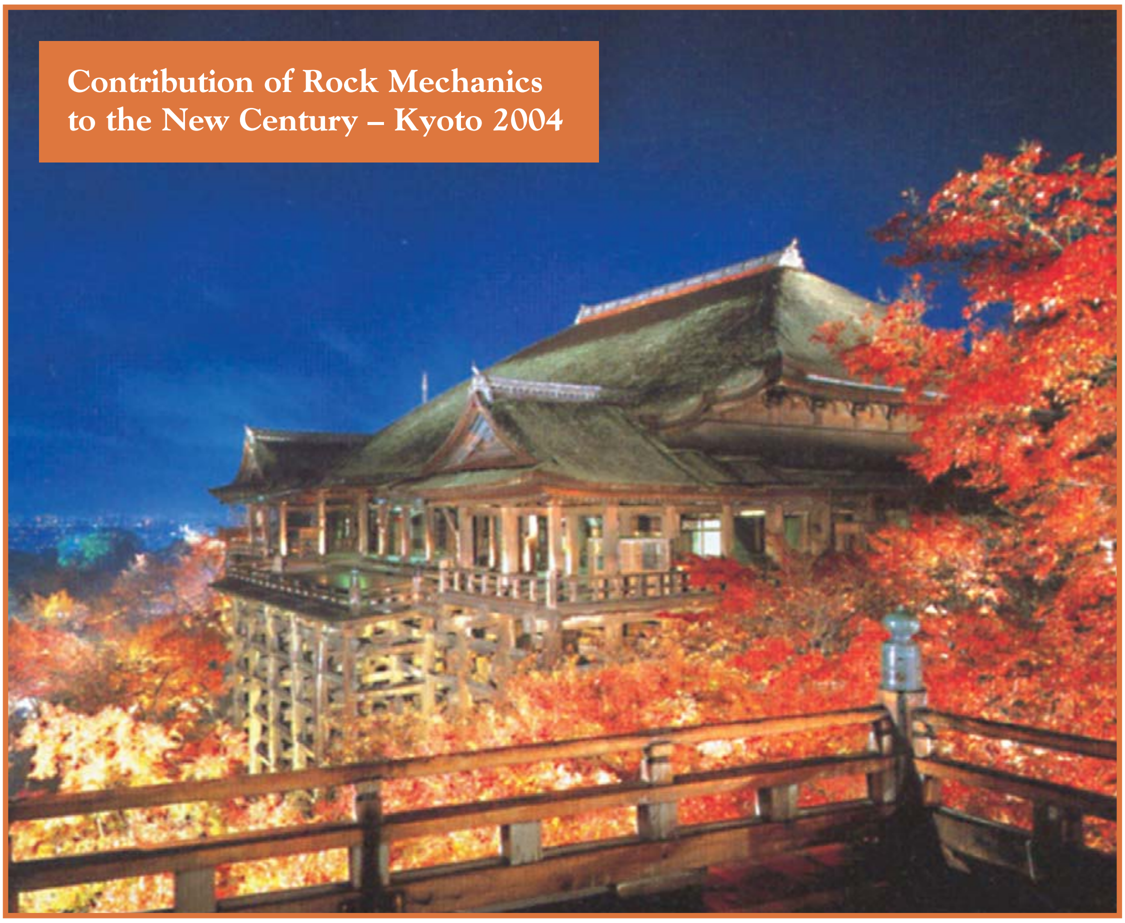
Société Internationale de Mécanique des Roches
INTERNATIONAL SOCIETY FOR ROCK MECHANICS
Internationale Gesellschaft für Felsmechanik

NEWS JOURNAL



The picture shows the beauty of Kyoto, where the ISRM International Symposium was held at the end of November 2004.

The Maple trees, seen everywhere in this ancient Japanese capital, residence of the Emperor from 794 to 1868, create a magnificent effect.

The autumn leaves, having hues ranging from gold to deep red and purple, are very attractive and romantic, producing splendid views.

TECHNICAL ARTICLES

ISRM News . . .

Volume 9 • Number 1 May 2005

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The ISRM Board

The Board of the Society is composed of:

- The President
- Six regional Vice Presidents
- Up to three Vice Presidents at Large, at least one of them from Europe
- For the last two years of the term, the President Elect
- The Secretary General

The ISRM Board after its first meeting, in Sandton, Johannesburg, South Africa, September 2003.

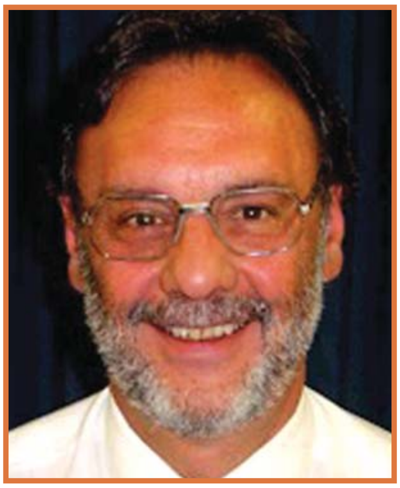
Standing, left to right:
John St. George, Martin Pretorius, Francois Heuze, Jian Zhao , Qian Qihu, Luís Ribeiro e Sousa, Luís Lamas.

Sitting, left to right:
Maria de Lourdes Eusébio (*executive secretary*), Nielen van der Merwe, Eda de Freitas Quadros, Claus Erichsen

For the term of office 2003-2007

President:	Prof. Nielen van der Merwe
President-elect:	Prof. John A. Hudson
Vice President for Africa:	Dr Martin J. Pretorius
Vice President for Asia:	Prof. Jian Zhao
Vice President for Australasia:	Dr John St. George
Vice President for Europe:	Dr Claus Erichsen
Vice President for N/America:	Dr François E. Heuze
Vice President for S/America:	Dr Eda Freitas de Quadros
Vice President at Large:	Prof. Qian Qihu
Vice President at Large:	Prof. Luís Ribeiro e Sousa
Secretary General:	Dr Luís Lamas

Message from the President



Prof. Neilen van der Merwe

We are on the eve of another Council meeting, only a few short months after the previous one in Kyoto. There has not been time to implement all the actions we decided on, but that does not mean that we have stagnated.

First, I would like to draw attention to some of the important matters facing Council at the meeting in Brno. We are a democratic society, and every member of the ISRM is represented in Council through our national structures. The issues before Council are therefore all of our issues.

