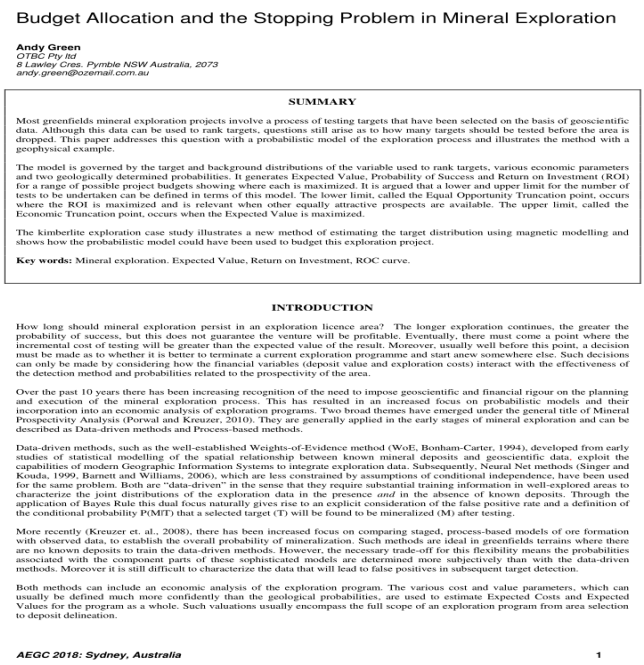
# Mineral Exploration Decisions: A Guide To Economic Analysis And Modeling



Budget Allocation and the Stopping Problem in Mineral Exploration

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**SUMMARY**

Most greenfields mineral exploration projects involve a process of testing targets that have been selected on the basis of geoscientific data. Although this data can be used to rank targets, questions still arise as to how many targets should be tested before the area is dropped. This paper addresses this question with a probabilistic model of the exploration process and illustrates the method with a geophysical example.

The model is governed by the target and background distributions of the variable used to rank targets, various economic parameters and two geologically determined probabilities. It generates Expected Value, Probability of Success and Return on Investment (ROI) for a range of possible project budgets showing where each is maximized. It is argued that a lower and upper limit for the number of tests to be undertaken can be defined in terms of this model. The lower limit, called the Equal Opportunity Truncation point, occurs where the ROI is maximized and is relevant when other equally attractive prospects are available. The upper limit, called the Economic Truncation point, occurs when the Expected Value is maximized.

The kimberlite exploration case study illustrates a new method of estimating the target distribution using magnetic modelling and shows how the probabilistic model could have been used to budget this exploration project.

**Key words:** Mineral exploration. Expected Value, Return on Investment, ROC curve.

**INTRODUCTION**

How long should mineral exploration persist in an exploration licence area? The longer exploration continues, the greater the probability of success, but this does not guarantee the venture will be profitable. Eventually, there must come a point where the incremental cost of testing will be greater than the expected value of the result. Moreover, usually well before this point, a decision must be made as to whether it is better to terminate a current exploration programme and start anew somewhere else. Such decisions can only be made by considering how the financial variables (deposit value and exploration costs) interact with the effectiveness of the detection method and probabilities related to the prospectivity of the area.

Over the past 10 years there has been increasing recognition of the need to impose geoscientific and financial rigour on the planning and execution of the mineral exploration process. This has resulted in an increased focus on probabilistic models and their incorporation into an economic analysis of exploration programs. Two broad themes have emerged under the general title of Mineral Prospectivity Analysis (Porwal and Kreuzer, 2010). They are generally applied in the early stages of mineral exploration and can be described as Data-driven methods and Process-based methods.

