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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Technical Letter
Saudi Arabian Mineral
Exploration - 99

Dr. Fadil K. Kabbani
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Directorate General for Mineral Resources
Ministry of Petroleum & Mineral Resources
Jiddah, Saudi Arabia

Dear Dr. Kabbani:

Transmitted herewith are 20 copies of:

TECHNICAL LETTER NUMBER 99
GEOPHYSICAL INVESTIGATIONS
BY THE U. S. GEOLOGICAL SURVEY
IN SAUDI ARABIA
OCTOBER 1966 TO SEPTEMBER 1967

by

Willard E. Davis

Sincerely,

Glen F. Brown

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U. S. Geological Survey

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ABSTRACT

Geophysical exploration for sulphide deposits was conducted over nine prospects in the southern part of the Precambrian shield. Subsurface conductive sources were detected in five localities. Test-drilling of the discoveries has been recommended and operations are underway in two areas. Preliminary results of drilling indicate that both areas contain massive sulphide bodies. More sulphide deposits may be found as exploratory reconnaissance is extended southward in the Ablah formation and in the belt including the Esh Qay'ib mine, Wadi Wassat and Wadi Qatan.

INTRODUCTION

Geophysical investigations were made of mineral prospects and ancient mines found in geologic reconnaissance of the Asir and Tihamat Ash Sham quadrangles. Electromagnetic methods supplemented partly by electrical resistivity, natural potential, and magnetic measurements were used to complement geologic and geochemical studies in searching for sulphide deposits. The interpretation of results of this combined effort served to evaluate prospects and to guide exploratory drilling.

The investigations are a continuation of work begun in 1964 by the Survey in behalf of the Ministry of Petroleum and Mineral Resources of the Kingdom of Saudi Arabia. Activities during July 1964 to June 1966 have been presented in Technical Letter No. 66 (Davis and Allen, 1966). Results of field work during the past year have been discussed in progress reports and technical letters submitted to the Ministry and are summarized briefly herein. Mineral prospects investigated since July 1964 and oorresponding reports are listed in table 1.

GEOPHYSICAL INVESTIGATIONS

Preliminary geophysical investigation of the Esh Qay'ib (Esh Sha'ib) mine area, Saudi Arabia Technical Letter 89

Geophysical exploration was done over gossan and ancient mine workings near lat. 19°15'N. long. 43°40'E. north of Hamdah. Results of electromagnetic dip-angle and horizontal-coil surveys indicate that subsurface conductive zones occur along the gossan and along a concealed contact between granite and metamorphic rock to the north. Both zones are inferred to lie at shallow depths and to dip steeply southward. Magnitudes of the anomalies are similar to those observed over the pyrite deposit in Wadi Wassat south of Bi'r Idimah. However, the in-phase to out-of-phase component ratios are larger and suggest that the Esh Qay'ib conductors have higher conductivity. Resistivity and magnetic data indicate that some high resistivity material lie in the conductive zones and that small amounts of magnetite occur in the gossan area. The presence of copper carbonate in mine workings and results of geochemical work suggest that sources of the electromagnetic anomalies contain sulphides. Test drilling of the conductive zones is recommended.

Exploration in the Wadi Duqah area, Tihamat Ash Sham quadrangle

An exploratory survey was conducted over gossan exposed along Wadi Duqah (lat. 19°44'N., long. 41°02'E.) about 15 km northeast of Musaylim. The gossan occurs in a shear zone that is more than 4 km long and is marked by highly altered rocks which in places contain small amounts of hematite and limonite. Vertical-coil electromagnetic measurements revealed dip-angles ranging from 30° over the

west part of the zone to 45° over the east part. The data indicate that a subsurface conductive bed lies along the south side of the shear zone, but does not seem to be associated with the gossan. The bed dips southward at a low angle and contains material of moderate conductivity. Very likely the dip-angle anomalies are the expression of a contact zone, which contains a high percentage of clay minerals.

Horizontal-coil measurements were made along traverses where the largest dip-angles occur. Prominent anomalies were found in a wadi that cuts the west part of the zone, but elsewhere only weak anomalies are associated with the shear zone. The anomalies do not coincide with the conductor trace inferred from dip-angle data. They seem to be caused by conductive surface material, whose response in the wadi probably is sufficient to mask reflection of deeply buried conductive sources.

Natural potential measurements were made in the wadi to detect sulphide bodies. Small variations in potential were observed over the trace of exposed clay beds. These beds probably are the source of the prominent horizontal-coil anomalies. Tests for sulphides by natural potential measurements also were made over quartz veins in the east part of the area, but no favorable indications were found.

