

# NEWS JOURNAL



ISRM

International Society for Rock Mechanics and Rock Engineering



## ANNUAL REVIEW 2023

- PAST PRESIDENT'S FAREWELL MESSAGE
- PRESIDENT'S INAUGURAL MESSAGE
- NEW FELLOWS AND AWARDS

## REPORTS

- SECRETARY-GENERAL
- CONFERENCES
- COMMITTEES
- VICE-PRESIDENTS

## TECHNICAL PAPERS

- MÜLLER LECTURE
- ROCHA MEDAL LECTURE

## The 2024 ISRM International Symposium

ARMS13  
Advances in Rock Mechanics -  
Infrastructure Development

22-27 September 2024  
New Dehli, India

## Advances in Rock Mechanics - Infrastructure Development

22-27 September 2024

The Indian National Group of ISRM cordially invites the ISRM family, rock mechanics community and the accompanying persons, to attend the ISRM International Symposium and 13th Asian Rock Mechanics Symposium (ARMS13), being held during September 22-27 September 2024 at New Delhi, India.

The conference title is Advances in Rock Mechanics - Infrastructure Development, and the following themes will be addressed:

Advancement in Site Investigations and Characterisation of Rocks & Rock Masses  
Application of Advance Geophysical Investigation Techniques  
Constitutive Modelling of Rocks and Soils  
Rock and Dump Slope Stability and Foundation Analysis  
Rock Supports, Instrumentations and Ground Improvement  
Design Methods and Analysis – Analytical and Numerical Modelling  
Preservation and Restoration of Ancient Monuments  
Deep Underground Mining Methods and Instrumentation  
Underground Space Development for Storages and Other Purposes  
Innovations and Applications of IoT in Rock Engineering  
Structural Health Monitoring and Rehabilitation  
Advancement in Laboratory Testing Techniques  
Geo-hazards and Risk Management  
Green Technologies for Zero Waste Generation and Sustainable Development  
Case Studies

The ISRM National Group of India is preparing an excellent program for the event in the modern and vibrant capital city of India. Short courses and workshops prior to the symposium are planned for young professionals, to update their knowledge about the present state-of-the-art, emerging trends and case studies in the area of rock mechanics and rock engineering.



Internationale Gesellschaft für Felsmechanik und Felsbau  
Uluslararası Kaya Mekaniği Birliği

# NEWS JOURNAL

ISRM

International Society for Rock Mechanics and Rock Engineering

## EDITORS

**PROF. SEOKWON JEON**

ISRM President

sjeon@snu.ac.kr

**DR. JOSÉ MURALHA**

LNEC, Portugal

jmuralha@lnecc.pt

## ISRM SECRETARY-GENERAL

**DR. LUÍS LAMAS**

LNEC, Portugal

secretariat@isrm.net

## LETTER FROM THE EDITORS

00

As in an Olympic cycle, every four years a new ISRM Board is inducted at the end of the congress. This happened again in 2023 in the 15th ISRM Congress held in Salzburg, Austria. It is a time to consolidate the achievements of the past Board that even going through a nearly shutdown caused by the Covid-19 pandemic, managed to increase in scientific activities and the growth in membership especially engaging younger members. This was possible only due to the enthusiasm of the Immediate Past President Prof. Reşat Ulusay and the commitment of the Board members. Likewise, it is a time for the new President and the Board to look forward and set new paths taking advantage of the opportunities that "going virtual" disclosed regarding the possibilities to reach wider and new audiences and to further promote communications and provide services to regular members.

There could be no more appropriate place for this relieve than Salzburg, where a group of Austrian experts started in the fifties of the 20th century to deal with rock engineering. This group was also called Salzburg Circle, that as early as 1951 started organizing a Colloquium about rock engineering. The 15th ISRM Congress was combined with this traditional Geomechanics Colloquium, which has been running almost uninterruptedly ever since, and was held to be the 72nd time in 2023.

This unique setting was the cause for the extraordinary success of the 15th ISRM Congress. With more than 1500 participants from 64 countries, 240 booth attendants from our 70 exhibitors and about 350 participants to the 14 workshops, it was the largest ISRM congress ever, and it will be remembered by foreign participants particularly by the Festive evening at the Stieglkeller.

Unfortunately, every so often, renewal goes hand in hand with departure. I am certain to be followed by all when I express my deepest regrets for the loss of Dr. Eda Freitas de Quadros, ISRM President for the term 2015-2019. She was a regular participant in all ISRM main events for the past 30 years and her unrelenting activity and joyful presence, since unreplaceable, will be sincerely missed. 🇵🇹

Seokwon Jeon and José Muralha  
News Journal Editors

**ISRM Regional Symposium**

Eurock 2024

15-19 July 2024  
Alicante, Spain

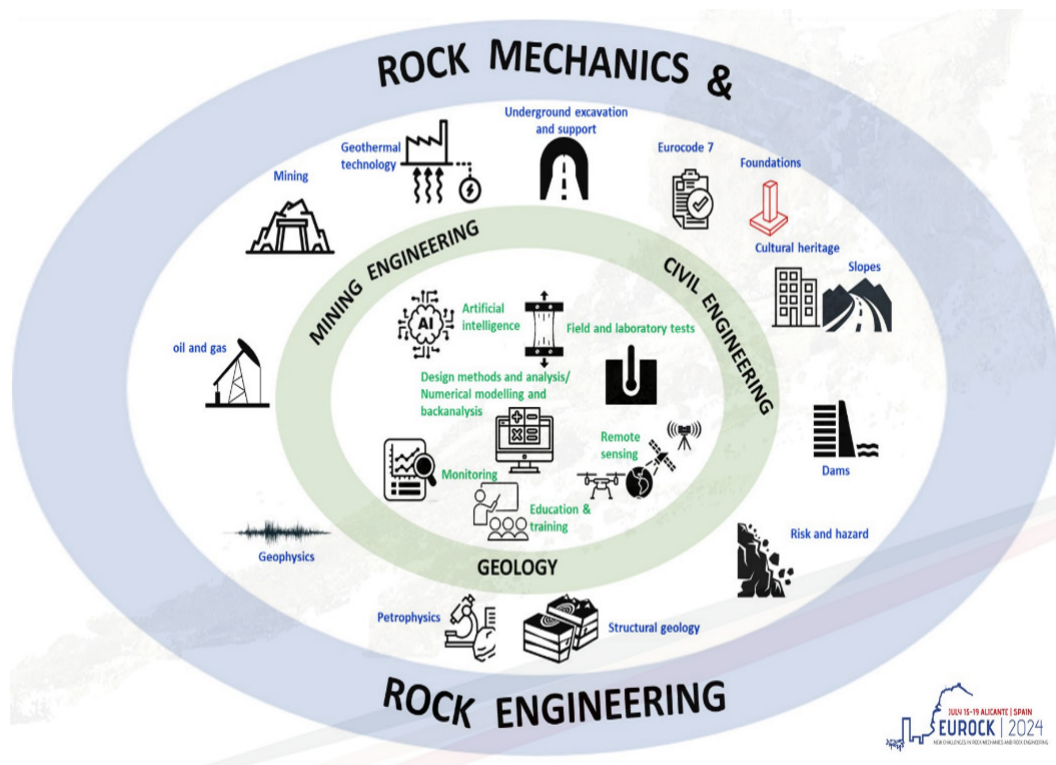


Universitat d'Alacant  
Universidad de Alicante



The Alicante University and the Spanish Society for Rock Mechanics (SEMR) are organizing the Eurock 2024, the ISRM European Regional Symposium, to be held in Alicante, Spain, during July 15-19, 2024. The conference title is New Challenges in Rock Mechanics and Rock Engineering, and the following topics will be addressed:

- Rock properties, testing methods and site characterization
- Rock mechanics for infrastructures
- Mining rock mechanics and rock engineering
- Design methods and analysis
- Rock mechanics for heritage
- Geophysics in rock mechanics
- Numerical modelling and back analysis
- Monitoring and back analysis
- Underground excavation and support
- Risk and hazard
- Applicability of EUROCODE-7 in rock engineering
- Geomechanics for the oil and gas industry
- Ores, building and industrial rocks
- Application of artificial intelligence to problems of rock mechanics
- Remote sensing in rock mechanics
- Geothermal technology
- Rock Mechanics education and training



[www.eurock2024.com](http://www.eurock2024.com)

[eurock2024@csidiomas.ua.es](mailto:eurock2024@csidiomas.ua.es)

## TABLE OF CONTENTS

00	Letter from the Editor	1
01	Table of Contents	3
02	The ISRM 2019-2023 Board	5
	Past-President's Farewell Message	6
	ISRM Board Activities	8
03	President's Inaugural Message	10
	The ISRM 2023-2027 Board	11
04	Report of the ISRM Secretary-General 2023	12
05	Membership in October 2023	15
06	Rocha Medal 2026	16
07	The 2023 ISRM Year	17
	Online Lecture Series	18
	ISRM Commissions	20
	ISRM Fellows	21
	Awards	22
	Online activities	25
	ISRM ISRM Video Courses	26
	Book Series	27
	Obituary	28
08	Forthcoming ISRM Sponsored Conferences	29
09	Reports of ISRM Conferences	
	15th ISRM Congress, Salzburg, Austria	30
	IV NROCK 2023, Reykjavik, Iceland	33
	3rd JTC1 Workshop, Oslo, Norway	34
	Nordic Grouting Symposium 2023, Stockholm, Sweden	35
	1st Chilean Congress in Rock Mechanics, Santiago, Chile	36
	1st SLRMES International Conference, Colombo, Sri Lanka	37
10	ISRM Technical Oversight Committee 2023 Annual Report	38
11	ISRM Educational Fund Committee 2023 Annual Report	42
11	ISRM Members Committee 2023 Annual Report	43
12	2023 Reports of ISRM Vice-Presidents	
	Africa	44
	Asia	45
	Australasia	47
	Europe	50
	Latin America	53
	North America	55
	Vice-Presidents at Large	56
13	Müller Award Lecture - Derek Martin	58
14	Rocha Medal Lecture - Jun Zhao	68
15	ISRM Corporate Members in 2023	80

FedIGS Joint Technical Commission JTC1 Conference

14th International Symposium on Landslides

8-12 July 2024, Chambéry, France



The theme of IS Landslides 2024 is “Landslides across the scales: from the fundamentals to engineering applications”, which will be addressed through the following items:

- Multiscale constitutive modeling for soils and rocks
- Weathering effects on soils and rocks destabilization
- Permafrost and ground stability
- Survey techniques
- Modeling of soil and rock hazards
- Recent progress in numerical tools for landslide modeling
- Risk analysis and mitigation
- Modeling and design of protective structures
- Artificial intelligence and machine learning techniques applied to slope engineering
- Make researchers, authorities and companies working together and involve inhabitants
- Case studies

[www.isl2024.com](http://www.isl2024.com)

[contact@isl2024.com](mailto:contact@isl2024.com)

FedIGS Joint Technical Commission JTC2 Conference

5th ICITG

5-8 August 2024 Golden, USA



The Joint Technical Committee 2 (JTC2) on Representation of Geo-engineering Data cordially invites you to the 5th International Conference on Information Technology in Geo-Engineering (5th ICITG). In accordance with the conference objective to promote advances in the development and application of IT in geo-engineering, full papers on the following topics are invited:

- Sensors and Sensing Technologies
- Geotechnical Instrumentation
- Data Collection and Transmission
- 3D Geological Modeling
- Information and Communications Technologies
- Digitalization
- Data-Driven Investigation and Modeling
- Big Data and Databases
- Imaging Technology
- Building Information Modeling (BIM)
- Artificial Intelligence and Machine Learning
- Virtual and Augmented Reality
- Intelligent Geomaterials
- Case Studies
- Other Topics Related to Advances in IT in Geo-Engineering

[learn.mines.edu/ICITG](http://learn.mines.edu/ICITG)

[mgutierr@mines.edu](mailto:mgutierr@mines.edu)

ISRM Specialized Conference

CouFrac 2024

13-15 November 2024 Kyoto, Japan



The 4th International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application (CouFrac2024) invites you to Kyoto, Japan, in November 13-15, 2024.

The conference, which succeeds the first held in Wuhan, China in 2018, the second held in Seoul, Korea in 2020, and the third held in Berkeley, USA in 2022, will focus on new and exciting advances in all areas of coupled processes associated with fractured geological media. Coupled thermal-hydro-mechanical-chemical (THMC) processes within fractured geological media not only provide insights into the earth's evolution, but also play a pivotal role in a myriad of near-surface and subsurface activities, such as carbon sequestration, energy storage, nuclear waste disposal, geothermal exploration, and oil and gas exploitation.

[ec-convention.com/coufrac2024/](http://ec-convention.com/coufrac2024/)

[yasuhara.hideaki7p@kyotot-u.ac.jp](mailto:yasuhara.hideaki7p@kyotot-u.ac.jp)

THE 2019-2023  
ISRM BOARD

**REŞAT ULUSAY**  
**TURKEY**  
President  
Prof. Reşat Ulusay  
Hacettepe University  
Dep. of Geological Engineering  
resat@hacettepe.edu.tr



**MICHAEL DU PLESSIS**  
**SOUTH AFRICA**  
Vice-President for Africa  
Dr Michael du Plessis  
dupiesam1@gmail.com



**SUSENO KRAMADIBRATA**  
**INDONESIA**  
Vice-President for Asia  
Dr Suseno Kramadibrata  
Bumi Resources Minerals  
suseno.kramadibrata@brm.co.id  
soeseno.kramadibrata@gmail.com



**SEVDA DEHKODA**  
**AUSTRALIA**  
Vice-President for Australasia  
Dr Sevda Dehkoda  
sdehkoda@beck.engineering



**LEANDRO ALEJANO**  
**SPAIN**  
Vice-President for Europe  
Prof. Leandro Alejano  
Escuela de Ingeniería de Minas y  
Energía  
Universidad de Vigo  
alejano@uvigo.gal



**JOSÉ PAVÓN MENDOZA**  
**PARAGUAY**  
Vice-President for Latin America  
Prof. José Pavón Mendoza  
José Pavón & Asociados  
jose.pavonm@gmail.com



**LAURA J. PYRAK-NOLTE**  
**UNITED STATES OF AMERICA**  
Vice-President for North America  
Prof. Laura J. Pyrak-Nolte  
Purdue University  
Department of Physics & Astronomy  
ljpn@purdue.edu



**QIANG YANG**  
**CHINA**  
Vice-President at Large  
Prof. Qiang Yang  
Dept. of Hydraulic Engineering  
Tsinghua University  
yangq@tsinghua.edu.cn



**ÖMER AYDAN**  
**JAPAN**  
Vice-President at Large  
Prof. Ömer Aydan  
University of the Ryukyus  
Department of Civil Engineering  
aydan@tec.u-ryukyu.ac.jp  
omeraydan@hotmail.co.jp



**VOJKAN JOVIČIĆ**  
**SLOVENIA**  
Vice-President at Large  
Dr Vojkan Jovičić  
Institute for Mining, Geotechnology  
and Environment  
vojkan.jovicic@irgo.si



**LUÍS LAMAS**  
**PORTUGAL**  
Secretary-General  
Dr Luís Lamas  
LNEC  
llamas@isrm.net

## 02 PAST PRESIDENT'S FAREWELL MESSAGE



FROM THE PRESENTATION IN THE  
CLOSING CEREMONY OF  
THE 15TH ISRM CONGRESS IN  
SALZBURG, AUSTRIA.

Dear colleagues and ladies and gentlemen,

Our four-year term of office finished in the mid of October. Our Board left and another Board under the leadership of our dear colleague Prof. Seokwon Jeon took over the mission with the objective of keeping our Society running for another period of four years, with some new paths to be delineated and new ideas to be developed. Particularly 2020 and 2021 have been the most difficult years for the whole world due to the Covid-19 pandemic as we all know. I think all the Immediate Past Board members (2019-2023) can look behind and be proud of the work developed in these four years serving our Society.

We succeeded in bringing four countries to join ISRM as its new members. We started in the mid of September 2019 with 8.505 individual members and have now 8.973 members. In spite of difficulties caused by the pandemic conditions, our 15th International Congress, two international ISRM Symposia, and a total of eighteen ISRM Specialized Conferences and Regional Symposia, two International Workshops, some on-line webinars/seminars at five different continents and one ISRM Lecture Tour for Latin America were successfully held with the close cooperation with our National Groups. Only five of these symposia were virtual, hybrid or on-line, the rest of them were organized as face-to-face events. Added to these events, our quarterly Newsletter and four issues of the News Journal were regularly published. Until the end of September 2023, 15 ISRM Online Lectures



© OeGG / J.Delgado



were given by prominent scientists and professionals from our community with the objective to disseminate and increase technical information among our members. Since 2022, new online activities were started. These are “Young Member Seminar Series” organized by the ISRM-Young Member Committee with the aim of attracting and engaging with young members of the society and the “European Rock Mechanics Debates” that aim at stimulating communication among academia and practitioners. Four Early Career Forums were also regularly and successfully organized in our term.

ISRM has been creating a collection of video courses in the field of Rock Mechanics and Rock Engineering. Particularly during the pandemic period, the necessity for these video courses highly increased and, in the term of office 2019-2023, the total number of such courses reached eleven.

In addition to eight ISRM Suggested Methods already published after 2014, a total of 11 new SMs are in preparation and/or review by several Working Groups and the related Commission, respectively. In case of their approval and publication in 2024 or until the mid of 2025, these suggested methods will be compiled in a new ISRM Suggested Methods Book, called “Brown Book”, to be published in 2025. Between 2019 and 2023, eight SM videos were prepared with the contribution of some universities and put in the website of the ISRM, and four new SMs videos are in preparation.

We also paid prime attention to continue the publication of ISRM Book Series. The books in this category are published to promote the scientific output of the ISRM. Between the term of office one book was published and two new books were already submitted to the publisher.

The work of ISRM in the dissemination of technical information and principles worldwide, through the publication of the products of our fourteen technical commissions, who have been working actively, and the lectures given to fulfill the requirements of some of our Awards such as the Müller Lecture, the Rocha Medal and the Franklin Lecture, have made a big contribution to updating our methods and techniques. In our term, eight new ISRM Fellows have been elected.

The new ISRM Survey were very useful for guiding the direction for the Society. I thank the ISRM Young Members Committee for their kind efforts for the preparation and evaluation of this most recent survey and to all respondents for their very kind interests and contributions.

This year ISRM was the host of the FedIGS annual meeting with the participation of the President, and the Secretary General to debate co-operation with the sister societies ISSMGE, IAEG and IGS. Due to health problem, our Immediate Past President couldn't attend this meeting. Participation of the President of ITA (International Tunneling and Underground Space

Association) to the ISRM annual Board meeting in Salzburg to discuss the details of an agreement for a cooperation with ISRM was a pleasure for us. We believe that this new initiative will be beneficial for both societies.

I want to express my deep gratitude for the strong collaboration I received from the Vice Presidents of the Immediate Past Board because it is due to their dedication and commitment that we could develop our work and for the contributions and very kind efforts of the present ISRM Secretary General, Dr. Luis Lamas, who worked with the Board with a great harmony. Special thanks to Sofia Farrusco, the ISRM Executive Secretary, for her very kind efforts and helps for the ISRM.

I would like to express my sincere appreciation to the works developed by our National Groups and their members who are the essence of our Society and nothing can be done without their strong commitment, to the Chairs and members of three ISRM Committees (Technical Oversight Committee, Young Member Committee, Education Fund Committee) and all ISRM Commissions, our Past Presidents and Boards, ISRM Fellows, the colleagues who organized ISRM on-line activities and contributed as speakers, the ISRM Webmaster and Co-Editor of the ISRM News Journal in Lisbon. I also thank the Laboratory of Civil Engineering (LNEC) in Lisbon for providing the infrastructure for the work of our Society and for allowing the time for the precious work of the ISRM Secretaries since its foundation.

Our Society had prominent people, such as John Hudson, Pierre Habib, Fernando de Mello Mendes, Giovanni Barla, Ove Stephansson, Manuel Romana, Françoise Cornet, Pierre Duffaut, Milton Kanji, Gérard Vouille, Álvaro González Garcia, Pierre Bérest, and most recently Eda Freitas de Quadros e Barton, who became the thirteen great losses for our Society between 2019 and 2023. Here I want to remember all of them again with respect. We will never forget their kindness and their great contributions to Rock Mechanics and Rock Engineering and ISRM, and keep their memories alive for the next generations.

Before finishing, personally, I sincerely thank to our Society for the opportunity to serve between 2019-2023 and on behalf of myself and of the members of the Immediate Past ISRM Board, I would like to express our best wishes for the success of our new President Seokwon Jeon and his Board. I also wish all of you a happy, healthy and successful New Year. 🎯

Thank you very much.

Reşat Ulusay  
ISRM President 2019 - 2023

## 03 ISRM BOARD ACTIVITIES

### ISRM ADVISORY FORUM

The ISRM Advisory Forum was established in July 2011. The Forum is chaired by the ISRM President, and it draws together ISRM Fellows and past ISRM Board members with the current Board in order to provide advice concerning topical issues. The Forum takes place every two years, i.e. at each 4-yearly ISRM Congress, and at the second ISRM International Symposium after each Congress.

The 2023 ISRM Advisory Forum was held in Salzburg, Austria, on 11 October 2023, in the first day of the 15th ISRM Congress. 23 ISRM members (the current ISRM President and eight Board members, the ISRM President Elect, four new ISRM Board members, eight ISRM Fellows, and one ISRM Past Vice President) participated in this Forum.

After the opening speech by the ISRM President Resat Ulusay, the following two topics, which were selected by the current Board to be discussed with the participants, were briefly presented:

- access (open or not) to the proceedings of the ISRM sponsored conferences;
- in-person, online and hybrid meetings.

After receiving the comments on the first topic from the participants, the President left the final decision for the next Board of the Society (2023-2027). A revision of the application form ISRM Conferences was recommended, so that ISRM can keep the control of the publication of proceedings. Discussion of the second topic were concentrated on the advantages and disadvantages of hybrid meetings.

In addition to the above topics, one of the participants indicated that the RockBowl competition, created by the NG Brazil and intended for university students, became property of the ISRM in 2015, and emphasized that all National Groups applying for the organization of this competition during the respective international conferences should follow the rules.

Before closing the meeting, the President informed that the next Advisory Forum will take place during the ISRM International Symposium EUROCK 2025, in Trondheim, Norway.

### COOPERATION WITH SISTER SOCIETIES (FEDIGS)

ISRM is one of the four international societies of the Federation of International Geo-Engineering Societies (FedIGS). FedIGS is a collaborative forum within which learned societies or associations involved in engineering with, on, or in geo-materials can meet and interact. The purpose of the Federation is to facilitate cooperation among the member societies, explore opportunities to promote their common interests and provide a unified response to common issues through effective collective actions that are more effective than individual responses of the members. Currently, the four members of the federation are the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the International Association of Engineering Geology and the Environment (IAEG), the International Geosynthetics Society (IGS) and the International Society for Rock Mechanics and Rock Engineering (ISRM). The FedIGS Board consists of the Presidents, Immediate Past Presidents and Secretary Generals of the four sister societies, and the President of the Federation is elected every four years. Prof. Chungsik Yoo from Korea is the current President of FedIGS.

The FedIGS Board approved the Joint Technical Committees (JTC) Guidelines. The running JTCs created and operating under the umbrella of FedIGS are: JTC 1 – Natural Slopes and Landslides, JTC 2 – Representation of Geo-Engineering Data, and JTC 3 – Education and Training.

The 2023 annual meeting of the FedIGS Board was held on 9 October 2023 in Salzburg, Austria. ISRM hosted this meeting during its International Congress. ISRM was represented by its President and Secretary General in this meeting, and the ISRM President Elect, Prof. Seokwon Jeon, also attended this meeting as an observer. In this meeting, the annual reports of member societies were presented by their respective Presidents, and the reports of the three Joint Technical Committees were presented by their Chairmen. The reports of the Joint Technical Commissions were discussed by the Board members and some suggestions to these Commissions were forwarded. A new commission – JTC4 - Environment and Geo-Sustainability – was proposed by ISSMGE, highlighting that it is important to create a commission dealing with environmental issues and nature sustainability. The creation of JTC4 was



ISRM Advisory Forum Meeting

approved by the Board and Boyd Ramsey was elected its Chairman. Creation of a European Working Group was decided and the formal proposal would be made by IAEG. The suggestion by IGS for the Chairman of JTC3 on Education was agreed by the Board. Other FedIGS initiatives, such as a proposal for FedIGS White Paper Project, member societies collaboration in organization of a joint conference, and engaging professional help to manage the FedIGS website, were discussed.

The ISRM President formalized the invitation to institute a FedIGS Lecture by each Society in each congress of the member societies, and informed that the ISRM had already started this practice at the 2015 Congress and repeated it in the 2019 and 2023 ISRM Congresses. The FedIGS Board discussed the various aspects of this suggestion and approved it.

The motion for organization of a GeoEng 2000 type of event around 2030 gathering all the four member societies, suggested by the ISRM President, was accepted in principle, and the details for this event will be discussed in the next Board meeting.

In addition, the Board noted that ITA is an association with different goals, but with a relevant geotechnical component, So, it was decided to formally invite ITA President to the FedIGS Board meeting in 2024 and inquire how FedIGS and ITA can cooperate.



FedIGS Meeting

## COOPERATION BETWEEN ISRM AND ITA

In the end of October 2020 the President of International Tunneling and Underground Space Association (ITA) suggested a conversation between the Presidents of ISRM and ITA about how both societies cooperate in the future. This suggestion was kindly accepted by the ISRM and comments of the ISRM Board members concerning this issue were asked by the ISRM President. Then a report was prepared by the ISRM President and sent to the President of ITA to prepare a formal meeting between ITA and ISRM, but no response was received. In 2022, the new ITA Executive Committee took over the mission and its new President Prof. Arnold Dix and Vice President Prof. Jamal Rostami contacted the ISRM President. They were informed about the previous efforts of the ISRM for a cooperation with ITA. Prof. Rostami

informed the ISRM about the topics for the cooperation. In addition, ISRM President and Prof. Ömer Aydan (ISRM VP at Large) also discussed on this cooperation with ITA Vice President and the Past President of ITA when they met at an international conference in June 2023. The report previously prepared by ISRM was sent to the new ITA President and he found it very informative and mentioned that it would be valuable to discuss the relationship between ITA and ISRM, and Prof. Dix was invited by ISRM to attend the 2023 annual Board and Council meetings in Salzburg to assess the mutual opportunities of cooperation between ITA and ISRM. This meeting was very successful and the ITA President declared that a memorandum based on the ISRM report for this cooperation would be prepared by ITA and sent to ISRM. ITA and ISRM believe that realization of this cooperation between ITA and ISRM will be beneficial for both societies.



ITA President Mr Arnold Dix

## ISRM PRESIDENT IN THE 14TH CONGRESS OF IAEG

The ISRM President Resat Ulusay was invited by the International Association of Engineering Geology and the Environment (IAEG) to attend the IAEG Council meeting and the 14th IAEG Congress, which were held on 21 September and between 23-25 September 2023, respectively, in Chengdu, China. During this conference he delivered a keynote lecture entitled Geo-Engineering Aspects of the 6 February 2023 Devastating Kahramanmaraş Earthquakes of Türkiye and Lessons Learned.



ISRM President Resat Ulusay in Chengdu

## 03 PRESIDENT'S INAUGURAL MESSAGE



Dear Colleagues in the Rock Mechanics and Rock Engineering Community,

It is my great honor and privilege to be elected as the ISRM President for the office term 2023-2027, succeeding our esteemed Immediate Past President, Prof. Reşat Ulusay.

I extend my deepest appreciation to the former Presidents and Board members, whose exceptional leadership and efforts have significantly contributed to our Society's success. I am especially grateful to Prof. Reşat Ulusay and the immediate past Board members for their unwavering dedication during the challenging times of the COVID-19 pandemic. Their commitment was instrumental in our continued growth in academic activities and membership. I also recognize and value the dedication of the Council members, Commission members, Committee members, and the Co-editor of our News Journal over the past years.

The Secretariat's support has been pivotal, and I sincerely thank our Secretary-General Dr. Luis Lamas and Executive Secretary Ms. Sofia Farrisco for their outstanding contributions.

We were saddened to hear of the passing of Dr. Eda Freitas de Quadros, a former President of ISRM, in November last year. The ISRM is profoundly grateful for her immense and persistent dedication to the Society. We remember Dr. Eda Quadros fondly and honor her memory.

The new Board, comprising dedicated members, is committed to serving ISRM and upholding the esteemed traditions and spirit established by our predecessors. We recognize the emerging challenges, initiatives, and opportunities within our Society and will address them with the utmost importance.

Enhancing communication and improving the dissemination of information, visibility, membership, and inclusion will be pivotal. We plan to leverage our website, publications, social networking platforms, meetings, online lectures, and courses to achieve these goals.

Our commitment to education continues through the Educational Fund Committee and the Young Members Committee. The Early Career Forum, having successfully organized eight events, has played an important role in encouraging young members to participate in international professional events, supported financially by the Educational Fund Committee (EFC). The Young Members Committee has been instrumental in attracting, engaging, and celebrating the achievements of our society's young members through diverse initiatives.

Technical Commissions are the vital components of our Society, fostering academic and technical advancements. Their contributions have been immense. The new Board will support these efforts, enhance their impact and recognition, and assist in forming new Commissions. We are exploring the establishment of new Commissions on Artificial Intelligence in Rock Engineering and other proposed topics, as well as revitalizing the Commission on Reservoir Geomechanics.

Our collaboration with sister societies under the FedIGS umbrella, including ISRM, ISSMGE, IAEG, IGS, and the newly involved ITA, has been mutually beneficial. We aim to promote collaborative events, such as thematic symposia and workshops, to facilitate the exchange of knowledge in overlapping interests and interdisciplinary areas.

Strengthening ties with the industry remains a priority. We seek not only to increase the number of Corporate members but also to foster mutual interests. The Board will explore innovative ways to showcase industry successes, such as through exhibitions, video presentations, and dedicated sessions at our meetings.

ISRM is a collective of Individual Members, Corresponding Members, National Groups, and Corporate Members. The Board is dedicated to supporting and valuing the activities, contributions, and recommendations of all our members.

Thank you for the opportunity to serve. I look forward to our collaborative efforts in advancing our field and wish each one of you success and fulfillment in the upcoming years. 🌟

Seokwon Jeon

ISRM President 2023-2027

**THE 2023-2027  
ISRM BOARD****SEOKWON JEON  
KOREA**

President  
Prof. Seokwon Jeon  
Dep. Energy Systems Engineering  
Seoul National University  
sjeon@snu.ac.kr

**JANNIE MARITZ  
SOUTH AFRICA**

Vice-President for Africa  
Dr Jannie Maritz  
Faculty of Engineering, Built Environment  
and Information Technology  
Department of Mining Engineering  
jannie.maritz@up.ac.za

**KI-BOK MIN  
KOREA**

Vice-President for Asia  
Prof. Ki-Bok Min  
Dep. of Energy Resources Engineering  
Seoul National University  
kbmin@snu.ac.kr

**QIANBING ZHANG  
AUSTRALIA**

Vice-President for Australasia  
Dr Qianbing Zhang  
Director of Research  
Department of Civil Engineering  
Monash University  
qianbing.zhang@monash.edu

**MURIEL GASC-BARBIER  
FRANCE**

Vice-President for Europe  
Dr. Muriel Gasc-Barbier  
GéoCOD / Cerema Méditerranée  
muriel.gasc@cerema.fr

**ESTEBAN HORMAZABAL  
CHILE**

Vice-President for Latin America  
Dr. Esteban Hormazabal  
Managing Director & Corporate  
Consultant  
SRK Consulting Chile  
ehormazabal@srk.cl

**MARTIN GRENON  
CANADA**

Vice-President for North America  
Prof. Martin Grenon  
Département de génie des mines, de la  
métallurgie et des matériaux  
Faculté des sciences et de génie  
Université Laval  
magre@ulaval.ca

**MILORAD JOVANOVSKI  
NORTH MACEDONIA**

Vice-President at Large  
Prof. Milorad Jovanovski  
University Ss.Cyril and Methodius  
in Skopje  
Faculty of Civil Engineering  
Department for Geotechnics  
jovanovski@gf.ukim.edu.mk

**FENGSHOU ZHANG  
CHINA**

Vice-President at Large  
Dr. Fengshou Zhang  
Dep. of Geotechnical Engineering  
Tongji University  
fengshou.zhang@tongji.edu.cn

**KIYOSHI KISHIDA  
JAPAN**

Vice-President at Large  
Prof. Kiyoshi Kishida  
Department of Urban Management  
Kyoto University  
kishida.kiyoshi.3r@kyoto-u.ac.jp

**LUÍS LAMAS  
PORTUGAL**

Secretary-General  
Dr. Luís Lamas  
LNEC  
llamas@isrm.net

# 04 REPORT OF THE ISRM SECRETARY-GENERAL 2023

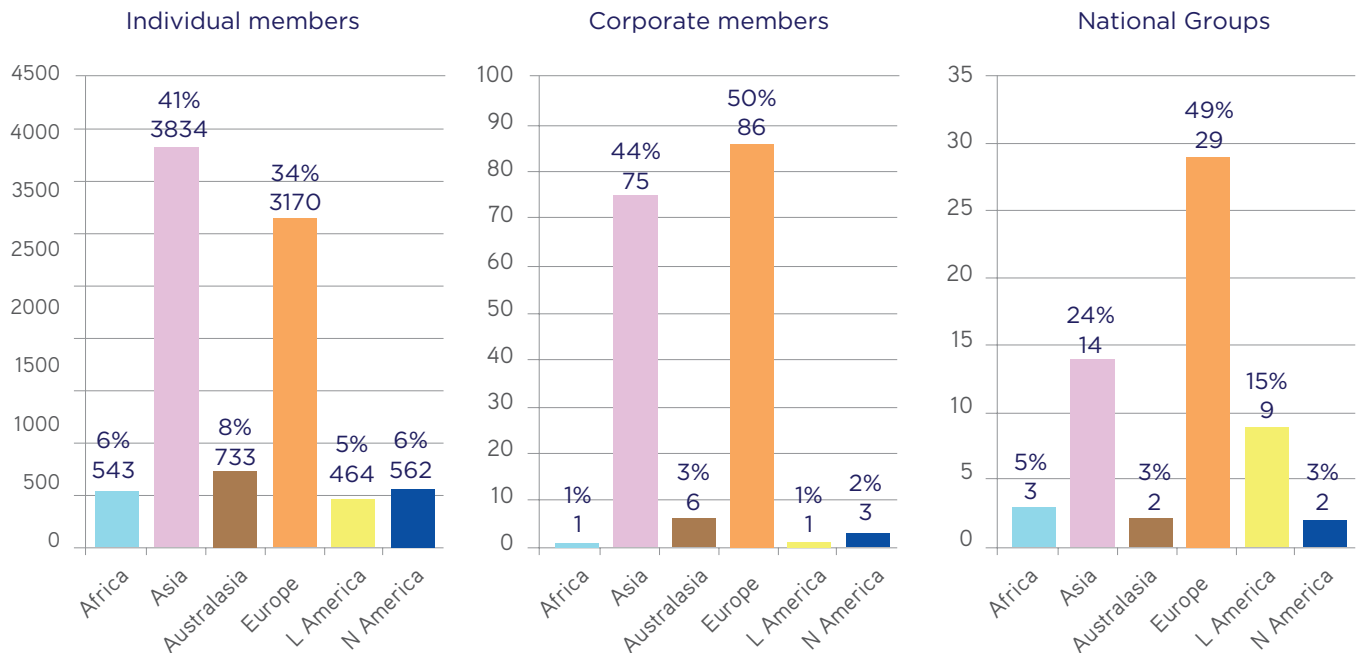
## 1. NATIONAL GROUPS AND MEMBERSHIP

The current number of individual members (ordinary and corresponding) and of corporate members is presented in the following Table. With the NG Romania having been excluded on 31 December 2022, and with the adhesion of the NG Sri Lanka in October 2022 and of the NG Bangladesh in the beginning of 2023, the current number of ISRM National Groups – also presented in the Table – is 59.

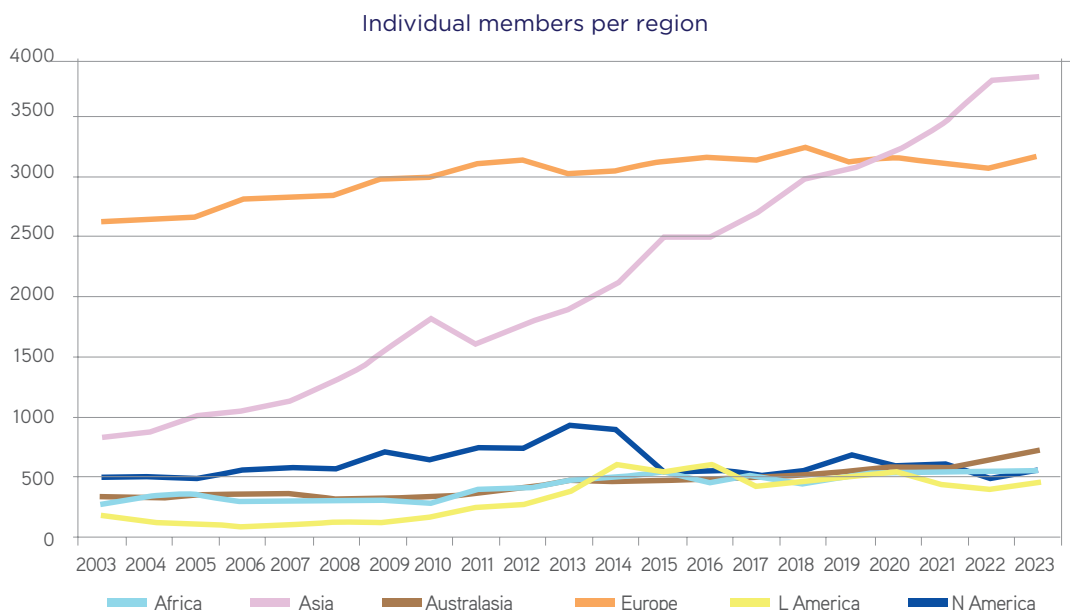
	Individual Members	Corporate Members	National Groups
Africa	543	1	3
Asia	3,834	75	14
Australasia	733	6	2
Europe	3,170	86	29
L America	464	1	9
N America	562	3	2
TOTAL	9,306	172	59

From the total number of individual members, 9,216 are registered through their respective National Groups and 90 are corresponding members. When compared with the figures presented in November 2022 at the previous Council meeting, this corresponds to an increase of 327 Individual members (3.6%), the number of corporate members increased by 5 and there is one more National Group.

The NGs with largest increase were Norway (103), USA (47), Australia (43), New Zealand (35), Singapore (32) and Chile (27). The distribution of individual members, corporate members and National Groups in each geographic region is shown in the graphs below.



The following graphic shows the evolution of the number of individual members in each geographic region since 2003.



## 2. ADDITIONAL ISRM BOARD MEETING

On 10 May 2023, the Board held a 3-hour meeting via videoconference to complement the annual Board meeting, to discuss important matters for the Society.

