ISRM 50th Anniversary Commemorative Book

1962–2012

Editors
John A. Hudson
Luís Lamas

ISRM
International Society for Rock Mechanics

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Publication of this book was financially suported by:

International Society for Rock Mechanics

ISRM

State Key Laboratory of Geomechanics and Geotechnical Engineering
Institute of Rock and Soil Mechanics, Chinese Academy of Sciences

Front cover: Extensional failure—hackles and plumose structures on the surface of an extensional fracture.

Page iii: Entrance to a 9th century monolithic Buddhist Temple in India—in the Deccan traps, thick successions of basaltic lava flows.

Page 155: DECOVALEX Field Trip to Äspö Hard Rock Laboratory in Sweden.

Photographs included in this book are courtesy of the following persons and organisations:
Austrian Society for Geomechanics, Fernando Peres Rodrigues, Jaroslav Černi Institute for Development of Water Resources, Belgrade, John A. Hudson, John W. Cosgrove, Luís Lamas, Portuguese National Laboratory for Civil Engineering (LNEC), Ricardo Oliveira and SKB.

Title: ISRM 50th Anniversary Commemorative Book

Editors: John A. Hudson and Luís Lamas

Published by: International Society for Rock Mechanics
c/o LNEC
Av. do Brasil, 101
1700-066 Lisboa, Portugal
e-mail: secretariat.isrm@lnec.pt
www.isrm.net

Concept and Graphic Design: Rita O. Paulo

Printed by: Cor Comum Serviços Gráficos Lda, Lisboa, Portugal

ISBN: 978-989-20-3012-8

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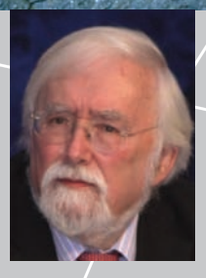


John A Hudson

Xia-Ting Feng

Luís Lamas

It has been a pleasure for the Editors to have compiled and published this Commemorative Book celebrating the 50th anniversary of the International Society for Rock Mechanics (ISRM). Although the history of mankind's use of rock as an engineering material is lost in the mists of time, it is only in the last 50 years that the subject of rock mechanics and its use in rock engineering have been formally recognised through the formation of the ISRM in 1962 and its 50-year continued activities through to 2012. As is outlined in the Chapter 3 history of the ISRM, during that time there have been many significant advances in the subject, both theoretical and practical, not to mention all the personnel interaction advantages of the many ISRM symposia that have taken place during the period.

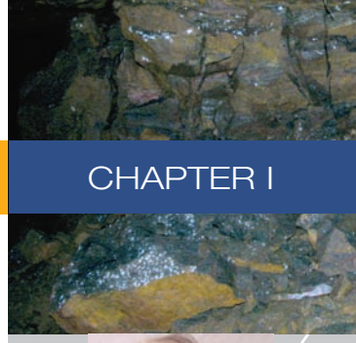
This book has, therefore been compiled to celebrate ISRM's 50-year anniversary by outlining the background to the formation of the ISRM and the most significant activities during the 50 years. The anniversary celebrations started at the 12th ISRM Congress held in Beijing, China, in October 2011 and continued until the ISRM EUROCK Symposium held in Stockholm, Sweden, in May 2012—when this book was published.

Following Chapters 1–3 on the formation of the ISRM, the founding documents, and an overview of the first 50 years, in Chapters 4–7 there are historical data on the sequence of the ISRM Presidents, the Müller Award recipients and Manuel Rocha medal recipients, plus reminiscences by the successive ISRM Secretaries-General. The book then includes a description of the ISRM in 2012, together with the current status of the six ISRM geographical regions, how rock mechanics developments have supported engineering practice, and the ISRM's co-operation with related professional Societies. Finally, in Chapter 12, there are predictions for the evolution of rock mechanics and the ISRM over the next 50 years. In the Appendices, there are further detailed historical data.

We should like to thank personally all the individual contributors to the various Chapters, and especially Professor Ted Brown who assisted in the development of the book's structure and wrote the extensive and authoritative historical article in Chapter 3 on "The First 50 Years of the ISRM". Both the ISRM and the State Key Laboratory of Geomechanics and Geoengineering of the Institute of Rock and Soil Mechanics of the Chinese Academy of Sciences are thanked for financially supporting the production of the book.

March, 2012

The Formation of the ISRM



CHAPTER I

Charles Fairhurst

Note: This Chapter is based on components of Professor Fairhurst's First Vienna Leopold Müller Lecture.

INTRODUCTION

Professor Müller was an inspiration and friend to me, especially during the period 1958–1970, formative years for the 'art and science' of rock mechanics. I was privileged to be invited by Dr Müller, during his visit to the US to attend the 3rd US Symposium on Rock Mechanics, held in Golden, Colorado, in 1958, to join the "Salzburger Kreis" (Salzburg Circle), a predominantly Austrian group formed to discuss critical issues of rock mechanics and rock engineering. The decision to establish the International Society for Rock Mechanics in May 1962 was an outgrowth of these discussions. Many of the first group of ISRM members came from the Salzburg Circle. The official ISRM list of the first twenty members is shown below. I was privileged to be included.

1 - Prof. Leopold Müller, Austria
2 - Mr F. Pacher, Austria
3 - Prof. L.V. Rabcewicz, Austria
4 - Mr C. Lorber, Austria
5 - Prof. F. Kahler, Austria
6 - Dr W. Zanoskar, Austria
7 - Mr W. Finger, Austria
8 - Dr A. Fuchs, Austria
9 - Prof. F. K. Müller, Austria
10 - Mr P. Reska, Austria
11 - Dr K. Waschek, Austria
12 - Prof. G. B. Fettweis, Austria
13 - Dr Georg Beurle, Austria
14 - Neue Reformbaugesellschaft mbH, Austria (Supporting Member)
15 - Dr Alois Kieser, Austria
16 - Prof. H. Seelmeier, Austria
17 - Dr Adolf Bretterklieber, Austria
18 - Mr W. Wessiak, Austria
19 - Prof. A. Watznauer, East Germany
20 - Prof. Charles Fairhurst, USA

Much of the literature on engineering geology rock mechanics, especially as it related to the challenge of determining the *in situ* behaviour of rock, had been published in the journal *Geologie und Bauwesen*, started and edited by Professor Josef Stini from1929. Professor Müller took over as Editor on the death of Professor Stini in 1958. In 1963, Professor Müller kindly invited me to assist him in extending the international reach of the journal, renamed '*Rock Mechanics and Engineering Geology*' (Figure 1). Currently known as '*Rock Mechanics and Rock Engineering*', the journal is now established as one of the most renowned international journals in rock mechanics and rock engineering.

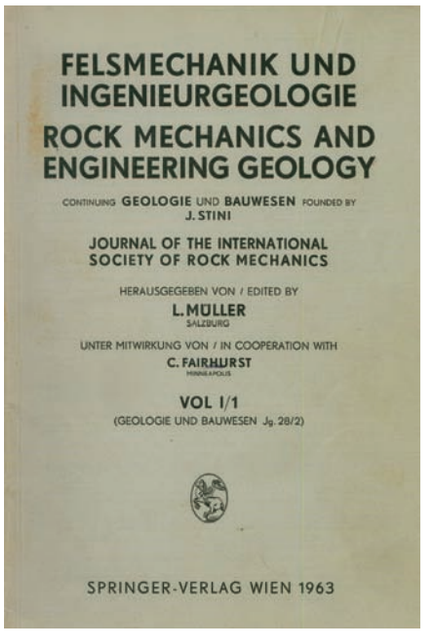


Figure 1. Cover of the journal *'Rock Mechanics and Engineering Geology'*

The enormous debt of the international geomechanics and geotechnical engineering community to Austria is demonstrated by Figure 2. It is truly remarkable that the founders of the disciplines of Engineering Geology (Stini), Soil Mechanics (Terzaghi), and Rock Mechanics (Müller)—each now represented by an International Society[(1)], were all from Austria. The challenges of developing roads, railway tunnels, dams and other civil works through the mountainous Alpine terrain, and, earlier still, mines, provided the stimulus.

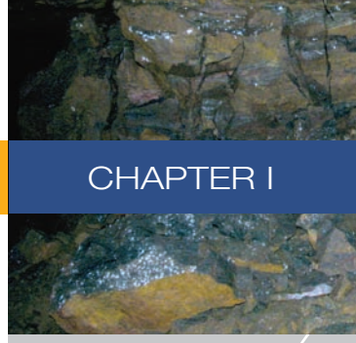
Prof. Josef Stini
Engineering Geology
(1883–1958)
Geologie und Bauwesen 1929

Prof. Leopold Müller
Rock Mechanics
(1908–1988)

Prof. Karl von Terzaghi
Soil Mechanics
(1883–1963)

Figure 2. *"Great things are done when men and mountains meet." William Blake.*
(The German structural geologist, Prof. H. Cloos is credited with introducing the term 'geomechanics'.)

(1) International Association for Engineering Geology and the Environment (IAEG), founded1964; International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), founded 1936; International Society for Rock Mechanics (ISRM), founded 1962. Co-ordination between the three Societies is maintained through the relatively recently established Federation of International Geo-engineering Societies (FedIGS). See Chapter XI of this book.



The constitutional meeting of the International Society for Rock Mechanics took place in Salzburg on 25 May,1962. The day before, Professor Müller and his colleague, Dr Franz Pacher, were interviewed on a Salzburg radio station. The transcript of the interview is now part of the official records of the ISRM, on file at the ISRM Secretariat in Lisbon[2]. A copy of the original German version of the interview, together with an English translation, is provided as the Annex to this Chapter. In the interview, the reporter asks:

> ***"Do we know the strength of rock?"***

Müller replied:

> *"For rock (specimens) tested in the laboratory, yes.* ***For a rock mass, no.*** *This is what we need to determine.* ***This is why we need an International Society for Rock Mechanics."*** [3]

This succinct statement defines what Müller considered to be the central question in rock mechanics:

> ***"What is the strength of a rock mass?"***

It seems appropriate, almost 50 years after Prof. Müller first defined this as the main challenge in rock mechanics, to consider how far we have come in answering the question.

INCORPORATING DISCONTINUITIES INTO ROCK MECHANICS ANALYSES

In his Opening Address at the First ISRM Congress in Lisbon, the then ISRM President Müller stated:

> *"Many experts agree with me that discontinuity and anisotropy are the most characteristic properties of the material rock and that the properties of jointed media depend much more upon the fabrics bond of the unit rock block system than upon the rock material. Therefore any theoretical investigation of that material has to go its own ways, in the same way as the construction material of soils years ago suggested to soil mechanics its own methods, which differ greatly from the way of thinking of technical mechanics".*

The dominant influence of '*discontinuity and anisotropy*' and associated scale effect *are*, of course a significant difference between rock mechanics and soil mechanics, alluded to in Müller's comment.

Two years later, Trollope noted:

> *"In the field of geomechanics, granular media and block-jointed rock masses are obvious examples where the concept of the ideal physical continuum—one in which no gaps are formed—cannot be expected to apply...The clastic* (i.e. discontinuum) *model offers an alternative approach. Indeed it is this writer's view that only with clastic models or some further development thereof can the problem of predicting the complete load-deformation of solids be tackled optimistically."*

In 1971, Peter Cundall, then a student of Prof E. Hoek at Imperial College, London presented the paper *"A Computer Model for Simulating Progressive Large Scale Movements in Blocky Rock Systems"* at the ISRM Symposium in Nancy, France. This introduced *'discontinuum analysis'* to rock mechanics. Joining the University of Minnesota in 1972, and Itasca in 1981, Cundall and his colleagues have continued to develop the *'discrete element method'* for modelling of jointed rock to the present time. Combined with (i) major and continuing advances in computational power and (ii) field testing of the

[2] I am grateful to Mrs Maria de Lourdes Eusébio and Dr Luis Lamas of ISRM for providing me with a copy of this interview.

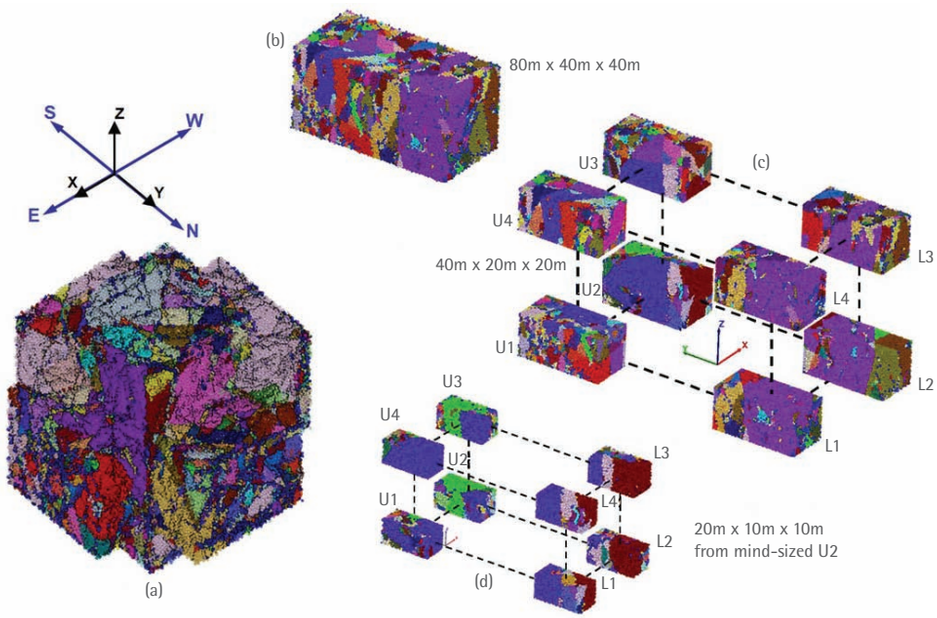
[3] Translated literally "Internationale Versuchsanstalt für Fels" is 'International Research Institute for Rock' but Professor Müller is clearly referring to "The International Society for Rock Mechanics" (Der Internationalen Gesellschaft für Felsmechanik) that he had just established.

modelling approach, determination of the strength and full constitutive behaviour to collapse of a rock mass is now a realistic possibility.

ADVANTAGES OF THE COMPUTER MODELLING CAPABILITIES AVAILABLE TODAY

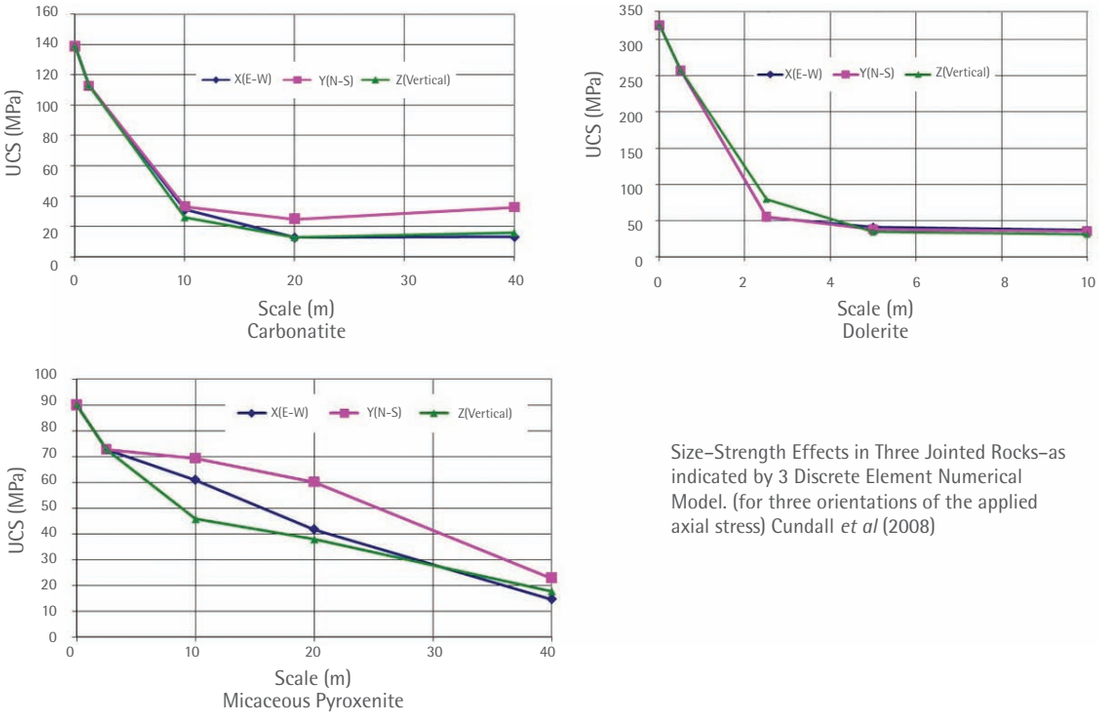
Lack of an adequate theoretical foundation on which to base design procedures leads inevitably to the development of empirical rules to help inform design. This is the case where the mechanical behaviour of the material is as complex as rock *in situ*. An important limitation of empirical rules (one that is not always respected) is that they should not be relied upon outside the boundaries within which the data used to develop the rule has been gathered. With many rock engineering projects moving beyond the bounds of experience, it is imperative that we now develop a more rational framework for design. Given the better theoretical framework that is becoming available, it is important to re-examine these rules. They do have value in that they are based on observations and data from field-scale projects, and can serve to validate the basis for the theoretical predictions.

In particular, computer methods now allow us to consider virtually many of the rock mechanics questions that have been raised over the last 50 years. An example is the size effect as explored by the Synthetic Rock Mass approach which is based on a clear quantitative model of the rock mass, see Figures 3 and 4.



3D Numerical Modelling of Size Effect in Jointed Rock. Cundall *et al.* (2008)

Figure 3. Determination of the Size Effect in a Synthetic Rock Mass computer model



Size–Strength Effects in Three Jointed Rocks–as indicated by 3 Discrete Element Numerical Model. (for three orientations of the applied axial stress) Cundall *et al* (2008)

Figure 4. Synthetic Rock Mass computer model results for the effect of sample size on rock mass strength

CONCLUSIONS

Since the formation of the ISRM, advances in computer power and discontinuum modelling have enabled the development of tools for making more reliable assessments of the strength and general constitutive behaviour of a rock mass. Such assessments provide a more rational framework for rock engineering design than current empirical rules.

An important attribute of such procedures is that it allows easy replication of results using ranges of input parameters in order to provide an estimate of the overall uncertainty, or reliability, of design predictions.

The critical next step to advance rock mechanics and rock engineering is to obtain reliable field-scale data to verify and improve numerical predictions. Urgent attention should be given to developing cost-effective ways of obtaining such data.

Underground laboratories such as the proposed US DUSEL (and other underground laboratories) serve a major role in field validation of theoretical development, but will be most effective when linked to observations in conjunction with rock engineering projects.
For a rock mechanics focus on the field scale, close interaction with engineering and structural geology is essential for optimal advances.

The major roles of discontinuum mechanics and numerical modelling should not overshadow the rich heritage and essential complementary roles of classical closed form and continuum analysis in rock mechanics.

As the ISRM enters its second half-century, it can best acknowledge the vision of its founder, Professor Leopold Müller, by continuing to pursue vigorously the focus on understanding the "mechanical behaviour of the rock mass".

ACKNOWLEDGMENTS

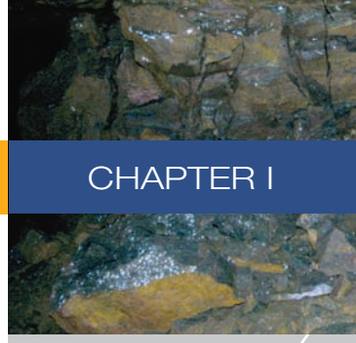
This Chapter has drawn heavily on the ideas and work of colleagues at the Itasca Consulting Group Inc. and its partner Applied Seismology Consultants. This assistance is gratefully acknowledged.

My daughter Anne Charlet and Dr Alfred Zettler kindly prepared the English translation of Prof. Müller's radio interview. Frau Christine Cerny, Secretary to Prof. Poisel, has been very patient and understanding during preparation of the Lecture on which this Chapter is based ■

REFERENCES

Cundall P.A., Pierce M.E., Ivars D.M. (2008) "Quantifying the Size Effect of Rock Mass Strength" in Proc. 1st Southern Hemisphere International Rock Symposium, SHIRMS 2008, Y. Potvin, J. Carter, A. Dyskin, R. Jeffrey (eds), Australian Centre for Geomechanics, Perth, Australia.

Fairhurst, C. (2010) "First Vienna-Leopold-Müller Lecture: What is the strength of a rock mass? Progress in answering Müller's (implicit) question" in Proc. 5th Colloquium, Rock Mechanics–Theory & Practice, Vienna, 26–27 November 2009, Mitteilungen für Ingenieurgeologie und Geomechanik, Band 9: 87–110.

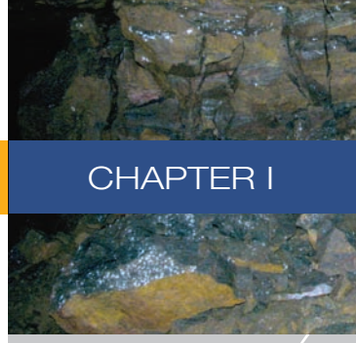


ANNEX

Radio interview by Prof. Leopold Müller, Salzburg, May 24, 1962, on the occasion of officially registering ISRM as an International Society.

	Original German Text	English Translation
	Rundfunk Interview, gesendet am 24.5.1962, 19:40. - 1. Program	Radio Interview. Broadcast on 24.5.1962, 19:40 - Program 1
	Hinweis: Kursiv gedruckte Wörter wurden in den aufgenommen Text hinzugefügt, um die Sätze für die Übersetzung ins Englisch auszufüllen.	*N.B.* Words in italics have been added to the original transcript of the interview, and incorporated into the English translation.
Reporter:	"Internationale Gesellschaft für Felsmechanik" - Was ist Felsmechanik?	"International Society for Rock Mechanics." What is Rock Mechanics?
Pacher:	Die Wissenschaft vom mechanischen Verhalten des zerklüfteten Gesteins gegenüber Kräften, Beanspruchungen und aufgezwungenen Formänderungen.	The scientific discipline that studies the response of jointed rock when subjected to forces.
Reporter:	Welche praktischen Auswirkungen und Aufgaben *hat die Felsmechanik*?	What are the practical results and problems of Rock Mechanics?
Pacher:	Auf der Grundlage einer theoretisch richtigen und praxisnahen Felsmechanik lassen sich Fundierungen von Seilbahnstützen *und* Staumauern in Fels mit grosser Sicherheit berechnen; aber auch die Verkleidung von Tunneln, grösseren unterirdischen Hohlräumen usw. lässt sich rechnerisch erfassen, so dass sie in der wirtschaftlichsten Weise und vor allem ohne Gefahr durchgeführt werden können.	Based on fundamental theoretical and practical Rock Mechanics, we are able to design foundations for cable-car pillars and arch dams in rock with a higher factor of safety. Tunnel linings, large underground excavations, etc. can also be calculated mathematically so that we can design economically and, above all, we can develop designs that are safe.
Reporter:	Das ist also etwas ganz Neues? Dann möchte ich fast vermuten, dass Malpasset der Anlass war?	Is this something new? Can we say that it has been stimulated by Malpasset?

Müller:	Nicht so neu. In Salzburg *gibt es* schon seit 1951 *die* "Internationale Arbeitsgemeinschaft für Geomechanik" *mit den* gleichen Aufgaben. Vor 4 Jahren wurde in Berlin das "Internationale Büro für Gebirgsmechanik der Deutschen Akademie der Wissenschaften" gegründet, bei welchem wir auch vertreten sind. Die Welt (*z.B. in Kongressen*) hat von uns wenig Notiz genommen. *Die "Internationale Gesellschaft für Felsmechanik" soll* nun *eine* breitere Basis *darstellen.*	Not so new. In Salzburg, the "International Working Group on Geomechanics" has been working on these problems since 1951. Four years ago, the International Bureau for Rock Mechanics was founded as a part of the Germany Academy of Sciences; we are part of this group. So far, the world (for instance in congresses) has taken little notice of us. But the "International Society for Rock Mechanics" will provide a wider sphere.
Reporter:	Was ist denn Bodenmechanik und *was ist* Geomechanik?	So what is Soil Mechanics and what is Geomechanics?
Müller:	Bodenmechanik befasst sich mit Lockermassen, Sand, Ton, usw. Geomechanik *ist die* Mechanik der festen Erdkruste, umfasst auch die Entstehung der Gebirge und *die* Erklärung *der gebirgsbildenden Vorgänge*, soweit sie mechanisch zu verstehen *sind.*	Soil mechanics is concerned with softer, porous materials such as sand, clay etc. Geomechanics deals with the mechanics of the earth's solid crust, incorporating also mountain-building and understanding of the associated mechanical processes.
Reporter:	Kann man denn solche Dinge *berechnen*?	Can we calculate such things?
Pacher:	*Ein* Beispiel ist die Fundierung einer Staumauer wie Malpasset. *Die* Kräfte *sind* bekannt, *der* Fels kommt unter zusätzliche Spannungen *und der* Vergleich mit den Festigkeiten zeigt, ob er ihnen gewachsen ist.	Consider the Malpasset Dam foundation, for example. The forces are known, the rock is subjected to additional stresses and comparison of these with the strength shows whether or not the rock strength is adequate.
Reporter:	*Zum* Begriff der Sicherheit. **Sind denn die Festigkeiten der Gesteine bekannt?**	With respect to safety. *Do we know the strength of rock?*
Müller:	**Der Gesteine,** *getestet im* **Labor, schon. Der Gebirge nicht.** *Diese Festigkeiten* **müssen geprüft werden.** *Daher brauchen wir eine* **'Internationale Versuchsanstalt für Fels'.**	*For rock (specimens) tested in the laboratory, yes. For a rock mass, no. This is what we need to determine. This is why we need an 'International Research Institute for Rock'.*
Reporter:	*Was sind die* Ziele der Gesellschaft?	What are the aims of such an organization?



Müller: *Foren*, Tagungen *und das* Kolloquium *im* Oktober. Ferner Publikationen und Forschungsvorhaben. Einheitliche Auffassungen, Bezeichnungen *und* Normen.

Forums, meetings and the Colloquium that we hold every October. These will lead to publications, research activities, uniform concepts, denominations and standards will be developed.

Reporter: Warum gerade in Salzburg?

Why in Salzburg?

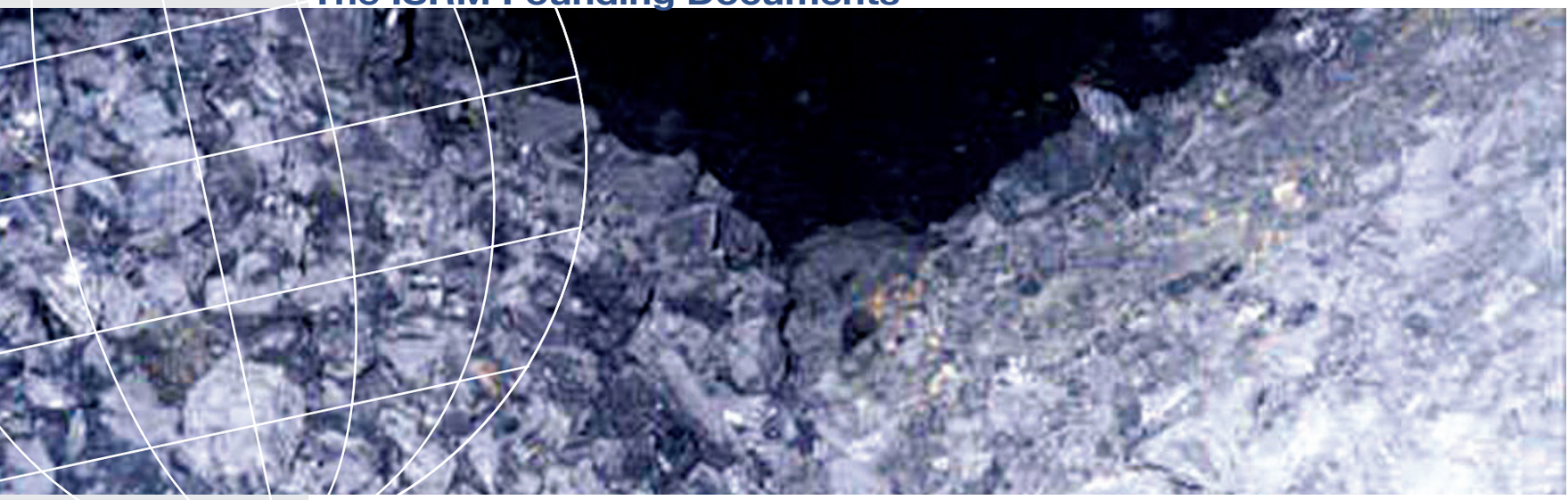
Müller: Alle Baugrundwissenschaften sind von Österreich ausgegangen, Terzaghi-–Stini–Geomechanik. Die Österreicher wissen gar nicht, dass sie auf diesen entscheidenden Gebieten führend sind und dass die ganze Welt dies anerkennt. In der Bodenmechanik wurde die Führung abgegeben, Terzaghi ging *in die* USA.

Hoffentlich gibt man uns die Mittel, führend zu bleiben. *Wir haben* Erfolge in Japan. Ob das so bleibt, hängt nicht von uns alleine ab, sondern auch davon, ob *der* Staat und *das* Land für diese speziell österreichische Wissenschaft und für die Wissenschaft überhaupt etwas tun.

All of the basic knowledge for construction in soil and rock has been developed in Austria–Terzaghi, Stini; Geomechanics. Austrians do not appreciate that we are definitely the leaders in this field, and recognised as such worldwide. We gave up this lead in soil mechanics when Terzaghi went to the USA. We hope that we will be given the means to maintain our lead.

We have succeeded in Japan. Whether that continues is not up to us alone, but depends also on whether the country and the state decide to do something for this Austrian scientific expertise, and indeed for Science in general.

The ISRM Founding Documents



Luís Lamas

The decision to include in the ISRM 50-year anniversary commemorative book a Chapter dedicated to the founding documents came to the author's mind after consulting the early archives of the Society when looking for documents requested by Professors Charles Fairhurst and Ted Brown. Professor Fairhurst was preparing the "First Vienna-Leopold-Müller Lecture"[(1)], which he delivered in Vienna in 2009 during the sequence of the commemorations of the 100th birthday of Professor Leopold Müller (1908–1988), the founder of the ISRM. Two years later, Professor Brown was preparing the keynote lecture "50 Years of the ISRM and Associated Progress in Rock Mechanics"[(2)] that he would present in Beijing in October 2011 during the 12th International Congress of the ISRM, to inaugurate the commemorations of the 50th anniversary of the ISRM.

The early archives of the ISRM were compiled by Professor Leopold Müller's Secretariat in Salzburg, and start with documents dated January 1962. The archives were handed over to the 2nd President of the ISRM, Professor Manuel Rocha, who organised the 1st International Congress of the Society in 1966, in Lisbon, where the ISRM Secretariat has been located until the present day.

The formation of the International Society for Rock Mechanics, which officially took place with the Constitutional Meeting on 25 May 1962, was preceded and followed by several events, from January to October of that year, which are worth being recorded. Facsimiles of the original documents referred to in the text are included here.

The oldest document in the archives is a letter of 16 January [1] to the Federal Police Directorate of Salzburg proposing the formation of a Society named "*Internationale Gesellschaft für Geomechanik*" (International Society for Geomechanics), and signed by Professor Leopold Müller and Dipl. Ing. Franz Pacher. The authorisation was given on 19 February [2].

The reason for this name derived from Leopold Müller's original intention to transform the "*Internationale Arbeitsgemeinschaft für Geomechanik*" (International Study Group[(3)] for Geomechanics)—also called the "*Salzburger Kreis*" (Salzburg Circle)—that he had founded in Salzburg in 1951, into a really international organisation. Since its foundation, this Study Group had an active involvement in the organisation of the oldest series of international conferences in Rock Mechanics, the Geomechanics Colloquies, which will have in 2012 its 61st edition.

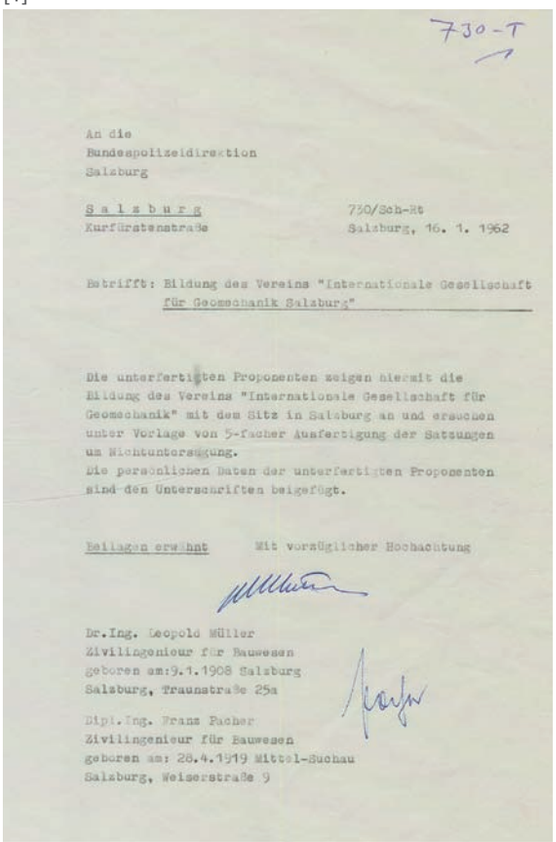
Müller then started establishing formal contacts with several eminent personalities in the field of Geomechanics, announcing the formation of the Society and inviting them to take part in it. It is interesting to read the correspondence he exchanged with Dr Laurits Bjerrum. Dr Bjerrum was, at that time, Director of the Norwegian Geotechnical Institute (NGI) and Vice-President of the International Society for Soil Mechanics and Foundation Engineering (ISSMFE). In 1965 he would become the 4th ISMMFE President, following Terzaghi, Skempton and Casagrande.

(1) Fairhurst, C. (2010) "First Vienna-Leopold-Müller Lecture: What is the strength of a rock mass? Progress in answering Müller's (implicit) question". *Proc. 5th Colloquium, Rock Mechanics–Theory & Practice*, Vienna, 26–27 November 2009, *Mitteilungen für Ingenieurgeologie und Geomechanik*, Vol. 9, pp 87–110.

(2) Brown, E.T. (2011) "50 Years of the ISRM and Associated Progress in Rock Mechanics". *Proc. 12th ISRM International Congress on Rock Mechanics: Harmonizing Rock Engineering and the Environment*, Qian & Zhou (eds), pp 29–45, London: Taylor and Francis.

(3) The German word "*Arbeitsgemeinschaft*" was translated into English as "*Study Group*", following the translation found in the English version of the minutes of the Constitutional Meeting.

[1]



730-T

An die
Bundespolizeidirektion
Salzburg

S a l z b u r g
Kurfürstenstraße

730/Sch-Rt
Salzburg, 16. 1. 1962

Betrifft: Bildung des Vereins "Internationale Gesellschaft für Geomechanik Salzburg"

Die unterfertigten Proponenten zeigen hiermit die Bildung des Vereins "Internationale Gesellschaft für Geomechanik" mit dem Sitz in Salzburg an und ersuchen unter Vorlage von 5-facher Ausfertigung der Satzungen um Nichtuntersagung.
Die persönlichen Daten der unterfertigten Proponenten sind den Unterschriften beigefügt.

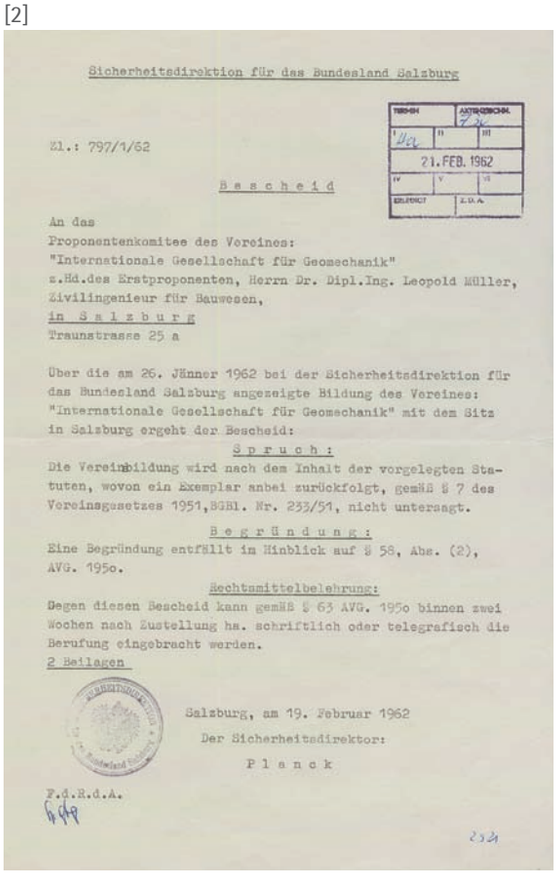
Beilagen erwähnt

Mit vorzüglicher Hochachtung

Dr.Ing. Leopold Müller
Zivilingenieur für Bauwesen
geboren am:9.1.1908 Salzburg
Salzburg, Traunstraße 25a

Dipl.Ing. Franz Pacher
Zivilingenieur für Bauwesen
geboren am: 28.4.1919 Mittel-Suchau
Salzburg, Weiserstraße 9

[2]



Sicherheitsdirektion für das Bundesland Salzburg

Zl.: 797/1/62

21. FEB. 1962

B e s c h e i d

An das
Proponentenkomitee des Vereines:
"Internationale Gesellschaft für Geomechanik"
z.Hd.des Erstproponenten, Herrn Dr. Dipl.Ing. Leopold Müller,
Zivilingenieur für Bauwesen,
in S a l z b u r g
Traunstrasse 25 a

Über die am 26. Jänner 1962 bei der Sicherheitsdirektion für das Bundesland Salzburg angezeigte Bildung des Vereines: "Internationale Gesellschaft für Geomechanik" mit dem Sitz in Salzburg ergeht der Bescheid:

S p r u c h :

Die Vereinbildung wird nach dem Inhalt der vorgelegten Statuten, wovon ein Exemplar anbei zurückfolgt, gemäß § 7 des Vereinsgesetzes 1951,BGBl. Nr. 233/51, nicht untersagt.

B e g r ü n d u n g :

Eine Begründung entfällt im Hinblick auf § 58, Abs. (2), AVG. 1950.

Rechtsmittelbelehrung:

Gegen diesen Bescheid kann gemäß § 63 AVG. 1950 binnen zwei Wochen nach Zustellung bs. schriftlich oder telegrafisch die Berufung eingebracht werden.

2 Beilagen

Salzburg, am 19. Februar 1962

Der Sicherheitsdirektor:

P l a n c k

F.d.R.d.A.

[1] Letter from Leopold Müller and Franz Pacher to the Federal Police Directorate of Salzburg, 16 January 1962.

[2] Decision of the Safety Directorate of the Federal State of Salzburg, 19 February 1962.

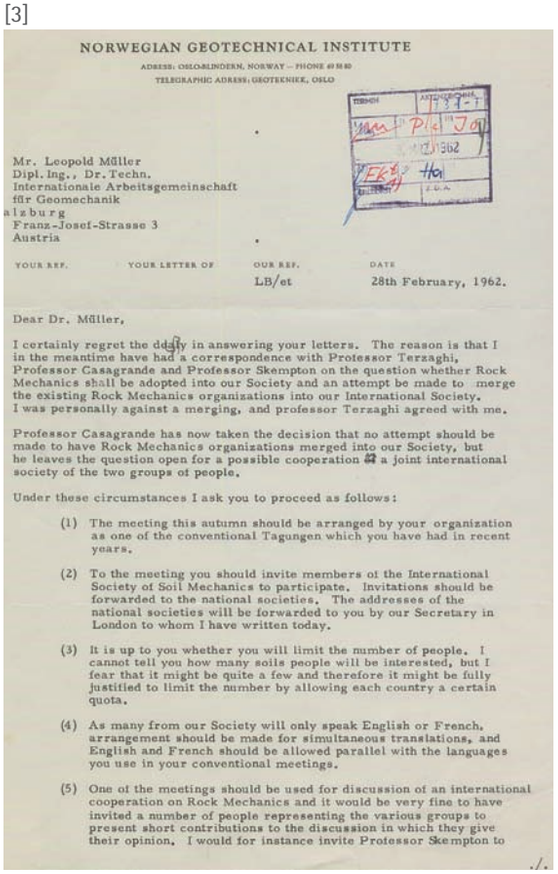
In a letter dated 28 February [3], Bjerrum replies to Müller's letters[4] regarding the formation of the "International Society for Geomechanics" and Müller's intention to invite members of the ISSMFE to a conference he planned to hold in October. The following quotation is of particular interest:

> "*I certainly regret the delay in answering your letters. The reason is that I in the meantime have had correspondence with Professor Terzaghi, Professor Casagrande and Professor Skempton on the question whether Rock Mechanics shall be adopted into our Society and an attempt be made to merge the existing Rock Mechanics organizations into our International Society. I was personally against a merging, and Professor Terzaghi agreed with me.*
>
> *Professor Casagrande has now taken the decision that no attempt should be made to have Rock Mechanics organizations merged into our Society, but he leaves the question open for a possible cooperation in a joint international society of the two groups of people.*"

In his reply of 12 March [4], Müller expresses[5] his satisfaction for the consultation of Terzaghi, Casagrande and Skempton, and for the clear decision. At the end of the letter, in a *Post Scriptum*, Müller invites Bjerrum to be a member of the future Society:

> *"In the interests of future cooperation, it would be extremely valuable to have you in our committee as a liaison to the ISSMFE".*

[3]



NORWEGIAN GEOTECHNICAL INSTITUTE

ADRESS: OSLO-BLINDERN, NORWAY – PHONE 46 38 80
TELEGRAPHIC ADRESS: GEOTEKNIKK, OSLO

Mr. Leopold Müller
Dipl. Ing., Dr. Techn.
Internationale Arbeitsgemeinschaft
für Geomechanik
alzburg
Franz-Josef-Strasse 3
Austria

YOUR REF.	YOUR LETTER OF	OUR REF.	DATE
		LB/et	28th February, 1962.

Dear Dr. Müller,

I certainly regret the delay in answering your letters. The reason is that I in the meantime have had a correspondence with Professor Terzaghi, Professor Casagrande and Professor Skempton on the question whether Rock Mechanics shall be adopted into our Society and an attempt be made to merge the existing Rock Mechanics organizations into our International Society. I was personally against a merging, and professor Terzaghi agreed with me.

Professor Casagrande has now taken the decision that no attempt should be made to have Rock Mechanics organizations merged into our Society, but he leaves the question open for a possible cooperation in a joint international society of the two groups of people.

Under these circumstances I ask you to proceed as follows:

(1) The meeting this autumn should be arranged by your organization as one of the conventional Tagungen which you have had in recent years.

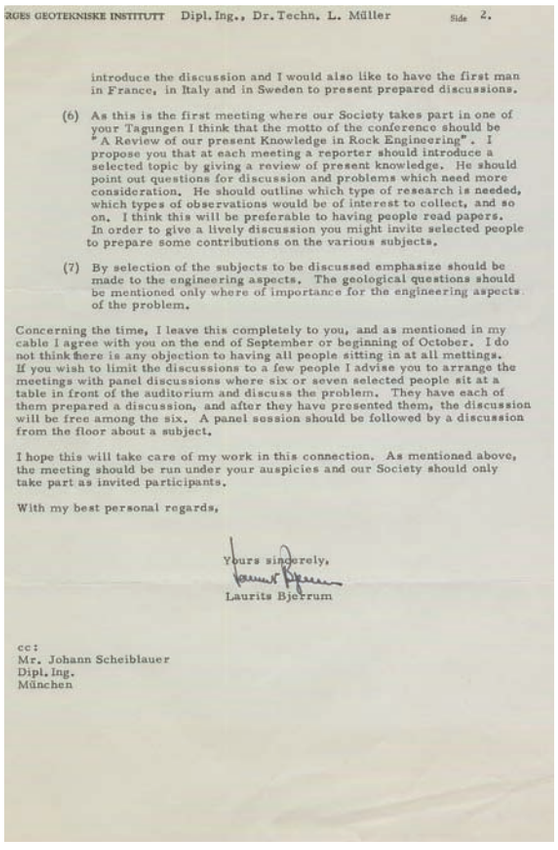
(2) To the meeting you should invite members of the International Society of Soil Mechanics to participate. Invitations should be forwarded to the national societies. The addresses of the national societies will be forwarded to you by our Secretary in London to whom I have written today.

(3) It is up to you whether you will limit the number of people. I cannot tell you how many soils people will be interested, but I fear that it might be quite a few and therefore it might be fully justified to limit the number by allowing each country a certain quota.

(4) As many from our Society will only speak English or French, arrangement should be made for simultaneous translations, and English and French should be allowed parallel with the languages you use in your conventional meetings.

(5) One of the meetings should be used for discussion of an international cooperation on Rock Mechanics and it would be very fine to have invited a number of people representing the various groups to present short contributions to the discussion in which they give their opinion. I would for instance invite Professor Skempton to

./.



RGES GEOTEKNISKE INSTITUTT Dipl. Ing., Dr. Techn. L. Müller Side 2.

introduce the discussion and I would also like to have the first man in France, in Italy and in Sweden to present prepared discussions.

(6) As this is the first meeting where our Society takes part in one of your Tagungen I think that the motto of the conference should be "A Review of our present Knowledge in Rock Engineering". I propose you that at each meeting a reporter should introduce a selected topic by giving a review of present knowledge. He should point out questions for discussion and problems which need more consideration. He should outline which type of research is needed, which types of observations would be of interest to collect, and so on. I think this will be preferable to having people read papers. In order to give a lively discussion you might invite selected people to prepare some contributions on the various subjects.

(7) By selection of the subjects to be discussed emphasize should be made to the engineering aspects. The geological questions should be mentioned only where of importance for the engineering aspects of the problem.

Concerning the time, I leave this completely to you, and as mentioned in my cable I agree with you on the end of September or beginning of October. I do not think there is any objection to having all people sitting in at all mettings. If you wish to limit the discussions to a few people I advise you to arrange the meetings with panel discussions where six or seven selected people sit at a table in front of the auditorium and discuss the problem. They have each of them prepared a discussion, and after they have presented them, the discussion will be free among the six. A panel session should be followed by a discussion from the floor about a subject.

I hope this will take care of my work in this connection. As mentioned above, the meeting should be run under your auspicies and our Society should only take part as invited participants.

With my best personal regards,

Yours sincerely,
Laurits Bjerrum

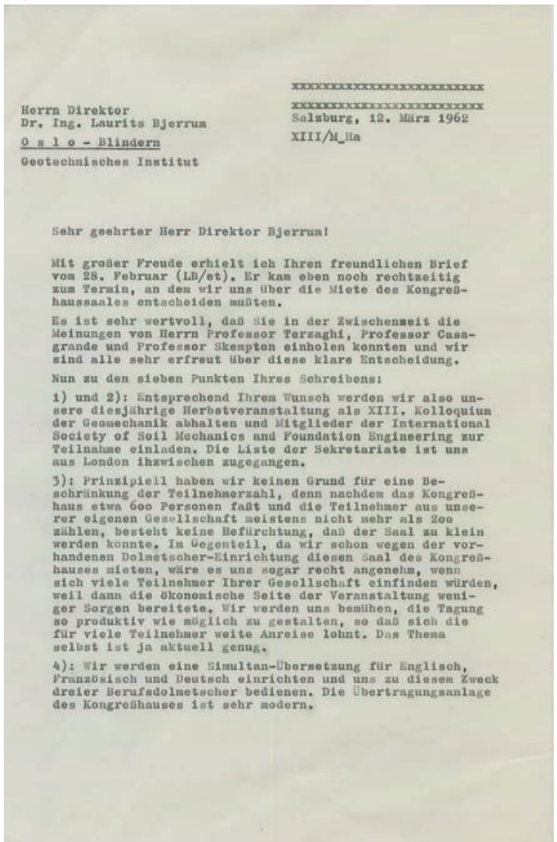
cc:
Mr. Johann Scheiblauer
Dipl. Ing.
München

[3] Letter from Laurits Bjerrum to Leopold Müller, 28 February 1962.

[4] Not in the ISRM archives.

[5] It is interesting to note that Müller wrote to Bjerrum in German, while Bjerrum replied to him in English.

[4]



Herrn Direktor
Dr. Ing. Laurits Bjerrum
O s l o - Blindern
Geotechnisches Institut

xxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxx
Salzburg, 12. März 1962
XIII/M_Ha

Sehr geehrter Herr Direktor Bjerrum!

Mit großer Freude erhielt ich Ihren freundlichen Brief vom 28. Februar (LB/et). Er kam eben noch rechtzeitig zum Terrain, an dem wir uns über die Miete des Kongreßhaussaales entscheiden mußten.

Es ist sehr wertvoll, daß Sie in der Zwischenzeit die Meinungen von Herrn Professor Terzaghi, Professor Casagrande und Professor Skempton einholen konnten und wir sind alle sehr erfreut über diese klare Entscheidung.

Nun zu den sieben Punkten Ihres Schreibens:

1) und 2): Entsprechend Ihrem Wunsch werden wir also unsere diesjährige Herbstveranstaltung als XIII. Kolloquium der Geomechanik abhalten und Mitglieder der International Society of Soil Mechanics and Foundation Engineering zur Teilnahme einladen. Die Liste der Sekretariate ist uns aus London ihzwischen zugegangen.

3): Prinzipiell haben wir keinen Grund für eine Beschränkung der Teilnehmerzahl, denn nachdem das Kongreßhaus etwa 600 Personen faßt und die Teilnehmer aus unserer eigenen Gesellschaft meistens nicht mehr als 200 zählen, besteht keine Befürchtung, daß der Saal zu klein werden könnte. Im Gegenteil, da wir schon wegen der vorhandenen Dolmetscher-Einrichtung diesen Saal des Kongreßhauses mieten, wäre es uns sogar recht angenehm, wenn sich viele Teilnehmer Ihrer Gesellschaft einfinden würden, weil dann die ökonomische Seite der Veranstaltung weniger Sorgen bereitete. Wir werden uns bemühen, die Tagung so produktiv wie möglich zu gestalten, so daß sich die für viele Teilnehmer weite Anreise lohnt. Das Thema selbst ist ja aktuell genug.

4): Wir werden eine Simultan-Übersetzung für Englisch, Französisch und Deutsch einrichten und uns zu diesem Zweck dreier Berufsdolmetscher bedienen. Die Übertragungsanlage des Kongreßhauses ist sehr modern.

INTERNATIONALE ARBEITSGEMEINSCHAFT FÜR GEOMECHANIK 2

5): Diesen Ihren Vorschlag werden wir gern und in der Form durchführen, daß wir mindestens einen oder zwei Teilnehmer einer jeden Nation, deren Auswahl wir der nationalen Gesellschaft überlassen, außerdem natürlich Professor Skempton als den Präsidenten der International Society, zu einem gesonderten Meeting einladen, in welchem die Möglichkeiten und Formen einer internationalen Zusammenarbeit auf dem Gebiet der Felsmechanik diskutiert werden. Eine solche internationale Zusammenarbeit besteht ja schon im Internationalen Büro für Gebirgsmechanik, in welchem vorwiegend Bergleute vertreten sind, und bei unserer Gesellschaft, welche hauptsächlich aus Bauingenieuren und Geologen besteht. Was noch fehlt, ist die internationale Zusammenarbeit mit den Fachleuten, welche sowohl in Bodenmechanik als auch in Felsmechanik arbeiten.
Einige gute Vertreter der verschiedenen Nationen sind mir selbst bekannt, aber es wäre mir lieb, wenn Sie mir gleichfalls eine Liste von Fachleuten übersenden lassen könnten, die dafür nach Ihrer Meinung in Betracht kommen. Gerne werden wir bei diesem Spezial-Meeting, das wir wahrscheinlich am Vormittag des 6. Oktober abzuhalten vorschlagen werden, Herrn Professor Skempton um die Führung der Diskussion bitten.

6): Ihr Vorschlag, als Motto der Tagung "A Review of our present Knowledge in Rock Engineering" zu wählen, ist ganz ausgezeichnet und wir werden ihn wörtlich übernehmen. Ihre Anregung, anstelle von einzelnen Vorträgen durch einige Referenten zusammenfassende Berichte über den gegenwärtigen Stand der Teilgebiete geben und einzelne Fragen und Probleme zur Diskussion stellen zu lassen, ist sicherlich sehr gut. Ich hoffe, sie in den nächsten Tagen mit unseren engeren Mitarbeitern besprechen zu können. Da allerdings ziemlich viele Themen auf diese Art diskutiert werden sollten, wird es wohl notwendig sein, an den meisten Halbtagen zwei solcher Referate halten zu lassen.

7): Bei unseren Meetings liegt allgemein die Betonung ohnedies auf dem Bauingenieur-Gesichtspunkt. Die geologischen Fragen spielen jedoch auch bei den Bauingenieur-Problemen eine wichtige Rolle und dürften nur bedingt in die zweite Reihe gestellt werden. Ganz besonders stehen die Gefügefragen immer sehr im Vordergrund. Ein dritter Gesichtspunkt ergibt sich aus den Berührungspunkten mit der bergmännischen Felsmechanik, von der wir sehr oft viel zu lernen haben.

Ihr Vorschlag einer Podium-Diskussion gefällt mir außerordentlich. Ich denke, wir werden es versuchen.

In meinem Brief vom 15. 1. 62 hatte ich Sie gebeten, das Eröffnungsreferat über "Berührungspunkte und Unterschiede zwischen Felsmechanik und Bodenmechanik" zu halten. Wie denken Sie darüber? Sollte ein solcher Vortrag nicht wertvoll und aufklärend sein im Rahmen dieses Kolloquiums?

INTERNATIONALE ARBEITSGEMEINSCHAFT FÜR GEOMECHANIK 3

Sehr geehrter Herr Direktor Bjerrum! Sie haben mit der Klärung der schwebenden Fragen und mit Ihren Vorschlägen für die Abhaltung des Meetings außerordentlich Wertvolles getan und uns zu sehr großem Dank verpflichtet.

Ich freue mich schon sehr, Sie im Herbst in Salzburg begrüßen zu können und verbleibe mit herzlichem

G l ü c k a u f !

Ihr sehr ergebener

Dr. Müller e.h.

PS: Mit gesonderter Post werden Sie inzwischen unsere Einladung bekommen haben, Ausschuß-Mitglied unserer bisherigen Internationalen Arbeitsgemeinschaft für Geomechanik zu werden, welche im April aus vereinsrechtlichen Gründen eine kleine Umorganisation erfahren muß. Im Sinne einer künftigen Zusamenarbeit zwischen Ihrer großen und unserer kleinen Gesellschaft wäre es außerordentlich wertvoll, Sie sozusagen als Verbindungsmann zur International Society of Soil Mechanics and Foundation Engineering in unserem Ausschuß zu wissen.

D.O.

[4] Letter from Leopold Müller to Laurits Bjerrum, 12 March 1962.

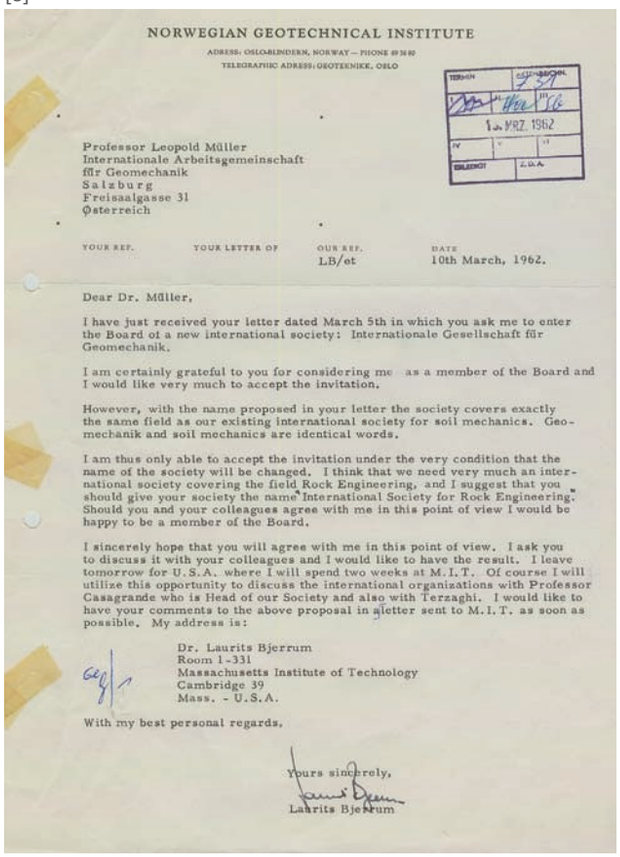
In another letter, of 10 March [5], Bjerrum replies to Müller's letter of 5 March[6], inviting him to join the Board of the "International Society for Geomechanics":

"I am certainly grateful to you for considering me as a member of the Board and I would like very much to accept the invitation.

However, with the name proposed in your letter, the society covers exactly the same field as our existing international society for soil mechanics. Geomechanik and soil mechanics are identical words.

I am thus only able to accept the invitation under the very condition that the name of the society will be changed. I think that we need very much an international society covering the fields of Rock Engineering, and I suggest that you should give your society the name 'International Society for Rock Engineering'."

[5]



NORWEGIAN GEOTECHNICAL INSTITUTE

ADRESS: OSLO-BLINDERN, NORWAY — PHONE 69 34 80
TELEGRAPHIC ADRESS: GEOTEKNIKK, OSLO

Professor Leopold Müller
Internationale Arbeitsgemeinschaft
für Geomechanik
Salzburg
Freisaalgasse 31
Österreich

YOUR REF.	YOUR LETTER OF	OUR REF.	DATE
		LB/et	10th March, 1962.

Dear Dr. Müller,

I have just received your letter dated March 5th in which you ask me to enter the Board of a new international society: Internationale Gesellschaft für Geomechanik.

I am certainly grateful to you for considering me as a member of the Board and I would like very much to accept the invitation.

However, with the name proposed in your letter the society covers exactly the same field as our existing international society for soil mechanics. Geomechanik and soil mechanics are identical words.

I am thus only able to accept the invitation under the very condition that the name of the society will be changed. I think that we need very much an international society covering the field Rock Engineering, and I suggest that you should give your society the name "International Society for Rock Engineering. Should you and your colleagues agree with me in this point of view I would be happy to be a member of the Board.

I sincerely hope that you will agree with me in this point of view. I ask you to discuss it with your colleagues and I would like to have the result. I leave tomorrow for U.S.A. where I will spend two weeks at M.I.T. Of course I will utilize this opportunity to discuss the international organizations with Professor Casagrande who is Head of our Society and also with Terzaghi. I would like to have your comments to the above proposal in a letter sent to M.I.T. as soon as possible. My address is:

Dr. Laurits Bjerrum
Room 1-331
Massachusetts Institute of Technology
Cambridge 39
Mass. - U.S.A.

With my best personal regards,

Yours sincerely,
Laurits Bjerrum

[5] Letter from Laurits Bjerrum to Leopold Müller, 10 March 1962.

[6] Not in the ISRM archives.

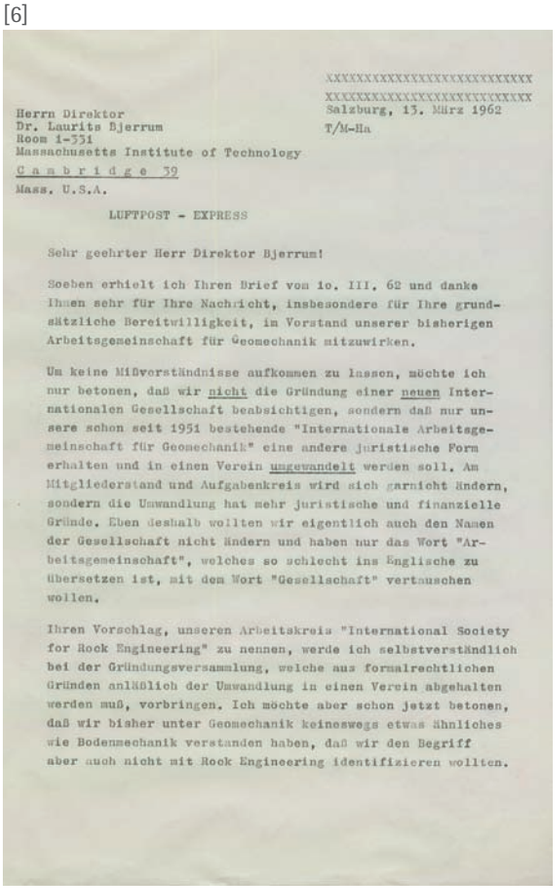
In his reply of 13 March [6], Müller explains the reason for the name of the Society:

> *"In order to avoid any misunderstandings, I would like to note that we have not in mind the foundation of a new international society, but only to give a new legal status to our "Internationale Arbeitsgemeinschaft für Geomechanik", which exists since 1951, and to transform it into a Society. As regards membership and field of interests, nothing will change, but the transformation has more to do with legal and financial issues. That is why we didn't want to change the name, and just wanted to replace the word 'Arbeitsgemeinschaft', which is so difficult to translate in English, with 'Gesellschaft'".*

In the same letter, Müller makes several considerations regarding the advantages and disadvantages of the words "Rock Engineering". In particular, he considers that the scope of the Society is wider than Engineering. Finally, he proposes the following:

> *"But I will take into consideration your wishes—and those of your colleagues in the ISSMFE—and I will propose to our members a name, which will not collide with the name of your Society, in the same way that our activity has not collided with yours. What would you think, for instance, of the designation 'International Society for Geomechanics and Rock Engineering'?"*

[6]



XXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXX
Salzburg, 13. März 1962
T/M-Ha

Herrn Direktor
Dr. Laurits Bjerrum
Room 1-331
Massachusetts Institute of Technology
Cambridge 39
Mass. U.S.A.

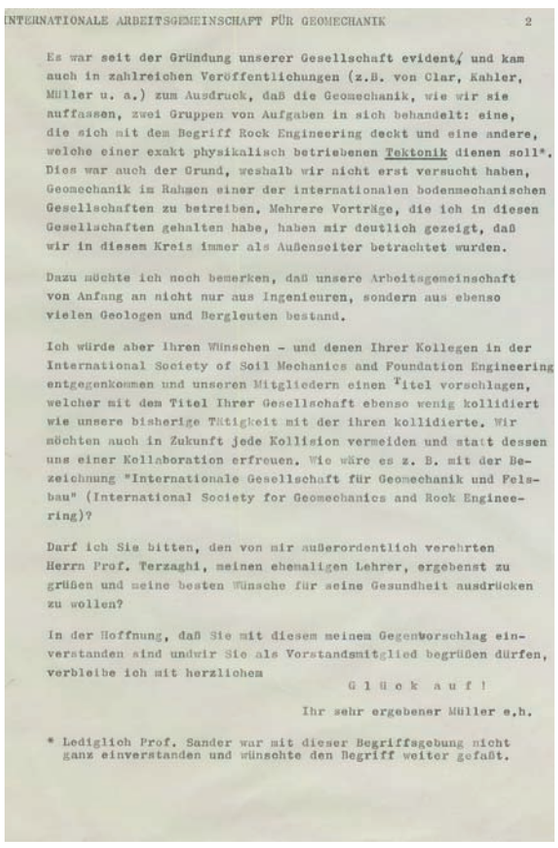
LUFTPOST - EXPRESS

Sehr geehrter Herr Direktor Bjerrum!

Soeben erhielt ich Ihren Brief vom 1o. III. 62 und danke Ihnen sehr für Ihre Nachricht, insbesondere für Ihre grundsätzliche Bereitwilligkeit, im Vorstand unserer bisherigen Arbeitsgemeinschaft für Geomechanik mitzuwirken.

Um keine Mißverständnisse aufkommen zu lassen, möchte ich nur betonen, daß wir nicht die Gründung einer neuen Internationalen Gesellschaft beabsichtigen, sondern daß nur unsere schon seit 1951 bestehende "Internationale Arbeitsgemeinschaft für Geomechanik" eine andere juristische Form erhalten und in einen Verein umgewandelt werden soll. Am Mitgliederstand und Aufgabenkreis wird sich garnicht ändern, sondern die Umwandlung hat mehr juristische und finanzielle Gründe. Eben deshalb wollten wir eigentlich auch den Namen der Gesellschaft nicht ändern und haben nur das Wort "Arbeitsgemeinschaft", welches so schlecht ins Englische zu übersetzen ist, mit dem Wort "Gesellschaft" vertauschen wollen.

Ihren Vorschlag, unseren Arbeitskreis "International Society for Rock Engineering" zu nennen, werde ich selbstverständlich bei der Gründungsversammlung, welche aus formalrechtlichen Gründen anläßlich der Umwandlung in einen Verein abgehalten werden muß, vorbringen. Ich möchte aber schon jetzt betonen, daß wir bisher unter Geomechanik keineswegs etwas ähnliches wie Bodenmechanik verstanden haben, daß wir den Begriff aber auch nicht mit Rock Engineering identifizieren wollten.



INTERNATIONALE ARBEITSGEMEINSCHAFT FÜR GEOMECHANIK 2

Es war seit der Gründung unserer Gesellschaft evident, und kam auch in zahlreichen Veröffentlichungen (z.B. von Clar, Kahler, Müller u. a.) zum Ausdruck, daß die Geomechanik, wie wir sie auffassen, zwei Gruppen von Aufgaben in sich behandelt: eine, die sich mit dem Begriff Rock Engineering deckt und eine andere, welche einer exakt physikalisch betriebenen Tektonik dienen soll*. Dies war auch der Grund, weshalb wir nicht erst versucht haben, Geomechanik im Rahmen einer der internationalen bodenmechanischen Gesellschaften zu betreiben. Mehrere Vorträge, die ich in diesen Gesellschaften gehalten habe, haben mir deutlich gezeigt, daß wir in diesen Kreis immer als Außenseiter betrachtet wurden.

Dazu möchte ich noch bemerken, daß unsere Arbeitsgemeinschaft von Anfang an nicht nur aus Ingenieuren, sondern aus ebenso vielen Geologen und Bergleuten bestand.

Ich würde aber Ihren Wünschen - und denen Ihrer Kollegen in der International Society of Soil Mechanics and Foundation Engineering entgegenkommen und unseren Mitgliedern einen Titel vorschlagen, welcher mit dem Titel Ihrer Gesellschaft ebenso wenig kollidiert wie unsere bisherige Tätigkeit mit der ihren kollidierte. Wir möchten auch in Zukunft jede Kollision vermeiden und statt dessen uns einer Kollaboration erfreuen. Wie wäre es z. B. mit der Bezeichnung "Internationale Gesellschaft für Geomechanik und Felsbau" (International Society for Geomechanics and Rock Engineering)?

Darf ich Sie bitten, den von mir außerordentlich verehrten Herrn Prof. Terzaghi, meinen ehemaligen Lehrer, ergebenst zu grüßen und seine besten Wünsche für seine Gesundheit ausdrücken zu wollen?

In der Hoffnung, daß Sie mit diesem meinem Gegenvorschlag einverstanden sind undwir Sie als Vorstandsmitglied begrüßen dürfen, verbleibe ich mit herzlichem

G l ü c k a u f !

Ihr sehr ergebener Müller e.h.

* Lediglich Prof. Sander war mit dieser Begriffsgebung nicht ganz einverstanden und wünschte den Begriff weiter gefaßt.

[6] Letter from Leopold Müller to Laurits Bjerrum, 13 March 1962.

