ARMA e-NEWSLETTER
WINTER 2014

AN EXCITING INITIATIVE

ARMA Publications Committee has decided to introduce a new way of attracting interesting technical contributions to the e-Newsletter. From time to time we will propose a topic of great interest to a large number of ARMA members, and solicit contributions to a special issue of the Newsletter, entirely dedicated to that topic. The first special issue will be entitled:

"Geomechanics of hydraulic fracturing in shale formations"

Pending your positive response, we plan to publish this special issue in May, 2014.

Call for Contributions

Please communicate your intent to submit a "*technical note*" or a "*case study*" related to the topic above to bhaimson@wisc.edu not later than 15 March, 2014. Formal submissions should be received by 30 April, 2014.

We would like to remind you that ARMA e-Newsletter solicits original contributions that can be later developed into refereed journal papers, or summaries of previously published papers in journals not commonly read by many ARMA members. There are two kinds of contributions:

***Technical Notes** are short original contributions (1,000 words plus a few Figures) on basic or applied innovative research related to a timely topic.*

***Case Studies** are short reports on investigations undertaken in rock mechanics/geomechanics field projects. Important scientific findings, major issues encountered, and lessons learned should be summarized in 1,000 words plus one or two Figures.*

Manuscripts submitted to ARMA e-Newsletter are reviewed by the ARMA Publications Committee. Manuscript acceptance is based on the relevance of the contents and the technical quality. Manuscripts containing commercial advertisements will not be published.

In this issue

By
Sidney Green, ARMA Fellow

"ARMA plays a big role in the energy picture."

The Changing Energy Picture: The Role of Rock Mechanics and ARMA

Editor's Note: *The following address was presented to the Future Leaders group on 25 June 2013 at the ARMA San Francisco Symposium.*

You all have been selected as ARMA Future Leaders by leaders in the rock mechanics/geomechanics field. This is a recognition to each of you based on your achievements already made -- and on your demonstrated potential for the future. I personally congratulate you, and note that it is an honor to be able to meet with you today and to speak to you. It's difficult to even guess what is ahead for each of you. But, as you contemplate this, it's worth noting what Forrest Gump's mother said, "Life is like a box of chocolates, you never know what you will get." I spoke at the graduation of the University of Utah, College of Science a year ago, and I noted this to my eight-year old granddaughter as I was preparing my presentation; my granddaughter spoke up, "I don't care. I just take a bite out of each piece, and if I don't like it, I put it back." You might try this in life, but in life, it's a bit harder to "put it back."

Membership in ARMA designates that the individual has an interest in rock mechanics/geomechanics. This is because ARMA is the recognized representation of rock mechanics/geomechanics advancements and applications. That's something; that's something big. That is, for ARMA to be the recognized representation of rock mechanics/geomechanics is something big. You are members of ARMA; you are a part of this recognized representation of rock mechanics/geomechanics. Furthermore, you have been designated as "ARMA Future Leaders" in this recognized representation of rock mechanics/ geomechanics.

In this few minutes today, I want to address the subject of "The Changing Energy Picture: The Role of Rock Mechanics and ARMA." Some very big things have happened that affect the world energy picture in the past few years -- very big things.

1. The Gulf of Mexico oil spill changed offshore drilling greatly in the U.S. and worldwide.
2. The Japan earthquake changed the perception of nuclear energy worldwide.
3. U.S. tight shale gas has changed from an unqualified hero to an environmental concern - "fracking" has become a buzz word.
4. The "Arab Spring" has led to disruptions and uncertainties regarding world oil production.
5. The tight shales are producing oil, not just gas.
6. The U.S. is heading toward energy supply independence.
7. We understand that the world is not running out of fossil fuels.

I spoke a few weeks ago at Northwestern University about hydraulic fracturing and energy. And I began by noting, "Please don't shoot the messenger." Maybe I should say the same today -- please don't shoot the messenger. I'm not saying what is good, nor what is bad, but just giving what I believe are facts. Good or bad, the world is not running out of oil and gas. Good or bad, the U.S. may be heading for a long period of relatively low and stable energy costs using fossil fuels.

ARMA plays a big role in the energy picture. More and more, fossil energy recovery is from unconventional formations. Take, for example, the famous tight shale rock. For these relatively new formations (that is, new, in the sense of recovering hydrocarbons from these rocks in a very big way), the old technologies developed over the past nearly one hundred years don't work. We have to have new calibrations for seismic, for wireline logs, for drill cuttings analysis. We have to have better and more detailed rock properties for our analysis, whether for drilling, for well completing, or for production. We have moved into an era where "Rocks Matter"-- Rocks Really Matter.

