On the occasion of the 50th ISRM Anniversary

Future Directions for Engineering Rock Mechanics

A presentation by Ricardo Resende, Portugal

SUMMARY

- Who am I
- What is RM
- Working in RM
- Global trends
- Research in RM
- Research topics in RM
- The role of ISRM
- ISRM challenges
- Interdisciplinary HACKING
- Conclusion
- Sources

WHO AM I

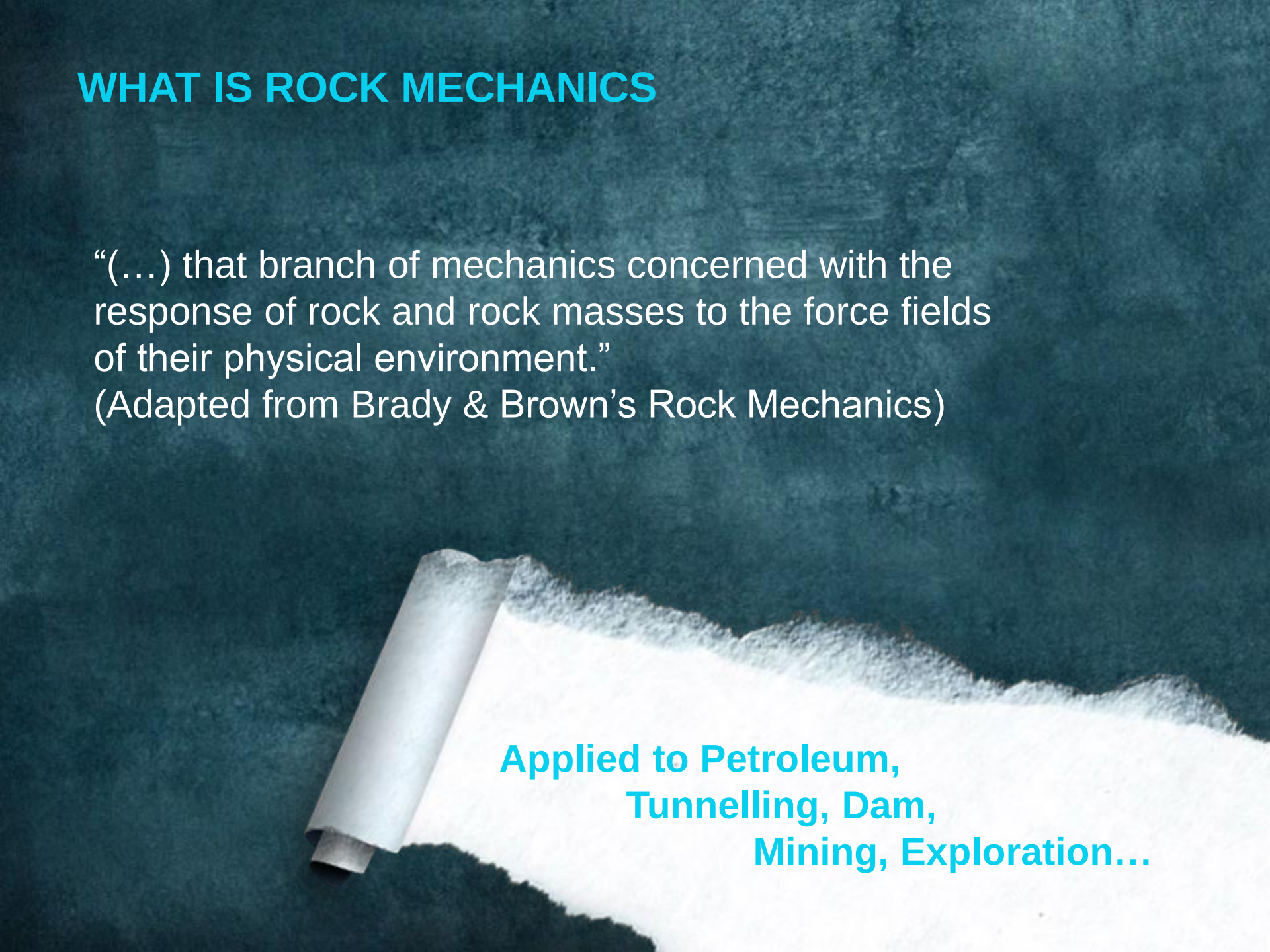
- 33 year old
- From Portugal – Southern Europe
- Structural engineer, in Rock Mechanics for 10 years
- PhD on Rock Dynamics and MSc on dam foundations
- Skilled on field testing and numerical modelling

Why is this important?

This presentation reflects my views, readings and experience

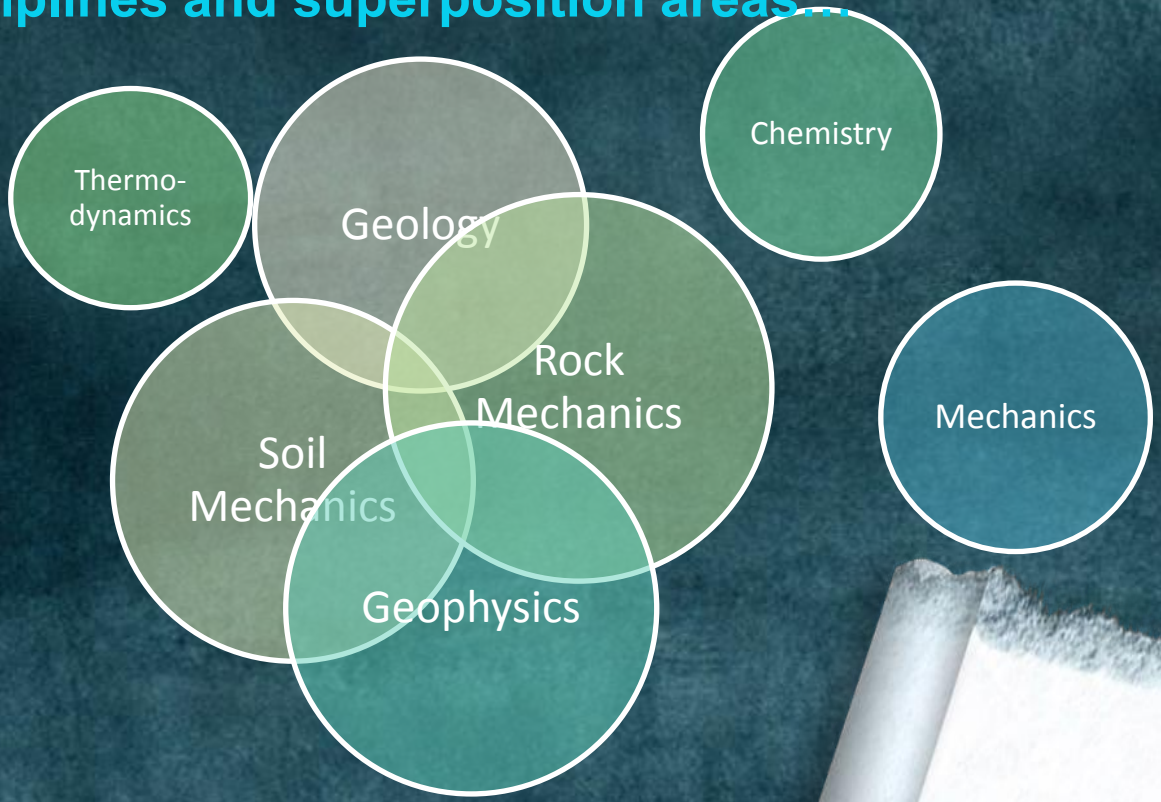
WHAT IS ROCK MECHANICS

"(…) that branch of mechanics concerned with the response of rock and rock masses to the force fields of their physical environment."
(Adapted from Brady & Brown's Rock Mechanics)