In a handwritten note, dated 14 March [7], which was probably a draft of a telegram to Bjerrum, Müller writes:

> *"Re your letter March 10 I propose to name Salzburg group International Society of Rock Mechanics stop Proposal of my letter dated March 10[7] is superseded. Sincerely Leopold Müller 14.III.62"*

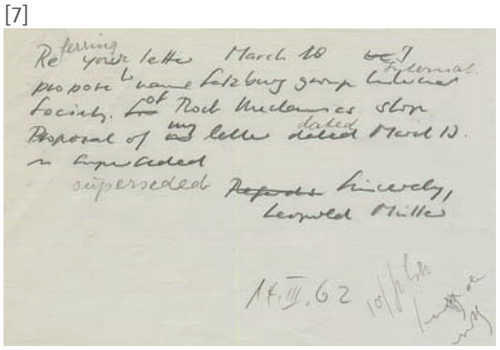
Bjerrum, on 20 March [8], replied:

> *"I [...] wish you to know that I am satisfied with your proposal for the change of the name of the society and the name has been approved by Terzaghi with whom I have discussed the matter."*

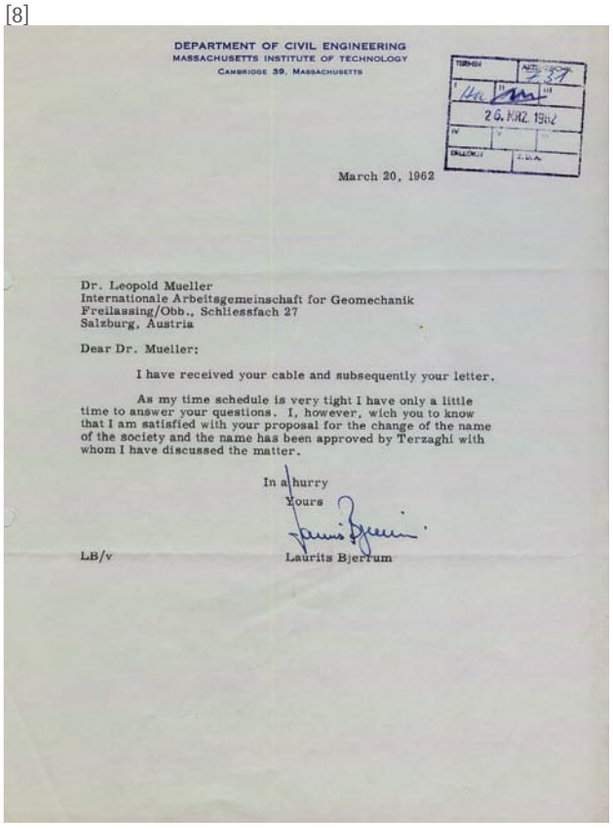
These letters demonstrate how important Laurits Bjerrum's role was in the interaction with the ISSMFE, and how important it was for Leopold Müller to have the ISSMFE's agreement—and in particular Karl Terzaghi's, his former Professor—for the formation of this new International Society, and also for its name. The ISSMFE was a well established learned Society, founded in 1936, gathering eminent personalities, and Leopold Müller not only wanted the new Society to be born with their agreement, but also wished the two Societies to have a close collaboration, which was also the ISSMFE's wish.

Having changed the proposed name of the Society, Müller was forced to change the original date of the Constitutional meeting from 14 April to 25 May. The new name was communicated to those invited for the meeting—such as Professor Charles Fairhurst [9]—and its approval was requested.

[7]



[8]



DEPARTMENT OF CIVIL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASSACHUSETTS

26 MAR 1962

March 20, 1962

Dr. Leopold Mueller
Internationale Arbeitsgemeinschaft for Geomechanik
Freilassing/Obb., Schliessfach 27
Salzburg, Austria

Dear Dr. Mueller:

I have received your cable and subsequently your letter.

As my time schedule is very tight I have only a little time to answer your questions. I, however, wich you to know that I am satisfied with your proposal for the change of the name of the society and the name has been approved by Terzaghi with whom I have discussed the matter.

In a hurry
Yours

LB/v

Laurits Bjerrum

[7] Handwritten note by Leopold Müller, 14 March 1962.

[8] Letter from Laurits Bjerrum to Leopold Müller, 20 March 1962.

[7] Probably a mistaken date; it should be March 13.

The discussion on the name of the Society certainly continued and, in an interesting letter to Leopold Müller, dated 3 April [10], Dr H.G. Denkhaus, Director of the National Mechanical Engineering Research Institute of the South African Council for Scientific and Industrial Research, made several considerations regarding the differences between Geomechanics, Ground Mechanics, Rock Mechanics and Soil Mechanics. Dr Denkhaus supported the name "*Internationale Gesellschaft für Felsmechanik*".

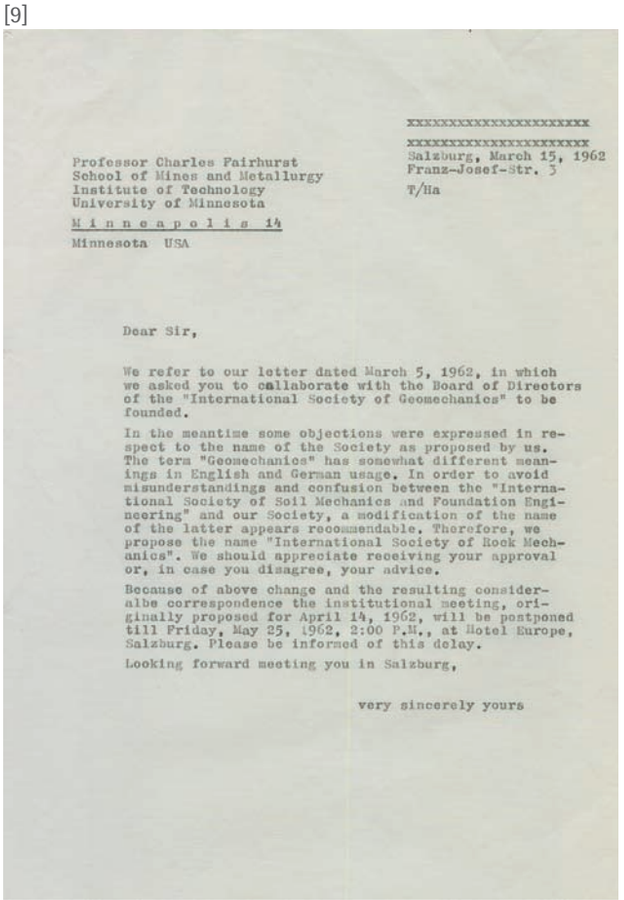
Leopold Müller then decided to register the Society with the approved name. He applied on 2 April to the Federal Police Directorate of Salzburg proposing the formation of the "*Internationale Gesellschaft für Felsmechanik (Verein für Pflege der Wechselsbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen)*", in English "International Society of Rock Mechanics (Association for the study of the interactions between Geology, Mechanics and Engineering)". The authorisation was given on 25 April [11].

On 24 May, Leopold Müller and Franz Pacher gave a radio interview [12] announcing the formation of the new Society, and explaining the justification for its existence and its objectives[8].

To the question "*Do we know the strength of rock?*" Müller replied:

> *"For rock (specimens) tested in the laboratory, yes. For a rock mass, no. This is what we need to determine. That is why we need an we need an International Society for Rock Mechanics."*.

[9]



xxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxx
Salzburg, March 15, 1962
Franz-Josef-Str. 5
T/Ha

Professor Charles Fairhurst
School of Mines and Metallurgy
Institute of Technology
University of Minnesota
Minneapolis 14
Minnesota USA

Dear Sir,

We refer to our letter dated March 5, 1962, in which we asked you to collaborate with the Board of Directors of the "International Society of Geomechanics" to be founded.

In the meantime some objections were expressed in respect to the name of the Society as proposed by us. The term "Geomechanics" has somewhat different meanings in English and German usage. In order to avoid misunderstandings and confusion between the "International Society of Soil Mechanics and Foundation Engineering" and our Society, a modification of the name of the latter appears recommendable. Therefore, we propose the name "International Society of Rock Mechanics". We should appreciate receiving your approval or, in case you disagree, your advice.

Because of above change and the resulting considerable correspondence the institutional meeting, originally proposed for April 14, 1962, will be postponed till Friday, May 25, 1962, 2:00 P.M., at Hotel Europe, Salzburg. Please be informed of this delay.

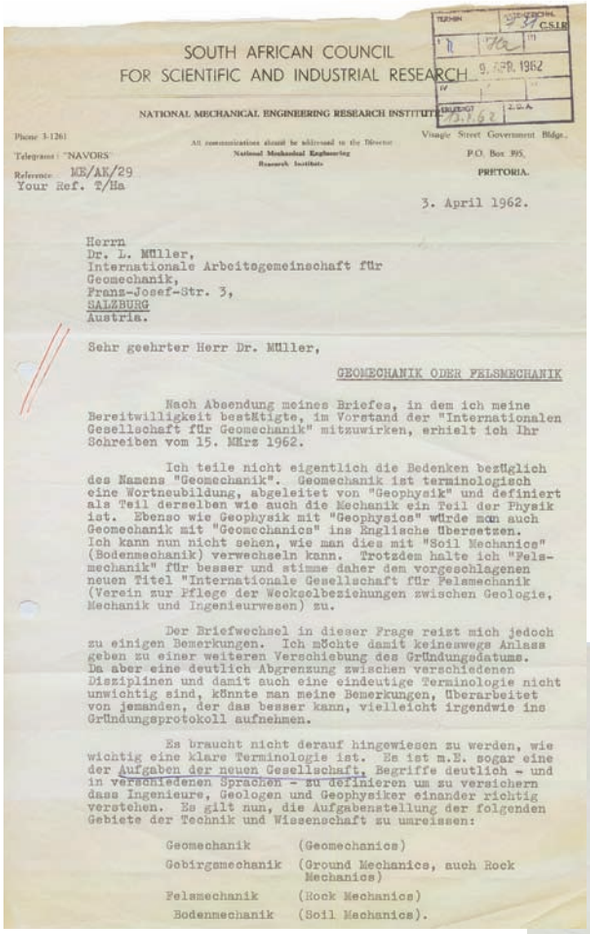
Looking forward meeting you in Salzburg,

very sincerely yours

[9] Letter from Leopold Müller to Charles Fairhurst, 15 March 1962.

[8] See Chapter 1 of this book for a transcription and an English translation of this interview, and comments by Professor Charles Fairhurst.

[10]



SOUTH AFRICAN COUNCIL
FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL MECHANICAL ENGINEERING RESEARCH INSTITUTE

Phone 3-1261
Telegrams: "NAVORS"
Reference: ME/AK/29
Your Ref. Z/Ha

All communications should be addressed to the Director
National Mechanical Engineering
Research Institute

Visagie Street Government Bldgs.,
P.O. Box 395,
PRETORIA.

3. April 1962.

Herrn
Dr. L. Müller,
Internationale Arbeitsgemeinschaft für
Geomechanik,
Franz-Josef-Str. 3,
SALZBURG
Austria.

Sehr geehrter Herr Dr. Müller,

GEOMECHANIK ODER FELSMECHANIK

Nach Absendung meines Briefes, in dem ich meine Bereitwilligkeit bestätigte, im Vorstand der "Internationalen Gesellschaft für Geomechanik" mitzuwirken, erhielt ich Ihr Schreiben vom 15. März 1962.

Ich teile nicht eigentlich die Bedenken bezüglich des Namens "Geomechanik". Geomechanik ist terminologisch eine Wortneubildung, abgeleitet von "Geophysik" und definiert als Teil derselben wie auch die Mechanik ein Teil der Physik ist. Ebenso wie Geophysik mit "Geophysics" würde man auch Geomechanik mit "Geomechanics" ins Englische übersetzen. Ich kann nun nicht sehen, wie man dies mit "Soil Mechanics" (Bodenmechanik) verwechseln kann. Trotzdem halte ich "Felsmechanik" für besser und stimme daher dem vorgeschlagenen neuen Titel "Internationale Gesellschaft für Felsmechanik (Verein zur Pflege der Wechselbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen) zu.

Der Briefwechsel in dieser Frage reizt mich jedoch zu einigen Bemerkungen. Ich möchte damit keineswegs Anlass geben zu einer weiteren Verschiebung des Gründungsdatums. Da aber eine deutlich Abgrenzung zwischen verschiedenen Disziplinen und damit auch eine eindeutige Terminologie nicht unwichtig sind, könnte man meine Bemerkungen, überarbeitet von jemanden, der das besser kann, vielleicht irgendwie ins Gründungsprotokoll aufnehmen.

Es braucht nicht darauf hingewiesen zu werden, wie wichtig eine klare Terminologie ist. Es ist m.E. sogar eine der Aufgaben der neuen Gesellschaft, Begriffe deutlich - und in verschiedenen Sprachen - zu definieren um zu verrichern dass Ingenieure, Geologen und Geophysiker einander richtig verstehen. Es gilt nun, die Aufgabenstellung der folgenden Gebiete der Technik und Wissenschaft zu umreissen:

Geomechanik	(Geomechanics)
Gebirgsmechanik	(Ground Mechanics, auch Rock Mechanics)
Felsmechanik	(Rock Mechanics)
Bodenmechanik	(Soil Mechanics).

-2-

Die Geomechanik kann als Teil der Geophysik angesehen werden und damit umfasst sie die Anwendung der Mechanik auf die Erde als mechanisches System. Obwohl die Erdschicht, in der Berg- und Felsbau umgeht, natürlich auch ein Teil der Erde ist und man gewisse Methoden zur Erforschung des Zustandes auch dieser Schicht gemeinhin als "Geophysikalische Methoden" bezeichnet, so besteht das eigentliche Arbeitsgebiet der Geophysik, und damit der Geomechanik, doch in der Erforschung der physikalischen Vorgänge und Zustände in den tieferen Schichten der Erdkruste und des Erdkerns, die für Berg- and Felsbau zur Zeit nicht interessant sind.

Die Gebirgsmechanik befasst sich mit den Vorgängen und Zuständen in jenem Teil der Erdkruste, in dem Bergbau umgeht und den der Bergmann als "Gebirge" (englisch: the ground) bezeichnet. Die physikalischen Materialien oder Systeme (Verbände) mit denen sich die Gebirgsmechanik befasst, können je nach den Umständen sein: Böden (z.B. beim Tagebau), Gesteine (z.B. Erforschung der Bohrbarkeit von Gestein) oder Fels (= Gestein + Klüfte). Die korrekte Übersetzung ins Englische wäre Gebirgsmechanik = Ground Mechanics; es hat sich jedoch Gebirgsmechanik = Rock Mechanics durchgesetzt. Der Name von der Colorado School of Mines in den U.S.A. gegeben, von Südafrika übernommen und beginnt sich auch in Grossbritannien selbst durchzusetzen. In Südafrika sprach auch die Übersetzung ins Afrikaans mit: Rotsmeganika = Rock Mechanics = Gebirgsmechanik, während unglücklicherweise Grondmeganika = Ground Mechanics auch die andere Bedeutung Grondmeganika = Soil Mechanics = Bodenmechanik hat.

Die Felsmechanik befasst sich mit den Vorgängen und Zuständen im Verband "Fels" und ist damit in gewissem Sinne eine Unterabteilung der Gebirgsmechanik, steht jedoch da als besonderes Gebiet, da sie nicht nur dem Bergbau sondern auch dem Bauwesen (Gründungen) Informationen liefert. Die englische Übersetzung lautet Rock Mechanics und die Verwechslungsmöglichkeit mit Gebirgsmechanik darf hingenommen werden, da beide Gebiete ja in der Tat eng miteinander verflochten sind.

Die Bodenmechanik (englisch: Soil Mechanics) befasst sich mit den Vorgängen und Zuständen im Verband "Boden". Sie liefert dem Bauwesen und gelegentlich auch dem Bergbau Informationen. Die Abgrenzung zur Felsmechanik ist deutlich und besteht eben in dem bekannten Unterschied zwischen "Fels" und "Boden".

Nach diesen kurzen Auslassungen, möchte ich Ihnen noch mitteilen, dass ich aus offensichtlichen Gründen natürlich leider nicht am 25. Mai in Salzburg sein kann. Ist es daher möglich, dass ich Sie - sehr geehrter Herr Dr. Müller - als meinen Vertreter benennen kann und Sie bitten, "meine Interessen wahrzunehmen"?

Einstweilen verbleibe ich mit

Glückauf

Ihr

Dr. H.G. DENKHAUS
DIRECTOR
NATIONAL MECHANICAL ENGINEERING
RESEARCH INSTITUTE

[10] Letter from H.G. Denkhaus to Leopold Müller, April 1962.

[11]

Sicherheitsdirektion für das Bundesland Salzburg

Zahl: 2559/2/62

27. APR. 1962

B e s c h e i d

An das
Proponentenkomitee des Vereines:
"Internationale Gesellschaft für Felsmechanik
(Verein zur Pflege der Wechselbeziehungen zwischen
Geologie, Mechanik und Ingenieurwesen)"
zu Hd.d.Zweitproponenten,Hrn.Dipl.Ing.Franz P a c h e r ,
Zivilingenieur für Bauwesen,
in S a l z b u r g
Weiserstraße 9

Über die am 2. April 1962 bei der Sicherheitsdirektion für das Bundesland Salzburg angezeigte Bildung des Vereines: "Internationale Gesellschaft für Felsmechanik (Verein zur Pflege der Wechselbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen)" mit dem Sitz in Salzburg ergeht der Bescheid:

S p r u c h

Die Vereinsbildung wird nach dem Inhalt der vorgelegten Statuten, wovon ein Exemplar anbei zurückfolgt, gemäß § 7 des Vereinsgesetzes 1951, BGBl.Nr.233/51, nicht untersagt.

B e g r ü n d u n g :

Eine Begründung entfällt im Hinblick auf § 58, Abs.(2),AVG.1950.

R e c h t s m i t t e l b e l e h r u n g :

Gegen diesen Bescheid kann gemäß § 63 AVG.1950 binnen zwei Wochen nach Zustellung ha. schriftlich oder telegrafisch die Berufung eingebracht werden.

2 Beilagen

Salzburg, am 25. April 1962
Für den Sicherheitsdirektor:
Dr.Daspelgruber

Für die Richtigkeit der Ausfertigung:

[12]

Rundfunk-Interview, gesendet am 24.5.62, 1940 1. Progr.

731-U/M-Ha

Reporter: "Internationale Gesellschaft für Felsmechanik" - Was ist Felsmechanik?

Pacher: Die Wissenschaft vom mechanischen Verhalten des zerklüfteten Gesteins gegenüber Kräften, Beanspruchungen und aufgezwungenen Formänderungen.

Reporter: Welche praktischen Auswirkungen und Aufgaben?

Pacher: Auf der Grundlage einer theoretisch richtigen und praxisnahen Felsmechanik lassen sich Fundierungen von Seilbahnstützen, Staumauern, in Fels mit großer Sicherheit berechnen; aber auch die Verkleidung von Tunnels, größeren unterirdischen Hohlräumen usw. läßt sich rechnerisch erfassen, so daß sie in der wirtschaftlichsten Weise und vor allem ohne Gefahr durchgeführt werden können.

Reporter: Das ist also etwas ganz Neues? Dann möchte ich fast vermuten, daß Malpasset der Anlaß war?

Müller: Nicht so neu. In Salzburg schon seit 1951 "Internationale Arbeitsgemeinschaft für Geomechanik". Die gleichen Aufgaben. Vor 4 Jahren wurde in Berlin das "Internationale Büro für Gebirgsmechanik" der Deutschen Akademie der Wissenschaften" gegründet, bei welchem wir auch vertreten sind. Die Welt hat von uns wenig Notiz genommen. Kongreß kaum. Nun breitere Basis.

2

Reporter: Was ist denn Bodenmechanik und Geomechanik?

Müller: Bodenmechanik befaßt sich mit Lockermassen, Sand, Ton usw. Geomechanik = Mechanik der festen Erdkruste, umfaßt auch Entstehung und Erklärung der Gebirge, soweit mechanisch zu verstehen.

Reporter: Kann man denn solche Dinge rechnen?

Pacher: Beispiel ist die Fundierung einer Staumauer wie Malpasset. Kräfte bekannt - Fels kommt unter zusätzliche Spannungen; Vergleich mit den Festigkeiten zeigt, ob er ihnen gewachsen ist.

Reporter: Begriff der Sicherheit. Sind denn die Festigkeiten der Gesteine bekannt?

Müller: Der Gesteine schon, Labor. Der Gebirge nicht. Müssen geprüft werden. Dazu "Internationale Versuchsanstalt für Fels"

Reporter: Ziele der Gesellschaft?

Müller: Forum - Tagungen, Kolloquium Oktober. Ferner Publikationen und Forschungsaufgaben vorhaben. Einheitliche Auffassungen und Bezeichnungen, Normen.

Reporter: Warum gerade in Salzburg?

3

Müller: Alle Baugrundwissenschaften sind von Österreich ausgegangen. Terzaghi - Stini - Geomechanik. Die Österreicher wissen gar nicht, daß sie auf diesen entscheidenden Gebieten führend sind und daß die ganze Welt dies anerkennt. In der Bodenmechanik wurde die Führung abgegeben. Terzaghi ging nach USA.
Hoffentlich gibt man uns die Mittel, führend zu bleiben. Erfolge in Japan. Ob das so bleibt, hängt nicht von uns alleine ab, sondern auch davon, ob Staat und Land für diese speziell österreichische Wissenschaft und für die Wissenschaft überhaupt etwas tun.

[11] Decision of the Safety Directorate of the Federal State of Salzburg, 25 April 1962.

[12] Radio interview of Leopold Müller and Franz Pacher, 24 May 1962.

Invitations to take part in the Constitutional Meeting of 25 May, at 14:00, in the Hotel Europa in Salzburg, were sent to 132 persons [13]. The meeting was attended by 46 participants from Austria, Italy, Norway, Poland, UK, USA, West Germany and Yugoslavia, who signed the minutes [14]. Franz Pacher reported on the activity of the Study Group during its 11 years of existence, and explained one of the main reasons to create the Society:

> *"As no contributions were to be paid, a total sum of 261,872 Austrian Schillings had to be borne by Dr Müller and Ing. Pacher and also Prof. Föppl privately. It was no longer possible to do further work upon this basis; therefore, the study group had to be transformed into a society."*

Several changes to the proposed Statutes of the Society were approved and a Board of Directors with 29 members was elected. Professor Leopold Müller was unanimously elected its Chairman, while Professor Leussink from West Germany and Professor Pancini from Italy were elected as his deputies. It is interesting to note that, at its formation, the Society had individuals as members. But already in this Constitutional Meeting it was proposed that there should be a representation of the national committees, which are now called the ISRM National Groups.

[13]

INTERNATIONALE GESELLSCHAFT FÜR FELSMECHANIK
IN GRÜNDUNG

SALZBURG, FRANZ-JOSEF-STRASSE 3
TELEFON 75740
FREILASSING/OBB., SCHLIESSFACH 27

Sehr geehrter Herr!

Die im Jahre 1951 gegründete Internationale Arbeitsgemeinschaft für Geomechanik, von deren Veranstaltungen und Forschungen wir Sie seit langem informieren durften, war bisher ein locker gefügter, nicht vereinsmäßig festgelegter Kreis von Mitarbeitern an geomechanischen Forschungsaufgaben und Teilnehmern an den in Salzburg veranstalteten Kolloquien.

Die wachsende Zahl von Teilnehmern legte den Entschluß nahe, diese Arbeitsgemeinschaft in einen Verein überzuführen. Dieser Verein, dessen Satzungen in der Zwischenzeit ausgearbeitet und bereits behördlich genehmigt wurden, soll den Namen

Internationale Gesellschaft für Felsmechanik

führen und seinen Sitz in Salzburg haben.

Der Verein strebt eine fruchtbare Zusammenarbeit mit Institutionen ähnlicher Ausrichtung an, wie z. B. dem Internationalen Büro für Gebirgsmechanik an der Akademie der Wissenschaften, Berlin, und der International Society of Soil Mechanics and Foundation Engineering, London.

Die unterzeichneten Proponenten laden Sie hiermit herzlichst ein, diesem Verein beizutreten und damit Ihre Verbundenheit mit der wissenschaftlichen Gemeinschaft des Salzburger geomechanischen Kreises zu dokumentieren. Eine Beitrittserklärung sowie eine Austertigung der Satzungen ist diesem Schreiben beigefügt.

Die Gründungsversammlung findet am 25. Mai 1962 um 14 Uhr im Hotel Europa, Salzburg, statt. Wir bitten Sie, aus den beiliegenden Satzungen zu entnehmen, daß Sie sich bei dieser Gründungsversammlung durch einen von Ihnen schriftlich, aber nicht notariell, bevollmächtigten Versammlungsteilnehmer vertreten lassen können. Zu Ihrer Information legen wir Ihnen eine Tagesordnung bei.

Es ist geplant, den Mitgliedsbeitrag für Einzelmitglieder pro Kalenderjahr mit etwa ö. S 100.— zu bemessen und den Mitgliedern Vergünstigungen bei der Teilnahme an den Kolloquien einzuräumen. Juristische Personen wie Behörden, Firmen, Vereinigungen und sonstige Körperschaften würden wir als Förderer des Vereins herzlich begrüßen. Von diesen wird ein Mindestbeitrag von ö. S 500.— erbeten, womit die gleichen Vergünstigungen für drei Personen verbunden sind.

Dürfen wir Sie bitten, sich vorzumerken, daß das diesjährige XIII. Kolloquium der Felsmechanik am 4. und 5. Oktober in Salzburg stattfinden wird. Einladung und Tagesordnung werden die Vereinsmitglieder gesondert erhalten.

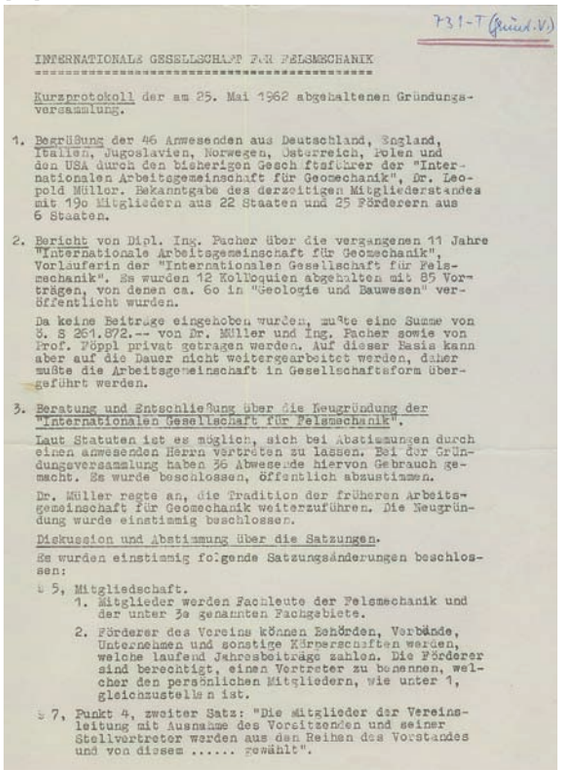
Allen Schriftverkehr bitten wir an die Internationale Gesellschaft für Felsmechanik, Salzburg, Franz-Josef-Straße 3, zu richten.

Wir würden uns sehr freuen, wenn Sie unserer Einladung Folge leisten würden, und begrüßen Sie mit

Glück auf!

[13] Letter of invitation to the Constitutional Meeting, to take place on 25 May 1962.

[14]



731-T (Gründ.V.)

INTERNATIONALE GESELLSCHAFT FÜR FELSMECHANIK

Kurzprotokoll der am 25. Mai 1962 abgehaltenen Gründungsversammlung.

1. Begrüßung der 46 Anwesenden aus Deutschland, England, Italien, Jugoslavien, Norwegen, Österreich, Polen und den USA durch den bisherigen Geschäftsführer der "Internationalen Arbeitsgemeinschaft für Geomechanik", Dr. Leopold Müller. Bekanntgabe des derzeitigen Mitgliederstandes mit 190 Mitgliedern aus 22 Staaten und 25 Förderern aus 6 Staaten.

2. Bericht von Dipl. Ing. Pacher über die vergangenen 11 Jahre "Internationale Arbeitsgemeinschaft für Geomechanik", Vorläuferin der "Internationalen Gesellschaft für Felsmechanik". Es wurden 12 Kolloquien abgehalten mit 85 Vorträgen, von denen ca. 60 in "Geologie und Bauwesen" veröffentlicht wurden.

Da keine Beiträge eingehoben wurden, mußte eine Summe von S. S 261.872.-- von Dr. Müller und Ing. Pacher sowie von Prof. Pöppl privat getragen werden. Auf dieser Basis kann aber auf die Dauer nicht weitergearbeitet werden, daher mußte die Arbeitsgemeinschaft in Gesellschaftsform übergeführt werden.

3. Beratung und Entschließung über die Neugründung der "Internationalen Gesellschaft für Felsmechanik".

Laut Statuten ist es möglich, sich bei Abstimmungen durch einen anwesenden Herrn vertreten zu lassen. Bei der Gründungsversammlung haben 36 Abwesende hiervon Gebrauch gemacht. Es wurde beschlossen, öffentlich abzustimmen.

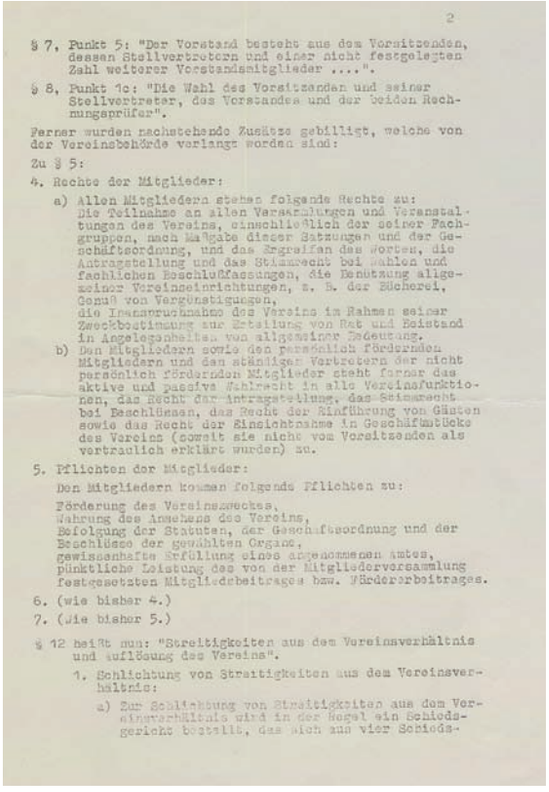
Dr. Müller regte an, die Tradition der früheren Arbeitsgemeinschaft für Geomechanik weiterzuführen. Die Neugründung wurde einstimmig beschlossen.

Diskussion und Abstimmung über die Satzungen.

Es wurden einstimmig folgende Satzungsänderungen beschlossen:

§ 5, Mitgliedschaft.
1. Mitglieder werden Fachleute der Felsmechanik und der unter 3e genannten Fachgebiete.
2. Förderer des Vereins können Behörden, Verbände, Unternehmen und sonstige Körperschaften werden, welche laufend Jahresbeiträge zahlen. Die Förderer sind berechtigt, einen Vertreter zu benennen, welcher den persönlichen Mitgliedern, wie unter 1, gleichzustellen ist.

§ 7, Punkt 4, zweiter Satz: "Die Mitglieder der Vereinsleitung mit Ausnahme des Vorsitzenden und seiner Stellvertreter werden aus den Reihen des Vorstandes und von diesem ..... gewählt".



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§ 7, Punkt 5: "Der Vorstand besteht aus dem Vorsitzenden, dessen Stellvertretern und einer nicht festgelegten Zahl weiterer Vorstandsmitglieder ....".

§ 8, Punkt 1c: "Die Wahl des Vorsitzenden und seiner Stellvertreter, des Vorstandes und der beiden Rechnungsprüfer".

Ferner wurden nachstehende Zusätze gebilligt, welche von der Vereinsbehörde verlangt worden sind:

Zu § 5:

4. Rechte der Mitglieder:

a) Allen Mitgliedern stehen folgende Rechte zu:
Die Teilnahme an allen Versammlungen und Veranstaltungen des Vereins, einschließlich der seiner Fachgruppen, nach Maßgabe dieser Satzungen und der Geschäftsordnung, und das Ergreifen des Wortes, die Antragstellung und das Stimmrecht bei Wahlen und fachlichen Beschlußfassungen, die Benützung allgemeiner Vereinseinrichtungen, z. B. der Bücherei, Genuß von Vergünstigungen,
die Inanspruchnahme des Vereins im Rahmen seiner Zweckbestimmung zur Erteilung von Rat und Beistand in Angelegenheiten von allgemeiner Bedeutung.

b) Den Mitgliedern sowie den persönlich Fördernden Mitgliedern und den ständigen Vertretern der nicht persönlich fördernden Mitglieder steht ferner das aktive und passive Wahlrecht in alle Vereinsfunktionen, das Recht der Antragstellung, das Stimmrecht bei Beschlüssen, das Recht der Einführung von Gästen sowie das Recht der Einsichtnahme in Geschäftsstücke des Vereins (soweit sie nicht vom Vorsitzenden als vertraulich erklärt wurden) zu.

5. Pflichten der Mitglieder:

Den Mitgliedern kommen folgende Pflichten zu:

Förderung des Vereinszweckes,
Wahrung des Ansehens des Vereins,
Befolgung der Statuten, der Geschäftsordnung und der Beschlüsse der gewählten Organe,
gewissenhafte Erfüllung eines angenommenen Amtes,
pünktliche Leistung des von der Mitgliederversammlung festgesetzten Mitgliedsbeitrages bzw. Förderbeitrages.

6. (wie bisher 4.)

7. (wie bisher 5.)

§ 12 heißt nun: "Streitigkeiten aus dem Vereinsverhältnis und Auflösung des Vereins".

1. Schlichtung von Streitigkeiten aus dem Vereinsverhältnis:

a) Zur Schlichtung von Streitigkeiten aus dem Vereinsverhältnis wird in der Regel ein Schiedsgericht bestellt, das sich aus vier Schiedsrichtern zusammensetzt. Je zwei davon werden jeweils von je einem Streitteil aus dem Stande der ordentlichen oder fördernden Vereinsmitglieder binnen 4 Wochen schriftlich namhaft gemacht. Die vier Schiedsrichter wählen aus ihrer Mitte einen Vorsitzenden; können sie sich über die Person des Vorsitzenden nicht einigen, entscheidet unter den Vorgeschlagenen das Los.

b) Die Entscheidung des Schiedsgerichtes, dessen Mitglieder nach freier Überzeugung im Rahmen der gültigen Rechtsnormen und der Statuten urteilen, ist endgültig.

3

Der bisherige Punkt 7 wird nun Punkt 8.

4. Wahl des Vorstandes.

Herr Dr. Müller schlägt im Hinblick auf eine Anregung von Herrn Dir. Bjerrum, Oslo, vor, den künftigen Vorstand auf Grund der Entsendung von Vorstandsmitgliedern einzelner Nationalkomitees zusammenzusetzen.

Für die nächsten 3 Jahre setzt sich auf Grund der Wahl der Vorstand aus den Herren zusammen, welche in beiliegender Liste aufgezählt sind.

Zum Vorsitzenden wurde einstimmig Dr. Leopold Müller gewählt, zu seinen Stellvertretern Prof. Leussink und Dr. Fancini.

Die Wahl der Rechnungsprüfer soll bei der nächsten Mitgliederversammlung in Oktober 1962 erfolgen.

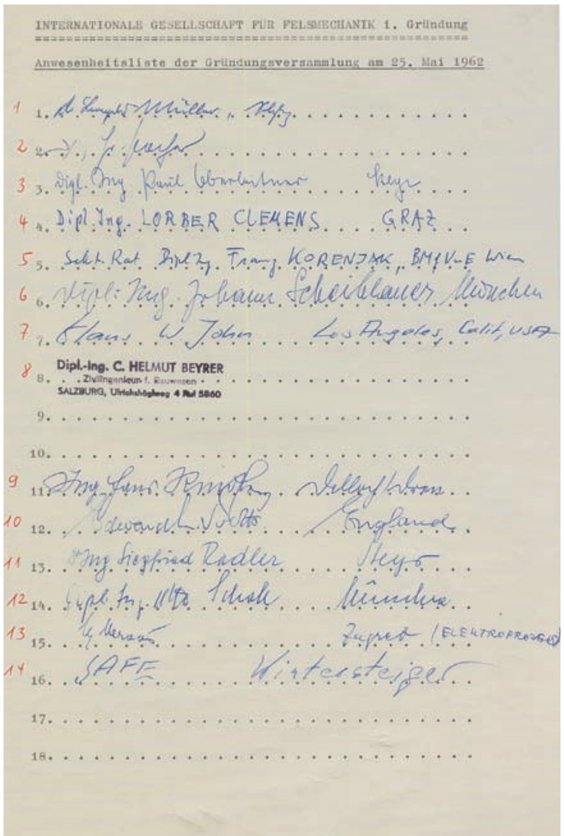
5. Bezüglich der Mitgliedsbeiträge wurde beschlossen, für 1962 den Betrag von S 700.-- für Mitglieder und mindestens S 500.-- für Förderer beizubehalten.

Bei der nächsten Generalversammlung wird über eine Erhöhung dieser Beiträge, andererseits über eine Ermäßigung für Studenten und Jungakademiker, diskutiert werden, da mit den derzeitigen Beträgen auf die Dauer nicht das Auslangen gefunden werden kann.

6. Dr. Müller gibt Vorschau auf das am 4. und 5. Oktober 1962 in Salzburg stattfindende XIII. Kolloquium.

7. Dank der Mitglieder an die Proponenten und an alle Herren, die die Gründung vorbereitet haben.

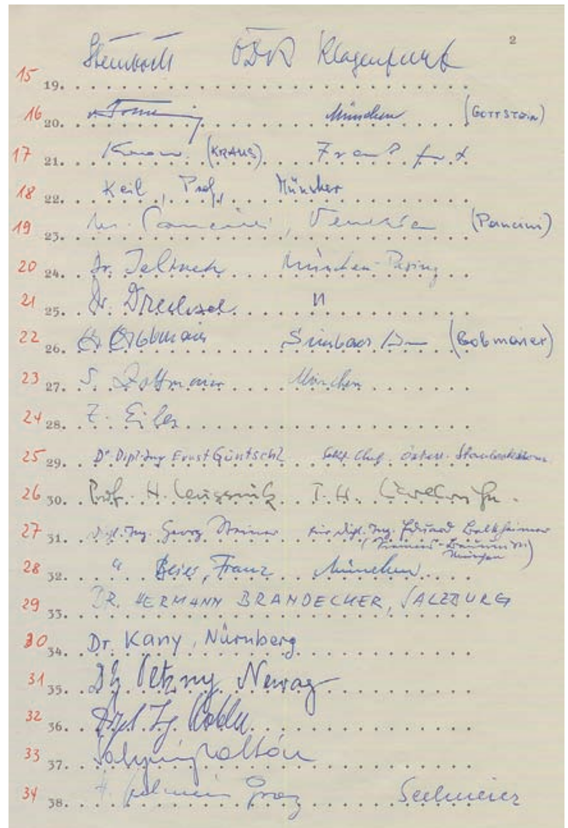
[14] Minutes of the Constitutional Meeting of 25 May 1962.



INTERNATIONALE GESELLSCHAFT FÜR FELSMECHANIK i. Gründung

Anwesenheitsliste der Gründungsversammlung am 25. Mai 1962

1 1. [illegible]
2 2. [illegible]
3 3. Dipl. Ing. [illegible] Steyr
4 4. Dipl. Ing. LORBER CLEMENS GRAZ
5 5. Sekt. Rat. Dipl. Ing. Franz KORENJAK, BMfV.-E Wien
6 6. Dipl. Ing. Johann Scheiblauer München
7 7. Hans W. John Los Angeles, Calif. USA
8 8. Dipl.-Ing. C. HELMUT BEYRER, Ziviltechniker f. Bauwesen, SALZBURG
9 11. [illegible]
10 12. [illegible] England
11 13. Ing. Siegfried Radler Steyr
12 14. Dipl. Ing. [illegible] München
13 15. [illegible] (ELEKTROPROJEKT)
14 16. SAFE Wintersteiger



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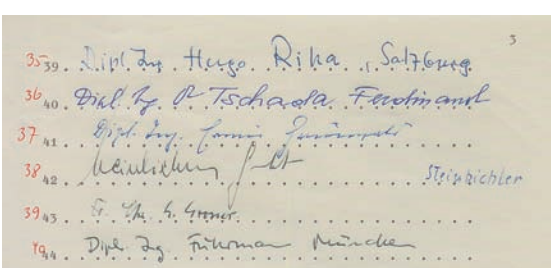
15 19. [illegible] ÖDK Klagenfurt
16 20. [illegible] München (GOTTSTEIN)
17 21. [illegible] (KRAUS)
18 22. Keil, Prof. München
19 23. [illegible] (Pancini)
20 24. Dr. Jeltsch [illegible]
21 25. Dr. [illegible] "
22 26. [illegible] (Bobmaier)
23 27. [illegible] München
24 28. [illegible]
25 29. Dr. Dipl. Ing. Ernst Güntschl [illegible]
26 30. Prof. H. Leussink T.H. [illegible]
27 31. [illegible]
28 32. Beier, Franz München
29 33. DR. HERMANN BRANDECKER, SALZBURG
30 34. Dr. Kany, Nürnberg
31 35. [illegible]
32 36. Dipl. Ing. [illegible]
33 37. [illegible]
34 38. [illegible] Graz Seelmeier



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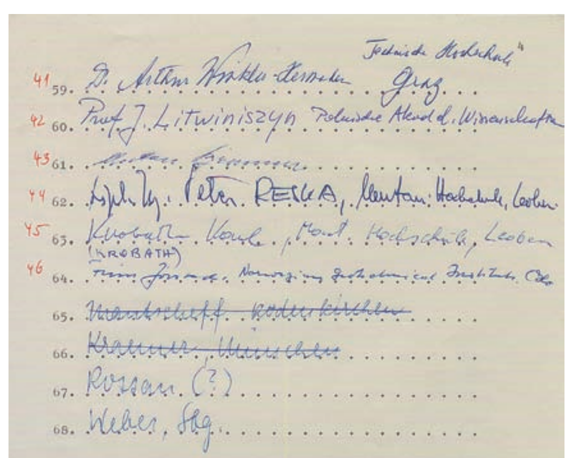
35 39. Dipl. Ing. Hugo Rika Salzburg
36 40. Dipl. Ing. Dr. Tschada Ferdinand
37 41. Dipl. Ing. [illegible]
38 42. [illegible] Steinbichler
39 43. [illegible]
40 44. Dipl. Ing. [illegible] München



41 59. Dr. Arthur [illegible] Technische Hochschule Graz
42 60. Prof. J. Litwiniszyn Polnische Akad. d. Wissenschaften
43 61. [illegible]
44 62. Dipl. Ing. Peter REIKA, Montan. Hochschule, Leoben
45 63. Krobath Karl, Mont. Hochschule, Leoben (KROBATH)
46 64. [illegible]
65. ~~[illegible]~~
66. ~~[illegible]~~
67. Rossan (?)
68. Weber, Sbg.

ISRM Constitutional Meeting in Salzburg, 25 May 1962. Head table with Leopold Müller and Franz Pacher

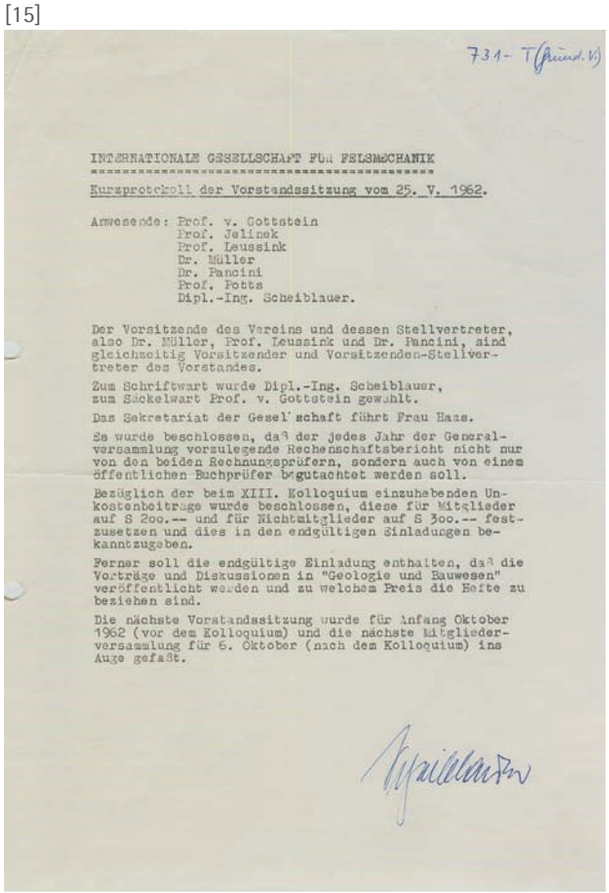
ISRM Constitutional Meeting in Salzburg, 25 May 1962. Voting

In the Journal *Geologie und Bauwesen* published in 1962, Leopold Müller presented a note reporting on the foundation of the Society[9] and the Constitutional Meeting, and expressed the hope that "*now, with its larger international basis, the new Society will contribute to the emergence of a unified concept of rock mechanics, which the science of soil mechanics already has*".

Still on 25 May, the first Board meeting of the ISRM took place [15]. Dipl. Ing. Scheiblauer and Professor v. Gottstein, both from West Germany, were appointed Secretary and Treasurer, respectively. The next Board meeting was scheduled for the beginning of October, before the Salzburg Colloquy, and the next General Assembly for 6 October.

In a letter dated 28 May [16], the Federal Police Directorate of Salzburg was informed about the Constitutional Meeting, the composition of the Board of Directors and the members of the Executive Committee elected during the meeting. On 26 June [17], the Safety Directorate of the Federal State of Salzburg approved the transformation of the Society, in agreement with the Statutes revised by the Constitutional Meeting of 25 May, which are formally the first Statutes of the ISRM. With this approval, the process of formation of the International Society of Rock Mechanics came to an end.

[15]



731- T (Gründ. V.)

INTERNATIONALE GESELLSCHAFT FÜR FELSMECHANIK

Kurzprotokoll der Vorstandssitzung vom 25. V. 1962.

Anwesende: Prof. v. Gottstein
Prof. Jelinek
Prof. Leussink
Dr. Müller
Dr. Pancini
Prof. Potts
Dipl.-Ing. Scheiblauer.

Der Vorsitzende des Vereins und dessen Stellvertreter, also Dr. Müller, Prof. Leussink und Dr. Pancini, sind gleichzeitig Vorsitzender und Vorsitzenden-Stellvertreter des Vorstandes.

Zum Schriftwart wurde Dipl.-Ing. Scheiblauer, zum Säckelwart Prof. v. Gottstein gewählt.

Das Sekretariat der Gesellschaft führt Frau Haas.

Es wurde beschlossen, daß der jedes Jahr der Generalversammlung vorzulegende Rechenschaftsbericht nicht nur von den beiden Rechnungsprüfern, sondern auch von einem öffentlichen Buchprüfer begutachtet werden soll.

Bezüglich der beim XIII. Kolloquium einzuhebenden Unkostenbeiträge wurde beschlossen, diese für Mitglieder auf S 200.-- und für Nichtmitglieder auf S 300.-- festzusetzen und dies in den endgültigen Einladungen bekanntzugeben.

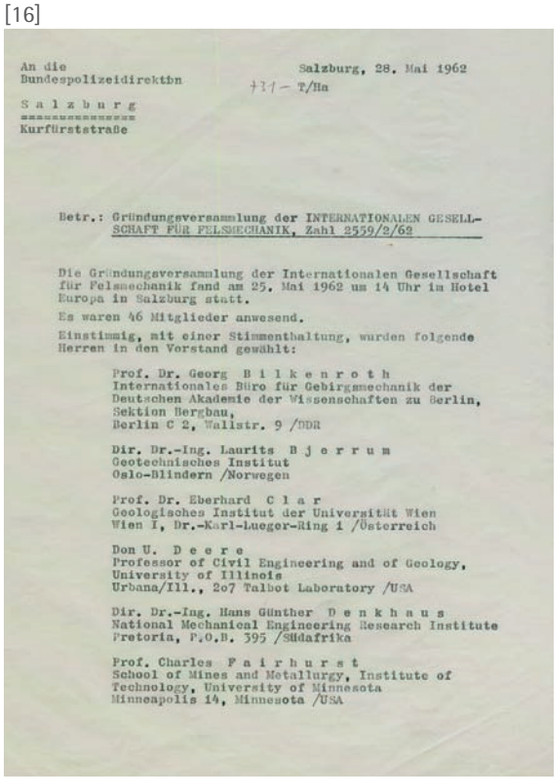
Ferner soll die endgültige Einladung enthalten, daß die Vorträge und Diskussionen in "Geologie und Bauwesen" veröffentlicht werden und zu welchem Preis die Hefte zu beziehen sind.

Die nächste Vorstandssitzung wurde für Anfang Oktober 1962 (vor dem Kolloquium) und die nächste Mitgliederversammlung für 6. Oktober (nach dem Kolloquium) ins Auge gefaßt.

[15] Minutes of the meeting of the Board of Directors of 25 May 1962.

[9] Müller L. (1962) "*Gründung der Intertionalen Gesellschaft für Felsmechanik*", *Geologie und Bauwesen*, a short note, Spinger, Vienna, Vol. 28/1, pp 77–78.

[16]



An die
Bundespolizeidirektion
Salzburg
Kurfürststraße

Salzburg, 28. Mai 1962
+11 - T/Ha

Betr.: Gründungsversammlung der INTERNATIONALEN GESELLSCHAFT FÜR FELSMECHANIK, Zahl 2559/2/62

Die Gründungsversammlung der Internationalen Gesellschaft für Felsmechanik fand am 25. Mai 1962 um 14 Uhr im Hotel Europa in Salzburg statt.

Es waren 46 Mitglieder anwesend.

Einstimmig, mit einer Stimmenthaltung, wurden folgende Herren in den Vorstand gewählt:

Prof. Dr. Georg Bilkenroth
Internationales Büro für Gebirgsmechanik der Deutschen Akademie der Wissenschaften zu Berlin, Sektion Bergbau,
Berlin C 2, Wallstr. 9 /DDR

Dir. Dr.-Ing. Laurits Bjerrum
Geotechnisches Institut
Oslo-Blindern /Norwegen

Prof. Dr. Eberhard Clar
Geologisches Institut der Universität Wien
Wien I, Dr.-Karl-Lueger-Ring 1 /Österreich

Don U. Deere
Professor of Civil Engineering and of Geology,
University of Illinois
Urbana/Ill., 207 Talbot Laboratory /USA

Dir. Dr.-Ing. Hans Günther Denkhaus
National Mechanical Engineering Research Institute
Pretoria, P.O.B. 395 /Südafrika

Prof. Charles Fairhurst
School of Mines and Metallurgy, Institute of Technology, University of Minnesota
Minneapolis 14, Minnesota /USA

2

Dr. Sc. Alfred Falconnier
Professeur Associé à l'Ecole Polytechnique de l'Université de Lausanne
Nyon, Rive 24 /Schweiz

Henri Gicot
Ingénieur-conseil
Fribourg, 25 Route Port St. Jacques /Schweiz

Prof. Dipl.-Ing. Ernst v. Gottstein
München 22, Widenmayerstr. 49 /BRD

Sektionschef Dipl. Ing. Dr. Ernst Güntschel
Vorsitzender der Staubeckenkommission im Bundesministerium f. Land- u. Forstwirtschaft
Wien I, Stubenring 1 /Österreich

Prof. Dr.-Ing. Helmut Hoffmann
Direktor des Institutes für Markscheidewesen, Bergschadenkunde und Geophysik im Bergbau an der Rhein.-Westf. Technischen Hochschule Aachen
Aachen, Wüllnerstr. 2 /BRD

Prof. Dr.-Ing. Richard Jelinek
Direktor des Institutes für Grundbau und Bodenmechanik an der Technischen Hochschule München
München 2, Arcisstr. 21 /BRD

Dr.-Ing. Rudolf Kvapil
Leiter der Abteilung für theoretische und angewandte Gebirgsmechanik
Kosice, Komenskeho 26/06 /CSR

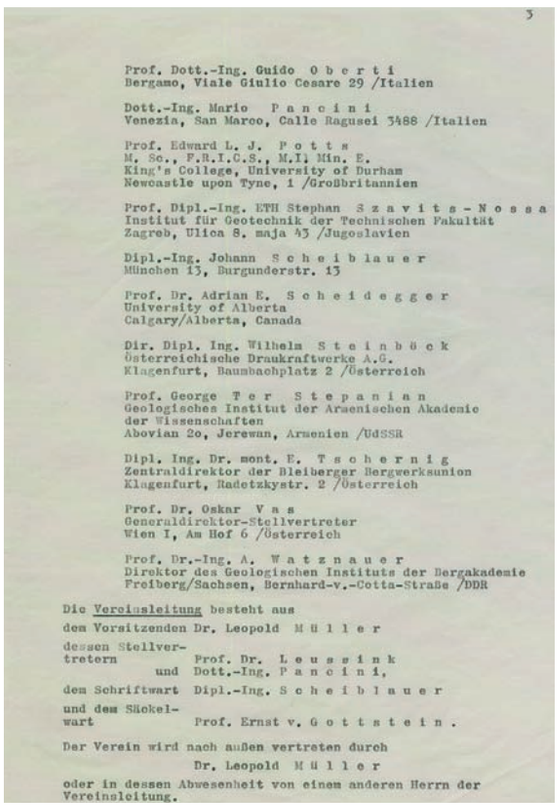
Dir. Dr.-techn. Harald Lauffer
Tiroler Wasserkraftwerke A.G.
Innsbruck, Landhausplatz 2 /Österreich

Prof. Dr.-Ing. Hans Leussink
Institut für Bodenmechanik und Grundbau an der Technischen Hochschule Karlsruhe
Karlsruhe, Kaiserstr. 12 /BRD

Prof. Dr. J. Litwiniszyn
Polnische Akademie der Wissenschaften und Berg- und Hüttenakademie
Krakow, Jaracza 5 m. 9 /Polen

Prof. Dr. H. J. Martini
Bundesanstalt für Bodenforschung
Hanover, Wiesenstr. 1 /BRD

Dr. techn. Leopold Müller
Ingenieurkonsulent für Bauwesen
Salzburg, Traunstr. 25a /Österreich



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Prof. Dott.-Ing. Guido Oberti
Bergamo, Viale Giulio Cesare 29 /Italien

Dott.-Ing. Mario Pancini
Venezia, San Marco, Calle Ragusei 3488 /Italien

Prof. Edward L. J. Potts
M. Sc., F.R.I.C.S., M.I. Min. E.
King's College, University of Durham
Newcastle upon Tyne, 1 /Großbritannien

Prof. Dipl.-Ing. ETH Stephan Szavits-Nossa
Institut für Geotechnik der Technischen Fakultät
Zagreb, Ulica 8. maja 43 /Jugoslavien

Dipl.-Ing. Johann Scheiblauer
München 13, Burgunderstr. 13

Prof. Dr. Adrian E. Scheidegger
University of Alberta
Calgary/Alberta, Canada

Dir. Dipl. Ing. Wilhelm Steinböck
Österreichische Draukraftwerke A.G.
Klagenfurt, Baumbachplatz 2 /Österreich

Prof. George Ter Stepanian
Geologisches Institut der Armenischen Akademie der Wissenschaften
Abovian 2o, Jerewan, Armenien /UdSSR

Dipl. Ing. Dr. mont. E. Tschernig
Zentraldirektor der Bleiberger Bergwerksunion
Klagenfurt, Radetzkystr. 2 /Österreich

Prof. Dr. Oskar Vas
Generaldirektor-Stellvertreter
Wien I, Am Hof 6 /Österreich

Prof. Dr.-Ing. A. Watznauer
Direktor des Geologischen Instituts der Bergakademie
Freiberg/Sachsen, Bernhard-v.-Cotta-Straße /DDR

Die Vereinsleitung besteht aus

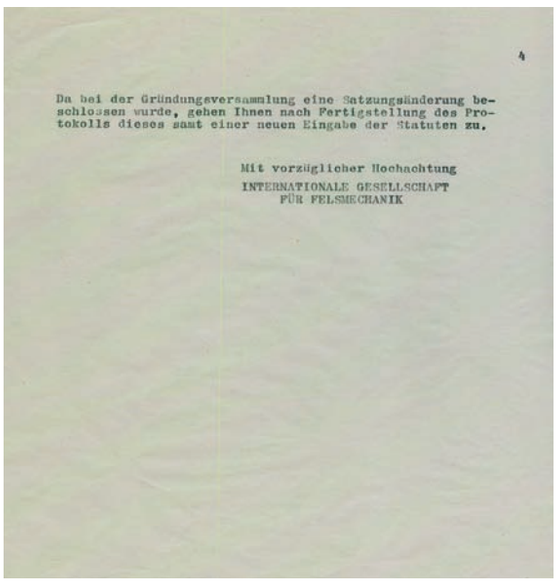
dem Vorsitzenden Dr. Leopold Müller

dessen Stellvertretern Prof. Dr. Leussink
und Dott.-Ing. Pancini,

dem Schriftwart Dipl.-Ing. Scheiblauer

und dem Säckelwart Prof. Ernst v. Gottstein.

Der Verein wird nach außen vertreten durch
Dr. Leopold Müller
oder in dessen Abwesenheit von einem anderen Herrn der Vereinsleitung.



4

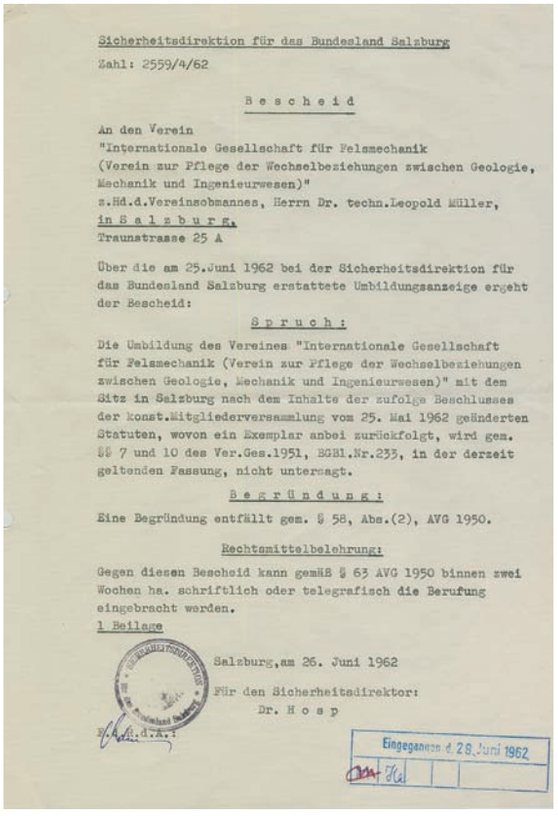
Da bei der Gründungsversammlung eine Satzungsänderung beschlossen wurde, gehen Ihnen nach Fertigstellung des Protokolls dieses samt einer neuen Eingabe der Statuten zu.

Mit vorzüglicher Hochachtung
INTERNATIONALE GESELLSCHAFT
FÜR FELSMECHANIK

[16] Letter to the Federal Police Directorate of Salzburg, 28 May 1962.

Having stressed the importance of the interaction with the ISSMFE in the formation of the ISRM and for their future collaboration, it is also interesting to refer the early contacts established between Leopold Müller and the North American Rock Mechanics community. Laurits Bjerrum, in a letter dated 5 June [18] to W.R. Judd, Chairman of the Committee on Rock Mechanics of the Division of Engineering Geology of the Geological Society of America, informs him of the recent formation of the ISRM, and puts him in contact with Müller, regarding future cooperation between Europe and America. Judd wrote to Müller on 19 June [19] expressing his positive attitude towards co-operating with the ISRM, and his intention to bring this issue to the next meeting of his Committee and to attend the Salzburg Colloquy in October.

[17]



Sicherheitsdirektion für das Bundesland Salzburg
Zahl: 2559/4/62

B e s c h e i d

An den Verein
"Internationale Gesellschaft für Felsmechanik
(Verein zur Pflege der Wechselbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen)"
z.Hd.d.Vereinsobmannes, Herrn Dr. techn.Leopold Müller,
in S a l z b u r g,
Traunstrasse 25 A

Über die am 25.Juni 1962 bei der Sicherheitsdirektion für das Bundesland Salzburg erstattete Umbildungsanzeige ergeht der Bescheid:

S p r u c h :

Die Umbildung des Vereines "Internationale Gesellschaft für Felsmechanik (Verein zur Pflege der Wechselbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen)" mit dem Sitz in Salzburg nach dem Inhalte der zufolge Beschlusses der konst.Mitgliederversammlung vom 25. Mai 1962 geänderten Statuten, wovon ein Exemplar anbei zurückfolgt, wird gem. §§ 7 und 10 des Ver.Ges.1951, BGBl.Nr.233, in der derzeit geltenden Fassung, nicht untersagt.

B e g r ü n d u n g :

Eine Begründung entfällt gem. § 58, Abs.(2), AVG 1950.

Rechtsmittelbelehrung:

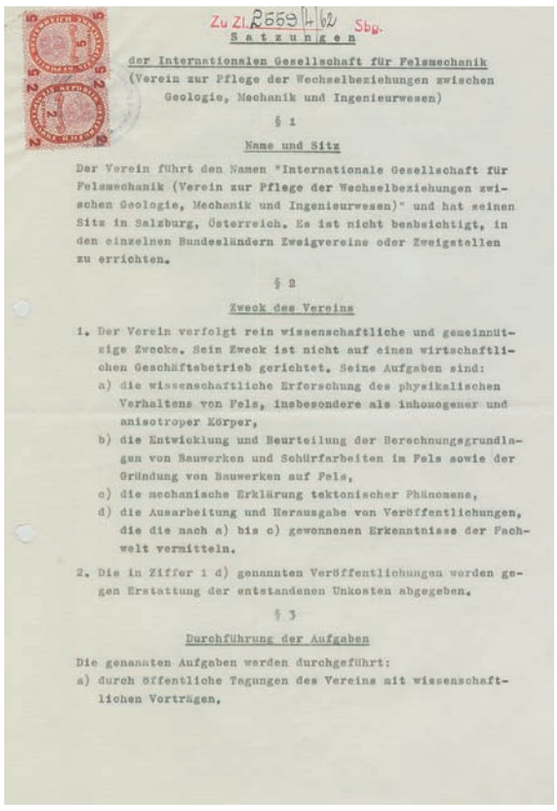
Gegen diesen Bescheid kann gemäß § 63 AVG 1950 binnen zwei Wochen ha. schriftlich oder telegrafisch die Berufung eingebracht werden.

1 Beilage

Salzburg,am 26. Juni 1962

Für den Sicherheitsdirektor:
Dr. H o s p

Eingegangen d. 28. Juni 1962



Zu Zl. 2559/4/62 Sbg.

S a t z u n g e n

der Internationalen Gesellschaft für Felsmechanik
(Verein zur Pflege der Wechselbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen)

§ 1

Name und Sitz

Der Verein führt den Namen "Internationale Gesellschaft für Felsmechanik (Verein zur Pflege der Wechselbeziehungen zwischen Geologie, Mechanik und Ingenieurwesen)" und hat seinen Sitz in Salzburg, Österreich. Es ist nicht beabsichtigt, in den einzelnen Bundesländern Zweigvereine oder Zweigstellen zu errichten.

§ 2

Zweck des Vereins

1. Der Verein verfolgt rein wissenschaftliche und gemeinnützige Zwecke. Sein Zweck ist nicht auf einen wirtschaftlichen Geschäftsbetrieb gerichtet. Seine Aufgaben sind:
   a) die wissenschaftliche Erforschung des physikalischen Verhaltens von Fels, insbesondere als inhomogener und anisotroper Körper,
   b) die Entwicklung und Beurteilung der Berechnungsgrundlagen von Bauwerken und Schürfarbeiten im Fels sowie der Gründung von Bauwerken auf Fels,
   c) die mechanische Erklärung tektonischer Phänomene,
   d) die Ausarbeitung und Herausgabe von Veröffentlichungen, die die nach a) bis c) gewonnenen Erkenntnisse der Fachwelt vermitteln.
2. Die in Ziffer 1 d) genannten Veröffentlichungen werden gegen Erstattung der entstandenen Unkosten abgegeben.

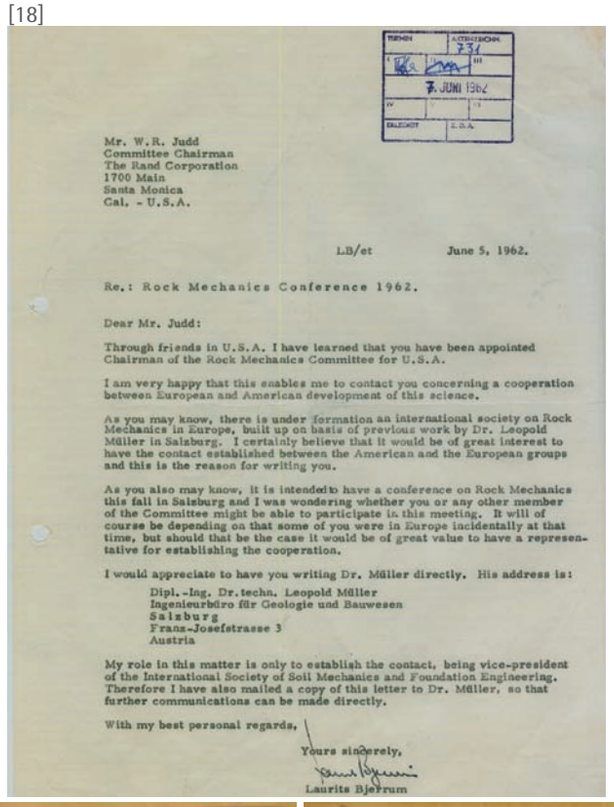
§ 3

Durchführung der Aufgaben

Die genannten Aufgaben werden durchgeführt:
a) durch öffentliche Tagungen des Vereins mit wissenschaftlichen Vorträgen,

[17] Decision of the Safety Directorate of the Federal State of Salzburg, 26 June 1962.

[18]



Mr. W.R. Judd
Committee Chairman
The Rand Corporation
1700 Main
Santa Monica
Cal. - U.S.A.

LB/et June 5, 1962.

Re.: Rock Mechanics Conference 1962.

Dear Mr. Judd:

Through friends in U.S.A. I have learned that you have been appointed Chairman of the Rock Mechanics Committee for U.S.A.

I am very happy that this enables me to contact you concerning a cooperation between European and American development of this science.

As you may know, there is under formation an international society on Rock Mechanics in Europe, built up on basis of previous work by Dr. Leopold Müller in Salzburg. I certainly believe that it would be of great interest to have the contact established between the American and the European groups and this is the reason for writing you.

As you also may know, it is intended to have a conference on Rock Mechanics this fall in Salzburg and I was wondering whether you or any other member of the Committee might be able to participate in this meeting. It will of course be depending on that some of you were in Europe incidentally at that time, but should that be the case it would be of great value to have a representative for establishing the cooperation.

