Constructing Branching Trees of Geostatistical Simulations

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Résumé

Mine planning is a critical step in open-pit mining, consisting of choosing the ultimate pit limits and the sequence in which to extract the blocks so as to maximize the net present value of the mining project. Initially, the mine plan was optimized on a single set of kriged block estimates. When geostatistical simulations became widespread, methods were developed for incorporating multiple simulations (generally about 20) into the optimization procedure. However, this still ignored the impact of new information obtained as mining advances. Our objective is to develop a method for incorporating information that could be obtained at a discrete set of times in the future into the mine planning procedure. We want to be able to use 100 conditional simulations at each time in order to capture the upside potential and the downside risk. The difficulty is to design a computationally efficient method for constructing such a large branching tree of geostatistical simulations conditional on information obtained at earlier times. This paper proposes using multi-stage stochastic programming with recourse for optimizing strategic open pit mine planning. The key innovations are firstly, that a branching tree of geostatistical simulations is developed from the outset in order to take account of uncertainty on the ore grades and secondly, that scenario reduction techniques are applied to keep the trees to a manageable size. Our example shows that different mine plans would be optimal for the down-side case when the deposit turns out to be of lower grade than expected compared to when it is of higher grade than expected. Moreover our approach gives the probabilities of these outcomes. More generally, the idea is to move toward adaptive mine planning rather than just producing a single "one-size fits all" mine plan that would be optimal when averaged over all possible ore grade realizations.

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