Minerals Engineering 23 (2010) 374–382

Contents lists available at ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

The effect of breakage mechanism on the mineral liberation properties of sulphide ores

T.G. Vizcarra [a,*], E.M. Wightman [a], N.W. Johnson [b], E.V. Manlapig [a]

[a] Julius Kruttschnitt Mineral Research Centre, Sustainable Minerals Institute, University of Queensland, Isles Rd., Indooroopilly, QLD 4068, Australia
[b] Mineralurgy Pty. Ltd., Unit 2, 42 Morrow St., Taringa, P.O. Box 818, Toowong, QLD 4066, Australia

ARTICLE INFO

Article history:
Received 22 October 2009
Accepted 23 November 2009
Available online 24 December 2009

Keywords:
Liberation
Comminution
Sulphide ores
Oxide ores
Ore mineralogy

ABSTRACT

The effect of particle-bed breakage mechanisms on the liberation properties of ores remains unclear. Surprisingly few studies have been published in this area and limitations in liberation measurement techniques previously used have prevented definitive conclusions from being reached regarding whether particle-bed breakage enhances the liberation properties of mineral ores relative to conventional grinding mechanisms. In this study, two sulphide ores of differing textures were comminuted to various size distributions using impact and particle-bed breakage mechanisms in a hammer mill and a piston–die compression unit respectively. The liberation properties of the various discharge samples were then characterised using a mineral liberation analyser – a mineralogical characterisation system based on automated scanning electron microscopy. It was found that the size-by-size liberation properties of both valuable and gangue mineral phases were independent of both the method used to comminute the samples, as well as the particle size distribution of the final products. These effects are discussed in terms of how they may be exploited in liberation modelling and characterising comminution circuit performance.

1. Introduction

The ability to selectively liberate minerals from surrounding phases would be a significant advance in minerals processing technology. Comminution typically represents 30–50% of the energy consumption within a given mining operation (La Nauze and Temos, 2002; Tromans, 2008), and the liberation of valuable minerals at sizes coarser than what is currently achieved would limit the degree of size reduction that is necessary in tumbling mills (such as SAG mills and ball mills), as well in regrinding stages that are currently employed for liberating fine-grained ores. Furthermore, the prospect of liberating gangue phases at coarse sizes also raises the possibility of the rejection of coarse gangue, limiting the amount of non-valuable material that is fed into energy-intensive grinding circuits and offering step-change progress in reducing the energy consumption of comminution operations.

Particle-bed breakage, via the use of high pressure grinding rolls (HPGR), has often been suggested as a possible route by which mineral liberation properties can be enhanced relative to conventional breakage methods. While there have been preliminary reports of benefits to diamond liberation using HPGR, due in part to the large working gap between rollers in typical HPGR units (Gerrard et al., 2004), the low grade of diamond ore bodies has generally prevented operators from statistically comparing its performance to conventional breakage methods, in turn precluding publication of their results in the technical literature (Napier-Munn, 2008). As a result, evidence surrounding the ability of particle-bed breakage mechanisms to improve mineral liberation properties has largely remained anecdotal. A small number of reports have suggested that liberation properties of metalliferous ores can be enhanced through the use of particle-bed breakage. Clinker (Celik and Oner, 2006), bauxite (Daniel, 2007), chromite (Hosten and Ozbay, 1998; Mörsky et al., 1995), cassiterite (Clarke and Wills, 1989), galena and sphalerite (Apling and Bwalya, 1997; Apling and Raissi, 2000; Daniel, 2007) as well as pyrite (Stephenson, 1997) have all been previously studied. Generally, it has been concluded that mineral liberation properties are enhanced compared with particles discharged from conventional rod/ball mills, although this has been disputed in several studies (Daniel, 2007; Mörsky et al., 1995). Our previous work (Vizcarra and Wightman, 2008) reported that at size fractions below 150 μm, liberation properties of a particular low-grade copper porphyry ore comminuted in a hammer mill and a piston–die compression unit were similar. The valuable bornite phase was found to have higher degrees of liberation at larger sizes following discharge from the piston–die compression unit, however the degree of uncertainty of each liberation measurement that is controlled by the number of particles measured was not examined.

Hence, the body of evidence surrounding these observations is still uncertain and conflicting, and apart from the aforementioned reports, only a few investigations in this area have otherwise been

* Corresponding author.
E-mail address: t.vizcarra@uq.edu.au (T.G. Vizcarra).

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doi:10.1016/j.mineng.2009.11.012

published. Furthermore, observed improvements in liberation following particle-bed breakage relative to conventional breakage methods have typically been very small (ca. 2–5% per size fraction) and it is possible that these differences lie within the errors associated with the liberation measurements of the previous studies. Thus, there remains much scope to conduct more detailed investigations into the relationship between breakage method and resultant liberation properties of both valuable and gangue mineral phases, particularly using the modern scanning electron microscope (SEM) based technologies that are currently employed for accurate and reliable liberation analysis.