I would appreciate to have you writing Dr. Müller directly. His address is:

Dipl.-Ing. Dr.techn. Leopold Müller
Ingenieurbüro für Geologie und Bauwesen
Salzburg
Franz-Josefstrasse 3
Austria

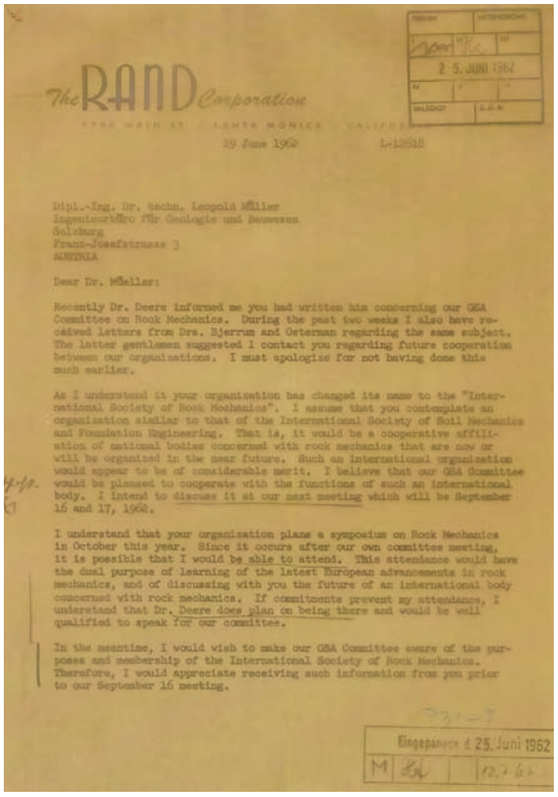
My role in this matter is only to establish the contact, being vice-president of the International Society of Soil Mechanics and Foundation Engineering. Therefore I have also mailed a copy of this letter to Dr. Müller, so that further communications can be made directly.

With my best personal regards,

Yours sincerely,

Laurits Bjerrum

[19]



The RAND Corporation
1700 MAIN ST. SANTA MONICA CALIFORNIA

19 June 1962 L-12618

Dipl.-Ing. Dr. techn. Leopold Müller
Ingenieurbüro für Geologie und Bauwesen
Salzburg
Franz-Josefstrasse 3
AUSTRIA

Dear Dr. Müller:

Recently Dr. Deere informed me you had written him concerning our GSA Committee on Rock Mechanics. During the past two weeks I also have received letters from Drs. Bjerrum and Osterman regarding the same subject. The latter gentlemen suggested I contact you regarding future cooperation between our organizations. I must apologise for not having done this much earlier.

As I understand it your organization has changed its name to the "International Society of Rock Mechanics". I assume that you contemplate an organization similar to that of the International Society of Soil Mechanics and Foundation Engineering. That is, it would be a cooperative affiliation of national bodies concerned with rock mechanics that are now or will be organized in the near future. Such an international organization would appear to be of considerable merit. I believe that our GSA Committee would be pleased to cooperate with the functions of such an international body. I intend to discuss it at our next meeting which will be September 16 and 17, 1962.

I understand that your organization plans a symposium on Rock Mechanics in October this year. Since it occurs after our own committee meeting, it is possible that I would be able to attend. This attendance would have the dual purpose of learning of the latest European advancements in rock mechanics, and of discussing with you the future of an international body concerned with rock mechanics. If commitments prevent my attendance, I understand that Dr. Deere does plan on being there and would be well qualified to speak for our committee.

In the meantime, I would wish to make our GSA Committee aware of the purposes and membership of the International Society of Rock Mechanics. Therefore, I would appreciate receiving such information from you prior to our September 16 meeting.

Eingegangen 25. Juni 1962

Dr. Leopold Müller - 2 - 19 June 1962
L-12618

In the event I am unable to be in Europe for your meeting I will look forward to making your acquaintance at our International Conference in June 1963. I was very happy to learn from Dr. Deere that you have found it possible to participate in this Conference. It now appears that we will have formal participation from England, Canada, Union of South Africa, Australia, Portugal, Sweden, and the United States, as well as from Austria. We hope to have the final program mailed to the formal participants within the next sixty days. The dates have been established as June 13 and 14, 1963, with a dinner for the formal participants on the evening of June 12.

Personally I was very pleased to hear that you had taken the initiative of forming an international rock mechanics group. I will very much look forward to working with you in this regard in the future.

Sincerely yours,

Wm. R. Judd
Aero-Astronautics Department

Chairman, Committee on Rock Mechanics
GSA Division of Engineering Geology

WRJ:ja
cc: Justus Osterman, Director
Swedish Geotechnical Institute
Banergatan 16, Stockholm No

Laurits Bjerrum
Norwegian Geotechnical Institute
Oslo, Blindern
Norway

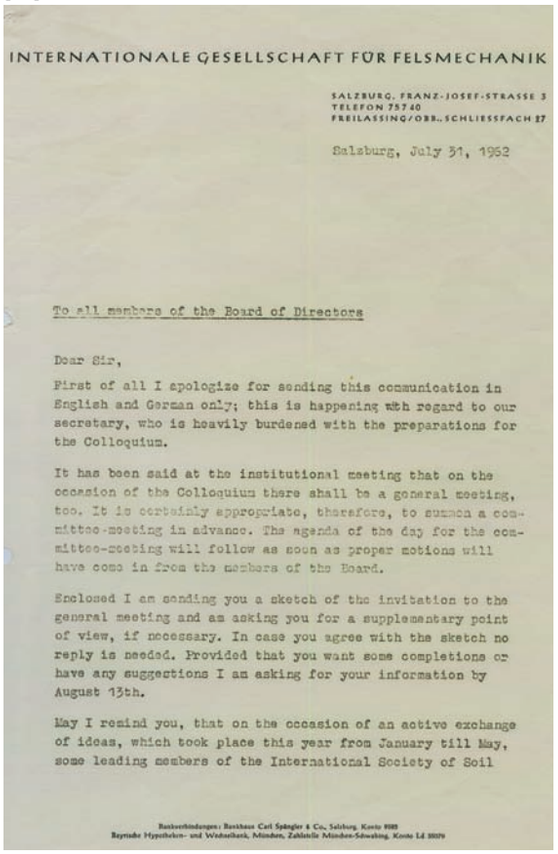
Dr. Don Deere
Department of Geology & Civil Engineering
University of Illinois
Urbana, Illinois

[18] Letter from Laurits Bjerrum to W.R. Judd, 5 June 1962.

[19] Letter from W.R. Judd to Leopold Müller, 19 June 1962.

In the summer of 1962 the ISRM had been founded, its Statutory bodies had been formed, and all the conditions existed for starting its activities. The circular letter of 31 July [20] is a demonstration of this. In this letter Leopold Müller calls the second meeting of the General Assembly and the second Board meeting of the ISRM. In the same letter, a closed meeting with the ISSMFE was also scheduled, to discuss future co-operation. All these meetings were to materialise during the Salzburg Colloquy on 4 and 5 October 1962, which was the first conference of the International Society for Rock Mechanics[10].

[20]



INTERNATIONALE GESELLSCHAFT FÜR FELSMECHANIK

SALZBURG, FRANZ-JOSEF-STRASSE 3
TELEFON 75740
FREILASSING/OBB., SCHLIESSFACH 27

Salzburg, July 31, 1962

To all members of the Board of Directors

Dear Sir,

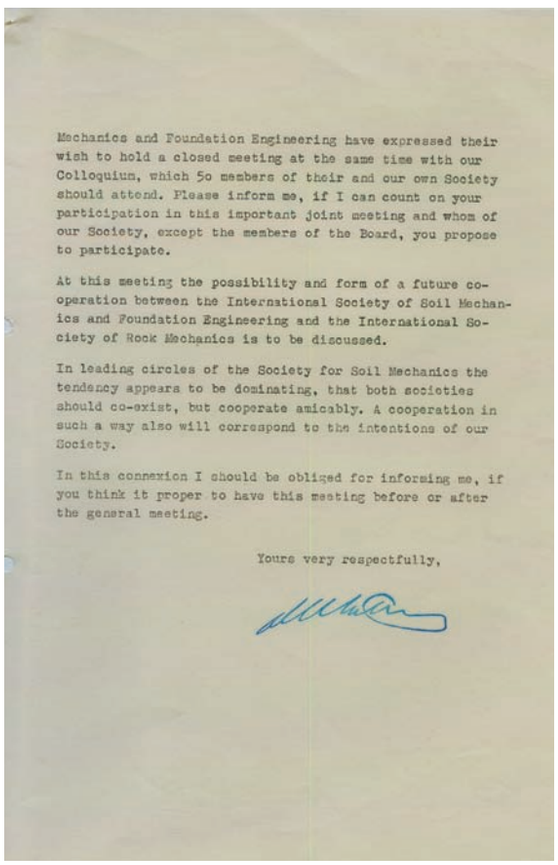
First of all I apologize for sending this communication in English and German only; this is happening with regard to our secretary, who is heavily burdened with the preparations for the Colloquium.

It has been said at the institutional meeting that on the occasion of the Colloquium there shall be a general meeting, too. It is certainly appropriate, therefore, to summon a committee-meeting in advance. The agenda of the day for the committee-meeting will follow as soon as proper motions will have come in from the members of the Board.

Enclosed I am sending you a sketch of the invitation to the general meeting and am asking you for a supplementary point of view, if necessary. In case you agree with the sketch no reply is needed. Provided that you want some completions or have any suggestions I am asking for your information by August 13th.

May I remind you, that on the occasion of an active exchange of ideas, which took place this year from January till May, some leading members of the International Society of Soil

Bankverbindungen: Bankhaus Carl Spängler & Co., Salzburg, Konto 9985
Bayrische Hypotheken- und Wechselbank, München, Zahlstelle München-Schwabing, Konto Ld 30570



Mechanics and Foundation Engineering have expressed their wish to hold a closed meeting at the same time with our Colloquium, which 50 members of their and our own Society should attend. Please inform me, if I can count on your participation in this important joint meeting and whom of our Society, except the members of the Board, you propose to participate.

At this meeting the possibility and form of a future co-operation between the International Society of Soil Mechanics and Foundation Engineering and the International Society of Rock Mechanics is to be discussed.

In leading circles of the Society for Soil Mechanics the tendency appears to be dominating, that both societies should co-exist, but cooperate amicably. A cooperation in such a way also will correspond to the intentions of our Society.

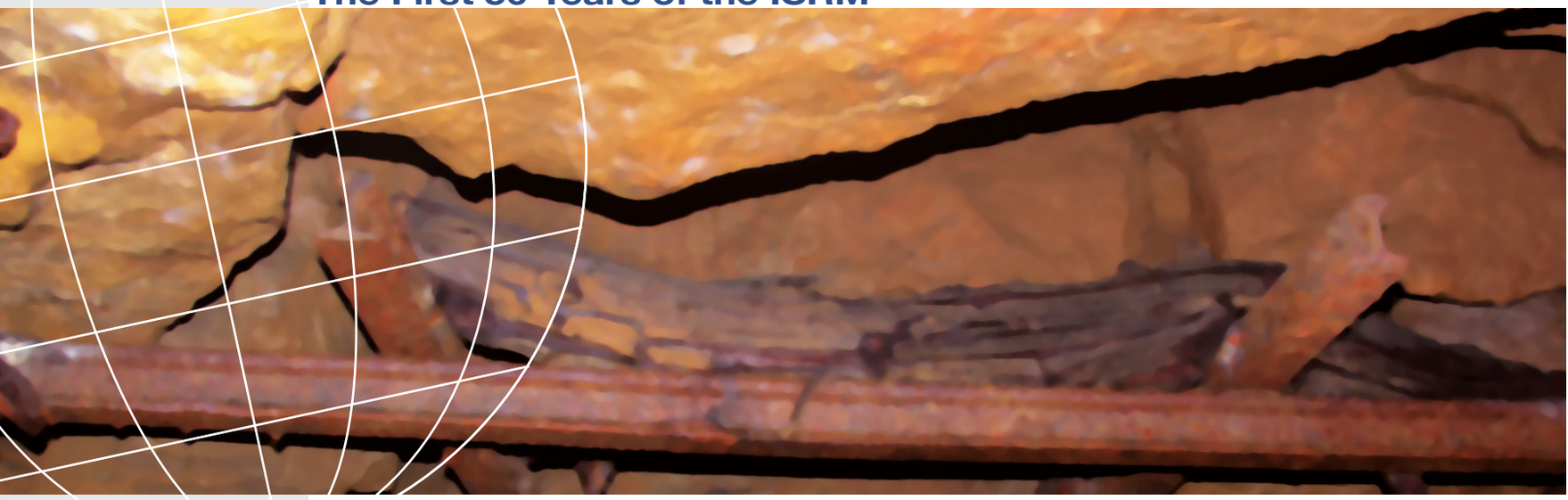
In this connexion I should be obliged for informing me, if you think it proper to have this meeting before or after the general meeting.

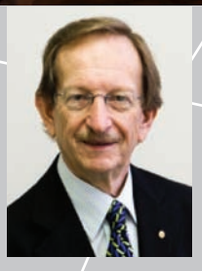
Yours very respectfully,

[20] Circular letter from Leopold Müller, 31 July 1962

[10] Müller, L. (1963) "*Das XIII Kolloquim der Internationalen Gesellschaft für Felsmechanik in Salzburg*", *Rock Mechanics and Engineering Geology*, Springer, Vienna, Vol. I/1, pp 1–3.

The First 50 Years of the ISRM





Ted Brown

INTRODUCTION

The 12th Congress of the International Society for Rock Mechanics (ISRM) fell in the fiftieth year of the life of the Society which was established formally on 25 May 1962 in Salzburg, Austria (see Chapter 1 and Fairhurst 2010). The Congress therefore provided an important opportunity for the Society to recall its foundation, reflect on its achievements and on the progress made in our discipline in the 50 years since its formation, and to look forward to the next 50 years.

This Chapter is based on the writer's keynote paper to the Congress (Brown 2011) which attempted the rather large and complex task of reviewing and synthesising the emergence of rock mechanics as a distinctive engineering and scientific discipline, the state and achievements of the discipline at the time the ISRM was founded in 1962, the events leading up to the formation of the Society, the development and achievements of the Society in the 50 years since 1962, and finally, the progress made in the discipline since that time.

Although too young to have been involved in the work of the Society in its earliest years before the First Congress held in Lisbon in 1966, the writer has followed the developments discussed here with keen interest for about 48 of these 50 years. He was honoured and delighted to have been invited by the Society's President for 2007–2011, Professor John Hudson, to prepare and present the 12th Congress paper and this Chapter. In a companion paper and in Chapter 12, Professor Hudson looks forward to the next 50 years of the Society and the discipline (Hudson 2011).

Throughout this Chapter, the term rock mechanics will be used in the sense given in the ISRM Statutes: *"The field of rock mechanics is taken to include all studies relative to the physical and mechanical behaviour of rocks and rock masses and the applications of this knowledge for the better understanding of geological processes and in the fields of engineering"*. Thus, the term rock mechanics will be generally taken to include rock engineering, although on occasion, the two may be expressed independently as in the now commonly-used term, rock mechanics and rock engineering.

THE WORLD IN 1962

To begin, it is worth recalling what the world was like in 1962. In ***world politics***, the Cold War was in full swing. The Premier of the then U.S.S.R., Nikita Kruschev, and the young President of the U.S.A., John F. Kennedy, were exercised over what became known as the Cuban missile crisis. Elsewhere, Harold Macmillan was the Prime Minster of the U.K., Charles de Gaulle was still the President of France, Jawaharlal Nehru was the Prime Minister of India and Chairman Mao Zedong was the leader of China. It has to be said that, at that time, the People's Republic of China was not at all well known to those living in what is usually referred to as "the West".

In ***culture***—popular and otherwise—the American writer, John Steinbeck, won the Nobel Prize for Literature. There was an unhappy link to one of the life-long interests of the ISRM's Founder and First President, Professor Leopold Müller, when the world-famous Austrian violinist, Fritz Kreisler, died on 29 January. In popular music, The Beatles released their first recording and The Rolling Stones made their public debut. In the writer's favourite form of music, jazz, the pianist Herbie Hancock's tune *Watermelon Man* topped not only the jazz charts but the popular music charts as well for several weeks in 1962.

In ***sport***, Brazil won the World Cup in football; the New York Yankees won the World Series in baseball; the American golfer, Arnold Palmer, won his second consecutive British Open and his third U.S. Masters titles; and an Australian, Rod Laver, won the Grand Slam in tennis.

In ***science and technology***, the first observation of laser activity was reported; the first practical light emitting diode was produced; the world's first active telecommunications satellite, Telstar 1, was launched on 10 July; the felt-tipped pen came into being; and, although digital computing was in its infancy and the personal computer was still some years off, in a sign of things to come, the first computer game was developed for a PDP-1 computer.

THE EMERGENCE OF ROCK MECHANICS AS AN IDENTIFIABLE DISCIPLINE

The writer has argued previously that, by the early 1960s, the subject of rock mechanics, if it wasn't yet fully established, was well on its way to becoming established as an identifiable scientific and engineering discipline (Brown 1999, 2002, Hood & Brown 1999). The state of knowledge in the discipline in 1962 will be summarised in the next section. Here, it will be demonstrated that it was at least well on the way to becoming established through the appearance of specialist journals, conferences and societies.

From the mid-nineteenth century, publications on what we would now recognize as rock mechanics and rock engineering appeared in mining and engineering journals, in the publications of professional societies, and in reports of university and other research institutes in a number of countries (Obert & Duvall 1967). In discussing what they refer to as the first stage of the development of rock mechanics, the Russian writers, Turchaninov *et al*. (1974) concluded that *"by the end of the 19th century, the basic patterns of deformation and fracture of rock in underground workings and on the surface had been studied, instrumented observations of the deformation of the surface had been made for the most important western European coal deposits, and the first practical rules had been suggested regarding the leaving of blocks of ore (safety pillars) and delineating the area of dangerous surface subsidence"*.

The first use of the term "rock mechanics" in English that the writer is aware of was in a paper published by Appleton (1944) in South Africa. The first issue of the first specialist journal devoted to rock mechanics and rock engineering, *Geologie und Bauwesen*, edited by Professor Josef Stini, was published in Vienna in 1929. Professor Leopold Müller who soon was to become the First President of the ISRM (Figure 1) succeeded Stini as editor in 1958, and in 1962 this journal changed its name to *Felsmechanik und Ingenieurgeologie* (*Rock Mechanics and Engineering Geology*). Further name changes to *Rock Mechanics* (Müller 1969) and to the current *Rock Mechanics and Rock Engineering* were made in 1969 and 1983, respectively. The other major journal in the field, the *International Journal of Rock*

Mechanics and Mining Sciences, was founded by Albert Roberts in the UK in 1963 with a primarily mining orientation (Roberts 1963) which has disappeared with the efflux of time.

Figure 1. The late Professor Leopold Müller, 1908–1988, founding President of the ISRM

Since 1950, annual colloquia on rock mechanics had been held in Austria. In 1951, the First International Conference on Rock Pressure and Ground Support was held in Liège, Belgium. In 1958, the International Bureau of Rock Mechanics was established at the third International Strata Control Congress held in Leipzig in the then East Germany. From the early 1950s, systematic research in rock mechanics began in the U.S.A., and in 1956 the first of what soon became annual U.S. symposia on rock mechanics was held at the Colorado School of Mines. In 1962, the eighth ISRM President, Professor Charles Fairhurst, organised the 5th U.S. Symposium at the University of Minnesota (Fairhurst 1963). In that year, the first Canadian Symposium on Rock Mechanics was held (Anon 1963). And as well as there being publications in dedicated and more broadly-based journals and in the various conference proceedings, by the early 1960s books on rock mechanics had started to appear, notably Talobre's *La Mécanique des Roches*, published in Paris in 1957 (Talobre 1957). A conference on the subject was also held in Paris in that year.

These few facts show clearly that, by 1962, the discipline of rock mechanics was identifiable and reasonably well established, at least in several parts of the world.

THE STATE AND ACHIEVEMENTS OF ROCK MECHANICS IN 1962

The next question that might reasonably be asked is what were the concerns, the state of knowledge, and the achievements of the discipline of rock mechanics and rock engineering at that time? The short answer is that, with one vital deficiency, they were perhaps more advanced than might now be first supposed.

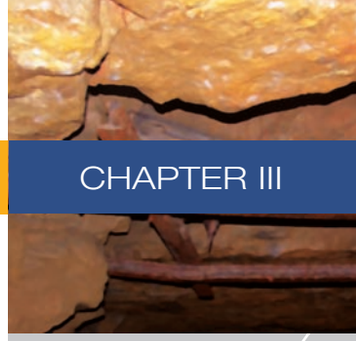
By 1962, many of the major concerns of the discipline had been clearly identified and were being investigated by both researchers and practitioners. For example, what is often referred to as the Austrian School of Rock Mechanics was well established. According to Müller (1979), as early as 1905, Albert Heim had recognized the distinction between rock material and the rock mass. The use of stereonets had been introduced by Schmidt (1925); methods of studying joint systems in rock masses had been developed by Stini in the 1920s (Stini 1922) and subsequently by Müller himself (Müller 1933, 1950, 1979); laboratory and large-scale field testing techniques were being used (e.g. Blanks & McHenry 1945, Golder & Akroyd 1954, John 1962, Rocha *et al.* 1955); ground-support interaction concepts had been developed (Pacher 1964, Rabcewicz 1969); and limiting equilibrium methods were used to analyse the stability of blocks of rock in slopes and foundations (John 1962, Terzaghi 1962b).

Experimental investigations of the engineering properties of rocks were well under way in many parts of the world (e.g. Mayer 1953, Obert *et al.* 1946). In fact, the mechanical testing of rock can be traced back at least to Coulomb and others in Europe in the mid-18th century (Coulomb 1776, Heyman 1972). From a perhaps more scientific, geological or geophysical rather than a rock engineering perspective, high pressure compression testing of rock material had been underway since the pioneering work of von Kármán (1911) and King (1912), followed by that of Griggs and Handin in the U.S.A. from the mid-1930s (Griggs 1936, Handin 1953). In Japan, Professor Kiyoo Mogi's large body of experimental work in this area was well under way by 1960 (Mogi 1959, 2007) as was that of Dr Mervyn Paterson in Australia (Paterson 1958, 1978). Also at a fundamental level, Professor John Jaeger's initial seminal work on the friction of rock joints and surfaces had been published (Jaeger 1959, 1960). At the same time, large-scale field shear testing of rock discontinuities was being practiced in many parts of the world (John 1962, Rocha *et al.* 1955).

Rock mechanics studies formed an important part of the investigation and design of dams and of tunnels for hydroelectric developments and other purposes (Jaeger 1955, 1972). As early as 1951, Dr Charles Jaeger had submitted a proposal to the International Commission on Large Dams (ICOLD) *"to create a sub-committee on rock mechanics"* (Jaeger 1972). Dr Klaus John later remarked that at the 7th ICOLD meeting held in Rome in 1961, *"an increased emphasis on rock mechanics could be observed"* (John 1962). The ISRM's second President, Professor Manuel Rocha, and his National Civil Engineering Laboratory in Lisbon, Portugal, was a world leader in that endeavour (Rocha 1964, Rocha *et al.* 1955). And in the writer's home country of Australia, from 1949, a team led by Tom Lang working on the monumental Snowy Mountains Hydro-electric Scheme, made significant contributions to the development of rock mechanics and rock engineering both nationally and internationally (e.g. Alexander 1960, Brown 1999, Lang 1961, Moye 1959, Pinkerton *et al.* 1961).

At that time, elastic stress analyses of underground excavations in rock were carried out using closed-form solutions such as those published by Terzaghi & Richart (1952). Photoelasticity was used for more complex excavation shapes (e.g. Hoek 1963, Pinkerton *et al.* 1961), and an electric analogue solution was being developed in South Africa (Cook *et al.* 1966, Salamon *et al.* 1964). Digital computers and numerical methods of stress analysis such as the finite element method existed (Clough 1960), but their serious application to rock engineering stress analyses was still a few years away (e.g. Goodman 1966, Zienkiewicz & Cheung 1964).

As part of this general effort, there was wide-spread interest in measuring the stresses in the Earth's crust (Judd 1964, Terzaghi 1962a). The Society's fourth President, Professor Pierre Habib of France, was involved in the development and application of the flat-jack method as early as 1950 (Habib 1950, Habib & Marchand 1952, Mayer *et al.* 1951). This method was also being used to measure the *in situ* moduli of rock masses (Habib 1950), as were dynamic methods (Brown & Robertshaw 1953, Evison 1953). In 1958, one of the more important papers in the history of rock stress measurement, or estimation, as we now prefer to call it in the ISRM Suggested Methods, was published by Nils Hast in Sweden (Hast 1958). By the early 1960s, a wide range of methods of rock stress measurement had been investigated and/or developed (see, for example, the papers in the proceedings of a 1963 conference edited by Judd (1964)). And, as has been discussed by Obert & Duvall (1967) and Hood & Brown (1999) in the context of mining rock mechanics, during the 1950s significant advances were made in the development of a range of instruments for other forms of field monitoring for rock engineering applications in both civil and mining engineering (e.g. Potts 1957).



A significant programme of research on rock mechanics as applied to deep-level hard rock mining and the associated problem of rock bursts, had been established in South Africa in 1953 (Hill 1954, 1966). At around the same time, a similar problem was under investigation at the Kolar goldfield, India (Taylor 1962–63). A number of towering figures in the history of our discipline, including two Müller Lecturers, Drs Neville Cook and Evert Hoek, made their initial theoretical and experimental contributions to the development of rock mechanics as part of the South African programme. A central feature of that work was the experimental and theoretical study of the brittle fracture of rock using, among other things, the modified Griffith crack theory (Cook 1965, Cook *et al.* 1966, Hoek 1964).

Importantly, as Hoek (2007) has argued, *"the early 1960s were very important in the general development of rock engineering world-wide because a number of catastrophic failures occurred which clearly demonstrated that, in rock as well as in soil, 'we were over-stepping the limits of our ability to predict the consequences of our actions' (Terzaghi & Voight, 1979)"*. Reference to just three of these failures will serve to make the point. In December 1959, the foundation of the Malpasset concrete arch dam in France failed with the resulting flood killing more than 400 people (Duffaut 2011, Londe 1987). A few weeks later in January 1960, the pillars at a coal mine at Coalbrook in South Africa collapsed with the loss of 432 lives (Bryan *et al.* 1964). And in October 1963, about 2500 people in the Italian town of Longarone were killed as a result of a landslide-generated wave that overtopped the Vaiont Dam (Müller 1964). These three failures led to detailed investigations, much debate in the literature, the establishment of research programmes, and the development and application of new methods of rock engineering investigation and analysis (see, for example, Bernaix 1969, Duffaut 2011, Jaeger 1972, Londe 1987, Londe *et al.* 1969, Müller 1968, Müller-Salzburg 1987, Salamon & Munro 1967).

The examples and references given in the preceding paragraphs will make the essential points that, by the early 1960s, many of the major concerns of our discipline had been identified, many of the techniques that we use were in at least the early stages of their development, and significant advances had been made in the understanding of at least some areas of rock mechanics and in its application in rock engineering. But, as is still the case today (Chapter 12 and Hudson 2011), many significant questions remained unanswered. The most important of these, at least in the context of the ISRM, was Müller's implicit question, *"what is the strength of a rock mass?"* (Müller 1967a). The background to this question and a masterly account of the progress made in answering it are given by Fairhurst (Chapter 1 and 2010).

THE FOUNDING OF THE ISRM

Following a meeting of 16 men held in Professor Müller's home in Salzburg, Austria, in 1951, an *Internationale Arbeitsgemeinschaft für Geomechanik* or *International Working Group for Geomechanics*, was established to study rock mechanics problems, essentially using the Austrian School approaches outlined above (Müller 1967b). This group which was also known as the *Salzburger Kreis* or *Salzburg Circle*, remained largely Austrian until Professor Müller invited Professor Fairhurst to join at the 3rd U.S. Rock Mechanics Symposium held at the Colorado School of Mines in 1958 (Fairhurst 2010). The Constitutional Meeting of the Internationale Gesellschaft für Felsmechanik (International Society for Rock Mechanics) was held in Salzburg on 25 May 1962. The minutes of the meeting lists 46 participants from Austria, Germany, Italy, Poland, U.K., U.S.A. and Yugoslavia. Under Professor Müller's dynamic leadership and with growing support from a number of other countries, particularly in Europe, the Society soon grew to become truly international.

As was noted at the 11th Congress held in Lisbon in July 2007, the historic First Congress held in Lisbon in September 1966 was a major milestone and highlight in the early life of the Society and in the writer's own life (Brown 2007). A total of 814 delegates from 40 countries attended that First Congress. In his Address given at the majestic Opening Ceremony, Professor Müller made this important statement (translated from the original German into English):

> *"Many experts agree with me that discontinuity and anisotropy are the most characteristic properties of the material rock and that the properties of jointed media depend much more upon the joints of the unit rock block system than upon the rock material. Therefore, any theoretical investigation of that material has to go its own ways, in the same way as the construction material of soils years ago suggested to soil mechanics its own methods, which differ greatly from the way of thinking of technical* (or continuum) *mechanics*" (Müller 1967a).

Thus, rock mechanics became recognized as being largely the study of the mechanics of discontinua as the writer's own PhD supervisor at that time, Professor Hugh Trollope, put it (Trollope 1968, Trollope & Brown 1965). That does not mean to say that theoretical continuum mechanics in the fields of both elasticity and plasticity did not, and does not, have application to rock mechanics and rock engineering. But it does mean that answering Professor Müller's implicit question about the strength of a rock mass requires consideration of the mechanics of a discontinuum.

An important development in the early life of the Society occurred in 1966 following the election of Manuel Rocha as our second President, when the Secretariat was established at the National Civil Engineering Laboratory (LNEC) in Lisbon, Portugal, with generous financial support provided by the Calouste Gulbenkian Foundation. Since that time, our Society has been well-served by a succession of seven Secretaries-General provided by LNEC.

So by 1966, our discipline had been established, our International Society had been well and truly founded with a well-funded Secretariat in Lisbon, and our highly successful First International Congress had been held.

THE DEVELOPMENT AND ACHIEVEMENTS OF THE ISRM

Objectives, purposes and main activities

The Statutes and By-laws by which the Society is governed have changed periodically over time since 1962, but the Society's essential *objectives and purposes* have remained:

- to encourage international collaboration and the exchange of ideas and information between rock mechanics practitioners;
- to encourage teaching, research, and the advancement of knowledge in rock mechanics; and
- to promote high standards for professional practice among rock engineers so that civil, mining and petroleum engineering works might be safer, more economic and less disruptive to the environment.

The *main activities* carried out by the Society in pursuit of these objectives are to:

- hold International Congresses at intervals of four years;

- sponsor a co-ordinated program of International Symposia, Regional Symposia and Specialised Conferences on topics in rock mechanics and rock engineering, organized by the National Groups of the Society;
- publish a News Journal to provide information about technology related to rock mechanics and up-to-date news on activities being carried out by the rock mechanics community;
- operate Commissions for studying scientific and technical matters of concern to the Society;
- award the Rocha Medal for an outstanding doctoral thesis, every year, and the Müller Award in recognition of distinguished service to the profession of rock mechanics and rock engineering once every four years; and
- co-operate with other international scientific associations.

The writer may be accused of bias, but on the basis of the evidence to be presented below he concludes that, over an extended period of time, the Society has been very successful in pursuing its objectives and purposes through these various activities, all of which have been carried out very effectively.

Membership and Regional influences

As shown in Figure 2, the total individual membership was only 375 at the time of the First Congress in 1966, but quickly grew to reach more than 4000 in 1970. It first passed 5000 in 1982 and 6000 in 1988, reaching a peak of 6466 in 1989. It then declined until about the year 2000 and then increased steadily to 6293 in 2010 and 6514 in 2011. Over the same period, the number of National Groups increased more steadily from 12 in 1966 to 47–49 in recent years.

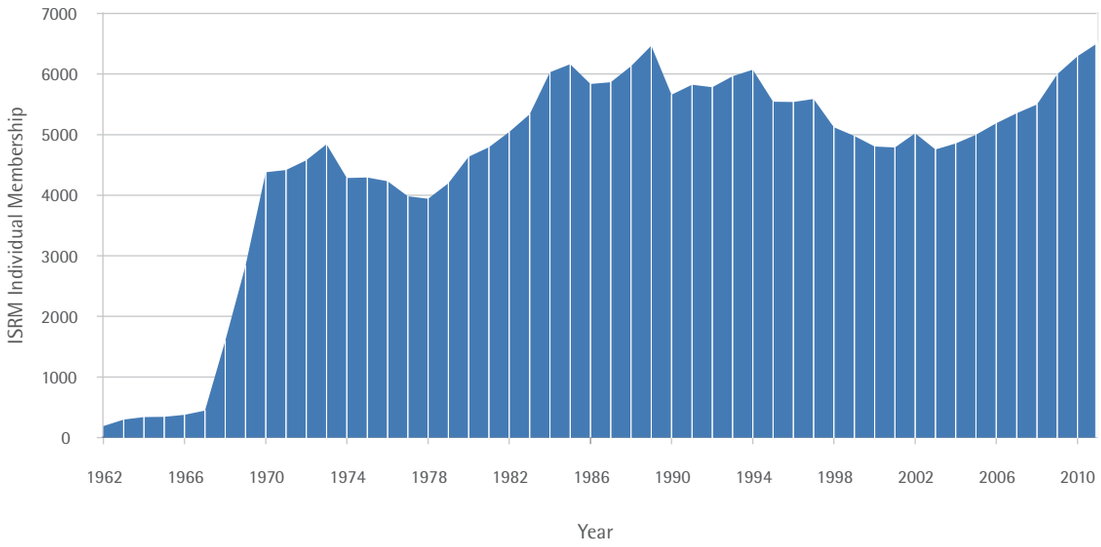


Figure 2. Total ISRM individual membership, 1962–2011

In many ways, Europe has always been the numerical and financial mainstay of the Society. Figure 3 taken from the 2011 annual review shows the distribution in individual membership by Region from 2003 to 2011. As well as the high and increasing European membership shown by the yellow bars, this

diagram illustrates the increasing Asian membership shown in blue, mainly as a result of relatively recent increases in membership in China and India.

In fact, the growth of rock mechanics in China has been a feature of the development of the Society and of our discipline over the last 25 to 30 years. The first 11 Chinese individual members joined the Society in 1979. China is now the Society's largest National Group with 554 members in 2011, followed closely by India. The writer's records and recollection suggest that China didn't really begin to participate in the work of the Society until about the time of the 5th Congress held in Melbourne, Australia, in 1983 when 18 Chinese delegates attended. The numbers were small for the next two Congresses but then grew steadily until 54 Chinese delegates attended the 11th Congress held in Lisbon in 2007. Of course, a great many more Chinese delegates attended the 12th Congress in Beijing in October 2011!

In the 1983 to 1987 ISRM term of office, the Society had its first Chinese Vice-President in Professor Tan Tjong Kie. The first ISRM International Symposium to be held in China was held in Beijing in November, 1986. Interestingly, in a paper given to that Symposium, Chen *et al.* (1986) reported that a programme of *in situ* stress measurement at the Three Gorges Dam area had been initiated by Professor Tan as early as 1958. Now the Society has its first Chinese President, Professor Xia-Ting Feng, who assumed the Presidency for the 2011 to 2015 term of office at the end of the Beijing Congress.

Despite the recent renewed increase in overall membership, perhaps one slightly disappointing feature of the Society's history has been the relative stagnation in individual membership numbers, both overall and in some of our six Regions of Africa, Asia, Australasia, Europe, North America and South America (see Figure 3), and in some countries within those Regions.

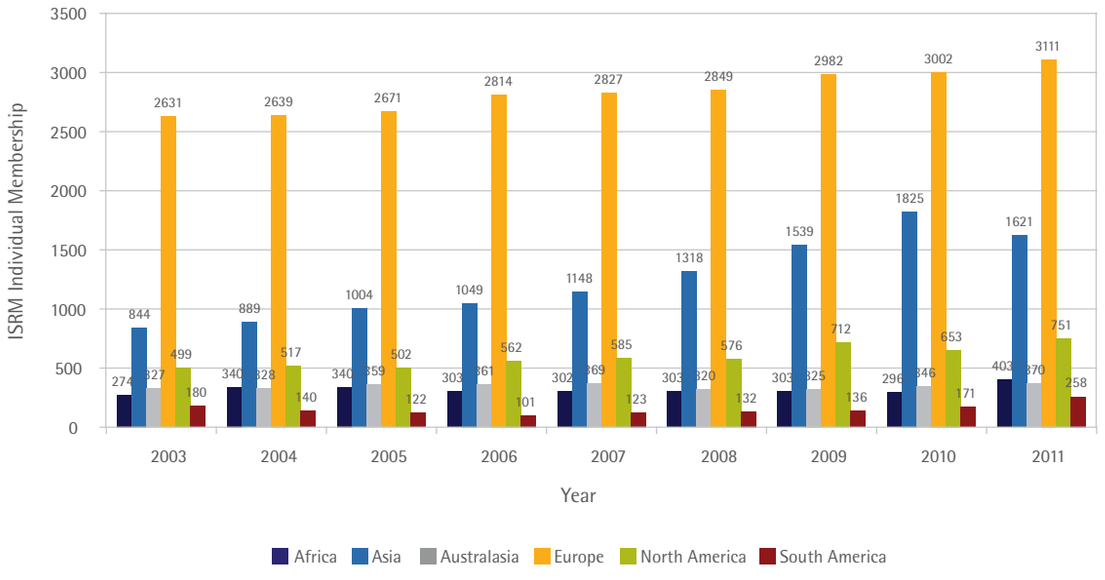
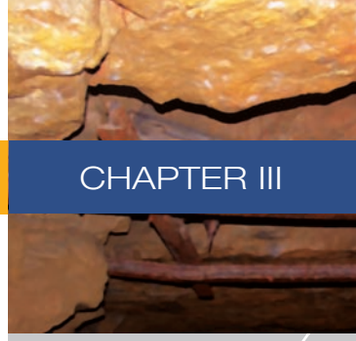


Figure 3. Individual ISRM membership by Region, 2003–2011



The European, and particularly the English-speaking, influence in our Society is illustrated in a number of ways other than by these individual membership numbers. As will be discussed below, six of the 12 ISRM Congresses held to date have been held in Europe. Of the 13 ISRM Presidents to date listed in Table 1, seven have been from European countries. Furthermore, another two of our Past Presidents, John Franklin and Charles Fairhurst, although North American when they became President, were both originally British.

Table 1. ISRM Presidents from 1962 to date

1962–1966	Leopold Müller (Austria)	1991–1995	Charles Fairhurst (U.S.A.)
1966–1970	Manuel Rocha (Portugal)	1995–1999	Shunsuke Sakurai (Japan)
1970–1974	Leonard Obert (U.S.A.)	1999–2003	Marc Panet (France)
1974–1979	Pierre Habib (France)	2003–2007	Nielen van der Merwe (South Africa)
1979–1983	Walter Wittke (Germany)	2007–2011	John A. Hudson (U.K.)
1983–1987	Edwin T. Brown (U.K.)	2011–2015	Xia-Ting Feng (China)
1987–1991	John A. Franklin (Canada)		

The Society's major award, the Müller Award, has been awarded every four years since the first Award was made to Dr Evert Hoek at the Seventh Congress held in Aachen, Germany, in 1991. The list of Müller Award recipients given in Table 2 shows a similar European and English-speaking influence to the list of Presidents. It should be understood that all four of the North American recipients were born and educated in other countries. Furthermore, the 2007 recipient, although an Australian, actually worked in the United Kingdom for 12 years when he was most closely involved in rock mechanics and in the work of the Society. The 2011 recipient who has been based in Norway for many years, was born and educated in the U.K.

Table 2. Müller Award recipients, 1991–2011

1991	Evert Hoek (Canada)
1995	Neville G. W. Cook (U.S.A.)
1999	Herbert H. Einstein (U.S.A.)
2003	Charles Fairhurst (U.S.A.)
2007	Edwin T. Brown (Australia)
2011	Nicholas R. Barton (Norway)

Annually since 1982, the Society has awarded the Rocha Medal for an outstanding doctoral thesis to honour the memory of its distinguished second President, Manuel Rocha of Portugal. As might be expected, the 30 Rocha Medal recipients to date have been spread more evenly among the Society's Regions and National Groups than have been the 13 Presidents and the six Müller Award recipients with five of the Society's six Regions and 17 different National Groups being represented. Importantly, a number of the Rocha Medal recipients have gone on to become senior and important figures in the discipline and in the Society.

Congresses, Symposia and Specialised Conferences

Congresses, Symposia and now Specialised Conferences have always been central to the Society's learned society function and constitute perhaps the most visible of the Society's activities. The quadrennial (except for a five-year gap between the 3rd and 4th) Congresses held since the First Congress in Lisbon in 1966 have been the most prestigious and well-attended of the range of meetings organised by the Society and its National Groups. Of the 12 Congresses held to date, one has been held in Africa, two in Asia, one in Australasia, six in Europe, two in North America, and none in South America. The 13th Congress will be held in Montreal, Canada, in the ISRM North American Region, in April–May 2015.

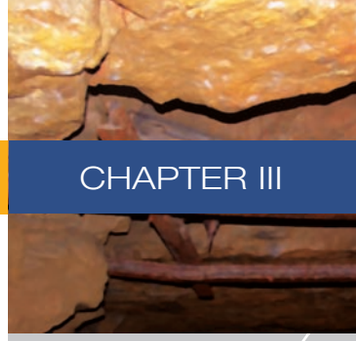
The excellent ISRM website maintained by the Secretariat indicates that, beginning with a Symposium held in Madrid in October 1968, by early 2011 the Society had sponsored a total of 33 International Symposia, 70 Regional Symposia and three Specialised Conferences. Lists of all ISRM Congresses and ISRM-sponsored, Symposia and Conferences are given in Appendix B.

For many years, the proceedings of our Congresses and Symposia have been published commercially, perhaps most frequently by Balkema which is now part of the Taylor & Francis Group. Over the past decade or so, the papers presented at many of our meetings have been made available on CD-ROM.

An important development in making the material contained in these proceedings and in ISRM-sponsored lectures more freely available to members occurred in October 2010 with the launch of the ISRM Digital Library. The published proceedings of all of the Congresses and International Symposia will be scanned progressively with optical character recognition to produce searchable files. More than 50,000 pages of this material have been prepared with 25,000 pages being available through the Digital Library at the time of writing.

Commissions

The work of the various Commissions that have operated since the time of the First Congress has brought great credit to the Society. Each Commission is established with an (initial) operational period corresponding to each ISRM President's term of office. During the 2007–2011 term of office, nine Commissions were in existence. An innovation made during this term was the introduction of Pre-Commissions which have been set up so that they can carry out preliminary work and be in a position to "hit the ground running" on their formal establishment and so make the fullest use of their four-year operational periods. At the time of writing, three Pre-Commissions existed in anticipation of their operational periods in the 2011–2015 term of office. A list of all Commissions and their Presidents is included in the Appendix C.



Without wishing to minimise the contributions made by the other Commissions in the past, and those being made by the current Commissions, in the writer's opinion, one of the most impressive and lasting achievements of the Society has been the work of what is now the *Commission on Testing Methods*. This Commission began its life at the time of the First Congress in 1966 as the Commission on Standardization of Laboratory and Field Tests under the Chairmanship of Dr Don Deere of the U.S.A. From 1972 to 1979 the Commission operated as two sub-committees on the Standardization of Laboratory Tests and the Standardization of Field Tests, respectively, under the co-presidency of Drs Dick Bieniawski of the U.S.A. and John Franklin of Canada. It became the Commission on Testing Methods at the 4th Congress held in Montreux, Switzerland, in 1979 with Drs Bieniawski and Franklin still as co-Presidents.

A great many members of the Society have been associated with the quite detailed work of the Commission on Testing Methods and its Working Groups over the last 45 years. However, it is believed that they will all agree with the writer's contention that the contributions of two people have towered above those of all others—Dr John Franklin, who was Commission President from 1974 (initially as co-President) until 1987 when he became the Society's seventh President, and the twelfth President, Professor John Hudson of the U.K., who was Commission President from 1987 until 2006. The lasting contribution made by the Commission in developing a wide range of Suggested Methods for laboratory and field testing is reflected in what we call the 'Blue Book" edited by the current Commission President, Professor Resat Ulusay of Turkey, and Professor Hudson (Ulusay & Hudson 2007).

In the writer's opinion, another major achievement of the Society's Commissions has been the recent publication of the book, Rock Engineering Design, reporting the outcomes of the work of the Commission on Rock Engineering Design Methodology by the Commission's President and now the Society's thirteenth President, Professor Xia-Ting Feng of China, and Professor Hudson (Feng & Hudson 2011). The production of this detailed book in less than four years after the Commission held its inaugural meeting in Lisbon in July 2007 is a remarkable achievement and stands as a tribute to its busy authors.

Other recent activities and innovations

Significant changes have been made progressively to the Society's *modus operandi* and to its range of activities over the last decade or so, particularly during the 2007–2011 term of office when a modernisation theme was pursued vigorously by the then President, Professor John Hudson, and the Board.

Some of the great many innovations made include:

- the introduction of the ISRM Lecture Tours from 2001;
- the publication of four electronic Newsletters annually from March 2008;
- the introduction of the International Young Scholars' Symposium on Rock Mechanics from 2008;
- the introduction of the ISRM Annual Technical and Cultural Field Trip from 2009;
- the production of a CD containing pdf files of all issues of the ISRM News Journal from 1996 to 2008, and making these issues available from the ISRM website;
- the launch of the ISRM Digital Library in October 2010;
- the revision of the Statutes in 2010 to create an all-inclusive ISRM language policy, but with English as the only official language;

- the revision of the Statutes in 2011 to create the grade of ISRM Fellow (the initial group of ISRM Fellows was inducted at the 12th Congress in Beijing in October 2011);
- the creation from 2011 of the ISRM Fellows and Ex-Board Members Forum to meet at the Congresses and provide advice (the first such meeting was held in Beijing);
- the updating of the ISRM slide collection prior to making it accessible online through the website; and
- the creation of the ISRM Annual Lecture to be presented at International Symposia from 2012.

Conclusions

It can be concluded that during the first 50 years of its life, the ISRM has pursued its stated objectives and purposes conscientiously by carrying out all of its main activities at least satisfactorily, with some being carried out to considerable effect. In terms of the ***objectives and purposes*** previously listed, it is suggested that the Society has been demonstrably successful in pursuing at least the first two objectives concerned with international collaboration and the exchange of ideas, and with the encouragement of teaching, research and the advancement of knowledge in rock mechanics. It might be argued that the third objective concerning standards of professional practice has been pursued and achieved perhaps more at an implicit, rather than at an explicit, level. Finally, the modernisation programme pursued over the last four-year term of office, has introduced a number of significant changes to the Society's *modus operandi* and to its range of activities.

DEVELOPMENTS AND PROGRESS IN ROCK MECHANICS

Scope

The task of making assessments of the main developments and the progress made in rock mechanics and rock engineering in the 50 years since the ISRM was established is a most challenging one. It is inevitable that any account such as that attempted here will reflect the writer's personal interests, knowledge and experience, and so, to at least some extent, will be idiosyncratic. It is also inevitable that, for much the same reasons, some important contributions made by some individuals and in some countries will be overlooked. In such cases, the writer offers his apologies. The references given for each of the advances listed under the sub-headings below are intended to provide examples of the significant contributions made to the various topics or techniques being discussed and are not intended to be either definitive or exhaustive. The references given are, quite simply, those known and available to the writer at the time of writing.

In making an assessment such as that attempted here, it is first necessary to establish a framework within which the assessment will be made and the results summarised. The framework used here is the simplified general rock engineering process used by a number of authors (e.g. Brady & Brown 2004, Hudson & Feng 2007, Read & Stacey 2009) as represented by the following headings of the sub-sections. This generalised process is necessarily simplified so that it can be adapted to apply to a wide range of rock engineering activities and applications. It should be emphasised that, in practice, the process is not linear but includes parallel activities and multiple feed-back loops. Figure 4 shows a rock mechanics modelling and rock engineering design flowchart which provides more detail of the design analysis stage of the overall process.

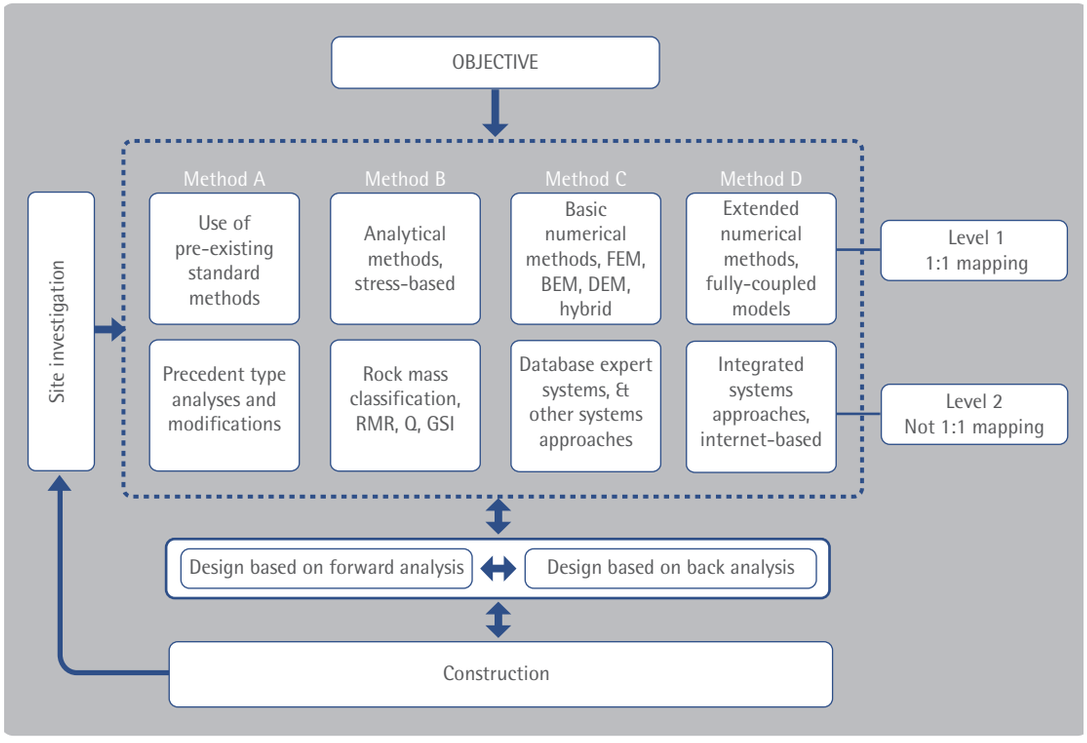


Figure 4. Flowchart of rock mechanics modelling and rock engineering design approaches (Feng & Hudson 2004)

Site investigation and site characterisation

Adequate site investigation and geological, geotechnical and hydrogeological site characterisation remain at the core of any successful rock engineering project. As was suggested earlier, the fundamentals and basic techniques of site investigation and site characterisation were established by the time the ISRM was founded. However, since that time, significant advances have been made in a number of relevant areas such as:

- drilling and borehole logging technologies, including core orientation methods and a range of geophysical logging techniques such as the Acoustic Televiewer (ATV) (Takahashi *et al.* 2006, Brown 2007a);
- geophysical methods of site investigation, including seismic reflection, refraction and cross-hole tomography (Barton 2006, Takahashi *et al.* 2006, Takahashi 2004);
- methods of discontinuity data collection using photogrammetric, remote sensing, laser scanning and 3D digital imaging technologies (Grobler *et al.* 2003, Gaich *et al.* 2007, Slob *et al.* 2007, Read & Stacey 2009);
- methods of carrying out and interpreting hydrogeological characterisation tests (Louis 1974, Elsworth & Mase 1993);
- modern rock mass classification schemes developed from the early 1970s (Barton *et al.* 1974, Bieniawski 1976, 1989, Hoek 1994, Barton 2006, Marinos *et al.* 2007);

- understanding the statistics of discontinuity systems (Priest & Hudson 1981, Dershowitz & Einstein 1988, Billaux *et al.* 1989, Zhang *et al.* 2002, Priest 2004) and the application of this knowledge in tools such as Discrete Fracture Network (DFN) simulations (Dershowitz 1995, Rogers *et al.* 2010);
- the 3D representation of site geology, structures and geotechnical domains using engineering design and mine planning software (Beer 2010); and
- methods of *in situ* stress estimation, although this process remains fraught with difficulty (Amadei & Stephansson 1997, Fairhurst 2003, Hudson *et al.* 2003).

For a range of reasons, one area of site investigation that has not developed to any great extent in the period since the early 1960s is *in situ* testing. Despite the range of tools now available to assist in the overall site investigation and site characterisation process, the writer's recent experience on some projects has been that basic core logging skills and the training provided for that important task sometimes leave much to be desired.

Rock and rock mass properties

Key developments in the general area of estimating the mechanical properties of rocks and rock masses in the last 50 years include:

- the study of the progressive breakdown of rock in laboratory tests and the development and use of servo-controlled testing techniques (Wawersik & Fairhurst 1970, Hudson *et al.* 1971, Martin 1997);
- the augmentation of these studies by the use of acoustic monitoring (Martin 1997);
- the development and dissemination by the ISRM of a set of Suggested Methods for laboratory and field rock property tests (Brown 1981, Ulusay & Hudson 2007);
- the use of computerised methods of test control and automatic test data collection and analysis (Barla *et al.* 2007);
- the development and refinement of empirical methods of estimating rock material and rock mass strength and deformation properties (Hoek & Brown 1980, Hoek & Diederichs 2006, Suorineni *et al.* 2009);
- the introduction of fracture mechanics concepts and the development of related theory and methods of testing and analysis (Zhou *et al.* 1986, Atkinson 1987, Ulusay & Hudson 2007);
- the development of improved methods of direct shear testing of rock discontinuities under constant normal load (CNL) and constant normal stiffness (CNS) conditions and of improved understandings of the influence of surface roughness and infilling materials on the shear strengths and stiffnesses of artificial and natural discontinuities (Goodman 1989, Barton & Bandis 1990, Grasselli & Egger 2003, Barla *et al.* 2007, Indraratna *et al.* 2010);
- the numerical modelling of the progressive fracture and break-down of rocks and rock masses using, in particular, Discrete Element Methods and bonded particle modelling (Potyondy & Cundall 2004). A most significant development in this area has been the Synthetic Rock Mass model approach which has the potential to answer Müller's implicit question, "*what is the strength of a rock mass*?" (Pierce *et al.* 2009, Fairhurst 2010, Mas Ivars *et al.* 2011); and
- improved fundamental understandings of fluid flow in single discontinuities and in discontinuous rock masses (Louis 1974, Witherspoon *et al.* 1980, Long & Witherspoon 1985, Barton & de Quadros 1997).

Despite the advances that have been made, the sophisticated approaches being used for rock and rock mass property estimation on some rock engineering projects, and the wide-spread availability of the ISRM Suggested Methods, the writer's experience has been that some practicing engineering geologists and geotechnical engineers do not have an adequate understanding of the purposes, complexities and requirements of good testing and rock property estimation programmes. All too often, empirical approaches such as the Hoek-Brown rock mass strength criterion are treated as "black boxes" without adequate thought being given to the engineering problem at hand (Brown 2008, Kaiser & Kim 2008). At the research level, some of the work being published, particularly in conference proceedings, appears to add little of value to the corpus of rock mechanics knowledge and to represent little more than "turning the handle". Based on his experience in rock mechanics research and in senior university management, the writer believes that this reflects the "publish or perish" syndrome at play within our universities.

Design analysis

Methods of rock engineering design analysis have continued to develop during the last 50 years with an emphasis on numerical methods of stress and deformation analysis, but not to the exclusion of other approaches. For present purposes, it is convenient to adopt the classification of rock mechanics modelling approaches used by Feng & Hudson (2004, 2010, 2011) and illustrated in Figure 4.

In this classification, Level1 methods are direct methods in which an explicit attempt is made to represent the geometry and mechanisms of the problem directly. They include the use of pre-existing standard methods, analytical methods, and basic and extended numerical methods. Level 2 methods are indirect methods in which the problem geometry and mechanisms are not represented explicitly. They include precedent type analysis, the use of rock mass classification schemes, basic systems methods and integrated systems approaches, possibly internet-based (Feng & Hudson 2004, Hudson & Feng 2007).

Of these eight approaches, pre-existing standard methods, analytical methods, precedent type analysis (but not of a formal type) and some early rock mass classification methods (but not the main methods used since the 1970s), were used before the early 1960s. Since that time, new and widely-used rock mass classification-based design methods have been introduced (Barton *et al.* 1974, Bieniawski 1976, 1989, Hoek 1994, Marinos *et al.* 2007), and a wide range of basic and extended numerical methods have been developed and applied. There has been some further development of previously existing analytical (e.g. Diederichs & Kaiser 1999, Sofianos *et al.* 1999) and empirical (e.g. Galvin *et al.* 1999, Hedley & Grant 1972, Salamon & Munro 1967) methods. In relatively recent years, artificial intelligence, expert systems, integrated intelligent, internet-based, neural network and other systems approaches have been developed and applied (e.g. Dershowitz & Einstein 1984, Feng & An 2004, Feng & Hudson 2004, 2010).

As noted in Section 4 above, the application of ***numerical methods***, specifically the finite element method, to rock engineering began in the early to mid-1960s. Since that time, the development and application of numerical methods of analysis has been a major feature of rock mechanics and rock engineering research and practice. A comprehensive review of the formulation of numerical methods and their application in rock mechanics and rock engineering was presented by Jing (2003). Jing's paper contained no less than 774 references to the published literature in the field to that date, but obviously does not deal with more recent developments. Here, it will be possible to refer to only a very

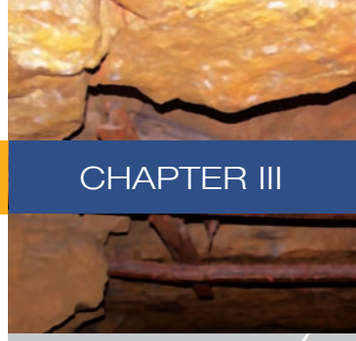
small number of the great many important contributions made internationally to numerical modelling in rock mechanics and rock engineering.

The main numerical methods were developed originally for continuum applications but, from the 1960s, were adapted to allow for the discontinuous nature of rock masses (e.g. Goodman *et al.* 1968, Wittke 1977), often treating them as equivalent continua. The fifth ISRM President, Professor Walter Wittke of Germany, made significant contributions to the rock engineering applications of the finite element method. Importantly, specific discontinuum methods of numerical analysis have been developed. In rock mechanics and rock engineering, these various methods have been applied mainly to stress and deformation analyses, but they have also been applied to the modelling of fracture processes and of fluid flow and heat transfer in rock masses. Following Jing (2003), the numerical methods that have been developed or adapted for rock mechanics and rock engineering applications may be classified as:

- Finite Element (FEM) and related methods, including meshless methods (Wittke 1977, 1990, Zienkiewicz 1977, Goodman *et al.* 1968, Beck *et al.* 2009, 2010);
- Finite Difference Methods (FDM) including the Finite Volume (FVM) approach, applied perhaps most notably in the well-known FLAC series of codes (Detournay & Hart 1999, Hart *et al.*, 2008, Itasca 2011, Sainsbury, D.P. *et al.* 2011);
- Boundary Element Methods (BEM) using direct and indirect formulations (Brady 1979, 1987, Crouch & Starfield 1983, Beer & Watson 1992);
- Discrete Element Methods (DEM) (see Jing & Stephansson 2007) including the explicit or Distinct Element Method (Cundall 1971, 1987, Itasca 2011), the implicit or Discontinuous Deformation Analysis Method (Shi & Goodman 1985), key block theory (Goodman & Shi 1985), DEM formulations for particle systems including bonded particle systems (Potyondy & Cundall 2004), and quasi-static and dynamic lattice network models (Cundall & Damjanac 2009, Oñederra *et al.* 2009, Cundall 2011);
- hybrid or linked methods of a number of types (FEM/BEM, DEM/BEM, DEM/FEM—see, for example, Beer & Watson 1992, Brady 1987, Elsworth 1986, Lorig & Brady 1982);
- DFN-based methods which may be combined with a number of the other methods (Pine *et al.* 2006, e.g. Beck *et al.* 2009, Rogers *et al.* 2010);
- coupled hydro-mechanical (Beck *et al.* 2010) and thermo-hydro-mechanical models (Detournay 1995, Stephansson *et al.* 1996, Hudson *et al.* 2001); and
- inverse solution methods as used in back analysis in rock engineering (see sub-section 7.6 below).

Despite the significant advances that have been made, it must be recognised that the successful application of numerical methods in rock engineering design analyses depends to a great extent on the geotechnical models, the constitutive models and boundary conditions developed from the site characterisation data. Because of the difficulty of defining some of the input data deterministically, probabilistic or stochastic methods are often used to represent the rock mass geometry, the mechanical properties of rocks and rock masses, and in the analyses themselves (Einstein & Baecher 1983, Priest & Brown 1983). When formal probabilistic or stochastic methods are not used, a range of input data may be used in sensitivity studies. As Starfield & Cundall (1988) pointed out, rock mechanics problems are data-limited problems that cannot be modelled unambiguously.

As the numerical methods of design analysis outlined here were developed, high levels of expertise in the numerical methods themselves, and in their application in rock mechanics and rock engineering,



were developed by a number of individuals and groups internationally. However, it has been the writer's experience that, despite the vast range of knowledge and experience that is now available in this field, the application of these methods in engineering practice often suffers because some analysts regard the computer codes used as "black boxes" and pay insufficient attention to the mechanics of the problems concerned, the input data and to the meaning or "believability" of the results obtained. Furthermore, there is a tendency to disregard features of a problem that are not catered for specifically in the software selected or available for use. Although the paper was written more than 20 years ago, the writer considers that many of those seeking to use modern numerical methods in rock engineering design analyses should pay greater attention to the guidance provided by Starfield & Cundall (1988), especially the warning that numerical modelling is an aid to thought rather than a substitute for thinking.

Excavation and support and reinforcement

Excavation

In the last 50 years, significant advances have been made in understanding the underlying mechanics and in developing the techniques and technologies associated with the two generic methods of rock excavation—drilling-and-blasting and mechanical excavation. In the 1950s and 1960s there was considerable research interest in the mechanics of percussive drilling, rock fragmentation by blasting and the mechanics of rock cutting, so much so that sessions on what came to be called rock dynamics were usually included in the programmes of general rock mechanics symposia and conferences (e.g. Fairhurst 1963). While these fundamental issues remain of concern to mainstream rock mechanics, it is the writer's impression that they have now become something of a special interest with their own specialist conferences, interest groups and societies having been established.

West (1988) traced the development of ***drilling and blasting*** and mechanical excavation technologies in the international tunnelling industry from the 1850s to the 1980s. The last 50 years have seen a range of developments in *drilling and blasting* technologies, many of them originating in Sweden. They include:

- integrated drilling systems with electronic controls and a range of drill support software for drill pattern design, navigation, automatic drilling and measurement while drilling (MWD) (Schunnesson 2009);
- large diameter blast hole drilling for both surface and underground applications;
- new and improved explosive types for a variety of applications;
- electronic detonators;
- blast monitoring systems to improve blasting operations (McKenzie 1987);
- blast vibration monitoring to assess environmental and other impacts (Dowding 1985); and
- improved understanding of drilling and blasting processes through a range of industrial and research-level experimental, theoretical and computational studies (e.g. Furtney *et al.* 2009, Minchinton & Dare-Bryan 2005, Ouchterlony & Moser 2006).

Building on a range of previous studies, Hustrulid (2010) provides a detailed account of current blast design practice for development drifts in hard rock underground mining, while Williams *et al.* (2009) give an account of blasting practices, including controlled blasting, in large open pit mines.

In the area of ***mechanical excavation***, new, larger and more powerful machines of a range of types have been developed for civil engineering and for soft rock mining, including coal mining, but not as yet with any great success for hard rock mining. The development of full-face tunnel boring machines (TBMs) can be traced back to the mid-19th century but successful hard rock TBM tunnelling dates back only to the 1950s. The largest full-face tunnelling machines are now some 15 m in diameter and can excavate in a range of ground conditions including very strong rocks (Zhao & Gong 2006). Rock mechanics-based data and methodologies are used in the selection of modern TBMs and in computer simulations of their performance (Barton 2000, Gong & Zhao 2009, Rojek *et al.* 2010, Zhao & Gong 2006). As with excavation by drilling and blasting, improvements in the performance, automation and control of TBMs and other types of mechanical excavators such as road headers and longwall coal shearers, are being achieved through industrial and research-level experimental, theoretical and computational studies (e.g. Rojek *et al.* 2010, Pichler *et al.* 2010).

Support and reinforcement

Following Windsor & Thompson (1993), a distinction will be made between support and reinforcement, although the two are often treated together as in the term ***ground support***. Support is the application of a reactive force to the surface of the excavation while ***reinforcement*** is a means of improving the overall rock mass properties from within the rock mass by techniques such as rock and cable bolts.

An essential concept in the mechanics of the support and reinforcement of underground excavations is ground-support interaction as represented in ground-support interaction diagrams. This concept had been developed by the Austrian School (Pacher 1964, Rabcewicz 1969) but has since been extended through the convergence-confinement method to which the 10th ISRM President, Marc Panet of France, made important contributions (Panet 1993, 1995), and a wide range of linear and non-linear closed-form and numerical solutions for ground response curves and the characteristic curves for support and reinforcing elements and systems (e.g. Daemen 1977, Carranza-Torres & Fairhurst 1999). Despite the advances that have been made in incorporating ground support and its effects into numerical analysis codes (e.g. Itasca 2011), as noted by Jing (2003), the numerical modelling of all aspects of support and reinforcement elements and systems, including their interfaces with the rock mass, still provides some challenges.

Considerable advances have been made in the development of support and reinforcement techniques and technology, including several new rock bolt types, for example, those with yielding or dynamic capabilities for use in rock burst prone environments (Falmagne & Simser 2004, Ortlepp 2007); cable bolts, particularly, but not exclusively, for application in the mining industry (Hutchinson & Diederichs 1996, Windsor 2004); shotcrete, particularly fibre-reinforced shotcrete and the wide-spread use of the wet mix process (Bernard 2010); mesh and thin sprayed liners (Potvin *et al.* 2004); the corrosion protection of rock bolts, cable bolts and ground anchors (Windsor 2004); the static and dynamic testing of support and reinforcement elements (Player *et al.* 2008); and understanding the corrosion process in rock bolts and cables in corrosive environments (Villaescusa *et al.* 2008). A range of design methods for support and reinforcement systems have now been developed (e.g. Barton *et al.* 1994, Barrett & McCreath 1995, Hutchinson & Diederichs 1995, Pells 2002, Hoek *et al.* 2008) to replace, or be used in conjunction with, the largely empirical methods that were used earlier in the 50-year period and still find wide-spread use today.

Monitoring and back analysis

Monitoring the performance of mining and civil excavations in rock had been carried out for many years before the establishment of the ISRM in 1962, and had become an integral part of rock engineering practice through the observational method. Early monitoring used mechanical and optical, and then electrical, electro-optical, electronic and microseismic techniques (see, for example, Franklin & Denton 1973, Kovari *et al.*1979, Dunnicliff 1988, Windsor 1993, Brady & Brown 2004). In open pit mining, for example, GPS, photogrammetry, laser scanning (LiDAR), radar and satellite imaging techniques and systems are now also used to monitor slope movements, in particular (Girard & McHugh 2001, Hawley *et al.* 2009, Sakurai *et al.* 2009, Herrera *et al.* 2010).

Subsequently, the on-line acquisition, storage, processing, management, interpretation and reporting of rock engineering monitoring data followed the introduction of computer and digital technologies (Kimmance 1999, Gilby & Socol 2010). Figure 5 illustrates the components of a current instrumentation data management and monitoring system. The formalisation and power of these processes today and their potential to support well-informed decision making and risk management systems (e.g. Schubert 2006, Hawley *et al.* 2009, Akutagawa 2010, Dewynter *et al.* 2010) represents a great advance on the comparable processes available 50 years ago, although the purposes and principles of good monitoring programs remain essentially unchanged (e.g. Franklin 1977, Kovari & Amstad 1993). There can be little doubt that modern monitoring systems have contributed significantly to the rock engineering achievements to be outlined below.