Data-driven methods, such as the well-established Weights-of-Evidence method (WoE, Bonham-Carter, 1994), developed from early studies of statistical modelling of the spatial relationship between known mineral deposits and geoscientific data, exploit the capabilities of modern Geographic Information Systems to integrate exploration data. Subsequently, Neural Net methods (Singer and Kouda, 1999, Barnett and Williams, 2006), which are less constrained by assumptions of conditional independence, have been used for the same problem. Both are "data-driven" in the sense that they require substantial training information in well-explored areas to characterize the joint distributions of the exploration data in the presence *and* in the absence of known deposits. Through the application of Bayes Rule this dual focus naturally gives rise to an explicit consideration of the false positive rate and a definition of the conditional probability P(M|T) that a selected target (T) will be found to be mineralized (M) after testing.

More recently (Kreuzer et. al., 2008), there has been increased focus on comparing staged, process-based models of ore formation with observed data, to establish the overall probability of mineralization. Such methods are ideal in greenfields terrains where there are no known deposits to train the data-driven methods. However, the necessary trade-off for this flexibility means the probabilities associated with the component parts of these sophisticated models are determined more subjectively than with the data-driven methods. Moreover it is still difficult to characterize the data that will lead to false positives in subsequent target detection.

Both methods can include an economic analysis of the exploration program. The various cost and value parameters, which can usually be defined much more confidently than the geological probabilities, are used to estimate Expected Costs and Expected Values for the program as a whole. Such valuations usually encompass the full scope of an exploration program from area selection to deposit delineation.



Mineral exploration endeavours to find mineral deposits, especially those with commercially of exploration target generation, GIS has become a decision- making tool. indicated, inferred) based on economic and technical feasibility analysis. .. model for epithermal Au deposits is not applicable to guide exploration for.Economic analysis of the potential profitability of projects is thus an important task Brook, A., Kendrick, D. and Murows, A. () GAMS User's Guide Release Mineral Exploration Decisions: Guide to Economic Analysis and Modeling.analysis is performed under deterministic data and imprecise data. .. Chapter 5 Standard Petroleum Economics Model (EcoPetro_Model). Making the decision to invest in petroleum exploration and production projects is Petroleum and Mineral Law and Policy. The Global oil and gas tax guide, available from.Decision Analysis for Petroleum Exploration: Edition [John R Schuyler, Paul D Project Economics and Decision Analysis: Probabilistic Models and B.S. and M.S. degrees in Mineral-Engineering Physics from Colorado School of Mines . decision analysis; however, it does provide a getting started guide that walks .risk analysis applied to petroleum exploration and pro- duction. This paper presents the contributions of risk and decision models are one of the . to integrate geological and economic uncertainties .. Mineral exploration decisions: A guide.Analysis of geologicai quality and its relationship to economic return shows that geological grade, other Ph.D. program at Queen's University and his vaiuable guidance in setting up the technical . Two deposit model of mineral extraction costs 1 Two deposit . decision point in the sequential exploration process.exploration and mining professionals to make difficult decisions, such as the classification of material as a and economic analysis of Mineral Reserves.economic benefits of the exploration investment process. JNTRODUCTION The mineral exploration environment comprises the distri- bution of Exploration continues as long as the analysis of information. 1 . the development of strategies to guide the investment of resources for the . exploration investment decisions.and unique strategic elements where risk analysis and decision models represent .. Mineral Exploration Decisions: A Guide to Economic Analysis and.Product 7 - 15 Using the Vision as guidance, the Mining Industry of the Future is . Geochemical exploration is the search for economic mineral deposits by detection of abnormal  Develop geophysical resolution modeling to enable enhanced mine ..  Non-invasive and deeper in-situ analysis of ore body technologies.Mineral exploration worldwide is in crisis. guidance in the four critical areas that govern success: exploration strategy, . Industry economics? . Certainly, modeling has its place: it can accelerate decision making and help .. possible andin conjunction with geochemical analysis of drill cuttings at the.Economic Analysis Software for Mining Projects APEX can help you put your project decisions on a solid foundation of economic principles. Terms such as.Table Modelling of Economic Impacts of Mining and Exploration Office's National Income Accounts for the Irish economy and input-output analysis of the relationships .. their guidance and inputs. . Due to low zinc prices, a

decision.