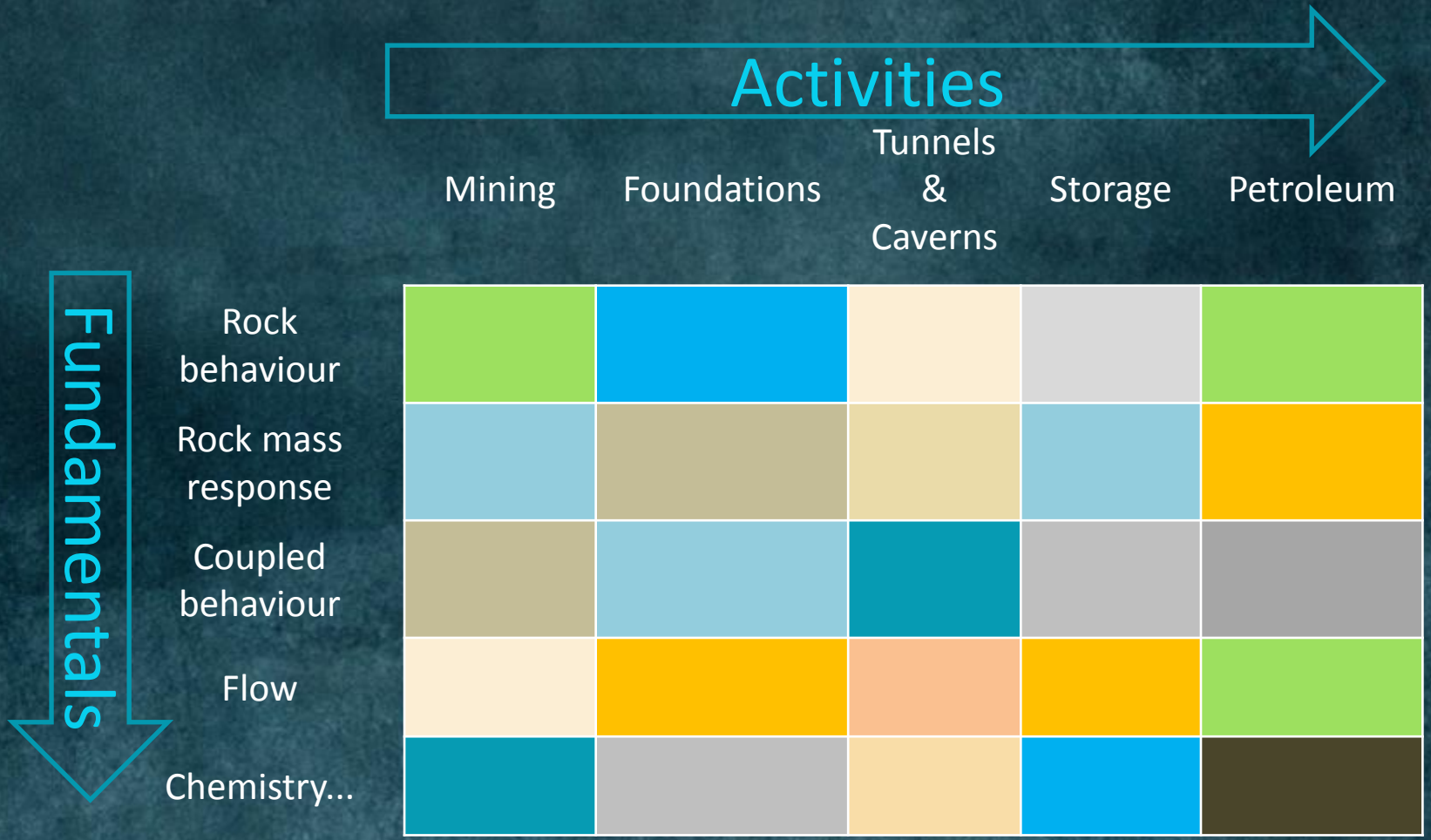
SCIENTIFIC DISCIPLINES…

A rich ecosystem, with more diffuse boundaries, sub-disciplines and superposition areas…



How will the system evolve?

OR, FUNDAMENTALS VS ACTIVITIES



… AND THE SPECIFIC SKILLS AND TOOLS

Will Rock Mechanics thrive as a discipline?

Or will it be shattered in sub-specializations?

WHICH NEW ROLES

Will a broad-band CV become a luxury that only a few can reach?

How will teams be composed, and how will they work?

Will we see greater intra and inter institutional cooperation?

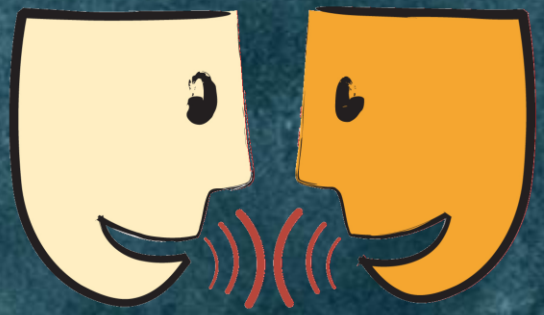
WHICH NEW ROLES

How will technology change the way we work:

- social-networks
- 24/24 connectivity
- easy and inexpensive circulation of documents, image and video?

Change is already happening but still far from its full potential

Will technology and different working methods drive greater real cooperation and communication instead of just swapping reports over email?



WHICH NEW ROLES

Research Centres

- Private
- Government based
- Inter-government, via international research projects
- Defense

Private Companies

- Consultants
- Construction (infrastructures, dams, tunnels, irrigation...)
- Mining
- Petroleum
- …

Academia

- Staff
- PhD, MSc students

In the actual ISRM Board all these roles are represented

GLOBAL TRENDS

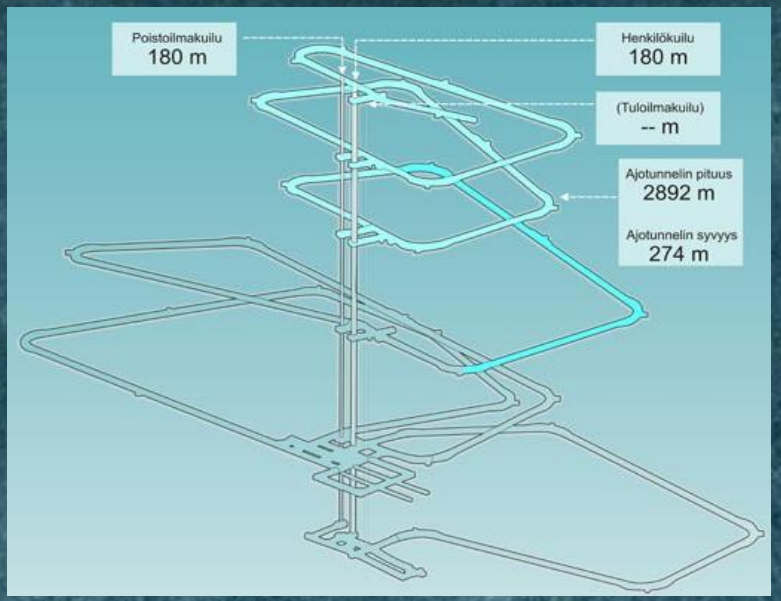
How will demand for Rock Mechanics activities evolve globally?