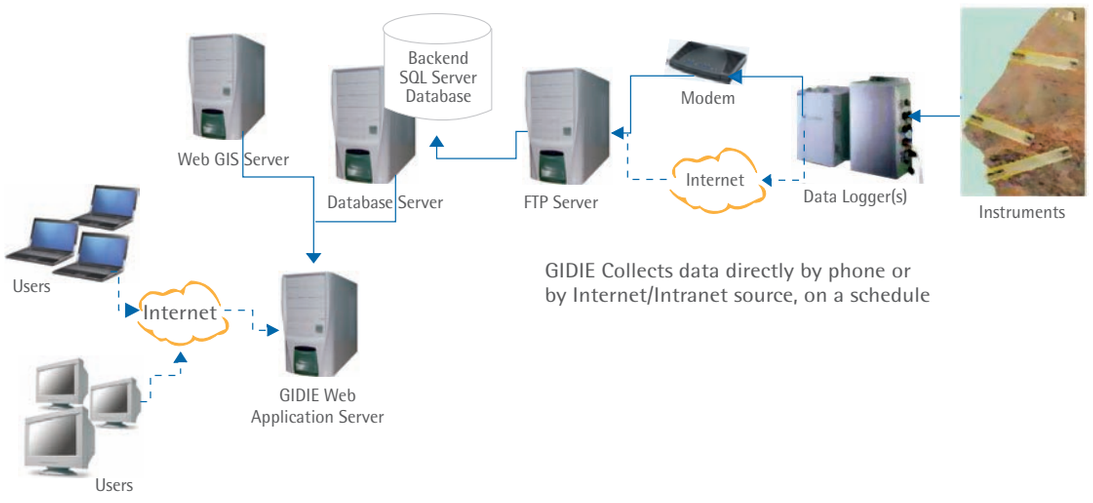


Figure 5. Geotechnical instrumentation data interpretation and evaluation (GIDIE) system components (Gilby & Socol 2010)

One of the common objectives of monitoring formalised by the seventh ISRM President, Dr John Franklin of Canada, is to check the validity of the assumptions, conceptual models and values of

rock mass properties used in design calculations (Franklin 1977). Originally, and often still today, these checks were made, and values of rock mass properties and the *in situ* stresses estimated, using a process of trial and error or curve fitting using forward analyses based on the theory of elasticity. However, in the late 1970s and early 1980s, it was realised that it was possible to improve this process by developing and applying more formal back analysis techniques. These techniques used essentially two approaches, the inverse and the identification or calibration methods (Gioda 1980). In the earliest use of the inverse method in rock mechanics known to the author, Kirsten (1976) used measured displacements in a slope and displacements calculated using the FEM to back calculate values of the elastic moduli.

The ninth ISRM President, Professor Shunsuke Sakurai of Japan, was heavily involved in the development of back analysis methods early in their history (Sakurai & Takeuchi 1983) and subsequently (Sakurai & Akutagawa 1995, Sakurai *et al.* 2009). Although formal back analysis methods were applied originally to 2D linear elastic problems, the theory was soon extended to the three dimensional and non-linear elasto-plastic problems encountered in rock engineering. A wide range of innovative techniques for solving the sets of non-linear equations involved have since been developed (Feng *et al.* 2004, Gioda & Sakurai 1987, Sakurai 1993).

Professor Sakurai has also emphasised the importance of monitoring the performance of excavations in rock for purposes other than the use of the measurement data in back analyses. For example, in order to assess the stability of tunnels from measured displacements, he proposed the concept of critical direct and shear strains, and on the basis of the critical strain, proposed hazard warning levels for the measured displacements as well as for the measured strains in tunnels Sakurai (1997, 1999). Hoek (2001) discusses a similar approach based on the normalised radial displacement at the tunnel boundary.

Rock engineering applications

Over the last 50 years, the pre-existing rock mechanics knowledge outlined earlier, and the further development of that knowledge outlined thus far, have contributed to some remarkable rock engineering achievements in the general area of earth resources engineering (Fairhurst 2011), including civil, mining, petroleum, energy resources and environmental engineering.

In ***civil engineering***, the scale of rock engineering projects has steadily increased in terms of project dimensions, costs and environmental significance (Feng & Hudson 2004). We might think, for example, of achievements such as the 62 m span cavern for the Olympic Ice Hockey stadium at Gjøvik, Norway (Barton *et al.* 1994); the helical underground car park for the Sydney Opera House, Australia, possibly the widest shallow-cover rock cavern in the world (Pells *et al.* 1991, Pells 2002); the Three Gorges Dam and the associated ship locks and hydro-electric developments in China (Liu *et al.* 2003a,b, Feng & Hudson 2004); and the long European alpine tunnels such as the Lötschberg and Gotthard base tunnels excavated under difficult conditions including squeezing and faulted ground and brittle rock under high stress at great depth (Hagedorn *et al.* 2007, Rojat *et al.* 2008).

In ***mining engineering***, greater numbers of larger, deeper and more productive open pit mines with optimised slope angles have been designed and operated effectively using a range of advances in rock mechanics and rock slope engineering dating back to the seminal work of Hoek & Bray (1974) and earlier. Read & Stacey (2009) provide a detailed account of the state of this particular art. In

underground metalliferous mining over the last 50 years, rock mechanics has contributed significantly to the mining of highly stressed, brittle, tabular orebodies in the deep-level gold mines of South Africa (Cook *et al.* 1966, Ryder & Jager 2002), and to the development and implementation firstly of cut-and-fill and then of long hole open stoping and bench stoping methods (Brady & Brown 2004, Villaescusa 1996, 2008). Most importantly, the last 20 years has seen an increased emphasis on underground mass mining methods using highly productive and cost effective sub-level and block and panel caving methods at greater depths and in stronger rocks (Brown 2007a, b, Chitombo 2010). Caving processes and cave propagation are now being modelled successfully (Sainsbury, *et al.* 2011). In underground coal mining, larger and more productive longwall faces have been introduced as has longwall top coal caving to mine thicker seams, especially in China (Alehossein & Paulsen 2010, Vakili & Hebblewhite 2011).

Rock mechanics has become increasingly important in ***petroleum engineering*** since the 1970s as production has taken place from deeper and more difficult geological settings (Roegiers 1999). Rock mechanics has contributed to the achievements of the petroleum and gas industry in areas such as geological and fracture modelling, including DFN modelling; seismic tomography and other geophysical techniques; borehole mechanics and wellbore stability; the measurement of *in situ* stresses; hydraulic fracturing and methods of enhanced oil recovery; poromechanics and coupled thermo-hydro-mechanical processes; the control of solids (generally sand) production; smart drilling including drilling deviated holes and drilling in deep water; and reservoir geomechanics (Detournay 1995, Roegiers 1999, Fjaer *et al.* 2008, Schutjens 2009). Rock mechanics has also contributed to a number of other achievements in the exploitation of a range of energy resources, including hot, dry rock geothermal energy at depth (Thorsteinsson *et al.* 2008), the underground storage of oil and gas (You *et al.* 2006), and underground radioactive waste repository planning and design (Fairhurst 2004, Hudson 2010, Hudson *et al.* 2001), and the deep injection of solid and liquid wastes (Dusseault 2010). Conversely, research in these areas, including through field trials, has contributed to basic and applied rock mechanics knowledge.

CONCLUSIONS

This necessarily brief overview of the development and achievements of the ISRM and of the discipline of rock mechanics and rock engineering in the 50 years since the ISRM was founded in 1962 shows clearly that much of significance has been achieved. New basic understandings and engineering tools have been developed to support an increasingly wide range of rock engineering applications. Many of the advances made in rock mechanics research, in the tools and techniques now available for data collection and analysis, and in the application of rock mechanics in engineering practice, have been enabled by modern digital computing, information and communications technologies. Others have drawn on advances made in other branches of science and technology. And during this first 50 years of its life, the ISRM has pursued its stated objectives and purposes conscientiously by carrying out all of its main activities at least satisfactorily, with some being carried out to considerable effect.

For those involved, the last 50 years has been an exciting, satisfying and possibly fortuitous time in which to have been involved in rock mechanics and the ISRM. However, increases in knowledge in our and other disciplines, and change and further development of our institutions and in society at large, are inevitable. From a rock mechanics and rock engineering perspective, much remains to be done (Chapter 12 and Hudson 2011) but the future remains full of promise, challenge and excitement.

ACKNOWLEDGEMENTS

The writer has been associated with the ISRM in one way or another almost continuously since he attended the First Congress held in Lisbon in 1966. He wishes to record his appreciation of the encouragement and support that he has received and the friendships that he has made through the ISRM during this 45-year period. He recalls, in particular, the encouragement that he received as a young man from the Society's first two Presidents, Leopold Müller and Manuel Rocha. He also wishes to thank the editors of this volume, John Hudson and Luís Lamas, for having given him the opportunity to contribute this Chapter.

The writer wishes to record his appreciation of the support and assistance of the following members of the international rock mechanics community in providing him with information and material used in the preparation of the paper on which this Chapter is based: Nick Barton, David Beck, Pierre Berest, Pierre Duffaut, Maria de Lurdes Eusébio, Charles Fairhurst, Xia-Ting Feng, John Gilby, Nuno Grossmann, Pierre Habib, Evert Hoek, John Hudson, Luís Lamas, Italo Oñederra, Matt Pierce, Eda Quadros, Bre-Anne Sainsbury, David Sainsbury, Shun Sakurai, Penny Stewart and Walter Wittke ■

REFERENCES

Akutagawa, S. 2010. On site visualisation as a new paradigm for field measurement in rock engineering. In K.G. Sharma, T. Ramamurthy, V.K. Kanjlia & A.C. Gupta (eds), *Advances in Rock Engineering, Proc. ISRM Int. Symp. 2010 & 6th Asian Rock Mech. Symp.*, New Delhi, 23–27 October, KN 34 - KN 45. New Delhi: Central Board of Irrigation & Power.

Alehossein, H. & Paulsen, B.A. 2010. Stress analysis of longwall top caving. *International Journal of Rock Mechanics & Mining Sciences*, 47(1): 30–41.

Alexander, L.G. 1960. Field and laboratory tests in rock mechanics. *Proc. 3rd Australia-New Zealand Conf. Soil Mechanics & Foundation Engineering*, Sydney, 161-168. Sydney: Institution of Engineers, Australia.

Amadei, B. & Stephansson, O. 1997. *Rock Stress and its Measurement*, 512 p. Dordrecht: Kluwer.

Anon, 1963. *Proceedings, Rock Mechanics Symposium*, McGill University, Montreal, 7–8 September, 1962, 218 p. Ottawa: Mines Branch, Department of Mines & Technical Surveys.

Appleton, E. 1944. Scientific research: fundamentals of its application to rock mechanics. *South African Mining & Engineering Journal*, 55(1): 519–520.

Atkinson, B.K. (ed.) 1987. *Fracture Mechanics of Rock*, 534 p. London: Academic Press.

Barla, G., Barla, M., Camusso, M. & Martinotti, M.E. 2007. Setting up a new direct shear testing apparatus. In L. Ribeiro e Sousa, C. Olalla & N.F. Grossmann (eds), *Proc. 11th Congr., Int. Soc. Rock Mech.*, Lisbon, 9–13 July, 1: 415–418. Leiden: Taylor & Francis.

Barrett, S.V.L. & McCreath, D.R. 1995. Shotcrete support design in blocky ground: towards a deterministic approach. *Tunnelling & Underground Space Technology*, 10(1): 79–89.

Barton, N. 2000. *TBM Tunnelling in Jointed and Faulted Rock*, 172 p. Rotterdam: Balkema.

Barton, N., 2006. *Rock Quality, Seismic Velocity, Attenuation and Anisotropy*, 729 p. London: Taylor & Francis.

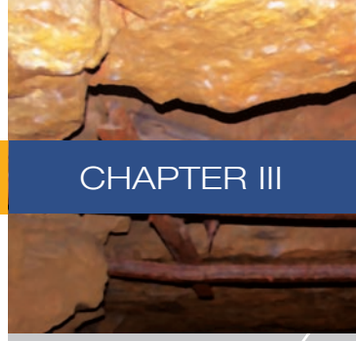
Barton, N. & Bandis, S.C. 1990. Review of predictive capabilities of JRC-JCS model in engineering practice. In N.R. Barton & O. Stephansson (eds), *Rock Joints, Proc. Int. Symp. on Rock Joints*, Loen, 4-6 June, 603-610. Rotterdam: Balkema.

Barton, N., By, T.L., Chryssanthakis, P., Tunbridge, L., Kristiansen, J., Løset, F., Bhasin, R.K., Westerdahl, H. & Vick, G. 1994. Predicted and measured performance of the 62 m span Norwegian Olympic Ice Hockey Cavern at Gjøvik. *International Journal of Rock Mechanics & Mining Sciences*, 31(6): 617–641.

Barton, N. & de Quadros, E.F. 1997. Joint aperture and roughness in the prediction of flow and groutability of rock masses. In K. Kim (ed.), *Linking Science to Rock Engineering, Proc. 36th U.S. Rock Mech. Symp. & ISRM Int. Symp.*, New York, 29 June–2 July, 2: 907-916. New York: Columbia University.

Barton, N., Lien, R. & Lunde, J. 1974. Engineering classification of rock masses for the design of tunnel support. *Rock Mechanics*, 6(4): 189-236.

Beck, D.A., Fillery, B. & Reusch, F. 2010. 3D hydro-mechanical simulation of faulted open pit slopes. *Proc. 44th U.S. Rock Mech. Symp. & 5th U.S.-Canada Rock Mech. Symp.*, Salt Lake City, 27–30 June, Paper ARMA-425, 6p (on CD-ROM).



Beck, D.A., Pfitzner, M.J., Arndt, S.M. & Fillery, B. 2009. Estimating rock mass properties and seismic response using higher order, discontinuous, Finite Element models. In M. Diederichs & G. Grasselli (eds), *Rock Engineering in Difficult Conditions, Proc. 3rd Canada-U.S. Rock Mech. Symp. & 20th Canadian Rock Mech. Symp.*, Toronto, 9-15 May, 12 p (on CD-ROM).

Beer, G. (ed.) 2010. *Technology Innovation in Underground Construction*, 504 p. Leiden: CRC Press/Balkema.

Beer, G. & Watson, J.O. 1992. *Introduction to Finite and Boundary Element Methods for Engineers*, 509 p. Chichester: John Wiley.

Bernaix, J. 1969. New laboratory methods of studying the mechanical properties of rock. *International Journal of Rock Mechanics & Mining Sciences*, 6(1): 43–90.

Bernard, S. (ed.) 2010. *Shotcrete: Elements of a System, Proc. 3rd Int. Conf. on Engineering Developments in Shotcrete*, Queenstown, 15–17 March, 310 p. Leiden: CRC Press/Balkema.

Bieniawski, Z.T. 1976. Rock mass classifications in rock engineering. In Z.T. Bieniawski (ed.), *Proc. Symp. on Exploration for Rock Engineering*, Johannesburg, 1–5 November, 1: 97–106. Cape Town: Balkema.

Bieniawski, Z.T. 1989. *Engineering Rock Mass Classification*, 251 p. New York: John Wiley.

Billaux, D., Chiles, J.P., Hestir, K. & Long, J. 1989. Three-dimensional statistical modelling of a fractured rock mass – an example from the Fanay-Augères Mine. *International Journal of Rock Mechanics & Mining Sciences*, 26(3–4): 281–299.

Blanks, R.F. & McHenry, D. 1945. Large triaxial testing machine built by Bureau of Reclamation. *Engineering News Record*, 135(6): 171-172.

Brady, B.H.G. 1979. A direct formulation of the boundary element method of stress analysis for complete plane strain. *International Journal of Rock Mechanics & Mining Sciences*, 16(4): 235-244.

Brady, B.H.G. 1987. Boundary element and linked methods for underground excavation design. In E.T. Brown (ed.), *Analytical & Computational Methods in Engineering Rock Mechanics*, 164-204. London: Allen & Unwin.

Brady, B.H.G. & Brown, E.T. 2004. *Rock Mechanics for Underground Mining*, 3rd edn, 628 p. Dordrecht: Kluwer.

Brown, E.T. (ed.) 1981. *Rock Characterization, Testing and Monitoring – ISRM Suggested Methods*, 211 p. Oxford: Pergamon Press.

Brown, E.T. 1999. Rock mechanics and the Snowy Mountains Scheme. In *The Spirit of the Snowy Fifty Years On, Proc. 1999 Invitation Symp., Australian Academy of Technological Sciences & Engineering*, Cooma, 23–24 November, 89–101. Melbourne: Australian Academy of Technological Sciences & Engineering.

Brown, E.T. 2002. Rock mechanics in Australia. *International Journal of Rock Mechanics & Mining Sciences,* 39(5): 529–538.

Brown, E.T. 2007a. *Block Caving Geomechanics*, 2nd edn, 696 p. Brisbane: JKMRC.

Brown, E.T. 2007b. Rock mechanics – the basic mining science: challenges in underground mass mining. In L. Ribeiro e Sousa, C. Olalla & N.F. Grossmann (eds), *Proc. 11th Congr., Int. Soc. Rock Mech.*, Lisbon, 9-13 July, 3: 1335-1347. Leiden: Taylor & Francis.

Brown, E.T. 2008. Estimating the mechanical properties of rock masses. In Y. Potvin, J. Carter, A. Dyskin & R. Jeffrey (eds), *Proc. 1st Southern Hemisphere Int. Rock Mech. Symp.*, Perth, 16–19 September, 1: 3–22. Perth: Australian Centre for Geomechanics.

Brown, E.T. 2011. Fifty years of the ISRM and associated progress in rock mechanics. In Q. Qian & Y.X. Zhou (eds), *Harmonising Rock Engineering and the Environment, Proc. 12th Congr., Int. Soc. Rock Mech.*, Beijing, 16–21 October, 1: (in press). Leiden: CRC Press/Balkema.

Brown, P.D. & Robertshaw, J. 1953. The in-situ measurement of Young's Modulus for rock by a dynamic method. *Géotechnique*, 3(7): 283-286.

Bryan, A., Bryan, J.G. & Fouché, J. 1964. Some problems of strata control and support in pillar workings. *The Mining Engineer*, 123(41): 238-266.

Carranza-Torres, C. & Fairhurst, C. 1999. The elasto-plastic response of underground excavations in rock masses that satisfy the Hoek-Brown failure criterion. *International Journal of Rock Mechanics & Mining Sciences*, 36(6): 777–809.

Chen, Y., Liu, Y., Zhang, M. & Chen, R. 1986. A preliminary study of in-situ stress field in the Three-Gorge Dam area. *Proc. Int. Symp. on Engineering in Complex Rock Formations*, Beijing, 3-7 November, 149-162. Beijing: Science Press.

Chitombo, G.P. 2010. Cave mining – 16 years after Laubscher's 1994 paper "cave mining – state of the art". In Y. Potvin (ed.), *Caving 2010, Proc. 2nd Int. Symp. on Block & Sublevel Caving*, Perth, 20-22 April, 45-61. Perth: Australian Centre for Geomechanics.

Clough, R.W. 1960. The finite element method in plane stress analysis. *Proc. 2nd A.S.C.E. Conf. on Electronic Computation*, Pittsburgh, September, 345–378.

Cook, N.G.W. 1965. The failure of rock. *International Journal of Rock Mechanics & Mining Sciences*, 2(4): 389–403.

Cook, N.G.W., Hoek, E., Pretorius, J.P.G., Ortlepp, W.D. & Salamon, M.D.G. 1966. Rock mechanics applied to the study of rockbursts. *Journal, South African Institute of Mining & Metallurgy*, 66(10): 436–528.

Coulomb, C.A. 1776. Essai sur une application des régles de maximis et minimis à quelques problèmes de statique, relatives à l'architecture. *Mémoires de Mathématique et de Physique, l'Académie Royale des Sciences*, 7: 343-382.

Crouch, S.L. & Starfield, A.M. 1983. *Boundary Element Methods in Solid Mechanics*, 322 p. London: Allen & Unwin.

Cundall, P.A. 1971. A computer model for simulating progressive, large-scale movements in blocky rock systems. In *Rock Fracture, Proc. Int. Symp. Rock Mech.*, Nancy, 4–6 October, 1: Paper II-8.

Cundall, P.A. 1987. Distinct element models of rock and soil structure. In E.T. Brown (ed.), *Analytical & Computational Methods in Engineering Rock Mechanics*, 129–163. London: Allen & Unwin.

Cundall, P.A. 2011. Lattice method for modelling brittle, jointed rock. In D.P. Sainsbury, R.D. Hart, C.L. Detournay & M.J. Nelson (eds), *Continuum and Distinct Element Numerical Modeling in Geomechanics – 2011, Proc. 2nd Int. FLAC/DEM Symp.*, Melbourne, 14–16 February, 11–19. Minneapolis: Itasca International Inc.

Cundall, P.A. & Damjanac, B. 2009. A comprehensive 3D model for rock slopes based on micromechanics. In *Slope Stability 2009, Proc. 3rd Int. Symp. on Rock Slope Stability,* Santiago, 9–11 November, 10 p (on CD-ROM).

Daemen, J.J.K. 1977. Problems in tunnel support mechanics. *Underground Space*, 1(3): 163–172.

Dershowitz, W. 1995. Interpretation and synthesis of discrete fracture orientation, size, shape, spatial structure and hydrologic data by forward modelling. In L.R. Myer, N.G.W. Cook, R.E. Goodman & C-F. Tsang (eds), *Proc. Conf. on Fractured & Jointed Rock Masses*, Lake Tahoe, 3-5 June 1992, 579-586. Rotterdam: Balkema.

Dershowitz, W.S. & Einstein, H.H. 1984. Applications of artificial intelligence to problems of rock mechanics. In C.H. Dowding & M.M. Singh (eds), *Rock Mechanics in Productivity & Protection, Proc. 25th U.S. Symp. Rock Mech.*, Evanston, 25-27 June, 483–494. New York: A.I.M.E.

Dershowitz, W.S. & Einstein, H.H. 1988. Characterizing rock joint geometry with joint system models. *Rock Mechanics & Rock Engineering*, 21(1): 21–51.

Desseault, M.B. 2010. Deep injection disposal: environmental and petroleum geomechanics. In K.G. Sharma, T. Ramamurthy, V.K. Kanjlia & A.C. Gupta (eds), *Advances in Rock Engineering, Proc. ISRM Int. Symp. 2010 & 6th Asian Rock Mech. Symp.*, New Delhi, 23–27 October, KN 21 - KN 33. New Delhi: Central Board of Irrigation & Power.

Detournay, C. & Hart, R. (eds) 1999. *FLAC and Numerical Modeling in Geomechanics, Proc. Int. FLAC Symp.*, Minneapolis, 1–3 September, 528 p. Rotterdam: Balkema.

Detournay, E. 1995. Coupled thermo-hydro-mechanical processes in rock mechanics, with applications to the petroleum industry. In T. Fujii (ed.), *Proc. 8th Congr., Int. Soc. Rock Mech.*, Tokyo, 25–29 September, 3: 1061–1068. Rotterdam: Balkema.

Dewynter, V., Magne, S., Rougeault, S., Ferdinand, P., Vallon, F., Avallone, L., Vacher, E., de Broissia, M., Canepa, C. & Poulain, A. 2009. Optical fiber sensing cable for underground settlement monitoring during tunnelling. In G. Beer (ed.), *Technology Innovation in Underground Construction*, 163–188. Leiden: CRC Press/Balkema.

Diederichs, M.S. & Kaiser, P.K. 1999. Stability of large excavations in laminated hard rock masses: the voussoir analogue revisited. *International Journal of Rock Mechanics & Mining Sciences*, 36(1): 97–117.

Dowding, C.H. 1985. *Blast Vibration Monitoring and Control*, 297 p. Englewood Cliffs: Prentice-Hall.

Duffaut, P. 2011. What modern rock mechanics owe to the Malpasset Arch Dam failure. In Q. Qian & Y.X. Zhou (eds), *Harmonising Rock Engineering and the Environment, Proc. 12th Congr., Int. Soc. Rock Mech.*, Beijing, 16-21 October, (in press). Leiden: CRC Press/Balkema.

Dunnicliff, J. 1988. *Geotechnical Instrumentation for Monitoring Field Performance*, 577 p. New York: John Wiley.

Einstein, H.H. & Baecher, G.B. 1983. Probabilistic and statistical methods in engineering geology. *Rock Mechanics & Engineering Geology*, 16(1): 39–72.

Elsworth, D. 1986. A hybrid boundary element-finite element analysis procedure for fluid flow simulation in fractured rock masses. *International Journal for Numerical & Analytical Methods in Geomechanics*, 10(6): 569–584.

Elsworth, D. & Mase, C.R. 1993. Groundwater in rock engineering. In J.A. Hudson, E.T. Brown, C. Fairhurst & E. Hoek (eds), *Comprehensive Rock Engineering*, 1: 201–226. Oxford: Pergamon Press.

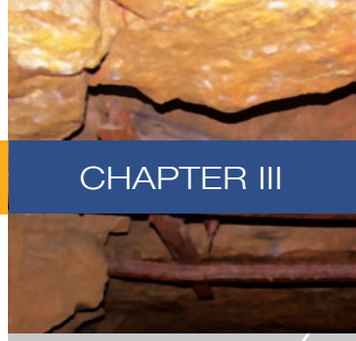
Evison, F.F. 1953. The seismic determination of Young's modulus and Poisson's ratio for rocks in situ. *Géotechnique*, 6(3): 118–123.

Fairhurst, C. (ed.) 1963. *Proceedings, Fifth Symposium on Rock Mechanics*, University of Minnesota, Minneapolis, May 1962, 726 p. Oxford: Pergamon Press.

Fairhurst, C. 2003. Stress estimation in rock: a brief history and review. *International Journal of Rock Mechanics & Mining Sciences*, 40(7-8): 957–973.

Fairhurst, C. 2004. Nuclear waste disposal and rock mechanics: contributions of the Underground Research Laboratory (URL), Pinawa, Manitoba, Canada. *International Journal of Rock Mechanics & Mining Sciences*, 41(8): 1221–1227.

Fairhurst, C. 2010. First Vienna-Leopold-Müller Lecture: What is the strength of a rock mass? Progress in answering Müller's (implicit) question. *Proc. 5th Colloquium, Rock Mechanics – Theory & Practice*, Vienna, 26–27 November 2009, *Mitteilungen für Ingenieurgeologie und Geomechanik,* Band 9: 87–110.



Fairhurst, C. 2011. Grand challenges in Earth Resources Engineering – and some implications for rock mechanics and rock engineering. In D.P. Sainsbury, R.D. Hart, C.L. Detournay & M.J. Nelson (eds), *Continuum and Distinct Element Numerical Modeling in Geomechanics – 2011, Proc. 2nd Int. FLAC/DEM Symp.*, Melbourne, 14–16 February, 3–10. Minneapolis: Itasca International Inc.

Falmagne, V. & Simser, B.P. 2004. Performance of rockburst support systems in Canadian mines. In E. Villaescusa & Y. Potvin (eds), *Ground Support in Mining & Underground Construction, Proc. 5th Int. Symp. on Ground Support*, Perth, 28–30 September, 313–318. Leiden: Balkema.

Feng, X.-T. & An, H. 2004. Hybrid intelligent method optimization of a soft rock replacement scheme for a large cavern excavated in alternate hard and soft rock strata. *International Journal of Rock Mechanics & Mining Sciences*, 41(4): 655-667.

Feng, X.-T. & Hudson, J.A. 2004. The ways ahead for rock engineering design methodologies. *International Journal of Rock Mechanics & Mining Sciences*, 41(2): 255–273.

Feng, X.-T. & Hudson, J.A. 2010. Specifying the information required for rock mechanics modelling and rock engineering design. *International Journal of Rock Mechanics & Mining Sciences*, 47(2): 179–194.

Feng, X.-T. & Hudson, J.A. 2011. *Rock Engineering Design*, 464 p. Leiden: CRC Press/Balkema.

Feng, X.-T., Zhao, H. & Li, S. 2004. A new displacement back analysis to identify mechanical geo-material parameters using integrated intelligent methodology. *International Journal for Numerical & Analytical Methods in Geomechanics*, 28(11): 1141–1165.

Fjaer, E., Holt, R.M., Horsrud, P., Raaen, A.M. & Risnes, R. 2008. *Petroleum Related Rock Mechanics*, 2nd edn, 514 p. Amsterdam: Elsevier.

Franklin, J.A. 1977. Monitoring of structures in rock. *International Journal of Rock Mechanics & Mining Sciences*, 14(4): 163-192.

Franklin, J.A. & Denton, P.E. 1973. The monitoring of rock slopes. *Quarterly Journal of Engineering Geology*, 6(3–4): 259–286.

Furtney, J.K., Cundall, P.A. & Chitombo, G.P. 2009. Developments in numerical modeling of blast induced fragmentation: updates from the HSBM project. In J.A. Sanchidrián (ed.), *Rock Fragmentation by Blasting – FragBlast 9, Proc. 9th Int. Symp. on Rock Fragmentation by Blasting*, Granada, 13–17 September, 335–342. Leiden: CRC Press/Balkema.

Gaich, A., Pötsch, M. & Schubert, W. 2007. Rock mass characterization for tunneling and mining using 3D images. In L. Ribeiro e Sousa, C. Olalla & N.F. Grossmann (eds), *Proc. 11th Congr., Int. Soc. Rock Mech.*, Lisbon, 9–13 July, 2: 1019–1024. Leiden: Taylor & Francis.

Galvin, J.M., Hebblewhite, B.K. & Salamon, M.D.G. 1999. University of New South Wales pillar strength determinations for Australian and South African mining conditions. In C. Mark, K.A. Heasley, A.T. Iannocchione & R.J. Tuchman (eds), *Proc. 2nd Int. Workshop on Coal Pillar Mechanics & Design*, Vail, 6 June, NIOSH IC 9448, 63–71. Pittsburgh: U.S. Department of Health & Human Services.

Gilby, J. & Socol, M. 2010. Geotechnical instrumentation data management. In K.G. Sharma, T. Ramamurthy, V.K. Kanjlia & A.C. Gupta (eds), *Advances in Rock Engineering, Proc. ISRM Int. Symp. 2010 & 6th Asian Rock Mech. Symp.*, New Delhi, 23–27 October, Paper 124, 7p (on CD-ROM). New Delhi: Central Board of Irrigation & Power.

Gioda, G. 1980. Indirect identification of the average elastic characteristics of rock masses. In P.J.N. Pells (ed.), *Structural Foundations on Rock, Proc. Int. Symp.*, Sydney, 7–9 May, 65–73. Rotterdam: Balkema.

Gioda, G. & Sakurai, S. 1987. Back analysis procedures for the interpretation of field measurements in geomechanics. *International Journal for Numerical & Analytical Methods in Geomechanics*, 11(6): 555–583.

Girard, J.M. & McHugh, E.L. 2001. Emerging technologies and the future of geotechnical instrumentation. In D. Elsworth, J.P. Tinucci & K.A. Heasley (eds), *Rock Mechanics in the National Interest, Proc. 38th U.S. Symp. Rock Mech.*, Washington D.C., 5-7 July, 1: 445–450. Lisse: Balkema.

Golder, H.Q. & Akroyd, T.N.W. 1954. An apparatus for triaxial-compression tests at high pressures. *Géotechnique*, 4(4): 131–136.

Gong, Q.M. & Zhao, J. 2009. Development of rock mass characteristics model for TBM penetration rate prediction. *International Journal of Rock Mechanics & Mining Sciences*, 46(1): 8–18.

Goodman, R.E. 1966. On the distribution of stresses around circular tunnels in non-homogeneous rocks. *Proc. 1st Congr., Int. Soc. Rock Mech.*, Lisbon, 25 September – 1 October, 2: 249–255. Lisbon: LNEC.

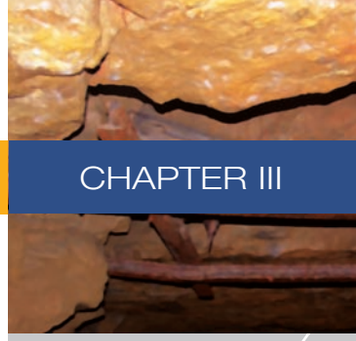
Goodman, R.E. 1989. *Introduction to Rock Mechanics*, 2nd edn, 562 p. New York: John Wiley.

Goodman, R.E. & Shi, G-H. 1985. *Block Theory and its Application to Rock Engineering*, 338p. Englewood Cliffs: Prentice-Hall.

Goodman, R.E., Taylor, R.L. & Brekke, T.L. 1968. A model for the mechanics of jointed rock. *Journal, Soil Mechanics & Foundations Division, A.S.C.E.*, 94(SM3): 637–659.

Grasselli, G. & Egger, P. 2003. Constitutive law for the shear strength of rock joints based on three-dimensional surface parameters. *International Journal of Rock Mechanics & Mining Sciences*, 40(1): 25–40.

Griggs, D.T. 1936. Deformation of rocks under high confining pressures. *Journal of Geology*, 44: 541-577.
Grobler, H.P., Poropat, G. & Guest, A.R. 2003. Photogrammetry for structural mapping in mining. *Technology Roadmap for Rock Mechanics, Proc. 10th Congr., Int. Soc. Rock Mech.*, Johannesburg, 8-12 September, 1: 431-436. Johannesburg: Southern African Institute of Mining & Metallurgy.
Habib, P. 1950. Détermination du module d'élasticité des roches en place. *Annales de l'Institut Technique du Bâtiment et des Travaux Publics*, No 145, September: 27-35.
Habib, P. & Marchand, R. 1952. Mesures des pressions de terrains par l'essai de vérin plat. *Suppléments aux Annales de l'Institut Technique du Bâtiment et des Travaux Publics, Série Sols et Foundations*, No 58, October: 967-971.
Hagedorn, H., Rehbock-Sander, M. & Stadelmann, R. 2007. Gotthard Base tunnel: rock burst phenomenon during construction of a multifunctional section in a fault zone area. In L. Ribeiro e Sousa, C. Olalla & N.F. Grossmann (eds), *Proc. 11th Congr., Int. Soc. Rock Mech.*, Lisbon, 9-13 July, 2: 917-920. Leiden: Taylor & Francis.
Handin, J. 1953. An application of high pressure geophysics: experimental rock mechanics. *Transactions, American Society of Mechanical Engineers*, 75: 315-324.
Hart, R.D., Detournay, C.L. & Cundall, P.A. (eds), 2008. *Continuum and Distinct Element Modeling in Geo-Engineering, Proc. 1st FLAC/DEM Symp.*, Minneapolis, 25-27 August, 698 p. Minneapolis: Itasca Consulting Group Inc.
Hast, N. 1958. The measurement of rock pressure in mines. *Sveriges Geologiska Undersokning*, Series C, 52(3).
Hawley, M., Marisett, S., Beale, G. & Stacey, P. 2009. Performance assessment and monitoring. In J. Read & P. Stacey (eds), *Guidelines for Open Pit Slope Design*, 327-379. Melbourne: CSIRO Publishing.
Hedley, D.G.F. & Grant, F. 1972. Stope and pillar design at the Elliot Lake uranium mines. *Canadian Institute of Mining & Metallurgy Bulletin*, 65(723): 37-44.
Herrera, G., Tomás, R., Vicente, F., Lopez-Sanchez, J.M., Mallorquí, J.J. & Mulas, J. 2010. Mapping ground movements in open pit mining areas using differential SAR interferometry. *International Journal of Rock Mechanics & Mining Sciences*, 47(7): 1114-1125.
Heyman, J. 1972. *Coulomb's Memoir on Statics*, 212p. Cambridge: Cambridge University Press.
Hill, F.G. 1954. An investigation of the problem of rockbursts; an operational research project. Part I. The approach to the problem and analyses of the rockbursts that have occurred on the ERPM during the years 1948-1953. *Journal, Chemical, Metallurgical & Mining Society of South Africa*, 55(October): 63-83.
Hill, F.G. 1966. Preface to "Rock Mechanics applied to the study of rockbursts". *Journal, South African Institute of Mining & Metallurgy*, 66(10): 435.
Hoek, E. 1963. Experimental study of rock-stress problems in deep level mining. *Experimental Mechanics*, 3: 177-194.
Hoek, E. 1964. Fracture of anisotropic rock. *Journal, South African Institute of Mining & Metallurgy,* 64(10): 501-518.
Hoek, E. 1994. Strength of rock and rock masses. *ISRM News Journal*, 2(2): 4-16.
Hoek, E. 2001. Big tunnels in bad rock. The 36th Karl Terzaghi Lecture. *Journal of Geotechnical & Geoenvironmental Engineering, A.S.C.E.*, 127(9): 726-740.
Hoek, E. 2007. The development of rock engineering. In *Practical Rock Engineering*. Available at http://Rocscience.com/hoek/pdf/1_The_development_of_rock_engineering.pdf .
Hoek, E. & Bray, J.W. 1974. *Rock Slope Engineering*, 309 p. London: Institution of Mining & Metallurgy.
Hoek, E. & Brown, E.T. 1980. *Underground Excavations in Rock*, 527 p. London: Institution of Mining & Metallurgy.
Hoek, E., Carranza-Torres, C., Diederichs, M.S. & Corkum, B. 2008. Integration of geotechnical and structural design in tunnelling. *Proc., University of Minnesota 56th Annual Geotechnical Engineering Conf.*, Minneapolis, 29 February, 1-53.
Hoek, E. & Diederichs, M.S. 2006. Empirical estimation of rock mass modulus. *International Journal of Rock Mechanics & Mining Sciences*, 43(2): 203-215.
Hood, M. & Brown, E.T. 1999. Mining rock mechanics, yesterday, today and tomorrow. In G. Vouille and P. Berest (eds), *Proc. 9th Congr., Int. Soc. Rock Mech.*, Paris, 25-28 August, 3: 1551-1576. Lisse: Balkema.
Hudson, J.A. 2010. Underground radioactive waste disposal: the rock mechanics contributions. In K.G. Sharma, T. Ramamurthy, V.K. Kanjlia & A.C. Gupta (eds), *Advances in Rock Engineering, Proc. ISRM Int. Symp. 2010 & 6th Asian Rock Mech. Symp.*, New Delhi, 23-27 October, KN 3 - KN 20. New Delhi: Central Board of Irrigation & Power.
Hudson, J.A. 2011. The next 50 years of the ISRM and anticipated future progress in rock mechanics. In Q. Qian & Y.X. Zhou (eds), *Harmonising Rock Engineering and the Environment, Proc. 12th Congr., Int. Soc. Rock Mech.*, Beijing, 16-21 October, 1: (in press). Leiden: CRC Press/Balkema.
Hudson, J.A., Brown, E.T. & Fairhurst, C. 1971. Optimizing the control of rock failure in servo-controlled laboratory tests. *Rock Mechanics*, 3(4): 217-224.
Hudson, J.A., Brown, E.T., Fairhurst, C. & Hoek, E. (eds) 1993. *Comprehensive Rock Engineering*, 5 Vols. Oxford: Pergamon Press.
Hudson, J.A., Cornet, F.H. & Christiansson, R. 2003. ISRM Suggested methods for rock stress estimation – Part 1: Strategy for rock stress estimation. *International Journal of Rock Mechanics & Mining Sciences*, 40(7-8): 991-998.



Hudson, J.A. & Feng, X-T. 2007. Updated flow charts for rock mechanics modelling and rock engineering design. *International Journal of Rock Mechanics & Mining Sciences*, 44(2): 174-195.

Hudson, J.A., Stephansson, O., Andersson, J., Tsang, C-F. & Jing, L. 2001. Coupled T-H-M issues relating to radioactive waste repository design and performance. *International Journal of Rock Mechanics & Mining Sciences*, 38(1): 143-161.

Hustrulid, W. 2010. Some comments regarding development drifting practices with special emphasis on caving applications. In Y. Potvin (ed.), *Caving 2010, Proc. 2nd Int. Symp. on Block & Sublevel Caving*, Perth, 20-22 April, 3-43. Perth: Australian Centre for Geomechanics.

Hutchinson, D.J. & Diederichs, M.S. 1996. *Cablebolting in Underground Mines*, 406 p. Richmond, B.C.: Bitech Publishers.

Indraratna, B., Oliveira, D.A.F. & Brown, E.T. 2010. A shear-displacement criterion for soil-infilled rock discontinuities. *Géotechnique*, 60(8): 623-633.

Itasca, 2011. *FLAC Ver 6.0, FLAC3D Ver 4.0, FLAC/Slope Ver 6.0, UDEC Ver 5.0 & 3DEC Ver 4.1* Minneapolis: Itasca Consulting Group Inc. (See www.itascacg.com/home.php.)

Jaeger, C. 1955. Present trends in the design of pressure tunnels and shafts for underground hydro-electric power stations. *Proc., Institution of Civil Engineers*, 4(2): 116-174.

Jaeger, C. 1972. *Rock Mechanics and Engineering*, 417 p. Cambridge: Cambridge University Press.

Jaeger, J.C. 1959. The frictional properties of joints in rock. *Geofisica Pura e Applicata*, 43(Part 2): 148-158.

Jaeger, J.C. 1960. Shear fracture of anisotropic rocks. *Geological Magazine*, 97: 65-72.

Jaeger, J.C. 1971. Friction of rocks and stability of rock slopes. *Géotechnique*, 21(2): 97-134.

Jing, L. 2003. A review of techniques, advances and outstanding issues in numerical modelling for rock mechanics and rock engineering. *International Journal of Rock Mechanics & Mining Sciences*, 40(3): 283-353.

Jing, L. & Stephansson, O. 2007. *Fundamentals of Discrete Element Methods for Rock Engineering: Theory and Applications*, 545 p. Amsterdam: Elsevier.

John, K.W. 1962. An approach to rock mechanics. *Journal, Soil Mechanics & Foundations Division, A.S.C.E.*, 88(SM4): 1-30.

Judd, W.R. (ed.) 1964. *State of Stress in the Earth's Crust*, *Proc. Int. Conf.*, Santa Monica, 13-14 June 1963, 732 p. New York: American Elsevier.

Kaiser, P.K. & Kim, B-H. 2008. Rock mechanics challenges in underground construction and mining. In Y. Potvin, J. Carter, A. Dyskin & R. Jeffrey (eds), *Proc. 1st Southern Hemisphere Int. Rock Mech. Symp.*, Perth, 16-19 September, 1: 23-38. Perth: Australian Centre for Geomechanics.

Kármán, T. von, 1911. Festigkeitsversuche unter allseitigem Druck. *Zeitschrift Verein Deutscher Ingenieure*, 55: 1749-1757.

Kimmance, J.P. 1999. Geographical information system application to construction and geotechnical data management on large projects. In C.F. Leung, S.A. Tan & K.K. Phoon (eds), *Proc. 5th Int. Symp. on Field Measurements in Geomechanics*, Singapore, 1-3 December, 151-156. Rotterdam: Balkema.

King, L.V. 1912. On the limiting strength of rocks under conditions of stress existing in the earth's interior. *Journal of Geology*, 20: 119-138.

Kirsten, H.A.D. 1976. Determination of rock mass elastic moduli by back analysis of deformation measurements. In Z.T. Bieniawski (ed.), *Proc. Symp. Exploration for Rock Engineering*, Johannesburg, 1-5 November, 1: 165-172. Cape Town: Balkema.

Kovari, K. & Amstad, C. 1993. Decision making in tunnelling based on field measurements. In J.A. Hudson, E.T. Brown, C. Fairhurst & E. Hoek (eds), *Comprehensive Rock Engineering*, 4: 571-606. Oxford: Pergamon Press.

Kovari, K., Amstad, C. & Köppel, J. 1979. New developments in the instrumentation of underground openings. In A.C. Maevis & W.A. Hustrulid (eds), *Proc. 1979 Rapid Excavation & Tunneling Conf.*, Atlanta, 18-21 June, 1: 817-837. New York: A.I.M.E.

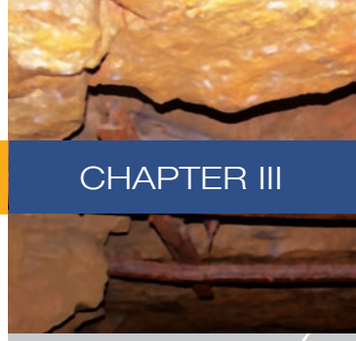
Lang, T.A. 1961. Theory and practice of rockbolting. *Transactions, Society of Mining Engineers of A.I.M.E.*, 220: 333-348.

Liu, J., Feng, X-T., Ding, X-L., Zhang, J. & Yue, D-M. 2003a. Stability assessment of the Three Gorges Dam foundation, China, using physical and numerical modeling – Part I: physical model tests. *International Journal of Rock Mechanics & Mining Sciences*, 40(5): 609-631.

Liu, J., Feng, X-T. & Ding, X-L. 2003b. Stability assessment of the Three Gorges Dam foundation, China, using physical and numerical modeling – Part II: numerical modeling. *International Journal of Rock Mechanics & Mining Sciences*, 40(5): 633-652.

Londe, P. 1987. The Malpasset Dam failure. *Engineering Geology*, 24(1-4): 295-329.

Londe, P., Vigier, G. & Vormeringer, R. 1969. Stability of rock slopes, a three-dimensional study. *Journal, Soil Mechanics & Foundations Division, A.S.C.E.*, 95(SM1): 235-262.
Long, J. & Witherspoon, P. 1985. The relationship of the degree of interconnection to permeability in fracture networks. *Journal of Geophysical Research*, 90(B4): 3087-3098.
Lorig, L.J. & Brady, B.H.G. 1982. A hybrid discrete element-boundary element method of stress analysis. In R.E. Goodman & F.E. Heuze (eds), *Issues in Rock Mechanics, Proc. 23rd U.S. Symp. Rock Mech*, Berkeley, 25-27 August, 628-636. New York: A.I.M.E.
Louis, C. 1974. Rock hydraulics. In Müller, L. (ed.), *Rock Mechanics*, (Course held at CISM, Udine, Italy), 300-387. Vienna: Springer-Verlag.
McKenzie, C.K. 1987. Blasting in hard rock: techniques for diagnosis and modeling for damage and fragmentation. In G. Herget & S. Vongpaisal (eds), *Proc. 6th Congr., Int. Soc. Rock Mech.*, Montreal, 30 August – 3 September, 3: 1425-1431. Rotterdam: Balkema.
Marinos, P.G., Marinos,V. & Hoek, E. 2007. The Geological Strength Index (GSI): a characterization tool for assessing engineering properties of rock masses. In C. Mark, R. Pakalnis & R.J. Tuchman (eds), *Proc. Int.Workshop on Rock Mass Classification for Underground Mining*, Vancouver, 31 May, NIOSH IC 9498, 87-94. Pittsburgh: U.S. Department of Health & Human Services.
Martin, C.D. 1997. Seventeenth Canadian Geotechnical Colloquium: the effect of cohesion loss and stress path on brittle rock strength. *Canadian Geotechnical Journal*, 34(5): 698-725.
Mas Ivars, D., Pierce, M.E., Darcel, C., Reyes-Montes, J., Potyondy, D., Young, R.P. & Cundall, P.A. 2011. The synthetic rock mass approach for jointed rock mass modelling. *International Journal of Rock Mechanics & Mining Sciences*, 48(2): 219-244.
Mayer, A. 1953. Les propriétés mécaniques des roches. *Géotechnique*, 3(8): 329-338.
Mayer, A. 1963. Recent work in rock mechanics. *Géotechnique*, 13(2): 99-118.
Mayer, A., Habib, P. & Marchand, R. 1951. Mesure en place des pressions de terrains. *Proc. Conf. Int. sur les Pressions de Terrains et le Soutènement dans les Chantiers d'Exploration*, Liège, 24-28 April, 217-221.
Minchinton, A. & Dare-Bryan, P. 2005. The application of computer modelling for blasting and flow in sublevel caving operations. *Proc. 9th AusIMM Underground Operators' Conf.*, Perth, 7-9 March, 65-73. Melbourne: Australasian Institute of Mining & Metallurgy.
Mogi, K. 1959. Experimental study of deformation and fracture of marble (1). On the fluctuation of compressive strength of marble and relation to the rate of stress application. *Bulletin, Earthquake Research Institute, University of Tokyo*, 37: 155-170.
Mogi, K. 2007. *Experimental Rock Mechanics*, 361 p. London: Taylor & Francis.
Moye, D.G. 1959. Rock mechanics in the investigation and construction of T.1 underground power station, Snowy Mountains, Australia. *Geological Society of America Engineering Geology Case Histories*, No 3: 13-44.
Müller, L. 1933. Untersuchungen über statistische Kluftmessungen. *Geologie und Bauwesen*, 5(4): 185-255.
Müller, L. 1950. Der Kluftkörper. *Geologie und Bauwesen*, 18(1): 52-60.
Müller, L. 1964. The rock slide in the Vajont Valley. *Rock Mechanics & Engineering Geology*, 2: 148-212.
Müller, L. 1966. Der progressive Bruch in geklüfteten Medien. *Proc. 1st Congr., Int. Soc. Rock Mech.*, Lisbon, 25 September – 1 October, 1: 679-686. Lisbon: LNEC.
Müller, L. 1967a. Address to the Opening Session. *Proc. 1st Congr., Int. Soc. Rock Mech.*, Lisbon, 25 September – 1 October, 1966, 3: 80-83. Lisbon: LNEC.
Müller, L. 1967b. Address to the Closing Session. *Proc. 1st Congr., Int. Soc. Rock Mech.*, Lisbon, 25 September – 1 October, 1966, 3: 90-92. Lisbon: LNEC.
Müller, L. 1968. New considerations of the Vajont slide. *Rock Mechanics & Rock Engineering*, 6(1): 1-91.
Müller, L. 1969. New editorial system. *Rock Mechanics*, 1(1): 1-4.
Müller, L. 1979. Josef Stini: contributions to engineering geology and slope movement investigations. In B. Voight (ed.), *Rockslides and Avalanches*, 2: 95-109. Amsterdam: Elsevier.
Müller-Salzburg, L. 1987. The Vajont catastrophe - a personal view. *Engineering Geology*, 24(1-4): 423-444.
Obert, L. & Duvall, W.I. 1967. *Rock Mechanics and the Design of Structures in Rock*, 650 p. New York: John Wiley.
Obert, L., Windes, S.L. & Duvall, W.I. 1946. Standardized tests for determining the physical properties of mine rock. *U.S. Bureau of Mines Report of Investigation* 3891.
Oñederra, I., Chitombo, G.P., Cundall, P.A. & Furtney, J.K. 2009. Towards a complete validation of the lattice scheme in the Hybrid Stress Blasting Model (HSBM). In J.A. Sanchidrián (ed.), *Rock Fragmentation by Blasting – FragBlast 9, Proc. 9th Int. Symp. on Rock Fragmentation by Blasting*, Granada, 13-17 September, 343-351. Leiden: CRC Press/ Balkema.
Ortlepp, W.D. 2007. Dynamic capacity in cable anchors and rockbolts. In *Cave Mining, 1st Int. Symp. on Block & Sub-level Caving*, Cape Town, 8-10 October, 405-419. Johannesburg: Southern African Institute of Mining & Metallurgy.



Ouchterlony, F. & Moser, P. 2006. Likenesses and differences in the fragmentation of full-scale and model-scale blasts. *Fragblast-8, Proc. 8th Int. Symp. on Rock Fragmentation by Blasting*, Santiago, 7-11 May, 207-220. Santiago: Editec.

Pacher, F. 1964. Deformationsmessungen im Versuchstollen als Mittel zur Erforschung des Gebirgsverhaltens und zur Bemessung des Ausbaues. *Rock Mechanics & Engineering Geology*, Suppl IV, 149-161.

Panet, M. 1993. Understanding deformations in tunnels. In J.A. Hudson, E.T. Brown, C. Fairhurst & E. Hoek (eds), *Comprehensive Rock Engineering*, 1: 663-690. Oxford: Pergamon Press.

Panet, M. 1995. *Calcul des Tunnels par la Méthode de Convergence-Confinement*. Paris: Presse de l'Ecole Nationale des Ponts et Chausses.

Paterson, M.S. 1958. Experimental deformation and faulting in Wombeyan marble. *Bulletin, Geological Society of America*, 69: 465-476.

Paterson, M.S. 1978. *Experimental Rock Deformation – The Brittle Field*, 254 p. Berlin: Springer-Verlag.

Pells, P.J.N. 2002. Developments in the design of tunnels and caverns in the Triassic rocks of the Sydney region. *International Journal of Rock Mechanics & Mining Sciences*, 39(5): 569-587.

Pells, P.J.N., Poulos, H.G. & Best, R.J. 1991. Rock reinforcement and design for a shallow large span cavern. In W. Wittke (ed.), *Proc. 7th Congr., Int. Soc. Rock Mech*, Aachen, 16-20 September, 2: 1193-1198. Rotterdam: Balkema.

Pichler, J., Lammer, E. & Bertignoll, H. 2010. Innovative roadheader technology for safe and economic tunnelling. In G. Beer (ed.), *Technology Innovation in Underground Construction*, 315-333. Leiden: CRC Press/Balkema.

Pierce, M., Gaida, M. & DeGagne, D. 2009. Estimation of rock block strength. In M. Diederichs & G. Grasselli (eds), *Rock Engineering in Difficult Conditions, Proc. 3rd Canada-U.S. Rock Mech. Symp*, Toronto, 9-15 May, Paper 4360 (on CD-ROM).

Pine, R.J., Coggan, J.S., Flynn, Z.N. & Elmo, D. 2006. The development of a new numerical modelling approach for naturally fractured rock masses. *Rock Mechanics & Rock Engineering*, 39(5): 395-419.

Pinkerton, I.L., Andrews, K.E., Bray, A.N.G. & Frost, A.C.H. 1961. The design, construction and commissioning of Tumut 1 Power Station. *Journal, Institution of Engineers, Australia*, 33(7-8): 235-252.

Player, J., Thompson, A. & Villaescusa, E. 2008. Dynamic testing of reinforcement systems. In T.R. Stacey & D.F. Malan (eds), *Proc. 6th Int. Symp. on Ground Support in Mining & Civil Engineering Construction*, Cape Town, 30 March – 3 April, 597-622. Johannesburg: Southern African Institute of Mining & Metallurgy.

Potts, E.L.J. 1957. Underground instrumentation. *Quarterly, Colorado School of Mines*, 52(3): 135-182.

Potvin, Y., Stacey, D. & Hadjigeorgiou, J. (eds) 2004. *Surface Support in Mining*, 416 p. Perth: Australian Centre for Geomechanics.

Potyondy, D.O. & Cundall, P.A. 2004. A bonded-particle model for rock. *International Journal of Rock Mechanics & Mining Sciences*, 41(8): 1329-1364.

Priest, S.D. 2004. Determination of discontinuity size distributions from scanline data. *Rock Mechanics & Rock Engineering*, 37(5): 347-368.

Priest, S.D. & Brown, E.T. 1983. Probabilistic stability analysis of variable rock slopes. *Transactions, Institution of Mining & Metallurgy, Section A: Mining Industry*, 92: A1-12.

Priest, S.D. & Hudson, J.A. 1981. Estimation of discontinuity spacing and trace length using scanline surveys. *International Journal of Rock Mechanics & Mining Sciences*, 18(3): 183-197.

Rabcewicz, L. 1969. Stability of tunnels under rock load. *Water Power*, 21(6-8): 225-229, 266-273, 297-304.

Read, J. & Stacey, P. (eds) 2009. *Guidelines for Open Pit Slope Design*, 496 p. Melbourne: CSIRO Publishing.

Roberts, A. 1963. Editorial. *International Journal of Rock Mechanics & Mining Sciences*, 1(1): 3-4.

Rocha, M. 1964. Mechanical behaviour of rock foundations in concrete dams. *Transactions, 8th Int. Congr. Large Dams*, Edinburgh, 1: 785-832.

Rocha, M., Serafim, J.L., Silveira, A. & Neto, J.R. 1955. Deformability of foundation rocks. *Proc. 5th Congr. Large Dams*, Paris, R75, 3: 531-559. Paris: Editions Science et Industrie.

Roegiers, J-C. 1999. The importance of rock mechanics to the petroleum industry. In G. Vouille & P. Berest (eds), *Proc. 9th Congr., Int. Soc. Rock Mech.*, Paris, 25-28 August, 3: 1525-1549. Lisse: Balkema.

Rogers, S., Elmo, D., Webb, G. & Catalan, A. 2010. A discrete fracture network based approach to defining in situ, primary and secondary fragmentation distributions for the Cadia East panel cave project. In Y. Potvin (ed.), *Caving 2010, Proc. 2nd Int. Symp. Block & Sublevel Caving*, Perth, 20-22 April, 425-439. Perth: Australian Centre for Geomechanics.

Rojat, F., Labiouse, V., Kaiser, P.K. & Descoeudres, F. 2008. Brittle rock failure in the Steg lateral adit of the Lötschberg base tunnel. *Rock Mechanics & Rock Engineering*, 42(2): 341-359.

Rojek, J., Oñate, E., Labra, C., Kargl, H. & Akerman, J. 2010. Optimizing rock cutting through computer simulation. In G. Beer (ed.), *Technology Innovation in Underground Construction*, 299-314. Leiden: CRC Press/Balkema.

Ryder, J.A. & Jager, A.J. (eds) 2002. *Rock Mechanics for Tabular Hard Rock Mines*, 489 p. Johannesburg: SIMRAC.

Sainsbury, B.L., Sainsbury, D.P. & Pierce, M.E. 2011. A historical review of the development of numerical cave propagation simulations. In D.P. Sainsbury, R.D. Hart, C.L. Detournay & M.J. Nelson (eds), *Continuum and Distinct Element Numerical Modeling in Geomechanics – 2011, Proc. 2nd Int. FLAC/DEM Symp.*, Melbourne, 14-16 February, 23-36. Minneapolis: Itasca International Inc.

Sainsbury, D.P., Hart, R.D., Detournay, C.L. & Nelson, M.J. (eds) 2011. *Continuum and Distinct Element Numerical Modeling in Geomechanics – 2011, Proc. 2nd Int. FLAC/DEM Symp.,* Melbourne, 14-16 February, 852 p. Minneapolis: Itasca International Inc.

Sakurai, S. 1993. Back analysis in rock engineering. In J.A. Hudson, E.T. Brown, C. Fairhurst & E. Hoek (eds), *Comprehensive Rock Engineering*, 4: 543-569. Oxford: Pergamon Press.

Sakurai, S. 1997. Lessons learned from field measurements in tunnelling. *Tunnelling & Underground Space Technology*, 12(4): 453-460.

Sakurai, S. 1999. Interpretation of field measurements in tunnelling practice. In G. Vouille & P. Berest (eds), *Proc. 9th Congr., Int. Soc. Rock Mech.*, Paris, 25-28 August, 3: 1517-1523. Lisse: Balkema.

Sakurai, S. & Akutagawa, S. 1995. Some aspects of back analysis in geotechnical engineering. In L. Ribeiro e Sousa & N.F. Grossmann (eds), *Eurock '93 - Safety & Environmental Issues in Rock Mechanics, Proc, Int, Symp.*, Lisbon, 21-24 June 1993, 1133-1140. Rotterdam: Balkema.

Sakurai, S., Farazmand, A. & Adachi, K. 2009. Assessment of the stability of slopes from surface displacements measured by GPS in an open pit mine. In G. Deák & Z. G. Agioutantis (eds), *Sustainable Exploitation of Natural Resources, Proc. 3rd Int. Seminar ECOMINING – Europe in 21st Century*, Milos Island, Greece, 4-5 September, 239-248.

Sakurai, S. & Takeuchi, K. 1983. Back analysis of measured displacement of tunnels. *Rock Mechanics & Rock Engineering*, 16(3): 173-180.

Salamon, M.D.G. & Munro, A.H. 1967. A study of the strength of coal pillars. *Journal, South African Institute of Mining & Metallurgy*, 68(2): 55-67.

Salamon, M.D.G., Ryder, J.A. & Ortlepp, W.D. 1964. An analogue solution for determining the elastic response of strata surrounding tabular mine excavations. *Journal, South African Institute of Mining & Metallurgy*, 65(2): 115-137.

Schmidt, W. 1925. Gefügestatistik. *Tschermaks Mineralogische und Petrographische Mitteilungen*, 38: 392-423.

Schubert, W. 2006. The role of on-site engineering in underground projects. In C.F. Leung & Y.X. Zhou (eds), *Rock Mechanics in Underground Construction, Proc., ISRM Int. Symp. 2006 & 4th Asian Rock Mech. Symp.*, Singapore, 8-10 November, 71-82. Singapore: World Scientific Publishing Co.

Schunnesson, H. 2009. Modern tools and equipment for tunnelling and drifting. In P. Dight (ed.), *Proc. 1st Int. Seminar on Safe & Rapid Development Mining*, Perth, 6-7 May, 139-148. Perth: Australian Centre for Geomechanics.

Schutjens, P. 2009. Book review: Petroleum Related Rock Mechanics, 2nd edn, 2008. *International Journal of Rock Mechanics & Mining Sciences*, 46(8): 1398-1399.

Shi, G-H. & Goodman, R.E. 1985. Two dimensional discontinuous deformation analysis. *International Journal for Numerical & Analytical Methods in Geomechanics*, 9(6): 541-556.

Slob, S., Hack, H.R.G.K., Feng, Q., Röshoff, K. & Turner, A.K. 2007. Fracture mapping using 3D laser scanning techniques. In L. Ribeiro e Sousa, C. Olalla & N.F. Grossmann (eds), *Proc. 11th Congr., Int. Soc. Rock Mech.*, Lisbon, 9-13 July, 1: 299-302. Leiden: Balkema.

Starfield, A.M. & Cundall, P.A. 1988. Towards a methodology for rock mechanics modelling. *International Journal of Rock Mechanics & Mining Sciences*, 25(3): 99-106.

Stephansson, O., Jing, L. & Tsang, C-F. (eds) 1996. *Coupled Thermo-Hydro-Mechanical Processes of Fractured Media*, 596 p. Amsterdam: Elsevier.

Stini, J. 1922. *Technische Geologie*, 789 p. Stuttgart: Ferdinand Enke.

Suorineni, F.T., Chinnasane, D.R. & Kaiser, P.K. 2009. A procedure for determining rock-type specific Hoek-Brown brittle parameters. *Rock Mechanics & Rock Engineering*, 42(6): 849-881.

Takahashi, T. 2004. ISRM Suggested Methods for land geophysics in rock engineering. *International Journal of Rock Mechanics & Mining Sciences*, 41(6): 885-914.

Takahashi, T., Takeuchi, T. & Sassa, K. 2006. Suggested Methods for borehole geophysics in rock engineering. *International Journal of Rock Mechanics & Mining Sciences*, 43(3): 337-368.

Talobre, J. 1957. *La Mécanique des Roches*, 444 p. Paris: Dunod.

Taylor, J.T.M. 1962-63. Research on ground control and rockbursts on the Kolar Goldfield, India. *Transactions, Institution of Mining & Metallurgy, Section A: Mining Industry*, 72: 317-338.

Terzaghi, K. 1962a. Measurement of stresses in rock. *Géotechnique*, 12(2): 105-124.

Terzaghi, K. 1962b. Stability of steep slopes on hard unweathered rock. *Géotechnique*, 12(4): 251-270.

Terzaghi, K. & Richart, F.E. 1952. Stresses in rock about cavities. *Géotechnique*, 3(2): 57-90.

Terzaghi, R.D. & Voight, B. 1979. Karl Terzaghi on rock slides: the perspective of a half-century. In B. Voight (ed.), *Rockslides and Avalanches*, 2: 111-133. Amsterdam: Elsevier.

Thorsteinsson, H., Augustine, C., Anderson, B.J., Moore, M.C. & Tester, J.W. 2008. The impacts of drilling and reservoir technology advances on EGS exploitation. *Proc., 33rd Workshop on Geothermal Reservoir Engineering*, Stanford University, 28-30 January, Stanford Geothermal Program Publication SGP-TR-2008, 14 p.

Tincelin, E. 1952. Mesures des pressions de terrains dans les mines de fer de l'est. *Annales de l'Institut Technique du Bâtiment et des Travaux Publics, Série Sols et Foundations*, No 58, October: 972-990.

Trollope, D.H. 1968. The mechanics of discontinua or clastic mechanics in rock problems. In K.G. Stagg & O.C. Zienkiewicz (eds), *Rock Mechanics in Engineering Practice*, 275-320. London: John Wiley.

Trollope, D.H. & Brown, E.T. 1965. Pressure distributions in some discontinua. *Water Power*, 17(8): 310-313.

Turchaninov, I.A., Iofis, M.A. & Kasparyan, E.V. 1979. *Principles of Rock Mechanics*, 493 p. Translated from Russian by A.L. Peabody; translation edited by W.A. Hustrulid. Rockville, MD: Terraspace.

Ulusay, R. & Hudson, J.A. (eds) 2007. *The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006*, 628 p. Ankara: ISRM Turkish National Group.

Vakili, A. & Hebblewhite, B.K. 2010. A new cavability assessment criterion for Longwall Top Coal Caving. *International Journal of Rock Mechanics & Mining Sciences*, 47(8): 1317-1329.

Villaescusa, E. 1996. Excavation design for bench stoping at Mount Isa mine, Queensland, Australia. *Transactions, Institution of Mining & Metallurgy, Section A: Mining Industry*, 105: A1-10.

Villaescusa, E. 2008. Geotechnical considerations for planning and design of open stopes. In H. Schunnesson & E. Nordlund (eds), *MassMin 2008, Proc. 5th Int. Conf & Exhibition on Mass Mining*, Luleå, 9-11 June, 341-352. Luleå: Luleå University of Technology.

Villaescusa, E., Hassell, R. & Thompson, A.G. 2008. Development of a corrosivity classification for cement grouted cable. In T.R. Stacey & D.F. Malan (eds), *Proc. 6th Int. Symp. on Ground Support in Mining & Civil Engineering Construction*, Cape Town, 30 March – 3 April, 461-476. Johannesburg: Southern African Institute of Mining & Metallurgy.

Wawersik, W.R. & Fairhurst, C. 1970. A study of brittle rock fracture in laboratory compression tests. *International Journal of Rock Mechanics & Mining Sciences*, 7(5): 561-575.

West, G. 1988. *Innovation and the Rise of the Tunnelling Industry*, 355 p. Cambridge: Cambridge University Press.

Williams, P., Floyd, J., Chitombo, G. & Maton, T. 2010. Design implementation. In J. Read & P. Stacey (eds), *Guidelines for Open Pit Mine Design*, 265-326. Melbourne: CSIRO Publishing.

Windsor, C.R. 1993. Measuring stress and deformation in rock masses. In T. Szwedzicki (ed.), *Proc. Australian Conf. on Geotechnical Instrumentation and Monitoring in Open Pit and Underground Mining*, Kalgoorlie, 21-23 June, 33-52. Rotterdam: Balkema.

Windsor, C.R. 2004. A review of long, high capacity reinforcing systems used in rock engineering. In E. Villaescusa & Y. Potvin (eds), Ground Support in Mining & Underground Construction, Proc. 5th Int. Symp. on Ground Support, Perth, 28-30 September, 17-41. Leiden: Balkema.

Windsor, C.R. & Thompson, A.G. 1993. Rock reinforcement – technology, testing, design and evaluation. In J.A. Hudson, E.T. Brown, C. Fairhurst & E. Hoek (eds), *Comprehensive Rock Engineering*, 4: 451-484. Oxford: Pergamon Press.

Witherspoon, P.A., Wang, J.S.Y., Iwai, K. & Gale, J.E. 1980. Validity of cubic law for fluid flow in a deformable rock fracture. *Water Resources Research*, 16(6): 1016-1024.

Wittke, W. 1977. Static analysis for underground openings in jointed rock. In C.S. Desai & J.T. Christian (eds), *Numerical Methods in Geotechnical Engineering*, 589-638. New York: McGraw-Hill.

