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Compiled by Maurice J. Grollier 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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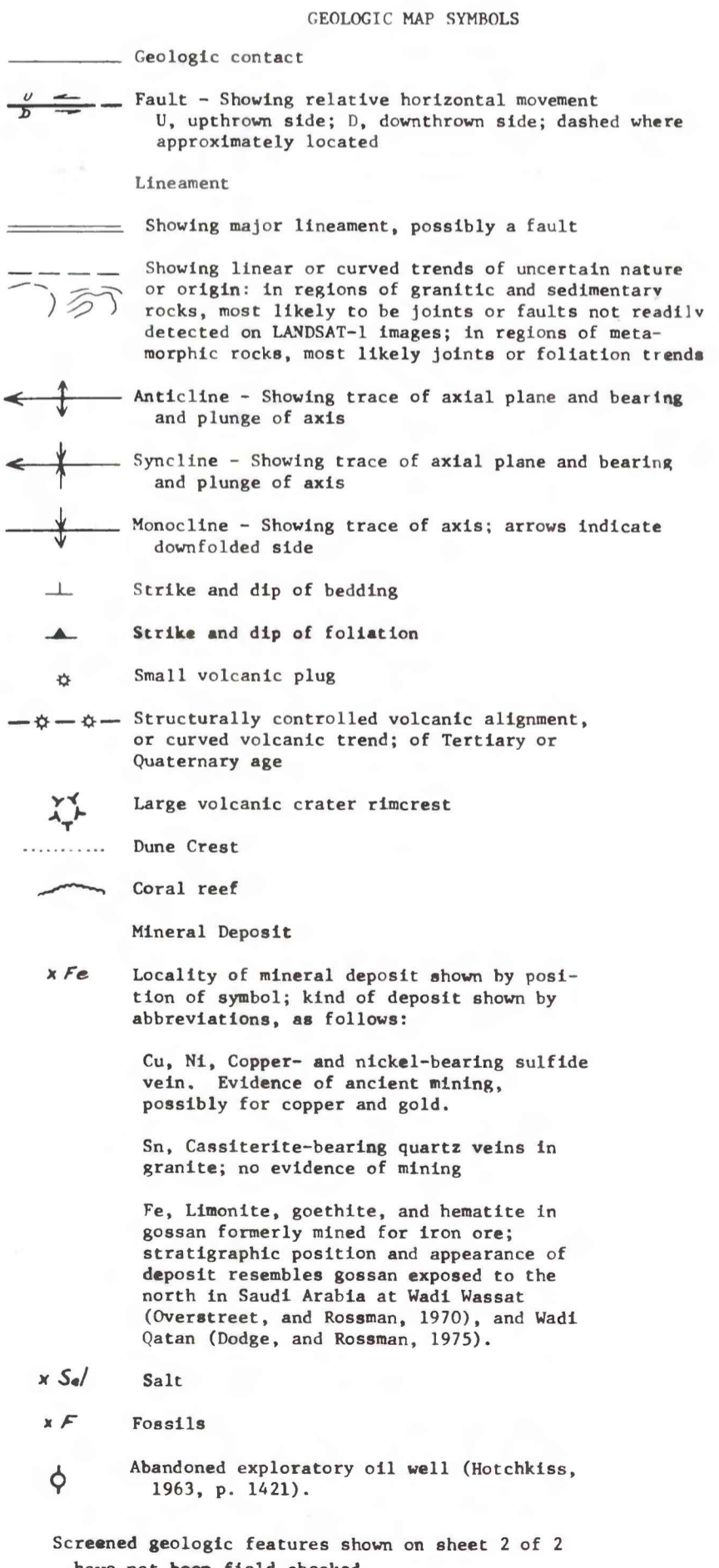
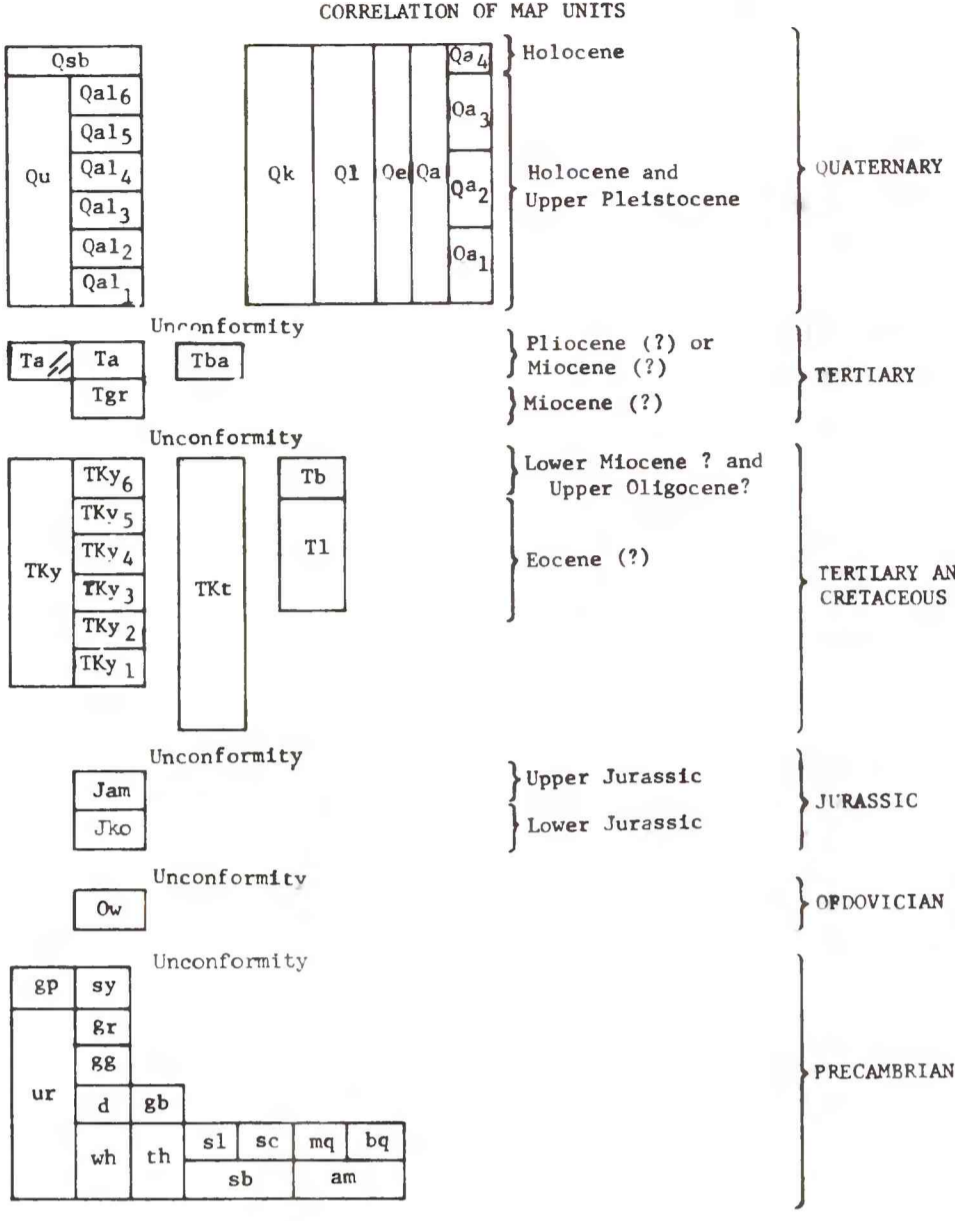
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GEOLOGIC EXPLANATION

