chapter IV

study

of

opaque

minerals.
CHAPTER IV

STUDY OF OPAQUE MINERALS

4.1 INTRODUCTION:

The occurrence of sulfide minerals is confined to the fracture zone, mainly to the highly altered diabase. This mineralised dyke has been traced intermittently for a length of 5 kms. The payable lode of sulfide concentration is established over a strike length of 2 kms. in the diabase, which is confined to the fracture zone. The other rock which is seen in this fracture zone and mineralised, is cataclasite. The highly sheared portions of diabase and cataclasite form a mineralised zone to the northern contact of fracture zone. However, the less altered and massive portions of diabase also show ore mineralisation. Adjacent to the fracture zone on either side, porphyritic granite show smaller amounts of sulfide minerals. The fractures in the diabase, cataclasite and porphyritic granite are traversed by quartz and calcite veins, which carry disseminations of sulfide minerals. The study of distribution of the sulfides in the fracture zone and adjacent to it indicates that they (sulfides) are dominant in the diabase, followed by cataclasite and porphyritic granite. The economically mineable ores are present mainly in the diabase and cataclasite. The dominant sulfide minerals occurring in this deposit are
chalcopyrite, pyrite, with very minor amounts of bornite, pyrrhotite and cobaltite. The oxide minerals are represented by specular hematite, which is in abundance and minor amount of magnetite-ilmenite as evolved phase.

Drilling exploration by State Department of Mines and Geology has been confined to the two stretches of diabase to the east and west of the Lingsaugur-Gulbarga main road and these are termed as eastern and western blocks respectively. Core data over a strike length of 2167 mtrs. on the mineralised zone indicate that mineralisation is present mainly in the diabase dyke and cataclasite band, with minor amount of mineralisation in porphyritic granite also. The width of mineralisation varies from 4.5 to 11 mtrs. in eastern block, whereas in western block it varies from 8 to 30 mtrs. with an average of 19 mtrs. As indicated by boreholes, at depth the mineralisation is confined almost to the centre of the diabase dyke (Map 4). A good correlation exists between surface outcrops and drillhole intersections on the eastern block, but on the western block the drillhole intersections cannot be correlated due to the scarcity of outcrops of diabase on the surface.

4.2 MODE OF OCCURRENCE:

The occurrence of sulfides in the fracture zone is mainly restricted to quartz and calcite veins. Subordinate
amounts of sulfides are also distributed as disseminations in the groundmass of the diabase. Numerous parallel and sub-parallel veins and stringers of quartz and calcite cutting both cataclasite and diabase are commonly seen (Fig. 1.6 and 1.15). Adjacent to the fracture zone a few E-W trending veins cutting porphyritic granite and pegmatite are also seen. The veins are confined to minor fractures and usually possess sharp and straight contacts with the host rocks. The veins vary in thickness from a few mm. to 1.5 m. and the horizontal distance between two successive veins varies from 2 to 15 cms. Majority of the veins are parallel to the fracture zone and only a few show transverse relation. The strike extension of individual veins vary from 2 to 10 m.

The fracture controlled ore mineralisation in the area is mainly due to cavity filling. The cavity filling process is dominantly of fissure vein type with localised structures like stock works and breccia filling. Majority of the veins are parallel and sub-parallel in nature with connecting diagonal veinlets, representing a large fracture zone and indicate the composite vein type of mineralisation (Fig. 3.1). When more than two minerals occur in a vein, crustification is generally observed. Rounded and angular brick red coloured microcline which measures 1-3 cms. occurs at the vein contact and extends towards the centre of the vein (Fig. 3.2). Quartz occurs at the centre of the vein. Microcline bears sharp
crystal boundaries with quartz. Larger veins of quartz show
typical 'comb and vug' structure and colour sonation. But
the narrow veins of solitary minerals show massive type of
vein filling, associated with sulfide minerals. Occasionally
both quartz and calcite form massive vein filling. Stockwork
and breccia filling structures are also seen, where the
former one is developed as a result of localisation of inter-
laying network of small ore bearing veinlets along both
longitudinal and transverse fractures in the highly sheared
portions of the diabase and the later one due to the minerala-
isation along the voids created by the shattering of the
country rocks. Here the angular pieces of country rocks are
surrounded by the ore bearing quartz veins (Fig.5.3).

Though the country rocks as such do not represent any
large scale replacement by sulfides, the hose rocks adjacent
to some veins are subjected to silicification and pyritisation.
The wall rock is invariably chloritised and sericitised.