In view of the negative results of the investigation and absence of exposed mineralization in the area, it was concluded that no economic sulphide deposits occur in the shear zone.

Investigations in the Al Qunfidah area, Tihamat Ash Sham Quadrangle

Geophysical prospecting was done as part of a geologic reconnaissance investigation in the Al Qunfidah area (Earhart, 1967). Surveys were made over outcrops containing sulphides along Wadi Sishah near Al Khamis and over gossan exposed in hills to the west near lat. 19°08'N. long. 41°19'E. and lat. 19°09'N. long. 41°29'E. No electromagnetic or natural potential anomalies indicative of sulphide deposits were observed over the outcrops near Al Khamis. Similarly no conductive response was obtained over water-bearing sand and gravel in the wadi. Small electromagnetic in-phase and out-of-phase variations were observed over the gossan near lat. 19°08'N. long. 41°19'E. Although, results of geochemical study show anomalous nickel and copper values in the northern part of the gossan, the electromagnetic data do not indicate the presence of massive sulphides. A pronounced anomaly occurs over alluvium west of the southern end of the gossan. This feature may be the expression of a northward-trending fault zone. Exploratory horizontal-coil data revealed a small anomaly over part of the gossan near lat. 19°09'N. long. 41°29'E. The entire gossan was prospected later by dip-angle measurements, but only the small anomalous part found by horizontal-coil measurements appeared to be weakly conductive. Results of geologic study indicate that the gossan ridge may be a volcanic source and should be mapped in more detail by electromagnetic methods.

Reconnaissance survey of the Muckahat lead mine, Tihamat Ash Sham Quadrangle

An exploratory dip-angle survey was made over the ancient workings of the Muckahat lead mine (lat. 19°17'N. long. 41°41'E.). Data were obtained along

several traverses 50m to 100m apart with the transmitter placed over the mine workings. The depth of penetration of measurements probably reached a maximum of 200m, but no indication of a subsurface sulphide-bearing zone was found. Apparently mineralization in the carbonate host rock is too disseminated or lies at too great a depth to be detected on the ground surface by electromagnetic techniques. The terrain is too barren and rugged to successfully apply other geophysical methods, such as, electrical resistivity, natural potential and induced polarization.

Geophysical exploration in the Wadi Qatan area, Saudi Arabia
Technical letter 93

An investigation was made of the Nahaum, Al Harr, and Simlal gossan in the Wadi Qatan area (lat. 18°07'N. long. 44°08'E.). Electromagnetic measurements reveal that hidden zones containing material of moderate to high conductivity are associated with the gossan. Test drilling of the Nahaum gossan indicates that the source of dip-angle anomalies is a large deposit of massive pyrite which may be more than 2400m in length. The ratio of in-phase to out-of-phase components of horizontal-coil measurements suggest that the southern part of the source is highly conductive. Anomalous amounts of disseminated pyrite found in the country indicate that the conductive zones associated with the Al Harr and Simlal gossan also contain massive pyrite. In order to determine if other sulphide minerals are associated with the pyrite, it is recommended that the more anomalous parts of the inferred conductive zones be test-drilled.

Preliminary geophysical investigation of
the Wadi Yiba copper prospect Saudi Arabia
Technical Letter 96

A brief electromagnetic investigation was made of a copper prospect near Wadi Yiba (lat. 19°10'N. long 41°50'E.) in the Al Qunfidah quadrangle. Dip-angle and horizontal-coil measurements were made along traverses across sulphide-bearing dolomite zones in the ast limb and nose of a syncline. Small anomalies were observed over the dolomite and parts of the country rock. Interpretation of the data indicates that no deposits of massive sulphides occur in the parts of the area investigated. The observed anomalies are weak and are probably caused mostly by minor changes in conductivity of the chlorite and chlorite-quartz schist. However, anomalies near the dolomite unit may represent deposits of disseminated sulphides. More geophysical work should done to establish anomalous trends and to determine their relationship to the sulphide-bearing dolomite unit. Such information in the light of geologic data would be helpful in locating concentrations of disseminated sulphides.

SUMMARY AND CONCLUSIONS

Exploratory surveys were made over nine prospects of which five were found to contain subsurface conductive sources. Test-drilling of the sources has been recommended and operations are underway in two areas (Esh Qay'ib and Wadi Qatan areas). Preliminary results of drilling indicate that both areas contain massive sulphides.

Results of the investigations indicate that geophysical methods are helpful in searching for sulphide deposits in the southern part of the Precambrian shield.

These methods are most successful when used in conjunction with detailed geologic and geochemical studies. Information from such studies serve as a guide in conducting geophysical operations and form a basis for proper interpretation of data.

