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Possibilities of concentrating the thallium mineral lorandite from the Allchar deposit, Crven Dol region

By

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With 3 figures and 3 tables in the text

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Abstract: The paper presents results obtained by laboratory testings on the possibilities of concentrating the thallium mineral lorandite from ore in the Allchar deposit, Crven Dol region. For concentrating the lorandite from ore, standard methods were used: gravity concentrating in heavy liquids, gravity concentrating on a concentrating table, high intensity magnetic separation by an isodynamic separator "Frantz" as well as their combinations. From the preconcentrates obtained, pure grains of lorandite were separated by picking of individual grains.

Key words: Thallium minerals; lorandite mineral; concentrating lorandite; gravity concentrating; high intensity magnetic separation.

Introduction

Thallium belongs to the rare metals. According to Arence, the average thallium content in the Earth's crust amounts to about 0.003 %. It mostly appears in a form of solid solution in the lattices of sulfide minerals. Thallium, very seldom, forms its own minerals. Most frequently, it is in paragenesis with the sulfide minerals particularly galenite, sphalerite, marcasite and pyrite. Usually, it can be obtained as a by-product when roasting pyrite for the production of sulphuric acid and smelting of lead and zinc. The best known thallium deposit, where lorandite occurs, is the Allchar deposit, Former Yugoslavian Republic of Macedonia.

Lorandite has no economic significance but its scientific importance has increased after Freedman's proposal (Freedman et al. 1976) that lorandite could be used as a solar neutrino detector. On the basis of this idea, a scientific research project "LOREX" was set up for the completition of which some amounts of pure lorandite will be obtained from the Allchar deposit.

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Results from investigations

1. Origin and ore dressing for investigation

The samples for investigations of the possibilities for concentrating lorandite were collected from Allchar deposit, Crven Dol region, i.e. from the deposit section with high grade mineralization and high content of thallium. Knowing the low hardness of lorandite, great attention was paid to the method of ore crushing to prevent getting difficulties for its separation.

The ore test sample had an average grain size of 100 mm. For ore crushing crushers for primary, secondary, and third crushing were used. Jaw crushers of "Denver" type were used for primary and secondary crushings, and for third crushing a roll crusher for ore with a grain size up to 100 % −1 mm.

After crushing of the ore at 100 % −1 mm, representative samples were taken by means of a Jonson's splitter.

Fig. 1 indicates the flowsheet of ore dressing for testing.

2. Mineralogical and chemical analysis of the ore

On the basis of the preliminary mineralogical analysis of ore samples it was established that ore, taken from the richer sections with mineralization from Allchar deposit had a complex composition containing realgar (AsS), marcasite (FeS_2), orpiment (As_2S_3), pyrite (FeS_2), arsenopyrite (FeAsS), limonite ($Fe_2O_3 \cdot H_2O$) ect.

The gangue minerals contained are dolomite, calcite and quartz. Lorandite ($TlAsS_2$), vrbaite ($Tl_4Hg_3As_8S_{20}$), reguinite ($TlFeS_2$), picopaulite ($TlFe_2S_3$), rebulite ($Tl_5Sb_5As_8S_{22}$) are thallium minerals identified in the deposit (Janković 1988).

In our preliminary mineralogical investigations only lorandite has occurred in several microscopic preparations.

Lorandite in ore more frequently occurs as a coarse crystal, seldomly fine grained, and intergrown with the other sulphide minerals. The crystals size of lorandite amounts from 0.5 – 10 mm and they are often found in the realgar.

Lorandite, as a mineral, has a metallic lustre. Its colour is dark red while the scratch is dark cherry-coloured. It is fragile and can be splitted into needle like forms. Its hardness, by Moh's scale, rates from 2 to 2.5; so it belongs to the soft minerals. The lorandite density amounts 5530 kg/m^3 (Salatić & Deušić 1988).

The chemical analysis indicates that ore contains: 16.65 % Fe, 11.11 % Fe_2O_3, 11.42 % FeO, 1.47 % SiO_2, 8.00 % CaO, 3.70 % MgO, 0.43 % Al_2O_3, 1.21 % MnO, 0.40 % Mn_2O_3, 0.14 % K_2O, 18.75 % S, 2.90 % SO_4^{2-}, 18.47 % As, 0.0004 % Cu, 0.03 % Zn, 1.35 % Tl, 20.35 l.annl.

