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CHEMICAL, BIOLOGICAL, AND METALLURGICAL ASPECTS OF LARGE-SCALE COLUMN LEACHING EXPERIMENTS FOR SOLUTION MINING AND IN-SITU LEACHING

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ABSTRACT

It is well known that the variations in temperature, chemical reactivity, and reaction rates which are presumed to occur and which in some cases have been shown to occur in a leach dump or similar solution mining activity are difficult to duplicate or model on a small laboratory scale, and the degree to which such large-size metallurgical processes can be scaled is not well established. In the present investigations the design criteria and sampling methods for large-scale leach tests on low-grade copper waste are outlined and the results of studies of temperature profiles and associated chemical and biological activity in 185 ton (1.63×10^5 Kg) waste samples (approx. 10.75m in height) are discussed. Various simple scaling features are presented, including drain-down characteristics and waste-body neutralization (of acid consuming minerals) for test samples of 7.0, 4×10^2, and 1.7×10^5 Kg. Simple geometrical scaling laws are shown to closely describe the greater part of these processes. Temperature profiles in a large waste body are shown to be related to or correlated with bacterial activity, which is further shown to be related to available oxygen (and oxygen consumption). Aeration of large waste bodies is shown to be correlated with enhanced bacterial activity and leaching rates, and certain features of bacterial catalysis observed in the large-scale tests are corrob-

orated by detailed laboratory studies of bacterial leaching phenomena utilizing the scanning electron microscope. Long-term data profiles showing a relationship between temperature, bacterial activity, oxygen consumption, and variations in Fe^{2+}, Fe^{3+}, Cu concentration, pH and Eh in the waste body are presented along with the variation of these parameters.

INTRODUCTION

The importance of bacterial activity in the sulfide copper leaching process was first recognized in the recovery of copper in the Rio Tinto (Razzell and Trussel[1]), and since then it has been convincingly demonstrated at least on a laboratory scale that leach solutions inoculated with an appropriate microorganism are much more effective in solubilizing copper from a mineral-bearing waste than those solutions which do not contain any measurable bacterial population or bacterial activity. Although the evidence supporting the effects of bacterial catalysis is overwhelming at the laboratory scale, there has been little direct evidence of the effect of bacterial catalysis in large leach dumps and similar large-scale processes. While Bhappu, et al.[2] have, for example, attempted to determine the extent of bacterial activity within a leach dump, there have been no detailed correlations of leach dump bacterial activity with temperature profile, elemental concentrations (of Fe^{2+}, Fe^{3+}, and Cu) indicative of the efficiency of the copper leaching process; as well as oxygen available within a leach dump. As a result of possible temperature, concentration, and oxygen profiles within a leach dump, and the effect these parameters would be expected to have upon bacterial activity, or the effect bacterial activity may have upon these parameters, it is difficult to characterize such effects in a large leach dump or similar large-scale solution mining operation by studying small-scale, laboratory column tests. There is in general a dearth of information relating to the ability to scale small column leach tests to large leach dump operations or to model such operations, and it is difficult if not impossible to effectively duplicate temperature and biochemical reaction profiles which are expected to occur in a large leach dump,