35th Applications of Computers and Operations Research in the Minerals Industry Symposium 2011

(APCOM 2011)

Wollongong, Australia 24-30 September 2011

Editors:

E.Y. Baafi R.J. Kininmonth I. Porter

ISBN: 978-1-61839-222-0

Printed from e-media with permission by:

Curran Associates, Inc. 57 Morehouse Lane Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2011) by the Australasian Institute for Mining and Metallurgy (AusIMM) All rights reserved.

Printed by Curran Associates, Inc. (2011)

For permission requests, please contact the Australasian Institute for Mining and Metallurgy (AusIMM) at the address below.

Australasian Institute for Mining and Metallurgy (AusIMM) PO Box 660 Carlton South, Victoria Australia

Phone: 61 3 9662 3166 Fax: 61 3 9662 3662

publications@ausimm.com.au

Additional copies of this publication are available from:

Curran Associates, Inc. 57 Morehouse Lane Red Hook, NY 12571 USA Phone: 845-758-0400 Fax: 845-758-2634 Email: curran@proceedings.com Web: www.proceedings.com

CONTENTS

Keynote Addresses

Multi-Disciplinary Engineering Research and Development Skills for Mining – A Case Study	C D Cook, S Van Duin and I Porter	1
The Decision of Stationarity in Modern Resource Estimation	C V Deutsch and B J Wilde	11
Formulating and Solving Complex Minerals Industry Optimisation Problems – A Systems Approach to Complex Systems Problems	P A Dowd	29
Visual Computing and Mine Design	K R Johnson	39
Reconciliation Principles for the Mining Industry	H M Parker	47
JORC and Mineral Resource Classification Systems	P Stoker	69
Long-Term Scheduling	J Whittle	75
Geological Modelling		
The Effects of Considering the Spatial Bulk Density Variability in Mineral Resources and Reserves	P M Dias, J F C L Costa, J C Koppe and C Diedrich	81
Interactive Modelling and Visualisation of Large Deposits Using Linear Octrees	Y D Jiang	89
Geological Domaining and Resource Estimation – A Discussion	N A Schofield	99
Boundary Classification for Automated Geological Modelling	K Silversides, A Melkumyan, P Hatherly and D Wyman	113
Geostatistical Resource Estimation		
Mineral Resource Classification Using a Data Geometry Index	A Arik	121
Localised Uniform Conditioning in the Multivariate Case – An Application to a Porphyry Copper Gold Deposit	J Deraisme and W Assibey-Bonsu	131
Localised Indicator Kriging	W Hardtke, L Allen and I Douglas	141
Learning from Simulation at Boddington Gold Mine	M Humphreys	149
Multivariate Block Co-Simulation of an Iron Ore Deposit	A Jewbali	157
A Non-Parametric Bayesian Framework for Automatic Block Estimation	A Jewbali, F Ramos and A Melkumyan	177

Field Parametric Geostatistics – Geostatistical Rigorous Solutions Dealing with Extreme Grades During Resource Estimation	R S Machado, M Armony, J F C L Costa and J C Koppe	191
A New Look at Multiple-Point Geostatistics for Geological Modelling	G Mariethoz and B F J Kelly	203
Non-Parametric Bayesian Learning for Resource Estimation in the Autonomous Mine	A Melkumyan and F Ramos	209
Multivariate Geostatistical Simulation via Joint Approximate Diagonalisation – A Case Study	U Mueller and J Ferreira	217
Looking for an Adequate Drilling Spacing and Heterotopic Sampling – An Iron Ore Example	J D V Reuwsaat, J F C L Costa, J C Koppe and D T Ribeiro	231
Calculating Similarity Among Geological Simulated Images and Reference Images Using Principal Component Analysis	D T Ribeiro, J F C L Costa, D Roldao, E Cunha, T Webber, C Monteiro and T Tamantini	243

