BOOK Review

The chemistry of gold extraction

Reviewer: R. Graham

The chemistry of gold extraction by John Marsden and Iain House. Ellis Horwood Series in Metals and Associated Materials. Chichester, Ellis Horwood. £80.

The chronology has been well researched, and the book defines all the milestones. It is a pity that there is no map of the early gold finds in South Africa, which would have offered a comparison with those shown of Australia and the USA. Nevertheless, the 'Pre-cyanidation, Cyanidation and Technical Development' eras fall logically into place, and reflect on the advances in social history and civilization, as well as in technology.

ORE DEPOSITS AND PROCESS MINERALOGY

This chapter is of immense value in providing all the basic information about the chemical and physical properties of native gold and gold-bearing minerals, and how these affect the performance of all the chemical processes involved in gold extraction. The important characteristics of placer ores versus free-milling ores are explained, as are the reasons for specific problems relating to gold extraction from oxidized ores, sulphides, carbonaceous ores, etc. Particularly useful are the sections dealing with the occurrence of gold in process products such as flotation and gravity concentrates, tailings, and refinery materials.

State-of-the-art methods for the quantitative characterization of gold ore that can lead to increased revenues or reduced costs are described.

FACTORS AFFECTING PROCESS SELECTION

The all-important factors affecting the extraction process are neatly divided into six categories, which are given in-depth treatment. Specifically, the metallurgical response of an ore (or concentrate) to a process can be thoroughly determined through the application of a detailed programme of testing, which is shown diagrammatically in flowsheet form. The unit process options used in extraction are neatly displayed in a similar manner, supported by detailed text.

Flowsheet options are described for the different types of ore (showing that a 'horses for courses' approach is necessary), and provide a very useful source of reference. Clearly, circuit complexity, and hence cost, vary with the degree of refractoriness of the gold-containing material. In this regard, a general guide is given for relative capital and operating cost factors for selected flowsheets, for which certain fixed parameters are assumed.

GOLD HYDROMETALLURGY

In this and succeeding chapters, the book's title topic is addressed in detail. Physical-chemistry principles of reaction equilibria and reaction kinetics are generally described, but are also specifically applied to gold chemistry where appropriate. The vital role played by particle characteristics in leaching reactions is stressed, both physical and mineralogical. The experimental techniques that can be employed to provide information on reaction mechanisms are briefly reviewed.

Oxidative Pretreatment

The reasons for the necessity of pretreating 'refractory' ores are given, and the various oxidative processes are detailed, i.e. hydrometallurgical sulphide, low-pressure oxygen, high-pressure oxygen (acidic and non-acidic), nitric acid, chlorine, biological, and pyrometallurgical oxidation. In all cases, the reaction chemistry and kinetics are reviewed, and attention is paid to effluent streams and gaseous emissions. The exciting concept of biological oxidation is given sound theoretical and practical treatment, identifying it as a cost-effective and environmentally acceptable process for gold-bearing sulphide ores and potentially for carbonaceous ores. The description of pyrometallurgical techniques benefits greatly from the liberal use of diagrams showing changes in structure, phase-stability diagrams, tables, and graphs.

Leaching

Eh–pH diagrams are used to full effect in this chapter. The chemistry of cyanidation as the classic gold-leaching technique is developed methodically, and the effects of interfering elements are discussed. A description is given of practical applications using agitated tanks, vats, heaps, etc., and alternative lixiviants and associated reaction chemistry are reviewed. However, the point is made that development and cost constraints impede the establishment of large-scale commercial processes using these reagents.

Solution Purification and Concentration

This chapter describes the vitally important step of concentrating and purifying gold-bearing solutions. The adsorption of the gold complex by activated carbon is dealt with in much detail, together with elution and the effects on the process parameters and the presence of other ionic species. The processes considered include carbon preparation, carbon-in-pulp, carbon-in-leach, carbon-in-column, elution, and reactivation. Ion-exchange resins are similarly dealt with, and resin-in-pulp and resin-in-solution processes are considered. Solvent extraction is reviewed briefly, its general principles being explained and specific gold-extraction systems being highlighted. The point is made that solvent extraction is not applied commercially to purify and concentrate gold-bearing solution.

Recovery

Details are given of the electrochemistry of the cementation (precipitation) of gold by zinc metal, effective

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