## 3. ISRM SPONSORED MEETINGS

Since the last Council meeting on 16 October 2022 held in Asuncion, Paraguay, the following conferences took place:

- LARMS2022 – an ISRM International Symposium 16-19 October 2022, Asuncion, Paraguay
- CouFrac 2022 – an ISRM Specialized Conference 14-16 November 2022, Berkeley, USA
- ARMS12 – an ISRM Regional Symposium 22-26 November 2022, Hanoi, Vietnam
- AusRock 2022 – an ISRM Regional Symposium 29 November-1 December 2022, Melbourne, Australia
- NROCK2023 – an ISRM Specialized Conference 24-26 May 2023, Reykjavik, Iceland
- 3rd JTC1 Workshop on Impact of Global Changes on Landslide Risk, 7-10 June 2023, Oslo, Norway
- 10th Nordic Grouting Symposium - an ISRM Specialized Conference 11-13 September 2023, Stockholm, Sweden

The following ISRM sponsored conferences are scheduled:

- 15th ISRM International Congress on Rock Mechanics, 9-14 October, Salzburg, Austria
- 1st Chilean Congress in Rock Mechanics – an ISRM Specialized Conference 22-24 November 2023, Santiago, Chile
- 1st SLRMES Conference on Rock Mechanics for Infrastructure and Geo-Resources Development - an ISRM Specialized Conference 2-7 December 2023, Colombo, Sri Lanka

- Eurock 2024 – an ISRM Regional Symposium 15-19 July 2024, Alicante, Spain
- ARMS13 – an ISRM International Symposium 22-27 September 2024, New Delhi, India
- CouFrac2024 – an ISRM Specialized Conference 13-15 November 2024, Kyoto, Japan
- Eurock 2025 – an ISRM International Symposium 16-20 June 2025, Trondheim, Norway
- Eurock 2026 – an ISRM Regional Symposium 14-19 September 2026, Skopje, North Macedonia
- 16th ISRM International Congress on Rock Mechanics 17-23 October 2027, Seoul, Korea

## 4. ROCHA MEDAL

19 applications were received for the Rocha Medal Award 2024. The Rocha Medal Committee selected the winner and two Proxime Accessit.

- Rocha Medal 2024:  
Dr Kazuki Sawayama, from Japan
- Proxime Accessit (runner-up certificate):  
Dr Kai Liu, from China
- Proxime Accessit (runner-up certificate):  
Dr Mingzheng Wang, from China

## 5. ISRM AWARDS

In 2023 the following awards were conferred:

- Müller Award conferred on Derek Martin, from Canada
- ISRM Fellowship conferred on François Malan, from South Africa, Norikazu Shimizu, from Japan and Sergio Fontoura, from Brazil
- Science and Technology Awards - Technological Innovation Award 2023 awarded to Shandong University, from China

- Young Rock Engineering Award awarded to Wang Qi, from China
- Best Performing National Group Award conferred on the National Groups of China and North Macedonia
- Outstanding Commission Award conferred on the Commission on Discontinuous Deformation Analysis – DDA
- Rocha Medal 2023 awarded to Jun Zhao, from China
- Rocha Medal 2023 runner-up awarded to Rupesh Verma, from India
- Rocha Medal 2023 runner-up awarded to Cyrille Couture, from Canada

## 6. ISRM MULTILINGUAL GLOSSARY ON ROCK MECHANICS

The multilingual glossary of rock mechanics technical terms is available on the ISRM website since March 2015, under the item "Products and Publications". The translation into 19 different languages has been achieved, Mongolian being the most recent language available.

## 7. ISRM NEWS JOURNAL

The electronic version of the ISRM News Journal, Vol. 25, December 2022, edited by the ISRM President, Prof. Reşat Ulusay and Dr José Muralha, was uploaded on the ISRM website, where it can be read and downloaded. The Secretariat sent an info-mail to all members, advertising it. 450 hard copies were printed for distribution during the ISRM sponsored conferences. This 98-page issue of the News Journal contains the annual review of the Society's activity along 2022 and technical articles related to the ISRM awards.

## 8. ISRM NEWSLETTER

Since the 2022 Council meeting, four quarterly Newsletters, prepared by the Secretary General, were published: in December 2022, in March, June and September 2023. As usual, all ISRM members and all those that subscribed to the Newsletter on the website received them by email. The Newsletters are also available on the website. ISRM National Groups and individual members are welcome to submit to the Secretariat contributions on rock mechanics topics of interest to our technical community.

## 9. ISRM WEBSITE

The website of the ISRM (<http://www.isrm.net>), launched on 1 April 2005, is the main means of information of the ISRM and the main channel for communication with the members. Most benefits being offered to the members are available in the password protected members' area. The information on the website has been continuously updated during the period corresponding to this report.

## 10. ISRM YOUTUBE CHANNEL

The ISRM YouTube channel was launched in October 2021. It allows streaming of live events organised by the

ISRM with Zoom, Teams, etc.; Storage of videos and several types of channels can be created (e.g. young members).

The 3rd and 4th European Rock Mechanics Debate have been included in the channel, as well as subscriptions available for the ISRM Commission on Deep Mining and the ISRM Young Members Channel.

## 11. DIGITAL LIBRARY

The ISRM Digital Library started in October 2010 and is part of OnePetro.org, a large online library managed by the Society of Petroleum Engineers. ISRM individual members are allowed to download, at no cost, up to 100 papers per year from the ISRM conferences. ISRM corporate members can download 250 papers.

Papers from the ISRM Congresses and sponsored Symposia have been gradually introduced in the library. Currently, the papers from 72 ISRM sponsored events are available, totalling around 11,700 papers and 98,300 pages.

## 12. ISRM ONLINE LECTURES

The first ISRM Online Lecture was broadcast from the ISRM website in February 2013. From those days to the present days, the ISRM broadcasted 43 ISRM Online Lectures, all given by prominent scholars. All lectures are kept in an appropriate page of the ISRM website. Four ISRM Online Lectures were broadcast during the period corresponding to this report, by Dr Norikazu Shimizu, Prof. Antonio Bobet and Prof. Anna Maria Ferrero and Prof. Manchao He.

## 13. SUPPORT AFFORDED

As usual, the Secretariat made ample use, at no charge, of several facilities available at the Portuguese National Laboratory for Civil Engineering – LNEC. This included use of office rooms and other facilities offered to the Secretariat, telephone and use of LNEC's computer network, namely for internet access. This support has long been instrumental to the well-being of the Society and is very much appreciated.

## 14. FINAL REMARKS

The life of the Society and the activity of the Secretariat during the period corresponding to this report were marked by:

- continuation of the increase in the number of members of the Society;
- update of the website;
- continuation of the upload of conference proceedings in the ISRM Digital Library;
- maintenance of a sound financial situation. ▶

Luís Lamas  
ISRM Secretary-General



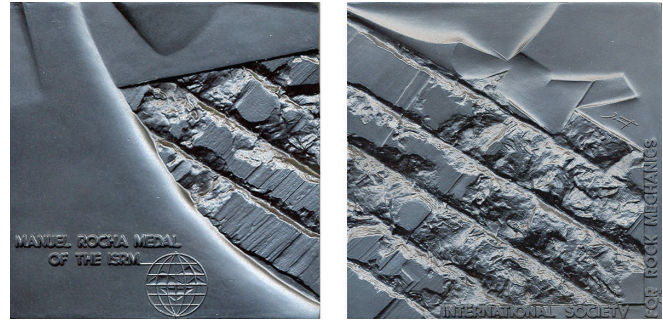
MEMBERSHIP IN  
OCTOBER 2023

REGION	NATIONAL GOUPS / Countries	Members			REGION	NATIONAL GOUPS / Countries	Members			
		Ordin.	Corr.	Corp.			Ordin.	Corr.	Corp.	
AFRICA	Angola		1		EUROPE	FINLAND	93	2	1	
	Botswana		1			FRANCE	140		12	
	Congo DR		1			GERMANY	307	5	4	
	Ghana		1			GREECE	38	2		
	Kenya		2			HUNGARY	18			
	Morocco		1			ICELAND	12			
	SOUTH AFRICA	505		1		Ireland		1	1	
	TUNISIA	10				ITALY	117	2	1	
	ZIMBABWE	20				MACEDONIA	11			
<b>TOTAL</b>	<b>3 NGs</b>	<b>535</b>	<b>8</b>	<b>1</b>		NETHERLANDS	29			
ASIA	BANGLADESH	10				NORWAY	345		15	
	Buthan		1			Poland		3		
	CHINA	2.762	9	27		PORTUGAL	84	1	6	
	INDIA	209	3			ROMANIA		2		
	INDONESIA	57	2			RUSSIA	240	2	13	
	ISRAEL	13				SERBIA	17			
	JAPAN	299		36		SLOVAKIA	6			
	Kazakhstan		4			SLOVENIA	41			
	KOREA	179		11		SPAIN	284	1		
	Korea DPR		3		SWEDEN	120	1	18		
	MALAYSIA	42			SWITZERLAND	139		9		
	MONGOLIA	24			TÜRKIYE	117	1			
	NEPAL	11			UKRAINE	8				
	Oman		1		UNITED KINGDOM	357	7	4		
	Philippines		2		<b>TOTAL</b>	<b>29 NGs</b>	<b>3.141</b>	<b>29</b>	<b>86</b>	
	Saudi Arabia		1		LATIN AMERICA	ARGENTINA	21			
	SINGAPORE	145				BOLIVIA	24			
	SOUTH EAST ASIA	13				BRAZIL	87	3		
	SRI LANKA	31				CHILE	108	2		
	Thailand		1			COLOMBIA	9			
Un. Arab Emirates		1		COSTA RICA		21				
VIETNAM	11			MEXICO		32	1			
<b>TOTAL</b>	<b>14 NGs</b>	<b>3.806</b>	<b>28</b>	<b>75</b>		Panama		1		
AUSTRALASIA	AUSTRALIA	415	5	6		PARAGUAY	39			
	NEW ZEALAND	235				PERU	110	4	1	
<b>TOTAL</b>	<b>2 NGs</b>	<b>650</b>	<b>5 NGs</b>	<b>6</b>	VENEZUELA		2			
EUROPE	ALBANIA	11			<b>TOTAL</b>	<b>9 NGs</b>	<b>451</b>	<b>13</b>	<b>1</b>	
	AUSTRIA	378		2	NORTH AMERICA	CANADA	129	1		
	BELGIUM	53				USA	431	1	3	
	BOSNIA AND HERZEGOVINA	14			<b>TOTAL</b>	<b>2 NGs</b>	<b>560</b>	<b>2</b>	<b>3</b>	
	BULGARIA	30			TOTAL ISRM	59 NGs		9.216	90	172
	CROATIA	91								
	CZECH REPUBLIC	26								
	DENMARK	15								



## ROCHA MEDAL 2026

Since 1982 a bronze medal and a cash prize have been **awarded annually by the ISRM** for an outstanding doctoral thesis in rock mechanics or rock engineering, to honour the memory of Past President Manuel Rocha while stimulating researchers.



In addition to the Rocha Medal award to the winning submission, one or two runner-up certificates may also be awarded. An invitation is now extended to the rock mechanics community for nominations for the Rocha Medal 2026.

Full details about the Rocha Medal are provided in ISRM By-law No. 7, and all relevant information can be obtained from the ISRM website - [isrm.net](http://isrm.net).

### Application

To be considered for an award the candidate must be nominated within two years of the date of the official doctorate degree certification.

Nominations shall be by the nominee, or by the nominee's National Group, or by some other person or organization acquainted with the nominee's work.

Nominations shall be sent electronically, addressed to the Secretary-General, and shall contain:

- a one page curriculum vitae, including nationality information;
- a written confirmation by the candidate's National Group that he/she is a member of the ISRM;
- a thesis summary, written in English, with between 5,000 and 10,000 words, detailed enough to convey the

full impact of the thesis and accompanied by selected tables and figures, and information on word count;

- one copy of the complete thesis;
- one copy of the doctorate degree certificate;
- a letter of copyright release, allowing the ISRM to copy the thesis for purposes of review and selection only;
- an undertaking by the nominee to submit an article describing the work, for publication in the ISRM News Journal.

### Application Deadline

The nomination must reach the ISRM Secretary-General by 31 December 2024.

### Past Recipients

1982	A.P. Cunha	PORTUGAL	2004	G. Grasselli	ITALY
1983	S. Bandis	GREECE	2005	M. Hildyard	UK
1984	B. Amadei	FRANCE	2006	D. Ask	SWEDEN
1985	P.M. Dight	AUSTRALIA	2007	H. Yasuhara	JAPAN
1986	W. Purrer	AUSTRIA	2008	Z.Z. Liang	CHINA
1987	D. Elsworth	UK	2009	G. Li	CHINA
1988	S. Gentier	FRANCE	2010	J.C. Andersson	SWEDEN
1989	B. Fröhlich	GERMANY	2011	D. Park	REP. OF KOREA
1990	R.K. Brummer	SOUTH AFRICA	2012	M.T. Zandarin	ARGENTINA
1991	T.H. Kleine	AUSTRALIA	2013	M. Pierce	CANADA
1992	A. Ghosh	INDIA	2014	M.S.A. Perera	AUSTRALIA
1993	O. Reyes W.	PHILIPPINES	2015	A.L. Bradley	ITALY
1994	S. Akutagawa	JAPAN	2016	C.W. Boon	MALAYSIA
1995	C. Derek Martin	CANADA	2017	Bryan Tatone	CANADA
1996	M.P. Board	USA	2018	M. du Plessis	SOUTH AFRICA
1997	M. Brudy	GERMANY	2019	Q. Lei	CHINA
1998	F. Mac Gregor	AUSTRALIA	2020	J. Shang	CHINA
1999	A. Daehnke	SOUTH AFRICA	2021	Y. Yasuhiro	JAPAN
2000	P. Cosenza	FRANCE	2022	R.S. De Silva	SRI LANKA
2001	D.F. Malan	SOUTH AFRICA	2023	J. Zhao	CHINA
2002	M.S. Diederichs	CANADA	2024	K. Sawayama	JAPAN
2003	L.M. Andersen	SOUTH AFRICA			

# THE 2023 ISRM YEAR

## EVENTS

January	- 3rd European Rock Mechanics Debate: "Different approaches for tunnelling: empirical, observational, modelling"
February	- 2nd Young Members' Online Seminar: "Comprehensive in-situ stress estimation for a fractured geothermal reservoir from drilling, hydraulic stimulations, and induced seismicity", by Sehyeok Park, South Korea
March	- Publication of the 2022 edition of the ISRM News Journal – Volume 25 - Publication of the e-Newsletter No. 61 - 41st ISRM Online Lecture by Dr Norikazu Shimizu: "Monitoring rock displacements using satellite technology"
April	- Adhesion of the new ISRM National Group of Bangladesh
May	- ISRM Specialized Conference NROCK2023 - The IV Nordic Symposium on "Rock Mechanics and Rock Engineering", in Reykjavik, Iceland - 4th European Rock Mechanics Debate "Two different tunnelling approaches: the New Austrian Tunnelling Method (NATM) and the Norwegian Method of Tunnelling (NMT)" - Interim meeting of the ISRM Board held online
June	- 3rd JTC1 Workshop on "Impact of global changes on landslide risk", in Oslo, Norway - Publication of the e-Newsletter No. 62 - 42nd ISRM Online Lecture by Prof. Antonio Bobet: "The Mechanics and Imaging of Slip along Frictional Discontinuities"
July	
August	
September	- ISRM Specialized Conference 10th Nordic Grouting Symposium, in Stockholm, Sweden - 12th ISRM Young Members' Seminar on "Rock fall phenomena, use of numerical method in rock engineering and micro to macro rock properties" - Publication of the e-Newsletter No. 63 - 43rd ISRM Online Lecture by Prof. Anna Maria Ferrero: "Design of rock fall protection works"
October	- ISRM Board meeting in Salzburg, Austria - Dr Kazuki Sawayama, from Japan, was selected as the recipient of the Rocha Medal 2024 - The ISRM Commission on Discontinuous Deformation Analysis – DDA was selected as the recipient of the ISRM Outstanding Commission Award 2019-2023 - The National Groups of North Macedonia and China were selected as the winners of the ISRM Best Performing NG Award 2021-2023 - ISRM Council meeting in Salzburg, Austria - Selection of the venue for the 2025 ISRM International Symposium - Election of the Regional Vice Presidents of the Society for 2023-2027 - 15th ISRM International Congress on Rock Mechanics "Challenges in Rock Mechanics and Rock Engineering", in Salzburg, Austria - Dr Jun Zhao presented the Rocha Ward 2023 Lecture - Prof. Derek Martin delivered the 2023 Müller Lecture - The 8th Early Career Forum was held, sponsored by the ISRM Education Fund. 6 young members from the European region delivered presentations. - Francois Malan, Norikazu Shimizu and Sérgio Fontoura were inducted as ISRM Fellows - Dr Wang Qi, from China, was awarded the ISRM Young Rock Engineer Award 2023 - Shandong University was awarded the ISRM Technological Innovation Award 2023 - RockBowl competition - Swearing in of the ISRM Board 2023-2027 - Meeting of the 7th ISRM Advisory Forum in Salzburg, Austria - FedIGS Board meeting in Salzburg, Austria - First meeting of the newly elected Board for the term of office 2023-2027, in Salzburg, Austria
November	- ISRM Specialized Conference 1st Chilean Congress in Rock Mechanics, in Santiago, Chile
December	- ISRM Specialized Conference 1st SLRMES Conference on "Rock Mechanics for Infrastructure and Geo-Resources Development", in Colombo, Sri Lanka - Publication of the e-Newsletter No. 64 - 44th ISRM Online Lecture by Prof. Manchao He: "Possible strategy for landslide prediction" 🚩

## 07 ONLINE LECTURE SERIES

The ISRM Online Lecture Series have been running in a trimestral basis uninterruptedly since February 2013. In 2023 another four high-level lectures were broadcast from the ISRM website at a preannounced date and time. The complete series of online lectures remain available for all interested to watch in the ISRM website ([isrm.net/page/show/138?tab=1104](http://isrm.net/page/show/138?tab=1104)).



41th ISRM Online Lecture, March 2023

Prof. Norikazu Shimizu

Monitoring rock displacements using satellite technology

There are various types of instruments for conducting displacement monitoring in Rock and Geotechnical Engineering. These conventional geotechnical instruments may not be adequate for monitoring extensive areas because generally they can only be applied to limited areas in size. Satellite technology, GPS/GNSS and SAR, can overcome the above problems.

This lecture begins with the concept of “spatio-temporal continuous displacement monitoring”, which uses satellite technology and geotechnical instruments together. Its practical application is demonstrated by means of the combination of GPS/GNSS and SAR for monitoring a large slope. Then, case studies of monitoring landslides along the Black Sea coast in Bulgaria, and land subsidence due to the extraction of brine from an underground salt mine in Bosnia and Herzegovina, which were conducted as international collaborative research, are discussed.

The following conclusions can be made: 1) Displacement monitoring using GPS/GNSS can provide three-dimensional displacements of the ground, automatically and continuously, with mm accuracy in real time. 2) SAR can provide the displacement distribution of the ground surface in extensive areas without the necessity for any devices on the ground. The temporal transitions of the displacements at the points of interest can also be found. 3) The combination of conventional geotechnical instruments and satellite technology will surely be an effective tool for monitoring the behavior over an entire target area and for bringing about the realization of spatial continuous monitoring.

Satellite technology can make invisible ground behavior visible. Its contribution to predicting the behavior of the ground, assessing its stability, finding the mechanism of the ground behavior, and identifying and mitigating risks is highly anticipated. On the other hand, SAR still has shortcomings and limitations in terms of its practical use. More examples of its application are needed in order to overcome these issues and to enhance its practical use.



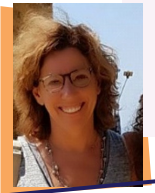
42nd ISRM Online Lecture, June 2023

Prof. Antonio Bobet

The mechanics and imaging of slip along frictional discontinuities

The mechanical and hydraulic properties of rocks are strongly influenced by the presence and properties of discontinuities, or fractures. The ability to locate and characterize natural as well as induced discontinuities in rock is of paramount importance to many engineering problems such as slope stability, rock bridge integrity, hydraulic fracturing, geothermal energy and CO<sub>2</sub> sequestration, to name a few. Although fracturing in rock has been much studied, the current state of knowledge, both theoretical and empirical, is largely based on direct observations on the surface of the specimens where inspection of the existing or induced fractures can be made.

The lecture presents experiments on rock and rock-model materials that show that active seismic monitoring can be used to detect the onset of slip along a frictional discontinuity, as well as the initiation of damage inside rock in the form of tensile or shear cracks. Precursors to failure along a frictional discontinuity undergoing shear are identified as the maximum in transmitted wave amplitude across the discontinuity or the minimum in the amplitude of the wave reflected from the discontinuity. Ultrasonic precursors are observed well before slip or failure occur along the discontinuity and are attributed to a reduction in the discontinuity local shear stiffness. In rock specimens subjected to uniaxial compression, tensile and shear crack initiation are identified as a distinct decrease in the amplitude of transmitted waves, which occurs prior to the detection of the crack on the specimen surface. In contrast, the amplitude of the transmitted waves does not change during shear crack initiation. However, seismic wave conversions (P-to-S or S-to-P wave) are found to be effective in identifying the initiation of shear cracks in rock.



43rd ISRM Online Lecture, September 2022

Prof. Anna Maria Ferrero

Design of rock fall protection works

The paper deals with rockfall phenomena and, in particular, with the design of protection works that are intended to mitigate connected risks.

The study is aimed to analyze all phases involved in these complex processes, including the study of the triggering phase, of the propagation phase and of the impact with structure designed to stop block motion and protect vulnerable objects. The lecture analyzes each phase illustrating the state of the art and development on going in the field.

Although the presence of flexible barriers (kind of structures specifically analyzed in the paper) is widely utilized in mountain areas, a design procedure that allow for dimensioning the structure with a given probability of failure is not available yet.

Limit state design (LSD) is still not applicable since partial factors specifically dedicated to flexible barrier are not available yet. Reliability Base Design (RBD) methods can be applied if a full dataset of the characteristic ruling the behavior of both the phenomenon and of the structure are available.

The lecture reports about the complete design process outlining the potential of new technologies applied to the design of flexible barriers considering a holistic design scenario.



44th ISRM Online Lecture, December 2022

Prof. Manchao He

Possible strategy for landslide prediction

Precise monitoring and prediction of landslide are the key to disaster prevention and mitigation. At present, the success rate of early warnings for landslides is very low and the early-warning time is often delayed. In response to these problems, a new monitoring and prediction method based on the academic idea that "the sufficient and necessary condition for a landslide occurring is the change of Newton force" has been proposed. First, the Newton force change law in rock mechanics was proposed for the first time, and a double-block mechanics model based on Newton force change measurement was constructed, and a complete set of landslide Newton force measurement theory was formed. Then the monitoring and prediction system and the NPR anchor cable suitable for landslide monitoring with high constant resistance and large deformation were independently developed. The warning mode and warning level for landslides based on Newton force was proposed and an integrated landslide control technology was formed. Finally, the system was implemented in 723 monitoring points in 26 demonstration areas in China. All 14 landslide disasters within the deployment scope were successfully warned, leading to the saving of more than 100 lives and the preservation of hundreds of millions of equipment and property. ▀

## 07 ISRM COMMISSIONS

The objective of ISRM Commissions is to study scientific and technical matters of interest to the Society. In recognition of the critical role of the ISRM Commissions, the ISRM Board created a committee – the Technical Oversight Committee (TOC) to coordinate the commission’s work, report on their performance and to act as oversight for the Commissions. Since ISRM Commissions are appointed by the Board for each 4-year period between ISRM Congresses. Establishment of new Commissions or the continuation of pre-existent ones is decided by the new Board following proposal by the TOC.

As per By-law No, 3 – “Rules to be Followed by Commissions and Joint Commissions”, all ISRM Commissions only run for the ISRM Presidential period during which they have been approved. However, commissions can be extended into a new 4-year period, depending on the approval by the Board. To ensure the uninterrupted activities of the commissions, the new ISRM Board maintained all ongoing commissions until further decision. Therefore, by the end of 2023, the same 14 ISRM technical commissions, involving 266 commission members from 36 different national groups, were kept.

COMMISSION	ESTABLISHED
Coupled Thermal-Hydro-Mechanical- Chemical Processes in Fractured Rocks	2018
Crustal Stress and Earthquakes	2011
Deep Mining	2019
Design Methodology	before 2004
Discontinuous Deformation Analysis	around 2011
Planetary Rock Mechanics	2019
Rockbursts	2019
Radioactive Waste	2010
Rock Dynamics	2007
Rock Grouting	2019
Soft Rocks	2019
Sorptive Rocks	2021
Testing Methods	around 1970
Underground Nuclear Power Plants	2012

Dealing with topics of mutual interest, three Joint Technical Committees work under the umbrella of the Federation of International Geo-Engineering Societies - FedIGS, which join the effort of the Sister Societies IAEG, IGS, ISRM and ISSMGE. The current list of JTCs is the following:

JTC 1 - Joint Technical Committee on Natural Slopes and Landslides

JTC 2 - Representation of Geo-engineering Data in Electronic Form

JTC 3 - Education and Training

## ISRM FELLOWS

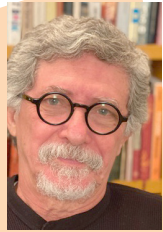
At its New Delhi meeting in October 2010, the ISRM Council decided to create the status of Fellow, as the highest and most senior grade of membership of the ISRM conferred on ISRM affiliated individuals, who have achieved outstanding accomplishment in the field of rock mechanics and/or rock engineering and who have contributed to the professional community through the ISRM.

An ISRM Fellowship is a lifetime position that carries a clear recognition of his or her scientific or professional achievements. The ISRM Fellows form a group of experts that can provide strong support and advice to the Society. They become members of the ISRM Advisory Forum, and they can be called upon as appropriate to contribute with their experience to ISRM activities.

Every two years the ISRM Board makes the appointment of a group of ISRM Fellows. In 2023, a group of three Fellows was inducted during the ISRM Congress in Salzburg, Austria.

### SÉRGIO FONTOURA (BRAZIL)

Sérgio Fontoura graduated in Civil Engineering at the Pontifical Catholic University of Rio de Janeiro, Brazil, and did his doctorate studies at the University of Alberta, Canada. After that, he joined the Civil Engineering Department of PUC-Rio, Brazil.



He has been a Visiting Researcher at the Disaster Prevention Research Institute, Kyoto University and a Visiting Professor at the Department of Civil Engineering of the University of Toronto, Canada, in the academic

year of 1988 – 1989. In 1990, he created the Group of Technology and Petroleum Engineering at PUC-Rio with the mission of carrying out research and development project for the Brazilian Oil Industry.

Professor Fontoura has supervised over 100 MSc and PhD students in their research work and has published over 120 articles in many areas of geotechnical engineering notably in the application of rock mechanics to petroleum engineering. He has worked as consultant for rock mechanics engineering projects and has served as expert in judicial case involving failure of oil engineering structures.

Professor Fontoura was the first President of the Brazilian Tunnelling Committee, has served as President of the Brazilian Rock Mechanics Committee for 8 years and he was the representative and voting delegate of Brazil in the ISRM Council from 2003 to 2015. He was a member of the Rock Testing Commission and Chair of the Petroleum Geomechanics Commission and Co-Chair of the ISRM Young Member Committee. He was ISRM Vice-President for South America from 2015 – 2019. He was the Chair of the Organizing Committee of the 14th ISRM Congress held in Foz do Iguaçu, Brazil in September 2019.

### FRANÇOIS MALAN (SOUTH AFRICA)

Prof. Malan started his geotechnical career in 1993 at the Chamber of Mines Research Organisation in South Africa. His particular interest during this period was the time-dependent behaviour of hard rock and he used this as topic for his PhD thesis. In 2004 he joined Groundwork Consulting and worked on pillar designs and layout problems in the South African platinum industry, geotechnical problems in the deep gold mines and instrumentation development for geotechnical applications.



In 2011, he joined the gold mining industry and was appointed as Senior Consultant Rock Engineering of Gold Fields and later Sibanye Stillwater. In 2018, he joined the University of Pretoria and was promoted to full Professor. He is currently the Director of the Mining Resilience Research Centre in the Department of Mining Engineering.

Between 2007-2011, Prof. Malan served as ISRM Vice-President for Africa. Prior to this, he was also the President of the South African National Institute of Rock Engineering.

He authored and co-authored more than a 100 journal and conference publications and has received various awards for these papers. These include five gold and silver medals from the South African Institute of Mining and Metallurgy and three Salomon awards from the South African National Institute of Rock Engineering.

The ISRM awarded him the Rocha Medal in 2001 for the best PhD in the world and in 2017 he presented the ISRM Franklin Lecture at the AfriRock Symposium in Cape Town. He also presented the 29th ISRM Online Lecture during March 2020.

## 07 NORIKAZU SHIMIZU (JAPAN)

Norikazu Shimizu is an Emeritus Professor of Yamaguchi University, Japan, who is currently working at Kansai University as a Specially Appointed Professor.



He obtained BE, MSc and DR degrees in Civil Engineering from Kobe University and started his academic career in 1981. He joined Yamaguchi University in 1992 and was appointed as a Full Professor of Rock Mechanics and Rock Engineering in 2000.

Professor Shimizu served as a Vice President at Large of the International Society for Rock Mechanics and Rock Engineering from 2015-2019. He was President of the Japan Society for Rock Mechanics and Chair of the Committee of Rock Mechanics in the Japan Society of Civil Engineers from 2011-2013. He organized the ISRM International Symposium “8th Asian Rock Mechanics Symposium” in Sapporo, 2014, and an ISRM Specialized Conference “5th Young Scholars’ Symposium on Rock Mechanics” in Okinawa, 2019.

His research topics are “Rock displacement monitoring using satellite technology”, “Numerical analyses and field measurements for slopes, tunnels, large underground caverns, dams, etc.”, and “Underground space design using human sensibility”. In 2014, he published the ISRM Suggested Method for Monitoring Rock Displacements Using GPS. He has conducted international collaborative research with several countries in Asia and Southeast Europe.

Professor Shimizu has received awards from the Japanese Prime Minister, the Minister of Land, Infrastructure, Transport and Tourism, and the Minister of Education, Culture, Sports, Science and Technology. He was also awarded the Meritorious Contribution Award from the Japan Society of Civil Engineers, and Distinguished Paper Award, Technical Development Award, etc. from several academic and professional societies. He was chosen to be an honorary member of the Geotechnical Society of Bosnia and Herzegovina. ▶

## AWARDS

The following winners of the 2023 ISRM awards were announced during the 15th ISRM Congress in Salzburg

Technological Innovation Award 2021-2023	Shandong University, China
Young Rock Engineer Award 2023	Dr Wang Qi, China
Best National Group Award 2021-2023	North Macedonia and China
Outstanding Commission Award 2019-2023	Commission on Discontinuous Deformation Analysis - DDA

### TECHNOLOGICAL INNOVATION AWARD

The Technological Innovation Award is conferred on a bi-annual basis in the 2nd and the 4th year of each ISRM presidential tenure period, on up to two ISRM corporate members in recognition of one or more of the following contributions to the progress of applied rock mechanics and rock engineering:

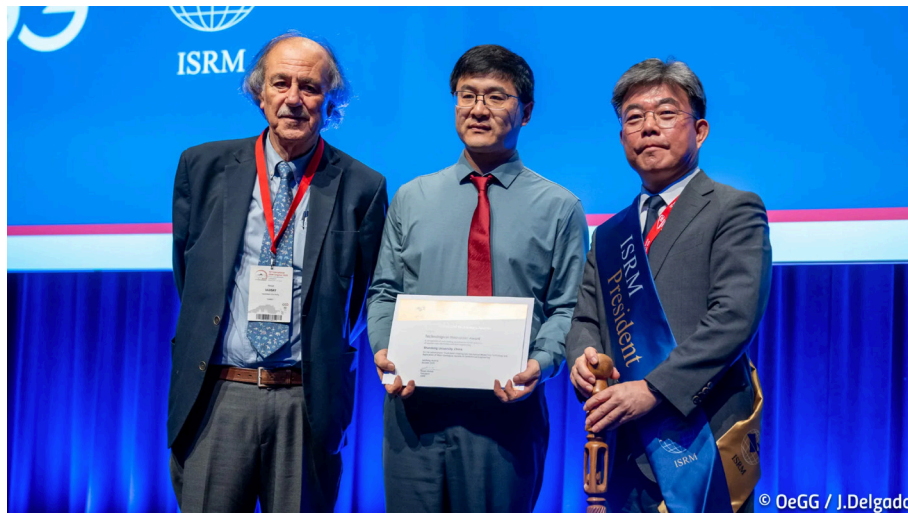
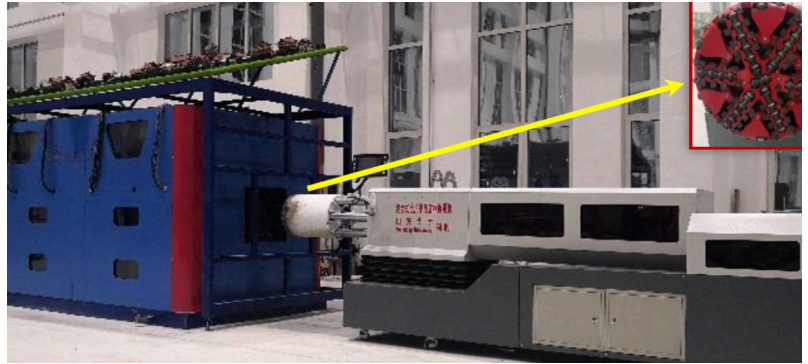
- development and application of a new equipment or testing system;
- development and application of a new testing method;
- development and application of a new technology;
- development and application of a new material.

In the 2021-2023 biennium the award is granted to the Shandong University, China, in recognition of their works concerning fluid solid coupling geo mechanical model test technology and application to major geological hazards in geotechnical engineering.

During construction of tunnels and underground projects, various sources that pose major geological threat are encountered, such as groundwater and its storage structures, limestone caves, and fractures. They can easily cause serious accidents, such as water and mud intrusions in tunnels, surface subsidence of subways, and the collapse of chamber groups, causing heavy economic loss, casualties, as well as extremely negative social impact. Controlling groundwater seepage disasters has been a long term problem faced by the engineering community. The fundamental reason for this is the unclear understanding of fluid solid coupling mechanism and the lack of effective test techniques and methods for evaluation of hazards, resulting in a long term passive situation in prevention and control of hazard.



Shandong University invented the fluid solid coupling model test system and technology for assessing geological hazards in the field of geotechnical engineering, which is a test model that simulates the occurrence environment of seawater surrounding rock fracture lining structure is built or the water and mud inrush in EPB driven shield tunnels.



© OeGG / J.Delgado

## YOUNG ROCK ENGINEER AWARD

In 2020, the ISRM Board decided to institute the ISRM Young Rock Engineer Award, to acknowledge excellence in the field of rock engineering by ISRM members who are in early stages of their career. The ISRM Young Rock Engineer Award is conferred in an annual basis to an under 40 ISRM member in recognition of one or more of the following achievements in rock engineering practice:

- novelty of the nominee's contribution to solve engineering problems and/or develop original design solutions;
- pioneering in the use of materials and/or methods;
- contribution to sustainable engineering practices;
- contribution to and promotion of the engineering profession.

In 2023, this award was bestowed upon Prof. Wang Qi, from China, who is Vice-president of the ISRM Soft Rock Commission, Executive Director of Energy and Environment (Qingdao) International Unit Laboratory, and Executive Dean of the Research Institute for Deep Underground Science and Engineering of Beijing.

Prof. Wang Qi work focuses on the combination of basic theoretical research and engineering application, and has outstanding scientific research ability and field practice ability. The main innovative achievements are as follows:

- The inversion theory of rock equivalent mechanical parameters based on digital rotary drilling is established. The in-situ classification of surrounding rock in drilling and quantitative evaluation method of anchor grouting are proposed, which provide effective means for in-situ classification and evaluation of surrounding rock.
- High-strength and integrity control method of confined concrete is established. Two kinds of construction methods of efficient composite construction and mechanized intelligent construction are formed, which provide theoretical and technical support for the safety control and efficient construction of underground engineering under complex conditions.
- No pillar mining method of automatically formed roadway by roof cutting and bolt grouting in deep mines is established, which is a major original innovation in the field of coal mining. He presided the design and application of the new mining method, and developed the coal mining and roadway forming equipment systems, which eliminates roadway excavation and coal pillar retention in working faces.



## 07 BEST PERFORMING NATIONAL GROUP AWARD

The Best Performing National Group Award was instituted in 2015 to recognize the outstanding performance of a National Group or to reward a young and small National Group who is active and growing. It is conferred to up to two National Groups on a two-yearly basis. Criteria for evaluation include:

- the growth in number of individual and corporate members of the ISRM;
- the extent of the National Group’s activities;
- the growth in achievements or new and recent developments.

In 2023 it was handed to the National Groups of North Macedonia and China during the ISRM Congress in Salzburg.



## OUTSTANDING COMMISSION AWARD

ISRM decided to institute the ISRM Outstanding Commission Award that to be conferred on an ISRM Commission in recognition of one or more of the following achievements:

- contributing to solving important theoretical or practical rock engineering problems;
- effectively introducing to current rock engineering new and important guidelines, technologies, testing methods or testing apparatuses;
- providing education and training concerning rock engineering issues.

The award shall be conferred by the ISRM President to up to three Commissions, on a four-yearly basis, at the quadrennial Congress of the ISRM, and concerns the Commission’s activities since the previous Congress. In the 2023 ISRM Congress in Salzburg, the award was handed to the Commission on Discontinuous Deformation Analysis – DDA. 🇳🇵

International Society for Rock Mechanics and Rock Engineering

## Best Outstanding Commission 2019-2023

**WINNER**

Commission on Discontinuous Deformation Analysis (DDA)

- Organized a series of conferences and forums to facilitate the exchange of ideas and research output among scholars worldwide.
- Implemented a comprehensive comparative study, directed at predicting rock failure using various numerical methods.
- Organized a comprehensive series of training courses focused on providing education and hands on experience in the application of discontinuous computation methods in rock engineering.
- Published books on Discontinuous Deformation Analysis (DDA) and Numerical Manifold Method (NMM).

2023

## ONLINE ACTIVITIES

### EUROPEAN ROCK MECHANICS DEBATES

Following the positive opinions received from the two previous editions, with over 100 attendants, the third and fourth European Rock Mechanics Debates, chaired by Philippe Vaskou, took place on 25 January and 19 June 2023, respectively.

The third debate had the participation of Nick Barton from Norway and Brazil, talking about "Empirical methods in tunnelling including site characterization, day-to-day solutions, and input for numerical discontinuum modelling" and Yossef H. Hatzor from Israel, talking about "empirical vs. analytical approaches for predicting rock response to tunnelling based on case studies from across the world".

### WEBINARS FOR LATIN AMERICA

On the initiative of José Pavon, ISRM Vice-President, and with the support of the Korean Society for Rock Mechanics and Rock Engineering (KSRM), webinars were organized and the video conferences were certainly a good opportunity for Latin American and Korean colleagues to share their knowledge on the latest rock mechanics topics, since these types of meetings are solid tools for connecting.

Sessions allowed the audience to post questions to the speakers, aimed at engaging the audience and allowing them to ask additional questions, regardless of where they are. The chosen topics were related to excavation, tunneling, and slope stability, given by distinguished speakers.

It is worth mentioning that the webinars are still hosted on the internet platform Geotecnia Brasil (<https://www.youtube.com/GeotecniaBrasil>) for people who want to watch them whenever they want.

### YOUNG MEMBERS SEMINARS

The ISRM Young Members' Seminar (YMS) Series are virtual events, with the goal of providing a global platform for ISRM young members to share knowledge, experiences, and ideas. The events foster knowledge and friendship among young professionals and students of rock mechanics and rock engineering on an international scale.

