

GEOCHEMICAL AND MINERALOGICAL EVALUATION OF PRECIOUS METAL BEARING IRON ORES OF CHILGHAZI, BALUCHISTAN

IZHARUL HAQUE KHAN, FARZANA RANI AND M. KHALID MASOOD

PCSIR Laboratories Complex, Lahore-54600, Pakistan

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The Chilghazi iron ores were found to contain 0.42-0.9 % copper, 0.1-0.22 ppm gold, 1.5-3.1 ppm silver and 1.5-1.7 ppm platinum. These metals were found as matrix minerals in magnetite. The results of mineral separation and analyses of product showed that Au, Ag and Pt were associated in chalcopyrite probably by substitution of Cu. The DTA of chalcopyrite showed an endothermic peak at 510° and exothermic peaks at 450, 520 and 765° in addition to the peaks of pyrite at 140 and 330°.

Keywords: Precious metal, Iron Ores, Chilghazi (Baluchistan).

Introduction

In view of the potential ore mineralization in the country, assesment and evaluation of domestic metallic mineral resources has been undertaken to determine their potential for the development of future mineral based industries.

The Pakistan Mineral Development Corporation (PMDC) has been conducting exploration work in Chilghazi area, Baluchistan where iron ore deposit contains disseminated pyrite and chalcopyrite mineralization.

The ore was reported [1] to be basically magnetite occurring as magnatic injections and has been established to bear appreciable values of gold, silver, platinum group of elements, copper and nickel. In view of the economic potential of the ore, a detail study was therefore, conducted on bulk samples collected from exploration adits in the area.

The run of the mine bulk sample of the ore was investigated in this study for its geochemistry and mineralogy by chemicals assay, ore microscopy, XRD/DTA studies and mineral separation.

General geology. The iron ore associated with Sinjrani volcanic rocks, is found at Chilghazi about 51 km northwest of Dalbandin in Baluchistan. The area is underlain by the Cretaceous volcanics and sedimentary rocks and early Tertitary sediments intruded by late Tertitary acid to intermediate rocks (Fig 1).

Chilghazi area is a region of irregular low to high hills. Prominent hills of the area are composed of dark coloured agglomerate, andesite and basalt formed as a result of volcanism which was a constant feature of the area from early Cretaceous to recent times.

Three horizons containing banded or disseminated magnetite are associated with Sinjrani volcanics of Cretaceous age. The topmost mineralized horizon is the principal zone containing andesite with Epidote-Magnetite bands. Second horzone is below 500 feet of topmost horizon and contains only low-grade ore but the third horizon which is 1500 feet below the top horizon contains minable magnetite bands.

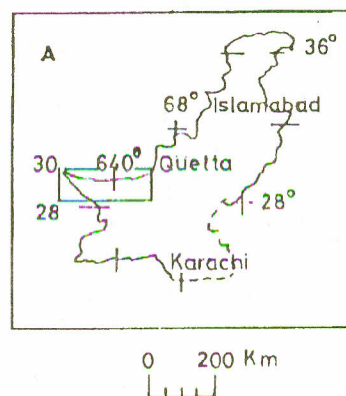
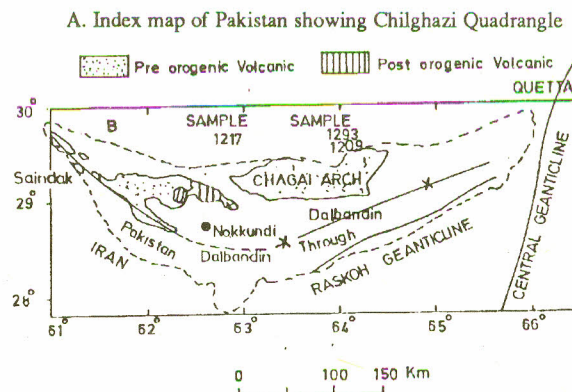
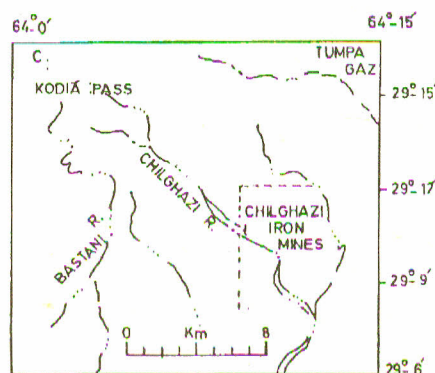


