Interfaces are encountered in every aspect of hydrometallurgy and mineral processing. One needs only to think of bubbles sticking to particles in flotation, the selective leaching of solids, aggregation of particles in salty waters, crystallization, pumping slurries, thickening and solvent extraction.

Understanding the properties of the relevant interfaces and how to manipulate them is the key to effective separation processes and thence unit operations, as is demonstrated in four industry examples.

1. The flotation of metal oxide and sulfide particles under defined bubble size and agitation conditions shows that there is a unique or critical contact angle below which particles will not float. This leads directly to the concept of a flotation domain, within which particles can float. The upper limits of this domain, predictable by both theory and experiment, are especially relevant for coarse particles and lead to a clear understanding of why coarse particles are generally recovered more efficiently in, for example, aerated fluidized bed separators compared with mechanically agitated flotation cells.

2. In the Mt Keith ore in Western Australia, about 70% of the nickel present in the slimes stream is present as fine pentlandite. Fine fibrous MgO bearing gangue minerals including chrysotile, lizardite, antigorite and hydroxy-carbonate flocculate with the pentlandite in the highly saline Mt Keith process water. Conventional industrial dispersants are highly inefficient under these pulp conditions. Dispersion of the adhering gangue slimes away from the pentlandite particles was successfully achieved using non-ionic triblock copolymers of polyethylene oxide and polypropylene oxide. A steric stabilization mechanism, anticipated from theory, is involved and the concepts and laboratory trials have been successful translated to plant practice.

3. In the Bayer process, where alumina is produced following the digestion of bauxite at high pH and elevated temperatures, gibbsite is precipitated from saturated sodium aluminate solutions. Conventional physical chemical and solution theories do not apply under these extreme but actual conditions. The growth of the gibbsite crystals is very slow during this precipitation process, behaviour which leads to a reduction in yield. In practice ‘seed crystals’ are added to accelerate the process, with some success, but without revealing the mechanisms involved. From experiments conducted at high concentration of NaOH and dissolved Al with small particles, strong repulsive forces are evident: long range hydrodynamic and shorter range steric, or structural forces. A steric layer of some 20 nm in thickness is indicated at the gibbsite-solution interface. The manipulation of these forces is very important in controlling particle agglomeration in the Bayer process.

4. Solvent extraction using conventional mixer-settlers is a major unit operation in hydrometallurgy. The presence of particles and surfactants at the oil-aqueous solution interface can hinder the process by forming particle layers at the interface, leading to stable emulsion phases [‘crud’] which prevent the full recovery of the organic phase and the valuable metals. A stream-based microfluidic extraction process is a promising approach for dealing with difficult, especially high value systems, in the presence of very small particles. Complexed metal ions may be extracted from leach solutions at high efficiencies and extraction rates. Extraction, scrubbing and stripping can all be realized with precise determination of phase disengagement in the absence of ‘crud’ formation.