Using borehole geophysics to improve the geologic interpretations of ore deposits

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As exploration projects throughout the world continue to focus on buried, deep, and inaccessible deposits, the ability to accurately and precisely interpret their geology becomes increasingly critical yet more difficult. The use of geophysical borehole imaging can be instrumental for defining the structural geology of many deposits, providing an abundance of data upon which to base geologic interpretations. Excelsior Mining’s Gunnison project in southeastern Arizona features the exploration and development of the North Star deposit which is a large, low-grade copper skarn related to contact metamorphism sourced from an igneous intrusion. The deposit is buried underneath an average of ~500 ft of alluvium and contains no outcrop. Exploration drilling began on the property in the mid 1950s and continued through a number of programs over the next several decades. Historical geologic interpretations from drilling suggested the deposit as structurally dominated by a series of N-NW striking normal faults dipping steeply to the west and displacing the deposit stratigraphy. In 2011, Excelsior continued drilling at the deposit and conducted borehole geophysical imaging on all of the drill holes. This allowed for the collection of true structural orientations. The geophysical data combined with detailed structural analysis demonstrated the majority of the major structures do in fact strike N-NW, however they dip to the east, not to the west as in the historical interpretations. After re-defining the structural orientations of these faults, a new interpretation of the deposit’s geology concluded that the faults needed to have reverse motion to explain the observed geologic relationships. The new interpretation pieced together the deposit with increased accuracy and precision. Formation thicknesses are more consistent in the new interpretation and the formations themselves are defined with much sharper boundaries. Stratigraphic repetitions which had previously been interpreted as primary stratigraphic heterogeneity, are now recognized as structural repetitions due to reverse faulting. Interpretation of the geologic history of the deposit has changed substantially due to the discoveries made with the geophysical data, which is fundamental for further regional exploration efforts. The borehole geophysical data also identified conjugate sets related to the reverse faults and defined orientations for other features like joints, veins, dikes, bedding, and other structural complexities throughout the deposit. The analysis of the structural data was used to create a detailed three-dimensional structural model of the deposit, which is critical for further exploration and development.