Table of contents

Preface V

Organization of the symposium VII

Organization of the US National Committee for Rock Mechanics (1988) IX

Paper Review Committee XI

Previous symposia proceedings XIII

Abstracts of award winning papers:

Basic Research Award 1

Case History Award 2

Keynote addresses

Rock mechanics and ground control for underground mining and construction 5
B.H. Brady

Underground storage, with emphasis on storage in excavated rock caverns 19
C. Fairhurst

Site characterization

Rock classification for portal design 23
G.K. Rogers & C. Haycocks

Moduli of deformation studies of the foundation and abutments of the 31
Portugues Dam – Puerto Rico
Robert E. Stephens & Don C. Banks

Experiments in rock mechanics for the site characterization of Yucca Mountain 39
T.E. Blejwas

XVII
Laboratory and field characterization of immediate floor strata in Illinois basin coal mines
Yoginder P. Chugh, Anil Atri & James Dougherty

Rock fracture and fluid in rock mass
Network modelling of flow in natural fractures
Genmei Yang, Neville G. W. Cook & Larry R. Myer

The unusual response of coal permeability to varying gas pressure and effective stress
S. Harpalani & X. Zhao

An investigation of poroelastic effects related to hydraulic fracture propagation in rock and stress measurement techniques
T.J. Boone & A.R. Trefethen

The effect of contact area on the permeability of fractures

Characteristic behavior of geologic material
General failure criteria for saltrock
Douglas F. Hambley, Chris J. Ferridam & Paul E. Senseny

Relevance of partial saturation to the mechanical behavior of tuffs
Francis B. Minnick & Ralph R. Peters

Effect of boundary conditions on the shear behavior of a dilatant rock joint
S. Saeb & B. Amadei

The formation and properties of fault zones in brittle rock
John M. Kemery & Jane C. Long

Longwall
Comparative study of western US longwall panel entry systems
Khanbis Y. Haryami & Richard O. Kneisley

Supercomputer assisted three-dimensional finite element analysis of a longwall panel
Duk Won Park & Vojtech Gall

DEPWS – A powered support selection model
Y.M. Jiang, S.S. Peng & J.S. Chen

A study of displacement field of main roof in longwall mining and its application
Deren Zhu, Mingqiao Qian & Syd S. Peng

Hard rock mining
Cavability investigation of a stratabound copper deposit, Tong Kuang Yu Mine, Shanxi Province, China
W.C. Lacy

Influence of discontinuity orientations and strength on cavability in a confined environment
L. J. Lorig, R. D. Hart, M. P. Board & G. Swan

Premining stability analysis of a shaft pillar at the Homestake Mine
J.C. Johnson & M. E. Poad

Assessment of joint failure surface
Identification of critical slope failure surfaces with critical tension cracks
S. Zhang & R. N. Chowdhury

Fractal characterization of joint surface roughness in welded tuff at Yucca Mountain, Nevada
James R. Carr

Evaluation of stereo digitizing for measuring rock fracture roughness
Stanley M. Miller, Paul C. McWilliams & John C. Kerkering

Analytical methods
An approach to wide-ranging correlation of fracture distributions using the concept of fractal
K. Kojima, H. Takashita & H. Ohno

A Bayesian analysis method for incorporating expert opinion and off-site data into rock mechanics studies
Robert Lundquist, Jane Fraser & Dermot Ross-Brown

Probabilistic and deterministic key block analyses
Dae S. Young & Steven F. Hoerger

Using fuzzy method to evaluate type of cut holes
Meng Zhang, Jiaoqi Zhou & Shuming Shangguan

AE/ME in laboratory application
Acoustic emission signatures of Yucca Mountain tuffs, Nevada
Robert J. Watters & Donald M. Cheek

Considerations for acoustic emission and gas emission in gas outburst processes
F. Nakajima & M. Ujihara
An evaluation of the amplitude distribution of AE activity in rock specimens stressed to failure
M.Y.M.S. Rao, X.Sun & H.Reginald Hardy, Jr.

Acoustic emissions during anelastic strain recovery of cores from deep boreholes
Lawrence W. Twiefel

Design in underground mines

Improving design methodology for innovative rock mechanics design
Dwayne C. Kicker & Z.T. Bieriewski

Stability evaluation of alternative designs of drift-and-fill stoping in Zhaoyuan Gold Mine, P.R. China
Xianming Zhou & Shu Zhang

In situ stress for underground excavation design in a naturally fractured rock mass
Andrew J. Hyett & John A. Hudson

Application of physical and mathematical modelling in underground excavations
E. Redorana, S. Naguleswar & A.S. Bala Subramaniam

Seismic analysis and application

Complex seismic trace attributes in coal exploration
Lawrence M. Gochioco

Changes in seismic measurements with blast induced fracturing: A field experiment
Clifford J. Roblee, Priscilla P. Nelson & Kenneth H. Sukow II