Wittke, W. 1990. *Rock Mechanics: Theory and Applications with Case Histories*, 1075 p. Translated from German by R. Sykes in co-operation with S. Semprich & B. Plischke. Berlin: Springer.

You, T., Gatelier, N. & Laurent, S. 2006. Design methodology for hydrocarbon caverns, influence of in-situ stresses on large sections. In C.F. Leung & Y.X. Zhou (eds), *Rock Mechanics in Underground Construction, Proc. ISRM Int. Symp. 2006 & 4th Asian Rock Mech. Symp.*, Singapore, 8-10 November, Paper 63, 9 p (on CD-ROM). Singapore: World Scientific Publ. Co.

Zhang, L., Einstein, H.H. & Dershowitz, W.S. 2002. Stereological relationship between trace length and size distribution of elliptical discontinuities. *Géotechnique*, 52(6): 419-433.

Zhao, J. & Gong, Q.M. 2006. Rock mechanics and excavation by tunnel boring machine. In C.F. Leung & Y.X. Zhou (eds), *Rock Mechanics in Underground Construction, Proc., ISRM Int. Symp. 2006 & 4th Asian Rock Mech. Symp.*, Singapore, 8-10 November, 83-96. Singapore: World Scientific Publ. Co.

Zhou, W., Yang, R. & Zhou, L. 1986. An analysis of jointed rock using fracture mechanics for stability of arch dam abutment. *Proc. Int. Symp. on Engineering in Complex Rock Formations*, Beijing, 3-7 November, 470-478. Beijing: Science Press.

Zienkiewicz, O.C. 1977. *The Finite Element Method*, 3rd edn, 787 p. London: McGraw-Hill.

Zienkiewicz, O.C. & Cheung, Y.K. 1964. Buttress dams on complex rock foundations. *Water Power*, 16(5): 193-217.

ISRM Presidents

During the 50-year history of the ISRM, there have been 13 Presidents of the Society: Leopold Müller, Manuel Rocha, Leonard Obert, Pierre Habib, Walter Wittke, Ted Brown, John A. Franklin, Charles Fairhurst, Shunsuke Sakurai, Marc Panet, Nielen van der Merwe, John A. Hudson and Xia-Ting Feng.

In this Chapter, we present a brief curriculum vitae for each of the Presidents. It is noteworthy that, in all cases, the Presidents have been involved not only with the theoretical and laboratory aspects of rock mechanics but also with practical rock engineering, i.e. the application of the rock mechanics principles to engineering construction on and in rock masses.

Leopold Müller was born in Salzburg in 1908. He graduated in Civil Engineering from the Technical University of Vienna and, after 1933, his doctoral thesis on the "Statistical Collation of Joint Measurements" became a foundation stone in rock and discontinuity mechanics.

Leopold Müller
1962–1966

He started working in road construction and underground projects. In 1948, after his return from captivity as a prisoner of war, he established his own engineering office, which engaged in all aspects of construction in rock, tunnelling, caverns, dams and hydropower installations, underground railways, landslides, rock anchoring and mining. In 1961, he founded the International Institute for Rock Mechanics which he directed until 1964. He then became Lecturer in Rock Mechanics at the Technical University of Munich and from, 1965 to 1976, Director of the Department of Rock Mechanics in the Institute for Soil and Rock Mechanics at the University of Karlsruhe.

Between 1957 and 1984, Prof. Müller edited the Journal "Geologie und Bauwesen", later entitled "Felsmechanik und Ingenieurgeologie" and "Rock Mechanics". Prof. Müller was the author of over 250 publications in the areas of Engineering Geology and Geomechanics, as well as of two volumes of the textbook "Der Felsbau" (Construction in rock) which he could not complete due to his sudden death in 1988.

Leopold Müller was an honorary professor at the universities of Karlsruhe and Salzburg and a honorary member of the Austrian Academy of Sciences, and was awarded the "Ring of the City and State of Salzburg", the "Gold Merit Medal of the State of Salzburg", the "Rock Mechanics Award" from the American International Society for Mining Engineers (AIME), the Heidinger Medal of the Vienna Federal Geological Institute, the Johann Joseph Ritter von Precht Medal of the Vienna Technical University, and the 1984 Hans Cloos Medal of the IAEG.

Manuel Rocha
1966–1970

Manuel Rocha was born in 1913. He graduated in Civil Engineering from the Lisbon College of Engineering (IST) in 1938 and completed post-graduate work at the Massachusetts Institute of Technology and at the Swiss Federal Institute of Technology Zurich. In1941 he set up the Civil Engineering Studies Centre at the IST, which became part of the National Laboratory for Civil Engineering (LNEC) in 1947.

He was the director of LNEC from 1954 to 1974. Here he was responsible for research in the fields of building materials, experimental design of structures, observation of works, soil mechanics, earth and concrete dams, and rock mechanics. He was also an active private consultant. He was Professor at the IST and at the New University of Lisbon, with responsibility for Rock Mechanics and Underground Structures.

Manuel Rocha was President of the Union of Testing and Research Laboratories for Materials and Structures (RILEM), Honorary President of the Portuguese Geotechnical Society, Member of the National Academy of Sciences of the USA, Fellow of the American Society of Civil Engineers and Minister for Housing and Public Works of Portugal.

In 1966, Professor Rocha organised the first ISRM Congress in Lisbon. During his Presidency, the ISRM membership increased from 400 to 4,400 members. He was Chairman of the Commission on Classification of Rocks and Rock Masses and was particularly active in drafting a Basic Geotechnical Description of Rock Masses. His acceptance to chair the ISRM Commission on Tunnel Failures could unfortunately not be materialised due to his premature death in 1981.

Leonard Obert
1970–1974

Leonard Obert was born in Minneapolis in 1906. He graduated in physics at the University of California, in 1933, and obtained his doctoral degree at the John Hopkins University in 1938. He was employed at the US Bureau of Mines, 1937–1965, and as a consultant at the Department of Navy, Bureau of Ordnance Contract, John Hopkins University and Behre Dolbear and Company.

He was the inventor of: microseismic equipment for predicting rock failure in underground mines; the dynamic strain gauge for use in blasting research, co-inventor, Wilbur Duvall; rockbolt compression pad, co-inventor, A. J. Barry; borehole strain gauge, co-inventor, R. H. Merrill.

Dr Obert was the author or co-author of over 50 technical papers related to rock mechanics and mining research. He was the co-author, with Wilbur Duvall, of the famous book “Rock Mechanics and the Design of Structures in Rock”, John Wiley and Sons, 1967, the author of Chapter 4, Vol.7, “Brittle Fracture of Rock”, in “Fracture—an Advanced Treatise”, edited by Harold Liebowitz and a co-author of Sections 4 and 5, AIME Mining Engineer’s Handbook.

He received the Department of the Interior Award for Excellence in 1944, the Naval Ordnance Development Award in 1945, the Department of the Interior Citation for Distinguished Service in 1962, and the Rock Mechanics Award of the SME–AIME in 1968.

He was a member or an honorary member of the American Institute of Mining Engineers, the American Geophysical Union, the American Association for the Advancement of Science, the International Society for Rock Mechanics, Gamma Alpha (Physics), Sigma Xi and Cosmos Club. Dr Leonard Obert passed away in 1994.

Pierre Habib
1974–1979

Pierre Habib was born in 1925. He attended the École Polytechnique in France from 1945 to 1948. He became a Research Engineer at CEBTP in Paris in 1948 and worked on *in situ* Young's modulus measurements in 1950 and *in situ* stress measurements in 1951. He then obtained his PhD in 1952. After the International Congress for Soil Mechanics held in Paris in 1961, Prof. J. Mandel created a Laboratory for Solid Mechanics (LMS) at the École Polytechnique and Pierre became the Director Adj.

Pierre studied rock creep in 1963, the scale effect during triaxial tests with lateral pressure in 1963, and the scale effect and scatter of simple compression tests of iron ore samples. He also studied high pressure triaxial tests on various rocks in 1974. He became a Professor in 1972, and was President of the ISRM (1974–1979). He has been Professor of Soil and Rock Mechanics in the École Nationale du Génie Rural des Eaux et des Forêts (1966–1998) and Lecturer at the École Nationale Supérieure des Mines in Paris and at the École Polytechnique.

Later and among other projects, Pierre studied the Malpasset dam failure in 1987, the mechanism of kink band formation in 1994, tunnel face equilibrium in 2010, and the Vierzy railway tunnel failure, also in 2010. He is now Scientific Advisor of the Laboratoire de Mécanique des Solides (École Polytechnique). He has written more than 250 articles and three books.

Walter Wittke
1979–1983

Walter Wittke obtained his MSc in civil engineering from the Technical University of Hannover and a PhD in soil mechanics from the Technical University of Karlsruhe in Germany. He was appointed in 1965 as a Lecturer and in 1970 as Associate Professor, and Senior Academic Official at the Technical University of Karlsruhe. In 1974, he became Professor and Director of the Institute for Geotechnical Engineering, Technical University (RWTH) Aachen.

Walter has also been a Visiting Professor at Northwestern and Purdue Universities in the USA, and at the Indian Institute of Technology in Madras, India. Since 1980, he has been Managing Director of the engineering firm Prof. Dr.-Ing. W. Wittke Consulting Engineers for Tunnelling and Geotechnical Engineering, WBI GmbH, which has been involved in many significant projects.

In addition to his work for the German Geotechnical Society, he has been an active member of ICOLD, the ISSMFE, the IAEG, and the ISRM, and was President of the ISRM from 1979–1983. Walter has also been active in editorial work and especially vigorous in organising the German National Symposia in Aachen. He has many awards and more than 300 publications of various kinds.

ISRM Presidents

Ted Brown
1983–1987

Ted Brown is a graduate of the Universities of Melbourne (BE 1960, MEngSc 1964), Queensland (PhD 1969) and London (DSc(Eng) 1985). His major career appointments have been as Professor of Rock Mechanics and Dean of the Royal School of Mines at Imperial College, London, and as Dean of Engineering and Senior Deputy Vice Chancellor of the University of Queensland, Australia. Since 2001, he has been a Senior Consultant to Golder Associates, Brisbane, and has served as a Director of Queensland Rail and the Port of Brisbane Corporation.

Ted has wide international experience as a researcher, teacher, consultant and writer on rock mechanics and its applications in the mining, civil engineering and energy resources industries. He served as ISRM President from 1983 to 1987. He is an International Fellow of The Royal Academy of Engineering, UK, and a Fellow of the Australian Academy of Technological Sciences and Engineering.

In 2001, he was appointed a Companion in the Order of Australia. He was awarded a Centenary Medal by the Australian Government in 2003, the John Jaeger Memorial Award of the Australian Geomechanics Society in 2004, the President's Award of the Australasian Institute of Mining & Metallurgy for 2006, the ISRM's Müller Award in 2007, and the SME Rock Mechanics Award in 2010.

John A. Franklin
1987–1991

John A. Franklin has degrees in civil engineering, engineering geology, and rock mechanics. During his 1965–1970 stay at Imperial College in London, he developed the point load and slake durability tests that now form the basis for much of present day rock classification, and also innovative methods for triaxial testing, direct shear and swell-testing. Until his retirement, he taught University of Waterloo courses in engineering geology, technical writing, tunnelling and underground works. He has authored and co-authored over 100 research articles and written two college textbooks.

As a consulting geotechnical/geological engineer, John directed several hundred investigations, including major highways, slope stability, dam sites, aggregate and mineral resources studies, and tunnelling and mining investigations deep underground in Bermuda, Bolivia, Canada, Colombia, France, Great Britain, Greece, Ireland, Jamaica, Kenya, Mexico, Saudi Arabia, South Africa, Spain, and the U.S.A.

Of his many lifetime accomplishments, he is most proud of his association with the ISRM, and has served as ISRM President (1987–1991), as well as chairing the Commissions on Testing Methods (1975–1987), and Education (1991–1995). In fact he has organised and directed the preparation of most of the ISRM "Suggested Methods" for rock testing.

Charles Fairhurst obtained his B.Eng. with First Class Honours and Ph.D (both in Mining Engineering) from Sheffield University in the UK. He is currently Professor Emeritus at the University of Minnesota and Senior Consultant, Itasca Consulting Group (ICG) Inc. Minneapolis, MN, USA.

Charles was the Director of the International Rock Mechanics Group, Salzburg, Austria (this being the pre-cursor of the ISRM) and a collaborator with Professor Müller during the evolution of the ISRM; in fact he was the first English-speaking ISRM member, No. 20. Many years later, from 1991–1995, Charles was the President of the ISRM.

Charles Fairhurst
1991–1995

He is a present and former member of many Advisory Panels, several being related to nuclear waste isolation. He is also an international consultant on mining and civil engineering projects and on rock mechanics projects concerning rock drilling, hydraulic fracturing, *in situ* stress measurements, mine design, design of tunnel supports, hazardous waste disposal, and use of underground space.

Charles has advised many PhD students from almost every part of the world and received many accolades, including honorary doctorates from France, Russia, UK and the USA. He has pioneered, *inter alia*, the analysis/measurement of rock drilling processes, *in situ* stress and tunnel support design.

Shunsuke Sakurai is an Emeritus Professor of both Kobe University and Hiroshima Institute of Technology in Japan. He obtained a ME degree at Kyoto University in 1960 and then joined the Transportation Bureau of the Osaka Municipal Office, Japan, as a civil engineer designing steel and concrete structures for the subway.

Shunsuke Sakurai
1995–1999

He then went to the USA in 1962 and was awarded a PhD in civil engineering by Michigan State University in 1966. After that, he worked at Kobe University as Professor of Rock Mechanics until 1999. During that time, he was the President of the ISRM for the term 1995–1999. Also, he was invited as a Visiting Professor at various Universities, for example, the Swiss Federal Institute of Technology (ETH) in Switzerland, the University of Queensland in Australia, and Graz Technical University in Austria. In 1999 he moved to the Hiroshima Institute of Technology where he worked as University President until 2003.

Shun has over 45 years of experience in teaching and research in the field of rock mechanics, especially in back analysis of field measurements for monitoring the stability of tunnels and slopes. He has published many technical papers related to this field. He has been involved in various rock engineering projects, not only in Japan, but also in overseas countries.

ISRM Presidents

Marc Panet
1999–2003

Marc Panet is a civil engineer with degrees from the École des Mines de Paris in 1962 and the University of California at Berkeley in 1963. From 1965 to 1982, he worked at the Laboratoire Central des Ponts et Chaussées in Paris, then for the SHP Group, SIMECSOL where he was President and CEO, FC International SA where he was also President and CEO, and since 2002 he has been a Consultant.

He has been in charge of numerous studies in geotechnical engineering for underground works, highways, bridges, and natural hazards, including the Mont Blanc Tunnel, Frejus Road Tunnel, LEP (CERN in Geneva), Channel Tunnel (from 1967 to the end of the construction), Millau Bridge, Loetschberg Base Tunnel (Switzerland), subways in Paris, Rennes, Caracas, Athens, Algiers, the landslides of the city of Constantine (Algeria), the project of the suspended bridge on the Straits of Messina (Italy), and the cable-stayed bridge on the Golden Horn (Turkey).

Additionally, Marc is a member of many international consultancy committees. He is the author of a great number of publications in professional journals and international conferences. He is a Member of the French Academy of Technology and was the President of the ISRM during the period 1999–2003. His distinctions include Chevalier de l'Ordre National du Mérite and Chevalier de l'Ordre des Palmes Académiques.

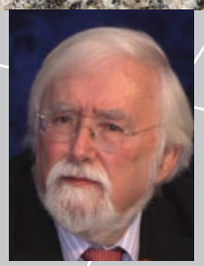
Nielen van der Merwe
2003–2007

Nielen van der Merwe gained a BSc in Mining Engineering in 1971 (University of Pretoria) and then worked at the West Driefontein gold mine. He obtained MSc and PhD degrees part time at the University of the Witwatersrand, plus the Mine Manager's Certificate of Competency.

In addition to being President of the South African National Institute of Rock Engineering for several terms and Vice-President for Africa of the ISRM, Nielen was President of the ISRM for the period 2003–2007. He was instrumental in the creation of the Federation of International Geo-Engineering Societies (FedIGS) and currently serves as its President. He is a registered Professional Engineer at the Engineering Council of South Africa and a Fellow of the South African Academy of Engineering.

His career of 40 years in the mining industry consisted of 27 years in industry and 13 years in academia, research and consulting. He was Head of the Department of Mining Engineering at the University of Pretoria 2001 to 2007 and, after two failed attempts at retirement, is currently Professor in the Centennial Chair for Rock Engineering at the University of the Witwatersrand, as well as being a consultant.

In addition to several papers, Nielen published two handbooks on coal mining rock engineering. He has been awarded two Gold Medals by the SAIMM and a Special Award from the South African Colliery Managers Association.



John A. Hudson
2007–2011

John A. Hudson obtained his BSc degree in Mining Engineering from the Heriot-Watt University in Edinburgh, Scotland, in 1965 and his PhD in rock mechanics as applied to both civil and mining engineering from the University of Minnesota, USA, in 1970. Following work in several UK governmental research organisations, he joined Imperial College in London in 1983, as Reader, then Professor, and now Emeritus Professor in the Department of Earth Science and Engineering where he has supervised 17 PhD students and 50 MSc students. He was elected as a Fellow of the UK Royal Academy of Engineering in 1998 and the American Rock Mechanics Association in 2009.

He was President of the ISRM Commission on Testing Methods from 1987–2007, Chairman of the first ISRM EUROCK Symposium—held in Chester, UK, 1992, and Co-Chairman of both of the ISRM SINOROCK Symposia, held in Yichang, China in 2004, and in Hong Kong, China in 2009.

He has authored/co-authored/edited nine books and more than 150 technical papers, He was the Editor of the International Journal of Rock Mechanics & Mining Sciences for 23 years from 1983 to 2006. Since 1985, he has acted as an independent consultant on more than 150 projects around the world.

Xia-Ting Feng
2011–2015

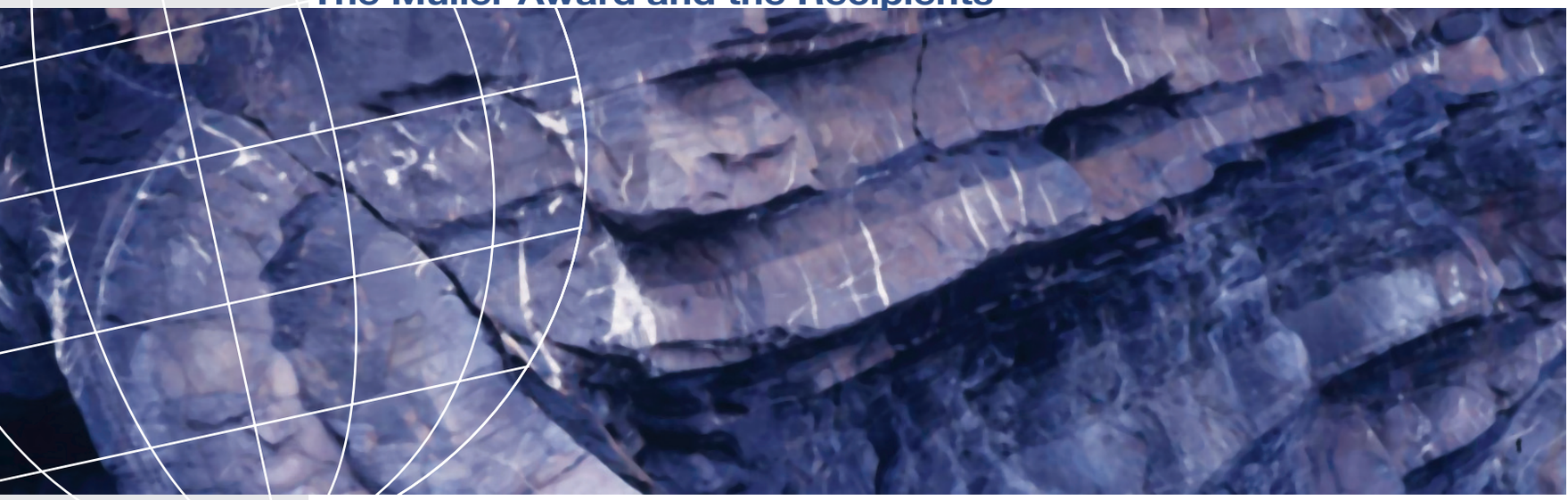
Xia-Ting Feng obtained his BSc degree in Mining Engineering from the Northeast University of Science and Technology in Shenyang, China, in 1986 and his PhD in rock mechanics from the Northeastern University, China, in 1992. He was Associate Professor and Professor at the same University from 1993 to 2001. As a Professor of the Hundred Talents Programme of the Chinese Academy of Sciences, he joined the Institute of Rock and Soil Mechanics of the Chinese Academy of Sciences in 1998. From 2003 to 2005 he was Director of this institute, from 2001 to 2007 Director of Key Laboratory of Rock and Soil Mechanics, and since 2007 he is Director of the State Key Laboratory of Geomechanics and Geotechnical Engineering.

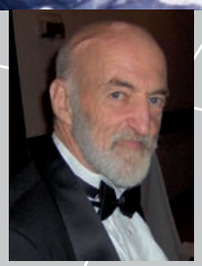
Prof. Feng is a member of the ISRM through the Chinese Society for Rock Mechanics and Engineering (CSRME). He is Vice President of the CSRME since 2004, and was ISRM Vice President at Large (2007–2011), President of ISRM National Group for China (2004–2007), Vice Chairman of the 12th ISRM International Congress on Rock Mechanics, Beijing, China, 2011, and Co-Chairman of both of the ISRM SINOROCK Symposia, held in Yichang, China in 2004, and in Hong Kong, China in 2009.

He is Editor-in-Chief of the Chinese Journal of Rock Mechanics and Engineering, Associate Editor-in-Chief of the Chinese Journal of Theoretical and Applied Mechanics and Member of the Editorial Board of the leading international journals in the field of Rock Mechanics. He has authored/co-authored six books and more than 200 technical papers.

His research interests cover 'intelligent' rock mechanics and engineering, including intelligent recognition of models and parameters, stability analysis, global optimum design, disaster prediction and prevention in rock engineering, coupled mechanical-chemical-hydraulic processes of rock masses and radioactive waste disposal ■

The Müller Award and the Recipients





John A. Franklin

Shunsuke Sakurai

The Müller Award is the most prestigious Award in the International Society for Rock Mechanics (ISRM). It is bestowed in recognition of distinguished contributions by professionals working in the fields of rock mechanics and rock engineering. The Müller Award was established in Pau, France in 1989, after a discussion by the ISRM Board regarding the creation of an Award to honour the memory of Professor Leopold Müller, the founder and the first President of ISRM. The Award is given to the most outstanding scholar and/or engineer once every four years. The recipient is honoured by a request to deliver a special Müller Lecture at the ISRM International Congress and is given a silver medallion with a portrait of Leopold Müller. Bestowing the Müller Award is one of the main activities carried out by the Society.

As reported in earlier Chapters, the International Society for Rock Mechanics (ISRM) was founded in Salzburg in 1962 as a result of the expansion of the "Salzburger Kreis" (Circle). Its foundation is mainly due to Professor Leopold Müller, who acted as President of the Society until September of 1966. Professor Müller, as the enthusiastic founder of the Society, took the initiative to assemble the Salzburger Group of scientists and engineers from all over the world who were interested in the newly-born branch of science called rock mechanics, for the purpose of giving unity, not only to the scattered knowledge obtained by groups working more or less on isolated problems posed by rock masses, but even to the knowledge contributed by those pursuing other aims, but with an interest in the field.

Professor Müller was also a pioneer of rock mechanics research in both theory and engineering practice. His contributions comprised distinguished works for developing new theories and technologies covering a wide area of rock mechanics and rock engineering. One of his important contributions to practical applications was the development of the New Austrian Tunnelling Method (NATM), which is now widely appreciated in various tunnelling projects all over the world. Professor Müller was involved in various well-known, international, rock mechanics projects taking a leadership role as a theoretician, a consulting engineer and a technical advisor for completing the projects successfully. Considering his great scientific achievements, in both theory and practice, it is implied that the recipient of the Müller Award should also be a person who has made a great contribution to the rock mechanics community, not only in theoretical works, but also in engineering practice. The recipient's work should be admired worldwide by many researchers, scholars and engineers.

As mentioned earlier, the Müller Award was established in 1989. Since that time, the following six persons have been presented with this great Award: the first recipient, Professor Evert Hoek (Canada) in 1991, was followed by Professor N. Cook (USA) in 1995, Professor H. Einstein (USA) in 1999, Professor C. Fairhurst (USA) in 2003, Professor E.T. Brown (Australia) in 2007 and Dr N. Barton (Norway and the UK) in 2011.

The Müller Award and the Recipients

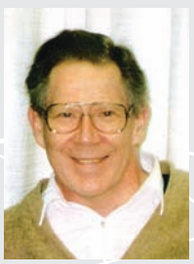
Evert Hoek
1991

Evert Hoek was born in Zimbabwe, graduated in mechanical engineering from the University of Cape Town and became involved in the young science of rock mechanics in 1958, when he started working in research on problems of brittle fracture associated with rockbursts in very deep mines in South Africa.

His degrees include a PhD from the University of Cape Town, a DSc (Eng) from the University of London, and honorary doctorates from the Universities of Waterloo and Toronto in Canada. He has been elected as a Fellow of the Royal Academy of Engineering (UK), a Foreign Associate of the US National Academy of Engineering and a Fellow of the Canadian Academy of Engineering. Dr Hoek has published more than 100 papers and three books. He spent nine years as a Reader and then Professor at the Imperial College of Science and Technology in London, six years as a Professor at the University of Toronto, 12 years as a Principal of Golder Associates in Vancouver, and the last 17 years as an independent consulting engineer based in North Vancouver.

His consulting work has included major civil and mining projects in 35 countries around the world and has involved rock slopes, dam foundations, hydroelectric projects, underground caverns and tunnels excavated conventionally and by TBM. Dr Hoek has now retired from active consulting work but, in 2012, is still a member of consulting boards on three major civil and mining engineering projects in Canada, the USA and Chile.

In 1991 Evert Hoek delivered the Müller Lecture “When is a Design in Rock Engineering Acceptable?” during the 7th ISRM International Congress on Rock Mechanics in Aachen, Germany.



Neville Cook
1995

Neville Cook laid many of the foundations for studies in rock mechanics and rock engineering. His career began by pioneering the development of 3-D seismic networks to study rockbursts in deep-level mines in South Africa, leading to the recognition of the concept of energy release rates. His 1965 papers on rockbursts set the scene for all the subsequent research on these subjects.

In 1962/63 he worked at the Australian National University in Canberra with Professor J.C. Jaeger, a period that led to the seminal book “Fundamentals of Rock Mechanics”. In 1963/64 he held a visiting position at the University of Minnesota and in 1964, he became the first Director of the Mining Research Laboratory of the Chamber of Mines in South Africa, a position he held for 12 years and where he oversaw work on analogue and digital computers to design mine layouts. His paper on “The Failure of Rock” published in 1965 is a perfect example of his pioneering work. He and Dr Salamon received the Gold Medal of the Associated Scientific and Technical Societies of South Africa in 1971 for their contributions to science and technology.

He became a Professor at the University of California at Berkeley where he supervised many students who, through their studies and guidance from Professor Cook, have themselves gone on to achieve considerable stature. In 1988, Professor Cook was elected as a Member of the US Academy of Engineering.

In 1995 Neville Cook delivered the Müller Lecture “Why Rock Mechanics” during the 8th ISRM International Congress on Rock Mechanics in Tokyo, Japan.

Herbert H. Einstein, Professor of Civil and Environmental Engineering at Massachusetts Institute of Technology, received his Dipl. Ing. and Sc.D. in Civil Engineering from ETH-Zürich. His teaching and research areas are underground construction, rock mechanics and engineering geology. He has particular expertise in the mechanical properties of soil and rock, field measurements, grouting, analysis, design and the project management of underground structures, landslides, together with probabilistic methods in rock engineering and engineering geology.

Herbert Einstein
1999

Professor Einstein has been involved as an advisor, consultant and researcher in issues related to underground construction, rock mechanics and rock engineering and natural disasters, notably landslides, including developing practical risk assessment procedures, and waste repository problems. These activities range through geotechnical and engineering geological research and design, plus the development and application of computerised decision tools. His knowledge has enabled him to advise government agencies in the United States and Europe.

He is Co-Editor of the journal, Rock Mechanics and Rock Engineering and a member of the editorial Boards of Tunnelling and Underground Space Technology, and of Engineering Geology. Professor Einstein is the author or co-author of over 200 publications in his area of expertise. He was the recipient of the "Outstanding Contribution to Rock Mechanics" Award of the American Rock Mechanics Association. He also received several teaching awards at MIT.

In 1999 Herbert Einstein delivered the Müller Lecture "Puzzles in Rock" during the 9th ISRM International Congress on Rock Mechanics in Paris, France.

Charles Fairhurst obtained his B.Eng. with First Class Honours and Ph.D (both in Mining Engineering) from Sheffield University in the UK. He is currently Professor Emeritus at the University of Minnesota and Senior Consultant, Itasca Consulting Group (ICG) Inc. Minneapolis, MN, USA.

Charles Fairhurst
2003

Charles was the Director of the International Rock Mechanics Group, Salzburg, Austria (this being the pre-cursor of the ISRM) and a collaborator with Professor Müller during the evolution of the ISRM; in fact he was the first English-speaking ISRM member, No. 20. Many years later, from 1991–1995, Charles was the President of the ISRM

He is a present and former member of many Advisory Panels, several being related to nuclear waste isolation. He is also an international consultant on mining and civil engineering projects and on rock mechanics projects concerning rock drilling, hydraulic fracturing, *in situ* stress measurements, mine design, design of tunnel supports, hazardous waste disposal, and use of underground space.

Charles has advised many PhD students from almost every part of the world and received many accolades, including honorary doctorates from France, Russia, UK and the USA. He has pioneered, *inter alia*, the analysis/measurement of rock drilling processes, *in situ* stress and tunnel support design.

In 2003 Charles Fairhurst delivered the Müller Lecture "Rock Mechanics and Radioactive Waste Isolation. 'One small step for geology, one giant leap for rock mechanics'" during the 10th ISRM International Congress on Rock Mechanics in Sandton, South Africa.

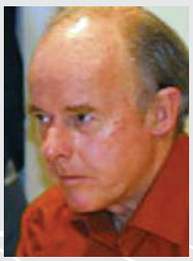
The Müller Award and the Recipients

Ted Brown
2007

Ted Brown is a graduate of the Universities of Melbourne (BE 1960, MEngSc 1964), Queensland (PhD 1969) and London (DSc(Eng) 1985). His major career appointments have been as Professor of Rock Mechanics and Dean of the Royal School of Mines at Imperial College, London, and as Dean of Engineering and Senior Deputy Vice Chancellor of the University of Queensland, Australia. Since 2001, he has been a Senior Consultant to Golder Associates, Brisbane, and has served as a Director of Queensland Rail and the Port of Brisbane Corporation.

Ted has wide international experience as a researcher, teacher, consultant and writer on rock mechanics and its applications in the mining, civil engineering and energy resources industries. He served as ISRM President from 1983 to 1987. He is an International Fellow of The Royal Academy of Engineering, UK, and a Fellow of the Australian Academy of Technological Sciences and Engineering. In 2001, he was appointed a Companion in the Order of Australia. He was awarded a Centenary Medal by the Australian Government in 2003, the John Jaeger Memorial Award of the Australian Geomechanics Society in 2004, the President's Award of the Australasian Institute of Mining & Metallurgy for 2006, the ISRM's Müller Award in 2007, and the SME Rock Mechanics Award in 2010.

In 2007 Ted Brown delivered the Müller Lecture "Rock Mechanics—The Basic Mining Science: Challenges in Underground Mass Mining" during the 11th ISRM International Congress on Rock Mechanics in Lisbon, Portugal.



Nick Barton
2011

Nick Barton obtained his Ph.D. on rock slope stability from Imperial College, London in 1971. He then worked for 25 years in the Norwegian Geotechnical Institute, part of the time as Division Director, and later as Technical Adviser. He developed the Q-system of rock mass characterisation, and a shear strength criterion for rock joints, each of which is widely used internationally. He has at least 40 years experience in rock engineering projects in 35 countries, mostly concerning road, rail and metro projects, but also tunnels and caverns for hydropower, rock slope stability, major dam abutments and foundation stability, plus the rock mechanics aspects of nuclear waste disposal studies in various countries. He has been frequently involved in TBM project trouble-shooting. In 2000 he started his own consultancy in Norway: Nick Barton & Associates.

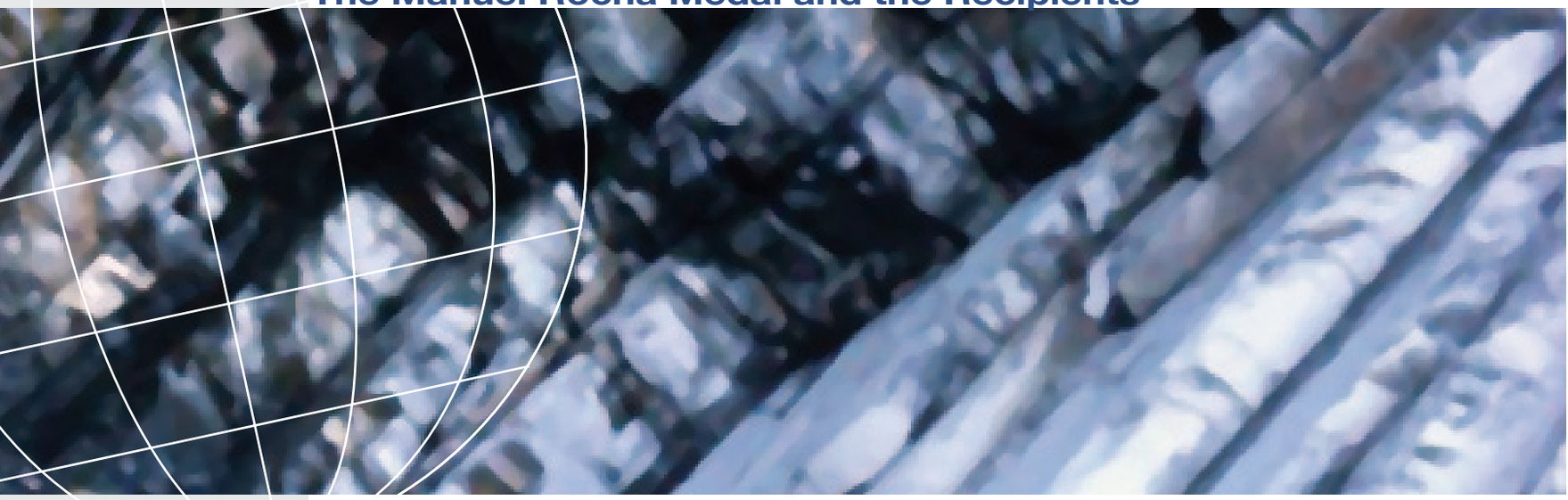
Among his many responsibilities he has been: Co-ordinator of the ISRM Working Party on Discontinuities, 1974–1980; Adjunct Professor, Dept. of Mining, University of Utah, 1983–1984; Adjunct Professor, Dept. of Rock Mechanics, University of Luleå, 1985–1989; Visiting Professor, São Paulo University, 1997–2001; member of the ISRM Commission on Rock Joints, 1988–1992; member of the ISRM Commission on Scale Effects in Rock Mechanics, 1988–1992; member of the ISRM Commission on Failure Mechanisms in Underground Openings, 1988–1990.

He is author/co-author of 260 papers, and author of a book on TBM Tunnelling in Jointed and Faulted Rock in 2000, and of a textbook on Rock Quality, Seismic Velocity, Attenuation and Anisotropy in 2006. He has given many short courses in countries around the world.

In 2011 Nick Barton delivered the Müller Lecture "From Empiricism, through Theory, to Problem Solving in Rock Engineering" during the 12th ISRM International Congress on Rock Mechanics in Beijing, China ■

Müller Lecture 2007 by Prof. Ted Brown

The Manuel Rocha Medal and the Recipients



Walter Wittke

Prof. Manuel Rocha can be considered as an outstanding personality within the field of our engineering science. From 1954 to 1974, Manuel Rocha was the Director of the Portuguese National Laboratory for Civil Engineering (LNEC), an Institute for research and development in various domains of Civil Engineering.

In 1966, Prof. Rocha organised the first ISRM Congress in Lisbon. This Congress was a great success and established new standards. From 1966 to 1970, he was the second President of the ISRM—following Prof. Leopold Müller. Also, since then the permanent ISRM Secretariat has been located within the LNEC.

During his Presidency, Manuel Rocha contributed decisively to progress in rock mechanics and also supported the further development of the Society. His particular concern was the promotion of young researchers and engineers.

During my Presidency, from 1979 to 1983, Prof. Rocha passed away in August 1981. It was my recommendation to the ISRM Board and Council at the meeting in Tokyo in 1981 to establish the Manuel Rocha Medal in remembrance of Prof. Rocha's work. This prize was created to be an award to young researchers in the field of rock mechanics and rock engineering. It consists of a bronze medal and a cash prize. It has been annually awarded since 1982 for outstanding doctoral theses.

The theses submitted to the Secretary-General are reviewed and subsequently rated with respect to the following criteria and weightings by the ISRM Board (as according to ISRM By-Law 7):

I – Problem statement: the issue that needs solving and why (weighted by 10%);
II – Appreciation of the State of the Art (weighted by 10%);
III – Theoretical and/or practical advancements (weighted by 35%);
IV – Verification of proposed solution (weighted by 35%); and
V – Quality of presentation (weighted by 10%).

The selection of the prize-winning thesis is within the responsibility of the Rocha Award Committee, chaired by the President, including the Vice-Presidents and other colleagues appointed to assist in the review process. The Rocha Medal is conferred by the President at the annual ISRM Congress or International Symposium.

The recipients of the Rocha Medal until 2012, as well as the titles of their theses, are compiled in the following list. Since 2010, there is also the option to award none, one, or two runner-up certificates; these are known as *Proxime Accessit* certificates.

Until now, the majority of the Rocha Medallists have been Europeans. However, in recent years the proportion of awarded young Asian researchers has grown ■

MANUEL ROCHA MEDAL RECIPIENTS

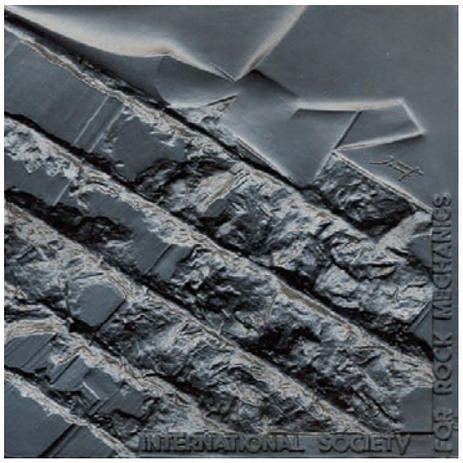
1982	A.P. Cunha	PORTUGAL	Mathematical Modelling of Rock Tunnels
1983	S. Bandis	GREECE	Experimental Studies of Scale Effects on Shear Strength and Deformation of Rock Joints
1984	B. Amadei	FRANCE	The Influence of Rock Anisotropy on Measurement of Stresses in Situ
1985	P.M. Dight	AUSTRALIA	Improvements to the Stability of Rock Walls in Open Pit Mines
1986	W. Purrer	AUSTRIA	Calculation Model for the Behaviour of a Deep-Lying Seam Roadway in a Solid (but cut by Bedding Planes) Surrounding Rock Mass, taking into Consideration the Failure Mechanisms of the Soft Layer Determined *In-Situ* on Models
1987	D. Elsworth	UK	Laminar and Turbulent Flow in Rock Fissures and Fissure Networks
1988	S. Gentier	FRANCE	Morphology and Hydromechanical Behaviour of a Natural Fracture in a Granite, under Normal Stress – Experimental and Theoretical Study
1989	B. Fröhlich	GERMANY	Anisotropic Swelling Behaviour of Diagenetically Consolidated Claystones
1990	R.K. Brummer	SOUTH AFRICA	Fracturing and Deformation at the Edges of Tabular Gold Mining Excavations and the Development of a Numerical Model describing such Phenomena
1991	T.H. Kleine	AUSTRALIA	A Mathematical Model of the Rock Breakage by Blasting
1992	A. Ghosh	INDIA	Fractal and Numerical Models of Explosive Rock Fragmentation
1993	O. Reyes W.	PHILIPPINES	Experimental Study and Analytical Modelling of Compressive Fracture in Brittle Materials

1994	S. Akutagawa	JAPAN	A Back Analysis Program System for Geomechanics Application
1995	C. Derek Martin	CANADA	The Strength of Massive Lac du Bonnet Granite around Underground Openings
1996	M. P. Board	USA	Numerical Examination of Mining-Induced Seismicity
1997	M. Brudy	GERMANY	Determination of In-Situ Stress Magnitude and Orientation of 9 km Depth at the KTB Site
1998	F. MacGregor	AUSTRALIA	The Rippability of Rock
1999	A. Daehnke	SOUTH AFRICA	Stress Wave and Fracture Propagation in Rock
2000	P. Cosenza	FRANCE	Coupled Effects between Mechanical Behaviour and Mass Transfer Phenomena in Rock Salt
2001	D. F. Malan	SOUTH AFRICA	An Investigation into the Identification and Modelling of Time-Dependent Behaviour of Deep Level Excavations in Hard Rock
2002	M.S. Diederichs	CANADA	Instability of Hard Rockmasses: the Role of Tensile Damage and Relaxation
2003	L.M. Andersen	SOUTH AFRICA	A Relative Moment Tensor Inversion Technique applied to Seismicity Induced by Mining
2004	G. Grasselli	ITALY	Shear Strength of Rock Joints based on the Quantified Surface Description
2005	M. Hildyard	UK	Wave Interaction with Underground Openings in Fractured Rock
2006	D. Ask	SWEDEN	New Developments of the Integrated Stress Determination Method and Application to the ÄSPÖ Hard Rock Laboratory, Sweden

2007	H. Yasuhara	JAPAN	Thermo-Hydro-Mechano-Chemical Couplings that Define the Evolution of Permeability in Rock Fractures
2008	Z.Z. Liang	CHINA	Three Dimensional Numerical Modelling of Rock Failure Process
2009	L. Gang	CHINA	Experimental and Numerical Study for Stress Measurement by Jack Fracturing and Estimation of Stress Distribution in Rock Mass
2010	J.C. Andersson	SWEDEN	Rock Mass Response to Coupled Mechanical Thermal Loading. Äspö Pillar Stability Experiment, Sweden
2011	D. Park	KOREA	Reduction of Blast-Induced Vibration in Tunnelling Using Barrier Holes and Air-deck
2012	M.T. Zandarin	ARGENTINA	Thermo-Hydro-Mechanical Analysis of Joints - A Theoretical and Experimental Study

MANUEL ROCHA PROXIME ACCESSIT CERTIFICATES RECIPIENTS

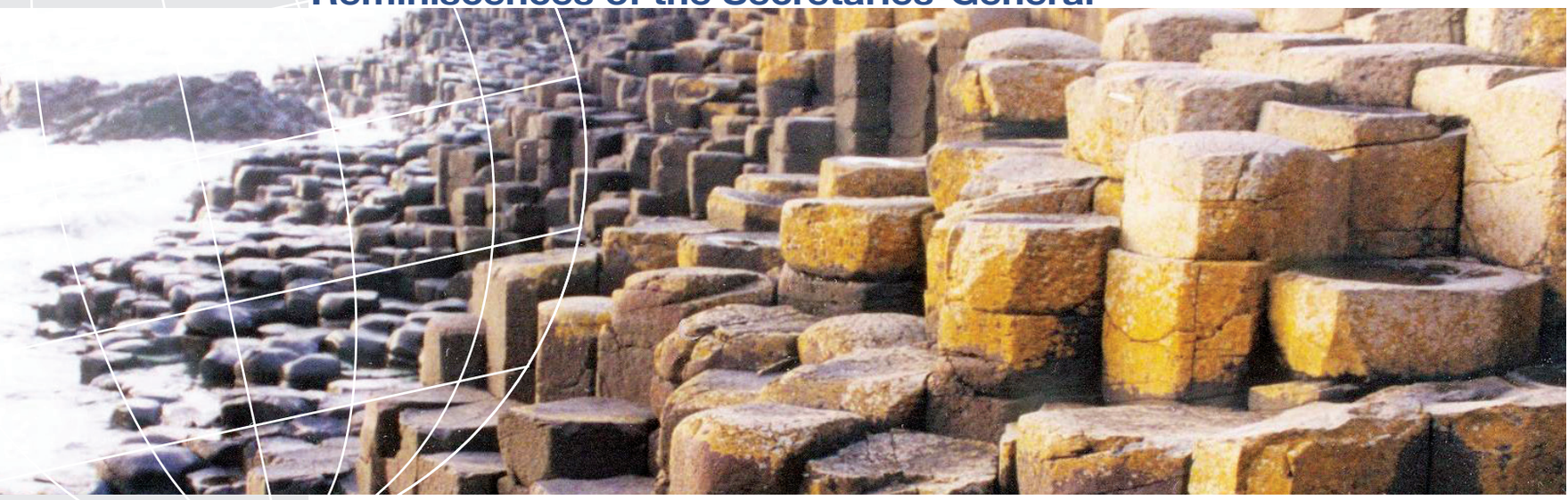
2010	J.S. Yoon	KOREA	Hydro-Mechanical Coupling of Shear-Induced Rock Fracturing by Bonded Particle Modeling
2010	A. Taheri	IRAN	Properties of Rock Masses by In-situ and Laboratory Testing Methods
2011	B. Li	CHINA	Coupled Shear-flow Properties of Rock Fractures
2012	B.P Watson	SOUTH AFRICA	Rock Behaviour of the Bushveld Merensky Reef and the Design of Crush Pillars
2012	J. Taron	USA	Geophysical and Geochemical Analyses of Flow and Deformation in Fractured Rock

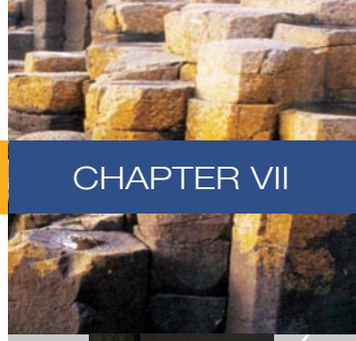


1st Manuel Rocha medal recipient A. Pinto da Cunha (left) with his thesis supervisor L. Ribeiro e Sousa (middle) and R. Oliveira (right)

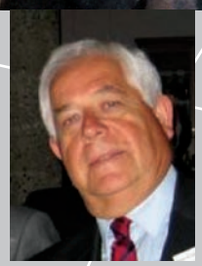
Mrs Manuel Rocha awards the Rocha medal 2007

Reminiscences of the Secretaries-General





CHAPTER VII



Nuno Grossmann

Luís Lamas

INTRODUCTION

The position of Secretary-General was created after the first ISRM International Congress in Lisbon, in 1966, following the election of Manuel Rocha as the second President of the Society.

During the early times of the Society, since its foundation in 1962 up to the Lisbon Congress, the functions of what was to be the Secretary-General were performed by a Secretary and a Treasurer—respectively Mr Johann Scheiblauer and Professor Ernst von Gottstein—appointed at the first Board meeting of the Society on 25 May 1962.

Mr Scheiblauer, from Munich, played an important role in the foundation of the Society, having proposed to the Board, at the meeting of 5 October 1962, relevant changes to the statutes and the organisation of national groups in the form of committees. Among other contributions, he proposed the amounts of the financial contributions from full members, sponsored members and students.

Professor v. Gottstein, of the University of Munich, took charge of the financial aspects the Society. Two auditors, from Austria and Germany, were appointed in order to assist in the organisation of the Society and to audit the accounts. At the General Assembly of 1963, Prof. v. Gottstein was already able to present audited accounts, with the financial contributions (the member fees, a grant from the city of Salzburg and the 1962 Salzburg Colloquium registration fees) and the expenses (the Secretariat activities, the organisation of the Colloquium and the audit of accounts).

In 1966, the Secretariat was established at the National Laboratory for Civil Engineering (LNEC) in Lisbon, Portugal, with generous financial support provided by the Calouste Gulbenkian Foundation. Since that time, the Society has been served by a succession of seven Secretaries-General provided by LNEC, whose reminiscences are included in this Chapter.

Soon after the establishment of the Secretariat, in 1967, Maria de Lurdes Eusébio became the Executive Secretary of the ISRM, a position she kept for over 40 years, until 2008. She served the Society with 11 Presidents, supported all Secretaries-General and attended 42 Council meetings. Although Maria stayed in the background, nearly always she was the person who made things happen. Maria was the dedicated and responsible person the Society relied upon, during all these years, to prepare the accounts and control the finances, to draft agendas and minutes of the meetings, to keep and update the membership list, to take care of the correspondence and of filing, and to organise the Secretariat travelling, among other things. She did it using pen, paper, telex, paper archives and huge accounting sheets, as efficiently as using e-mails, Excel spreadsheets and digital archives today. When she retired, Nielen van der Merwe wrote a dedication, which was signed by many past Board members of the ISRM, which was:

"Maria, we who have had the pleasure and the privilege to have worked with you for the last 40 years, wish you and José a peaceful and happy retirement. You carry with you the memories of the people of the ISRM over 40 years. When you reflect on those years, we want you to know that you will always be in all of our hearts with gratitude and with love."

Maria de Lurdes Eusébio
Executive-Secretary
1967–2008

In 2012, Maria is as energetic as always and continues to provide help to the Secretariat, on a less intense, but still regular basis. The search for materials in the early ISRM archives and its organisation, essential for preparation of this book, is a good example.

The Secretariat has been extremely lucky to be supported by the services of Sofia Meess who, despite being initially new to the role, has put her heart and soul into providing invaluable support to the ISRM Secretariat over the last few years. Together with Dr Ricardo Resende, the diligent webmaster and expert in information technology, they are the core of the ISRM Secretariat.

Standing, l.t.r. Luís Lamas, Ricardo Resende and Sofia Meess. Sitting, Maria de Lurdes Eusébio

Fernando de Mello Mendes

Fernando de Mello Mendes, 1966–1968

Rock Mechanics is an addiction. I contracted it in the now remote year of 1959 while preparing a thesis to compete for Full Professor of Mining at the Technical University of Lisbon. The theme was the mechanisation of the Panasqueira mine. As, at that time, no data on the deformability and strength of the occurring rocks existed, I resorted to the Laboratório Nacional de Engenharia Civil (LNEC) where mechanical tests for rock characterisation were performed. I carried out both uniaxial and triaxial tests on schistous rocks, and even designed a testing chamber for the triaxial tests. With my thesis, Mechanical Behaviour of Schistose Rocks, I obtained the post of Professor for Mine Exploration, and introduced lectures on the support of mine openings.

Meanwhile, the Director of the LNEC, Manuel Rocha, had invited me to become consultant there, a position I held for 25 years, only interrupted from 1969 to 1973 when I went to the University of Luanda, in Angola. Even there, I continued to devote time to Geomechanics, with a special interest in rock failure. During my first years as consultant for the LNEC, I accompanied the Head of the Dams Department to a Geomechanics Colloquy in Salzburg. I am proud to remember that I was one of the first three Portuguese members of the ISRM.

In 1965, Manuel Rocha was responsible for the organisation, through the LNEC, of the 1st Congress of the ISRM. This Congress, Lisbon 1966, was undoubtedly a great success and contributions were made by all departments of the LNEC. I was tasked with reviewing and accepting the papers for the Congress proceedings. At the end of the Congress, Manuel Rocha was elected President of the ISRM. Also, at the first Board meeting, it was decided that the Secretariat of the Society would have its headquarters in Lisbon, at the LNEC, and I was elected as Secretary-General.

The performance of the duties of Secretary-General, which I fulfilled until the end of 1968, was for me a challenge. Having to organise the Secretariat from the scratch, functioning in the three official languages of the Society (English, French, and German), I recognised the necessity of obtaining the assistance of a full time Executive Secretary. I selected, by means of a public contest, Mrs Maria de Lurdes Eusébio, the inestimable colleague to whom the Society owes a lot. The first work of the Secretariat was very arduous because all the logistics had to be organised at a time during which the Board of the Society stimulated the creation of National Groups, and a spectacular increase in the number of members took place. Then also, the first Working Groups for the standardisation of the rock testing techniques were constituted. In order to supply information about the activity of the Society and to communicate with its members, the Secretariat initiated the ISRM News, a modest publication, whose No. 1 (1967) had only four pages, but which remained keeping alive until the voluminous No. 97 (1992).

As Secretary-General, I worked together with the President in the preparation of the meetings of the Board and the Council of the Society, which took place in different countries, often in conjunction with an International Symposium of the ISRM. Of these meetings, I especially recall two—due to the diplomacy they demanded: one in which, with great difficulty, obstacles to the presence of representatives of the South African Union were removed because some countries did not want to receive them due to the apartheid regime which was in force there; and another one in which an agreement between representatives of East Germany and West Germany, then separated by the Berlin wall, was obtained.

After having written these words and back to the past, I feel rewarded for having contributed, in some way, for the first steps of the ISRM.

Ricardo Oliveira

Ricardo Oliveira, 1968–1974

Professor Manuel Rocha had been elected President of the ISRM on the occasion of the first ISRM Congress held in Lisbon in 1966. At that time, the elected Board appointed Prof. Mello Mendes as Secretary-General for the term 1966–1970 but he asked to leave the post in 1968 for personal reasons. I was then invited by Professor Manuel Rocha to accept the position of Secretary-General, my nomination being approved by the Board at the time of the International Symposium held in Madrid, in 1968. The Secretariat was established at LNEC, in Lisbon, having Maria de Lurdes Eusébio as its Executive Secretary. Although she had started her activity only one year before I was nominated, she was already very much aware of the current tasks of the Society and she had been very helpful in my integration in the Secretariat. Although I had already worked with Professor Manuel Rocha at LNEC, as Research Officer, the two years I worked more closely with him, in his duties as ISRM President, were outstanding and I still keep them in my memory.

He and his Board recognised the need for an organised Secretariat in order to help the establishment of the foundations of the Society, having as its main goal the spreading of rock mechanics all over the world and the calling of international expertise to help in the definition of the main principles of the discipline. At that time some Commissions were established and very relevant work has since been produced and published.

In this period (1968–70), several international symposia were organised, the most relevant in Oslo in 1969, together with ISRM Board and Council meetings. The highlight at the end of this short period was the second ISRM Congress, held in Belgrade in 1970. A new Board was then elected, the President being Dr Leonard Obert from the USA. I was invited to continue as Secretary-General.

This term (1970–74) was very relevant for the consolidation of rock mechanics, the ISRM having supported many international meetings, namely the symposia in Nancy in 1971, in Lucerne in 1972 and in Katowice in 1973, as well as the third ISRM Congress in Denver in 1974. During this term I would like to remark on the establishment of a Permanent Co-ordinating Secretariat, as a result of the effort of Prof. De Beer from Belgium. The Secretariat was created to co-ordinate the activities of the Geotechnical Sister Societies, the ISSMFE, the IAEG and the ISRM and the officers were Prof. De Beer (Co-ordinator) and the Secretaries-General of the three Societies. All the expenses related to travel and accommodation and to run the meetings in Brussels every year were met by the Belgian Government due to the strong involvement of Prof. De Beer during this project. The most relevant achievements of this Co-ordinating Secretariat were the establishment of some joint Commissions and avoiding overlapping of scientific activities and meetings. Since the International Congresses of ISRM and IAEG were run in the same years (1970 and 1974), it was approved to postpone the next ISRM Congress to 1979 (instead of 1978) because the IAEG Congress was being held in 1978.

Just before the Denver Congress, I announced the wish to end my activities as Secretary-General due to my other activities in research, teaching and consulting. Prof. Pierre Habib had been elected ISRM President at the Council meeting in 1974 and I kept my duties until the end of that year.

It was a real privilege to serve as Secretary-General of the ISRM for so many years, mainly because this activity gave me the opportunity for close contacts with brilliant scientists and professionals who were outstanding experts in all the areas of rock mechanics and to learn from all of them. It is also important to mention that real personal friendships were created with many of them which still last today.

Arnaldo Silvério

Arnaldo Silvério, 1974–1983

Most of my recollections of the ISRM are anecdotical flashes; they bring back plenty of people though they are scarce in facts. Members I discussed with at Board and Council meetings, in my two consecutive terms of office as ISRM Secretary-General, are vividly present in my remembrance. To acknowledge but a handful, let me jot down the names of W. Bamford, D. Banks, E.T. Brown, N. Grossmann, P. Habib, A. Hargraves, L. Obert, R. Oliveira, and W. Wittke. A further name I list—tenth in order, first in rank: M. Eusébio. Mrs Eusébio seconded me as the efficient and exceedingly devoted ISRM Executive-Secretary. I can easily spot her from here, our esteemed Maria, as she double-checks nameplates for attendees at the forthcoming meeting.

My fellow Secretaries-General of the ISSMFE and IAEG I yearly joined at the PCS meeting in Brussels, to discuss questions of common interest with an emphasis on administrative matters. The Permanent Co-ordinating Secretariat was supported by the Belgium Government and we were quite willing to contribute a cobblestone to paving the way for "Brussels capital city of Europe". PCS officers always treated us with the utmost deference; should we need to stay overnight they would graciously offer to accommodate us at the exclusive university club there. This both K. Nash of the ISSMFE and I gladly accepted: while R. Wolters of the IAEG came by train and reached Brussels on the day of the meeting, the two of us had to fly from our home countries one day in advance. Nash arrived early in the afternoon and was kind enough to play host to me, who arrived second; not later than 7p.m. he would come down in his slippers and entertain me for a couple of hours. Professor Nash's untimely death at 59 years of age closely followed Dr Wolter's, also at 59. I was 52 by then and, as third man in a row, would not hear of getting to 59 while holding office in the ISRM.

A third death occurred in 1981 that was a cause of consternation among us, namely M. Rocha's. Professor Rocha was a fine scientist, a brilliant engineer, undoubtedly a great man. For an extended period of time he had been Director of the LNEC, my home Civil Engineering National Laboratory in Lisbon, and I had had the honour and pleasure of being associated with him in a number of rock mechanics projects. Soon after Past-President Rocha passed away the ISRM Board decided to institute an annual prize—cash and a medal—to honour his memory. The medal was to be the work of a Portuguese artist and I came to be entrusted with establishing the right mood in the medallist selected. This I was supposed to achieve by lecturing him on rock mechanics made easy through a 5-day term. It was my good fortune that sculptor Helder Batista excelled at creating a Manuel Rocha Medal that won the favour of ISRM members in general; I myself was so carried away by its beauty I thought I saw "man-made shapes become simple" on its obverse "and flow over the medal surface with the elegance that is the watermark of accomplishment in structural design."

I reckon my allotted space has been depleted by now. I put down my pen and peruse the text. Amazing that the troika age/death/the dead have crept into my writing to a point of prominence. Will this have to do with the fact that I am drawing close to 83? I wonder.

Nuno Grossmann

Nuno Grossmann, 1983–1987

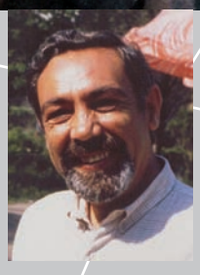
My involvement in the Secretarial duties started already in 1980, as Dr Arnaldo Silvério asked me to help him in the production of the ISRM News, at that time, one of the major tasks of a Secretary-General. The preparation of this quarterly newsletter included handwriting, correction of the typewritten text, and correction of the typeset pages of a manuscript which, in the early eighties, had around 37 pages, during my time of Secretary-General, increased to a mean of 48 pages, and finished, in 1992, with around 74 pages. The use of the computer, which arrived in the late eighties, eased the work a lot, but I still recall how my dog, which was already lying in our bedroom, where my wife was sleeping, came immediately for the night stroll with his master upon hearing the almost imperceptible sound of the button which shut down the computer. My connection to the ISRM Secretariat never ceased, first by helping Dr José Charrua Graça in the production of the ISRM News, then by assuming the then created position of its Editor-in-Chief (1989–1993), and finally as Contributing Editor of the ISRM News Journal.

From my time as Secretary-General, I mostly recall the evening in Zacatecas (1985) that started with a concert by the State Music Band at the Plaza Goitia, and the distribution to all of us of a small jar for the tequila, which had a cord, in order to have it dangling from our neck. At the end of the performance, the Band started to march through the streets of the town, always playing its music, and followed by the donkey with the tequila barrels, and all symposium participants, towards the Plazuela del Moral, where an informal dinner was to take place. The organisation of the Zacatecas symposium was a major effort made by our Mexican colleagues, and resulted in a very nice symposium which had, as its only drawback, a rather small attendance from the international community.

The other two International Symposia of my term of office took place in Europe. From the first one, in Cambridge UK (1984), I remember specially the night of the Manuel Rocha Medal Committee meeting, which ended a little before midnight, and obliged the President, Ted Brown, and myself to return in a hurry to Pembroke College, in which we stayed, where, at the door, we found my wife arguing with the doorkeeper that he should not close the door, because we were still outside. The Elizabethan style banquet of that symposium, in the Main Hall of King's College, was one of the highlights of the symposium.

In order to disseminate, as quickly as possible, the most recent advances in the field of Rock Mechanics, which presumably were obtained by the different doctoral candidates worldwide, at the 1986 Council, in Stockholm, I obtained approval to prepare a yearly booklet with the Rock Mechanics thesis abstracts published the year before. Unfortunately, only the first issue saw the light of the day, partly because, in the meantime, the era of the computer and the internet had begun.

At the meetings of the Permanent Co-ordinating Secretariat during my term of office, one of the main concerns was the clashes between the different Congresses and International Symposia of the three Societies (IAEG, ISRM, and ISSMFE), and we (the three Secretaries-General) agreed that our respective Councils should approve a decision which, at least, avoided the clashes between the major meetings of the sister societies. Although these decisions were all approved, their implementation, in the following years, started to be forgotten, in part, due to the extreme proliferation of the meetings sponsored by the three Societies.



José G. Charrua Graça

Note: prepared by Nuno Grossmann and Maria de Lurdes Eusébio

José G. Charrua Graça, 1987–1990

Regretfully, the term of office of the 6th Secretary-General of the ISRM, Dr José Gabriel Charrua Graça, was not completed: he suddenly passed away on 24 August 1990, aged 51. He had been appointed by the ISRM President Prof. John Franklin in September 1987, on the occasion of the 6th International Congress of the Society held in Montréal, Canada. During his term as Secretary-General, important changes in the Society took place. The Statutes and By-laws were extensively revised and numerous Guidelines were created. The ISRM Board was enlarged with the introduction of two Vice-Presidents at Large, one of which had to be from Europe. The Müller Award was created in 1989 to honour the memory of Prof. Müller who died in August 1988.

The Society met in Madrid in 1988, and the 1989 International Symposium, held in Pau, was jointly organised with the Society of Petroleum Engineers (SPE). There, Japan was selected as the organiser of the 8th International Congress.

In 1988, Charrua Graça and the ISRM President paid a visit to the Soviet Union to try to increase the involvement of the local rock mechanics community in the ISRM activities. The later selection of Academician Eugeny Shemyakin as Vice-President at Large was one of the consequences of this visit. He visited Yugoslavia on the occasion of the national conference in 1989. He also attended three meetings of the Permanent Co-ordinating Secretariat which took place in Brussels, chaired by Prof. E. De Beer.

Relevant educational material was made available to the members, such as Commission reports, John Franklin's slide collection, and technical videos. ISRM promotional material was created, such as lapel pins, ties, hats, magnifiers, key rings and pens.

José Delgado Rodrigues

José Delgado Rodrigues, 1991–2003

When recording history, a period may be described with numbers, events, facts and highlights regarding the successes and failures, with personal considerations and subjective appreciations, and with feelings relegated to a minor presence. But, while respecting the facts, allow me to assume a bias towards the personal approaches and subjective appreciations.

My term as Secretary-General of ISRM spanned from 1991 to 2003. In this period, the Society had already reached its cruising speed: all its major objectives were established, and the activities were running lively and smoothly. Congresses, international and regional symposia, and Board and Council meetings were the top activities to ensure that the ISRM was moving ahead, while bestowing the Rocha Medal and Müller Award were symbolic moments to revitalise the society and to bring members a link with its past.

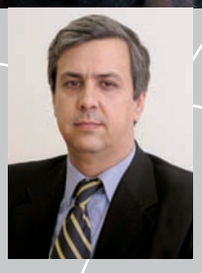
During this period, a few significant changes were decided and implemented. The "ISRM News" acquired a new format under the "ISRM News Journal", and included technical contributions both scientific and professionally relevant. The number of sponsored meetings was increased, both the ISRM-specific meetings and those co-sponsored jointly with the ISRM sister-Societies. The close proximity to the ISRM staff under the diligent supervision of Maria de Lurdes Eusébio made things easy and all the duties could be fulfilled according to her proverbial quietness and efficiency. By this period, the Society had its first website installed and communication was preferentially made by e-mail—two new working tools and powerful communication instruments. Since then, the ISRM was never the same, the Secretariat daily life changed drastically, the productivity increased significantly, and we felt to be much closer to the ISRM officials and members. As in our daily life, this was a point of no-return.

The co-ordination with the sister-Societies, International Society of Soil Mechanics and Geotechnical Engineering and International Association of Engineering Geology and Environment, went through a low period with the passing away of its main animator, Prof. de Beer. By the end of the term, the creation of FIGS (International Federation of Geotechnical Societies), now FedIGS, brought the co-ordination to the agenda again.

Yet, indubitably, what I praise more is the privilege I had to have contact and interact with so many relevant people, brilliant professionals, acute intelligences, delicate personalities, dedicated enthusiasts of the rock mechanics world. Let me personalise these feelings with reference to a few top personalities that I had the privilege to know and to work with during my term.

The enthusiasm, sympathy, and proactive attitude of Prof. John Franklin is the first. His firm intention to work hard from the beginning was reflected in his attitude to invite me to Norman (Oklahoma) to settle methods and plans when I had suddenly to take care of the Secretariat to replace the late José Charrua Graça. And I respect his unparalleled strength, courage and perseverance to fight the terrible illness that struck him so dramatically.

Charles Fairhurst gave me the opportunity to work with a brilliant mind, with a permanent warm and friendly attitude. Mark Panet and Shunsuke Sakurai are also mentioned—with their competence, availability and permanent willingness complete a group of ISRM Presidents that any Secretary-General would like to have as leaders. Also, I had the privilege to know, to work with and to include these in the number of my personal friends.



Luís Lamas

Luís Lamas, 2003 to date

At the beginning of 2003, while spending a few days in my hometown Lisbon—away from my position at that time in Macau, China—I was informed that José Delgado Rodrigues intended to leave the position of Secretary-General of the ISRM and that I should replace him soon after my return to the LNEC, in March of that year. Despite having been away from rock mechanics for nearly 10 years, I decided to accept the challenge influenced by two facts: firstly, during those years, I had had the chance to attend most of the annual symposia of the Society, and even some Council meetings; secondly, Maria de Lurdes Eusébio would continue as Executive Secretary, and I was sure she would be proficient in teaching me everything I needed to know. My judgement in this regard proved to be correct.

When my term as Secretary-General started, in the last months of Marc Panet's Presidency, activities of the Society were running smoothly. However, a big challenge could already be seen ahead of us. With the spreading of the electronic means of communication, which was then becoming easily available to virtually everybody, access to the technical information had become much easier, without the need to personally attend conferences, to visit libraries, to consult journals and conference proceedings, or to receive news in the mail box at home. This meant that new paths would have to be explored to continue to fulfil the main objectives of the ISRM.