Fig. 1. Location maps of Chilghazi area:



B. Location of Chilghazi Quadrangle



C. Location of Chilghazi mines.

Total iron in high grade ore varies from 32 to 55% and in low grade from 10 to 12%. The reserves calculations were based on ores containing total iron percent of 45 or above with magnetite content ranging from 60 to 85%. A total of 2.46 million tons of reserved were proved [1,2] in seven blocks of the area and in another three blocks probable reserves were estimated at about 0.9 million tons. The total proved and probable reserves in the area was therefore, calculated as 3.3 million tons.

Materials and Methods

The chemical evaluation was conducted on Hitachi z-8000 spectrophotometer. The mineralogical examination of thin and polished sections was done using reflected and transmitted light Reichert Nevar-Pol microscope. The DTA/TGA analyses on thermobalance of Netsch (Germany). A.R. grade reagents of BDH were used for chemical analyses.

Sampling of Chilghazi ore was undertaken on main iron zones by taking 12 kg and 40 kg samples from all blocks in Chilghazi mines and 12 kg from Chigendik. The ore was subjected to primary and secondary crushing in laboratory jaw and roll crushers. A 0.5 kg samples obtained by coning and quartering of bulk sample, was ground in Teema mill to about 80 mesh size for mineral separation and other studies. A batch of 100 grams was also sampled and pulverized in a Teema mill to about 300 mesh by pulverizing for 3 min.

Major elements were determined by standard chemical methods. The Chilghazi ore generally contain 32-55% Fe, 8-20% SiO₂, 2-20% Al₂O₃, 0.3-1.1% CaO, 0.5-1.8% MgO, 0.3-1.4% P₂O₅. Several methods using Atomic Absorption were investigated for the determination of gold, platinum and silver in the rocks [4]. For the determination of copper, gold and silver, the 5-10 g rock was dissolved using HF-HClO₄-HNO₃ and diluted with 20% HCl solution in 100ml volumetric flask. Platinum was determined using the method of Stanon and Ramankutti [6].

The conditions of analyses using flame-less (graphite furnace) atomic absorption spectrometer is given in Table 1 for Cooper, Gold, Silver and Platinum, and the results of chemical analyses of the ores are reported in Table 2.

For the study of mesh of Liberation and Davies tube tests different batches of the bulk ore were ground and passed 100% through different mesh sieves. The ground ore was passed through Davies tube tester. The magnetic and non-magnetic fractions were collected, dried and weighed.

The non-magnetic fraction obtained after the separation of magnetite was enriched with respect of copper and precious metals. In order to find the distribution of these metals in different mineral phases, heavy liquid separation was attempted using the density gradient techniques of Muller and Burton. The non-magnetic fraction obtained by grinding was

divided into three portions. A portion was subjected to heavy liquid separation using Clerici solution and the second and third portions were ground to pass 150 and 180 mesh sieves respectively before separation. The sink and float product

TABLE 1. OPERATING CONDITIONS USED FOR ANALYZING COPPER, SILVER, GOLD AND PLATINUM IN Z-8000 A.A. SPECTROMETER.