Open Pit Planning

A New Approach to Flexible Open Pit Optimisation and Scheduling	M Armstrong and A Galli	253
Contemporary Criteria of Open Pit Long-Term Production Scheduling	R A Halatchev	265
Investigating the Effect of Different Block Dimensions on the Economic Life of Open Pit Mines	A Hekmat, M Osanloo and P Moarefvand	287
Blast Movement Modelling and Measurement	D La Rosa and D Thornton	297
Four-Dimensional Network Relaxation Method for Long-Term Open Pit Mine Scheduling	S Murakami, Y Tamanishi, S Miwa and J Yamatomi	311
A New Metaheuristic Algorithm for Long-Term Open Pit Production Planning	J Sattarvand and C Niemann-Delius	319
Mine Planning		
Mine Planning Integration of Oil Sands Mine Planning and Waste Management Using Goal Programming	H Askari-Nasab and E Ben-Awuah	329
Mine Planning Integration of Oil Sands Mine Planning and Waste Management Using Goal Programming Selection Criteria for Open Pit Production Equipment – Payload Distributions and the '10/10/20' Policy	H Askari-Nasab and E Ben-Awuah E K Chanda and R J Hardy	329 351
Mine Planning Integration of Oil Sands Mine Planning and Waste Management Using Goal Programming Selection Criteria for Open Pit Production Equipment – Payload Distributions and the '10/10/20' Policy Creating the Optimal Coal Working Section	H Askari-Nasab and E Ben-Awuah E K Chanda and R J Hardy R de Jongh and P Lukic	329 351 365

Improving Truck-Shovel Matching	S Nel, M S Kizil and P Knights	381
Eight-Dimensional Planning – Construction of an Integrated Model for Mine Planning Involving Constructability	W Rocher, E Rubio and N Morales	393
Panel Caving Scheduling Under Precedence Constraints Considering Mining System	M Smoljanovic, E Rubio and N Morales	407
A Novel Approach to Estimate the Gap Between the Middle- and Short- Term Plans	J Yarmuch and J Ortiz	419
Mineral Processing		
An Integer Programming Model for Optimisation of a Heavy Media Coal Preparation Plant	E A Gunn and J Zhou	427
Application of Statistical Approaches for the Development of Cost Estimation Models for Jaw Crushers	H Haghi, A R Sayadi and J V Mehrabani	439
A Numerical Approach for Prefeasibility Analysis of Tailings Disposal Options	M S Kizil and B Muller	455
Screen Media Aperture Size Measurement Using Metso's Screen Tracker	K J Riihioja, G van Niekerk and M Wortley	465
Computer Simulation of the Direct Iron Reduction in MIDREX Ovens	A C Silva and A T Bernardes	471
A Fractal Approach for Mineral Breakage	A C Silva, J A M Luz and A T Bernardes	479
Fuzzy Model of a Multigrade Structure for Support of Decision-Making and Management in Mineral Processing	S Vujić, I Miljanović, T Benović, A Milutinović, A Petrovski and M J Pejović	485
Project Evaluation		
Multi-Stage Stochastic Optimisation for Managing Major Production Incidents	M Armstrong, A Galli and R Razanatsimba	491
Optimisation of Mining Policy Under Different Economical Conditions Using a Combination of Non-Linear Programming and Genetic Algorithm	Y Azimi, M Osanloo and A Esfahanipour	501
Development and Application of a Holistic Quantitative Deterministic Technique for Risk Modelling (Quadrim) in Mine Valuation	T Y Dube	517
The Resource Valuation and Optimisation Model – Real Impact from Real Options	G W Evatt, P V Johnson, J Moriarty, P W Duck, S D Howell and C Tonkin	535

Internalising Ecological Costs in Evaluating and Planning a Mining Project	X Gu and Q Wang	547
What do Geostatistics and Cut-Off Grade Optimisation have to do with Real Options Applied to Mine Project Evaluation?	L Martinez, O Leiva and J Araya	557
Risk Assessment of Consumables Supplies Management in Mines	S Vujić, S Boševski, I Miljanović, M Hudej, A Petrovski, A Milutinović and M J Pejović	571
Health and Safety		
Prediction of Acid Gas Generation in the Petroleum Industry	M Farrokhrouz and M R Asef	581
Monitoring Haul Truck Operator Fatigue Using Gyroscope Data	J Humphries, A Koh, I Thomas and L van Latum	593
Computational Fluid Dynamics Modelling of Gas Flow Dynamics in Large Longwall Goaf Areas	T Ren, R Balusu and C Claassen	603
Rock Mechanics		
Synthetic Rock Mass Modelling of a Rock Mass with Non-Persistent Joints	M Bahaaddini, G Sharrock, and B K Hebblewhite	615
Assessing Deformability of Siltstone Under Compressive Loading by Ultrasonic Wave Propagation	M Karakus and B Tutmez	625
Optimisation of a Stochastic Rock Fracture Model Using Markov Chain Monte Carlo Simulation	C Xu, P A Dowd and D Wyborn	635
Probabilistic Slope Stability Assessment of Fresh Bulldog Shale in Prominent Hill Open Pit	C Xu, M Karakus, N Melkoumian, C Wang, Q Sui, J Wang, Q Qian and D Goodchild	643
Simulation of Mining Systems		
Dynamic Simulation as a Test Bed for Emerging Technologies	H Askew	651
Mill Modelling Using an Extensible Station-Based Framework	J T Blake, E A Gunn and J Zhou	655
Application of Simulation Technology to the Design of Coal Clearance Systems	G J Gray	669
A Multibody Simulation Solution to Analyse Attachment Kinematics of Hydraulic Excavators and Other Linkages	H Haut and M Dietrich	679
Using Flexsim Simulation Models to Assess Coalmine Roadway Development Performance	I Porter, D Cai and E Baafi	689

