Preface

This book seeks to fill a gap in the bibliography of the mineral processing industry. Subjects such as comminution and flotation have received much attention by researchers in the field of Mineral Processing, while thickening and filtration have not.

It seems that the economic importance of size reduction, obviously the most costly stage in Mineral Processing, and the strategic position of flotation as the main concentration process, have relegated the last stages of mineral beneficiation, solid-liquid separation, to a lower level of importance. It is true that when a mineral processing plant is operating normally operators tend to regard thickening and filtration as auxiliary rather than fundamental processes in the plant. But the situation changes when problems appear in sedimentation of tailings or filtration of concentrates and it is not possible to recover all the water necessary for the process, or when it is not possible to obtain the required level of moisture in the final product. In those cases, solid–fluid separation acquires a fundamental importance.

Process engineers find themselves ill-prepared to face problems such as those described above. Possibly they ask themselves why their university gave less attention to these areas. The truth is that this academic "carelessness" has deeper roots related to the low level that mechanics and fluid mechanics has been given in mining, mineral, and metallurgical engineering programs. As a result very little research has been done in the areas of thickening, filtration, and pulp transport and therefore instructors lack knowledge and experience to share with their students.

Currently, there are research groups worldwide working on solid–liquid separation, especially in the field of Chemical Engineering, where the works of authors such as Tarleton and Wakeman (1999, 2005) are available. There has been less work in the field of Mineral Processing. It is necessary to change this situation by providing an adequate framework to solid–liquid separation in the mineral industry. I hope that this book will help in this respect.

This book is divided into 11 chapters. Chapter 1 introduces the field of Mineral Processing and the importance of water in processing minerals. The consumption of water in the various stages of concentration and the need to recover most of that water by recycling are discussed.

Chapter 2 lays the conceptual basis for the study of processes of solid–liquid separation. A rigorous but limited account of the Theory of Mixtures of continuum mechanics is given. It was considered unnecessary to deal with thermodynamic aspects. An introduction discusses the conditions that a multi-component body must fulfill to be considered a continuum. The concepts of body, component and mixture are then introduced and the concepts of deformation and rate of deformation are discussed. Mass and momentum balance equations are formulated for each component of the mixture and the need to establish constitutive equations to complete a dynamic process is discussed.

Mixtures of finely divided solid particles in water are the subject of Chap. 3. Here the equations derived in Chap. 2 are applied to particulate systems.

Chapter 4 deals with sedimentation of particulate systems considered as discrete media. Starting from the sedimentation of a sphere in an unbound fluid, a complete analysis is made of the settling of individual particles and suspensions, establishing their settling and fluidization velocities.

Sedimentation of suspensions, treated as continuous media, is studied in Chap. 5. The concept of an ideal suspension and ideal thickeners is established. Kynch's theory and its extension to a continuous process are presented. The solution to Kynch's problem is deduced through the theory of characteristics. Also the concept of Modes of Sedimentation is introduced.

Flow through porous media is dealt with in Chap. 6. Equations for particulate systems are reduced for the case of the flow of a fluid through a rigid porous material. Darcy's and Forchheimer's equations are used as constitutive equations for the relative solid–fluid force. Permeability and its geometric concept are studied. For the case of two-phase flow through a rigid porous medium, the concepts of relative permeability, saturation, and capillary pressure are introduced.

Chapter 7 considers particle aggregation. When agglomerated particles in a suspension increase in size they acquire greater sedimentation velocity essential to obtain a good separation by sedimentation. The agglomerates also form more permeable cakes, which accelerates the filtration process. Different methods to increase the size of solid particles are studied in this chapter, these being *coagulation*, by reduction of the interparticle electrostatic repulsion and *flocculation* by bridging particles with polymeric agents.

Chapter 8 history of thickening is laid out from the Stone Age to the present, emphasizing people and institutions that have been important actors. The chapter then reviews the thickeners used in the mining-mineral industry. The theory of sedimentation–consolidation is deduced from the equations for a particulate system and constitutive equations for the solid–fluid interaction force and sediment compressibility are postulated. Batch and continuous sedimentation are analyzed and simulations are compared to data from the literature. Experimental determination of thickening parameters and instruments for their determination are presented. Old and new methods for thickening design are reviewed and software for the design and simulation of batch and continuous thickening are presented. Finally, strategies for the operation and control of industrial thickening are discussed.

Chapter 9 deals with filtration. Following the same scheme as in the previous chapter, equipment, the theory of filtration, constitutive equations, and parameter determination are discussed and the operations of vacuum and pressure filters are simulated.

Chapter 10 discusses Rheology. The fluid mechanics of Newtonian and non-Newtonian materials are briefly presented and the different constitutive equations for shear stress are discussed. The measurement of viscosity and yield stress in the laboratory is described and models for the relationship of these parameters with concentration are deduced.

The last chapter of the book is related to the transport of pulps in mineral processing plants. Starting from the continuity equation and the equation of motion for a continuous medium, the expression for the pressure drop during fluid flow in a tube is obtained. Newtonian fluids are then treated for cases of laminar and turbulent flows. The concepts of friction factor and Reynolds number are introduced and the distribution of velocity, flow rate, and pressure drop in a tube is obtained. The transport of suspensions in pipelines is then treated, defining the different regimes separated by the limiting deposit velocity. First, the flow of heterogeneous suspensions is introduced and the form to calculate head loss is presented. Next, homogeneous suspensions modeled by different rheological approaches are discussed. Finally, equations for the transport of suspensions in open channel are dealt with.

All the chapters present problems with solutions to aid the reader in understanding the subjects.

A substantial part of this book, especially the chapters on sedimentation and thickening, are the results of research by the author and his research group at the Department of Metallurgical Engineering and the work of Prof. M. C. Bustos and R. Bürger at the Department of Mathematical Engineering at the University of Concepción, Chile. We had the important collaboration of Profs. Wolfgang Wendland at the University of Stuttgart, Germany, Kenneth Karlsen at the University of Bergen, Norway, and Elmer Tory at the University of Mount Allison in Canada. Special thanks to all of them.

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