Changes in the seismic properties of the cover produced by longwall mining
Guoqi He & Thomas H. Wilson

Crossbore seismics: Applications in mining
Richard E. Thill, James A. Jessop & Michael J. Frield

Geotechnical mapping by seismic imaging in underground mines
W.J. McGaughey & R.P. Young

Rock mechanics considerations

The delineation of the disturbed rock zone surrounding excavations in salt
David J. Borns & John C. Stornett

Computed and measured responses of a thick-walled hollow cylinder of salt subjected to both homogeneous and inhomogeneous loading
Harold S. Morgan & Wolfgang R. Wawersik

Experimental study of line electrode method to detect underground cavities
F. Ziaie, S.S. Peng & S.M. Hsiung

Application of the pressurized hollow poroelastic cylinder solution to the interpretation of laboratory burst experiments
Emmanuel Detournay & José L. Carvalho

Time-dependent behavior of rocks: Laboratory tests on hollow cylinder
Gilles Rousset, Behrooz Bazargan-Sabet & Rafaele Lenain

Pillar studies

Pillar sizing
Matej J. Mrugala & R.M. Belesky

An applications approach to barrier pillar design for improved resource recovery
John R. Kocher, Steven D. Jones & Matthew J. DeMarco

Yield pillar application under strong roof and strong floor condition - A case study
P. Tsang, S.S. Peng & S.M. Hsiung

Methods to determine pillar stress distribution and its effect on stability
David P. Conover, Khamis Y. Haromy & Kanaan Hanna

Hydrofracturing

Hydrofracturing stress measurements in fractured rock - A laboratory study
Lok S. Cheung & Benadell C. Haimson

Stress measurements in a burst-prone heterogeneous rock mass using a novel miniature hydraulic fracturing tool
M.R. Wold, J.R. Enever & C.R. Crawford

Laboratory observations of the effect of geologic discontinuities on hydraulic fracture propagation

Parametric sensitivity investigations for hydraulic fracture configuration optimization
S.H. Advani, T.S. Lee & J.M. Avasthi
General – Laboratory studies
Correlation between unconfined compressive and point load strengths for Appalachian rocks
Luis E. Vallejo, Robert A. Welsh, Jr., & Michael R. Robinson
Study of coal fragmentation under conical bit indentation
S. J. Jung & A. W. Khair
Development of in-situ stress measurement technique using ultrasonic wave attenuation method – A progress report
Y. L. Sun & S. S. Peng
Understanding the hydraulic pressure cell
Keith A. Heasley

Subsidence 1
Development of a mechanistic model for prediction of maximum subsidence and subsidence profile due to longwall mining
Richard D. Begley & A. W. Khair
Subsidence prediction using a laminated linear model
Miklos D. G. Samon
Subsidence and environmental impacts in Japanese coal mining
Tetsuro Enoki, Tsuyoshi Kimura & Koichi Shikata
Surface damage due to longwall mining – A case study
P. M. Lin & S. S. Peng

Assessment of stress
In-situ determination of the angle of internal friction using the magnetic fabric method
J. S. Rushmore & H. J. Mauritsch
In-place and excavated block size distributions
Navid Mojtabai, Arif Cetinbas, Ian W. Farmer & James P. Savely
Pre-mining stresses at some hard rock mines in the Canadian Shield
B. Arjang
State of stress and the relation to tectonics in the central Savannah River area of South Carolina
M. D. Zoback, D. Moos & D. E. Stephenson

Field studies
Abrasive jet drilling – A new technology
Sina Yazici & David A. Summers
Estimation of in-situ material strength
R. E. Dawell
The research on the mechanical properties of hard roof in underground coal mining
Xia Lin Sheng & Sheng Yong Jing
Prediction of fragmentation by blasting
Ronald B. Rollins & Shih-Wei Wang
SELTICA: A remote control system for in situ tests
B. Blicq & S. Subet

Ground control
Relationship between the clay fabric of roof shales and roof collapse in mines of the Herrin coal, southern Illinois
Theresa M. Bodas
Failure mechanisms in ultra-close seam mining
Yongxin Zhong & Christopher Haycock
An analysis of roof-pillar-weak floor interaction in partial extraction room-and-pillar mining
W. M. Pytel & Y. P. Chuah
Finite element analysis and comparison of shaly mine roof support systems
K. P. Unrug & S. C. Naundy

AE/ME characterization and source location
Characterization of acoustic emission waveforms produced by rock during Mode I and Mode II crack propagation
Steven D. Glazer & Priscilla Petson
Acoustic emission analyses and tomographic velocity imaging in the study of failure in Brazilian disk tests
S. D. Faller, T. Chin, R. P. Young & D. A. Hutchins
A Simplex Method-based algorithm for source location of microseismic events associated with underground mining
Jennifer Rifeberg
A statistical method for evaluation of AE/MS source location accuracy and transducer array geometry
M. C. C. Gris & H. Reginald Hardy, Jr.
### Underground storage

