Mineralogy Study on a Fine-Grained Cu-Mo Sulphide Ore in Jiudingshan China

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Abstract. This study researched mineralogy characteristics of Jiudingshan Cu-Mo sulphide ore by modern testing instruments, such as scanning electron microscope (SEM), reflected light microscope (RLM), X-ray diffractometer (XRD), and mineral liberation analyzer (MLA). The occurrence of Cu, Mo and other valuable minerals were mainly investigated. Results show that: it contain 0.50% Cu, 0.15% Mo and 7.04% Fe. Forty individual minerals are involved in the ore. Main valuable minerals are molybdenite, chalcopyrite, magnetite, pyrite; main gangue minerals are quartz, feldspar, garnet, calcite, dolomite. Molybdenite, chalcopyrite are finely disseminated in the magnetite, quartz, feldspar, garnet; some are inlayed along other minerals such as idocrase, actynolin.

1. Introduction
Porphry deposits are the principal sources of Cu and Mo in the world [1]. Molybdenite and chalcopyrite usually have nature flotability, but it is difficult to recover due to low grade, fine grained size because molybdenite particles has two kinds of surface, namely face and edge, when the size reduces, the face/edge ration decreased and thus the hydrophobicity of molybdenite surfaces decreased, leading to sharp falling of flotation efficiency [2]. Bulk flotation of Cu and Mo then separation them by preferential flotation or obtain copper concentrate and molybdenite concentrate by selective flotation directly is the usual flowsheet. The most common plant practice involves depression of chalcopyrite from molybdenite using sodium cyanide, sodium hydrogen sulfide (NaHS) or Noke’s reagent to generate a molybdenite concentrate [3].

Molybdenite processes excellent natural floatability [4], but not obvious when it finely disseminates and has a complex mineralogy in the raw ore. Only by fine grinding or combing hydrometallurgy process, high quality molybdenite concentrate can be obtained.

Mineralogy of ore deposits, slime coatings, optimizing copper metallurgy at the expense of molybdenum, grinding and liberation, and flotation reagents are the main factors affecting beneficiation index [5], so it’s necessary to investigate the mineralogy of ore before ore dressing. The mineralogy of ore of Jiudingshan mine was investigated in this paper, including chemical composition, mineral category, occurrence characteristics and so on.
2. Materials and methods
Representative samples were taken from Jiudingshan mine and arrived to Kunming University of Science and Technology on March 20, 2010. After sample preparation, the samples were used for phase analysis and mineralogy study. The chemical analysis, copper and molybdenum phase analysis results shown in tables 1, 2 and 3.

| Table 1. Results of chemical analysis of the sample |
|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| element | Mo | Cu | S | Fe | Sn | Zn | Pb | Mn | Ag | As | P |
| content (%) | 0.150 | 0.500 | 1.450 | 7.04 | 0.082 | 0.034 | <0.050 | 0.093 | 14g/t | 0.067 | 0.059 |
| element | TiO2 | CaO | MgO | SiO2 | Al2O3 | WO3 | Cr2O3 | Bi | V2O5 | Ni |
| content (%) | 0.430 | 2.490 | 0.860 | 65.550 | 8.490 | 0.060 | <0.030 | 0.050 | 0.080 | 0.030 |

| Table 2. Results of molybdenum phase analysis |
|---------------------------------|-----|-----|-----|-----|
| phase | molybdenite | oxide | others | total |
| Content (%) | 0.161 | 0.004 | 0.005 | 0.170 |
| Distribution (%) | 94.71 | 2.35 | 2.94 | 100 |

| Table 3. Results of copper phase analysis |
|---------------------------------|-----|-----|-----|-----|
| phase | sulphide | Combined copper oxide | Free copper oxide | others | total |
| Content (%) | 0.40 | 0.01 | 0.02 | 0 | 0.43 |
| Distribution (%) | 93.02 | 2.33 | 4.65 | 0 | 100 |

In order to investigate the mineralogy of the ore, many modern analysis means were used as below: the optical microscope and stereomicroscope were used to certain mineral textures, and to determine mineral quantities by point counting; In order to determine mineral textures and quantities on a high correct degree, X-ray diffractometer was used; Scanning electron microscope(SEM) was used to analysis the morphology and composition of minerals; The mineral liberation analyzer(MLA) was used to study the liberation degree of main minerals.

3. Results and discussion
As table 1 shown: This ore contain 0.150% Mo, 0.500% Cu, 65.550% SiO2, 8.490% Al2O3 and 2.490% CaO, these elements are major elements in gangue minerals and have little value, especially the Al2O3 should be removed carefully, because it will cause many undesired effect on flotation, such as: (a) loss in recovery, possibly due to the presence of slime coating on air-bubbles or on the mineral surfaces; (b) increase reagents consumption by fine particles; (c) the transfer of large quantities of slimes/clay minerals into the concentrate during the roughing and scavenging flotation stages, which subsequently requires higher temperatures in the smelting process and difficulties in discharging the slag; (d) increase in the quantities of fine particles in the crushing and grinding circuits; (e) the flocculation phenomenon in the froth zone [6].

