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Geophysical Well Logging in Order to Reduce Operating Costs in Mineral Exploration

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Abstract

The geophysical well logging is the practice of making a detailed record of the geological formations penetrated by a well. The record can be based on visual inspection of samples brought to the surface (geological records) or physical measurements made by instruments lowered into the hole (geophysical records). Some types of logs can be made during any phase of a well's history: drilling, completion, production, or abandonment. The logs are carried out in drilled holes for the exploration of oil and gas, underground, mineral, and geothermal water, in addition to part of environmental and geotechnical studies. In the case of mineral exploration, the main interest in using well logs is to seek on compositional and textural variations caused by changes in moisture and hardness of the rocks. Thus, the technic is satisfactory to detect the presence of clay and hydrated bodies, as well as the transition between friable and compact minerals. Therefore, the results open possibilities to changes exploratory drilling meshes with partial replacement of core sampling by rotary percussive boreholes. This allows to do a mineral exploration with lower costs using a faster and cheaper technique, but always using well logs to support the geological interpretation in subsurface.

Keywords: Mineral industry; Metallic minerals; Oil industry; Open pit mines

Introduction

Prospecting in mineral industry involves regional geological mapping, aerial geophysical surveys, and research in subsurface [1]. The traditional subsurface investigation is done by drilling wells to obtain core samples of the geological medium. However, this is an expensive and slow method, while providing detailed but located information [2]. Geophysical well logs are also used for these purposes, but the combination of both methodologies helps to generate precise data in less time and with reduced costs [3]. Thus, well logging presents many advantages because it is used in the correction of drilling data, definition of the geological contacts, correlations between wells etc. [4]. Almost all the well logging devices currently used in the oil industry have found some limited application in the exploration and mining of metallic minerals. However, due to various problems, the emphasis in the mineral industries has been on devices considered "exotic" or "special" by the oil industry. This includes devices for measuring or determining induced polarization, magnetic susceptibility and, hopefully, nuclear activation and the use of spectral analysis. Problems that the mining industry believes can be solved with well logging methods include mass testing and recognition of adjacent and removed minerals from a well, design of joint and fracture systems, leaching problems involving porosity, permeability and groundwater movement, stability of open pit mines, roof and pillar loading in well mines, grinding, and drilling penetration rates. Devices currently offered by the well logging industry that can be useful for these problems include those capable of measuring electrical properties, natural and induced nuclear radiation, seismic velocities, of both compression and shear modes, temperature, mechanical characteristics of a well, such as diameter and roughness, and direct well or television photography [5].

Geophysical well logging is assuming greater importance in mineral exploration and development as targets become deeper, as drilling costs increase, and as solution mining becomes necessary. Resistivity and induced polarization are the most important logs in base metal applications because they can be used to estimate sulfide content and to aid interpretation of surface surveys. Natural gamma-ray logs are used extensively to estimate uranium content; a recently developed cryogenic logging tool measures an early daughter product of uranium to avoid disequilibrium problems. Other logging tools, usually used in combination, provide information on physical properties such as fracturing, density, and porosity, which are important for solution mining, and on potassium, magnetite, sulfide, and chemically bound water content. Borehole assaying with neutron activation is a promising area of current research. Borehole geophysical techniques such as mise a la masse, induced polarization, resistivity, and electromagnetics greatly increase, at little additional cost, the amount of information derived from a drill hole.

Example

As an example of the theme exposed in this mini review, we will mention the work developed by Fonseca & Carrasquilla [6]. In this work, a site test for geophysical well logging calibration was built by Vale S.A. (Brazilian mineral company) and 3 wells of Capanema Mine were selected to show the utility of joint interpretation of core sampling and geophysical well logging in the delimitation of iron ores. The results show that this approach is a useful tool to identify hydrated materials, define interfaces, detect clay levels etc. In general, during the analysis of iron minerals, it was observed that the influence with depth of increasing compression in density log was greater than the reduction in content of heavy minerals rich in iron. Only in some localized points, changes were observed in density and sonic logs caused by the presence of richest iron levels. As a final contribution of this study, the methodology provides operating subsidies in prospecting iron ores, having utility in reducing costs and time in mineral exploration, when suggests modifying the drilling mesh putting more rotary percussive boreholes in the place of core sampling perforations, but always using geophysical well logging in both the cases as a support of the geological interpretation in subsurface.

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