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Investigating froth stability: A comparative study of ionic strength and frother dosage

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ABSTRACT

Valuable mineral recoveries and grades are strongly dependent on the stability of the froth phase within the flotation system; a stable froth zone allows for the efficient transportation of material for downstream processing, while entrainment of gangue is directly proportional to the amount of water recovered from the froth phase (Engelbrecht and Woodburn, 1975; Zheng et al., 2006a,b; Neethling and Cilliers, 2002). In an attempt to reduce the naturally floatable gangue (NFG) present in platinum bearing ores and to improve the grades of the valuable minerals, the use of high depressant dosages have been investigated. These high depressant dosages have significantly destabilised the froth phase in a number of studies (Bradshaw et al., 2005; Martinovic et al., 2005; Wiese, 2009). Wiese et al. (2010) has shown that an increase in frother dosage impacted the stability of the froth resulting in enhanced recovery of valuable minerals. In a separate study by Corin et al. (2011), the effect of an increase in the ionic strength of plant water on the stability of the froth was considered. As water restrictions become more stringent, many operations are recycling and reusing their process water causing an increase in the amount of dissolved ions present in the water, the effects of which are little understood. The same study also considered depressant addition at high dosages. It was noted that an increase in the ionic strength of the plant water increased the froth stability. This paper therefore compares the outcomes of increased frother dosage with increased ionic strength, and attempts to better understand the factors which influence the froth stability. The data presented in this paper forms part of much larger studies and complementary data has been published elsewhere (Wiese and Harris, 2012; Manono et al., 2012, 2013).

1. Introduction

Platinum group mineral (PGM) ores from the Merensky reef contain approximately 1% sulphide minerals. It is documented that the PGMs are closely associated with these sulphide minerals (Wiese et al., 2005). Froth flotation is the most commonly used method for concentration of PGM ore and the use of various reagents to enable the selective flotation of sulphides has been extensively explored (Wiese et al., 2007; Dhliwayo, 2005; Mailula, 2004; Liddel et al., 1986; Klimpel, 1984; Ross et al., 1984; Klaasen and Mokrousov, 1963).

It is well known that the presence of NFG can impact the froth phase. Although talc has been found to occur in only trace quantities in ore (0.5–5% by mass), it has an inordinate effect and has been known to stabilise the froth phase and allow for the recovery of larger amounts of gangue. Talc has been shown to exist along pyroxene grain boundaries (Becker et al., 2006; Jasieniak and Smart, 2009) allowing these gangue minerals to be naturally floatable.

In order to combat this increase in gangue recovery, many operations have chosen to use increased concentrations of depressants. The most commonly used depressants are guar gum (guar) and carboxymethylcellulose (CMC). CMC has a negative charge density and results in a dispersed pulp, while guar has a very low charge density and does not result in dispersed pulps. This is especially significant under high ionic strength conditions as Parolis et al. (2008) showed that the adsorption of CMC onto talc was enhanced when Ca^{2+}, Mg^{2+} and K^{+} were present in solution. Water recycling has been shown to result in ions; Ca^{2+}, Mg^{2+}, NO_3^{2-}, SO_4^{2-} and Cl^{-} to be present in large quantities (Wiese et al., 2007; Khraisheh et al., 2005; Shortridge, 2002; Fuerstenau et al., 1988). This may result in larger concentrations of ions to be present in solution and may impact on the actions of the reagents as well as the flotation outcomes (Corin et al., 2011; Muzenda, 2010; Slatter et al., 2009; Levay et al., 2001; Viviers, 1979). Liu et al. (2013) conducted a thorough review of the effect that water quality has on flotation.

The recovery of valuable minerals is directly related to the stability of the froth phase, since entrained gangue follows water

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recovery (Engelbrecht and Woodburn, 1975; Zheng et al., 2006a,b; Neethling and Cilliers, 2002). Although the presence of talc in PGM ores is known to stabilise the froth phase (Kracht and Finch, 2010; Parolis et al., 2008; Iwasaki et al., 1980; Viviers, 1979), the use of high depressant dosages removes this froth stabilising talc and therefore destabilises the froth phase (Bradshaw et al., 2005; Martinovic et al., 2005; Wiese, 2009). The use of recycled water in which there exist high concentrations on ions is able to stabilise the froth phase, this could be as a result of the inadvertent activation of gangue (Wiese et al., 2006; Rao and Chernyshova, 2011) as

Table 1
Ions present in synthetic plant water.