The mineralogical study of the veins has revealed the
presence of veins of different composition like 1) quartz,
2) quartz-microcline, 3) microcline-quartz-pyrite, 4) quartz-
pyrite, 5) quartz-pyrite-chalcopyrite, 6) quartz-pyrite-
calcite-chalcopyrite, 7) quartz-calcite, 8) calcite, 9)
calcite-flourite, 10) calcite-hematite and 11) quartz-
calcite-hematite. The barren quartz veins which are often
cut and displaced by sulfide bearing quartz veins are
frequently noticed at the contact of porphyritic granites-diabase, diabase-cataclasite and cataclasite-porphyritic granite. Quartz and quartz sulfide veins with microcline are noticed mainly towards the northern limit of the fracture zone in contact with cataclasite. Sulfide bearing quartz and quartz calcite veins are seen throughout the fracture zone but are more prominent in the northern side, where the fracturing of the rocks is more. Calcite and quartz-calcite veins are more prominent at the contact zones of different rock types but are also encountered within a single rock type. They usually occur as parallel veins confined to 1-2 m. wide narrow zones spaced at 2-6 cms. intervals. Hematite bearing veins are prominent towards the southern limit of the fracture zone and are also noticed within the porphyritic granites. They are similar to sulfide bearing veins in distribution but are lesser in abundance (Fig.3.4).

As mentioned before, the opaque minerals in this deposit are both sulfides and oxides. Sulfides are dominated by chalcopyrite and pyrite with smaller amounts of bornite, pyrrhotite and cobaltite. The oxide minerals are mainly represented by specular hematite with minor amount of magnetite-ilmenite. Besides there are some secondary minerals like malachite, azurite and ilmenite, which are the alteration products of sulfides and oxides.
4.2.1 Sulfides:

The sulfides are found confined mainly in the fracture zone dominantly occurring in diabase and cataclasite with sporadic disseminations in the adjacent porphyritic granite.

4.2.1.1 Pyrite:

Pyrite occurs as medium to coarse grained euhedral to subhedral crystals which are disseminated in quartz veins (Fig. 3.4). Massive aggregates of pyrite are also seen in some veins in the form of elongated ribbons. Idiomorphic pyrite with rectangular outline are disseminated in groundmass of the host diabase. In brecciated grains the fractures of pyrite have been partially filled and replaced by chalcopyrite.

4.2.1.2 Chalcopyrite:

Chalcopyrite occurs in many forms. It is seen as anhedral massive aggregates, subhedral grains, monomineralic stringers and as patches, in quartz and calcite veins. The monomineralic stringers which are 0.2–0.8 cm thick are mainly confined to the highly sheared portions of the host rock. Disseminations of chalcopyrite in the form of small discrete grains is seen throughout the diabase. Minute veins and veinlets are also seen filling the cracks in pyrite.

The other sulfide minerals like bornite, pyrrhotite and cobaltite are very rare in occurrence. When they occur,
they confine to quartz sulfide or quartz-calcite sulfide veins either in the form of individual grains or as inclusions within chalcopyrite. Since they are meager in occurrence and fine grained, it is not possible for their study in hand specimen.

4.2.2 Oxide minerals:

4.2.2.1 Specular hematite:

Hematite is seen as net-like aggregates and radial clusters intersecting chalcopyrite and gangue minerals (Fig. 3.4). It is also noticed along the rhombic planes of calcite crystals. Near the fracture zone some of the veins traversing the porphyritic granites are composed of hematite closely associated with quartz and calcite. Hematite occurs abundantly in the western block, traversing the fractured breciated, silicified and epidotised diabase dyke at the northern limit in contact with the porphyritic granite.

4.2.2.2 Magnetite:

This mineral most of the times associated with exsolved ilmenite is confined only to the interstices of diabase. Because of its scarce abundance and fine grained nature, it is not visible in hand specimen.
4.2.3 Secondary minerals:

Secondary minerals like limonite, malachite and azurite are commonly noticed in the fracture zone. Limonite is commonly seen as yellow dusty encrustation. Malachite and azurite form green and blue encrustations and occur in the vugs and cavities found in the quartz veins in the surface levels.

4.3 STUDY OF OPAQUE MINERALS UNDER MICROSCOPE:

A number of well polished ores representing all varieties of minerals have been studied under the reflecting ore microscope. The study reveals that chalcopyrite is the dominant ore mineral followed by pyrite. Hematite is the next abundant mineral representing the oxide phase. The dominating sulfides, chalcopyrite and pyrite occur in different forms like anhedral to euhedral grains, small veins and stringes, brecciated and disseminated ores. Chalcopyrite invariably replaces pyrite along the cracks and also along the boundaries. Other sulfide minerals like pyrrhotite, cobaltite and bornite are very rare and are noticed only in one or two polished sections.