The ISRM Young Members Committee and the YMS organising committee invite young members with careers in research or industry, working in the public or private

GEOTECNIA BRASIL PRESENTS

**KOREAN SOCIETY FOR ROCK MECHANICS AND ROCK ENGINEERING WEBINARS**

FREE PRESENTATIONS WITH WORLDWIDE ONLINE ACCESS

**ROCK FRAGMENTATION BY BLASTING AND MECHANICAL CUTTING**  
Dsc. SEOKWON JEON, Seoul National University, ISRM President-elect, August 28th, 17:00 BRT (UTC-3)

**RISK MANAGEMENT FOR TUNNELLING PROJECTS**  
Dsc. YOUNG-GEUN KIM, Kunwha Engineering & Consulting, Korean Tunneling and Underground Space Association (KTA), August 29th, 17:00 BRT (UTC-3)

**LANDSLIDE AND CUT SLOPE MANAGEMENT SYSTEM IN KOREA**  
Dsc. SEUNG-HYUN KIM, Korea Institute of Civil Engineering and Building Technology (KICT), August 30th, 17:00 BRT (UTC-3)

ACCESS VIA YOUTUBE: [youtube.com/GeotecniaBrasil](https://www.youtube.com/GeotecniaBrasil)

SUPPORT: ISRM, KOREAN SOCIETY FOR ROCK MECHANICS AND ROCK ENGINEERING, Geotecnia

### 3<sup>RD</sup> ISRM EUROPEAN ROCK MECHANICS DEBATE (Eurock Debate 3)

Different approaches for tunnelling: empirical, observational, modelling

Time: 2023, January 25th, 2:30 PM (CET)- 1:30 PM (GMT)

**Moderator: Philippe Vaskou (France)**

**Speaker 1: Nick Barton (Norway & Brazil)**

**Subject: Empirical Methods in Tunnelling including Site Characterization, Day-to-Day solutions, and input for Numerical Discontinuum Modelling.**

Bio: Dr. Nick Barton developed the widely used Q-system for classifying rock masses and for selecting rock tunnel support (1974) and the Barton-Bandis constitutive laws for coupled M-H rock joint modelling following his JRC-JCS constitutive law suggestion (1982). Through Nick Barton & Associates, he provides international consultancy on rock engineering projects.

**Speaker 2: Yossef H. Hatzor (Israel)**

**Subject: Empirical vs. Analytical Approaches for predicting Rock Response to Tunnelling based on Case Studies from across the World.**

Bio: Prof. Yossef H. Hatzor is currently Chair Professor of Rock Mechanics at Ben-Gurion University of the Negev, Israel. He published together with Prof. Guowei Ma and Prof. Genhua Shi the book entitled "Discontinuous Deformation Analysis in Rock Mechanics Practice". He has been involved in major consulting rock engineering projects.

### 4<sup>TH</sup> ISRM EUROPEAN ROCK MECHANICS DEBATE

Two different tunnelling approaches: the New Austrian Tunnelling Method (NATM) and the Norwegian Method of Tunnelling (NMT)

Time: 2023, June 19th, 14:30 (CET) - 12:30 (GMT)

**Moderator: Philippe Vaskou (France)**

**Speaker 1: Wulf Schubert (Austria)**

**Subject: The New Austrian Tunnelling Method (NATM)**



Bio: Emeritus Professor Wulf Schubert received his Dipl.-Ing. degree from the Graz University of Technology, and the PhD degree from the Mining University in Leoben. He joined Geoconsult in 1980, where he worked on tunnelling and rock engineering projects around the world. In 1992 he became full Professor for Rock Mechanics and Tunneling at the Graz University of Technology, a position he held until his retirement in 2018. His research focused on rock mass characterization, all aspects of tunnelling in poor and faulted ground, as well as monitoring data evaluation and interpretation.

**Speaker 2: Krishna Kanta Panthi (Norway)**

**Subject: Norwegian Tunneling Principles for tunneling in hard rocks**



Bio: Dr. Krishna Kanta Panthi is a professor at the Department of Geoscience and Petroleum at NTNU since 2008. His area of expertise is rock and tunnel engineering. Before joining NTNU, Prof. Panthi worked for the tunneling and hydropower industry for 16 years. During this period, he was responsible in the planning, design and construction management of projects in to road and hydropower tunnels and slopes. He was also involved in research associated to rock mass quality and stability assessment for tunnels and rock slopes.

sectors, to participate and share their work with the broader rock mechanics and rock engineering community.

In 2023 a single seminar took place on 7 September. The following conferences were delivered:

Block volume and shape and their role in rockfall problems - Battista Taboni, PhD student, Department of Earth Sciences, University of Torino (Italy)

The Distinct Element Method – Application in Rock Engineering Projects - Dr. José G. Gutiérrez-Ch, Assistant Professor at ETSI de Caminos, Canales y Puertos of the Universidad Politécnica de Madrid, UPM (Spain)

Using synthetic rocks to investigate the link between microstructural attributes and mechanical properties of porous rocks - Dr. Lucille Carbillet, Postdoc at the Rock Deformation team at EPFL (Lausanne, Switzerland).

## 07 ISRM VIDEO COURSES

Following the rapid increase in the use of virtual tools that took place in previous years, two new video courses were made available to the general public on the ISRM website.

In 2023, the online course on “Slope Engineering” was recorded by Prof. Shunchuan Wu from the Kunming University of Science and Technology, China, and added to the ISRM Video Courses library. Focusing on slope engineering, the course starts from the basic concepts and theory of rock slope engineering, and then introduces the influencing factors, calculation methods, stability and protection measures, and concludes with references to slope monitoring. The course has 10 parts, with a total of 37 lectures.



### THE TABLE OF CONTENTS OF THE COURSE IS AS FOLLOWS:

#### Part 1 - Slope and Hazards

- Lecture 1.1 Introduction
- Lecture 1.2 Slope Deformation and Failure
- Lecture 1.3 Classification Cases of Slope Disaster

#### Part 2 - Factors Affecting Slope Stability

- Lecture 2.1 Internal Factors
- Lecture 2.2 External Factors

#### Part 3 - Slope Engineering Design and Analysis Method

- Lecture 3.1 Introduction to Slope Engineering Design
- Lecture 3.2 Design Safety Factor and its Application
- Lecture 3.3 Introduction to Slope Stability Analysis Methods

#### Part 4 - Limit Equilibrium Slice Method for Slope Stability

- Lecture 4.1 Overview
- Lecture 4.2 Swedish Slice Method
- Lecture 4.3 Calculation Case of Swedish Slice Method
- Lecture 4.4 Bishop Simplified Method
- Lecture 4.5 Calculation Case of Bishop Simplified Method
- Lecture 4.6 General Limit Equilibrium Method

#### Part 5 - Stability Analysis Method of Slope Controlled by Weakness Plane

- Lecture 5.1 Single Plane Sliding Analysis
- Lecture 5.2 Dog-legged Sliding Analysis
- Lecture 5.3 Toppling Failure Analysis
- Lecture 5.4 Wedge Failure Analysis

#### Part 6 - Stereographic Projection and Kinematic Analysis of Slope Stability

- Lecture 6.1 Basic Principle of Stereographic Projection (S.P.)
- Lecture 6.2 S.P. Reading and Drawing
- Lecture 6.3 Kinematic Analysis of Rock Slope Stability

#### Part 7 - Numerical Analysis for Slope Stability

- Lecture 7.1 Continuous Medium Analysis Method—Finite Element Method
- Lecture 7.2 Continuous Medium Analysis Method—Finite Difference Method
- Lecture 7.3 Discontinuous Medium Analysis Method—Discrete Element Method

#### Part 8 - Determination of Geotechnical Parameters

- Lecture 8.1 Determination of Soil Mechanical Parameters
- Lecture 8.2 Determination of Rock Mechanical Parameters

#### Part 9 - Slope Protection and Reinforcement

- Lecture 9.1 Slope Disaster Prevention Principles and Measures
- Lecture 9.2 Slope Surface Protection and Rockfall Control
- Lecture 9.3 Slope Retaining
- Lecture 9.4 Slope Anchoring
- Lecture 9.5 Anti-slide Pile

#### Part 10 - Slope Engineering Stability Monitoring Technology

- Lecture 10.1 Overview
- Lecture 10.2 Slope Displacement Monitoring
- Lecture 10.3 Groundwater Monitoring
- Lecture 10.4 Vibration Monitoring
- Lecture 10.5 Reinforced Structure Load Monitoring
- Lecture 10.6 Automatic Monitoring System

## ISRM BOOK SERIES

The aim of the ISRM Book Series is to promote the scientific output of Rock Engineering topics, namely of the ISRM Commissions. The Series is published according to the emergence of noteworthy scientific developments. Each volume in the Series is prepared independently and focuses on a topical theme. Since 2020, Professors Xia-Ting Feng and Reşat Ulusay act as Co-Editors-in-Chief. In 2023, the Series had its eighth release.

### STORAGE OF LPG IN LARGE ROCK CAVERNS BY KENJI AOKI

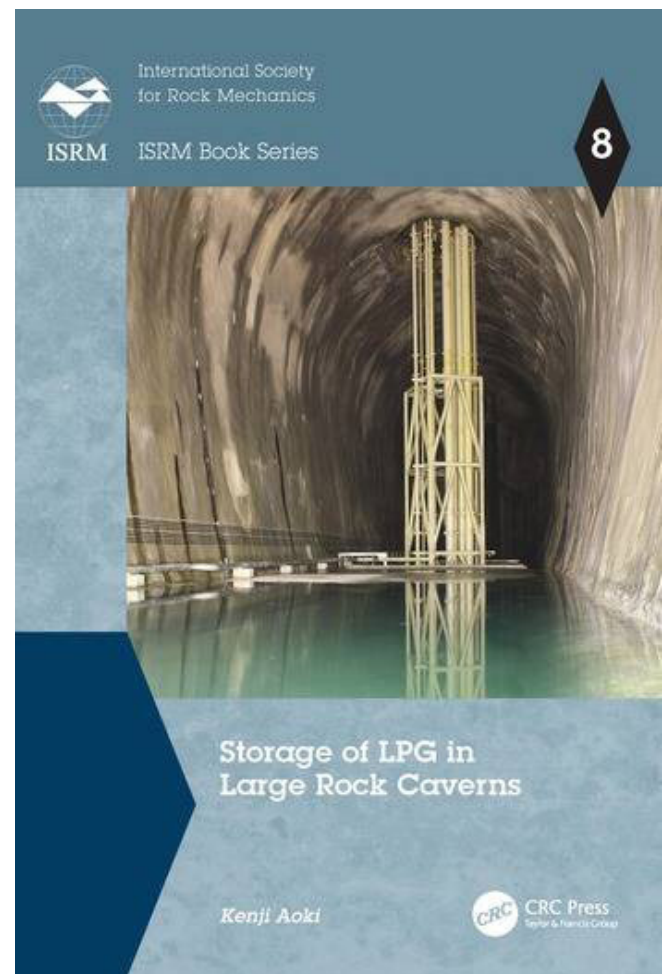
This book uses actual construction projects as examples to elaborate the various technologies regarding groundwater control and air-tightness guarantees for the construction of large storage rock caverns in complicated geological conditions. It introduces the latest technologies to give hands-on experience of what to do in unexpected geological conditions, and provides insight into the design, construction and operation of underground facilities. The book is hence useful in feasibility studies, developments and other research into these underground facilities.

Drawing on the experience gained from building Japan's largest LPG storage caves, *Storage of LPG in Large Rock Caverns* is a must-read for engineers, academics and students in the fields of rock mechanics, geotechnical engineering and related disciplines.

### AUTHOR BIO

Dr. Kenji Aoki, the principal author, was born in 1946. Graduating from the Department of Engineering of Kyoto University with a Bachelor's degree in 1969 and a Master's in 1971, he joined Kajima Institute of Construction Technology, where, as well as research and development, he participated in design, construction and measurement management in a number of civil engineering structures including rock caverns and long tunnels. He was awarded a PhD from Kyoto University in 1989 and he became professor of the same university in 1999.

Through over 20 years' experience in construction of large-scale caverns, he developed many testing and measurement techniques and numerical analysis methods of the mechanical properties of rocks during excavation. He researched the mechanisms of groundwater flow in and around deep caverns and presented the results as papers in the JSCE and the ISRM and through lectures. He has been active in these committees. In the early 1980s, he introduced the technology of storing crude oil in an unlined rock cavern in Japan utilising groundwater, which had been developed in the Scandinavian countries.



Over more than ten years from 1981, Aoki contributed to construction of Japan's first pilot plant of rock cavern storage of crude oil and to clarify the role of groundwater in cavern storage with cracks (this project was led by former Japan National Oil Corporation). Based on the site measurements, he contributed to establishing technical standards for the design and construction of this sorts of facilities. These standards were used in constructing three large-scale rock cavern crude oil storages in Japan in the early 1990s with a total capacity of five million kilolitres. Their ability for earthquake endurance is well recognised and they are still in operation. ▶

## 07 IN MEMORY OF



### EDA FREITAS DE QUADROS

Dr. Eda Freitas de Quadros, President of the International Society for Rock Mechanics, from 2015 to 2019, passed away in São Paulo, Brazil, on 13 November 2023.

It is with great sadness that we write this message on behalf of the ISRM, in honour of our dear friend Dr. Eda Freitas de Quadros who passed away on 13 November 2023 after

fighting against cancer for almost two years. She was the ISRM President between 2015 and 2019.

Born in Brazil and graduated in Civil Engineering in 1967 at the University of Pernambuco, Eda Freitas de Quadros obtained her MSc and her PhD degrees in Engineering Sciences at Polytechnic School of the São Paulo University, in 1982 and 1992, respectively.

In the period 1968-1974, she worked in the field of soil mechanics and foundation engineering. In 1975, she joined the Technological Research Institute of the State of São Paulo (IPT), Brazil, where she was Assistant Researcher, Official Researcher, Senior Researcher, Head of the Rock Mechanics and Rock Hydraulics Laboratory (1994-1996; 2006-2011) and Head of the Rock Engineering Department (1996-1998). Since 1978 she worked in the Hydro-geotechnical Section. During this period, she continuously devoted to the development of equipment, methods and techniques to characterize flow in rock joints and rock masses based on laboratory and field researches. In particular, she focused on hydraulic conductivity tensors in rock masses applied to dam and mining engineering. From 2003 to 2011 she was Manager for some advanced research and equipment development for long-term elevated temperature creep and hollow cylinder tests in salt rocks for the Brazilian oil company Petrobras. Between 2007 and 2011 she was the Coordinator of the Petrobras Inter-Laboratory Net, a joint research project with IPT for study of off-shore pre-salt cap rocks. From 2011 to present, Dr. Quadros was Technical Director of BGTech Soil and Rock Engineering, a Brazilian consultancy company in rock mechanics testing and rock hydraulics. From August 1982 to January 1984, Eda Freitas de Quadros stayed at the LNEC in Lisbon, Portugal, for rock mechanics and rock hydraulics studies and also visited universities and

laboratories in Europe, such as the BRGM (French Geological Survey) where she met C. Louis in the field of hydromechanics behaviour of fractured rock masses.

She has taught flow and rock mechanics in advanced courses at the IPT, short courses at universities and institutes not only in Brazil, but also in Australia, mainland China, Hong Kong and Taiwan, Portugal, and Singapore in collaboration with Dr. Nick Barton, as well as post-graduation lectures. She participated in several PhD and MSc thesis juries and has also supervised many students at the IPT.

Dr. Quadros has been a Member of ABMS National Council (Brazilian Society for Soil Mechanics and Geotechnical Engineering) and President of the Brazilian Committee for Rock Mechanics (1989-1991). Within the ISRM, Dr. Quadros was very active as a frequent participant in the ISRM Symposia and Congresses, a member of the ISRM Commission on Testing Methods since 2006, Vice-President for South America during the term 2003-2007, the ISRM President during the term 2015-2019, the Co-Chairman of the Working Group developing the "ISRM Suggested Method for the Lugeon Test", which was approved by the ISRM and published in 2019. In addition, due to her activities in our society, Eda Freitas de Quadros received relevant recognitions such as the ISRM Fellow nomination in 2021 and the Honorary Chairman of the 2022 ISRM International Symposium (9th Latin America Rock Mechanics Symposium) held in Asuncion, Paraguay.

Eda Freitas de Quadros was also one of two authors of a book entitled "Flow of Water in Fractured Rock Masses: Basic Theory and Practical Applications", to be published in the ISRM Book Series. The cancer made too difficult the efforts required to write such a book and, at present, major chapters are still pending.

Eda Freitas de Quadros will also be remembered by our society as the "first female President of the ISRM National Group in Brazil in 1989", "first female Vice President of ISRM (2003-2007)" and "first female President of ISRM (2015-2019)".

It was happiness for us to meet Eda in 2022 during the face-to-face ISRM Symposium in Paraguay and to have online talks with her. Since she felt better in the last summer, she was very keen to attend the 15th ISRM Congress in Salzburg, but unfortunately it was not possible.

The ISRM deeply regrets her loss and wishes to express its deepest and heartfelt condolences to her devoted husband, Dr. Nick Barton, her daughters and family members, friends, colleagues and the Brazilian ISRM National Group and its members. During the future ISRM conferences and other activities she will be missed by many colleagues and friends and will be remembered as a real friend, full of kindness and extremely joyful towards life, showing a true passion for the ISRM and very kind efforts for the benefit of our society. 🏹

Reşat Ulusay and Philippe Vaskou



## FORTHCOMING ISRM SPONSORED CONFERENCES

2024	8-12	June	14th International Symposium on Landslides (14th ISL) - a JTC 1 Conference Chambéry, France
	15-19	July	Eurock 2024: New Challenges in Rock Mechanics and Rock Engineering - an ISRM Regional Symposium Alicante, Spain
	5-8	August	5th International Conference on Information Technology in Geo-Engineering - a JTC2 Conference Golden, USA
	24-28	September	ARMS13 - 13th Asian Rock Mechanics Symposium: Advances in Rock Mechanics - Infrastructure Development - an ISRM International Symposium New Dehli, India
	13-15	November	CouFrac2024 - The 4th International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling and Application - an ISRM Specialized Conference Kyoto, Japan
2025	16-20	June	Eurock 2025: Expanding the Underground Space. Future development of the sub-surface - an ISRM International Symposium Trondheim, Norway
2026	14-19	September	Eurock 2026: Risk Management in Rock Engineering - an ISRM Regional Symposium Skopje, North Macedonia
2027	17-23	October	16th ISRM International Congress on Rock Mechanics Seoul, Korea

The ISRM holds International Congresses on Rock Mechanics and Rock Engineering, at four year intervals, on themes of general interest to the majority of the membership, and sponsors a co-ordinated program of International Symposia, Regional Symposia and Specialized Conferences organised by National Groups of the Society.

The annual ISRM International Symposium is chosen from the ISRM Regional Symposia that take place in that year and is the venue for the annual meetings of the Council, Board, and Commissions of the Society. ISRM Specialized Conferences are events of a smaller nature, usually focused on a specific theme.

National Groups seeking to host an ISRM Regional Symposium or Specialized Conference shall submit a written proposal to the Secretariat, at least one, but preferably two to three years before the date of the event. Their organization is ruled by By-law No. 5, and application forms are included in specific Guidelines prepared by the Board, and available on the ISRM website (<https://www.isrm.net/conferencias/submit.php?show=conf>). Since 2018 no financial contribution to the ISRM is due from ISRM Specialized Conferences.

Proceedings of ISRM conferences are stored in the ISRM digital library available in the OnePetro platform ([onepetro.org](http://onepetro.org)). ▶

## 09 REPORTS OF ISRM CONFERENCES

### 15TH ISRM CONGRESS

Salzburg, Austria

All photos, including cover, by ÖeGG / J. Delgado

The 15th International ISRM Congress was held as a face-to-face event between 11 and 14 October 2023 at the Salzburg Congress in Salzburg, Austria with perfect sunshine. The Congress with the leading theme "Challenges in Rock Mechanics and Rock Engineering" was organized by the Austrian Society for Geomechanics and chaired by Prof. Wulf Schubert.

entitled: "Conveying geological reality in rock engineering design". Prof. Jun Zhao presented the Rocha Medal lecture and received the award. The Müller award lecture was given by Prof. Derek Martin. At the end of the first plenary session 18 teams competed in the first round of the Rock Bowl students' competition.

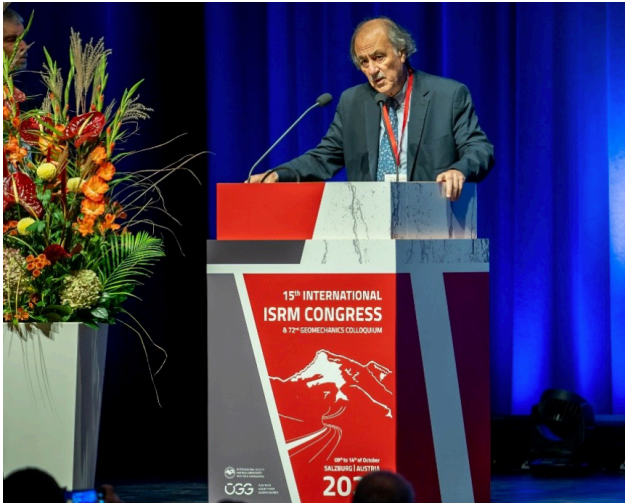


The congress was attended by 1.460 participants from 64 countries. The Congress was preceded by the Board, Council and FedIGS meetings, as well as 14 workshops and seminars with 350 participants and a number of field trips and commission meetings, as well as the welcome reception. 71 companies took the opportunity to present their products and services at the exhibition with a total of 241 persons available for customer contact.

After the welcome speech of the Congress Chairman Prof. Wulf Schubert, the Congress started with an opening address by the ISRM President Prof. Reşat Ulusay, followed by an address of Prof. Chungsik Yoo, President of FedIGS. After a short musical performance, Dr Luís Lamas presented the status of the ISRM. Prof. Christian Hellmich gave a Keynote lecture with the theme "The Mechanics of Pandemics: "Empowering Boltzmann creep for the prediction of Covid-19 fatality trends". Prof. Vassilis Marinou, the President of IAEG, gave the FedIGS lecture







The 18 topics were covered in 41 sessions. During the Early Career Forum six young engineers from Spain, Portugal, Italy, Greece, Hungary, and Albania had the opportunity to present their research results after Prof. Ömer Aydan gave a talk on “Some thoughts on Rock Mechanics and Rock Engineering on Mars” and Prof. Michael Alber on “How to form competent rock engineers”.

In total about 230 papers were presented orally, and 180 posters displayed and discussed in the respective sessions. The proceedings contain 503 full papers with a total of 1532 authors and co-authors from countries all over the five continents.



A chamber concert at the Mozarteum concluded the second day of the Congress. A wide range of scenic tours was offered for accompanying persons and participants. A highlight was the congress dinner at the Stiegl Keller, a unique beer hall with a long history at the foot of the Salzburg fortress.

The winners of the Rock Bowl competition – the team from University of New South Wales – and the two follow-up teams received their certificates and prizes at the dinner.





During the closing ceremony the Leopold Müller Award of the Austrian Society of Geomechanics was handed over to Dr Laurin Hauser, who briefly presented his thesis. Sérgio Fontoura, Francois Malan, and Norikazu Shimizu were inducted as new ISRM Fellows. The John Hudson Rock Engineering Award was conferred to Dr Chistine Detournay, the Science Achievement Award to Prof. Jean Sulem, and the Young Rock Engineering Award to Dr Wang Qi and Dr Yota Togashi, the Technological Innovation Award to Shandong University. The best performing national group award went to the NG China and NG North Macedonia. The outstanding commission award was conferred to the Commission on Discontinuous Deformation Analysis – DDA.

Finally, the farewell speech to the outgoing board and the inauguration of the new board were held.

Prof. Seokwon Jeon was inaugurated as the new ISRM President and Prof. Resat Ulusay handed him the presidential symbols – the sash and the baton – before he delivered his inaugural speech. ▀



## IV NROCK 2023

Reykjavik, Iceland

The Icelandic Geotechnical Society and the Icelandic Tunnelling Society organized the IV Nordic Symposium on Rock Mechanics and Rock Engineering in Reykjavik, Iceland 24 - 26 of May 2023. NROCK 2023 was an ISRM-sponsored Specialized Conference.

The symposium gathered Nordic rock mechanics and engineering geology experts to discuss the current state of research, infrastructure, rock caverns, tunnelling, mining, use of underground space for energy recovery and storage, and case histories. Use of underground space for various purposes is a natural choice in Nordic countries and it has made the understanding of rock mechanics and rock engineering vital.

The theme of the symposium was within all fields of rock mechanics and rock engineering and the program was very exciting with interesting papers and presentations covering various topics, such as mining, tunnelling and usage of underground space, design and digitalization, testing and modelling, grouting and rock support.

The symposium program consisted of four keynote presentations, from Canada, Norway, and Iceland, and 22 technical oral presentations from nine countries. There were also two very interesting field excursions. The first one on May 26th, a field trip to the extremely active volcanic area of Reykjanes peninsula. The second one on May 27th in South Iceland, to visit Carbfix and the geothermal power plant of Hellisheiði and the hydropower plant Búrfell II. Participants were 67 in total, from 10 countries, worldwide.

At the closing ceremony, Atli Karl Ingimarsson, Chairman of the Icelandic Organizing Committee, handed the rock core over to Eyðbjörg Amanda Petersen from the Faroe Islands, who will host the next symposium in four years. 🇫🇷



### Keynote lectures

John Hadjigeorgiou - University of Toronto, Canada  
Ground Support for Extreme Conditions

Sandra Ósk Snæbjörnsdóttir - Head of CO2 Mineral Storage Technology, Reykjavik, Iceland  
Carbfix: CO2 Mineral Storage in Basaltic Rocks

Krishna Kanta Panthi - NTNU, Trondheim, Norway  
Engineering Geology in Hydropower Engineering

Kristín Jónsdóttir - Icelandic Met office, Reykjavik, Iceland  
The Unrest on the Reykjanes Peninsula and Eruption in Fagradalsfjall 2021 & 2022



NROCK 2023 field excursion to the extremely active volcanic area of Reykjanes peninsula. The group standing on a warm and "newborn" basalt lava.

## 09 3RD JTC1 WORKSHOP

Oslo, Norway

The third workshop of the Joint Technical Committee 1 of FedIGS, JTC1 on Natural Slopes and Landslides, was held in Oslo, 7th – 10th June, 2023. The Department of Natural Hazards of the Norwegian Geotechnical Institute (NGI), with Dominik Lang as host, organised the workshop this year. The two young researchers Vittoria Capobianco and Laura Rødvand, supported by Suzanne Lacasse, Farrokh Nadim and Håkon Heyerdal, were the team that orchestrated the success of the event.

This year the workshop addressed topics related to anthropogenic impacts and related climate change on landslide hazards and risk, and registered a total of 114 participants from 19 different nationalities.

The workshop consisted of two lecture days (8th and 9th June), in the beautiful venue of the Deichman Library, with a splendid view on the iconic Opera ballet and the famous Oslo fjord. A half-day case study and the NGI lab visit were held on Saturday, the 10th.

The lecture days were rich of fruitful discussions around the burning topic of global change on landslide hazards and risks, and included five keynote lectures, five invited lectures, the 3rd Hutchinson Lecture as well as themed sessions. The third Hutchinson lecture was addressed by Prof. Clarence Choi from the Hong Kong University on “Engineered and nature-based solutions against flow-type landslide hazards”.

A diverse and international group of top-level scientists presented five keynote lectures on topics related to landslide hazard and risk, covering tools and methods for the assessment of rock and geomorphological instabilities, quantitative assessment of landslide risk and interdisciplinary risk reduction strategies, and how plants and their related chemical processes influence soil properties.

Five themed sessions, for a total of 26 oral presentations, started with an invited lecture. The advanced topics in focus for the discussions included:

- Impact of climate-driven perils and climate change on landslide hazard;
- Numerical modelling of landslides;
- Landslide hazard and risk - Assessment and mitigation;
- Landslide mobility, runout and impact forces;
- Monitoring and early warning systems for landslides.



The poster session registered 27 contributions and was focused on:

- Rock mass degradation and landslide initiation;
- Climate and anthropogenic impact on landslide risk in different geographic regions, including the Arctic;
- Prediction of landslide mobility and inundation; application of modern remote sensing technologies to landslide risk assessment;
- Landslide risk reduction strategies: risk mitigation including early warning and nature-based solutions.

A fruitful panel discussion at the end of the first technical day orbited around effective landslide risk management under rapid climate change, demographic change and changing societal priorities, highlighting the need for the landslide community to move towards more sustainable landslide risk mitigation strategies which are holistic and system-oriented.

Proceedings of the workshop can be downloaded from the website at this link: [www.ngi.no/en/jtc1-workshop](http://www.ngi.no/en/jtc1-workshop). A total of 10 to 15 articles are envisioned to be collected on the Thematic Issue of the JTC1 workshop launched on the journal *Landslides*. 🇳🇴



## NORDIC GROUTING SYMPOSIUM – NGS 2023

Stockholm, Sweden



### NGS 2023

10th Nordic Grouting Symposium

The Nordic Grouting Symposium 2023 was the 10th symposium in this series of events organized by national association every third year. This time it was the Swedish Association of Rock Engineering, and it was held in Stockholm, Sweden on September 12 and 13. NGS 2023 was jointly endorsed by ISRM, together with ITA, BeFo – Rock Engineering Research Foundation and the Swedish Transport Administration.

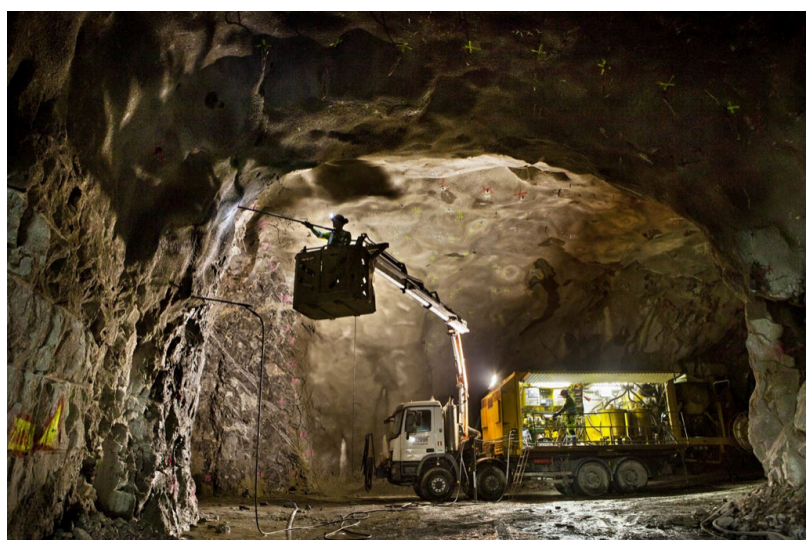
The symposium had 108 registered participants from 14 countries covering all the Nordic countries and included 21 presentations within five different themes along

with two keynote talks and a professional discussion focusing on what different partners within the rock engineering industry could do to improve the result of grouting. The industry was actively involved and included five sponsors and four exhibitors. The two large infrastructure projects, Stockholm by-pass and the Metro extension both participated with presentations and provided opportunities for excellent field visits.

The keynote talks were given by Håkan Stille and Knut Garshol, two of the most distinguished Nordic grouting experts from Sweden and Norway, respectively. They presented historical records and experiences, and, in a way, they together illustrated how grouting in hard fractured rock has moved from black magic to an art of engineering. The themes included requirement and verifications, concept and design, grouting equipment and for the first-time grouting of the soil-rock-concrete interface. ▶



Opening by Lisa Hernqvist from the NGS Conference Organization



Grouting in the Stockholm underground (photo: BeFo)

## 09 1ST CHILEAN CONGRESS IN ROCK MECHANICS

Santiago, Chile



The 1st Chilean Congress in Rock Mechanics was held between 22 and 24 November 2023. The Congress was jointly organized by the Chilean Society of Rock Mechanics and the University of Santiago, Chile (USACH). The Congress gathered 283 guests, co-authors and participants from the industry and academia.

Before the Congress, three short courses were held: "Induced seismicity in mining" delivered by Juan Jarufe from the University of Santiago and mXrap, "Geotechnical characterization of rock masses and practical applications for mining and geotechnical design" delivered by Andrea Russo and Catalina Ramírez from SRK, and "Numerical modeling: Lessons from three decades of progress in the South American mining industry" delivered by Loren Lorig, Catalina Álvarez, Rodrigo Silva, Camila Soto, Felipe Orellana and María E. Valencia from Itasca Chile.

In total, 98 papers are included in the Proceedings. The main topics of the Congress were: Rock Mass Characterization, Ground Support, Instrumentation and Field Measurements, Numerical Modeling, Blast Induced Damage, Experimental and Laboratory Advances, Seismic Hazard and Rock Bursts, Slope Stability, New Projects, Cases Studies, Geomechanical Risk, and Big Data and Machine Learning in Geomechanics. The papers were presented in parallel sessions, in which 78 were oral presentations, 14 posters presentations, and six international and national experts delivered the following keynote lectures:

- Carlos Carranza-Torres (University of Minnesota, United States): "Power law failure criteria for intact rock and rockfill shear interfaces and their application to rock excavation and rock fill problems"
- Catalina Álvarez (Itasca Chile, Chile): "Application of advanced numerical models in mining design: benefits and challenges"
- Eduardo Rojas (Codelco, Chile): "Impact of geomechanical risks on the evolution of the undercut strategies in the El Teniente mine"
- Esteban Hormazábal (SRK, Chile): "Quantifying uncertainty in the open pit slope design"
- Mark Diederichs (Queen's University, Canada): "Six decades of evolution of brittle damage prediction and spalling analysis"
- Steve Mckinnon (Queen's University, Canada): "Characteristics of stress field in mines"

At the end of each day, a panel discussion was organized. The first panel centered around the topic of "Challenges in underground excavations" and was moderated by Juan Jarufe from the University of Santiago. The panelists were Soledad Celis, Mark Diederichs, Fernando Fernández and Andrea Russo. The second panel addressed the theme of "Challenges in surface excavations" and was moderated by Alejandra Villouta from GHD. The panelists were Danko Díaz, Patricio Gómez, Gastón González and Luis Olivares. The concluding panel session centered around the topic of "Future challenges in geomechanics" and was moderated by Kimie Suzuki from the University of Chile. The panelists were Pedro Landeros, Katherine Toro, and Michel Van Sint Jan.

The "Dr. Antonio Karzulovic" award, named in honour of Dr. Antonio Karzulovic, who led the original Chilean Group, was given to Michel Van Sint Jan, Emeritus Professor of the Pontifical Catholic University of Chile, for his contribution to rock mechanics. At the closing ceremony, the Award for best oral presentation and best poster presentation were delivered. The best oral presentation award was to Pablo Vásquez for his presentation "Lessons learned, collapses MBN01S02, Chuquicamata Underground" and the best poster presentation award was to Fernanda Espínola for her poster "Impact of the particle size distribution on the movement ellipses in gravity flow in cave engineering".



Keynote lecture by Eduardo Rojas



Antonio Karzulovic Award for Michel Van Sint Jan (in the middle)

## 1ST SLRMES INTERNATIONAL CONFERENCE

Colombo, Sri Lanka

The first ever SLRMES International Conference on Rock Mechanics for Infrastructure and Geo-Resources Development was held in Renuka City Hotel, Colombo, Sri Lanka between December 3rd and 7th, 2023. It was an ISRM Specialized Conference organized by the Sri Lankan Rock Mechanics and Engineering Society (SLRMES) and Chaired by Professor Pinnaduwa H. S. W. Kulatilake, the SLRMES President. This was the first major conference fully devoted to Rock Mechanics and Rock Engineering that was held in Sri Lanka. It included a welcome reception, conference banquet, and post-conference technical/sightseeing tours, at an affordable price.

About 70 delegates from 13 countries participated in the conference which included a welcome reception and registration session on December 3rd before the official commencement of the event. The first day of the conference was inaugurated with an exquisite, memorable Sri Lankan Kandyan dance performed by a 7-member dance group wearing glamorous outfits. This was followed up with the tradition of lighting the oil lamp as a testament to ushering positive energy and playing the National Anthem. The welcome speech by the ISRM President Prof. Seokwon Jeon and an Introductory speech by the Conference Chair and SLRMES President Prof. Pinnaduwa Kulatilake took place next. This inaugural session was compered by Eng. Gamsavi Kanagasundaram, a postgraduate from the University of Moratuwa.

The conference presentations covered all areas of rock mechanics and rock engineering encompassing the fields of mining, civil, geological, and petroleum engineering, and geophysics and hydrogeology focusing on the theme "Rock Mechanics for Infrastructure and Geo-Resources Development". Out of a total of eighty-two abstracts received, four keynotes, eleven session lead lectures, and 36 regular lectures were delivered in parallel sessions during December 4th and 5th at the conference. The parallel sessions were coordinated by Mr. Brinthan Kanesalingam and Eng. Madushani Ruwanthi Peter with the assistance of two undergraduates from the University of Sri Jayewardenepura Mr. Pankaja Amarasinghe and Mr. Chinthana Hewawitharana. The presentations had a balanced mix of theory and practice and were more inclined toward applied research addressing rock engineering problems. Some of the keynotes and session lead lectures provided state-of-the-art on the topics dealt with. The closing ceremony included presenting awards for the top three extended abstracts/presentations, out of the 36 regular lectures.

Post-conference technical tours were coordinated by Eng. Chamith Beddage, which included a visit to a TBM tunneling project (organized by Eng. Isuru Indunil) and a visit to a graphite underground mine (organized by Dr. Thushara A. Madanayake and Eng. Madushani Ruwanthi Peter) on December 6th and 7th, respectively.



Lighting the Traditional Oil Lamp at the Inaugural Ceremony

Customized sightseeing tours to many beautiful spots in Sri Lanka were also available for the conference delegates while residing at the conference venue or nearby economical hotels with magnificent beach views. The banquet dinner had a

musical event with the company of a 4-piece local band to entertain the conference delegates and some of them enjoyed singing and dancing. The delegates thoroughly enjoyed the music, refreshments, and meals while making the event a blast. The delegates expressed their

high appreciation throughout the event which enabled collecting many wonderful memories, and a unique experience with Sri Lankan hospitality and cuisine.



Address by the Conference Chair and SLRMES President Prof. Pinnaduwa H. S. W. Kulatilake

Committed and talented individuals of the Local Organizing Committee, listed in the conference proceedings, assisted in executing this successful conference, which was highly

commended by the participants during the feedback session at the closing ceremony. The elegant conference proceeding which included the extended abstracts was designed and developed under the leadership of Dr. Chulantha Jayawardena, with the editorial committee consisting of Professor Pinnaduwa Kulatilake and Mr. Brinthan Kanesalingam. Eng. Chamith Beddage did the digital wall backdrop and the proceedings cover design while Dr. Chulantha Jayawardena designed the award certificates. The conference pack and some of the conference secretary's responsibilities were handled by Mrs. Sujeewa Kulatilake. A digital copy of the conference proceedings and the photos of the event can be downloaded upon submitting the feedback form that can be accessed via the following link: <https://forms.gle/MGYNmUg8Jx8VGEYg8>.



