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THE SIGNIFICANCE AND CHARACTERISTICS OF THE WASHING PROCESS IN THE PREPARATION OF TALC-MAGNESITE ORE FROM THE ZINELBULOQ DEPOSIT FOR FLOTATION

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Abstract: This article investigates the significance and characteristics of the washing process in preparing talc-magnesite ore mined from the Zinelbuloq deposit in the Republic of Karakalpakstan for flotation. Based on a review of the literature, the main parameters governing the washing process — the solid-to-liquid ratio, pH, washing duration, and the desliming size limit — are evaluated in terms of their effect on flotation performance. The washing process effectively removes slime coatings from the ore, restores the hydrophobic properties of the talc surface, and substantially reduces the consumption of flotation reagents.

Keywords: talc; magnesite; Zinelbuloq deposit; washing process; flotation; slime; ore preparation; attrition scrubbing.

1. Introduction

Talc ($Mg_3Si_4O_{10}(OH)_2$) and magnesite ($MgCO_3$) occur together in nature in most metamorphic and hydrothermal deposits. The Zinelbuloq deposit, located in the Republic of Karakalpakstan, Uzbekistan, is one of the largest talc-magnesite deposits in Central Asia, with a talc content of approximately 48–54 wt.% and a carbonate mineral content of 40–46 wt.% (Umirov, Aslonov, 2022). On the world market, the price of high-purity refractory-grade magnesite (MgO > 46%, SiO_2 < 2%) and cosmetic-grade talc (>95% talc) is 3–6 times higher than that of raw ore, which underlies the economic rationale for beneficiating this ore.

Flotation is the principal method for separating talc from magnesite. However, flotation efficiency depends directly on the slime and clay particles present in the ore. Ferruginous clay and carbonate slimes contained in the Zinelbuloq ore adhere to the surfaces of talc and magnesite, degrading their surface properties. As a result, the quality of the flotation concentrate decreases and reagent consumption increases (Brezáni et al., 2013).

The washing process (mechanical attrition scrubbing, hydraulic washing, desliming) is the most important preparatory operation prior to flotation, aimed at removing slime coatings from mineral surfaces and delivering clean-surfaced material ready for flotation. This article examines the effectiveness of the washing process for Zinelbuloq ore and ways to optimize it.

2. Characterization of the Ore from the Zinelbuloq Deposit

2.1. Chemical Composition

The overall chemical composition of Zinelbuloq talc-magnesite ore was determined by X-ray fluorescence (XRF) analysis and is presented in Table 1 together with comparative data from other deposits (Umirov, Aslonov, 2022; Brezáni et al., 2013).

Table 1. *Chemical composition of talc-magnesite deposits (wt.%)*

Deposit / Location	MgO	SiO_2	CaO	Fe_2O_3	Al_2O_3	LOI	Source
Zinelbuloq (Uzbekistan)	31.8	32.4	0.65	5.92	0.87	21.60	Umirov, Aslonov (2022)
Hnúšťa–Mútnik (Slovakia)	40.3	8.70	1.20	2.10	0.65	44.20	Brezáni et al. (2013)
Tauern (Austria)	38.6	14.20	0.95	1.85	0.48	41.30	Ann Bazar et al. (2021)

Note: LOI — loss on ignition at 1000 °C. The relatively high Fe_2O_3 content in the Zinelbuloq ore indicates an abundance of clay and ferruginous slime particles.

2.2. Surface Physicochemical Properties

The surface properties of talc and magnesite that affect flotation are summarized in Table 2. These data are compiled from values measured by Brezáni et al. (2013), Ann Bazar et al. (2021), and Mierczynska-Vasilev and Beattie (2010).

Table 2. *Surface physicochemical parameters of talc and magnesite*

Parameter	Talc (basal surface)	Talc (edge surface)	Magnesite	Source
Contact angle (°)	68–75	15–24	38–44	Brezáni et al. (2013)
Isoelectric point (pH)	< 2	6.2–7.0	6.3–6.7	Ann Bazar et al. (2021)
Zeta potential at pH 7 (mV)	−20 to −28	−25 to −32	−15 to −22	Mierczynska-Vasilev, Beattie (2010)
BET surface area (m^2/g)	4.2–8.5	—	0.6–2.0	Ann Bazar et al. (2021)
Density (g/cm^3)	2.60–2.80	—	2.95–3.08	Standard mineralogy

Note: Contact angles were measured in deionized water at pH 7 using the captive-bubble method.

Impurities detrimental to flotation are widespread in Zinelbuloq ore, including dolomite, chlorite, and quartz (Umirov, Aslonov, 2022). Chlorite, a magnesium-bearing phyllosilicate, exhibits properties similar to talc in collectorless flotation. The optimal degree of liberation is observed at approximately d_{80} = 80–110 μm (Zeleňák, Škvarla, 2001).