(continued)

Above: Future Leaders Class of 2012 at the ARMA San Francisco Symposium. (Photo by Hill Montague for ARMA)

The Changing Energy Picture: The Role of Rock Mechanics and ARMA

(continued)

By
Sidney Green, ARMA Fellow

"…the role of ARMA has never been more appropriate; it has never been more important."

Furthermore, we have not only unconventional reservoirs to pursue -- like the tight shales, but we have harsh environments like ultra-deep water to hot dry deserts to the arctic. These are environments where a mistake can potentially bankrupt even a large company, or even something worse. We have justifiable public concern about long-term adverse effects to the environment, that are indeed "front stage" in America and worldwide. Rock mechanics/geomechanics is more important than ever for world energy.

I'll briefly give two examples. One involves fluid flow in highly impermeable rock. That's what the tight shale gas --and now liquids -- production involves. We need to understand how fluids move through nano-meter openings taking into account stresses, temperature, pore pressures, and the rock-fluid interaction. In the last decade the rock mechanics community had to invent ways to measure this fluid mobility, including rock heterogeneity that creates large variability leading to scaling issues from nano-meters to basin scales of hundreds of miles.

A second example. Horizontal well drilling leads to more severe well stability problems. That is, it is generally more difficult to keep a horizontal hole open when the maximum stress is vertical. And when the rock has highly anisotropic stiffness parameters -- as many of the unconventional reservoirs do, it is even more difficult to maintain hole stability when building angle approaching horizontal drilling. Rock mechanics/geomechanics clearly explain why drillers tend to have more difficulty building angle than drilling the horizontal portion of the well. It's not "rocket science" -- it's geomechanics using rock mechanics properties.

In closing, the role of ARMA has never been more appropriate; it has never been more important. And, ARMA has never had a role with such upside potential to make a contribution. The ARMA vision is to be the recognized representation of multi-disciplinary rock mechanics. The ARMA strategy to accomplish this vision is to encourage individuals and accept members who share a common interest in rock mechanics; to be the technical leader in rock mechanics via sponsored symposium, publications, workshops, training courses, and other means; to provide recognition of its members for individual accomplishments, expertise in rock mechanics, and public benefit; and to offer advisory expertise to help government, academia, industry, and the public. As ARMA Future Leaders, you are much a part of achieving the ARMA vision.

48th US Rock Mechanics Geomechanics Symposium
1 – 4 June, 2014 Minneapolis

Workshop Report: San Francisco Petroleum Gemechanics Testing

By
Russ Ewy, Chevron Energy Technology Co.

With the convening of the 2nd Workshop on Petroleum Geo-mechanics Testing, in conjunction with the 47th U.S. Rock Mechanics/ Geomechanics Symposium in San Francisco (June 2013), a new tradition was established. This session followed upon the 1st Workshop, which met at the 2012 Chicago Symposium and was jointly sponsored by ARMA and the ISRM Petroleum Geomechanics Commission. The initial workshop touched on several topics, including best practice testing methods (lithology-dependent), special testing situations, core damage, sampling protocols, index testing, and analogue materials. The second workshop took a different tack, with the theme "rock physics methods for determining mechanical properties."

Presentations were organized into four topics: experimental/apparatus, static vs. dynamic, prediction from well logs, and additional applications. The 70-plus attendees enjoyed presentations from Øistein Johnsen, Richard Rosen, Umesh Prasad, Erling Fjær, Santhosh Narasimhan, Abbas Khaksar, David Dewhurst, Rune Holt, Suzanne Hangx and Roberto Suarez-Rivera. In addition, John Dudley provided an update on the efforts of the ISRM working group tasked with establishing recommended procedures for the uniaxial-strain compressibility test. This working group was established as a direct result of the first workshop, which identified the great need for standardization of this common test which is used by the petroleum geomechanics community to assess reservoir compaction related deformations. (Note: Tony Addis of Baker-Hughes deserves great thanks for almost single-handedly putting together this second workshop.)