| Element | Cu | Ag | Au | Pt |
|--------------------|-------------------------------|-----------|-----------|-----------|
| Lamp current | 7.5 | 7.5 | 10.0 | 12.5 |
| Wave length | 324.8 | 328.1 | 242.8 | 265.9 |
| Slit | 1.3 | 1.3 | 0.09 | 0.4 |
| Atomization | Flame | Graphite | Graphite | Graphite |
| Atomizer | Std. Burner | — | — | — |
| Oxidant | Air | — | — | — |
| Air Pressure | 1.6kg/cm ² | — | — | — |
| Fuel | C ₂ H ₂ | — | — | — |
| Fuel Pressure | 0.3kg/cm ² | — | — | — |
| Bunner height | 7.5 mm | — | — | — |
| Cuvette | — | Tube | Tube | Tube |
| Carrier gas | — | 200ml/min | 200ml/min | 200ml/min |
| Interrupted gas | — | 30ml/min | 30ml/min | 30ml/min |
| Sample volume (µg) | — | 20 | 10 | 20 |
| <i>Temperature</i> | | | | |
| 1. Drying time Sec | — | 30 | 30 | 30 |
| Start temp. °C | — | 80 | 80 | 80 |
| End temp. °C | — | 120 | 120 | 120 |
| 2. Ashing time | — | 30 | 30 | 30 |
| Start temp. | — | 500 | 700 | 500 |
| End temp. | — | 500 | 800 | 800 |
| 3. Atom. time | — | 6 | 8 | 10 |
| Start temp. | — | 2500 | 2700 | 2800 |
| End temp. | — | 2500 | 2700 | 2800 |
| 4. Cleaning time | — | 3 | 3 | 3 |
| Start temp. | — | 2800 | 2900 | 2800 |
| End temp. | — | 2800 | 2900 | 2800 |

TABLE 2. RESULTS OF THE ANALYSES OF COPPER AND PRECIOUS METALS

| Sample No. (Batch No.) | Copper % | Gold ppm | Silver ppm | Platinum ppm |
|-----------------------------|----------|----------|------------|--------------|
| 1293(a) | 0.90 | 0.15 | 1.8 | 1.5 |
| 1293(b) | 0.92 | 0.18 | 1.5 | 1.2 |
| 1293(c) | 0.90 | 0.16 | 1.2 | 1.5 |
| 1293(d) | 0.88 | 0.19 | 2.2 | 3.0 |
| 1293(e) | 0.89 | 0.22 | 1.0 | 0.8 |
| 1293(f) | 0.91 | 0.24 | 1.3 | 1.0 |
| Mean | 0.90 | 0.19 | 1.5 | 1.5 |
| Standard Deviation (Sample) | 0.013 | 0.032 | 0.40 | 0.71 |
| 1217(a) | 0.43 | 0.28 | 3.2 | 1.2 |
| 1217(b) | 0.47 | 0.22 | 3.0 | 2.2 |
| Mean | 0.42 | 0.25 | 3.1 | 1.7 |
| 1209(a) | 0.50 | 0.1 | 2.3 | 1.7 |
| 1209(b) | 0.48 | 0.1 | 1.7 | 1.3 |
| Mean | 0.49 | 0.1 | 2.0 | 1.5 |

were taken on filter paper and weighed after washing and drying. These were then analysed for copper, silver, gold and platinum.

Results and Discussion

Mineralogy. The examination of polished section under ore-microscope showed predominant magnetite with sulphide ore in veins and coarse grained gangue consisting of altered ferromagnesian minerals, quartz, epidote, andesine

TABLE 3. MINERAL ASSEMBLAGES FOUND IN ORE HOST ROCK AND BYPRODUCTS

| Sample No. | Fraction | Mineral Assemblage |
|------------|-----------------------|--|
| 1293(a) | Ore | Magnetite + Andesine ± Chalcopyrite |
| 1293(b) | Host rock | Andesine + Chalcopyrite ± quartz ± haematite ± epidote ± quartz ± calcite |
| 1293(c) | Magnetic concentrate | Magnetite ± haematite |
| 1293(d) | Non-magnetic gangue | Andesine ± Chalcopyrite ± quartz ± haematite ± quartz ± calcite |
| 1293(e) | Flotation concentrate | Chalcopyrite ± pyrite |
| 1293(f) | Flotation Tail | Andesine ± calcite ± haematite ± quartz |

etc. The rocks appear to be altered by martization, sericitization and propylitization. Table 3 shows the mineral assemblages of ore and gangue. The characteristics of the individual ore minerals were as follows:

