

## CHAPTER I

### INTRODUCTION

*Flotation*, or more specifically *Froth flotation*, is commonly employed to concentrate finely ground ores such as iron oxide, fluoride, and silica minerals, among others. The process involves chemical treatment of an ore pulp to create favorable conditions for the attachment of certain mineral particles to air bubbles. The air bubbles will then carry the selected minerals to the surface of the pulp and form a stabilized froth, which is skimmed off, while the other mineral remains submerged in the pulp.

According to Fuerstenau *et al.*(Chapter 1 of Reagents in Mineral Technology, edited by Somasundaran, *et al.*, 1987), the flotation process is today considered one of the most efficient methods for removing of solid particle from suspensions such as ore pulps, algae, clays, bacteria, and colloidal precipitates. The principal area of application of the flotation process is still in the mining industry, however. Moreover, the flotation process has been extended to other fields such as wastewater treatment. Theoretically, it can be applied to any mixture of particles that are essentially free from one another and small enough to be lifted by rising gas bubbles.

Actually, however, limited knowledge of the flotation mechanism has restricted the use of this technique to a relatively small but growing list of minerals. The mineral industry requires the use of a wide variety of both inorganic and organic chemical reagents for its operation.

In terms of this new model of the flotation mechanism, Fuerstenau's elementary steps would be modified as follows:

1. Bubble - aggregate collision breaks the aggregate, exposing hydrophobic patches at the points of fracture.
2. Thin film of water forms between the bubble and the fresh fracture surface.
3. Thinning of the film to the point of rupture.

Flotation involves both physical and chemical aspects which require better understandings. For the *physical* point of view, one wants to know what makes some solids readily floatable while others are not. It is imperative to know what controls the kinetics of capture of particles by bubbles in the overall operating kinetics of flotation cells. For the *chemical* point of view, one wants to know what controls the surface chemistry of mineral powders in water such as the mechanism of action of flotation reagents in regulating the wettability of various minerals, the effect of crystal chemistry in flotation, and the development of reagent schemes for separating various mineral combination.

The mechanism accepted to describe how the flotation process works is based on research performed during the 1950s and 1970s by Gaudin, Fuerstenau, Somasundaran, and co-workers. Gaudin and Fuerstenau (1955) studied quartz flotation with anionic collectors. This paper presented results of experimental measurement of adsorption to determine the total amount of collector adsorbed at the quartz-solution interface. It was concluded that the ionic structure of the solid/solution interface played an importance role in the flotation process.

Somasundaran *et al.* (1964) studied the role of the hydrocarbon chain of alkyl collectors in flotation and of surfactant adsorption at the solid-liquid interface-dependence on chain length. It was found that cationic surfactants (alkylammonium compounds) exhibited the same surface condensation as anionics to form surfactant hemimicelles (the reverse orientation model) on quartz particles. It was concluded that an increase in the length of the surfactant hydrocarbon chain resulted in increasing the binding forces. Hence, the

concentration of alkylammonium acetate decreased because of adsorption on the mineral.

Somasandaran and Fuerstenau (1966) studied the mechanism of alkyl sulfonate adsorption at the alumina-water interface. In this study, an adsorption model for the surfactant on the solid surface in aqueous phase was proposed. This model, in fact, is the reverse orientation model with the adsorption isotherm divided into three distinct regions.

Ball and Fuerstenau (1971) studied thermodynamics and adsorption behavior of the quartz/aqueous surfactant system. In this study, the temperature dependency of the electrokinetic potential and of the adsorption density in the system of quartz/dodecylammonium acetate solution was pointed out. Using experimental adsorption densities and the Stern-Grahame equation, calculations indicated a large entropic effect which was attributed to the phenomenon of hydrophobic bonding between the chains of adsorbed surfactants. A change in the adsorption mechanism in the temperature range greater than 25 °C was proposed to be due to a major breakdown of the ordered water structure at the solid surface. The electrokinetic results appear contrary to the prediction of both the simple Gouy-Chapman and the modified Stern theory. It was concluded that the measured effects must be due to changes occurring at, or associated with, both the plane of closest approach and the shear plane.

Based on the work conducted by Guadin, Fuerstenau and Somasandaran and co-worker from the 1950s to the 1970s, it has been concluded that the adsorbed surfactant molecules form hydrophobic patches (local monolayers) on the ore fines in region II, and that bubbles stick to these hydrophobic patches. In this work, we want to propose a new mechanism of ore flotation that it is a slightly different from the above proposed mechanism. Instead, we propose that the surfactant molecules form bilayers on the ore fine, the bilayers cause aggregation of the particles of ore, and then the hydrophobic patches are exposed on collision with the bubbles and thus make the particles stick to the

bubbles. In other words, surfactant adsorption causes flocculation of the ore fine, and that hydrophobic patches (local monolayers) will only be exposed by the collision of air bubbles with the floc particles, which causes the floc aggregate to rearrange. It is uniformly observed that the maximum efficiency of ore flotation lies in region II of the adsorption isotherm. We hypothesize that, if local bilayers form on the particles, the flotation system will yield the maximum flotation efficiency as a result of attaining a maximum size of aggregate, with surfactant making the ore particles stick together in region II.

The main objective of this thesis work was to verify partially the proposed mechanism of ore flotation process by looking for correlation between flotation efficiency and particle aggregation. Ground quartz and a cationic surfactant (dodecyltrimethylammonium bromide, DTAB) were used in this experiments in order to closely reproduce the original work of Gaudin and Fuerstenau.