- Geopolitics
- Global economy and finance
- Energy and manufacturing demand
- Environmental restrictions

GLOBAL TRENDS

Which energy solutions will dominate?

- Nuclear
- Wind
- Oil
- Natural gas
- Shale
- Wave
- Hydro
- Geothermal



GLOBAL TRENDS

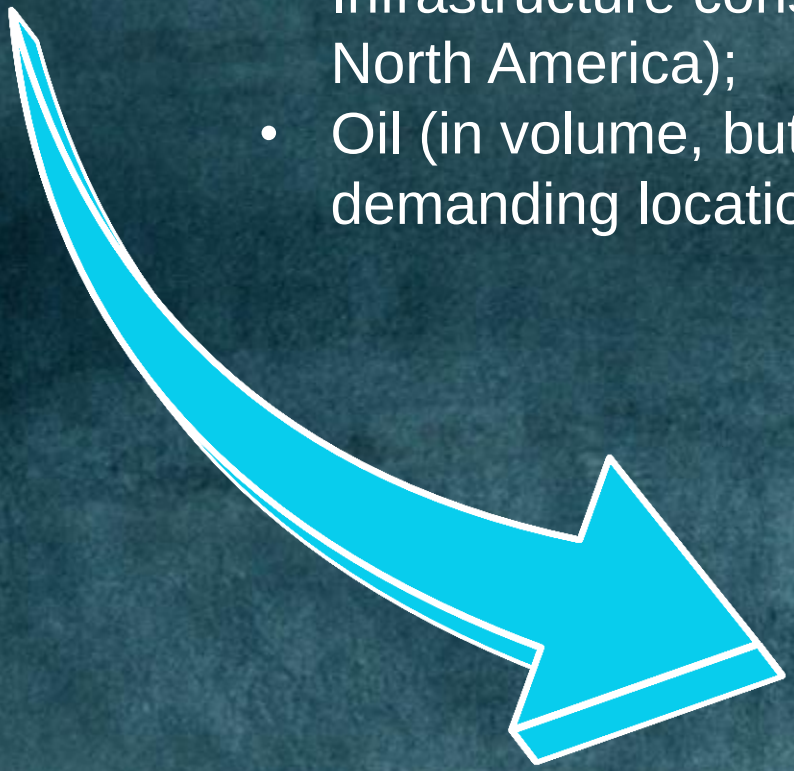
Demand may go up for…

- Minerals: in volume but also in harder places to mine;
- Construction of infrastructures (in Asia, Africa and South America);
- Rehabilitation and conservation of existing underground structures (globally);
- Safety assessment of slopes
- Dam construction for hydropower and strategic water reserves (globally)
- geothermal;
- Hydrocarbons storage (due to instability in prices);
- CO_2 sequestration

GLOBAL TRENDS

Demand may go down for…

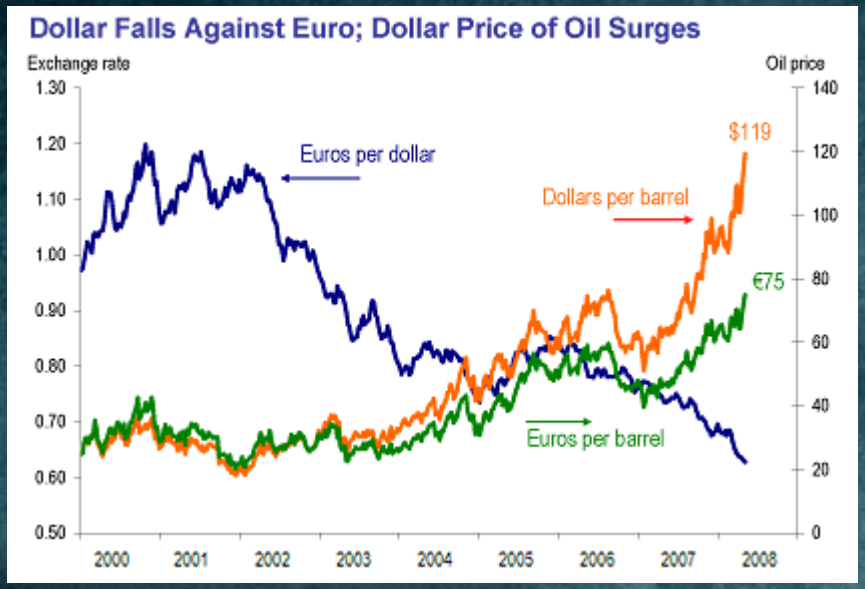
- Infrastructure construction (in Europe and in North America);
- Oil (in volume, but moving to more demanding locations);

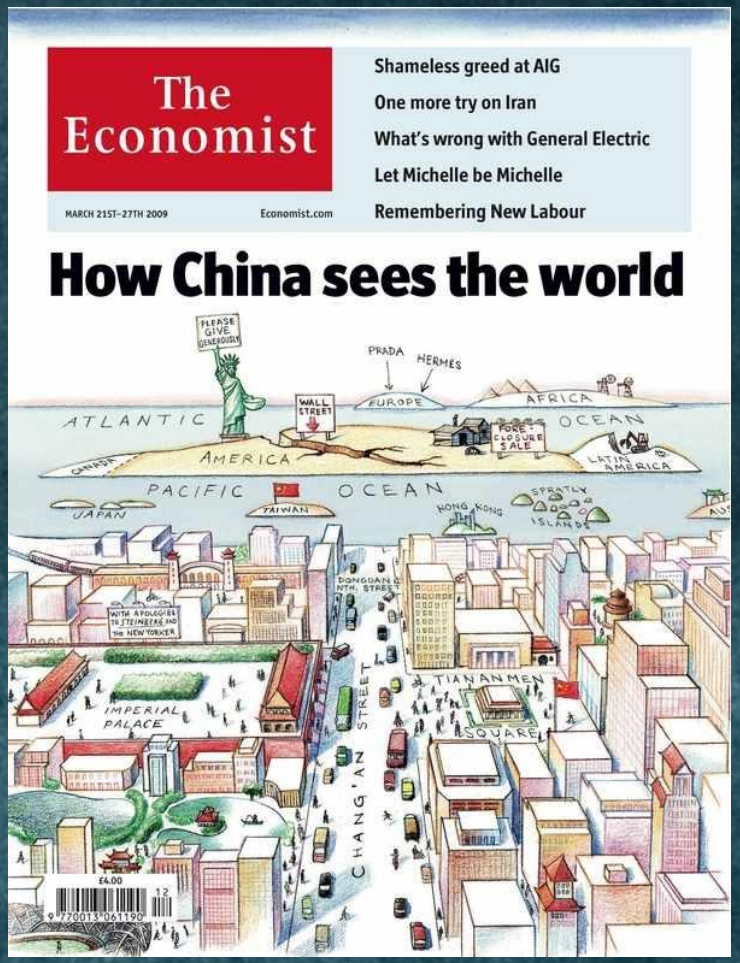


RESEARCH IN ROCK MECHANICS

Government funding

- Smaller budgets in Europe and North America
- Higher budgets in Asia and South America
- What about Africa, in the next 10 to 20 years?