One of the important discussion topics has continued to be core/sample damage -- how to prevent it, how to assess it, and how to rectify it. For this reason, the next workshop (to be held in Minneapolis on 31 May just prior to the 2014 ARMA Symposium) will have a primary focus on this topic. Additional topics of interest to both the geomechanics and core analyst communities, such as compressibility measurements and permeability vs. stress measurements, will also be featured. With joint sponsorship by ARMA, ISRM and the Society of Core Analysts, we expect robust discussion and relevant presentations. If you would like to present at this upcoming workshop or lead a discussion, please contact one of the following individuals:

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Joint Conference Report: Houston

"From Micro- to Macro-scale: Interdisciplinary Consideration of Unconventional Reservoirs"

Based on a report by Gang Han, Aramco Services Company

ARMA joined Houston Geological Society in organizing a two-day conference on "From Micro- to Macro-scale: Interdisciplinary Consideration of Unconventional Reservoirs", 4-5 November, 2013.

Seventeen invited talks from operators, service providers, and academia were shared and discussed. Through four technical sessions, the meeting clearly demonstrated how geomechanics is closely allied with geology, geophysics, petrophysics, microseismicity, and engineering. Presentations covered topics such as the integration of logs, cores, seismic data, drilling records, and tectonic history.

In addition to the technical sessions, Prof. Mark Zoback from Stanford University gave a keynote address, "The Geomechanics of Shale Gas Reservoirs: From NanoScale to Reservoir Scale." Dr. Zoback shared the results of several research projects investigating how rock properties, natural fractures, and the state of stress affect the success of hydraulic fracturing operations.

Another highlight of the conference was the student poster competition with graduate students from eight universities. Alireza Ashrafi Moghadam of the University of Alberta received the Best Poster award for his work, "Analytical Study of Gas Slippage."

48th US Rock Mechanics Geomechanics Symposium
1 – 4 June, 2014
Minneapolis

My Career in Rock Mechanics

By
Charles Fairhurst, University of Minnesota/Itasca Consulting Group

Editor's note: This is the third installment of Charles Fairhurst's account of his career, which not only demonstrates how he "came into rock mechanics" but traces the history of the profession and its acceptance in the academic and commercial worlds. It covers the years from 1970 to his retirement from the University of Minnesota in 1997. He will provide a final installment in a future issue of the e-Newsletter.

Owing to space limitations in this issue, this installment was abridged by the editors. The unabridged version with informative footnotes, references, and illustrations is published at the ARMA website (http://www.armarocks.org/resources.html). Editors plan to compile the entire series as a single document when all installments are available, and publish it on the website.

Part Three: How I Came into Rock Mechanics

Organizational Changes

My story continues with changes in departmental structures with the decision by the Institute of Technology of the University of Minnesota to abolish the School of Mineral and Metallurgical Engineering in 1970. At that time, I was the head of the school. The Physical Metallurgy component of the school was to be joined with Chemical Engineering, then renamed the Department of Chemical Engineering and Materials Science. Mineral Engineering and Process Metallurgy were to be joined with the Department of Civil Engineering and Applied Hydraulics (CEAH) to become the Department of Civil and Mineral Engineering (CME).

Professor L.E. Goodman, formerly with the Department of Mechanics and Materials, who had helped me considerably to establish rock mechanics at Minnesota (See Fairhurst Part 1, AMRA e-Newsletter Issue 9) was now Head of CEAH, and saw potential in linking rock mechanics and soil mechanics as "geomechanics." I was allowed to add another faculty member, and was pleased when Dr. Steve Crouch, one of the initial group of graduate students, accepted the position. Together with Tony Starfield, we now had the nucleus of a group to develop a rock mechanics program.

Aware of the coming change, I had arranged to take a sabbatical leave for the 1970-71 academic year. I was based, again, in England partly at the Royal School of Mines, Imperial College, London, where Evert Hoek had established the postgraduate School of Rock Mechanics and partly visiting colleagues and laboratories in France and West Germany.

My family and I lived for the year in Cheltenham in the heart of the Cotswolds. This was good fortune, for it was designated an "Area of Outstanding Natural Beauty." Not infrequently, my explanation to "locals" that I was a professor on leave from an American university would be met by a quizzical look which often changed to a knowing smile, accompanied by "*Aha,*" then on to other topics.

There is no university in Cheltenham, but it is the home of the Government Communications Headquarters (GCHQ), the British counterpart to the U.S. National Security Agency (the two agencies cooperate). Professor Hoek's research placed emphasis on the role of discontinuities, such as joints and faults, on the overall strength and stability of rock slopes and the development of sound rock engineering design rules. It was here that I first met Peter Cundall, then a graduate student with Professor Hoek. Peter was developing a discrete element model (DEM) to simulate the progressive deformation and failure of an assembly of blocks. Although limited by computer power, the method clearly had major potential in rock mechanics. I resolved to stay in contact with Peter.