In this study we report a detailed investigation into the mineral liberation properties of two sulphide ores as a function of the breakage method employed. A hammer mill and a piston–die unit

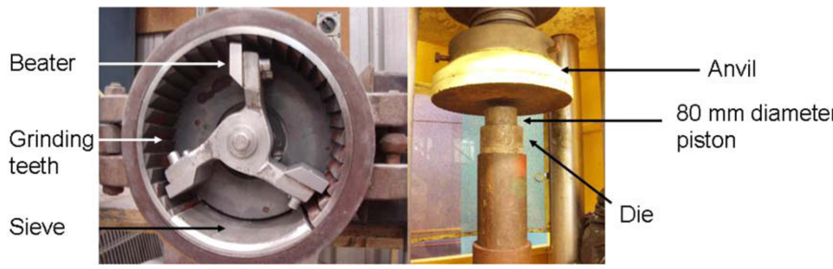

Fig. 1. (Left). Interior chamber of the hammer mill; (Right) piston–die compression unit.

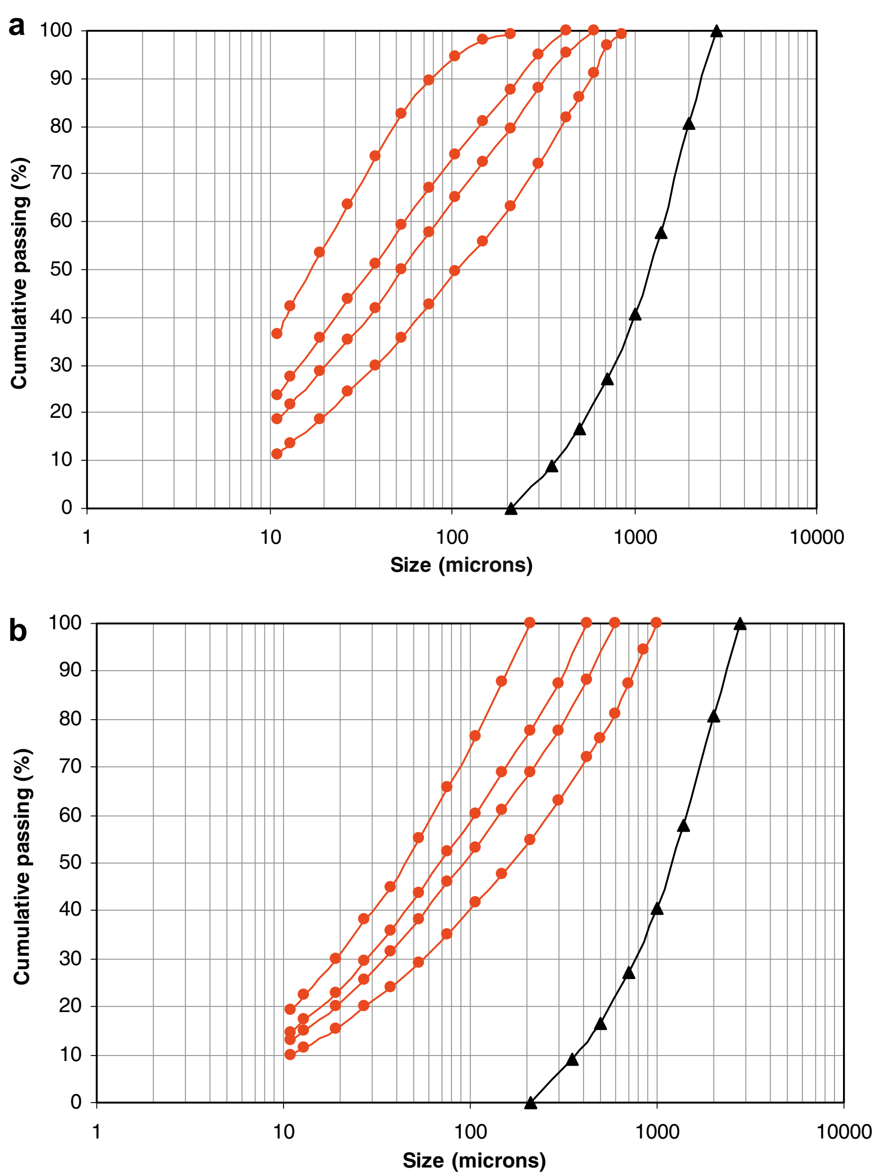

Fig. 2. Particle size distributions for Ore 1: (a) hammer mill samples; and (b) piston–die samples. Feed particle size distributions are shown as black triangles. Progeny are referred to as Hammer Mill 1 (coarsest) to Hammer Mill 4 (finest), and Piston–die 1 (coarsest) to Piston–die 4 (finest).