These units consist of Tertiary and Quaternary deposits. The Tertiary deposits consist of yellow marl with large foraminifera (e2M1) and upper nodular limestone (e2L2) of late Paleocene to early Eocene and sedimentary breccia (Br). The Quaternary deposits consist of ancient alluvial fans (Qgx), sub-Recent alluvial fans (Qgy), active or sub-Recent slope deposits (Qcy-z), Khagra of depression with Recent or sub-Recent clay and silt (Qky-z), eolian sand of Recent or sub-Recent dunes (Qdy-z), coating of sub-Recent dunes (Qsy-z) and Recent alluvial fans and alluvium (Qtgz).

(2) Geologic Structure

Main structure in the central Batinah coast area is considered as the piled-up structure formed when allochthonous Samail ophiolite and supra-ophiolite sediments have been thrust over the Arabian shield at the late Cretaceous age. The Tertiary and Quaternary deposits of the post-nappe autochthonous units unconformably overlie the allochthonous units in the central Batinah coast area. The Samail Nappe which formed the piled-up structure consists of two blocks: Haylayn block (west part of the area) and and Rustaq block (east part). The blocks are bounded by NE-SW faults and lineaments located at 10km west of Barka in the Batinah coast. Many thrust faults are developed in the area which formed contacts of piled-up blocks formed before Tertiary and sliced the autochthonous and allochthonous blocks. High-angle faults developed in the area cut each of the above blocks and displaced the geologic boundaries. These fault were formed before Tertiary.

2-3-2 Survey results in the Area A

(1) Distribution of geologic units

The geologic map and profile of the area A is shown in Fig. II-2-2 and PlateII-2-1.

The Samail ophiolite is distributed in the south and north of this area along the E-W direction. In the south area, it is distributed from Wadi al Hawashina (west part) to Wadi Mayhah (east part). Tectonite (TH), cumulate sequence (C), high level gabbro (HG), sheeted-dyke complex (SD) and Samail volcanic rocks (SV) from lower part are distributed from south to north. In the north area, the ophiolite is widely distributed from Wadi Doqal (west part) to Sanah village area (east part) and seen interrupted at the north of Mashin village. Cumulate sequence (C), high level gabbro (HG), sheeted-dyke complex (SD) and Samail volcanic rocks (SV) from lower part are distributed from south to north.

The supra-ophiolite sediments (BO) are distributed to the north of Samail ophiolite and overlies unconformably it.

The Tertiary deposits are distributed in the area from north to southeast and overlies unconformably the ophiolite and the supra-ophiolite sediments.

The Quaternary deposits are covering the area.

(2) Distribution of ore-forming horizon

Based on previous exploration results (Bishimetal,1987), massive sulphide ore deposits is found out to exist at the top of the lower extrusives 1 (V1-1) near the boundary between the lower extrusives 1 (V1-1) and the lower extrusives 2 (V1-2) of the lower volcanic rocks (SV1). Lasail type ore deposit is the typical model of massive sulphide ore deposits in the Samail ophiolite area. Geological setting of the lasail type massive sulphide ore deposits is shown in Fig.II-2-3. Section A includes the horizon which controled the lasail type massive sulphide ore deposits, however, Section B and C does not include the horizon which controled this type of deposits. Accordingly, the distribution of Samail volcanic rocks is very important for the exploration of Lasail type massive sulphide ore deposits. These distributions are described below.

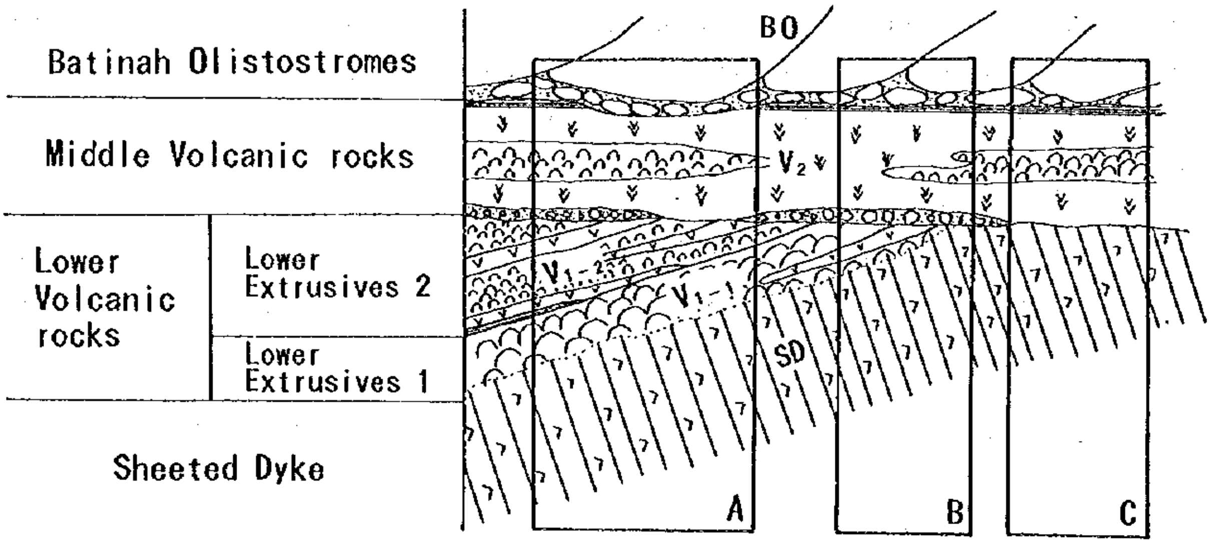


Fig.II-2-3 Stratigraphic Columnar Section of Samail Volcanic Rocks.

Two horizon of the Samail volcanic rocks (SV) are distributed in north and south of the area along the E-W direction. The lower volcanic rocks (V1) related to the ore hosted horizon are distributed in a wide area from Doqal village to Ghuzayn village and also distributed in the Fardah area, the Mashin area and the Qulayyah area.

In the area from Doqal village to Ghuzayn village are seen distributed sheeted-dyke complex (SD), lower extrusives 1 (V1-1), lower extrusives 2 (V1-2) and lower metalliferous sediments (U1) of the lower volcanic rocks, volcanic conglomerate and breccia (V2c), middle extrusives (V2) and middle metalliferous sediments (U2) of middle volcanic rocks and Suhaylah formation (Sh). The area correspond to the section A shown in Fig.II-2-3. Accordingly, there exist good indications that Lasail type massive sulphide ore deposits exist in the area. Ghuzayn ore deposit has been previously known in the area.

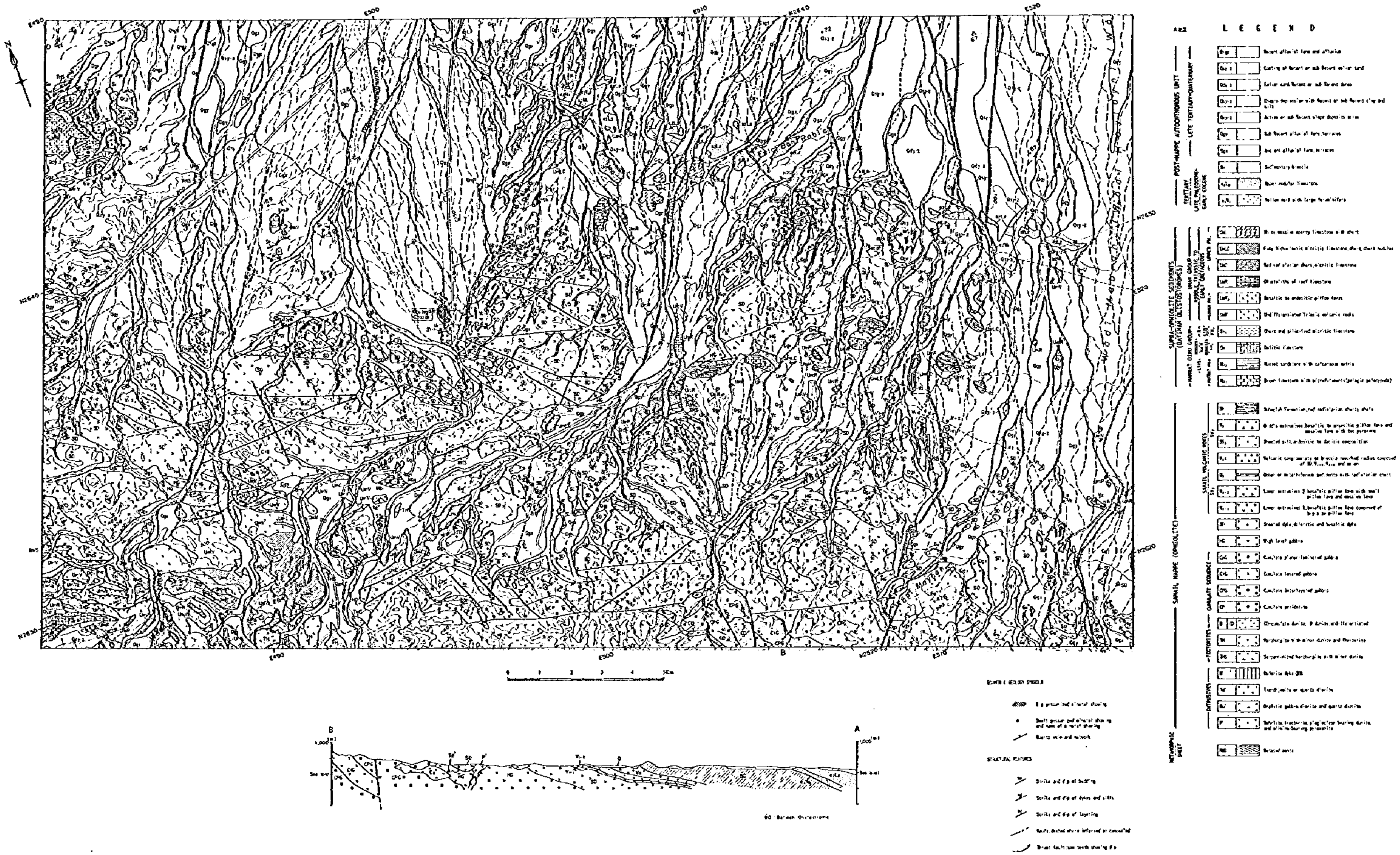


Fig. II-2-2 Geologic map, profile and Mineral showings of Area A.

In the Fardah area is seen distributed sheeted-dyke complex (SD), lower extrusives 1 (V1-1), lower extrusives 2 (V1-2) and lower metalliferous sediments (U1) of the lower volcanic rocks and Tertiary formations (e2M1 and e2L2). Tertiary deposits overlie them. The area corresponds to the section A shown in Fig.II-2-3. Gossanized lower metalliferous sediments and Tertiary formation are found in the area. White argillized clays and gypsum are observed in the gossan. Accordingly, there seems to be good indications that Lasail type massive sulphide ore deposits exist in the area.

In the Mashin area is seen distributed sheeted-dyke complex (SD), lower extrusives 1 (V1-1) and lower extrusives 2 (V1-2) of the lower volcanic rocks and volcanic conglomerate and breccia (V2c) and middle extrusives (V2) of middle volcanic rocks. The area corresponds to the sections A, B and C shown in Fig.II-2-3. However, since they are distributed in a narrow area and no mineralization is observed, no potential of Lasail type massive sulphide ore deposits can be expectyed to exist in the area.

In the Qulayyah area is seen distributed sheeted-dyke complex (SD), lower extrusives 1 (V1-1) and lower extrusives 2 (V1-2) of the lower volcanic rocks and middle extrusives (V2) of middle volcanic rocks. The area corresponds to the section A shown in Fig. II-2-3. Gossanized stockwork quartz veins are observed in the sheeted-dyke complex as well as lower extrusives 1, and consequently, a potential for the existence of Lasail type massive sulphide ore deposits can be expected in the area.

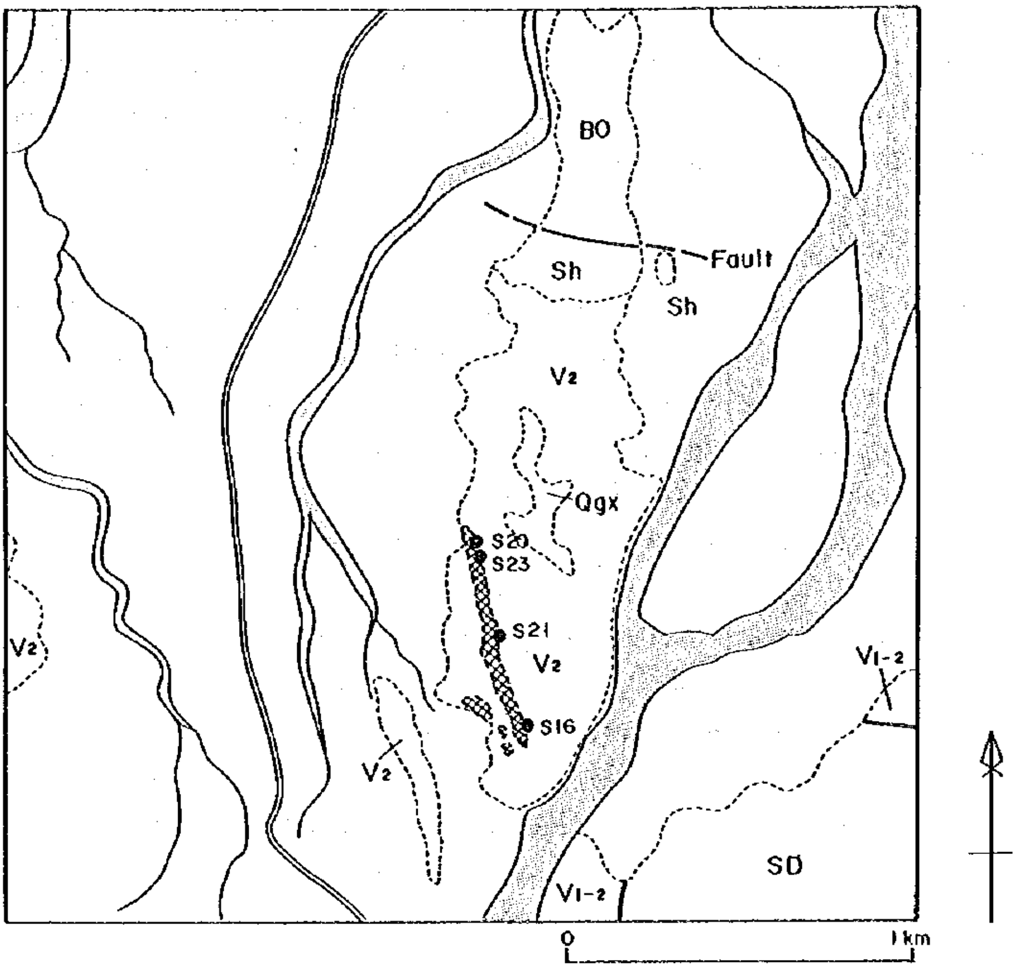
In the other remaining areas, sheeted-dyke complex (SD) and middle extrusives (V2) of middle volcanic rocks are seen distributed. These areas corresponds to the section C shown in Fig. II-2-3. Accordingly, there are good possibilities that Lasail type massive sulphide ore deposits exist in these areas.

(3) Mineralization

In the area A, the previous known mineralization is Ghuzayn gossan. Newly observed mineralizations are Doqal, north Ghuzayn village, Fardah, Sanah and Qulayyah mineral showings. The mineral showings located outside of the semi-detail survey area are described below.

The Doqal mineral showing is located south of Doqal village in west part of the area. Mineral showing existing in the middle extrusives (V2) is shown in Fig. II-2-4. Gossan is 10 m in width and more than 600 m in length. Ore minerals shown in Table II-2-1 consist of great amount of goethite. Ore assays shown in Table II-2-2 show maximum values of 7,529 ppm Cu, 2,021 ppm Zn, 44.2 g/t Ag and 2.0 g/t Au.

The north Ghuzayn village mineral showing is located southeast of Ghuzayn village, south of Ghuzayn gossan. Mineral showing is seen in the lower extrusives 1 (V1-1) and 2 (V1-2) of lower volcanic rocks (V1) as shown in Fig.II-2-5. Gossan and argillization are observed in the area. Small gossanized and silicified zone are scattered in the 1 km zone. Ore assays shown in Table II-2-2 indicates maximum values of 12,260 ppm Cu, 1,637 ppm Zn and 5.3 g/t Ag. Altered minerals shown in Table II-2-3 are found to consist of quartz, chlorite and alunite.



LITHOLOGY
QUATERNARY

- Wadi sediments and Sub-recent alluvial fans;terraces
- Qgx — Ancient alluvial fans;terraces

SUPRA-OPHIOLITE SEDIMENTS

- BO — Batinah Olistostromes

SMAIL OPHIOLITE
Samail Volcanic Rocks

- Sh — Suhaylah Formation
- V2 — Middle Volcanic Rocks
- V1-2 — Lower Volcanic Rocks, Lower extrusives 2

Sheeted-dyke complex

- SD — Sheeted dykes;dolerite

MINERALIZATION

- Gossan

Other symbols

- S20 — Sample location
- Road
- Wadi

Fig.II-2-4 Mineral showing of Doqal area in Area A.

Table II-2-1 Ore minerals of samples determinate by microscopic observation.