The important decisions before Council at this meeting include the selection of a venue for the 12th Congress. The competition has been stiff and the campaigns conducted at a high level of professionalism and ethics by both the candidate countries. Council has all the information required to make a wise and well considered selection. The high quality of the presentations indicates that whoever manages to gain the selection, will do it in the same manner and we can look forward to a well organised Congress. I wish also to express the hope that not winning will not dampen enthusiasm for the ISRM activities and support on the side of the unsuccessful candidate.

Having managed the organisation of a Congress, I am not sure that the same amount of enthusiasm would prevail from candidates if they were to be fully aware of the consequences of winning the bid! Be that as it may, I want to say good luck to the winner and assure the team of the full support of the international community.

The second important decision will be the election of the President of the Society for the term 2007 – 2011. Here we have three candidates, all of whom are well respected for their scientific ability and personal integrity. As with the Congress election, we are fortunate in the sense that all three candidates are more than worthy and we can be assured that the Society will be in good hands.

We have a unique situation where two of the candidates are current Board members and should either of them be elected as the next President, minor adjustment to the composition of the Board will be considered to avoid possible conflict of interest.

I request Council members to consider their choices in both matters carefully, following discussion with their constituents based on the requirements and the ability of the candidates to conform to them. I know that the choices will be difficult indeed, but it is good for the Society that we have to choose between excellent candidates for both the Congress venue and the next President.

The third decision with long term impacts that will have to be taken is whether or not to support the creation of the Federation of Geo-Engineering Societies (FIGS) based on the principles that were agreed upon by the Presidents of the Sister Societies. We tried to find the delicate balance between creating an organisation that will not endanger the autonomy of any one organisation, and yet be tight enough to have the necessary impact.

The principles were agreed upon at a meeting between the Presidents of the Sister Societies in Gent, Belgium, following a report by the Joint Task Force. It was later finalised by circulation of the document between the Presidents. The ISRM members of the Joint Task Force were Dr Marc Panet, Dr Luis Sousa and Dr.-Ing. Claus Erichsen. Their valuable input is acknowledged.

FIGS also has to cater for the possible entry at a later stage of other related societies. To avoid unnecessary complications and delays, it was decided to restrict membership initially to the Sister Societies, they being the main players as learned organisations.

Should all three Societies approve the principles as a back bone, the final step will be to create a mutually acceptable constitution based on the principles. This will also have to be approved by all three Councils. Due to the uncoordinated dates of Council Meetings of the Sister Societies, the earliest date at which the FIGS can be formally created will be 2007, if there are no delays due to objections from any of the participants. We felt that this issue was too important to be handled by mail.

On a personal note, I left the meeting in Gent with mixed feelings. On the one hand, there was the satisfaction of having had a very good and constructive meeting with my colleagues about the FIGS and the warm hospitality of our host, Dr William van Impe of the ISSMGE. On the other hand, I am now officially classified as a senior citizen following the insistence of the ticket seller at the Castle Museum there that I pay the reduced entry fee for seniors! It was also interesting to note that some of the social discussions could be conducted in my home language, Afrikaans, as it is sufficiently similar to Flemish and Dutch, the home languages of the other two Presidents.

I had the opportunity to meet colleagues in Moscow at the occasion of the “Rock Mechanics for Underground Environment” conference in January, which was a Regional Conference of the ISRM. Even though attendance suffered due to a number of external factors beyond the control of the organisers, the discussions were conducted at a high level and I congratulate the chair of the organising committee, Prof Sergey Yufin, who had to do the work under difficult circumstances.

A small group of foreign delegates to the “Rock Mechanics for Underground Environment” braved the cold to visit the Kemlin.

Prof Eugeny Shemyakin, Chairperson of the Russian Committee, at the conclusion of a successful meeting with the President.

This particular conference highlighted one of the difficulties of organising international events, namely the different statutory requirements for entry into countries by different nationals. This problem unfortunately prevented a large delegation from participating. Both parties, the conference and the intended delegation, were the poorer for this.

I was also fortunate to meet one of the giants of rock engineering in Russia and indeed the world, Prof Eugeny Shemyakin, and several members of the Russian Committee. In spite of the current economic problems in that vast country, we look forward to increased membership in Russia.

For the immediate future, we will meet again in Brno and I look forward to see as many as possible of our colleagues there. Please book early, and pay particular attention to travel arrangements.

Each of the Vice Presidents will in turn be responsible for an edition of the News Journal. This edition was compiled by the Vice President for South America, Dr Eda de Quadros. I want to thank Eda for her hard work and congratulate her on a job well done.

Nielen van der Merwe

ISRM President Elect (2007 - 2011)

PROFESSOR JOHN A HUDSON
FREng (UK)

PROFESSIONAL ACTIVITIES AND ACCOMPLISHMENTS

- FREng: Fellow of the Royal Academy of Engineering, UK
- Professor, Department of Earth Science and Engineering, Imperial College, University of London, UK; have supervised 50 MSc and 15 PhD students in engineering rock mechanics to date
- Adjunct/Visiting/Honourary Professor: Royal Institute of Technology, Stockholm, Sweden; Chinese Academy of Sciences, Wuhan, PRC; and Hong Kong University. Earlier visiting Professorial appointments at other Universities including the Nanyang Technological University, Singapore, and Universities of Wisconsin and Minnesota, USA
- Editor: International Journal of Rock Mechanics & Mining Sciences, and Elsevier's Geo-Engineering Book Series
- Independent Consultant specializing in providing solutions for civil and mining rock engineering design and construction problems, often in difficult or non-precedent practice circumstances, for radioactive waste disposal, tunnels, foundations, slopes, caverns
- Authored/co-authored four books and more than 150 technical papers, plus a further three edited books, including "*Comprehensive Rock Engineering*", 5 vols, 4407 pages, which is the only international benchmark overview of all aspects of rock engineering

PAST WORK FOR THE ISRM

.UK National Group representative 1987-present

- ISRM Vice-President at Large (1995-1999).
- President: ISRM Commission on Testing Methods (1987-present)
- Chairman: Technical Committee for the ISRM Cambridge Symposium, UK, 1984
- Chairman: ISRM EUROCK Symposium, Chester, UK, 1992
- Co-Chairman: ISRM SINOROCK Symposium, Yichang, China, 2004

MANIFESTO: GOALS FOR THE ISRM

As ISRM President, I intend to be extremely active and to inject significant dynamism into the ISRM activities.