Returning to Minnesota in 1971, I was looking forward to focusing on teaching and research, free of academic administration. But this change was to be short-lived! In 1972, Dr. Goodman resigned as department head in order to return to teaching and research. I was stunned when the search committee, composed largely of civil engineering faculty, invited me to be head of the combined department. I had not applied for the position. But eventually, I accepted the challenge.

Although the undergraduate degree programs in mineral engineering were continued after the merger with civil engineering, the problem of low enrollment relative to other engineering programs on the Twin Cities campus was a constant concern. Professor Pfleider led a successful effort to establish the Mineral Industry Education Fund, providing scholarships to encourage students to enroll in mineral engineering. This was supplemented by brochures, faculty visits to high schools and the occasional participation in television programs promoting mining.

Research in Geoengineering, covering both rock mechanics and mineral resource topics, (via the Mineral Resources Research Center (MRRC)) continued vigorously on the Twin Cities campus -- although the invaluable support of the U.S. Bureau of Mines, both nationally and via the local Twin Cities USBM Research Center, declined progressively, as the Bureau's research budget was reduced by Congress, culminating in the closure of the Bureau in 1995.

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How I Came into Rock Mechanics (Part 3)

(continued)

By
Charles Fairhurst
University of Minnesota/Itasca

Rock Mechanics and the U.S. Army Corps of Engineers

Although not formally educated as a civil engineer, I was fortunate to have been befriended, soon after my arrival at Minnesota, by Ken Lane, Lloyd Underwood and colleagues at the U.S. Army Corps of Engineers. They were keen to extend developments in rock mechanics to applications in Corps projects. This included funding of the project on Rational Design of Tunnel Supports, a number of stimulating consulting activities (such as the Niagara Falls Preservation Project, 1968-74), and two intensive six-month courses in geoengineering for groups of Corps engineers and geologists. This was a stimulating and valuable experience from which faculty colleagues and I learned a great deal from the "students" from the Corps. This occurred both during the courses and later, when faculty were asked to participate as consultants on Corps projects.

The Corps also stepped up to keep our research moving ahead in other important ways. One of my first moves as CME Head was to persuade Peter Cundall to accept appointment as assistant professor in 1972. When he arrived, I asked Peter to prepare a research proposal for funding to a national agency to pursue his research on DEM numerical modeling. The proposal, for one year of research at a cost of $75,000, was denied. Although not unusual for a first proposal, both Peter and I were upset at the reason for the rejection. In effect, it was indicated that reviewers considered the proposal to be too ambitious. They felt the applicant did not realize the difficulties involved.

I asked Peter, "*What is the minimum amount you need to demonstrate that you could achieve what you had proposed*?" After some thought, he answered, "*$25,000 will allow me to demonstrate the procedure using interactive graphics, but I may need to modify the computer, and I would not be able to provide adequate documentation to allow others to replicate my work readily.*" I submitted this lower cost proposal to the Corps of Engineers who, recognizing the potential, provided the support. Peter completed the project and submitted the report in less than five months. This allowed the Corps to begin studies to further develop the DEM procedure. To my chagrin, Peter then decided to return to England to accept appointment with a consulting company. Eight years later, I was able to persuade him to rejoin the CME department, this time as an associate professor. He has remained in Minnesota and his legendary contributions are known to all.

Underground Space at the University of Minnesota

Another aspect of the development of rock mechanics at the University of Minnesota was the provision for suitable facilities. This was addressed in a unique fashion -- by going underground.

Studies on rock drilling, blasting, and tunnel support design at the University of Minnesota led, in 1968, to an invitation for me to join the ASCE/AIME Underground Construction Research Council (UCRC). The subsequent UCRC report indicated major potential benefits, both economic and environmental, from greater use of the subsurface. Geological isolation of high-level radioactive waste was also under active investigation. Initial focus in the early 1970s was on salt: Project Salt Vault in Lyons, Kansas and in Triassic sediments beneath the Oak Ridge plant at Savannah River, Georgia. My association with these and subsequent nuclear waste isolation projects in the U.S. and other countries has continued to the present.

Several other major international developments added to the interest in underground development. The Channel Tunnel, intended to connect France and the United Kingdom, was being discussed actively. The International Tunneling Association (ITA) was founded in 1974. The Third Congress of the International Society for Rock Mechanics (ISRM) was held in Denver, 1-7 September 1974. Dr. Leonard Obert of the U.S. Bureau of Mines (and a native of Minneapolis) was ISRM President.