Ser. No.	Sample No.	Coodinates		Location	Description	Cp	Cc	Dg	Cv	Ml	Ch	Py	Gt	Ht	Mt	Sp
		N (km)	E (km)													
1	G11a	N2600.65	E556.85	Mansur	Quartz veins in SD	<1	<1	<1	<1	<1			1			
2	G11b	N2600.65	E556.85	Mansur	Quartz veins in SD					<1			3			
3	G33a	N2611.70	E532.15	South of 3A5	Gossan in SD	<1				1	1		1			
4	G33b	N2611.70	E532.15	South of 3A5	Gossan in SD					1			3			
5	G35	N2614.20	E532.75	Daris 3A5	Gossan silicified with Py dissemination in V_2							10				
6	G38a	N2614.20	E534.70	Daris 3A5	Gossan silicified with Py dissemination in V_2							7	1			
7	G38b	N2614.20	E534.70	Daris 3A5	Gossan silicified with Py dissemination in V_2		<1	<1				15	2			
8	G43	N2626.35	E512.15	North of Mabrah	Quartz network veins in V_{1-1}		2	2	2			3	2			
9	G47	N2627.00	E509.45	SE of Qulayyhah	Gossan and Quartz network veins in SD								50			
10	G72a	N2633.95	E510.25	Fardah	Gossanized sediments with Mt in V_{1-2}								3	2	<1	
11	G72b	N2633.95	E510.25	Fardah	Gossanized sediments with Mt in V_{1-2}								5		<1	
12	G74	N2634.05	E510.95	Fardah	Gossanized sediments in V_{1-2}									10		
13	S04	N2635.45	E500.60	Ghuzayn East	Quartz veins with Cu oxide in V_{1-2}							<1	1			
14	S07	N2635.35	E500.50	Ghuzayn East	Quartz veins with Cu oxide and Py in V_{1-2}	1			<1				2	<1		
15	S09a	N2634.95	E501.35	Ghuzayn East	Quartz veins with Cu oxide and Py in V_{1-2}	<1							1	<1		
16	S10	N2635.30	E501.00	Ghuzayn East	Quartz veins with Cu oxide and Py in V_{1-2}	<1	<1	<1	<1					1		
17	S13	N2634.65	E501.95	Ghuzayn East	Quartz veins with Cu oxide and Py in V_{1-1}	<1	<1	<1	<1			<1	3			
18	S14	N2634.30	E503.15	Ghuzayn East	Quartz veins with Cu oxide and Py in SD	<1	<1	<1	<1	<1		<1	2			
19	S16	N2636.20	E491.15	Doqal	Gossanized veins in V_2								7			
20	S17	N2632.55	E499.95	Ghuzayn South	Gossanized silicvified rocks in V_2	<1	<1	<1								<1

Abbreviation:
- Cp:Chalcopyrite
- Cv:Covellin
- Py:Pyrite
- Cc:Chalcocite
- Ml:Malachite
- Gt:Goethite
- Dg:Digenite
- Ch:Chrysocolla
- Sp:Sphalerite
- Ht:Hematite
- Mt:Magnetite

Quantity of minerals
- % :Percentage

Geology
- SD :Sheeted-dyke Complex
- V_{1-1}:Lower Extrusives 1
- V_{1-2}:Lower Extrusives 2
- V_2 :Middle Extrusives

Table II-2-2(1) Analytical data obtained on ore samples from outcrops.

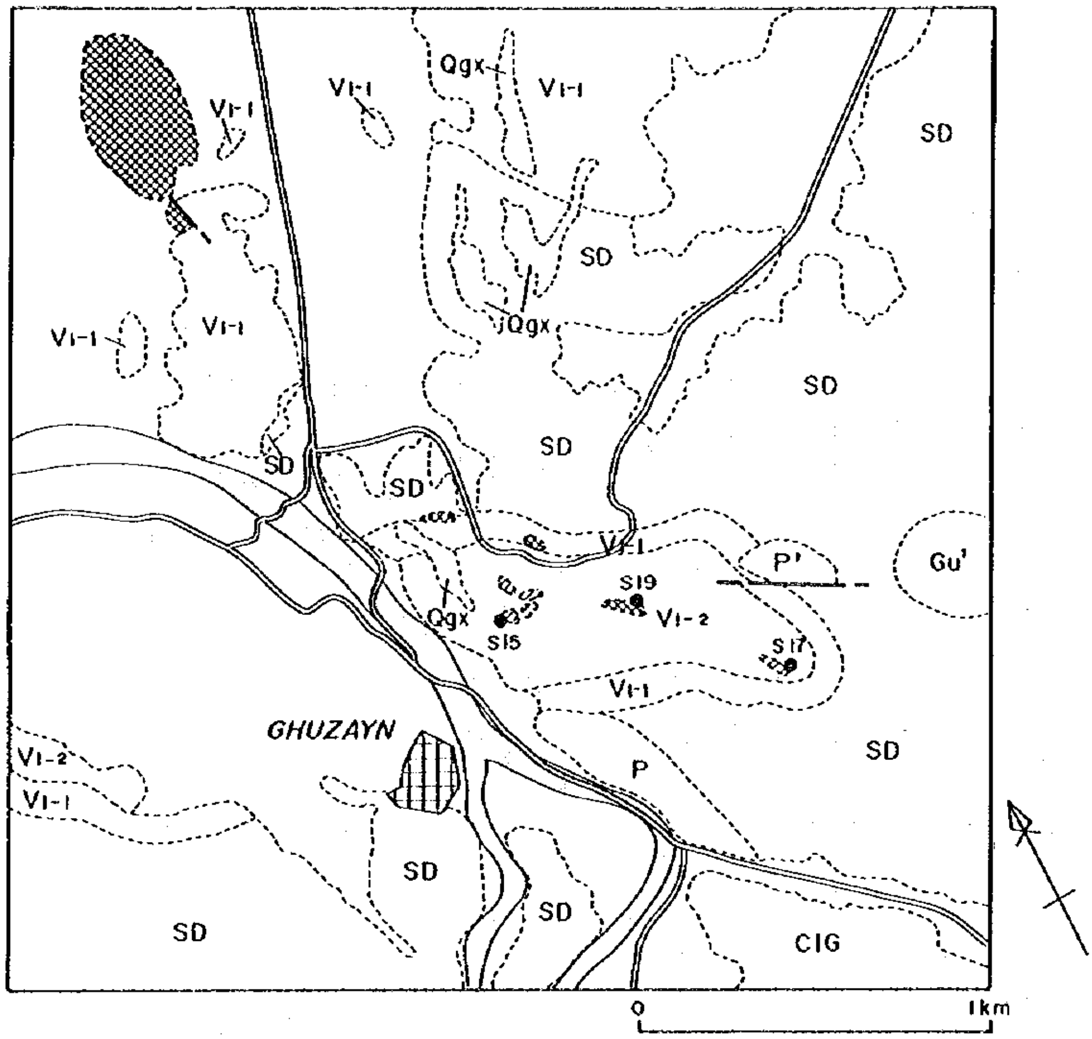
Ser. No.	Sample No.	Coodinates N (km)	Coodinates E (km)	Location	Description of mineralization	Ore Assay Cr ppm	Mn ppm	Fe_2O_3 %	Cu ppm	Zn ppm	Ag g/t	Au g/t	Pb ppm
1	G09	N2600.65	E556.84	Mansur	Gossan and quartz network in SD	96	223	8.5	1,743	25	1.0	N.D.	Tr.
2	G10	N2600.65	E556.84	Mansur	Gossan and quartz network in SD	67	125	6.6	1,199	16	2.0	N.D.	Tr.
3	G11	N2600.65	E556.84	Mansur	Quartz vein with Cu oxide in SD	54	129	4.6	875	16	1.0	N.D.	Tr.
4	G20	N2609.15	E543.35	Daris	Gossan in V_{1-2} (W:3m)	335	31	67.9	1,486	41	2.0	N.D.	42
5	G21	N2609.15	E543.35	Daris	Gossan in V_{1-2} (W:2m)	229	292	84.5	1,561	80	2.0	N.D.	48
6	G22	N2608.70	E540.20	Daris West	Gossan in SD (W:30cm)	139	125	7.3	76	24	N.D.	N.D.	Tr.
7	G25	N2611.55	E532.30	South of Daris 3A5	Quartz network veins in V_{1-1} (W:1m)	162	147	6.8	1,963	86	N.D.	N.D.	Tr.
8	G26	N2611.70	E532.15	South of Daris 3A5	Quartz network veins in V_{1-1} (W:2m)	57	165	5.9	5,716	82	N.D.	N.D.	Tr.
9	G27	N2611.70	E532.15	South of Daris 3A5	Quartz network veins in V_{1-1} (W:1m)	40	127	4.5	1,346	80	N.D.	N.D.	Tr.
10	G28	N2611.70	E532.15	South of Daris 3A5	Quartz network veins in V_{1-1} (W:70cm)	66	315	5.0	852	115	N.D.	N.D.	Tr.
11	G29	N2611.70	E532.15	South of Daris 3A5	Quartz network veins in V_{1-1} (W:60cm)	68	268	5.6	1,751	42	N.D.	N.D.	Tr.
12	G30	N2611.70	E532.15	South of Daris 3A5	Quartz network veins in V_{1-1} (W:60cm)	73	223	6.6	959	58	1.0	N.D.	Tr.
13	G34	N2614.20	E532.75	Daris 3A5	Gossan in V_2 (W:9m)	141	138	8.5	635	365	44.5	3.4	511
14	G36	N2614.20	E532.75	Daris 3A5	Gossan in V_2 (W:8m)	330	204	14.7	890	482	16.1	1.8	844
15	G37	N2614.20	E534.70	Daris 3A5	Gossan in V_2 (W:5m)	345	79	34.8	1,414	652	9.3	1.7	2,169
16	G38	N2614.20	E534.70	Daris 3A5	Spot-sample in silicified gossan in V_2	101	111	8.6	1,524	145	18.6	1.7	380
17	G41	N2626.35	E512.15	Mabrah North	Quartz network veins in V_{1-1} (W:50cm)	74	88	6.6	702	31	N.D.	N.D.	17
18	G42	N2626.35	E512.15	Mabrah North	Quartz network veins in V_{1-1} (W:60cm)	111	77	14.2	249	32	1.0	N.D.	10
19	G46	N2627.00	E509.45	Qulayyhah	Gossan and network veins in SD (W:60cm)	89	38	36.9	240	24	N.D.	N.D.	19
20	G47	N2627.00	E509.45	Qulayyhah	Gossan and network veins in SD (W:60cm)	73	44	45.5	159	18	N.D.	N.D.	17
21	G48	N2627.00	E509.45	Qulayyhah	Spot-sample in silicified gossan in SD	69	69	47.1	209	22	N.D.	N.D.	14
22	G71	N2639.55	E494.85	Ghuzayn Weat	Network quartz veins in limestone (UmR)	27	501	7.8	196	23	N.D.	N.D.	10
23	G72	N2633.95	E510.25	Fardah	Gossanized sediments with Mt in V_{1-2}	161	13,545	0.6	17	6	1.0	N.D.	Tr.
24	G74	N2634.05	E510.95	Fardah	Gossanized sediments in V_{1-2}	31	12,565	8.5	22	15	Tr.	N.D.	Tr.
25	S03a	N2635.40	E500.55	Ghuzayn East	Gossanized quartz veins in V_{1-2}	91	50	18.3	25	16	N.D.	N.D.	Tr.
26	S03b	N2635.40	E500.55	Ghuzayn East	Gossanized quartz veins in V_{1-2}	409	418	6.4	2,928	47	N.D.	N.D.	Tr.
27	S04	N2635.45	E500.60	Ghuzayn East	Quartz vein with Cu oxide in V_{1-2}	55	153	6.0	5,382	19	N.D.	N.D.	Tr.
28	S06a	N2635.45	E501.10	Ghuzayn East	Gossanized quartz network in V_{1-2}	47	32	5.1	152	33	N.D.	N.D.	104
29	S06b	N2635.45	E501.10	Ghuzayn East	Gossanized quartz network in V_{1-2}	251	172	41.4	3,091	1,575	N.D.	N.D.	2,272
30	S07	N2635.35	E500.50	Ghuzayn East	Quartz vein with Cu oxide and Py in V_{1-2}	86	104	2.9	8,939	18	N.D.	N.D.	Tr.

Geology
SD :Sheeted-dyke Complex
V_{1-1} :Lower Extrusives 1
V_{1-2} :Lower Extrusives 2
V_2 :Middle Extrusives

Table II-2-2(2) Analytical data obtained on ore samples from outcrops.

Ser. No.	Sample No.	Coodinates		Location	Description of mineralization	Ore Assay							
		N (km)	E (km)			Cr ppm	Mn ppm	Fe_2O_3 %	Cu ppm	Zn ppm	Ag g/t	Au g/t	Pb ppm
31	S08	N2635.05	E501.95	Ghuzayn East	Quartz vein with Cu oxide and Py in V_{1-2}	27	174	5.0	12,088	33	N.D.	N.D.	Tr.
32	S09a	N2634.95	E501.35	Ghuzayn East	Quartz vein with Cu oxide and Py in V_{1-2}	32	84	1.1	2,331	10	N.D.	N.D.	Tr.
33	S09b	N2634.85	E501.45	Ghuzayn East	Silicifed basalt with Cu oxide and Py	162	136	2.6	167	11	N.D.	N.D.	Tr.
34	S10	N2635.30	E501.00	Ghuzayn East	Quartz vein with Cu oxide and Py in V_{1-2}	104	176	3.6	3,832	858	N.D.	N.D.	Tr.
35	S11	N2634.95	E501.20	Ghuzayn East	Gossan in V_{1-2}	22	75	2.9	633	80	N.D.	N.D.	10
36	S13	N2634.65	E501.95	Ghuzayn East	Quartz vein with Cu oxide and Py in V_{1-1}	30	67	3.8	5,355	14	N.D.	N.D.	Tr.
37	S14	N2634.30	E503.15	Ghuzayn East	Quartz vein with Cu oxide and Py in SD	54	292	4.0	1,366	193	N.D.	N.D.	Tr.
38	S15	N2633.05	E499.20	Ghuzayn Village	Silicifed rock in V_{1-2}	46	58	3.1	31	10	N.D.	N.D.	Tr.
39	S16	N2636.20	E491.15	Doqal	Gossan and veins in V_2	151	149	48.4	3,953	2,021	N.D.	N.D.	102
40	S17	N2632.55	E499.95	Ghuzayn Village	Gossanized silicifed rock in V_{1-2}	44	51	6.5	4,105	1,637	5.3	N.D.	63
41	S19	N2632.80	E499.50	Ghuzayn Village	Silicifed basalt with Cu oxide in V_{1-2}	234	266	7.0	12,260	17	0.8	N.D.	Tr.
42	S20	N2636.65	E491.65	Doqal	Gossan with Cu oxide in V_2	70	51	15.1	7,529	288	44.2	2.0	270
43	S21	N2636.45	E491.10	Doqal	Gossan with Cu oxide in V_2	31	80	11.2	3,523	205	40.8	0.8	17
44	S23	N2636.60	E491.10	Doqal	Gossanized quartz vein in V_2	17	91	2.2	246	20	9.4	N.D.	Tr.
45	S26	N2631.70	E513.40	Sanah	Gossanized conglomarate in e_2M_1	538	44	43.6	74	28	0.8	N.D.	17
46	S28	N2631.70	E513.55	Sanah	Gossanized conglomarate in e_2M_1	491	429	50.6	122	107	0.8	N.D.	23
47	S29	N2631.65	E513.50	Sanah	Gossanized conglomarate in e_2M_1	529	193	54.7	110	131	0.8	N.D.	17
48	S30	N2635.05	E498.75	Ghuzayn Gossan	Siliceous gossan in V_{1-2}	105	67	46.0	233	103	2.0	0.8	23
49	S31	N2634.85	E498.80	Ghuzayn Gossan	Siliceous gossan in V_{1-2}	137	58	58.7	139	18	0.8	N.D.	74
50	S32	N2634.85	E498.80	Ghuzayn Gossan	Chalcedony in V_{1-2}	83	32	1.9	122	6	0.8	N.D.	Tr.
51	S33	N2631.75	E513.55	Sanah	Limonitized argillized rock in e_2M_1	613	339	19.2	81	110	N.D.	N.D.	28
52	S35	N2634.05	E511.00	Fardah	Chalcocite or pyrolusite in V_{1-2}	13	N.D.	4.7	93	31	N.D.	N.D.	17
53	S36	N2634.15	E511.05	Fardah	Gossanized conglomarate in e_2M_1	747	1,097	76.4	53	122	N.D.	N.D.	34
54	S37	N2634.05	E511.00	Fardah	Gossan in e_2M_1	628	5,337	81.7	79	182	N.D.	N.D.	28
55	S38	N2634.15	E511.05	Fardah	Limonitized argillized rock in e_2M_1	333	574	5.8	22	35	4.0	0.5	17
56	S40	N2614.25	E534.85	Daris 3A5	Chalcocite or pyrolusite in V_2	142	N.D.	0.8	546	21	Tr.	N.D.	N.D.