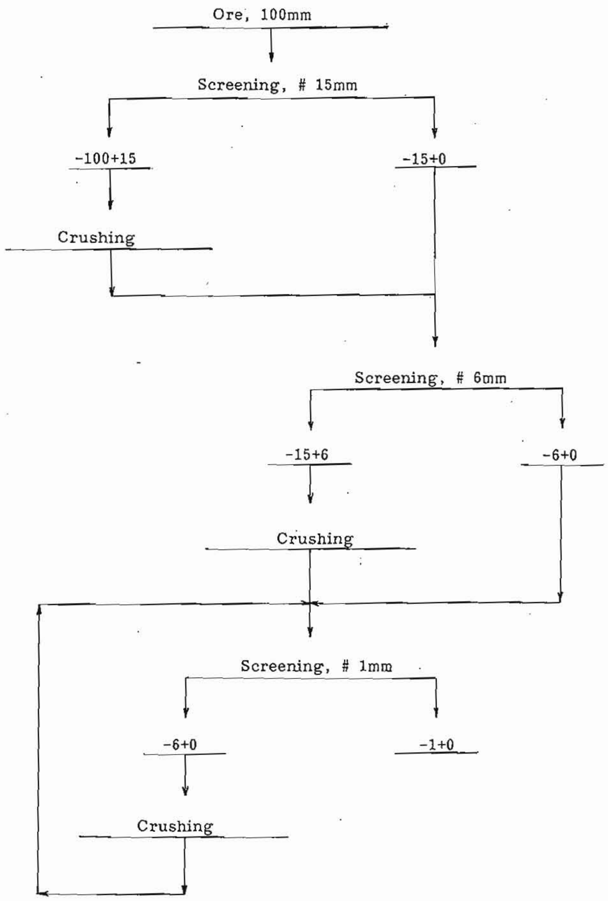

Fig. 1. Flowsheet of ore crushing for testing.

3. Lorandite concentration from Allchar

Taking into consideration the physical features of lorandite, the high density (5530 kg/m^3) and its insensibility in high intensity magnetic field (non-magnetic mineral) standard methods were used such as:

- gravity concentrating in heavy liquids
- gravity concentrating on a concentrating table
- high intensity magnetic separation by isodynamic magnetic separator "Frantz"
- combination of gravity high intensity magnetic separation.

None of the aforementioned methods can produce concentrates of pure lorandite but they give preconcentrates whereform pure lorandite grains are separated by hand picking under a binocular microscope.

By size reduction of ore at 100 % −1 mm, its sizing in two grain sizes, −1+0.3 mm and −0.3+0 mm, and their treatment separately on a concentrating table, concentrates resulted with Tl content of 1.73−2.21 %. The increased content of Tl in concentrates is due to the concentration of free lorandite grains. The Tl recovery in concentrates is very low because thallium minerals (lorandite) are soft and go into the small grain sizes (slime), on one side. With such coarse crushing of ore, on the other side, a great number of thallium minerals, particularly lorandite, are still intergrown with the other ore and tailing minerals, thus, go into tailings and intermediate products. From the concentrates obtained on a concentrating table, pure grains of lorandite can be separated.

3.3. Lorandite concentrating in high intensity magnetic field

Lorandite's characteristic not to react in a high intensity magnetic field (it is a non-magnetic mineral) has helped us to perform the laboratory testing for its concentrating in high intensity magnetic field. Laboratory testings were done by a dry high intensity isodynamic magnetic separator type "Frantz".

The test sampling was formerly wet screened on a sieve 0.3 mm and 0.037 mm, however, the obtained grain sizes −1+0.3 mm and −0.3+0.037 mm separately passed through an isodynamic magnetic separator "Frantz" after drying at an intensity of the magnetic field 1.0−1.5 A.

The grain size −0.037+0 mm has not been treated as this separator has a small efficiency for such small grain sizes. Table 3 gives the obtained results.

Testings performed by a high intensity isodynamic magnetic separator at grain sizes of −1+0.3 mm and −0.2+0.37 mm with a magnetic field intensity of 1.0−1.5 A indicated that the free grains of lorandite could be used separately by this method. As the pure grains of lorandite are non-magnetic they were obtained in a non-magnetic fraction with magnetic field intensity of 1.5 A. Mineralogical investigations have shown that 90 % of thallium in these products proved to originate from the grains of lorandite. Free grains of realgar and

Table 3. Results from "Frantz" testings.

