Preg-robbing gold ores: an example of a non-linear estimation workflow when dealing with non-additive geometallurgical variables

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ABSTRACT

Carlin-type mineral systems exhibit a unique combination of geometallurgical material types characterised as oxide, single refractory, and double refractory ores. Oxide ores are the simplest to process and have been the dominant ore source since bulk open pit mining began in the mid-1960s in the Carlin Trend. Though most carlin ores are refractory, that is nanoscale gold inclusions in the crystal lattice of hydrothermal arsenian pyrite rims. Autoclave technology has been utilized since the 1990s to process refractory ores, which breaks down the pyrite crystal structure using moderate heat under high-pressure with oxidizing agents. The residue is then treated with carbon-in-leach during cyanidation that uses activated carbon to adsorb free gold particles as the primary recovery method.

The problem is that most high-grade carlin ores exhibit high total carbonaceous matter from graphite to organic carbon that may offer a higher affinity for gold to adsorb to, essentially robbing gold from the pregnant solution, significantly reducing gold recoveries ('preg-robbing'). These ore types are referred to as 'double' refractory and require energy-intensive roasting at high-temperatures for effective processing. The challenges this poses are multi-faceted. Preg-robbing material is a contaminant to carbon-in-leach processing thus it is not the concentration rather the presence. Not all preg-robbing ores behave alike either, with some carbonaceous matter may significantly impact gold recoveries versus others that essentially 'preg-borrow' i.e., only a partial loss of recovery.

Robust resource estimation is therefore critical to ensuring accurate geometallurgical characterization of ore types for economic, blending and routing considerations. The misclassification of oxide as refractory material has material impacts to the total potential recovered gold ounces produced in any given year as processing facilities are spatially dispersed across Nevada. Sites compete for roast material to be processed with those located furthest away required to meet a higher-grade threshold often resulting in material to be stockpiled.

Most geometallurgical variables are non-additive meaning they are the product of a calculation of multiple variables e.g., from a regression, that do not average linearly yet traditional linear estimation techniques like inverse weighted distance is commonly used. To calculate the final geometallurgical variable usually requires each variable comprising the underlying equation to be estimated but only if consistent data exists. Preg-robbing analyses involve a gold spike, which is subject to change over time or with different laboratories that is not reliably documented. To reduce estimation error, this study explores the use of a non-linear estimation approach utilizing a Truncated Pluri-Gaussian

(TPG) simulation that categorises preg-robbing data using a threshold of 40%. This approach utilised carbon logging that improved geologic domaining aiding in higher resolution zones of potentially preg-robbing zones that were otherwise poorly sampled.

This study highlights the importance of integrating advanced geostatistical methods, geological interpretations, and robust assay frameworks for addressing complex geometallurgical challenges.