Process mineralogy detection and analysis of a cyanide tailings

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Abstract. The process mineralogy test was carried out on the cyanide tailings produced by a gold smelting enterprise to explore the target elements and mineral dissemination characteristics, the occurrence state of the target elements, and the particle size distribution of the target minerals in the cyanide tailings samples. The results show that the gold minerals in the samples are mainly natural gold and electrum. Gold minerals are mainly symbiotic with pyrite, and a small amount is symbiotic with arsenopyrite and quartz. Gold minerals mainly exist in the form of encapsulated gold, which is embedded in fine particles. The content of fine particles accounts for 93.46 %, and the average particle size is 5.81 μm.The process mineralogy test of the cyanide tailings sample provides important data support for the subsequent experimental study of the cyanide tailings and the comprehensive utilization of valuable metals.

Keywords: Cyanide tailings; gold minerals; Pyrite; Gangue; micro-fine particles.

1 Introduction

With the continuous improvement of mineral detection technology, the accuracy of detection data has been greatly improved. Process mineralogy has been widely used in the detection of refractory minerals, which has important guiding significance for the efficient development and utilization of minerals [1-2]. Cyanide tailings are solid hazardous wastes produced by cyanide gold extraction process in gold production process. Cyanide tailings produced by different processes have different characteristics, and there will be corresponding requirements for disposal technology and process. As a bulk solid waste produced by gold smelting enterprises, cyanide tailings not only contain a certain amount of gold, but also contain other valuable metals and minerals that can be comprehensively recovered [3-4].Through the process mineralogy detection of cyanide tailings samples, the target elements and mineral dissemination characteristics, the occurrence state of target elements, the particle size distribution of target

A. E. Abomohra et al. (eds.), *Proceedings of the 2023 9th International Conference on Advances in Energy Resources and Environment Engineering (ICAESEE 2023)*, Atlantis Highlights in Engineering 29,
https://doi.org/10.2991/978-94-6463-415-0_63

minerals and other information in the samples are proved, which provides important data support for the subsequent experimental research and comprehensive utilization of cyanide tailings [5-9].

2 Multielement analysis of samples

A gold smelting enterprise produces a part of high-sulfur arsenic-containing cyanide tailings with a gold grade of about 4.4 g / t, a sulfur grade of about 17 % -20 %, and an arsenic grade of about 4.5 %. This part of the cyanide tailings is discharged into the tailings pond for stockpiling and has not been comprehensively utilized.The cyanide tailings sample was subjected to multi-element analysis and the results are shown in Table 1 below.

Table 1. Results of multi-element analysis of samples.

Element	Au(g/t)	Ag(g/t)	Cu	Pb	Zn	Fe	S	As
Grade (%)	4.41	11.14	0.08	0.16	0.18	20.70	19.02	4.58
Element	SiO_2	Al_2O_3	MgO	CaO	Na_2O	K_2O	C	
Grade (%)	36.77	4.61	0.92	1.98	0.48	1.61	3.67	

It can be seen from the data in Table 1 that the gold content in the sample is 4.41 g / t. The gold grade is high and has recovery value, while the content of other metal elements is low and has no recovery value.

3 Mineral constituent

Through the analysis of electron microscope and energy spectrum, the main gold mineral in the sample is natural gold, with a small am ount of electrum; in addition, there are pyrite, arsenopyrite, a small amount of chalcopyrite, Galena, sphalerite, pyrrhotite and other metal minerals; gangue minerals mainly include quartz, feldspar, mica, whole column stone, amphibole, ordinary pyroxene and so on. The mineral composition and relative content of the samples are shown in Table 2.

Table 2. Mineral composition and relative content.

Mineral	Content (%)	Mineral	Content (%)
Pyrite	31.88	Quartz	24.92
Pyrrhotite	1.59	Feldspar	6.02
Chalcopyrite	0.26	Thorn mica	10.13
Galena	0.18	Milarite	2.21
Sphalerite	0.49	Amphibole	2.15
Arsenopyrite	9.91	Ordinary pyroxene	0.87
other	3.15	other	6.24
total	47.46	total	52.54

4 Grain size analysis and dissociation characteristics of gold minerals

The gold in the cyanide tailings sample is mainly distributed in natural gold and electrum, and the gold distribution rates are 93.32 % and 6.68 %, respectively. The particle size analysis of gold minerals in the sample is shown in table 3.