Total Integrated System Simulation for Master Planning of the Dalrymple Bay Coal Chain	B Reynolds, M Volz, B Olsson and R Norman	699
Using Quantile Regression in Cloud Transform Simulation	O Rondon	709
Mine Automation		
A System for Ore Tracking in Autonomous Mining	C Innes, E Nettleton and A Melkumyan	719
Automatic Material and Boundary Layer Detection During the Process of Mining on a Bucket Wheel Excavator	T Mathiak, M Kesting, L Overmeyer and V Gau	735
Efficient Utilisation of Raw Materials by Applying Innovative Sensor Technologies	K Nienhaus, M Gaastra and F Mavroudis	743
Productivity Enhancement Driver Assistance for Mining Machinery Based on Unique Two-Dimensional Radar Sensor Fusion Concept	R Winkel, C Augustin, K Nienhaus and M Hahn	751
Process Optimisation and Control		
Gravity Flow Under Moisture Conditions – Control and Management of Drawpoint Mudflow	M Ferrada	761
A Practical Approach to Truck Dispatch for Open Pit Mines	R F Subtil, D M Silva and J C Alves	765
Assessment Model for Quantifiably Measuring the Impact of an Information-Based Decision Support System in a Coal Mine Integrated Remote Control Room	V O Tenorio and S D Dessureault	779
Information Systems		
Development of a Real-Time Fleet Cost Tool as Part of an Integrated Remote Mine Control Centre	M A Antuñano and S D Dessureault	789
Data Generation in the Hunter Valley Coal Chain – A Case Study in Capacity Assessment	N Boland, F Engineer, M Reisi, M Savelsbergh and H Waterer	795
Using SAP Business Objects to Deliver Actionable Information for Operators to Management	D J Hunter	807
Development of a Real-Time Adherence to Mine Plan Tools as Part of an Integrated Remote Mine Control Centre	M M Kahraman and S D Dessureault	819
Safety Support Functions for Underground Network Communications	C Müller and A Noack	827
Mining Network and the Security Question	C Müller, A Noack and A Huebner	835
Metso SmartTag – The Next Generation and Beyond	M Wortley, E Nozawa and K J Riihioja	841

Remote Sensing

Direct Detection of Buried Orebodies Using Gradiometry	D FitzGerald, A Christensen and R Paterson	853
Radar-Based Surface Scanning with the World's First Fully Digital Beam Forming Technology Sensor Especially Developed for Mining Productivity and Safety	K Nienhaus, M Hahn, J Berg and R Winkel	857
Autonomous Mapping of Mine Face Geology Using Hyperspectral Data	S Schneider, R J Murphy, A Melkumyan and E Nettleton	865
Artificial Intelligence Applications		
Prediction of Burden at the Sungun Copper Mine by Artificial Neural Network	M Badroddin, H Khoshrou and A Siamaki	877
An Optimisation Approach to Maintenance Scheduling for Capacity Alignment in the Hunter Valley Coal Chain	N Boland, T Kalinowski, H Waterer and L Zheng	887
Critical Assessment of Machine Learning Algorithms as Estimation Techniques for a Polymetallic Ore Deposit	S Dutta, S Bandopadhyay, R Ganguli and D Misra	899
Author Index		915