The thrusts that I will introduce in the period 2007-2011 are related to the four main subject areas of:

- enhancing awareness, membership, and effectiveness of the ISRM through the ISRM website and other initiatives,
- ensuring that the ISRM actively supports rock mechanics activities worldwide, including conferences, Commissions, and interaction with industry, education and sister societies,
- giving particular ISRM encouragement and assistance to the less developed countries, and
- considerably increasing the generation of ISRM publications (hard copy and electronic), especially reports of Commissions.

Rocha Medal

A Bronze Medal and cash prize has been awarded annually since 1982 by the ISRM to honour the memory of Past President Manuel Rocha and to recognize outstanding young researchers in the field of Rock Mechanics.

The award shall be for an outstanding doctoral thesis in rock mechanics or rock engineering. The thesis must have qualified the candidate for a doctorate or the equivalent. To be considered for the award, a candidate must be nominated within two years of the date of the official doctoral degree certificate.

The nomination should be submitted to the appropriate ISRM Regional Vice-President by registered letter, and may be presented by the nominee, the nominee's National Group or some other person or organization acquainted with the nominee's work. The nomination should include the following supporting information:

- A one page curriculum vitae (include the name, nationality, place and date of birth of the nominee; also position, address, telephone & fax numbers);
- A thesis summary in English, of about 5,000 words, detailed enough to convey the full impact of the thesis, and accompanied by selected tables and figures, with headings and captions also in English; one hard and one digital copy are required;
- One copy of the complete thesis and one copy of the doctoral degree certificate;
- A letter of copyright release, allowing the ISRM to make copies for review & selection purposes.

Nominations for the 2006 Medal must be received by 31 December 2005.

Supplementary details of the selection procedure, conferring of the award, etc., are provided in ISRM By-Law No. 7. National Groups and Corresponding Members will be officially reminded by the Secretariat as the deadline approaches, but are encouraged to consider possible nominees and to recommend names to the appropriate ISRM Regional Vice-President as early as possible.

2004 WINNER

Dr Giovanni Grasselli

The 23rd Rocha Medal was conferred on Dr Giovanni Grasselli for his thesis ***"Shear Strength of Rock Joints based on the Quantified Surface Description"*** on the occasion of the ISRM International Symposium on Contribution of Rock Mechanics to the New Century (3rd ARMS 2004) held in Kyoto last November.

Also in Kyoto, the Board, acting as the Rocha Medal Award Committee, selected the prize-winning Ph.D. thesis for 2005 from among the nine outstanding shortlisted theses for that year. The winning thesis "*Wave Interaction with Underground Openings in Fractured Rocks*" was submitted by Dr Mark Hildyard and had been presented in 2002 to the University of Liverpool in the United Kingdom. The award will be conferred at the ISRM International Symposium "Impact of the Human Activity on the Geological Environment" (EUROCK 2005) to be held in Brno Czech Republic from the 18th to 20th May 2005.

Professor Nielen van der Merwe and Dr Giovanni Grasselli, 2004 Rocha Medal winner.

Non-Linearity of flow and deformation in Basaltic Rock

E. F. de Quadros
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ABSTRACT: This paper discusses the results of water pressure tests performed at a dam site in São Paulo, Brazil and the effect of the high pressures on the deformation of the basaltic rock. The method consisted of alternating injection (water pressure) tests and pumping tests at various test intervals. Pumping was performed before, immediately after the injection tests and after periods of 12, 24, 72 and 96 hours. In general, deformations observed as a result of these tests were in the elastic domain.

1 INTRODUCTION

Conventional single hole water pressure tests performed in boreholes to investigate the hydraulic behaviour of rock masses are only valid in the vicinity of the test intervals. They are not appropriate to investigate the hydraulic anisotropy present in jointed rocks. Nevertheless, these tests have been the most widely used tool to characterize rock mass permeability in engineering works over the past 70 years.

Water pressure tests were originally proposed by *Lugeon (1933)* to characterize regions of major and minor permeability in dam foundations. However, their use has become so widely spread that it is now considered a reference for decisions about the need for grouting in tunnelling, foundations and abutments of dams as well as other subterranian excavations.

The interpretation of water pressure test results has been the source of several controversies around the world. Many attempts have been made to interpret the results using Darcy's Law to evaluate an isotropically equivalent permeability coefficient **k**. Often however, the often non-linear characteristics of the pressure and flow are not taken into consideration.

Another error commonly made, is to average the test results. This has often been used to characterize the permeability of the rock in the test section as well as to extrapolate the results to a larger volume of the rock mass being investigated. The increase in pressures at each stage has influence on the deformations occurring during the test and hence on the flow regime. This makes the practice of averaging results erroneous.

The extrapolation of results for larger volumes of the rock mass, can only be done if the test results are consistent with results of other investigations in larger scales, such as geological-structural surveys, geophysics tests and so forth.

2 NON-LINEAR FLUID FLOW VERSUS DEFORMATION

The non-linearity of flow observed in water pressure tests has also been the subject of many discussions. Deformations have an influence on the non-linear relationship between flow and pressure. Unfortunately, despite many authors stating that the high pressures used in the injection tests cause unrecoverable deformations around the borehole, it appears that only limited investigations have been conducted on this subject based on results from field tests.

The non-linearity of fluid flow in jointed rock can be due to the effect of turbulence, leakage or deformation of the preferential flow channels. The apperture of joint systems can still be affected, even at some distance from the borehole as the channels can open or close as a result of the deformations imposed in the test zone by the high pressures used in the water tests.

Deformation can be an important factor in field situations. If deformation does occur, it is necessary to know whether it is recoverable or permenant or a combination of both, since this would determine how the permeability of the joints intersecting the borehole would be permanently changed.

Some authors such as *Foyo (1993)* state that the conventional Lugeon tests *(Lugeon, 1933)* are not suitable to characterize permeability because in a number of cases hydraulic fracturing is induced in the test zone. *Foyo (1993)* based his assumptions on packer tests performed in a weak and permiable sequence of carboniferous shales and sandstones and a weak but impermiable sequence of volcanic rocks at different sites. He proposed the use of lower pressure testing rather to define permeability.