The Local Organizing Committee that executed a highly successful conference

# 10 ISRM TECHNICAL OVERSIGHT COMMITTEE

## 2023 ANNUAL REPORT

Laura J. Pyrak-Nolte, Chair, VP for North America

Leandro R. Alejano, Member, VP for Europe

Ömer Aydan, Member, VP at Large

### 1. INTRODUCTION

The ISRM has established technical commissions to study scientific and technical matters of interest to the Society. ISRM commissions cover different topics, so they are varied in terms of their aims, type of activities, membership and products. In recognition of the critical role of the ISRM commissions for the achievement of the ISRM goals of international collaboration, advancement of rock mechanics and the promotion of high standards, the ISRM Board created the Technical Oversight Committee (here in referred to as “the TOC”), to report on the performance and to act as oversight for the commissions. The TOC assesses commission performance based on commission-generated Annual Reports by the chair of each commission.

This report contains the TOC’s assessments of the commission for the 2022-2023 and planned activities for the next year.

### 2. CURRENT TECHNICAL COMMISSIONS

There are 14 ISRM technical commissions (Table 1) with 231 commission members from 35 different national groups. Table 1 contains a list of current commissions, the year the commission was established and the rating of the performance of each commission.

Commissions are typically composed of 12-15 members (Figure 1). The Commission on Coupled Processes in Fractured Rock (CTHMCPFR) has nearly 46 members because of their strong commitment to encouraging participation by early- and mid-career scientist and engineers.

The TOC reviewed the composition of the commissions to assess and encourage diversity in participation from different national groups (Figure 2). In 2023,, 35 national groups have members on a technical commission with China making the largest contributions to the commissions. If analyzed by region (Figure 3), Asia and Europe have the strongest participation in the commissions. However, participation from Europe and Asia has decreased because of sunseting of the commission Preservation of Ancient Sites and rebalancing of commission membership to have representatives from more regions.

**TABLE 1. ISRM TECHNICAL COMMISSIONS.**

Commission Name	Year Established	Rating
1. Coupled Processes in Fractured Rock (CTHMCPFR)	2018	Excellent
2. Crustal Stress & Earthquakes (CSE)	2011	Very Good
3. Deep Mining (DeepM)	2019	Very Good
4. Design Methodology (DM)	pre 2004	Excellent
5. Discontinuous Deformation Analysis (DDA)	2011	Excellent
6. Planetary Rock Mechanics (PRM)	2019	Good
8. Rockbursts (RB)	2019	Good
9. Radioactive Waste (RW)	2010	Fair
10. Rock Dynamics (RD)	2007	Very Good
11. Rock Grouting (RG)	2019	Good
12. Soft Rock (SR)	2019	Poor
13. Sorptive Rock (SORPROC)	2021	Excellent
14. Testing Methods	~1970s	Excellent
15. Underground Nuclear Power Plants (UNPP)	2012	Completed



Commission Members by Countries

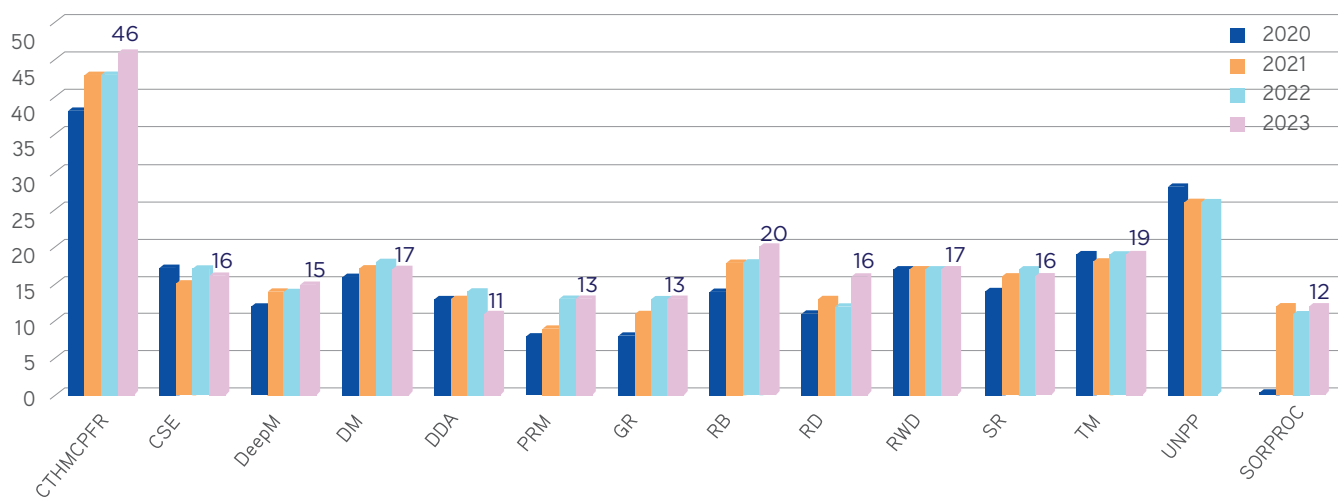


Fig 1. Comparison of number of members for each commission for 2020, 2021, 2022 and 2023

Commission Members by Country

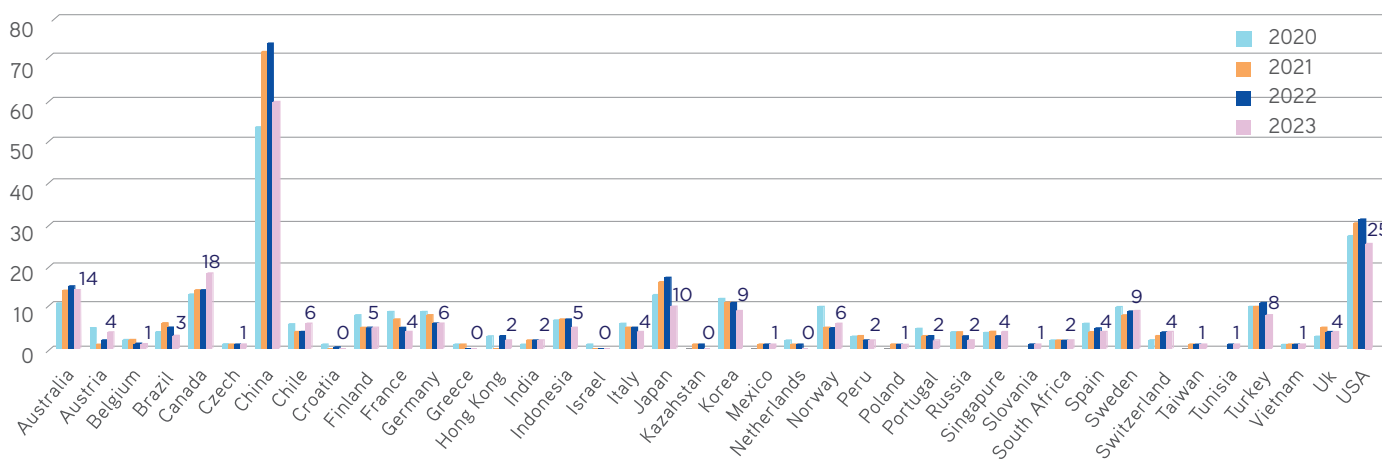


Fig 2. Comparison of number of members by national group for 2020, 2021, 2022 and 2023

10 The number of regions represented on each commission is shown in Figure 3 and the number of members from a particular country for each commission is shown in Figure 4. The commissions on Deep Mining (DeepM), Rock Burst (RB) and Test Methods have good representation with member from all six regions. Radioactive Waste (RWD), Crustal Stress & Earthquakes (CSE), Discontinuous Deformation Analysis (DDA) and Soft Rock (SR) have members from only 3 regions.

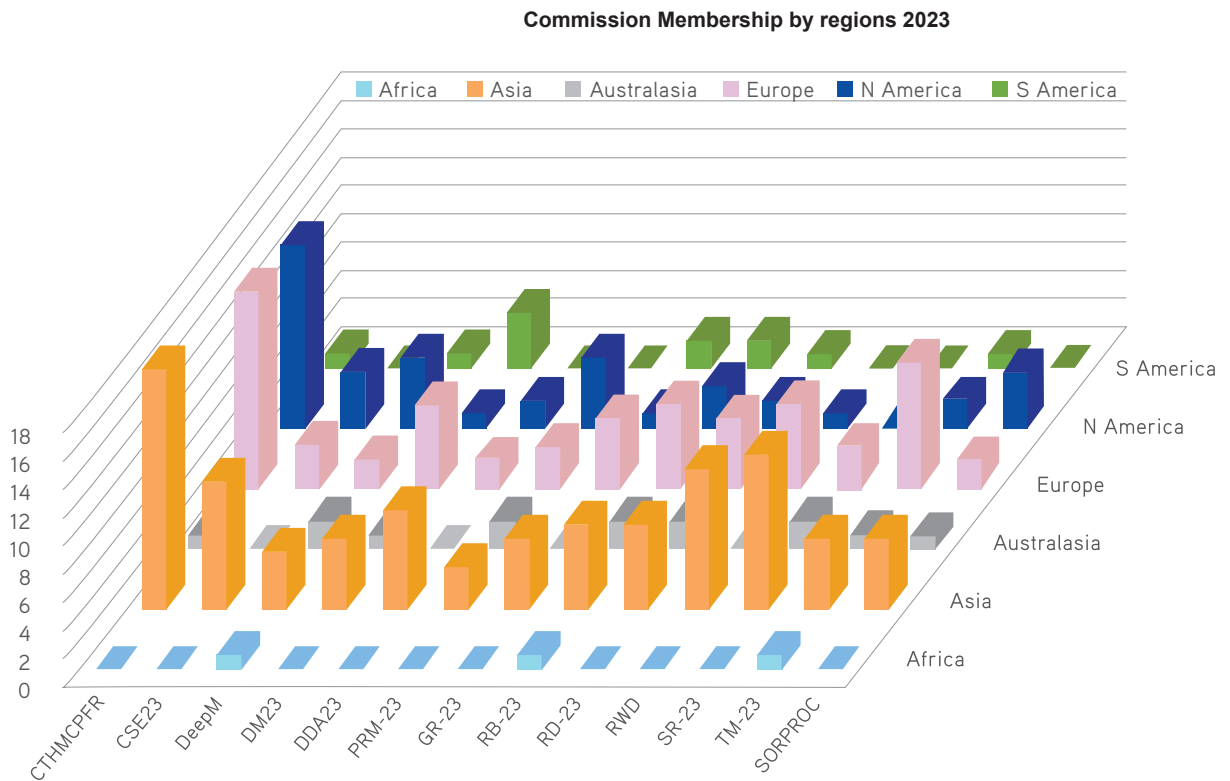


Fig 3. Number of members from each region on each commission in 2023

**3. SUMMARY OF COMMISSION ACTIVITIES**

Previous TOCs developed a standard template for the Annual report to provide awareness of a commission’s activities, products, and progress during the year. The rating for each commission is based on the TOC’s review of the annual reports.

**4. SUMMARY AND RECOMMENDATIONS**

4.1 ISRM Commission Activity Summary

13 Commissions produced an annual report describing the commission activities for 2022-2023

Some of concern and improvement are as follows:

- Concern with the diversity of the commissions remains but much improvement did occur. Diversity is used in the broadest sense and includes gender, ISRM region, area of study, academic-industry-national laboratories, academic heritage, etc.
- Good job: TM, DeepM and RB have or continue to have members from 6 regions.

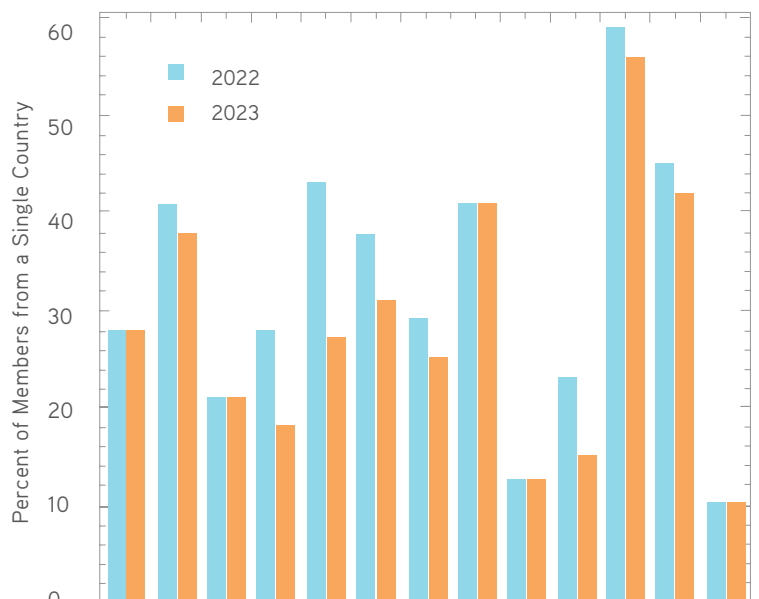


Fig 4. Representation value by commission

- Need for Improvement: CSE, DDA, RWD and SR only have members from < 3 regions.
- Concern: Commissions should not be dominated by members from a single country. Membership from a single country should be ~ 30% or below of the total number of members. Figure 4 shows the representation value by commission.
- Continue to encourage members from Africa and Latin America to participate in the commissions.
- Continue to encourage women to participate in commissions.
- Commission of Concern Merger: RB is a new commission that is not productive and merging with DeepM should be considered.

#### 4.2 Overview of ISRM Commission Activity Summary Publications

The Sorptive Rock (SORPROC) published a book in 2023 entitled: "Small Angle X-ray and Neutron Scattering with Applications to Geomaterials". The commission on Underground Nuclear Power Plants (UNPP) published a book in October 2022. The Soft Rock (SR) plans to publish a book on "Deep mine Construction Mechanics 2023". The proceedings from the RocDyn-4 by the Rock Dynamics (RD) commission is not available from by CRC Press/Balkema 2023. The commission Discontinuous Deformation Analysis (DDA) published: NumericalBox3D with by online instructional videos, a paper on "A Benchmark Study of Different Numerical Methods for Predicting Rock Failure" (IJRMMS March 2023); the Proceeding of 15th Inter. Conference on Analysis of Discontinuous Deformation (ICADD15); and a book on "Numerical Manifold Method" (2022). The Design Methodology (DM) commission has started a new international journal Deep Resources Engineering and published a book "Hard Rock Mechanics in Deep Engineering" in 2023. While the Commission on Deep Mining (DeepM) developed and posted a 9-part video course on "Rock Failure Behavior and Control in Deep Mining" (with 200-400 views) posted on Commission's YouTube channel. The 5 special journal issues from the Coupled Processes in Rock (CTHMCPFR) commission from threere conference CouFrac 2022 will be published in 2024 in Rock Mechanics and Rock Engineering, Geomechanics and Geophysics for Geo-Energy and Geo-Resources, Journal of Rock Mechanics and Geotechnical Engineering, and Tunnelling and Underground Space Technology, Water Resources Research.

The Commission of Testing Methods (TM) will also publish a book when around 15 new Suggested Methods are published. The last book was published in 2015 (the orange book) and the new one is expected in one or two years. The TM commission has a suggested methods (SM) at various levels of progress: on topics "Dynamic Shear Testing of Rock Discontinuities and Interfaces", "Determining strength, deformation and toughness parameters of rock reinforcement tendons

under an impulsive load- Method 1: Mass Freefall (MF) Method", "Small-scale Linear Rock Cutting Test", "Quantitative Description of Discontinuities in Rock Masses", "In-Situ Determination of the Shear Strength of Discontinuities and Interfaces", "Direct Tensile Strength Test", "Triaxial Compression Testing of Shales and Mudstones", "Saturation of Rocks", "Determining the dynamic shear strength and mode II fracture toughness of rock materials using the Split Hopkinson Pressure Bar (SHPB)", "Achieving Full Water Saturation in Rock", "Determining the elastic constants of transversely isotropic rocks with uniaxial Compression Tests", "Leeb Hardness Test", Quantitative Description of Discontinuities in Rock Masses. The TM commissions also has videos in progress: "Determination of the Schmidt Hammer Rebound Hardness", "Determining the Abrasivity of Rock by the Cerchar Abrasivity Test", "Determining the Creep Characteristics of Rock Materials. 4th ISRM SMs Book".

#### Conferences, Workshops, Short Courses

The Commission on Coupled Processes (CTHMCPFR) held a hybrid Conference "CouFrac-2022" at Lawrence Berkeley National Laboratory, Berkeley, California in November 2022. Several commissions held special sessions at ChinaRock 2022 & 2023 (CSE, RW, RD, SR, SORPROC). Workshops and special sessions held at the 15th Congress of the ISRM in Salzburg, Austria include Deep Mining Geomechanics by DEEPM, RockBurst (RB), Planetary Rock Mechanics (PRM), Rock Grouting (RG), Rock Mechanics in Nuclear Waste Disposal (RW).

The Commission on DDA held an Inter. Frontier Forum on Geotechnical Eng. and Disaster Prevention & Mitigation (2022-2023), 2nd International Young Scientist Forum on DDA & Training, 2022; with RD online training sessions for NumericalBox3D, 2022. DDA is also planning the 16th Inter. Conference on Analysis of Discontinuous Deformation, the 3rd International Young Scientists Forum for DDA (IYSF-DDA), Short courses on DDA, DLMS, and "NumericalBox3D", International Numerical Modeling Contest of Rock Mechanics and Engineering. The Sorptive Rock (SORPROC) commission held a Session at Unconventional Resources Technology Conference 2023; international workshop on "Sorptive Rocks Mechanism and Engineering"; First Doctoral Students Forum 2023; online.

#### 4.4 Activities of the ISRM TOC

In 2023, the TOC assessed all reports that were received from 13 technical commissions.

#### 4.5 TOC Goals

The TOC plans to hand over relevant files to the new TOC as this TOC term has ended. The TOC thanks the commissions for their continued to service to the International Rock Mechanics community, and it was a pleasure to learn about the commissions' efforts and activities. ▀

# 11 ISRM EDUCATION FUND COMMITTEE 2023 ANNUAL REPORT

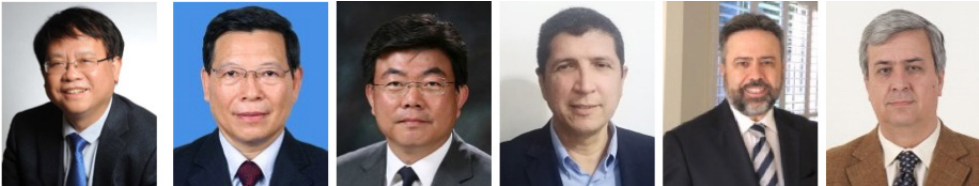
Qiang Yang | EFC Chair

## 1. EDUCATION FUND COMMITTEE (EFC)

The objective of the ISRM Education Fund is to further the ISRM’s mission, by enhancing education in Rock Mechanics and Rock Engineering. It will do this by planning, funding, coordinating and conducting educational activities for the benefit of the ISRM community. The ISRM Education Fund is managed by the ISRM Education Fund Committee.

The members of the ISRM Education Fund Committee from 2019 to 2023 are:

CHAIR



Qiang Yang    Manchao He    Seokwon    José Pavón    Ismet Canbulat    Luís Lamas

## 2. MANAGEMENT OF EDUCATION FUND

Qiang Yang has successfully raised a fund of 100 000 RMB (about € 12 842) to the EFC Beijing office, which was used to support the 7th Early Career Forum associated with LARMS 2022 and the 8th Early Career Forum associated with ISRM2023. In 2023, the total cost of the 8th Early Career Forum was € 9 600, which is shared in equal parts by ISRM and ISRM Beijing Office.

## 3. 8TH EARLY CAREER FORUM

The 8th Early Career Forum chaired by Dr. Vojkan Jovičić, Prof. Resat Ulusay, and Prof. Qiang Yang was successfully organized in 2023. Six young engineers and researchers from Europe participated in the forum, and they are Anastasios Tsikrikis (Greece, 1991), Andor Németh (Hungary), Ardita Malaj (Albania, 1987), Ignacio Pérez-rey (Spain, 1988), Maria Teresa Carreiro (Italy, 1993), and Renato Pereira (Portugal, 1988). 🇳🇵



## ISRM YOUNG MEMBERS COMMITTEE 2023 ANNUAL REPORT

Sevda Dekhoda, Chair  
Vojkan Jovicic  
Michael du Plessis

### INTRODUCTION

2019-2023 ISRM Young Members' Committee established the following objectives during its initial official gatherings on February 1-2, 2020, in Ljubljana:

- Attracting and engaging with young members of the society
- Building opportunities for technical and professional learning and development
- Showcasing and celebrating the achievements of young members.
- Providing platforms for networking and connection of young members

This report provides a summary of the committee's accomplishments during its term in line with these objectives.

In conjunction with the 2023 ISRM Congress, committee members held their inaugural face-to-face meeting on October 12, 2023, in Salzburg to deliberate and strategize their activities for the year 2024. The organizing committee is actively soliciting volunteers globally and is inviting speaker candidates. If you are interested, please reach out to the committee at [ismr.ym.seminar@gmail.com](mailto:ismr.ym.seminar@gmail.com).

### ISRM YOUNG MEMBERS SEMINAR SERIES

The ISRM Young Members' Seminar Series is a series of virtual events, with a goal of providing a global platform for ISRM young members to share knowledge, experiences, and ideas. Since its establishment in November 2021, the ISRM Young Members' Seminar Series has served as a platform for young members to collaborate and highlight the accomplishments of their peers. The series has hosted 12 live seminars, featuring 25 speakers from various parts of the world. The recordings of these presentations are



International Society for Rock Mechanics and Rock Engineering

				
<b>Romy Ridl</b>	<b>Lina Maria G. Carrillo</b>	<b>Ryota Hashimoto</b>	<b>Daisuke Fukuda</b>	<b>Kimie Suzuki</b>
University of Canterbury & KiwiRail New Zealand	École des Ponts ParisTech France	Hiroshima University Japan (currently in USA)	Hokkaido University Japan	Chile University Chile
				
<b>Ignacio Pérez-Rey</b>	<b>Federico Vagnon</b>	<b>Zhihong Zhao</b>	<b>Jennifer Day</b>	<b>Yudhidya Wicaksana</b>
CEDEX Spain	University of Torino Italy	Tsinghua University China	Queen's University Canada	Institute Teknologi Bandung Indonesia

### ISRM YOUNG MEMBERS' ORGANIZING COMMITTEE

The ISRM Young Members' Organizing Committee is composed of 10 young members from all ISRM regions with the main duty of organizing online technical sessions which showcase the achievements of their peers. With the assistance of numerous other young society members, the committee successfully coordinated 12 webinars spanning the period from 2022 to 2023, featuring a total of 25 presentations from the following countries: Italy, France, South Korea, Japan, Peru, Chile, New Zealand, Australia, US, Canada, South Africa, India, China, South Africa, Canada, Spain, United State, Italy, and Switzerland.

available on ISRM Young Members YouTube channel [@isrmyoungmemberschannel7287](https://www.youtube.com/channel/UCisrmyoungmemberschannel7287), which has been viewed over 3000 times.

Young members interested in this event are encouraged to contact YMC and the organizing committee through [ISRM.YM.Seminar@gmail.com](mailto:ISRM.YM.Seminar@gmail.com). Criteria for the speakers are as below:

- be an ISRM member
- have a maximum age of 35 years, or of 40 years if a PhD degree was obtained in the previous 5 years;
- have worked in rock mechanics and rock engineering for a period no longer than ten years. ➤

## 12 2023 REPORTS OF ISRM VICE-PRESIDENTS

### AFRICA

Michael du Plessis | Vice President for Africa

The African continent hosts huge potential for broadening the ISRM footprint. Increasing participation remains a challenge as Rock Engineering practitioners in remote countries are isolated due to the location of mines where they are based at. The ISRM, have, nevertheless for many years focussed on growing the membership throughout Africa. There is still only three recognised national groups (NG) of the ISRM within the African Region. These are the South African National Institute of Rock Engineering (SANIRE), the Tunisian Society for Rock Mechanics (TSRM) and the Zimbabwean National Institute of Rock Engineering (ZINIRE). Botswana is actively pursuing the establishment of their national group. Other potential growth areas identified includes Zambia, Namibia, Ghana, Morocco, Mali, Tanzania, Nigeria, Egypt and the DRC. Currently, individuals interested in joining the ISRM are doing so through the established national group; i.e. SANIRE or TSRM. SANIRE being a very active NG attracts a lot of interest from international delegates and has various active members from various African countries and countries on other continents.

The following feedback was obtained from the three recognised national groups.

#### SANIRE (SOUTH AFRICA)

Mr Kevin Le Bron is the newly elected president for the term 2023 – 2025. SANIRE currently has approximately 700 members with membership continuing to grow annually. The council arranged many technical events, workshops and social activities. This is further supported by the technical visits and technical evenings hosted by the 6 branches which ensures that members in various areas of the country remain engaged.

Some of the prominent events hosted over the past year include:

- National symposium held in June which attracted more than 200 attendees,
- Rockbowl competition hosted to select the national team which participated at the ISRM congress in Austria,
- AGM hosted in August,
- Council tour to the various branches to encourage membership participation,
- Various technical days covering areas of interests selected by the members (i.e. seismicity, education, deep mining strategies and support methods),
- Various golf days.

SANIRE communicates through a quarterly newsletter, the SANIRE website and social media.

#### TSRM (TUNISIAN SOCIETY FOR ROCK MECHANICS)

Prof Essaieb Hamdi is the president of the Tunisian society. The membership growth has remained steady over the past years. Following on from the International Conference hosted in 2022, they participated in the 2nd International Symposium on Landslides in October 2023.

The society is very active in initiating, arranging and hosting topical research topics. More specifically, the assisted with the establishment of a new "Petroleum Production Engineering Executive Masters" at the National Engineering school at Tunis which is fully funded by the national oil company. They are also participating to the Organizing and Scientific committees of the fifth international conference on Geotechnical Engineering ICGE24 which will be held during April 2024

#### ZINIRE (ZIMBABWE)

Mr. Renias Tirivabaya was elected as the new president for the term 2023 – 2025 at the AGM held in June. The membership has remained constant. The NG activity was relatively low post COVID, but they are again hosting meetings and technical events. They continue to promote the professional development of their members and the participation in ISRM activities and events. 🏹

## ASIA

Suseno Kramadibrata | Vice President for Asia

Currently, the ISRM Asia region comprises 14 National Groups. Following Sri Lanka's inclusion in ISRM in the year 2022, Bangladesh has now joined as the latest National Group of ISRM in 2023. The Asian Council Meeting 2023 was successfully held in Salzburg, Austria, in conjunction with the ISRM Congress 2023.

The leadership of ISRM Vice President for Asia has been handed over from Suseno Kramadibrata (Indonesia/VP for Asia 2019-2023) to Ki-Bok Min (Korea/VP for Asia 2023-2027). The report below will provide information on various activities of National Groups in Asia during the period from October 2022 to October 2023.

### BANGLADESH

National Group Bangladesh has joined ISRM Asia in April 2023 under the leadership of Dr Akm Badrul Alam. There is no written report yet for the 2023 activity.

### CHINA

The National Group of China (CSRME) is highly active in the field of Rock Mechanics and Rock Engineering. Among its significant achievements, the society has made substantial contributions to several major construction projects in China, including the Changning Tunnel, Muzhailing Tunnel, Tabeiyi Tunnel, Ningtiaota Coal Mine, and Yunnan Middle Reach Water Diversion Project.

Additionally, the NG China has successfully organized large conferences and seminars, such as China Rock 2022, the 25th East Asia Round Table Meeting of the Academy of Engineering (EA-RTM), as well as various symposiums and academic seminars. Dr. Zhao Jun from Northeastern University won the ISRM Rocha Medal 2023.

In 2023, China Rock 2023 will take place in Beijing, focusing on the theme "Earthquakes and Rock Mechanics." CSRME is one of the co-organizers of the International Geomechanics Symposium 2023 in Al Khobar, Saudi Arabia.

The NG China has two journals, the Rock Mechanics Bulletin and Geohazard Mechanics, both selected as China High-Level Journals in the 2022 China Science and Technology Journal Excellence Action Plan. The individual ISRM membership from China is 2762, with 27 corporate members registered.

### INDIA

The Indian NG of the ISRM has been actively organizing conferences and workshops, including the Workshop on Rock Mechanics and Tunnelling Techniques in September 2023, at CBIP New Delhi. In June 2022, the Tunnelling Association of India, Central Board of Irrigation and Power (CBIP) New Delhi, Delhi Metro Rail Corporation Ltd., Mumbai Metro Rail Corporation Ltd, and ISRM India jointly organized the International Conference Tunnelling Asia 2022 in Mumbai, India.

Since January 2012, the Indian NG of ISRM has been publishing a Technical Journal on a half-yearly basis (January – June and July-December), which has both print and online versions. The Indian NG will be hosting the 13th ISRM Asian Rock Mechanics Symposium in 2024, with the proposed theme of "Advances in Rock Mechanics – Infrastructure Development" on 24-28th September 2024, in New Delhi. Additionally, the 208 members have renewed their ISRM membership for the year 2023.

### INDONESIA

The Indonesian Rock Mechanics Society (IRMS) is actively involved in various seminars, lectures, webinars, and conferences related to rock mechanics and rock engineering in Indonesia. Some of these activities include the PERHAPI Geotechnical webinar in July 2023, the Indonesia Mining Safety Summit in June 2023, the Drill & Blast Conference in June 2023, and the Geotechnical Workshop at UPN Yogyakarta in August 2023. Additionally, the Indonesia NG is preparing to host a national seminar on Geomechanics and a Joint Conference between Indonesia and Malaysia on Rock Mechanics and Rock Engineering. The society currently has 47 individual members of ISRM.

### ISRAEL

The Israel Rock Mechanics Association (IRMA) has reported several activities from October 2022 to October 2023. Firstly, the membership of Israel NG consists of 15 members from academic institutions, governmental research agencies, and the private sector. Secondly, the IRMA board organized a special session on geohazards during the Israel Geological Society annual meeting, which covered topics in rock mechanics, geomechanics, and seismic hazard evaluation. Thirdly, IRMA members lead courses in Rock Mechanics and Rock Engineering as part of the Master's degree in Geotechnical Engineering at the Department of Civil and Environmental Engineering at Ben Gurion University. Lastly, IRMA members lead the double degree (B.Sc.) track in Civil Engineering and Earth Sciences at Ben Gurion University.

## 12 JAPAN

The Japan Society for Rock Mechanics (JSRM) has reported several activities from October 2022 to October 2023. JSRM encourages young members by selecting the best doctoral dissertation, excellent papers, technologies, and frontier works for JSRM Awards annually. JSRM members lead courses in Rock Mechanics and Rock Engineering. JSRM held the 49th symposium on Rock Mechanics virtually on 10-12 January 2023, organized by Japan Society of Civil Engineers (JSCE) with the support of JSRM.

JSRM regularly disseminates information through its news magazine and Rock Net mail news. As of September 2023, JSRM has 36 corporate members and 310 individual members.

### KOREA

The Korean National Group (KSRM) has reported several activities from October 2022 to October 2023. KSRM organizes national conferences twice a year, with the Fall Conference 2022 held in High1 Grand Hotel at Gangwon-do in November 2022, and the Spring Conference 2023 held in Seoul National University Hoam Convention Center in March 2023. Then, KSRM hosted a symposium commemorating the hosting of the 2027 ISRM congress in Seoul in June 2023, at the main conference hall of the Korea Science and Technology Center. KSRM has 179 individual members and 11 corporate members registered with ISRM.

### MALAYSIA

The National Group of Malaysia (SEGRM) has reported several activities from October 2022 to October 2023. These activities include giving lectures to engineering rock mechanic students, holding a technical talk, hosting an annual general meeting, organizing a field trip, and conducting a half-day seminar on underground space.

In February 2024, SEGRM will host the 14th Asian Regional Conference of IAEG in Kuala Lumpur, with the topic of Engineering Geology and Geotechnics for Disaster Resilience.

### MONGOLIA

National Group of Mongolia did not provided a report on its activities.

### NEPAL

The Nepal Society for Rock Mechanics (NSRM) has reported several activities from October 2022 to October 2023. These activities include supporting the Nepal Tunnelling Conference 2022, giving a technical talk, contributing to the tunnel engineering curriculum, and advocating for the adoption of road tunnels and tunnelling technology in Nepal.

### SINGAPORE

The SRMEG has reported several activities from October 2022 to August 2023. These activities include holding the 18th Annual General Meeting, organizing monthly webinars, and hosting the 18th World Conference on Associated Research Centres for the Urban Underground Space (ACUUS2023 Conference) in November 2023.

### SOUTH-EAST ASIA

National Group of South-East Asia did not provided a report on its activities.

### SRI LANKA

The Sri Lankan Rock Mechanics and Engineering Society (SLRMES) will hold the first SLRMES Conference on Rock Mechanics for Infrastructure and Geo-resources Development in Sri Lanka during December 2-7, 2023. The society has delivered educational lectures to the Sri Lankan Rock Mechanics and Geotechnical communities on rock mechanics and rock engineering.

Additionally, more than 60 journal papers have been published by the SLRMES/ISRM members during the period 2022-2023. As of December 2022, 11 SLRMES members had an ISRM membership, which has grown to 31 members with about 36% being under the age of 40 years.

### VIETNAM

The 12th Asian Rock Mechanics Symposium (ARMS12) was held in November 2022 in Hanoi, Vietnam. Additionally, VSRM jointly with some sister societies in the field of soil mechanics, geotechnical, and civil engineering organized the National Congress of Mechanics in December 2022 at Vietnam National University, Hanoi. 🚩



## AUSTRALASIA

Sevda Dehkhoda | Vice-President for Australasia

### INTRODUCTION

The two national groups for Australasia are

Australian Geomechanics Society (AGS)

- 492 individual members (21% of total membership: 2586)
- 4 corporate members
- Female membership: 12.5% of total vs 21.0 of Under 35

Chair: David Lacey 2022-24

New Zealand Geotechnical Society (NZGS)

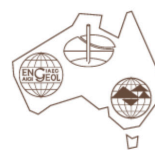
- 253 individual members (17% of total membership: 1448)
- Chair: Eleni Gkeli 2022-24
- ISRM Liaison: Paul Horrey

AGS and NZGS are technical societies of National Engineering Institutions:

- Engineers Australia
- Engineering New Zealand

The two societies operate similarly through regional chapters. General activities of the two societies include:

- Local chapter/branch meetings
- Monthly technical seminars by Professionals
- Distinguished Speakers Series (coordinated by both NZGS and AGS national committees for arranging the tours, ie UK Rankine Lecture winners)
- Annual Chapters and National symposiums
- Workshops and courses (Engineering geology, Geotechnical mapping, Core logging)
- Students focused events;
- Coordination of national standard reviews.



**AUSTRALIAN  
GEOMECHANICS  
SOCIETY**



**NEW ZEALAND  
GEOTECHNICAL  
SOCIETY INC**

The societies reach and attract young members by providing free membership for undergraduate students and heavily discounting the membership fees for graduate students. Several chapters have dedicated annual student events and awards for final year thesis presentations as well as networking events for students to meet and greet with professional engineers. In addition, NZGS have formed Young Geotechnical Professional (YGP) Representative role, which is co-opted to the NZGS national management committee. This is an opportunity for YGPs to get involved with and contribute to the NZGS, as well as interacting with the wider NZ geotechnical community. The two societies are also National Groups for:

- International Society for Soil Mechanics Geotechnical Engineering
- International Association for Engineering Geology and Environment

### ACTIVITIES FOR YEAR 2023

Major event of the year for the region was 14th Australia-New Zealand Conference on Geomechanics, held 2-5 July 2023 at Cairns Australia. This conference is held every 4 years with location alternating between Australia and New Zealand

In addition, several events have been organized for the year 2023 by both AGS and NZGS local chapters. These included technical talks either as in person seminars or online webinars, annual symposia, and workshops. Selected events from both societies are listed below.



HOME ▾ CONFERENCE PROGRAM ▾ JOHN JAEGER MEMORIAL AWARD REGISTRATION ▾ SPONSORSHIP & EXHIBITION GENERAL INFORMATION ▾



## 12 SLECTED AGS EVENTS

**AGS Victoria Symposium 2023**  
Novel Solutions in Geotechnical Engineering

**The role of engineering geology in delivering the United Nations Sustainable Development Goals**

**SPEAKER:**  
Jennifer Manning  
Associate Director  
Engineering, Sydney Metro



**AGS Western Australia Symposium 2023**  
Geotechnical Engineering for a Sustainable Future

**Sydney Tunnelling, Geology and Sustainable Data for the Future**

**SPEAKER:**  
Dr David J. Ooh  
Technical Director –  
Tunnels (Geology) WSP  
Australia Pty Ltd



**Rockfall Mitigation Using Flexible-Net Systems**

**SPEAKER:**  
Ahren Bichler  
General Manager,  
Turner Schutzbauteilen  
Canada



**Synergizing Sustainability in Geotechnical Engineering**

**SPEAKERS:**  
Philip O'Neil  
Samuel Henwood  
Cindy Liles and  
Robert M'agye



**Computational Slope Stability Analysis**

**Prof. Vaughan Griffiths**



Prof. Vaughan Griffiths  
Professor of Civil Engineering, Ontario School of Mine Eng, University of Toronto

**AGS Sydney Symposium 2023**  
Sustainable Geotechnics in Design, Materials,  
Construction and Maintenance



**Let's show our kids what Engineers can do !!!**

## SELECTED NZGS EVENTS

### NZGS Guidelines Series:

- NZGS Ground Anchor Guideline has been issued for industry consultation in March 2023.
- NZGS Slope Stability Guideline is under development, expected to be released for industry consultation end of 2023.

### New Zealand National Seismic Hazard Model (NSHM)

NZGS provided several introductory seminars and workshops for structural and geotechnical engineers or updated design Standards and Registrations.

### NZ geomechanics Lecture

Ann Williams for her contribution to understanding of geotechnical risk and hazards

14TH QUADRENNIAL AGS/NZGA JOINT CONFERENCE ON GEOMECHANICS

JULY 2023, CAIRNS, AU

2-DAY SHORT COURSE ON IN-SITU SEISMIC INVESTIGATION METHODS FOR ITE CHARACTERISATION

JUNE 2023, MULTIPLE CITIES, NZ

PROBABILISTIC METHODS IN GEOTECHNICAL ENGINEERING: FROM BACK OF ENVELOPE TO SUPER COMPUTERS

MARCH 2023, MULTIPLE CITIES, NZ

## PROJECTS NZGS CLIMATE CHANGE FOCUS GROUP

- The NZGS Climate Change Focus Group is established in response to the strong interest from members in developments in this area. Focusing on role of geotechnical engineers in climate change, the focus group engages the geotechnical industry in New Zealand on how the industry can reach the carbon emission goals set by the New Zealand government.
- The group is currently looking to collaborate with the Ground Level Alliance (Australia) to explore common goals, aims and research opportunities. The Ground Levels Alliance is an Australian group of Civil Construction Professionals which aims to empower and equip construction professionals to make sustainability a daily practice.
- 2nd NZGS Climate Change Symposium is being planned for late 2023.

## PUBLICATIONS

The regular publications of the two societies are:

- Australian Geomechanics Journal, published quarterly
- New Zealand Geomechanics News, published twice a year
- Local symposium proceedings

The current issues of the journals are shown below. Members can directly download the contents from the official websites of the societies. The journals can also be purchased by contacting society secretariates.



