at minimum, 5 km long.
MJG-76-59B	37	59	$14^{o}14'02''$	$45^{o}23'25''$	do.	Precambrian, coarse-grained, feldspathic quartz vein in marble; siderite crystals up to 10 mm by 20 mm present in vein, and quartz in vein has sparse limonitic stain.
MJG-76-60	24	60	$14^{o}25'30''$	$44^{o}51'02''$	4.8 km by road E. of Ridā'	Cretaceous, ferruginous layer in sandstone of the Tawilah Group; the ferruginous cement is hematite, and some layers 15 to 30 mm thick are nearly pure hematite.
MJG-76-63	51	--	No data	No data	Sample received from Dr. Hamed M. El-Shatoury, Dept. of Geology, Faculty of Science, Sana'a University, and reported to be from the Ma'rib area.	Precambrian (?), hydrothermally altered, dolomitic siltstone having texture of an intraformational breccia (possible turbidite) extensively replaced by pyrite, chalcopyrite, galena, and sphalerite.

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
MJG-76-67C	15	--	15°42'29"	42°41'50"	NE. end of Al Luhayyah salt dome.	Pliocene, ferruginous sandstone near top of sedimentary sequence overlying Al Luhayyah salt dome; Baid Formation.
MJG-76-68	16	--	15°41'19"	42°48'42"	Northernmost part of the Guma salt dome 16 km E. of the coastal town of Al Luhayyah.	Pliocene, brown and white limestone at the top of the marine, tuffaceous sedimentary section exposing the salt diapir of the Guma salt dome; Baid Formation.
MJG-76-69A	16	--	15°41'19"	42°48'42"	South side of Guma salt dome, sampled just south of the old Turkish fort.	Pliocene, red, laminated limestone from top of south side of Guma salt dome; Baid Formation.
MJG-76-69B	16	--	15°41'19"	42°48'42"	do.	Pliocene, brown and white, coarse-grained, crystalline limestone with pockets of limonite, near the top of the sedimentary sequence.
MJG-76-70A	16	--	15°40'55"	42°49'05"	do.	Miocene, rock salt from the Guma salt dome at site of mining.
MJG-76-71	16	--	15°40'50"	42°48'41"	do.	Pliocene, ferruginous rock stratigraphically above the limestones at the top of the sedimentary sequence at the Guma salt dome; Baid Formation.
MJG-76-72A	17	--	15°11'03"	43°30'42"	Southern edge of Jibāl Hufash on San'ā'--Hudaydah road.	Tertiary, pinkish gray, medium-grained hornblende granite; sample MJG-76-72A taken of the granite about 30 meters inside of eastern contact of granite pluton with felsite of the Yemen Volcanics; Miocene (?).
MJG-76-72B	17	--	15°11'03"	43°30'42"	do.	Tertiary, gray to pink, coarse-grained, hornblende granite; contains a conchoidally breaking, brown-weathering accessory mineral that may be allanite; Miocene (?); megascopically quite similar to possible late Precambrian granite represented by sample MJG-76-56A.
MJG-76-72C	17	--	15°11'03"	43°30'42"	do.	Tertiary, grayish buff felsite of Yemen Volcanics (TK_y), 0.3 meter E. of contact with Tertiary granite.

Field sample number	Locality numbers		Coordinates		Locality description	Field description of rock
	Figure 1	Figure 2	North latitude	East longitude		
MJG-76-72D	17	--	15°11'03"	43°30'42"	Southern edge of Jibāl Hufash on San'ā'--Hudaydah road.	Tertiary, purplish gray altered felsite of Yemen Volcanics (TK_y) at the contact with the Tertiary granite; zone 10 to 25 mm thick adjacent to granite has been recrystallized from felsite to microgranite, and normal to contact fine-grained femic minerals replace parts of the felsite in small lobate masses about 5 mm by 25 mm.
MJG-76-73A	17	--	15°11'07"	43°31'07"	1.5 km by road E. of eastern contact of Jibāl Hufash pluton at MJG-76-72A.	Tertiary, altered yellow felsite in Yemen Volcanics (TK_y), brown stains present, possibly from the weathering of iron sulfide minerals; yellow, clayey crust-like alteration products also present.
MJG-76-73B	17	--	15°11'07"	43°31'07	do.	Holocene, dark red iron oxides forming stains and crusts on altered felsite of Yemen Volcanics (TK_y); these stains and crusts are geologically young, having developed during the present erosion cycle through the weathering of iron sulfide minerals in the altered felsite; sample MJG-76-73B represents only the iron oxide crusts.
MJG-76-73C	17	--	15°11'07"	43°31'07"	100 meters E. of MJG-76-73B.	Tertiary, altered crystal tuff of Yemen Volcanics (TK_y) localized zones of kaolinization and hematite-filled fractures from which hematite stains spread up to 6 mm into walls on each side of fractures; no visible sulfides.
MJG-76-74A	17	--	15°10'26"	43°31'03"	1.5 km by road E. of sample MJG-76-73A.	Tertiary, white felsite in Yemen Volcanics (TK_y) is altered over an exposed width of at least 200 meters; alteration consists of impregnations and replacement of felsite by black, red, and purple hematite, generally the felsite is pervasively stained, locally the felsite is replaced; no sulfide minerals seen.
MJG-76-74B	17	--	15°10'26"	43°31'03"	2.5 meters E. of sample MJG-76-74A and 3 km E. of Jibāl Hufash pluton on San'ā'--Hudaydah road.	Tertiary, altered rhyolitic felsite of the Yemen Volcanics (TK_y) has been thoroughly replaced by hematite, but no sulfide minerals were seen.

Field sample number	Locality numbers Figure 1	Locality numbers Figure 2	Coordinates North latitude	Coordinates East longitude	Locality description	Field description of rock
JA-75-1	50	--	15°10'10"	45°14'43"	Spoil from a water well at Ya'arah, between Wādī Kharhla and Wādī al Khāniq, about 35 km SSW. of Ma'rib.	Precambrian (?), meta-shale with disseminated pyrrhotite.
JA-75-2	50	--	15°10'10"	45°14'43"	do.	do
ROJ-1	11	--	13°34'00"	44°02'00"	Small quarry on north side of Jibāl Sabir south of Ta'izz; coordinates approximate; R. O. Jackson, written commun 1/31/77.	Miocene (?) riebeckite granite.

REGIONAL GEOLOGY OF THE SOUTHEASTERN PART OF THE YEMEN ARAB REPUBLIC

An interpretation of the geology of the southeastern part of the Yemen Arab Republic was made through use of Landsat-1 imagery (Grolier and Overstreet, 1976e-1976i) prior to the field work in this area. The long traverse made in February 1976 has afforded an opportunity to add to the original interpretation, particularly in the area of Landsat-1 image 1206-06504 (Grolier and Overstreet, 1976i), and a revised geologic map of that region is included here (fig. 2). The complex stratigraphy and structure of the Precambrian rocks in this area are still poorly known, because the major uncomformities that separate the units of metamorphosed layered rocks have not been defined and mapped. The angular uncomformity between Precambrian and Phanerozoic rocks, as seen from the road from Ridā' to Al Baydā' is illustrated in figure 3.

The vast assemblage (fig. 4) of Precambrian metamorphosed volcanic and sedimentary rocks, where mapped across the national boundary with the Peoples' Democratic Republic of Yemen, was called the Aden Metamorphic Group (Greenwood, Bleackley, and Beydoun, 1976, sheet 2). Eleven varieties of rock were recognized on a lithologic basis, but major stratigraphic divisions were not defined in the Group. The term Aden Metamorphic Group is not extended here into the area of the Yemen Arab Republic. In the present work, these rocks are divided lithologically into mappable units, but formation names are not assigned.

Doubtless two, and possibly three, major unconformities are present within north-striking Precambrian layered rocks in the area of Yemen covered by figure 2. These rocks may also be unconformable with

Figure 3. Angular unconformity between Precambrian metamorphosed schist and overlying Phanerozoic sedimentary rocks. Looking southwestward from Ridā'-Al Baydā' road, 11.7 miles east-southeast from Ridā', and 1 mile northwest of sample locality MJG-76-13, February 1, 1976.

Figure 4. Rough dissected terrain, typical of the southeastern Precambrian province, Yemen Arab Republic, February 15, 1976. Trail is the Ridā'-Al Baydā' road, at sample localities MJG-76-10, 11, and 12.

respect to the Precambrian layered rocks that crop out along the eastern border of figure 2, but the stratigraphic relations are complicated by faults.

The north-trending mafic volcanic and metamorphic rocks represented by the symbols "am" and "sb" (fig. 2) probably are extensions of the Baish and Jiddah Groups mapped in Saudi Arabia (Greenwood and others, 1976, pp. 519-521). Interspersed with these units of metavolcanic rocks are units of metamorphosed sedimentary rocks shown by the symbols "bq" and "mq." They may be equivalent to the sedimentary members of the Baish and Jiddah Groups as well as equivalent to the Bahah Group of Saudi Arabia (Greenwood and others, 1976, p. 520). The folded and metamorphosed volcanic and sedimentary rocks entering the area from the northeast may be equivalent respectively to the Halaban Group and the Ablah Group of Saudi Arabia (Greenwood and others, 1976, p. 522-523). The metamorphosed sedimentary and volcanic rocks in this northeasterly trend that have been correlated with the Thaniya Group as shown on the geologic map of the Arabian Peninsula (U. S. Geological Survey-Arabian American Oil Company, 1963) may also be equivalent to the Ablah Group of southwestern Arabia. However, the possibility is not excluded that the metamorphosed rocks of northeasterly strike in this part of the Yemen Arab Republic may actually be older than the Baish and Jiddah Groups--a prospect that will require detailed field work to resolve.

The units mapped as diorite (d) and gabbro (gb) on figure 2 may be equivalent to the "second dioritic series" in Saudi Arabia, and the gneissic granite and gneissic granodiorite (gg) may be equivalent to the "injection gneiss" of Saudi Arabia (Greenwood and others, 1976, table 1). Post-tectonic granites (gr and gp) in the area of figure 2 in the YAR have been tentatively correlated with the calc-alkaline and peralkaline granites of Late Precambrian age in Saudi Arabia (U. S. Geological Survey-Arabian American Oil Company 1963), but diverse radiometric ages from Middle Cambrian to Ordovician have been reported (Greenwood, Bleackly, and Beydoun, 1967, sheet II) for apparently similar granite plutons in the Peoples' Democratic Republic of Yemen. As noted in table 2, some small granitic plutons in the area underlain by Precambrian rocks in figure 2 yield specimens that are indistinguishable in hand speciman from the alkalic granite of Miocene (?) age elsewhere in the Yemen Arab Republic. Resolution of these problems of relative age and composition of the post-tectonic granitic plutons will require further field work and analyses.

Several persistent faults of great length are shown in the Precambrian area of figure 2. Of these, the most important is the northeasterly fault that extends across the mapped area and enters the Peoples' Democratic Republic of Yemen at Wādī Khirr. Wādī Khirr is a left-bank tributary of Wādī Bayhān, which joins Wādī Bayhān about 3 km north of the city of Bayhān al Qaṣab, in the Peoples' Democratic Republic of Yemen. This fault can be traced southwestward on Landsat-1 imagery across the YAR and the Peoples' Democratic Republic of Yemen to the Gulf of Aden. As interpreted from Landsat image 1206-06504, movement along the fault appears to be left lateral. This structure may be a transform fault. Areas of dark rock adjacent to the fault and plotted as amphibolite (am) on figure 2, may be serpentinite.

ANALYSES OF ROCK SAMPLES

Methods and results

Spectrographic analyses for 31 elements

Semiquantitative spectrographic analyses for 31 elements were made by James A. Domenico, USGS, of 126 rock samples principally representing specimens collected in 1976 in the YAR. The method of analysis, reporting intervals, and precision of the results are the same as those described for the samples collected in 1975 (Overstreet, Domenico, and others, 1976, pp. 10-11). It is well to repeat here, however, that the analytical results are reported in six steps as the approximate geometric midpoints of ranges in concentration of which the respective limits are:

Approximate geometric midpoint (reporting value)	Range of values represented by each midpoint
1.0	1.2 - 0.83
0.7	.83 - .56
0.5	.56 - .38
0.3	.38 - .22
0.2	.22 - .18
0.15	.18 - .12
0.1	.12 - .08

The results of these analyses are listed in table 2, where it can be seen that 2 of the 31 elements sought were not detected in any sample, and 6 elements were detected in only 4, or fewer, samples. The undetected elements, and their lower limits of determination, are: gold, 10 ppm; thorium; 20 ppm. The rarely detected elements and their lower limits of determination, are: silver, 0.5 ppm; arsenic, 200 ppm; bismuth, 10 ppm; cadmium, 20 ppm; antimony, 100 ppm; and tungsten, 50 ppm. Mostly, where these rarer elements were observed, they are present in abundances much greater than their lower limits of determination (see footnote to table 3), but silver and tungsten values only reached the lower limits of determination for these elements.

The more commonly detected elements are rarely present in anomalous abundance. Indeed, as most of the high values for individual elements are achieved in appropriate rocks for the reported values, the elements can be regarded as being present in expected crustal abundances (table 4). A summary of the averages in table 4 shows:

Lithologic unit by geologic age	Elements reaching their highest values in given unit
1. Holocene weathering products	Fe, Nb, and Zr.
2. Pliocene limestone	Ca and Sr.
3. Pliocene(?) or Miocene(?) dikes.	Mo.
4. Miocene(?) alkalic granite plutons . . .	Be, La, and Sn.
5. Tertiary and/or Cretaceous felsic tuff .	As, Be, and La.
6. Tertiary and/or Cretaceous carbonaceous sedimentary rocks interbedded with volcanic rocks.	V.
7. Tertiary and/or Cretaceous undivided volcanic rocks.	Be, La, Sn, and Zr.
8. Precambrian felsite, pegmatite, and quartz veins.	Sn and W.
9. Precambrian mafic rocks.	Co, Cr, Ni, and Ti.
10. Precambrian marble and calc-silicate rocks	Mg and Sr.
11. Precambrian schist	Y.
12. Dispersed in rocks of many ages.	B and Sc.
13. Hydrothermally altered Precambrian sediment; age of alteration unknown . .	Ag, Ba, Bi, Cd, Cu, Mn, Pb, Sb, Sn, and Zn.

Table 3.--Results of semiquantitative spectrographic analyses of rocks from the Yemen Arab Republic

[6-step D.C. arc semiquantitative spectrographic analyzes by James A. Domenico, U.S. Geological Survey, November 30, 1976; lower limits of determination of individual elements shown in parentheses after symbol of element; other symbols used are: N, not detected at lower limit of determination shown; L, detected but below limit of determination; G, greater than value shown; sample MJG-76-63 analyzed by Donald A. Risoli, U.S. Geological Survey, October 3, 1976; sample ROJ-1 analyzed by H. G. Neiman, U.S. Geological Survey, April 15, 1974]

Sample numbers		Results in percentage				Results in parts per million (ppm)																		
Field	Laboratory	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)	Zn (200)	Zr (10)
Rocks of Holocene age--dark red weathering product on altered felsite of Yemen Volcanics																								
MJG-76-73B	MAM-820	20	0.03	0.07	0.2	300	15	70	3	N	N	5	50	30	150	L	100	N	N	N	10	150	N	1,000
Rocks of Pliocene age--sandstone, limestone, and ferruginous caprock of Baid Formation																								
MJG-76-67C	MAM-926	5	5	7	.5	5,000	15	200	2	20	300	20	N	N	N	70	L	30	N	1,500	200	20	N	100
-71	-931	10	10	15	.05	G5,000	10	2,000	1	10	10	10	N	N	N	30	30	20	N	1,500	100	20	N	20
-68	-927	.3	.5	G20	.05	700	10	L	N	N	10	L	N	N	N	L	10	L	N	5,000	50	N	N	30
-69A	-928	.5	.3	15	.07	150	10	20	L	N	15	L	50	N	N	7	10	5	N	1,500	50	N	N	30
-69B	-929	1	.3	G20	.15	700	10	100	L	7	70	10	N	N	N	15	N	5	N	2,000	70	10	N	100
Rocks of Pliocene (?) or Miocene (?) age--Hypabyssal andesite and diabase intrusives																								
MJG-76- 7	MAM-831	10	5	5	1	2,000	10	500	1.5	70	300	150	N	100	N	150	20	70	N	700	700	30	N	100
-12	-837	15	2	3	1	1,500	20	1,500	2	50	50	150	N	N	N	20	10	15	N	700	500	30	N	200
Rocks of Miocene age--rock salt																								
MJG-76-70A	MAM-930	.05	.2	1.5	.002	50	N	N	N	N	N	L	N	30	N	10	N	N	N	100	30	N	N	N
Rocks of Miocene (?) age--alkalic granite																								
MJG-76-72A	MAM-932	2	.2	.5	.15	5,000	L	100	7	N	N	N	200	10	150	5	20	N	15	N	N	100	300	300
-72B	-933	3	.2	.5	.3	3,000	10	70	10	N	N	L	200	N	100	L	20	N	15	N	N	70	500	300
ROJ-1	D-165544	2	.1	.2	.15	1,000	N	70	7	N	N	N	100	L	100	N	100	L	N	15	N	70	N	200
Rocks of Tertiary and/or Cretaceous age--tuff and ignimbrite of Yemen Volcanics																								
MJG-76- 6	MAM-830	2	.15	.7	.15	1,000	15	50	5	N	L	L	200	N	50	5	30	N	N	N	15	70	L	500
- 4	-828	2	.3	.3	.2	1,500	15	200	10	N	L	L	200	N	70	N	30	5	L	N	20	100	300	1,000
- 2	-826	3	.3	.2	.2	700	20	150	10	N	L	7	100	7	70	10	70	5	L	N	30	150	200	700
Rocks of Tertiary and/or Cretaceous age--carbonaceous siltstones interbedded in Yemen Volcanics																								
MJG-76- 5	MAM-829	3	1	.5	1	50	15	150	2	7	70	50	50	N	L	30	N	10	N	100	1,000	30	N	300
- 3	-827	1.5	1.5	3	.3	1,000	10	150	1	L	70	15	50	70	L	20	N	5	N	1,000	700	20	N	150
Rocks of Tertiary and/or Cretaceous age--undivided obsidian, ignimbrite, and felsite of Yemen Volcanics																								
MJG-76- 1A	MAM-824	3	.3	.5	.3	2,000	15	1,000	7	N	L	L	200	10	50	5	20	7	L	N	30	100	L	500
- 1B	-825	3	.1	.1	.5	1,500	N	700	5	5	L	L	100	7	50	30	10	5	L	N	30	100	L	700
-72C	-934	.7	.1	.3	.07	150	N	70	5	N	N	L	100	10	50	5	70	N	15	N	N	50	N	200
-72D	-818	2	.07	.3	.1	5,000	10	50	15	5	N	L	150	N	50	L	L	N	15	N	N	50	300	500
-73A	-819	5	.02	.15	.15	200	20	30	5	N	N	5	200	10	200	L	70	L	20	N	N	200	N	1,000
-73C	-821	3	.3	.2	.2	500	10	300	7	N	L	7	200	N	150	L	15	N	15	N	N	100	500	1,000
-74A	-822	5	.15	.1	.2	100	20	70	5	N	N	5	200	20	100	L	20	N	N	N	30	100	N	500
-74B	-823	10	.2	.5	.7	300	20	150	7	N	10	7	300	30	200	L	50	7	30	N	50	200	N	1,000

Table 3.—Results of semiquantitative spectrographic analyses of rocks from the Yemen Arab Republic—Continued

Sample numbers		Results in percentage				Results in parts per million (ppm)																		
Field	Laboratory	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)	Zn (200)	Zr (10)
Rocks of Cretaceous age--ferruginous sandstone in Tawilah Group																								
MJG-76-60	MAM-925	10	0.2	2	0.2	1,500	20	500	L	100	70	30	N	10	N	50	70	30	N	N	500	30	N	200
Rocks of Precambrian age--felsite, pegmatite, quartz veins, and feldspathic segregations																								
MJG-76-18A	MAM-843	.7	.2	1	.15	200	N	1,000	5	N	N	L	N	N	N	5	70	L	N	500	20	50	N	200
-18B	-844	.2	.07	.5	.02	200	N	2,000	L	N	N	N	N	N	N	10	100	N	N	500	10	N	N	N
-20A	-810	.07	.02	.05	.01	200	N	30	L	10	15	L	50	N	N	7	10	N	N	N	15	L	N	10
-20B	-811	1	1	1.5	.05	200	30	700	5	L	10	20	N	N	N	30	70	L	N	700	30	N	N	30
-28C	-858	.15	.1	1	.03	150	N	700	2	N	N	N	N	N	N	5	L	N	N	150	10	N	N	50
-28D	-812	.05	.05	.1	.015	70	N	100	L	N	10	N	50	N	N	5	L	N	N	N	10	N	N	N
-37C	-877	3	.7	1.5	.3	700	N	1,500	L	5	L	5	100	N	N	10	15	N	N	300	70	20	N	300
-45A	-892	.5	.1	.2	.02	100	N	70	1	N	L	L	N	N	N	7	100	N	N	N	15	30	N	20
-45B	-813	.05	.03	.15	.005	70	70	50	L	L	10	L	50	N	N	5	N	N	N	N	10	N	N	N
-45C	-893	15	.5	1	.1	G5,000	L	150	2	N	30	30	N	N	50	5	10	100	150	N	70	500	N	50
-45D	-894	10	.3	.7	.07	G5,000	L	100	2	N	10	20	N	N	20	5	70	50	20	N	30	200	N	20
-45E	-895	15	.7	1	.2	G5,000	10	100	3	N	15	10	N	N	300	7	70	70	100	N	150	150	N	30
-45F	-896	15	.7	1.5	.2	G5,000	10	150	2	N	N	20	N	N	300	5	N	100	100	N	200	300	N	50
-45G	-897	15	.7	.7	.15	G5,000	L	1,500	2	N	N	200	N	N	70	5	200	G100	50	N	100	500	N	70
-45H	-898	10	1.5	2	.7	1,500	10	70	3	30	15	5	N	N	300	30	15	100	200	150	300	15	N	50
-56B	-815	10	1.5	3	.15	700	G2,000	50	5	20	20	5	300	N	N	50	10	10	70	1,000	200	100	N	100
-57B	-816	10	1.5	15	.7	G5,000	G2,000	200	L	200	150	30	N	5	N	70	10	30	N	200	300	50	N	150
-59B	-817	1.5	2	15	.05	2,000	20	200	2	5	N	70	30	7	N	10	15	5	N	300	30	20	N	30
Rocks of Late Precambrian age—peralkaline granite																								
MJG-76-13	MAM-838	5	.2	5	.5	1,000	15	1,000	5	5	10	10	N	N	N	10	L	L	N	1,500	150	20	N	200
-14	-839	1	.15	.7	.15	500	N	200	7	N	N	5	N	N	N	10	70	7	N	N	15	15	N	30
-15	-840	1.5	.1	.5	.1	300	N	500	2	N	L	L	N	N	N	10	30	N	N	150	30	10	N	20
-26B	-853	1	.3	.7	.2	500	N	700	2	N	L	L	70	N	N	7	50	5	N	200	20	N	N	150
-32A	-863	10	.7	2	.7	1,500	10	150	1.5	5	10	L	N	N	N	5	10	15	N	200	100	30	N	200
-32C	-865	15	.7	15	1	2,000	L	100	L	10	150	L	N	N	N	10	15	70	N	2,000	700	20	N	50
-36A	-872	7	.7	1.5	.5	700	L	1,500	1	5	N	L	70	N	N	L	10	7	N	300	70	20	N	300
-39A	-881	1.5	.1	.5	.1	150	N	150	2	N	L	N	50	N	N	5	15	N	N	N	15	30	N	50
-39B	-882	.5	.02	.3	.03	50	N	N	1	N	N	N	N	N	N	5	15	N	N	N	N	10	N	50
-50	-907	1	.02	.2	.07	70	L	N	2	N	N	L	20	N	N	L	30	N	N	N	10	70	N	100
-56A	-920	10	2	2	.7	3,000	30	500	5	20	10	20	200	N	30	L	70	20	30	200	150	100	N	500
Rocks of Precambrian age--calc-alkaline granite																								
MJG-76-21	MAM-874	2	.2	.7	.2	700	N	1,000	2	L	L	L	100	N	N	5	15	10	N	L	15	50	N	300
Rocks of Precambrian age--granodiorite gneiss																								
MJG-76-16	MAM-841	2	.7	1.5	.15	1,500	N	700	3	10	L	20	N	N	N	10	70	10	N	200	70	30	200	150
-25	-851	2	.5	.7	.2	500	N	1,500	L	L	L	L	50	N	N	10	70	L	N	150	20	L	N	70
-27A	-854	7	.7	1.5	.7	1,000	N	1,500	1.5	15	10	20	150	N	L	15	20	15	N	150	150	100	N	300
-27B	-855	5	.5	1.5	.7	1,000	N	1,000	2	10	10	10	500	N	N	10	30	10	N	100	70	70	N	300
-28A	-856	5	.5	1	.5	1,000	N	500	2	7	L	L	200	N	N	5	15	7	N	100	30	70	N	300
-30	-861	2	.5	1.5	.2	1,000	N	300	7	5	N	30	30	L	N	10	30	5	N	L	30	100	N	150
-35C	-871	7	2	3	.5	1,000	10	1,500	1.5	30	150	5	20	N	N	70	10	30	N	300	200	30	N	100
-54A	-916	5	1	2	.5	3,000	L	500	1	5	N	5	20	N	N	L	30	15	N	700	70	30	N	300

