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SURFACE MINING



Ken Lane

Kenneth F. Lane led the way for value based optimisation of the full scope of mining activities. In particular, showing how cutoff grade policies bridge the disciplines and developed the framework for maximising the whole project value by optimising this policy every year as the resource was depleted.

This work led to more valuable mining in many of the largest surface mines in the world and for the underground projects that have used these principles.

Lane used his Mathematics degree from Cambridge University (1950) as a foundation for his role in Rio Tinto's Group Planning Department which he joined in 1960. Lane could see how to apply dynamic programming formulations (by Richard Bellman) to the economic definition of ore and how this would vary as the project was mined and as the economic environment changed.

In 1964, he published his first paper on the topic entitled, *Choosing the Optimum Cut-off Grade*, in which he identified the best economic criteria for making decisions (Net present Value) and then showed how to optimise the project considering the three main stages - mine, mill (or concentrating) and market (or refining), with each one having its own limiting capacity. Lane then went on to showcase the six critical values he has successfully formulated for cutoff grade selection and demonstrated that under deterministic prices, the optimum cutoff grade is always one of these values. Due to the remarkable and innovative concepts he presented in the paper, *Choosing the Optimum Cut-off Grade* (1964) has been considered the pioneering formal investigation into the topic of cutoff grade optimisation.

Since this initial publication, many academics and operations planners have been inspired and adopted Lane's techniques as standard practices. These include Mike Blackwell, the engineer who nursed the infant ideas to maturity

on their first major application in the planning and development of a large-scale project in Bougainville, Papua New Guinea in 1971. The Rössing Uranium mine was another early adopter of Lane's work with two cutoff grade dimensions.

Under Lane's management, RTZ Consultants rapidly gained an international reputation for its pioneering work on the development and application of optimisation software in mining. The concept and formulation of the 'opportunity cost' was brought from financial parlance into the mining industry by Lane, making a particular impact on many South American projects as Lane conducted seminars and discussions with the mine planning community (often facilitated by Juan Camus at Metálica Consultores SA).

Having become a Director of Rio Tinto and seeing the lack of good mining references available for the next generation, Lane was inspired to create a book on cutoff grade optimisation, hoping this would also inspire others to follow in other mining disciplines. Lane wrote a book dedicated to optimisation of the entire mining business, first published in 1988 titled *The Economic Definition of Ore: Cut-off grades in theory in practice*. Filled with practical guidance and the theoretical algorithm derivations, Lane held nothing back, it was



designed to genuinely help the industry make more from the precious resources that we normally only have one opportunity to process.

Internally, Rio Tinto's OGRE software was written to use Lane's single sequence cutoff grade optimisation principles. Once Lane's book was published, it also inspired other software including Whittle's Opti-cut (1996) and Strategy Optimisation System's Free-cut (2000). Lane's Dynamic Programming technique was shown extremely capable in ensuring that an optimal cutoff grade is chosen at any given point in time while also drastically simplifying the complex process of cutoff grade calculations.



Lane worked with Dr Brett King in 1996 to build upon his cutoff grade foundations to create a multi-dimensional, multi-policy and multi-sequence cutoff grade optimisation algorithm. The Rio Tinto software prototype COSMOS (1997) and then the commercially available COMET Optimal Scheduler used today was built upon Lane's optimisation framework. This extended theory is used by most of the largest mining companies and mines around the world including Rio Tinto, Anglo American, Codelco, Teck and many others.

Due to demand from the industry and exactly 50 years from when Lane's seminal paper was published (Oct 1964 – Oct 2014), Lane's 1988 book was reprinted again in Oct 2014 by COMET Strategy. This book remains in regular demand is still referenced as the inspiration and foundation for optimisation in the mining industry.

Despite the recognition and popularity that was achieved by Ken Lane, perhaps his most endearing quality is the humility that he approaches his challenges and his willingness to listen to others and pass on his experiences. "Ken 'CutoffGrade' Lane is a true gentleman and a great contributor to the mining industry whom I am blessed to have known and worked with," said Dr Brett King, COMET Strategy, who made the nomination.

The following were Kenneth Lane's papers, contributing to the development of Mining Economics and Optimal Mine Planning:

Lane, K. F., 1964. *Choosing the Optimum Cut-off Grade*, Q. COL. Sch. Mines Vol. 59, No.4, pp 811-829

Lane, K. F., 1979. *Commercial aspects of choosing cut-off grades*, 18th Application of Computers and Operations Research in the Mining Industry Symposium Ch 27, pp280-285

Lane, K. F., 1983. *Optimum grades for resource exploitation*, Paper presented at the RTZ meeting: Data Processing Conference, Bristol RTZ meeting data processing conference

Lane, K. F. Hamilton, D. J., and Parker, J. B., 1984. *Cutoff grades for two minerals*, 18th Application of Computers and Operations Research in the Mining Industry Symposium, London pp. 485-491 (The Institution of Mining and Metallurgy, London)

Lane, K. F., 1988. *The Economic definition of ore: cut-off grades in theory and practice*, (Mining Journal Books Limited)

Lane, K. F., 1989. *Implementing cut-off grades*, Paper presented at RTZ meeting: Computerised Mine Design, Bristol, RTZ meeting computerises mine design. Paper 12, (unpublished)

Lane, K. F., 2014. *The economic definition of ore: Cut-off grades in theory in practice*, COMET Strategy, Brisbane, Australia (www.cometstrategy.com)