Hydraulic fracturing resulting from deformation in the test zones is most likely to occur when the rock in the test zone is extremely fractured or weathered.

These deformations can lead to incorrect interpretation of the water pressure tests.

Flow in a single joint is a function of it's apeture *(Equation 1)*. Any change in the apeture of the joint or joint system in the borehole will have considerable influence on the water percolation on the joint planes, which explains the interest in the subject.

$$k = \frac{ge^2}{12v} \qquad (1)$$

where **k** = isotropic coeffiecient of hydraulic conductivity, g = gravity, *e* = joint aperture and *v* = co-effiecient of kinematic viscosity of the fluid.

It is suggested that only the initial part of the flow pressure curve obtained from field tests *(see Figure 1)*, can be used to characterize the isotropic coefficient of permeability, **k**. The inclusion of the lower pressures later in the curve will reduce the effect of deformation on flow. When **k** is calculated using the initial curve it will be closer to reality. Non-linearity however, can persist even when small pressures (a few g/cm^2) are used due to the effect of viscosity and influence of surface roughness, undulations, geometry and distribution of head losses. This is shown in *Figure 1*, which corresponds to a water pressure test performed with very low pressures (*Cruz, Quadros & Correa Filho, 1983)*.

Hydraulic tests performed with a number of increasing pressure stages having a significant interval of low pressures (*Figures 1 and 2*) would be more advisable to characterize permeability. The test results can be compared with diagrams based on laboratory tests of single joints with controlled aperture and roughness (*Figure 2*).

Instead of water pressure injection tests, pumping out (suction) tests performed with an appropriate hydraulic probe using four packers (*Louis, 1974; Hsieh et al. 1985; Quadros & Correa Filho, 1993*) seems to be more suitable to characterize **k** because the deformations are minimized. Most probably when suction occurs, change in the aperture of the rock joints are caused by the reduced pore pressure, or other effects such as dislocations of particles, thus discounting the effect of hydraulic fracturing.

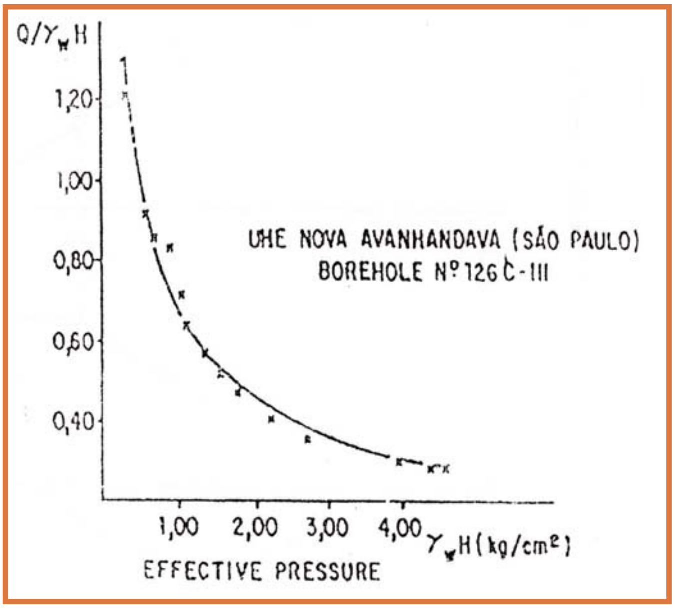

Figure 1. *Flow normalized to effective head versus effective pressure (Cruz, Quadros & Correa Filho, 1983)*.

When hydraulic investigations are performed for evaluation of a site for nuclear waste disposal particularly to collect data to be used for the modelling of radio-nuclide migration through discontinuities in the rock mass, the use of small pressures to characterize permeability would be especially advisable.

In such cases, pumping tests should also rather be used. More realistic measurements could also be achieved by registering the recovery response of the subterraneon water pressure after the end of pumping. This test of recuperation rates increase the time to obtain results, by one to a few more hours depending on the permeability of the rock. However, it also results in a more precise method to evaluate permeability.

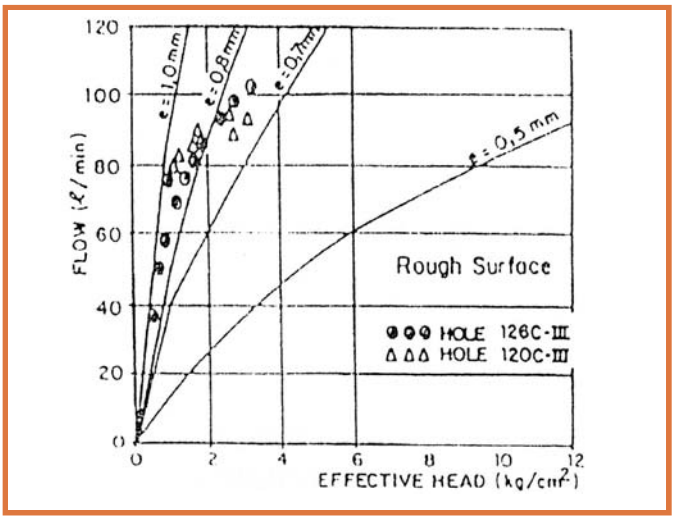

Figure 2. *Relationship between flow Q (l /min) and effective head γΔh (kg/cm²) (Cruz, Quadros & Correa Filho, 1983).*

3 HEAD LOSSES

When fluid is injected into the borehole, most of the influence of high pressures used in the tests occurs in the immediate vicinity of the borehole. In this region, the roughness of the flow is predominantly due to the drag around surface protrusions, and the Nikuradse Equations for a rough turbulant regime is valid.

Limits of validity for flow laws in terms of the Reynolds Number and water pressure tests, are explained in Figure 3 (*Rissler, 1978*). Critical values are designated by Re_{k1} and Re_k, related to corresponding radius of influence.