## CONTRIBUTIONS TO THE ISRM COMMISSIONS

Members of the region contribute to several of the ISRM Commissions. These include:

- Commission on Rock Dynamics (chaired from Australia)
- Commission on Deep Mining
- Commission on Design Methodology
- Commission on Rockburst
- Commission on Soft Rocks
- Commission on Sorptive Rocks
- Commission on Testing Methods
- Commission on Coupled THMC Processes in Fractured Rock



**NZ Geomechanics News**  
Issue 105  
June 2023



**Australian Geomechanics Journal**  
Volume 58, Number 3  
September 2023

## 12 EUROPE

Leandro R. Alejano | Vice President for Europe

Europe is the region encompassing half of the National Groups (NGs) of the ISRM with 30 countries represented. Due to their idiosyncratic, historical and linguistic differences, they are rather heterogeneous. Moreover, the NGs focus different disciplines. While in some cases, they are restricted to rock mechanics, in some countries they are part or a branch of a wider typically geotechnical or other type (tunneling, mining) society.

In the last year, Europe has overcome the Covid-19 times, so many activities have come back to take place in a face-to-face way and some conferences have also taken place.

The Finnish NG successfully organized the EUROCK 2022 symposium in Espoo on September, 2022. Around 200 papers were accepted corresponding to two tracks, namely scientific and industry, and around 300 delegates attended. Some interesting short courses were given the day before the congress, including "Modern Rock Engineering Principles", "2D and 3D Modelling of Fracturing Processes in Rock Mechanics", "Photogrammetry for Rock Mass Characterization" and "Recent ISRM Suggested Methods and Future Prospects". Four keynote lectures were delivered by John Harrison, Michael Giovinazzo, Caroline Darcel and Sanna Mustonen. An excellent representation of the industry was presented in the technical exhibition, where more than 10 companies represented. Some excursions took place after the congress. This was a successful event where the European rock mechanics community were able to meet in person again.

On 2023 there was no EUROCK conference, since the International ISRM has taken place in Salzburg (Austria), organized by the Austrian National Group. Around 60 years ago, a few rock mechanics experts gathered by Professor Müller in Austria decided to launch the ISRM. So, rock mechanics is coming back to its very cradle. This 2023 ISRM congress has been a successful event with over 1,000 delegates from countries all over the world. A relevant participation of delegates of most European countries have actively participate in this congress.

Two years ago, it was decided to select Alicante in Spain as the venue of the EUROCK 2024. The organization of this meeting is going well and more than 300 abstracts have been collected after closing the deadline. Five excellent keynote speakers have been appointed for this conference and some courses and excursions are being prepared for this singular symposium, including an exciting geological cruise in the Mediterranean coast near this town. All members of the ISRM are warmly welcome to attend this hopefully interesting and entertaining event!

Trondheim in Norway was chosen to hold EUROCK 2025. It is worthy to mention that Norwegian National group tried to organize EUROCK 2020 that was finally cancelled due to pandemics. They have, moreover, applied to become the international ISRM congress in 2025, an honor that was awarded to them in the Council meeting hold in Salzburg. We wish our Norwegian colleagues the best in the preparation of this congress.

The ISRM VP for Europe organizes annually informal council meetings of the European NGs. This year an informal meeting of European NGs was also held successfully in Salzburg in parallel with the ISRM International Congress. A good representation of European Groups show up in this meeting where the former ISRM VP for Europe, Leandro R. Alejano, warmly thanked European NGs for their help and support in the past four years. In this meeting, Muriel Gasc-Barbier, the new elected ISRM VP for Europe, was introduced to the present members. She presented some relevant ideas for her coming office. She additionally asked for the help and support of European NGs. The undersigned wishes her the best in the challenging coming years.

Based on an initiative of Charlie Li and with the acquiescence of the European council, European Rock Mechanics Debates are organized by the ISRM VP for Europe with the help of Philippe Vaskou from France. The first Rock Mechanics European Debate took place in the Zoom platform in October 2021 and the second one in June 2022.

This year two more debates have taken place. The third European debate took place on the 25th January 2023 and it addressed the topic "Different approaches for tunnelling: empirical, observational, modelling" starring Nick Barton (Norway and Brazil) and Yosef H. Hatzor (Israel). The fourth European debate was hold on the 19th June 2023 and it covered the subject "Two different tunnelling approaches: the New Austrian Tunnelling Method (NATM)



Representatives of the European NGs after the Informal Meeting held on 11th October in Salzburg, Austria.

and the Norwegian Method of Tunnelling (NMT)” being the opponents Wulf Schübert (Austria) and Krishna Kanta Panthi (Norway). Both debates were held in the Zoom platform and broadcasted through the ISRM YouTube channel, where they can be revisited. It is fair to recognize that these debates would not have been possible without the tireless efforts of Philippe Vaskou, who organized them, contacted the speakers and acted as moderator.

Some European NGs (France, Italy, Spain...) encouraged a year ago young members to organize international webinars. These activities have continued and increased under the umbrella of ISRM’s Young Member Group with a strong participation of the European NGs’ members.

The activities developed by European ISRM NGs are varied. The 2-3 most relevant activities of European NGs are synthesized in the following table, based on the answers of ISRM NG’s presidents to a call sent by the ISRM VP. In addition to that, a good number of other activities including rock mechanics days, working group studies, awards for young researchers, professional or academic short courses, excursions to relevant sites or projects and so on take place in the different countries of Europe fostered by the National groups. 🇪🇺

## NG SOME RELEVANT ACTIVITIES

AUSTRIA	Creation of Young Members section Preparation and organization of the 15th ISRM Congress Revision of guideline for geotechnical design of underground structures
BELGIUM	9/9/2022: jubilee “50 years of Engineering Geology and Rock Mechanics in Belgium” 7/3/2023: workshop “Damages related to swelling clays” 31/5/2023: General Assembly and visit of a future hospital building site
BOSNIA-HERZ.	Geotechnical Society of Bosnia and Herzegovina held the expert 2023 scientific and expert conference in Mostar October 19, 2023 Geotechnical Society of Bosnia and Herzegovina published Proceedings of the scientific and expert conference GEO-EXPO 2022
BULGARIA	Holding of the XVII International Conference on the open and underwater mining of minerals in the period 18-22 September, 2023 at the Astor Garden Hotel, Sts. Constantine and Helena Resort, Varna, Bulgaria
CZECH REPUBLIC	International conference - New Knowledge and Measurements in Seismology, Engineering Geophysics and Geotechnical Engineering, March 28-29, 2023 Mining in 21st century – international workshop (May 10-11, 2023) Co-organizing of the Workshop on post-mining seismicity, September 24-25, 2023, Katowice, Poland ( <a href="https://postminquake.eu/workshop-2023/">https://postminquake.eu/workshop-2023/</a> )
FINLAND	The Finnish national group has changed name from Kalliomekaniikkatoimikunta to Kalliomekaniikkayhdistys, and made necessary changes to fulfil the GDPRP
FRANCE	December 1 2022: General Assembly (2022 Jean Mandel Lecture) new challenges of landslides and ground movements. A.M. Ferrero Organization of technical and scientific meetings (4 per year) 2023 March 23: Joint session with CFGI: “The role of the expert in rock mechanics and engineering geology in situations of multi-stakeholder controversy” May 11: Session devoted to “The young colleagues’ views on geo-education” October 19: Technical and scientific session dedicated to French communications presented at the ISRM congress in Salzburg December 7: General Assembly (2023 Jean Mandel Lecture) and session devoted to “Innovations in Underground” co-organized with CFMS and CFGI Organization of the International Conference: Underground Storage and Geoennergies: Solutions for Energy Transition? held at Ecole Polytechnique (Palaiseau, France) and Ecole des Mines de Paris on 14-15 June 2023
GERMANY	From 5 to 7 October 2022, the 37th Baugrundtagung took place in Wiesbaden From 12 – 13 September 2023 the German Geotechnical Society (DGGT) organized the Fachsektionstage Geotechnik – Interdisziplinäres Forum (Meeting of Expert Groups - Interdisciplinary Forum) with 5 parallel Conferences

GREECE	<p>Organization of the 9th Hellenic Conference on Geotechnical Engineering – Athens, Greece / 4 – 6th October 2023.</p> <p>14th Athenian Lecture on Geotechnical Engineering was given by Dr Paul Mayne, Emeritus Professor of Georgia Institute of Technology, Atlanta, USA</p> <p>The 3rd Blight Lecture by Professor Eduardo Alonso was given during the 8th Int. Conf. on Unsaturated Soils held on Milos island, Greece, in April</p>
ICELAND	<p>Iceland was the host of NROCK 2023 – The 4th Nordic Symposium on Rock Mechanics and Rock Engineering, Reykjavik, May 24-26th 2023. The symposium was established by both The Icelandic Geotechnical Society and The Icelandic Tunnelling Society. Link to the symposium proceedings and papers:  <a href="http://www.nrock2023.com/uploads/2/1/7/9/21790806/nrock2023_proceedings_all_papers.pdf">http://www.nrock2023.com/uploads/2/1/7/9/21790806/nrock2023_proceedings_all_papers.pdf</a></p>
ITALY	<p>Geotechnical Models for Slope Stability of excavation faces in rock masses: from theory to case studies. Chair: Prof. Tatiana Rotonda. 24 November 2022</p>
MACEDONIA	<p>2022.06.23-25 5th Symposium of MAG, ISRM Specialized conference, supported also by ISSMGE</p> <p>2023.03.02-03 Co-organization of course: “Applied Geomechanical Modeling of Rock Mass Behavior in light of infrastructure projects”</p>
THE NETHERLANDS	<p>18 November 2022- Ingeokring-TU Delft Autumn symposium From Rock to Opera in honor of Robert Hack.</p> <p>17 February 2023- Ingeokring Get together! Series of lectures on Engineering geology at the Fehmarnbelt tunnel project</p>
NORWAY	<p>Rock mechanics day 2022 (200+ participants every year). Last Friday November</p> <p>RS2 course, January 2023</p> <p>“Vårsleppet” which is combined with the Annual general meeting. Half day of lectures and debates on various Rock mechanics matters, followed by general meeting and a dinner afterwards with our members</p> <p>Various Board meeting where EUROCK 2025 is being organized</p>
PORTUGAL	<p>Celebrations of 50 years of SPG - Seminar “Geotechnics as a reference for Portuguese Engineering” (November 2022)</p> <p>The XXXIX Manuel Rocha Lecture by Dr. Luís Lamas entitled “Determination of the stress state in rock masses for the design of underground structures” (Oct.22). The 18th National Geotechnical Congress (18CNG) was held at the University of Évora between May 14 and 17, 2023</p> <p>Geotecnia journal indexation</p>
SLOVENIA	<p>General Assembly of Slovenian Geotechnical Society, April 2022</p> <p>Technical Excursion on the building site of Karavanke Tunnel, July 2022</p> <p>Technical Excursion to the building site of Second railway line Divača-Koper, June 2023.</p>
SPAIN	<p>XX Annual Technical Conference: Rock mechanics on underground works</p> <p>Professor Cesar Sagaseta is named Honorary Member</p> <p>14th SEMR Newsletter</p>
SWITZERLAND	<p>3rd and 4th November 2022 Excursion to Munich, 2. S-Bahn-Main Line Munich</p> <p>29th March 2023 Conference on “Wasserhaltung, Drainage, Abdichtung (Dewatering, Drainage, Waterproofing)” in Biel Switzerland</p>
TÜRKIYE	<p>Turkish NG Chairman and members who contributed to Rock Mechanics society were awarded.</p> <p>UYAK 2023, 5th International Underground Excavations Symposium and Exhibition was held in Istanbul, Türkiye on June 5-7, 2023. The symposium was organized by the UCTEA Chamber of Mining Engineers and supported by the Turkish National Group of ISRM. The ISRM President Reşat Ulusay attended the symposium as a session chair</p>
UNITED KINGDOM	<p>Prof John Carter delivered the 61st Rankine Lecture at Imperial College London: Constitutive Modelling in Computational Geomechanics (15/03/2023)</p> <p>The BGA Biennial Conference Series: Geo-Resilience 2023 conference took place in Cardiff on 28-29 March 2023.</p> <p>The BGA Annual Dinner is a new addition to BGA's annual calendar of events. This prestigious occasion brings together the geotechnical community for an evening of fine food, socializing and networking. The inaugural BGA Annual Dinner included a lecture by Professors John Burland and Jamie Standing on the underpinning of Winchester Cathedral. (26/09/2023)</p>

## LATIN-AMERICA

José Pavón | Vice President for Latin-America

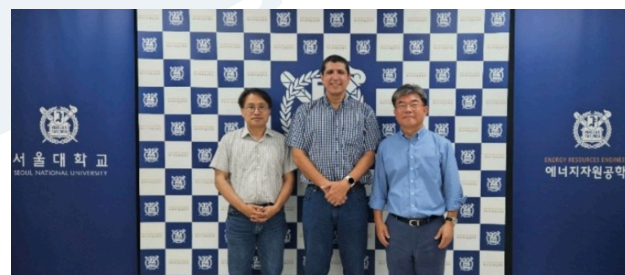
The ISRM Latin American region has nine National Groups: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Paraguay and Peru. Recently, Chile and Peru have been increasing the number of associates; currently, there are more than 500 members. The daily participation of academics, practitioners, and students in rock mechanics was relevant.

The interaction between societies has been fundamental during the year. In addition, representatives of the societies have participated in regular regional meetings to discuss major activities and plan for the future. We are preparing the next edition of the 10th Latin American Rock Mechanics Symposium.

Symposia, seminars, courses, and webinars have reached many professionals, and a growing demand for training in different areas. Open pit mines and deep mining stood out with special mention.

Last July, the ISRM VP for Latin America was invited to present a seminar, "Geologic Concerns with Itaipu Dam," at the Seoul National University (SNU). During his stay in Korea, he visited several works in progress, like Gimpo-Paju TBM tunnel (14m in diameter), slope construction at the express highway site Ahnsung-Yong-In, and Yemi underground research laboratory (1.000m depth).

Last August, with the support of the Korean Society for Rock Mechanics and Rock Engineering (KSREM), webinars were given as a cooperation between KSREM and Latin American Societies. The chosen topics were related to rock excavation, tunneling, and slope stability, given by relevant lecturers. The webinars were hosted on the Youtube platform. Future cooperation between KSREM and the Latin American NGOs is open.



Some important activities of the National Group are mentioned below:

### ARGENTINA

Argentine Congress of Soil Mechanics and Geotechnical Engineering, Comodoro Rivadavia, August 30-31, 2023.

<http://saig.org.ar/congresos/>

### BOLIVIA

Online presentations and Webinars. <https://www.geomecanicabolivia.com>

### BRAZIL

YouTube videos about laboratory tests and Online presentations published on IX Brazilian Rock Mechanics Seminary. Journals published quarterly and social media. <https://www.cbmr.com.br>

CBMR nas Universidades ▶ Reproduzir tudo

Thumbnail	Thumbnail	Thumbnail	Thumbnail	Thumbnail	Thumbnail
Introdução: "CBMR nas Universidades"	Extração de Amostras de Rocha	Preparação de Amostras para Ensaios de Laboratório	Ensaio de Resistência - Esclerômetro de Schmidt	Ensaio de Velocidade de Propagação de Ondas	Tilt Test
CBMR Oficial 124 visualizações • há 3 meses	CBMR Oficial 192 visualizações • há 3 meses	CBMR Oficial 103 visualizações • há 3 meses	CBMR Oficial 388 visualizações • há 3 meses	CBMR Oficial 67 visualizações • há 2 meses	CBMR Oficial 75 visualizações • há 2 meses

IX Simpósio Brasileiro de Mecânica das Rochas ▶ Reproduzir tudo

Thumbnail	Thumbnail	Thumbnail	Thumbnail	Thumbnail	Thumbnail
Resistência de juntas alteradas e não alteradas...	Uso de ensaios na determinação da...	Estudo de melhoria contínua do sistema de enchimento...	AVALIAÇÃO DO VALOR DE EXPECTATIVA EMPÍRICA...	NOVOS MÉTODOS PARA DETERMINAÇÃO DE...	REDUÇÃO DAS POROPRESSÕES EM...
CBMR Oficial 124 visualizações • Transmitido há 6 meses	CBMR Oficial 115 visualizações • Transmitido há 7 meses	CBMR Oficial 157 visualizações • Transmitido há 7 meses	CBMR Oficial 127 visualizações • Transmitido há 7 meses	CBMR Oficial 155 visualizações • Transmitido há 9 meses	CBMR Oficial 211 visualizações • há 8 meses

## 12 CHILE

Online presentations and Webinars like “Geomechanics challenges”, June 2023.

First Chilean Congress on Rock Mechanics, November 2023.

<https://www.scmr.cl>



## COLOMBIA

Online presentations and Webinars.

<https://www.scg.org.co>

## COSTA RICA

Online presentations and Webinars.

<https://www.geotecniacr.com>



## MEXICO

5th Congress on Tunnels and Underground Constructions, Mexico City, November 2023

Journals published quarterly and social media.

<http://www.smig.org.mx>



## PARAGUAY

Paraguayan Geotechnical Congress, Asuncion, August 2023.

Geotechnical challenges considering climate change, Lecture, Asunción, September 2023.

<https://larms2022.com/>



## PERU

VII Geoenvironmental Peruvian Symposium, Lima, December 2023.

Elements of seismic hazard in mines, short course, November 28, 2023

<http://speg.org.pe>





## NORTH-AMERICA

Laura Pyrak-Nolte | Vice President for North America

The total ISRM membership in North America is approximately 537 members. The US National Group, ARMA (American Rock Mechanics Association), has 417 ISRM members. The Canadian National group, CARMA (Canadian Rock Mechanics Association), has 120 ISRM members.

### UNITED STATES OF AMERICA

ARMA represents the ISRM's National Group for the United States of America and currently has 712 active members. One third of its members are from outside the US and 15% of the members are students. The President of ARMA is Dr. Andrew Bungler (University of Pittsburgh).

ARMA held its **57th US Rock Mechanics/Geomechanics Symposium (hybrid)** in June 25-28, 2023, that included workshops on Distributed Fiber Optics Sensing, Drilling Geomechanics, Educational Session and Hydrogen Storage. ARMA also held an **East Asia Geomechanics Workshop** 11-12 August 2023 at the Hong Kong Polytechnic University with a theme of "Geomechanics and Geophysics for Sustainable Energy Development. This was followed by the **International Geomechanics Symposium** on 30 October–2 November 2023, in Al-Khobar, Saudi Arabia.

### ARMA HONORS AND AWARDS

The **ARMA 2021 Class of New Future Leaders** consists of 10 inductees: Eric Edelman, Maalouf Elsa, Yao Huang, Teeratorn Kadeethum, Liu Li, Andreas Michael, Mostafa Mobasher, Mohammed Abdul Qadeer Siddiqui, Qi Zhang and Yinquin Zhang.

**The Neville G. W. Cook Ph.D. Thesis Award:** Ziyang Li (Penn State University): "Predicting Induced Seismicity and Permeability Evolution through Laboratory Experiments and Machine Learning Methods".

**Rock Mechanics Research Award:** Mengke An, Fengshou Zhang, Derek Elsworth (Penn State University): "HPHT Fault Gouge Friction Experiments: Implications for Hydraulic Fracturing Induced Seismicity in the Suchan Basin".

**Case History Award:** Lauren Reeher (University of Arizona), Seth Busetti (Aramco Services), Amanda Hughes (University of Arizona): "Field Evidence and Elastic Dislocation Modeling of Stress Field Alteration in the Rock "

### ARMA ACTIVITIES

**ARMA Technical Committees:** There are currently 7 Technical Committees that include (1) Hydraulic Fracturing, (2) Induced Seismicity, (3) Drilling Mechanics and Engineering, (4) Underground Storage and Utilization, (5) Tunneling, (6) Discrete Fracture Networks, and Artificial Intelligence and Data.

**ARMA Student Chapters:** Supporting engagement with the next generation of practitioners, ARMA now has 25 student chapter with the addition of American University - Beirut, University of Utah, University of New South Wales – Sydney, and Chengdu University of Technology.

### CANADA

CARMA represents the ISRM's National Group for Canada. Members are from CARMA's two constituent groups, the Rock Mechanics Division of the Canadian Geotechnical Society (CGS), and the Society for Rock Engineering of the Canadian Institute of Mining and Metallurgy (CIM). CARMA currently has 120 active members and the President of CARMA is Dr. Jennifer Day (Queens University).

CGS RMD had 22 papers across 4 sessions at GeoSaskatoon 2023, the 76th Annual Canadian Geotechnical Conference – October 1-4, 2023, Saskatoon, SK, Canada. The CIM RES had good representation at the CIM Annual Conference in May 2023 in Montreal, Quebec with a rock mechanics technical stream with 27 presentations

In 2023 on CARMA's social media accounts, the number of followers have increased on LinkedIn (1,392 followers) and Instagram (126 followers). The design of the CARMA website has been modernized and updated to include both English and French languages (both Official Languages of Canada). The Dr. Evert Hoek Master's Thesis award was created to recognize outstanding contributions in rock mechanics and rock engineering Canadian community. A new webinar series has been initiated with the RES & CGS RMD. The 1st webinar was given by Dr. Matthew Pierce on "Application of systematic point load testing to characterization of massive, veined orebodies".

## 12 VICE-PRESIDENTS AT LARGE

Ömer Aydan  
Qiang Yang  
Vojkan Jovičić

In each term of office, the ISRM Statutes allow the Board to appoint a maximum of three Vice-Presidents at Large. Their role is to support their regional Vice-President and to contribute to the Board activities, to ISRM Committees and Commissions and sponsored events, and to assist the organizing commission of the sponsored events with their know-how.

Ömer Aydan served as the member of ISRM Technical Oversight Committee and evaluated the activities of ISRM commissions, in evaluating Doctorate Theses for Rocha Medal 2024, and of the ISRM Commissions on Planetary Rock Mechanics, on Testing Methods and on Underground Nuclear Power Plants as its member. He also participated in ISRM Board and Council meetings held in Salzburg, Austria, in October 2023. In addition, he participated in several online board meetings related to the activities of ISRM since the board meeting held in Asunción, Paraguay in October, 2022.

Besides his activities of ISRM Planetary Rock Mechanics Commission as its member, he gave a talk on the Workshop of the commission on “Some attempts to infer mechanical properties of rocks and discontinuities in Mars and some comets” and a lecture on “Some thoughts on Rock Mechanics and Rock Engineering in Mars” at Early Career Forum during 15th ISRM Congress in Salzburg.

He has been promoting the activities of the ISRM Commission on Testing Methods as its member. In addition to the SM on Dynamic Shear Testing, he has been promoting activities on the preparation of some suggested methods on “Discontinuity Characterization” and “Drop Tests” and “Impression Creep Testing”.

He has been started a video lecture on “Rock Dynamics and Recent Advances” as an ISRM Video Course (11 lectures).

He has been participating the board meetings of National Group of Japan Rock Mechanics and Rock Engineering Society as an observer member as a ISRM Vice-president. He continued to write essays to convey the activities of ISRM to the digital newsletter of the Japanese Society for Rock Mechanics (JSRM), the Japanese National Group, denoted as “From the ISRM Vice-President”.

He carried out a reconnaissance of 2023 Great Turkish Earthquakes (some information available in ISRM web-site) with President Ulusay twice and some other members from Japan and China. He gave some keynote presentations on ‘2023 Türkiye Earthquakes with Emphasis on Rock Mechanics and Rock Engineering’ in China-Rock

2023. He will deliver another lecture on “2023 Great Turkish Earthquakes and some Lessons” in the Young Engineers evening seminar organized by Japan Rock Mechanics Society on December 11, 2023. In addition, he delivered a recorded video lecture on “Recent Pazarçık and Ekinözü Earthquakes in Türkiye’ for Geotechnia Brasil on May 31, 2023.

He published from CRC Press a book on Earthquake Science and Engineering from a rock mechanics view point and he has been now planning to publish another book on “Geomechanical aspects of Abandoned Room and Pillar Mines and Remediation, which is now under review and will be published in the ISRM Book Series category.

This is the outline of activities that Vojkan Jovičić, VP of ISRM at large, undertook during the period from November 2022 to November 2023. The outline is divided into several main events he was taking part or organising it, as follows:

Invited keynote lecturer on ChinaRock2022 organised by the China Society of Rock Mechanics and Engineering (CSRME), in November 2022.

As an invited speaker, Dr. Vojkan Jovičić, VP of ISRM at large, delivered the keynote lecture on the topic: “Temporary and Final Portal Structures for Tunnels in Soft Rock”. The lecture was delivered during the plenary session on 4th November. The annual conference was organised on-line by the NG of China (CSRME) and assembled engineers from Rock Mechanics related professions of China.

### Activities for the application of Macedonian Association for Geotechnics for EUROCK 2026

Vojkan Jovičić, as a member of the organisation committee, took part in the activities for the application of Macedonian Association for Geotechnics for EUROCK2026, an ISRM Regional Conference to take place in Skopje in 2026. These activities were carried out on-line with participation of Ivan Vrkljan (fISRM Fellow) and representatives of the North Macedonia national group.

This was a successful application and the national group of North Macedonia will host EUROCK 2026 under the title “Risk Management in Rock Engineering” between the 14th and 19th September 2026.

### Organization of the activities of Slovenian Geotechnical Society: Technical Excursion to Lokev tunnel construction: Invited lecture and guiding of the site visit

Vojkan Jovičić, former president of SLOGE – Slovenian Geotechnical Society, organised and hosted a technical excursion to the members of the society to the building site of Divača Koper Railway line. The new railway line Divača-Koper connects the only Slovenian port – Luka Koper – with the logistics railway hub in Divača. The route is 27.1 km long and overcomes a 400 m height difference between the Slovenian karst plateau and sea level. Tunnel T1 (Lokev) is approximately 7 kilometers long and goes through a heavily karstified rock mass. Vojkan Jovičić delivered an invited lecture on the topic of experience gained in overcoming karstic features during the ongoing construction of the tunnel.



### Organisation of the 8th Early Career Forum at EUROCK 2023 in Salzburg

Vojkan Jovičić was delegated the task to organise the 8th Early Career Forum that took place at EUROCK 2023 in Salzburg. The 8th Early Career Forum assembled young engineers from South-Eastern Europe: Ignacio Pérez-Rey (Spain), Renato Pereira (Portugal), Maria Teresa Carriero (Italy), Anastasios Tsikrikis (Greece), Ardita Malaj (Albania) and Andor Németh (Hungary). The 8th Early Career Forum session was very well attended and it was

chaired by Resat Ulusay (Past-President of ISRM), Vojkan Jovičić and Yand Qiang (ISRM Vice-Presidents of ISRM).

As the chairman of the Education Fund Committee (EFC), Qiang Yang has successfully raised a fund of 100 000 RMB (about € 12 842) to the EFC Beijing office. The 8th Early Career Forum, chaired by Vojkan Jovičić, Resat Ulusay, and Qiang Yang, was successfully held during the 15th International ISRM Congress 2023. Six young engineers and researchers from Europe participated in the forum. The budget of the 8th Early Career Forum was € 9 600, which is shared in equal parts by ISRM and the EFC Beijing Office.

Qiang Yang served as the organizing committee chair of the ChinaRock 2023, which was held on Oct. 20-22, in Beijing, China. In addition to the main venue in Beijing, there were 13 central venues in other major cities, and 191 satellite venues in universities and institutes. In total, the conference attracted a total of 118,600 participants from China and foreign countries. Qiang Yang and his colleagues also chaired a parallel session on “Unloading induced disasters in deep rock mass and



mitigation methods”, and he also delivered a keynote lecture in the session.

Qiang Yang served as the organizing committee chair of the 7th National Conference of Rock Mechanics in Hydraulic Engineering, which was held on Nov. 17-19, in Xian, China. There were 12 keynote lectures and 6 parallel sessions. A young forum for postgraduate students was also organized, and a few awards

were given to excellent presentations.

This seminar series on Rock Mechanics organized by Tsinghua University were initiated and organized by Qiang Yang Assoc. Prof. Zhihong Zhao from Tsinghua University, Hywel R Thomas from Cardiff University, who is a foreign academican of the Chinese Academy of Sciences and a distinguished visiting professor in Tsinghua University, gave a seminar titled “Energy and the Ground, Some Recent Developments” on Oct. 20, 2023. ▀

## 13 MÜLLER LECTURE

Derek Martin PhD, FCAE, FEIC



### STRESS PATH, STIFFNESS AND MOBILIZED STRENGTH IN ROCK MASSES FOR NEAR SURFACE STRUCTURES

Leopold Müller, the founding father of the ISRM, did his doctoral thesis on the “Statistical Collation of Joint Measurements”. It was the role of fractures in the behaviour of rock masses that underpinned the formation of the ISRM and became the topic of many of the early publications. One of those early publications was the Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses (ISRM 1978) which proposed that the quantitative description of discontinuities could be established using: orientation, spacing, persistence, roughness, wall strength, aperture, filling, seepage, number of sets and block size.

#### 1. BACKGROUND

Leopold Müller, the founding father of the ISRM, did his doctoral thesis on the “Statistical Collation of Joint Measurements”. It was the role of fractures in the behaviour of rock masses that underpinned the formation of the ISRM and became the topic of many of the early publications. One of those early publications was the Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses (ISRM 1978) which proposed that the quantitative description of discontinuities could be established using: orientation, spacing, persistence, roughness, wall strength, aperture, filling, seepage, number of sets and block size. The focus of these descriptors enabled the practitioner to move from core logging and outcrop mapping to limit equilibrium stability analyses, commonly used in practice when assessing stability of rock blocks sliding on discontinuities. That 1978 Suggested Method focused on geometry and shear strength of the discontinuity and ignored the stiffness characteristics. That deficiency was corrected by Bandis et al (1983).

Using the framework developed by Goodman (1970), Bandis et al (1983) showed that the normal stiffness ( $k_n$ ) of a discrete fracture in a laboratory sample was highly nonlinear (Figure 1). They also concluded that both the normal stiffness and shear stiffness was a function of the normal stress and that the shear stiffness was a function of experimental setup and the size of the sample being tested. Recent work by Packulak et al., (2022) to correct the direct shear testing data for machine influences when determining the normal and shear joint stiffness also supported the early findings of Goodman (1970) and Bandis et al., (1983).

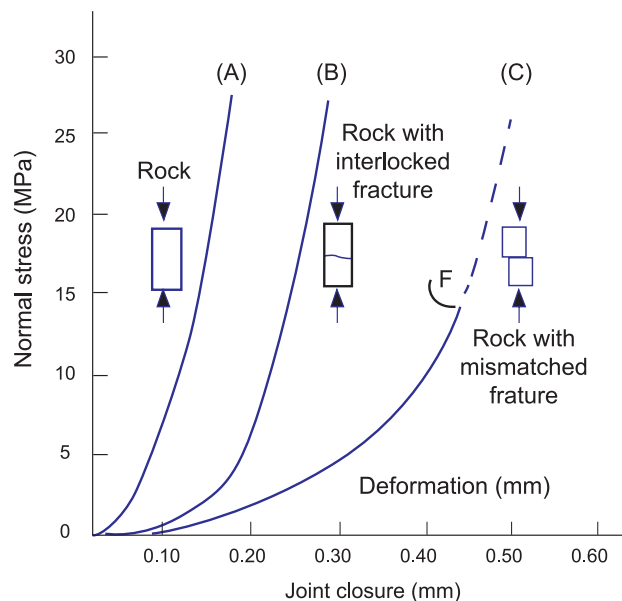


Fig 1. Nonlinear relationship between normal stress and joint closure of a joint in granodiorite (modified after Bandis et al., 1983)

In rock engineering, deformation analyses are commonly needed to forecast expected displacements. Such analyses incorporate the effect of fractures using continuum approaches where the modulus of the continuum is reduced from the modulus of the intact rock to reflect the role of the fractures, and/or using discrete fractures. In the analyses including discrete fractures, the normal stiffness is a controlling parameter when forecasting the rock mass deformation. For near surface rock structures, the normal stress that influences the normal stiffness is relatively low,

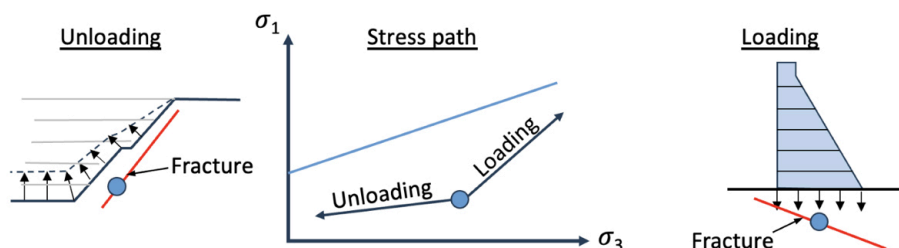


Fig 2. Illustration of unloading and loading stress path for fractures in near surface rock structures.

typically less than a few MPa. In Figure 1, the normal stress needed to observe the nonlinearity of ( $k_n$ ) can be quite large typically exceeding 5 to 20 MPa. Hence questions that arise for near surface structures are: 1) Is the nonlinear behaviour of the fractures observed in the laboratory at high normal stresses also observed in-situ? and 2) What normal stiffness is relevant for a deformation analysis? In this Müller lecture, case histories are used to address those questions using the loading beneath a dam foundation and the unloading of a rock slope (Figure 2).

## 2. GEOLOGICAL FRACTURES AND NORMAL STIFFNESS

### 2.1 Terminology

In the ISRM (1978) Suggested Method "Contributors to the Working Party were divided in their recommendations for the best general term to represent all "breaks" in rock masses. However, a clear majority preferred discontinuity rather than fracture, as the collective term for all joints, bedding planes, contacts and faults." In rock engineering practice, fractures mapped at the project scale are referred to as joints, shears and faults. Joints are defined as parting planes with no evidence of movement. These fractures are typically found at the metre scale (1m to 10 m) and were formed in an extensional stress environment.

The terms shears and faults in rock engineering are often used synonymously. Similarly in geology, Fossen et al (2017) note that shear zones separate less strained or unstrained portions of the lithosphere, and are the deeper counterparts to upper crustal faults and fault zones. Both shears and faults imply the fractures have been subject to shear displacement that has resulted in the formation of "gouge". Skempton (1966) described the characteristics of the tectonic shear zones found in the sedimentary sequence at the Mangla Dam Project and Deere (1973) describe the foliation shear commonly found in metamorphic complexes. Bedding plane shears formed during river valley down cutting were described by Patton and Hendron (1974). The trace length of shear zones can vary significantly from metres to kilometre despite being only centimetres thick.

The fault term is often relegated to regional brittle fractures with an associated mechanically-induced deformation zone. In this deformation zone microcracking and the joint/fracture frequency increases

significantly and the thickness of this zone can reach many 10s metres. Shear offsets are typically measured at the metre scale and the fault gouge/breccia can also be measured at the metre scale. Riedmüller et al (2001) proposed a fault classification but acknowledged that their extreme complexity makes their geotechnical characterization and investigation difficult. To the author's knowledge this situation remains today.

### 2.2 Values of measured Normal Stiffness

When Goodman (1970) compiled his seminal work on the deformability of joints, he concluded "... almost nothing is known of the correct values for normal stiffness". Since then, reporting of normal stiffness values of joints can be found in the literature. Zangerl et al., (2008) compiled the normal stiffness values reported for 91 laboratory tests and 24 in-situ tests. The joints tested included artificial fractures, tension fractures, natural fracture and shear fractures primarily all in granitic type rocks. The normal stress values used to measure the stiffness in the laboratory tests ranged from 2 MPa to 160 MPa, while for the in-situ tests the normal stress ranged 1.4 to 10 MPa. The distribution of the normal stiffness values associated with those normal stresses is provided in Figure 3.

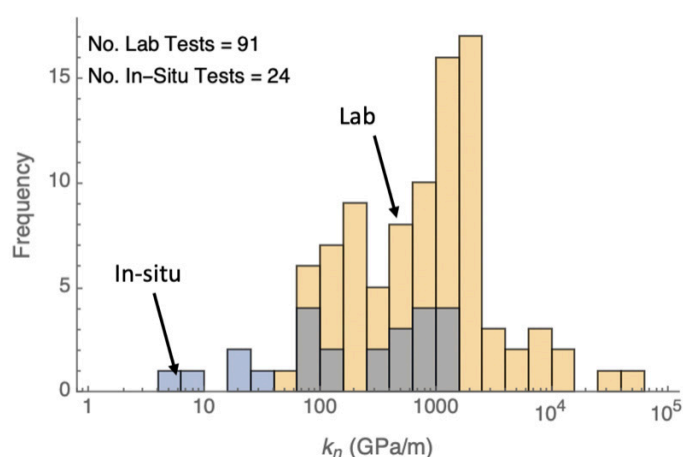


Fig 3. Range in normal stiffness values from 91 laboratory tests (yellow) and 24 in-situ tests (gray). Data from Zangerl et al (2008).

Table 1: Summary of normal stiffness values from in-situ shear tests on shear zones with different thicknesses

Thickness [mm]	$(k_n)$ [GPa/m]	Normal Stress [MPa]	Reference
<1	>5	1	Infanti & Kanji (1978)
10 - 20	0.5 - 2.0	0 - 0.45	Infanti & Kanji (1978)
50 - 100	0.1 - 0.5	0.3 - 0.55	Infanti & Kanji (1978)
10 - 15	0.1 - 1.7	0.5 - 0.9	Personal Files

As noted by Bandis (1980) in-situ testing is the only reliable means of evaluating the deformation characteristics of geological fractures such as shear zones. In-situ direct shear tests are typically carried out to establish the shear strength of a weak plane/zone, with the  $(k_n)$  seldom being measured. The scale of these blocks used in these tests are approximately 1 m to 2 m and the maximum normal stresses are typically less than 1 MPa. The low normal stresses used in these tests reflect the confining stresses found in near surface structures. Table 1 summarizes the normal stiffness values from these in-situ tests for shear zones containing varying thicknesses of infilling. Note that these normal stiffness values are much lower than the values in Figure 3 and decreases as the infilling thickness increases. It is important to note that the moisture content of the shear zone infill can influence these results and that the values in Table 1 were obtained using the natural moisture content of the infill.

The normal stiffness values for faults are seldom reported in the literature. Martin et al., (1990) conducted borehole tests to measure the normal stiffness of a major fault zone at a depth of 240 m. Using a specially designed borehole tool called the PAC-EX they measured the change in normal stress and the associated change in normal displacement. They concluded that the normal stiffness of the fault was highly variable and that the core for the fault zone ranged from 2 to 6 GPa/m over a confining stress range from 0.1 to 1.9 MPa (Figure 4). Over the range of normal stresses used for their testing, there was no obvious nonlinear relation between normal stiffness and confining stress.

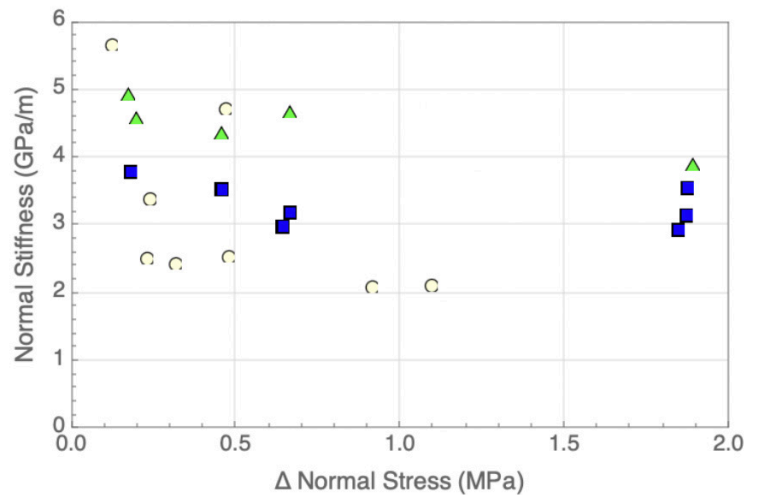


Fig 4. Normal stiffness of a major thrust fault (data from Martin et al., 1990)

### 3. LOADING OF A DAM FOUNDATION

The B. C. Hydro Revelstoke Dam consists of a 160m high concrete gravity dam constructed between 1977 and 1984 (Figure 5). Imrie and Moore (1993) described the project challenges and summarized the geological conditions as micaceous gneisses interlayered with calc-silicate and lesser amounts of quartzite and marble. The complex metaphoric rock mass foundation contained, a regional fault, 10 to 30 mm thick foliation shears containing graphitic gouge and extensive jointing in close proximity to the regional fault. The RQD for the concrete dam foundation varied from 25 to 50%, reflecting the intensity of the brittle deformation associated with the regional faulting.