Geology
SD :Sheeted-dyke Complex
V_{1-1} :Lower Extrusives 1
V_{1-2} :Lower Extrusives 2
V_2 :Middle Extrusives



LITHOLOGY
QUATERNARY

	Wadi sediments and Sub-recent alluvial fans;terraces
Qgx	Ancient alluvial fans;terraces

SAMAIL OPHIOLITE
Samail Volcanic Rocks

V₁₋₂	Lower extrusives 2
V₁₋₁	Lower extrusives 1

Sheeted-dyke complex

SD	Sheeted dykes;dolerite

Cumulate Sequence

CIG	Cumulate layered gabbro

Intrusives

Gu'	Uralitic Gabbro
P'	Peridotite

MINERALIZATION

Gossan

Silicified or argillized zone

Other symbols

● S15 Sample location

Ghuzayn village

Road

Wadi

Fig.II-2-5 Mineral showing of Ghuzayn Village in Area A.

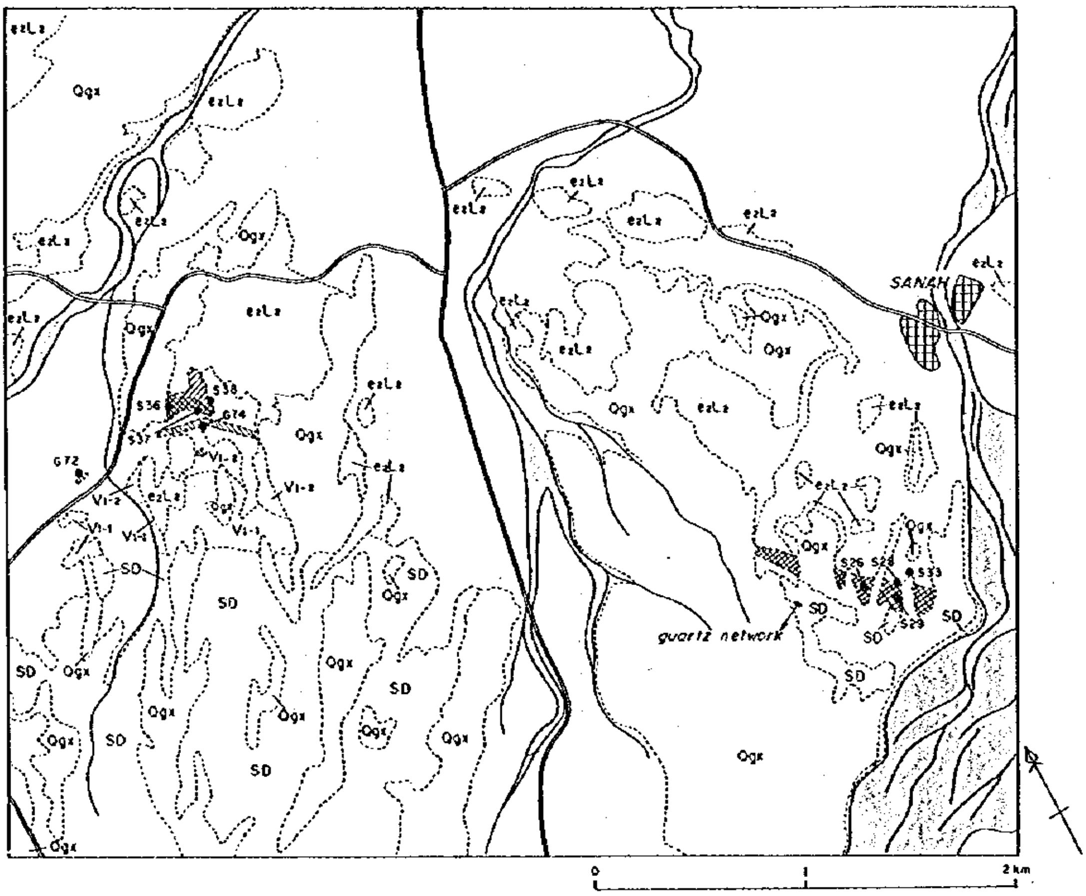
Table II-2-3 Rocks and mineral assemblages of samples determinate by X-ray diffraction.

Ser. No.	Sample No.	Coodinates N (km)	Coodinates E (km)	Location	Description	Qz	As	Pl	Fl	Px	Tr	Ch	Gy	Cc	Do	Ja	Al	Ka	Ha	Mm	Hm	Go
1	G23	N2608.70	E540.20	Daris West	Gossanized silicifed rock in SD	◎																•
2	G24	N2608.70	E540.20	Daris West	Sil. and ep. dorelite in SD	◎						◎										
3	G31	N2611.70	E532.15	South of 3A5	Sil. and ep. dorelite in SD	◎						●										
4	G32	N2611.70	E532.15	South of 3A5	Sil. and ep. dorelite in SD	◎						●										
5	G44	N2626.35	E512.15	Mabrah North	Sil. basalt in V_{1-1}	◎															●	•
6	G53	N2634.65	E498.90	Ghuzayn	Basaltic pillow lava of V_{1-1}	◎			◎			•										
7	G55	N2634.65	E498.85	Ghuzayn	Massive lava of V_{1-2}			??		??		◎										
8	G57	N2634.85	E498.80	Ghuzayn	White argillized rock in gossan												◎		●			
9	G58	N2634.80	E498.80	Ghuzayn	Epidotozed pillow lava of V_{1-2}		◎														●	
10	G59	N2634.85	E498.85	Ghuzayn	White argillized rock in gossan			??		??		•										
11	G60	N2634.85	E498.85	Ghuzayn	Yellow argillized rock in gossan	●																◎
12	G61	N2634.85	E498.85	Ghuzayn	Red argillized rock in gossan						◎										●	
13	G62	N2634.85	E498.85	Ghuzayn	Black argillized rock in gossan	◎					●										◎	
14	G63	N2635.15	E498.90	Ghuzayn	White argillized rock in gossan		◎										◎		●			
15	G64	N2636.85	E502.60	Ghuzayn	Massive lava of V_2	◎			◎													
16	G73	N2634.05	E510.95	Fardah	White argillized clays in V_{1-2}							•	●	◎								
17	S12	N2634.95	E501.20	Ghuzayn East	Kaolinized basalt in V_{1-2}	◎			◎			•										
18	S18	N2632.55	E499.95	Ghuzayn Village	Argillzed rock in V_{1-2}	◎	•					•				●						
19	S27	N2631.75	E513.55	Sanah South	Limonitized and argillzed rock	●												◎			•	
20	S32	N2634.85	E498.80	Ghuzayn	Chalcedony in V_{1-2}						◎										•	
21	S39	N2614.20	E534.85	Daris 3A5	Dolomite										◎							
22	S41	N2614.20	E534.85	Daris 3A5	Altered basalt of V_2									•						◎		

Abbreviation;
Qz:Quartz
As:Amorphous silica
Pl:plageoclase
Fl:Feldspars
Px:Pyroxenes
Tr:Tridymite
Ch:Chlorite(Clinochlore)
Gy:Gypsum
Cc:Calcite
Do:Dolomite
Ja:Jarosite
Al:Alunite
Ka:Clays-Kaolinite
Ha:Halite
Mm:Montmorillonite
Hm:Hematite
Go:Goethite

Quantity of minerals
◎:Major
●:Minor
•:Traces
??:Uncertain minerals

Geology
SD :Sheeted-dyke Complex
V_{1-1}:Lower Extrusives 1
V_{1-2}:Lower Extrusives 2
V_2 :Middle Extrusives



LITHOLOGY
QUATERNARY

(blank box)	Wadi sediments and Sub-recent alluvial fans;terraces
Qgx	Ancient alluvial fans;terraces

TERTIARY

e_2L_2	Upper nodular limestone

SAMAIL OPHIOLITE
Samail Volcanic Rocks

V_{1-2}	Lower extrusives 2
V_{1-1}	Lower extrusives 1

Sheeted-dyke complex

SD	Sheeted dykes;dolerite

MINERALIZATION

Gossan

Argillized zone

Gossanized metalliferous sediments

Other symbols

● S36 Sample location

Road

Wadi

Fig.II-2-6 Mineral showing of Fardah and Sanah in Area A.

The Fardah mineral showing is located near the Fardah village, 12 km east of Ghuzayn gossan. The mineral showing detected in the lower extrusives 1 (V1-1) and 2 (V1-2) of lower volcanic rocks (V1) is shown Fig. II-2-6. Gossanized metalliferous sediments and argillized clays are observed in the area. Gossan is 10 m in width and more than 700 m in length. Ore minerals shown in Table II-2-1 consist of great amount of goethite and hematite. Ore assays results are shown in Table II-2-2 indicating maximum values of 93 ppm Cu, 182 ppm Zn, 4.0 g/t Ag and 0.5 g/t Au. Altered minerals shown in Table II-2-3 consist of chlorite, gypsum and calcite.

The Sanah mineral showing is located near the Sanah village, 15 km east of Ghuzayn gossan. Gossanized zone of the mineral showing is seen in the lowest conglomerate formation (e2M1) of the Tertiary deposits as shown in Fig.II-2-6. Gossan is 10 m in width and more than 900 m in length. The mineralized zone is extended along the E-W direction. Ore assays shown in Table II-2-2 indicate maximum values of 122 ppm Cu, 131 ppm Zn and 0.8 g/t. Altered minerals shown in TableII-2-3 consist of quartz, halite and hematite.

The Qulayyah mineral showing is located south of Qulayyah village in the south east of the area. The mineral showings consisting of gossan and quartz veins are seen in the sheeted-dyke complex. Gossanized quartz veins are 10 m in width and more than 80 m in length. The quartz vein is 60 cm in width, striking N60W and dipping 90 degrees. Ore minerals shown in Table II-2-1 consists of great amount of goethite. Ore assays shown in Table II-2-2 show maximum values of 240 ppm Cu and 24 ppm Zn

2-3-3 Survey results in Area B

(1) Geologic setting

The area B is located in the central part of the central Batinah coast area as shown in Fig. 2. The geologic map and profile of the area B are shown in Fig. II-2-7 and Plate II-2-2.

The Samail ophiolite is distributed in south of the area along the NW-SE direction. It consists of tectonite (TH), cumulate sequence (C), high level gabbro (HG), sheeted-dyke complex (SD) and Samail volcanic rocks (SV).

The supra-ophiolite sediments (BO) are widely distributed in the north of Samail ophiolite. The Tertiary deposits are widely distributed in the area along NW-SE direction while the Quaternary deposits are widely covering the area.

(2) Distribution of ore-forming horizon

Two horizons of the Samail volcanic rocks (SV) are distributed in the south of the area along W-NW to E-SE direction. The lower volcanic rocks (V1) related to the ore horizons are distributed in the Mabrah west, Buwayrik east, Falaj as Salidi north and Daris areas.

Sheeted-dyke complex (SD) and lower extrusives 1 (V1-1) of the lower volcanic rocks are distributed in the Mabrah west area, which concurs with the section B of Fig.II-2-3. On these bases, this area does not present potential for Lasail type massive sulphide ore deposits.

In the Buwayrik east area, sheeted-dyke complex (SD), lower extrusives 1 (V1-1), lower extrusives 2 (V1-2) and lower metalliferous sediments (U1) of the lower volcanic rocks and middle extrusives (V2) of the middle volcanic rocks are seen distributed. This area, which corresponds to the section B of Fig.II-2-3, does not represent any economic target for the existence of Lasail type massive sulphide ore deposits. However, Daris 3A5 prospect which is located in the middle extrusives (V2) of the middle volcanic rocks bears massive sulphide (OMCO,1993).

In the Falaj as Salidin north area, it is seen distributed sheeted-dyke complex (SD), lower extrusives 1(V1-1) and lower extrusives 2 (V1-2) of the lower volcanic rocks and middle extrusives (V2) of middle volcanic rocks. This area corresponds to the sections A, B and C shown Fig.II-2-3, however, most of the lower extrusives 2 (V1-2) are eroded away in the area. The middle volcanic rocks overlie the area. Accordingly, no potential for Lasail type massive sulphide ore deposits can be expected in the area.

In the Daris area, sheeted-dyke complex (SD), lower extrusives 1 (V1-1) and extrusives 2 (V1-2) of the lower volcanic rocks and middle extrusives (V2) of middle volcanic rocks are distributed. The area corresponds to the section A shown in Fig.II-2-3. This area, where the Daris prospect is also located, includes Lasail type massive sulphide. Accordingly, there exists good indications for finding a promising potential for finding Lasail type massive sulphide ore deposits in the area.

(3) Mineralization

In the area B, the previous known prospects are Buwayrik, Daris 3A5, Daris west and Daris. However, mineralizations are existing only in Daris 3A5 and Daris. Other mineralization is located southwest of the Daris 3A5. Three mineral showings are explained in Chapter 3.

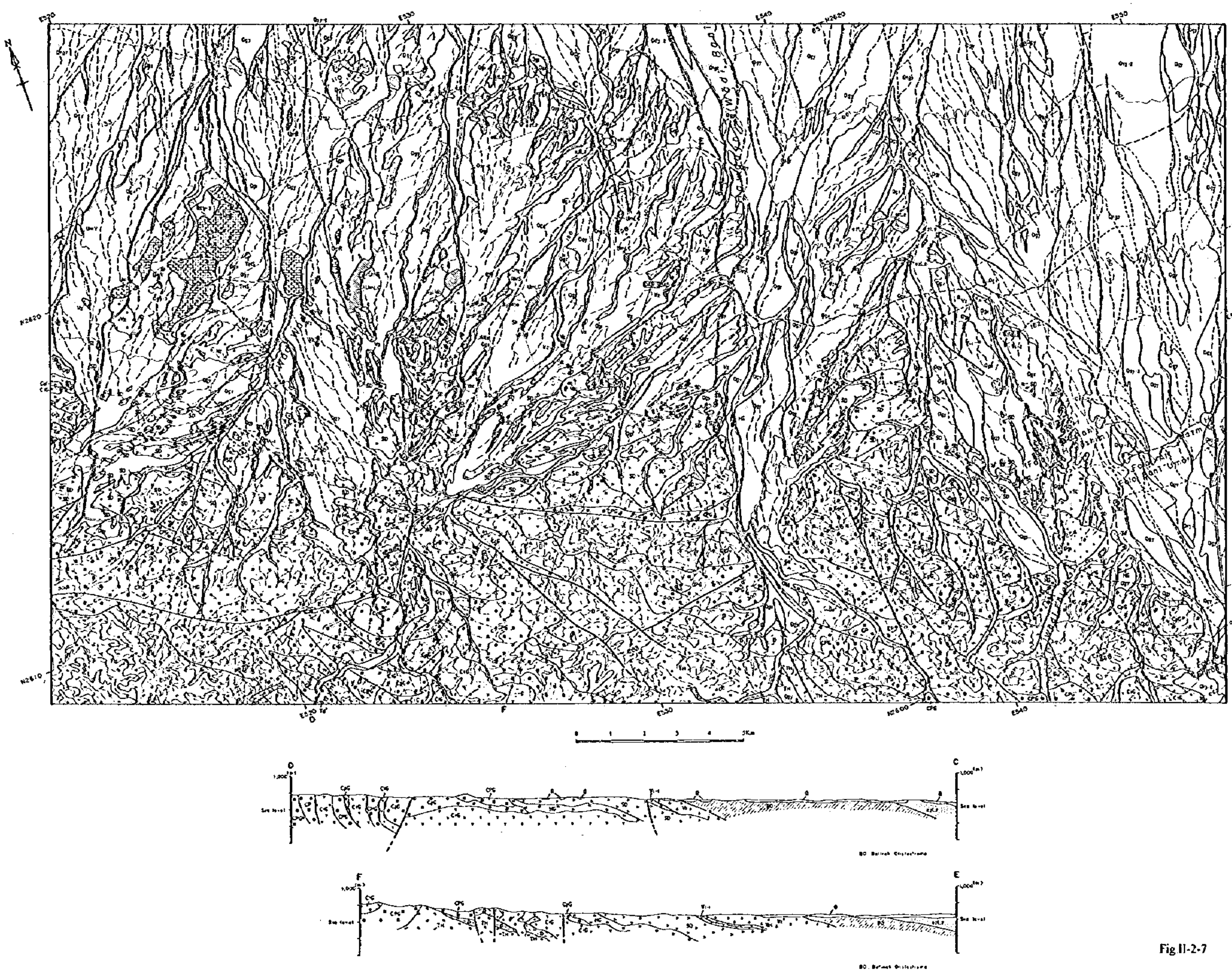
2-3-4 Survey results in Area C

(1) Distribution of geologic units

The area C is located in the east part of the central Batinah coast area as shown Fig. 2. The geology and profile map of the area C is shown Fig. II-2-8 and PlateII-2-3.

The Samail ophiolite is distributed in the south of the area along the E-W direction.