The mineragraphic description of all the sulfide ores and the associated oxide minerals is given in Table 5.
### TABLE 5

**DESCRIPTION OF ORE MINERALS UNDER MICROSCOPE**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Description</th>
<th>Mode of occurrence</th>
<th>Micro-hardness $H_v(\text{kg/mm}^2)$</th>
<th>Etch tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrite</td>
<td>Yellowish white to pale brassy yellow colour. Higher reflectivity, and is isotropic</td>
<td>Subhedral to euhedral fine to coarse (1123) grained pyrite are disseminated in chloritic ground mass of the country rock. Pyrite grains in quartz and calcite veins are commonly patchy in appearance, also occurs as granular aggregates. Breciated and corroded grains are commonly seen enclosed in chalcopyrite.</td>
<td>Excerpt $\text{HNO}_3$ negative to all other reagents. With $\text{HNO}_3$ turns light brownish.</td>
<td></td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Brass yellow in colour with very weak reflection pleochroism. Anisotropy is weak to moderate in shades of light grey blue and greenish yellow. Twinning is rarely seen.</td>
<td>Occurs as massive, subhedral to xenomorphic aggregates and disseminations in quartz sulfide veins and also in the intergranular spaces of the host rocks. Monomineralic stringers of chalcopyrite are common which are mainly confined to highly sheared portions of diabase. It commonly fills fractures in pyrite.</td>
<td>$\text{HNO}_3$ tarnishes very slow with slight darkening of the colour. Acquaragia stains brown. Negative to all other reagents.</td>
<td></td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td>It is pale brown with pinkish tint. Reflection pleochroism is moderate. Anisotropy is distinct in yellow grey and greenish grey colours.</td>
<td>It occurs as anhedral and rounded grains within chalcopyrite.</td>
<td>$\text{ND}^*$</td>
<td>-</td>
</tr>
<tr>
<td>Mineral</td>
<td>Description</td>
<td>Tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bornite</td>
<td>Creamy brown in colour. Anisotropy is moderate in shades of greyish brown and yellowish brown. Reflection pleochroism is distinct in brownish creamy and pinkish brown colour.</td>
<td>It is rarely seen in sulfide bearing quartz-calcite veins, showing exsolution relationship with chalcopyrite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cobaltite</td>
<td>White with distinct pinkish tint. Reflection pleochroism is distinct with pinkish brown and reddish brown colours. Anisotropy is moderate.</td>
<td>Occurs as rounded to euhedral inclusions within massive chalcopyrite.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>Grey with brownish tint. Low reflectivity. It is isotropic.</td>
<td>Occurs as subhedral to euhedral grains in the interstices of diabase. Its alteration to hematite (martitisation) is common.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ilmenite</td>
<td>Greyish white in colour with brownish tint. Reflectivity is low. Bireflectance is moderate. Anisotropy is distinct in grey and greyish brown colours.</td>
<td>Occurs as thin parallel exsolved lamellae in magnetite.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5 contd.

| Hematite (specular variety) | Shows whitish grey colour with slight bluish tint. It has higher reflectivity. Bireflectance and anisotropy are weak. Sharp extinction anisotropism is sometimes seen on twin boundaries. | Occurs as net like aggregates, stringers and radial clusters in quartz and calcite veins. Also occurs along the rhombic planes of calcite (Fig.3.14). Brecciated portions of host rock adjacent to mineralised veins are also filled by hematite. | Negative to all reagents. |

*The microhardness and etch tests have not been determined because either the grains were too small or altered.*
4.3.1 Textures exhibited by ore minerals:

Different textures have been noticed in sulfide and oxide minerals. The textures recognised are as follows:

I Primary textures: 1) Panidiomorphic texture
2) Unmixing texture
3) Inclusion texture

II Post mineralisation textures: 1) Replacement texture
2) Martitisation
3) Cataclastic texture.

1) Panidiomorphic texture: This texture is well exhibited by pyrite. Cubic and rectangular pyrite ranging in size from 0.3 cm. to 1.3 cms. are found scattered in the chloritic groundmass of the diabase and also found embedded in quartz-sulfide veins (Fig. 3.5). The euhedrism of pyrite is seen even in hand specimen (Fig. 3.4).

2) Unmixing texture: This texture is observed in magnetite-ilmenite and bornite-chalcopyrite associations. Fine parallel lamellae of ilmenite are seen as exsolved mineral phase in magnetite. The exsolved lamellae are elongated and oriented in the (111) direction of magnetite (Fig. 3.6).