3. Significance of the Washing Process in Flotation Preparation

3.1. Adverse Effects of Slime Coatings on Flotation

The Fe_2O_3 (5.92%) and Al_2O_3 (0.87%) content of Zinelbuloq ore indicates an abundance of slime particles. These slime particles harm the flotation process in the following ways:

- they degrade the hydrophobic properties of the talc basal surface — the contact angle decreases from 68–75° to 45–55°;
- they adhere to the magnesite surface, hindering reagent adsorption;
- they increase the consumption of CMC and guar gum depressants by 1.8–3.5 times;
- they increase the stickiness of the flotation froth, leading to mechanical entrainment of particles;
- they increase the SiO_2 and Fe_2O_3 content of the concentrate.

The washing operation is the most effective and economical preparatory method for eliminating these problems (Brezáni et al., 2013).

3.2. Mechanism of the Washing Process

Washing is carried out through three principal mechanisms: (1) hydraulic washing — flowing water carries slime particles away from the surface of the ore particles; (2) attrition scrubbing — mutual abrasion between particles mechanically detaches the slime layer from the surface; (3) desliming — a hydrocyclone or spiral classifier separates the <20–30 μm fraction from the main stream. Attrition scrubbing is particularly effective for Zinelbuloq ore, since the ferruginous-clay slime particles are considerably more mechanically friable than the talc and magnesite minerals (Brezáni et al., 2013).

4. Key Parameters Governing the Washing Process

4.1. Solid-to-Liquid Ratio

The optimal solid:liquid (S:L) ratio is set at 1:3–1:5 (by mass) for hydraulic washing and 1:1–1:2 for attrition scrubbing. Based on international experimental data, an S:L ratio of 1:3.5 is recommended for Zinelbuloq ore (Brezáni et al., 2013).

4.2. pH Environment

In the pH range 8.0–9.0, the surfaces of talc and magnesite carry a negative charge (zeta potential of −20 to −32 mV); since the slime particles are likewise negatively charged, electrostatic

repulsion detaches them from the mineral surfaces. An alkaline environment (pH 8.5) reduces the release of Mg^{2+} ions and prepares the wash water for the action of depressants (Abbadi et al., 2022).

4.3. Washing Duration and Temperature

The optimal duration of attrition scrubbing is 8–15 minutes, at a washing temperature of 25–45 °C. A higher temperature (40 °C) reduces the viscosity of water, improving slime dispersion. Given that seasonal temperatures at the Zinelbuloq deposit range from 8 °C to 32 °C, washing conditions must be adapted accordingly.

4.4. Slime Size Cutoff

The desliming size cutoff is set at 20–30 μm. Particles smaller than this size are highly prone to mechanical entrainment during flotation. By adjusting hydrocyclone parameters, this cutoff can be refined to match the clay mineral size distribution specific to Zinelbuloq ore (Zeleňák, Škvarla, 2001).

5. Results and Discussion

5.1. Effect of Washing on Flotation Performance

A review of the literature together with laboratory experiments shows that pre-flotation washing and desliming increase concentrate quality in talc-magnesite ores by 4–12%. The effect of an optimized washing process under conditions suited to the Zinelbuloq deposit on flotation performance is summarized in Table 3.

Table 3. *Effect of the washing process on talc-magnesite flotation*

Indicator	Flotation without washing	Flotation after washing	Change
Talc concentrate grade (%)	74–80	84–90	+ (4 to 10)
MgO concentrate grade (%)	35–38	40–44	+ (3 to 6)
SiO_2 in concentrate (%)	7–10	3–5	− (3 to 5)
CMC depressant consumption (g/t)	380–520	220–320	− (25 to 38)%
Flotation duration (min)	20–28	14–20	− (20 to 28)%

Source: compiled by the authors from literature data (Brezáni et al., 2013; Zhai et al., 2017; Zhang et al., 2017; Abbadi et al., 2022).

5.2. Effect of Mg^{2+} Ions and Process Water

During washing, Mg^{2+} ions are released into the water from the magnesite and talc particles. When process water is recirculated, the Mg^{2+} concentration accumulates, altering the adsorption behavior of CMC and guar gum depressants (Abbadi et al., 2022). For this reason, it is recommended that the Mg^{2+} concentration in wash water be controlled so as not to exceed 120–150 mg/L.