Magnetite. The dark brown colour of the ore is due to martization of magnetite. The magnetite showed a wide variety of texture from fine-grained dendritic to spherulitic and granoblastic to massive with veining of gangue. The gangue is generally a mixture of ferromagnesian (grey) and felsic (black) minerals present as interstitial mineral of 20-200 microns size and inclusions (2-10 microns size). In the recrystallized coarse-grained massive magnetite, the inclusion and interstitial gangue is reduced due to its expulsion out of grain boundaries. Haematite is formed at the expense of magnetite as fine-grained ore replacement martite texture. The grain size of magnetite is generally 100-200 microns with inclusion of 2-10 microns consisting of felsic and mafic gangue. The inclusion rarely contain sulfide minerals.

Chalcopyrite. The grain size of chalcopyrite is extremely variable from 5 micron to 400 microns. Generally it is present as flakes of 100-200 microns and as dissemination of 5-50 micron size. It is recognized from its deep yellow colour and high reflectance. Under incident light the grains are flame shaped crystals with xenomorphic-texture showing polysynthetic twinning. Some specimens contain sphalerite and pyrrhotite probably formed as exsolution.

Pyrite/pyrrhotite. Pyrite is an important gangue mineral present as dissemination, commonly as vein fillings in these rocks. It is common in small anhedral crystals but sometime

shows cubic shape. Its colour varies from yellow to light yellow and at places appear to have alteration relation with pyrrhotite.

In polished sections pyrite shows a grain size of 10-50 microns. It also forms spherical or semi-spherical aggregates constituted by the association of smaller crystals. Pyrrhotite occurs as anhedral grains with light brown to bronze colour in association with pyrite often showing replacement relation.

Sphalerite. Sphalerite occurs as a few disseminated grains of about 50 micron size usually as replacement mineral and anhedral crystals. Under reflected light the mineral shows a light grey colour with a very delicate blue shade.

Galena. Occasional grains of galena are seen as high reflecting isotropic mineral which when freshly polished shows pure white lustre. On etching with HNO₃ the grains tarnishes black. Most commonly the galena shows myrmekitic texture in the ores without its characteristics cubic shape.

X-ray diffraction study. The X-ray diffraction pattern of the ore was taken after the removal of magnetite by magnetic separation, in order to eliminate the background due to iron. The diffractogram obtained was found to be complex, due to polyminerallitic and altered mineral phases. The intensity of 'd' values being moderate to low. The major mineral components

TABLE 4(A). RESULTS OF DTA AND TGA STUDIES ON CHILGHAZI ORE CONCENTRATES AND TAILINGS

| Sample | Endothermic peak | Exothermic peak | TGA(%wt. loss) | |
|--------------------|------------------|-----------------|----------------|------|
| | | | °C | % |
| Magnetite conc. | 230m (mt) | 390m (mt) | 390 | 0.56 |
| | 580m (q) | 480m (mt) | | |
| | 600m (Py) | | | |
| Chalcopyrite conc. | 750 (Sil. g) | | 750 | 1.04 |
| | 140 (Pyr) | 450s (Cpy) | 140 | 0.48 |
| | 330 (Py,Pyr) | 520w (Cpy) | 330 | 0.8 |
| Tailings | 510 (Cpy) | 765s (Cpy) | 510 | 4.0 |
| | 120 (Pyr) | 415m (Cpy) | 310 | 0.56 |
| | 310 (Py,Pyr) | 540m (py) | 600 | 0.48 |
| | 600 (Py,Pyr) | 780m | 780 | 0.32 |

Abbreviations: Cpy-chalcopyrite, Py-pyrite, Pyr-pyrrhotite q-quartz, Sil-ferromagnesian and felsic gangue.