RESEARCH IN ROCK MECHANICS

Large-scale testing facilities or long-term studies

- Who, if anyone, will fill the role of Governments, if research budgets decrease?
- How will international cooperation evolve?

Privately funded research

- Will private companies have the financial capacity to invest more in research?
- Will they have a choice, in order to keep the competitive edge?

RESEARCH IN ROCK MECHANICS

Intellectual Property in a ever-competitive world

And how will all this affect knowledge dissemination?

Will intellectual property legal battles become current?

Benchmarking

With so many methods, it is not necessary to select the best method, but some sort of comparison is needed

More comparison of methods and results is needed

RESEARCH IN ROCK MECHANICS

Validation and Quality control

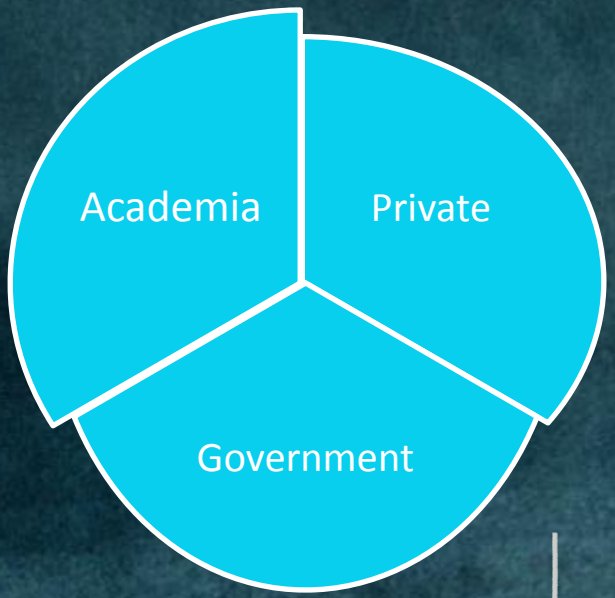
How do we know if our results reproduce nature's real mechanisms?

Importance of back-analysis, long-scale monitoring, full-scale testing facilities and open data dissemination

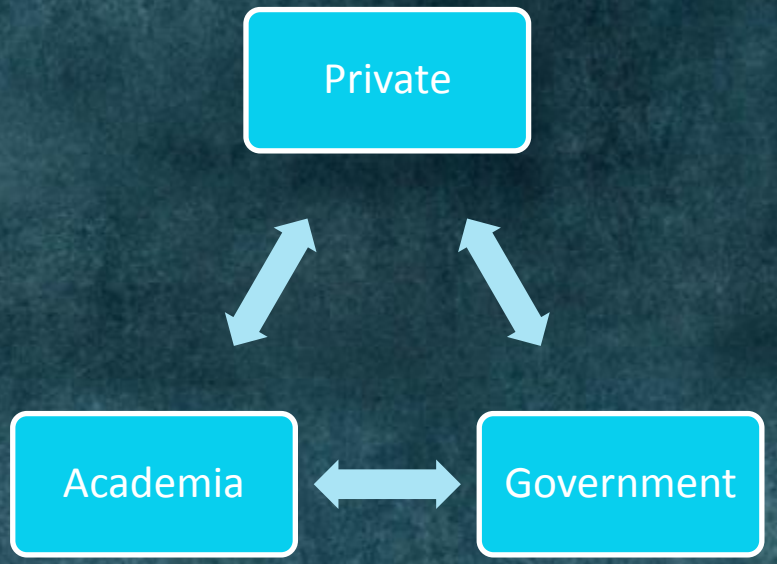
Open, universal formats for testing results and for numerical models data: increase cross-testing and verification

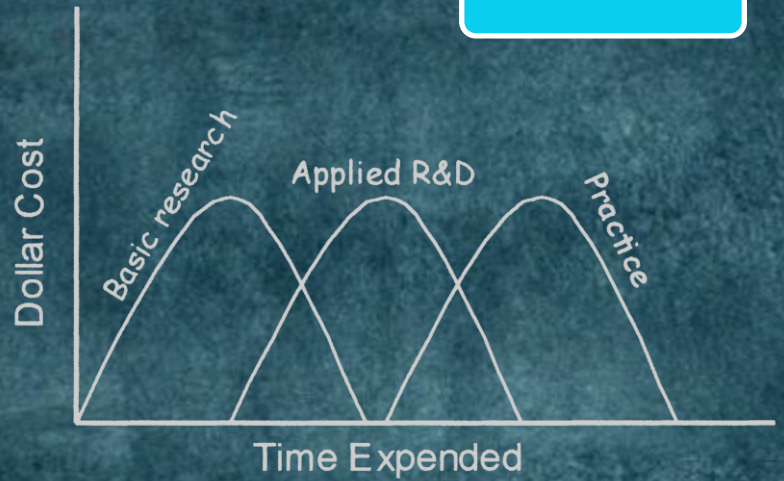
RESEARCH IN ROCK MECHANICS

Is the size of each slice the most important?



Or how the research is shared and integrated?





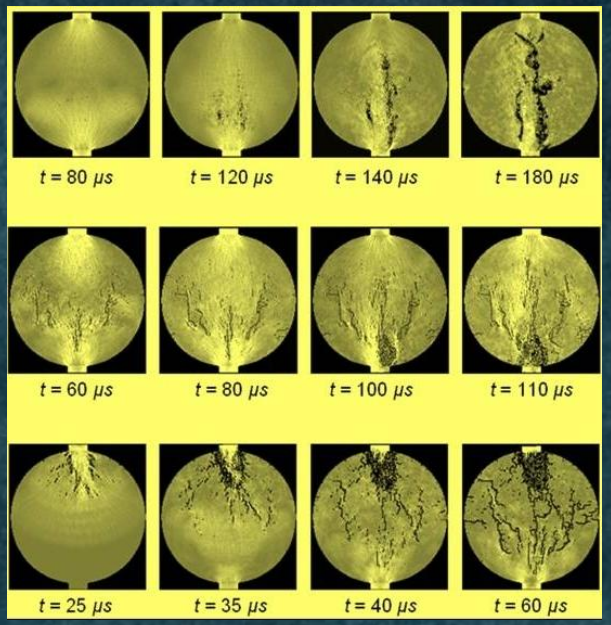
RESEARCH TOPICS IN ROCK MECHANICS

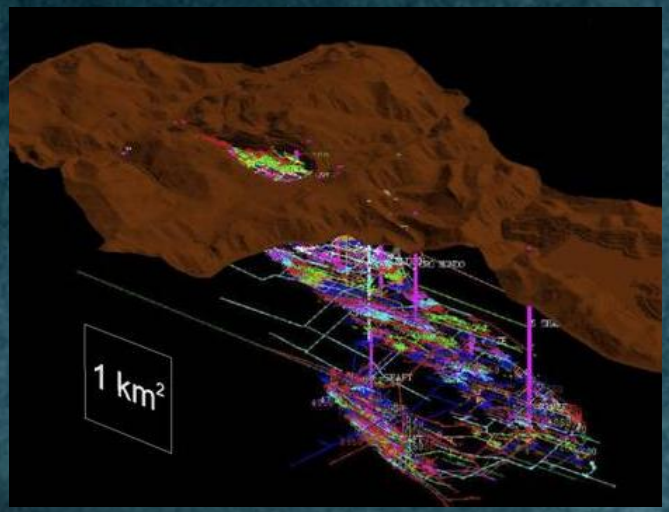
Rock testing vs Micromechanical modelling

