Process mineralogy analysis and beneficiation test of deep high-grade ore in Sanshandao Gold Mine

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Abstract. The high-grade ore produced from the deep ore body of Sanshandao Gold Mine differs significantly from the grade of the produced ore. For the efficient recovery of the deposit, the BPMA process mineralogical analysis system is used to analyze the ore. The main gold minerals are natural gold and silver gold, with an average particle size of 8.18 μ m. Gold deposits mainly coexist with pyrite. By adopting a single optimization, one rough selection, two sweeping and one concentrate flotation process, and increasing the amount of collector by 30g/t, a gold concentrate with a yield of 15.15%, a gold recovery rate of 98.08%, and a gold grade of 54.45g/t was produced. The gold grade in tailings was 0.19g/t, achieving efficient recovery of gold from high-grade ores.

Keywords: Gold ore; High grade; Process mineralogy.

1 Introduction

Metal fittings have good metal ductility and chemical stability[1], and are widely used in industries, information and electronic technology, aerospace, new energy, new materials, and other fields. Shandong Province has abundant gold resources, and both reserves and production occupy a major position in the country[2]. The existing gold resources of Sanshandao Gold Mine are as high as over 1000 tons[3]. At present, the main methods for selecting high-grade gold containing ores include gravity separation, flotation, and combined process methods[4-5].

This article conducts process mineralogical analysis and beneficiation experiments on the deep mining of high-grade gold bearing ores in Sanshandao Gold Mine. The existing production process can no longer meet the recovery requirements of high-grade ores. This experiment achieved efficient gold recovery by increasing the amount of collector[6], providing reference for the production of similar mines.

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2 Experiment

2.1 Sample properties

(1)Component analysis

The results of multi-element analysis of the samples are shown in Table 1.

Table 1. Multi-element analysis results of samples

Element	Au*	Ag*	Cu	Pb	Zn	Fe	S	As
Grade/%	8.41	10.98	0.05	0.03	0.02	6.47	6.72	0.02
Element	SiO_2	Al_2O_3	MgO	CaO	Na_2O	K_2O		
Grade/%	69.68	6.97	0.42	0.28	0.28	2.14		

Note: The unit of gold and silver element content is g/t.

It can be seen that the main valuable elements in the sample are gold and silver, with low content of other elements. The main gangue ore is quartz From Table 1.

(2)Mineral composition

The sample was subjected to process mineralogical analysis under the condition of -200 with a content of 56%. The gold minerals in the sample include natural gold and silver gold, while the metal minerals mainly include pyrite, a small amount of chalcopyrite, galena, sphalerite, hematite, etc; Gangue minerals mainly include quartz, mica (sericite, muscovite, biotite, etc.), feldspar (potassium feldspar, plagioclase, etc.), clinopyroxene, dolomite (dolomite and iron dolomite), pyroxene, etc The mineral composition and relative content of the sample are shown in table 2, and the distribution results of gold in the sample are shown in table 3.

Table 2. Mineral composition and relative content of samples

Metal minerals	Pyrite	Galena	Chalcopyrite	Sphalerite	Hematite	Other	Total/%
Content/%	11.66	0.04	0.11	0.03	0.33	0.42	12.59
Gangue	Quartz	Feldspar	Mica	Milarite	Pyroxene	Other	Total/%
Content/%	59.01	5.49	18.43	0.52	0.37	3.59	87.41

Table 3. Results of Au distribution in samples

Phase	Gold in natural gold	Gold in electrum	Total%
Content/($g \cdot t^{-1}$)	1.66	6.75	8.41
Distribution/%	19.74	80.26	100.00

From Table 3, it can be seen that gold in the sample is mainly distributed in natural gold and silver gold, with gold distribution rates of 19.74% and 80.26%, respectively.

(3)Main mineral embedding characteristics.

The main sulfide ore in the sample is pyrite, with a mineral content of 11.66% and an average particle size of 80.02 μ m. It is embedded in coarse grains. The main mineral embedding relationships are shown in Figures 1 to 4 and Table 4.

Table 4. Particle size distribution of major minerals

Mineral	Pyrite	
Fraction/um	Concent/%	Accumulation/%
-300+147	8.27	8.27
-147+104	21.94	30.21
-104+74	20.90	51.11
-74+38	28.87	79.98
-38+20	11.54	91.52
-20+15	2.77	94.29
-15+10	2.55	96.84
-10+5	2.38	99.22
-5	0.78	100
Average particle size(um)	80.02	