TABLE 4(B). DIFFRACTOMETRIC ANALYSIS OF NON-MAGNETIC FRACTION.

| Mineral | 'd' Values (Intensities) | | |
|--------------------|--------------------------|----------------------|--------------------|
| Chlorite | 7.30(4), | 3.55(3), | 2.82(4) |
| Goethite/Haematite | 5.15(3), 2.54(7), | 4.21(3), 2.19(3) | 2.68(5), |
| Magnetite | 4.85(2), | 2.91(8) | |
| Pyrite, Pyrrhotite | 3.13(3), 2.40(4), | 2.70(6), 2.19(3), | 2.61(5) 2.01(2) |
| Chalcopyrite | 3.05(6), 1.54(3) | 1.07(3), | 1.59(1), |
| Quartz | 4.21(3), | 3.37(8) | |
| Ande | 4.02(5), | 3.21(5) | |

shown by XRD were chalcopyrite, magnetite, andesine, chlorite, pyrite/pyrrhotite and goethite/hematite. Minor amounts of quartz, galena and sphalerite may also be present, however, their peak intensities were small. The results of XRD are given in Table 4A and 4B.

DTA and TGA studies. The magnetite as obtained by magnetic separation, chalcopyrite and remaining gangue obtained by mineral separation were investigated using STA-409 equipment of Netsch (Germany). The results are presented in Table 3 and Figs. 2-4. The magnetite showed an endothermic peak at 230° and exothermic peaks at 390° and 480°. The TGA showed weight loss of 0.56% at 390° which

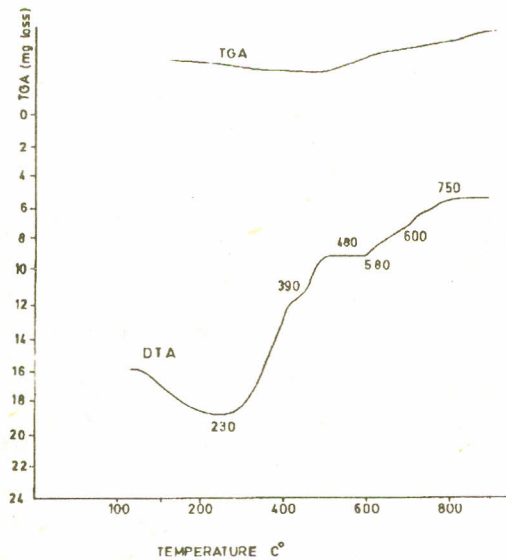


Fig 2. DTA/TGA of Chilghazi Magnetic concentrate using 0.1 gm sample.

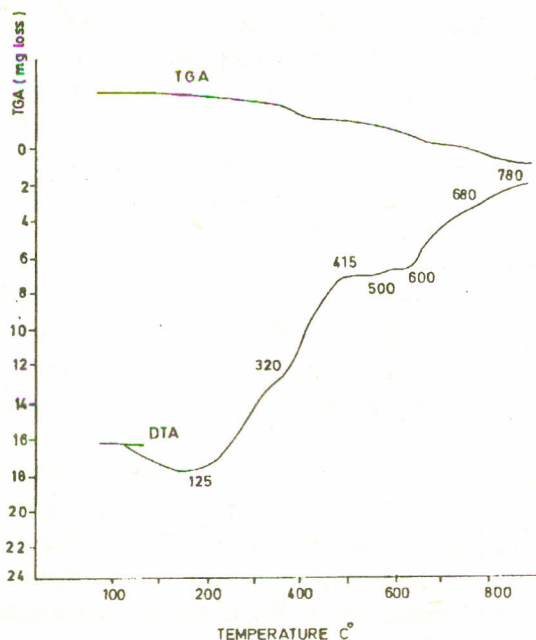


Fig 3. TDA/TGA of Chilghazi ore tailing using 0.1 gm sample.