Further development was shown with the agreement in 1976 with Pergamon Press (Oxford) to introduce the journal, "Underground Space." I contributed a general article that attempted to survey the general economic and environmental potential of the shallow subsurface.

In 1977, Swedish colleagues led by Magnus Bergman, organized "*Rockstore 77 -- Storage in Excavated Rock Caverns*." This was a major international event with some emphasis on the extensive Scandinavian experience of using underground excavations in hard rock for a wide variety of applications. Part of the emphasis in Scandinavia was on incorporating routine use of the subsurface by the general population to prepare them to take shelter in the event that nuclear hostilities developed between the U.S. and the then USSR.

Awareness of the potential for subsurface development presented by the near-surface geology of the Twin Cities of Minneapolis and St. Paul pre-dated my arrival at the university. Native Americans used caves well before European settlers arrived.

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How I Came into Rock Mechanics (Part 3)

(continued)

By
Charles Fairhurst
University of Minnesota/Itasca

Storm water run-off and sanitary systems had been constructed since the mid 19th century in the friable St. Peter Sandstone, which can be excavated by water jet. Professor Don Yardley, geological engineer and faculty colleague in the School of Mines and Metallurgy, was a keen advocate of developing an underground mass transit system for the Twin Cities from the early 1950s.

In general, development of underground rapid transit systems must contend with either hard rock, which is costly to excavate but tends to be self-supporting (as in Stockholm), or with soft rock, which is easy to excavate but requires expensive support (as in much of the London metro). The Twin Cities region is covered by a superficial layer of glacial drift, usually to a depth of several tens of feet, followed by a 20 feet or so layer of competent Platteville Limestone, which overlies the St. Peter Sandstone, usually 30 feet or more thick. The sandstone can be excavated with ease, leaving the limestone as a competent roof. The Mississippi River flows at the base of the sandstone, with steep-sided flanks of limestone. Rail, barge and road transportation is at the river level, with commercial buildings and further road transportation located on top of the till. This geology is well-suited for three-dimensional development of the Twin Cities.

The research organization with perhaps the broadest mission related to underground construction was the state-funded Underground Space Center (USC) at the University of Minnesota, founded as part of CME in 1977. Dr. Ray Sterling, who had just completed his Ph.D. thesis on a study of the structural characteristics of the Platteville Limestone, was named director of the center. Faculty colleagues John Carmody, Thomas Bligh, Charles Nelson and Don Yardley provided valuable assistance.

The USC assembled a multi-disciplinary team to look broadly at issues affecting underground space use, including public policy, planning, architectural design, geotechnical engineering, and underground heat transfer. The USC became a model for several other centers around the world that guide underground space use in their respective countries. These include centers at the Delft University of Technology in the Netherlands, Tongji University, Chongqing University and Nanjing Engineering Institute and other universities in China, and the Urban Underground Space Center of Japan.

The Legislative Commission on Minnesota Resources (LCMR) and its Executive Director, Robert E. Hansen, developed an interest in the potential of subsurface development in Minnesota, and agreed to provide research support. St. Paul Mayor George Latimer recognized the potential and was a strong supporter of "the underground movement."

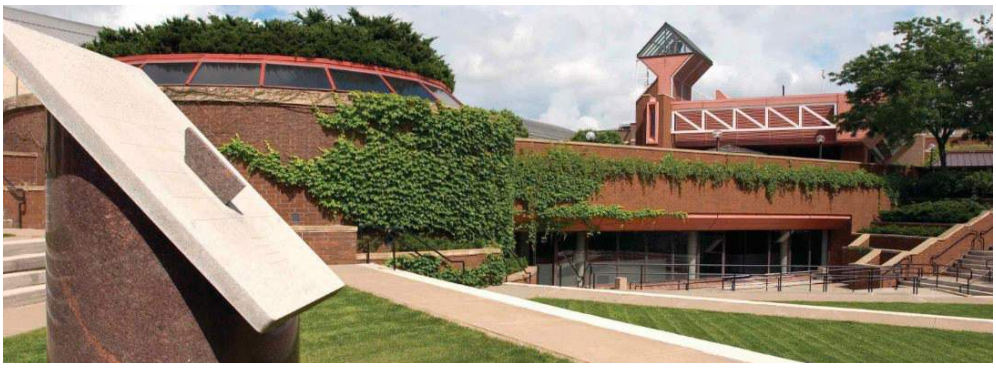
LCMR maintained an active interest in the studies of underground space and earth- sheltered design, and in 1980, a group of LCMR members took advantage of the symposium, "*Rockstore 80,*" to arrange a meeting with Swedish legislators in Stockholm to discuss their experience in gaining public acceptance of underground space development. This encouraged the LCMR to continue funding the USC, which went on under Dr. Sterling's leadership. While the USC was successful in terms of research activity and maintaining its broad mandate, the lack of stable base funding for its mission left it vulnerable to a university and state funding recession that resulted in its closure in 1995.