Table 3.--Results of semiquantitative spectrographic analyses of rocks from the Yemen Arab Republic--Continued

Sample numbers		Results in percentage				Results in parts per million (ppm)																		
Field	Laboratory	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)	Zn (200)	Zr (10)
Rocks of Precambrian age--granitic rocks undivided																								
MJG-76- 9	MAM-834	1	0.15	0.7	0.1	1,000	20	500	7	N	N	7	70	N	L	5	100	5	N	100	20	20	N	50
-19A	-845	2	.2	1	.2	300	N	700	1.5	N	10	N	150	N	N	7	30	L	N	150	50	30	N	150
-19B	-846	1.5	.15	3	.1	200	N	150	2	5	L	N	100	N	N	7	L	5	N	500	70	30	N	200
-24	-850	1.5	.5	.7	.2	500	N	1,000	5	L	10	10	100	N	N	5	30	L	N	100	10	50	N	100
-29A	-859	5	.15	.5	.2	1,000	N	700	3	N	L	L	150	N	20	5	10	L	N	N	L	150	N	300
-33A	-866	2	.2	1	.2	300	N	1,500	1	N	N	5	300	N	N	L	30	L	N	100	10	10	N	500
-33B	-867	5	.7	1.5	.5	700	N	1,500	1	7	N	7	200	L	20	7	20	10	N	300	100	70	N	300
-37B	-876	1	.7	1.5	.2	300	N	1,500	1	N	10	10	30	N	N	15	15	N	N	700	20	N	N	50
-38A	-878	.2	.2	.7	.1	200	N	500	2	L	N	N	30	N	N	L	10	L	N	L	10	50	N	150
-42B	-888	2	.07	.5	.15	200	N	30	1	N	N	L	20	N	N	5	10	N	N	N	10	30	N	100
-44	-891	.7	.1	.7	.07	300	N	500	2	N	L	L	70	N	N	5	70	5	N	100	10	20	N	100
-45I	-899	5	2	5	.5	1,000	N	2,000	1.5	20	10	15	30	N	N	30	150	10	N	2,000	200	15	N	200
-46	-814	15	.07	15	.15	G5,000	200	1,500	1.5	30	200	L	N	10	N	150	10	30	N	300	200	50	N	150
-48B	-902	7	3	3	.3	1,500	L	300	1	20	100	10	30	N	N	30	20	10	N	700	150	10	N	150
-52C	-912	1	.2	.5	.07	500	L	1,500	L	N	N	5	70	N	N	5	100	L	N	200	15	N	N	50
-53C	-915	2	.15	.2	.07	300	N	700	L	N	N	L	20	N	N	5	50	5	N	100	15	20	N	100
Rocks of Precambrian age--diorite, diabase, gabbro, and pyroxenite																								
MJG-76-41B	MAM-885	10	1.5	2	.7	2,000	L	1,500	1.5	20	15	20	50	N	N	10	15	20	N	300	300	70	N	200
-41C	-886	15	7	10	.5	3,000	L	100	L	100	500	100	N	N	N	200	N	50	N	200	500	20	N	30
-41A	-884	15	10	15	1	2,000	10	200	N	150	1,000	150	N	N	N	300	N	70	N	200	1,000	30	N	100
-36C	-874	15	2	3	G1	3,000	L	2,000	1	50	30	70	N	N	N	20	N	70	N	200	300	100	N	300
-38C	-880	15	7	10	.7	3,000	L	300	L	200	70	70	N	N	N	200	N	70	N	150	700	30	N	50
Rocks of Precambrian age--metadiorite, metagabbro, meta-andesite, and greenstone																								
MJG-76-29B	MAM-860	15	5	7	.7	2,000	L	150	L	100	700	L	N	N	N	200	10	70	N	500	700	30	N	100
-32B	-864	15	7	10	1	2,000	15	200	1	150	1,000	70	N	N	N	300	10	70	N	500	500	20	N	100
-35B	-870	10	5	3	.7	1,500	L	700	1.5	70	500	5	50	N	N	150	N	50	N	500	500	70	N	150
-37A	-875	10	3	5	1	2,000	10	1,500	L	150	10	50	30	N	N	30	10	70	N	700	700	70	N	500
-42A	-887	15	3	10	G1	2,000	15	200	L	30	150	70	N	N	N	70	10	50	N	500	500	30	N	100
-43	-890	15	7	10	.7	2,000	20	300	1	70	200	50	N	N	N	100	15	50	N	500	300	30	N	50
-49D	-906	10	.15	1	.7	1,000	10	2,000	L	N	15	20	20	N	N	5	70	20	N	100	200	50	N	200
-52B	-911	15	10	10	.7	1,500	N	150	N	70	700	100	N	N	N	100	20	70	N	700	500	30	N	50
-53B	-914	15	7	15	1	3,000	N	150	L	70	500	150	N	N	N	70	L	70	N	500	300	50	N	150
-22	-848	10	5	5	G1	1,500	L	200	2	100	150	20	N	L	N	150	15	30	N	300	700	50	N	150
-36B	-873	15	3	5	1	2,000	L	500	L	100	N	70	N	N	N	L	10	50	N	700	1,000	50	N	200
-52A	-910	7	5	2	.7	700	L	2,000	2	20	50	20	100	N	N	70	70	15	N	3,000	200	20	N	200
-35A	-869	10	3	5	.5	1,500	L	200	1	70	700	20	N	N	N	150	10	50	N	500	500	20	N	100
-42C	-889	10	7	10	.7	2,000	L	150	L	100	500	100	N	N	N	200	L	70	N	100	500	50	N	50
Rocks of Precambrian age--metamorphosed sedimentary rocks																								
MJG-76-63	None	15	3	15	.03	G5,000	N	G5,000	N	500	N	G20,000	20	N	L	15	G20,000	N	300	1,500	20	N	G10,000	N
75-JA-1 a	MAM-618	2	.5	1	.3	700	N	1,000	5	5	N	N	100	N	30	5	L	5	N	1,000	30	100	N	500
75-JA-2 a	-619	3	.5	.1	.3	700	15	200	10	5	15	L	70	N	50	5	10	5	N	1,000	100	100	N	700
MJG-76-47	-900	7	2	1.5	.7	1,500	N	300	1	15	15	50	N	N	N	15	30	20	N	300	200	30	N	150
-55A	-918	7	2	5	.5	3,000	L	500	1.5	20	30	50	50	N	N	15	50	30	N	700	300	50	N	200
-55B	-919	10	10	10	.5	3,000	L	150	N	100	1,000	70	N	N	N	200	10	50	N	200	500	30	N	100
-57A	-921	10	3	15	G1	3,000	10	150	L	30	200	70	N	N	N	50	L	70	N	500	500	50	N	150
-49A	-903	20	3	5	G1	3,000	10	700	L	70	10	70	N	N	N	20	20	50	N	N	1,000	100	300	200

Table 3.—Results of semiquantitative spectrographic analyses of rocks from the Yemen Arab Republic—Continued

Sample numbers		Results in percentage				Results in parts per million (ppm)																		
Field	Laboratory	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)	Zn (200)	Zr (10)
Rocks of Precambrian age--metamorphosed sedimentary rocks—Continued																								
MJG-76-49B	MAM-904	3	0.5	2	0.2	2,000	10	1,500	1	N	N	15	150	N	L	5	15	7	N	N	30	100	N	500
-51A	-908	15	3	10	G1	5,000	N	50	L	100	150	7	N	N	N	150	10	50	N	500	500	50	N	150
- 8B	-833	7	2	2	.7	1,500	20	1,000	1.5	30	70	20	50	N	N	30	20	30	N	200	300	50	N	300
-11	-836	10	3	5	.7	2,000	20	1,500	1	70	200	200	N	N	N	70	20	50	N	700	500	30	N	150
-17	-842	7	1.5	2	.7	1,000	N	1,000	2	30	100	10	N	N	N	70	20	15	N	700	200	30	N	300
-23	-849	3	1	1.5	.3	1,000	N	1,500	3	5	50	20	100	N	N	15	20	10	N	700	100	20	N	150
-28B	-857	10	2	5	G1	2,000	L	500	3	50	50	50	50	N	N	50	15	30	N	100	500	70	N	300
-26A	-852	5	1	3	.5	1,000	N	500	1.5	15	150	15	50	N	N	70	L	15	N	100	150	15	N	300
-31	-862	5	.7	1.5	.3	700	N	1,500	1	5	10	L	50	N	N	7	L	5	N	700	70	15	N	150
-34	-868	3	.7	3	.3	500	N	500	2	7	10	30	N	N	N	7	15	5	N	1,000	100	10	N	150
-48A	-901	5	3	5	.5	1,000	10	700	1	20	30	50	50	N	N	20	150	10	N	500	150	30	N	200
-53A	-913	10	3	5	1	1,500	N	1,500	1	50	20	15	50	N	N	20	70	30	N	500	300	70	N	200
-58	-923	15	3	10	.7	G5,000	L	300	1	50	15	L	N	N	N	30	100	30	N	700	300	30	700	100
- 8A	-835	5	1	1	.5	500	70	700	1.5	15	70	100	50	10	N	30	20	20	N	150	500	20	N	200
-10	-835	1.5	.15	.5	.15	300	15	1,000	2	N	N	N	70	N	N	7	10	10	N	N	15	30	N	150
-54B	-917	.5	.3	15	.05	5,000	L	70	L	N	10	10	N	N	N	7	10	L	N	150	50	10	N	50
-38B	-879	1.5	10	20	.05	1,000	10	20	L	N	30	L	N	N	N	10	N	N	N	100	30	10	N	20
-40	-883	10	5	10	.7	1,500	10	300	L	50	200	70	N	N	N	150	20	50	N	300	300	20	N	100
-49C	-905	15	2	10	.7	3,000	L	100	L	30	150	70	N	N	N	50	20	50	N	5,000	500	50	N	100
-57A1	-922	15	5	15	1	3,000	L	100	L	30	200	50	N	N	N	50	L	70	N	500	500	50	N	150
-51B	-909	.1	3	3	.01	300	L	L	L	N	N	N	N	N	N	5	20	L	N	N	20	N	N	N
-59A	-924	1	G10	20	.05	1,000	50	20	N	5	50	7	N	N	N	L	10	L	N	200	100	N	N	20

a, Analyzed by James A. Domenico, U.S. Geological Survey, November 24, 1975. Elements not detected, and their lower limits of determination are: AU, 10 ppm; Th, 20 ppm. Rarely detected elements, reported as below the limit of determination for most samples, were observed only in a few specimens as follows:

Element and limit of determination (ppm)	Samples in which reported (field numbers)	Abundance (ppm)
Ag (0.5)	MJG-76- 5	0.5
Ag (0.5)	- 8A	L
Ag (0.5)	-63	700
As (200)	MJG-76-73A	200
As (200)	-73B	1,500
As (200)	-74B	L
Bi (10)	MJG-76-63	300
Cd (20)	MJG-76-63	G500
Sb (100)	MJG-76-63	3,000
W (50)	MJG-76- 3	L
W (50)	-18B	L
W (50)	-28C	L
W (50)	-35B	L

Table 4.--Average values of selected elements in rocks from the Yemen Arab Republic
[Numerical averages of values in table 2; symbols and conventions follow table 2]

Rock units (from table 2)	Averages in percentage				Averages in parts per million (ppm)																		
	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)	Zn (200)	Zr (10)
Holocene weathering product	20	0.03	0.07	0.2	300	15	70	3	N	N	5	50	30	150	L	100	N	N	N	10	150	N	1,000
Pliocene Baid Formation	3	3	20	.15	3,000	10	500	L	7	70	10	20	N	N	20	10	10	N	2,000	100	10	N	50
Pliocene (?) or Miocene (?) andesite and diabase	10	3	3	1	1,500	15	1,000	1.5	50	150	150	N	50	N	70	15	50	N	700	500	30	N	150
Miocene rock salt	.05	.2	1.5	.002	50	N	N	N	N	N	L	N	30	N	10	N	N	N	100	30	N	N	N
Miocene (?) alkalic granite	2	.2	.5	.2	3,000	L	70	7	N	N	L	200	L	100	L	20	N	15	N	N	70	300	300
Tertiary and/or Cretaceous tuff of Yemen Volcanics	2	.2	.5	.2	1,000	15	300	10	N	L	L	150	L	70	5	50	L	L	N	20	100	200	700
Tertiary and/or Cretaceous sediments of Yemen Volcanics	2	1	2	.7	500	10	150	1	L	70	30	50	10	L	20	N	7	N	500	700	20	N	200
Tertiary and/or Cretaceous undivided Yemen Volcanics	3	.15	.3	.3	1,000	10	300	7	L	L	L	200	10	100	5	30	L	15	N	20	100	L	700
Cretaceous Tawilah Group	10	.2	2	.2	1,500	20	500	L	100	70	30	N	10	N	50	70	30	N	N	500	30	N	200
Precambrian veins	5	.7	3	.15	2,000	L	500	2	10	15	20	30	N	70	15	50	30	40	200	100	100	N	70
Precambrian peralkaline granite	5	.5	2.5	.3	1,000	L	500	3	5	10	5	30	N	N	7	30	10	N	300	100	30	N	150
Precambrian calc-alkaline granite	2	.2	.7	.2	700	N	1,000	2	L	L	L	100	N	N	5	15	10	N	L	15	50	N	300
Precambrian granodiorite gniess	5	.7	1.5	.5	1,000	N	1,000	2	10	20	10	100	N	N	15	30	10	N	200	70	50	N	200
Precambrian granitic rocks undivided	3	.5	2	.1	1,000	10	1,000	2	5	20	5	100	N	N	20	30	7	N	300	50	30	N	100
Precambrian intermediate and mafic rocks	15	5	7	.7	3,000	L	700	L	100	300	70	N	N	N	150	N	50	N	200	500	50	N	150
Precambrian metamorphosed intermediate and mafic rocks	10	5	7	1	1,500	L	700	L	70	300	50	20	N	N	100	20	50	N	700	500	50	N	150
Precambrian metamorphosed sedimentary rocks																							
Sulfide replacement	15	3	15	.03	G5,000	N	G5,000	N	500	N	G20,000	20	N	L	15	G20,000	N	300	1,500	20	N	G10,000	N
Argillite and meta-shale	5	1	2	.5	1,500	L	500	5	10	15	25	50	N	20	10	25	15	N	700	150	70	N	300
Sericite schist	10	3	7	1	3,000	10	500	L	50	300	50	L	N	N	70	10	50	N	200	500	700	L	200
Biotite schist	7	1.5	3	.7	1,500	L	1,000	2	30	100	50	20	N	N	50	20	30	N	700	300	50	N	200
Biotite gneiss	7	2	5	.5	2,000	L	700	1	20	30	20	50	N	N	30	50	15	N	500	150	30	N	200
Quartzite	2	.5	.5	.2	2,000	30	500	1	5	20	30	30	L	N	15	15	10	N	100	200	20	N	100
Calc-silicate rock	10	7	15	.7	2,000	L	100	L	30	150	50	N	N	N	70	10	50	N	1,500	300	30	N	100
Marble	.5	7	15	.03	700	20	L	N	N	L	L	N	N	N	L	15	L	N	N	50	N	N	N

Radiometric analyses for uranium

Radiometric analyses for uranium were made by Geiger counter on all the MJG-76 series of samples listed in table 3 prior to spectrographic analysis. The lower limit of determination by this method is 250 ppm equivalent uranium (eU). None of the samples had as much as 250 ppm eU.

A yellow incrustation of a clayey mineral, the color of which is bright enough to resemble that of certain secondary uranium minerals, is present on altered felsite of the Yemen Volcanics exposed on the highway west of Manākah and 1.5 each of Jibāl Hufash pluton. A sample of this material (MJG-76-73A, table 2) was found by radiometric analysis to be nonradioactive. By X-ray diffraction analysis, it gives the pattern of jarosite (Theodore Botinelly, written commun., Dec. 10, 1976), a potassium-bearing hydrous iron sulfate having the general formula $K(FeO)_3(SO_4)_2 + 3H_2O$. Jarosite is a secondary mineral formed by the alteration--commonly through weathering--of iron sulfide minerals in potassium-bearing silicic rocks.

Atomic absorption analyses of 14 samples for gold and mercury

An unfinished part of the analytical work on the samples collected in 1976 is the determination of their gold, mercury, and selenium content. Fourteen samples from veins and altered rocks, however, were analyzed by J. A. Domenico and R. W. Leinz, U. S. Geological Survey, on December 8, 1976, for gold and mercury using instrumental procedures previously described (Overstreet, Domenico, and others, 1976, pp. 11-12). The results of these analyses showed that gold was absent in all samples at a lower limit of determination of 0.5 ppm, but that small amounts of mercury were present:

Field sample no.	Laboratory no.	Mercury (ppm)
MJG-76-20A	MAM-810	0.02
-20B	-811	.02
-28D	-812	.02
-45B	-813	.04
-46	-814	.02
-56B	-815	.04
-57B	-816	.04
-59B	-817	.04
-72D	-818	.04
-73A	-819	.08
-73B	-820	.02
-73C	-821	.02
-74A	-822	.06
-74B	-823	.16

Known mineral occurrences

The locations of mineral occurrences reported in the Yemen Arab Republic by previous authors or described for the first time in this report are shown on figure 5, according to a four-fold classification based on preferential enrichment in precious metals, ferroalloy metals, iron, and base metals. These localities are listed below, with a summary of the mode of mineralization at each site; the various bibliographic references in which mineralized occurrences in the Yemen Arab Republic are mentioned are also cited. Numbers refer to location numbers on figure 5.

Precious metals

Locality 1. Gold placers, Sirwāh area (Halévy, 1872, p. 53-54); exploited about 100 years ago.

Locality 2. Gold deposit northeast of Ma'bar (Altmann and Delfour, 1971, p. 13, Appendix 1; Miclea, 1973, p. 66; Minerals Department, 1974, p. 65); mode of occurrence, size, grade, and exploitation not stated.

NOTE: Silver is present in the base-metal sulfide replacement deposit in the Ma'rib area (see locality 6 under base metals).

Base metals

Locality 1.--Prospect pit or cistern disclosing a trace of chrysacolla in sheared mafic lava of Yemen Volcanics, 4 km southwest of Qaryat an Naqīl (this investigation), on the east side of a valley. It was observed by the writers on June 27, 1975. The sheared zone strikes to the east and dips 80° N. Rhyolite dikes intrude the andesite. A trench 0.4-1.2 meters wide and about 30 meters long has been opened to depths of 0.3-2.5 meters uphill along the shear zone. The walls of this trench are massive, unsheared andesite. No evidence of mineralization was seen in the wall rocks, or in the joints in the rock, but about 12 meters to the south of the trench, small pieces of chrysocolla-coated andesite were found on the ground. This open trench is linked at its eastern end to a surface-runoff catchment system and serves to direct rainwater to fields on the west.

Locality 2.--Al Baydā' region, includes Taffa-Al Fatha and El Gheili areas which are said (Yemen Minerals Department, 1974, p. 64-65) to occupy 25 km^2 where quartz veins with impregnations of chalcocite, bornite, and malachite (Altmann and Delfour, 1971, p. 13) are emplaced in Precambrian rocks; the veins are said to crop out over strike lengths of 10-700 meters and to be 1-1.5 meters wide; copper content reported to be generally 1-10 percent with 15 percent of copper reached in samples from the largest vein, which attains 260 meters in length and 20-30 meters in depth; explored by Boliden of Sweden in 1964.