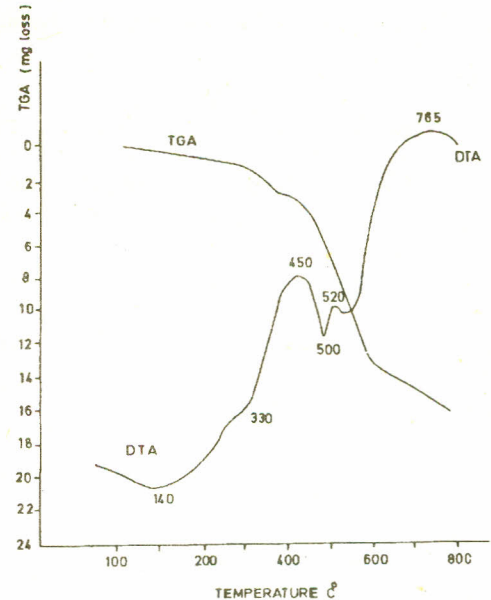


Fig 4. DTA/TGA of Chilghazi chalcopyrite concentrate using 0.1g sample.

is probably due to the breakdown of goethite or pyrite present as impurity. The weight of the sample is increased by 1.04% on further heating to 480° due to the oxidation of magnetite forming Fe_2O_3 . The calculations based on the weight loss of the sample showed that Chilghazi magnetite is partially oxidized. The endothermic peaks obtained at 580, 600 and 750° are due to the impurity minerals such as quartz, pyrite and silicate gangue.

The chalcopyrite shows an endothermic peak at 510° pyrrhotite and pyrite at 140 and 330° respectively. The weight losses at 140, 330 and 510° were 0.48, 0.8 and 4.0% respectively due to the breakdown of pyrrhotite, pyrite and chalcopyrite.

Mineral separation. The magnetite in Chilghazi iron ore appears to be easily separable by magnetic separation due to the presence as separate phases of magnetite, gangue and precious-metals minerals. Davies tube tests of the bulk ore sample No. 1293 showed a good recovery of magnetite under low intensity magnetic separation, while the sample No. 1209 and 1217 showed a little less recovery due to same alteration of magnetite.

The iron ore under microscope invariably showed micro inclusions of siliceous gangue minerals in magnetite grains. The size of the micro inclusions (10-20 microns) was found to be below the practical limit of mineral beneficiation, using gravity, magnetic or flotation methods. However, the chemical analyses showed that it would not contribute more than 3.5% SiO_2 to the reconcentrated magnetite. The matrix gangue mineral after the removal of magnetite by magnetic separation could be an economic by-product containing copper, gold, silver and platinum.

TABLE 5. COMPOSITION AND RECOVERY OF COPPER, PRECIOUS METALS IN MAG. (M) AND NON-MAG. (N.M.) FRACTIONS IN CHILGHAZI ORE SAMPLE No. 1239

| | Wt. % | Copper | | Silver | | Gold | | Platinum | |
|-------|--------|--------|--------|--------|--------|-------|--------|----------|--------|
| | | % | Rec. % | PPM | Rec. % | PPM | Rec. % | PPM | Rec. % |
| Head | 100.00 | 00.90 | 100.00 | 01.50 | 100.00 | 00.19 | 100.00 | 01.50 | 100.00 |
| M | 84.20 | 00.47 | 43.90 | 00.90 | 50.50 | 00.13 | 57.60 | 00.90 | 50.30 |
| -60# | | | | | | | | | |
| N.M. | 15.80 | 03.20 | 56.60 | 03.80 | 40.00 | 00.45 | 42.40 | 04.20 | 49.70 |
| M | 74.00 | 00.30 | 25.70 | 00.40 | 08.50 | 00.05 | 17.90 | 00.50 | 24.00 |
| -120# | | | | | | | | | |
| N.M. | 26.00 | 02.60 | 66.40 | 05.50 | 95.30 | 00.70 | 82.10 | 04.50 | 76.00 |
| M | 86.40 | 00.76 | 72.80 | 00.70 | 40.30 | 00.10 | 56.00 | 00.60 | 28.40 |
| -150# | | | | | | | | | |
| N.M. | 13.60 | 02.10 | 31.70 | 07.00 | 63.50 | 00.50 | 44.00 | 07.00 | 71.60 |