Test the fundamentals of rock static and dynamic behaviour at crystal level

Time effects

From very fast to very slow behaviour changes dramatically. Do the key mechanisms apply across time and space scale? Will we be able to find a general phenomenological theory?





RESEARCH TOPICS IN ROCK MECHANICS

Long-term behavior

How will we define the life span of existing underground structures? And of linings, rockbolts, etc? How do stress fields evolve around a large span tunnel 100 years after its opening?

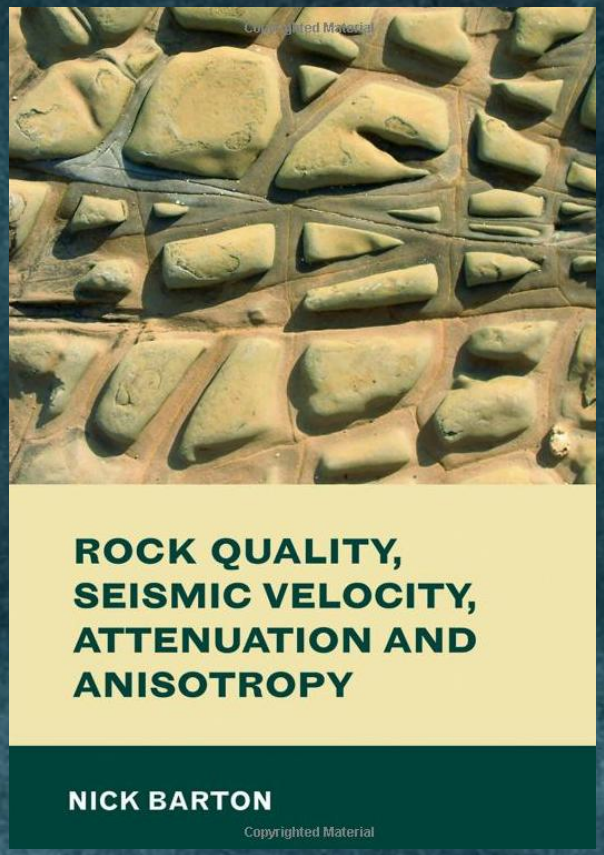
T-C-H-M coupling

An interdisiplinary topic, is fundamental for specific problems, but can also be the key to explain many aspects of rock mass behaviour (e.g. long-term behaviour)

RESEARCH TOPICS IN ROCK MECHANICS

New ways to deal with Uncertainty
Massive scenarios simulations using parallel computing, integration of more sophisticated risk analysis in everyday practice

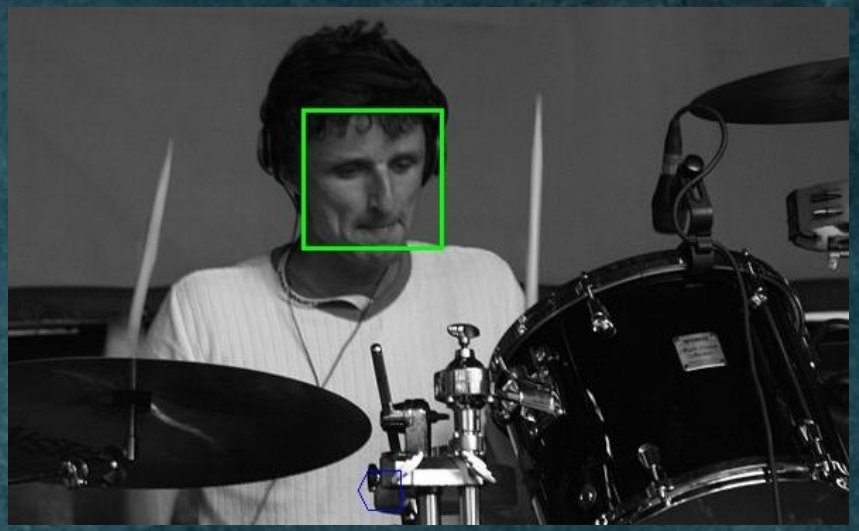
Greater Integration
With geophysics, geomechanics, etc (and other areas), as fundamental mechanisms drives research to similar findings through converging paths



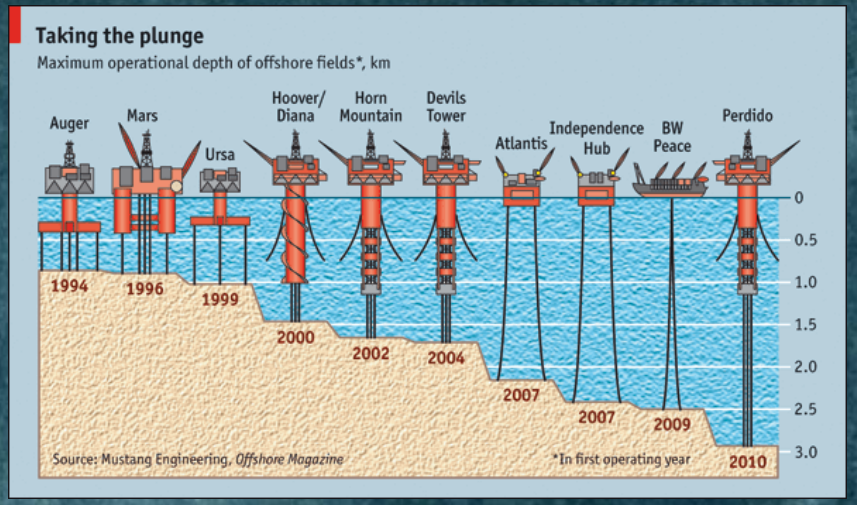
More sophisticated Measurements
Will other kinds of measurement become common? Acoustic emissions, electric and magnetic fields, acceleration in parallel with force and displacement?