Locality 3.--Ar Rāhidah area veins and disseminated deposits in Precambrian rocks at seven localities explored in 1971 by YOMICO of Japan, as follows (Yemen Minerals Department, 1974, p. 65):

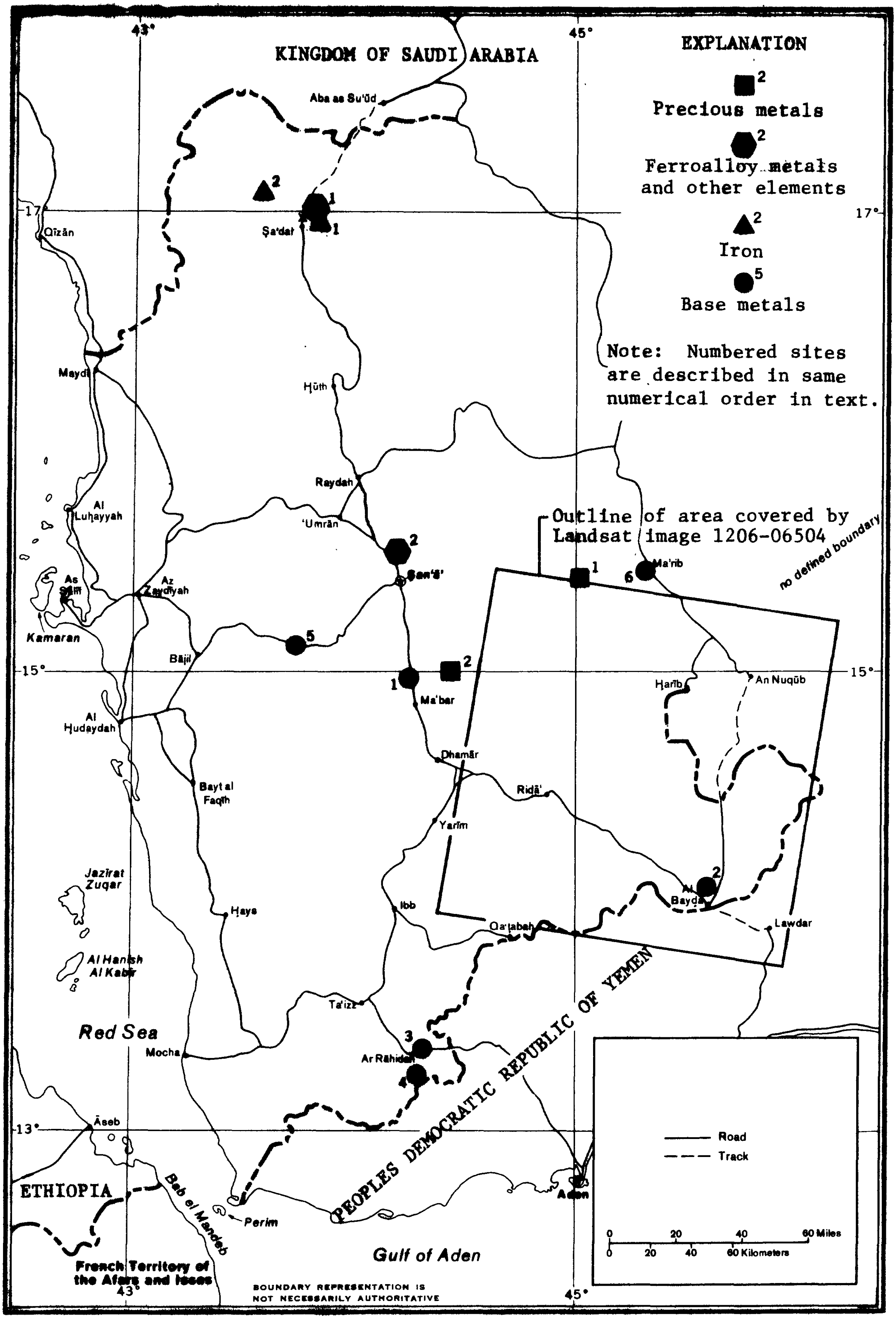

Figure 5. Index map of the Yemen Arab Republic showing distribution of some metalliferous mines, prospects, and mineral localities.

Locality	Minerals	Type of deposit
A. Wādī Rakam	Pyrite, chalcopyrite	Disseminated in gneiss.
B. Wādī al Ahrooz	Malachite, antimonite	Vein.
C. Wādī Hamid	Malachite, chalcopyrite	Veins in pegmatite.
D. Jabal Hatary	do.	Disseminated in gneiss.
E. Wādī al Sheiveifa	Malachite	Quartz vein.
F. Wādī al Regelma	Malachite, chalcocite	Do.
G. Jabal al Salwy	Malachite, azurite	In mafic rocks.

Locality 4.--Hayfān area, veins in Precambrian rocks at two localities (Altmann and Delfour, 1971, p. 13; Miclea, 1973, p. 66; Minerals Department, 1974, p. 61-64; Atia, Hegab, and Morsey, 1974; Overstreet and others, 1976, p. 27-32):

A. Al Humura-Maazig vein:--1,200 meters long, 30 meters wide; vein said to consist of quartz, pyroxene, and epidote with pyrrotite, chalcopyrite, digenite, pyrite, and magnetite; four analyses of vein reported by Atia and others (1974, table 5) to show 0.35-20.4 percent Cu, 0.06-1.2 percent Ni, and 0.05-0.7 percent Co; similar values observed by Overstreet and others (1976, table 2); four analyses of the Maazig vein are reported (Atia and others, 1974, table 5) to have shown 0.02-0.45 percent Cu and 0.01-0.25 percent Ni.

B. Mazabi-Shakkat vein consists of lenticular bodies of quartz up to 150 meters long and 20 meters wide striking northwestward and dipping vertically; vein composed of same gangue and ore minerals reported for Al Hamura vein, except that digenite is absent; the results of two analyses of the Shakkat vein show 0.1-2.1 percent Cu, 0.03-1.02 percent Ni, and 0.0-0.25 percent Co (Atia and others, 1974, table 5).

Locality 5.--Vicinity of Jabal Harāz in the Manākhah area, chalcopyrite and native copper are reported (Ansaldi, 1933, p. 193) in lavas of the Yemen Volcanics.

Locality 6.--Uncertain locality said to be in the vicinity of Ma'rib (oral commun., 1976, Dr. Hamed M. El Shatoury), yielded specimen of hydrothermally altered dolomitic siltstone, of probable Precambrian age, which is partly replaced by pyrite, chalcopyrite, galena, and sphalerite; analysis by present investigation shows more than 2 percent each of Cu and Pb, more than 1 percent Zn, 700 ppm Ag, and >500 ppm Cd.

Locality 7.--Khoban, deposits of galena reported (Miclea, 1973, p. 66); locality, origin, grade, and size not indicated; apparently unexploited. (Not shown on fig. 5.)

Iron

Locality 1.--Localities east of Sa'dah (Geukens, 1966, p. B21; Altmann and Delfour, 1971, p. 13; Miçlea, 1973, p. 66; Minerals Department, 1974, p. 65; Overstreet and others, 1976; p. 33-55); goethite and hematite gossan developed over massive sulfide iron formation; probably large deposits of pyrite and pyrrhotite; nickel may be present locally; exploited since antiquity; magnetite deposits said to be in this area (Minerals Department, 1974, p. 65).

Locality 2.--Locality near Majadh, about 30 km northwest of Sa'dah (Geukens, 1966, p. B21); probably similar to the iron deposits at Sa'dah; exploited since antiquity.

Locality 3.--Deposit in Wādī Rijam (Miclea, 1973, p. 66); locality, origin, mineralogy, and size not described; grade said to be 32-40 percent Fe; not exploited. (Not shown on fig. 5.)

Ferro-alloy metals and other elements

Locality 1.--Illmenite (an ore of titanium) deposits reported in Wadi Akwām basin northeast of Sa'dah (Geukens, 1960, p. B21); mode of occurrence, size, and grade not stated; not exploited.

Locality 2.--Nickel deposits reported north of San'a (Miclea, 1973, p. 66); locality, mode of occurrence, size and grade not stated; not exploited.

> NOTE: Nickel and cobalt are present in base-metal sulfide vein deposits in the Hayfān area (see locality 4 under Base metals). Cadmium is present in base-metal sulfide replacement deposit in the Ma'rib area (see locality 6 under Base metals). Cassiterite (an ore of tin) has been reported (oral commun., 1975, Dr. Joachim Thiele, Bundesanstalt für Geowissenschaften und Rohstoffe) in Precambrian granite immediately northeast of Jabal Abbelle and adjacent to iron deposits near Sa'dah (see locality 1 under Iron).

Economic interpretation

The sparsity of precious metals in the rocks from the YAR, as shown from the atomic absorption analyses and in table 3, seemingly sustains the observation made 2,000 years ago by the Greek geographer Strabo, that the great quantity of articles wrought from gold and silver possessed by the Sabaeans was acquired through trade in incense rather than from mining (Hamilton and Falconer, 1889, p. 207-208). However, most of the analyses represent unmineralized rocks, and the 14 altered rocks and veins checked for low abundances of gold are not necessarily representative of the kinds of geologic materials in which gold would be found. Indeed, the later literature mentions a gold placer near Sirwāh (fig. 5) that was being worked in a small way about 100 years ago (Halevy, 1872, p. 53-54), and a gold deposit near Ma'bar (fig. 5) that is frequently mentioned but not described (Altmann and Delfour, 1971, p. 13; Miclea, 1973, p. 66; Minerals Department, 1974, p. 65). Thus, gold is present in the nation, but surface deposits such as would be found and exploited in the past are evidently small because the historical record accords little prominence to the metal. The same must be said also for silver. However, the possibility for silver being associated with base-metal sulfide ores increases the potential for its future discovery in deposits where it might be recovered as a co-product with copper, lead, and zinc. In this connection, sample MJG-76-63 is discussed on pages 43, and 50-51.

Seven areas of base-metal sulfide deposits are reported for the Yemen Arab Republic (fig. 5). Probably many more areas have been exploited in the past, and the geologic and geochemical data acquired in 1976 afford reason to expect that modern methods of exploration have an acceptable chance to reveal other deposits of copper, lead and zinc.

Data acquired in the present investigation reflect on three base-metal localities shown on figure 5 (sites 1, 5, and 6) as well as a locality near Ya'arah, which is the source of the 75-JA series of samples on figure 1 and in tables 1 and 2, but not located on figure 5. Two of these localities, sites 5 and 6 on figure 5, yielded geochemical data that require follow-up in the interest of economic development of the Yemen Arab Republic. Before discussing sites 5 and 6, a few comments will be made to describe the apparently unimportant localities near Qaryat on Naqil and Ya'arah.

Base-metal locality 1 (fig. 5) is a prospect pit or cistern that discloses a trace of chrysacolla in sheared andesite of the Yemen Volcanics of Tertiary and/or Cretaceous age. This may be an ancient prospect trench now adapted to irrigation, but no waste or ore is piled near the trench, and the chrysocolla is too sparse to suggest that copper was mined here.

About 45 meters farther south along the hillside is a broad, shallow trench opened on a spheroidally weathering diabase dike in the Yemen Volcanics. This trench extends N. 75° E., and its walls dip 80° N., thus it is subparallel to the shear zone to the north. Its length is about 25 meters. The trench is 1.5-4 meters wide, and it steps downward on shallow benches to a maximum depth of 3 meters. Off the west end of this trench, about 10 meters, and across a trail, is a circular pit 12-14 meters in diameter and 6-8 meters deep. On the west, the wall of the pit is in alluvium resting on weathered amygdaloidal basalt. The circular opening appears to have been dug more recently then the trench, possibly within the last 20 years. These structures may also have had some other use than test pits for possible copper, but the circular opening more closely resembles a test pit than a cistern. However, no evidence of mineralization was seen, and the area seems to be unmineralized.

Samples 75-JA-1 and 75-JA-2 (tables 2 and 3) at locality 50 on figure 1 were collected by James W. Aubel, geologist with the U. S. Peace Corps, from debris from a water well being dug at the village of Ya'arah between Wādī Kharhla and Wādī Khāniq, about 35 km south-southwest of Ma'rib. The well is in a fault in Precambrian meta-shale that strikes to the northeast and dips 40° SE. in an area of metamorphic rocks and granite. Rocks in the fault zone are impregnated with a light-colored sulfide mineral that was determined through X-ray diffraction analysis by Roy O. Jackson, U. S. Geological Survey, to be pyrrhotite. The residents of Ya'arah were hopeful that the pyrrhotite-bearing rock was auriferous, and gave the material to Aubel for testing. Results of the semiquantitative spectographic analyses show that the material lacks precious and base metals at their respective lower limits of determination (table 3), except that 75-JA-2 contains a trifle (10 ppm) of lead. Further tests were made by James A. Domenico, Donald G. Murrey, and James Turner, U. S. Geological Survey, on December 4, 1975, using atomic absorption procedures for gold, mercury, and selenium. These results confirmed the absence of gold at this locality:

Field sample number	Element (ppm)		
	Au	Hg	Se
75-JA-1	<0.05	<0.02	0.2
75-JA-2	<0.05	<0.02	0.2

Thus, the Ya'arah occurrence is neither a precious-metal nor a base-metal deposits.

Base-metal locality 5 on figure 5 consists of occurrences of chalcopyrite and native copper reported in the Yemen Volcanics in the vicinity of Jabal Ḥarāz in the Manākhah area (Ansaldi, 1933, p. 193). This report of copper increases the interest that attaches to the anomalous and weakly anomalous values reported above for As, Cu, Hg, Mo, and Pb in samples MJG-76-73 and 74 collected from crystal tuff and felsite of the Yemen Volcanics exposed along the highway west of Manākhah and near the eastern end of Jibāl Hufash (table and footnote).

Field sample number	Element (ppm)				
	As 1/	Cu	Hg 1/	Mo	Pb
MJG-76-73A	200	5	0.08	10	70
-73B	1,500	5	.02	30	100
-74A	N	5	.06	20	20
-74B	L	7	.16	30	50

1/ See footnote, table 3.

Samples in the MJG-76-73 and 74 series were collected about 1.5 km east of the eastern contact of the Miocene (?) alkalic granite that makes up the Jibāl Hufash pluton. The pluton is intrusive into the Yemen Volcanics, but where the highway crosses the contact at the locality of samples MJG-76-72A-72D (table 2), the granite of the pluton is thrust over felsic lavas of the Yemen Volcanics. Both at this locality and at the localities represented by the MJG-76-73 and-74 series of samples, the lavas are extensively altered. The most evident alteration has been caused by the secular weathering of the lava in Holocene time. Zones of yellow, brown, maroon, purple, and black stain are present in the lavas, films of hematite coat some joints, small masses of hematite replace parts of the lava near fractures; elsewhere the lava is replaced by kaolinite, and incrustations of jarosite (see section on Radiometric analyses for uranium) are on the lava. The iron oxides and jarosite are products of the weathering of iron sulfide minerals, probably pyrite. The kaolinite may have formed from the weathering of the lava, or it may predate the weathering and be a product of hydrothermal alteration, possibly connected with the formation of the iron oxides. These relations need considerable further study, because the outcrop gives the impression that the felsic lavas of the Yemen Volcanics in this area have been hydrothermally altered, and subsequent to that alteration, they have been chemically weathered, which has caused the pyrite to oxidize and yield iron oxides and iron sulfates to stain the rocks.

Arsenic and mercury are volatile elements that may form distant aureoles around sulfide ore deposits. This group of four samples contains the most As and Hg detected in specimens analyzed and listed in table 3. During supergene weathering of sulfide deposits in siliceous rocks, As, Cu, Mo, and Pb tend to follow a pattern of decreasing mobility Mo>Cu>As>Pb. The least mobile elements of the group, As and Pb, reach their highest values in the most weathered parts of these rocks. Mobility relations during weathering may account for the abundances reported for these elements in the four samples, because As, Cu, Mo, and Pb are less abundant on average (table 4) in the Yemen Volcanics and Miocene (?) alkalic granite than they are in these altered rocks, thus leaving room for some concentration during alteration:

Average for rock (tables 3 and 4, table 3 footnote)	Element (ppm)			
	As	Cu	Mo	Pb
Miocene (?) granite	N	L	L	20
Tuff of Yemen Volcanics	N	L	L	50
Yemen Volcanics undivided	N	L	10	30
MJG-76-73A	200	5	10	70
-73B	1,500	5	30	100
-74A	N	5	20	20
-74B	L	7	30	50

None of these values except the larger of the two for arsenic represents a major increase over the normal abundance in the source rocks, and they all may be attributable to concentration during weathering, but the small amount of data is insufficient to dismiss the possibility that the trace element content of these altered felsic volcanic rocks signals the outer edge of an alteration halo around otherwise hidden sulfide deposits. The combination of anomalous As and Hg and weakly anomalous Cu, Mo, and Pb taken together with the report of chalcopyrite and native copper in the Yemen Volcanics to the east means that a reconnaissance geochemical survey covering several hundred square kilometers in the Manākhah area is required to determine the possibility for base-metal sulfides in blind deposits of large size and low grade.

Base-metal locality 6 (fig. 5) is uncertainly sited both geographically and geologically. It is represented by sample MJG-76-63 (tables 2 and 3) that was given to the writers by Dr. Hamed M. El Shatoury of San'ā' University, who stated that the specimen was from the vicinity of Ma'rib. The rock is a hydrothermally altered dolomitic siltstone of possible Precambrian age having the texture of an intraformational breccia--possibly a turbidite. The matrix is extensively replaced by pyrite, chalcopyrite, galena, and sphalerite. It is unfortunate that the source of this rock is not better known, because the specimen is a high-grade base-metal and silver ore.

The spectrographic results (table 3) confirm the megascopic description of the sample. The high value for Fe is caused by the abundant pyrite. High values for Mg and Ca, combined with the extremely low value for Ti, indicate a sedimentary rock with scant mafic volcanic detritus. In the field, the rock may form a layer in a more dolomitic or more calcareous sequence than can be inferred from the specimen, or it may be in a shaly or calcareous bed in a dominant volcanic-sedimentary sequence.

The distribution of the minor elements is quite interesting economically, because the analyst noted that where the values were flagged with the letter "G" signifying "greater than" the indicated quantity (table 4), those elements so shown were vastly more abundant than the upper limits of spectrographic determination, particularly Cu, Pb, and Zn, but also Ba, Cd, and Mn. Zinc is the most abundant of the three base metals, which is supported by the high value for Cd, an element typically associated with zinc in sphalerite, and brown sphalerite forms prominent bands in the sample. Silver, equal to 700 grams per ton, is probably associated with the lead in the galena. High values for Ba, Bi, and Sb indicate that the ore mineralogy is complex, although they may be associated with the Mn. If the Co and Ni are mainly in the pyrite, as is possible, then the actual abundances of the two elements, the value of the Co/Ni ratio, and the fact that the Co is more abundant than Ni, shows the hydrothermal origin of this ore (Overstreet, Hubert, and others, 1976, p. 40-48). Absence of Mo, W, Y, and Zr suggests a moderate temperature of hydrothermal deposition, but the Sn is high. It may be associated with the Cu.

Thus, the spectrographic analyses can be interpreted to show a moderate-temperature hydrothermal replacement deposit in a sedimentary rock. The ores are sulfides of Cu, Pb, and Zn, with accessory Ag and Cd. The sample shows that the area and the specific locality from which the specimen came should be examined thoroughly until the area can be dismissed or drilled. If there is much material like sample MJG-76-63 present, an extensive program of geologic mapping, geophysical surveying, geochemical exploration, diamond drilling, and assaying would be needed to appraise the deposit. The locality must be revisited, and a plan for study worked out after the locality has been seen. We have not observed base-metal ore of this type and grade elsewhere in the YAR.

Known iron deposits of the Yemen Arab Republic are shown on figure 3 as plotted from the literature. Field work in February 1976 added the interesting, but economically not significant, information that ferruginous cap rock on salt domes in the Tihāmah at Al Luhayyah and Guma (localities 15 and 16, fig. 1) is locally sufficiently rich in iron to have been smelted in a small way. Scattered fragments of slag in the vicinity of the caprock showed the existance of this cottage industry, but examples of the furnaces were not observed.

Sample MJG-76-71 (tables 2 and 3) is from a low-grade ferruginous rock capping the Guma salt dome. This rock is dominantly dolomite with some calcite, hematite, and geothite(?) as determined by X-ray diffraction analysis (Theodore Botinelly, written commun., Dec. 10, 1976). Far more ferruginous material was observed. Some consists of mixture of siderite ($FeCo_3$) and iron oxides. Other ferruginous rock is mainly secondary iron oxides, which may have formed from the weathering of pyrite (FeS_2), a mineral commonly present in the rocks that make the cap of salt domes. Seemingly, the highest grade ferruginous rock was hand-picked to yield a charge of iron ore for a small furnace, which may have been situated to take advantage of the sea breeze to force a draft for smelting.

The distribution of reported ferro-alloy elements and cassiterite (tin ore) are shown on figure 3 from available data. The results of the analyses given in table 3 show that tin is present in small amounts--generally geochemically expectable amounts--in 15 samples from Miocene(?) alkalic granite, Tertiary and/or Cretaceous felsic lavas of the Yemen Volcanics, and Precambrian pegmatites, where the tin tends to be associated with Nb and Y. However, B, Be, Cu, Mo, Th, and W are all quite sparse in the stanniferous samples, which appears to indicate that none of the samples is an indicator of possible tin deposits. Tungsten and Be are lacking in the calc-silicate rocks, which elsewhere locally have proven to be hosts for ores of both metals. However, Be, exceeds crustal abundance (2-3.5 ppm) in enough samples to raise the question whether felsic lavas of the Yemen Volcanics and Miocene (?) and Late Precambrian granites may not locally be enriched in this element. The same can probably be said for Mo, Nb, and Ti. However, Bi, Co, Cr, and Ni are notably lean in the specimens of rocks thus far analyzed.

PALEONTOLOGIC SAMPLES

The geographic and stratigraphic distributions of samples of rocks collected by the authors in June-July 1975 and February 1976, in the YAR for use in paleontologic examinations are shown in figure 6. These samples range in probable stratigraphic position from Upper Jurassic to Holocene. A brief description of them and corresponding localities is given below. Localities are keyed to site numbers on figure 6.