TABLE 7. EFFECT OF SULPHURIC ACID CONCENTRATION ON LEACHING

| S. No. | Conc. of Acid | | Cu | | Ag | | Au | | Pt | |
|--------|-------------------------|-------|------|--------|-------|--------|------|--------|------|--------|
| | (100ml) | | % | Rec. % | PPM | Rec. % | PPM | Rec. % | PPM | Rec. % |
| 1. | 1.00% | 100ml | 0.65 | 72.00 | 00.00 | 00.00 | 0.05 | 26.00 | 0.60 | 40.00 |
| 2. | 2.50% | 100ml | 0.75 | 83.00 | 0.2 | 13.00 | 0.06 | 31.00 | 0.20 | 13.00 |
| 3. | 5.00% | 100ml | 0.90 | 100.00 | 0.8 | 53.00 | 0.02 | 10.00 | 0.30 | 20.00 |
| 4. | 7.50% | 100ml | 0.80 | 89.00 | 1.2 | 80.00 | 0.02 | 10.00 | 0.40 | 27.00 |
| 5. | 10.00% | 10ml | 0.88 | 98.00 | 1.2 | 80.00 | 0.03 | 16.00 | 0.80 | 53.00 |
| 6. | Total extraction method | | 0.90 | 100.00 | 1.5 | 100.00 | 0.19 | 100.00 | 1.5 | 100.00 |

Ore Size : -100#
 Time of stirring : 30 minutes
 Final volume made : 500.00ml

TABLE 6. RESULTS OF HEAVY LIQUID SEPARATION OF NON-MAGNETIC FRACTIONS USING CLERICI SOLUTION OF 3.5 SPECIFIC GRAVITY

| Mesh Size | Weight Percent | Copper | | Silver | | Gold | |
|---------------------|----------------|--------|--------|--------|--------|------|--------|
| | | % | Rec. % | PPM | Rec. % | PPM | Rec. % |
| Non-magnetic (Head) | 100 | 2.6 | 100 | 5.5 | 100 | 0.7 | 100 |
| -120 Mesh | | | | | | | |
| Sink | 29 | 8.1 | 90 | 16.8 | 89 | 2.1 | 87 |
| Float | 71 | 0.36 | - | 0.9 | - | 0.1 | - |
| -150 Mesh | | | | | | | |
| Sink | 22 | 9.5 | 80 | 18.1 | 72 | 2.3 | 72 |
| Float | 78 | 0.7 | - | 1.9 | - | 0.2 | - |
| -180 Mesh | | | | | | | |
| Sink | 17 | 11.1 | 73 | 20.2 | 69 | 2.4 | 58 |
| Float | 81 | 0.85 | - | 2.5 | - | 0.3 | - |

Davies tube tests show that at -18 mesh size, the weight percent recovery was only 65% due to the generation of gangue dominated locked particles. On further grinding to 40-80 mesh weight percent of magnetic fraction is increased to 90-84% due to the separation and generation of magnetite and magnetite dominated locked particles. But grinding to 20 mesh size resulted in decrease of the weight of magnetics to 74%. The ore was found to show liberation at about 120 mesh size.

The chemical composition and recovery of different precious metals in magnetic concentrate and non-magnetic fraction are given in Table 5.

