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Acknowledgement. This study was supported by the Grant No. FR1054900 of the Smithsonian Institution.

Received 12 October 1992; revised accepted 2 February 1993

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TECHNICAL NOTES

Effect of ultrasonication on the flotability of galena

B. P. Singh

The ability of ultrasound to improve the grade and recovery of valuable minerals has attracted a lot of attention[1,2]. The state-of-the-art application of ultrasonics in mineral beneficiation reveals that acoustic field can produce conducive effects on mineral flotation[2]. Most of the earlier ultrasonic studies examined the effect of ultrasound on the removal of adsorbed layer of reagents from minerals[3,4], and in the emulsification of flotation reagents[5], while a few other studies revealed the effect of ultrasonic treatment during and after the flotation processes[6–8]. Successful applications of ultrasonication to mineral surface cleaning[9] and removal of surface precipitates[10] have also been reported. Eremin[11] studied the ultrasonic activation of an elementary flotation event and explained the process causing stimulation of hydrophobic interaction on the basis of increase in entropy of the aqueous system under acoustic treatment.

Various researchers have shown that an intensive acoustic field can modify the state of a material, leading to chemical or dispersive effects[1,12,13]. Chemical effects are characterized by cavitation and are accompanied by a local increase in pressure and temperature, while dispersive effects are realized when ultrasound is applied to a pulp containing a stabilizer such as a surfactant. This results in the formation of an emulsion. Ultrasonication thus improves the effectiveness of the reagent due to its more uniform distribution in the suspension and also in the enhancement of the activity of the chemicals used[8].

The present work aims at studying the ultrasonication effect on the flotability of galena under different experimental conditions. The influence of sonication time, slime removal and collector concentration on flotability is elucidated.

Hand-picked, high purity natural mineral samples in the form of lumps were crushed and ground in an agate mortar and separated into narrow particle size fractions for experimental studies. The fractions ($-250+90\ \mu m$) were used for flotation tests. Semi-quantitative spectroscopic analysis of the minerals showed the presence of the following impurities: Zn: 0.23%, Cu: 0.03%, SiO_2: 0.12% Fe: 0.15%, apart from galena (86.3%). The surface area of the sample determined by BET method was found to be $1.12\ m^2/g$ using pure N_2 as adsorbate at liquid nitrogen temperature.

The flotation tests were performed in a small laboratory cell at 20 g scale. A commercial sample of Na-isopropyl xanthate was used as a collector. The floated and unfloated materials were dried, weighed and analysed. All the experiments were carried out at natural pH (6.5).

It was noted earlier[14] that prolonged tumbling or conditioning showed some sign of improvement in flotability. Apparently the bonds holding galena and slimes together were disrupted and replaced by xanthate. But in the above process time needed would be too long to be useful in practice. Since ultrasonics was reported to yield good results in a similar process in a relatively short time[8], its use was tested in the present system. Ultrasonic treatment of galena/xanthate suspensions was carried out using a horn-type ultrasonicator, at a frequency of 20 kHz. To process the samples, the horn tip was immersed 5–7 cm deep into the samples. The power output was at approximately 220 W.

Figure 1*a* shows per cent galena floated as a function of conditioning time in the absence of ultrasonication at a pH of 6.5 and a collector concentration of 0.02 kg/tonne. Collector concentration and pH of the system were kept invariant unless mentioned otherwise. The flotability of galena increased marginally with increasing conditioning time. The flotation recovery was, however, rather low at this collector concentration; it was found that only by

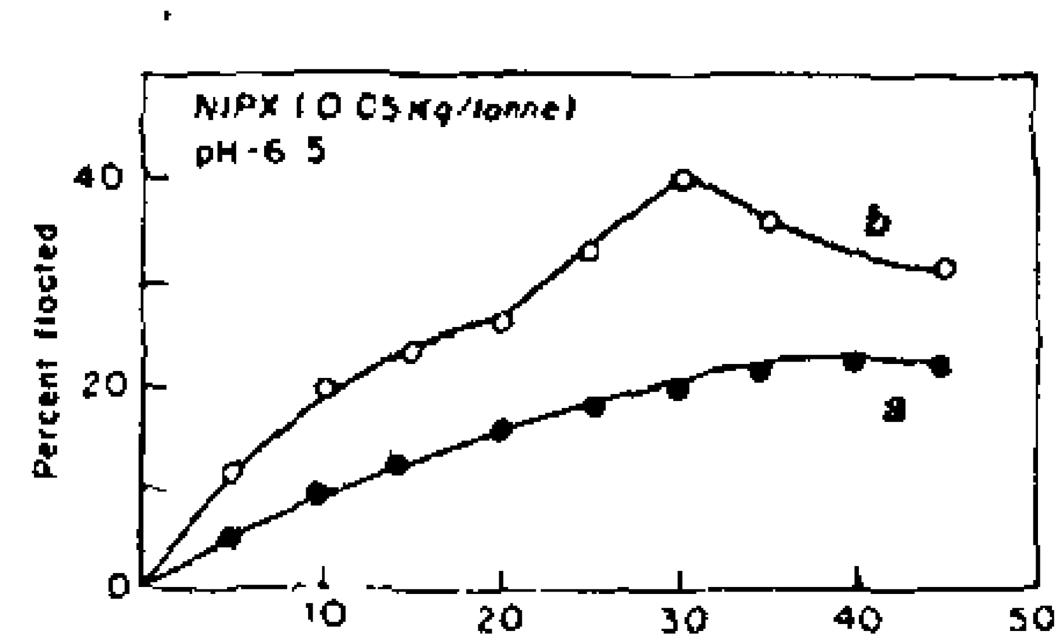

Figure 1. Effect of conditioning time on the flotability of galena

doubling the collector concentration could complete recovery be achieved. This incipient collector concentration was deliberately chosen to study the effect of sonication on flotation recovery.