RESEARCH TOPICS IN ROCK MECHANICS

Imaging techniques
In boreholes, rock faces, etc. using digital image processing, pattern recognition. Maybe learning from other engineering areas with larger budgets (e.g. face recognition in digital cameras)



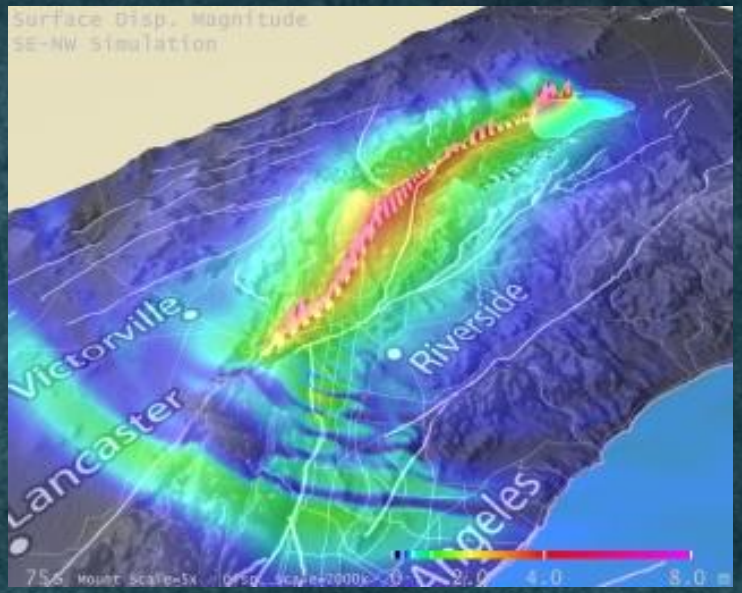
New Environments
Deeper excavations, fault zones, overstressed rocks, ocean foundations (offshore wind farms, ocean mineral exploration)



RESEARCH TOPICS IN ROCK MECHANICS

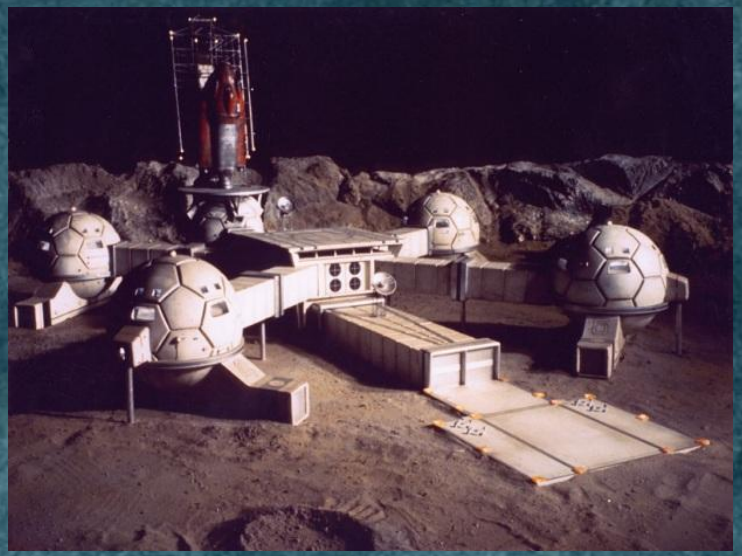
Geodynamics

Highly stressed environments: prediction and prevention of rockburst, prediction of earthquake triggering mechanisms



Space exploration

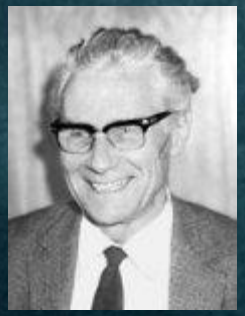
Moon and Mars bases? How different is Martian rock mechanics from ours? Different gravity, mineral. Also, no margin for errors



THE ROLE OF ISRM

History

50 year old, founded to establish Rock Mechanics as a new discipline.



Prof. Leopold Muller (1908-1988)

Prof. Manuel Rocha (1913-1981)

ISRM will, for the second time, have a President from Asia (2012-2015)

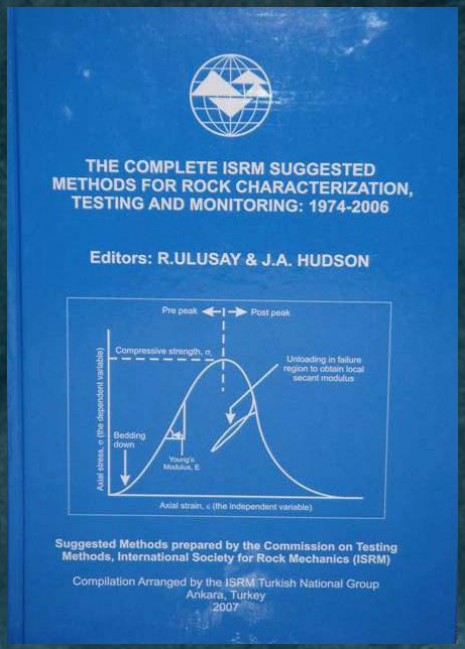
Demand for Rock Mechanics products (minerals, oil, gas, etc.) is growing with an impetus that is hard to keep up with. Can ISRM keep up and support the discipline and its professionals?

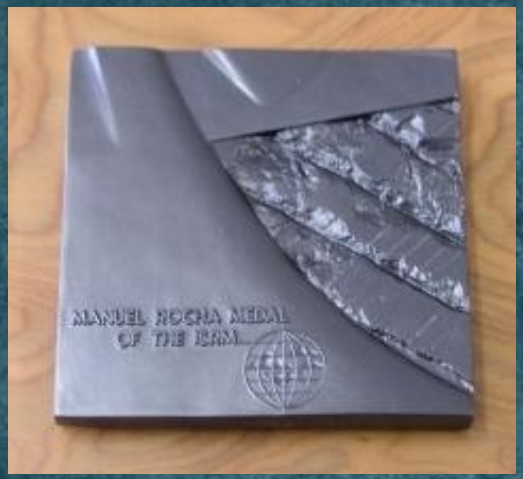
THE ROLE OF ISRM

Current roles

- Organizes meetings
- Produces Suggested Methods
- Harbours thematic Commissions
- Distinguishes outstanding research and careers (Rocha Medal and Müller Award)

ISRM is on an effort to reinvent itself for the next 50 years





ISRM CHALLENGES

Work is being done on deeper, more dangerous environments, where rock properties are different, rock behaviour is highly coupled, scarcely known and hard to characterize, in most testing facilities

Demands on technicians are great and not always entirely fair as the tools, means and schedules are often set by financial rules, not engineering

ISRM must set guidelines that protect good practice in Rock Mechanics

ISRM CHALLENGES

Foster communication and networking: member to member and member-organization, other than traditional conferences and meetings. Do this both at local and global level, using new communications channels: social networks, webinars…

ISRM CHALLENGES

Education

Suggest education standards and reconversion for existing professionals and people coming from other areas. Should ISRM suggest a curriculum? Or sponsor MSc degrees?
Collaborate with authors to provide training material in a more structured way?

Numerical Methods

How does ISRM address Numerical Methods? Should ISRM develop Suggested Methods for numerical modelling?

Open Data formats

Promote the standardization of data formats for numerical models to facilitate benchmarking

Relation with industry sponsors

Suggest education standards and reconversion for existing professionals and people coming from other areas. Should ISRM suggest a curriculum? Or sponsor MSc degrees?

ISRM CHALLENGES

Sister Societies

Set common goals and foster relations with sister Societies: “horizontal”: Soil Mechanics, Engineering Geology and “vertical”: Tunneling, Explosives, Petroleum

Most ISRM members are also members of other societies (ISRM Survey, 2008).