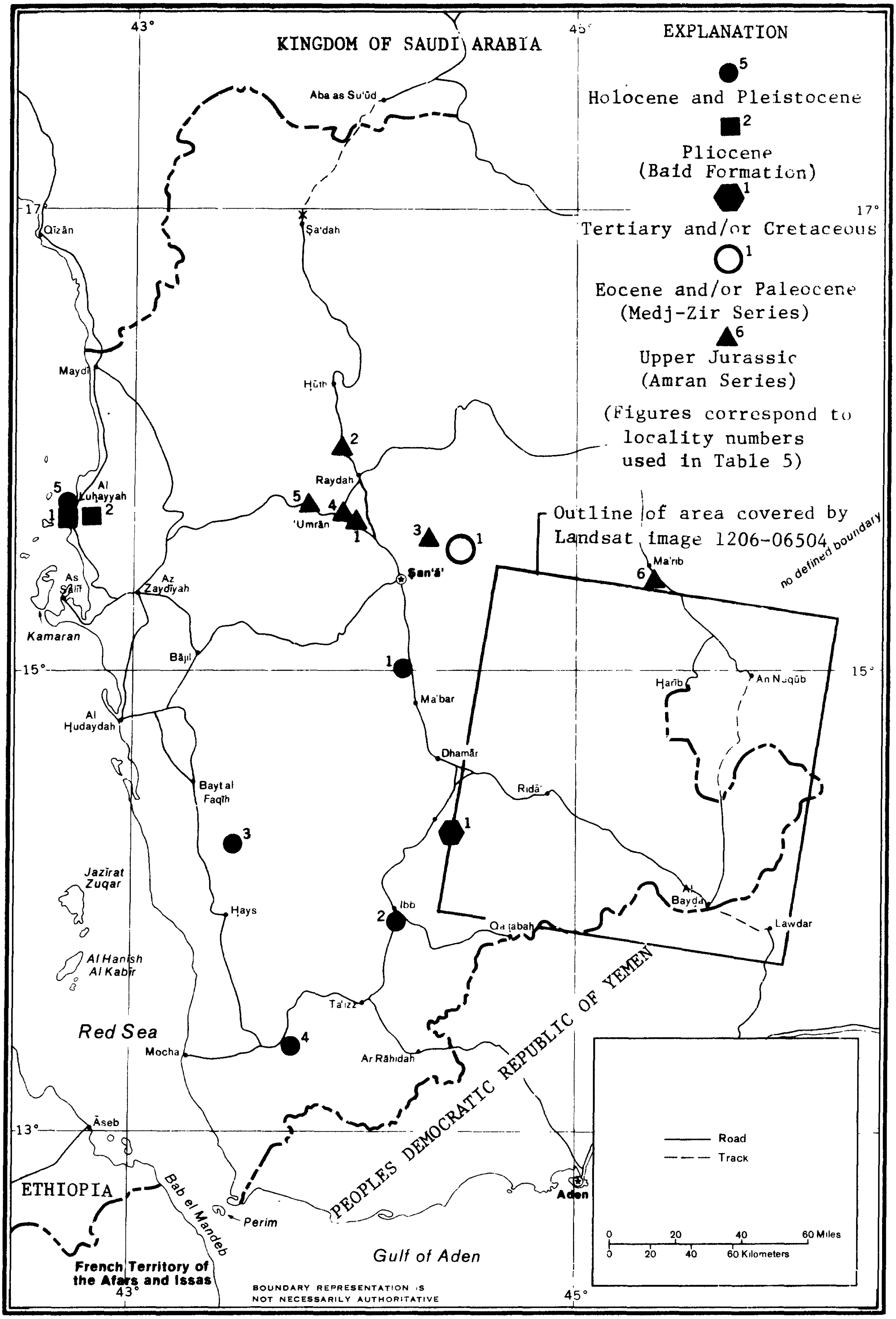

Figure 6. Index map of the Yemen Arab Republic showing localities where rocks were sampled for paleontological examination.

Upper Jurassic fossil localities in the Amran Series

Locality 1.--Sample MJG-1 collected 9 km southeast of Amran in a shallow borrow pit on the southwest side of the highway; mollusks.

Locality 2.--Samples MJG-75-2a and MJG-75-2b collected 12 km north-northwest of Raydah in the Amran Series exposed in the west side of a gully halfway up the valley wall on the northeast side of the highway and north of a cistern; mollusks.

Locality 3.--Samples MJG-75-4a and MJG-75-4b, collected June 28, 1975, in a spoil heap from a dug well on the west side of the road 2.5 km south-southeast of Khabshah, a village 6.5 km due north of Al Ghirās; mollusks.

Included in locality 3 on figure 6, sample MJG-75-5, collected June 28, 1975, from a locality 1 km south-southeast of Khabshah on a stripped structural surface, is a gastropod-rich fossiliferous layer in limestone of Amran Series; sample MJG-75-6, from windblown silt on the stripped structural surface 5 meters above the richly fossiliferous layer, consists of echinoderm spines that are residual on the surface from the solution of the limestone.

Locality 4.--Sample MJG-76-61 from the Al Jannāt area northeast of Amrān about 3 km; collected by Korosaki in 1976; echinoids and ostracodes.

Locality 5.--Sample MJG-76-75, from top of Red Sea escarpment about 7 km southeast of Kuhlān; gastropods in limestone correlated with the Amran Series.

Locality 6.--Sample JA-75-1, collected in April (?) 1975 by James Aubel at a locality about 15 km south-southeast of Ma'rib in float below a limestone escarpment in the Amran Series; corals.

Locality 7.--Unnumbered sample collected by students of San'ā' University near the top of the escarpment at an altitude of 2,000 meters east of a tributary to Wādī Warazān at Najd Thujahāt; brachipod in limestone of Amran Series (?).

Tertiary and/or Cretaceous fossil localities in the Yemen Volcanics

Locality 1.--Sample MJG-76-3 collected in February 1976 about 25 km southeast of Yarīm on the trail to Damt at a point about 3.2 km northwest of Adh Dhārrah; material may be charcoal; from carbonaceous and silty layers a few centimenters thick in felsic tuff and basalt of Yemen Volcanics; collected for microfossils.

Locality 2.--Sample MJG-76-5 collected in February 1976 at a point 8.8 km along Shibām gravel road from its junction with the Wādī Dahr road about 20 km northwest of San'ā'; material may be charcoal; from carbonaceous and silty layers a few centimeters thick in felsic tuff and basalt of the Yemen Volcanics; collected for microfossils.

Eocene and/or Paleocene (?) fossil localities in the Medj-Zir Series

Locality 1.--Sample MJG-75-14a through MJG-75-14c (float) collected July 11, 1975, about 30 km northeast of San'ā', on the north valley slope of Wadi as Sirr and about 0.5 km north of As Sālahī village in a gullied terrace slope; opalized-silicified coquina of fresh-water gastropods; stratigraphic position is near the base of the Yemen Volcanics. This is an important locality that could lead to more accurate dating of the Yemen Volcanics and Tawilah Group.

Samples MJG-75-15 and MJG-75-16 are from the same locality as MJG-75-14a through MJG 75-14c; samples MJG-75-15 and -16 are fish vertebrae, fish scales, and possible pollen; the two samples are a few meters apart stratigraphically and are interlayered with the gastropod coquina represented by MJG-75-14a through -14c.

Pliocene fossil localities in the Baid Formation

Locality 1. Samples MJG-76-65a through MJG-76-65f collected in February 1976 from dirty tuffaceous marine sediments and MJG-76-65g from ferruginous dolomite at the west tip of a small diapir exposed along the beach 0.2 km south of Al Luhayyah; sample MJG-76-66 collected in February 1976 from limestone 0.5 km east of the Red Sea coast from the west-facing slope of an east-dipping cuesta on the Al Luhayyah diapir (fig. 7); MJG-76-67a through MJG-76-67c collected in February 1976 from silty sandstone exposed in the west-facing slope of the easternmost cuesta on the Al Luhayyah diapir; collected for possible microfossils (spores, pollen, Foraminifera).

Figure 7. Small diapir located a few meters inland from the beach at high tide, and 0.2 km south of Al Luhayyah. Broken blocks strewn about the uplift consist of unfossiliferous ferruginous dolomite, which disconformably caps the uplifted sedimentary sequence. Sample MJG-76-66 is from the same dolomite layer, which is exposed along the beach a few hundred meters east of this diapir.

Locality 2.--Sample MJG-76-69c collected in February 1976 from siltstone on top of a small diapir about 300 meters northwest of the Guma salt dome; sample MJG-76-70b collected in February 1976 from marine tuffaceous beds exposed in the diapir around the Guma salt quarry; fossil spores and pollen have been reported (Heybroek, 1975, p. 17-40), and ostracods have been reported from nearby diapirs (Goerlich, 1956, p. 213-214.

Holocene and Pleistocene fossil localities

Locality 1.--Sample MJG-75-3 collected June 27, 1975, at a locality 17 km north-northwest of Ma'bar and 6.5 km west of highway in a structural valley between fault blocks on north rim of caldera 10 km wide: Holocene gastropods in angular colluvium, and one live gastropod from nearby well for comparison.

Locality 2.--Samples JJG-75-7a--MJG-75-7d collected June 29, 1975, in a low pass about 9 km south of Ibb on the highway leading from Ibb to Ta'izz; four samples of fossiliferous loess collected in a 5-10 meter section, upward as follows: MJG-75-7a, 7b, kc, and 7d; black paleosols separate 7a from 7b, and separate 7b from 7c; 7d was taken a few tens of centimeters below the present soil surface.

Locality 3.--Samples MJG-75-8a and MJG-75-8b collected July 8, 1975, about 7 km east of At Turbah and just northeast of Al Akamah village, near Jabal al Qalah and overlooking the escarpment; a most spectacular section of loess; sample MJG-75-8a from bottom of exposure and 8b from upper part of section about 15 meters above 8a; collected by James W. Aubel, U. S. Peace Corps.

Locality 4.--Sample MJG-75-9 collected July 6, 1975, about 53 km east of Mocha in the north valley slope west of Jabal 'Akamah; fossiliferous tufa. Remnants of tufa indicate ponding of many streams debouching on the Red Sea coastal plain in late Pleistocene or early Holocene time.

Locality 5.--Sample MJG-76-64 collected in February 1976 from a marine terrace 1-2 meters above mean sea level at a point on the coast 2.5 km north of Al Luhayyah; the site is a few hundred meters from a large salt diapir and several smaller piercement domes bringing upper Pliocene rocks close to the surface. Quaternary marine terraces are developed at various levels on the slopes of the diapir; these terraces are strewn with marine mollusks not collected on this trip. This sample will be useful for future comparison with samples from the higher and older terraces.

Locality 6.--Samples MJG-76-70c, and MJG-76-70c_2 (fig. 8) collected in February 1976 from a layer of silt and clay 0.3 meter thick unconformably overlying salt in the Guma salt dome and fluviatile in origin; collected for possible microfossils (spores, pollen, and other material).

NOTE: Locality 6 is at the same site as Pliocene fossil locality number 2; thus, it is not separately numbered on figure 6.

Figure 8. Northeast wall at bottom of Guma salt quarry, about 14 km east of Al Luhayyah. Hammer is held against contact between rock salt and overlying fluvial deposits. Note horizontality of upper salt surface along contact. Samples MJG-76-70a, and MJG-76-70c_1 through 70c_3 were collected here; sample MJG-76-70b, a few feet nearby in the quarry.

Paleontological analysis

The rock samples listed above have been examined by paleontologists of the U. S. Geological Survey, as follows:

Upper Jurassic mollusks.--Ralph W. Imlay (USGS., written commun., January 5, 1977) described the Upper Jurassic mollusks listed in figure 4, as follows:

"The pelecypods from Jurassic beds in Yemen are too poorly preserved and represented by too few genera to be of much age value. However, the presence of Exogyra cf. E. nana (Sowerby) suggests a Late Jurassic age on the basis that the species in nearby Saudi Arabia has been recorded only from Tuwayq Mountain Limestone and the overlying Hanifa Formation. These formations are respectively of Oxfordian and early Kimmeridgian age. By contrast, in England that species is recorded from beds of Bajocian to Tithonian (Portlandian) age.

"Pelecypods from Yemen Arab Republic: MJG-75-1 - ..., 9 km southeast of Amran, Amran series, in shallow borrow pit, southwest side of highway:

Gryphaea or Exogyra

"MJG-75-2a - ... 12 km north-northwest of Raydah, Amran series, west side of gully, northeast side of highway, halfway up valley wall, north of cistern:

Exogyra cf. E. nana (Sowerby), Echinoid spine (Pseudocidaris)

"MJG-75-2b - Locality same as 2a above·

Oyster fragments

"MJG-75-4a - ... 2.5 km south-southeast of Khabshah, ... in spoil heap of dug well...:

Exogyra cf. E. nana (Sowerby)

"MJG-75-4b - Locality same as 4a above:

Oyster fragments

"MJG-75-5 - 1 km south-southeast of Khabshah, fossiliferous surfaces both sides of trail:

Protocarida
Pteropera
Trigonia
Thracia (?)
Pseudisocardia (?)"

Another report from Imlay (written commun., January 1, 1977) describes the Jurassic material from locality 5, figure 4:

"Loc. MJG-76-75 contains one large gastropod and fragments of the following bivalves (locality, top edge of Red Sea escarpment, about 7 km southeast of Kuhlān):

Modiolus cf. M. Subangustissima Dacque
Orca?
Chlamys?
Camptonectes?
Ostrea or Gryphaea?

"The pelecypods are poorly preserved and of no value for close age determinations. Previous collections from the Amran Series at locs. MJG-75-2a and -4a contain Exogyra cf. E. nana (Sowerby). That species, if correctly identified, indicates an early Late Jurassic age (Oxfordian to early Kimmeridgian)."

Eocene and/or Paleocene (?) fossil localities in the Medj-Zir series.--The fossil materials from the important locality in the Medj-Zir series (Eocene and/or Paleocene (?) locality 1, fig. 4) have been examined for palynomorphs by Norman Frederiksen who reported (written commun., March 3, 1976):

"...the samples labelled MJG-75-15 and MJG-75-16...were both barren of palynomorphs. Several objects were seen that looked vaguely like pollen, but they could not be identified. There was a great deal of organic material in both samples, but it was strongly carbonized. Whether this was due to metamorphism or to action of bacteria during diagenesis under a slow rate of deposition could not be determined."

On the basis of these results, Frederiksen was unable to assign an age to the material.

Pliocene fossil localities in the Baid Formation.--Charles C. Smith (USGS, written commun., December 14, 1976) examined two samples from Pliocene locality 1, figure 4, for calcareous nannoplankton. Both samples were barren, thus a stratigraphic range could not be assigned:

"MJG-76-65g collected from the west tip of small diapir.....south of Al Luhayyah. Carbonate sinter at top of section: approximately same stratigraphic position as MJG-76-66, unconformable over older marine sediments. Field stratigraphic assignment: Pliocene or Pleistocene.

"MJG-76-66 collected from the Al Luhayyah diapir..... Field stratigraphic assignment: Pliocene or Pleistocene.

"Sample MJG-76-65g is barren of calcareous nannoplankton and thus no biostratigraphic determination can be assigned this sample based on nannoplankton. The sample consists of light gray to tan indurated and well cemented, slightly ferruginous dolomite containing authigenic (often doubly terminated) quartz crystals along both weathered as well as in freshly fractured surfaces. This sample contains common to abundant fragments of what appears to be algally laminated sediment, although preservation is very poor and structures obliterated due to recrystallization. Along fresh surfaces, algal(?) laminae appear as very uniform, thin (1 mm thick), pale gray to milky colored dolomite lenses interlaminated with 0.5 mm thick lenses consisting of tan to light brown dolomite. Individual irregular pieces of algally(?) laminated sediment vary from one-half inch to about 3 inches in length. These fragments are randomly oriented, indicating the possibility that this section consists of recemented, torn and broken fragments of a pre-existing algally(?) laminated limestone.

"Sample MJG-76-66 is barren of calcareous nannoplankton and thus no biostratigraphic determination can be assigned this sample based on the nannoplankton. This sample consists of light brown to tan, indurated, case hardened, well cemented, thinly and irregularly laminated dolomitic (?) limestone. Freshly fractured surfaces show thin lenses of pale gray dolomite (?) one-half to 1 mm in thickness interlaminated with 1-3 mm thick lenses of ferruginous, clayey, very finely divided dolomite or limestone. The origin of these structures is unknown to the present investigator. They could represent algally laminated sediment, or nonbiologic interlaminated clean and more clayey carbonate. Details of microstructure are obscured by recrystallization of these samples."

Another report from Dr. Smith (written commun., February 4, 1977) describes one sample from Pliocene (?) locality 2 (fig. 6) examined for foraminifers and ostracods. The sample was barren, thus a stratigraphic range could not be assigned:

"Field loc. number MJG-76-70b, salt quarry at Guma, 7.5 km. east of Al Luhayyah; 15°41' N., 42°49' E. approx.

"The sample was washed and concentrated by flotation, but no calcareous fossils, either Foraminifera or Ostracoda were found. Therefore, no date is possible."

Pleistocene mollusks.--The sample MJG-76-64 from Holocene and Pleistocene locality 5 (fig. 6) was referred by Blake Blackwelder, USGS, to Dr. H. E. Rehder of the U. S. National Museum for study. The following mollusks were identified, and the stratigraphic range was given as Pleistocene (Blackwelder, written commun., January 18, 1977):

Pleuroploca trapezium (Linne, 1758)
Anadara sp cf. A. crebricostata (Reeve, 1844)
Anadara Ehrenbergi (Dunker, 1868)
Anadara antiquata (Linne, 1758)
Polinices mamilla (Linne, 1758)
Volema pyrum (Gmelin, 1791)
Chicoreus virgineus (Roding, 1798)
Strombus (Tricornis) tricornis Lightfoot, 1786
Terebralia palustris (Linne, 1758)

These mollusks inhabit shallow marine environments and lagoons.

In connection with this report, reference was made to R. B. Newton's article on Pleistocene shells and raised beach deposits of the Red Sea (Newton, 1900).

AERIAL PHOTOGRAPHY AND SATELLITE IMAGERY

Aerial photography covering the territory of the YAR was obtained in 1973 by the United Kingdom Royal Air Force. It was used by the United Kingdom Mapping and Charting Establishment to compile the 8 topographic sheets of the country at 1:250,000 scale. This photographic coverage is available from the appropriate British agency, after special authorization from the Government of the YAR has been secured.

In addition to conventional photographs, a growing amount of image data about the atmosphere and the earth's surface has been accumulating in the last 15 years, particularly since the advent of U. S. weather and land-resources satellites. All these data are archived in the United States and may be purchased upon request. Some of these data cover the YAR. The weather data gathered by the National Aeronautical and Space Administration (NASA), and National Oceanic and Atmospheric Administration (NOAA) satellites provide a small-scale synoptic view of the weather over the YAR at regular time intervals.

The land resources data, available since July 1972 when the first Land Resources Imaging Satellite (Landsat-1) was launched by NASA, have proven to be a useful addition to existing medium-scale topographic maps in many countries. In the YAR, Landsat data have been used in preparing a nine-image mosaic of the country, and in compiling a reconnaissance geologic map at 1:500,000 scale. Ultimately, the potential usefulness of Landsat data will be revealed, when repetitive coverage is fully exploited for study of the changes brought about on the earth's surface by fluctuating climatic and other natural processes, or by the activities of man.

In the YAR, a first attempt at using repetitive Landsat coverage was made in determining changes in the regional pattern of vegetation and streamflow at irregular time intervals between the years 1972 and 1976 (Grolier and others, unpub. data).

Because of their potential usefulness to scientists and regional planners as well, the Landsat-1 and Landsat-2 data available for the YAR as of January 28, 1977, are presented in table 5. In table 5, Landsat images are listed scene by scene. As explained in the index for figure 2, a Landsat scene, identified by orbital path and row numbers, uniquely defines each square area of 100 by 100 nautical miles covered by a Landsat image. A total number of nine Landsat scenes covers the Yemen Arab Republic; from north to south, and from east to west, they are: 177/049, 177/050, 178/048, 178/049, 178/050, 178/051, 179/048, 179/049, and 179/050.

Decoding sheets listing instructions to interpret the data on the computer printout list of Landsat images (table 5), and to

Table 5. Computer print-out list of Landsat-1 and Landsat-2 images available for the Yemen Arab Republic and adjacent regions of the Kingdom of Saudi Arabia and the Peoples' Democratic Republic of Yemen, as of January 28, 1977.

SOURCE AGENCY / PHOTO IDENTIFICATION	TYPE ACCES.	NO. / FRAME MICROFILM	ROLL NUMBER	FIRST FRAME / LAST FRAME FLIGHT SEGMENT	NO. OF FRAMES	4 5 6 7 / 1 2 3 BAND AVAIL.	YR. MO. DY. DATE OF EXPOSURE	SCALE OF IMAGERY	ALTI-TUDE	Q C	OVER-LAP	SEN-SOR	ZONE	LATITUDE / LONGITUDE CENTER POINT COORDINATE

FIRST LINE OF ACCESSION INFORMATION

COMPUTER PRINTOUT DECODING SHEET

FOR INTERPRETATION OF IMAGERY FROM EROS DATA CENTER

SHEET 1

INSTRUCTIONS:

This decoding sheet is used in conjunction with the enclosed computer listing to interpret characteristics of imagery available from the EROS Data Center.

The computer listing may list several possible images available over your area of interest. Each will be described by two printed lines indicating in detail parameters of the individual image or photograph accession.

Detailed data can be read by aligning the scale on the top and bottom of this sheet with the upper and lower lines of each accession respectively on the computer listing and noting the characteristics.

Descriptions and code breakdown for data fields are shown on the right. A further breakdown of selected data fields is itemized on supplemental sheet 2.

Note that special procedures are required for imagery accessed by photo index or photo strip. Refer to instructions enclosed for further information and order procedures.