Flotability of galena in the presence of ultrasonication with Na-isopropyl xanthate is shown in Figure 1*b*. As is evident, ultrasonication improved the flotation recovery up to 30 minutes, but recovery decreased beyond this period due to the formation of excessive amounts of slime which consumed the available collector reducing the per cent floated material. This observation can be corroborated with the finding of Celik[8]. Ultrasonic pretreatment of the pulp activates the galena surface for collector adsorption.

Figure 2*a* shows the effectiveness of ultrasonication with stirring in distilled water followed by collector addition and conditioning. It was presumed that introduction of stirring in distilled water (no collector) during ultrasonication prevented adsorption of some collector by slimes. Subsequent addition of collector followed by conditioning (5 minutes) led to substantial improvement in recoveries. Exposure of the clean galena surfaces which are more conducive to xanthate adsorption resulted in higher recoveries, despite the presence of slimes.

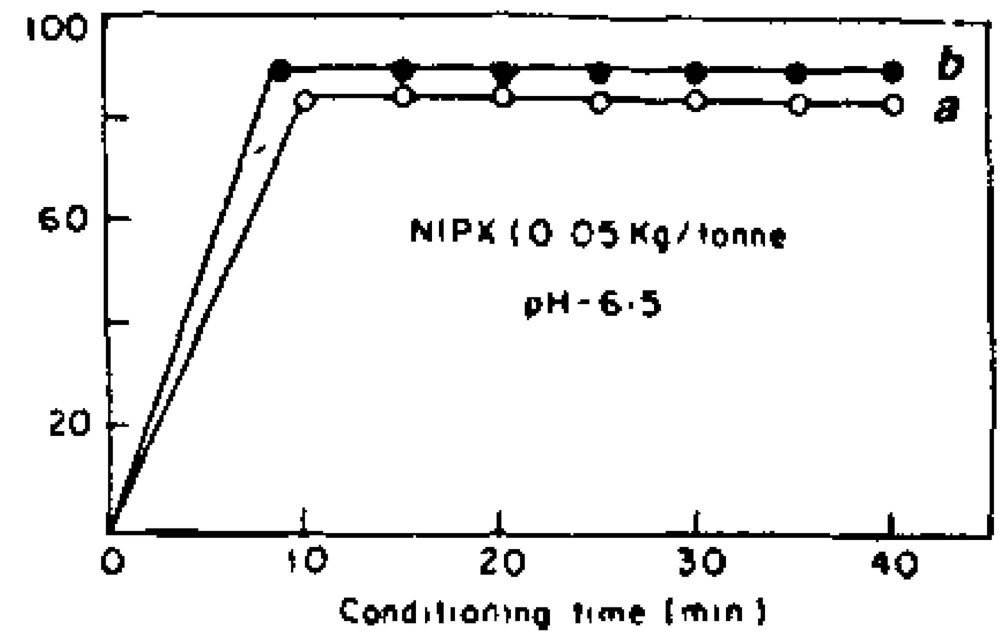

Figure 2. Effect of ultrasonication on the flotability of galena. ***a***, sonication + stirring in distilled water +10 min conditioning with collector; ***b***, sonication + stirring in distilled water + 10 min conditioning with collector + desliming

Figure 2*b* corresponds to the conditions of Figure 2*a* except for the desliming prior to flotation. The flotation recovery in this case was found to be higher. The presence of slime generally hinders particle-bubble attachment and leads to excessive collector consumption. The above results indicate that ultrasonication under appropriate conditions can achieve at least a 40–50% reduction in collector consumption. The imposition of ultrasonication creates a surface which is not only partially hydrophobic but also highly conducive to collector adsorption.

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Received 24 August 1992; revised accepted 7 December 1992

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Studies on weathering of Kailasanatha Temple, Kancheepuram

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Kancheepuram, situated about 65 km from Madras is a treasure trove of art and architecture as it houses more than 300 ancient temples. During the heydays of Pallavas, this city was a citadel of learning. Among the monuments of Kancheepuram, the Kailasanatha temple is the most important and was built by Raja Sinha Pallava in the 8th century AD. Vikramaditya, a second Chalukya ruler, though invaded Kancheepuram, he ordered preservation of the monument and its sculptures. It is also said that granite slabs were laid for conservation of the temple by Mahendra II.

The temple consists of the main Vimana (Figure 1) a four-storey structure, and was named after its builder Rajasimheswara. On the eastern side, there is a small shrine called Mahendravermeswara, built by his son Mahendra Varman. The entire temple complex is surrounded by a compound wall which was built in array of 58 cells (Figure 2) on the inner side and contains figures of Gods and paintings.

The temple was constructed with dark yellowish sandstone as well as granite which was a later addition. The sandstone particles are medium-to-fine grained consisting of quartz cemented by calcite. The deterioration of the temple was due to biological growth and salt action. Salts were carried by speedy sea winds or capillary action. Due to this as well as the variation in atmospheric conditions, sandstone lost its compactness and became powdery. The surface was so pulverized that sharp features of the sculptures and fineness of the ornamental design were lost (Figure 3). The plinth walls and pillars of the cells lost their finely-chiselled polish surface and show sand particles loosely adhering to the surface.