One of the challenges facing me as department head was the poor quality of classroom and laboratory facilities, especially in civil engineering. Faculty were also dispersed in several locations on campus. In this respect, the merger with Mineral Engineering compounded the problem. The CME Advisory Committee, composed of leaders in Minnesota civil engineering practice and business, chaired by Richard (Dick) Vasatka, was formed to provide advice to me and to help guide efforts to obtain new facilities for the department.

The University's administration allowed us to develop a request for a new Civil and Mineral Engineering building, to be submitted as part of the university's request to the 1980 Legislature. To our surprise, the request was approved by the Legislature with the proviso that the building be constructed underground!

The building was completed in late 1982. In 1983, the building received the Outstanding Civil Engineering Award of the American Society of Civil Engineers. (continued)

Below: Civil and Mineral Engineering Building, University of Minnesota



How I Came into Rock Mechanics (Part 3)

(continued)

By
Charles Fairhurst
University of Minnesota/Itasca

The Founding of Itasca Consulting Group

In the late 1970's, I was part of a team assembled by Dames and Moore, geotechnical consultants to Niagara Mohawk, to assess the suitability of the rock foundation proposed for Unit II of the Nine Mile Point Nuclear Power Plant in Scriba, on the shore of Lake Ontario in New York. The Dames and Moore group was led by John Markham. Impressed by John's effectiveness managing what was, at times, a very contentious group and by his sense of humor, I decided to approach him with an idea that I had been considering for some time.

Although first stated in a quite different context, the following quotation applies well to engineering research in rock mechanics: *Theory without practice is sterile; Practice without theory is blind.* The rock mechanics' research program was progressing well with respect to faculty and students but, as an engineering group, our efforts needed to be tested by practical application. Studies at the USC were also going well. *Rockstore 80* in Stockholm had generated considerable international interest. Perhaps we could form a company in Minneapolis to carry these two fields into practice. I had 'broached' the idea to Magnus Bergman during the conference in Stockholm; he had indicated some interest. I presented the same idea to John. He promised to think about it.

Early in 1981, John and Magnus came to the Twin Cities to discuss the idea further. Several days later, we agreed to form a company. We also agreed that we wanted a distinctive name. I recalled how the "true source" of the Mississippi, Lake Itasca, had been named and suggested Itasca as the name. John and Magnus returned to their families to inform them of this quite dramatic decision. John was living in Hawaii. *"How do I tell Deb [his wife] to leave Hawaii for Minnesota in winter?"* he asked me, as he left.

John and Magnus formed an excellent team. They endured significant financial hardship, as the company searched for projects. Roger Hart and Mark Christainson (both University of Minnesota graduates in rock mechanics) were the first two employees. Faculty, including Barry Brady, Peter Cundall, and Ray Sterling gave part-time help. Soon they were joined by others and eventually the company started to prosper. Unfortunately, as the threat of oil embargoes and shortages subsided, so did interest in energy conservation and earth-sheltered structures.

Itasca carried forward Peter Cundall's numerical modeling ideas into application in all aspects of subsurface engineering and has enjoyed considerable success as a result. Today, Itasca International Inc. has over 160 staff and offices in 12 locations around the world. Over 60 of the staff have Ph.Ds and almost all have graduate degrees. The company maintains close relationships with faculty at the University of Minnesota and interacts with many other universities internationally through its educational programs.

President, International Society for Rock Mechanics, 1991-95

As described in earlier parts of this narrative, I was fortunate to become associated with Professor Leopold Müller in the late 1950s. In the early 1960s, he and his colleagues in Austria were urging the international civil engineering community to recognize that rock *in situ* behaved very differently than soil, and warranted the formation of a separate international society. I retained an interest in the society, was in contact with the staff in Lisbon, and attended almost all of the ISRM Congresses.

In 1991, colleagues in Europe persuaded me to become a candidate for ISRM President. I took office from the late John Franklin at the end of the 7th Congress, held September 1991 in Aachen, Germany. When elected, I found that I really had a lot to learn about the society. The entire complement of the ISRM Board, Presidents, and Regional Vice-Presidents were all elected at the same time. We quickly agreed to change the rules, so that the election of President would take place two years before taking office. This allowed the President-Elect to sit with the board as an observer before assuming the office, and provided some level of continuity. The system is still in effect.

