NOMINEE: Dr. Peter K. Kaiser (e-mail: pkgeok@gmail.com)

NOMINATING GROUP: Canadian Rock Mechanics Association

PROFESSIONAL SUMMARY, ACHIEVEMENTS AND CONTRIBUTIONS

The impact of Dr. Peter K. Kaiser's work is best exemplified by the J.C. Smith Medal he received in 2013 from the Engineering Institute of Canada for his 'Achievements in the Development of Canada'. CARMA is honoured to nominate Dr. Kaiser for the ISRM Müller award because his achievements are far reaching; he deserves to be recognized for his important contributions towards the development of Rock Mechanics and Rock Engineering at the international level.

Dr. Peter Kaiser's contributions have had a profound impact on the rock mechanics profession, and these continue to lead the way as civil tunnelling and underground mining projects continue to push deeper. His vision of rock mechanics as a multi-disciplinary subject has driven his research and contributed greatly to our understanding of time-dependent rock behaviour, brittle rock failure, micro-seismicity, and ground support in highly stressed rock. He has used his vast experience in burstprone ground to develop innovative support design principles and solutions, which he has communicated through numerous international short courses. His achievements and publication record over the past 30 years may be unmatched in terms of quality, quantity, breadth and impact: 110 international journal articles, 240 conference proceedings, contributions to 15 books, and 8 software packages. He is currently in the process of publishing a Rockburst Support Reference Book in three volumes to capture his long-term practical experience in a fundamentally revised rockburst support design process.

Dr. Kaiser started his career at the University of Alberta, before being appointed Professor and Chair for Rock Engineering and Ground Control at Laurentian University and Director of the Geomechanics Research Centre in Sudbury, Ontario. This centre, under his leadership and vision, grew rapidly into a team of researchers working to support the industry's needs for safer and more economical excavations at depth. In 1998, Dr. Kaiser expanded his R&D effort by creating MIRARCO - Mining Innovation, Rehabilitation and Applied Research Co. Over his ten-year presidency, MIRARCO grew to an internationally recognized research centre with over 40 staff and graduate students. In 2007, he was appointed as Founding CEO of CEMI - the Centre for Excellence in Mining Innovation, which he established as a networked centre for world-class, industry-focused research and innovation, advancing state-of-the-art concepts and methodologies in support of the mining and underground construction industries. Before retiring from Laurentian in 2015, he served as Director of the RTC-UMC - the Rio Tinto Centre for Underground Mine Construction from 2011 to 2014. This state-of-the-art research and knowledge centre was tasked with developing and implementing innovative step-change technology designed to improve mine safety and create value by mitigating geo-risk for the next generation of deep mines.

In his different leadership roles, he has supervised over 50 graduate students and 20 post-doctoral fellows, many of whom have assumed key positions in industry and academia, with six having received university appointments as professors: Prof.'s Zou (Dalhousie), Hutchinson (Queen's U.), Tannant (UBC Okanagan), Martin (U. of Alberta), Diederichs (Queen's U.), Cai (Laurentian U.) and Grasselli (U. of Toronto). Dr. Diederichs' thesis, completed under Dr. Kaiser's supervision, was awarded the ISRM Rocha Medal in 2002. Dr. Kaiser's unique approach to research has attracted numerous mining companies around the world to work with him and his graduate students to give them practical experiences, accelerating the transfer of research results into practice at mine sites and universities.

In terms of honours, he has received many awards including those from the International Society for Rock Mechanics, the Canadian Geotechnical Society, and the Canadian Institute of Mining. He has been elected

a Fellow of the Engineering Institute of Canada for his 'exceptional contributions to engineering'. He is a Fellow of the ISRM, Chinese Academy of Sciences, and Canadian Academy of Engineers. He was recently selected to present the 2016 Sir Muir Wood lecture on 'Ground Support for Constructability of Deep Underground Excavations' at the World Tunnelling Congress in San Francisco.

His steady involvement with the international rock mechanics community resulted in his serving as an ISRM Vice President (North America) and as a member of several international commissions. Most recently, he delivered the 13th ISRM lecture on 'Challenges in Rock Mass Strength Determination for Design of Deep Underground Excavations'. As an advisor and consultant, he has worked on all continents, for numerous mines in Australia, Brazil, Canada, Chile, South Africa, and the USA, as well as many challenging tunnelling projects in Canada, Nepal, India, Switzerland (including the Lötschberg and Gotthard base tunnels) and China (Jinping II hydro project).