Another ophiolite is distributed northwest of the area. It consists of tectonite (TH), cumulate sequence



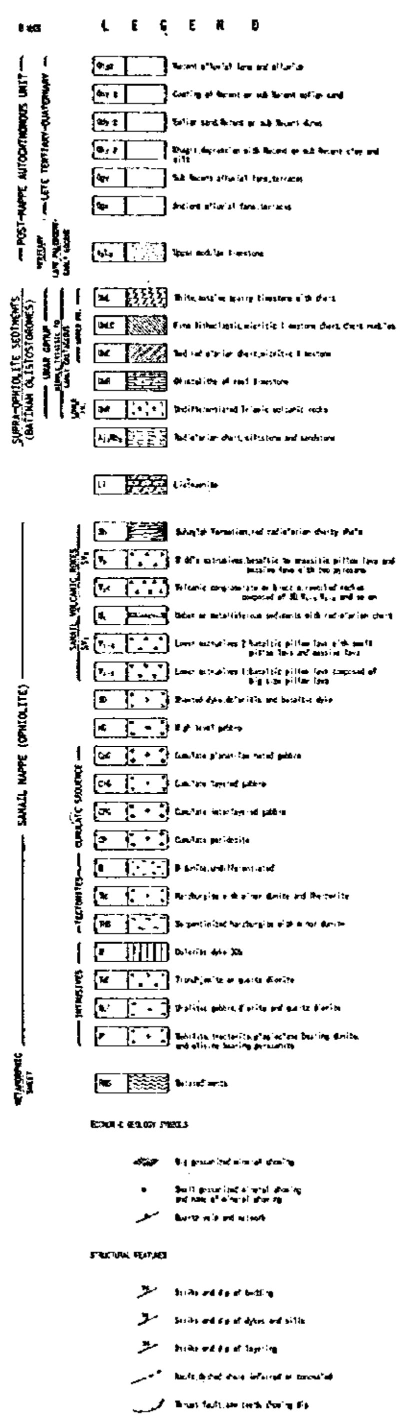


Fig II-2-7 Geologic map, profile and Mineral showings of Area B.

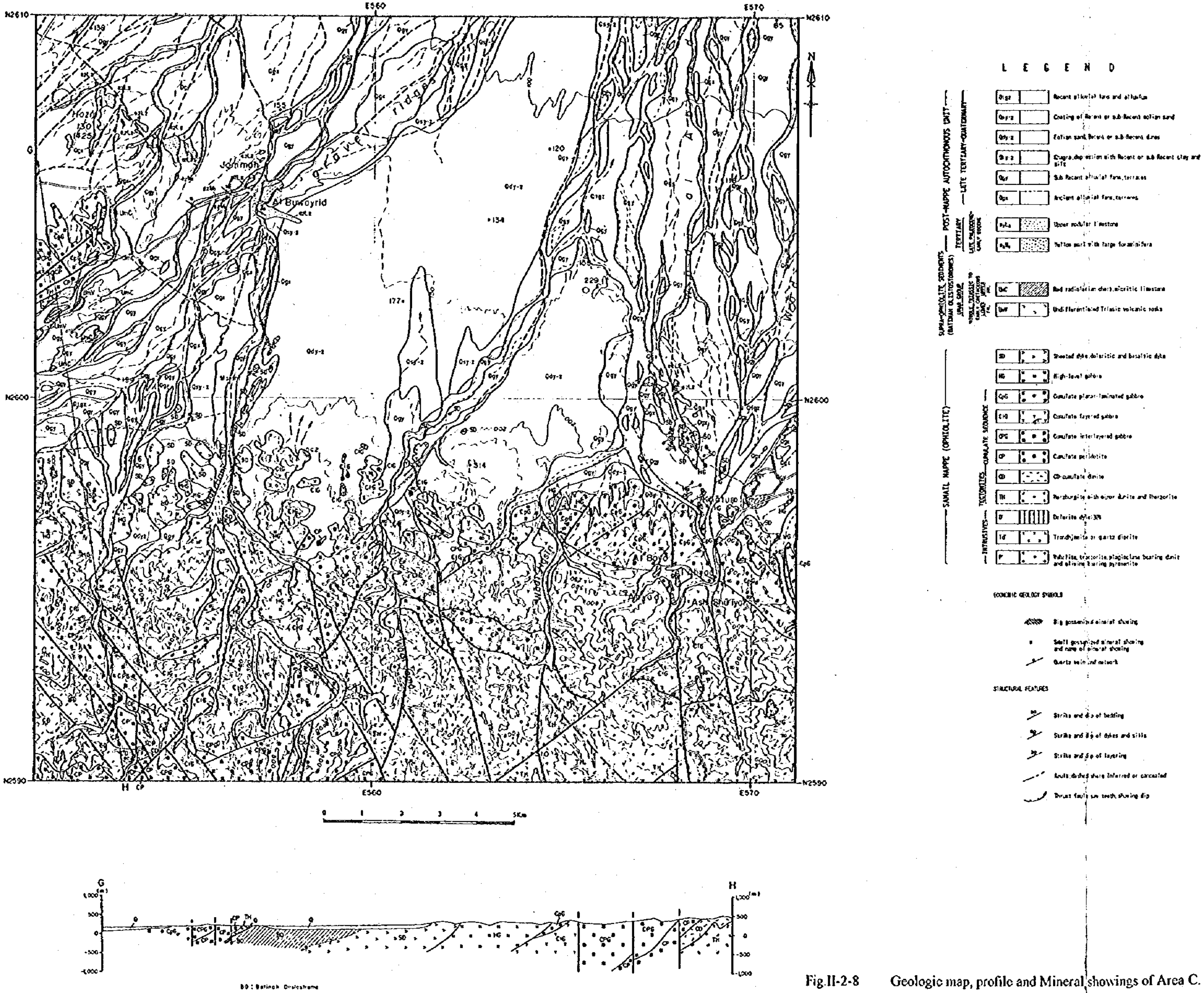


Fig.II-2-8 Geologic map, profile and Mineral showings of Area C.

(C), high level gabbro (HG), sheeted-dyke complex (SD) and Samail volcanic rocks (SV).

The supra-ophiolite sediments (BO) are distributed west of the area.

The Tertiary deposits are distributed from northwest to southeast in the area.

The Quaternary deposits are found widely covering the area.

(2) Distribution of ore-forming horizon

Samail volcanic rocks (SV) unit is not distributed In the area. The area correspond to the section C shown in Fig.II-2-3. Accordingly, no potential for Lasail type massive sulphide ore deposits are expected in the area.

(3) Mineralization

Mansul mineral showing is located near Mansul village in the west part of the area in the sheeted-dyke complex. It consists of gossan and network quartz. Two network quartz are seen striking N55°W and dipping 90°. The veins are 20 m in length. The ore minerals shown in Table II-2-1 consist of chalcopyrite, covelin, digenite, chalcocite, malachite and geothite. Ore assays shown in Table II-2-2 show maximum values of 1,734 ppm Cu, 25 ppm Zn and 2.0 g/t Ag.

2-4 Relation between Significant Magnetic Contact zone and Geology

World Geoscience Co.(1993) performed airborne magnetic survey in the area. Significant magnetic zones were drawn from the area. Target areas are shown Table II-2-4 on the basis of the result of the geophysical survey. The relation between significant magnetic contact zones and geology in twelve areas are explained below.

The area A includes Doqal, Ghuzayn, Ghuzayn west, Mashin, Fardah, Mushayq and Qulayyah areas. The area B includes Buwayrik, Wadiyah and Daris areas. The area C includes Buwayrik, Wadiyah and Daris areas.

The seven target areas in the area A are Doqal, Ghuzayn, Ghuzayn west, Mashin, Fardah, Mushayq and Qulayyah areas.

(1) Doqal area

The area is located south of Doqal village in the area. In this area, lower volcanic rocks and middle volcanic rocks are distributed. West magnetic contact zones are distributed crossing the geologic boundary, being part of them located east of trondhjemite body. In the east of the area, the magnetic zones are distributed

Table II-2-4 Target areas for VSM Exploration in Regional survey areas.

Area	Dominant Contacts	Outcrop	Known Mineralization	Priority
Area A				
Doqal	Vbm/Vba, NS	Poor	None	Moderate
Ghuzayn	Vbm/Vba, NW, NS	Negligible	Ghuzayn	Very high
Ghuzayn West	Vbm/Vbn, NW	Nil	None	Moderate
Mashin North	VbM/Vb, NW	Moderate	None	Moderate
Fardah	VbM/Vbn, NE, NW	Moderate	None	Moderate
Mushayq	VbM/Vbn/Vb, various	Very poor	None	Moderate
Qulayyah	VbM, NS, NW	Very poor	None	Low
Area B				
Buwayrik	VbM/Vbn, WNW	Reasonable	Minor Gossans only	Moderate
Wadiyah	Vbm/Vbn, WNW	Reasonable	None	Moderate
Daris	Vbm/Vbn, NW	Negligible	Daris	High
Area C				
Mansur	Vbn/VbM/Vb/Vbm, various	Negligible	None	Low
Khatum West	Vbm/Vb	Nil	None	Low

From World Geoscience Co., Ltd. (1992)

cutting the geologic boundary or parallel to it. In this area, silicified gossan and stockwork are observed in the middle volcanic rocks and extended along north-south direction.

(2) Ghuzayn area

Lower extrusives 1 (V1-1) and lower extrusives 2 (V1-2) of the lower volcanic rocks as well as the middle volcanic rocks are found distributed in the area. The magnetic contact zones are distributed north-south crossing the geologic boundary and particularly, the west magnetic contact zones are seen where the gossan is located. Silicified gossan and argillized zone are existing on the surface, however, low grade massive sulphide seems to be existing underground.

(3) Ghuzayn west area

Lower extrusives 1 (V1-1) and lower extrusives 2 (V1-2) of the lower volcanic rocks as well as middle volcanic rocks are found distributed in this area. The north magnetic contact zone is distributed parallel to the geologic boundary between the lower volcanic rocks and the middle volcanic rocks, while the south magnetic contact zone is found distributed in the lower extrusives 2 of the lower volcanic rocks. Gossanized basalt crops out at the boundary between the lower extrusives 1 and 2 in the south of the magnetic contact zone.

(4) Mashin area

In this area is located Ghuzayn east area which is the area selected for geophysical exploration survey. In the area, the lower extrusives 1(V1-1) and 2(V1-2) of the lower volcanic rocks and middle volcanic rocks are distributed. Three magnetic zones were distributed along the northwest-southeast direction which cross the geologic boundary and extended from the sheeted-dyke complex to the middle volcanic rocks. In the magnetic contact zones, alteration zone including epidotization and silicification are developed.

(5) Fardah area

The area is located near the Fardah village. Lower extrusives 1(V1-1) and 2(V1-2) of lower volcanic rocks are distributed in this area. Two magnetic contact zones were detected distributed parallel to the geologic boundary, especially the north magnetic zone is seen distributed in the geologic boundary between the lower volcanic rocks and the Tertiary formation and running parallel to the geologic boundary between the lower extrusives 1 and 2 of the lower volcanic rocks. Newly observed gossan is located at this north magnetic contact zone. On the other hand, the south magnetic contact zone is seen distributed parallel to the geologic boundary between the sheeted-dyke complex and the lower volcanic rocks.

(6) **Mushayq area**

Olistoliths of volcanic rocks of Umar group and Tertiary formation are distributed in this area. The magnetic contact zones are distributed along the east-west direction in the area.

(7) **Qulayyah area**

Lower extrusives 1 and 2 of the lower volcanic rocks and Batinah Olistostrome are distributed in this area. The magnetic contact zones are distributed not only in the area that includes the Batinah Olistostrome, but also at the geologic boundary between the middle volcanic rocks and the Batinah Olistostrome. In the south of the magnetic contact, gossan and stockwork quartz veins are developed in the sheeted-dyke complex and the middle volcanic rocks.

The three target areas in the area B are Buwayrik, Wadiyah and Daris areas.

(8) **Buwayrik area**

Sheeted-dyke complex and middle extrusives are distributed in this area. The magnetic contact zones were detected distributed parallel to the geologic boundary between them.

(9) **Buwayrik area**

Lower extrusives 1 (V1-1) of the lower volcanic rocks and middle volcanic rocks are distributed in this area. The magnetic contact zones are distributed at the geologic boundaries between the sheeted-dyke complex and the middle volcanic rocks and also distributed between the middle volcanic rocks and the Batinah Olistostrome. Daris 3A5 prospect including ore deposit is located at the top of the middle volcanic rocks.

(10) **Daris area**

In the area, the Daris ore deposit is located. The magnetic contact zone is distributed crossing the geologic boundary in the sheeted-dyke complex, the lower extrusives 1 (V1-1) and the lower extrusives 2 (V1-2) of the lower volcanic rocks and the middle volcanic rocks are distributed.

The two target areas in the area C are Mansul and Khatum west areas.

(11) **Mansul area**

In the area, the sheeted-dyke complex and the Batinah Olistostrome are distributed. The west part of the magnetic contact zones are distributed in the Batinah Olistostrome, whereas The east part of the magnetic contact zones are distributed in the sheeted-dyke complex. The stockwork quartz veins are located south of the east part of the magnetic contact zones.

(12) Khatum west area

Sheeted-dyke complex is distributed in this area. The detected magnetic zones are found distributed in the Recent or sub-Recent dunes of the Quaternary deposits.

Significant magnetic contact zones detected in the Areas A, B and C are seen parallel to the geologic boundary. Magnetic zones are also distributed cutting the boundary and also in the formations or the units. Regarding the relation between the mineralization and the significant magnetic contact zones, the mineralization, Ghuzayn ore deposit and Daris 3A5 ore deposit are located in the magnetic contact zones. Other mineral showings are also found outside of the magnetic contact zones. The above means that the significant magnetic contact zones are not always due to the mineralization process.

CHAPTER 3 SEMI-DETAILED GEOLOGICAL SURVEY

3-1 Objectives of the Survey

The objectives of the survey in the Ghuzayn, Buwayrik-Daris 3A5 and Daris-Daris west areas are to assist in the finding of new ore deposits by clarifying the geology and the mineralization of the surveyed areas. The survey was carried in the Area A, area B and area C , including the known prospects where the known ore deposits and mineral showings are located.

3-2 Survey Areas and Method

The Ghuzayn area is located in the Area A and covers an area of 50 km^2 in area. The Buwayrik-Daris 3A5 area and the Daris-Daris west area are located in the center of the area B and are 50km^2 each in area.

The route maps were made by using topographic maps at 1:10,000 obtained by making enlargements from 1:100,000 map. After the study of the existing data, the survey routes were selected in the areas where Sheeted-dyke Complex and Samail Volcanic rocks were distributed. Landsat image, air photos and existing data were also used for the geological survey. The results of survey including the existing data were compiled on the 1:10,000 maps.

3-3 Geological Survey Results

3-3-1 Ghuzayn area

(1) Stratigraphy

The geology and geological structure of Ghuzayn area was described below.

The stratigraphy of the survey area is shown in Fig. II-3-1. The geology of the area which is shown in Fig. II-3-2, Fig. II-3-3, Plate II-3-1 and Plate II-3-4 is composed of Samail ophiolite and Supra-ophiolite sediments of allochthonous Samail Nappe and Tertiary and Quaternary of post-nappe autochthonous Unit.

The Samail ophiolite in the area includes a sheeted-dyke complex, Samail volcanic rocks (SV) and intrusive rocks (I') from lower part of ophiolite.

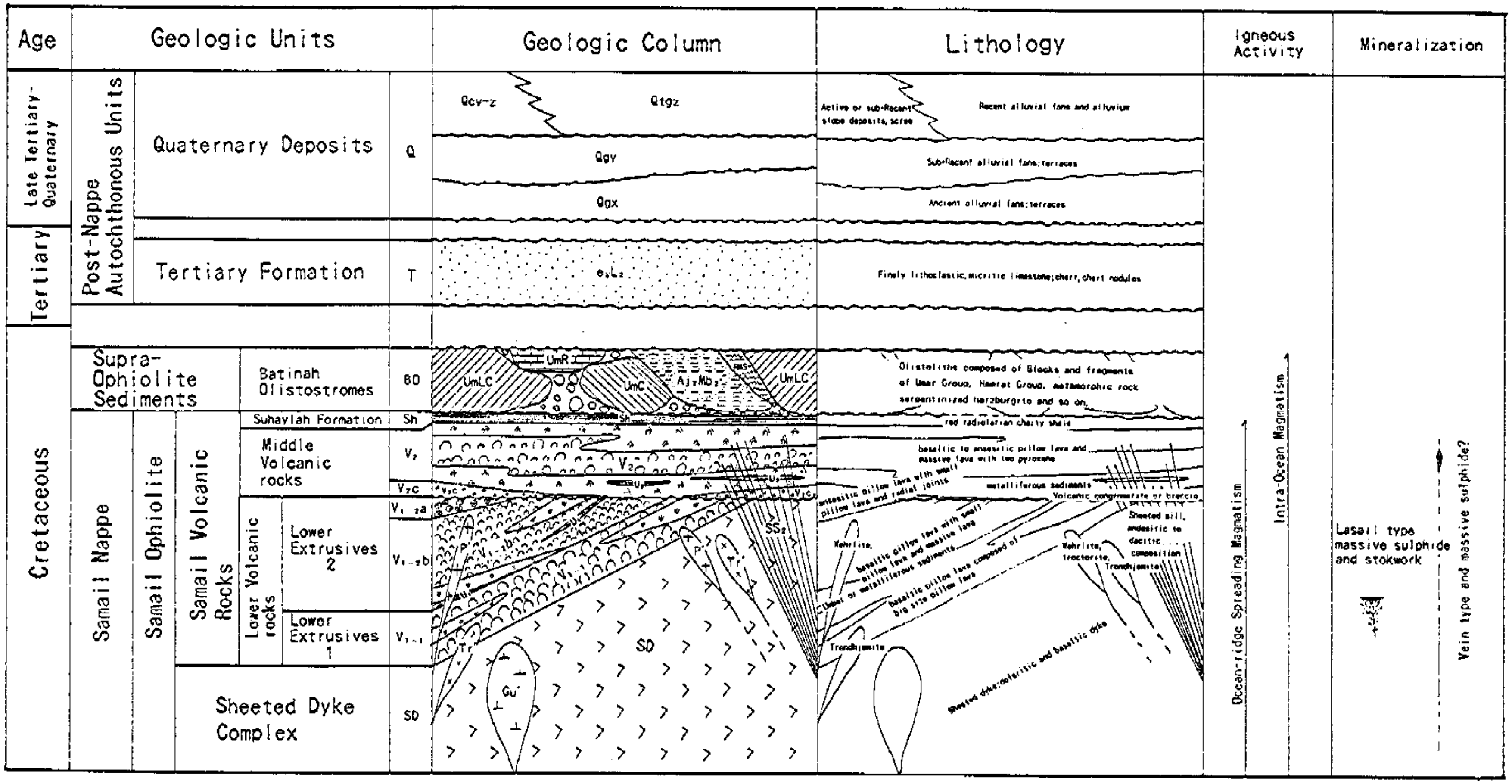


Fig.II-3-1 Stratigraphic Columnar Section of Semi-detail survey areas.