CODE EXPLANATIONS (REFER TO SHEET 2 FOR FURTHER BREAKDOWN)

PHOTO IDENTIFICATION

- COLUMN 1 – SOURCE AGENCY

CODE	AGENCY	AIRCRAFT	SPACE
1	USGS	X	
4	US BLM	X	
5	NASA-AMES	X	
6	NASA-JSC	X	
7	APOLLO/GEMINI		X
8	ERTS		X
A	AMS	X	
B	AIRFORCE	X	
G	SKYLAB		X
J	ERTS-(QRS)		X

- SEE SHEET 2 FOR DETAILED BREAKDOWN

TYPE ACCESSION

- 5 = INDIVIDUAL SCENE
  2 = PHOTO STRIP
  1 = PHOTO INDEX

MICROFILM

- LOCATION OF THIS IMAGE IN MICROFILM LIBRARY

ROLL NUMBER

- NUMBER OF MASTER FILM ROLL CONTAINING IMAGE
- ASTERISKS INDICATE COLOR COMPOSITE

FLIGHT SEGMENT

- FIRST AND LAST FRAME OF ACCESSION (FLIGHT LINE)

NUMBER OF FRAMES

- NUMBER OF FRAMES IN THIS ACCESSION

BAND AVAILABILITY CODES (ERTS ONLY)

- 4, 5, 6, 7 (MSS)
- 1, 2, 3 (RBV)
  1 = AVAILABLE
  0 = NOT AVAILABLE

DATE OF EXPOSURE

- DATE OF EXPOSURE FOR THIS IMAGE

SCALE OF IMAGERY

- SCALE OF IMAGERY FOR THIS ACCESSION

ALTITUDE

- HEIGHT FROM WHICH EXPOSURE WAS MADE (IN HUNDREDS OF METERS)

IMAGE QUALITY & CLOUD COVER

COL.	MEANING
Q	IMAGE QUALITY 0 = INFERIOR TO 9 = EXCELLENT
C	CLOUD COVER IN 10'S OF PERCENT 0 = NO CLOUD COVER TO 9 = 90% OR MORE

OVERLAP

- FORWARD OVERLAP IN TENS OF PERCENT

SENSOR CODES

- (SEE SHEET 2)

ZONE OF ACCESSION

- DESIGNATES HEMISPHERE
  1 = NORTHEAST 3 = SOUTHEAST
  2 = NORTHWEST (U.S.A.) 4 = SOUTHWEST

CENTER POINT COORDINATE

- SCENE-CENTER OF SCENE
- PHOTO STRIP-CENTER OF FIRST FRAME
- PHOTO INDEX-CENTER OF ENTIRE PHOTO INDEX

IMAGE CORNER COORDINATES

- SCENE-COORDINATES OR SCENE
- PHOTO STRIP-COORDINATES OF ENTIRE STRIP (SEVERAL SCENES)
- PHOTO INDEX-COORDINATES OF ENTIRE PHOTO INDEX (MANY SCENES)

FILTER CODE

- (SEE SHEET 2)

FILM CODE & COLOR

- 100-199 = B & W
- 200-299 = COLOR
- 300-399 = B & W IR (INFRA RED)
- 400-499 = COLOR IR (INFRA RED)
- (SEE SHEET 2 FOR DETAILED CODES)

SENSOR CLASS

- (SEE SHEET 2)

IMAGE CLASS

- (SEE SHEET 2)

FORMAT SIZE

- LENGTH AND WIDTH OF IMAGE ON FILM MASTER IN MM.

SECOND LINE OF ACCESSION INFORMATION

LATITUDES AND LONGITUDES OF IMAGE CORNER COORDINATE POINTS								FIL-TER CODE	FILM CODE	SENSOR CLASS	IMAGE CLASS	FORMAT SIZE (MM)	
LATITUDE	LONGITUDE	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE					LENG.	WIDTH

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GEOR 8 19/ 177,048     POINT COORDINATES ARE N171836    E0461105
  11 ACCESSIONS
LIST FOR KMW - 61203049

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ERTS-1 (MSS)          B&W-02.2" 81350064925A000  8888 30% 730708 N17 23 07 E045 57 37 3369000 9172 10%                1200250661
 SCENE      (N18 01 34,E047 01 02)(N18 16 14,E045 19 31)(N16 29 51,E046 35 18)(N16 44 21,E044 54 38) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81350064925A200 5BG R 30% 730708 N17 23 07 E045 57 37 1000000 9172 00%               1200250681
 SCENE      (N18 01 34,E047 01 01)(N18 16 14,E045 19 31)(N16 29 51,E046 35 18)(N16 44 21,E044 54 38) S11 3808 M5 500  185 178

ERTS-1 (MSS)          B&W-02.2" 81044064905G000  8888 80% 720905 N17 14 22 E046 09 41 3369000 9059 10%               1200021736
 SCENE      (N17 51 54,E047 12 35)(N18 07 08,E045 32 33)(N16 21 29,E046 46 25)(N16 36 32,E045 07 11) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81152064945G000  8228 00% 721222 N17 22 12 E046 10 48 3369000 9089 10%               1200110445
 SCENE      (N17 59 38,E047 14 01)(N18 15 13,E045 33 44)(N16 29 04,E046 47 29)(N16 44 28,E045 07 59) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81170064935A000  2828 00% 730109 N17 16 21 E046 12 44 3369000 9055 10%               1200120436
 SCENE      (N17 53 50,E047 15 39)(N18 09 07,E045 35 39)(N16 23 28,E046 49 25)(N16 38 34,E045 10 13) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81170064935A200 4BG R 00% 730109 N17 16 21 E046 12 44 1000000 9055 00%               1200120436
 SCENE      (N17 53 50,E047 15 39)(N18 09 07,E045 35 39)(N16 23 28,E046 49 25)(N16 38 34,E045 10 13) S11 3805 M5 500  185 176

ERTS-2 (MSS)          B&W-02.2" 82184063735000O  5555 10% 750725 N17 23 59 E046 10 59 3369000 9026 10%               2200111820
 SCENE      (N18 00 55,E047 14 02)(N18 16 52,E045 34 24)(N16 31 00,E046 47 11)(N16 46 45,E045 08 21) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82274063625000O  5555 10% 751023 N17 19 59 E046 11 59 3369000 9170 10%               2200160251
 SCENE      (N17 57 50,E047 15 46)(N18 13 30,E045 34 29)(N16 26 21,E046 49 05)(N16 41 50,E045 06 37) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82400063435000O  5888 10% 760226 N17 19 59 E046 03 59 3369000 9189 10%               2200210551
 SCENE      (N17 56 53,E047 07 55)(N18 12 38,E045 26 27)(N16 25 13,E046 41 08)(N16 40 47,E045 00 29) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82418063405000O  5388 00% 760315 N17 21 00 E046 06 00 3369000 9115 10%               2200211676
 SCENE      (N17 58 38,E047 09 23)(N18 14 10,E045 28 42)(N16 27 41,E046 42 53)(N16 43 03,E045 03 01) S11 3806 M5 113   55  53

ERTS-2 (MSS)          FCC-07.3" 82184063735020O 5BG R 10% 750725 N17 23 59 E046 10 59 1000000 9026 00%               2200111820
 SCENE      (N18 00 55,E047 14 02)(N18 16 52,E045 34 24)(N16 31 00,E046 47 11)(N16 46 45,E045 08 21) S11 3808 M5 500  185 176
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GEOR 8 19/ 177,049      POINT COORDINATES ARE N155212    E0455005
  12 ACCESSIONS
LIST FOR KMW - 61203049

 TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

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 SCENE       (N16 25 10,E046 50 56)(N16 40 18,E045 11 40)(N14 54 44,E046 25 00)(N15 09 42,E044 46 27) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81116065015N000  52 5 00% 721116 N15 48 39 E045 43 42 3369000 9183 10%                1200080251
 SCENE       (N16 26 51,E046 46 55)(N16 42 03,E045 06 15)(N14 55 08,E046 20 47)(N15 10 11,E044 40 52) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81152065015G000  8228 00% 721222 N15 55 57 E045 49 28 3369000 9078 10%                1200110446
 SCENE       (N16 33 28,E046 52 10)(N16 48 54,E045 12 39)(N15 02 54,E046 25 54)(N15 18 09,E044 47 07) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81170064955A000  8288 10% 730109 N15 49 45 E045 51 56 3369000 9055 10%                1200120437
 SCENE       (N16 27 15,E046 54 24)(N16 42 30,E045 15 11)(N14 56 53,E046 28 20)(N15 11 58,E044 49 50) S11 3806 M5 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81350064945A000  8888 20% 730708 N15 57 24 E045 36 41 3369000 9173 10%                1200250682
 SCENE       (N16 35 56,E046 39 36)(N16 50 29,E044 58 53)(N15 04 11,E046 14 07)(N15 18 35,E044 34 08) S11 3806 M5 113   55  53

ERTS-1 (MSS)           FCC-07.3" 81350064945A200 5BG P 20% 730708 N15 57 24 E045 36 41 1000000 9173 10%                1200250682
 SCENE       (N16 35 56,E046 39 36)(N16 50 29,E044 58 53)(N15 04 11,E046 14 07)(N15 18 35,E044 34 08) S11 3808 M5 500  185 178

ERTS-2 (MSS)           B&W-02.2" 82130063815G000  5865 00% 750601 N15 43 59 E045 47 59 3369000 9211 10%                2200060116
 SCENE       (N16 21 54,E046 51 30)(N16 37 52,E045 10 41)(N14 50 00,E046 24 55)(N15 05 48,E044 44 50) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82148063825 0000  8885 60% 750619 N15 49 59 E045 43 59 3369000 9144 10%                2200090219
 SCENE       (N16 27 42,E046 47 10)(N16 43 22,E045 07 00)(N14 56 30,E046 20 37)(N15 11 59,E044 41 11) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82184063835000 0 5555 20% 750725 N15 57 59 E045 48 59 3369000 9026 10%                2200111821
 SCENE       (N16 35 02,E046 51 32)(N16 50 48,E045 12 39)(N15 05 04,E046 24 58)(N15 20 40,E044 46 49) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82274OF36450000  5558 00% 751023 N15 53 59 E045 50 59 3369000 9167 10%                2200160252
 SCENE       (N16 31 53,E046 54 16)(N16 47 27,E045 13 48)(N15 00 25,E046 27 49)(N15 15 49,E044 48 05) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82400OF35050000  5888 10% 760226 N15 52 59 E045 42 59 3369000 9187 10%                2200210552
 SCENE       (N16 30 58,E046 46 24)(N16 46 34,E045 05 43)(N14 59 18,E046 19 54)(N15 14 44,E044 39 58) S11 3806 M5 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82418063435 0000 5558 00% 760315 N15 54 59 E045 45 00 3369000 9111 10%                2200211677
 SCENE       (N16 32 43,E046 47 52)(N16 48 05,E045 07 59)(N15 01 47,E046 21 39)(N15 16 59,E044 42 29) S11 3806 M5 113   55  53
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GEOR 8 19/ 177,050      POINT COORDINATES ARE N142548     E0452405
  12 ACCESSIONS
LIST FOR KMW - 61203049

 TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

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 SCENE       (N14 58 37,E046 29 11)(N15 13 35,E044 50 36)(N13 28 03,E046 03 30)(N13 42 58,E044 25 34) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81116065045N000  8858 10% 721116 N14 22 11 E045 22 33 3369000 9182 10%              1200080252
 SCENE       (N15 00 28,E046 25 18)(N15 15 31,E044 45 21)(N13 28 44,E045 59 25)(N13 43 39,E044 20 08) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81152065035G000  2288 20% 721222 N14 29 07 E045 28 18 3369000 9077 10%              1200110447
 SCENE       (N15 06 43,E046 30 32)(N15 22 00,E044 51 45)(N13 36 08,E046 04 31)(N13 51 16,E044 26 22) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81170065025A000  2888 20% 730109 N14 23 18 E045 31 15 3369000 9055 10%              1200120438
 SCENE       (N15 03 50,E046 33 18)(N15 16 02,E044 54 47)(N13 30 27,E046 07 23)(N13 45 10,E044 29 31) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81206065045G000  8888 00% 730214 N14 32 44 E045 23 35 3369000 9139 10%              1200180029
 SCENE       (N15 10 51,E046 26 03)(N15 25 48,E044 46 30)(N13 39 33,E046 00 19)(N13 54 21,E044 21 26) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81206065045G200  6BG R 00% 730214 N14 32 44 EC45 23 35 1000000 9139 00%             1200180029
 SCENE       (N15 10 51,EC46 26 03)(N15 25 48,E044 46 30)(N13 39 33,E046 00 19)(N13 54 21,E044 21 26) S11 3808 M5 500  185 178

ERTS-1 (MSS)          B&W-02.2" 81350065015A000  8888 10% 730708 N14 30 49 E045 15 25 3369000 9174 10%              1200025063
 SCENE       (N15 09 28,E046 17 53)(N15 23 51,E044 37 51)(N13 37 41,E045 52 39)(N13 51 55,E044 13 17) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82130063845G000  5885 10% 750601 N14 17 59 EC45 26 59 3369000 9219 10%              2200080117
 SCENE       (N14 55 58,E046 30 06)(N15 11 49,E044 49 59)(N13 24 04,E046 03 40)(N13 39 45,E044 24 13) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82148063855000  8868 10% 750619 N14 23 59 E045 23 59 3369000 9143 10%              2200090220
 SCENE       (N15 01 44,E046 26 44)(N15 17 20,E044 47 18)(N13 30 32,E046 00 21)(N13 45 59,E044 21 34) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82184063825000  5855 60% 750725 N14 30 59 EC45 27 59 3369000 9024 10%              2200111822
 SCENE       (N15 08 08,E046 30 33)(N15 23 44,E044 51 53)(N13 38 09,E046 03 47)(N13 53 36,E044 26 15) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82274063715000  8588 00% 751023 N14 27 59 E045 30 00 3369000 9165 10%              2200160253
 SCENE       (N15 05 56,EC46 32 49)(N15 21 23,E044 53 04)(N13 34 30,E046 06 35)(N13 49 45,E044 27 30) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82400063525000  8888 10% 760226 N14 25 59 EC45 21 59 3369000 9165 10%              2200210553
 SCENE       (N15 04 02,E046 24 37)(N15 19 31,E044 44 59)(N13 32 22,E045 58 40)(N13 47 41,E044 19 23) S11 3806 M5 113   55  53
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GEOR A 19/ 177,051     POINT COORDINATES ARE N125924    E0450805
  10 ACCESSIONS
LIST FOR KMW - 61203049

 TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)         B&W-02.2" 81044065025A000  2222 20% 720905 N12 53 54 E045 06 10 3369000 9969 10%                 1200021739
 SCENE       (N13 31 41,E046 07 45)(N13 46 32,E044 29 46)(N12 01 11,E045 42 17)(N12 15 54,E044 04 53) S11 3806 M5 113   55  53

ERTS-1 (MSS)         B&W-02.2" 81116065105N000  5588 10% 721116 N12 55 31 E045 01 41 3369000 9181 10%                1200080253
 SCENE       (N13 33 52,E046 04 02)(N13 48 49,E044 24 43)(N12 02 08,E045 38 22)(N12 16 57,E043 59 38) S11 3806 M5 113   55  53

ERTS-1 (MSS)         FCC-07.3" 81116065105N200 88G R 10% 721116 N12 55 31 E045 01 41 1000000 9181 00%               1200080253
 SCENE       (N13 33 52,E046 04 02)(N13 48 49,E044 24 43)(N12 02 08,E045 38 22)(N12 16 57,E043 59 38) S11 3808 M5 500  185 178

ERTS-1 (MSS)         B&W-02.2" 81170065045A000  8828 70% 730109 N12 56 56 E045 10 34 3369000 9055 10%                1200120439
 SCENE       (N13 34 32,E046 12 15)(N13 49 39,E044 34 21)(N12 04 08,E045 46 30)(N12 19 07,E044 09 11) S11 3806 M5 113   55  53

ERTS-2 (MSS)         B&W-02.2" 82330063905G000  5558 10% 750601 N12 51 59 E045 05 59 3369000 9209 10%                2200080118
 SCENE       (N13 30 02,E046 08 43)(N13 45 45,E044 29 15)(N11 58 08,E045 42 27)(N12 13 43,E044 03 33) S11 3806 M5 113   55  53

ERTS-1 (MSS)         B&W-02.2" 81750065035A000  8888 10% 730706 N13 03 39 E044 54 22 3369000 9175 10%                1200250684
 SCENE       (N13 42 24,E045 56 25)(N13 56 38,E044 17 00)(N12 10 34,E045 31 26)(N12 24 41,E043 52 37) S11 3806 M5 113   55  53

ERTS-1 (MSS)         B&W-02.2" 91206065115G000  8888 10% 730214 N13 07 01 E045 02 10 3369000 9149 10%                1200180030
 SCENE       (N13 45 18,E046 04 13)(N14 00 00,E044 25 14)(N12 13 56,E045 38 49)(N12 28 30,E044 00 26) S11 3806 M5 113   55  53

ERTS-2 (MSS)         B&W-02.2" 82184063855000  5585 80% 750725 N13 03 59 E045 06 59 3369000 9024 10%                 2200111823
 SCENE       (N13 41 13,E046 08 40)(N13 56 41,E044 31 07)(N12 11 13,E045 42 34)(N12 26 33,E044 05 36) S11 3806 M5 113   55  53

ERTS-2 (MSS)         B&W-02.2" 82274063735000  5555 10% 751023 N13 00 59 E045 08 59 3369000 9163 10%                 2200160254
 SCENE       (N13 39 02,E046 11 23)(N13 54 20,E044 32 17)(N12 07 34,E045 45 24)(N12 22 43,E044 06 53) S11 3806 M5 113   55  53

ERTS-2 (MSS)         B&W-02.2" 82400063555000  8888 80% 760226 N13 00 00 E045 00 59 3369000 9183 10%                 2200210554
 SCENE       (N13 39 05,E046 03 33)(N13 53 20,E044 24 14)(N12 06 25,E045 37 27)(N12 21 40,E043 58 44) S11 3806 M5 113   55  53
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GEOR 8 19/ 178,048      POINT COORDINATES ARE N171836    E0444502
  21 ACCESSIONS
LIST FOR KMW - 61203049

 TYPE COVERAGE      FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NCF  MICROFILM CCT

ERTS-1 (MSS)            B&W-02.2" 81045065455G000  8885 00% 720936 N17 14 07 E044 43 15 3369000 9069 10%              1200021766
 SCENE     (N17 51 45,E045 46 05)(N18 06 50,E044 06 02)(N16 21 17,E045 20 04)(N16 36 12,E043 40 47) S11 3806 M5 113    55  53

ERTS-1 (MSS)            FCC-07.3" 81045065455G200 2BG R 00% 720936 N17 14 07 E044 43 14 1000000 9169 00%              1200021766
 SCENE     (N17 51 45,E045 46 05)(N18 06 50,E044 06 02)(N16 21 17,E045 20 04)(N16 36 12,E043 40 47) S11 3808 M5 500   185 178

ERTS-1 (MSS)            B&W-02.2" 81063065445G000  8288 00% 720924 N17 16 48 E044 47 46 3369000 9109 10%              1200041355
 SCENE     (N17 54 26,E045 51 00)(N18 09 50,E044 10 31)(N16 23 37,E045 24 37)(N16 38 51,E043 44 56) S11 3806 M5 113    55  53

ERTS-1 (MSS)            FCC-07.3" 81063065445G200 5BG R 00% 720924 N17 16 47 E044 47 46 1000000 9109 00%              1200041355
 SCENE     (N17 54 26,E045 51 00)(N18 09 50,E044 10 31)(N16 23 37,E045 24 37)(N16 38 51,E043 44 56) S11 3808 M5 500   185 178

ERTS-1 (MSS)            B&W-02.2" 81099065525G000  8888 10% 721030 N17 12 40 E044 40 44 3369000 9194 10%              1200060945
 SCENE     (N17 50 44,E045 44 33)(N18 06 14,E044 03 03)(N16 18 58,E045 18 00)(N16 34 18,E043 37 19) S11 3806 M5 113    55  53

ERTS-1 (MSS)            FCC-07.3" 81099065525G200 2BG R 10% 721030 N17 12 40 E044 40 44 1000000 9194 00%              1200060945
 SCENE     (N17 50 44,E045 44 33)(N18 06 14,E044 03 03)(N16 18 58,E045 18 00)(N16 34 18,E043 37 19) S11 3808 M5 500   185 178

ERTS-1 (MSS)            B&W-02.2" 81117065535A000  8888 00% 721117 N17 16 51 E044 40 10 3369000 9183 10%              1200100022 Y
 SCENE     (N17 54 50,E045 43 57)(N18 10 23,E044 02 33)(N16 23 12,E045 17 23)(N16 38 33,E043 36 48) S11 3806 M5 113    55  53

ERTS-1 (MSS)            FCC-07.3" 81117065535A200 4BG R 00% 721117 N17 16 51 E044 40 10 1000000 9183 00%              1200100022
 SCENE     (N17 54 50,E045 43 57)(N18 10 23,E044 02 33)(N16 23 12,E045 17 23)(N16 38 33,E043 36 48) S11 3808 M5 500   185 178

ERTS-1 (MSS)            B&W-02.2" 81135065545A000  8858 00% 721205 N17 12 19 E044 38 34 3369000 9133 10%              1200090059
 SCENE     (N17 50 19,E045 41 56)(N18 05 30,E044 01 06)(N16 19 05,E045 15 37)(N16 34 39,E043 35 35) S11 3806 M5 113    55  53

ERTS-1 (MSS)            B&W-02.2" 81153065535N000  2288 10% 721223 N17 22 59 E044 43 03 3369000 9079 10%              1200110568
 SCENE     (N18 00 49,E045 45 14)(N18 15 48,E044 05 44)(N16 30 01,E045 19 58)(N16 44 59,E043 40 25) S11 3806 M5 113    55  53

ERTS-1 (MSS)            B&W-02.2" 81171065515N000  8888 20% 730110 N17 17 00 E044 48 08 3369000 9055 10%              1200120571
 SCENE     (N17 54 20,E045 51 08)(N18 09 51,E044 11 10)(N16 24 01,E045 24 41)(N16 39 20,E043 45 30) S11 3806 M5 113    55  53

ERTS-1 (MSS)            FCC-07.3" 81171065515N200 6BG R 20% 730110 N17 16 59 E044 48 08 1000000 9055 00%              1200120571
 SCENE     (N17 54 20,E045 51 08)(N18 09 51,E044 11 10)(N16 24 01,E045 24 41)(N16 39 20,E043 45 30) S11 3808 M5 500   185 178

ERTS-1 (MSS)            B&W-02.2" 81189065525G000  8288 00% 730128 N17 27 02 E044 43 12 3369000 9082 10%              1200131889
 SCENE     (N18 04 55,E045 46 09)(N18 19 46,E044 05 41)(N16 34 10,E045 20 19)(N16 48 50,E043 40 39) S11 3806 M5 113    55  53

ERTS-1 (MSS)            B&W-02.2" 81369065455A000  8888 10% 730727 N17 24 39 E044 34 14 3369000 9196 10%              1200261058
 SCENE     (N18 03 02,E045 37 45)(N18 18 02,E043 56 02)(N16 31 08,E045 11 42)(N16 45 57,E043 30 48) S11 3806 M5 113    55  53

ERTS-1 (MSS)            B&W-02.2" 81423065355A000  2882 60% 730919 N17 24 58 E044 39 56 3369000 9063 10%              1200290966
 SCENE     (N18 02 40,E045 38 38)(N18 17 38,E043 58 25)(N16 32 09,E045 21 03)(N16 46 57,E043 37 25) S11 3806 M5 113    55  53

ERTS-1 (MSS)            B&W-02.2" 81441065335A000  8822 10% 731007 N17 18 14 E044 41 45 3369000 9053 10%              1200300193
 SCENE     (N17 55 53,E045 40 25)(N18 10 54,E044 00 19)(N16 25 26,E045 22 48)(N16 40 16,E043 39 17) S11 3806 M5 113    55  53