As presented in table 2: molybdenum mainly in the form of molybdenite, its distribution ratio is 94.71%, the maximum beneficiation recovery may 94.71% theoretically. Seen from table 3, copper mainly in the form of sulphide, and its distribution ratio is 93.02%, copper beneficiation recovery won’t higher than 93.02% theoretically. In this ore, copper and molybdenum are main in form of sulphide, so it’s reasonable to recover them by flotation.

3.1. Molybdenite mineralogy characteristics
Molybdenite grain size ranges from 0.06–0.35mm. The molybdenite occurred as semi-idiomorphism or allotriomorphic crystals, it conjunction with calcite to form coarse assemblages at the grain size ranging from 0.010mm to 0.045mm, calcite associated with garnet (Fig.1-a.). Some molybdenite
particles are fine grained or micrograined, the grain size ranges from 0.001~0.013mm, and molybdenite disseminated in gangue minerals such as quartz, feldspar (Fig.1-b.). A part of molybdenite particles are inlayed gangue minerals such as garnet and quartz (Fig.1-c and Fig.1-d). Another part of some fine grained or micrograined quartz, chalcopyrite are coated by coarse molybdenite, this occurrence have a favorable effect for molybdenum recovery. In a word, molybdenite are irregularly distributed, Most of them occurred as assemblages, and rich part can see dozens of molybdenite crystals; Molybdenite particle size classified three fraction: middle grained size, fine grained size and micrograined size, the fine grained size is the most distributed ones.

![SEM image](image1.jpg)

**Figure 1.** SEM image

### 3.2. Chalcopyrite mineralogy characteristics

Observe chalcopyrite mineralogy by RLM, it’s crystal size unequally-distributed, the coarse particle size reached 0.85mm, while fine particle size just 0.0005mm, chalcopyrite show a complex occurrence:

1. single chalcopyrite crystal or multi crystals present a bulk distribution, and chalcopyrite mainly associated with magnetite, sphalerite, marmatite, quartz, feldspar, garnet, idocrase, calcite (Fig.2-a and Fig.2-b). The maximum size of aggregate is 0.3mm, most of them under 0.07~0.2mm. (2) Course chalcopyrite coating fine grained quartz, garnet and feldspar, while fine grained and micro-grained chalcopyrite disseminated in quartz, feldspar, garnet, idocrase, calcite, sphalerite, marmatite (Fig.2-c), and trace amount of chalcopyrite distributed around edges of these minerals. (3) micro-grained chalcopyrite inlayed quartz, feldspar, garnet, idocrase, calcite, sphalerite, marmatite (Fig.2-d and Fig.2-e), its occurrence is very similar with the above one, but chalcopyrite crystal size is more fine as most of them are among 0.001mm~0.010mm. (4) Vein chalcopyrite distributed among gangue minerals, or inlayed fractures of gangue minerals (Fig.2-f). (5) Chalopyrite coated by bornite. In a word, chalcopyrite irregularly distributed, and its grain size classified three fraction: middle grained size, fine grained size and micrograined size, and the fine grained and micrograined size are the most distributed ones.
3.3. Iron-bearing minerals mineralogy characteristics

3.3.1. Magnetite mineralogy. Observed magnetite mineralogy by SEM, magnetite irregularly inlayed gangue minerals, its crystal size is very fine, usually among 0.08mm~0.2mm, and magnetite mainly associated or disseminated with quartz, feldspar, garnet, calcite, pyroxene, chlorite, marmatite, sphalerite, chalcopyrite, molybdenite. Typical occurrence shown in figure 3.

3.3.2. Pyrite mineralogy. Observed pyrite mineralogy by reflected light microscope (RLM), pyrite comprised mainly of dense block, granulated, irregular angular output. It mainly associated or disseminated with quartz, feldspar, pyroxene, chlorite, magnetite, chalcopyrite, garnet, idocrase, actynolin. Typical occurrence shown in figure 4-a and b.
3.4. Main gangue minerals mineralogy characteristics

Observed by SEM, quartz and garnet mainly comprised mainly of massive, granulated, irregular angular output. Both of them associated or disseminated with feldspar, pyroxene, chlorite, magnetite, chalcopyrite, idocrase, actynolin, and quartz is the “carrier” of molybdenite. In addition, feldspar and calcite also disseminated with above minerals. Typical occurrence shown in figure 5.a, b, c, d.

Details for other gangue minerals such as mica, idocrase and arsenopyrite, etc, are unimportant and ignored due to their small amount of contents.

4. Conclusion

Studies show that forty individual minerals are found in this ore sample, valuable minerals are molybdenite and chalcopyrite, meanwhile magnetite and pyrite can be recovered. Both molybdenite and chalcopyrite shown a complex occurrence, most of them occurred as inclusions and intergrowth.
This ore contains a large amount of gangue minerals, molybdenite, and chalcopyrite, presenting a finely bulk dissemination in them. Quartz is the major gangue mineral accounting for 65.550% of the total mineral weight, and other gangue minerals contain Al2O3 to a great extent, which make great difficulty in flotation, because it is easily be slimed during grinding process, so measures should be taken in grinding operation to prevent it.

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