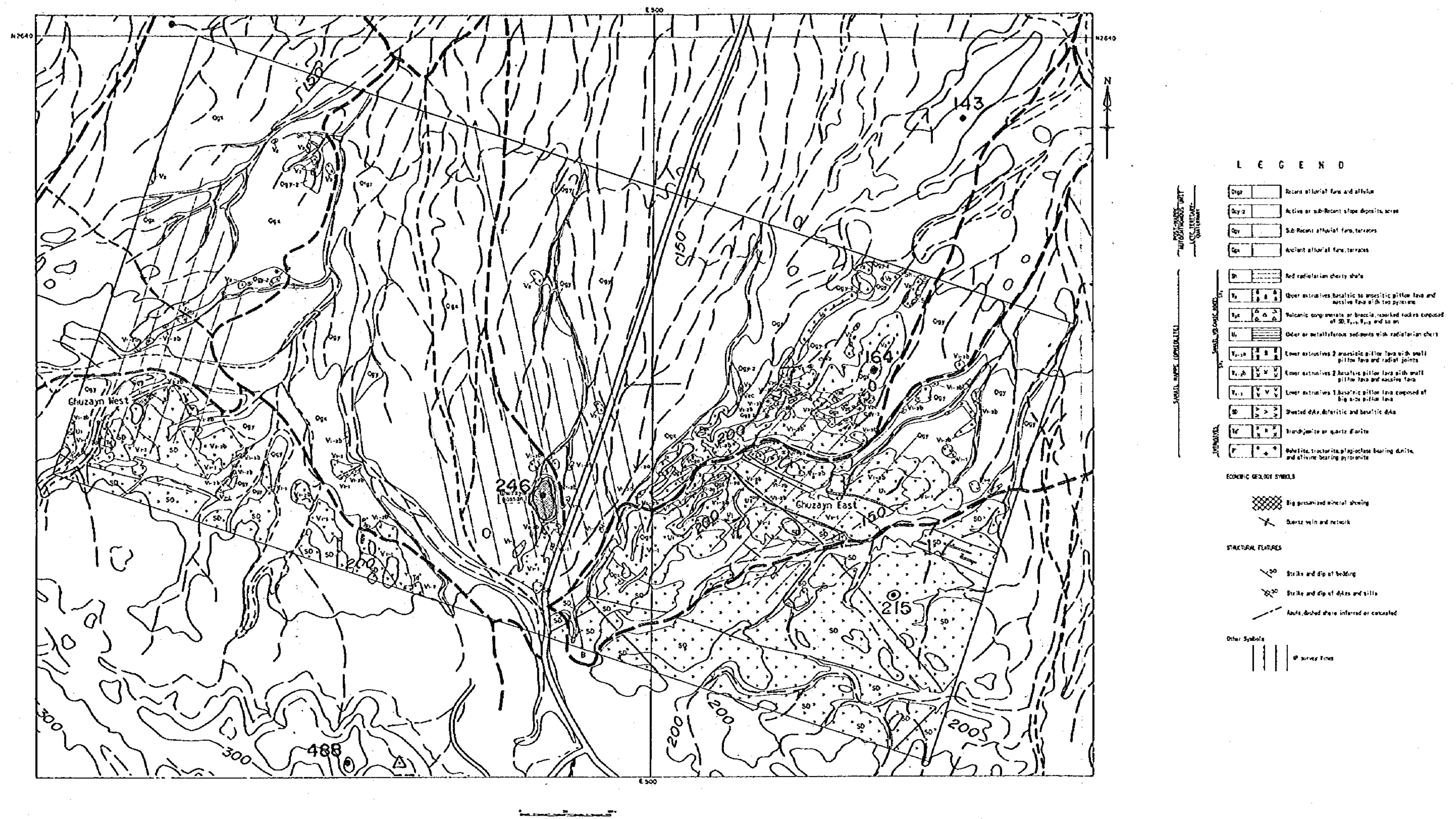


Fig.II-3-2 Geologic map and Mineral showings of Ghuzayn Area.

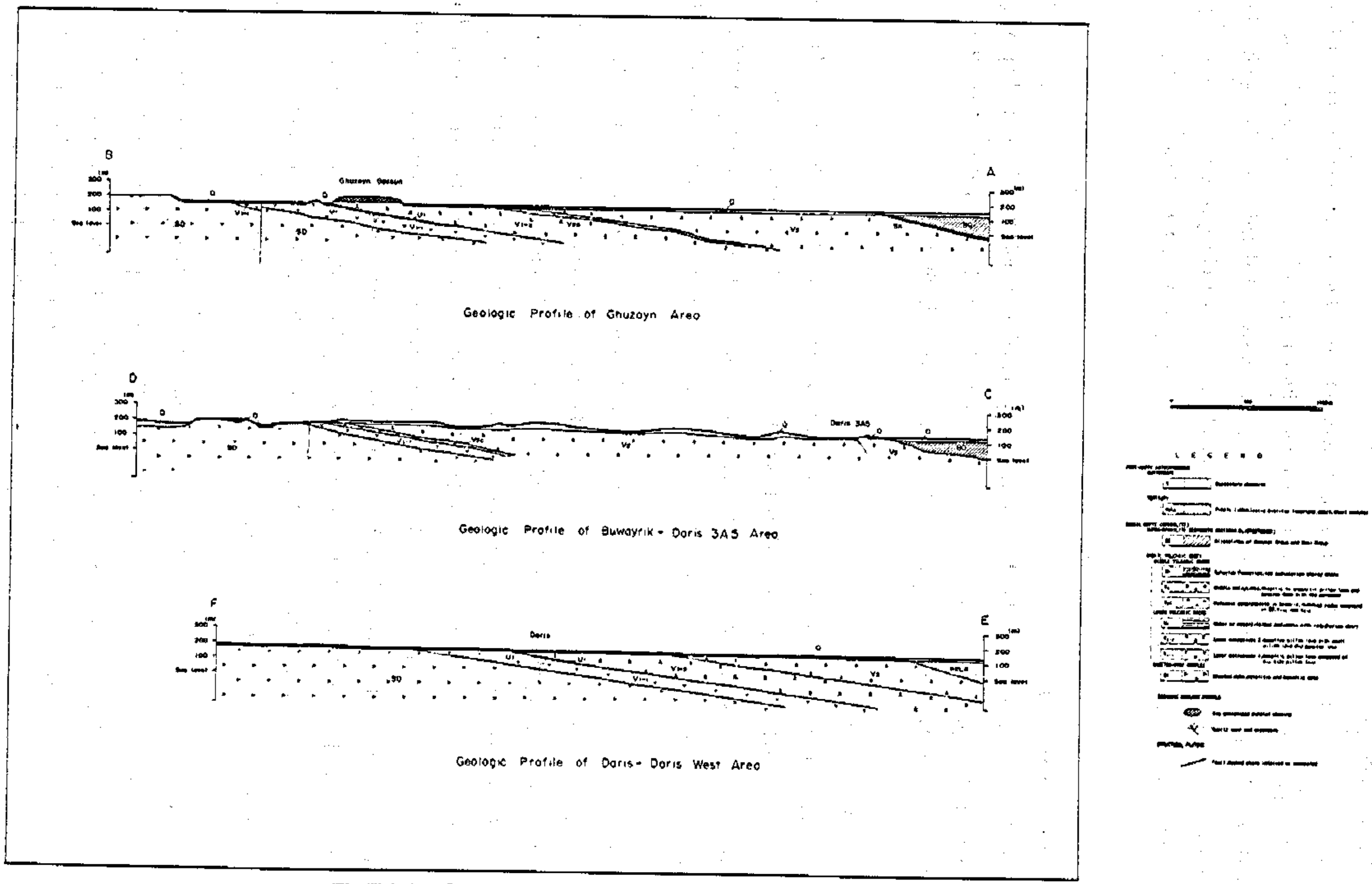


Fig.II-3-3 Geologic profile of Ghuzayn Area, Buwayrik-Daris 3A5 Area. and Daris-Daris West Area.

(a) Sheeted-dyke complex (SD)

In outcrops, the sheeted-dyke complex appears as a set of sub parallel dykes of 0.5 to 3 m thick and in general with 5 to 10 cm -wide chilled margins whose composition ranges from fine-grained gabbroic to doleritic rocks. As shown in TableII-3-1, the sheeted dykes consists of dolerite showing ophitic to intergranular textures and including primary minerals of plagioclase and clinopyroxene and accessory minerals of apatite and opaque minerals. Alteration minerals are composed of albite, chlorite, epidote and smectite.

(b) Samail volcanic rocks (SV)

The Samail volcanic rocks consist of lower volcanic rocks (SV1) and middle volcanic rocks (SV2). The lower volcanic rocks appear gradually at the top of the sheeted-dyke complex, while the middle volcanic rocks overlie unconformably the sheeted-dyke complex and the lower volcanic rocks.

i) Lower volcanic rocks (SV1)

The lower volcanic rocks consist of lower extrusives 1 (V1-1), lower extrusives 2 (V1-2) and lower metalliferous sediments (U1). The lower extrusives 1 (V1-1) and the sheeted-dyke complex bear a gradual relationship. The lower extrusives 2 conformably overlies the lower extrusives 1, while the lower metalliferous sediments are observed at the top of the lower extrusives 1 and/or are intercalated in the lower extrusives 2.

The lower extrusives 1 (V1-1) consists of differential basalt to andesite. It is composed mainly of 1.5 m to 2 m -size big pillow lavas in diameter, colored reddish brown. The lower extrusives 1 also consists of massive lavas, hyaloclastite and pillow breccia. The weathered surfaces of the pillow lavas show sharp cracks like a saw edge. The massive lavas show grey to brownish grey color and with a thickness of several 10 cm to several meters. The columnar joints are developed in the thick massive lavas. As shown in Table II-3-1, the pillow lavas are composed of basalt showing interstitial texture and including primary minerals of plagioclase, clinopyroxene and volcanic glass. Alteration minerals are composed of quartz, albite, chlorite, epidote, actinolite, pumpellyite, prehnite, calcite and smectite. The hyaloclastite consists of volcanic glasses. The alteration minerals are composed of quartz, albite, chlorite, epidote, actinolite, pumpellyite, prehnite, calcite, halite, smectite, hematite and opaque minerals. The rocks are strongly silicified.

The lower extrusives 2 (V1-2) consists of primitive basalt to andesite and composed of pillow lavas and massive lavas. The pillow lavas are big pillow lavas colored from light grey to purplish grey with sizes mainly of 10 cm to 1 m in size and with a maximum of 1.5 m in size. It is characteristic that the lower extrusives 2 includes small pillow lavas of 10 cm to 30 cm in size. The upper part of the lower extrusives 2 includes pillow lavas with radial fractures. The massive lavas show grey to brownish grey color and with thickness of several

Table II-3-1 Rocks and mineral assemblages of samples determinate by thin section.

Ser. No.	Sample No.	Coodinates		Location	Geologic Unit	Rock Name	Texture	Primary Minerals								Secondary Minerals																Remarks
		N (km)	E (km)					Qz	Pl	Cp	Op	Ol	Pi	Ap	OM	Qz	Ab	Am	Ch	Ep	Ac	Tr	Pu	Pr	Cc	Sp	Ha	Sm	Hm	Py	OM	
1	G01	N2606.70	E541.30	Daris	SD	Dolerite	Ophitic		◎	◎				●	◎		○		◎	●								●				
2	G02	N2605.80	E541.50	Daris	Tr'	Tonalite	Hypidiomorphic granular	○	◎					·			○		●	●				●								
3	G04	N2634.70	E496.95	Ghuzayn	P'	Plagioclase wehrlite	Cumulus		○	◎	●	◎	·		·				●		●	○				◎		●			·	
4	G08	N2613.95	E528.25	Buwairik	Tr'	Trondhjemite	Xenomorphic granular	○	◎					·		●	○		●	·											·	Sheared, cataclastic
5	G15	N2598.40	E568.75	Al Ghayl	G'	Gabbroic pegmatite	Granular		◎	●								◎	○	·	◎	·			·						·	Cpx → green amphibole
6	G16	N2594.85	E561.50	Al Ghayl	CIG	Clinopyroxene gabbro	Orth-cumulate		◎	◎							◎		·	·	○	●			·	·		·				
7	G50	N2634.05	E498.80	Ghuzayn	Dyke	Basalt	Ophitic		◎	○					·	●	◎		●	·				·	●			·			●	
8	G51	N2634.45	E498.85	Ghuzayn	V_{1-1}	Basalt (pillow lv.)	Intersertal		○	○						●			○	·			●	·	·			●			●	Glass(◎)
9	G52	N2634.65	E498.90	Ghuzayn	V_{1-1}	Hayaloclastite	Pyroclastic									○			○	●			●	◎	●		·	○	·			Fragments of Glass (◎)
10	G53	N2634.65	E498.90	Ghuzayn	V_{1-1}	Basalt (pillow lv.)	Intersertal		◎	●						○	○		·	·			·	●	●			●				Glass(○)
11	G54	N2634.65	E498.90	Ghuzayn	U_1	Radiorarian shale	Clastic									○			●					·	●			●	○		○	Radioraria (◎)
12	G55	N2634.65	E498.85	Ghuzayn	V_{1-2}	Basalt (massive lv.)	Intersertal		◎	·							◎		◎	●				●					●	●	○	Glass(○)
13	G56	N2634.80	E498.90	Ghuzayn	V_{1-2}	Basalt (pillow lv.)	Intergranular		◎	○							◎		●					●	●			●			·	Phenocryst of Cpx & Pl
14	G64	N2636.85	E502.60	Ghuzayn	V_2	Basalt (massive lv.)	Hyalo-ophitic		◎	◎	●				○		●		○									○				Phenocryst of Cpx., glass
15	G65	N2636.65	E502.45	Ghuzayn	V_2	Basalt (pillow lv.)	Hyalo-ophitic		◎	◎	·						●		●					●	○							Glass(◎), zeolite (◎)
16	G66	N2635.35	E501.55	Ghuzayn	V_{1-2}	Basalt (pillow lv.)	Intergranular		◎	◎					●		●		●	·					·			·	·			
17	G67	N2635.30	E502.20	Ghuzayn	V_{1-2}	Basalt (pillow lv.)	Intersertal		◎	●					·	·	●		●	●			●	●	●			·			·	Glass(●)
18	G68	N2634.90	E502.65	Ghuzayn	V_{1-2}	Basalt (pillow lv.)	Intersertal		◎	●					·	●	◎		·	·			●	○	●			·			·	Glass(○)
19	G69	N2634.95	E502.90	Ghuzayn	V_{1-1}	Basalt (pillow lv.)	Intersertal		◎	·						○	◎		·	●	·		●		●			·			●	Glass(●)
20	G70	N2634.60	E502.95	Ghuzayn	SD	Dolerite	Intergranular		◎	○					·		◎		●	●	●			●								
21	G75	N2594.65	E560.74	Al Ghayl	TH	Lherzolite	Granular			○	○	◎	●													○					·	

V_2 :Middle Volcanic Rocks, U_1:Metalliferous Sediments, V_{1-2}:Lower Extrusive 2,
V_{1-1}:Lower Extrusive 1, SD:Sheeted-dyke Complex, HG :High-level Gabbro,
CIG :Cumulate layered Gabbro, TH:Tectonized Harzburgite, Tr' :Trondhjemite,
P' :Peridotite, lv:lava

◎ :abundant ○ :common ● :rare · :very rare
Qz:Quartz, Pl:Plagioclase, Cp:Clinopyroxene, Op:Orthopyroxene, Ol:Olivine, Pi:Picotite,
OM:Opaque minerals, Ab:Albite, Am:Amphibole, Ch:Chrolite, Ep:Epidote, Ac:Actinolite
Tr:Tremolite, Pu:Pumpellyite, Pr:Prehnite, Cc:Calcite, Sp:Serpentine, Ha:Halite,
Sm:Smectite, Hm:Hematite, Py:Pyrite.

meters. Columnar joints are developed in the thick massive lavas. As shown in Table II-3-1, the pillow lavas are composed of basalt showing interstitial and intergranular textures and including primary minerals of plagioclase, clinopyroxene, apatite and volcanic glass. Alteration minerals are composed of quartz, chlorite, epidote, prehnite, calcite, smectite and opaque minerals. The rocks are weakly silicified.