- Approach to first principles model prediction of measured WIPP in situ closure in salt 673
- Darrell E. Runyon, Arlo F. Fossam & Paul E. Saveny

#### 3D thermal stress analysis of WIPP Room TRH TRU experiments

- JG. Guadalupe Argüello, Mario A. Molecke & Ricardo Berdan

#### Performance of a three-cavern storage system using finite element method

- Marek J. Migula & William Bishop

#### Results of pressurized-sink measurements in the G-Tunnel underground facility

- Roger M. Zimmerman, Kevin L. Mauk, Robert A. Bellman & Donald J. Dodds

### Subsidence 2

- Stability analysis and characterization of ground subsidence of abandoned lead-zinc mines in northeastern Oklahoma 707
  - M.M. Zeman, J.L. Ahern & Y.M. Najjar

#### Subsidence monitoring at a shallow partial extraction room-and-pillar mine in midwestern United States

- Yoginder P. Chugh & Anil Atri

#### Assessment of surface fracture depth and intensity due to subsidence over the longwall panel using a sonic technique

- A.W. Khair & Y.S. Ro

#### Prediction of surface movement with emphasis on horizontal deformation due to mining

- Mao Bai, Lee W. Saperstein & Derek Elsworth

### Stress effects

- Laboratory investigation of wellbore breakouts as an indicator of in-situ stresses 741
  - R. Hugo Morales, Ahmed Abou-Sayed & Arton I. Jones

#### Stress induced microcrack geometry at failure in unconfined and confined axial compressive tests

- Ziqiong Zheng, Larry R. Myer & Neville G. Cook

#### Indentation resistance of shale: The effects of stress state and strain rate

- J.M. Cook & M. Thiercelin

#### Effects of stress history on petrophysical properties of granular rocks

- J.S. Rathore, R.M. Holt & E. Fjaer

### Numerical methods

- Numerical simulation of coal pillar loading with the aid of a strain-softening finite difference model 775
  - A.T. Jannaccone

#### Three-dimensional FEM analysis to scale field measurements from deep mine accessways

- M.I. Bess & S. M. Dar

### Poster papers

- Determination of rock mass modulus of deformation from field measurements during excavation 793
  - Ali Amini & John L. Hill, III

#### The pressure showing of gentle inclined seams and its control

- Dehai Ren & Liao Wang

#### Front abutment effects on supplemental support in predriven longwall equipment recovery rooms

- Jeffrey M. Littak & Eric R. Bauer

#### Direct determination of failure surfaces in earth slopes

- S.L. Huang, R.C. Speck & K. Yamaski

#### The measurement of small grain size dimensions of crushed halite

- Sandy H. Strout

#### Hydraulic stowing – A solution for subsidence due to underground mining in the USA

- Kausik M. Sinha

#### Calculation of vertical stress on a surface at depth exerted by topographic features using digital elevation model (DEM) data

- V.R. Shea-Albin, D.R. Dolinar & D.C. Peters

#### Research on the rational structure of tensile rockbolt and the effect of surrounding rock reinforcement

- Chao-jong Hou, Ya-nan He & Hong-pu Kang

#### System behavior analysis of the ground movement around a longwall

- Jian Wu & Shichang Zhao

#### CSPM – A subsidence prediction model

- Y. Luo & S. P. Pang

#### Performance evaluation of Appalachian wells using gas simulation model

- John J. Yu, Adil Mustafa & M.H. Hefnur

#### Dynamic rock anchors

- James J. Scott

XXV
Field investigation of wellbore breakouts as an indicator on in-situ stress orientation
R.Hugo Morales, Ahmed Abou-Sayed & Arton H.Jones

Structural analysis of the methane content in the deposit
T.Cyrul

Some applications of the frictionless laminated model
Miklos D.G.Salaman

Laboratory study of shear behaviour of rock joints under constant normal stiffness conditions
Brahim Benmokrane & Gérard Ballivy

Late papers

Ropes mine crown pillar rock mechanics

Deformation and failure-time prediction in rock mechanics
Barry Voight, Nebil Orkan & Kirby Young

Influence of joints on the elastic response of a LFUFL stope to FEM mining
W.G.Pariseau & H.Moon

Support selection of mine roadways by means of a computer program
Erdȧl Ünal

Theoretical analysis of breaking strength of mine pillars and test specimens
D.S.Choi

A comparison between two- and three-dimensional numerical models of a Coeur d’Alene District mine
T.J.McMahon & W.G.Pariseau

Author index

971