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



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.

QUATERNARY

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:
Qa₆, alluvial gravel, sand, and silt restricted to channels and flood plains of present-day ephemeral streams
Qa₅, 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 Qa₄; may include colluvium at base of foothills
Qa₄, same as above, but darker, and possibly older
Qa₃, same as Qa₄, but higher and farther inland from the Red Sea Coast
Qa₂, alluvial gravel heavily coated with desert varnish, restricted to dissected valley slope of Wadi Jawf, north of Jabal Bahra and west of Wadi Raghwan
Qa₁, yellow and green marly limestone, white limestone, and reef limestone, undifferentiated, exposed on Kamaran Island. Fossiliferous, and of probable Pleistocene age (MacFayden, 1930; Cox, 1931). Probably correlative with unmapped marine terrace deposits which disconformably overlie Plio-Miocene tuffaceous sandstone at the Al Luhayyah diapirs

TERTIARY

Ta Pliocene (?) or Miocene (?)

Tgr Miocene (?)

Tertiary and (or) Cretaceous

TKy Lower Miocene ? and Upper Oligocene?

TKt Eocene (?)

Tl Eocene (?)

JURASSIC

Jam Upper Jurassic

Jko Lower Jurassic

ORDOVICIAN

Ow Ordovician

PRECAMBRIAN

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

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

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

mq 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 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

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

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

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

Q1 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 tuff 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:
Qa₄, 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)
Qa₃, dark basaltic flows
Qa₂, thin basalt flows, discontinuous over older rocks; appear lighter gray than units Qa₃ and Qa₄ on LANDSAT-1 images
Qa₁, basalt flows forming a continuous mantle over older rocks; Qa₁ and Qa₂ 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 Qimamah, 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).