Thin parallel stringers and lamellae of chalcopyrite are seen within bornite, which indicates that it has been formed as a result of unmixing of solid solution which was cooled
rapidly, in which bornite was dominating below 475°C (Schwartz 1931).

3) Inclusion texture: This texture is resulted by the inclusion of cobaltite in chalcopyrite (Fig.3.7). The nature of cobaltite grains as euhedral crystals with generally uncorroded borders indicates that they were either already present before the formation of chalcopyrite or were being formed concurrently with the growing host mineral (Yermakov 1965).

II Post mineralisation texture:

1) Replacement texture: Replacement of early formed sulfide and oxide minerals by later minerals is commonly seen. Replacement relation is seen between:
   a) Pyrite-chalcopyrite
   b) Pyrrhotite-chalcopyrite
   c) Chalcopyrite-hematite

a) Pyrite-chalcopyrite:

The replacement of pyrite by chalcopyrite takes place along the grain boundaries, margins of the veins and from the core of the grains. The fractures developed in pyrite due to deformational activity have been filled by chalcopyrite veins which sometimes give network replacement pattern (Fig.3.8). In most of such replacements chalcopyrite
has enclosed the pyrite grains. (Fig. 3.9). In some grains the fractures in pyrite are healed by calcite veins which carry specks of chalcopyrite (Fig. 3.10).

b) Pyrrhotite-chalcopyrite:

Here the early formed pyrrhotite is replaced by chalcopyrite along the grain boundaries. Pyrrhotite with corroded borders at the contacts of chalcopyrite are sometimes seen.

c) Chalcopyrite-hematite:

Medium to coarse needles of hematite which is later to chalcopyrite are seen intersecting and replacing chalcopyrite along their grain boundaries (Fig. 3.11).

2) Martitisation: Martitisation of magnetite is evidenced in the form of development of thin hematite lamellae along the cracks, and the alteration is more pronounced at the margins of the crystals (Fig. 3.12). This alteration of magnetite takes place as a result of either hypogene or supergene oxidation of magnetite (Edwards 1965). With progressive oxidation hematite has developed irregular extensions within magnetite and intensified the replacement.

3) Cataclastic texture: This texture is shown by pyrite. Elongated grains of pyrite have been crystallised as a mosaic of small inequigrannular grains due to cataclastic effects. Marginal granulation and brecciation of the coarse pyrite
grains is also seen (Fig.3.13). The fractures developed have served as channel ways to initiate the replacement by the later formed chalcopyrite. At some places pyrite is mildly sheared parallel to its cleavage planes and has suffered replacement by later formed chalcopyrite.

Based on textural features, the paragenetic sequence of the ore minerals is drawn and presented in Table 6.

The detailed ore microscopic study of diabase intrusives other than the mineralised one, reveal that they are barren in nature. Seldom, they show the presence of discrete grains of pyrite in their groundmass.
# Table 6

## Paragenetic Sequence of Ore Minerals

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary (hydrothermal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magmatic phase</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
</tr>
<tr>
<td>Ilmenite</td>
<td></td>
</tr>
<tr>
<td><strong>Hydrothermal phase</strong></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td></td>
</tr>
<tr>
<td>Cobaltite</td>
<td></td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td></td>
</tr>
<tr>
<td>Bornite with exsolved chalcopyrite</td>
<td></td>
</tr>
<tr>
<td>Specular hematite</td>
<td></td>
</tr>
</tbody>
</table>
3.1 Parallel and subparallel veins of quartz and calcite with connecting diagonals. Pyrite and chalcopyrite grains are disseminated in the veins. Width of the specimen .25 cms.

3.2 Cavity filling in diabase. Microcline at the vein contact and quartz at the centre are seen with dissemination of sulfides. Width of the specimen 13 cms.

3.3 Breccia structure in diabase. Angular pieces of the host rock are seen surrounded by the ore bearing quartz veins.
3.4 Polished ore section showing hematite and sulfide bearing veins in diabase. Width of the specimen 6 cms.

3.5 Panidiomorphic texture shown by pyrite. x 15

3.6 Exsolved lamellae of ilmenite in magnetite. x 40
3.7 Euhedral cobaltite inclusions (light grey) in chalcopyrite. x 25

3.8 Net work replacement of pyrite (dark grey) by chalcopyrite (white). x 15

3.9 Replacement and enclosure of pyrite by chalcopyrite. x 15

3.10 Calcite vein disseminated with small grains of chalcopyrite, healing a fracture in pyrite. x 15
3.7 Euhedral cobaltite inclusions (light grey) in chalcopyrite. x 25

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