In most areas the application of electromagnetic, electrical resistivity natural potential, and induced polarization methods is limited because of irregular topography and inadequate soil cover. The electromagnetic dip-angle technique seems to be the most feasible. However, in some localities its use is hindered by "line-of-sight" obstacles. Generally, by supplementing dip-angle measurements with data obtained where possible by other methods sufficient information can be gathered to detect sulphide deposits.

It is the author's opinion that the dip-angle method will continue to serve as a major means of searching for massive sulphide deposits in rugged parts of the shield. The equipment can be operated by two people. It will give adequate depth penetration and is especially suitable for conducting rapid reconnaissance investigations. In order to obtain maximum subsurface information, the dip-angle equipment should be of the dual-frequency type and designed so that either coil may be used as a transmitter and receiver.

During the past three years, a large part of the shield area has been sampled by geophysical methods in exploring for sulphide deposits. The effort seems to have been most successful in the belt including the Esh Qay'ib mine, Wadi Wassat, and Wadi Qatan and in the Ablah formation off the escarpment east of Al Qunfidah. Presumably we may expect continued success as exploratory reconnaissance is extended southward in these belts. The least applicable areas for geophysical prospecting lie at higher elevations in the Southern Hijaz, including the belt of ancient mines

along the escarpment west of Aqiq. Results of work in these areas suggest that the zone of oxidation extends to considerable depth and that any existing sulphide deposits probably lie at depths beyond the reach of prospecting techniques; or the sulphide mineralization may be too disseminated to be detected by such means.

REFERENCES

Davis, W. E. and Allen, R. V., 1966, Review of geophysical activities by the U. S. Geological Survey in Saudi Arabia, July 1964 to June 1966: U. S. Geol. Survey Tech. Letter Saudi Arabian Mineral Explor. 66.

Earhart, Robert L., 1967, Geologic reconnaissance of the Al Qunfidah area, Tihamat Ash Sham quadrangle, Kingdom of Saudi Arabia: U. S. Geol. Survey Tech. Letter Saudi Arabian Mineral Explor. 97.

Table 1. Mineral prospects investigated during period of July 1964 to September 1967

Prospect	Latitude	Longitude	Technical Letter
Mahad adh Dhahab mine	23°30'N.	40°52'E.	14
Lahuf mine	23°29'N.	40°45'E.	14
Jebel Idsas area	23°18'N.	45°12'E.	18
Methgal iron deposit	22°42'N.	39°51'E.	34
Shaihab mine	22°36'N.	39°45'E.	57
Bahran gossan	22°31'N.	39°45'E.	57
Jabal Samran area	22°18'N.	39°32'E.	12
Mehaid mine	20°34'N.	41°23'E.	27
Mulha mine	20°32'N.	41°22'E.	27
As Sut mine	20°26'N.	41°20'E.	27
Mahawiyah mine	20°20'N.	41°19'E.	27
Mindaha mine	20°18'N.	41°19'E.	27
South Mindaha mine	20°17'N.	41°20'E.	27
Camden anomaly	20°11'N.	41°27'E.	27
Unnamed mine pit	20°10'N.	41°28'E.	27
Wadi Fig prospect	20°00'N.	41°32'E.	27
Wadi Tha mine	19°59'N.	42°01'E.	27
El Wakaban mine	19°56'N.	42°00'E.	27
El Kuthain mine	19°53'N.	42°00'E.	27

Table 1. Mineral prospects investigated during period of July 1964 to September 1967 (con'td.)

Prospect	Latitude	Longitude	Technical Letter
Esh Kamp mine	19°52'N.	41°59.5'E.	27
Unnamed mine pit	19°51'N.	41°59.5'E.	27
Unnamed mine pit	19°50.6'N.	41°59'E.	27
Tea garden prospect	19°50'N.	41°59'E.	27
Wadi Duqah area	19°44'N.	41°02'E.	99
Muckahat mine	19°17'N.	41°41'E.	91
Esh Qay'ib mine	19°15'N.	43°40'E.	89
Wadi Yiba copper prospect	19°10'N.	41°50'E.	99
Al Qunfidah area:			
Al Khamis	19°10'N.	41°30'E.	99
Gossan	19°09'N.	41°29'E.	99
Gossan	19°08'N.	41°19'E.	99
Bi'r Idimah-Wadi Wassat area	18°20'N.	44°20'E.	53 & 54
Wadi Qatan area:			93
Nahaum gossan	18°08'N.	44°08'E.	93
Al Harr gossan	18°08'N.	44°07'E.	93
Simlal gossan	18°06'N.	44°06'E.	93