We learned also that some National Groups questioned the value of ISRM to them. "There is very little communication between Congresses," they complained. Working with a colleague in Minneapolis, Jenny Bartholomew, we introduced the *ISRM News Journal*. John Hudson, ISRM President (2007- 2011) worked intensively and effectively to improve communications in several ways. The *News Journal* continues, and is now distributed electronically.

Underground Nuclear Testing in French Polynesia

One morning in mid-1995, I received a telephone call that started what was probably the most stimulating and rewarding geoengineering study in which I have been involved.

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How I Came into Rock Mechanics (Part 3)

(continued)

By
Charles Fairhurst
University of Minnesota/Itasca

"Charles, this is Pierre Bérest. I am calling from a telephone box in Ireland and don't have many coins, so must be brief. Would you be willing to organize an international study of the effects of French underground nuclear tests on the mechanical stability and hydrology of the atolls of Mururoa and Fangataufa in the South Pacific? This request comes directly from President Chirac. You will have complete independence in selection of members, and on how your study is conducted."

Fearing that the transatlantic call would soon consume his remaining coins, I could only stammer, *"Er…Yes! But please send me details."*

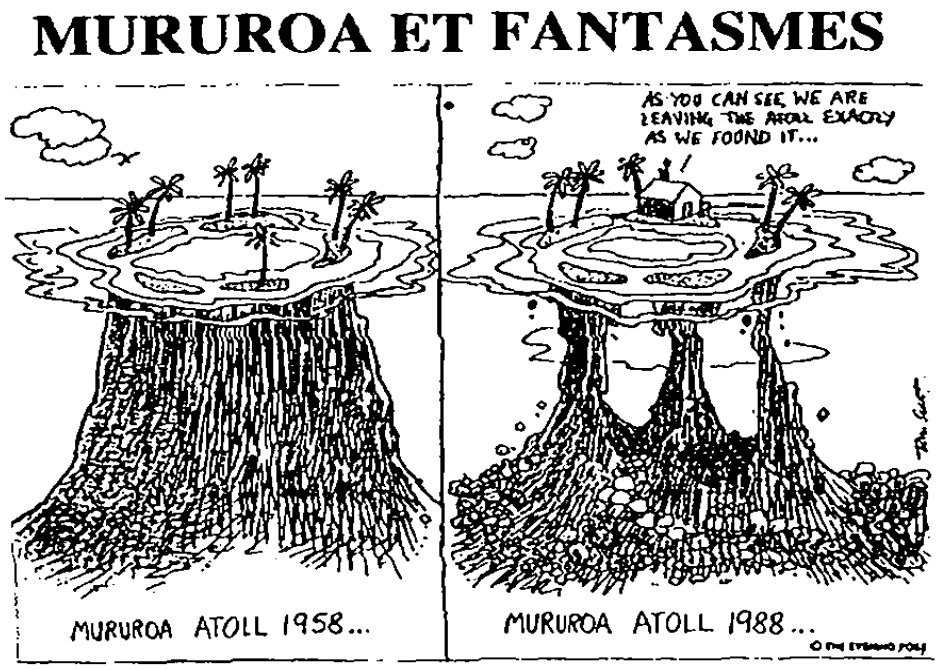
The Comprehensive Nuclear Test Ban Treaty (CTBT) was being readied by the United Nations for signature in September 1996 by all nuclear powers. President Chirac's announcement in June 1995 that France would conduct a "Final Campaign" of eight underground nuclear tests in the atolls in French Polynesia provoked a storm of international protest and public demonstrations, targeting France and French products. Nuclear tests in the atolls had been conducted since 1975. Opposition was particularly strong in New Zealand (as seen from the cartoon, *right*).

The International Atomic Energy Agency (IAEA) in Vienna had agreed to study the consequences of radionuclides released by the tests into the Pacific Ocean, but a complementary study of structural and hydrologic changes was also needed.

A contract was signed with the University of Minnesota, and the International Geomechanical Commission (IGC) was formed. The report, "Underground Nuclear Testing in French Polynesia," was published in 1999. The Stability group, led by Emmanuel Detournay (U.S. and Belgium) of the University of Minnesota, included Ted Brown (Australia), Victor Nikolaevsky (Russia), and Anthony Pearson (U.K.) with Peter Cundall, Branko Damjanac, and Charles Archambeau as consultants.