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 Cretaceous 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 Khums 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)

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. Mehner, 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 KTy₆

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:
TKy₆, dark basaltic flows;
TKy₅, 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;
TKy₄, predominantly felsic and tuffaceous, underlies TKy₅ and TKy₆;
TKy₃, predominantly felsic and tuffaceous; older than TKy₄;
TKy₂, predominantly felsic and tuffaceous; older than TKy₃;
TKy₁, 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 Med-zir 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 Cretaceous to Kimmeridgian age. In the extreme northwestern part of the Yemen Arab Republic formerly designated the Hanifa Formation (Brown and Jackson, 1959)

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

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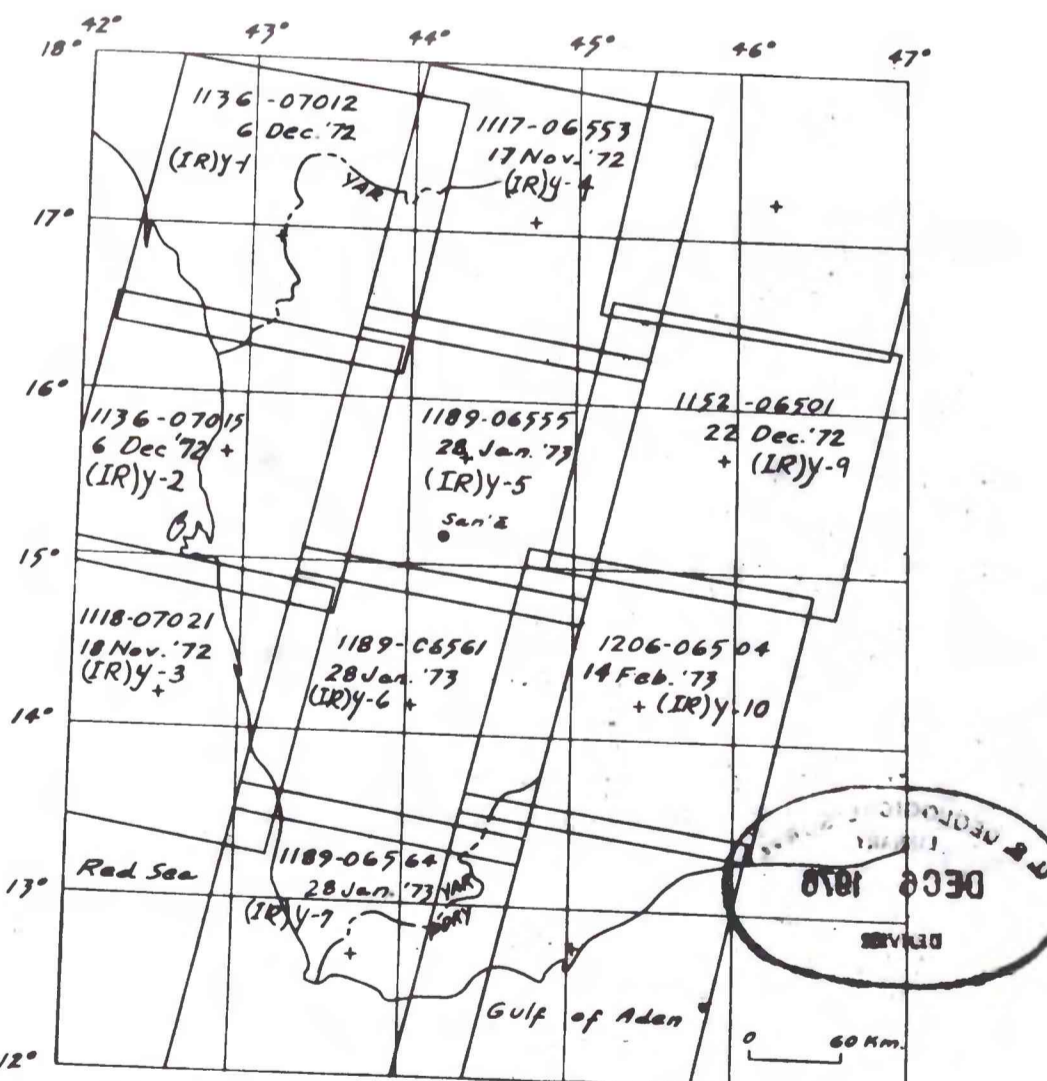
ur Predominantly granite, gneiss, and mica schist with subordinate quartzite, hornblende schist, and marble

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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 volcanic 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.



INDEX MAP OF YEMEN ARAB REPUBLIC - Showing location of Landsat-1 images used as bases for the geologic investigation maps published by the U.S. Geological Survey. Scale 1:500,000

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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.

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).

Sa Salt

F Fossils

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

Screened geologic features shown on sheet 2 of 2 have not been field checked.