The proactive attitude of the two Presidents with whom I had the opportunity to work during their entire terms—Nielen van der Merwe and John A. Hudson, who both had a vision for the ISRM and found the energy and the time to work hard to implement their ideas—proved to be fruitful. The best indicator was the continuous growth of members, which was to reach an all time record by the end of 2011. Election of Xia-Ting Feng as President for the period 2011–2015, coming from the most dynamic region in the world, assures continuation of this trend.

A new website was launched in 2005, and it quickly became the main tool for communication with the members. Gradually, the ISRM publications became freely available to members through the website. The News Journal, distributed in paper form to all members, was now also available on the website. In 2008, a quarterly electronic Newsletter started being distributed. Video presentations were requested from the nominees for President and Vice-Presidents, and members could watch them on the website. The Board could now work and make decisions continuously, instead of having to wait for the annual meetings. A major landmark was the launch, in 2010, of the ISRM digital library—an internet based platform where papers presented at the ISRM conferences since 1966 are available to the members for download at no cost.

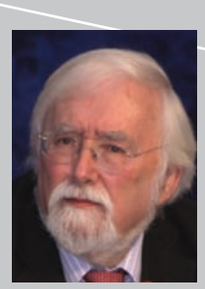
A series of other initiatives was also implemented during this period: lecture tours took place in Asia and South America; specialised conferences as well as technical and cultural field trips were created; the category of Fellow of the ISRM was instituted and the first group was inducted; an Advisory Forum of all past Board members and Fellows started for the purpose of supporting the Society; the annual ISRM Lecture was created to recognise the achievements of a mid-career member; the ISRM joined the ISSMGE and the IAEG to form the Federation of International Geo-Engineering Societies (FedIGS).

Being the Secretary-General during what is already a long period of time has been an enriching experience. It gave me the chance to interact with outstanding professionals and brilliant minds, coming from a great diversity of cultures that also represent the diversity of the ISRM members—its primary asset. Many of them I am grateful to count now also as friends ■

The ISRM in 2012

Luís Lamas

Xia-Ting Feng



John A. Hudson

INTRODUCTION

The year 2012 for the International Society for Rock Mechanics is marked by the celebrations of the 50-year anniversary of the ISRM. The celebrations started in October 2011, in Beijing, during the 12th International Congress on Rock Mechanics and will continue until the EUROCK symposium held in Stockholm during May 2012. Several initiatives were planned, starting with a competition for the commemorative logo and another for a slide show on "The Future Directions for Engineering Rock Mechanics". A banquet officially inaugurated the commemorations during the 12th ISRM Congress held in Beijing. The availability of this commemorative book in Stockholm, during the 2012 International ISRM Symposium will be the peak concluding moment of the celebrations.

The ISRM is a non-profit scientific association, registered in Portugal, supported by the fees of the members and grants that do not impair its free action, and it is useful to recall what the Statutes state about the field of rock mechanics and the objectives of the Society.

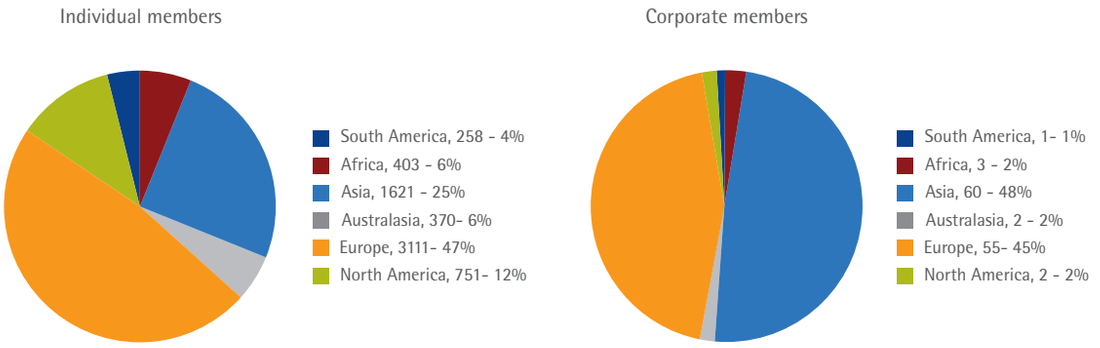
> *"The field of rock mechanics is taken to include all studies relative to the physical and mechanical behaviour of rocks and rock masses and the applications of this knowledge for the better understanding of geological processes and in the fields of engineering."*
>
> *"The objectives and purposes of the Society are:*
> - *to encourage international collaboration and the exchange of ideas and information between rock mechanics practitioners;*
> - *to encourage teaching, research, and the advancement of knowledge in rock mechanics; and*
> - *to promote high standards for professional practice among rock engineers so that civil, mining and petroleum engineering works might be safer, more economic and less disruptive to the environment."*

The activities of the ISRM have evolved during its 50-year long life, having in mind these statutory statements.

MEMBERSHIP AND GOVERNMENT OF THE SOCIETY

The Membership of the Society consists of:
- individual members affiliated through National Groups,
- corporate members, which are associations, companies, and other collective bodies, interested in supporting the advancement of rock mechanics, and
- corresponding members, who are individuals that pay fees directly to the Secretariat.

In January 2012, the Society had 6,514 individual members (affiliated through the National Groups and corresponding)—an all time record—and 123 corporate members, distributed by the six geographical regions as follows:



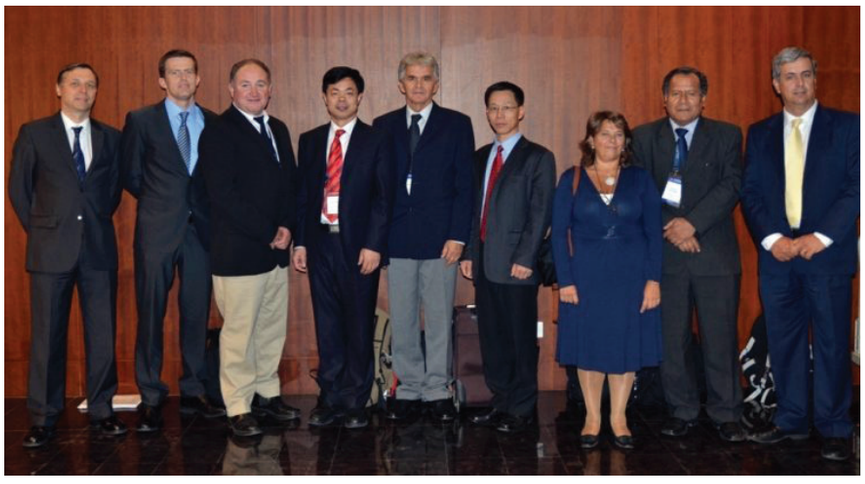
The ISRM members are affiliated through the following 48 National Groups:

- Africa: South Africa;
- Australasia: Australia and New Zealand;
- Asia: China, India, Indonesia, Iran, Israel, Japan, Korea, Middle East, Nepal, Singapore, Southeast Asia;
- Europe: Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Portugal, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden. Switzerland, Turkey, UK;
- North America: Canada and USA;
- South America: Argentina, Bolívia, Brazil, Colombia, Chile, Costa Rica, Paraguay, Peru, Venezuela.

An advanced membership management system is being developed and started being implemented in December 2011. This system includes a database of members that is used for managing the payment of the fees, the access to the restricted areas of the website, the attribution of certain privileges, the access to the digital library, and the contact with the members by e-mail using automatic info-mails or newsletters. In January 2012, the Secretariat can already reach over 85% of the ISRM members by e-mail. This membership management system will be fully operational during 2012.

The Society is governed by a Council, a Board and a Secretariat. The Council is the supreme body of the Society, which represents the National Groups and meets annually at the time and place of the yearly ISRM International Symposium or of the Congress. The Board is elected by Council and has the duty to administer the affairs of the Society. It is composed of the President, six Regional Vice-Presidents, up to 3 Vice-Presidents at Large, the President-Elect, and the Secretary-General as a non-voting member. The composition of the Board for the 2011–2015 term is:

President	Prof. Xia-Ting Feng, China
Vice-President for Africa	Mr Jacques Lucas, South Africa
Vice-President for Asia	Dr Yingxin Zhou, Singapore
Vice-President for Australasia	Dr David Beck, Australia
Vice-President for Europe	Prof. Frederic Pellet, France
Vice-President for North America	Dr John Tinucci, USA
Vice-President for South America	Dr Antonio Samaniego, Peru
Vice-President at Large	Prof. Yuzo Onishi, Japan
Vice-President at Large	Prof. Ivan Vrkljan, Croatia
Vice-President at Large	Dr Manoj Verman, India
Secretary-General	Dr Luís Lamas, Portugal



The 2011–2015 ISRM Board after its first meeting in Beijing, China in October 2011. Left to right: Frederic Pellet, David Beck, Jacques Lucas, Xia-Ting Feng, Ivan Vrkljan, Yingxin Zhou, Sofia Meess (executive secretary), António Samaniego, Luís Lamas

In 2011, the ISRM established an Advisory Forum, so that the ISRM Board can obtain advice from Fellows and previous Board Members. The first Forum took place in Beijing during the 12th International Congress on Rock Mechanics and will take place again every two years.

TECHNICAL ACTIVITY

The technical activity of the Society is mainly achieved through Commissions, appointed for each four-year Presidential term, in order to study scientific, technical, or administrative matters of concern to the Society. The Commissions are formed by members of the Society and usually meet at the venue of the yearly ISRM International Symposium or of the Congress. Important goals of the Commissions are to prepare reports with the results of the Commission's work, and to present these during the ISRM conferences in order to convey the benefits to the ISRM members.

The following Commissions were appointed for the 2011–2015 term:

- Commission on Application of Geophysics to Rock Engineering
- Commission on Coupled Thermo-Hydro-Mechano-Chemical Processes in Geological Materials and Systems
- Commission on Crustal Stress and Earthquakes
- Commission on Design Methodology
- Commission on Discontinuous Deformation Analysis
- Commission on Education
- Commission on Hard Rock Excavation
- Commission on Petroleum Geomechanics
- Commission on Preservation of Ancient Sites
- Commission on Radioactive Waste Disposal
- Commission on Rock Dynamics
- Commission on Soft Rocks
- Commission on Spalling Prediction
- Commission on Testing Methods
- Commission on Underground Research Laboratory Networking

Of particular relevance throughout the history of the Society has been the Commission on Testing Methods, which is responsible for co-ordinating the preparation of the ISRM Suggested Methods, approving and publishing them. These have been published in the ISRM 'Blue Book' in 2007 and the more recent ones will be published in the ISRM 'Orange Book' shortly.

The four-yearly ISRM International Congress on Rock Mechanics is the main event held by the Society and deals with themes of general interest to the members. The yearly International Symposia, the Regional Symposia and the Specialised Conferences are ISRM sponsored conferences where the advances registered worldwide in topics of rock mechanics and rock engineering are presented.

In 2012 the main conference, i.e. the ISRM International Symposium, will be the conference *EUROCK 2012, Rock Engineering and Technology for Sustainable Underground Construction*, which will be held from 28 to 30 May 2012 in Stockholm, Sweden. This is also where the Board, Council and Commission meetings will take place.

EUROCK Stockholm 2012

Other ISRM conferences already approved at the time this book was prepared are:

- II SASORE - II South American Symposium on Rock Excavations. An ISRM Regional Symposium, 7–9 August 2012, San Jose, Costa Rica
- ARMS 2012 - 7th Asian Rock Mechanics Symposium. An ISRM Asian Regional Symposium, 15–19 October 2012, Seoul, Korea
- Effective and Sustainable Hydraulic Fracturing. An ISRM Specialised Conference, 20–22 May 2013, Brisbane, Australia
- The 6th International Symposium on Rock Stress. An ISRM Specialised Conference, 20–22 August 2013, Sendai, Japan
- EUROCK 2013 - Rock Mechanics for Resources, Energy and Environment. The 2013 ISRM International Symposium, 23–26 September 2013, Wroclaw, Poland
- EUROCK 2014 - Rock Engineering and Rock Mechanics: Structures in and on Rock Masses. An ISRM Regional Symposium, 26–28 May 2014, Vigo, Spain
- ISRM 13th International Congress on Rock Mechanics, 29 April–6 May 2015, Montréal, Canada

The ISRM Technical and Cultural Field Trip was created recently as a regular event, and will generally be held every year, except for years in which the ISRM Congresses take place. The field trip consists of an appropriate combination of technical rock mechanics and rock engineering visits plus cultural visits. Previous ISRM Field Trips have taken place in Italy and Switzerland. The 2012 field trip will be to northern Sweden, immediately preceding the EUROCK 2012 conference, and will include visits to the Boliden, Malmberg and Kiruna mines, to the Dundret Mountain and to the Esrange Space Centre.

MEMBERS' BENEFITS AND RECOGNITION

The reason for the existence of any Society is to provide benefits to the members that justify their membership. An additional benefit, which is highly valued by many, is the sense of belonging to the international rock mechanics fraternity. But benefits must also be tangible, and currently in 2012 the ISRM offers the following to its individual members:

- free download of up to 100 papers per year from the ISRM digital library;
- free download from the website of the ISRM Suggested Methods and Commission reports, rock mechanics lectures, educational videos, slide collection, etc;
- access to the members' area in the website;
- the ISRM News Journal;
- the ISRM Newsletter;
- right to participate in the ISRM Commissions;
- registration with a 20% discount for the ISRM Congress, International and Regional Symposia and Specialised Conferences;
- personal subscription to the International Journal of Rock Mechanics and Mining Sciences and to the Journal Rock Mechanics and Rock Engineering at a discounted price; and
- right to receive one of the ISRM awards.

Currently, new ideas are being discussed for increasing the benefits offered to members, namely communication through professional networks, support to young members and less favoured countries, increase in the amount and quality of the educational material, expansion of the digital library and creation of new awards.

The awards given by the ISRM are the way the Society recognises its members. Currently, the ISRM has the following awards:

The Müller Award, the highest award of the ISRM, given once every four years in recognition of distinguished contributions to the profession of rock mechanics and rock engineering. The recipient delivers the prestigious Müller Lecture at the ISRM Congress. The Müller Medal for 2011 was awarded to Nick Barton at the 12th ISRM Congress held in Beijing China in October 2011.

Nick Barton receives the 2011 Müller Medal from the ISRM 2007–2011 President John A. Hudson

The Rocha Medal, awarded annually, which aims at stimulating young rock mechanics researchers for an outstanding doctoral thesis, as a result of a worldwide competition. The recipient presents the Rocha Lecture at the ISRM International Symposia or at the Congress. In 2012 the Rocha Lecture will be given by Dr Maria Teresa Zandarin, from Argentina.

The ISRM Lecture, given every year at the ISRM International Symposium, as recognition of a mid-career member who has made a significant contribution to a specific area of rock mechanics or rock engineering. In 2012, the ISRM Lecture will be given by Dr José Muralha, from Portugal.

Maria Teresa Zandarin

José Muralha

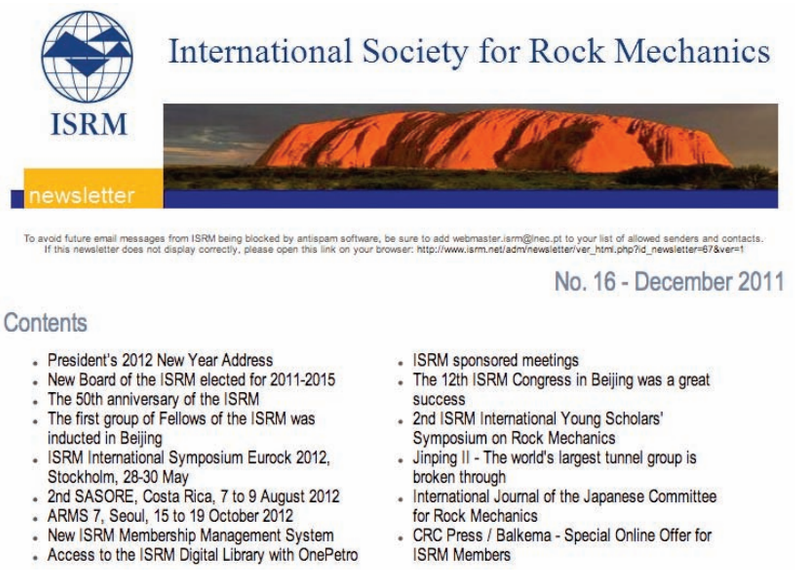
Recently, the ISRM created the status of Fellow, as the highest and most senior grade of membership of the ISRM, to acknowledge select individuals who have achieved outstanding accomplishment in the areas of rock mechanics and/or rock engineering and have contributed to the professional community through the ISRM. The induction of ISRM Fellows creates a group of experts that can provide strong

support and advice to the ISRM, and can be called upon as appropriate for ISRM activities. The first group of Fellows was inducted in Beijing, during the 12th International Congress on Rock Mechanics.

COMMUNICATION

The ISRM News Journal was started in 1992 and is currently published yearly. The cover of the most recent issue is shown on the right. It reflects the achievements and activities of the ISRM for each particular year, and includes technical articles of high quality, such as the Rocha Medal presentation of the previous year and a summary of the Müller Lecture. From 2012, the News Journal will be distributed electronically to all members. Printed copies will be available for select distribution, namely to the National Groups and the sister Societies. The Editors of the News Journal are the immediate Past President Professor John Hudson and the current President Professor Xia-Ting Feng, assisted by the Secretary-General Dr Luís Lamas and by Dr Yan Guo.

A quarterly electronic Newsletter started being published by the ISRM in March 2008. The Newsletter conveys news of the Society and other news of interest in the field of rock mechanics, and is distributed by e-mail to all ISRM members and to all those who subscribe to it on the website. Using the same facility, info-mails have been sent to the members, whenever an urgent issue needs to be announced. The new membership management system has dramatically increased the reach of the Newsletter and of the info-mails, because they are now sent to all members whose e-mail addresses are made available to the Secretariat by the National Groups.



International Society for Rock Mechanics

ISRM

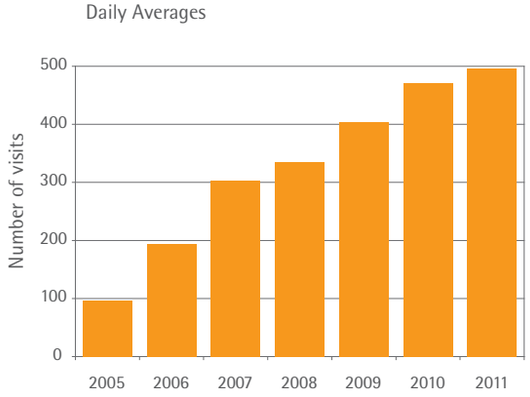
newsletter

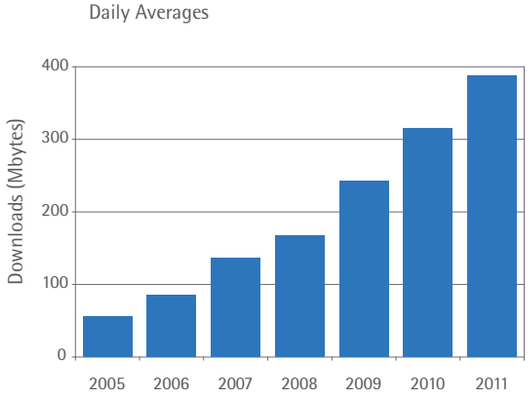
To avoid future email messages from ISRM being blocked by antispam software, be sure to add webmaster.isrm@lnec.pt to your list of allowed senders and contacts.
If this newsletter does not display correctly, please open this link on your browser: http://www.isrm.net/adm/newsletter/ver_html.php?id_newsletter=67&ver=1

No. 16 - December 2011

Contents

The ISRM website (http://isrm.net) was launched in 2005 and is the main means of information of the ISRM and the main channel for communication with the members and the rock mechanics community. Most benefits offered to the members are available in a password protected members' area. Statistics of the number of visits and of downloads are summarised in the graphics below.





PUBLICATIONS

The all time best seller of the ISRM publications is the well known "Blue Book"—The Complete ISRM Suggested Methods for Rock Characterisation, Testing and Monitoring: 1974–2006. It will be complemented in 2012 with a new "Orange Book"—ISRM Suggested Methods: Volume 2 - 2007–2012 The ISRM Suggested Methods for Rock Characterisation, Testing and Monitoring: 2007–2012 with Additional Articles on Rock Characterisation, edited by the Chairman of the Commission on Testing Methods, Professor Resat Ulusay.

All the Suggested Methods and the Commission reports are also published electronically on the Society's website and can be downloaded free by the ISRM members.

The ISRM and the Society of Petroleum Engineers signed a contract for distribution of the papers presented in ISRM-sponsored conferences through the OnePetro.org website. Launch of the ISRM digital library took place in October 2010. ISRM Individual members are entitled to freely download 100 papers per year, while corporate members are entitled to download 250 papers. In January 2012, the papers from eight ISRM Congresses and 12 International Symposia had been introduced in the Library, and other will be introduced soon.

MAIN ACHIEVEMENTS OF THE 2007–2011 BOARD

An ISRM modernisation programme was implemented by the 2007–2011 Board which resulted in the following achievements.

- Survey of ISRM Members;
- Report of the ISRM Commission on Mine Closure uploaded and available from the ISRM website;
- Erik Eberhardt's lectures on rock mechanics inaugurated as a series of downloadable ISRM Lectures on rock mechanics and rock engineering from the ISRM website;
- Historical videos of the ISRM and videos of the Keynote Lectures of ISRM conferences accessible from the ISRM website;
- Launch of the ISRM Virtual Library hosted by the OnePetro website;
- Creation of the ISRM Fellows and Advisory Forum, to provide advice;
- Creation of pre-Commissions (i.e., early organisation of Commissions for the next Board's tenure period);
- Nature and frequency of the ISRM Regional Symposia have been changed, and ISRM Specialised Conferences have been created as a new type of ISRM-sponsored event (revision of By-Law No. 5);
- Creation of Proxime Accessit certificates for up to two Rocha Medal runners-up (revision of By-Law no.7);
- Creation of ISRM Fellows (revision of the Statutes);
- Creation of the ISRM Annual Lecture;
- Planning the ISRM 50th year anniversary celebrations with associated logo and book;
- Pdfs of ISRM membership certificates available;
- Creation of Young Members' Slide Show Competition;
- ISRM Lecture Tour in China in May 2009;
- Creation of the Annual ISRM Technical and Cultural Field Trip, the first one being to the Carrara marble quarries and the Florence region, Italy, 2009 led by Massimo Coli;
- 2nd ISRM Technical and Cultural Annual Field Trip to the Lausanne region, Switzerland, 2010, led by Christophe Bonnard;
- ISRM Lecture Tour in Colombia and Peru, 2010;
- Creation of the ITA-ISRM Joint Action Group on "Site Investigation Strategy for Rock Tunnels" with the aim of preparing a Guidance Document;

- Participation (with ISSMGE and IAEG) in the reconfiguration of FedIGS to a less cumbersome and more flexible operation;
- Start of the ISRM electronic Newsletter (March 2008) and continuation with four Newsletters/ year;
- Launch of a CD containing pdfs of all the ISRM News Journal Issues 1996 to 2008, and making these available from the ISRM website;
- Creation of the ISRM Young Members' Presidential Group;
- Creation of an all-language inclusive ISRM policy, but with English as the only official language (revision of the Statutes);
- 22% increase of the individual ISRM Members, from 5354 in 2007 to 6514 in 2011.

CHALLENGES AND OPPORTUNITIES FOR THE 2011–2015 BOARD

The ISRM is the international collaborative body for professional rock mechanics engineers. Our purpose is to act on behalf of members to co-ordinate international collaboration amongst rock engineers, be an advocate for the profession of rock mechanics, and promote progress in the area of rock mechanics for the good of the community.

Over 50 years, through its leadership role in these areas, the Society has had a strong influence over the steady forward progress of rock mechanics. Local groups and members drive ongoing growth through symposia, special Commissions and education, but the ISRM is the main continuous source of leadership and the coming together point. Our success can be measured by the Society's continuing growth which is now at record levels, by the strength of our profession evidenced by the quality and number of scholarly articles submitted to our Journal, and the levels of activity of the National Groups.

The purpose of the ISRM will remain unchanged, but to continue the successful execution of our mission we need to adapt to evolving demands and take advantage of the opportunities, especially those presented by advances in technology. We particularly need this evolution to be towards the execution of our mission, rather than to be just change for change's sake.

Challenges and constraints for the ISRM include the following.

– Technical and community:
  - In mining rock mechanics, easy-to-extract resources are diminishing. The challenges of deeper, low grade, weaker rock deposits means rock mechanics problems are more frequently a constraint on supplies of essential commodities, even as demand is expected to grow rapidly. Rock mechanics has a role to play in ensuring the supply can meet demand, and this is of great potential consequence;
  - The impacts of extractive industries on the environment do, or should more frequently, involve rock mechanics considerations;
  - The need for more awareness of rock mechanics constraints on environmental impacts is especially clear for oil and gas industries, coal seam gas operations and in the areas of sequestration of pollutants.

– Membership:
  - The massive growth in numbers of rock engineering professionals, especially in China, South America and India. Engaging these potential members and existing ones sufficiently is a challenge;
  - Changes in the interests of our members, especially as the roles and specialities change and converge with other fields.

– Communication:
  - The diversification and expansion of our field is an opportunity, but also a challenge. We need to be able to communicate and engage members and potential members with vastly different backgrounds, languages and interests;
  - Our membership is increasingly mobile.

– Constraints:
  - Our resources are limited. We need to stay focused and work on those areas that will bring us the most results. Some prioritisation will be necessary;
  - The Society must find ways to generate more income so that we can have the financial resources to fund our activities.

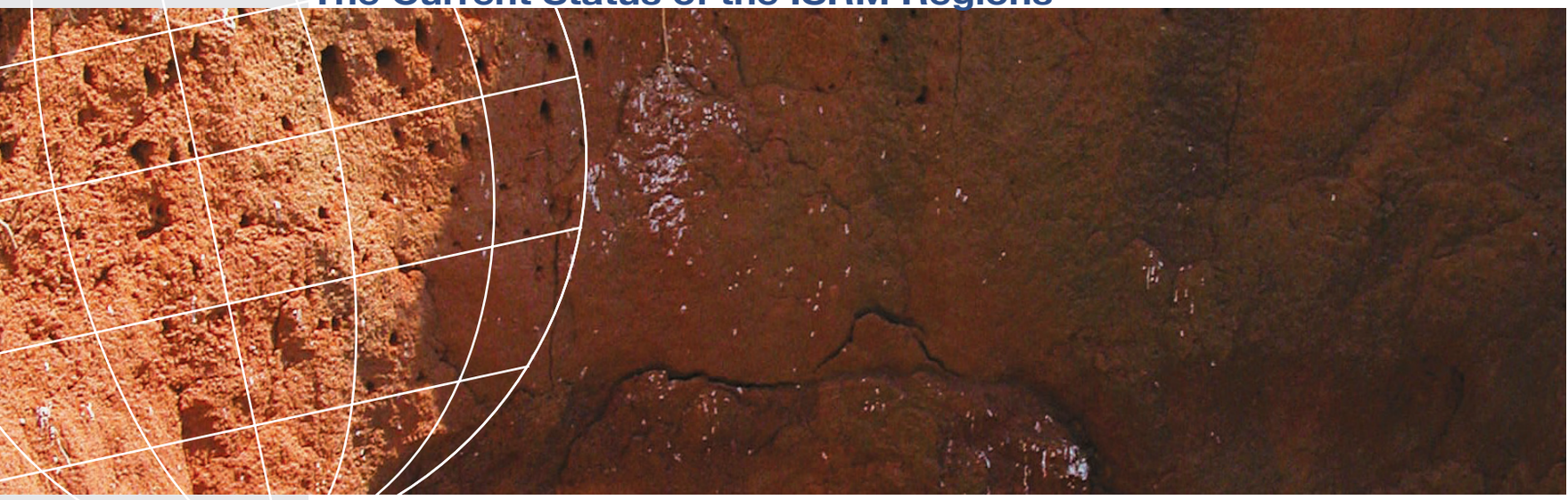
The opportunities include:
– A rapidly growing body of rock engineers, especially in developing countries;
– Rapidly growing demand for professional rock mechanics engineers;
– Resource challenges, such as diminishing grade and increasing depth are extremely difficult technical problems, but the need to solve them calls for leadership and the ISRM will grow by providing it. The ISRM can have a positive impact by executing our key goals of promoting collaboration and progress in rock mechanics;
– Active National Groups and a strong interest from rock mechanics professionals, including non-ISRM members in collaboration;
– Convergence of technology across rock mechanics and related disciplines;
– Mining members have drifted away from the ISRM in some countries, but there are opportunities and mutual benefits in re-engaging them.

The 2011–2015 ISRM President has outlined a guiding principle for continuing modernisation efforts: "To make ISRM be even more REAP—Responsible, Effective, Attractive, and Publicly aware—through injecting proper dynamism". These principles of responsibility, effectiveness, awareness and service will guide all the modernisation initiatives.

The President has also identified several essential groups of modernisation tasks:
– improved benefits to members;
– communication;
– growth;
– technical relevancy;
– governance.

Successfully progressing each of these key areas is essential to meet the expected challenges and take advantage of the opportunities of the next four years. Together, improvements in these areas are the modernisation mission for 2011–2015. We will measure our success by our progress in each of these five areas ■

The Current Status of the ISRM Regions



CURRENT STATUS OF THE AFRICA REGION

Francois Malan

With mining being such an important component of the economic activity in Africa, it is expected that rock engineering activities will continue to feature prominently on the continent. Most of the ISRM members on the continent are mainly involved in the mining sector as relatively few large civil engineering projects are being undertaken. Occasionally some large civil engineering projects, which require significant rock engineering input, are nevertheless conducted. Examples of these are the Gautrain and the Lesotho Highlands Water scheme.

The worldwide shortage of geotechnical skills unfortunately also affects Africa detrimentally and the required rock engineering expertise in many African countries is imported on a temporary basis as required. The temporary nature of these positions implies that it is logistically difficult to establish and maintain national groups in many African countries. The South African National Group (SANIRE) nevertheless remains very active and is growing its membership base. The current thinking is that it may be better to form larger multi-national ISRM groups in Africa. SANIRE might possibly be used as a base for a Sub-Saharan ISRM group and they have now adopted the policy that all geotechnical engineers from other African countries are welcome to join their ranks.

The South African National Group has a proud history and it is worthwhile to give a brief overview of this history (copied from an article written by Prof Dick Stacey for the SANIRE website). SANIRE's predecessor, the South African National Group on Rock Mechanics (SANGORM) was formed in March 1969 through the efforts of Dick Bieniawski. It had an initial membership of six. At the time, the ISRM was in its infancy, but it had held its first international congress and it was encouraging the formation of national groups. SANGORM proved to be one of the stronger national groups, despite political challenges such as no South Africans being able to attend the second ISRM congress, held in Belgrade, Yugoslavia.

Regarding the involvement of other African countries, Prof. Stacey particularly remembers how hard SANGORM worked at being inclusive. For instance, the regional conferences in 1988 and 1990 were both held in Swaziland, to ensure that other African countries would feel welcome to attend. The 1990 regional conference was also the official international symposium for that year, and the ISRM held its official Board and Council meetings at the same time, boosting the number of international visitors. The strong tradition of technical evenings and site visits that SANIRE still honours was a feature of SANGORM right from the start.

Prof Stacey said: "One of the first meetings we held took place underground at the ERPM mine. We examined rock fracturing around the tunnel and peered into boreholes to see the dog earing. The equipment to project slides for the talk, presented by Neville Cook, came down the mine with us. It was a unique, hands-on opportunity for 30 to 40 people." Initially, the membership included many civil engineering members, several of them involved in tunnelling projects. However, when SANGORM gave

way to SANIRE, the focus shifted to mining rock mechanics and some of the civil engineering members were lost. However, SANIRE has rebuilt its membership and maintained a high international profile. Once South Africa was no longer considered a pariah state, SANIRE was able to host the ISRM's 10th International Congress in conjunction with the Southern African Institute of Mining and Metallurgy. It took place at the Sandton Convention Centre in 2003 and was a great success. Another noteworthy achievement is that Prof Nielen van der Merwe served a four-year term as President of the ISRM, for the 2003–2007 period.

Regarding the current status, a growing number of rock engineers from diverse backgrounds are joining SANIRE. The membership has reached a record total for the 2011 financial year and now exceeds 400. This includes all categories of membership. Associate membership has grown by far the most, as has been the case for the past two years. It appears as if the trend of emigration of skilled rock engineering personnel to other continents has now been reversed and a number of rock engineers have recently returned to the country. The distribution of SANIRE members by country shows that 85% of members are active in South Africa. Australia has attracted the most members outside South Africa. Surprisingly, the number of members active in the rest of Africa is low (2%) and it is planned to increase this in future.

An important development within SANGORM was the formation of regional branches which commenced with the Eastern Transvaal Branch in June 1981. This was followed by the Western Transvaal Branch in May 1983, the Orange Free State Branch in May 1984 and the PWV Branch in August 1987. This tradition is continued by SANIRE as these Branches encourage active participation from a large number of its members. Each branch typically organises a quarterly technical meeting and these meetings are well attended. SANIRE currently consists of seven branches, namely: the North West Branch, the Free State Branch, the Coalfields Branch, the Western Bushveld Branch, the Eastern Bushveld Branch, the Gauteng Branch, and an Open Pit Branch.

Regarding communication with members, the SANIRE website has become an important and frequently used communication tool during the last few years (www.sanire.co.za). Furthermore, the tradition of holding an annual SANIRE symposium has been maintained in the last few years. The 2010 symposium was held in Carletonville and had the interesting theme of "Shake rattle and roll". The symposium planned for 2011 has the theme "Back to Basics" and will be held in the Rustenburg area.

CURRENT STATUS OF THE ASIA REGION

Abdolhadi Ghazvinian

Asia has hosted many ancient civilizations throughout history, dating back for several millennia B.C. There are remains of prestigious giant ancient structures such as monuments (Persepolis), dams (the 2000 year old Amir Multipurpose Dam), water storage and water conveyance tunnels in rock, tunnels and ancient mining. Aqueducts (Ghanat/Kariz) were invented around six thousand years ago in ancient Persia for transferring the water from the deep aquifers to the surface and thence to living locations through underground galleries, of even 70 km long in some instances. This know-how was then propagated to other nations.

It is evident that the knowledge of Rock Mechanics and Engineering has been well employed in establishing such important and huge structures. Nevertheless, Rock Mechanics subsequently found its true identification through the formation of the International Society for Rock Mechanics (ISRM)

only fifty years ago. Under the banner of the ISRM, the Asian Groups have played a pivotal role in promoting the development of rock mechanics through the exchange of technical information and academic research among the members of the rock engineering profession in this continent.

The Chinese Society for Rock Mechanics and Engineering (CSRME) since its inception in Sep. 1979 has achieved great success in the field of rock mechanics and rock engineering. Being the largest National Group (NG) in Asia, it has, at the time of writing, 554 ISRM members. More than 20 International Symposia/Conferences have been organised by the ISRM NG of China and more than 400 domestic Symposia, including 11 National Congresses. Moreover, there are many other activities, such as the publication of the JRMGE journal, organising several lecture tours, a series of international consulting activities, and the award of the ISRM Rocha Medal to Dr Z.Z. Liang from China in 2008.

China has served the ISRM through Professor Tan Tjong Kie who was the Vice-President from 1983 to 1987, Dr Ou Chin-Der as Vice-President from 1995 to 1999, Professor Sun Jun as Vice-President at Large from 1995 to 1999, Professor Qian Qihu as Vice-President at Large from 2003 to 2007 and Professor Xia-Ting Feng as Vice-President at Large from 2007 to 2011 and now ISRM President for the 2011–2015 period following the 12th ISRM Congress held in Beijing in October 2011.

The Indian National Group of ISRM, a most active member in term of increase in membership has, at the time of writing, 438 members. This NG has the following major international activities on its record:

- ISRM International Symposium and 6th Asian Rock Mechanics Symposium "Advances in Rock Engineering", 23–27 October 2010, New Delhi;
- International Conference on "Accelerated Construction of Hydropower Projects", October 2003, Bhutan;
- ISRM Sponsored Regional Symposium on "Advancing Rock Mechanics Frontiers to Meet the Challenges of 21st Century", 24–27 September 2002, New Delhi;
- Workshop on Rock Mechanics and Tunnelling Techniques, September 2001, Kathmandu, Nepal;
- International Symposium on Rock Slopes, 7–11 December 1992, New Delhi.

The Indian NG has published a manual on rock mechanics. Dr A. Ghosh was presented with the ISRM Rocha Medal for his thesis. Also, India has served the ISRM through Professor T. Ramamurthy as Vice-President from 1987 to 1991.

The Iran National Group represented by the Iranian Society for Rock Mechanics (IRSRM) was established in the year 1999. Since its formation, the group has carried out various activities and plays a leading role in the Middle East/Persian Gulf Region in the field of rock mechanics and rock engineering. The main activities are summarised below:

- organised four national rock mechanics conferences and various state level conferences;
- organised successfully the ISRM International Symposium and 5th Asian Rock Mechanics Symposium in November, 2008;
- organised numerous Workshops at various levels and several lecture tours throughout the country;
- published newsletters in the English and Persian languages.

Iran has served the ISRM through Professor Abdolhadi Ghazvinian as Vice-President from 2007 to 2011.

The Korean National Group (KSRM) founded in 1981 has presently over 1200 local and 50 ISRM members. The group has been active and its performance is summarised below:

- every year, two national conferences are organised, in spring and in autumn;
- six issues of the KSRM Journal (also called 'Tunnels and Underground Space') are published each year;
- the group has hosted its first Asian Rock Mechanics Symposium (ARMS) in1997 and the 7th ARMS Symposium will be held in Korea in Oct, 2012. The Group has been active in holding regular meetings and exchange programmes with Japan and China.

Korea has served the ISRM through Professor Chung-In Lee as Vice-President from 1999 to 2003.

The Japanese Committee for Rock Mechanics (JCRM) was formed in 1964 and presently has 370 ISRM individual members and 44 corporate members. A brief overview of its activities is given below:

- more than four International Symposia/Conferences have been organised by the Japanese National Group and also several domestic Symposia have been held in Japan;
- since 2005, the JCRM has published electronic journals.

Japan has served the ISRM through Professor S. Sakurai as President from 1995 to 1999, Dr M. Yoshida as Vice-President from 1966 to 1970, Professor Y. Hiramatsu as Vice-President from 1974 to 1979, Dr M. Yoshida as Vice-President from 1979 to 1983, Professor S. Sakurai as Vice-President at Large from 1987 to 1991, Professor Koichi Sassa as Vice-President from 1991 to 1995 and Dr Satoshi Hibino as Vice-President from 1999 to 2003.

The Singapore Society of Rock Mechanics and Engineering Geology (SRMGE) was formed in 1998 and currently, with its 70 members, the group has grown along with the growth in rock mechanics activities in Singapore. This NG has been active in organising various activities, a summary of which is given below:

- in 2006, the SRMGE organised the 4th Asian Rock Mechanics Symposium held in Singapore;
- in 2009, the SRMGE organised the 9th International Conference on Discontinuous Deformation Analysis;
- the Society was the co-organiser of the ISRM 2011 International Congress on Rock Mechanics held in Beijing, and the organiser of the 13th International Conference of the Associated Research Centres for Urban Underground Space (ACUUS) in Singapore in November 2012;
- SRMGE has also conducted various Short Courses, Seminars and Workshops, in particular, a successful Workshop on Norwegian Tunnelling Technology during 17–18 Feb 2009.

Singapore has served the ISRM through Professor Jian Zhao as Vice-President from 2003 to 2007.

There are various other National Groups, such as Israel (Israel has served the ISRM through Professor B. Aisenstein as Vice-President from 1970 to 1974), Indonesia, Nepal and Indonesia, and the Regional Groups of South East Asia and the Middle East.

To summarise, it is pertinent to mention here that the field of rock mechanics and engineering has witnessed an increasing growth and development in the region for last two decades and it is expected that the same trend will continue as the need and importance is critically felt.

Tony Meyers

CURRENT STATUS OF THE AUSTRALASIA REGION

Background

The practice of rock mechanics in the region is continually evolving and contributing to improvements in the economic and safety aspects of mining and civil construction. Over the years, many of these contributions have provided benefits internationally. For example, in the early 1950s, research during the Snowy Mountains hydro-electric dam project demonstrated the effectiveness of, and principles behind, pattern rockbolting for tunnel support. The early 1960s saw significant advances in the use of hydraulic backfill for supporting mining stopes at the Mount Isa, Queensland, mine and CSA's mine at Cobar, New South Wales. The 1970s saw advances in the use of 7-strand cable bolts for supporting excavations in Broken Hill, New South Wales and, in the early 1980s, the birdcage cable bolt was first trialled at Mount Isa. Over the recent decade, there have been many developments including successful implementation and/or trials of:

- slope stability radar, for reducing the risk to persons working within large open-pits;
- photogrammetric techniques, to provide accurate data on rock mass structure and excavation profiles;
- automated programmable scaling machines with laser control, to provide accurate profiling of underground excavations;
- high-tensile strength flexible wire mesh and rockbolts, for use as primary ground support in underground mines; and
- advances in corrosion protection and *in situ* quality testing of rock mass reinforcement.

Over the past decade, other than the period of the 2007/2008 GFC, the mining industry in the region has been operating at full capacity. This activity has led to unprecedented demand for, and shortage of, rock mechanics professionals by mining and civil companies, consulting companies, regulators and suppliers. This shortage is expected to continue for the next decade as many practitioners reach retirement age and insufficient numbers of students with rock mechanics specialisations graduate from universities.

In Australasia, the universities offering rock mechanics education at undergraduate and/or postgraduate levels are as follows:

- School of Civil, Environmental and Mining Engineering, University of Adelaide, South Australia
- School of Science and Engineering, University of Ballarat, Victoria
- WA School of Mines affiliated with Curtin University, Western Australia
- Melbourne School of Engineering, University of Melbourne, Victoria
- School of Engineering, University of Newcastle, New South Wales
- School of Mining Engineering, University of New South Wales
- School of Mechanical and Mining Engineering, University of Queensland
- School of Civil and Resource Engineering, University of Western Australia
- School of Civil, Mining & Environmental Engineering, University of Wollongong, New South Wales.

In addition to these institutions, the Australian Centre for Geomechanics (ACG) and the East Australian Ground Control Group (EGCG) provide professional development for mining based rock mechanics practitioners. The ACG is associated with Curtin University, University of WA and CSIRO. Since the

ACG's inception in 1992, more than 6,500 mining rock mechanics professionals have attended at least one of the eight to ten formal events and courses held by the organisation each year. The EAGCG provides a forum for mining ground control practitioners to exchange ideas and disseminate information on ground control in an informal environment. The Group also provides a technical support network for isolated members. It achieves these goals by holding two, two-day, technical meetings each year at various mining centres or in nearby cities.

ISRM in Australasia

The ISRM is represented in Australia and New Zealand by the Australian Geomechanics Society (AGS) and the New Zealand Geotechnical Society (NZGS) respectively. In Australia, the AGS is affiliated with Engineers Australia (EA) and the Australasian Institute of Mining and Metallurgy (AusIMM). In New Zealand, the NZGS is affiliated with the Institution of Professional Engineers New Zealand (IPENZ). EA and IPENZ embrace all disciplines of engineering. AusIMM embraces mining and minerals related disciplines of engineering.

Approximately 60% of rock mechanics practitioners are involved predominantly in the mining industry. In Australia, EA and the AGS are often perceived as having a civil and/or soil mechanics focus rather than a mining and/or rock mechanics focus. Practitioners in the mining industry tend therefore to be members of AusIMM rather than EA. They may not therefore be members of the AGS and hence are not entitled to ISRM membership as a free benefit of AGS membership.

A further impediment to ISRM membership in Australia is that the annual cost of membership, via membership of the AGS, is significantly greater than it is in most other countries (allowing for purchasing power parity).

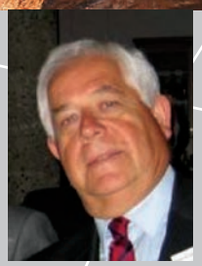
In spite of these challenges, the number of ISRM members in the region has increased by 8% p.a. during the term of the most recent Board (2007–2011). Australia and New Zealand now have 270 and 100 normal members respectively. However, for reasons noted above, ISRM members represent only a moderate proportion of rock mechanics practitioners in the region.

Challenges

The greatest challenges facing the ISRM in the region over the next decade will be to maintain its relevancy to rock mechanics practitioners, a large proportion of whom work in the mining industry. The Society must also aim to contribute to dialogue concerning:

- the establishment of a national mine safety framework, which aims to achieve a nationally consistent occupational health and safety regimen for the Australian mining industry;
- regulation and registration of mining geotechnical professionals; and
- the lack of civil and mining rock mechanics professionals in the region.

With the increased interest in ISRM membership over the term of the most recent Board, undoubtable the Society will continue to grow and remain as a significant contributor to rock mechanics activities in the region.



Nuno Grossmann

CURRENT STATUS OF THE EUROPE REGION

The current situation of Rock Mechanics in Europe may be assessed in different ways. If we consider the activities of the ISRM, we may list the following events which took place in Europe in the quadrennium 2007–2011:

- 2007 – 11th International Congress on Rock Mechanics (Lisbon Portugal, July);
- 2009 – Carrara Marble Quarries, the 1st Annual ISRM Technical and Cultural Field Trip (Italy, September);
- 2009 – EUROCK 2009, the European Regional Symposium on Rock Engineering in Difficult Ground Conditions – Soft Rocks and Karst (Cavtat (Dubrovnik) Croatia, October);
- 2010 – 3rd International Workshop on Rock Mechanics and Geo-Engineering in Volcanic Environments, the 1st ISRM-Sponsored Specialised Meeting (Puerto de la Cruz (Canary Islands) Spain, May–June);
- 2010 – Landslides in the Vaud and Freiburg Cantons, the 2nd Annual ISRM Technical and Cultural Field Trip (Switzerland, June);
- 2010 – EUROCK 2010, the European Regional Symposium on Rock Mechanics in Civil and Environmental Engineering (Lausanne, Switzerland, June).

To this list, we should add the two European meetings at which the 100th birthday of Prof. Leopold Müller, the 1st President of the ISRM, was remembered:

- 2008 – GKK 08 – Geomechanics Colloquium Karlsruhe (Karlsruhe, Germany, July);
- 2008 – 100 Years Leopold Müller – 40 Years ÖGG, the 57th Geomechanics Colloquy 2008 (Salzburg, Austria, October);

as well as the meeting for which the ISRM received a special invitation to be present:

- 2009 – Get Underground (Helsinki Finland, November).

For the quadrennium 2011–2015, the following events are already scheduled:

- 2012 – EUROCK 2012, the International Symposium on Rock Engineering and Technology for Sustainable Underground Construction (Stockholm, Sweden, May 28);
- 2013 – EUROCK 2013, the International Symposium on Rock Mechanics for Resources, Energy, and Environment (Wroclaw, Poland, September);
- 2014 – EUROCK 2014, the European Regional Symposium on Rock Engineering and Rock Mechanics: Structures in and on Rock Masses (Vigo, Spain, May).

If, further to all these quite diversified events, we recall that Europe, at the last ISRM Board elections (2011) had three candidates for the office of Vice-President, and that many European National Groups organise, on a regular basis, national meetings on rock mechanics, we come to the conclusion that the subject is currently very active in Europe.

If we now look at the specific activities that take place in the different European ISRM National Groups, as presented in the papers at the 12th International Congress on Rock Mechanics (Beijing, China, 2011), we obtain the following information:

- Austria concentrates its activities mainly on the organisation of the yearly Geomechanics Colloquy, which had its 60th meeting in 2011, attracts nearly 1,000 participants, and includes a large technical exhibition. The papers at the Beijing Congress dealt basically with issues related to tunnelling in hard and weak rock;

- Belgium presented papers on laboratory studies on weak rocks related to mining and environmental engineering issues;
- Croatia submitted a paper comparing the results of different types of rock mass deformability tests;
- The Czech Republic had papers on different mining related issues;
- Finland regularly organises rock mechanics meetings, usually in collaboration with other Nordic countries. The papers at the Beijing Congress dealt mainly with hard rocks, and were related to numerical modelling and high stress problems in tunnels and caverns;
- France also organises regularly rock mechanics meetings. 21 papers were presented at the Beijing Congress, on a wide variety of themes, including underground storage, mining, dams, soft rocks, hydromechanical analyses, etc;
- Germany holds its national rock mechanics meeting every two years. The 15 papers at the Beijing Congress dealt with many themes, including problems of radioactive waste disposal, tunnelling, thermohydromechanical analyses, seismic events, etc;
- Greece had papers on rockbolts, tunnels, and laboratory tests;
- Italy submitted papers on slope stability, tunnelling, and mining;
- Netherlands presented a paper on rockfill properties;
- Norway had papers on tunnelling in high stress conditions, rock support, and seismic issues.;
- Poland submitted papers on laboratory tests and stochastic problems;
- Portugal organises regularly geotechnical meetings, many of them including rock mechanics issues. 12 papers were presented at the Beijing Congress, on a wide variety of themes, including building stones, rock mass characterisation, dynamic problems, CO2 storage, foundations, caverns, and dam engineering;
- Russia had papers on many different subjects, including dam engineering, petroleum engineering, as well as more theoretical subjects.;
- Slovenia presented a paper on tunnelling;
- Spain regularly organises rock mechanics meetings. The 17 papers at the Beijing Congress dealt with a great variety of themes, including volcanic rocks, tunnelling, foundations, laboratory tests, open pit and underground mining, etc;
- Sweden submitted 12 papers, mainly related to issues of nuclear waste repositories, but also to laser scanning, train vibrations, CO2 injection, mining, etc;
- Switzerland presented 16 papers at the Beijing Congress, dealing mainly with dynamic issues, but also with deep tunnels, numerical methods, dam stability, etc;
- Turkey had papers on blast-induced vibrations, underground caverns, and tunnelling;
- The UK submitted papers on both theoretical and practical issues, mainly connected with underground research laboratories;
- Finally, there were two papers from Luxemburg and Ukraine, which do not have an ISRM National Group;
- Denmark, Serbia, and Slovakia did not present any papers, and the same happened with the former ISRM NGs from Hungary and Iceland.

We may conclude that the issues related to the underground disposal of radioactive waste continue to be of paramount importance in the field of rock mechanics, in spite of all the efforts that have already been invested in the previous decennia. The existence of several specific underground research facilities, in different countries, will certainly provide new insights in the coming years.

Another area of great interest relates to the numerous underground works for the European transportation networks which are being built or still in the planning phase. The number of papers concerning their safety issues, calculation procedures, support measures, etc. attest to this fact. The return of issues related with dam engineering must also be emphasised, a subject which had been godfather to the creation of rock mechanics. Mining and petroleum engineering problems were also dealt with at the Beijing Congress, showing that Europe did not close totally its raw-material provisioning. Finally, a mention should be made of the strong increase in the studies related to dynamic issues, such as earthquakes, blasting, and other human-induced vibrations.

Thus, Europe demonstrates a continuing development in rock engineering projects, in spite of the adverse economic situation. Therefore, I should like to express my feeling that the activity in the field of rock mechanics in Europe is currently quite satisfactory and has a very positive outlook.

CURRENT STATUS OF THE NORTH AMERICA REGION

Derek Martin

There was a great deal of early rock engineering conducted during the infrastructural development of both Canada and the United States. In Canada, one outstanding example is the Canadian Pacific Railway's transcontinental construction stretching from eastern Canada to British Columbia which was completed in 1885, the railway being at that time the longest in the world. In the United States, the 1930s construction of the 221m high Hoover Dam on the Colorado River in Black Canyon at the Arizona–Nevada border is an excellent example of 'pre-modern day' rock engineering construction. These and many other major projects were constructed in the days before there was any attempt to co-ordinate rock mechanics and rock engineering information on the national and international scales.

However, today we are fortunate in the North American continent in having two active national groups: the American Rock Mechanics Association (ARMA); and the Canadian Rock Mechanics Association (CARMA). Both of these are affiliated with the international ISRM. In this article, a summary of both these Associations is provided.

ARMA Activities (United States)

The American Rock Mechanics Association (ARMA), the US National Group in ISRM, continues to grow and diversify. Currently at close to 500 members, ARMA holds annual US rock mechanics/geomechanics symposia. In June 2011, ARMA organised its 45th US Rock Mechanics/Geomechanics Symposium in San Francisco. Almost 280 podium or poster presentations were delivered to over 500 participants who hailed from 37 different nations. At the time of writing, the next ARMA Symposium will be the 46th and will be held in Chicago in June 2012.

In 2008, ARMA inaugurated an ARMA Fellows programme to recognise distinguished members of the profession. To date, there are 17 ARMA Fellows.

ARMA's digital library, run in conjunction through SPE's One Petro system (as is the overall ISRM digital library), provides an electronic resource for all to access 55 years of US rock mechanics proceedings. ARMA was one of the first outside organisations to join SPE's OnePetro digital library, ARMA currently having about 3,500 papers included in the OnePetro website. During 2010, more than three million papers were downloaded from OnePetro by all the website's participating members.

The ISRM President from 1970–1974 was L. Obert and from 1991–1995 it was C. Fairhurst, both of the United States. Over the years, ISRM Board members from the USA have been D.U. Deere, W. Judd, J. Handin, T.C. Atchison, J. Coulson, H.H. Einstein, F. Heuzé and J. Tinucci.

CARMA Activities (Canada)

The Canadian Rock Mechanics Association (CARMA) serves as 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). A combined total of 269 CIM and CGS members paid for ISRM membership in 2011.

In 2012, the 21st Canadian Rock Mechanics Symposium in conjunction with the CIM Annual Conference and Exhibition, will be held on May 5–9 at the Westin Edmonton Hotel, Edmonton, Alberta, Canada. The theme of this symposium, "Rock Engineering for Natural Resources", was chosen with the objective of developing a better understanding of the rock mechanics-related challenges encountered during the development of mineral deposits, hydrocarbons, and alternative energy sources.

Following the 6th ISRM Congress held in Montreal in 1987, CARMA will be hosting the 13th ISRM Congress in 2015 again in Montreal. This Congress will be chaired by Dr Ferri Hassani of McGill University and has the support of ARMA, Canadian industry, the Federal Government of Canada, the Provincial Government of Quebec, and of academia from across Canada.

The ISRM President from 1987–1991 was J.A. Franklin of Canada. Over the years, ISRM Board members from Canada have been D.F. Coates, P.K. Kaiser and D. Martin.

CURRENT STATUS OF THE SOUTH AMERICA REGION

Alvaro J. González-García

Rock mechanics development in the South American region was in the beginning mainly associated with mining, railway, dam and roadway engineering. Due to significant reserves of gas and oil in some of the countries in the region, like Venezuela, Brazil, Ecuador, Bolivia and Colombia, rock mechanics activities as related to oil engineering have shown an increase in recent years.

ISRM National Groups and Members

In October 2011, the ISRM South American Region has 9 National Groups, 224 ordinary members, 34 corresponding members and 1 corporate member from Peru. Of the National Groups, only Chile, Peru and Bolivia do not have a website.

Most ISRM national groups in South America are merged with the National Geotechnical Societies and only Brazil has a Rock Mechanics Committee (as well as a Tunnelling Committee) and Paraguay a Rock Mechanics Vice-Presidency. From the economic viewpoint, this merging is a worldwide common and somewhat desirable feature for small National Groups but it does not easily allow separation of the rock mechanics activities from general geotechnical activities.

Country	ISRM Group Name	Acronym	Members
Argentina	Sociedad Argentina de Ingeniería Geotécnica	SAIG	8
Bolivia (*)	Asociación Boliviana de Geomecánica	BAG	22
Brazil	Associação Brasileira de Mecânica dos Solos e Engenharia Geotécnica	ABMS	104
Chile (*)	Chile ISRM National Group	–	14
Colombia	Sociedad Colombiana de Geotecnia	SCG	20
Costa Rica	Asociación Costarricense de Geotecnia	ACG	14
Paraguay	Sociedad Paraguaya de Geotecnia	SPG	6
Peru (*)	Sociedad Peruana de Geoingeniería	SPEG	25
Venezuela	Sociedad Venezolana de Geotecnia	SVDG	11
	SOUTH AMERICA TOTAL		224

Independent NG groups (*) have been recently created in Chile, Perú and Bolivia, all three countries with intense mining industry, and the newly formed groups belong mainly to the mining professions.

ISRM Vice-Presidents

1966–1970	Prof. A. Costa Nunes	Brazil
1970–1974	Prof. Victor F.B. de Mello	Brazil
1974–1979	Prof. Milton Kanji	Brazil
1979–1983	Prof. Orestes Moretto	Argentina
1983–1987	Prof. Fernando Tinoco	Venezuela
1987–1991	Prof. Dinis da Gama	Brazil
1987–1991	Prof. Tarcísio Celestino (at-large)	Brazil
1991–1995	Dr Oscar Vardé	Argentina
1995–1999	Prof. M. Van Sint Jan	Chile
1999–2003	Prof. Eurípedes Vargas	Brazil
2003–2007	Dr Eda F. Quadros	Brazil
2007–2011	Prof. Alvaro J. González	Colombia
2011–2015	Dr Antonio Samaniego A.	Perú

There has not been an ISRM President from South America.

Regional Activities

The main South American Rock Mechanics activities are the South American Rock Mechanics Congress and the South American Rock Mechanics Symposium, of which their first versions of both events were held in Colombia, the Congress in 1982 and the Symposium in 2008.

South American Rock Mechanics Congresses

I	November, 1982	Bogotá, Colombia
II	October, 1986	Porto Alegre, Brazil
III	October, 1990	Caracas, Venezuela
IV	May, 1994	Santiago, Chile
V	November, 1998	Santos, Brazil
VI	October, 2006	Cartagena, Colombia
VII	December, 2010	Lima, Peru.
VIII	2015	Buenos Aires, Argentina

Peru organised the VII South American Rock Mechanics Congress, held from December 2nd to 4th, 2010 in the Sheraton Hotel of Lima, as a Regional ISRM event. The main lecturers were Prof. Evert Hoek, Prof. John Hudson, Prof. Xia-Ting Feng, Dr Nick Barton, Dr Carlos Carranza-Torres, Dr Tarsicio Celestino, Dr David Wood and Dr Rimas Palkanis. There was also the oral presentations of 38 papers, mainly from Peru and South America, but also from outside the region. The event was preceded by three short courses. A post-event 3-day technical tour was organised to the Cerro Verde Mining Field near Arequipa; and there was also a technical Exhibition with around 20 stands. More than 450 people attended the Congress.

One day before the event, the South American ISRM Council met. Dr Antonio Samaniego from Peru was elected as candidate for the next Vice-Presidency, Argentine was selected to organise the VIII South American Congress in 2015, and Costa Rica was assigned to hold the II South American Symposium in 2012.

Activities of the National Groups

The Argentinian Society of Geotechnical Engineering (SAIG), the ISRM NG group, routinely holds the Argentinian Congress on Soil Mechanics and Geotechnical Engineering, which includes Rock Mechanics. The last one, CAMSIG-2010, the 20th one, was held from October 6th to 9th, 2010, in Mendoza.

In Brazil, several geotechnical events are organised by ABMS (NG-Brazil). In this period, there were two short courses on Rock Slope Engineering (R. de Janeiro, São Paulo - Sep, 2011). There will be two Workshops: Underground Works (Rio de Janeiro - Nov. 24th, 2011); and Underground Storage, within the 3rd Brazilian Congress on Tunnels and Underground Structures (20–22 March, 2012 - São Paulo).

There are several rock mechanics events in Chile. The Chilean Catholic University organised the 5th International Seminar on Deep and High Stress Mining 2010 from 6th to 8th October, 2010.

The Colombian NG (SCG) organises several regular geotechnical events, the last ones being the XIII Colombian Geotechnical Congress and the VII Colombian Geotechnical Seminar, the second one being dedicated to Mining Geotechnics, from 21st to 25th September, 2010, in the city of Manizales.

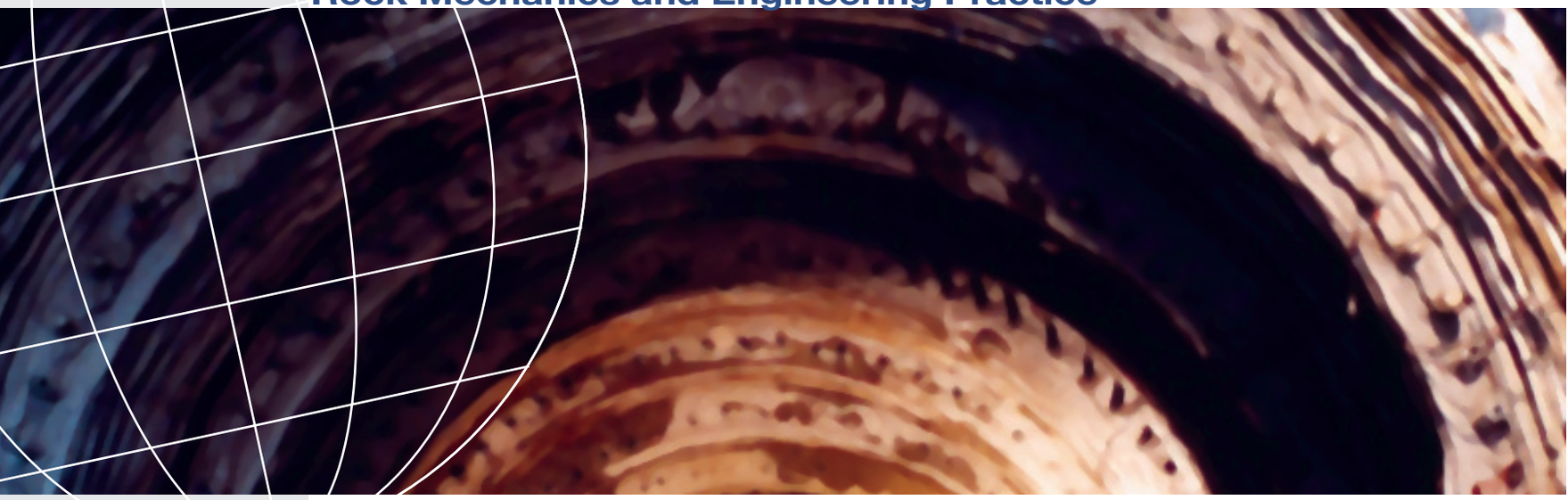
The Costa Rican Geotechnical Association (ACG), the ISRM NG, organises periodic local lectures and meetings on rock mechanics. It will hold the II South American Symposium in 2012.

Paraguay: The Paraguayan NG (Sociedad Paraguaya de Geotecnia-SPG), which has a Rock Mechanics Vice-Presidency, had a Lecture Series on the Weak Rocks and Indurated Soils of Paraguay.

The Peruvian NG (Sociedad Peruana de Geoingeniería-SPEG), in association with the Peru Mining Engineering Institute (IIMP), organises several events in mining and rock mechanics.

Venezuela: The Venezuelan NG (SVG) organises several geotechnical meetings, the most recent one at the time of writing being the 19th Venezuelan Geotechnical Seminar, from 28th to 30th October, 2010, in Caracas ■

Rock Mechanics and Engineering Practice



Pierre Habib

Marc Panet

INTRODUCTION

The study of rock behaviour is much older than fifty years. For a long time before the birth of the International Society of Rock Mechanics, scientists researched explanations for the tectonic deformations of rock masses, and mining engineers looked for the optimisation of the modes of excavation and of the types of support for underground openings. But, as explained in earlier Chapters, the creation of the International Society for Rock Mechanics was the expression of the need to increase the knowledge in the field of rock mechanics and the will to create greater co-operation between many countries. The memorable First Congress of Rock Mechanics in Lisbon in 1966 remains a landmark and may be considered as a reference to evaluate the progress that has been brought about by rock mechanics to engineering activities since the time of this Congress. In this Chapter, we will make some summary remarks concerning the progress in rock mechanics and rock engineering.

KEY PROGRESS IN ROCK MECHANICS

For engineers, the main progress can be summarised as follows.

- There is now a common language to describe rocks and rock masses;
- A clear distinction between two scales has been established: the scale of rock samples which can be tested in the laboratory; and the rock mass scale which is that of most engineering works and which must take into account the presence of various discontinuities;
- Several rock mass classification schemes have been introduced. These classifications are different but they are based on the same type of parameters: the rock resistance, the discontinuity index RQD, the characteristics of discontinuities, the hydraulic conditions, and the *in situ* state of stress. Though disputed when they are extended to directly indicate engineering solutions, rock mass classifications are used worldwide. They help in preliminary design and they have brought about a codified description of rock masses. In particular, they have proved to be very useful in contractual disputes where there have been changes in the geological conditions;
- Many rock mechanics tests have been standardised. The relatively recent 'Blue Book' of ISRM Suggested Methods for example is a very useful reference;
- Numerical models have been developed (e.g. finite elements, finite differences, block models) and have significantly assisted in the methodology of design through enabling the analyses of various bi-dimensional or tri-dimensional situations, the introduction of complex laws for rock behaviour and of the discontinuous nature of rock masses. Consequently, the large physical models made previously in specialised laboratories and the large *in situ* tests used mainly for dam design have almost disappeared;
- Monitoring techniques, which are a necessary complement to numerical models and observational methods, have developed significantly.

ROCK ENGINEERING DESIGN AND CONSTRUCTION

Rock Mechanics has also contributed to important improvements in the design of various works founded on or excavated within rock masses, such as dams and tunnels, but also in mining engineering and oil exploitation. In the middle of the last century, the occurrence of dramatic events, such as the failure of the Malpasset Dam in France (1959), Figure 1, and the slide of the Mont Toc hillside in the Vajont Dam reservoir in Italy (1963), was a shock for all engineers involved in dam design. In the following years, many research centres, laboratories and engineering companies developed important programmes of research to develop a better understanding of the mechanisms involved in these failures in order to design safer structures.

Figure 1. The Malpasset Dam Failure: left, the rock failure on the left bank abutment; right, the large fissure along the upstream abutment on the right bank

The main improvements were to take into account:

- the stress distribution in a discontinuous rock mass, and
- the permeability variations with the state of stress in the foundations of a dam.

New programmes of stability introducing the rock mass discontinuities and the hydrostatic pressures in the discontinuities were introduced. The design of grouted watertight sheets and drainage in the dam foundations were improved.

In the last decades, large changes have also occurred in tunnel construction. New types of primary support, shotcrete and rockbolts, have modified the traditional mode of excavation. Tunnel boring machines are now commonly used in rock and allow rates of advance unforeseen some decades ago. Different methods have been carried out to predict the rate of penetration and the wear of the discs and cutters. In fact, most advances in tunnelling construction stem from research in rock mechanics and were later extended for soil formations. Better understanding of the interaction between the ground and the support close to the face of excavation was a major step for the design of tunnels. The monitoring of the rock displacements behind the excavation face (convergence, and more recently ahead of the face of excavation, expansion) are now considered as customary tools for application of the observational method—in order to adapt the mode of excavation and the support to the actual conditions met during construction.

Also, much progress has been achieved in the technology and the understanding of the behaviour of various types of support, such as rockbolts and shotcrete. However, the final lining design of the tunnel is dependent on the long-term rock deformations. Much research in the laboratory and in the field has been conduced with a view to forecasting the final loading of the lining. Although viscoplastic deformation laws are being increasingly introduced in numerical models, the different loadings on the tunnel lining is still a matter for further research.

Many underground openings have been excavated at great depth where some particular difficulties may be encountered, such as large convergence in squeezing rocks (Figure 2), or large inflows of water, or slabbing (Figure 3) and rockbursting (Figure 4). In brittle rocks, the compressive stresses in the wall of the underground opening may initiate fractures parallel to the walls to produce slabs. The conditions of the initiation of this slabbing are now understood and can be predicted. In some cases, the rock slabs may burst violently. This rockbursting phenomenon is to be compared with the instability of a brittle rock sample loaded in compression in the laboratory by a soft testing machine. However the conditions of the instability of the slabs at the walls of a tunnel after their formation have not yet been fully established.