The Hydrology group, led by Lloyd Townley (Australia), included Ghislain de Marsily and Anthony Pearson, with Pierre Perrochet and Laurent Tacher (Switzerland) as consultants. The IGC visited the atolls, and met both in Europe and in the U.S. The report has been praised for its thoroughness and high scientific quality. France reduced the number of tests from eight to six and signed the CTBT, on time, in September 1996.

Unlikely to find projects as exciting as the atolls study, and buoyed by the increased value of my retirement in June 1997. It had been an eventful four decades. I will attempt to account for the activities since then in my next installment, but compressing such a period into a relatively few pages must inevitably leave out events and contributions from numerous professional colleagues, faculty and students who have made important contributions to my career. To all, I say thank you for a wonderful and rewarding experience.■



Above: "As you can see, we are leaving the atoll exactly as we found it." Cartoon, Auckland Post, 1988

ARMA News Briefs

2014 Minneapolis Symposium. The ARMA 48th U.S. Rock Mechanics/ Geomechanics Symposium will be held in Minneapolis, Minnesota on 1-4 June 2014. The Organizing Committee, led by Joseph Labuz and Emmanuel Detournay, is working to ensure an exciting and quality program for ARMA members. The theme is "Rock Mechanics Across Length and Time Scales." The symposium, located largely on the campus of the University of Minnesota, will feature four workshops, three short courses, three technical tours, keynote speakers, poster sessions, and the ever-popular rock mechanics trivia contest. 405 papers have been accepted for presentation; see the sidebar for the 24 topics. For further information, visit the website at www.ARMAsymposium.org.

Workshop on Petroleum Geomechanics Testing. In conjunction with the Minneapolis Symposium, the Petroleum Geomechanics Commission, International Society for Rock Mechanics (ISRM) will conduct its third workshop. This workshop will be co-sponsored by the Society of Core Analysts (SCA) and will convene on 31 May 2014. This ISRM workshop provides an opportunity for core analysts and rock mechanics experts to interact. For more information, visit the website at: http://www.armasymposium.org/mn_2014/workshops.html

VI Brazilian Rock Mechanics Symposium. This ARMA and ISRM co-sponsored symposium will be held on 9-13 September 2014 in Goiania, Brazil. The theme of the event is rock mechanics for natural resources and infrastructure. For further information, visit the website at: http://www.gtep.civ.puc-rio.br/sbmr2014

Corporate Members. ARMA is pleased to announce 2014 Corporate Members: Rocscience; Agapito Associates; Southwest Research Institute; Baker-Hughes; Itasca Consulting Group; Golder Associates; TerraTek, a Schlumberger Company; ConocoPhillips; and MTS. For information on how your company can join ARMA Corporate Members, visit the website at: http://www.armarocks.org/corporate.html

ARMA Foundation: Become a Sustaining Member. Members have witnessed the rapid growth and success of ARMA in recent years. The objectives of the association, stated as follows, have been significantly advanced:

- To promote the development and application of rock mechanics, rock engineering and geomechanics worldwide;
- To bring together individuals from multiple disciplines interested in application of these fields to problems of societal importance;
- To support students and young scientists and engineers launching their careers in rock mechanics, rock engineering and geomechanics; and
- To help disseminate knowledge and information through symposia, workshops, publications, and other means.

The ARMA Foundation, a sister organization of ARMA, was created as a tax-exempt educational organization to promote rock mechanics and geoengineering. The Foundation supports students with scholarships for attending the annual symposium. Other educational activities will help fulfill the foundation's objectives.

The Foundation has created "sustaining memberships" to help advance educational initiatives in the area of rock mechanics and geomechanics.

ARMA members and others are encouraged to contribute to the Foundation through purchasing an annual membership for $250.

To make a gift as a sustaining member, simply visit http://www.armarocks.org/join.html.

Minneapolis Symposium

Papers and posters will be presented on the following topics at the Minneapolis Symposium:

- Acoustic emission, micro- and induced seismicity
- CO2 sequestration
- Constitutive response
- Dams and foundations
- Discrete fracture networks
- Drilling mechanics
- Fracture mechanics
- Geothermal systems
- Hydraulic fracturing
- In situ stress
- Novel testing techniques
- Poromechanics
- Reservoir mechanics
- Rock mass behavior
- Rock physics
- Salt mechanics
- Shale mechanics
- Site characterization
- Slopes and rock falls
- Surface mining
- Transport and hydrogeology
- Tunnels and caverns
- Underground mining
- Wellbore mechanics