Water type	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Na^{+} (ppm)	Cl^{-} (ppm)	SO_4^{2-} (ppm)	NO_3^{-} (ppm)	NO_2^{-} (ppm)	CO_3^{2-} (ppm)	TDS (mg/L)	*I* (M)
1PW	80	70	153	287	240	176	–	17	1023	0.0213
3PW	240	210	459	861	720	528	–	51	3069	0.0620
5PW	400	350	765	1435	1200	880	–	85	5115	0.0977
10PW	800	700	1530	2870	2400	1760	–	850	10230	0.1860

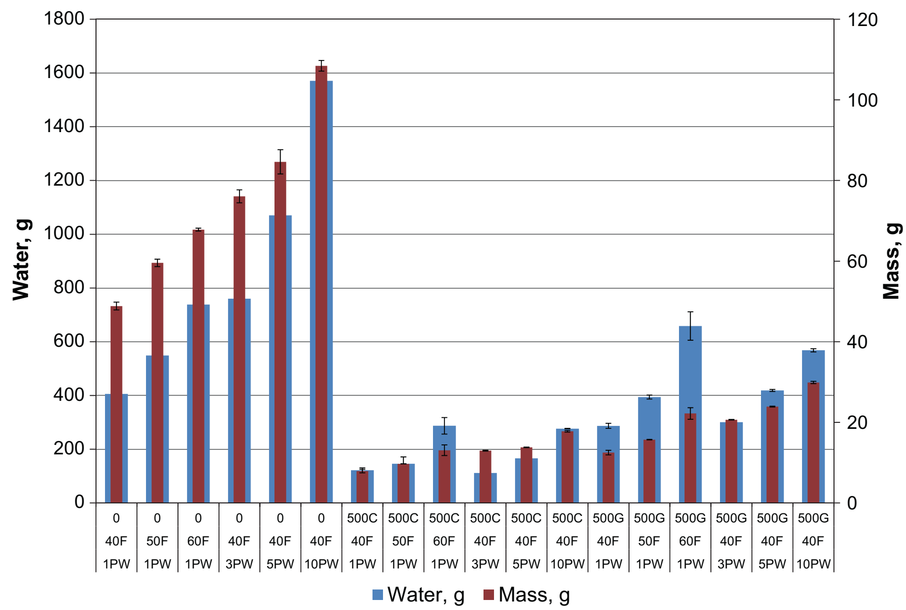

Fig. 1. Final mass and water recovered for batch flotation tests conducted under 0 g/t and 500 g/t guar (G) and CMC (C) while increasing ionic strength (PW) or increasing frother dosage (F).

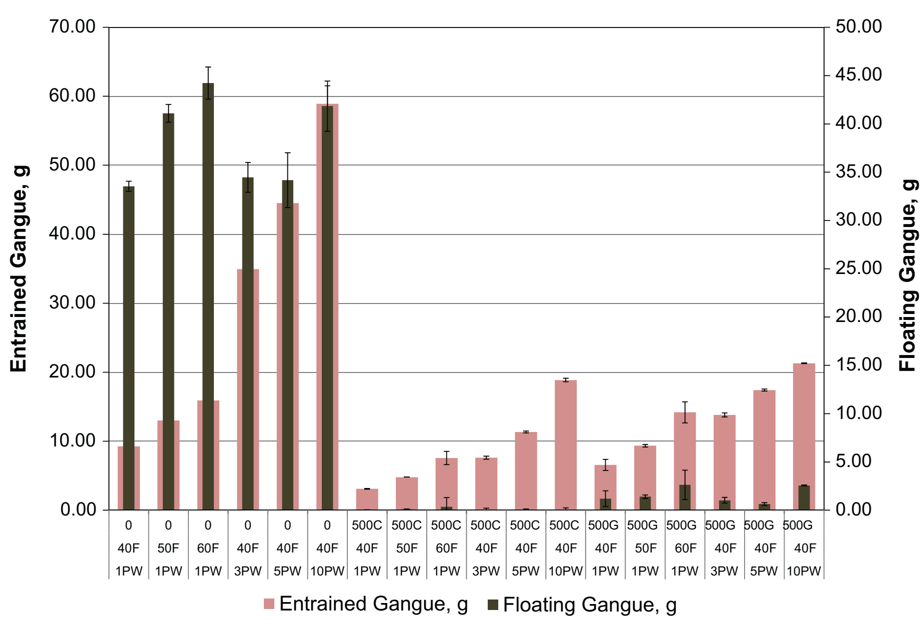

Fig. 2. Final entrained and total gangue calculated for all tests.