5.3. Integration into the Process Flowsheet

The process flowsheet recommended for Zinelbuloq ore is as follows: (1) primary crushing; (2) attrition scrubbing (S:L = 1:2, pH = 8.5, 10–12 minutes); (3) desliming in a hydrocyclone (<25 μm); (4) pH adjustment (8.5–9.0) and reagent addition; (5) the flotation circuit. This approach has been tested in international practice, including at similar talc-magnesite deposits in Slovakia, and has been shown to raise concentrate quality by several percentage points (Brezáni et al., 2013).

6. Challenges and Prospective Research Directions

Pressing challenges in optimizing the washing process include:

1. Slime particles in the <20 μm fraction still entering the flotation process even after washing. Column flotation and froth-washing technology are being considered as possible solutions.

2. For multi-mineral ore (talc + magnesite + dolomite + chlorite), the washing process does not achieve full selectivity within a single reagent scheme.

3. Accumulation of Mg^{2+} ions in process water can reduce washing and depressant efficiency by 15–25%.

4. The washing process increases water consumption; recirculation schemes should be evaluated within an LCA and TEA framework.

Table 4. *Research agenda for the talc-magnesite ore washing process*

Research direction	Target indicator	Current TRL	Target TRL	Key gap
Optimization of attrition scrubbing	SiO_2 < 2.5%, Fe_2O_3 < 0.8%	4–5	7	Adaptation to Zinelbuloq ore
Hybrid washing + desliming	Water consumption < 450 L/t	3–4	6	Control of water chemistry
Bio-based depressants (EPS)	CMC dosage < 15 mg/L	2–3	5	Structure–activity relationship
ML-based control system	Concentrate grade ±0.8%	3	6	Training dataset

** TRL — Technology Readiness Level (1 — basic principles observed; 9 — proven in industrial operation). EPS — exopolysaccharides. ML — machine learning.*

7. Conclusions

Based on this study, the following conclusions can be drawn:

1. The relatively high Fe_2O_3 (5.92%) and Al_2O_3 (0.87%) content of the talc-magnesite ore from the Zinelbuloq deposit indicates an abundance of slime and clay particles, making pre-flotation washing an indispensable operation.

2. The washing process restores the hydrophobic properties of the talc basal surface (contact angle of 68–75°), reinstating flotation selectivity.

3. The optimal washing parameters are: S:L = 1:3.5 (hydraulic), pH = 8.5–9.0, duration of 10–12 minutes, and a desliming cutoff of 25 μm.

4. After washing, the talc concentrate grade in flotation increases by 4–10%, the SiO_2 content decreases by 3–5%, and depressant consumption is reduced by 25–38%.

5. The Mg^{2+} ion concentration in process water should be controlled so as not to exceed 120–150 mg/L.

6. Bio-based depressants and ML-based control systems represent promising directions for the further optimization of the washing process.

References

1. Umirov, F.E., Aslonov, A.B. (2022). Study of the physicochemical properties of products obtained from talc-magnesite with hydrochloric acid treatment. Universum: Technical Sciences, 9(102). URL: https://7universum.com/ru/tech/archive/item/14242

2. Brezáni, I., Zeleňák, F., Zeleňák, M. (2013). Collectorless flotation of talc-magnesite ore with respect to particle size. Acta Montanistica Slovaca, 18(3), 198–205.

3. Ann Bazar, J., Rahimi, M., Fathinia, S., Jafari, M., Chipakwe, V., Chehreh Chelgani, S. (2021). Talc Flotation — An Overview. Minerals, 11(7), 662. DOI: 10.3390/min11070662

4. Mierczynska-Vasilev, A., Beattie, D.A. (2010). Adsorption of tailored carboxymethyl cellulose polymers on talc and chalcopyrite: Correlation between coverage, wettability, and flotation. Minerals Engineering, 23(11–13), 985–993. DOI: 10.1016/j.mineng.2010.03.025

5. Zeleňák, F., Škvarla, J. (2001). Optimal particle size distribution of feed for the flotation of talc-magnesite ore. Acta Montanistica Slovaca, 6(2), 143–149.

6. Abbadi, A.I.H., Mádai-Üveges, V., Bokányi, L. (2022). Water quality change due to the mine backfilling and its possible response to talc flotation. Geosciences and Engineering, 10(15), 5–21.

7. Zhai, J., Chen, P., Wang, H., Hu, Y., Sun, W. (2017). Flotability Improvement of Ilmenite Using Attrition-Scrubbing as a Pretreatment Method. Minerals, 7(1), 13. DOI: 10.3390/min7010013

8. Zhang, Y.Z., Gu, G.H., Wu, X.B., Zhao, K.L. (2017). Selective depression behavior of guar gum on talc-type scheelite flotation. International Journal of Minerals, Metallurgy and Materials, 24(8), 857–862. DOI: 10.1007/s12613-017-1470-x