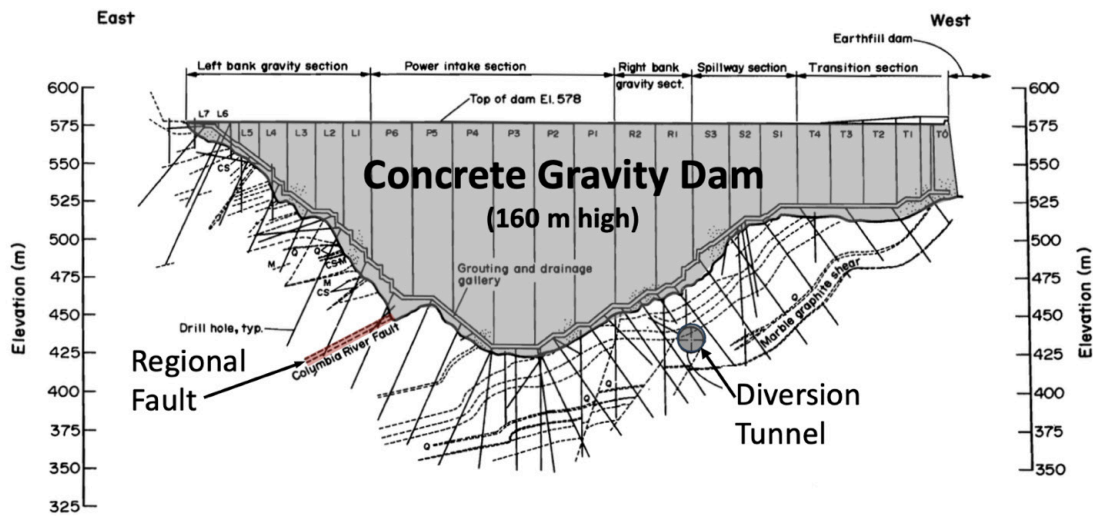


Fig 5. Cross Section of the Revelstoke concrete gravity dam (modified from Imrie and Moore, 1993)

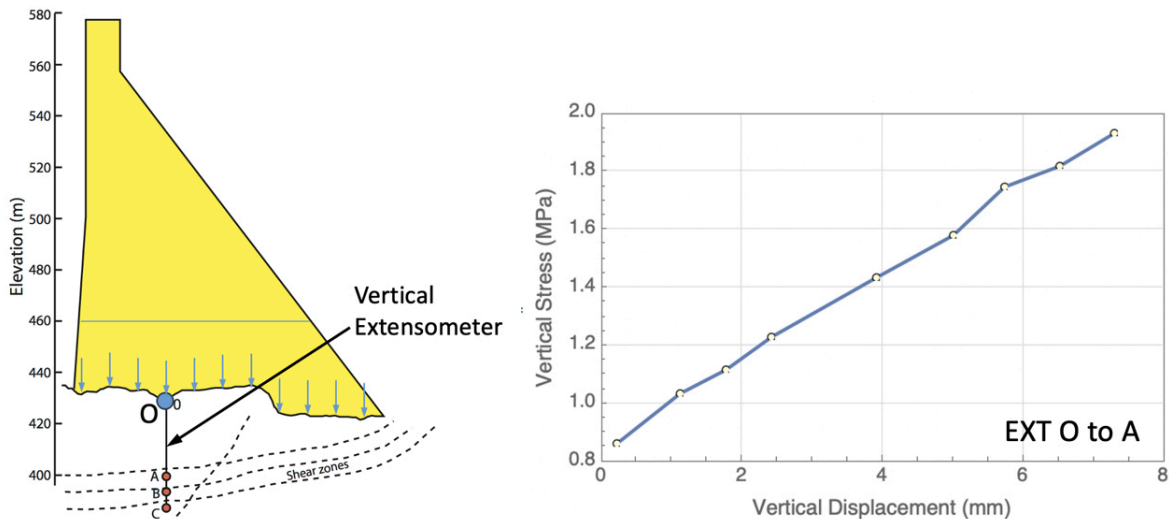


Fig 6. Location of the vertical multipoint extensometer beneath the dam foundation, and the measured vertical displacement and the vertical stress applied by the concrete dam at O as construction progressed.

The foundation displacements associated the concrete dam loading were recorded by a multipoint vertical extensometer. The location of the extensometer is shown in Figure 6. As the dam height increased the associated displacements were measured. The height of the dam was converted to a vertical stress using a simple elastic model. The relationship between the vertical stress induced by the dam construction at point O and the measured displacement between O and A, is shown in Figure 6.

The results shown in Figure 6 indicate that the vertical stress at Point O increases to a maximum of approximately 2 MPa, while the stress increase at Point A is approximately 1.5 MPa. The displacement response measured between O to A is essentially linear suggesting that the stiffness of the foundation is constant over the stress range imposed by the loading.

# 13 4. UNLOADING OF A FRACTURED SHALE SLOPE

## 4.1 Geology and Slope Excavation

The Site C Clean Energy Project is currently being constructed on the Peace River near Fort St. John, British Columbia. An overview of the Site C design is given by Watson et al. (2022). The project required 1V:1.6H slope excavations in the Shaftesbury shales to be phased. As each excavation phase was completed, the removed rock was to be replaced with Roller Compacted Concrete (RCC) buttress forming the foundation for the spillway and powerhouse structures. This phased excavation and replacement approach was required to limit ground movements and the risks of exposing all of the rock slopes at once. This staged approach would also

allow the instrumentation responses to be reconciled with the geological model in a step-wise process. Figure 7 shows an excavated slope and the powerhouse RCC buttress. The slopes were excavated using a combination of machine and drill-and-blast methods. The final slope was machine trimmed.

Martin et al (2022) documented the measured response of the shale to unloading. A summary of their findings follows. The Shaftesbury shales at Site C contain two prominent discontinuities that are characteristic of valleys found in the interior plains of Western Canada: 1) near horizontal bedding plane shears and, 2) subvertical relaxations joints that strike subparallel to the river valley. The relaxation joints that strike subparallel to the

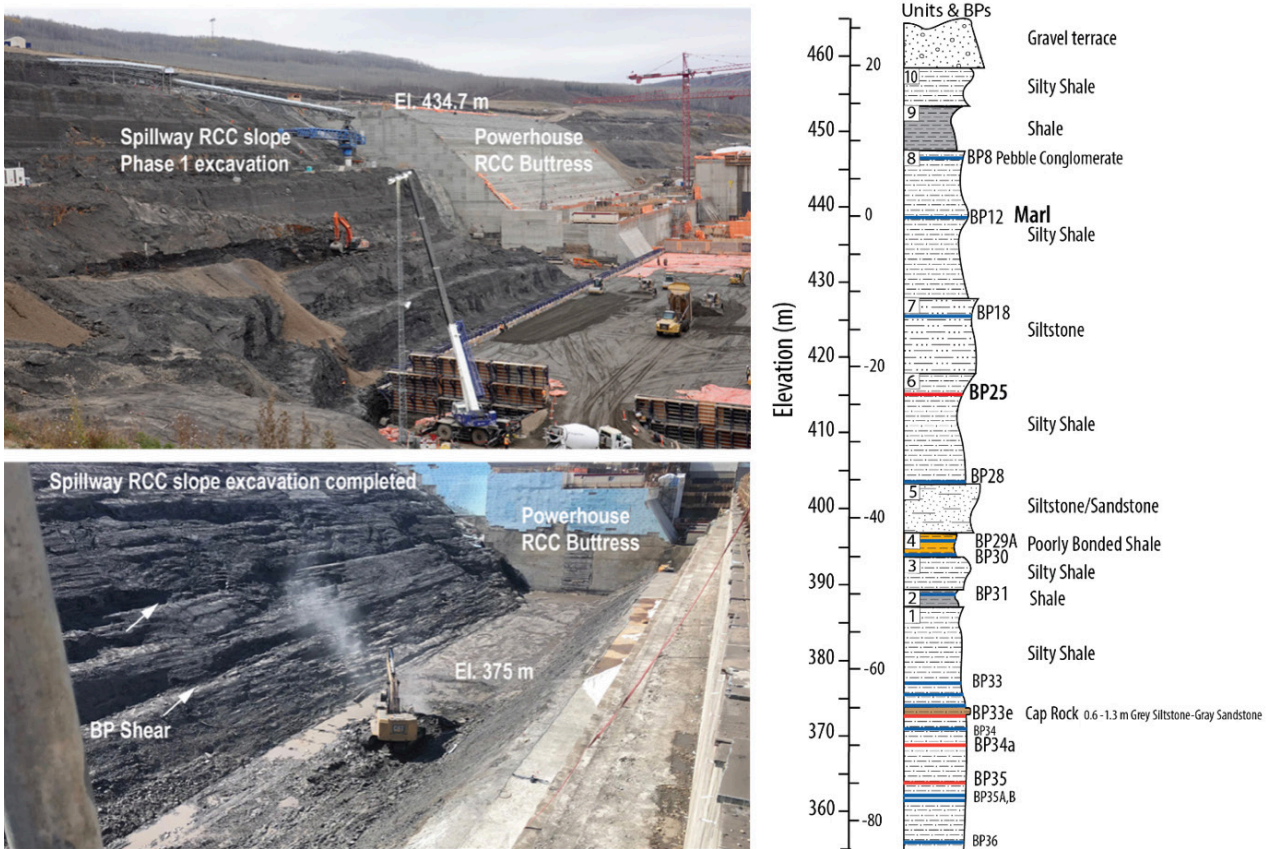


Fig 7. Powerhouse buttress and excavated slope for the spillway RCC buttress. The geological rock units 1 to 10, and bedding planes (BP) are shown on the stratigraphic column on the right.

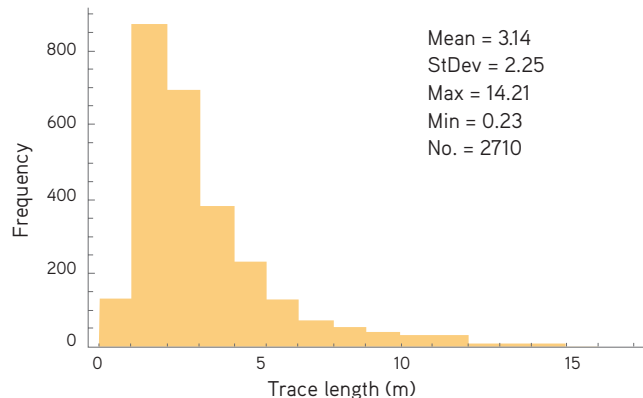


Fig 8. Photo of the subvertical relaxation joints observed in the slope excavation near the valley wall, and the histogram for the relaxation joints mapped at the final spillway slope.



valley wall are “open” near the face of the valley slopes, with partial infilling of silty clay and shale fragments. Beyond a horizontal depth of about 35 m the joints were mapped as tight with negligible apertures.

The excavated rock mass near the original rock surface contained relaxation joints with trace lengths that often exceeded 10 m as shown in Figure 8. However, as the excavation advanced about 30 m into the abutment the trace lengths and frequency of the joints decreased significantly. The histogram in Figure 8 shows the trace lengths of the relaxation joints mapped on the final spillway buttress slope. Of the 2710 mapped joints only 400 (~15%) had trace lengths exceeding 5 m. Based on the joint mapping the rock mass is classified as massive.

#### 4.2 Deformation modelling and history matching

The deformation modelling to track the displacements as slope excavation progressed was carried out using the RocScience software RS2 (www.RocScience.com). The initial model contained homogeneous elastic shale with the discrete bedding plane shears and input parameters shown in Figure 9. The bedding planes were elastic perfectly plastic and assigned the friction angles that were measured in the laboratory.

The normal and shear stiffness values of the bedding planes were assigned  $k_n=k_s=4$  GPa/m based on laboratory results. The objective of the deformation modelling was to simulate the Phase1 excavations for the spillway buttress. Three slope inclinometers were installed at the crest of the slope and used to guide the history matching for the Phase 1 excavation. The Phase 1 excavation was simulated in 4 steps and the initial results for inclinometer M1A are shown in Figure 9. It is clear from Figure 9 that the calculated RS2 results were not in agreement with the measurements. Similar results were obtained for inclinometers M1B and M5. The modelling was repeated using different in situ stress ratios, different moduli and a modulus increasing with depth. None of these models provided results that were in agreement with the measurements.

The relaxation joints were added to the RS2 model approximating the trace lengths, dip and mapping frequency (Figure 10). The evidence on site from tunnels, boreholes and mapping showed that these joints were tight and spaced 1 to 1.5 m apart. The stiffness of these relaxation joints was assigned the same value as that used for the deep bedding plane shears, because these shears and joints are very similar in nature, mainly

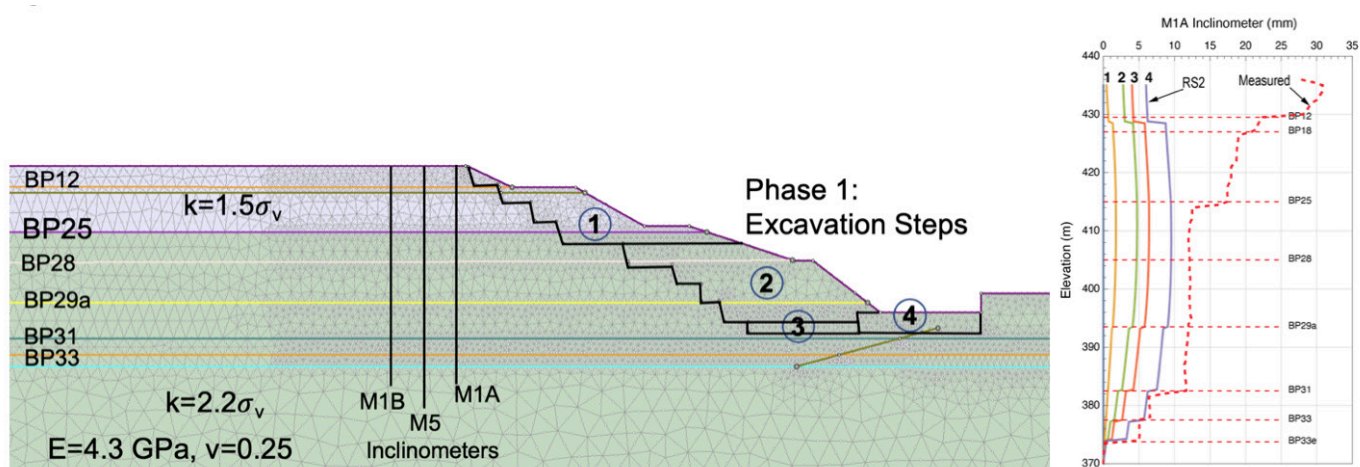


Fig 9. The finite element model used to simulate the excavation sequence and examine the displacements at the inclinometers at the crest of the slope. The only discrete fractures in the model are the bedding plane shears.

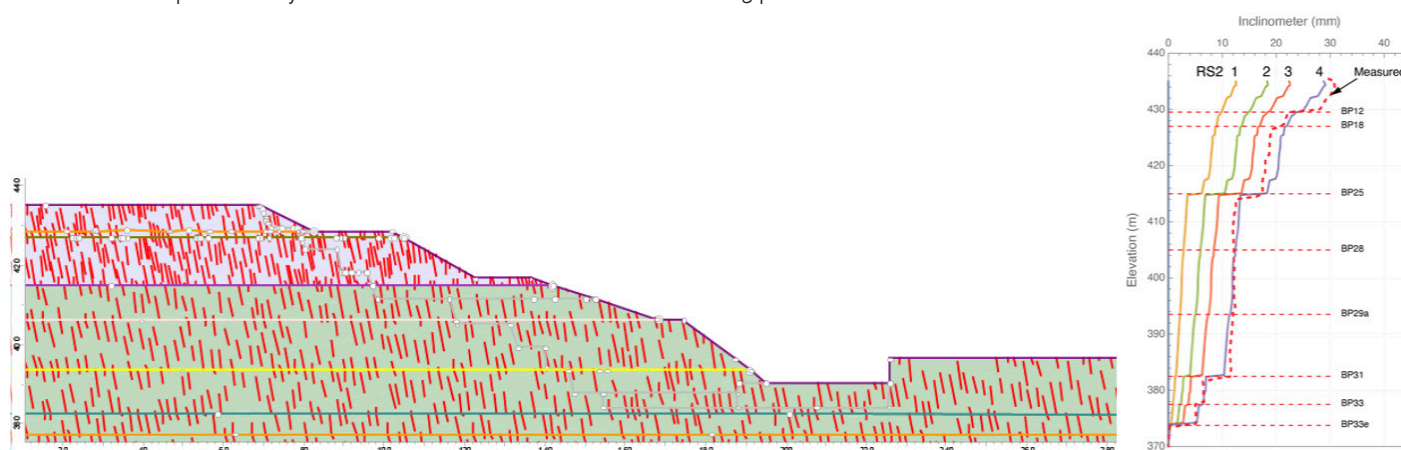


Fig 10. Simulation of the relaxation joints in the RS2 model. The inclinometer on the right shows the agreement obtained by reducing the relaxation joint  $k_n$  to 50 MPa/m.

13 a break in the rock with no mineralogical difference with the intact shale. Despite the addition of the relaxation joints the deformation pattern at the inclinometers remained essentially the same. Agreement with the measurements was finally achieved by reducing the  $k_n$  of the relaxation joints to 50 MPa/m compared to the measured  $k_n$  of 4 GPa/m.

Despite the massive nature of the rock mass at the location of the inclinometers, the relaxation joints and their unloading stiffness are clearly playing a role in the slope deformation pattern. Various sensitivity analyses were carried out but, in all cases, the low unloading stiffness of the relaxation joints was the primary parameter controlling the deformation pattern. The findings were also checked using the distinct element formulation in UDEC, with essentially identical results.

#### 4.3 Summary

The unique opportunity during the excavation of the shale slopes and construction of the RCC buttress at the Site C Clean Energy Project demonstrated the challenges in predicting realistic deformation patterns and magnitudes in a rock mass and the importance of considering the unloading stress path in selecting model parameters. Despite the relatively simple and well characterized site geology the following input parameters in the deformation model had to be adjusted to history match the measurements:

- The sparse relaxation joints in the massive shale had to be included in the model to simulate the displacement patterns measured by the inclinometers. This induces the direction of stiffness and strength anisotropy which was not captured by a simple continuum model.
- At the end of the excavation the confining stress ( $\sigma_3$ ) at the slope mid-height gradually increases from 0 at the surface to a maximum of 0.2 MPa at a horizontal depth of 50 m. Hence any input parameters must be measured at the relevant confining stresses.
- With these low confining stresses, the  $k_n$  of the joints needed to be reduced to 0.05 GPa/m to capture the deformations measured during excavation unloading. The shear stiffness and friction angle of the relaxation joints did not influence the deformation pattern.

Predicting the slope displacements required the strength and stiffness of the rock and the fractures. For this case study the strength values obtained in conventional laboratory tests were adequate for the deformation analyses. However, the stiffness values obtained from laboratory tests required considerable reduction for simulating the slope deformation response to unloading.

## 5. STABILITY OF AN OPEN PIT SLOPE WITH NON-DAYLIGHTING FAULTS

### 5.1 Pit Slope Confining stress and instabilities

The deepest open pits are now at 1000 m depth, with many in the 400 m to 700 m depth range. The pit slope at this scale is excavated using 15 to 30 m high benches packaged into stacks referred to as an inter-ramp. The top and bottom of the inter-ramp stack is typically the access ramp for removing the ore and waste rock. Figure 11 illustrates the pit slope terminology. Design of the pit slope is focused at the inter-ramp scale, which typically varies in height from 100 to 200 m, depending on the rock mass quality. The excavation of a large open pit is an unloading response of unprecedented scale. The effect of this unloading is shown in Figure 11 where the minimum principal stress near the pit slope is reduced to very low values. This unloading phenomenon resulting in very low confining stresses near the surface of the pit slope occurs regardless of the depth of the pit.

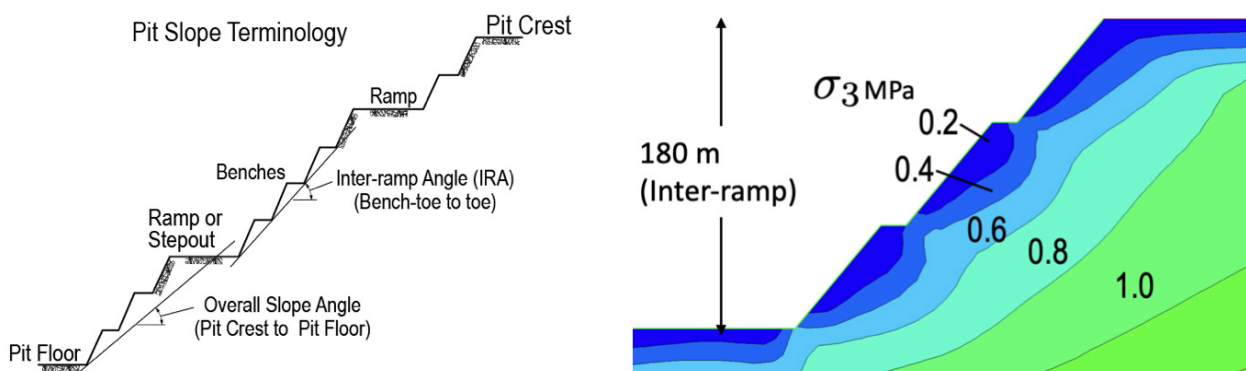


Fig 11. Pit slope terminology and the minimum principal stresses in a slope with the 180 m high inter-ramp



Fig 12. Example of a class of instability in open pit mines referred to as non-daylighting wedge. The instability occurs along the fault (indicated by the red dashed line).

At the kilometer-scale of these large open pits, experience has shown that most failures observed in open pit slopes are governed by geological structures, referred to as faults. A class of instability that is often associated with these faults is referred to as non-daylighting wedges. An example of such an instability is shown in Figure 12. The traditional approach when back analyzing such instabilities is to assume that the rock near the toe of the non-daylighting wedge is weak. In the following sections the effect of fault normal stiffness on this type of instability is explored.

## 5.2 Inter-ramp Instability

Open pit mining advances progressively downward using what is termed a “pushback”. The stability of the pushback is assessed using numerical analyses. A geological structural model is developed for the pit that incorporates the spatial location of the faults as discrete structures. Because of the scale of the problem, the faults in the numerical model are typically input as interface-surfaces that are characterized using the normal and shear stiffness, and shear strength. Figure 13 illustrates the geological model that can be used to assess the impact of the non-daylighting faults on the performance of the pit wall.

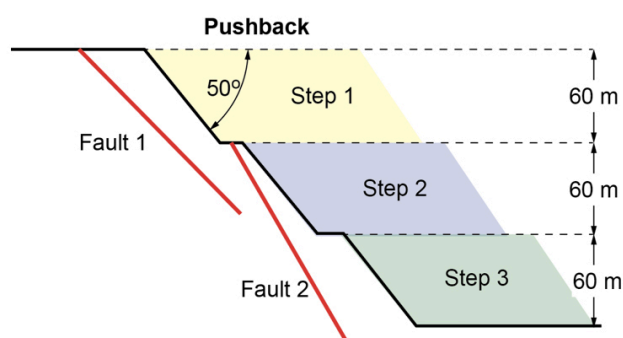


Fig 13. The inter-ramp example used for assessing the impact of fault normal stiffness

The geometry shown in Figure 13 was used to create a numerical model in RocScience RS2 and the Itasca's Slope Model. Slope Model is a 3D Itasca code developed as part of the Large Open Pit (LOP) Project. The code implements a version of the Synthetic Rock Mass (SRM) approach applied to rock slope stability. Each modelling step is equivalent to excavating four 15-m-high benches, which provides an inter-ramp angle of 45

The rock mass was assigned the following properties typically used in porphyry copper deposits: unit weight 25 kn/m<sup>3</sup>, GSI=40,  $\sigma_{ci}$ = 40 MPa,  $m_i$ =10, deformation modulus = 4.8 GPa, and the faults assigned:

$$\phi = 30^\circ, k_n = k_s = 1 \text{ GPa/m.}$$

The behaviour of both the rock mass and the faults was assumed to be elastic-perfectly plastic. For the base case the normal stiffness and shear stiffness of the faults were assigned a value of 1 GPa/m which is considered representative of the values measured in-situ and discussed in Section 2. Analyses were repeated keeping all parameters constant while decreasing the normal stiffness of the fault. The shear strength reduction method was used to assess the stability of the pit slope and the results are summarized in Figure 14.

For the base case with  $k_n = k_s = 1$  GPa/m the pit slope is stable with a factor of safety of approximately 1.4. As the normal stiffness of the faults is reduced the factor of safety decreases and eventually approaches a FoS =1. The reduction in the normal stiffness from 1 to 0.1 GPa/m is in the range of values measured in-situ by Infanti & Kanji (1978) and reflects the variation observed as the fault infill increases.

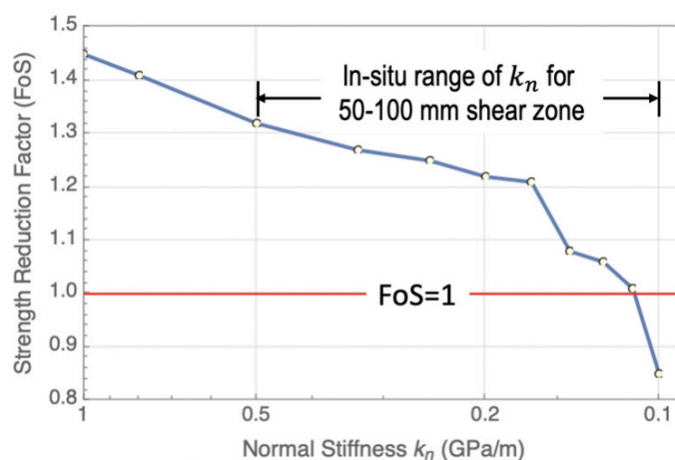


Fig 14. The shear strength reduction factor as a function of Normal Stiffness of the faults

- 13 The reason for the reduction in stability can be seen in the displacements provided in Figure 15. For the base case where the fault has a normal stiffness that approaches that of the rock mass the displacements are only a few mm. However, by reducing the normal stiffness of the fault the rock mass in front of the fault incurs displacements of several centimeters. It appears that the incompatibility of strain between the fault and the rock mass is primary reason leading to the instability.

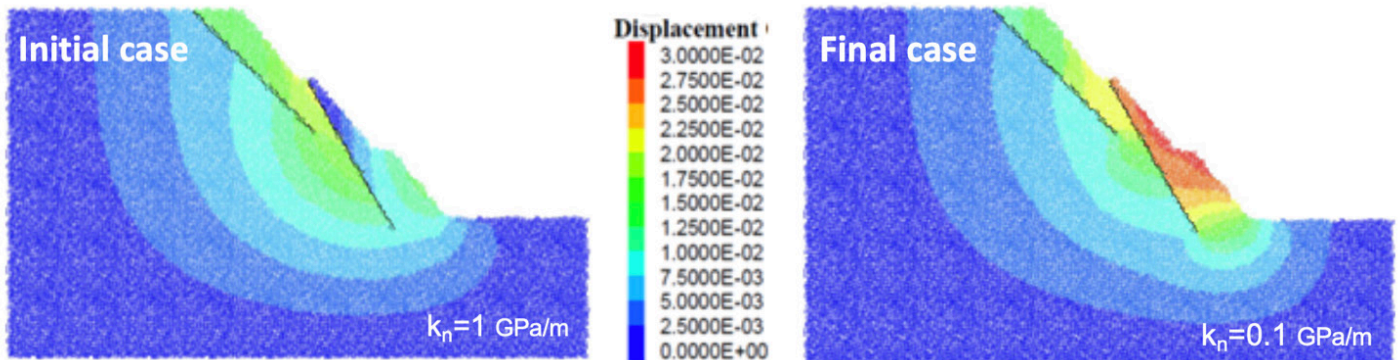


Fig 15. Comparison of the displacement contour for the initial case with  $k_n=k_s = 1$  GPa/m with the final case where  $k_n$  has been reduced to 0.1 GPa/m

## 6. CONCLUDING REMARKS

The behaviour of soils and rocks is stress-path dependent. In rock engineering for near surface structures (foundations and slopes) the confining stresses are typically less than 2 MPa, and hence determining the strength and stiffness should be carried out using relevant stress paths and confining stresses encountered in-situ. From the cases studies reviewed the following points can be made.

- The non-linear behaviour of joints which is observed in laboratory tests at high normal stress was not observed to be significant in-situ for either the loading beneath the gravity dam or the unloading of the rock slope.
- The in-situ normal stiffness of geological fractures during slope excavation (unloading) was found to be much lower than that measured in the laboratory using loading and unloading conditions.
- The excavation-induced unloading of non-daylighting faults in open pit slopes may reduce the normal stiffness and cause strain incompatibility with the rock mass. This strain incompatibility between the behaviour of faults and the rock mass may lead to failure of slopes that were considered stabled when the low normal stiffness is ignored.

## ACKNOWLEDGEMENTS

I wish to thank the Canadian Rock Mechanics Association for my nomination and the ISRM for my selection. Many colleagues have influenced my career, too many to list in detail.

I also wish to acknowledge the open pit numerical analysis and results provided by Gustavo Velarde (PhD Student) and Prof. Renato Macciotta, Department Civil and Environmental Engineering, University of Alberta, Edmonton, Canada. This work was financially supported by the Natural Sciences and Engineering Research Council of Canada. Itasca International supplied the Slope Model software and RocScience provided the RS2 software. 🚀



## REFERENCES

- Bandis, S, Lumsden, A. C., Barton, N. R., (1983). Fundamentals of Rock Joint Deformation. *Int. J. of Rock Mech. and Min. Sci.*, 20(6): 249-268.
- Bandis, S. (1980). Experimental Studies of Scale Effects on Shear Strength, and Deformation of Rock Joints. Unpublished PhD, Dept. Earth Sciences, University of Leeds, Leeds UK
- Deere, D. U. (1973). The foliation shear zone-An adverse engineering geologic feature of metamorphic rocks. *Journal of the Boston Society of Civil Engineers*, 60(4), 163-176.
- Fossen, H., & Cavalcante, G. C. G. (2017). Shear Zones – a Review. *Earth-Science Reviews*, 171, 434-455.
- Goodman, R. E. (1970). The Deformability of Joints. In *Determination of the in-situ Modulus of Deformation of rock ASTM STP 477* pp. 174-196.
- Imrie, A. S., & Moore, D. P. (1993). The Use of Rock Engineering to Overcome Adverse Geology At Revelstoke Dam. In J. A. Hudson (Ed.), *Comprehensive Rock Engineering - Surface and Underground Project Case Histories Vol. 5*, pp. 701-725.
- Infanti, N. and Kanji, M.A. 1978. In situ shear strength, normal and shear stiffness determinations at Agua Vermelha Project. *Proc. 3rd Int. Congress of the Int. Assoc. Engin. Geologists, Madrid, Spain. Vol. 3* pp.175-183.
- ISRM (1978). Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses. *Int. J. Rock Mech. and Min. Sci. & Geomech. Abstr.*, 15:319-368.
- Martin, C. D., & Chandler, N. A. (1993). Stress Heterogeneity and Geological Structures. *Int. J. Rock Mech. and Min. Sci. & Geomech. Abstr.*, 30:993-999.
- Martin, C. D., Davison, C. C., & Kozak, E. T. (1990). Characterizing Normal Stiffness and Hydraulic Conductivity of a Major Shear Zone in Granite. *Proc. Int. Conf. on Rock Joints, Leon, Norway*, (Editors: N. Barton & O. Stephansson). 549-556. A.A. Balkema, Rotterdam
- Martin, C. D., Renani, H. R., Stevenson, G., & Watson, A. (2022). Constraining Joint Stiffness and In-situ Stress in a Slope Deformation Model. *Proc. Slope Stability, Tucson*, 6p.
- Patton, F. D., & Hendron Jr, A. J. (1974). General Report - Mass Movements. *Proceedings Second International Congress of the International Association of Engineering Geology, Sao Paulo, Brazil, Vol V*, pp1-57.
- Packulak, T. R. M., Day, J. J., Ahmed Labeid, M. T., & Diederichs, M. S. (2022). New Data Processing Protocols to Isolate Fracture Deformations to Measure Normal and Shear Joint Stiffness. *Rock Mechanics and Rock Engineering*, 55(5), 2631-2650.
- Riedmüller, G., Brosch, F. J., Klima, K., & Medley, E. W. (2001). Engineering geological characterization of brittle faults and classification of fault rocks. *Felsbau*, 19(4), 13-19.
- Skempton, A. W. (1966). Some Observations on Tectonic Shear Zones. *Proc. 1st ISRM Congress on Rock Mechanics, Lisbon*, 329-335.
- Watson, et al. (2022). Site C Clean Energy Project, Design and Construction Overview. *Proc. Can. Dam Assoc. 2022 Annual Conference, October 17-19*, 15p.
- Zangerl, C., Evans, K. F., Eberhardt, E., & Loew, S. (2008). Normal Stiffness of Fractures in Granitic Rock: A Compilation of Laboratory and in-Situ Experiments. *Int. J. Rock Mech. and Min. Sci.*, 45:1500-1507.

## 14 ROCHA MEDAL LECTURE

Jun Zhao | Northeastern University, China



### TIME-DEPENDENT FAILURE CHARACTERISTICS AND MECHANISM OF HARD ROCK IN DEEP ENGINEERING

Increasingly more mines, traffic tunnels, underground laboratories, diversion tunnels and underground powerhouses are developing to greater depths below ground. After deep engineering excavation, the hard rock is in the true three-dimensional unequal stress environment, the deep hard rock are basically characterized by high triaxial stress conditions. High triaxial stress can generally induce various time-delayed disasters, such as time-delayed cracking, time-delayed spalling, time-delayed collapse, time-delayed large deformation and time-delayed rock burst.

#### 1. INTRODUCTION

Increasingly more mines, traffic tunnels, underground laboratories, diversion tunnels and underground powerhouses are developing to greater depths below ground. After deep engineering excavation, the hard rock is in the true three-dimensional unequal stress environment, the deep hard rock are basically characterized by high triaxial stress conditions. High triaxial stress can generally induce various time-delayed disasters, such as time-delayed cracking, time-delayed spalling, time-delayed collapse, time-delayed large deformation and time-delayed rock burst. These time-delayed disasters cause serious casualties, damage equipment, result in project schedule delay and even lead to engineering failure, restricting the safe construction and operation of deep underground engineering projects. Therefore, it is necessary to study the time-dependent failure mechanism of deep hard rock under high triaxial stress condition. To study the time-dependent failure mechanism of deep hard rock, the author developed the true triaxial rheological test device for hard rock. Meanwhile, the brittle and ductile mechanical properties of hard rock under true triaxial compression were studied, which provides guidance for stress setting of true triaxial creep tests. Then, by using the self-developed apparatus, true triaxial creep and relaxation tests of hard rock were systematically conducted. The influences of the stress level and stress difference on brittle-ductile transition of hard rock were investigated. Moreover, time-dependent failure characteristics and mechanisms of hard rock under the true triaxial stress were explored. A stress-induced three-dimensional anisotropic rheological model and time-dependent fracture degree indices of hard rock was established. The research results have successfully applied to ensure the long-term stable operation of Jinping underground laboratory for dark matter detection at a burial depth of 2400 m for five years.

#### 2. DEVELOPMENT OF THE TRUE TRIAXIAL RHEOLOGICAL TEST DEVICE FOR HARD ROCK

A novel true triaxial rheology apparatus (Feng et al., 2018) was developed to ascertain the time-dependent failure process of deep hard rock under true triaxial stress, as shown in Fig. 1a. The maximum outputs of actuators in the directions of  $\sigma_1$  and  $\sigma_2$  were 3000 kN and 6000 kN, respectively, while hydraulic oil delivers pressure in the direction of the minimum principal stress at a maximum pressure of 100 MPa. By utilizing high integrated integration structure design, the global stiffness of the apparatus greatly increased to 16 GN/m, which is much higher than 5 GN/m of the traditional device. By applying follow-up loading control, the center deviation of rock sample in coaxial direction is always less than 0.002 mm. Through the crack intelligent identification technology of hard rock under long-term loading, the noise acquisition ratio of hard rock is reduced from 95% to 3%. The equipment can be used for true triaxial creep test (Fig. 1b) of hard rock under constant stress and true triaxial relaxation test (Fig. 1c) of hard rock under constant strain for up to 6 months. During the test, the long-term deformation and fracture process of rock can be accurately measured.