Size, mm	Product	Wt %	Tl %	R % Tl
	Magn. −1.0 A	42.67	1.67	49.77
−1+0.3	Magn. −1.5 A	5.08	0.95	3.37
	Non-magn. −1.5 A	1.63	2.04	2.32
		49.38	1.61	55.46
	Magn. −1.5 A	29.21	1.49	30.39
−0.3+0.037	Magn. −1.5 A	4.72	0.47	1.55
	on-magn. −1.5 A	4.23	0.70	2.07
		38.16	1.27	34.01
−0.037+0		12.46	1.21	10.53
Feed (−1+0)		100.0	1.43	100.00

dolomite were concentrated together with lorandite in these products. In the other products, respectively, the magnetic fractions obtained by the magnetic field intensity of 1.0 and 1.5 A free grains were not noticed although they took 85.08 % of the total Tl in the ore.

3.4. Combined method of concentrating

Within the laboratory testings for lorandite concentrating from the ore of Allchar deposit, there was the highest recovery of lorandite free grains obtained by a high intensity magnetic separation in the isodynamic magnetic separator "Frantz". To obtain lorandite directly from the ore by the method referred to, it would take time considering the small capacity of the separator. For this reason, a combined method of concentrating was used to get pure lorandite, i.e. a gravity and magnetic concentrating.

Thus, the obtained preconcentrates (concentrates) from the concentrating table pass through "Frantz" with a magnetic field intensity of 1.5 A. Fig. 3 presents the way of performing the testings.

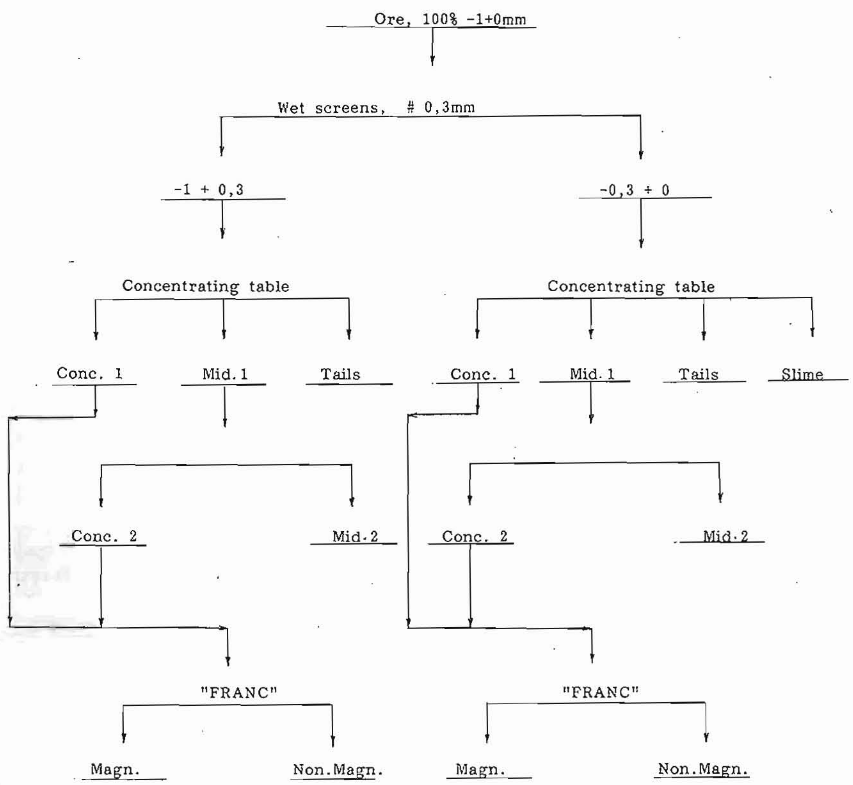

Fig. 3. Combination flowsheet of gravity concentrating – high intensity magnetic separation testings.

Lorandite free grains were obtained in the non-magnetic product together with the free grains of realgar. The manual separation of this product allowed the free grains of lorandite to be separated.

Conclusions

The laboratory investigations on the lorandite concentrating were performed with ore samples collected from the rich mineralization zones from the Allchar deposit. The medium content of Tl in the sampling ore was high averaging 1.4 %. In our preliminary investigations only lorandite was found in the ore as thallium mineral.

The quantitative content of lorandite as one of the bearer of thallium in the ore was unknown, consequently we were not able to follow its distribution during the laboratory testings.

In order to make an optimum choice for the methods and circumstances under which concentrating is to be carried out, detailed mineralogical researches will require to be performed in order to find out which of the minerals, excluding lorandite, are also bearers of Tl in the ore.

The amount of pure lorandite from 30 to 35 grammes was obtained by using the methods of gravity and magnetic concentrating or combination of both. In order to achieve greater amounts of lorandite it would be necessary to provide a high intensity magnetic separator of higher efficiency and capacity.

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