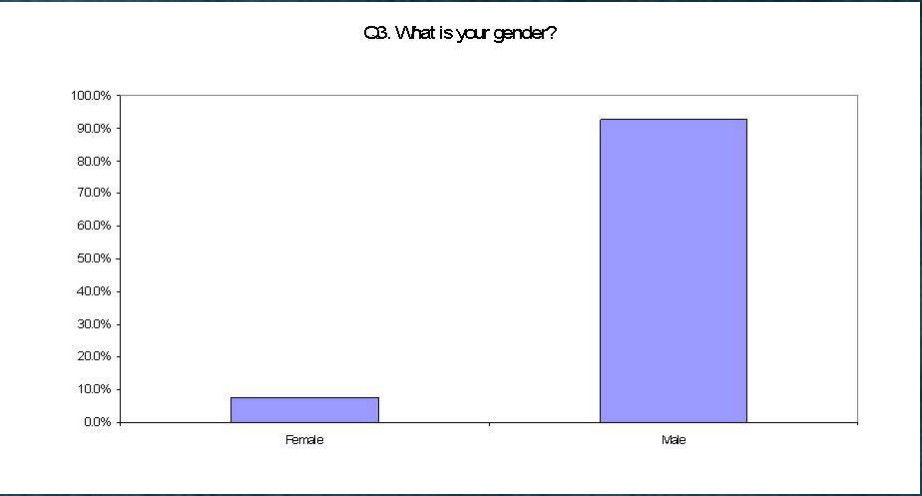
ISRM CHALLENGES

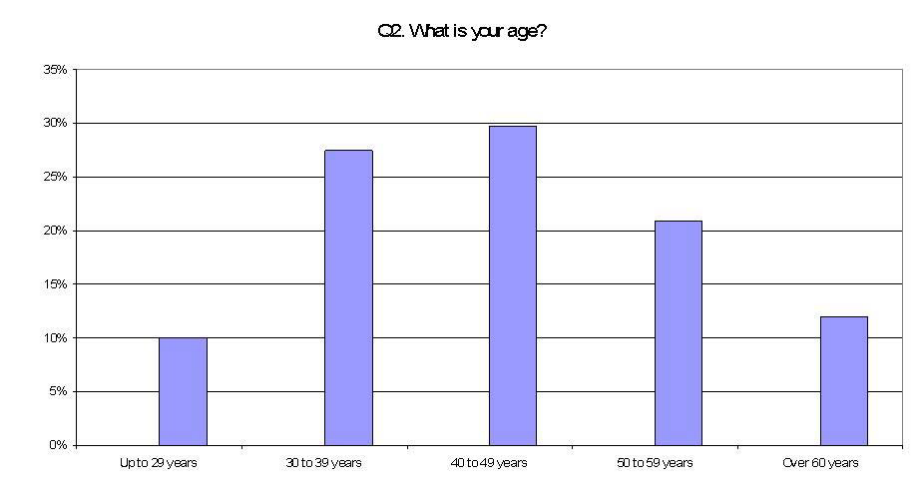
Membership

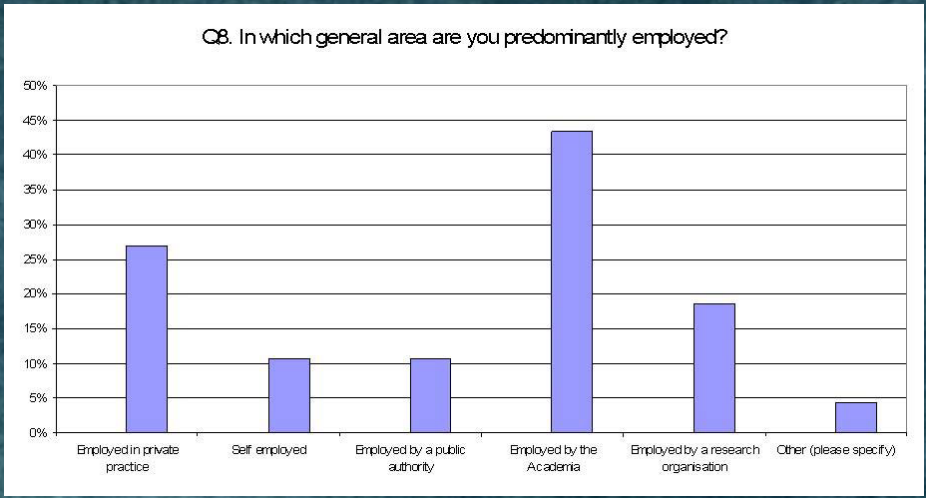
ISRM members are predominantly:

- Male;
- Working in academia;
- Over 40

Does this reflect the real Rock Mechanics population? Is ISRM missing a lot of professionals?





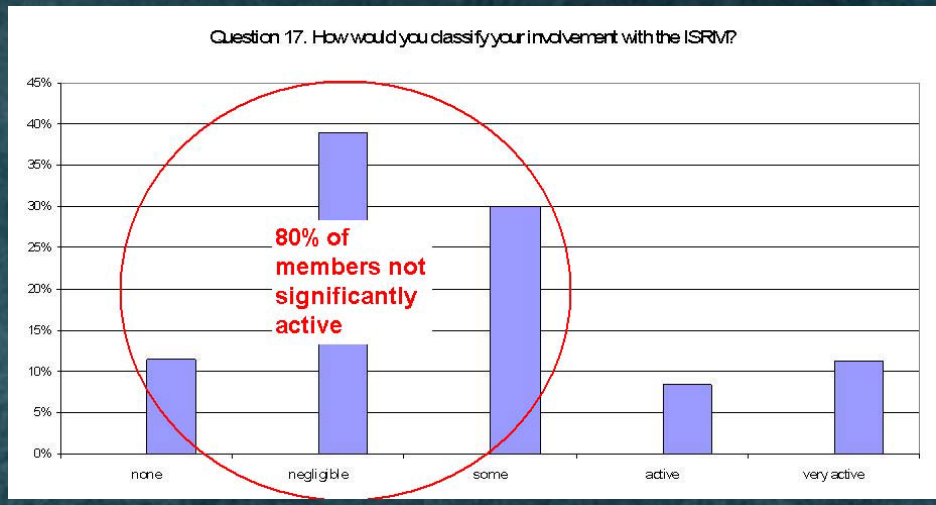


Source: 2008 ISRM survey

ISRM CHALLENGES

Membership

Most members do not have any significant involvement in ISRM. How to change this?



What do Rock Mechanics engineers ask from ISRM?

- Access to databases of technical papers
- Access to educational material (e.g. online education and training)
- Expanded opportunity to network with other Rock Mechanics professionals
- Access to specific technical papers for inclusion on the website
- Lecture tours by experts on particular topics

Source: 2008 ISRM survey

ISRM CHALLENGES

Governance

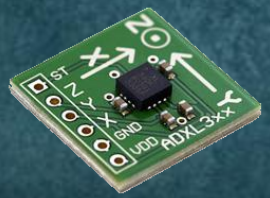
Reinvent its structure. Is the actual structure fit for future challenges? Should the structure be reengineered?