Table 3. Analysis table of particle size of gold minerals in samples.

Grading(μm)		Content (%)	Accumulation (%)
fine grain(-37+10)		6.54	6.54
fine particle	-10+5	55.21	61.75
	-5	38.25	100.00
average		5.81	

It can be seen from the data in Table 3 that the particle size of gold minerals in the sample is fine, mainly fine-grained.

The dissociation characteristics of gold minerals in cyanide tailings samples are shown in table 4. The analysis results of gold mineral dissociation characteristics in cyanide tailings samples are shown in Table 5.

Table 4. Dissociation characteristics of gold minerals in samples.

Dissociation X	Monomer X=100%	25%≤X＜100%	0＜X＜25%	Inclosure X=0	total（%）
Gold minerals	2.54	0	14.65	82.81	100.00

Table 5. Analysis results of gold mineral dissociation characteristics in samples.

embedded type		comparative content（%）		total（%）
bare gold	Monomer	2.54	17.19	100.00
	coenobium	14.65		
inclusion gold	Packaging	82.81	82.81	
	Intercrystal	0		

It can be seen from the data in Table 4 that the gold minerals in the cyanide tailings samples mainly exist in the form of inclusions, accounting for 82.81 %, the content of intergrowth is 14.65 %, and the degree of dissociation of intergrowth is very low.

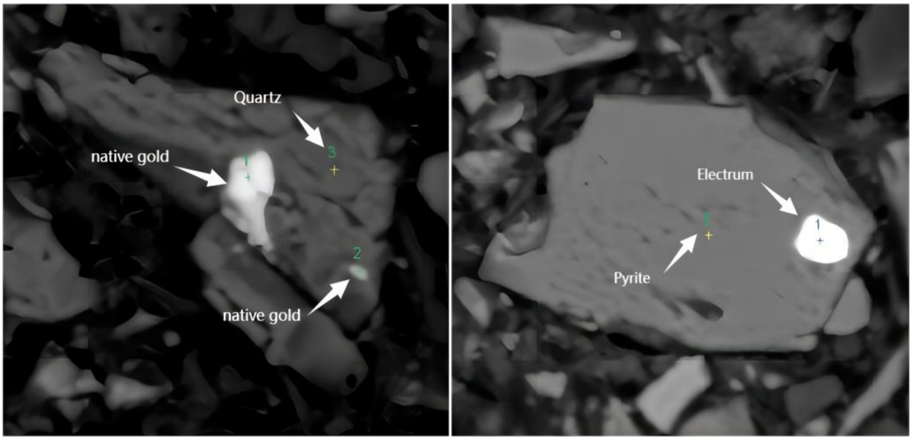
5 Dissemination characteristics of gold minerals

Gold minerals mainly exist in the form of pyrite, followed by arsenopyrite and quartz. The dissemination size of gold minerals is mainly fine particles, and the maximum particle size is 11.91 μm × 7.83 μm. The statistics of gold minerals in the samples are shown in Table 6, the dissemination characteristics of gold minerals can be seen in figure 1.

Table 6. Statistical table of dissemination characteristics of main gold minerals in samples.

Minerals	Monomer(%)	symbiont(%)			total(%)
		Pyrite	Arsenopyrite	Quar tz and other gangue	
Gold miner-als	2.54	78.77	10.54	8.15	100.00

From the data of table 5, it can be seen that gold minerals mainly exist in the form of pyrite; the content of associated gold minerals with pyrite is 78.77 %, the content of associated gold minerals with arsenopyrite is 10.54 %, the content of associated gold minerals with gangue such as quartz is 8.15 %, and the content of individual gold minerals is 2.54 %.



①Natural gold is wrapped in quartz. ②Electrum is wrapped by pyrite.

Fig. 1. The dissemination characteristic diagram of gold minerals

6 Dissemination characteristics of main gold-bearing minerals

Pyrite

The main sulfide ore in the sample is pyrite, the mineral content is 31.88 %, the average particle size is 7.30μm, mainly concentrated below-10μm, the content is 76.83 %, the content of-20-10μm is 21.14 %, and the remaining 2.03 % is distributed between-38μm-20μm, which is medium-fine grained.