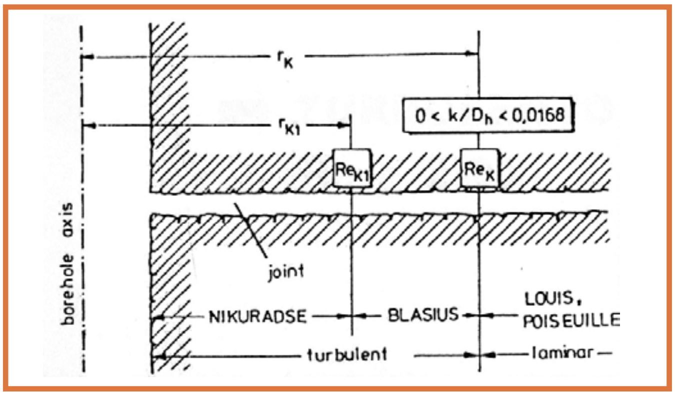

Figure 3. *Head losses, flow laws and Reynolds num-ber) in a water pressure test; in the insert k/DH is the relative roughness (Rissler, 1978).*

At the scale of the rock mass the spacing, persistence and interconnection of the joint systems are the main factors influencing flow. In the rock joints the aperture and roughness are the most important parameters governing flow and head losses.

For rock joints, the Reynolds Number (a ratio of inertial to viscous forces) is defined as Re = V.2e/n, where V is the mean velocity, e is the mean aperture of the joint and n is the kynematic fluid viscosity. In the hydrodynamic processes the co-efficient of resistance to flow λ (*Equation 2*) is affected by both the geometry of the flow channels as described above and also by the vortex and mixing of directions of the fluid in the zone of high turbulence and highest Reynolds Numbers limited by Re_{k1}.

$$\frac{1}{\sqrt{\lambda}} = -2\log\frac{ra/2e}{3.7} \qquad (2)$$

where ra = height of asperities; e = aperture; ra/2e = relative roughness; λ = coefficient of resistance to flow; 3.7 = constant.

The validity of the Nikuradse Equations for flow in rock-joints were first confirmed in laboratory by *Lomize (1951)*. *Figure 4* shows the limits of validity for different hydraulic equations according to distinct flow regimens for a smooth granite fracture in laboratory tests.

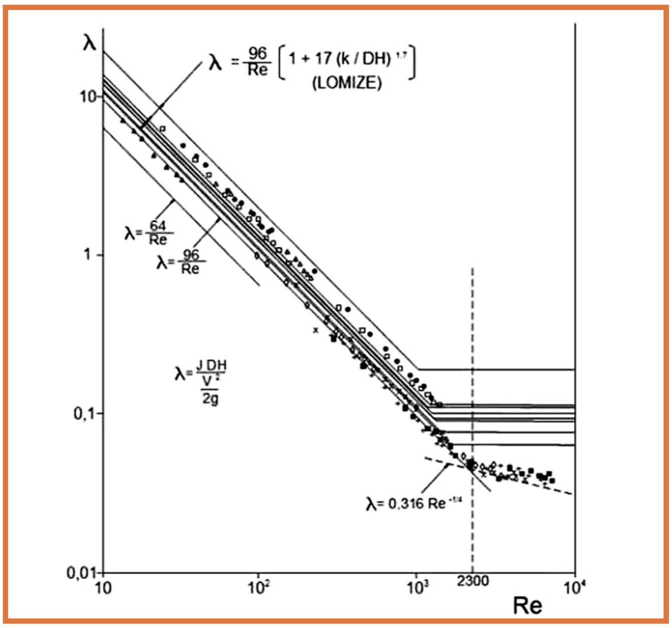

Figure 4.

Laboratory test results performed by the author in a smooth granite, showing the co-efficient of resistance λ versus Reynolds Number Re and limits of validity for some flow equations.

In-situ tests of head losses caused by the geometry of the flow channels, roughness of the joint walls and interconnections of the joint systems shows these factors can have a strong effect in the pressure decay and reduce of flow velocities a few meters from the borehole walls.

The limits defined in *Figure 4* for a smooth rock joint shows that in the zone of turbulence, where lower values of velocities are observed the coefficient of resistance λ depends only on the Reynolds Number. In this regime head losses are due to viscous friction. Laboratory test results fits well with the limits imposed by the hydraulic law of Blasius (*Equation 3*) for Reynolds Numbers larger than 2300 (the transition limit from laminar to turbulent flow) and for smooth joints where ra≈0 (or JRC = 0).

$$\lambda = 0.316 Re^{-1/4} \qquad (3)$$

At greater distance from the borehole, despite the low velocities and low Reynolds Number, non-linear flow still occurs in the majority of the cases. This is due to the effect of asperities and viscous friction on the joint walls as discussed before. Calculations can be made using equations proposed by Lomize (*1953*); Louis (*1969*) and Quadros (*1982*) (*Equations 4, 5 and 6, respectively*) which are valid for laminar non-linear flow.

$$k = \frac{ge^2}{12v} \cdot \frac{1}{\left[1+17(ra2e)^{1.5}\right]} \qquad (4)$$

$$k = \frac{ge^2}{12v} \cdot \frac{1}{\left[1+8\cdot 8(ra2e)^{1.5}\right]} \qquad (5)$$

$$k = \frac{ge^2}{12v} \cdot \frac{1}{\left[1+20.5(ra2e)^{1.5}\right]} \qquad (6)$$

In these equations, the term in brackets is a coefficient that accounts for the influence of roughness in the cubic law.

In field tests, the non-linearity can be understood as a phenomena resulting from a coupled hydraulic and deformation process, where the geometric characteristics of the joints (aperture, roughness, spacing and interconnection), the flow regime occurring under the influence of high pressures and high Reynolds Number, together with the deformation of the testing zone, cause high head losses during the process of percolation.

Unfortunately the non-linearity of flow, which is the consequence of these many factors occurring during the flow processes is seldom taken into consideration in the calculations to evaluate the permeability of jointed rocks.

An attempt was made by Instituto de Pesquisas Tecnologicas (IPT) to define this and to ensure some questions related to deformations in the test zone when a water pressure test is performed in a basalt. The method consisted of alternately performing injection tests followed by pumping tests at various time intervals.

4 RESULTS OF FIELD TESTS

The field tests were made at a dam site in Brazil. The characteristics and the geology of the location is reported in Quadros and Correa Filho (*1993*). The rock at the location of the tests consists of closely spaced basaltic lava flows.

The tests were performed using a hydraulic probe (with 4 packers) developed by IPT. Injection and pumping tests were performed into seven vertical boreholes up to 12.0m into the basaltic rock (at a depth of about ~25 meters). The tests consisted of injecting water under high pressure using five stages of constant pressure alternating with pumping out tests.

