PAPER 58.1 — 8:30
**ROLES OF METAL OXIDATION SPECIES IN THE FLOTATION OF FINE SULPHIDE MINERALS**

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In this study, flotation of fine galena, chalcopyrite and pyrite was performed after grinding with different extent of oxidation-reduction condition adjusted by grinding media. Sodium dithionite and iron ions were added in mill to simulate pulp potentials and iron oxidation species produced by grinding media, respectively. The types and quantities of the metal oxidation species on mineral surfaces were determined by EDTA extractions, while the surface electrical properties of minerals and interaction of different types of metal oxidation species were studied by zeta potential measurements. It was found that the nature and concentration of the absorbed metal oxidation species were dependent on oxidation atmosphere controlled by the iron amount of grinding media. These species interacted with each other and had an important role in determining flotation of fine galena and chalcopyrite as well as activation of fine pyrite by lead and copper.

PAPER 58.2 — 8:55
**EFFECT OF AIR-OXIDATION ON FLOTATION OF PYRRHOTITE AND PENTLANDITE: STOCKPILE OXIDATION VS ARTIFICIAL OXIDATION**

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Batch flotation tests were carried out using samples from stockpiles that were up to 1.5 months old as well as fresh samples oxidized in the lab for up to six months. Head grades and size distributions of samples were equalized whenever possible. The samples from stockpiles and oxidation experiments produced inferior nickel grade-recovery compared to the fresh sample. The poorer grade-recovery performance was attributable to two factors. First, a significant dilution effect was observed due to complete flotation of pyrrhotite. Secondly, the same stockpiling conditions caused nickel losses that were attributable to non-floatability of some pentlandite. Application of a high pH of 10 compared to the regular pH of 9.2 slowed down pyrrhotite flotation kinetics, but was not able to prevent complete flotation after 8 minutes. The samples oxidized in the lab did not match full characteristics of stockpile samples. They provided somewhat better selectivity for pentlandite. Some correlations were observed on a qualitative basis between surface characteristics such as elemental sulphur formation, activation and flotation behaviour. Oxidation conditions, which induce floatability on pyrrhotite while causing incremental loss in pentlandite floatability appear to be the root cause of difficulties in the processing of oxidized forms of these ores.
The flotation separation selectivity of pentlandite against pyrrhotite has been a research focus at Inco for many years. The successful rejection of pyrrhotite from the Sudbury area ores by flotation at Clarabelle Mill is essential to Inco’s Sudbury operation allowing the lowering of sulfur dioxide emissions while maintaining metal throughput. In this operation, triethylene tetramine (TETA) has been successfully used in combination with sodium sulfite in depressing pyrrhotite. Although highly effective, the roles of the reagents are not well understood. More and more evidence suggests that oxidizing conditions are beneficial for improved pentlandite and pyrrhotite flotation separation when TETA and sulfite are used in contrast to the situation where reducing conditions are better when TETA and sulfite are not used. It has been recently observed from both miniplant and plant operations that the rock content in the flotation feed has a significant impact on pentlandite and pyrrhotite separation with TETA and sulfite are used. As the ratio of pyrrhotite to rock in the feed increases, the separation efficiency of pentlandite over pyrrhotite improves. It is theorized that rock minerals play two adverse roles in this case: a) adsorbing TETA, b) weakening the electrochemical interactions between pentlandite and pyrrhotite. Both lead to the reduced flotation selectivity of pentlandite over pyrrhotite.

Mercapto organic compound SDMP was used as a depressant for separation of copper activated marmatite from pyrrhotite in the presence of butyl xanthate. Flotation results show that SDMP has strong depressing effect on pyrrhotite recovery in the absence and presence of copper ion, but has promotional effect on marmatite recovery when added together with copper ion. The flotation test of mineral mixtures shows that copper-activated marmatite could be separated efficiently from pyrrhotite using SDMP as depressant. Infrared adsorption spectra demonstrate that SDMP has a strong adsorption on pyrrhotite surface through its functional groups such as -SH, -SO₃⁻.