The lower metalliferous sediments (U1) are composed of the so-called umber and includes many radiolarias as indicated in Table II-3-1 and shows dark brown color. Alteration minerals are composed of quartz, prehnite, calcite, smectite, hematite and opaque minerals.

ii) Middle volcanic rocks (SV2)

The Middle volcanic rocks (SV2) consist of volcanic conglomerate and breccia (V2c) , sheeted sills (SS2), middle extrusives (V2) and middle metalliferous sediments (U2).

The volcanic conglomerate and breccia (V2c) consist of angular to rounded matrices of sand to gravels and of fragments and blocks of sheeted dykes and lower volcanic rocks. The rocks unconformably overlie the sheeted-dyke complex and the lower volcanic rocks.

The sheeted sills (SS2) consist of dykes, sheets and sills of grey-colored andesite to dacite.

The middle extrusives (V2) consists mainly of pillow lavas and massive lavas of andesite including clinopyroxene and orthopyroxene. Most of the lavas are massive. Its weathered surface show the colors of grey, brownish grey, green, blueish grey, orange color, etc. Especially most of the chilled margin of lavas show orange color. The center of massive lavas show green and blueish grey colors. The lowest part of the massive lavas shows dirty brownish grey color composed of doleritic rock. The pillow lavas show purple, green and greenish grey colors. Most of the pillow lavas present irregular pillow shape and have sizes from 0.5 to 1.0 meters. As shown in TableII-3-1, the pillow lavas are composed of basalt showing hyalophitic texture and including primary minerals of plagioclase, clinopyroxene, orthopyroxene and opaque minerals. Alteration minerals are composed of quartz, albite, chlorite, epidote, pumpellyite, prehnite, calcite, smectite and opaque minerals. The rocks are weakly silicified.

The middle matalliferous sediments (U2) are composed of the so-called umber which includes many radiolarias and show brownish black colors.

iii) Suhaylaeh Formation (Sh)

This formation occupies the top of the Samail volcanic rocks and consists of reddish brown cherty shale which includes many radiolarias.

(c) Intrusive rocks (I')

The intrusive rocks include peridotite (P'), uralitic gabbro (Gu'), Trondhjemite (Tr') and late dolerite dykes.

(d) Supra-ophiolite Sediments (Batinah Olistostrome)

The sediments (BO) unconformably overlie the sheeted-dyke complex and the Samail volcanic rocks. The sediments are composed of olistoliths of Hamrat Duru group and Umar group.

(e) Post-nappe autochthonous units

These units consist of Tertiary and Quaternary deposits. The Tertiary deposits consist of yellow marl with large foraminifera (e2M1) and upper nodular limestone (e2L2) of late Paleocene to early Eocene. The Quaternary deposits consist of ancient alluvial fans (Qgx), sub-Recent alluvial fans (Qgy), active or sub-Recent slope deposits (Qcy-z), Khagra of depression with Recent or sub-Recent clay and silt (Qky-z) and Recent alluvial fans and alluvium (Qtgz).

(2) Distribution of geologic units

The Samail ophiolite consists of the sheeted-dyke complex, the Samail volcanic rocks and the Suhaylah formation.

The sheeted-dyke complex (SD) is distributed in the southwest end and the southeast part of the area. The distribution of the sheeted-dyke complex is interrupted at the Ghuzayn village.

The Samail volcanic rocks (SV) consist of the lower volcanic rocks and the middle volcanic rocks.

The lower extrusives 1 (V1-1) is distributed in the north part of the sheeted-dyke complex. In the west part of Ghuzayn village, it is distributed along the E-W direction. however, in the area from the north part to the northeast part of Ghuzayn village, it is distributed along a curve that goes to the north along east-west direction. At the north of Ghuzayn village, this unit is distributed by turning to the east.

The lower extrusives 2 (V1-2) overlies the lower extrusives 1. In the west of Ghuzayn village, it is distributed following a trending along E-W direction, however, in the area from north to northeast of Ghuzayn village, it is distributed by following a curve along a north direction. Around Ghuzayn village, this unit is distributed by following a curve to the east.

The lower metalliferous sediments (U1) are distributed at the south and east of Ghuzayn gossan. They exist at the boundary between the lower extrusives 1 and 2, and found intercalated in the lower extrusives 2.

The volcanic conglomerate and breccia (V2c) and the middle extrusives (V2) of the middle volcanic rocks as well as the Suhaylah formation are distributed south to north in the NE part of the area.

The intrusive rocks consist of peridotite (P') and trondhjemite (Tr'). The peridotite is distributed at the west of Ghuzayn village and forms small stocks, but the trondhjemite is distributed at the west of Ghuzayn village and forms dykes.

The Quaternary deposits are widely covering the area.

(3) Distribution of ore-forming horizon

The geological setting of the lasail type massive sulphide ore deposits is shown in Fig. II-2-3.

The hanging wall of the lasail type ore deposits are composed of the lower extrusives 2 of the Samail volcanic rocks, and therefore, the distribution of the lower extrusives 2 (V1-2) is very important for the exploration of the Lasail type massive sulphide deposits.

The lower extrusives 2 is widely distributed in the area. The area corresponds to the section A shown in Fig. II-2-3. Accordingly, there is a good possibility that Lasail type massive sulphide ore deposits are to be found in the area.

(4) Mineralization

In area Ghuzayn Area, the previous known mineralization is Ghuzayn gossan. Mineralizations newly observed are Ghuzayn east mineral showing and Ghuzayn west mineral showing.

The Ghuzayn gossan is located north of Ghuzayn village. As shown in Fig. II-3-4 and Fig. II-3-5, Ghuzayn gossan is distributed in the lower extrusives 2 (V1-2) of lower volcanic rocks (V1) and consists of silicified gossan and argillized zone. The gossan is about 400m in length, 100 m in width and 60 m high. The top of the mountain is made up by the silicified gossan, however, on the slop of the mountain, it is formed an argillized zone. Ore assays shown in Table II-2-2 indicate maximum values of 233 ppm Cu, 103 ppm Zn and 2.0 g/t Ag. Altered minerals shown in Table II-2-3 consist of quartz, tremolite, chlorite, alunite, halite, hematite and goethite in the argillized zone.

3-3-2 Buwayrik-Daris 3A5 area

(1) Distribution of geologic units

The geology of the area is shown in Fig. II-3-6, Fig.II-3-3, Plate II-3-2 and Plate II-3-4. The area is composed of the sheeted-dyke complex, the Samail volcanic rocks, the supra-ophiolite sediments and the Quaternary deposits. Outcrops from the Samail volcanic rocks are very few.

The sheeted-dyke complex (SD) is distributed in the south of the area.

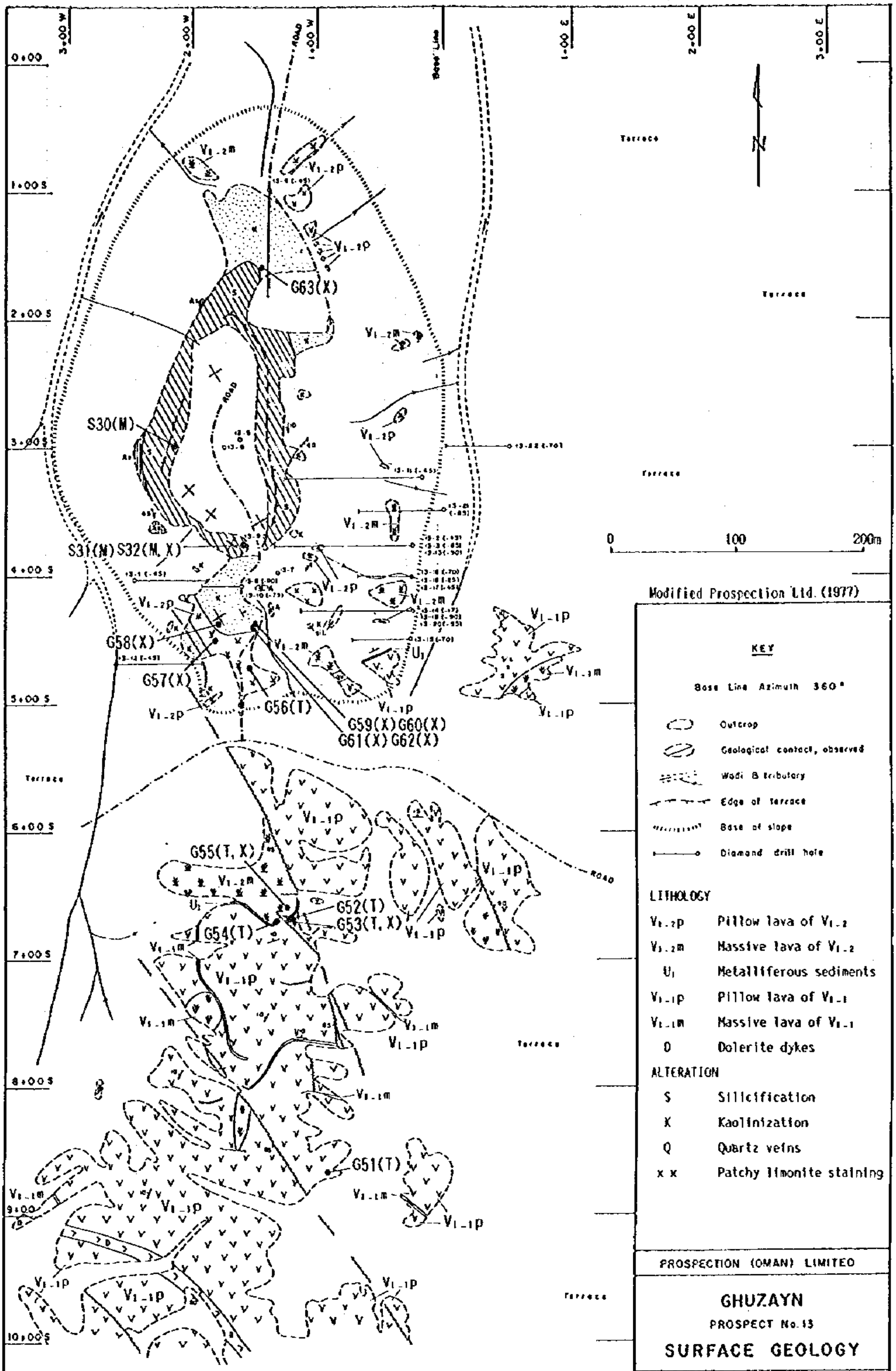


Fig.II-3-4 Geologic map and Mineral showing of Ghuzayn Gossan in Area A.

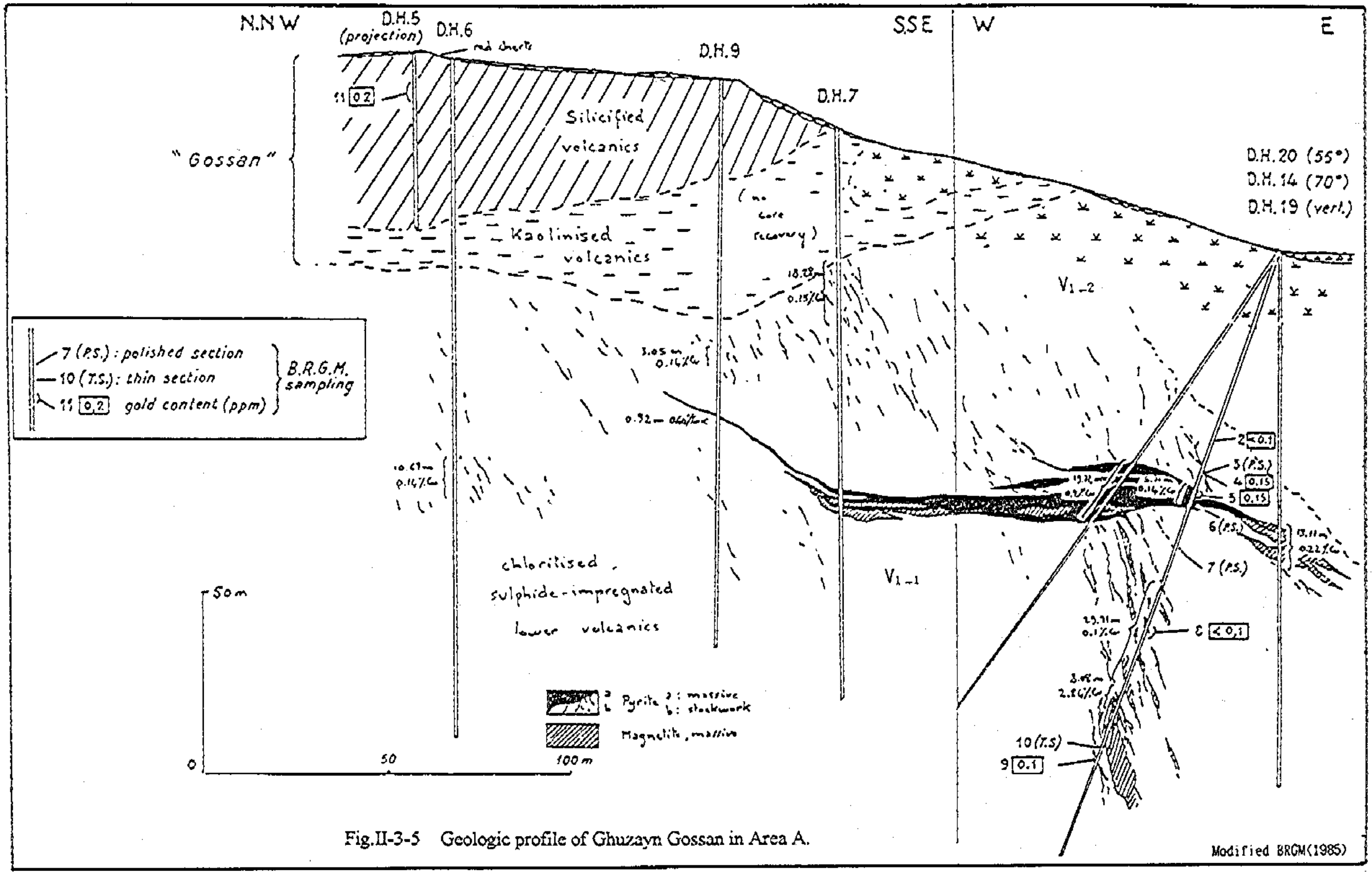


Fig.II-3-5 Geologic profile of Ghuzayn Gossan in Area A.

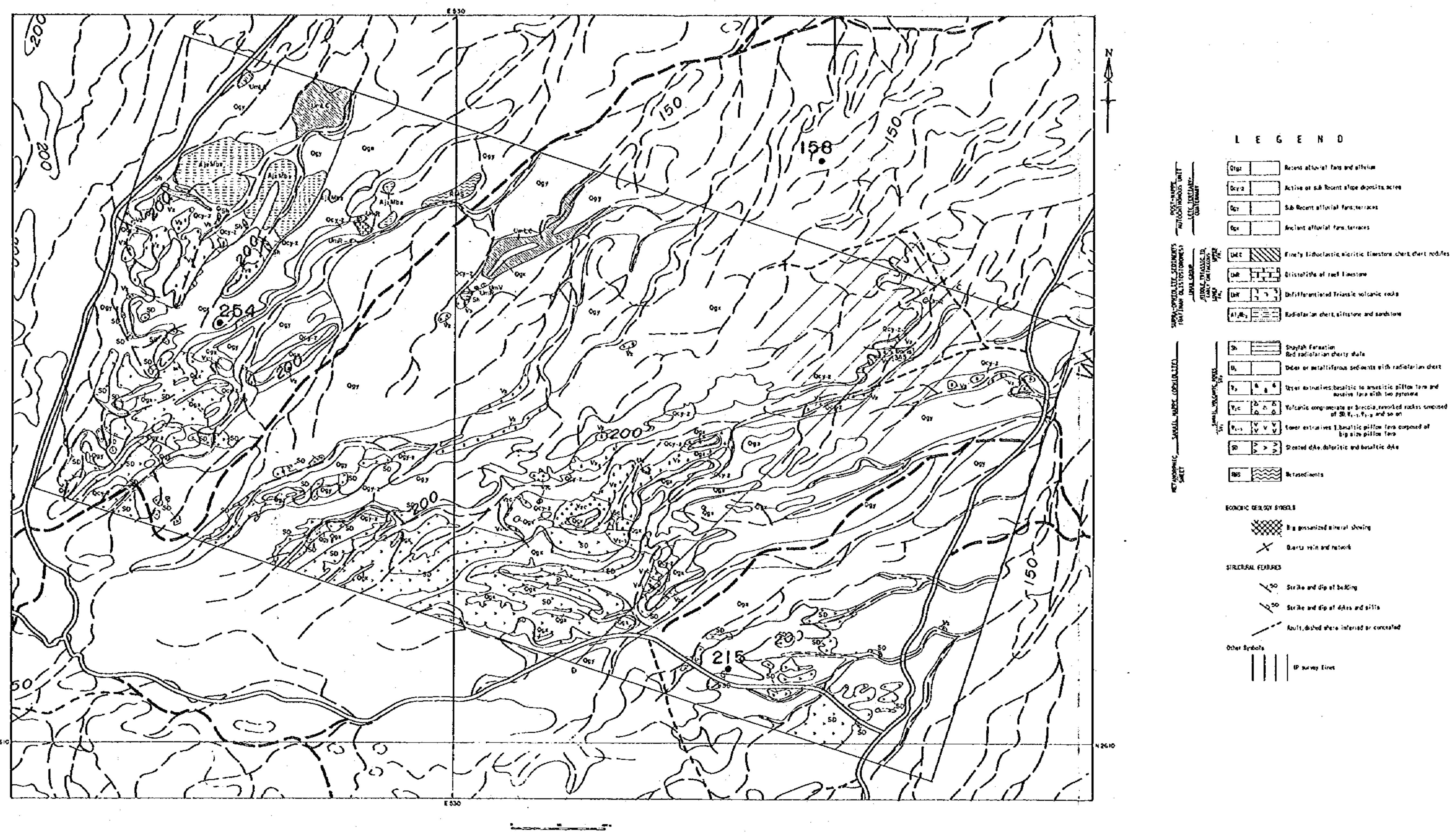


Fig.II-3-6 Geologic map and Mineral showings of Buwayrik-Daris 3A5 Area.