The results (Table 6) of heavy liquid separation of non-magnetic fraction indicated that the heavy minerals like chalcopyrite and pyrite could be separated from the fraction. The concentration of copper, silver and gold could be achieved along with chalcopyrite rich fraction. Gold and silver, therefore, appeared to substitute sulphide minerals as no individual mineral of gold and silver was observed by ore microscopy and X-ray diffractometry.

The mineral separation using the grind size of 120 mesh showed maximum recovery of economic metals i.e. 90% for copper, 89% for silver and 87% for gold. The content of copper, silver and gold were 8.1% 16.8 ppm and 2.1 ppm respectively. The grind size of 150 mesh was found optimum for mineral separation.

Leaching. Experiments on leaching/extraction of copper from the Chilghazi ore using sulphuric acid were conducted, and the results are given in Table 7. The original ore containing 0.9% copper was used in these experiments. The ore was treated with H₂SO₄ of different concentrations along with NHO₃ and was stirred for fifteen, thirty, and sixty

minutes time periods. After stirring, the material was kept as such for 24 hrs. and then decanted and filtered.

The results of these experiments (Table 7) showed that while copper and silver values can be recovered by sulphuric acid leaching, the gold remain undissolved and was not recovered. Sulphuric acid leaching was generally recommended for oxidised copper ores. However, for Chilghazi ore HNO_3 addition was necessary to oxidize the sulphide minerals.

No detail work at this stage is attempted to recover gold except an experiment using 5 gm ore and a litre of 0.05% cyanide solution and agitation. About 80% gold was dissolved in the solutions many gold ores creates no problems during dissolution in cyanide solutions under normal conditions[5].

However, the presence of copper mineral in an ore always present a major problem on both the dissolution and precipitation of gold [5]. The copper minerals dissolve in cyanide causing excessive consumption of chemicals and also form copper cyanogen complex which indirectly affect the dissolution of gold. In addition, the copper present in solution also influence the precipitation of gold by zinc, resulting in copper containing gold precipitate, which is undersirable in subsequent metallurgical operation. Detail work on the leaching of Chilghazi ore with cyanide is required as gold occurs in ore in many different forms and the scheme of treatment has to be evolved accordingly.

No two ores are exactly alike and each presents its own problems in cyanidation. For example rpesence of traces of carbonaceous matter precipitate gold in cyanide solution and the sulphide minerals like pyrrhotite, covellite, sphalerite, etc., affect the dissolution and precipitation of gold by forming alkaline sulphide, thiosulphates and thiocyanites. If flotation is used to concentrate the ore, the coatings of reagents such as zanthate, dithiophosphate, frothing oil, copper sulphate retard the action between gold particles and cyanide solution. Further work is required in this connection and would be published later.

Conclusion

The Chilghazi iron ores were found to contain 0.42–0.9% copper, 0.1–0.22 ppm gold, 1.5–3.1 ppm silver 1.5–1.7 ppm platinum. The copper and precious metals appear to be paragenetically related to late intrusive minerals in magnetite lenses and andesitic rocks of the area. The iron ore contains magnetite grains of 100–200 microns size forming the bulk of the ore with gangue and sulphide minerals in the matrix. The magnetite is separable using low intensity magnetic separator from associated gangue minerals at 120–150 mesh size. The sulphide minerals such as chalcopyrite and pyrite along with gold and silver values collected as non-magnetics showed 2.6% copper, 5–5 ppm silver and 0.3 ppm gold. The sink float tests showed that 90% copper, 89% silver and 87% gold can be recovered with 8.1% copper, 16.8 ppm silver, 2.1 ppm gold in sink as concentrate. It is recommended to survey the whole area and not just the iron ore bodies for copper and precious metals in the area due to its separate paragenesis and intrusive nature. Detailed study is also required to evolve hydrometallurgical processes for the treatment of this complex ore as elaborated in the discussion part of this paper.

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