Features	Index
Horizontal force	0 ~ 3000 kN
Vertical force	0 ~ 6000 kN
Cell pressure	0 ~ 100 MPa
Stiffness	16 GN/m
Eccentricity	2 $\mu$ m
Holding time with constant stress	6 months

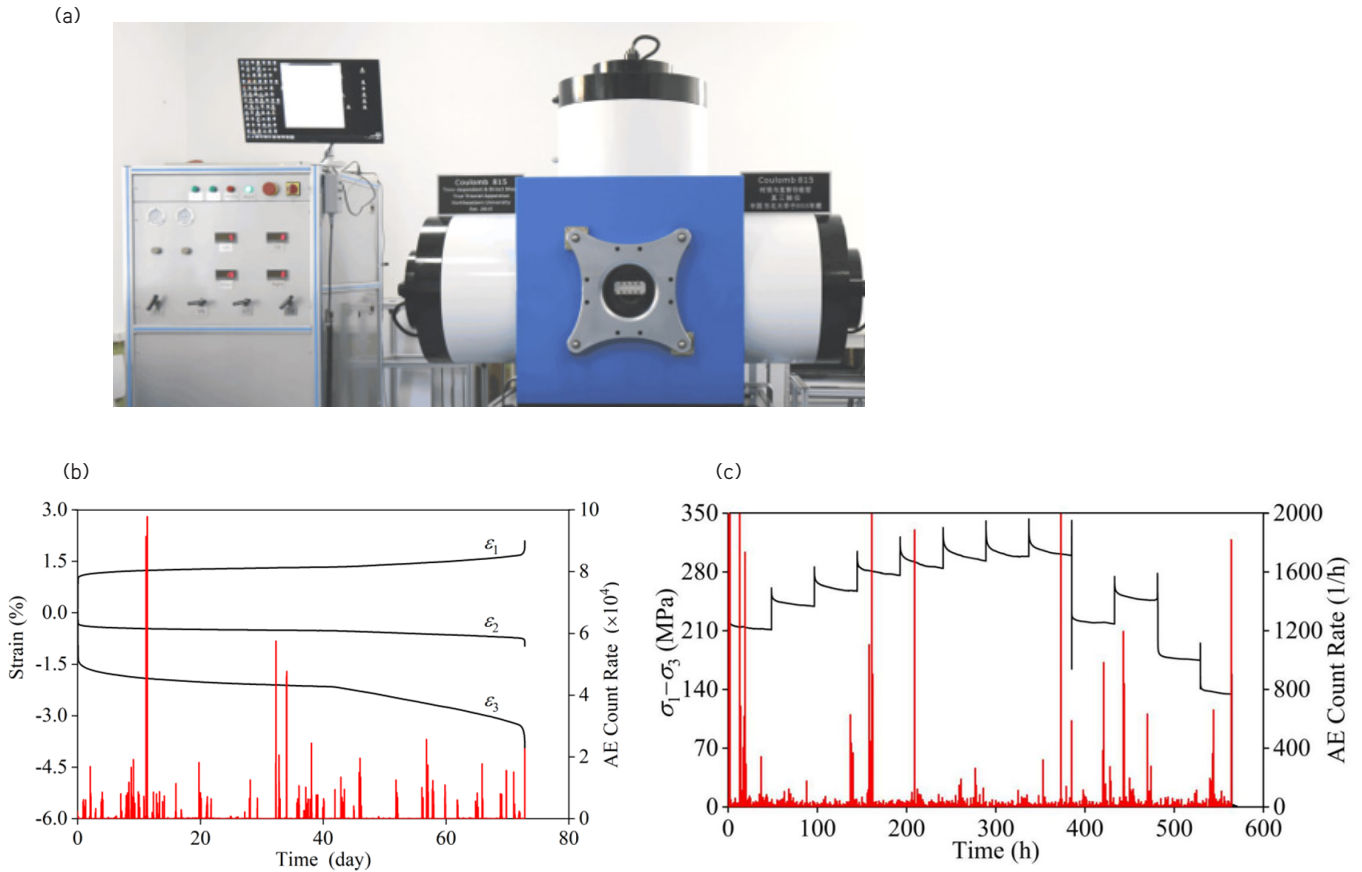


Fig 1. True triaxial rheology apparatus for hard rock. (a) Device diagram and performance parameters (b) Typical creep results (c) Typical relaxation test. (Feng et al., 2018)

### 3. BRITTLE AND DUCTILE BEHAVIORS OF HARD ROCK UNDER TRUE TRIAXIAL COMPRESSION

The brittle and ductile behaviours (Zhao et al. 2018a) are affected by the  $\sigma_2$  and  $\sigma_3$ . When  $\sigma_3$  is small, no matter how large  $\sigma_2$  is, the hard rock shows a sudden stress drop after reaching the peak strength, which is defined as brittle failure of type I (Fig. 2a). When  $\sigma_3$  is high, hard rock gradually transforms from ductility to brittleness with the increase of  $\sigma_2$ . However, it is significantly different from the brittleness of low  $\sigma_3$  condition. At brittle failure with high  $\sigma_3$  condition, the stress of hard rock decreases slowly after reaching the peak strength, and then the sudden stress drop occurs at a certain stage. Under this high  $\sigma_3$  condition, the brittleness of hard rock is defined as brittle failure of type II (Fig. 2b). The brittle and ductile failure modes of hard rock are different under true triaxial stress (Fig. 2c). Under conventional stress condition, the macroscopic failure surface of hard rock opens along the  $\sigma_2$  and  $\sigma_3$  directions at the same time. However, under true triaxial stress, the macroscopic failure surfaces of hard rock are nearly parallel to  $\sigma_2$  and open along  $\sigma_3$  direction. During brittle failure of type I occurs, vertical cracks are distributed near the hard rock boundary, showing a splitting failure mode. During brittle failure of type II occurs, The macroscopic failure mode of the rock specimen shows the shear characteristics with a gentle dip angle. During ductile failure, the rock specimen is

mainly in the shear mode with slow dip angle. The ductile deformation of Jinping marble increases markedly with the increase of  $\sigma_3$ , but decreases with the increase of  $\sigma_2$ , so the brittle-ductile transition boundary under general stress states is determined by an empirical formula as follows:

$$\sigma_3 - r_1\sigma_2 = r_2 \quad (1)$$

where  $r_1$  and  $r_2$  are constants, which are obtained through the true triaxial test.

Based on Formula (1), stress regions of brittle failure of type I, type II, and ductile failure of Jinping marble are demonstrated, as shown in Fig. 2d.

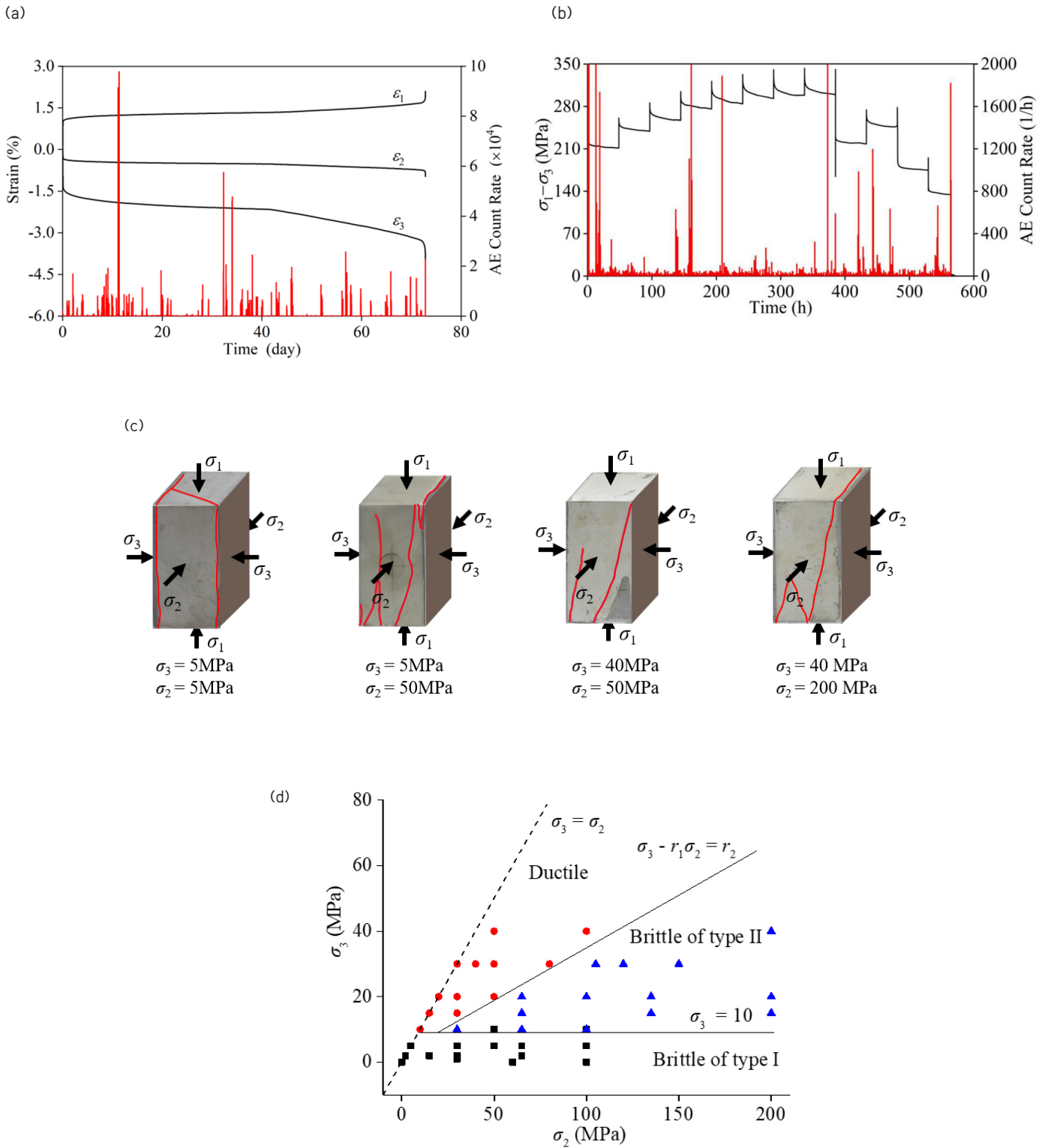


Fig 2. The brittle-ductile transition characteristics of Jinping marble (Zhao et al. 2018a).

- (a) Brittle failure of type I with low  $\sigma_3$
- (b) Changed from ductile failure to brittle failure of type II with the increase of  $\sigma_2$  at high  $\sigma_3$
- (c) Different failure modes
- (d) True triaxial stress conditions boundary of brittle-ductile transition



#### 4. TIME-DEPENDENT FAILURE BEHAVIOR OF HARD ROCK UNDER TRUE TRIAXIAL COMPRESSION

##### 4.1 Stress-induced anisotropic creep failure mechanism of hard rock

True triaxial stress causes anisotropic deformation and fracture during the time-dependent failure process of hard rocks (Zhao et al. 2018b and 2021). During creep test at  $\sigma_2 = \sigma_3$  (Fig. 3a),  $\varepsilon_2$  and  $\sigma_3$  of Jinping marble almost always coincide with the increase of  $\sigma_1$ . Compressive deformation is mainly shown in the  $\sigma_1$  direction, while expansive deformation is mainly dominant in the  $\sigma_2$  and  $\sigma_3$  directions. In the true triaxial test (Fig. 3b),  $\varepsilon_2$  and  $\varepsilon_3$  of Jinping marble cannot coincide because  $\sigma_2$  exceeds  $\sigma_3$ . The stress difference between  $\sigma_2$  and  $\sigma_3$  leads to differences in the creep deformation of hard rock. When creep test at  $\sigma_2 = \sigma_3$  (Fig. 3c), the ultimate failure surfaces of Jinping marble are opened along both the  $\sigma_2$  and  $\sigma_3$  directions after a long period of creep. In the case of  $\sigma_2 > \sigma_3$ , the ultimate failure surfaces are opened along the  $\sigma_3$  direction and there is no macro-failure surface opened along the  $\sigma_2$  direction after the long-term creep of Jinping marble.

Compared with conventional creep test, the most significant characteristic of the true triaxial creep test is the difference in deformation and failure in the  $\sigma_2$  and  $\sigma_3$  directions. Therefore, to quantify differences in deformation and failure of hard rock in the  $\sigma_2$  and  $\sigma_3$  directions under true triaxial conditions, a difference index (DI) that can describe lateral deformation and failure is defined as follows (Zhao et al. 2021):

$$DI = f(\sigma_1, \sigma_2, \sigma_3, t) = \frac{|\Delta\varepsilon_3| - |\Delta\varepsilon_2|}{|\Delta\varepsilon_3|} \quad (2)$$

where,  $t$  denotes the loading time in the test.  $\Delta\varepsilon_2$  and  $\Delta\varepsilon_3$  are creep strain increments in the  $\sigma_2$  and  $\varepsilon_2$  directions at each designated loading level, respectively.

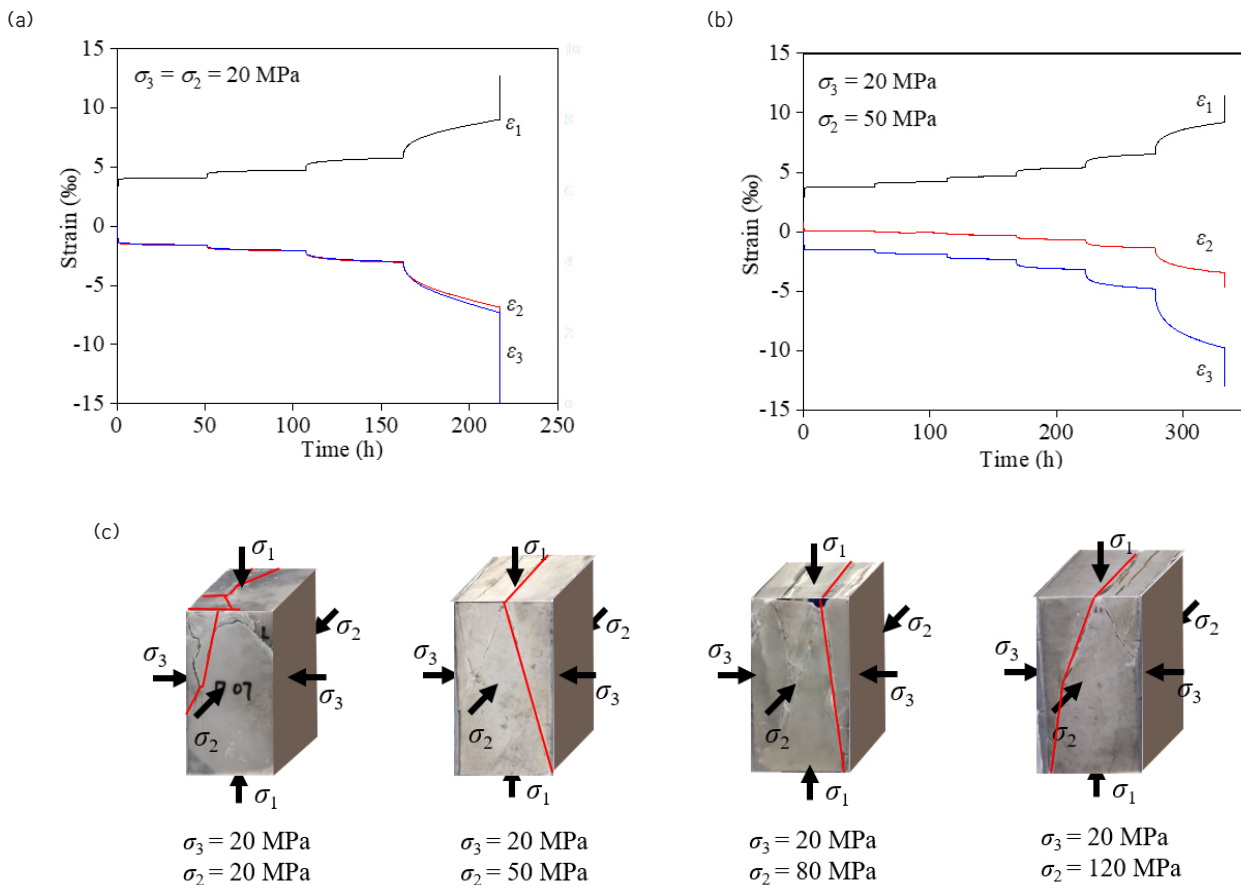


Fig. 3. Strain-time curves and failure modes of Jinping marble in the true triaxial creep test (Zhao et al. 2018b and 2021).

- (a) Strain-time curves at  $\sigma_2 = \sigma_3$   
 (b) Strain-time curves at  $\sigma_2 > \sigma_3$   
 (c) Creep failure modes of Jinping marble

14 When the three principal stresses remain unchanged, DI hardly changes with the increase of time and  $\sigma_1$  (Fig. 4a and b). With the increase of  $\sigma_2$ , DI increases in a non-linear manner. The increase of  $\sigma_2$  increases the time-dependent differential deformation of the rock. While keeping  $\sigma_1$  and  $\sigma_2$  unchanged, DI linearly decreases with the increase of  $\sigma_3$  (Fig. 4d). Then, there is bound to have a function that satisfies

$DI = f(\sigma_2, \sigma_3)$ .  $\sigma_2 - \sigma_3$  can increase the difference, while  $\sigma_3$  can inhibit the difference. Moreover, the

formula needs to be dimensionless. For this reason, the relationship between DI and stress can be expressed as follows (Fig. 4e):

$$DI = f\left(\frac{\sigma_2 - \sigma_3}{\sigma_3}\right) = d_1 \left\{ 1 - \exp\left[-\frac{d_2(\sigma_2 - \sigma_3)}{\sigma_3}\right] \right\} \quad (3)$$

where,  $d_1$  and  $d_2$  represent the parameters irrelevant to the difference, respectively.

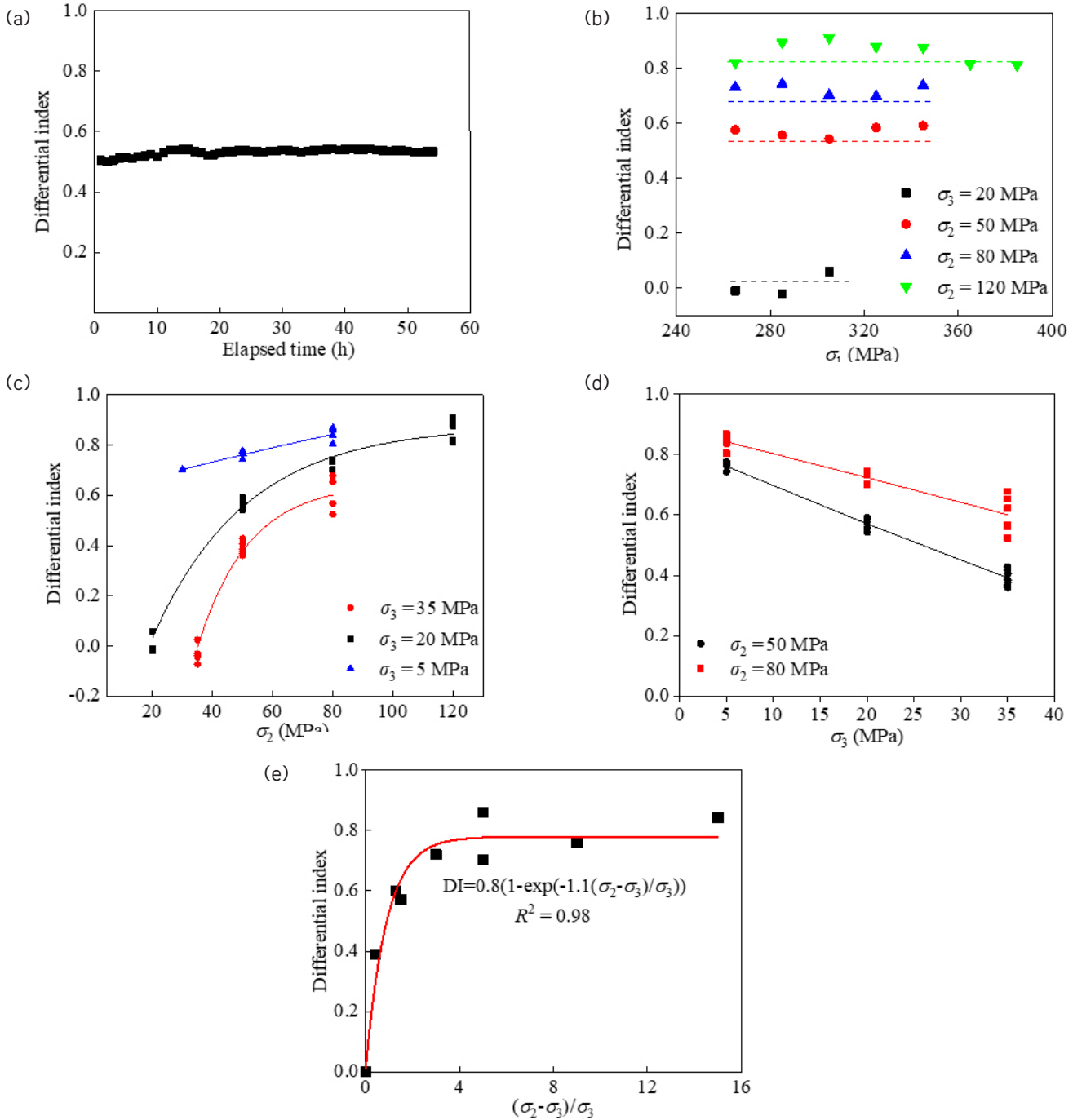


Fig 4. Differential Index for Jinping marble (Zhao et al. 2021).

- (a) Relationship between differential index and time for Jinping marble at  $\sigma_3 = 20$  MPa,  $\sigma_2 = 50$  MPa,  $\sigma_1 = 305$  MPa
- (b) Relationship between differential index and  $\sigma_1$  for Jinping marble at  $\sigma_3 = 20$  MPa
- (c) The difference index law of Jinping marble with the increase of  $\sigma_2$
- (d) The difference index law of Jinping marble with the increase of  $\sigma_3$
- (e) Relationship between the difference index and 3-d stress for Jinping marble

#### 4.2 Crack time-dependent growth induced creep failure of hard rock

The time effect can cause creep failure of hard rock under conditions below its short-term strength. Under the same conditions of  $\sigma_2$  and  $\sigma_3$ , the failure strength of rocks significantly decreases after creep loading (Fig. 5a and 5b). This is due to the internal damage of hard rock caused by long-term high stress. By comparing the acoustic emission information of the failure process of hard rock between short-term (Fig. 5c) and long-term tests (Fig. 5d), it can be found that the final cumulative acoustic emission count rate of hard rock in creep test is higher than that of instantaneous test. Observing the

microscopic characteristics of the rock after failure (as shown in Fig. 5e and 5f), it was found that the secondary crack and microcracks in the multi-stage long-term test were significantly more than those in the short-term compression test. The time-dependent failure of hard rock in deep engineering is caused by the time-dependent growth of hard crack. From acoustic emission and microscopic characteristics, it can be observed that many microcracks developed in the rock. There is enough time for cracks to fully grow and develop. Then, the connection between cracks ultimately leads to the creep failure of hard rock.

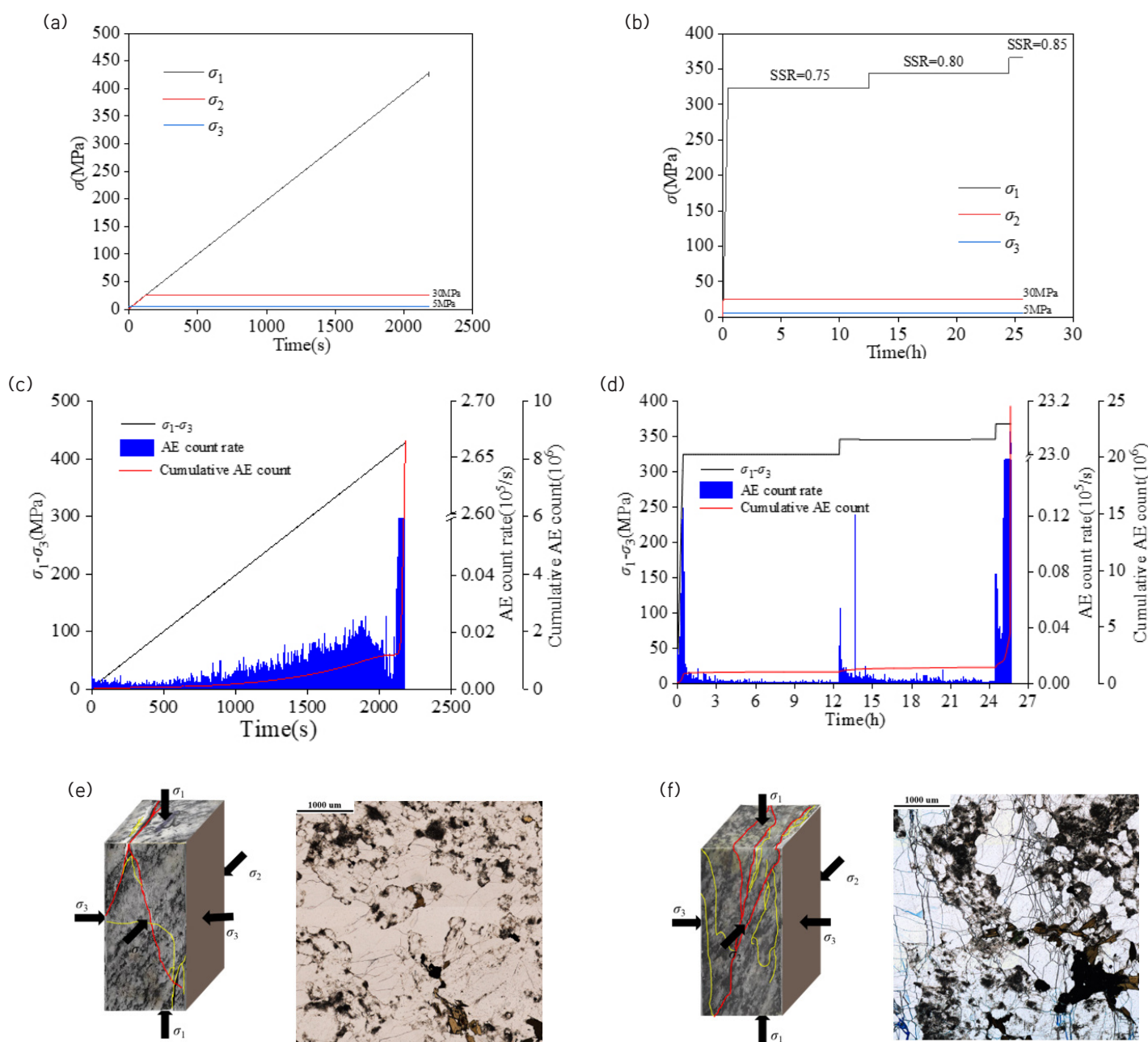


Fig 5. Deformation and failure behaviours of hard rock.

(a) and (b) are the stress path during short-term compression test and creep test  
(c) and (d) are the AE characteristics during short-term compression test and creep test  
(e) and (f) are the failure modes during short-term compression test and creep test.

14 4.3 Small deformation for hard rock to creep failure under true triaxial stress

As  $\sigma_2$  increases, the ultimate deformation and the strength of rock gradually decrease when the rock loses its bearing capacity (Fig. 6a). The axial permanent deformation corresponding to the failure point is taken as the index  $\epsilon_D$  for characterizing the ductile characteristics of rock. The final axial permanent deformation of rock under true triaxial stresses is plotted against the parameter  $\sigma_3 - \alpha\sigma_2$  (Fig. 6b). Although the Jinping marble has experienced long-term stress loading, the final deformation of the rock remains stress-dependent. The formula also indicates that the increase in  $\sigma_2$  reduces the time-dependent deformation required for rock failure; and the increase in  $\sigma_3$  can increase the time-dependent deformation required for the ultimate failure of hard rock.

High  $\sigma_2$  and low  $\sigma_3$  increases the brittleness of hard rock, causing deformation decrease of hard rock. This is because the high  $\sigma_2$  and low  $\sigma_3$  increases the brittleness of hard rock and causes these cracks to grow intensively in local areas. Moreover, the high stress and time cause continuous aggregation of crack in hard rock. When enough micro-fractures are interconnected, sudden brittle creep failure of hard rock is induced. Small creep deformation occurs throughout the process. As the stress level decreases, the longer for the rock to undergo creep failure, the more sufficient the crack propagation, resulting in small creep deformation of hard rock. This law is different from the creep failure law of soft rocks (Fig. 6c).

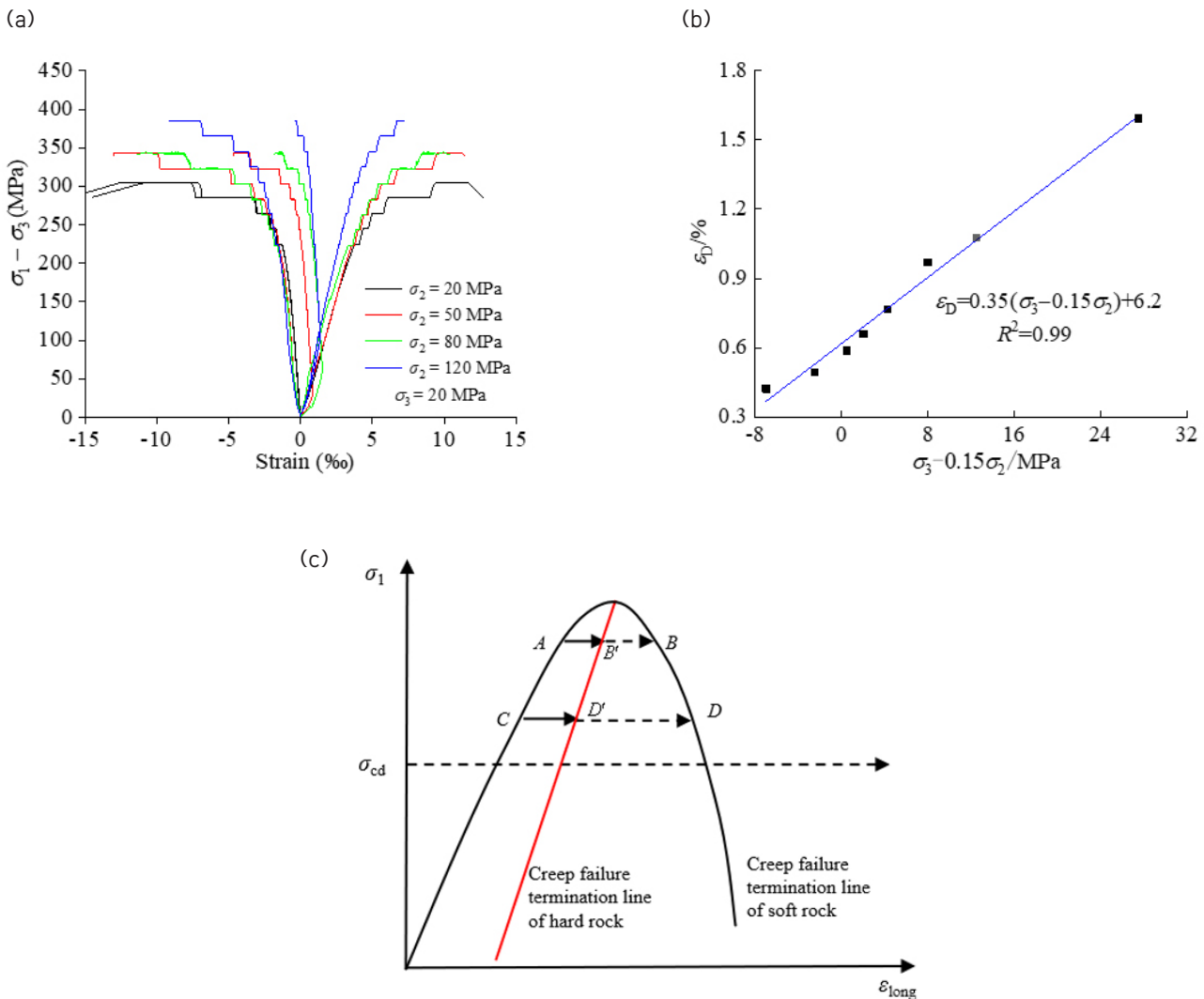


Fig 6. Ultimate creep deformation characteristics of Jinping marble under true triaxial stress (Zhao et al. 2019).

- (a) Stress-strain curves with the increase of  $\sigma_2$
- (b) The final axial permanent deformation  $\epsilon_D$  plotted against  $\sigma_3 - \alpha\sigma_2$
- (c) Creep termination conditions for hard rock and soft rock.

#### 4.4 Time-dependent failure modes of hard rock during brittle-ductile transition

During brittle creep, the rock is in a brittle stress condition, and the stress is relatively concentrated in the local area. Therefore, when the local failure occurs, the crack time-dependent propagation mainly occurs in the local brittle failure zone that has been formed. With the increase of  $\sigma_1$ , the crack propagation is also relatively stable. At the macro level, the steady-state creep rate increases linearly with the increase of deviatoric stress ( $\sigma_1 - \sigma_3$ ) (Fig. 7a). During ductile creep, the rock is in ductile stress condition, and the stress distribution is uniform. With the increase of  $\sigma_1$ , the initial distribution

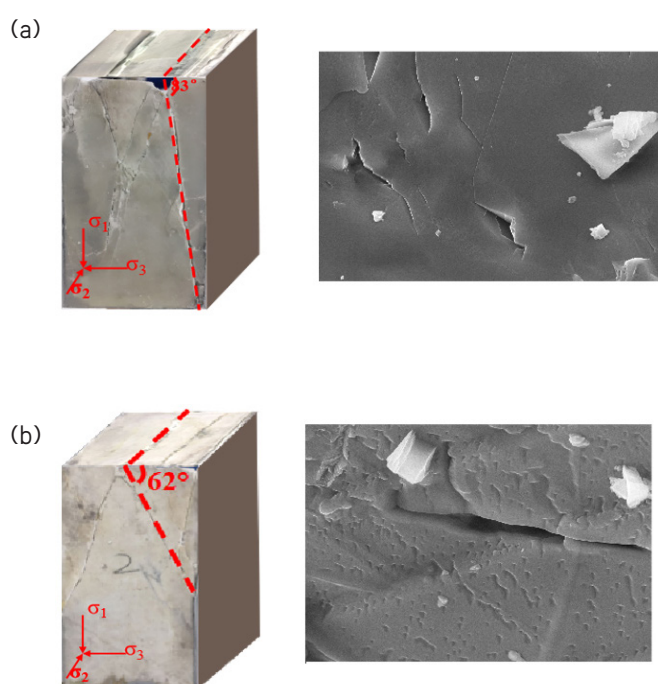


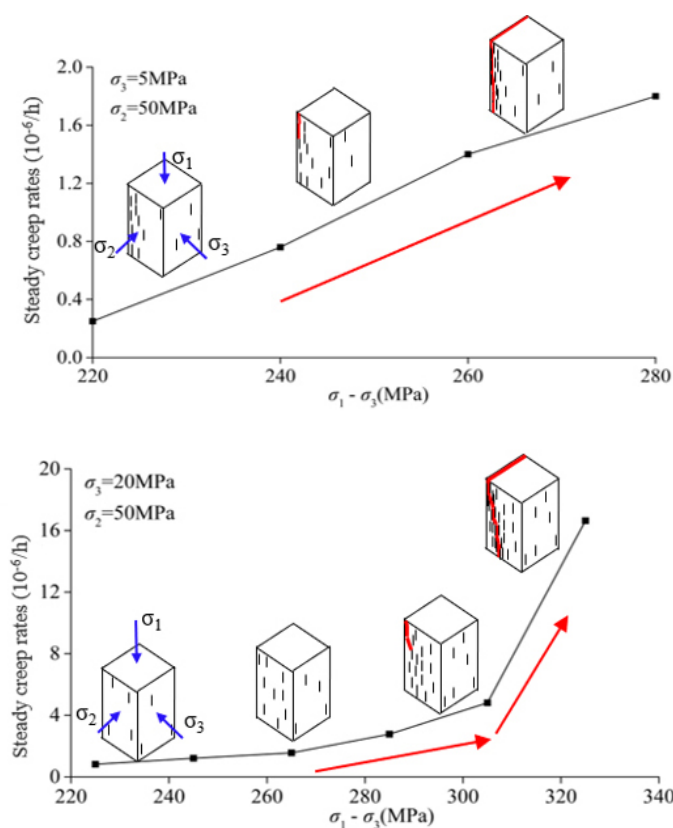
Fig 7. Time-dependent failure modes of hard rock during brittle-ductile transition  
(a) Brittle creep (b) Ductile creep (Zhao et al. 2019).

of cracks in rock is more dispersed, and the crack propagation speed changes slowly with the increase of deviatoric stress ( $\sigma_1 - \sigma_3$ ). Only when the deviatoric stress ( $\sigma_1 - \sigma_3$ ) increases to a certain limit value, the internal crack density of the rock reaches a certain amount, and local failure occurs. After that, the time-dependent propagation of the crack is mainly carried out along the already formed local shear band, which is macroscopically manifested as the growth of the same deviatoric stress ( $\sigma_1 - \sigma_3$ ) resulting in a sudden increase in the creep rate (Fig. 7b).

#### 5. METHOD FOR ANALYZING THE LONG-TERM STABILITY OF DEEP HARD ROCK ENGINEERING

##### 5.1 Stress-induced anisotropic time-dependent failure model for hard rock

To reflect the non-linear evolution of the creep rate caused by true triaxial stress, time-dependent failure caused by tensile fracture and the stress-induced failure and deformation anisotropy, a three-dimensional anisotropic time-dependent failure model for hard rocks was defined in Zhao et al. (2019, 2021):



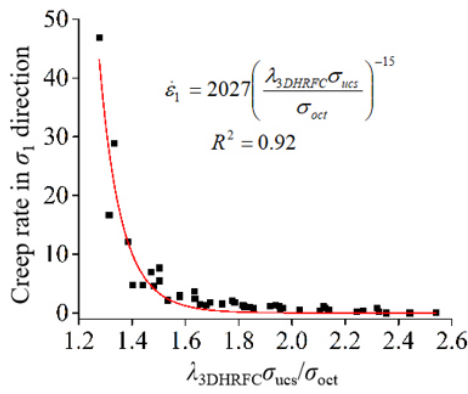
The creep failure of hard rock is mainly caused by tensile fracture, which weakens the strength and deformation parameters of rock, and finally induces the failure thereof. Therefore, it is assumed that the time-dependent fracture of hard rock mainly causes the changes in elastic modulus ( $E$ ) and cohesion ( $c$ ).

$$E = (1 - D)E_0 \quad (4)$$

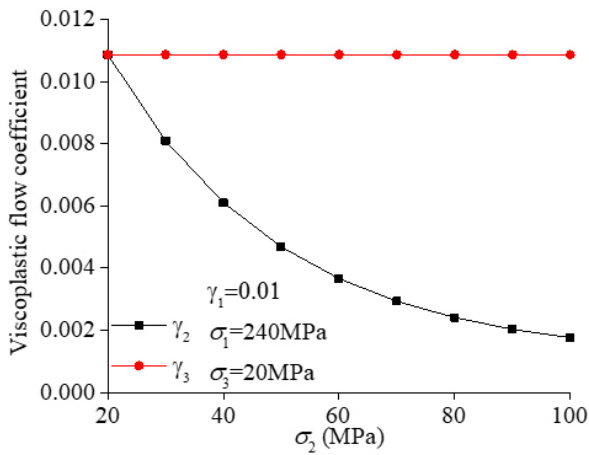
$$c = (1 - D)c_0 + c_1 \quad (5)$$

where,  $D$  is damage variable which varies from 0 (intact rock) to 1 (destroyed rock);  $E_0$  is initial elastic modulus.

(a)



(b)



space to the distance from the most stable stress point along the most unfavorable stress path to the unstable crack propagation surface at the same angle in the three-dimensional stress space.

$$TFRI = \frac{\sqrt{2J_2}}{\sqrt{3}g(\theta) \left( \frac{2\sqrt{2}\sin\varphi}{3(3-\sin\varphi)} I_1 + \frac{2\sqrt{2}c_1 \cos\varphi}{3-\sin\varphi} \right)} \quad (6)$$

The TFAI is defined as the ratio of the cumulative axial plastic deformation at any moment to the cumulative axial plastic deformation at the final moment of time-

(c)

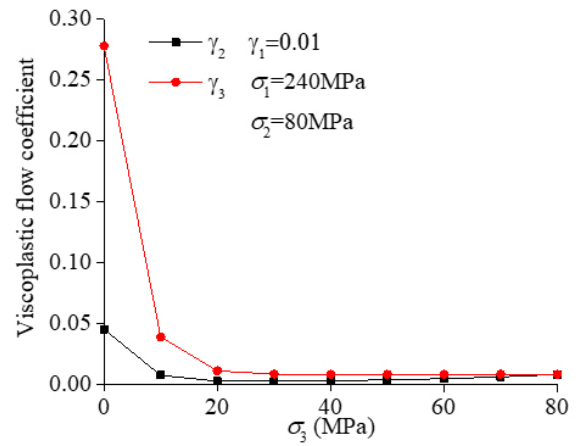


Fig 8. The creep rate and viscoplastic flow coefficient characteristic.

