Engineering Geology Applied to Rock Mechanics and Planning Process During Cave Mining at the El Teniente Mine

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The El Teniente deposit can be described as a typical porphyry Co-Mo system, one of the largest in the world. It is located in the central Chile porphyry belt. The El Teniente Cu-Mo deposit is hosted by the late Miocene Teniente Mafic Complex, a largely subvolcanic package of primarily basaltic-andesitic porphyry sills and stocks emplaced within the mid-late Miocene Farellones Formation. In the late Miocene-Pliocene, a series of felsic plutons were intruded into the Teniente Mafic Complex, and are responsible for the multiple alteration and mineralization events. Mining at El Teniente began in the early 20th century; currently, about 137,000 t per day of mainly hypogene ore is being mined using different panel caving methods.

The primary hypogene ore is described as very competent and massive, exhibiting brittle, often violent failure under high-stress conditions. Several large-magnitude seismic events have been responsible for temporary mine closure, and major collapses related to the large fault system during mine production have also occurred. Geological discontinuities recognized within primary copper ore are mainly a widely spaced large-scale fault system and a high frequency of small-scale veins (stockwork). No or few open discontinuities are found within the primary ore, which is in accordance with its brittle behavior during caving. In fact, rock mass preconditioning is currently being implemented to soften the rock mass for better caving performance.

A comprehensive geotechnical characterization has been undertaken at the mine site to describe and determine the primary rock mass strength properties to be used during rock mechanics analysis for mine planning. This work included (1) an intensive structural data collection campaign from several oriented cores within the main geotechnical units, plus reviewing of the historical underground mapping; (2) full characterization of the geological and geometrical discontinuities; (3) the development of discrete fracture network models to represent the natural faults and stockwork rock fabric at different mine scales; (4) lab strength properties measurements of the intact rock material and veins, to be used particularly in the application of synthetic rock mass simulation to determine rock mass failure envelopes of the geotechnical units; and (5) numerical modeling at both caving and pillar scales as the final stage, where previous results and data analysis are all integrated.

Since primary ore is not a fractured rock mass, a traditional rock mass classification system for mine design cannot be readily applied without forcing and manipulating the parameters of the rock mass characterization (geological discontinuities, infill, and mineralogical assemblage, among others). Instead, the concept of weak paths within the rock mass, such as weak storkwork veins and faults, is used to describe, characterize, and quantify rock mass strength parameters of the primary ore. This paper describes the whole characterization process, its results, and the application of the geologic information of the rock mechanics analyses to influence the planning process for production at the El Teniente mine.