The Samail volcanic rocks (SV) consist of the lower volcanic rocks and the middle volcanic rocks.

The lower extrusives 1 (V1-1) of the lower volcanic rocks is distributed in the north of Buwayrik village and in the south of Daris 3A5 prospect.

The middle volcanic rocks consist of the volcanic conglomerate and breccia (V2c),the middle extrusives (V2) and the middle metalliferous sediments (U2).

The volcanic conglomerate and breccia (V2c) are distributed 3.5 km southeast of Daris 3A5 prospect. They unconformably overlie the lower extrusives 1 (V1-1). The middle extrusives (V2) is scattered in the west and the east of the area. The middle metalliferous sediments (U2) are distributed 3.5 km southwest of Daris 3A5 prospect and intercalated in the lower extrusives.

The Suhaylah formation is distributed in the northeast end of the area along the E-W direction.

The supra-ophiolite sediments (BO) are distributed in the north of the area.

The Quaternary deposits are widely covering the area.

(2) Distribution of ore-forming horizon

Geological setting for the Lasail type massive sulphide ore deposits is shown in Fig. II-2-3.

The hanging wall of the Lasail type ore deposits corresponds to the lower extrusives 2 (V1-2) of the Samail volcanic rocks, however, the lower extrusives 2 (V1-2) of the lower volcanic rocks is not distributed in the area. Consequently, the area which corresponds to the section B and C shown in Fig. II-2-3, does not seem to indicate any potential for the existence of Lasail type massive sulphide ore deposits.

In spite of the above mentioned, The Daris 3A5 ore deposit is set in the lower extrusive rocks distributed in the northeast of the area.

(3) Mineralization

In the Buwayrik-Daris 3A5 area, the previous known prospects are Daris 3A5 ore deposit and Buwayrik prospect.

The Daris 3A5 ore deposit is located in the northeast of the area. The ore deposits was reported by BRGM(1986) and OMCO(1993). The ore deposit is existing in the middle extrusives (V2) and consists silicified gossan and stockwork. The ore minerals such as the ones shown in Table II-2-1 consist of covelline, digenite, pyrite and goethite. Ore assays shown in Table II-2-2 show maximum values of 5,716 ppm Cu, 115 ppm Zn and 1.0 g/t Ag. The altered minerals shown in Table II-2-3 consist of quartz and chlorite.

The Buwayrik prospect is located in the north of Buwayrik village. The prospect was found by a geochemical survey carried out by BRGM(1986). In this area, SP geophysical survey and drilling survey were also performed, however, the results of the surveys, did not detect any mineralization. The prospect is found in the sheeted-dyke complex and/or the middle volcanic rocks, but no promising potential for ore deposits are envisaged in this prospect.

3-3-3 Daris-Daris West area

(1) Distribution of geology

The geology of the area is shown in Fig. II-3-7, Fig.II-3-3, Plate II-3-3 and PlateII-3-4. The area is composed of the sheeted-dyke complex, the Samail volcanic rocks, the supra-ophiolite sediments and the Quaternary deposits. Outcrops of the Samail volcanic rocks are very few.

The sheeted-dyke complex (SD) is distributed in the south of the area.

The Samail volcanic rocks (SV) consist of the lower volcanic rocks and the middle volcanic rocks.

The lower extrusives 1 (V1-1) of the lower volcanic rocks is distributed in the southwest and the east of the area. The lower extrusives 1 (V1-2) of the lower volcanic rocks is distributed in the east of the area. The lower metalliferous sediments is distributed in the Daris gossan area.

The middle volcanic rocks consist of the sheeted sill (SS2) and the middle extrusives (V2).

The sheeted sills (SS2) are distributed in the center of the area. It is intruded the sheeted-dyke complex and gradually changed to the middle extrusives. The middle extrusives (V2) are distributed in the center and northeast of the area.

The Tertiary deposits (e2L2) are distributed in the northeast of the area, however, the Quaternary deposits are widely seen covering the area.

(2) Distribution of ore-forming horizon

Geological setting of the Lasail type massive sulphide ore deposits is shown in Fig. II-2-3.

The hanging wall of the Lasail type ore deposits correspond to the lower extrusives 2 (V1-2) of the Samail volcanic rocks.

The lower extrusives 2 (V1-2) of the lower volcanic rocks is distributed in the west part and the east part of the area.

In the west part of the area, the sheeted-dyke complex (SD), the lower extrusives 1 (V1-1) and the lower extrusives 2 (V1-2) of the lower volcanic rocks and the middle volcanic rocks are seen distributed. Only few outcrops corresponding to the lower extrusives 2 (V1-2) are seen in the area. Most of the lower extrusives 2 (V1-2) has been eroded out in the area. The area correspond to the section B and C shown in Fig. II-2-3 and therefore, low potentiality for finding Lasail type massive sulphide ore deposits are expected in the area.

In the east part of the area, the sheeted-dyke complex (SD), the lower extrusives 1 (V1-1) and the lower extrusives 2 (V1-2) of the lower volcanic rocks and the middle volcanic rocks are found distributed. The lower extrusives 2 (V1-2) is distributed along a trending NW-SE in the north of the area. The area corresponds to the section A shown in Fig. II-2-3. Accordingly, the area seems to present good indications for Lasail type

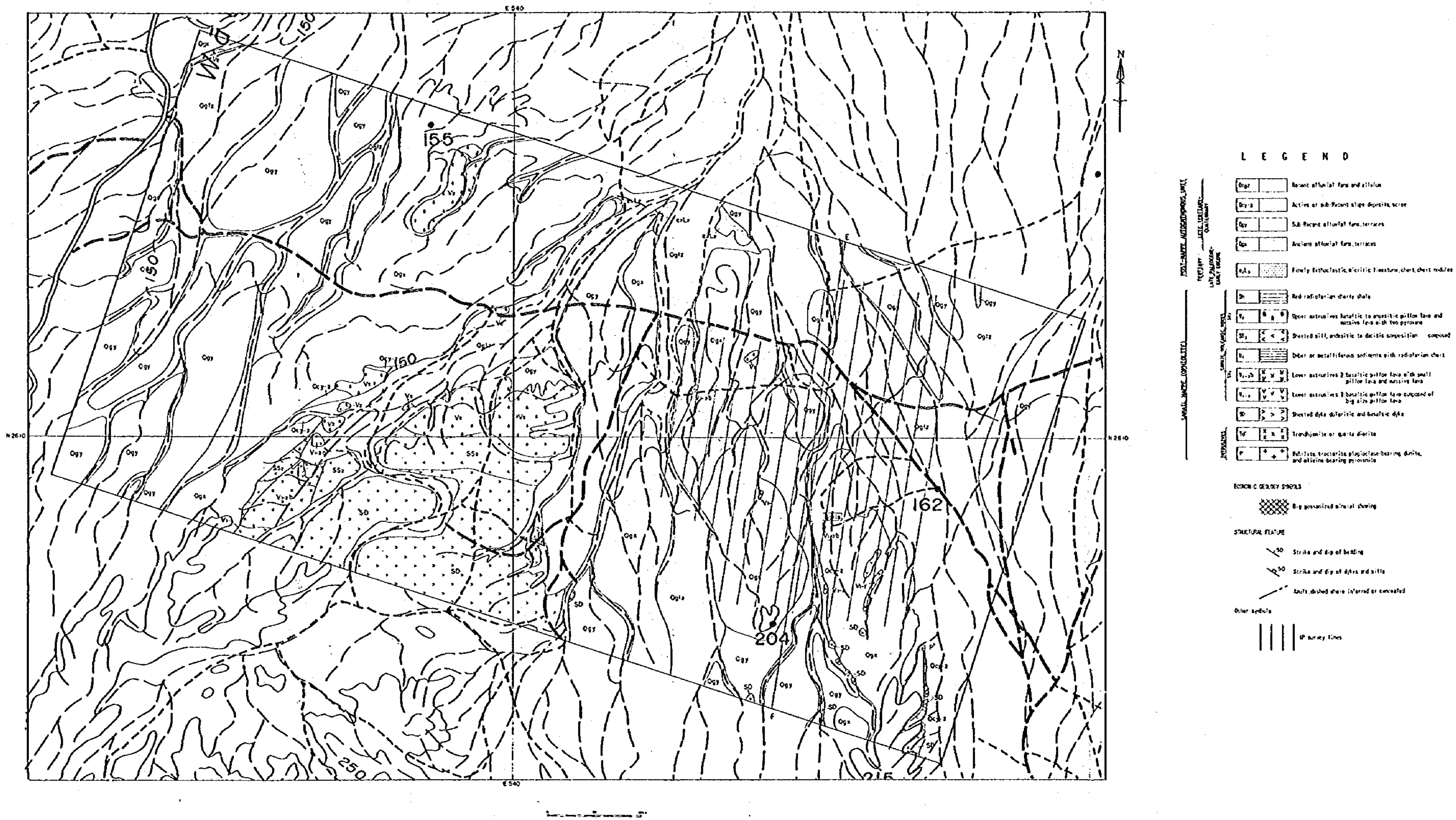


Fig.II-3-7 Geologic map and Mineral showings of Daris-Daris West Area

massive sulphide ore deposits.

(3) Mineralization

In the Daris-Daris west area, the previous known prospects are Daris ore deposit and Daris west prospect.

The Daris ore deposit is located in the northeast of the area. The ore deposit was reported by BRGM(1986). The ore deposit is existing in the lower extrusives 2 (V1-2) and consists silicified gossan. Ore assays as shown TableII-2-2 show maximum values of 1,561 ppm Cu, 80 ppm Zn and 2.0 g/t Ag.

The Daris west prospect, found by BRGM(1986), is located in the central south part of the area and existing in the sheeted-dyke complex. Ore assays of this area as shown in Table II-2-2 indicate maximum values of 196 ppm Cu and 23 ppm Zn. Altered minerals as shown in Table II-2-3 consist of quartz and goethite in the gossan.

CHAPTER 4 TDIP SURVEY

4-1 Objectives

A detailed airborne magnetic survey carried out in 1992 along the Batinah Coast area served as a base to design the location of the areas to carry out follow-up geophysical surveys. Based on the results of the magnetic anomalies associated to mineralization, five areas were selected for further geoscientifical studies. The location of the surveyed areas are shown in Fig.2

As a follow-up to the airborne magnetic survey and to complement the geological investigations, a geophysical program was undertaken. The geophysics was intended to assist in mapping geological structure and also to delineate primary sulphide zones which could contain promising mineralization. Time domain IP(TDIP) and Time domain EM(TEM) were implemented. A program of physical property of samples from the areas was also carried out to assist in the geological interpretation.

The TDIP geophysical method was first carried out in order to detect chargeable zones which could arise from sulphide and associted mineralization in the areas. These results were intended to be used as a preliminary appraisal of the potentiality of the sulphide mineralization of the areas in order to carry out a follow-up TEM geophysical survey. It was considered that the TEM method might assist in better defining more conductive zones for delineating possible sulphide-associated mineralizations.

The integrated results of both surveys were very useful in providing additional information to assist in drill sites selections.

4-2 Survey Locations and Specifications

Among the five selected survey areas, Daris and Daris 3A5 are located in the central part of the Batinah Coast region, while Ghuzayn Gossan, Ghuzayn East and Ghuzayn West are located in the west side of this region.

The amounts of survey of these 5 areas are as indicated in the following Table II -4-1.

4-3 IP Survey Method

4-3-1 Procedure

The measurements were carried out by means of the time-domain method and adopting a dipole-dipole

Table II-4-1 Survey Amounts

AREA	LENGTH, Km	NUMBER OF LINES	NUMBER OF POINTS
DARIS	45.2	8 Lines × 3.6 km 3 Lines × 2.8 km 4 Lines × 2.0 km	1598
DARIS 3A5	18.0	9 Lines × 2.0 km	594
GHUZAYN GOSSAN	21.5	1 Line × 1.7 km 1 Line × 1.8 km 1 Line × 1.9 km 7 Lines × 2.0 km 1 Line × 2.1 km	706
GHUZAYN EAST	16.8	6 Lines × 2.0 km 2 Lines × 2.4 km	560
GHUZAYN WEST	14.6	2 Lines × 1.8 km 2 Lines × 2.5 km 2 Lines × 3.0 km	500
Total	116.1	49 Lines	3958

electrode configuration with a separation factor from 1 to 4. IP data were taken every 100 m along lines by keeping a potential dipole of 100m. In field IP surveys, the current is injected into the earth through current electrodes and a resulting voltage is measured across potential electrodes. The Fig. II -4-1 shows the array utilized as well as the location of the plotting points.

For TDIP surveys, the current is turned on for a certain length of time (on-time) then turned off (off-time). The transmitted waveform is then repeated with current flow in opposite direction. The pair of positive and negative on-off waveforms constitutes a cycle, which in this survey lasted 8 seconds, as indicated in Fig. II -4-2. According to the Fig. II -4-3, the polarization of the target creates a transient decay voltage and its corresponding charging response is observed in the received waveform.

In order to obtain a desired signal-to-noise ratio, the measurements were, in general, repeated 3 times with a stacking of about 10 times.

4-3-2 Instrumentation

The instrumentation used for the conventional time-domain IP survey are described in the following table:

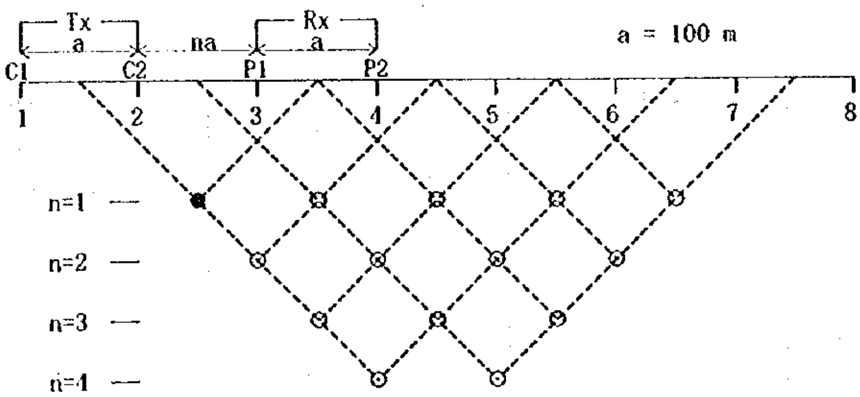


Fig. II-4-1 Dipole-dipole array and plotting procedure

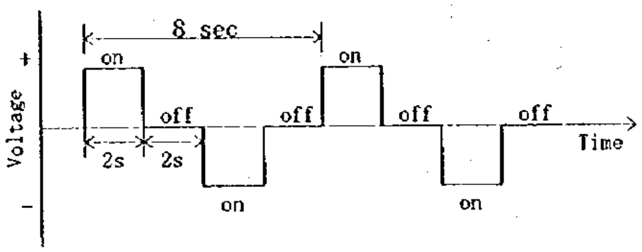


Fig. II-4-2 Waveform produced by the transmitter

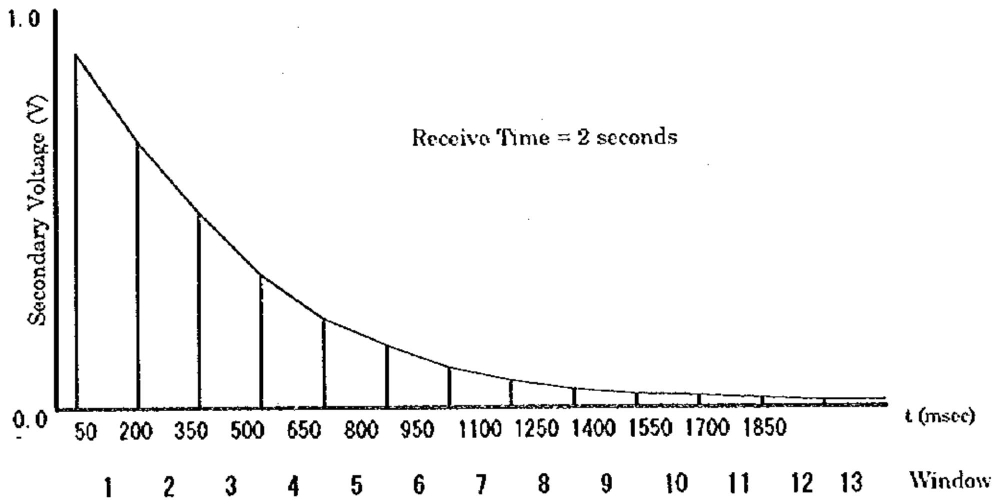


Fig. II-4-3 Sampling interval of the TDIP receiver stations

(1) Receiver Unit:

ITEM	ZERO Co.	PHOENIX Co.
Receiver unit	Multiple-channel GDP-16/3T	V5 - 16
Frequency range	DC to 8 Khz	DC to 10 Khz
Number of Channels	3	8
Number of Stackings	8096	No restriction
Minimum detectable signal	0.03 μV	10 μV
A/D converter	16 bits/ch	16 bits/ch
Number of Windows	13 (from 50 to 1930 msec)	13 (from 50 to 1550 msec)

(2) Transmitter Unit

ITEM	CHIBA ELECTRICAL Co.	PHOENIX
Transmitter unit	CH-95A	IPT - 1
Output power	2kw, 800V, 12A	2kw, 800V, 10A
Output frequency	DC to 10 kHz	DC to 12 kHz
Frequency controller	XMT-16	IPT - 1

4-4 Analysis Method

4-4-1 Data processing

The TDIP data processing involves the determination of 3 parameters, i.e., apparent resistivity, chargeability as well as metal factor. The first 2 parameters are calculated directly by the receiver unit during data acquisition. The third one is calculated as a simple relation between the first 2 parameters. These 3 parameters are calculated as follow:

a)Aparent resistivity(ρ a)

$$\rho_a = \Pi \frac{V}{I} an(n+1)(n+2)$$

where,

V: Received voltage in volts

a : a-spacing in meters

n : n-spacing

I : Transmitted current in Amp

b)Chargeability(M)

$$M = T\frac{1.87}{V_p}\int V_s$$

where,

T : Sampling rate in seconds

Vp : Primary voltage in volts

Vs : Secondary voltage in volts.