The maximum head used in the water pressure tests was 0.25H where H is the depth of the center of the test interval. Pressure transducers were installed in the test intervals, for pressure control. Readings were automatically taken each minute. Deformation effects were observed while performing pumping tests before, immediately after the injection tests, and over longer periods that is 12, 24, 72 and 96 hours after the injection tests.

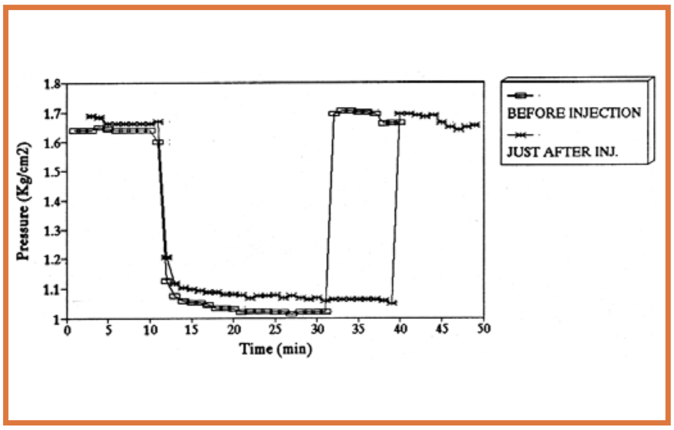

Figure 5. *(a)*.

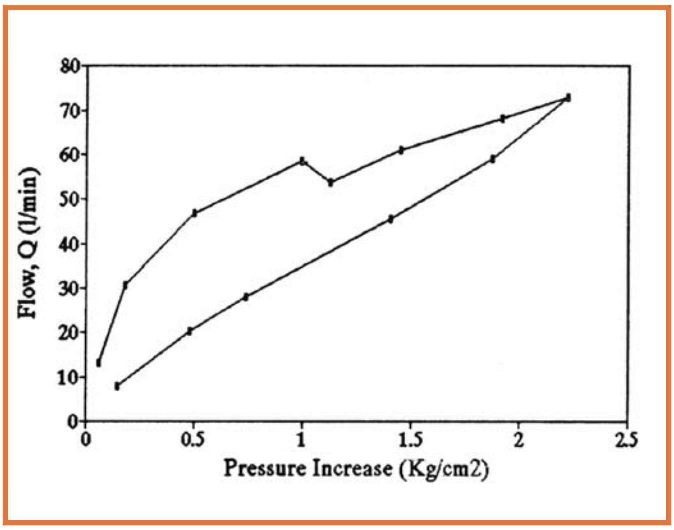

Figure 5. *(b)*.

Figure 5. *(a). Results of pumping tests and (b) results of injection (multiple stages) tests. Borehole SR-2800B. Depth 17.14 to18.64m.*

Table 1 and *Figures 5 to 9* show some of the test results in diagrams relating flow (ℓ/min) to pressure (kg/cm^2) in the injection tests and diagrams relating pressure to time (minutes) in pumping tests. These injection tests show the easine of the water percolation in the same conditions.

Figure 5(a) shows the results of pumping tests performed before and just after the injection test. *Figure 6(a)* shows these results together with the results of pumping tests performed 24 hours later. In *Figures 5(b) and 6(b)* results of corresponding water pressure tests are shown.

The results obtained from the first injection tests (*Figure 5(b)*) shows that the flow channels closed during the test. In *Figure 6(b)* the effect is seen to be contrary, flow is affected by deformations 54% immediately after the injection tests and 9% after 24 hours (*Table 1*).

Figure 7 (a) and (b) shows the results for another borehole — SR-2802D. In *Figure 7(b)* the injection tests results show, that only a small deformation effect on flow occurs during the 5 stages of water pressure tests. Suction tests made before and just after the injection test are in good agreement with these results. The magnitude of the deformation effect on flow was only 10% according to the calculations.

Table 1. *Comparative pumping and water pressure test results*

HOLE	PUMPING TESTS Flow (L/Min)				INJECTION TESTS Flow (L/Min)			
SR	Before	Just after	After	hours	1st Step	2nd Step	3rd Step	(2)/(1)
2800 (B)	47.40 49,20	36.60 46.74	– 24	– 49,20	12,99 44,21	53,72 57,08	73.00 53,76	54% 9%
2801 (C)	13,2 0	14,90	–	–	1,10	17,60	32,80	148%
2802 (D)	3,69 52,90	2,46 51,70	– 24	– 52,15	1,20 35,50	21,00 61,50	33,80 77,80	10% 47%
2803 (E)	59,0 4	58,7	15	59,00	38,40	49,30	63,60	8%
2804 (F)	60,0 0	59,20	–	–	34,20	74,30	107,50	79%
2805 (G)	49,2 0	48,91	96	54,34	11,90	63,90	89,50	82%

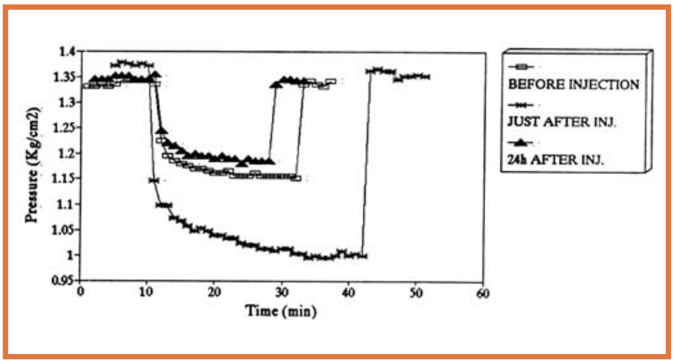

Figure 6. *(a)*.

Figure 6. *(b)*.

