Sequential Planning of Downhole Geophysical Surveys in Mineral Explorations by Optimizing Efficacy of Information

David Zhen Yin[1], Celine Scheidt[2], Tyler Hall[1], Lijing Wang[1], Jef Caers[1]
1. Department of Geological Sciences, Stanford University, Stanford, CA, USA, 2. Department of Energy Resources Engineering, Stanford University, Stanford, CA, USA

Downhole geophysical survey plays an important role in mineral explorations. Optimal planning of future downhole geophysical surveys is challenging. This is because the future downhole geophysical data are highly uncertain. There are no current available approaches to quantitatively assess such uncertain future geophysical data from planned boreholes. More importantly, the sequential nature of downhole geophysical acquisitions should be addressed. In this work, we introduce a new measure, named efficacy of information (EOI), to steer the sequential planning of downhole geophysical surveys. EOI quantifies how much the future actions of downhole geophysical data acquisition will reduce uncertainty in key economic parameters, such as orebody volume and depth. Maximizing EOI sequentially will lead to obtain the most informative geophysical signals to reduce the deposit exploration uncertainty. Using EOI, we will show the optimal borehole for geophysical survey changes when planning to acquire at one borehole at a time compared to acquisition at two boreholes sequentially. To emulate all the potential future geophysical data for sequential EOI calculation, we train an artificial neural network (ANN). The trained ANN can fast generate the potential borehole geophysical data once given the borehole locations, thus enhancing the computational speed. We will demonstrate this approach on a real metal deposit derived from the Mid-Continent Rift system.