The flotation of copper sulfides with sulfhydryl collectors in porphyry ores is commonly carried out at high pH values of 10-11.5 in order to depress pyrite. Lime is added to reach such pH values. It has been found that lime is detrimental to copper flotation. Calcium ions resulting from lime promote the heterocoagulation between fines copper sulfides and coarse particles of non-sulfide gangue and pyrite, causing losses of copper to tailings. At high pH, these cations lead to a very
low value of the zeta potential of the sulfide minerals, pyrite and silicates. In addition, at high pH, copper sulfides present low flotation kinetics. It is shown that dextrin is an alternative to lime. Batch flotation studies on porphyry ores has been carried out at pH 8 using dextrin as pyrite depressant and thionocarbamate as copper collector. The conditioning scheme for the successful application of dextrin as pyrite depressant without affecting the recovery of copper is presented. At pH 8, the flotation kinetics and the recovery of copper are improved.

PAPER 58.6 — 11:05
DEXTRIN AS A REGULATOR FOR THE SELECTIVE FLOTATION OF GALENA, CHALCOPYRITE, AND PYRITE
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The application of dextrin as a depressant in the selective flotation of galena, chalcopyrite and pyrite has been investigated through adsorption, microflotation, electrokinetic and batch flotation studies. Studies have been carried out on single crystals of the sulfides, mixtures of galena and pyrite crystals and on an ore containing pyrite, galena and chalcopyrite. The principles underlying the adsorption of dextrin and xanthate ions on pyrite, galena and chalcopyrite are presented. The oxidation of the pyrite surface determined the adsorption of dextrin, which takes place on ferric hydroxide phases making the surface hydrophilic. Co-adsorption of xanthate ions as dixanthogen occurs on unoxidized pyrite phases. Adsorption of dextrin on galena takes place on surface hydroxyl groups. Xanthate ions desorb dextrin rendering the galena surface hydrophobic. Accordingly, the flotation and depression of galena is affected by the concentration of both dextrin and xanthate. When galena and pyrite are together, pyrite promotes the oxidation of the galena surface making it highly hydrophilic in the presence of dextrin despite adsorption of xanthate. This prevents the selective flotation of galena from pyrite using dextrin and xanthate. The pyrite-promoted oxidation of galena has made possible the flotation of chalcopyrite with xanthates while depressing both pyrite and galena using dextrin as depressant in an ore containing the three sulfides.

PAPER 58.7 — 11:30
EFFECT OF LIGNOSULFONATES ON THE FLOATABILITY OF MOLYBDENITE AND CHALCOPYRITE
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Standard depressants used in the selective separation of copper and molybdenum sulphides by flotation pose environmental and health hazards. In this investigation, the floatability of chalcopyrite and molybdenite in the presence of six well-characterized lignosulfonates was studied through Hallimond tube flotation and adsorption tests. The results define the physicochemical conditions (lignosulfonate type and dosage, pH, presence of ions) for possible selective separation of molybdenite from chalcopyrite. Dissolved polyvalent cations, especially calcium, appear to serve as “activators” for lignosulfonate adsorption on both minerals. From this point of view, the use of lime as a pH modifier is not always appropriate for optimum selectivity since high dosages of lime to produce high pH tend to indiscriminately depress both sulphides.
Three novel dextrin polymers of varying functional group chemistry but similar molecular weight have been used to depress talc in single and mixed mineral studies. The mixed mineral system was a model sulphide ore consisting of talc, pentlandite, and chalcopyrite. Adsorption isotherms for the three polymers on both valuable and gangue mineral phases were determined to give initial clues as to the ability of the polymers to depress talc. Flotation testing revealed a distinct hierarchy of effectiveness of the polymers in the depression of talc in the single mineral system (MP Dextrin > CM Dextrin > Dextrin TYM), reflecting the observed adsorption affinity and adsorbed amount of the polymers on talc. However, a different order of effectiveness was observed for talc depression in the mixed mineral system (CM Dextrin ≥ MP Dextrin > Dextrin TYM). Competition between the valuable and gangue mineral phases for uptake of MP Dextrin is responsible for its observed decrease in efficiency in mixed mineral flotation. All three polymers were found to be reasonably selective in their action, although at high dosages the polymers began to affect the flotation of the valuable minerals.