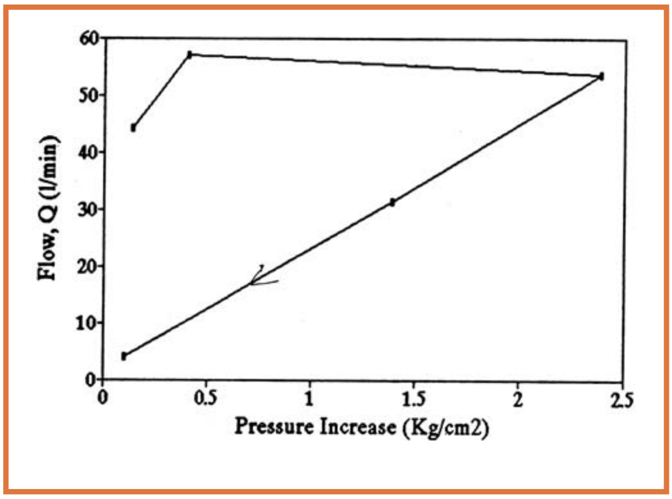

Figure 6. *(a) Results of pumping tests and (b) re-sults of injection tests. Borehole SR-2800(B). Depth 14.14 to15.64m.*

Examples of water pressure and pumping tests performed before, immediately after the injection tests and 15 hours later are shown in *Figures 8(a) and (b)*.

Figure 7. *(a)*.

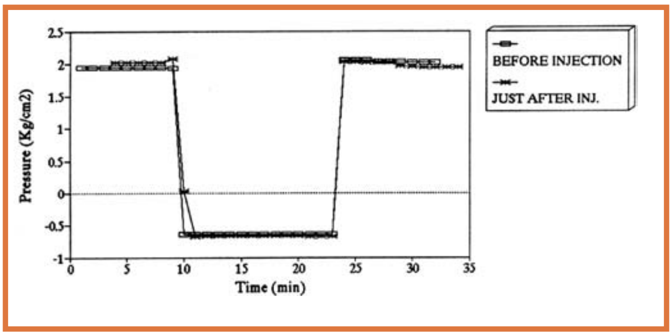

Figure 7. *(b)*.

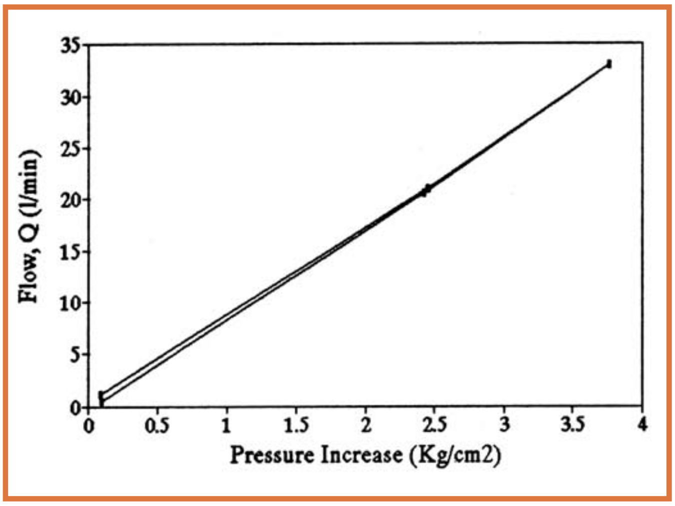

Figure 7. *(a). Results of pumping tests and (b) results of injection tests. Borehole SR-2802(B). Depth 20.40 to 21.90m.*

Figure 8. (a)

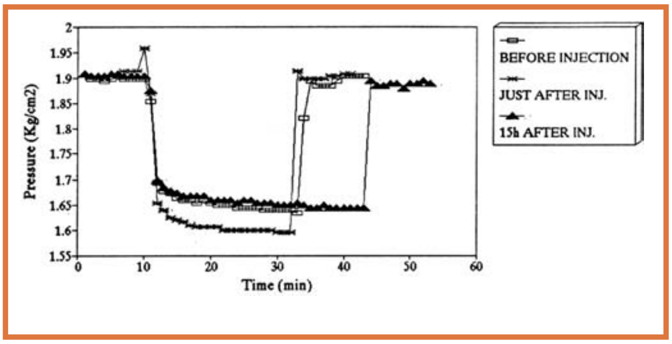

Figure 8. (a). Results of pumping tests. Borehole SR-2803(E). Depth 20.14 to 21.64m.

The results of pumping tests performed just after the injection tests *Figure 8(a)* shows that flow was affected by deformations on the rock in the testing zone. Results from injection tests in *Figure 8(b)* suggests an opening in the flow channels. Nevertheless, after 15 hours the rock was almost recovered and effect of deformation on flow was only 8% *(Table 1)*.

Figure 8. *(b)*.

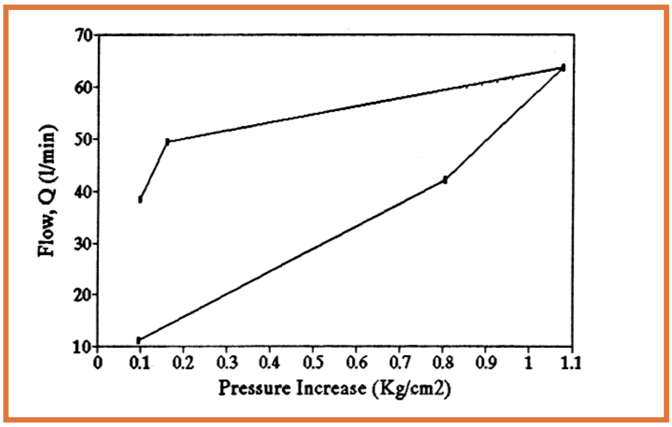

Figure 8(b). *Results of injection tests performed before and just after injection tests. Borehole 2803(E). Depth 20.14 to 21.4m.*

Figure 9. *(a)*.

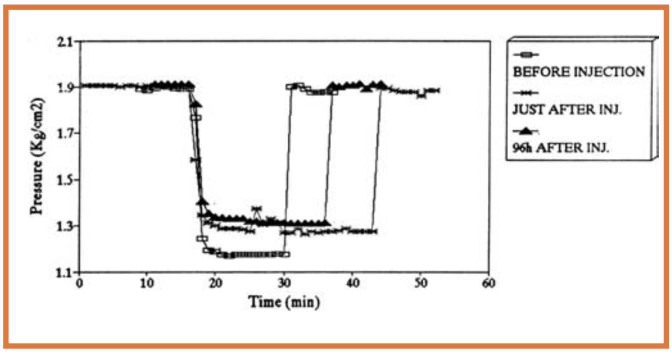

Figure 9. *(b)*.