ERTS-2 (MSS)            B&W-02.2" 82049064345G000  5585 00% 750620 N17 17 59 E044 39 59 3369000 9143 10%              2200190454
 SCENE     (N17 55 37,E045 43 38)(N18 11 24,E044 02 43)(N16 24 27,E045 16 52)(N16 40 03,E043 36 45) S11 3806 M5 113    55  53

ERTS-2 (MSS)            B&W-02.2" 82185064325G000  5555 10% 750726 N17 22 59 E044 43 59 3369000 9126 10%              2200120020
 SCENE     (N17 59 59,E045 46 59)(N18 15 50,E044 07 22)(N16 30 02,E045 20 14)(N16 45 42,E043 41 23) S11 3806 M5 113    55  53
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GEOR 8 19/ 178.048      POINT COORDINATES ARE N171836     E0444502
  21 ACCESSIONS
LIST FOR KMW - 61223049

 TYPE COVERAGE       FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NCF  MICROFILM CCT

73ERTS-2 (MSS)           B&W-02.2" 82257064215000 0  5858 00% 751006 N17 16 59 E044 45 00 3369000 921" 10%                  2200151063
 SCENE       (N17 55 04,E045 49 02)(N18 13 45,E044 07 16)(N16 23 06,E045 22 19)(N16 38 36,E043 41 21) S11 3806 M5 113   55  53

ERTS-2 (MSS)             B&W-02.2" 82347064125000 0  5555 10% 760104 N17 16 59 E044 39 00 3369000 9105 10%                 2200181296
 SCENE       (N17 54 33,E045 42 23)(N18 10 08,E044 01 48)(N16 23 43,E045 15 47)(N16 39 07,E043 36 04) S11 3806 M5 113   55  53

ERTS-2 (MSS)             FCC-07.3" 82257064215020 0 58G R 00% 751006 N17 16 59 E044 45 00 1000000 921" 00%                 2200151063
 SCENE       (N17 55 04,E045 49 02)(N18 13 45,E044 07 16)(N16 23 06,E045 22 19)(N16 38 36,E043 41 21) S11 380H M5 500  185 176
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GEOR P 19/ 178,049      POINT COORDINATES ARE N155212    E0442402
 18 ACCESSIONS
LIST FOR KMW - 61203049

 TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)          B&W-02.2" 81045065515G000  8888 10% 720906 N15 47 32 E044 21 59 3369000 906) 10%             1200021767
 SCENE      (N16 25 15,E045 24 21)(N16 40 12,E043 45 03)(N14 54 45,E044 58 34)(N15 09 34,E043 19 59) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81045065515G200 6BG R 10% 720906 N15 47 32 E044 21 59 1000000 9960 00%           1200021767
 SCENE      (N16 25 15,E045 24 21)(N16 40 12,E043 45 03)(N14 54 45,E044 58 34)(N15 09 34,E043 19 59) S11 3808 M5 500  185 178

ERTS-1 (MSS)          B&W-02.2" 81063065515G000  8888 10% 720924 N15 50 42 E044 26 34 3369000 9101 10%            1200041356
 SCENE      (N16 28 25,E045 29 20)(N16 43 42,E043 49 36)(N14 57 35,E045 03 11)(N15 12 42,E043 24 11) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81063065515G200 4BG R 10% 720924 N15 50 42 E044 26 34 1000000 9101 00%           1200041356
 SCENE      (N16 28 25,E045 29 20)(N16 43 42,E043 49 36)(N14 57 35,E045 03 11)(N15 12 42,E043 24 11) S11 3808 M5 500  185 178

ERTS-1 (MSS)          B&W-02.2" 81117065605A000  8888 10% 721117 N15 50 39 E044 18 34 3369000 9181 10%            1200100C23
 SCENE      (N16 28 45,E045 21 49)(N16 44 04,E043 41 11)(N14 57 06,E044 55 35)(N15 12 15,E043 15 41) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81135065605A000  8958 10% 721205 N15 45 08 E044 17 03 3369000 9130 10%            1200090060
 SCENE      (N16 24 06,E045 19 53)(N16 39 13,E043 39 50)(N14 52 55,E044 53 53)(N15 07 53,E043 14 34) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81153065555N000  2288 10% 721223 N15 56 27 E044 21 53 3369000 9075 10%            120011C569
 SCENE      (N16 34 12,E045 24 24)(N16 49 13,E043 44 51)(N15 03 33,E044 58 32)(N15 18 25,E043 19 43) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81171065535N000  8888 00% 730110 N15 50 24 E044 27 03 3369000 9055 10%            1200120572
 SCENE      (N16 27 48,E045 29 35)(N16 43 13,E043 50 23)(N14 57 28,E045 03 21)(N15 12 43,E043 24 52) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81171065535N200 5BG R 00% 730110 N15 50 24 E044 27 03 1000000 9055 00%           1200120572
 SCENE      (N16 27 48,E045 29 35)(N16 43 13,E043 50 23)(N14 57 28,E045 03 21)(N15 12 43,E043 24 52) S11 3808 M5 500  185 178

ERTS-1 (MSS)          B&W-02.2" 81369065515A000  8888 10% 730727 N15 58 28 E044 13 01 3369000 9195 10%            1200261C55
 SCENE      (N16 36 55,E045 16 13)(N16 51 48,E043 35 17)(N15 05 01,E044 50 23)(N15 19 44,E043 10 12) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81423065425A000  2888 10% 730919 N15 57 59 E044 19 39 3369000 9769 10%            1200290967
 SCENE      (N16 35 42,E045 17 23)(N16 50 39,E043 37 59)(N15 05 12,E044 59 59)(N15 19 59,E043 17 04) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82049064405C000  5555 10% 750621 N15 51 59 E044 17 59 3369000 9141 10%            2200090955
 SCENE      (N16 29 44,E045 21 07)(N16 43 20,E043 40 59)(N14 58 32,E044 54 38)(N15 13 58,E043 15 13) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82067064405C000  5555 00% 750708 N15 49 59 E044 18 59 3369000 9161 10%            2200110556
 SCENE      (N16 27 12,E045 21 43)(N16 43 00,E043 42 31)(N14 56 53,E044 55 06)(N15 12 30,E043 16 37) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82085064345C000  5855 10% 750726 N15 55 59 E044 22 59 3369000 9324 10%            2200120021
 SCENE      (N16 33 04,E045 25 29)(N16 48 46,E043 46 38)(N15 03 05,E044 58 59)(N15 18 39,E043 20 51) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82157064245J000  8888 00% 751006 N15 50 59 E044 23 59 3369000 9215 10%            2200151064
 SCENE      (N16 29 10,E045 27 32)(N16 44 40,E043 46 32)(N14 57 12,E045 01 05)(N15 12 32,E043 20 51) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82347064145J000  5555 20% 760104 N15 50 59 E044 19 00 3369000 9107 10%            2200181297
 SCENE      (N16 28 37,E045 20 53)(N16 44 37,E043 41 06)(N14 57 45,E044 54 32)(N15 13 15,E043 15 23) S11 3806 M5 113   55  53

ERTS-1 (MSS)          B&W-02.2" 81189065555G000  8888 10% 730128 N16 00 37 E044 22 18 3369000 9703 10%            1200131697
 SCENE      (N16 38 33,E045 24 48)(N16 53 20,E043 45 06)(N15 07 47,E044 59 08)(N15 22 24,E043 20 11) S11 3806 M5 113   55  53

ERTS-1 (MSS)          FCC-07.3" 81189065555G200 6BG R 10% 730128 N16 00 37 E044 22 18 1000000 9703 00%           1200131697
 SCENE      (N16 38 33,E045 24 48)(N16 53 20,E043 45 06)(N15 07 47,E044 59 08)(N15 22 24,E043 20 11) S11 3808 M5 500  185 178
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GEOR 8 19/ 178.050     POINT COORDINATES ARE N142548     E0440302
  17 ACCESSIONS
LIST FOR KMW - 612U3049

 TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)            B&W-02.2" 81117065625A000  8888 10% 721117 N14 24 37 E043 57 25 3369000 9180 10%              1200100024
 SCENE      (N15 02 50,E045 00 12)(N15 17 59,E043 20 16)(N13 31 09,E044 34 14)(N13 46 09,E042 54 57) S11 3806 MS 113   55  53

ERTS-1 (MSS)            B&W-02.2" 81135065635A000  8888 10% 721205 N14 19 30 E043 55 56 3369000 9128 10%              1200090061
 SCENE      (N14 57 32,E044 58 20)(N15 12 31,E043 18 59)(N13 26 21,E044 32 33)(N13 41 12,E042 53 52) S11 3806 MS 113   55  53

ERTS-1 (MSS)            B&W-02.2" 81369065545A000  8888 20% 730727 N14 32 45 E043 52 08 3369000 9195 10%              1200261060
 SCENE      (N15 11 16,E044 54 54)(N15 26 02,E043 14 40)(N13 39 21,E044 29 17)(N13 53 58,E042 49 43) S11 3806 MS 113   55  53

ERTS-1 (MSS)            B&W-02.2" 81423065445A000  2888 10% 730919 N14 30 57 E043 58 12 3369000 9060 10%              1200290968
 SCENE      (N15 08 44,E044 55 59)(N15 23 35,E043 17 18)(N13 38 13,E044 38 49)(N13 52 55,E042 56 33) S11 3806 MS 113   55  53

ERTS-2 (MSS)            B&W-02.2" 82149064435000O  5555 10% 750620 N14 24 59 E043 56 59 3369000 9137 10%              2200090956
 SCENE      (N15 02 48,E044 59 39)(N15 18 15,E043 20 14)(N13 31 38,E044 33 25)(N13 46 55,E042 54 40) S11 3806 MS 113   55  53

ERTS-2 (MSS)            B&W-02.2" 82347064215000O  5585 40% 760104 N14 24 00 E043 57 00 3369000 9109 10%              2200181298
 SCENE      (N15 01 41,E044 59 28)(N15 17 06,E043 20 22)(N13 30 47,E044 33 18)(N13 46 03,E042 54 51) S11 3806 MS 113   55  53

ERTS-2 (MSS)            B&W-02.2" 82365064155000O  0888 00% 760122 N14 25 59 E043 55 59 3369000 9187 10%              2200200082
 SCENE      (N15 04 03,E044 58 58)(N15 19 31,E043 18 59)(N13 32 21,E044 32 40)(N13 47 41,E042 53 21) S11 3806 MS 113   55  53

ERTS-1 (MSS)            B&W-02.2" 81045065545G000  8888 10% 720906 N14 20 44 E044 00 46 3369000 9061 10%              1200021768 Y
 SCENE      (N14 58 32,E045 02 42)(N15 13 21,E043 24 04)(N13 28 00,E044 37 09)(N13 42 41,E042 59 10) S11 3806 MS 113   55  53

ERTS-1 (MSS)            FCC-07.3" 81045065545G200  6BG R 10% 720906 N14 20 44 E044 00 46 1000000 9061 00%          1200021768
 SCENE      (N14 58 32,E045 02 42)(N15 13 21,E043 24 04)(N13 28 00,E044 37 09)(N13 42 41,E042 59 10) S11 3808 MS 500  185 178

ERTS-1 (MSS)            B&W-02.2" 81063065535G000  8888 10% 720924 N14 23 58 E044 05 35 3369000 9102 10%              1200041357
 SCENE      (N15 01 45,E045 07 55)(N15 16 57,E043 28 52)(N13 30 53,E044 41 58)(N13 45 56,E043 03 34) S11 3806 MS 113   55  53

ERTS-1 (MSS)            FCC-07.3" 81063065535G200  4BG R 10% 720924 N14 23 58 E044 05 35 1000000 9102 00%          1200041357
 SCENE      (N15 01 45,E045 07 55)(N15 16 57,E043 28 52)(N13 30 53,E044 41 58)(N13 45 56,E043 03 34) S11 3808 MS 500  185 178

ERTS-1 (MSS)            B&W-02.2" 81153065625N000  2288 10% 721223 N14 29 49 E044 00 50 3369000 9074 10%              1200110570
 SCENE      (N15 07 38,E045 02 54)(N15 22 32,E043 24 04)(N13 36 59,E044 37 15)(N13 51 45,E042 59 05) S11 3806 MS 113   55  53

ERTS-1 (MSS)            B&W-02.2" 81171065605N000  8888 10% 730110 N14 23 30 E044 05 57 3369000 9055 10%              1200120573
 SCENE      (N15 00 58,E045 08 03)(N15 16 17,E043 29 33)(N13 30 37,E044 42 02)(N13 45 46,E043 04 10) S11 3806 MS 113   55  53

ERTS-1 (MSS)            FCC-07.3" 81171065605N200  4BG R 10% 730110 N14 23 30 E044 05 57 1000000 9055 00%          1200120573
 SCENE      (N15 00 58,E045 08 03)(N15 16 17,E043 29 33)(N13 30 37,E044 42 02)(N13 45 46,E043 04 10) S11 3808 MS 500  185 178

ERTS-1 (MSS)            B&W-02.2" 81189065615G000  8888 10% 730128 N14 34 10 E044 01 27 3369000 9084 10%              1200131891
 SCENE      (N15 12 09,E045 03 32)(N15 26 52,E043 24 32)(N13 41 22,E044 38 03)(N13 55 56,E042 59 42) S11 3806 MS 113   55  53

ERTS-1 (MSS)            FCC-07.3" 81189065615G200  3BG R 10% 730128 N14 34 10 E044 01 27 1000000 9084 00%          1200131891
 SCENE      (N15 12 09,E045 03 32)(N15 26 52,E043 24 32)(N13 41 22,E044 38 03)(N13 55 56,E042 59 42) S11 3808 MS 500  185 178

ERTS-2 (MSS)            B&W-02.2" 82257064305000O  5858 00% 751006 N14 23 59 E044 02 59 3369000 9215 10%              2200151065
 SCENE      (N15 02 14,E045 06 05)(N15 17 38,E043 25 48)(N13 30 14,E044 39 51)(N13 45 30,E043 00 14) S11 3806 MS 113   55  53
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GEJR 8 19/ 178,051      POINT COORDINATES ARE N125924      E0434202
 15 ACCESSIONS
LIST FOR KMW - 61203049

 TYPE COVERAGE      FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR   SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (MSS)           B&W-02.2" 81045065605G000  8885 10% 720906 N12 54 23 E043 39 37 3369000 9061 10%                1200021769
 SCENE      (N13 32 17,E044 41 08)(N13 46 56,E043 03 07)(N12 01 44,E044 15 51)(N12 16 15,E042 38 24) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81063065605G000  8888 20% 720924 N12 57 31 E043 44 48 3369000 9104 10%                1200041358
 SCENE      (N13 35 22,E044 46 45)(N13 50 28,E043 08 18)(N12 04 28,E044 20 59)(N12 19 26,E042 43 07) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81117065655A000  8888 10% 721117 N12 58 23 E043 36 38 3369000 9179 10%                1200100025
 SCENE      (N13 36 39,E044 39 01)(N13 51 42,E042 59 43)(N12 04 58,E044 13 14)(N12 19 53,E042 34 32) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81135065655A000  8858 10% 721205 N12 52 32 E043 35 14 3369000 9126 10%                1200090062 Y
 SCENE      (N13 30 37,E044 37 15)(N13 45 32,E042 58 33)(N11 59 26,E044 11 38)(N12 14 13,E042 33 31) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81171065625N000  8888 30% 730110 N12 56 29 E043 45 02 3369000 9055 10%                1200120574
 SCENE      (N13 34 02,E044 46 45)(N13 49 14,E043 08 52)(N12 03 39,E044 20 55)(N12 18 43,E042 43 37) S11 3806 MS 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82257064335C000  5558 20% 751006 N12 57 59 E043 42 59 3369000 9213 10%                2200151066
 SCENE      (N13 36 18,E044 45 41)(N13 51 35,E043 06 02)(N12 04 18,E044 19 39)(N12 19 27,E042 40 36) S11 3806 MS 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82347064235C000  5555 70% 760104 N12 57 59 E043 36 59 3369000 9113 10%                2200181299
 SCENE      (N13 35 47,E044 39 05)(N13 51 04,E043 00 34)(N12 04 49,E044 13 08)(N12 19 58,E042 35 11) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81153065645N000  2288 10% 721223 N13 03 07 E043 39 57 3369000 9073 10%                1200110571
 SCENE      (N13 41 00,E044 41 38)(N13 55 48,E043 03 26)(N12 10 21,E044 16 10)(N12 25 01,E042 38 34) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81189065645G000  8888 20% 730128 N13 07 37 E043 40 44 3369000 9085 10%                1200131892
 SCENE      (N13 45 40,E044 42 26)(N14 00 17,E043 04 03)(N12 14 51,E044 17 07)(N12 29 21,E042 39 19) S11 3806 MS 113   55  53

ERTS-1 (MSS)           FCC-07.3" 81189065645G200 5BG R 20% 730128 N13 07 37 E043 40 44 1000000 9085 00%                1200131892
 SCENE      (N13 45 40,E044 42 26)(N14 00 17,E043 04 03)(N12 14 51,E044 17 07)(N12 29 21,E042 39 19) S11 3808 MS 500  185 178

ERTS-1 (MSS)           B&W-02.2" 81225065705G000  8828 20% 730305 N13 08 20 E043 31 29 3369000 9189 10%                1200161194
 SCENE      (N13 46 59,E044 33 45)(N14 01 29,E042 54 11)(N12 15 05,E044 08 29)(N12 29 27,E042 29 32) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81369065605A000  8688 30% 730727 N13 06 06 E043 31 25 3369000 9195 10%                1200261061
 SCENE      (N13 44 41,E044 33 46)(N13 59 21,E042 54 11)(N12 12 44,E044 08 20)(N12 27 16,E042 29 21) S11 3806 MS 113   55  53

ERTS-1 (MSS)           B&W-02.2" 81423065515A000  2888 10% 730919 N13 03 59 E043 37 07 3369000 9659 10%                1200290969
 SCENE      (N13 41 51,E044 34 28)(N13 56 33,E042 56 24)(N12 11 20,E044 17 34)(N12 25 53,E042 35 52) S11 3806 MS 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82293064315U000  5555 10% 751111 N13 01 59 E043 41 59 3369000 9078 10%                2200161278
 SCENE      (N13 39 41,E044 43 50)(N13 54 50,E043 05 39)(N12 09 03,E044 18 03)(N12 24 04,E042 40 26) S11 3806 MS 113   55  53

ERTS-2 (MSS)           B&W-02.2" 82365064225C000  8888 20% 760122 N13 00 00 E043 34 59 3369000 9187 10%                2200200083
 SCENE      (N13 38 05,E044 37 35)(N13 53 30,E042 58 14)(N12 06 23,E044 11 27)(N12 21 40,E042 32 42) S11 3806 MS 113   55  53
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GEJR 8 19/ 179.048      POINT COORDINATES ARE N171836     E0431859
 19 ACCESSIONS
LIST FOR KMN - 61203049

TYPE COVERAGE     FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE   CENTER/1ST FRAME CTR   SCALE   ALT OLAP  1 ST LAST NOF   MICROFILM CCT

ERTS-1 (RBV)          B&W-02.2" 81010070022N000  222  80% 720802 N17 21 09 E043 19 00 3369000 9110 10%                     1200011039
 SCENE     (N17 59 10,E044 17 15)(N18 15 02,E042 36 41)(N16 27 07,E044 00 54)(N16 42 51,E042 21 09) S1C 3706 R2 113     55  55

ERTS-1 (MSS)          B&W-02.2" 81010070025N000  8888 50% 720802 N17 21 09 E043 19 00 3369000 9110 10%                     1200011040
 SCENE     (N17 58 33,E044 22 31)(N18 14 26,E042 41 57)(N16 27 44,E043 55 39)(N16 43 26,E042 15 53) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81118070125A000  8888 10% 721118 N17 15 33 E043 13 32 3369000 9181 10%                     1200080489
 SCENE     (N17 53 34,E044 17 16)(N18 09 02,E042 35 53)(N16 21 56,E043 50 46)(N16 37 13,E042 10 12) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81136070125G000  8888 10% 721206 N17 07 19 E043 10 13 3369000 9129 10%                     1200100568
 SCENE     (N17 45 20,E044 13 25)(N18 00 22,E042 32 38)(N16 14 09,E043 47 24)(N16 29 01,E042 07 25) S11 3806 M5 113     55  53

ERTS-1 (MSS)          FCC-07.3" 81136070125G200  4BG R 10% 721206 N17 07 19 E043 10 13 1000000 9129 00%                    1200100568
 SCENE     (N17 45 20,E044 13 25)(N18 00 22,E042 32 38)(N16 14 09,E043 47 24)(N16 29 01,E042 07 25) S11 3808 M5 500    185 178

ERTS-1 (MSS)          B&W-02.2" 81154070115N000  8888 10% 721224 N17 22 14 E043 18 40 3369000 9075 10%                     1200110680
 SCENE     (N17 59 41,E044 21 49)(N18 15 11,E042 41 35)(N16 29 09,E043 55 22)(N16 44 25,E042 15 55) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81208070125A000  8888 20% 730216 N17 23 55 E043 12 42 3369000 9142 10%                     1200150907
 SCENE     (N18 04 55,E044 16 08)(N18 17 05,E042 35 03)(N16 30 38,E043 49 57)(N16 45 36,E042 09 42) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81226070135N000  8888 10% 730306 N17 26 04 E043 08 42 3369000 9189 10%                     1200161286
 SCENE     (N18 04 25,E044 12 20)(N18 19 23,E042 30 40)(N16 32 36,E043 46 18)(N16 47 23,E042 05 28) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81244070145A000  8888 10% 730324 N17 25 07 E043 06 28 3369000 9192 10%                     1200181787
 SCENE     (N18 03 26,E044 10 09)(N18 18 30,E042 28 29)(N16 31 36,E043 44 02)(N16 46 29,E042 03 12) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81316070115A000  8888 10% 730604 N17 25 43 E043 07 34 3369000 9070 10%                     1200240195
 SCENE     (N18 04 22,E044 10 33)(N18 19 29,E042 30 16)(N16 33 49,E043 44 28)(N16 48 45,E042 04 59) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81334070105A000  8268 00% 730622 N17 25 31 E043 05 27 3369000 9122 10%                     1200241327
 SCENE     (N18 03 46,E044 08 32)(N18 18 22,E042 27 34)(N16 32 33,E043 42 56)(N16 46 58,E042 02 47) S11 3806 M5 113     55  53

ERTS-1 (MSS)          B&W-02.2" 81406070005A000  8855 00% 730902 N17 21 27 E043 10 41 3369000 9107 10%                     1200281497 Y
 SCENE     (N17 59 21,E044 13 49)(N18 14 22,E042 33 09)(N16 28 23,E043 47 49)(N16 43 14,E042 07 57) S11 3806 M5 113     55  53