Very large convergences may occur when tunnelling at great depth in squeezing rocks. Numerical models introducing viscoplastic rock mass behaviour and semi-empirical laws for convergence may help to analyse and predict this behaviour. The choice of the primary support must deal with these large convergences that increase as the distance to the excavation face increases, and with time. Various devices installed in the primary support help prevent its failure.

Figure 2. Very large convergence during the excavation of the Saint Martin la Porte adit for the project of the Lyon-Torino railway project

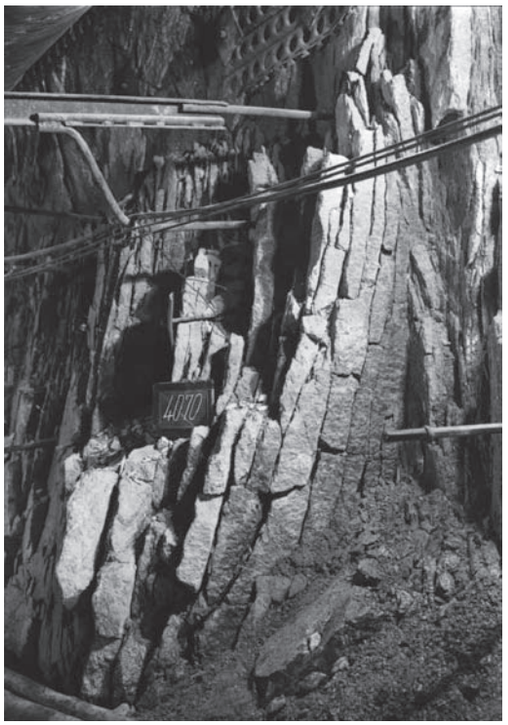


Figure 3. Slabbing in the Mont Blanc Tunnel

Figure 4. Heavy rockbursting in the Mont Blanc tunnel

Oil production has taken advantage of the improvements in porous rock mechanics and in rock hydrofracturing. The development of geothermal energy in hot rocks may also benefit from these improvements. However the cost of development may hinder its future.

Important research programmes were initiated for new, sophisticated processes of rock comminution—such as using lasers and high pressure jets—but they have not yet found any significant practical development.

The study of radioactive waste disposal underground at significant depth in salt, argillite or granitic rocks has been and is still a challenge for the rock mechanics community. It has, however, provided the opportunity to undertake important research in well-equipped underground laboratories and has developed numerical models coupling thermo-hydro-mechanical phenomena.

For the future, we may forecast that new results obtained by the current rock mechanics research will continue to bring about important improvements for engineering projects ■

Collaboration Between the Geo-Engineering Sister Societies

Nielen van der Merwe

In the broad field of geo-engineering, there are currently three learned Societies with separate but related areas of activity, commonly referred to as the 'Sister Societies'. They are the International Society for Engineering Geology and the Environment (IAEG), the International Society for Rock Mechanics (ISRM), and the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE).

The ISSMGE is the oldest: its origins date back to 1936 when the first International Conference on Soil Mechanics and Dam Foundations was held in the United States. There does not appear to be a single moment when it was formalised as a Society, but by 1957 the international conference was so well established that it had a permanent Secretariat and a Board and functioned as a Society. Today, it is also the largest of the three Societies with approximately 18,000 members and the primary focus being on soil mechanics.

The ISRM was created in 1962 through the expansion of the Salzburger Kreis, an informal discussion group on rock mechanics. The person behind the creation of the Society was the Austrian engineer Leopold Müller, who initially studied music but later switched to civil engineering at the same time as one of his fellow matriculants, Herbert von Karajan, reciprocally switched from studying engineering to music and later became one of the world's greatest conductors. The ISRM now has approximately 6,500 members who are primarily active in rock mechanics and rock engineering.

In 1964, the IAEG was created with largely similar areas of activity as the other two, but more from a geological perspective. The IAEG is of similar size as the ISRM.

A simplified description of the fields of activity is that the ISRM focuses on strong rocks, the ISSMGE on soil and weaker rocks, while the IAEG straddles the two, but more from a geological than engineering perspective. In many countries of the world, geo-engineering practitioners have a single national Society with individual members belonging to different international bodies.

Due to the large overlaps in the fields of activity of the three Geotechnical Sister Societies, possible unification or collaboration was discussed intermittently from the 1960s. In 1973, as a result of the effort of Prof. Edward De Beer from Belgium, and with financial support from the Belgian Government, a Permanent Co-ordinating Secretariat (PCS) was created to co-ordinate the activities of the ISSMFE, the IAEG and the ISRM, and its statutes were approved by the three Societies. The officers were Prof. De Beer (Secretary) and the three Secretaries-General of the Societies. Yearly meetings took place in Brussels, and the most relevant achievements of this Co-ordinating Secretariat were the establishment of some joint Commissions and avoiding overlapping of scientific activities and clashing of conferences. Prof. De Beer ran the meetings until 1991 but, after his departure, the committee gradually faded and ceased to be operational. The last meeting of the PCS took place in 1995.

Collaboration Between the Geo-Engineering Sister Societies

The idea of collaboration was strongly revived in the final years of the previous millennium, resulting in the joint GeoEng Conference in Australia. After that successful venture, the three Societies formed the Joint European Working Group (JEWG) in 2002, that described the professional competencies of engineering geologists and geotechnical engineers, as well as their fields of activity, thus indicating the areas of overlap. Although the investigation focused on Europe, the outcomes were largely valid for the world.

The next formal step was taken in January 2004, when the Presidents of the three Societies (Niek Rengers of the IAEG, Nielen van der Merwe of the ISRM, and William van Impe of the ISSMGE) and their Secretaries-General (Luis Lamas of the ISRM, Michel Deveughèle of the IAEG and Neil Taylor of the ISSMGE) met in Lisbon, with the specific aim of deciding whether or not collaboration should be pursued, and if so, in what manner. The outcome of these deliberations was that all three Societies supported collaboration. At the one extreme, the notion of full integration was discussed and rejected as the Societies were considered to be sufficiently specialised to warrant the existence of separate Societies. At the other extreme, the idea of merely recreating the committee of Secretaries-General to co-ordinate major conferences was also rejected, as the Societies were considered to be sufficiently similar to warrant stronger collaboration.

The extent of the collaboration and the manner in which it should be done was considered to be both sensitive and too complex to be discussed at a single meeting. It was decided at the meeting to set up a Joint Task Force (JTF), consisting of representatives of all three Societies, to investigate the best way in which the desired collaboration could be achieved.

Often minutes of meetings reflect important statements and decisions, but seldom the underlying issues that have important bearing on decisions. In this case, the underlying fear was that the new organisation could result in domination of one or more by the others. It was important that the people involved in discussions of this nature had to build mutual personal trust in one another if any measure of success was to be achieved. In this case, it did happen: the negotiations were always open and honest, sometimes lively, but never bitter and personal.

It was decided to proceed with caution and for each Society to obtain the approval of their respective Councils at each milestone. It was realised that this would delay matters, as the dates of the Council meetings were not synchronised and that, while the ISRM and IAEG had annual Council meetings, the ISSMGE Council only met every second year.

In the meanwhile, as there was nothing in the statutes of any of the Societies that prevented informal collaboration, it was decided to continue with the formation of inter-Society Commissions, called Joint Technical Committees (JTCs) to investigate matters of common interest, such as education and landslides.

The brief to the Joint Task Force was then to advise the committee of Presidents concerning the manner of collaboration with the proviso that the new organisation should guarantee the autonomy of all three, yet be strong enough to represent all three with a single voice on occasions where the broader geo-engineering field of activity was to be represented. The JTF was expected to provide a preliminary report by July 2004 and to be finalised following comments from the Presidents by the end of 2004.

The ISRM representatives on the JTF were Marc Panet (Past-President), Luis Ribeiro e Sousa, Claus Erichsen and Luis Lamas. The Chairpersons of the JTF were Harry Poulos and Paul Marinos, who happened to belong to all three Sister Societies. The JTF met in Athens in June 2004. The members used the report of the JEWG as a starting point. They supported the view of the Presidents, concluding as follows:

> *"There was unanimous agreement that, regardless of the structure of the Federation, there would be two unwavering principles that would be adhered to:*
> 1. *The Federation should advance the broad field of geo-engineering;*
> 2. *The character of the individual Societies should not be altered, and each Society should retain its autonomy. In other words, each of the participating Societies would still continue to represent its members in the appropriate specialist areas, and would continue to hold its own conferences and seminars etc., but would do so within an underlying spirit of co-operation with other member Societies within the Federation."*

They suggested the following fields of collaboration:
- the promotion of the geo-engineering profession;
- relevant technical issues, for which Joint Technical Committees or Commissions would be formed;
- education in geo-engineering;
- the development of jointly-sponsored conferences; and
- other initiatives of co-operation (publications, awards).

The JTF recommended that there should be a Board consisting of two representatives from each Society plus their Secretaries-General and a President, to be elected from outside the Board and that meetings should be held annually while bi-annual meetings could be required in the formative stages. The final report by the JTF was accepted with minor changes by the meeting of Presidents in Ghent in February 2005; they then compiled a summary to serve as a document outlining the principles for the creation of the Federation. The most important change to the proposal of the JTF was that the President of the Federation could be elected either from outside the current Board or from one of the past presidents of the Sister Societies, but that it should not be one of the current Presidents.

The ISRM Council accepted the creation of the Federation and mandated the President to proceed with negotiations against the background of the statement of principles at the Council meeting held in Brno in May 2005. The IAEG Council decided similarly, also in May 2005; the ISSMGE accepted the principle in September 2005.

The Presidents then met again in Orly, France, in November 2005 to take the matter forward. By this time, the ISSMGE had undergone a leadership change with Pedro Seco e Pinto replacing William van Impe as President, the latter continuing to be a member of the meeting of Presidents in order to retain continuity. At this meeting, it was decided to take the vital next step of drafting the constitution of the Federation based on the accepted principles. An associated committee was formed and headed by Niek Rengers, then President of the IAEG, who chair the committee and he was to be assisted by the three Secretaries-General.

A schedule was agreed upon that would result in the final proposal of the statutes to be ready for final consideration of the three Councils by mid 2006, following a number of iterations. As both the ISRM

and IAEG had Council meetings in 2006, they could then approve the constitution, while approval by the ISSMGE could only be obtained at their next Council meeting in 2007.

The number of JTC's had by now increased to ten. Not all were active and in retrospect, not all were created for the right reasons. The desire to settle the Federation was then so strong that some JTC's were registered merely to have a large number of them.

At this point, an unresolved legal issue arose. If the Federation was to be formalised as a Society, it had to be registered, but in which country? There were also tax implications and a host of other statutory difficulties. It was decided to continue on an informal basis with the costs being managed as a separate account by the Sister Societies on a rotational basis. The ISSMGE would be the first host of the finances.

It was foreseen that the initial costs would be borne on an equal basis by the three Sister Societies, but that in a short time the Federation would be self-funding via donations and fees from a Liaison Committee. In essence, the Liaison Committee would consist of large international corporations who would give guidance to the Federation as to which developments in the geo-engineering sphere were required and also to serve as the industrial guidance body to the Federation. There were to be annual meetings of the Liaison Committee attended by the Federation Board. The income from the Liaison Committee would be used to cover the costs of the Federation and also finance the workings of the JTC's, something which none of the individual Societies had so far been able to do.

The name of the Federation would be the Federation of International Geo-Engineering Societies, with the acronym FIGS. That was later changed to FedIGS when it was discovered that FIGS had an unfortunate connotation in the language of one of the member Societies. In January, 2006, the ISRM Board had a mammoth extraordinary meeting in Lisbon, *inter alia* to discuss the FedIGS Terms of Agreement in detail. This was done literally word for word and in the end the Board proposed a number of minor changes. In May, 2006, the constituent Presidents met in Amsterdam to discuss and approve the final version of the statutes, which by now had been renamed as Terms of Agreement, because there was not yet a Society ready for registration in any specific country. At this meeting, the ISRM proposals were accepted.

The Council of the IAEG was the first to approve the Terms of Agreement in Nottingham, UK, in July 2006. The ISRM Council followed suit in November 2006 in Singapore, with a unanimous vote. As there was no ISSMGE Council meeting in 2006, the final step had to be delayed to their next meeting in November 2007.

The Presidents met again in January 2007 in Lisbon. By this time, the Board was almost fully functional with the exception that the envisaged Liaison Committee could not yet be formed and the meetings were chaired on a rotational basis by the presidents of the Sister Societies. While this *modus operandi* allowed co-operation to be achieved, it could not facilitate the fulfilment of one of the important roles of the Federation, namely the advancement and representation of the broad geo-engineering science, as there was no figurehead and not sufficient continuity.

At this meeting, the Board composition underwent a further change, with Fred Baynes replacing Niek Rengers as President of the IAEG. Niek Rengers continued to be a Board member, in line with the yet to be finalised constitution according to which each Society would be represented by its President and

Immediate Past-President. Each time a new Board member entered the arena, there was a slight loss of momentum as the new member first had to be familiarised with the events of the past. Yet, even so, remarkably little time was lost, mainly due to the continuity afforded by the continued presence of the Past-Presidents.

The ISSMGE Council was the last to approve the Terms of Agreement at their meeting in Australia in November 2007. By the end of 2007, all three sister Societies had approved the Terms of Agreement and FedIGS could eventually be formally created. This happened in January 2008 at a meeting in London, UK. At this meeting, John Hudson replaced Nielen van der Merwe as the President of the ISRM, the latter remaining on the Board as Past President. According to the Terms of Agreement, the President of FedIGS was to be elected by the Board by secret ballot. However, there was an objection to the election because one of the candidates, William van Impe, was in an advantageous position relative to the other candidate being present in the room where the election was held.

The election was then postponed for a period of four weeks and took place by postal ballot. Niek Rengers was elected as the caretaker President to maintain the existence of the Federation and to officiate over the election. After this delay, William van Impe was elected as the first official President of FedIGS. From the beginning of the discussions to create FedIGS, he played a leading role. He was the driver behind the creation of the JTC's and the long term vision of the Federation. While practitioners in the different Societies have a reasonable view of their specific areas of activity and expertise (even if they are seldom aware of the commonalities), the same cannot be said of the general public or the decision makers who tended to regard all members of the Societies as geologists and were not aware of the engineering aspects of the sciences. William van Impe had the vision to change that and to involve the major private corporations as well as governments in order to raise awareness and provide funding for joint investigations.

In October 2009, the first meeting of the Liaison Committee took place in Antwerp, Belgium, with the first three Liaison Committee members. This was followed by a FedIGS Board meeting in Ghent the following day, which was also Jean-Louis Briaud's first meeting, he having replaced Pedro Seco e Pinto as President of the ISSMGE. At this Board meeting, it was decided that the income from the Liaison Committee was sufficient to cancel the subscription fees from the three sister Societies.

Early in 2010, a major change occurred. The three sitting Presidents of the Sister Societies, Fred Baynes of the IAEG, John Hudson of the ISRM, and Jean-Louis Briaud of the ISSMGE, felt that FedIGS was going too far too soon and was becoming inherently cumbersome and functionally inflexible; so they insisted on a substantially reduced level of activity. As a result, the number of JTC's was reduced to three and the Liaison Committee was disbanded. Funds that had been received from the Liaison Committee members were refunded to them. William van Impe resigned as President. At the meeting in London in May 2010, the Board accepted William van Impe's resignation and Nielen van der Merwe was elected as Chairperson of the Board. At that stage, it was believed that changes to the Terms of Agreement were required to accommodate the reduced activity.

However, in May 2011 at the next Board meeting in Rome, it was seen after careful scrutiny, that the changes could be accommodated without going the full route of approval by the three Councils. The Terms of Agreement were sufficiently flexible to accommodate a lower level of collaboration and, by not changing them, the door was left open to increase that level again in the future if the Sister

Societies so desired. The first potential enlargement of the Federation also occurred at that meeting, with an application by the International Society for Geosynthetics to join as a member.

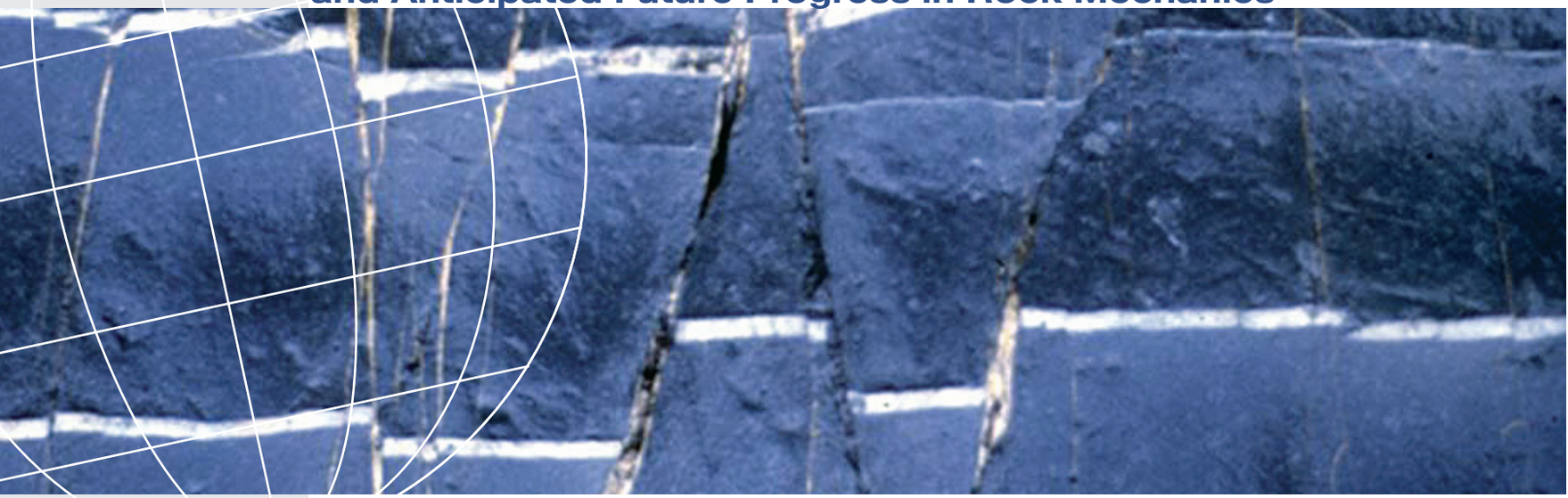
At that meeting, the ISSMGE invited discussion on a proposal to change their name to the International Society for Geotechnical Engineering. The other members objected, arguing that the proposed name was all embracing and could be interpreted as including their fields of activity as well. Notice was also given that the ISSMGE were contemplating creating divisions for rock engineering and engineering geology within their organisation, a notion which was also met with strong objections. FedIGS provided a platform for these matters to be discussed openly and when the ISSMGE Council met in early 2011, it was possible for FedIGS to make the position of the other two Societies known to Council. The motion was defeated by the ISSMGE Council.

The current position is still that FedIGS operates at a minimum cost, low level of activity without secretarial assistance and with only three JTC's. Each of the Sister Societies is responsible for hosting one of the JTC's. The future of FedIGS will be determined by the Sister Societies. It has been seen that the careful work over a long period to create the Federation has not been in vain and at any time in the future, the level of activity can be raised if the needs of the time require it to be ■

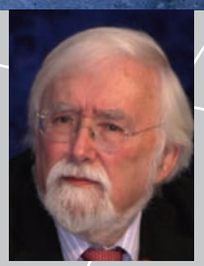
The historic meeting of the Presidents of the Sister Societies in Lisbon where it was decided in principle to create an organisation that would facilitate collaboration without jeopardising autonomy. In the photo, l.t.r. Michel Deveughèle (Secretary-General of the IAEG), Niek Rengers (President of the IAEG), William van Impe (President of the ISSMGE), Nielen van der Merwe (President of the ISRM), Luís Lamas (Secretary-General of the ISRM), Maria Lurdes e Eusébio (Executive Secretary of the ISRM) and Neil Taylor (Secretary-General of the ISSMGE).

FedIGS inaugural meeting in London, on 25 January 2008, with the Presidents, Immediate Past-Presidents and Secretaries General of the three Sister Societies. In the photo, l.t.r., Luís Lamas, John Hudson, Nielen van der Merwe, Niek Rengers, Neil Taylor, William van Impe, Pedro Sêco e Pinto, Sébastien Dupray and Fred Baynes.

The Next 50 Years of the ISRM and Anticipated Future Progress in Rock Mechanics



CHAPTER XII



John A. Hudson

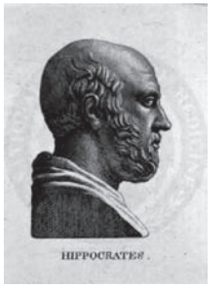
This Chapter on the 50-year anticipated future of the ISRM and rock mechanics was written as part of the ISRM 50-year anniversary celebrations and was presented at the 12th ISRM Congress held in Beijing in October 2011. It complements the content of Chapter 3 written by E.T. Brown covering the previous 50 years of the ISRM.

The current status of rock mechanics and the unsolved problems are summarised—so that the results of extrapolating our current capabilities can be considered. The problems are noted under the headings of geology, rock stress, intact rock, fractures, water flow, modelling and design. The anticipated future developments are then highlighted under the headings of information access, site investigation, subject integration, international co-operation, 'intelligent' computer programs, increased excavation speed and larger excavations, environmental aspects, the future of the ISRM itself, and the implications of future computing power. It is predicted that the greatest changes to rock mechanics and the ISRM itself will result from the continuing growth in computing power.

INTRODUCTION

It is useful on this 50th anniversary of the ISRM that we not only consider the developments over the last 50 years in our subject of rock mechanics and its application to rock engineering, but that we also anticipate the directions that are likely to be taken in the future. The method for predicting the future will be through extrapolation of the present, although some 'blue skies' thinking is also included. Implicit in the title of the Chapter is consideration of the ISRM entity itself—and so, in the light of the predicted technological and developments, a later section discusses whether the ISRM will continue to exist for another 50 years.

Hippocrates (Figure 1), the Greek physician, used a method for predicting the future which is summarised as:



"Consider the past, diagnose the present, foretell the future."

Figure 1. Hippocrates (460–377 BC)

So, in this Chapter, and based on what has been achieved in the past, let us identify some of the major problems that have not yet been solved.

This leads naturally to consideration of which technological developments are likely in the future and hence whether these will enable the remaining problems to be solved. Consideration of the far future for the ISRM is interesting because it encompasses relevant questions relating to the nature of individual and group interactions, the storage and dissemination of corporate knowledge, and the impact of the continuing increase in computing power.

THE CURRENT ROCK MECHANICS KNOWLEDGE AND CAPABILITIES

The rock mechanics knowledge and capabilities in 1993 have been summarised in encyclopaedic form via the 4407 page compendium "Comprehensive Rock Engineering" which was produced by Elsevier (Hudson, 1993). The five volumes comprising the compendium cover the subjects of:

1. Fundamentals
2. Analysis and Design Methods
3. Rock Testing and Site Characterisation
4. Excavation, Support and Monitoring
5. Surface and Underground Case Histories.

Although it is now 19 years since this compendium was published and some advances have been made in many areas, the essence of the state-of-the-art remains similar, so let us now consider the current unsolved problems.

UNSOLVED PROBLEMS IN ROCK MECHANICS

Despite the major progress that has been made in rock mechanics and rock engineering over the last 50 years as described by Professor Brown in Chapter 3, there are still outstanding problems. In fact, Leopold Müller's motivation for founding the ISRM in 1962 was encapsulated in his May 1962 comment, "We do not know the rock mass strength, and that is why we need an International Society", yet we still have problems estimating the rock mass strength!

In this Section, some of the major unsolved problems in rock mechanics will be outlined. These are presented under the subject headings of

- Geology
- Rock stress
- Intact rock
- Fractures
- Water flow
- Modelling
- Design

At the end of each of these secondary headings, italicised text is included concerning a key point related to that particular subject.

Geology

The roles of geology, particularly structural geology, and rock mechanics for engineering are highlighted in Figure 2.

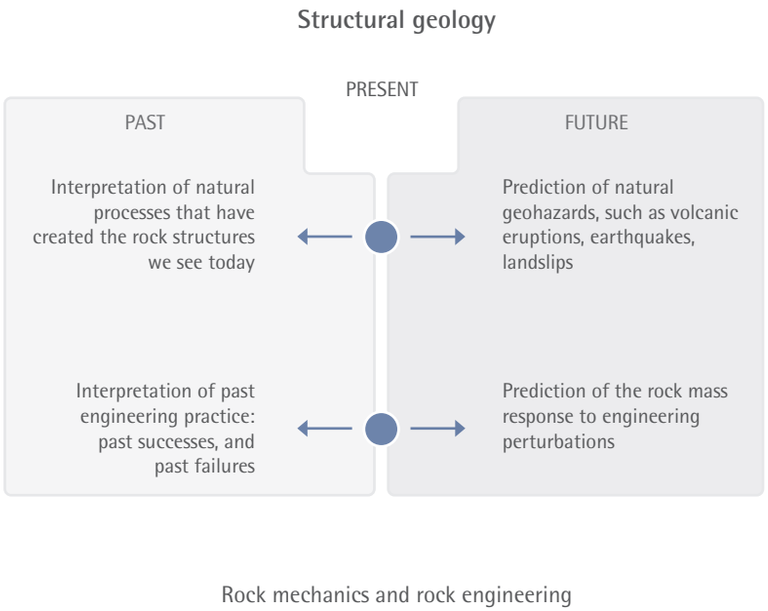


Figure 2. Similarities in the roles of structural geology and rock mechanics for engineering

In both cases, structural geology and rock mechanics/engineering, we are interested in deciphering the mechanisms that led to the current circumstances and then in predicting what will happen in the future. In fact, the quintessence of rock engineering is predicting the future. We wish to predict what will happen in the future so that rock engineering designs are appropriate; if such prediction is not possible, there can be no coherent design. For example, we might wish to predict what will occur if a tunnel is driven in a certain direction and depth as opposed to other directions and depths.

In this context and because the engineered structure will be founded on or contained within a rock mass, it is essential to have an adequate understanding of the geological circumstances relating to the host rock, yet the engineer will be sorely stretched without expert geological advice in obtaining the correct data for modelling and identifying the hazards that may accompany certain geological formations. For example, many rock mechanics modelling exercises require knowledge of the rock fractures, but this may be difficult to obtain. The three photographs in Figures 3–5 illustrate three different types of fracturing—all observed in close proximity within the same Lower Middle Coal Measures strata in South Wales, UK.

Figure 3. Orthogonal fracturing in the Coal Measures strata, South Wales, UK (~ 1 m wide sample)

Figure 4. More irregular fracturing in the Coal Measures strata, South Wales, UK (~ 1 m wide sample)

Figure 5. Even more irregular fracturing in the Coal Measures strata, South Wales, UK (~ 1 m wide sample)

Needless to say, significant help can be given to the rock mechanics modeller and designer in dealing with the types of fracture networks illustrated in Figures 3–5 by a geologist who is familiar with the host rock circumstances. Illustrations of the value of structural geology interpretations can be seen in Price & Cosgrove (1990), Hudson & Cosgrove (1997) and Cosgrove & Hudson (2011).

However, the major unsolved problem in the current context is that often either a geologist is not consulted or the geologist is not intimately involved with the rock mechanics studies, so that the advice is only received remotely, e.g., through some form of standardised site investigation.

This is a management problem but one which we must address and one that ought to be easy to solve.

Rock stress

Unlike other forms of engineering, in underground rock engineering the primary activity is to remove material from a pre-loaded rock mass, i.e., rather than fabricating components and then assembling them, as in other forms of engineering. This means that we need to estimate the natural stress state existing in the rock mass—both for basic considerations of the intensity of loading and as boundary condition input to numerical modelling.

Rock stress estimation is one of the most intractable problems that we have to face: stress is a tensor quantity which requires six independent pieces of information; measuring/estimating rock stress is difficult; and the rock stress may vary considerably at all scales, mainly through the various types of fracturing inherent in the different rock types. A Special Issue of the International Journal of Rock Mechanics and Mining Sciences (Vol. 40, Issues 7–8, 2003) is devoted to rock stress estimation. This Special Issue contains the four new ISRM Suggested Methods on rock stress estimation and 17 supporting papers describing various aspects of rock stress and rock stress estimation campaigns. A summary of the contents of these 17 papers in eight words is: “Rock stress estimation is not an easy task.” The actual measurement is a problem and the stress itself generally varies throughout the rock mass.

However, recent developments in understanding, presenting and modelling *in situ* rock stress have improved the situation. For example, Lee (2006) has shown that plotting each principal stress versus the first stress invariant (i.e., the sum of the principal stresses) provides a more coherent picture than plotting the principal stresses versus depth. A recent book (Zang & Stephansson, 2010) provides a clear understanding of the distribution of rock stress and the stress measurement procedures. And numerically modelling the stress distribution through fractured rock masses using computer programs such as 3DEC can provide a significantly enhanced understanding of the role of fractures in perturbing a regional stress state.

The two major unsolved problems in the context of rock stress are:

- developing a method of rapidly and reliably estimating the six components of the rock stress tensor at a given location; and
- understanding the variations in the stress state due to the presence of discontinuities, inhomogeneities and anisotropies at various scales.

The first problem above is intractable and not likely to be solved quickly. The second problem is amenable to numerical modelling studies and will be solved relatively soon.

Intact rock

Because it is easy to obtain and test samples of intact rock, this subject has been studied in greater detail than any other in rock mechanics, and we now have a good understanding of intact rock behaviour and the relation between the type of rock and its mechanical characteristics. Also, through the advent of high speed, servo-controlled testing machines in the 1970s, the full mechanical behaviour, from initial loading through to complete disintegration of the specimen, can be studied in detail. An example of a complete stress–strain curve for marble is shown in Figure 6. Through the use of a polyaxial testing machine with appropriate servo-control, the behaviour of intact rock can be studied in circumstances only limited by the imagination. Nevertheless, there are still aspects of the intact rock requiring further study, particularly in relation to the inhomogeneity, anisotropy and time dependency.

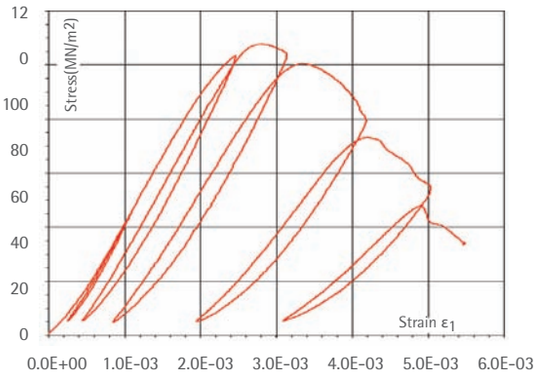


Figure 6. Complete stress–strain curve for marble (courtesy EPFL Laboratory, Switzerland)

The illustration in Figure 7 shows how studies of the potential failure of rock around the periphery of an excavation involve a function of both the concentrated rock stress around the opening and the rock strength in different directions. For this problem, a knowledge of the rock strength as a function of the anisotropy is required. In the same way, the influence of the inhomogeneity of the rock and its time dependency also need to be understood.

Thus, although a great deal of work has been conducted on the mechanical behaviour of intact rock (i.e., without Discontinuities), there are still unsolved problems relating to its IANE nature (Inhomogeneous, Anisotropic and Not Elastic). As noted in the previous section, computer modelling can improve our understanding of *in situ* stress variability and, in a similar way, the failure of intact rock in a wide variety of loading conditions can also be studied via computer modelling (Tang & Hudson, 2010). However, the subject of time dependency remains intractable.

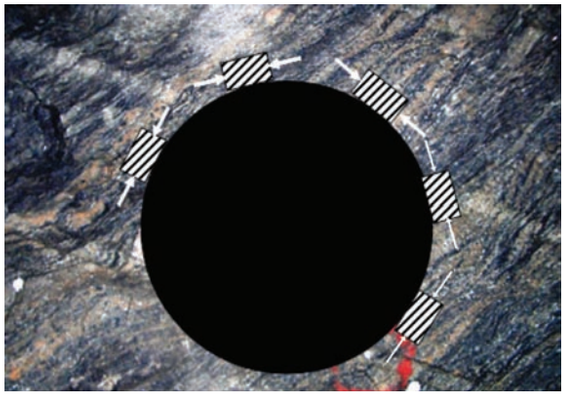


Figure 7. The concentrated principal stress component around the periphery of an underground opening is parallel to the periphery but the anisotropy induced by foliation is in one main direction, meaning that the rock failure will not necessarily begin at the location of the highest stress value

Perhaps the most surprising omission in relation to intact rock is the general use of a failure criterion which incorporates the three principal stresses. Despite the nature of rock stress as a tensor with its three principal stresses, the failure criteria most commonly used in modelling and in practice for intact rock and rock masses are the Mohr–Coulomb and Hoek–Brown criteria—but both of these only contain the major and minor principal stresses: the intermediate principal stress is not included. At the time of writing this paper, the ISRM Commission on Testing Methods is developing advice on the use of rock failure criteria which will be published in the International Journal of Rock Mechanics and Mining Sciences and in the new 2012 ISRM 'Orange Book' which will follow the style of the ISRM 'Blue Book' (Ulusay & Hudson, 2007)

In terms of solving these problems, the inhomogeneity and anisotropy characteristics of intact rock are easily approached via testing and numerical modelling but the issue of time dependency is more intractable. The general use of a failure criterion incorporating the three principal stresses is imminent because several candidate criteria have already been suggested in the literature.

Fractures

Figures 3–5 have indicated some types of fracture variation that can occur and the importance of including a structural geologist in rock mechanics studies has been emphasised. In fact, it is useful to consider the spectrum of rock fractures that can occur from a geological viewpoint, as shown in Figure 8 (Hudson *et al.*, 2011).

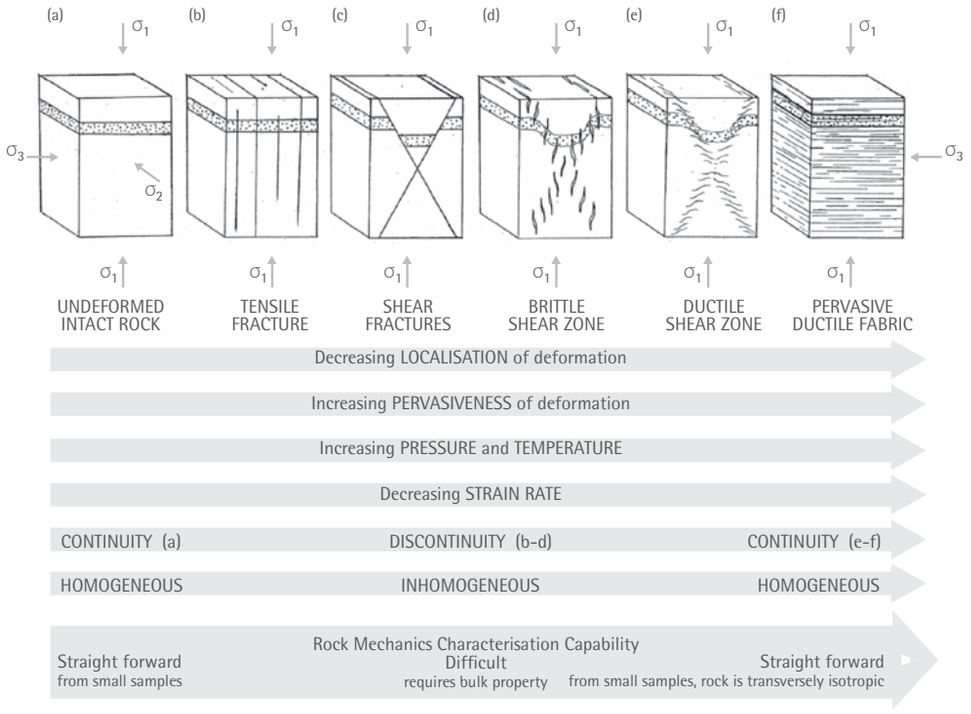


Figure 8. The types of deformation and fracturing that can develop in rock masses, from tensile fractures through to a pervasive ductile fabric

The fracture properties recommended for measurement by the ISRM are shown in Figure 9. It is evident that these fracture properties are variable in terms of whether the measurement is possible from a borehole core or television image of the borehole wall. The spacing between the fractures can be readily estimated, but many aspects, such as the fracture tracelength (persistence), cannot.

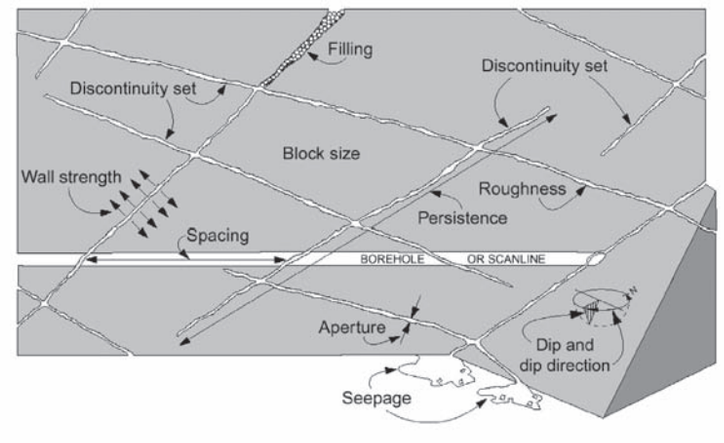


Figure 9. The fracture properties recommended for measurement by the ISRM

In Figure 10, Follin (2008) has illustrated the limited scales at which one can obtain fracture information. Given the D in the DIANE nature of the rock, the Discontinuousness, the ability to characterise the geometry and mechanical behaviour of the fractures is essential for input to our modelling for rock engineering design—and to achieve Leopold Müller's original ISRM ambition of estimating the rock mass strength.

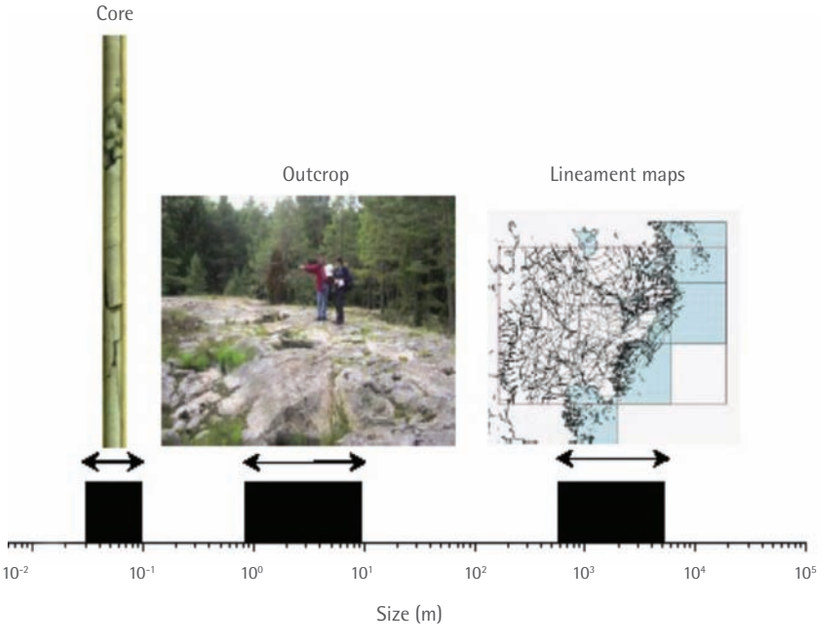


Figure 10. The limited scales at which one can obtain rock fracture information (from Follin (2008) of SF GeoLogic AB, Sweden)

Thus, developing the ability to adequately establish and characterise the geometry and mechanical properties of rock fractures at a given site is the major unsolved problem in relation to the subject of rock fractures.

Although solving the problem of reliably obtaining fracture information (geometry and mechanical properties) may be considered easier than obtaining reliable stress information for a given rock mass, there is still a long way to go because of the multi-parametric nature of rock fracturing and the uncertainty related to reducing the mass of fracture data to the quantity that can be input to numerical models. There is also the problem of including 'stochastic' fractures in models.

Water flow/permeability

Following on from the need to characterise the rock fractures is the subject of modelling water flow and establishing the rock mass permeability—another tensor with three principal components. Note the white arrow in Figure 11 indicating the highly localised nature of water flow in the rock mass illustrated.

Figure 11. Idiosyncratic water flow in a fractured rock mass (the Mountsorrel granodiorite, UK)

For rock masses where the intact rock is relatively impermeable, water flow and the associated hydraulic conductivity tensor will be dominated by the network of fractures (their geometry, connectivity, aperture) plus the rock stress state (Franciss, 2010). Not only is the water in the heavily fractured rock mass in Figure 11 only exiting through one fracture but it is exiting at specific points along the fracture, indicating channel flow within the fractures. Additionally, this channel flow can change if there are any significant fracture displacements due to engineering activities.

Considerable advances have been made in incorporating fracture geometries into discrete fracture networks and establishing the flow characteristics of the associated rock masses. However, the problem is obtaining sufficiently accurate data on the fracture characteristics. This is the major unsolved problem relating to rock mass hydraulic conductivity/permeability.

The solution to this problem is also intractable because not only are the geometrical fracture data required but also the hydrogeological data, especially the equivalent fracture apertures.

Modelling

In the early years of rock mechanics, physical models played an important role in supporting rock engineering design, especially for dams located on rock masses. Also today, such physical models can play a useful role in establishing mechanisms and verifying numerical models. However, the emphasis has gradually changed (Figure 12) to rock mass classification methods (Barton, 2011) and computer numerical modelling, especially using discrete element methods (Jing and Stephansson, 2007).

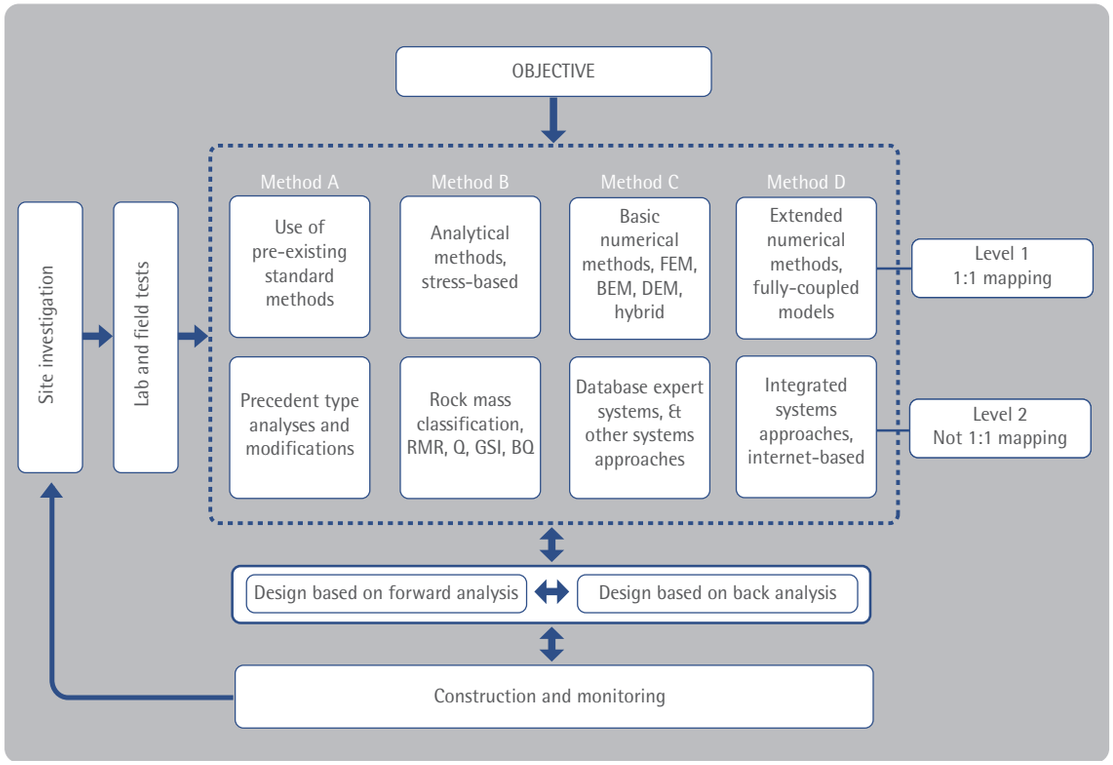


Figure 12. The eight main methods of rock mechanics modelling (within the emboldened dashed box). The four columns, Methods A–D, represent increasing complexity from A–D; whilst the two rows, Levels 1 & 2, represent 1:1 mapping and non-1:1 mapping respectively. In 1:1 mapping there is an explicit attempt to model the engineering geometry; in non-1:1 mapping there is not

The major unsolved problems in the numerical modelling area begin with the need to develop one model which captures all the required variables, mechanisms and parameters, i.e., the models relating to the separate sub-disciplines giving way to the required all-encompassing coupled model. It is anticipated that such a model will include, *inter alia*, the following aspects.

Geological	*site geometry, lithology, fractures*
Thermal	*heat loads, heat flow*
Hydrological	*water pressures, water flow*
Mechanical	*rock stress, stiffness, strength*
Chemical	*rock and water chemistry*
Engineering	*effects of excavation*

Currently, the separate models are mostly constructed within separate sub-disciplines, e.g., mechanical and hydraulic, and these have to be 'stitched together'—which cannot always be done smoothly. However, considerable progress has been made recently in developing coupled models.

A complementary necessity is the development of methods to technically audit such a fully-coupled numerical model, and indeed existing sub-models, both concurrently during their use and subsequently when they are used for back analysis after observation of the construction perturbation. The validation of numerical model inputs, operation and outputs is a particular problem in rock mechanics because of the scale of rock masses. We can test small samples in the laboratory and we can conduct tests in underground laboratories at specific sites (Wang *et al.*, 2011), but the overall problem of technically auditing computer models supporting rock engineering design in large rock masses is an intractable problem, although a start has been made in Feng & Hudson (2011), see Figure 13.

It is unlikely that the actual validation problem will be solved quickly (i.e., does the model actually represent the rock behaviour) because of the need to conduct large experiments. However, projects such as DUSEL (Deep Underground Science and Engineering Laboratory) being envisaged at the Homestake Mine in South Dakota, USA, will eventually lead to full validation checks. Basic technical auditing can be implemented now, but the final auditing capability with actual validation checks will take much longer.

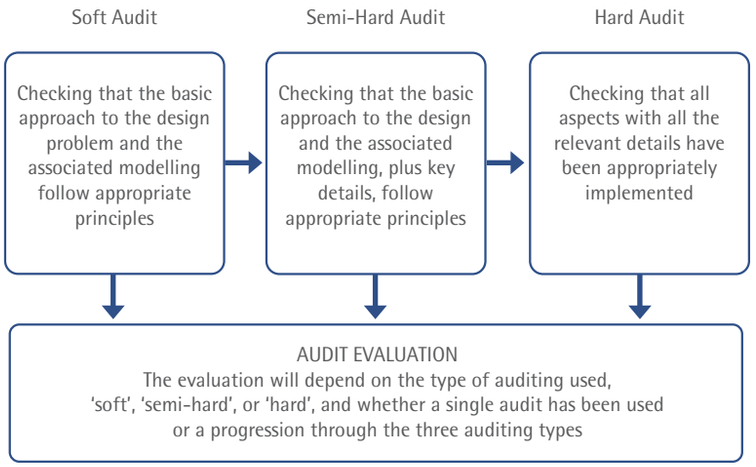


Figure 13. The technical auditing required for numerical modelling used to support rock engineering design

Rock engineering design

An ISRM Commission on Rock Engineering Design has been operative in the years 2007–2011, culminating in the book by Feng and Hudson (2011). The modelling for rock engineering has already been summarised in Figure 12 and the design components are now summarised in Figure 14 below.

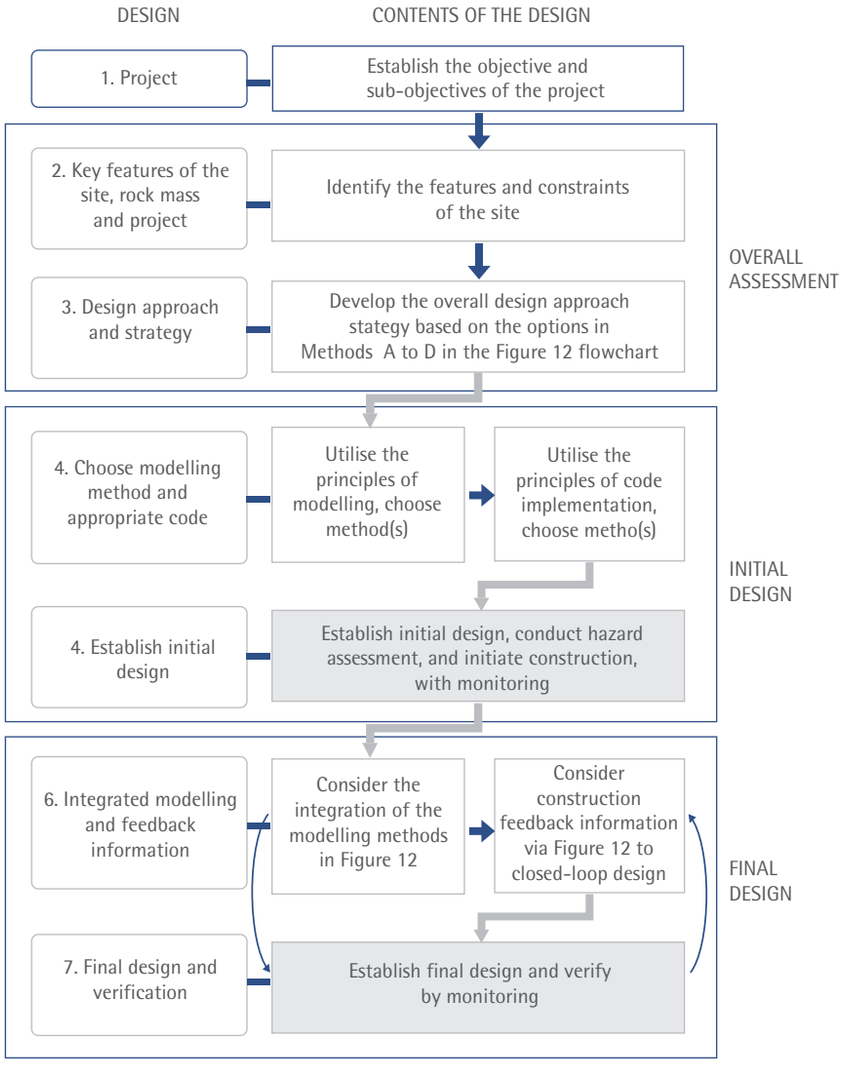


Figure 14. Rock engineering design flowchart

With regard to the immediate future of rock engineering design, we anticipate that there will be much more use of 'intelligent' methods, i.e., computer processes in which the previous behaviour of the rock is learnt—thus enabling more accurate predictions of its future behaviour. For example, computer learning from the initial displacements induced by excavation of the top level of a cavern enables better predictions of the subsequent displacements as the successive layers are excavated downwards.

Artificial neural networks have already been used successfully for many subjects in rock mechanics modelling, as described in Jing (2003). The principle, copying the operation of the brain, is that the model consists of a series of interconnected nodes and is trained to match a set of known inputs and outputs by altering weighting functions at the nodes. When a person catches a ball, they do not solve a series of mathematical equations to do so: they just catch the ball using a neural network that has spent a lifetime learning and memorising how objects move around and how to catch them. Only the inputs and outputs of a neural network have a direct physical meaning: the values at the internal nodes cannot be directly related to specific geometrical or mechanical parameters. Indeed, this is the way that we humans analyse what we see and perceive: as the British painter David Hockney has said, "We always see with memory".

This computer learning and memorising concept should be extended, not only for the learning process in one rock engineering project, but so that the computer retains a memory of its analyses of all projects, i.e., the computer then begins to analyse projects on a similar basis to human experience and its subsequent scrutiny of new situations.

Rock engineering design will continue to be enhanced by the use of feedback from the construction itself, both directly and via 'intelligent' computer procedures that retain a memory not only of the current project but of all previous projects they have experienced.

THE NEXT 50 YEARS

In this Section, the future for rock mechanics and the ISRM is predicted.

Improved methods of obtaining/accessing/collating information

There are many aspects of information processing that are developing rapidly—from laser capture of rock surface geometry, to seismic tomographic methods of rock mass properties, to internet databases of rock properties. All these are functions of the current rapid technological and computer advances and there is every reason to expect that this will continue.

More emphasis on geophysical methods in site investigation

As mentioned earlier, there is a fundamental need to obtain more rock property information, especially on the geometry and mechanical properties of rock fractures. The ideal method of non-destructive rock mass interrogation is through the also rapidly developing seismic techniques, especially tomography, and the associated advanced 3-D visualisation methods.

More integration of subjects (e.g., fully-coupled numerical modelling)

There are initiatives underway to enhance the degree of coupling in numerical models which will eventually lead to a Geo-Thermo-Hydro-Mechanical-Chemical-Biological model. Currently, the numerical models tend to be developed separately within specific subject areas, such as geology, rock mechanics, petroleum engineering, soil mechanics, hydrogeology, etc. The future must lie in more expansive models firmly based on thermodynamic principles with a range of primary state variables

and incorporating the associated coupled mechanisms that hence allow more coherent and auditable modelling to support rock engineering and the other fields of endeavour.

More international co-operation

On studying the early issues of journals, i.e., those published in the 1960s, there were often papers written by a single author—because it was possible for a single person to make significant contributions. Although this single person endeavour is still possible, it is certainly more stimulating and probably more efficient for a group of people to tackle a given problem. Indeed, on looking at the contents of the April 2011 issue of the International Journal of Rock Mechanics and Mining Sciences, one notices that all 21 of the contributions are written by two or more authors. This trend will definitely continue as the facilities for national and international co-operation continue to improve.

More use of neural network 'intelligent' computer programs

Currently, the researcher/engineer inputs the required values into the computer, runs the program, and evaluates the result. As mentioned earlier, there is considerable scope for augmenting this procedure through the increased use of more 'intelligent' computer programs, ranging from further development of neural network architectures to the inclusion of 'perception' into the programs. Even in the near future, it is not beyond the realms of possibility to relay television images of underground excavation surfaces, e.g., the roof, and arrange for the computer to automatically alert the user to developing roof fall hazards and to conduct continuing re-analyses based on new automated displacement values.

Larger, deeper and longer excavations

As the demand for materials and underground space continues to increase, it is anticipated that there will be larger, deeper and longer excavations. Currently, one of the largest caverns open to the public has a span of 61 m: the Gjøvik ice hockey stadium in Norway. But how large can a cavern be? The Kirsch solution for the stress concentrations around a circular hole includes neither the absolute size of the hole nor the elastic properties of the rock. In a rock mass free of fractures, such as can be found in the Canadian Shield, it should be possible to construct caverns with spans considerably larger than 61 m. How far can we go? A 100 m span? A 1000 m span? No doubt the record will soon be broken by some entrepreneurial group of engineers.

Increased rate of mechanised excavation

It is difficult to imagine how rock support can be improved. The rock blocks can be held together with rockbolts so that a fractured rock mass behaves literally more like a monolithic continuum. A resisting force can be induced through the use of introduced supports. Shotcrete can be used to provide additional resistance and to combat deterioration of the rock surface induced by weathering.

Conversely, overall energetic principles indicate that mechanised excavation can be greatly increased. In Figure 15, the two ways that energy is input during current methods of tunnel construction are illustrated. When blasting, large amounts of energy are input for a few seconds at widely spaced intervals, e.g., eight hours. This is represented in Figure 15 by the narrow vertical white bands. However, when a tunnel boring machine (TBM) is cutting, a lower level of energy is continuously

input, represented by the lower horizontal white band. It is extraordinary that we have only these two excavation methods characterised by the two extreme conditions.

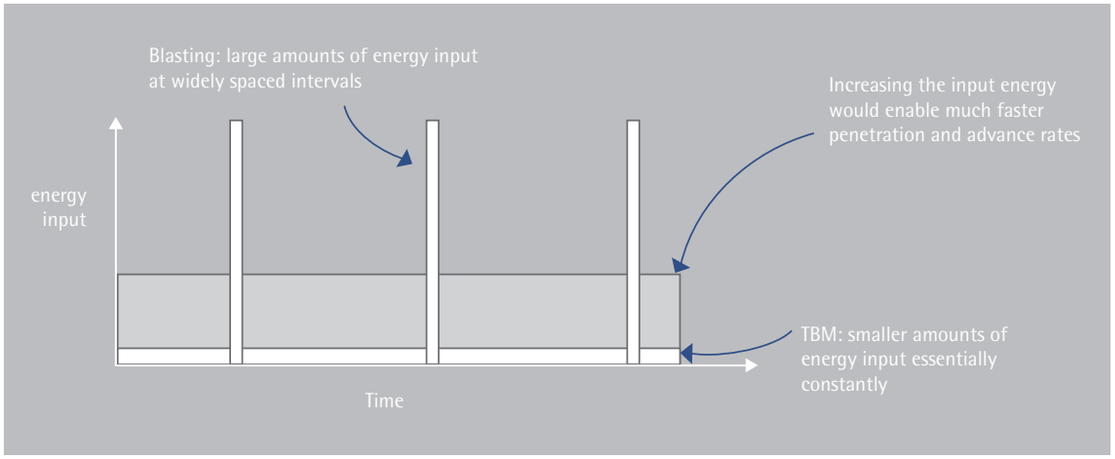


Figure 15. Energy input during blasting and the use of a TBM

Since there is generally no problem in providing energy to the tunnel construction, it is likely that new methods of excavation with significantly improved penetration rates will be developed, as represented by the wider horizontal band in Figure 15. This may be by some combination of continuous ANFO blasting with the TBM continuously removing the debris or by some entirely new procedure. The point is that the energy potential is there.

Emphasis on environmental aspects

It may appear at first sight that the construction of underground excavations in rock is intrinsically environmentally friendly—being out of sight—but it must be remembered that any engineering activity results in an increase in entropy. Whatever, the order created in the engineered structure, there will be a greater degree of disorder induced in the surrounding environment. This is often visibly manifested in mining operations but it is also true for all civil engineering projects. Of course, the disturbance can be reduced to some extent, but from thermodynamic principles it cannot be avoided.

This leads to the question, "Is the exploitation of underground space compatible with the concept of sustainable development?" The Bruntland (1987) definition of sustainable development is

> *"Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs."*

Thus, when planning a new rock engineering project, we should ask the question, "Given the existing system (whether a virgin rock mass or a rock mass already containing developed space), is it acceptable to locate a new facility in the rock mass, i.e., within the context of sustainable development as defined above? The whole subject of sustainable development in rock engineering has not yet been properly tackled in the above context and the subject urgently needs attention.

The future of the ISRM

For the ISRM to have any purpose, it must provide a benefit to the members. Accordingly, the ISRM must continually develop to provide the required benefits in our changing world, especially in relation to 'immediate' access to information. The previous and current Boards of the ISRM, operating from 2007–2011 and from 2011–2015, have been and are engaged in a modernisation process to ensure that the necessary benefits are provided to members. This has included a survey of ISRM Members to establish what they want, increasing the downloadable material from the ISRM website, the availability of papers from all the previous ISRM symposia in pdf form via the OnePetro website, emailing a digital newsletter to members on a regular basis, increasing the appreciation of the ISRM members' achievements, rationalising the style of the ISRM meetings, and organising lecture tours and field trips. There are many further possibilities for the future, including electronic conferences.

The advantages of interacting with other researchers and engineers has already been mentioned in previous sections on coupled models and international co-operation. The same applies to increasing the co-operation with other Societies. Additionally, cross-promotion of websites and events is being developed, together with interaction between similar commissions and interest groups. However, some new method of interaction needs to be developed. As is evident from the fact that the vast majority of papers published on rock mechanics and rock engineering are by more than one author, interaction is to everyone's advantage. Perhaps, the current method of *ad hoc* interaction is sufficient, but one feels that some form of organised interaction would be more beneficial to the subject itself.

Future computing power

The greatest changes in rock mechanics and in the ISRM will be caused by the continuing increase in computer power. It is not easy to predict totally new future technological developments: no one (except perhaps some forward thinking science fiction writers) predicted the emergence of the WorldWideWeb at the time of the start of the ISRM in 1962. However, we can certainly consider the extrapolation of current trends. For example, at the current time, for US$1000, we can purchase somewhere between the computing power of an insect brain and a mouse brain. However, at some time between 2020 and 2040, we will be able to buy the computing power of a human brain for $1000 and before 2062, when the ISRM will have its centenary anniversary, it is predicted that the $1000 will purchase the computing power of all human brains in the world. What could/should we do with such massive computing power and how would it assist rock mechanics and rock engineering? What will the developments be?

Already most published papers are available online. Microsoft and Google are currently enabling books from major libraries to be available on the Internet. In the long-term, all publications will be available online. (Last year, the digital content of the Web was more than one zettabyte: a million, million gigabytes). It will be possible for computer robots to automatically search all literature relevant to a given profile. Computers could then compile papers about the cumulative advances in rock mechanics via all the papers and information generated each year. If computers become authors, how should they be identified, or identify themselves? Will we be able to tell if the author is human or a computer? (Currently, the semantic web is being developed with which computers can analyse the content to aid their and human interpretations.)

Fully-coupled models will be able to be run virtually instantaneously and adjusted for feedback from the actual rock behaviour in real time. Computers will have memory and perception. They will use the 'intelligent' methods that are currently being developed. The computer models will be linked to the internet and continuously updated for all new developments. If computers are monitoring construction experiences and already have installed or can themselves write fully-coupled programs, will the computers be able to design rock engineering projects on their own? It is tempting to say that human input will always be required but will this actually be so?—certainly in the near-future but not necessarily in the long-term future.

Conferences

In the near future, it will be an option whether we attend a conference physically or electronically. Some people will continue to wish to attend physically but, with more and more pressure on everyone's time, the electronic attendance will be preferred by others. Electronic conferences have several advantages, not least of which is that one could attend many more conferences, e.g., one every Monday morning. The Powerpoint presentations and pdfs of papers would be instantly available. One could talk through the computer to any other registrants. The registration fee would be much less than now and travel and accommodation expenses would be eliminated.

Extra-terrestrial rock mechanics and engineering

For its first 50 years, the ISRM has studied rock mechanics on Earth—but do all the fundamentals that we have developed also apply on the planets? At the moment, we need a theoretician to go through the fundamentals of rock mechanics and establish whether they all apply 'out of this world'. The information will be required in the longer term future for the facilities which will be constructed on and beneath the surface of asteroids and planets.

THE LONG-TERM FUTURE FOR THE ISRM

Given the rapid advances in computing power and communication systems which are expected to continue, the long-term future for the ISRM is not easy to predict.

- On the one hand, one could predict that in a world with an increasing information overload, the ISRM will be increasingly needed to provide clear and focused guidance to its members on rock mechanics advances and new capabilities as they develop;
- On the other hand, one could predict that the type of user profiling pioneered by Google and others will be increasingly effective and it will only be necessary to be individually profiled to receive all the information that one needs in whatever discipline and sub-discipline one happened to be—and hence the ISRM would not then be needed.

No action can be taken now to anticipate this longer term future because either of the two possibilities above could come to pass, probably that in the first bullet point followed by that in the second bullet point.

CONCLUSIONS

The intention of this Chapter has been to outline the future for rock mechanics and the ISRM. This has been done through the Hippocratic method of considering the past, diagnosing the present, and foretelling the future, but also with 'blue skies' thinking added.

Problems that will be addressed in the next 50 years

It was noted that the past developments have been summarised in the 1993 compendium "Comprehensive Rock Engineering" but that there are still many unsolved problems needing to be tackled. The ones mentioned in this paper are as follows.

- Ensuring that geological knowledge is incorporated into rock mechanics studies, both in the technical and management senses;
- Developing better methods of measuring and estimating the rock stress in a given rock mass;
- Implementing the general use of a failure criterion that includes all three principal stresses;
- Developing better methods of establishing and characterising the geometry and mechanical properties of the fractures in a given rock mass;
- And the related problem of improving discrete fracture network models for water flow predictions;
- Constructing a fully-coupled numerical model that captures all the required variables, parameters and mechanisms;
- Developing a method for auditing rock mechanics modelling and rock engineering design;
- Incorporating 'intelligent' computer methods, which have memory and perception, into rock engineering design.

Future trends

The predictions for the near future in rock mechanics and the ISRM were outlined through the anticipated developments and extrapolation of the current ISRM modernisation initiatives. The anticipated developments mentioned in the Chapter are as follows.

- Improved methods of accessing/collating information;
- More emphasis on geophysical methods in site investigation;
- More integration of subjects (e.g., fully-coupled numerical modelling);
- More international co-operation;
- More use of neural network 'intelligent' computer programs;
- Larger, deeper and longer excavations;
- Emphasis on environmental aspects;
- Increased rates of mechanised excavation.

In terms of the events beyond the near future, the increase in computing power was highlighted, together with

- Computers as authors;
- Computers as rock engineering designers, and
- Extra-terrestrial rock mechanics.

Two possibilities have been envisaged for the future of the ISRM in the longer term (more integration of science and engineering or less necessity to be integrated), but no action is required now because either of these two possibilities could prevail. We will have to await the outcome.

POSTSCRIPT

The theme of this paper has been the prediction of rock mechanics and rock engineering over the next 50 years. Those interested in general technological developments and their implications over a much longer period are referred to the books by Adrian Berry: "The Next 500 Years" and "The Next 10,000 Years", see the reference section.

ACKNOWLEDGEMENTS

For their many suggestions, which have supported the ISRM modernisation programme in 2007–2011, the author is grateful to the ISRM Board Members: Claus Erichsen, Xia-Ting Feng, Abdolhadi Ghazvinian, Alvaro Gonzalez-Garcia, Nuno Grossmann, Luís Lamas, Francois Malan, Derek Martin, and Tony Meyers ■

REFERENCES

Barton, N. 2011. From empiricism through theory to problem solving in rock engineering. ISRM Mueller Lecture. Proc. 12th ISRM Int. Congress on Rock Mechanics: Harmonising Rock Mechanics and the Environment. London: Taylor & Francis.

Berry, A. 1974. The Next Ten Thousand Years: A Vision of Man's Future in the Universe. London: Jonathan Cape Ltd., 224p.

Berry, A. 1995. The Next 500 Years: Life in the Coming Millennium. London: Headline Book publishing, 338p.

Brown, E.T. 2011. 50 years of the ISRM and associated progress in rock mechanics. Proc. 12th ISRM Int. Congress on Rock Mechanics: Harmonising Rock Mechanics and the Environment. London: Taylor & Francis.

Bruntland, G. (ed.) 1987. Our Common Future: The World Commission on Environment and Development. Oxford, Oxford University Press.

Cosgrove, J.W. & Hudson, J.A. 2011. The structural geology contribution to rock mechanics modelling and rock engineering design. Proc. 12th ISRM Int. Congress on Rock Mechanics: Harmonising Rock Mechanics and the Environment. London: Taylor & Francis.

Feng, X.T. & Hudson, J.A. 2011. Rock Engineering Design. London: CRC Press, Taylor & Francis, 460p.

Follin, S. 2008. Personal communication.

Franciss, F.O. 2010. Fractured Rock Hydraulics. London: CRC Press, Taylor & Francis, 188p.

Hudson, J.A. (ed.) 1993. Comprehensive Rock Engineering. Oxford: Pergamon Press, Elsevier. 5 vols, 4407p.

Hudson, J.A. 2008. The future for rock mechanics and the ISRM. In A. Majdi & A. Ghasvinian (eds.), Proc. ARMS5 New Horizons in Rock Mechanics. Tehran: Iranian Soc. Rock Mech., 105–118.