Here the secondary voltage is calculated from 451.38 msec to 1097.32 msec.

c) Metal factor (MF)

$$MF = \frac{M}{\rho_a}100$$

where,

M : Chargeability (mV/V)

ρ a : Apparent resistivity (ohm-m)

4-4-2 Topographic corrections

Since the apparent resistivity is also function of the location of the current and potential electrodes, it is affected by topography depending on the location of the elctrodes. For the case of a dipole-dipole configuration, the apparent resistivity appears to be high beneath a hill and low beneath a valley. On the other hand, the chargeability values are less affected by topography.

For the present survey, topography corrections were carried out only in the areas of Ghuzayn East and Ghuzayn Main Gossan around the Line 0, by using a finite element method which assumes a two dimensional half space topography.

4-4-3 Two-dimensional analysis

For the IP data analysis and according to the standard model, the apparent resistivity distribution and the chargeability distribution are used in combination to make a quantitative analysis of the pseudo-sections and plan maps. The resultant undergound model is inferred by making use of the theoretical results given by the model. This is called in, general, a model simulation.

In the present survey, according to the limitations of the results of the forward modeling and to match the field results, it was used a 2-D inversion model which combines the FEM forward calculations with a nonlinear square method. The inconveniences presented by the 1-D analysis to make a more realistic layer analysis of the undergound structure are best solved by the approximation made by the 2-D model.

In order to make the model calculations, the geological structure is divided into many small blocks, each of them having initially assigned their own chargeability and resistivity value. The blocks are designed so that small blocks are placed close to the surface and they increase in size as the blocks are located at deeper levels.

4-5 Electrical Measurements of Rock Samples

4-5-1 Measurement method

Measure of the electrical properties of rock samples were carried out in order to determine the actual electrical properties of the rocks distributed on the survey area. 21 pieces of the rocks collected from the surface were formed into a cubic shape and after soaked into water for a reasonable amount of days, apparent resistivity as well as chargeability values were measured according to the IP time domain. In order to collect magnetic data of the rocks, magnetic susceptibility measurements were also taken to the above mentioned rocks.

4-5-2 Results

The results of the measurements are indicated in Table II-4-2. By comparison of the resistivity results obtained, for instance, in Daris 3A5, the resistivity of dolomite resulted as low as 44 ohm-m , and of pillow lava between 60 to 11,100 ohm-m., gossan between 1,030 and 15,400, sheet dike rocks beween 1,160 and 4,600, jasper indicated values higher than 17,700. In comparison to the standards for sulfide potentiality, the chargeability values of pillow lava, as well as sheet dikes rocks resulted high, but gossan as well as jasper gave values lower than 5.0 mV/V.

In relation to the massive sulfide and network ore samples of the table II-4-2, the samples Nos. 22 and 23, indicated resistivity values of about 3 and 16 ohm-m respectively. In addition, the chargeability values were about 160 and 340 mV/V respectively.

Regarding the magnetic susceptibility results, pillow lava as well as sheeted dike rocks gave values between 9 to 65, however, gossan, jasper, massive sulfide as well as network ore were as low as values between 0.02 and 1.15 indicating that in general, they do not contain magnetic materials.

Table II-4-2 Resistivity and chargeability of rock samples

Sample No.	Sampling Area	Latitude	Longnitude	Resis. (Ω.m)	Charge. (mV/V)	Suscep. MKS Unit	Rock Name	Remarks
1	D3	2614.138	534.791	44.4	7.0	0.05	Do	
2	D3	2614.045	534.735	8,450	0.1	0.02	Gs	
3	D3	2611.798	531.793	871	4.4	10.7	Pw	V2
4	DA	2609.025	543.391	1,030	1.9	1.15	Gs	
5	GE	2633.900	501.131	4,680	0.9	12.4	An	Sd,Py diss.
6	GE	2634.054	501.131	1,160	7.7	39.2	Ba	Sd,Py diss.
7	GE	2634.454	500.990	375	5.0	33.1	Bapw	V1-1
8	GE	2634.607	500.961	17,700	0.6	0.98	Js	V1-1
9	GE	2634.853	501.131	9,380	0.3	0.11	Qv	
10	GE	2635.985	501.103	6,300	7.1	8.76	Bams	V1-2
11	GE	2635.130	500.655	11,100	0.5	12.1	Pw	V1-2
12	GE	2634.823	502.178	510	3.2	26.4	Pw	V1-2
13	GE	2634.976	501.178	12,300	0.8	21.3	Baan	
14	GM	2635.960	499.603	193	8.5	0.44	Pw	V2
15	GM	2634.761	498.653	3,730	3.2	0.36	Gs	
16	GM	2634.884	498.840	14,700	4.7	0.05	Gs	
17	GM	2634.884	498.868	15,400	4.1	0.18	Gs	
18	GM	2634.577	499.009	468	7.5	65.2	Bapw	V1-1
19	GM	2634.423	499.038	59.5	2.8	35.8	Bapw	V1-1
20	GW	2636.637	502.461	229	12.0	43.3	Bapw	V2
21	GW	2635.961	502.432	367	7.0	15.8	Bapw	V2
22				3.10	159	0.66	On	Cp 7%,Py 10%
23				16.2	344	0.13	Om	Cp 20%,Py 75%

Notes

D3 : DARIS 3A5
DA : DARIS
GM : GHUZAYN MAIN
GE : GHUZAYN EAST
GW : GHUZAYN WEST
Resis : Resistivity
Charge : Chargeability
Suscept : Susceptibility
diss : dissemination
V2 : Middle Volcanics rocks
V1-1 : Lower Extrusives1
V1-2 : Lower Extrusives2

Do : Dolomite
Gs : Gossan
Pw : Pillow lava
An : Andesite
Ba : Basalt
Bapw : Pillow lava(Basalt)
Js : Jaspar
Qv : Quartz vein
Sd : Sheeted dyke
Bams : Massive basalt lava
Baan : Andesitic basalt
On : Network ore
Om : Massive ore
Cp : Chalcopyrite
Py : Pyrite

4-6 Ghuzayn Gossan Area

4-6-1 Lines locations

In this survey area, the IP lines were oriented along the N14W direction. 11 lines for a total of 21.5 km were measured. To avoid the south edge of a wadi, 2 of the lines located in the west side were reduced between 200 and 300m as indicated in Fig. II-4-4 which shows the location of the lines.

4-6-2 Results

A zone of high resistivity above 100ohm-m surrounds the gossan area in the area which includes the station 6 of line 0. To the south of the area, including the gossan and its surrounding, it is seen a zone of less than 50 Ohm-m. The apparent resistivity zone to the south of the area, shows a NE-SW trending which is in agreement with the magnetic anomaly detected by the aeromagnetic survey. In the gossan as well as its surroundings it is seen at n=1 (exploration depth=100m) around the stations 0 of line 5 a central zone of low resistivity, which seems to be displaced at a part so that, for instance, at n=4 (expl. depth=250m), this central zone lies around station 9 of line 0.

Regarding the chargeability, it can be generally stated, that in places where the resistivity zone was high, the chargeability values were high and inversely, when the resistivity zone was low, the chargeability was also low. From the gossan to the west of the area, it can entirely be seen values of chargeability higher than 15 mV/V (around station 7 of line 400W). At n=4 (expl. depth 250m) it can be seen high values of 29mV/V around the stations 7 of line 0 and 7 of line 400. As it was mentioned above, the north side of the area which shows low values of apparent resistivity, shows also low values of chargeability as low as 5 mV/V.

Regarding the metal factor, its distribution presents also the same characteristics as the chargeability distribution, specially at n=4(expl. depth 250m), the places that indicated high values of chargeability, seems quite coincident with the high values of 40, which are the highest in the area.

4-6-3 2-D Interpretation

(1) Line 0

The resistivity values detected in the gossan area around station 5 indicated low values. This low zone seems to be extended to the north at deep levels, in such a way that a low central value zone can be seen at the deep parts between stations 8 and 9. Both sides of this resistivity distribution are surrounded by high resistivity distributions. All the surroundings of station 16 show low resistivity distributions.

Regarding the chargeability, from the central part to the south of this line it can be seen high values, however, in the opposite side, i.e. to the north, only low values were detected. At the deep parts of stations 6 to 9 chargeability values indicated values higher than 20mV/V.

Regarding the metal factor, it resembles the apparent resistivity distributions. From stations 5 to 9, values above 30 were detected from shallow to deep parts.

(2) Line 400W

From stations 10 to 13 relatively low resistivity values can be seen. From stations 5 to 6 at shallow depths can be seen a central distribution of high resistivity, and from station 7 to the south, only relatively high resistivity values are seen.

The chargeability values of this line from stations 7 to 9 show at deep depths high chargeability distribution of values above 30mV/V.

The metal factor also indicated high values in the zones where high chargeability are distributed, and specially at deep levels from stations 7 to 8 values above 40 are seen. The north and south end of this line show low values.

4-7 Ghuzayn East Area

4-7-1 Line locations

In this survey area, the lines were oriented along the N40E direction. 8 IP lines for a total of 16.8 km were carried. 2 of the lines located in the east side of the area were extended 400 meters in order to compare the results of the magnetic anomalies detected in this surroundings. The location of the lines are shown in Fig. II-4-13.

4-7-2 Results

The central zone of the area presents high resistivity values, however, the north and south ends tends to become lower. The central part shows resistivities higher than 100 Ohm-m along a E-W direction with a width of about 500m. The values of less than 50 Ohm-m corresponding to the low apparent resistivity distribution zone located at the north end of the survey area are in agreement with the magnetic anomalies extracted from the aero-magnetic survey.

Regarding the chargeability, the above mentioned zone of of low resistivity distribution at the north end show chargeability values of less than 5 mV/V, however outside of this zone and after the 10mV/V distribution, medium chargeability values are seen and with a tendency to become higher towards the south.This zone of medium chargeability corresponds to the outcrops as well as to the pyrite which includes the quartz veins reflecting the contrast in the sulfide mineralization of the distribution. The south part of the stations from 4 to 7 of line 800E for n=4 (expl depth=250m), as well as the station 9 of line 1000E for n=3, 4 (expl depth 200, 250m) and station 10 of lines 1200E and 1400E show high chargeabilities higher than 15 mV/V.

The metal factor shows almost same distribution pattern as the chargeability. For n=4 (expl. depth 250m) the above mentioned zone, which has chargeability values higher than 15 mV/v of the observed chargeability distribution zone located to the south of the station 10 corresponding to the lines 1200E and 1400E, indicate metal factor values as high as 40.

4-7-3 2-D analysis

(1) Line 1200E

This section shows in general high resistivity values. In the middle of this line from stations 11 to 19, and from shallow to the deep part are seen resistivities higher than 100 Ohm-m. To the north end of the line at shallow depths a zone of relatively low resistivities are seen distributed.

Regarding the chargeability, at the deep parts of the stations 7 and 8, a distribution zone of high chargeabilities are seen, while to the south of the station 8, high chargeability values above 30mV/V are generally seen.

The metal factor follows same pattern as chargeability distribution zone, and as such, below stations 7 and 8 at the deep parts are seen high metal factor values above 50.

(2) Line 1400E

In general this section shows high resistivity values, specially at shallow depths the resistivity values are even higher. The chargeability values of this line resemble the distribution of the above mentioned lIne 1200E. Between stations 6 to 9 at a depth of about 200m a wide zone of high chargeability is seen. To the south of the station 10 high chargeability values are seen.

Between stations 5 and 6, the metal factor shows at the deep parts high values above 60. To the south of this line, in places where chargeability values are high, metal values are also high.

4-8 Ghuzayn West Area

4-8-1 Line locations

In this survey area, the lines were oriented along the N20E direction. 6 IP lines for a total of 14.6 km were carried. At the beginning the plan was to set 6 lines of 3.0 km each, however, during the survey process, the chargeabilities of the north side of the lines were resulting with low values in general, and therefore, it became clear that the lines located to the north should have short length between 0.5 to 1.0 Km. The location of the lines measured during the TDIP survey in this area is indicated in Fig. II-4-22.

4-8-2 Results

In this survey area, the south side presented high resistivity values, however, the north side indicated relatively low values. As can be seen in the plan map for n=1 (explor. depth 100m), resistivities above 100 Ohm-m can be seen to the south of the stations 7 between the lines 200W and 600E. Moreover, from the station 19 of the line 400W to the station 15 of the line 600E, a low resistivity zone of about 20 Ohm-m is seen extended along the direction NW-SE. This low resistivity is in agreement with the magnetic anomaly detected durante the aero-magnetic survey.

The pattern shown by the chargeability distribution in the zone is the usual inverse pattern reflected by the apparent resistivity structure, i.e., high values to the south and low values to the north. In the surroundings of the line 200E between stations 3 and 5, it can be seen a central region of high chargeability values with values around 20 mV/V.

In relation to the metal factor, the pattern agreement of low-high and high-low values of chargeability and apparent resistivities give as a result a general pattern of metal factor values in the order of 20.

4-8-3 2-D analysis

(1) Line 200E

The resistivity distribution to the south of the station 7 shows high values from shallow to the deep part, however, towards the north side, the resistivities become lower.

With reference to the chargeabilities, it can be said that their values get higher towards the south side and lower towards the north. From the shallow parts of station 3 to the deep part of station 5, it can be seen a zone of comparatively high chargeability.

In connection with the metal factor values, when the relatively high values of chargeability is are compared to the high values of the resistivity, the obtained metal factor values become relatively low in all the area.

(2) Line 200W

To the south of station 3, high resistivity values are distributed by following same pattern as the previous mentioned line 200E. A low resistivity distribution is seen at shallow depths from stations 18 to 22 but becomes higher at deep levels.

The chargeability values seen at the stations 4 and 5 and their suroundings, show comparatively high values at the deep parts, however, from station 10 to the north a general trending of low chargeabilities are seen.

Concerning the metal factor, just as same as the line 200E, high chargeability values which are in agreement with high resistivity values, show in general, relatively low metal factor values.

4-9 Daris 3A5 Area

4-9-1 Lines location

In this survey area, according to the results of the aeromagnetic survey, the detected magnetic anomalies intersect the gossan in the central part. On this basis, 7 lines of 2km length each, were located by oriented them along the direction N45E. Due to the low resistivity results which became clear during this survey, 2 more lines were added to the west side, making a total of 18.0 km of TDIP survey. The locations of the lines are indicated in Fig. II-4-31.

4-9-2 Results

The apparent resistivities detected in this survey area were very low (average value less than 10 Ohm-m), especially in the central area towards the west, were detected apparent resistivity values of extremely low values of less than 4 Ohm-m. This extremely low distributions, agree with the results extracted from the aeromagnetic survey. Moreover, from the central part of this survey area to the south, the apparent resistivity values gradually increase, for which a E-W boundary can be estimated.

The chargeability also shows in general low values. The chargeability zone of the central part of the area, which detected middle values from 5 to 10mV/V indicates a central belt along E-W direction. In the station 9 of the line 0 to the south and the station 11 of the line 400W to the north, low chargeabilities of less than 5mV/V can be seen, indicating a clear difference between the central zone trending E-W and the rest of the area.

In the case of the metal factor, the combination of the extremely low values of the apparent resistivity with the low values of the chargeability values, gives relatively high metal factor values, especially, the central zone of the area towards the west which has low resistivity values showed metal factor values as high as 100.

4-9-3 2-D analysis

(1) Line 0

In general low resistivities are present in all the area. At shallow depths the resistivities are very low, especially near the surface where resistivities as low as 4 Ohm-m are seen.

The chargeability values are also low, being about 6 mV/V the highest values detected.

Regarding the metal factor, due to the extremely low values of the resistivity, the resultant metal factor showed in general high values, especially in the cental zone between the stations 8 to 15 where high metal