ERTS-1 (MSS)          FCC-07.3" 81406070005A200  28G R 00% 730902 N17 21 27 E043 10 41 1000000 9107 00%                    1200281497
 SCENE     (N17 59 21,E044 13 49)(N18 14 22,E042 33 09)(N16 28 23,E043 47 49)(N16 43 14,E042 07 57) S11 3808 M5 500    185 178

ERTS-1 (MSS)          B&W-02.2" 81424065935A000  8822 00% 730920 N17 22 22 E043 12 06 3369000 9061 10%                     1200281810 N
 SCENE     (N18 00 15,E044 10 51)(N18 14 55,E042 30 38)(N16 29 41,E043 53 11)(N16 44 11,E042 09 56) S11 3806 M5 113     55  53

ERTS-2 (MSS)          B&W-02.2" 82150064925000O  5585 40% 750621 N17 15 59 E043 13 59 3369000 9139 10%                     2200091043
 SCENE     (N17 53 30,E044 17 41)(N18 09 27,E042 36 51)(N16 22 25,E043 50 44)(N16 38 10,E042 10 42) S11 3806 M5 113     55  53

ERTS-2 (MSS)          B&W-02.2" 82168064925000O  8858 30% 750709 N17 15 00 E043 12 59 3369000 9061 10%                     2200110624
 SCENE     (N17 52 12,E044 16 08)(N18 07 59,E042 36 10)(N16 21 53,E043 49 25)(N16 37 28,E042 10 14) S11 3806 M5 113     55  53

ERTS-2 (MSS)          B&W-02.2" 82186064905000O  5555 20% 750727 N17 24 59 E043 18 59 3369000 9026 10%                     2200120058
 SCENE     (N18 02 00,E044 22 00)(N19 17 48,E042 42 20)(N16 32 03,E043 55 15)(N16 47 40,E042 16 23) S11 3806 M5 113     55  53

ERTS-2 (MSS)          B&W-02.2" 82276064755C000  5555 10% 751025 N17 20 59 E043 19 59 3369000 9161 10%                     2200151705
 SCENE     (N17 58 43,E044 23 46)(N18 14 30,E042 42 36)(N16 27 21,E043 56 58)(N16 42 57,E042 16 37) S11 3806 M5 113     55  53

ERTS-2 (MSS)          B&W-02.2" 82366064655000O  8888 10% 760123 N17 18 59 E043 09 59 3369000 9187 10%                     2200200139
 SCENE     (N17 57 04,E044 13 46)(N18 12 30,E042 32 16)(N16 25 21,E043 47 18)(N16 40 36,E042 06 37) S11 3806 M5 113     55  53
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GEOR 8 19/ 179-050      POINT COORDINATES ARE N142548    E0423559
  22 ACCESSIONS
LIST FOR MMA - 61203049

 TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-2 (MSS)          B&W-02.2" 82168065015U000  5585 40% 750709 N14 21 59 E042 30 59 3369000 9C55 10%               2200110626
 SCENE       (N14 59 21,E043 33 11)(N15 14 51,E041 54 42)(N13 29 02,E043 06 57)(N13 44 23,E041 29 08) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 82186064955000O  5555 30% 750727 N14 31 59 E042 36 59 3369000 9024 10%               2200120060
 SCENE       (N15 09 09,E043 39 03)(N15 24 43,E042 00 52)(N13 39 10,E043 12 47)(N13 54 35,E041 35 15) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 822760648450000  5555 10% 751025 N14 27 59 E042 37 59 3369000 9157 10%               2200151707
 SCENE       (N15 05 54,E043 40 47)(N15 21 21,E042 01 08)(N13 34 31,E043 14 32)(N13 49 49,E041 35 32) S11 3806 M5 113   55  53

ERTS-2 (MSS)          B&W-02.2" 823660647450000  5888 10% 760123 N14 25 59 E042 28 59 3369000 9189 10%               2200200141
 SCENE       (N15 05 10,E043 31 54)(N15 20 27,E041 51 52)(N13 33 25,E043 05 47)(N13 48 33,E041 26 25) S11 3806 M5 113   55  53
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GEOR 8 19/ 179,050      POINT COORDINATES ARE N142548     E0423559
  22 ACCESSIONS
LIST FOR KMW - 61203049

TYPE COVERAGE       FILM SOURCE    PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM CCT

ERTS-1 (RBV)              B&W-02.2" 81010070112N000  888  30% 720802 N14 28 15 E042 36 46 3369000 9106 10%              1200011043
 SCENE        (N15 06 24,E043 34 03)(N15 22 02,E041 55 00)(N13 34 21,E043 18 13)(N13 49 53,E041 39 49) S10 3706 R2 113   55  55

ERTS-1 (MSS)              B&W-02.2" 81010070115N000  8882 20% 720802 N14 28 15 E042 36 46 3369000 9106 10%              1200011044
 SCENE        (N15 05 46,E043 39 20)(N15 21 26,E042 00 17)(N13 34 58,E043 12 56)(N13 50 29,E041 34 32) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81082070135A000  885M 00% 721013 N14 26 42 E042 36 38 3369000 9163 10%              1200051171
 SCENE        (N15 04 52,E043 39 18)(N15 19 57,E041 59 32)(N13 33 21,E043 13 25)(N13 48 16,E041 34 18) S11 3806 M5 113   55  53

ERTS-1 (MSS)              FCC-07.3" 81082070135A200  8BG R 00% 721013 N14 26 42 E042 36 38 1000000 9163 00%             1200051171
 SCENE        (N15 04 52,E043 39 18)(N15 19 57,E041 59 32)(N13 33 21,E043 13 25)(N13 48 16,E041 34 18) S11 3808 M5 500  185 178

ERTS-1 (MSS)              B&W-02.2" 81100070155A000  8888 00% 721031 N14 19 24 E042 32 38 3369000 9194 10%              1200061058
 SCENE        (N14 57 34,E043 35 34)(N15 12 55,E041 55 32)(N13 25 47,E043 09 23)(N13 40 59,E041 30 02) S11 3806 M5 113   55  53

ERTS-1 (MSS)              FCC-07.3" 81100070155A200  2BG R 00% 721031 N14 19 24 E042 32 38 1000000 9194 00%             1200061058
 SCENE        (N14 57 34,E043 35 34)(N15 12 55,E041 55 32)(N13 25 47,E043 09 23)(N13 40 59,E041 30 02) S11 3808 M5 500  185 178

ERTS-1 (MSS)              B&W-02.2" 81118070215A000  8888 00% 721118 N14 23 14 E042 31 02 3369000 9178 10%              1200080491
 SCENE        (N15 01 26,E043 33 48)(N15 16 35,E041 53 54)(N13 29 46,E043 07 50)(N13 44 46,E041 28 36) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81136070215G000  5588 10% 721206 N14 14 35 E042 28 11 3369000 9125 10%              1200100570
 SCENE        (N14 52 43,E043 30 29)(N15 07 32,E041 51 11)(N13 21 32,E043 04 53)(N13 36 12,E041 26 14) S11 3806 M5 113   55  53
79
ERTS-1 (MSS)              B&W-02.2" 81154070205N000  8888 40% 721224 N14 28 55 E042 36 17 3369000 9072 10%              1200110682
 SCENE        (N15 06 31,E043 38 30)(N15 21 46,E041 59 45)(N13 35 58,E043 12 30)(N13 51 04,E041 34 25) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81190070205G000  8888 10% 730129 N14 34 32 E042 37 25 3369000 9087 10%              1200140130
 SCENE        (N15 12 16,E043 39 42)(N15 27 26,E042 00 44)(N13 41 33,E043 13 47)(N13 56 34,E041 35 28) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81208070215A000  8888 10% 730216 N14 31 37 E042 30 50 3369000 9145 10%              1200150909
 SCENE        (N15 09 46,E043 33 22)(N15 24 44,E041 53 44)(N13 38 24,E043 07 35)(N13 53 13,E041 28 37) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81226070225N000  8888 30% 730306 N14 33 52 E042 26 16 3369000 9190 10%              1200161288
 SCENE        (N15 12 26,E043 28 57)(N15 27 05,E041 48 45)(N13 40 32,E043 03 27)(N13 55 02,E041 23 56) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81244070235A000  8888 10% 730324 N14 31 21 E042 23 49 3369000 9190 10%              1200181789
 SCENE        (N15 09 52,E043 26 31)(N15 24 36,E041 46 21)(N13 37 59,E043 00 56)(N13 52 35,E041 21 26) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81316070205A000  8888 20% 730604 N14 32 57 E042 25 28 3369000 9071 10%              1200240197
 SCENE        (N15 10 44,E043 27 33)(N15 25 40,E041 48 43)(N13 40 08,E043 01 53)(N13 54 54,E041 23 43) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81406070055A000  5558 10% 730902 N14 28 18 E042 28 34 3369000 9103 10%              1200281499
 SCENE        (N15 06 21,E043 30 46)(N15 21 07,E041 51 36)(N13 35 23,E043 05 13)(N13 50 00,E041 26 42) S11 3806 M5 113   55  53

ERTS-1 (MSS)              B&W-02.2" 81424070025A000  8622 30% 730920 N14 29 33 E042 29 26 3369000 9059 10%              1200281812
 SCENE        (N15 07 39,E043 27 11)(N15 21 57,E041 48 26)(N13 37 02,E043 10 08)(N13 51 12,E041 28 13) S11 3806 M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 82132065015G000  5525 40% 750603 N14 15 00 E042 32 59 3369000 9205 10%              2200080283
 SCENE        (N14 53 03,E043 36 04)(N15 08 41,E041 56 00)(N13 21 11,E043 09 39)(N13 36 41,E041 30 15) S11 3806 M5 113   55  53

ERTS-2 (MSS)              B&W-02.2" 82150065015O000  5858 50% 750621 N14 22 59 E042 30 59 3369000 9133 10%              2200091045
 SCENE        (N15 00 39,E043 33 43)(N15 16 19,E041 54 23)(N13 29 34,E043 07 16)(N13 45 05,E041 28 36) S11 3806 M5 113   55  53
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GEOR 8 19/ 179,049     POINT COORDINATES ARE N155212     E0425759
 19 ACCESSIONS
LIST FOR KMW - 61203049

TYPE COVERAGE      FILM SOURCE   PHOTO/SCENE ID  QUAL CLD  DATE  CENTER/1ST FRAME CTR  SCALE  ALT OLAP  1 ST LAST NOF  MICROFILM OCT

ERTS-1 (RBV)         B&W-02.2" 81010070042N000  888  20% 720802 N15 54 50 E042 57 50 3369000 9108 10%                 1200011041
 SCENE      (N16 32 55,E043 55 34)(N16 48 40,E042 15 48)(N15 00 52,E043 39 29)(N15 16 30,E042 00 27) S10 3706 R2 113    55  55

ERTS-1 (MSS)         B&W-02.2" 81010070045N000  8588 30% 720802 N15 54 50 E042 57 50 3369000 9108 10%                 1200011042
 SCENE      (N16 32 17,E044 00 51)(N16 48 04,E042 21 05)(N15 01 29,E043 34 13)(N15 17 05,E041 55 10) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81082070115A000  8888 10% 721013 N15 52 53 E042 57 38 3369000 9162 10%                 1200051170
 SCENE      (N16 30 59,E044 00 44)(N16 46 10,E042 20 16)(N14 59 29,E043 34 37)(N15 14 31,E041 54 54) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81118070145A000  8888 10% 721118 N15 49 30 E042 52 08 3369000 9179 10%                 1200080490
 SCENE      (N16 27 37,E043 55 21)(N16 42 55,E042 14 45)(N14 55 59,E043 29 09)(N15 11 06,E041 49 16) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81136070155G000  5858 20% 721206 N15 41 03 E042 48 56 3369000 9127 10%                 1200100569
 SCENE      (N16 19 09,E043 51 39)(N16 34 02,E042 11 38)(N14 47 58,E043 25 53)(N15 02 41,E041 46 35) S11 3806 MS 113    55  53

ERTS-1 (MSS)         FCC-07.3" 81136070155G200 88G R 10% 721206 N15 41 03 E042 48 56 1000000 9127 00%                 1200100569
 SCENE      (N16 19 09,E043 51 39)(N16 34 02,E042 11 38)(N14 47 58,E043 25 53)(N15 02 41,E041 46 35) S11 3808 MS 500  185 178

ERTS-1 (MSS)         B&W-02.2" 81154070135N000  8888 50% 721224 N15 55 49 E042 57 14 3369000 9074 10%                 1200110681
 SCENE      (N16 33 22,E043 59 53)(N16 48 42,E042 20 25)(N15 02 49,E043 33 42)(N15 17 59,E041 54 57) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81208070155A000  8888 30% 730216 N15 57 49 E042 51 39 3369000 9144 10%                 1200150968
 SCENE      (N16 35 54,E043 54 37)(N16 50 57,E042 14 17)(N15 04 34,E043 28 39)(N15 19 27,E041 49 04) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81226070205N000  8888 50% 730306 N15 59 57 E042 47 25 3369000 9189 10%                 1200161287
 SCENE      (N16 38 24,E043 50 33)(N16 53 13,E042 09 39)(N15 06 33,E043 24 47)(N15 21 12,E041 44 39) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81244070205A000  8888 10% 730324 N15 58 11 E042 44 45 3369000 9191 10%                 1200181788
 SCENE      (N16 36 39,E043 47 54)(N16 51 29,E042 07 00)(N15 04 47,E043 22 07)(N15 19 27,E041 41 58) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81316070145A000  8888 20% 730604 N15 59 22 E042 46 34 3369000 9070 10%                 1200240196
 SCENE      (N16 37 04,E043 49 06)(N16 52 08,E042 09 36)(N15 06 30,E043 23 11)(N15 21 24,E041 44 25) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81334070125A000  8288 00% 730622 N15 59 00 E042 44 16 3369000 9124 10%                 1200241328
 SCENE      (N16 37 20,E043 46 52)(N16 51 48,E042 06 40)(N15 06 04,E043 21 30)(N15 20 23,E041 42 02) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81406070025A000  5255 10% 730902 N15 55 10 E042 49 33 3369000 9105 10%                 1200281498
 SCENE      (N16 33 21,E043 52 31)(N16 48 19,E042 12 06)(N15 01 54,E043 26 38)(N15 16 42,E041 46 58) S11 3806 MS 113    55  53

ERTS-1 (MSS)         B&W-02.2" 81424070005A000  8882 20% 730920 N15 56 02 E042 50 44 3369000 9060 10%                 1200281811
 SCENE      (N16 34 01,E043 48 58)(N16 48 31,E042 09 31)(N15 03 26,E043 31 36)(N15 17 46,E041 49 04) S11 3806 MS 113    55  53

ERTS-2 (MSS)         B&W-02.2" 82150064955O000  5555 60% 750621 N15 48 59 E042 52 59 3369000 9135 10%                 2200001044
 SCENE      (N16 26 34,E043 56 10)(N16 42 23,E042 16 08)(N14 55 29,E043 29 29)(N15 11 08,E041 50 11) S11 3806 MS 113    55  53

ERTS-2 (MSS)         B&W-02.2" 82168064945O000  8555 40% 750709 N15 47 59 E042 51 59 3369000 9057 10%                 2200110625
 SCENE      (N16 25 18,E043 54 37)(N16 40 54,E042 15 27)(N14 54 59,E043 28 11)(N15 10 25,E041 49 43) S11 3806 MS 113    55  53

ERTS-2 (MSS)         B&W-02.2" 82186064925O000  5555 20% 750727 N15 57 59 E042 57 59 3369000 9024 10%                 2200120059
 SCENE      (N16 35 04,E044 00 30)(N16 50 45,E042 21 38)(N15 05 07,E043 34 00)(N15 20 38,E041 55 50) S11 3806 MS 113    55  53

ERTS-2 (MSS)         B&W-02.2" 82276064815O000  5255 10% 751025 N15 54 59 E042 58 59 3369000 9159 10%                 2200151706
 SCENE      (N16 32 48,E044 02 16)(N16 48 26,E042 21 53)(N15 02 26,E043 35 44)(N15 16 54,E041 56 05) S11 3806 MS 113    55  53

ERTS-2 (MSS)         B&W-02.2" 82366064715O000  5888 10% 760123 N15 52 59 E042 48 59 3369000 9189 10%                 2200200140
 SCENE      (N16 31 09,E043 52 19)(N16 46 28,E042 11 34)(N14 59 24,E043 26 03)(N15 14 33,E041 46 02) S11 3806 MS 113    55  53
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interpret the annotation block at the bottom of each Landsat image after it has been purchased by the analyst, are presented in tables 1 and 5. Identified Landsat images can be ordered and purchased from: EROS Data Center, Sioux Falls, South Dakota, USA.

RECOMMENDATIONS

Three specific recommendations arise from the geochemical and paleontological data presented above: 1) Find and appraise the unknown locality purported to be in the Ma'rib region and from which sample MJG-76-63 is said to have come. The specimen is high-grade ore for Cu, Pb, Zn, Ag, and Cd. If it is from the YAR, then the deposit must be evaluated early in the program of national economic development. 2) Conduct a geologic and geochemical reconnaissance investigation at 1:100,000 scale for Cu, Pb, and Zn in the Yemen Volcanics in a region approximately centered at Manākhah and extending from 14°30' N. to 15°30'N. by 43°15' E. to 44°00' E. 3) Begin a broad stratigraphic, structural, and geophysical investigation of the Amran Series in Wādī Jawf and eastward and southward in the desert to the national boundary; determine the extent of the series and what sedimentary rocks lie above the limestone in the Amran Series now that biostratigraphic evidence, available from the paleontological examinations, shows this unit to be correlative with the Tuwayq Mountain Limestone of Saudi Arabia. This limestone is reported in the Ramlat Dahm (U. S. Geological Survey-Arabian American Oil Company, 1963). The extent of the Amran Series or Tuwayq Mountain Limestone and associated sedimentary rocks in the Ramlat Dahm area and Ramlat as Sab'atayn area within the borders of the YAR is important for possible sources of water and of petroleum.

Planning for economic development in the YAR would be aided by a census of known or reported mineral deposits, mineral occurrences, and ancient mines. Preliminary to any sustained exploration program for base metals, as well as for gold, silver, and other ores that were used historically in the region, a search of national archives, libraries, and local records should be made to recover and plot the localities said to have been prospected or mined for metals or minerals (for example, early comment on the presence of turquoise could become evidence for copper). Complementing the search of records should be an active field program to locate on the ground all ancient prospects and mines known to local residents throughout the country. Obviously, a national effort involving many reporters would be required for the field search, but it could be undertaken as part of a census of population and agriculture.

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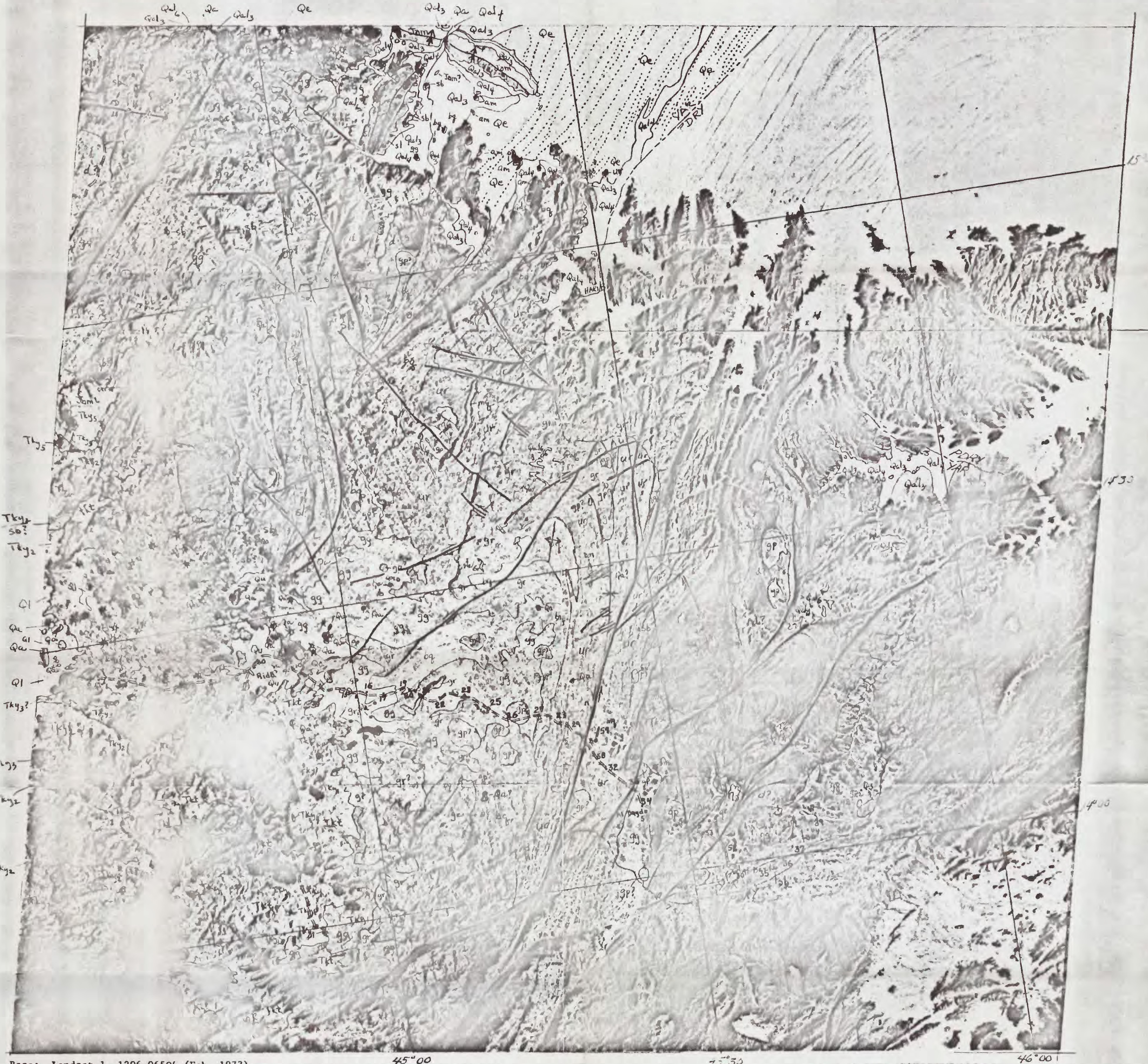
77-733

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the Yemen Arab Republic Ministry of Economic Development, Minerals and Petroleum Authority and under the sponsorship of the Agency for International Development, U.S. Department of State.