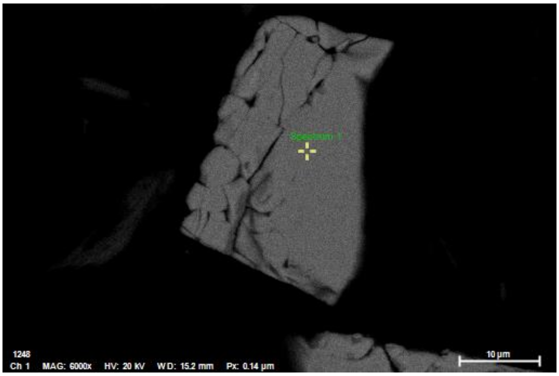

Fig. 1. Pyrite monomer

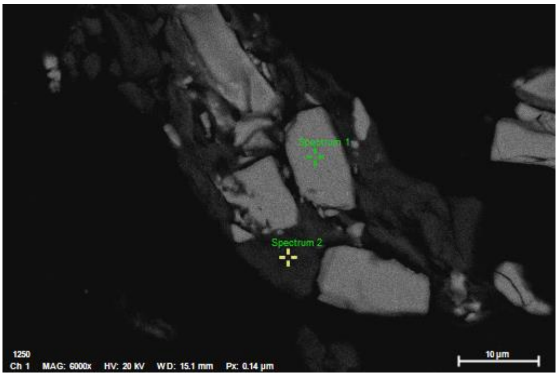

Fig. 2. Pyrite and sericite intergrowth

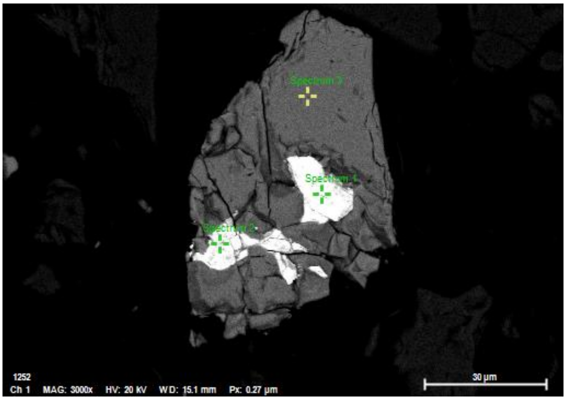

Fig. 3. Pyrite associated with galena

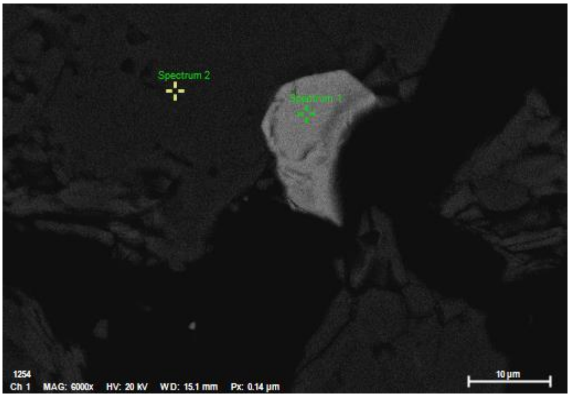

Fig. 4. Pyrite associated with quartz

(4) Particle size analysis of gold minerals

The distribution particle size analysis of gold minerals in the sample is shown in Table 5.

Table 5. Sample gold mineral particle size analysis table

Fraction/um		Content/%	Accumulation/%
Medium/-74+37		0.00	0.00
Fine/-37+10		45.66	45.66
Micro-fine	-10+5	28.01	73.67
	-5	26.33	100.00
Average		8.18	

As can be seen from Table 5, the particle size of the gold mineral in the sample is relatively fine, with an average particle size of 8.18μm, which is mainly in the form of fine-fine-grained embedding.

2.2 Instruments and reagents

Single cell flotation machine, automatic grinding and polishing machine, multifunctional experimental surface treatment machine, MD3 Nielsen beneficiation machine, BPMA process mineralogical detection and analysis system, butyl xanthate, 2# oil.

3 Results and discussion

3.1 Nielsen reselection exploration experiment

To investigate the feasibility of deep mining ore re selection and gold recovery in Sanshandao Gold Mine, a Nielsen re selection exploration experiment was conducted. The experiment was conducted using an MD3 Nielsen beneficiation machine under the following conditions: sample mass of 5000g, gravity of 60G, fluidization water volume of 3.0-3.5L/min, and feed rate of 600-1000g/min. The experimental results are shown in table 6.

Table 6. Nielsen reselection exploration test results

Product	*Productivity/%*	*Grade*		*Recovery/%*	
		Au/(g·t^{-1})	*S/%*	*Au*	*S*
Concentrate	0.63	100.29	39.84	7.52	3.74
Middling	0.31	15.67	6.16	0.58	0.28
Tailing	99.06	7.80	6.51	91.90	95.98
Total	100.0	8.41	6.72	100.00	100.00

From table 6, it can be seen that after Nielsen re-selection exploration, the concentrate yield was 0.63%, the gold grade was 100.29g/t, the recovery rate was 7.52%, the effective sulfur content was 39.84%, the recovery rate was 3.74%, the yield in tailings was 99.06%, the gold grade was 7.80g/t, and the effective sulfur content was 6.51%. Based on the analysis results of process mineralogy, the gold ore particles in the sample are relatively fine, with an average particle size of 8.18μm. Mainly distributed in the form of fine to fine particles. In summary, the Nielsen reselection process is not suitable for the selection of this sample.

3.2 Closed circuit flotation test

Adopting a process of one optimization, one rough selection, one selection, and two sweeping selections. Conduct a closed circuit test on the sample to investigate the distribution of mineral products during the closed circuit process. The test results are shown in Table 7.

Table 7. Closed-circuit test results

Product	*Productivity/%*	*Grade*		*Recovery/%*	
		Au/($g \cdot t^{-1}$)	S/%	Au	S
Concentrate	15.15	54.45	42.56	98.08	95.96
Tailing	84.85	0.19	0.32	1.92	4.04
Total	100.0	8.41	6.72	100.0	100.0

From Table 7, it can be seen that the concentrate yield in the closed circuit test is 15.15%, the gold recovery rate is 98.08%, the gold grade is 54.45g/t, and the effective sulfur grade is 42.56%. The gold grade in tailings is 0.19g/t, and the effective sulfur grade is 0.32%.

4 Conclusion

(1)The gold content in the sample is 8.41g/t, and gold is mainly distributed in natural gold and silver gold, with gold distribution rates of 19.74% and 80.26%, respectively. Gold deposits mainly coexist with pyrite, with a gold content of 90.22%, a single gold mineral content of 7.00%, and a gold content of 2.78% coexisting with quartz.

(2)According to the on-site production process, the amount of collector increased by 30g/t, resulting in a yield of 15.15%, a gold recovery rate of 98.08%, a gold grade of 54.45g/t, and a gold grade of 0.19g/t in the tailings.

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