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Decision Theoretic Methods for Mineral Exploration

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As the global demand for batteries increases, the need to find to find new battery metals deposits become more critical. Exploring the subsurface for new deposits requires gathering data about prospective targets through geophysical testing, geochemical surveys, and drill sampling. Finding a prospective subsurface deposit can require a large amount of well targeted testing. Testing is often conducted according to fixed test schedules that define the sequence measurements to be taken before any measurements are taken. Decision theory suggests that dynamic plans, in which the measurements taken adapt based on what is observed in previous measurements, will outperform static plans on most information-gathering tasks. This improved performance can allow decisions to be made with fewer measurements required.

We have formulated mineral exploration problems as sequntial optimization problems called partially observable Markov decision processs (POMDPs). We develop methods to solve for optimal dynamic sequntial measurement plans using POMDP search methods. Each step of the resulting dynamic plan takes as input a distribution over the possible states of the sub-surface geology. Along with the dynamic planning process, we implemented a Baysian regression method to update an initial distribution with the information gained from each measurement. When testing a prospective target, a natural question that arises is when has enough data been gathered to falsify the hypothesis that an economic deposit exists. The distribution resulting from each update provides a quantiative estimate of the deposit state that can be used to make a principled decision of when to falsify a deposit hypothesis. We have implemented these methods for a drill measurement campaign for a prospective deposit and compared the predicted results to a baseline measurement method.