Hudson, J.A. & Cosgrove, J.W. 1997. Integrated structural geology and engineering rock mechanics approach to site characterisation. Int. J. Rock Mech. Min. Sci., 34, 3–4, paper 136.

Hudson, J.A., Cosgrove, J.W., Kemppainen, K. & Johansson, E. 2011. Faults in crystalline rock and the estimation of their mechanical properties at the Olkiluoto site, western Finland. Eng. Geol., 117, 246–258.

Jing, L. 2003. A review of techniques, advances and outstanding issues in numerical modelling for rock mechanics and rock engineering Int. J. Rock Mech. Min. Sci. 40, 3, 283–353.

Jing, L. & Stephansson, O. 2007. Fundamentals of Discrete Element Methods for Rock Engineering: Theory and Applications. Oxford: Elsevier, 545 p.

Lee, M.F. 2006. *In situ* rock stress measurements in Western Australia's Yilgarn Craton. In M. Lu, C.C. Li, H. Kjørholt & H. Dahle (eds.), *In situ* Rock Stress: Measurement, Interpretation and Application: 35–42 London: Taylor & Francis.

Price, N.J. & Cosgrove, J.W. 1990. Analysis of Geological Structures. Cambridge University Press, 502p.

Tang, C.A. & Hudson, J.A. 2010. Rock Failure Mechanisms. London: Taylor & Francis, 322p.

Ulusay, R. & Hudson, J.A. (eds.) 2007. The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974–2006. The compilation prepared by the ISRM Turkish National Group on behalf of the ISRM, 2007.

Wang, J.S.Y., Smeallie, P.H., Feng, X.T. & Hudson, J.A. 2011. Underground research laboratory network. Proc. 12th ISRM Int. Congress on Rock Mechanics: Harmonising Rock Mechanics and the Environment. London: Taylor & Francis.

Zang, A. & Stephansson, O. 2010. Stress Field of the Earth's Crust. Springer, 322 p.

Appendices

A - ISRM Board Members 1962–2015

B - ISRM Congresses and Sponsored Conferences

C - ISRM Commissions

D - ISRM News and ISRM News Journal

E - Photographs of the Early Years of the ISRM

A

ISRM BOARD MEMBERS 1962–2015

The Society is governed by a Council, a Board and a Secretariat. The Council is the supreme body of the Society, which represents the National Groups and meets annually at the time and place of the yearly ISRM International Symposium or of the Congress. The Board is elected by Council and has the duty to administer the affairs of the Society. Currently, the ISRM Board is composed of the President, six Regional Vice-Presidents, up to three Vice-Presidents at Large and the Secretary-General as a non-voting member. Since the election for President takes place two years before the beginning of his/her Presidential term, the President-Elect joins the Board as soon as he/she is elected, as a non-voting member.

When the Society was founded, in 1962, a Board of Directors with 29 members was elected, but only five Board Members had assigned functions. After the Congress of 1966, the composition of the Board was changed: besides the President, six Vice-Presidents were elected for the six geographic regions (Africa, Asia, Australasia, Europe, North America, South America), and a Secretary-General was appointed. Since the 1987–1991 Board, the possibility of appointing Vice-Presidents at Large exists in order to adequately balance the composition of the Board.

1962–1966

President
- Prof. Leopold Müller, Austria

Vice-Presidents
- Prof. Hans Leussink, Germany (1962–1963)
- Dr Mario Pancini, Italy (1962–1965)
- Prof. H.J. Martini, Germany (1966)
- Prof. Guido Oberti, Italy (1966)

Secretary
- Mr Johann Scheiblauer, Germany

Treasurer
- Prof. Ernst von Gottstein, Germany

1966–1970

President
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Vice-Presidents
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- Asia: Dr M. Yoshida, Japan
- Australasia: Mr L. Endersbee, Australia
- Europe: Dr Armin von Moos, Switzerland
- North America: Prof. W. Judd, USA
- South America: Prof. Costa Nunes, Brazil

Secretary-General
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- Dr Ricardo Oliveira, Portugal (1968–1970)

1970–1974

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- Asia: Prof. B. Aisenstein, Israel
- Australasia: Prof. J.C. Jaeger, Australia
- Europe: Prof. B. Kujundžić, Yugoslavia
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- South America: Prof. Victor de Mello, Brazil

Secretary-General
- Dr Ricardo Oliveira, Portugal

1974–1979

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Secretary-General
- Dr Arnaldo Silvério, Portugal

ISRM Board Members 1962–2015

1979–1983

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- Australasia: Mr W.E. Bamford, Australia
- Europe: Prof. S. Uriel Romero, Spain
- North America: Dr T. C. Atchison, USA
- South America: Prof. O. Moretto, Argentina

Secretary-General
- Dr Arnaldo Silvério, Portugal

1983–1987

President
- Prof. E.T. (Ted) Brown, UK

Vice-Presidents
- Africa: Dr Horst Wagner, South Africa
- Asia: Prof. Tjong Kie Tan, China
- Australasia: Mr W. E. Bamford, Australia
- Europe: Dr S. A. G. Bjurström, Sweden
- North America: Mr A. A. Bello, Mexico
- South America: Prof. F.H. Tinoco, Venezuela

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1987–1991

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- Australasia: Dr Ian W. Johnston, Australia
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- South America: Dr Carlos Dinis da Gama, Brazil
- at Large: Prof. Shun-suke Sakurai, Japan
- at Large: Academician Eugeny J. Shemyakin, Soviet Union

Secretary-General
- Dr José Charrua Graça, Portugal (1987–1990)
- Dr José Delgado Rodrigues, Portugal (1991)

1991–1995

President
- Prof. Charles Fairhurst, USA

Vice-Presidents
- Africa: Dr T. R. (Dick) Stacey, South Africa
- Asia: Prof. Koichi Sassa, Japan
- Australasia: Prof. Michael J. Pender, New Zealand
- Europe: Prof. Ove Stephansson Sweden
- North America: Dr Peter K. Kaiser, Canada
- South America: Dr Oscar A. Vardé, Argentina
- at Large: Dr R. Widmann, Austria

Secretary-General
- Dr José Delgado Rodrigues, Portugal

1995–1999

President
- Prof. Shun-suke Sakurai, Japan

Vice-Presidents
- Africa: Dr Nielen van der Merwe, South Africa
- Asia: Dr Ou Chin-Der, China
- Australasia: Mr Garry R. Mostyn, Australia
- Europe: Prof. Giovanni Barla, Italy
- North America: Prof. Herbert H. Einstein, USA
- South America: Prof. Michel L. van Sint Jan, Chile
- at Large: Prof. John A. Hudson, UK
- at large: Prof. Sun Jun, China

Secretary-General
- Dr José Delgado Rodrigues, Portugal

1999–2003

President
- Prof. Marc Panet, France

Vice-Presidents
- Africa: Dr Güner Gürtunca, South Africa
- Asia: Prof. Chung-In Lee, Korea
- Australasia: Prof. Chris M. Haberfield, Australia
- Europe: Prof. Pekka Särkkä, Finland
- North America: Mr Alfredo Sanchez Gomez Mexico
- South America: Prof. Eurípedes Vargas, Brazil
- at Large: Dr Satoshi Hibino, Japan
- at Large: Prof. Wulf Schubert, Austria

Secretary-General
- Dr José Delgado Rodrigues, Portugal (1999–2003)
- Dr Luís Lamas, Portugal (2003)

2003–2007

President
- Dr Nielen van der Merwe, South Africa

Vice-Presidents
- Africa: Dr Martin J. Pretorius, South Africa
- Asia: Prof. Jian Zhao, Singapore
- Australasia: Dr John St George, New Zealand
- Europe: Dr Claus Erichsen, Germany
- North America: François Heuzé, USA
- South America: Dr Eda F de Quadros, Brazil
- at Large: Prof. Qihu Qian, China
- at Large: Prof Luís Ribeiro e Sousa, Portugal

Secretary-General
- Dr Luís Lamas, Portugal

2007–2011

President
- Prof. John A. Hudson, UK

Vice-Presidents
- Africa: Dr Francois Malan, South Africa
- Asia: Dr Abdolhadi Ghazvinian, Iran
- Australasia: Dr Anthony (Tony) Meyers, Australia
- Europe: Dr Nuno F. Grossmann, Portugal
- North America: Prof. Derek Martin, Canada
- South America: Prof. Álvaro J. González-Garcia, Colombia
- at Large: Dr Claus Erichsen, Germany
- at Large: Prof. Xia-Ting Feng, China

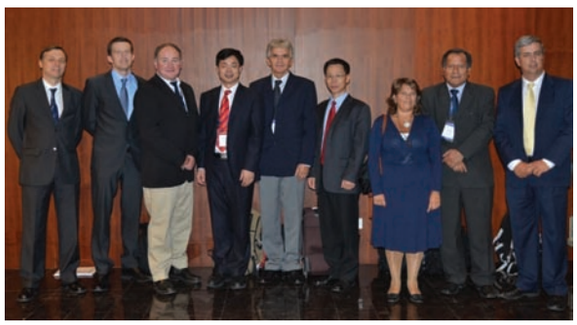
Secretary-General
- Dr Luís Lamas, Portugal

2011–2015

President
- Prof. Xia-Ting Feng, China

Vice-Presidents
- Africa: Mr Jacques Lucas, South Africa
- Asia: Dr Yingxin Zhou, Singapore
- Australasia: Dr David Beck, Australia
- Europe: Prof. Frederic Pellet, France
- North America: Dr John Tinucci ,USA
- South America: Dr Antonio Samaniego, Peru
- at Large: Prof. Yuzo Onishi, Japan
- at Large: Prof. Ivan Vrkljan, Croatia
- at Large: Dr Manoj Verman, India

Secretary-General
- Dr Luís Lamas, Portugal



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1. Board 1999–2003
2. Board 2003–2007
3. Board 2007–2011
4. Board 2011–2015

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ISRM CONGRESSES AND SPONSORED CONFERENCES

The XIII Geomechanics Colloquy held on 4 and 5 October 1962 in Salzburg, Austria was the first international conference of the International Society for Rock Mechanics, which was founded on 25 May of that year by a group of people with strong Austrian influence, who had been linked to the organisation of the Salzburg Geomechanics Colloquies. The General Assembly and the Council meetings took place at that occasion, and the Colloquy registration fees and expenses were included in the ISRM accounts. The papers of the Colloquy were published in the journal Rock Mechanics and Engineering Geology, Vol I/1–3, 1963.

The Society organised its first International Congress on Rock Mechanics in Lisbon, Portugal, in September 1966, where the interest of the researchers from all over the world in the activities of the ISRM was demonstrated. The number of participants was 814 from 40 countries, and 241 papers were presented. For the first time, coverage of the whole field of Rock Mechanics was possible. From then on, the ISRM International Congresses on Rock Mechanics have taken place every four years, with the purpose of providing a periodic survey of the advances in rock mechanics and rock engineering.

Every year since 1968, except in the years of the Congresses, an ISRM International Symposium has been organised by an ISRM National Group. This is the main event of the Society in each year, and where the ISRM Board, Council and Commission Meetings are held. Other events, such as Short Courses and Workshops, have often been associated with these International Symposia. Also, ISRM Regional Symposia have been organised by the National Groups since 1969 in the six geographical regions of the Society, totalling over 70 conferences. Currently, a maximum of one Regional Symposium is organised in each region in each year. ISRM Specialised Conferences, organised by the National Groups, were created in 2009: these are events that may not have the format of a Symposium, are usually of a smaller nature, and are focused on a specialised theme.

LIST OF THE ISRM INTERNATIONAL CONGRESSES ON ROCK MECHANICS

1st Congress

1966, 25 September–1 October, Lisbon, Portugal
Editor: Manuel Rocha
Organisers: Portuguese Group of Soil and Rock Mechanics and National Laboratory for Civil Engineering (LNEC)

2nd Congress

1970, 21–26 September, Belgrade, Yugoslavia
Editor: Branislav Kujudžic
Organisers: Yugoslav Society for Rock Mechanics and Underground Works

3rd Congress: Advances in Rock Mechanics

1974, 1–7 September, Denver, USA
Editor: Charles Fairhurst and Steven L. Crouch
Organisers: US National Committee for Rock Mechanics

4th Congress

1979, 2–9 September, Montreux, Switzerland
Editors: Jachen Huder and Bernhard Gilg
Organisers: Swiss Society for Soil and Rock Mechanics

5th Congress

1983, 10–15 April, Melbourne, Australia
Editor: W.E. Bramford
Organisers: Australian Geomechanics Society

6th Congress

1987, 30 August–3 September, Montreal, Canada
Editors: G. Herget and S. Vongpaisal
Organisers: Canadian National Committee on Rock Mechanics

7th Congress

1991, 16–20 September, Aachen, Germany
Editor: Walter Wittke
Organisers: Deutsche Gesellschaft für Erd- und Grundbau e.V.

8th Congress

1995, 25–29 September, Tokyo, Japan
Editor: T. Fuji
Organisers: Japanese Association on Rock Mechanics

9th Congress

1999, 25–28 August, Paris, France
Editors: Gérard Vouille and Pierre Berest
Organisers: Comité Français de Mécanique des Roches

10th Congress: Technology Roadmap for Rock Mechanics

2003, 7–12 September, Sandton, South Africa
Editors: Mathew Handley and Dick Stacey
Organisers: South African National Institute of Rock Mechanics

11th Congress: The Second Half Century of Rock Mechanics

2007, 9–13 July, Lisbon, Portugal
Editors: Luís Ribeiro e Sousa, Claudio Olalla, Nuno F. Grossmann
Organisers: Sociedade Portuguesa de Geotecnia

12th Congress: Harmonising Rock Mechanics and Environment

2011, 16–21 October, Beijing, China
Editors: Qihu Qian and Yingxin Zhou
Organisers: Chinese Society for Rock Mechanics and Engineering, and Society for Rock Mechanics and Engineering Geology (Singapore)

The next ISRM International Congress on Rock Mechanics is already approved.

13th Congress: Innovations in Applied and Theoretical Rock Mechanics

2015, 29 April–6 May, Montreal, Canada
Organisers: Canadian Rock Mechanics Association, McGill University, Queens University

LIST OF THE ISRM INTERNATIONAL SYMPOSIA

Determination of the Properties of Rock Masses in Foundations and Observation of their Behaviour

1968 October, Madrid, Spain
Editors: José A. Jiménez Salas, José M. Rodríguez Ortiz
Organiser: Sociedad Española de Mecánica de las Rocas

Large Permanent Underground Openings

1969 September, Oslo, Norway
Editors: Tor L. Brekke and Finn A. Jörstad
Organisers: Norwegian Group for Rock Mechanics

Rock Fracture

1971 September, Nancy, France
Editors: René Houpert
Organisers: Comité Français de Mécanique des Roches

Pressure Problems in Underground Openings

1972 September, Lucerne, Switzerland
Editors: H. Grob and K. Kovári
Organisers: Swiss Society for Soil and Rock Mechanics

Protection against Rock Fall

1973 September, Katowice, Poland
Editors: A. Kidybinski
Organisers: Association of Mining Engineers and Technicians – Central Mining Institute, and Polish National Group of the ISRM

16th US Symposium on Rock Mechanics: Design Methods in Rock Mechanics

1975 September, Minneapolis, USA
Editors: Charles Fairhurst and Steven L. Crouch
Organisers: US National Committee for Rock Mechanics of the National Academy of Engineering and the University of Minnesota

25th Salzburg Geomechanics Colloquy: Geomechanics of Orogenetic Events and their Effects on the Construction of Rock Structures on Subsurface and Underground

1976 October, Salzburg, Austria
Editors. F. Pacher
Organisers: Österreichische Gesellschaft für Geomechanik

Storage in Excavated Rock Caverns: Rockstore 77

1977 September, Stockholm, Sweden
Editor: Magnus Bergman
Organisers: Royal Swedish Academy of Engineering Sciences

Rock Mechanics Related to Dam Foundations

1978 September, Rio de Janeiro, Brazil
Editors: M.A. Kanji and R.A. Abrahão
Organisers: Associação Brasileira de Mecânica dos Solos - Comité Brasileiro de Mecânica de Rochas

Subsurface Space for Environmental Protection, Low-Cost Storage and Energy Savings: Rockstore 80

1980 June, Stockholm, Sweden
Editor: Magnus Bergman
Organisers: Swedish National Committee for Rock Mechanics

Weak Rock: Soft, Fractured and Weathered Rock

1981 September, Tokyo, Japan
Editors: Koichi Akai, Masao Hayashi and Yuichi Nishimatsu
Organisers: Japanese Association on Rock Mechanics

Rock Mechanics Related to Caverns and Pressure Shafts

1982 May, Aachen, Germany
Editors: W. Wittke
Organisers: Deutsche Gesellschaft für Erd- und Grundbau e.V. (DGEG)

Design and Performance of Underground Excavations

1984 September, Cambridge, UK
Editors: E.T. Brown and J.A. Hudson
Organisers: British Geotechnical Society

Role of Rock Mechanics in Excavations for Mining and Civil Works

1985 September, Zacatecas, Mexico
Editors: R. Sanchez Trejo and R. de la Llata R.
Organisers: Sociedad Mexicana de Mecánica de las Rocas

Rock Stress and Rock Stress Measurements

1986 September, Stockholm, Sweden
Editor: Ove Stephansson
Organisers: Swedish National Committee for Rock Mechanics

Rock Mechanics and Power Plants

1988 September, Madrid, Spain
Editor: M. Romana
Organisers: Sociedad Española de Mecánica de las Rocas

Rock at Great Depth

1989 August, Pau, France
Editors: V. Maury and D. Fourmaintraux
Organisers: Comité Français de Mécanique des Roches

Static and Dynamic Considerations in Rock Engineering

1990 September, Mbabane, Swaziland
Editor: Richard Brummer
Organisers: South African National Group of Rock Mechanics

Eurock '92: Rock Characterisation

1992 September, Chester, UK
Editor: J.A. Hudson
Organisers: British Geotechnical Society

Eurock '93: Safety and Environmental Issues in Rock Mechanics

1993 June, Lisbon, Portugal
Editors: L. Ribeiro e Sousa and N.F. Grossmann
Organisers: Sociedade Portuguesa de Geotecnia

Integral Approach to Applied Rock Mechanics

1994 May, Santiago, Chile
Editor: M. Van Sint Jan
Organisers: Sociedad Chilena de Geotecnia

Eurock '96: Prediction and Performance in Rock Mechanics and Rock Engineering

1996 September, Turin, Italy
Editor: Giovanni Barla
Organisers: Associazione Geotecnica Italiana

36th US Rock Mechanics Symposium NYRocks '97: Original Research, New Development and Case Studies in Rock Mechanics and Rock Engineering for Mining and Civil Application

1997 July, New York, USA
Editor: Kunsoo Kim
Organisers: US National Committee for Rock Mechanics

NARMS '98: Rock Mechanics in Mining, Petroleum and Civil

1998 June, Cancún, Mexico
Editors: Jorge Orozco and Juan Schmitter
Organisers: Sociedad Mexicana de Mecánica de las Rocas

GeoEng 2000: Geotechnical and Geological Engineering

2000 November, Melbourne, Australia
Editor: M. C. Enever
Organisers: Australian Geomechanics Society

2nd Asian Rock Mechanics Symposium: Frontiers of Rock Mechanics & Sustainable Development in the 21st Century

2001 September, Beijing, China
Editors: Wang Sijing, Fu Bingjun and Li Zhongkui
Organisers: Chinese Society for Rock Mechanics and Engineering

Eurock '2002: Rock Engineering for Mountainous Regions

2002 November, Madeira, Portugal
Editors: C. Dinis da Gama and L. Ribeiro e Sousa
Organisers: Sociedade Portuguesa de Geotecnia

3rd Asian Rock Mechanics Symposium: Contribution of Rock Mechanics to the New Century

2004 November, Kyoto, Japan
Editors: Yuzo Ohnishi and Kenji Aoki
Organisers: Japanese Committee for Rock Mechanics

Eurock '2005: Impact of Human Activity on the Geological Environment

2005 May, Brno, Czech Republic
Editor: Pavel Konečný
Organisers: ISRM National Group of the Czech Republic and Mining Society of Moravia and Silesia

3rd Asian Rock Mechanics Symposium: Rock Mechanics in Underground Construction

2006 June, Singapore
Editors: C.F. Leung and Y.X. Zhou
Organisers: ISRM National Group of Singapore, Tunnelling and Underground Construction Society (Singapore) Nanyang Technological University

5th Asian Rock Mechanics Symposium: New Horizons in Rock Mechanics – Developments and Applications

2008 November, Tehran, Iran
Editors: Abbas Majdi and Abdolhadi Ghazvinian
Organisers: Iranian Society for Rock Mechanics

SINOROCK 2009: Rock Characterisation, Modelling and Engineering Design Methods

2009 May, Hong Kong, China
Editors: J.A. Hudson, L.G. Tham, X.T. Feng, A.K.L. Kwong
Organisers: Chinese Society for Rock Mechanics and Engineering and the University of Hong Kong

6th Asian Rock Mechanics Symposium: Advances in Rock Engineering

2010 October, New Delhi, India
Editors: K.G. Sharma, T. Ramamurthy, V.K. Kanjlia, A.C. Gupta
Organisers: Indian National Group of the ISRM and Central Board of Irrigation and Power

The 2012 and 2013 ISRM International Symposia are already approved.

Eurock '2012: Rock Engineering and Technology for Sustainable Underground Construction

2012 May, Stockholm, Sweden
Organisers: Swedish Rock Engineering Research Foundation (BeFo)

Eurock '2013: Rock Mechanics for Resources, Energy and Environment

2013 September, Wroclaw, Poland
Organisers: Polish Society for Rock Mechanics and Wroclaw University of Technology

LIST OF THE ISRM REGIONAL SYMPOSIA

Determination of Stresses in Rock Masses

1969 May, Lisbon, Portugal
Organisers: Sociedade Portuguesa de Geotecnia

Percolation through Fissured Rock

1972 September, Stuttgart, Germany
Organisers: Deutsche Gesellschaft für Erd- und Grundbau e. V.

International Symposium on Investigation of Stress in Rock. Advances in Stress Measurements

1976 August, Sydney, Australia
Organisers: Australian Geomechanics Society

International Symposium on the Geotechnics of Structurally Complex Formations

1977 September, Capri, Italy
Organisers: Associazione Geotecnica Italiana

Colloquium on Geomechanical Models

1979 March, Bergamo, Italy
Organisers:Associazione Geotecnica Italiana

International Conference on Structural Foundations on Rock

1980 May, Sydney, Australia
Organisers: Australian Geomechanics Society

International Tunnelling Congress: Tunnel' 81

1981 June, Düsseldorf, Germany
Organisers: Deutsche Gesellschaft für Erd- und Grundbau e. V.

23rd US Rock Mechanics Symposium: Issues in Rock Mechanics

1982 August, Berkeley, CA USA
Organisers: University of California – Berkeley

Engineering in Complex Rock Formation

1986 November, Beijing, China
Organisers: Chinese Society for Rock Mechanics and Engineering

29th US Rock Mechanics Symposium: Key Questions in Rock Mechanics

1988 June, Minneapolis, MN USA
Organisers: US National Committee for Rock Mechanics

30th US Rock Mechanics Symposium

1989 June, Morgantown, WV USA
Organisers: US National Committee for Rock Mechanics

International Symposium on Rock Joints

1990 June, Loen, Norway
Organisers: Commission on Rock Joints and Norwegian Rock Mechanics Group

31st US Rock Mechanics Symposium: Rock Mechanics Contributions and Challenges

1990 June, Golden CO, USA
Organisers: US National Committee for Rock Mechanics

3rd South American Congress on Rock Mechanics

1990 October, Caracas, Venezuela
Organisers: Sociedad Venezolana de Mecánica del Suelo e Ingenieria de Fundaciones

32nd US Rock Mechanics Symposium: Rock Mechanics as a Multidisciplinary Science

1991 July, Norman, OK USA
Organisers: University of Oklahoma and USNC/RM

6th Australia-New Zealand Geomechanics Conference and 6th International Symposium on Landslides

1992 February, Christchurch, New Zealand
Organisers: New Zealand Geomechanics Society

International Symposium on Fractured and Jointed Rock Masses

1992 June, Lake Tahoe, CA USA
Organisers: ISRM Commission on Rock Joints and US National Committee for Rock Mechanics

33rd US Rock Mechanics Symposium

1992 June, Santa Fe, NM USA
Organisers: US National Committee for Rock Mechanics and the Geotechnical Board of the National Research Council

US - Canada Workshop on Recent Accomplishments and Future Trends in Geomechanics in the 21st Century

1992 October, Norman, OK USA
Organisers: National Science Foundation

International Symposium on Rock Slopes

1992 December, New Delhi, India
Organisers: Indian National Group of the ISRM

International Symposium on Assessment and Prevention of Failure Phenomena in Rock Engineering

1993 April, Istanbul, Turkey
Organisers: Turkish National Society for Rock Mechanics and the Japan Rock Mechanics Group

34th US Rock Mechanics Symposium

1993 June, Madison, WI USA
Organisers: US National Committee for Rock Mechanics and the University Wisconsin Madison

Fragblast 4: the 4th International Symposium on Rock Fragmentation by Blasting

1993 July, Vienna, Austria
Organisers: Österreichische Gesellschaft für Geomechanik and the Technical University Vienna

International Symposium on Hard Soils–Soft Rocks

1993 September, Athens, Greece
Organisers: Hellenic Society of Soil Mechanics and Foundation Engineering and the French Committee of Soil Mechanics and Foundation Engineering

1st North American Rock Mechanics Symposium - NARMS

1994, Austin, Texas, USA
Organisers: University of Texas, Austin, US National Committee on Rock Mechanics, CARMA and Sociedad Mexicana de Mecánica de Rocas

Eurock '94: Rock Mechanics in Petroleum Engineering

1994 August, Delft, Netherlands
Organisers: ISRM NG Netherlands

Colloquium on Chalk and Shales

1995 March, Brussels, Belgium
Organisers: Groupement Belge de Mécanique des Roches

NARMS'96: 2nd North American Rock Mechanics Symposium

1996 June, Montreal, PQ Canada
Organisers: École Polytechnique de Montréal and McGill University

7th Australian and New Zealand Conference on Geomechanics

1996 July, Adelaide, Australia
Organisers: Australian Geomechanics Society and New Zealand Geomechanics Society

Eurock '97: World Tunnel Congress 97

1997 April, Vienna, Austria
Organisers: Österreichische Gesellschaft für Geomechanik

International Symposium on Rock Support

1997 June, Lillehammer, Norway
Organisers: Norwegian Group for Rock Mechanics and Norwegian Tunnelling Society

4th International Symposium on Rockbursts and Seismicity in Mines

1997 August, Krakow, Poland
Organisers: ISRM National Group Poland

SARES 1997: Implementing Rock Engineering Knowledge

1997 September, Johannesburg, South Africa
Organisers: South African National Group on Rock Mechanics

Environmental and Safety Concerns in Underground Construction

1997 October, Seoul, Korea
Organisers: Korean Society for Rock Mechanics

International Congress on Underground Construction in Modern Infrastructure

1998 June, Stockholm, Sweden
Organisers: Swedish Rock Engineering Foundation (BeFo) and the Swedish Rock Construction Committee (BK)

Eurock '98: Rock Mechanics in Petroleum Engineering

1998 July, Trondheim, Norway
Organisers: NG Norway and the Society of Petroleum Engineers –SPE

The Geotechnics of Hard Soils and Soft Rocks

1998 October, Naples, Italy
Organisers: Associazione Geotecnica Italiana

International Symposium on Sedimentary Rocks

1998 November, Taipei, China
Organisers: SE Asian Geotechnical Society

2nd Brazilian Symposium on Rock Mechanics

1998 November, São Paulo, Brasil
Organisers: Brazilian Committee on Rock Mechanics, the Polytechnical School of São Paulo University and the Technological Research Institute of the State of São Paulo

37th US Rock Mechanics Symposium: Vail Rocks'99

1999 June, Vail, USA
Organisers: US National Committee on Rock Mechanics and the American Rock Mechanics Association

SARES 99, the 2nd Southern African Rock Engineering Symposium

1999 September, Johannesburg, South Africa
Organisers: South African National Group on Rock Mechanics

Eurock '2000: 14th Symposium on Rock Mechanics and Tunnel Construction

2000 March, Aachen, Germany
Organisers: Deutsche Gesellschaft für Erd- und Grundbau e. V.

10th IACMAG: 10th International Conference on Computer Methods and Advances in Geomechanics

2001 January, Tucson, Arizona, USA
Organisers: University of Arizona and American Rock Mechanics Association

GEONICS 2001: Conference on Temperature and its Influence on Geomaterials

2001 May, Ostrava, Czech Republic
Organisers: Institute of Geonics ASCR, Mining Society of Moravia and Silesia, and ISRM NG Czech Republic

Eurock '2001 – Rock Mechanics – A Challenge for Society

2001 June, Espoo, Finland
Organisers: ISRM National Group Finland

1st International Conference Albert Caquot

2001 October, Paris, France
Organisers: Comité Français de Mécanique des Roches

Modern Tunnelling Science and Technology

2001 October, Kyoto, Japan
Organisers: Japan Tunnelling Association and the Japan Society of Civil Engineers

Symposium on Rock Engineering Problems and Approaches in Underground Construction

2002 July, Seoul, Korea
Organisers: Korean Society for Rock Mechanics and the Japanese Association on Rock Mechanics

Symposium on Advancing Rock Mechanics Frontiers to meet the Challenges of the 21st Century

2002 September, New Delhi, India
Organisers: ISRM NG India and Central Board of Irrigation and Power

ICCAD-5: 5th International Conference on Analysis of Discontinuous Deformation - Stability of Ancient and Modern Rock Structures

2002 October, Wuhan, China

OILROCK SPE/ISRM Rock Mechanics Conference

2002 October, Dallas, Texas, USA
Organisers: Society of Petroleum Engineers and American Rock Mechanics Association

Post Mining 2003: Impacts and Risks Management

2003 February, Nancy, France
Organisers: Research Group of the Impact and Safety of Underground Works (GISOS), INPL, BRGM, INERIS, and ENSMS

ICCAD-6: 6th International Conference on Analysis of Discontinuous Deformation

2003 October, Trondheim, Norway
Organisers: SINTEF and Norwegian Group for Rock Mechanics

Geoproc 2003: International Conference on Coupled T-H-M-C Processes in Geosystems: Fundamentals, Modelling, Experiments and Applications

2003 October, Stockholm, Sweden
Organisers: Royal Institute of Technology (KTH) and Swedish Rock Engineering Research (BeFo)

SINOROCK 2004: International Symposium on Rock Mechanics, Rock Characterisation, Modelling and Engineering Design Methods

2004 May, Three Gorges Project Site, China
Organisers: Chinese Society of Rock Mechanics and Engineering

Eurock '2004 & 53rd Geomechanics Colloquy

2004 October, Salzburg, Austria
Organisers: Österreichische Gesellschaft für Geomechanik

Regional Symposium on Rock Mechanics for Underground Environment

2005 January, Moscow, Russian Federation
Organisers: Russian Geomechanics Association, Russian Tunnelling Association, American Rock Mechanics Association and several scientific committees of the Russian Academy of Sciences

Eurock '2006 - International Symposium on Multiphysics Coupling and Long Term Behaviour in Rock Mechanics

2006 May, Liège, Belgium
Organisers: Belgian National Group of Rock Mechanics

International Symposium on In-Situ Rock Stress

2006 June, Trondheim, Norway
Organisers: Norwegian National Group for Rock Mechanics

VI South American Congress on Rock Mechanics

2006 October, Cartagena, Colombia
Organisers: Colombian Geotechnical Society

Construction Technique of Subsea Tunnels

2007 November, Xiamen, China
Organisers: Chinese Society for Rock Mechanics and Engineering

6th International Symposium on Ground Support in Mining and Civil Engineering Construction

2008 March, Cape Town, South Africa
Organisers: South African National Institute of Rock Engineering and the Southern African Institute of Mining and Metallurgy

2nd US-Canada Rock Mechanics Symposium and 42nd US Rock Mechanics Symposium

2008 November, San Francisco, USA
Organisers: American Rock Mechanics Association and the Canadian Rock Mechanics Association

1st South American Symposium on Rock Excavations

2008 September, Santa Fé de Bogotá, Colombia
Organisers: Colombian Geotechnical Society

SHIRMS 2008 - 1st Southern Hemisphere International Rock Mechanics Symposium

2008 September, Perth, Australia
Organisers: Australian Centre for Geomechanics

International Symposium on Conservation of Ancient Sites 2008

2008 September, Dunhuang, China
Organisers: Commission on the Preservation and Consolidation Engineering of Ancient Sites of the CSRME

Eurock '2009 - Rock Engineering in Difficult Ground Conditions - Soft Rocks and Karst

2009 October, Cavtat, Croatia
Organisers: Croatian Geotechnical Society

Eurock '2010 - Rock Mechanics in Civil and Environmental Engineering

2010 June, Lausanne, Switzerland
Organisers: Swiss Society of Soils and Rock Mechanics and Swiss Federal Institute of Technology in Lausanne

VII South America Rock Mechanics Congress

2010 December, Lima, Peru
Organisers: Sociedad Peruana de Ingenieria and Instituto de Ingenieros de Minas del Peru

The following ISRM Regional Symposia are already approved.

II South American Symposium on Rock Excavations

2012 August, San José, Costa Rica
Organisers: Asociación Costarricense de Geotecnia

7th Asian Rock Mechanics Symposium (ARMS 2012)

2012 October, Seoul, Korea
Organisers: Korean Society for Rock Mechanics

Eurock '2014: Rock Engineering and Rock Mechanics: Structures in and on Rock Masses

2014 May, Vigo, Spain
Organisers: University of Vigo School of Mines and Spanish Rock Mechanics Society

8th Asian Rock Mechanics Symposium (ARMS 2014)

2014 October, Sapporo, Japan
Organisers: Japanese Committee for Rock Mechanics

LIST OF THE ISRM SPECIALISED CONFERENCES

3rd International Workshop on Rock Mechanics and Geo-Engineering in Volcanic Environments

2010 May, Tenerife, Spain
Editors: Claudio Olalla, Luis E. Hernandez, J.A. Rodriquez-Losada, Áurea Perucho, Javier González-Gallego
Organisers: Sociedad Española de Mecánica de las Rocas and the Regional Ministry of Public Works of the Government of the Canary Islands

5th International Symposium on In-Situ Rock Stress

2010 August, Beijing, China
Editor: F.R.Xie
Organisers: Institute of Crustal Dynamics from China Earthquake Administration, Chinese Society for Rock Mechanics and Engineering

The 2nd ISRM International Young Scholars' Symposium on Rock Mechanics

2011 October, Beijing, China
Editor: Meifeng Cai
Organisers: ISRM Commission on Education, and Chinese Society for Rock Mechanics and Engineering

The following ISRM Specialised Conferences are already approved.

Effective and Sustainable Hydraulic Fracturing

2013, May, Brisbane, Australia
Organisers: Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Australian Geomechanics Society

6th International Symposium on Rock Stress

2013 August, Sendai, Japan
Organisers: Japanese Committee for Rock Mechanics

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ISRM COMMISSIONS

The technical activity of the Society is mainly achieved through Commissions, appointed for each four year Presidential term, in order to study scientific, technical, or administrative matters of concern to the Society. The Commissions are formed by members of the Society and usually meet at the venue of the yearly ISRM International Symposium or of the Congress. Important goals of the Commissions are to prepare reports with the results of the Commission's work, and to present these during the ISRM conferences in order to convey the benefits to the ISRM members.

Two Commissions were appointed as early as 1967, the Commission on Recommendations on Site Investigation Techniques and the Commission on Testing Methods, and others followed soon afterwards. The Society has currently 14 Commissions dedicated to different fields of study for the 2011–2015 Presidential tenure period.

The following is a complete list of all the Commissions of the Society, with their chairmen and duration.

Commission on Application of Geophysics to Rock Engineering

Prof. Koichi Sassa, 1996–2007
Prof. Toshifumi Matsuoka, 2007–present

Commission on Behaviour of Tunnels and other Permanent Openings

Dr B. Gilg, 1973–1980

Commission on Case Histories

Dr Don C. Banks, 1980–1988

Commission on Case Histories in Rock Engineering

Prof. Fensheng Shen, 2004–2007

Commission on Classification of Rocks and Rock Masses

Prof. Manuel Rocha, 1971–1979

Commission on Communications

Prof. S. Sakurai, 1988–1991

Commission on Computer Programs

Prof. W. Wittke, 1976–1980
Dr S. Semprich, 1980–1982
Dr Bertold Plischke, 1982–1987

Commission on Coupled Thermo-Hydro-Mechano-Chemical Processes in Geological Materials and Systems

Prof. Liu Jishan, 2011–present

Commission on Crustal Stress and Earthquake

Prof. Furen Xie, 2011–present

Commission on Design of High Slopes in Mining

Dr D.R. Piteau, 1980–1983
Dr D. Coates, 1983–1987

Commission on Discontinuous Deformation Analysis (DDA)

Dr Yossef Hatzor and Dr Guowei Ma, 2011–present

Commission on Education

Dr S. Budavari, 1988–1992
Dr John Franklin, 1992–1994
Prof. Marek Kwasniewski, 1994–2004
Prof Meifeng Cai, 2004–present

Commission on Environment

Dr John Gale, 2004–2007

Commission on Hard Rock Excavation

Dr Manoj Verman, 2011–present

Commission on Information Technology
Prof. Ove Stephansson, 2000–2003

Commission on Interpretation of Hydraulic Fracturing Records
Mr Jim Enever. 1983–1989

Commission on Maintenance and Repair of Underground Structures in Rock Masses
Prof. Luís Ribeiro e Sousa, 2004–2007

Commission on Mine Closure
Mr Christophe Didier, 2004–2011

Commission on Petroleum Engineering
Prof. F.J. Santarelli, 1989–1995

Commission on Petroleum Geomechanics
Prof. Maurice Dusseault, 2011–present

Commission on Preservation of Ancient Sites
Prof. Zui Xiong Li, 2007–present

Commission on Preservation of Natural Stone Monuments
Prof. Chikaosa Tanimoto, 1997–2007

Commission on Publication and Translation
Dr H.K. Kutter, 1973–1979

Commission on Radioactive Waste Disposal
Prof. Wang Ju, 2007–present

Commission on Recommendations on Site Investigation Techniques
Prof. J. Laginha Serafim, 1967–1975

Commission on Research, previously called Commission on Definition of most Promising Lines of Research
Prof. P. Habib, 1967–1981
Dr S. Bjurström, 1981–1987

Commission on Revision of Statutes
Mr P. Duffaut, 1974–1978

Commission on Revision of Statutes, By–laws and Guidelines
Dr John Franklin, 1987–1988

Commission on Rock Boreability, Cuttability and Drillability
Prof. E.T. Brown, 1980–1983
Prof. W. Bamford, 1983–1989

Commission on Rockbursts in Hardrock Situations
Mr N.C. Gay, 1994–1996
Dr Sten Spottiswoode, 1996–2000

Commission on Rock Dynamics
Prof. Yingxin Zhou, 2007–2011
Prof. Kaiwen Xia, 2011–present

Commission on Rock Engineering Design Methodology
Prof. Xia-Ting Feng and Prof. John A. Hudson, 2007–2011
Prof. John A. Hudson and Prof. Xia-Ting Feng, 2011–present

Commission on Rock Failure Mechanisms in Underground Openings
Dr Vincent Maury, 1981–1991

Commission on Rock Fragmentation by Blasting
Dr William Fourney, 1989–1999

Commission on Rock Grouting
Dr R. Widmann, 1988–1995

Commission on Rock Joints
Prof. Ove Stephansson, 1988–1992

Commission on Rock Properties for Petroleum Engineering
Dr Vincent Maury, 1989–1995

Commission on Rock Slope Stability
Mr Garry R. Mostyn, 1995–1999

Commission on Scale Effects in Rock Mechanics
Dr A. Pinto da Cunha, 1988–1995

Commission on Soft Rocks
Prof. Milton A. Kanji, 2011–present

Commission on Spalling Prediction
Prof. Mark Diederichs, 2008–present

Commission on Squeezing Rocks in Tunnels
Prof. Kalman Kovari, 1988–1989
Prof. Giovani Barla, 1989–1999

Commission on Swelling Rocks
Prof. W.E. Bamford, 1977–1983
Prof. Herbert Einstein, 1983–1995
Dr Fritz Madsen, 1995–2003

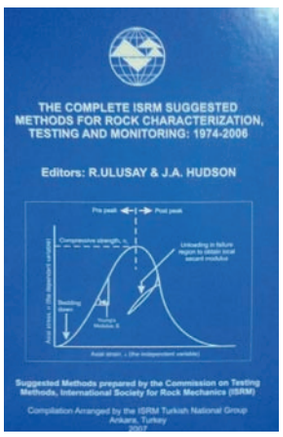
Commission on Teaching of Rock Mechanics
Dr Evert Hoek, 1971–1973
Prof. Edward J. Cording, 1973–1983

Commission on Tectonic Stability and Site Selection
Dr Chack Lee, 1989–1991

Commission on Terminology, Symbols, and Graphic Representation
Dr M. Langer, 1967–1975

Commission on Testing Methods
Dr Don Deere, 1966–1972
Dr Z.T. Bieniawski (Committee on Standardisation of Laboratory Tests) 1972–1979
Dr John Franklin (Committee on Standardisation of Field Tests), 1972–1979
Dr John Franklin, 1979–1987
Prof. John A. Hudson, 1987–2006
Prof. Resat Ulusay, 2006–present

Commission on Underground Research Laboratory (URL) Networking
Dr Joseph S.Y. Wang, 2011–present



Launch of the "Blue Book" of the Commission on Testing Methods, Lisbon, 2007. J.A. Hudson and R. Ulusay

D

ISRM NEWS AND ISRM NEWS JOURNAL

Soon after the first Congress, the ISRM started a publication, the News. In the Editorial of the first issue—of January–March 1967—the President Manuel Rocha wrote:

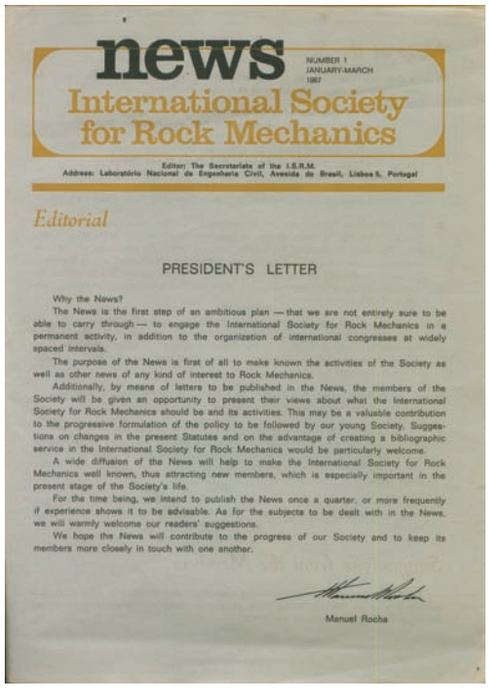
> *"The News is the first step of an ambitious plan—that we are not entirely sure to be able to carry through—to engage the International Society for Rock Mechanics in a permanent activity, in addition to the organisation of international Congresses at widely spaced intervals.*
>
> *The purpose of the News is first of all to make known the activities of the Society as well as other news of any kind of interest to Rock Mechanics. [...]*
>
> *A wide diffusion of the News will help to make the International Society for Rock Mechanics well known, thus attracting new members, which is especially important in the present stage of the Society's life."*

The News soon became the means of communication of the ISRM, with information on the Society and on the field of rock mechanics, with a very complete directory of conferences, book revisions, and many other articles of interest. Besides the conferences, this was for many years the only link that the members had with the Society, and it was an instrument of vital importance to the growth and to the effective establishment of the ISRM internationally.

In 1992, after 97 issues were published, President Charles Fairhurst decided to replace the News by the News Journal. His main intention was to broaden the scope of the publication, by including technical articles on the latest developments in rock mechanics, and to reach an audience that would go beyond the ISRM members. In the Letter from the President included in the first Issue, of September 1992, he defined his idea for the News Journal:

> *"The International Society for Rock Mechanics (ISRM) exists to promote world-wide awareness of the latest developments in understanding of the principles of rock mechanics and their effective practical application. Thus, if we are to be fully effective as a society, all ISRM members should be aware of new observations, ideas and solutions as they arise, be fully informed of relevant rock mechanics experience elsewhere in the world, and have an opportunity to raise questions and make suggestions. The ISRM News Journal is a new venture intended to promote this communication and awareness among ISRM members and, indeed, anyone interested in rock mechanics. (Non-members are invited to join ISRM; simply complete and mail the application on page 61 of this Issue.)*
>
> *The News Journal incorporates ISRM News, and will appear quarterly when fully established. We plan to include overview articles and reports, discuss areas and topics where there has been significant progress, lack of progress, surprising or intriguing observations (see the back cover of this issue!), member comments, etc.—in short, anything that can stimulate creative thinking and a more rapid development of rock mechanics. Such articles should complement but in no way compete with the specific reports on scientific-technical advances that are more appropriately published in the established review journals in rock mechanics and rock engineering."*

A total of 33 issues of the News Journal has been published so far. With the advent of the internet and electronic communication, its role as a communication tool was complemented by the ISRM website and digital Newsletter, and, with the 2011 issue, it started being distributed electronically to the members. Compared with the volatile information, that nowadays circulates at high speed through our computers, the more perennial nature of the News Journal—with contents prepared with time and care—justifies the very important role that it continues to have in our Society.



news

NUMBER 1
JANUARY-MARCH
1967

International Society for Rock Mechanics

Editor: The Secretariate of the I.S.R.M.
Address: Laboratório Nacional de Engenharia Civil, Avenida do Brasil, Lisboa 5, Portugal

Editorial

PRESIDENT'S LETTER

Why the News?

The News is the first step of an ambitious plan — that we are not entirely sure to be able to carry through — to engage the International Society for Rock Mechanics in a permanent activity, in addition to the organization of international congresses at widely spaced intervals.

The purpose of the News is first of all to make known the activities of the Society as well as other news of any kind of interest to Rock Mechanics.

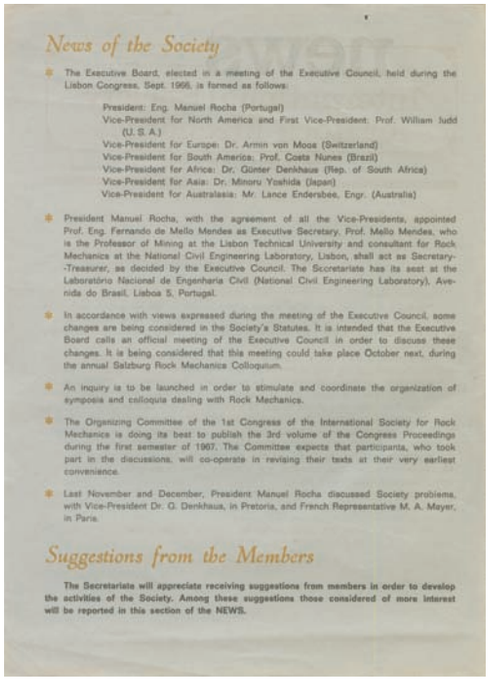
Additionally, by means of letters to be published in the News, the members of the Society will be given an opportunity to present their views about what the International Society for Rock Mechanics should be and its activities. This may be a valuable contribution to the progressive formulation of the policy to be followed by our young Society. Suggestions on changes in the present Statutes and on the advantage of creating a bibliographic service in the International Society for Rock Mechanics would be particularly welcome.

A wide diffusion of the News will help to make the International Society for Rock Mechanics well known, thus attracting new members, which is especially important in the present stage of the Society's life.

For the time being, we intend to publish the News once a quarter, or more frequently if experience shows it to be advisable. As for the subjects to be dealt with in the News, we will warmly welcome our readers' suggestions.

We hope the News will contribute to the progress of our Society and to keep its members more closely in touch with one another.

Manuel Rocha



News of the Society

* The Executive Board, elected in a meeting of the Executive Council, held during the Lisbon Congress, Sept. 1966, is formed as follows:

President: Eng. Manuel Rocha (Portugal)
Vice-President for North America and First Vice-President: Prof. William Judd (U. S. A.)
Vice-President for Europe: Dr. Armin von Moos (Switzerland)
Vice-President for South America: Prof. Costa Nunes (Brazil)
Vice-President for Africa: Dr. Günter Denkhaus (Rep. of South Africa)
Vice-President for Asia: Dr. Minoru Yoshida (Japan)
Vice-President for Australasia: Mr. Lance Endersbee, Engr. (Australia)

* President Manuel Rocha, with the agreement of all the Vice-Presidents, appointed Prof. Eng. Fernando de Mello Mendes as Executive Secretary. Prof. Mello Mendes, who is the Professor of Mining at the Lisbon Technical University and consultant for Rock Mechanics at the National Civil Engineering Laboratory, Lisbon, shall act as Secretary-Treasurer, as decided by the Executive Council. The Secretariate has its seat at the Laboratório Nacional de Engenharia Civil (National Civil Engineering Laboratory), Avenida do Brasil, Lisboa 5, Portugal.

* In accordance with views expressed during the meeting of the Executive Council, some changes are being considered in the Society's Statutes. It is intended that the Executive Board calls an official meeting of the Executive Council in order to discuss these changes. It is being considered that this meeting could take place October next, during the annual Salzburg Rock Mechanics Colloquium.

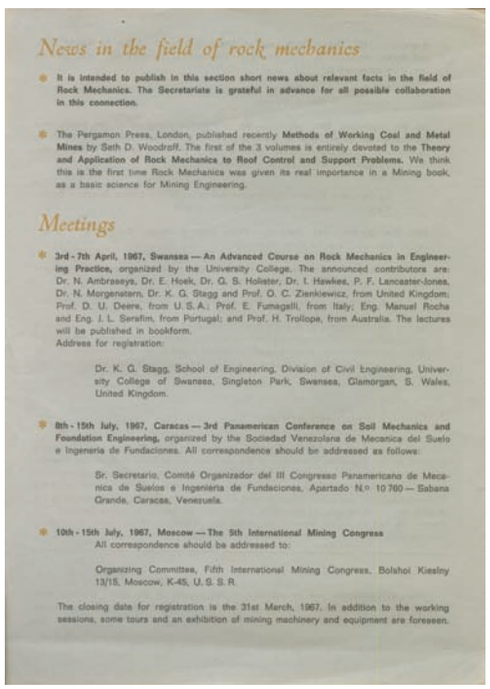
* An inquiry is to be launched in order to stimulate and coordinate the organization of symposia and colloquia dealing with Rock Mechanics.

* The Organizing Committee of the 1st Congress of the International Society for Rock Mechanics is doing its best to publish the 3rd volume of the Congress Proceedings during the first semester of 1967. The Committee expects that participants, who took part in the discussions, will co-operate in revising their texts at their very earliest convenience.

* Last November and December, President Manuel Rocha discussed Society problems, with Vice-President Dr. G. Denkhaus, in Pretoria, and French Representative M. A. Mayer, in Paris.

Suggestions from the Members

The Secretariate will appreciate receiving suggestions from members in order to develop the activities of the Society. Among these suggestions those considered of more interest will be reported in this section of the NEWS.



News in the field of rock mechanics

* **It is intended to publish in this section short news about relevant facts in the field of Rock Mechanics. The Secretariate is grateful in advance for all possible collaboration in this connection.**

* The Pergamon Press, London, published recently **Methods of Working Coal and Metal Mines** by Seth D. Woodroff. The first of the 3 volumes is entirely devoted to the **Theory and Application of Rock Mechanics to Roof Control and Support Problems.** We think this is the first time Rock Mechanics was given its real importance in a Mining book, as a basic science for Mining Engineering.

Meetings

* **3rd - 7th April, 1967, Swansea — An Advanced Course on Rock Mechanics in Engineering Practice,** organized by the University College. The announced contributors are: Dr. N. Ambraseys, Dr. E. Hoek, Dr. G. S. Holister, Dr. I. Hawkes, P. F. Lancaster-Jones, Dr. N. Morgenstern, Dr. K. G. Stagg and Prof. O. C. Zienkiewicz, from United Kingdom; Prof. D. U. Deere, from U. S. A.; Prof. E. Fumagalli, from Italy; Eng. Manuel Rocha and Eng. J. L. Serafim, from Portugal; and Prof. H. Trollope, from Australia. The lectures will be published in bookform.
Address for registration:

Dr. K. G. Stagg, School of Engineering, Division of Civil Engineering, University College of Swansea, Singleton Park, Swansea, Glamorgan, S. Wales, United Kingdom.

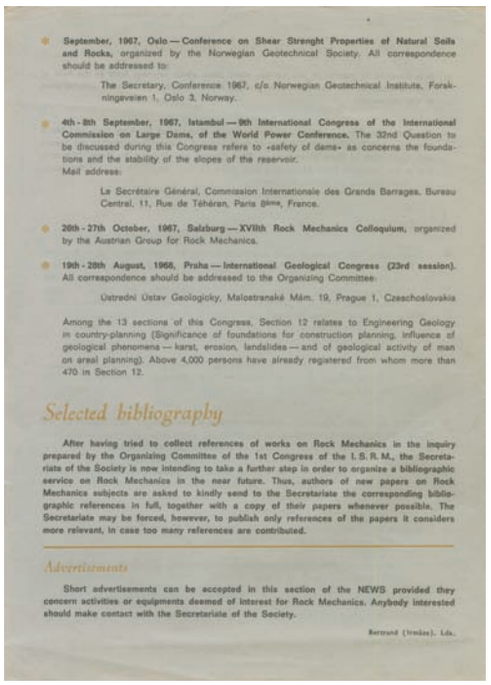
* **8th - 15th July, 1967, Caracas — 3rd Panamerican Conference on Soil Mechanics and Foundation Engineering,** organized by the Sociedad Venezolana de Mecanica del Suelo e Ingeneria de Fundaciones. All correspondence should be addressed as follows:

Sr. Secretario, Comité Organizador del III Congreso Panamericano de Mecanica de Suelos e Ingeniería de Fundaciones, Apartado N.º 10 760 — Sabana Grande, Caracas, Venezuela.

* **10th - 15th July, 1967, Moscow — The 5th International Mining Congress**
All correspondence should be addressed to:

Organizing Committee, Fifth International Mining Congress, Bolshoi Kiselny 13/15, Moscow, K-45, U. S. S. R.

The closing date for registration is the 31st March, 1967. In addition to the working sessions, some tours and an exhibition of mining machinery and equipment are foreseen.



* **September, 1967, Oslo — Conference on Shear Strenght Properties of Natural Soils and Rocks,** organized by the Norwegian Geotechnical Society. All correspondence should be addressed to:

The Secretary, Conference 1967, c/o Norwegian Geotechnical Institute, Forskningsveien 1, Oslo 3, Norway.

* **4th - 8th September, 1967, Istambul — 9th International Congress of the International Commission on Large Dams, of the World Power Conference.** The 32nd Question to be discussed during this Congress refers to «safety of dams» as concerns the foundations and the stability of the slopes of the reservoir.
Mail address:

Le Secrétaire Général, Commission Internationale des Grands Barrages, Bureau Central, 11, Rue de Téhéran, Paris 8ème, France.

* **20th - 27th October, 1967, Salzburg — XVIIth Rock Mechanics Colloquium,** organized by the Austrian Group for Rock Mechanics.

* **19th - 26th August, 1968, Praha — International Geological Congress (23rd session).** All correspondence should be addressed to the Organizing Committee:

Ústřední Ústav Geologicky, Malostranské Mám. 19, Prague 1, Czechoslovakia

Among the 13 sections of this Congress, Section 12 relates to Engineering Geology in country-planning (Significance of foundations for construction planning, influence of geological phenomena — karst, erosion, landslides — and of geological activity of man on areal planning). Above 4,000 persons have already registered from whom more than 470 in Section 12.

Selected bibliography

After having tried to collect references of works on Rock Mechanics in the inquiry prepared by the Organizing Committee of the 1st Congress of the I. S. R. M., the Secretariate of the Society is now intending to take a further step in order to organize a bibliographic service on Rock Mechanics in the near future. Thus, authors of new papers on Rock Mechanics subjects are asked to kindly send to the Secretariate the corresponding bibliographic references in full, together with a copy of their papers whenever possible. The Secretariate may be forced, however, to publish only references of the papers it considers more relevant, in case too many references are contributed.

Advertisements

Short advertisements can be accepted in this section of the NEWS provided they concern activities or equipments deemed of interest for Rock Mechanics. Anybody interested should make contact with the Secretariate of the Society.

Bertrand (Irmãos), Lda.

Issue number 1 of the ISRM News

Société Internationale de Mécanique des Roches
INTERNATIONAL SOCIETY FOR ROCK MECHANICS
Internationale Gesellschaft für Felsmechanik
NEWS JOURNAL

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The mine – by tunnel at the Underground Research Laboratory.
The tunnel is excavated by ring drilling and mechanical splitting of the face.

Letter from the President

Charles Fairhurst

The International Society for Rock Mechanics (ISRM) exists to promote world-wide awareness of the latest developments in understanding of the principles of rock mechanics and their effective practical application. Thus, if we are to be fully effective as a society, all ISRM members should be aware of new observations, ideas and solutions as they arise, be fully informed of relevant rock mechanics experience elsewhere in the world, and have an opportunity to raise questions and make suggestions. The ISRM *News Journal* is a new venture intended to promote this communication and awareness among ISRM members and, indeed, anyone interested in rock mechanics. (Non-members are invited to join ISRM; simply complete and mail the application on page 61 of this issue.)

The *News Journal* incorporates ISRM *News*, and will appear quarterly when fully established. We plan to include overview articles and reports, discuss areas and topics where there has been significant progress, lack of progress, surprising or intriguing observations (see the back cover of this issue!), member comments, etc.—in short, anything that can stimulate creative thinking and a more rapid development of rock mechanics. Such articles should complement but in no way compete with the specific reports on scientific-technical advances that are more appropriately published in the established review journals in rock mechanics and rock engineering.

Professor Widmann (page 22), recalls "the need to clarify the behaviour and treatment of those rock masses that cannot be described by the methods of continuum theory and the principles of soil mechanics" as a main motivation of Dr. Leopold Müller, the first ISRM President, when he led the drive to establish the ISRM in 1966. It is sobering to realize that some 35 years later, there is still much to be done to achieve this early goal—initially a concern primarily of civil engineers—and that there are many unanswered rock mechanics questions of comparable importance in other fields of science and engineering. Our membership is not large compared to the size of the task. The ISRM *News Journal* should help us become more effective, individually and collectively, in our efforts.

To further improve communication, two additional options have been introduced:

- ISRM National Groups with twenty or more current (i.e. fully paid) individual ISRM members are encouraged to translate part or all of the contents of the *News Journal* for distribution to their members, without royalty or other charges by ISRM.
- As with the ISRM *News*, copies of the ISRM *News Journal* will be mailed in bulk to each National Group for subsequent distribution to the individual and supporting members. This procedure sometimes leads to considerable delay in arrival of the individual copies. Where this is the case, members are offered the option of having the *News Journal* airmailed directly to them by paying the mailing costs. (Members wishing to use this option should complete the appropriate parts of the ISRM application form on page 61.)

Finally, the strong support of the *News Journal* by the advertisers is greatly appreciated. This new venture would not be possible without their participation. (See page 1 for advertising rates and mailing information.)

—Charles Fairhurst

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PHOTOGRAPHS OF THE EARLY YEARS OF THE ISRM

ISRM Constitutional Meeting, Salzburg, 25 May 1962

1 | 2
3 | 4
5 | 6

1. Head table with Leopold Müller and Franz Pacher

2. Voting

3, 4, 5, 6. Participants

First Congress in Lisbon, 1966

1 | 2
3 | 4
5
6 | 7

1. The Portuguese President arrives

2, 3. Opening ceremony

4. Leopold Müller and Manuel Rocha

5. ISRM Board meeting

6, 7. Technical sessions

First Congress in Lisbon, 1966

1
2
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4

1. Technical visit to the Tagus bridge under construction

2. Technical visit to the LNEC

3. Flags in front of the Lisbon University

4. Tour departure from the Lisbon University

First Congress in Lisbon, 1966

1 | 2
3
4 | 5
6

1, 2. Banquets

3. Folk dances

4. Bullfight

5. Concert

6. Visit to the Queluz palace

AISENSTEIN, Boris
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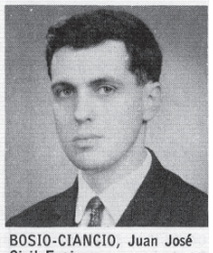

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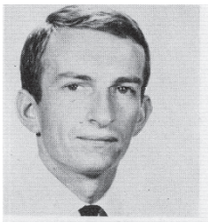

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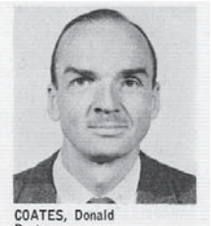

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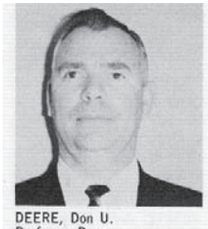

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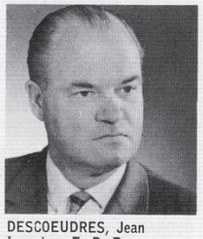

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Selection of photos of the participants in the First Congress in Lisbon, 1966, from the Congress Proceeding

Selection of photos of the participants in the First Congress in Lisbon, 1966, from the Congress Proceeding

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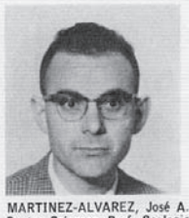

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Selection of photos of the participants in the First Congress in Lisbon, 1966, from the Congress Proceeding

Selection of photos of the participants in the First Congress in Lisbon, 1966, from the Congress Proceeding

1966–1969

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4 | 5

1. Leipzig, November 1966. The ISRM President Manuel Rocha (center), Vice-President Costa Nunes (2nd from the right) and Secretary General Mello Mendes (2nd from the left), meet Prof. Bolesław Krupiński (extreme left), first Chairman of the World Mining Congress and Prof. Georg Bilkenroth (extreme right), founder and first President of the International Bureau of Strata Mechanics

2. Geomechanics Colloquy, Salzburg, 1967. Leopold Müller, Manuel Rocha, Mello Mendes

3, 4, 5. Symposium on "Determination of the Properties of Rock Masses in Foundations and Observation of their Behaviour", Madrid, 1968

1966–1969

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4 | 5

1. Symposium "Determination of Stress in Rock Masses", Lisbon, 1969. Organising committee

Symposium on "Large Permanent Underground Openings", Oslo, 1969

2. W. Wittke and R. Goodman

3. l.t.r. M. Rocha, R. Oliveira, W. Judd, M. L. Eusébio, G. Denkhaus

4. P. Duffaut, M. L. Eusébio, F. Mello Mendes and wife

5. Reception at the Munch museum

Second Congress in Belgrade, 1970

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1. Venue
2. Opening ceremony
3. Technical session

Second Congress in Belgrade, 1970

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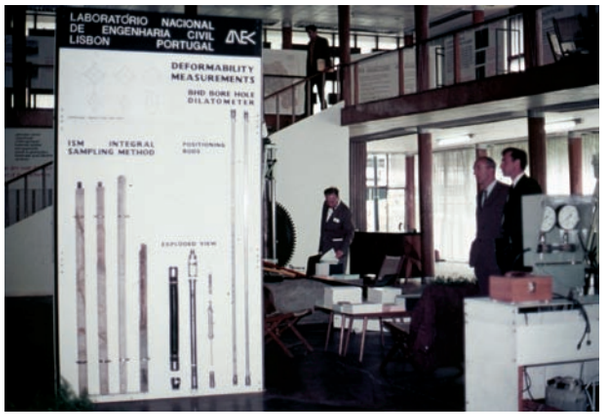
3
4 | 5

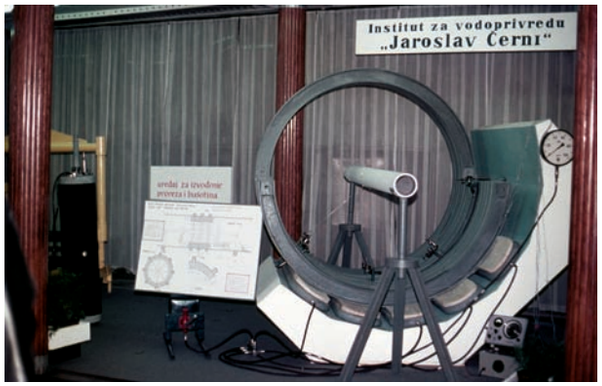
1. Council meeting. L. Endersbee, M. Rocha, R. Oliveira, A. von Moos, M. Yoshida

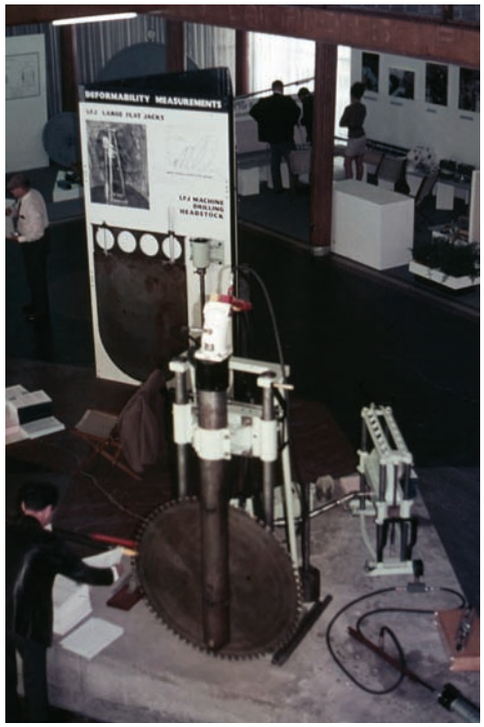
2. Council meeting. A. von Moos, R. Oliveira, M. Rocha, A. Costa Nunes, L. Müller

3, 4, 5. Reception by the deputy mayor

Second Congress in Belgrade, 1970







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1, 2, 3, 4. Technical exhibition

Second Congress in Belgrade, 1970

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2 | 3

1. Excursion to the hydropower and navigation system Djerdap

2, 3. Closing banquet

Selection of photos of the participants in the Second Congress in Belgrade, 1970, from the Congress Proceedings

ANAGNOSTOPOULOS
Andreas — Greece

BAMFORD W. E.
Australia

BERGH-CHRISTENSEN Jan
Norway

BJURSTRÖM Sten
Sweden

BROMS Bengt
Sweden

CHAOUI Abdellatif
Maroc

DE MELLO V. F. B.
Brazil

DESAI Chandrakant S.
USA

DINIS DA GAMA Carlos
Portugal

EGGER Peter
BRD


ENDERSBEE Lance A.
Australia


GANEV Ivan
Bulgaria


GOODMAN E. Richard
USA


HARDY H. Reginald
USA


HEUZE Francois D.
USA


HOUPERT René
France


KING M. S.
Canada


KOVARI Kalman
Schweiz


KUTTER Herbert K.
Great Britain


LIEN Reidar
Norway


LOUSBERG Emmanue
Belgique


LUNDE Johnny
Norway


PACHER Franz
Austria


PARISEAU William G.
USA


PASAMEHMETOGLU Ahmet Günhan — Great Britain


ROEGIERS Jean-Claude
USA


ROMANA RUIEZ Manuel
Spain


ROMERO Uriel S.
Spain


SHARP John Christian
Canada


SINGH R. D.
India


ŠIŠKA Lubomir
ČSSR


SZECHY K
Ungarn


THIEL Kazimierz
Polen


VAUGHAN Peter Rolfe
Great Britain


VOUILLE Gérard
France

Selection of photos of the participants in the Second Congress in Belgrade, 1970, from the Congress Proceedings

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