Suggest Education standards and reconversion for existing professionals and people coming from other areas.

- Should ISRM suggest a curriculum?
- Sponsor MSc degrees?
- Collaborate with authors to provide training material in a more structured way?

INTERDISCIPLINARY HACKING

Cheap, small, water-resistant, rugged, digital HD cameras
For radical sports enthusiasts, can they be adapted in exploration tasks

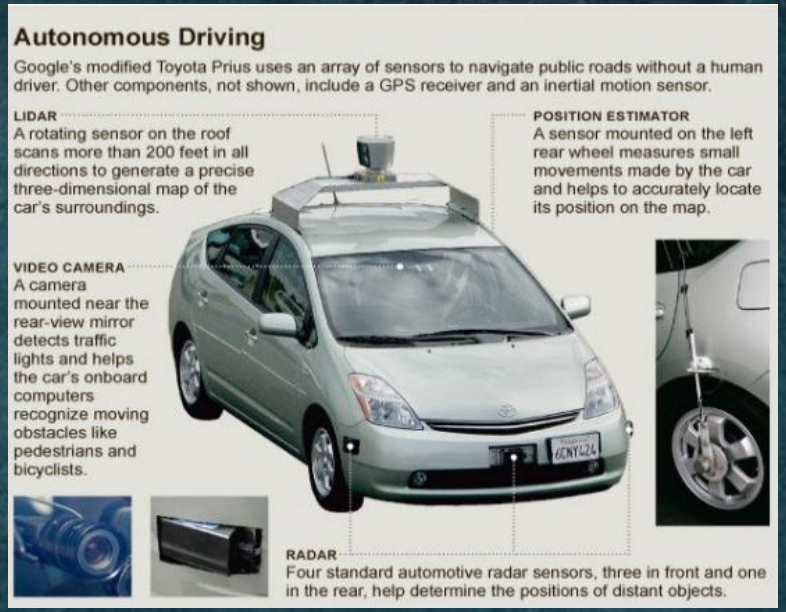


GPS and accelerometers on watches, mobile-phones
The prices, availability and precision of a number electronic equipment has plummeted

INTERDISCIPLINARY HACKING

Robots, drones, self-driving vehicles

Already extensively used in military conflicts, may change dramatically the way exploration and excavation is performed



More efficient batteries

How will self sufficient equipment change the way work is done on site?

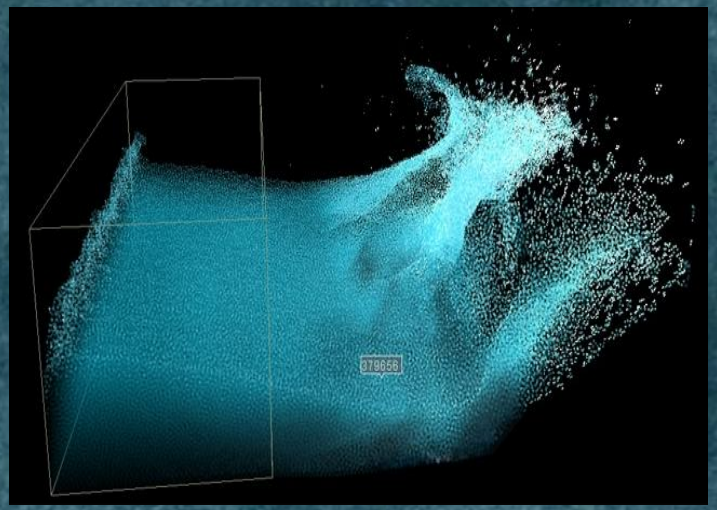
INTERDISCIPLINARY HACKING

Cloud computing

Instead of using 1 CPU for 10 hours, use 3000 CPUs for 1 second. Some companies (e.g. Google, Amazon) provide free initial storage and CPU time, but codes must be converted to run there

Gamming and cinema physics engines

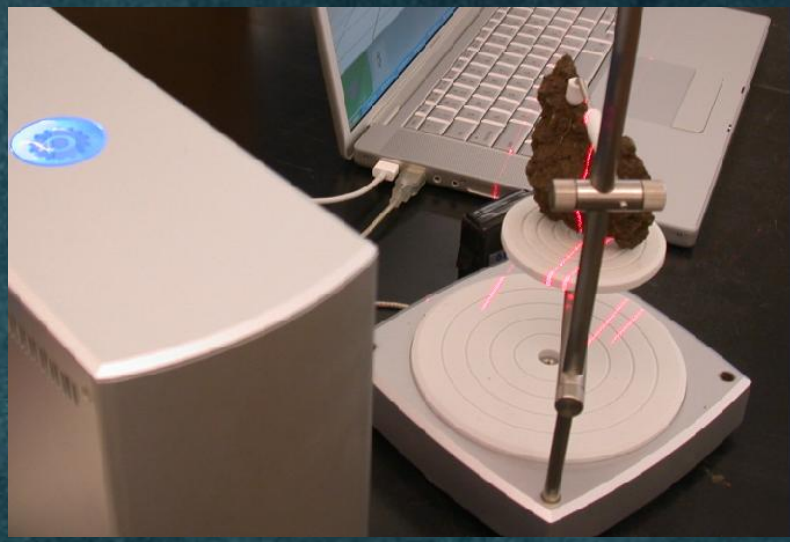
Developed for the entertainment industry, they are in some ways more advanced than engineering software

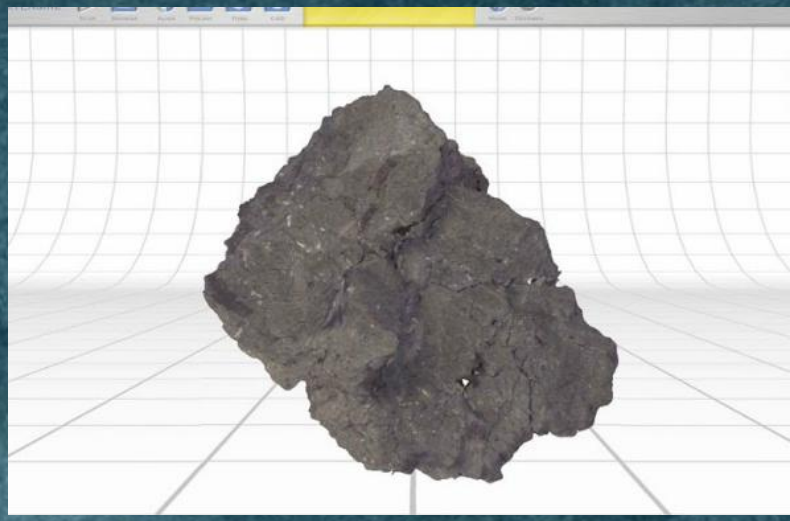


INTERDISCIPLINARY HACKING

3D Scanning and image recognition

Scanning devices are getting cheaper. They can deliver accurate 3D representations of small and large objects in easy to use formats





INTERDISCIPLINARY HACKING

Are we open to these changes?

Which skills should we acquire (other than an open mind)? Where will we do it? University, in-company, on our own?

How different from today working in Rock Mechanics be like, with so many new technologies? What will we have to know and forget?

THANK YOU!

MAIN SOURCES

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