PROJECT REPORT (IR)Y-12



Base: Landsat-1, 1206-06504 (Feb. 1973)
Geographic coordinates developed by NASA.

Note: Country boundaries indefinite

1:500,000

5 0 5 10 15 20 25 KILOMETERS

This geologic map is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

FIGURE 2 GEOLOGIC MAP OF THE AREA COVERED BY LANDSAT-1
IMAGE 1206-06504, YEMEN ARAB REPUBLIC

Compiled by Maurice J. Grolier and William C. Overstreet, U. S. Geological Survey, and based on:

A. Geologic interpretation of LANDSAT-1 images, supplemented by reconnaissance airborne and field surveys in June and July 1975.

B. References, as follows:

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NOTES

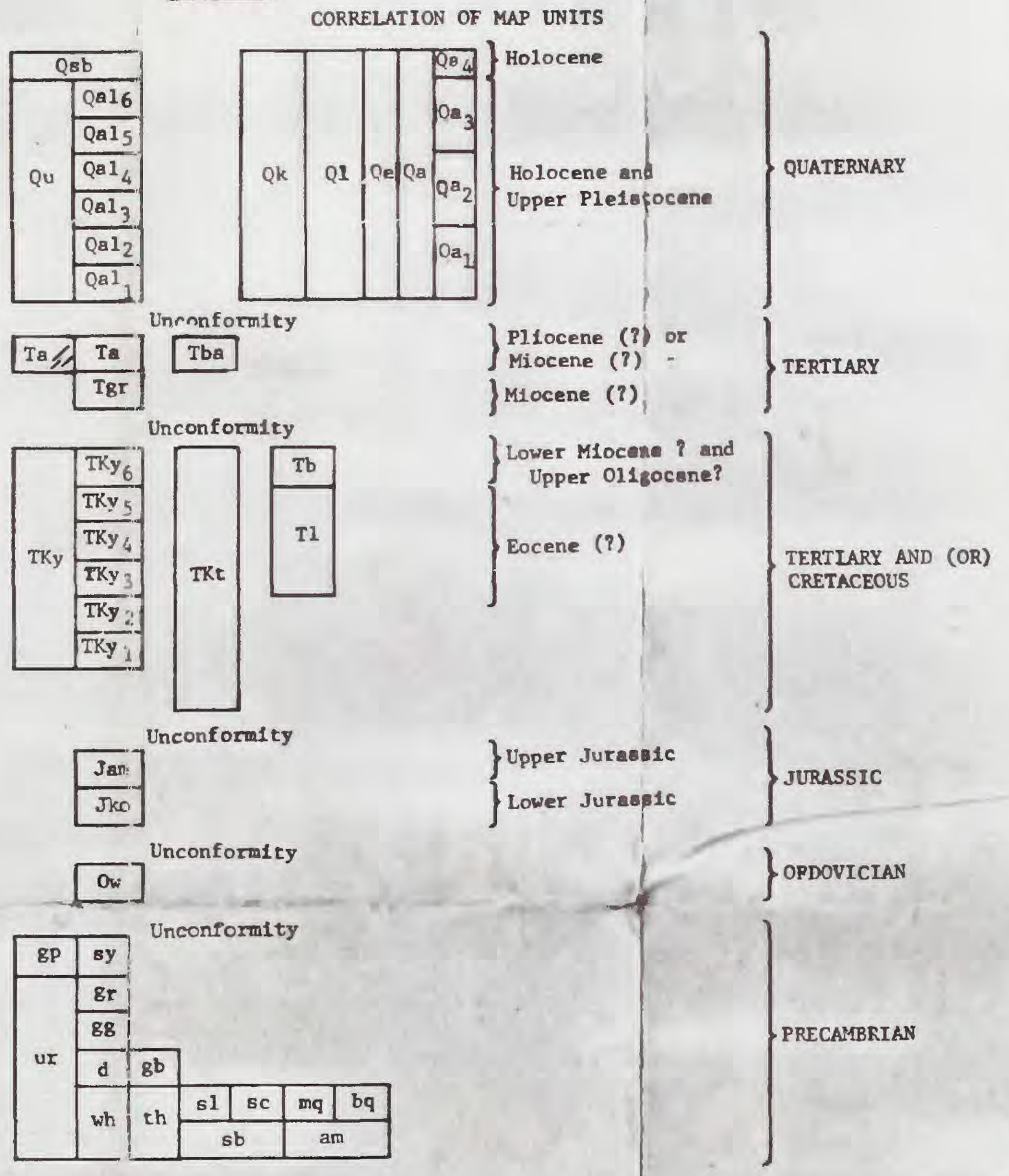
Copies of this map are available at the Ministry of Economic Development, Minerals and Petroleum Authority, San'a, Yemen Arab Republic, and at the U. S. Geological Survey, Washington, D. C., U. S. A. The base for this map is a two-, or three-band (5,7; or 4,5,7) false-color composite of the LANDSAT-1 image indexed hereby, and is available in a black and white positive print at the same places.

Indicated positions of boundary lines not demarcated on the ground are not necessarily definitive. Abbreviations: YAR - Yemen Arab Republic; PDRY - Peoples' Democratic Republic of Yemen.

GEOLOGIC EXPLANATION

Double or fractional symbols indicate grouped formations: Symbols queried where identification doubtful.

CORRELATION OF MAP UNITS



GEOLOGIC MAP SYMBOLS

Geologic contact

Fault - Showing relative horizontal movement U, upthrown side; D, downthrown side; dashed where approximately located

Lineament

Showing major lineament, possibly a fault

Showing linear or curved trends of uncertain nature or origin: in regions of granitic and sedimentary rocks, most likely to be joints or faults not readily detected on LANDSAT-1 images; in regions of metamorphic rocks, most likely joints or foliation trends

Anticline - Showing trace of axial plane and bearing and plunge of axis

Syncline - Showing trace of axial plane and bearing and plunge of axis

Monocline - Showing trace of axis; arrows indicate downfolded side

Strike and dip of bedding

Strike and dip of foliation

Small volcanic plug

Structurally controlled volcanic alignment, or curved volcanic trend; of Tertiary or Quaternary age

Large volcanic crater rimcrest

Dune Crest

Coral reef

Mineral Deposit

x Fe — Locality of mineral deposit shown by position of symbol; kind of deposit shown by abbreviations, as follows:

Cu, Ni, Copper- and nickel-bearing sulfide vein. Evidence of ancient mining, possibly for copper and gold.

Sn, Cassiterite-bearing quartz veins in granite; no evidence of mining

Fe, Limonite, goethite, and hematite in gossan formerly mined for iron ore; stratigraphic position and appearance of deposit resembles gossan exposed to the north in Saudi Arabia at Wadi Wassat (Overstreet, and Rossman, 1970), and Wadi Qatan (Dodge, and Rossman, 1975).

x Sal — Salt

x F — Fossils

Abandoned exploratory oil well (Hotchkiss, 1963, p. 1421).

.24 — Rock samples collected by Grolier, Feb. 1976

DESCRIPTION OF MAP UNITS

Geologic names and symbols given below apply to the whole area of the Yemen Arab Republic; some names and symbols may not appear on the geologic map of an area covered by an individual LANDSAT-1 image. Names and descriptions of geologic units, unless otherwise noted, are adopted from U.S. Geological Survey and Arabian American Oil Company, 1963, Geologic map of the Arabian Peninsula; U.S. Geol. Survey Misc. Geol. Inv. Map 270-A, and Brown, G. F., and Jackson, R. O., 1959, Geology of the Asir quadrangle, Kingdom of Saudi Arabia: U.S. Geol. Survey Misc. Geol. Inv. Map 217-A.

Qsb Silt, clay, and muddy sand; commonly saturated with brine and salt encrusted; in mud flats (sabkhas) along the Red Sea coast

Qu River terrace deposits, alluvial fans, gravel, sand, and silt including unmapped alluvium which overlies rock salt at Jabal Kushah, near Guma; numerous loess deposits particularly in the central plains. Wherever possible, alluvial deposits have been divided regionally on a basis of reflectance, natural vegetation and crops, altitude, and location into six sub-units, as follows:

- Qal_6, alluvial gravel, sand, and silt restricted to channels and flood plains of present-day ephemeral streams
- Qal_5, alluvial gravel, sand, and silt on river terraces and fans, adjacent to and higher than the flood plains of present-day streams; generally darker than Qal_6; may include colluvium at base of foothills
- Qal_4, same as above, but darker, and possibly older
- Qal_3, same as Qal_4, but higher and older
- Qal_2, same as Qal_3, but higher and farther inland from the Red Sea Coast
- Qal_1, alluvial gravel heavily coated with desert varnish, restricted to dissected river terraces on the south valley slope of Wadi Jawf, north of Jabal Bahra and west of Wadi Raghwan

Qk Yellow and green marly limestone, white limestone, and reef limestone, undifferentiated, exposed on Kamaran Island. Fossiliferous, and of probable Pleistocene age (MacFadyen, 1930; Cox, 1931). Probably correlative with unmapped marine terrace deposits which disconformably overlie Plio-Miocene tuffaceous sandstone at the Al Luhayyah diapirs

Ql Loess deposits, with calcareous concretions and caliche layers; fossil mollusks abundant locally; may include alluvial silt alternating with alluvial or colluvial gravel

Qe Eolian sand, commonly mobile

Qa Basalt flows and dikes; numerous scattered cones and craters; at places covered with tuff and volcanic bombs. May be rock and time equivalent of the Aden Volcanic Series in the People's Democratic Republic of Yemen; in the San'a region, lava flows have been divided regionally on a basis of reflectance into four sub-units, as follows:

- Qa_4, very dark basaltic lobate flows, extruded in historical times, possibly in 3rd century A. D. (Rathjens, G., and Wissman, H. V., 1934, v. 2, p. 13; v. 3., p. 105, fig. 51; p. 162-163; Rathjens, C., and Wissman, 1942, v. 33, p. 276)
- Qa_3, dark basaltic flows
- Qa_2, thin basalt flows, discontinuous over older rocks; appear lighter gray than units Qa_3 and Qa_4 on LANDSAT-1 images
- Qa_1, basalt flows forming a continuous mantle over older rocks; Qa_1 and Qa_2 possible are part of only one eruption phase

Tba BAID FORMATION--Gray, red, and green siliceous and tuffaceous shale and sandstone; also limestone and evaporite layers. Includes rock salt of salt domes at Salif and Jabal Qimmah, and at Jabal Kushah near Guma. Generally unfossiliferous, but middle to late Miocene microflora reported by Klaus (in Heybroek, 1965, p. 34-35) from rock salt at Jabal Kushah, and at Salif, and late Pliocene microfauna reported from marine sediments overlying salt (Goerlich, 1956, p. 213-214). Correlated with rocks of the Baid Formation exposed in Wadi Baid, Saudi Arabia, because of similar lithology (Gillmann, Letullier, and Renouard, 1966, p. 1479-1480, pl. 1, fig. 4).

Ta Hypabyssal andesite and diabase intrusives, commonly glomeroporphyritic, and in dike swarms

Tgr Alkali granite and diorite in subvolcanic plugs, stocks, and plutons (Karrenberg, 1959, v. 17, no. 1, p. 33-36); leucocratic granite locally has primary flow banding. Crests of unbreached plugs may be overlain by hydrothermally altered rocks of the Yemen Volcanics, locally in northwestern part of the Yemen Arab Republic mapped as Tertiary laccoliths (U.S. Geol. Survey and Arabian American Oil Co., 1963). Some granitic plutons as at Jibal Sabir, south of Taiz, have syenite margins. A K-Ar age of 22.7 ± 0.9 m.y. is reported for a granite sample from Jibal Sabir collected by R. O. Jackson (Field No. ROJ-1), and analysed by R. F. Marvin, H. H. Mehnert, and Violet Merritt (Marvin, 1974, written commun. to G. F. Brown). A similar K-Ar age (22.0 ± 0.7 m.y.) is reported by Marvin (1974, written commun. to Brown) for a syenite sample which had been collected from a plug cutting a laterite deposit in the Sirat Plateau, Saudi Arabia, by Brown (Field No. 519B).

Tb Alkali basalt flows. Erosional remnants on laterite (Tl) developed over Precambrian crystalline rocks; basalts probably equivalent to As Sirat Volcanic rocks of Saudi Arabia (Coleman, and others, 1975) for which isotopic ages of 25 to 29 m.y. are reported (Brown, 1970, p. 75-87); may be equivalent to Yemen volcanics sub-unit KTy_6

Tl Laterite and saprolite, mainly white, may be yellow or red, developed on upper surface of Precambrian crystalline rocks by prolonged weathering during Eocene (?) time, to 50 meters in thickness; probably equivalent to laterite in As Sirat Mountains, Saudi Arabia (Brown and others, 1959)

TKy YEMEN VOLCANICS, undivided--Bedded alkalic flows and pyroclastic rocks including but not restricted to rhyolite, comendite, pantellerite, trachyte, andesite, basalt, and ankaramite (Shukri and Basta, 1955, v. 36, p. 129-163), with interbedded lenticles of fluviatile and lacustrine sand, clay, and shale; locally contains fresh-water Oligocene-Miocene fossils; upper surfaces of many volcanic beds weather to reddish paleosols a few centimeters to a few meters thick, particularly in middle and upper parts of the sequence; whole sequence of Yemen Volcanics at least 2,000 meters thick. Term Yemen Volcanics introduced here to replace former name Trap Series (Geukens, 1966), to emphasize presence of thick sequence of highly fractionated felsic volcanic rocks. Wherever possible, the Yemen Volcanics have been divided regionally on basis of reflectivity and stratigraphic succession into six sub-units, as follows:

- TKy_6, dark basaltic flows;
- TKy_5, generally leucocratic felsic tuffs with some dark basaltic flows, associated with the formation and collapse of a circular volcanic structure, 8.5 km in diameter, in the north-central part of the area covered by LANDSAT-1 image 1189-06561;
- TKy_4, predominantly felsic and tuffaceous, with some basaltic flows, underlies TKy_6 and TKy_5;
- TKy_3, predominantly felsic and tuffaceous; older than TKy_4;
- TKy_2, predominantly felsic and tuffaceous; older than TKy_3;
- TKy_1, predominantly basaltic, but includes green felsic conglomerate, porphyritic trachyte, and pink tuffs; overlies the Tawilah Group.

In certain areas the rock types are shown on the maps by symbols without definite boundaries, owing to the uncertainty of establishing the contact between sub-units or between a sub-unit and the undivided Yemen Volcanics on the basis of reflectance.

TKt TAWILAH GROUP AND MEDJ-ZIR SERIES undivided--Continental type coarse crossbedded sandstone with lenses of conglomerate and gravel; interbedded shale and sandstone in lower part; overlies rocks of Jurassic age or the basement complex; includes the Medzir Series, consisting of crossbedded sandstone with locally fossiliferous calcareous sandstone and shale; upper part of sandstone locally rich in hematite; the Med-zir Series cannot be separated with certainty from the Tawilah Group on basis of stratigraphic relations or reflectance

Jam AMRAN SERIES--Limestone, marl, and shale; lower part locally includes detrital beds. The series is overlain by a less widespread Upper Jurassic transition zone of gypsum, clay, marl, shale, sandstone, and some limestone. Of Callovian to Kimmeridgian age. In the extreme northwestern part of the Yemen Arab Republic formerly designated the Hanifa Formation (Brown and Jackson, 1959)

Jko KOHLAN SERIES--Green shale with sandstone and conglomeratic bands in lower part; sandstone and some conglomerates in upper part. Contact with overlying Amran Series is gradational. May be in part Triassic in age; in the extreme northwestern part of the Yemen Arab Republic, formerly designated as the Khuma Formation (Brown and Jackson, 1959)

Ow WAJID SANDSTONE--Partly crossbedded, locally conglomeratic sandstone; includes common quartz granule and pebble zones; of Ordovician age (Brown, 1970); formerly designated as Permian or older (U.S. Geol. Survey, and Arabian American Oil Co., 1963)

gp Peralkaline granite, gp, and syenite, sy, generally

sy in circular plugs, stocks, and ring dikes

gr Calc-alkaline granite, gray and pink, generally massive; includes some quartz monzonite; may have been intruded during second and third episodes of the Hijaz tectonic cycle recognized in southwestern Saudi Arabia (Greenwood and others, 1975, p. 23)

gg Gneissic granite, gneissic granodiorite, and injection gneiss; commonly intruded by swarms of mafic dikes, contains numerous septa and inclusions of schist and gneiss; may have been intruded during second episode of Hijaz tectonic cycle

d | gb Diorite, d, and gabbro, gb; may have been intruded during second episode of the Hijaz tectonic cycle

sc | sl Slate, pelitic schist, and quartzite, sl; chlorite-schist, graphitic schist, sc; low-grade metamorphosed sedimentary rocks possibly of second and first episodes of Hijaz tectonic cycle

mq | bq Marble, quartzite, and biotite gneiss, mq; biotite schist, biotite gneiss, and quartzite, bq, intruded by dikes of gneissic pink granite, diorite, and gabbro; medium- and high-grade metamorphosed sedimentary rocks possibly of second and first episodes of Hijaz tectonic cycle

am | sb Mafic volcanic and metavolcanic rocks, with some interlayered metagraywacke and metaconglomerate, consisting of andesite, meta-andesite, metabasalt, greenstone, and chlorite schist, sb; hornblende gneiss, and amphibolite, am; possibly of second and first episodes of Hijaz tectonic cycle

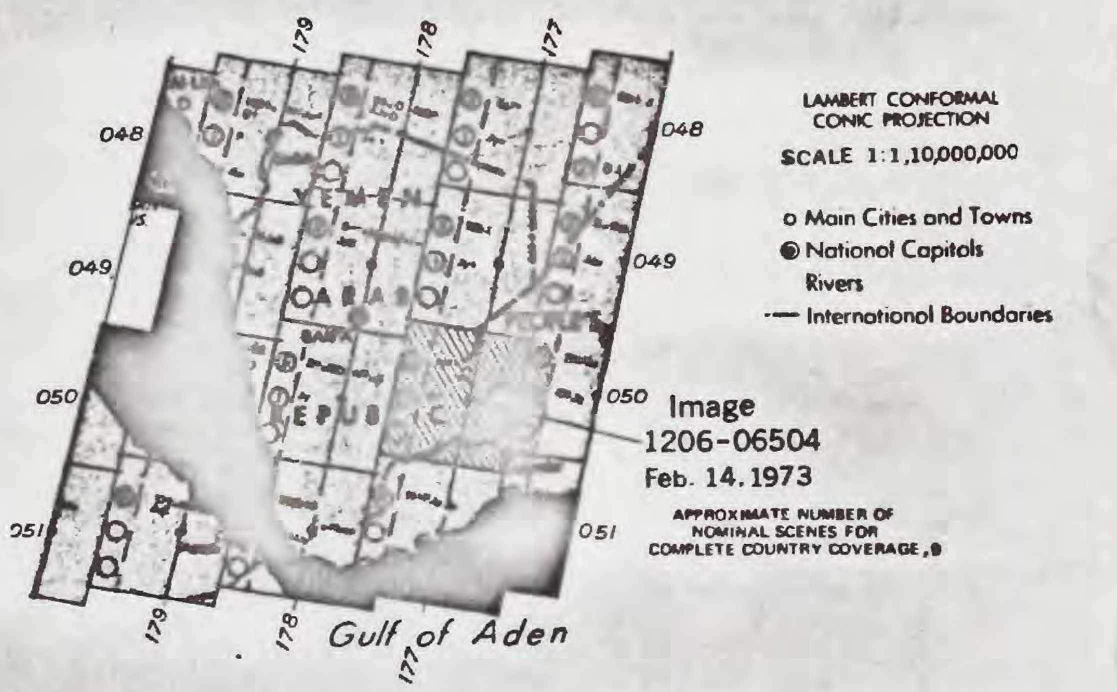
ur Predominantly granite, gneiss, and mica schist with subordinate quartzite, hornblende schist, and marble

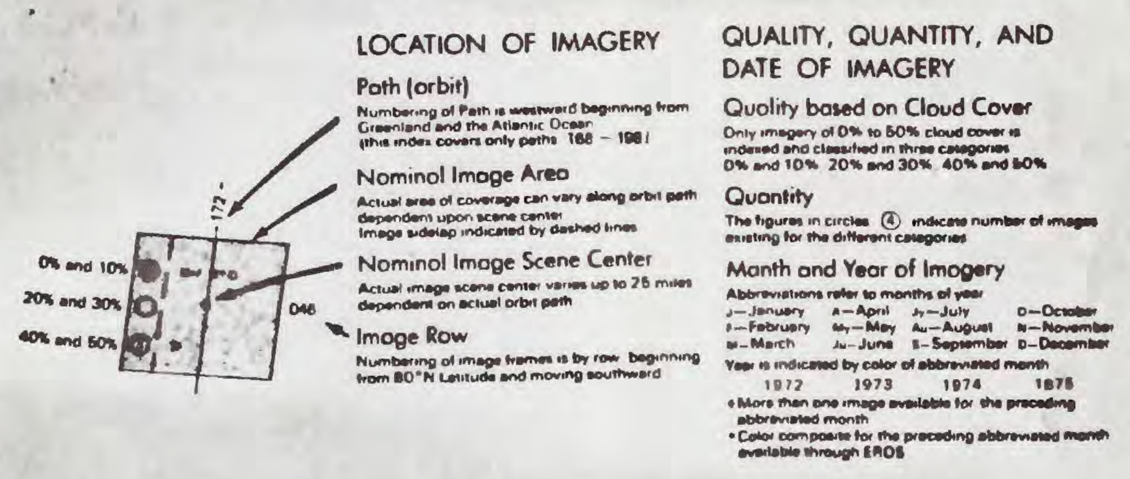
wh Chlorite-sericite schist, amphibole schist, graphite schist, marble, quartzite, slate, conglomerate, and greenstone

th Thaniya Group, contorted and cleaved metasediments consisting of graphitic calc-schist, quartzite, phlogopite marble, chert, and associated volcanics

NOTE

The gossans in the Kingdom of Saudi Arabia at Wadi Wassat (Overstreet and Rossman, 1970), and at Wadi Qatan (Dodge and Rossman, 1975) were formed over extensive deposits of stratabound massive and disseminated pyrite and pyrrhotite in Precambrian volcanogenic rocks. Should the iron deposits near Sa'dah, which are known to extend tens of kilometers northward, and similar deposits gossans over massive sulfide, then the region mined for iron northward from the vicinity of Sa'dah and Majadh to the border between the Yemen Arab Republic and the Kingdom of Saudi Arabia merit geologic, geophysical, and geochemical exploration for base metals, nickel, silver, gold and molybdenum.





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