HIGHLIGHTS OF KEY TECHNICAL CONTRIBUTIONS

1. Effect of Stress Change on Excavation and Support Performance
This work revealed the significant effect of stress changes on the bond capacity of cable bolts and demonstrated that the apparent lack of support capacity can largely be attributed to the loss of confinement. This resulted in a major shift in support configuration in deep mining. Dr. Kaiser's group found that rock mass relaxation not only affects the support performance, but is also the primary cause for excavation instability. The results have now been successfully applied by industry to ensure workplace safety and to reduce production costs.

2. Utilization of Microseismic Monitoring Data for Ground Control
Dr. Kaiser's research on microseismicity at Brunswick Mine led to the development of a new tensile source mechanism model, producing realistic source sizes, as well as new data interpretation procedures that assist in the daily ground control decision-making process. By linking seismic observations and stress models, progress has been made on the detection of zones with serious rock mass degradation. He was a leader in introducing Virtual Reality, combining it with rock engineering advances to assist in mine sequencing, support design, and mine safety enhancement. Hazard maps are now utilized to identify safety risks and to implement risk management procedures.

3. **Support and Ground Control in Burst-Prone Rock**
This work provided the rock mechanics community with a rational design methodology for selecting support systems in burst prone ground. Rockburst damage mechanisms were identified and methods of analysis and support design were developed. Extensive field and laboratory testing of support systems (e.g., spray-on liners) under both static and dynamic conditions not only generated design data, but led to new insights concerning rock support interaction. The handbook he wrote stands as the most innovative and comprehensive practical document related to this important area of rock engineering. However, his mind does not rest and a completely revised version with fundamental and practical advances is being released this year as a freely accessible Rockburst Support Reference Book.

4. Brittle Rock Mass Failure Model
The concept of a brittle failure criterion was first introduced by Dr. Kaiser at the ISRM sponsored Schlumberger lecture in 1993. Since then, in collaboration with many of his students and colleagues, extensive research with numerous case studies have been conducted and the results summarized in a series of keynote papers. These include the now well-known 's-shaped' strength envelope for brittle rock, which differentiates between extensional and shear failure behaviour with increasing confinement. This work has revolutionized the application of numerical models for stability assessment of deep underground excavations. Dr. Kaiser's more recent 'Gabion Support' concept integrates deformation-based support components to provide bulking control of stress-fractured rock and tangential load bearing components to reduce roof convergence and floor heave.

LIST OF PUBLICATIONS

Fully Refereed Journals:

1. Bahrani N, PK Kaiser, 2017. Estimation of confined peak strength of crack-damaged rocks. *Rock Mechanics and Rock Engineering*, **50**(2): 309-326.
2. Bewick, RP, PK Kaiser and WF Bawden, 2016. Shear rupture under constant normal stiffness boundary conditions. *Tectonophysics*, **634**: 76-90.
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26 April 2018

Re: Nomination of Dr. Peter Kaiser for the 2019 Müller Award

Dear ISRM Council Members:

The American Rock Mechanics Association strongly and enthusiastically supports the nomination of Dr. Peter Kaiser as the sole North American nominee for the 2019 Müller Award from the ISRM. Dr. Kaiser needs no introduction to the rock engineering community; he is an exceptional engineer, researcher and educator with worldwide impact in the fields of underground mining and civil tunneling. His impact will continue to be felt for many years to come through the engineers who have benefited from his guidance and who are now taking leadership roles in shaping the future of rock mechanics. Dr. Kaiser's insight, experience and leadership in the practical application of rock mechanics principles to challenging situations place a high demand on his skills as a consultant and advisor to governments, companies both large and small, and academic institutions. His distinguished contributions make him a most deserving candidate for the Award.

Dr. Kaiser's many significant contributions include the scientific study, understanding and mitigation of seismicity and rock bursts in underground mines. He has advanced the theoretical understanding of the mechanisms of rock bursts as well as the development of innovative and practical ground support solutions to mitigate their impacts. This work has had a profound impact on the practice of mining and tunneling in challenging conditions. The Canadian mining industry handbook on rock burst support design, developed under Dr. Kaiser's guidance, has become a standard reference for practicing mining and tunneling engineers who must deal with these potentially devastating events.

His more recent work on addressing the related issue of brittle rock failure has led to greater understanding of the fracture and bulk response in the near-excavation environment, which has led to the development of constitutive relations that better represent the behavior of brittle rocks in low-confinement conditions. He developed procedures to enable engineers to anticipate the degree of brittle failure and to design appropriate support systems to improve safety, an achievement that is cost effective in creating excavations. Peter's work has resulted in a paradigm shift in the way rock engineers think about pillar and underground excavation design in hard, brittle rock.

Dr. Peter Kaiser would be a worthy recipient of the Müller Award and the American Rock Mechanics Association is honored to endorse his nomination.

Sincerely,

Laura Pyrak-Nolte

Laura Pyrak-Nolte
President, ARMA