(a) Relationship between the axial creep rate and

(b) Difference between  $\gamma_2$  and  $\gamma_3$  at  $\sigma_2$  and

(c) Difference between  $\sigma_2$  and  $\sigma_3$  at different  $\sigma_3$ . ( $\sigma_1$  and  $\sigma_2$  are viscoplastic flow coefficients in the  $\sigma_2$  and  $\sigma_3$  directions).

The model has the following characteristics:

- (1) The non-linear evolution characteristics of creep rate and three-dimensional stress can be well described by the defined stress state index  $\lambda$  (Fig. 8a).
- (2) The stress-induced anisotropic time-dependent deformation can be described by the viscoplastic flow coefficient (Fig. 8b and 8c).

## 5.2 Rock time-dependent fracture degree

The rock time-dependent fracture degree (TRFD) includes two states: when the stress is lower than the damage stress, time-dependent fracture does not occur in hard rock. However, with the increase in stress, the risk of time-dependent fracture in hard rock rises, as denoted by the time-dependent failure risk index (TFRI). If the stress exceeds the damage stress, time-dependent fracturing occurs in the rock and it gradually approaches failure over time (as adjudged by the so-called time-dependent failure approach index (TFAI)).

The time-dependent failure risk index is defined as the ratio of the distance from the stress point along the most unfavorable stress path to the unstable crack propagation surface in the three-dimensional stress

dependent failure. After the applied stress exceeds the damage stress, fractures accumulate over time, which increases the plastic deformation. The specific expression for the TFAI is as follows:

$$TFAI = \frac{\epsilon_1^{vp}}{m_1(\sigma_3 - \sigma_3 m_2) + m_2} \quad (7)$$

Where,

$\epsilon_1^{vp}$  is the cumulative plastic strain in the  $\sigma_1$  direction.  $m_1$ ,  $m_2$  and  $m_3$  are constant parameter, which can be obtained by true triaxial test.

Based on the above conclusions, the TRFD is expressed as follows:

$$TRFD = \begin{cases} TFRI & F_1 \leq 0 \\ TFAI + 1 & F_1 > 0 \end{cases} \quad (8)$$

where,  $F_1$  is the yield function.

## 5.3 Numerical verification

The model and index was implemented in the software CASRock (Feng et al. 2006). Good agreement was achieved between the numerical simulation and experimental results (Fig. 9), indicating that the new model is applied to describe the brittle and ductile creep failure behaviors of hard rocks under true triaxial stress.

## 6. APPLICATION IN THE JINPING UNDERGROUND

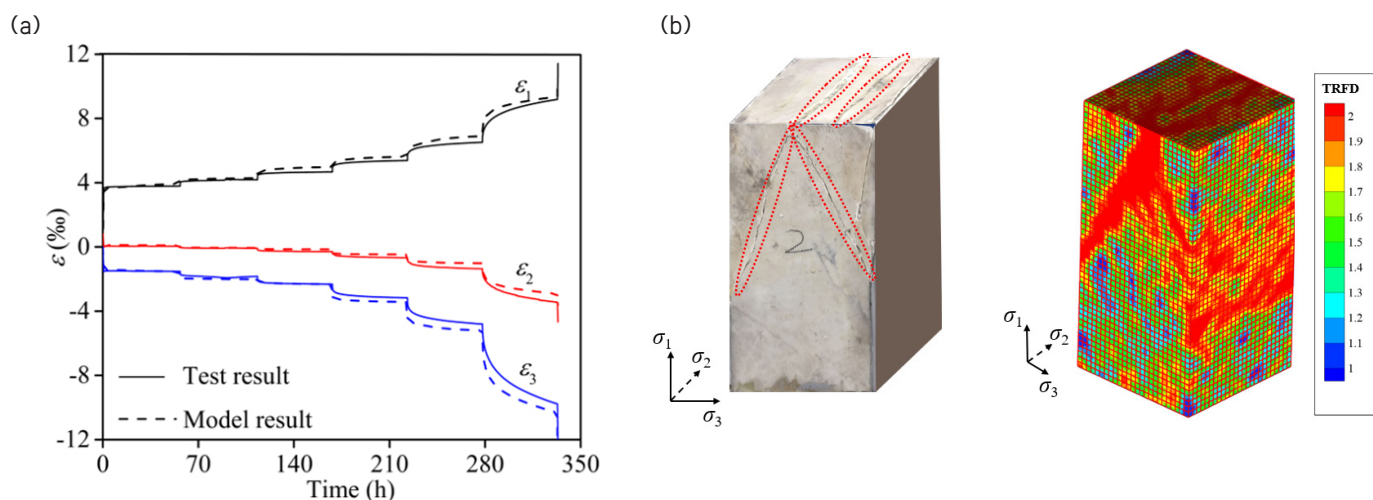


Fig 9. Simulated true triaxial creep tests of Jinping marble at  $\sigma_3 = 20$  MPa and  $\sigma_2 = 50$  MPa using the new model (a) Strain-time curve, (b) Failure mode.

Table 2 Parameters for field calculation

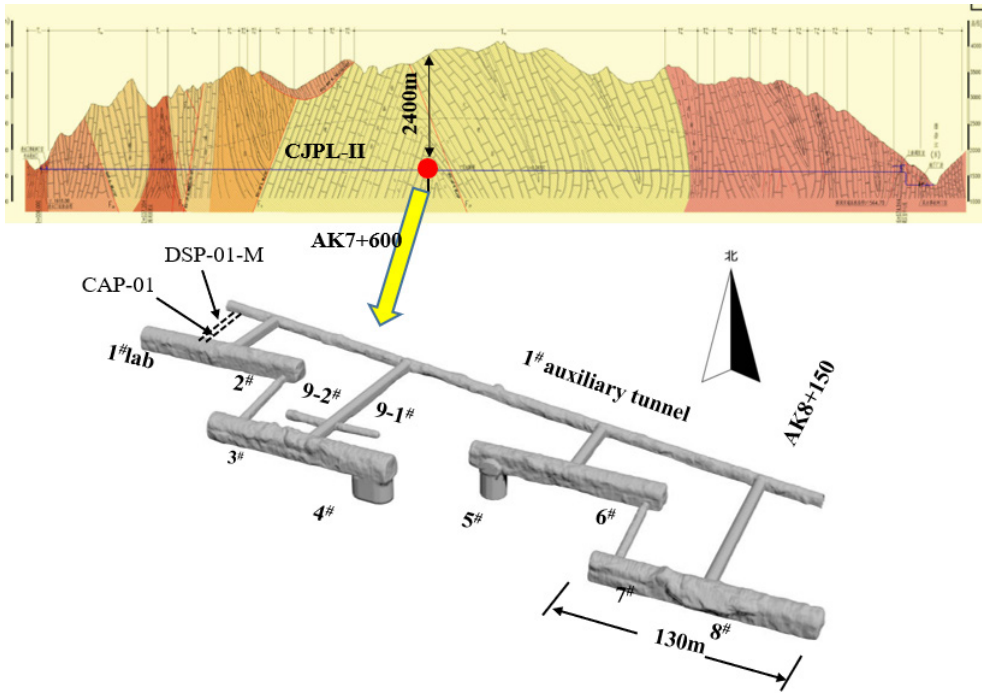
$E$ (GPa)	$\nu$	$c_1$ (MPa)	$c_0$ (MPa)	$\Phi$ (°)	$\gamma_1$
30	0.25	13	30	38	0.025

## LABORATORY

The China Jinping Underground Laboratory Phase II (CJPL-II) is located to the south of the traffic auxiliary tunnel A of Jinping II Hydropower Station in Jinping Mountain, Liangshan Prefecture, Sichuan Province, China. The maximum burial depth was 2400 m. The CJPL-II includes nine laboratories (Fig. 10a). The laboratories are mainly used to capture dark matter. The excavation of Jinping underground laboratory was completed in 2016. The research results have successfully ensured the long-term stable operation of Jinping underground laboratory for dark matter detection for five years. Based on the above research results, the long-term stability of the 1# laboratory was evaluated. Table 2 lists the main mechanical parameters obtained by back analysis on time-dependent deformation of the side wall of the 1# laboratory.

Fig. 10b shows the simulated long-term stability of the 1# laboratory tunnel. On the 10th day after excavation, time-dependent fracture occurs to varying degrees at the south spandrel. Although the time-dependent fracture conditions have not been met at the north corner and the deep layer of south spandrel, there are still risks of time-dependent fracture arising in these areas. The instability failure caused by time-dependent fracture of rock mass occurred at the south spandrel in the 1st year after excavation. In the 2nd year, the same failure mode can be seen at the lower side wall and bottom plate on the north side of the tunnel. In addition, from the comparison between the situation in the 5th year and 10th year, the overall failure state of the tunnel has not changed and the rock mass tends to be stable in these five years.

(a)



(b)

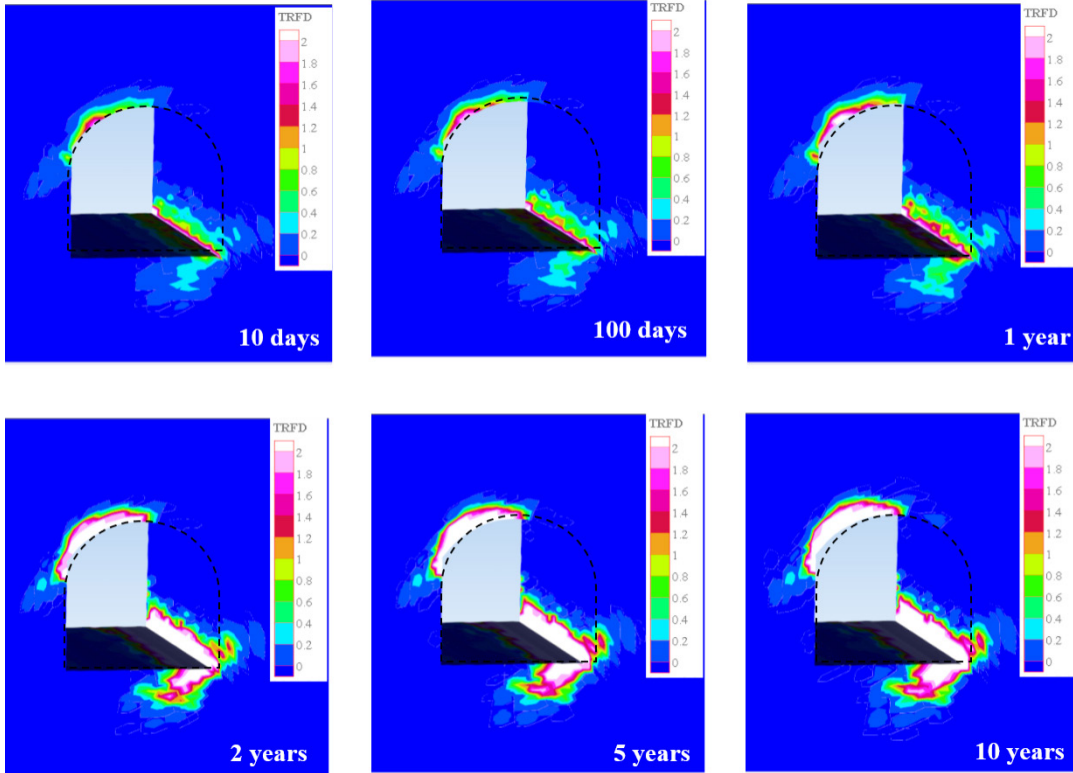


Fig 10. Application results: (a) Configuration of the deep tunnels of CJPL-II, and (b) Simulations of the long-term stability of the 1# laboratory tunnel.





## 7. CONCLUSION

The topic of this research has important theoretical significance and practical engineering value. The main innovations are as follows:

By solving a series of key technical problems, such as high stiffness loading frame, long-term non-eccentric loading control method, orthogonal three-dimensional deformation measurement technology and fracture measurement technology, a novel testing device for time-dependent failure process of hard rock under true triaxial stress has been developed. The true triaxial creep and relaxation test for hard rock are realized for the first time.

According to the post peak deformation characteristics of stress-strain curve, the failure of hard rock under true triaxial stress can be divided into three categories: brittle of type I, brittle of type II and ductile. The true triaxial stress conditions for brittle-ductile transition of hard rock were firstly proposed by the relationship between  $\sigma_2$  and  $\sigma_3$ .

Due to the time effect, high stress causes aggregation of numerous tensile fractures in hard rocks. Moreover, a high stress difference ( $\sigma_2 - \sigma_3$ ) increases the brittleness and causes time-dependent failure with small deformation. The creep deformation of hard rock is caused by crack growth, and the creep deformation in the  $\sigma_3$  direction is significantly higher than that in the  $\sigma_2$  direction. This is because the creep failure process of hard rock caused by true triaxial stress is also directional. Due to the inhibitory effect of the high value of  $\sigma_2$ , the number of cracks opening along the  $\sigma_2$  direction is much lower than that opening along the  $\sigma_3$  direction.

To reflect the stress-induced fracturing and deformation anisotropy of deep hard rocks, a stress-induced anisotropic time-dependent failure model and evaluation index of rock time-dependent fracture degree are established. By embedding the model and index into the independently developed CASRock software for rock fracture process analysis, the anisotropic time-dependent failure and deformation process of hard rock under true triaxial stress are reproduced.

The long-term stability evaluation method has been successfully applied to Jinping underground laboratory with a buried depth of 2400m.

## ACKNOWLEDGEMENTS

I sincerely thank my supervisor, Academician Xia-Ting Feng, the Former President of the International Society for Rock Mechanics and Rock Engineering. The completion of this article is inseparable from his valuable advice and guidance. At the same time, I also thank the research participants for their contributions in the collection of experimental data. 📌

## 8. SELECTED REFERENCES

- Feng XT, Pan PZ, Zhou H (2006) Simulation of the rock microfracturing process under uniaxial compression using an elasto-plastic cellular automaton. *Int J Rock Mech Min Sci* 43 (7): 1091–1108. <https://doi.org/10.1016/j.ijrmms.2006.02.006>
- Feng XT, Zhao J, Zhang X W, Kong R (2018) A Novel True Triaxial Apparatus for Studying the Time-Dependent Behaviour of Hard Rocks Under High Stress. *Rock Mech Rock Eng* 51(9): 2653–2667. <https://doi.org/10.1007/s00603-018-1516-z>
- Zhao J, Feng XT, Zhang XW, Zhang Y, Zhou YY, Yang CX (2018a) Brittle-ductile transition and failure mechanism of Jinping marble under true triaxial compression. *Eng Geol* 232, 160–170. <https://doi.org/10.1016/j.enggeo.2017.11.008>
- Zhao J, Feng XT, Zhang XW, Yang CX, Zhou YY (2018b) Time-dependent behaviour and modeling of Jinping marble under true triaxial compression. *Int J Rock Mech Min Sci* 110: 218–230. <https://doi.org/10.1016/j.ijrmms.2018.08.009>
- Zhao J, Feng XT, Zhang XW, Yang CX (2019) Brittle and ductile creep of Jinping marble under true triaxial stress. *Eng Geol* 258: 105157. <https://doi.org/10.1016/j.enggeo.2019.105157>
- Zhao J, Feng XT, Yang CX, Zhang XW, Jiang MF (2021) Differential time-dependent fracturing and deformation characteristics of Jinping marble under true triaxial stress. *Int J Rock Mech Min Sci* 138: 1–17. <https://doi.org/10.1016/j.ijrmms.2021.104651>

## 15 ISRM CORPORATE MEMBERS IN 2022

### A SUPPLIERS OF ROCK MECHANICS EQUIPMENT AND MATERIALS

Applied Seismology Consulting, United Kingdom  
 Beijing Anke Technology Co. Ltd., China  
 China Coal Technology & Engineering Group (CCTEG), China  
 China University of Mining and Technology, Beijing, China  
 China University of Petroleum-Beijing, China  
 ESS Earth Sciences, Richmong, Australia  
 Fondasol, Avignon, France  
 GCTS Testing Systems, Tempe AZ, USA  
 Geobrugg, Romanshorn, Switzerland  
 Geobrugg Andina SpA, Chile  
 GeoConnect Technology Development Co., Ltd;China  
 GEOS Ingénieurs Conseils, Courbevoie, France  
 Glöttzl, Rheinstetten, Germany  
 Golder Associates, Montreal, Canada  
 Guangdong Hongda Blasting Engineering Co. Ltd., China  
 Hanjiang-To-Weihe River Valley Water Diversion Project Construction Co.Ltd.,Shaanxi Province, China  
 Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, China  
 Katecs Co. Ltd., Japan  
 KFC Ltd., Japan  
 LNEC - Laboratório Nacional de Engenharia Civil, Lisbon, Portugal  
 MTS System Corporation, Eden Prairie, USA  
 National Institute of Natural Hazards, China  
 New Concept Mining, Johannesburg, South Africa  
 NGE Fondations, France  
 Orica Mining Services Portugal, SA., Lisboa, Portugal  
 Oyo Corporation, Tokyo, Japan  
 Pagani Geotechnical Equipment, Calendasco, Italy  
 Sibelco Nordic AS Avd Stjernøy, Alta, Norway  
 Solexperts Ag., Mönchaltorf, Switzerland

### B SUPPLIERS OF ROCK MECHANICS SERVICES

3GSM GmbH, Graz, Austria  
 AF Gruppen Norge AS, Oslo, Norway  
 Alliance Geotechnical Pty Ltd, Seven Hills, Australia  
 Applied Seismology Consulting, United Kingdom  
 Arcadis ESG, Le Plessis Robinson, France  
 Beck Engineering Pty Ltd, Chatswood, Australia  
 Beijing Anke Technology Co. Ltd., China  
 Bergab AB, Solna, Sweden  
 Besab AB Hisings Backa, Sweden  
 Boliden Mineral, Boliden, Sweden  
 Chalmers University of Technology, Göteborg, Sweden  
 China Coal Technology & Engineering Group (CCTEG), China  
 China University of Mining and Technology, Beijing, China  
 Cumbra Ingeniería, Peru  
 China University of Petroleum-Beijing, China  
 DynaFrax UG, Ltd., Germany  
 Enzan Koubou Co. Ltd., Japan  
 ESS Earth Sciences, Richmong, Australia  
 FF Geomechanics Ingeniería Limitada, Chile  
 Fondasol, Avignon, France  
 Geobrugg, Romanshorn, Switzerland  
 Geobrugg Andina SpA, Chile  
 GEOS Ingénieurs Conseils, Courbevoie, France  
 Geoscience Ltd., Falmouth, United Kingdom  
 Geoconsult ZT GmbH, Austria  
 GeoConnect Technology Development Co., Ltd, China  
 Geosigma AB, Stockholm, Sweden  
 Golder Associates, Montreal, Canada  
 Ineris, Verneuil en Halatte, France  
 Ingenieursozietät Prof. Dr.-Ing. Katzenbach GmbH, Frankfurt am Main, Germany  
 Institute of Geology and Geophysics, Chinese Academy of Geological Sciences, China

Institute of Rock and Soil Mechanics, The Chinese Academy of Science, Wuhan City, China  
 LECM - Civil Engineering Laboratory of Macau, Macau, China  
 LLC Science Development Company, Mining Geomechanics, Russia  
 LNEC - Laboratório Nacional de Engenharia Civil, Lisbon, Portugal  
 Luleå University of Technology - LTU, Luleå, Sweden  
 National Institute of Natural Hazards, China  
 Nick Barton and Associates, Høvik, Norway  
 Nitro Consult Ab., Stockholm, Sweden  
 Norconsult AS, Sandvika, Norway  
 Orica Mining Services Portugal, SA., Lisboa, Portugal  
 Oyo Corporation, Tokyo, Japan  
 Pagani Geotechnical Equipment, Calendasco, Italy  
 RISE Research Institute of Sweden, Borås, Sweden  
 Rock Engineering Research Foundation - BeFo, Stockholm, Sweden  
 Royal Institute of Technology - KTH, Stockholm, Sweden  
 Skanska AB, Solna, Sweden  
 Skanska Norge AS, Oslo, Norway  
 Solexperts Ag., Mönchaltorf, Switzerland  
 State Key Lab. For Geomechanics and Deep Underground Engineering, China University of Mining and Technology, Beijing, China  
 Sweco AB, Stockholm, Sweden  
 Sweco Norge AS, Lysaker, Norway  
 Swedish Nuclear Fuel and Waste Management, SKB AB, Figeholm, Sweden  
 Tongji University, China  
 Tractebel Engineering, Gennevilliers, France  
 Trilab Pty Ltd, Geebung, Australia  
 Tyréns AB, Stockholm, Sweden  
 WSP Sverige AB, Stockholm-Globen, Sweden

### C CONSULTANTS

3GSM GmbH, Graz, Austria  
 Abesiktning AB, Norway  
 AF Gruppen Norge AS, Oslo, Norway  
 AFRY, Solne, Sweden  
 AGL Consulting, Dublin, Ireland  
 Alliance Geotechnical Pty Ltd, Seven Hills, Australia  
 Applied Seismology Consulting, United Kingdom  
 Arcadis ESG, Le Plessis Robinson, France  
 Bauer Spezialtiefbau Schweiz AG, Switzerland  
 Beck Engineering Pty Ltd, Chatswood, Australia  
 Beijing Urban Construction Design and Development Group Co. Ltd., China  
 Bergab AB, Solna, Sweden  
 Besab AB Hisings Backa, Sweden  
 BG Ingénieurs Conseils SA, Switzerland  
 Boliden Mineral, Boliden, Sweden  
 Cartledge Mining & Geotechnics, Brisbane, Australia  
 Cautus GEO AS, Norway  
 CETU (Centre d' Études des Tunnels), Lyon, France  
 Chalmers University of Technology, Göteborg, Sweden  
 Changjiang River Scientific Research Institute, Wuhan, China  
 Changjiang Survey Planning Design Research Co. Ltd, China  
 Chengdu Engineering Co. Ltd.Ç, PowerChina; China  
 China Academy of Railway Sciences Co. Ltd., China  
 China Coal Technology & Engineering Group (CCTEG), Beijing, China  
 China Railway 18th Bureau Group Tunnel Engineering Co. Ltd., China  
 China Three Gorges Corporation, China  
 China University of Mining and Technology-Beijing, China  
 China University of Petroleum-Beijing, China  
 Chuo Kaihatsu Corporation, Tokyo, Japan  
 Cumbra Ingeniería, Peru  
 Dia Consultants Co., Ltd., Tokyo, Japan  
 DL E&C, Korea  
 DMEC - Dong Meyong Engineering Consultants & Architecture Co., Ltd., Seoul, Korea

Docon Corporation, Hokkaido, Japan  
 DynaFrax UG, Ltd., Germany  
 Electric Power Dev. Co., Ltd., Tokyo, Japan  
 ESS Earth Sciences, Richmong, Australia  
 FF Geomechanics Ingenieria Limitada, Chile  
 Fondasol, Avignon, France  
 GeoConnect Technology Development Co. Ltd., China  
 GEOS Ingénieurs Conseils, Courbevoie, France  
 Geoscience Ltd., Falmouth, United Kingdom  
 Geoconsult ZT GmbH, Austria  
 Geosigma AB, Stockholm, Sweden  
 Glöttzl, Rheinstetten, Germany  
 Golder Associates, Montreal, Canada  
 Guangdong Hongda Blasting Engineering Co. Ltd., China  
 Hanjiang-To-Weihe River Valley Water Diversion Project Construction Co.Ltd., Shaanxi Province, China  
 Hazama Corporation, Ibaraki, Japan  
 Hubei University of Technology, China  
 Implenia Suisse SA, Switzerland  
 Ineris, Verneuil en Halatte, France  
 Ingenieursozietät Prof. Dr.-Ing. Katzenbach GmbH, Frankfurt am Main, Germany  
 Institute of Complex Development of Mineral Resources of the RAS (RAS IPKON), Moscow, Russia  
 Institute of Geology and Geophysics, Chinese Academy of Geological Sciences, China  
 Institute jsc „VNIMI”, Russia  
 Institute of Mining Siberian Branch of RAS, Novosibirsk, Russia  
 Institute of Mining, Far Eastern Branch of the RAS, Khabarovsk, Russia  
 Itasca, Santiago, Chile  
 Itasca Consulting Group Inc., Minneapolis, USA  
 Itasca Consulting Ltd, Shrewsbury, United Kingdom  
 ITOCHU Techno – Solutions Corporation, Tokyo, Japan  
 J-Power Engineering Co. Ltd., Japan  
 Japan Conservation Engineers & Co. Ltd., Japan  
 Japan Underground Oil Storage Group Comp., Tokyo, Japan  
 Kajima Technical Research Institute., Tokyo, Japan  
 Kawasaki Geological Engng. Co., Tokyo, Japan  
 Kiso-Jiban Consultants Co., Ltd., Tokyo, Japan  
 Kolong Global Corporation, Korea  
 LCW Consult , S.A., Algés, Portugal  
 LLC Science Development Company, Mining Geomechanics, Russia  
 LNEC - Laboratório Nacional de Engenharia Civil, Lisbon, Portugal  
 Locher Ingenieure AG, Zurich, Switzerland  
 Lombardi Engineering Ltd., Minusio, Switzerland  
 Lombardi SA, Switzerland  
 LOTTE E&C, Seoul, Korea  
 Luleå University of Technology - LTU, Luleå, Sweden  
 Multiconsult AS, Oslo, Norway  
 National Institute of Natural Hazards, China  
 Newjtec Inc., Osaka, Japan  
 NGE Foundations, France  
 Nick Barton and Associates, Høvik, Norway  
 Nishimatsu Construction CO., Ltd., Tokyo, Japan  
 Nitro Consult Ab., Stockholm, Sweden  
 Norconsult AS, Sandvika, Norway  
 NTNU Inst for Geologi og Bergteknikk, Trondheim, Norway  
 Ove Arup & Partners Ltd, London, UK  
 Perm National Research Polytechnic University, Perm, Russia  
 Posco E&C, Korea  
 Prof. Quick und Kollegen, Darmstadt, Germany  
 Ramböll Sverige, Stockholm, Sweden  
 Ramboll UK Ltd., London, United Kingdom  
 RCC-Group, Moscow, Russia  
 RISE Research Institute of Sweden, Borås, Sweden  
 Research Institute of Experiment and Detection, Xinjiang Oilfield Company, Petro China, China  
 Royal Institute of Technology - KTH, Stockholm, Sweden  
 SAMSUNG C&T, Korea

Shaanxi Key Laboratory of Geotechnical and Underground Space Engineering, XAUAT, China  
 Shandong University, China  
 Shijiazhuang Tiedao University, China  
 SK E&C, Seoul, Korea  
 Skanska AB, Solna, Sweden  
 Solexperts Ag., Mönchaltorf, Switzerland  
 Suncoh Consultants Co., Ltd., Tokyo, Japan  
 Sweco AB, Stockholm, Sweden  
 Sweco Norge AS, Oslo, Norway  
 Swedish Nuclear Fuel and Waste Management Co. – SKB, Stockholm, Sweden  
 Swedish Rock Engineering Association, Sweden  
 Temro Corporation, Japan  
 Terrasol, France  
 Tetra Tech Coffey, Australia  
 Tongji University, Shanghai, China  
 Tractebel Engineering, Gennevilliers, France  
 Tyréns AB, Stockholm, Sweden  
 UJI Teguh Resources, Malaysia  
 WSP Sverige AB, Stockholm-Globen, Sweden  
 Yachiyo Engineering Co., Ltd., Tokyo, Japan

## D CONTRACTORS

Beijing Urban Construction Design and Development Group Co. Ltd., China  
 Besab AB, Sweden  
 Changjiang River Scientific Research Institute, Wuhan, China  
 China Academy of Railway Sciences Co. Ltd., China  
 China Coal Technology & Engineering Group (CCTEG), Beijing, China  
 China Three Gorges Project Corporation, Yichang, China  
 China University of Petroleum-Beijing, China  
 China University of Mining and Technology-Beijing, China  
 Docon Corporation, Hokkaido, Japan  
 DynaFrax UG, Ltd., Germany  
 ESS Earth Sciences, Richmong, Australia  
 GeoConnect Technology Development Co., Ltd, China  
 Geoscience Ltd., Falmouth, United Kingdom  
 Glöttzl, Rheinstetten, Germany  
 Guangdong Hongda Blasting Engineering Co. Ltd., China  
 Institute of Geology and Geophysics, Chinese Academy of Geological Sciences, China  
 Hanjiang-To-WEIHE River Valley Water Diversion Project Construction Co.Ltd., Shaanxi Province, China  
 Japan Underground Oil Storage Comp., Tokyo, Japan  
 Kajima Technical Research Institute., Tokyo, Japan  
 NGE Foundations, France  
 Nishimatsu Construction CO., Ltd., Tokyo, Japan  
 Obayashi Corporation, Tokyo, Japan  
 Shandong Innovative Material Technology Co.,Ltd, China  
 Shandong University, China  
 Shimizu Corporation, Tokyo, Japan  
 Skanska AB, Sweden  
 Skanska Norge AS, Oslo, Norway  
 Solexperts Ag., Mönchaltorf, Switzerland  
 State Key Lab for Geomechanics and Deep Underground Engineering  
 China University of Mining and Technology, China  
 Sweco Norge AS, Oslo, Norway  
 Taisei Corporation, Tokyo, Japan  
 Tekken Corporation, Tokyo, Japan  
 Tobishima Corp., Chiba, Japan  
 Toda Corporation, Tokyo, Japan  
 Tongji University, Shanghai, China  
 Zhejiang Society for Geotechnical Mechanics & Engineering, China

## E ELECTRICITY SUPPLY COMPANIES

China University of Mining and Technology, Beijing, China  
 Chugoku Electric Power Co., Inc., Hiroshima, Japan  
 China University of Petroleum-Beijing, China

**15** Electric Power Dev. Co., Ltd., Tokyo, Japan  
 GeoConnect Technology Development Co., Ltd, China  
 Hanjiang-to-Weihe River Valley Water Diversion Project  
 Construction Co., Ltd.SHAANXI Province, China  
 Hokkaido Electric Power Co. Inc., Hokkaido, Japan  
 Kyushu Electric Power Company, Fukuoka, Japan  
 Shandong University, China  
 Shikoku Electric Power Co., Kagawa, Japan

## F MINING COMPANIES

Boliden Mineral AB, Boliden, Sweden  
 China University of Mining and Technology, Beijing, China  
 China University of Petroleum-Beijing, China  
 GeoConnect Technology Development Co., Ltd, China  
 Hanjiang-to-Weihe River Valley Water Diversion Project  
 Construction Co., Ltd.SHAANXI Province, China  
 KOMIR (Korea Mine Rehabilitation and Mineral Resources  
 Corporation), Korea  
 Luossavaara-Kiirunavaara AB (LKAB), Luleå, Sweden  
 Nittetsu Mining Company, Ltd., Tokyo, Japan  
 Orica Mining Services Portugal, SA., Lisboa, Portugal  
 Phosagro, Kirovsk, Russia  
 Polymetal, St. Petersburg, Russia  
 RCC-Group, Ekaterinburg, Russia  
 Somincor - Sociedade Mineira de Neves Corvo, S.A., Castro  
 Verde, Portugal  
 Uralkali, Berezniiki, Russia

## G RESEARCH ORGANIZATIONS

Beijing Anke Technology Co. Ltd., China  
 Beijing Urban Construction Design and Development Group  
 Co. Ltd., China  
 Bergab AB, Solna, Sweden  
 Besab AB Hisings Backa, Sweden  
 Boliden Mineral, Boliden, Sweden  
 Central Research Institute of Electric Power Industry,  
 Chiba, Japan  
 CETU (Centre d'Études des Tunnels), Lyon, France  
 Chalmers University of Technology, Göteborg, Sweden  
 Changjiang Survey Planning Design and Research, China  
 China Coal Technology & Engineering Group  
 (CCTEG), China  
 China Three Gorges Corporation, China  
 China University of Mining and Technology, Beijing, China  
 China University of Petroleum-Beijing, China  
 DynaFrax UG, Ltd., Germany  
 Fachhochschule Nordwestschweiz, Switzerland  
 Geobruigg Andina SpA, Chile  
 GeoConnect Technology Development Co., Ltd, China  
 Geoscience Research Laboratory, Co. Ltd, Yamato, Japan  
 Geosigma AB, Stockholm, Sweden  
 Hanjiang-to-Weihe River Valley Water Diversion Project  
 Construction Co., Ltd.SHAANXI Province, China  
 Hubei University of Technology, China  
 Institute of Complex Development of Mineral Resources of  
 the RAS (RAS IPKON), Moscow, Russia  
 Institute of Geology and Geophysics, Chinese Academy of  
 Geological Sciences, China  
 Institute jsc „VNIMI”, Russia  
 Institute of Mining Siberian Branch of RAS,  
 Novosibirsk, Russia  
 Institute of Mining, Far Eastern Branch of the RAS,  
 Khabarovsk, Russia  
 Institute of Rock and Soil Mechanics, Chinese Academy of  
 Sciences, China  
 Kajima Technical Research Institute., Tokyo, Japan  
 Korea Expressway Corporation Research Institute (KECRI),  
 Hwaseong-si, Korea  
 LECM - Civil Engineering Laboratory of Macau, Macau, China  
 LLC Science Development Company,  
 Mining Geomechanics, Russia  
 LNEC - Laboratório Nacional de Engenharia Civil,  
 Lisbon, Portugal

Luleå University of Technology - LTU, Luleå, Sweden  
 Mining Institute KSC RAS, Apatity, Russia  
 Mining Institute Ural Branch of RAS, Siberia, Russia  
 National Institute of Natural Hazards, China  
 Nitro Consult Ab., Stockholm, Sweden  
 Norges Geologiske Undersøkelse, Trondheim, Norway  
 Norsk Forening for Fjellsprengningsteknikk, Oslo, Norway  
 Norsk Geoteknisk Forening, Oslo, Norway  
 NTNU Inst for Geologi og Bergteknikk, Trondheim, Norway  
 Perm National Research Polytechnic University,  
 Perm, Russia  
 RCC-Group, Moscow, Russia  
 Research Institute of Experiment and Detection, Xinjiang  
 Oilfield Company, Petro China, China  
 RISE Research Institute of Sweden, Borås, Sweden  
 Royal Institute of Technology - KTH, Stockholm, Sweden  
 Saint-Petersburg Mining University, St. Petersburg, Russia  
 Shaanxi Key Laboratory of Geotechnical and Underground  
 Space Engineering, XAUAT, China  
 Shandong Innovative Material Technology Co.,Ltd, China  
 Shijiazhuang Tiedao University, China  
 Sinopec Research Institute of Petroleum Engineering, China  
 SINTEF Teknologi og samfunn, Trondheim, Norway  
 Skanska AB, Solna, Sweden  
 Solexperts AG., Mönchaltorf, Switzerland  
 State Key Lab for Geomechanics and Deep Underground  
 Engineering, China University of Mining and  
 Technology, China  
 Stiftelsen Norges Geotekniske Institutt Oslo, Norway  
 Sweco AB, Stockholm, Sweden  
 Swedish Nuclear Fuel and Waste Management Co. – SKB,  
 Stockholm, Sweden  
 Tongji University, China  
 Tyréns AB, Stockholm, Sweden  
 WSP Sverige AB, Stockholm-Globen, Sweden  
 Zhejiang Society for Geotechnical Mechanics &  
 Engineering, China

## H UNIVERSITY

Chalmers University of Technology, Sweden  
 China University of Mining and Technology-Beijing, China  
 China University of Petroleum-Beijing, China  
 Hubei University of Technology, China  
 Royal Institute of Technology, KTH, Sweden  
 Shandong University, China  
 Shijiazhuang Tiedao University, China

## I GOVERNMENT DEPARTMENTS

CETU (Centre d'Études des Tunnels), Lyon, France  
 Chengdu Engineering Co. Ltd., Power, China  
 China University of Mining and Technology-Beijing, China  
 China University of Petroleum-Beijing, China  
 GeoConnect Technology Development Co., Ltd, China  
 Hanjiang-to-Weihe River Valley Water Diversion Project  
 Construction Co., Ltd.SHAANXI Province, China  
 LECM - Civil Engineering Laboratory of Macau, Macau, China  
 LNEC - Laboratório Nacional de Engenharia Civil,  
 Lisbon, Portugal  
 Okumura Corporation, Ibaraki, Japan  
 Shandong University, China  
 Southwest Jiaotong University, China

## J OTHER CORPORATE MEMBERS

ITOCHU Techno – Solutions Corporation, Tokyo, Japan  
 Kumagai Gumi Co., Ltd., Tokyo, Japan  
 Okumura Corporation, Ibaraki, Japan  
 Orica Mining Services Portugal, SA., Lisboa, Portugal  
 Phosagro, Leningradskaya, Russia  
 Swedish Rock Engineering Association, Sweden  
 WSP Finland Oy, Helsinki, Finland

## HOW TO JOIN THE ISRM

### Individual members:

Individuals shall normally apply for membership of the ISRM through their National Group.

### Corresponding members:

As some countries do not have a National Group, individuals may also apply for ISRM membership directly to the Secretariat.

### Corporate members:

Companies shall apply for membership of the ISRM as corporate members directly to the Secretariat.

In some cases companies have also joined the ISRM as corporate members through their National Group.

### National Groups:

For a national organisation to be recognised as a National Group, it is required to formally apply to the President through the Secretary-General for recognition according to the ISRM statutes. This shall be an organisation such as a society or a committee that represents Rock Mechanics in that country, either solely concerned with Rock Mechanics, or as part of a broader field of scientific or engineering interest. Each country shall have no more than one National Group.

## BENEFITS TO MEMBERS

### Current benefits given to ISRM Individual and corresponding members are:

- ISRM Newsletter
- Access to the members area in the website (download of Suggested Methods and Reports, Rock Mechanics lectures, videos, slide collection, etc.)
- Right to participate in the ISRM Commissions
- Registration with a 20% discount in the ISRM Congress, International and Regional Symposia and Specialized Conferences
- Personal subscription to the International Journal of Rock Mechanics and Mining Sciences at a discounted price (see details).
- Personal subscription to the Journal Rock Mechanics and Rock Engineering at a discounted price.
- Free download of up to 100 papers per year from the ISRM Digital Library at OnePetro: [www.onepetro.org](http://www.onepetro.org)
- Discount on purchases of CRC Press books: 40% discount on books in the ISRM Book Series; 30% discount on all other CRC Press books.

### Current benefits given to ISRM corporate members are:

- Being listed in the ISRM website, with a link to the company's website
- Being listed in the ISRM News Journal
- Access to the members area in the ISRM website
- ISRM Newsletter
- 1 copy of the ISRM News Journal
- 1 registration with a 20% discount as ISRM member in the ISRM Congress, International and Regional Symposia and Specialized Conferences
- Free download of up to 250 papers per year from the ISRM Digital Library at OnePetro: [www.onepetro.org](http://www.onepetro.org).



ISRM

International Society for Rock Mechanics and Rock Engineering



Semmering Basistunnel, photo by OBB

#### ISRM Board

President  
Vice-President for Africa  
Vice-President for Asia  
Vice-President for Australasia  
Vice-President for Europe  
Vice-President for Latin America  
Vice-President for North America  
Vice-President at Large  
Vice-President at Large  
Vice-President at Large  
Secretary-General

Prof. Seokwon Jeon  
Dr. Jannie Maritz  
Prof. Ki-Bok Min  
Dr. Qianbing Zhang  
Dr. Muriel Gasc-Barbier  
Dr. Esteban Hormazabal  
Prof. Martin Grenon  
Prof. Milorad Jovanovski  
Prof. Kiyoshi Kishida  
Dr. Fengshou Zhang  
Dr. Luís Lamas