Pyrite in the sample mainly exists in the form of monomer and rich-intergrowth (part of the dissociation degree > 80 % is called rich-intergrowth). The monomer content is 36.15 %, and the content of rich-intergrowth with gangue is 17.53 %. 26.15 % is intergrowth with other sulfides, and the remaining 20.17 % is intergrowth with gangue or wrapped by gangue.

Arsenopyrite

The harmful element in the sample is arsenic, which mainly occurs in the arsenopyrite. The amount of arsenopyrite minerals is 9.91 %, the average particle size is 7.33μm, mainly concentrated below-10μm, and the content accounts for 69.54 %. The content of-20-10μm accounts for 24.21 %, and the remaining 6.25 % is distributed between-38μm-20μm, which is medium-fine grained.

The arsenopyrite in the sample mainly exists in the form of monomer and rich intergrowth. The content of monomer is 29.15 %, the content of rich intergrowth with gangue is 30.24 %, 12.21 % is intergrowth with other sulfides, and the remaining 28.40 % is poor intergrowth with gangue or wrapped by gangue.

7 Summary

(1) The gold grade of the cyanide tailings is 4.41g / t, which is high and has the value of recycling.

(2) The gold minerals in the cyanide tailings samples are mainly natural gold and electrum, with gold content accounting for 93.32 % and 6.68 %, respectively. In addition, there are pyrite, arsenopyrite, a small amount of chalcopyrite, Galena, sphalerite and other metal minerals; gangue minerals mainly include quartz, feldspar, mica, amphibole, and monolith.

(3) The gold minerals mainly exist in the form of wrapped gold, the wrapped gold content is 82.81 %, the intergrowth gold content is 14.65 %, and the monomer gold content is 2.54 %. Gold minerals are mainly embedded in fine particles, and the content of fine particles accounts for 93.46 %, with an average particle size of 5.81 μm.

(4) The high content of encapsulated gold is the main reason for the high gold grade and low recovery rate of cyanide tailings. The problem of gold mineral encapsulation must be solved to recover the gold element in cyanide tailings. Ultrafine grinding, roasting, pre-oxidation and other processes can be attempted to further increase the dissociation degree of gold minerals in cyanide tailings.

(5) Process mineralogy detection will play an increasingly important role in the comprehensive utilization of mineral resources.

References

1. Xiao Yiwu, Fang Mingshan, Fu Qiang, Ye Xiaolu, Ma Nan. New technologies and concepts in process mineralogy [J]. Protection and utilization of minerals, 2018,6 (3): 49-53.
2. Tie Ying, Xiong Zhaohua, Hu Mengzhong, Ma Shengping. Process Mineralogy of a Micro-fine Disseminated Refractory Gold Ore in Qinghai [J]. Gold, 2022,4 (43): 79-83.
3. Feng Yang, Li Huan, Zhu Jianjian. Research progress on comprehensive recycling and utilization of cyanide tailings resources [J]. Resources and environment, 2018,44 (9): 201.
4. Song Xuewen, Zhu Jiagan, Luo Zengxin, Chen Bo. Process mineralogy and gold flotation process of a cyanide tailings [J]. Gold Science and Technology, 2018, 26 (1): 89-95.
5. Ji Qiang. Process mineralogy of a cyanide tailings [J]. World Nonferrous Metals, 2021 (11): 177-178.
6. Zhu Xingfu, Zhang Wenping. Study on process mineralogy of a gold-bearing ore in Shandong [J]. Shandong Chemical Industry, 2020,49 (22): 128-129.
7. Bahrami A, Abdollahi M, Mirmohammadi M, et al. A process mineralogy approach to study the efficiency of milling of molybdenite circuit processing[J]. Scientific Reports, 2020,10(1):1-4.
8. HRSTKA t, Gottlieb P, SK ála R, et al. Automated Minerals and petrology -- applications of test can integrated mineral analyzer (Tima)[J]. Journal of Geosciences, 2018,63(1): 47-63.
9. Wang Yizhu, Wang Jiayi, Xiang Zehui, Nannan, Dong Hongliang, Song Baoxu. Study on Process Mineralogy and Influencing Factors of Mineral Processing of a Gold Mine in Shandong Province [J]. Gold, 2024, 2 (45): 33-36.