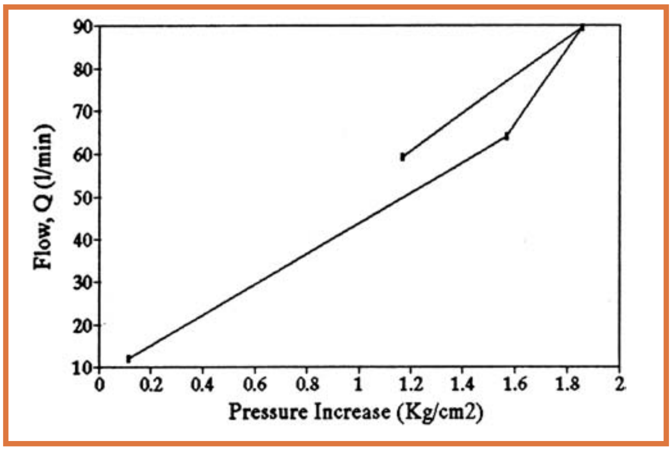

Figure 9. (a).Results of pumping tests and (b) Re-sults of injection test results. Borehole SR-2805(G). Depth 19.64 to 21.64m.

Figure 9 *(a) and (b)* show that after 96 hours, the effect of deformation on flow remains 80%. Comparing this behaviour with the results observed in the previous tests (*Figures* 6-8), the deformation effect on the flow suggests hydraulic fracturing of the testing zone.

5 CONCLUSIONS

It is evident from the results shown that the water pressure tests caused some deformation in the basaltic rock in the testing zones. The deformation effects are registered on the results of pumping tests performed before, immediately after and some days later.

In some cases deformation seems to be recoverable after a period of time, possibly being in the elastic linear or non-linear range. In *Figure* 9 an example of unrecoverable deformation after 96 hours delay is shown. Most probably hydraulic fracturing occurred in the test zone due to the high pressures used during the injection test and some weakness of the rock in the testing zone.

The effect of deformation on flow tests can be up to 100% magnitude. This effect is probably due to the deformations induced in the testing zone by the high pressures used in the injection tests.

Multiple stage water pressure tests with an increased number of lower pressure stages is recommended when the objective is to characterize accurately the rock mass permeability. A curve relating flow to pressures can be clearly defined from these tests and comparisons can be made with similar curves obtained from laboratory tests.

Pumping tests instead of injection tests at a fixed interval in the borehole appears to be more suitable when the objective is to characterize rock mass permeability or when linear equations are used to extrapolate the results of in-situ tests. These tests will cause less damage to the rock in the testing zone.

The use of high pressures tests is consider improper when the objective is to evaluate permeability because they induce deformations, thus changing the aperture of the pre-existing systems of joints and hence affecting the test results.

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TRIAXIAL CREEP TESTS IN SALT – Applied in drilling through thick salt layers in Campos Basin - Brazil

A. Maia C., E. Poiate J., J. L. Falcão / PETROBRAS, L. F. M. Coelho / IPT

ABSTRACT: The presence of salt structures in prospects for oil and gas exploration is, in itself, a factor that increases the probability of success due to favorable conditions for hydrocarbon generation and trapping. However, many operational problems such as stuck pipes and casing collapse have been reported by the industry when drilling through those salt layers.

Historically, many deep wells have been drilled through thick salt intervals in the Campos Basin, Brazil. Until the 1990's, the lack of a reliable ways to predict salt behavior at high temperatures and high differential stresses led to very high drilling costs and even the loss of wells.

In this paper we present a methodology for mud weight and casing design and also to define the drilling strategies employed for drilling through thick salt layers. Numerical simulations to evaluate the creep behavior of salt submitted to high differential stresses and high temperatures were done through the applications of an in-house finite element code. To calibrate the model, triaxial creep tests in salt samples were performed to evaluate and isolate reological properties that represent creep behavior under different differential stresses and temperatures. Numerical models conformed well.

A recent application of this methodology in a sub salt well in the Campos Basin allowed drilling through the salt without a problem. Results obtained by numerical simulations were used to predict the evolution of the well closure. This gave time for various mud weights and several alternatives of casings capable to be analysed for supporting salt creep. As a result, stuck rods and casing collapse were avoided and drilling costs reduced.

INTRODUCTION

The Campos Basin in Brazil is one of the most active offshore oil and gas prospecting regions in the world. This currently provides some of the greatest challenges and opportunities for the oil industry. However, the complex salt tectonics and the extreme water and reservoir depths require not only high development costs, but also innovative technology to bring these fields on stream. At the edge of the industry's experience are salt sections of 2000-3000 m thick that overlie targets at depths of 3000-4000 m below mudline in water depth of 2000-2500 m. The cost of drilling these ultra deepwater sub salt wells is substantial, and in some cases, operators have been forced to sidetrack or even abandon wells after experiencing drilling difficulties, with losses of several millions of dollars.

The presence of evaporite sections in locations for oil and gas exploration is, in itself, a factor that increases the probabilities of success in the area due to favorable conditions for the generation and trapping of hydrocarbons. On the other hand, the presence of evaporites (or salt rocks) can cause major operational problems if special procedures to drill through salt are not used.

Many operational problems, such as stuck drill rods and casing collapse have been reported by the oil industry when drilling through and near salt layers. Historically, in the Campos Basin, many deep wells have been drilled through great salt intervals [1].

In the 1980's, the lack of reliable ways to predict salt behavior at high temperatures and high differential stresses led to the loss of wells and very high drilling costs.

Salt strain prediction and its effects in open and cased wells is of major importance for the drilling design. It allows the design of the mud weight at levels to keep creep under control without fracturing formations above and below the salt zone. Furthermore, the need to run intermediate casing strings before and after the salt layer in order to maintain the integrity of those formations can be evaluated.

In this paper we present a methodology for mud weight and casing design and also to define the strategy to drilling sub salt prospects. A series of triaxial creep tests in salt rocks were performed to evaluate and isolate reological properties to represent the ideal creep behavior of salts under different differential stress and temperature. In addition, numerical modeling of the wellbore stability during drilling has been performed.

The numerical simulations have been done through the application of an in-house computer code based on the finite element method [2]. The computer code, ANVEC has been validated for more than 20 years by the comparison between the numerical results and measured closure of in an underground potash mine in Brazil [2-6].

Results obtained by the numerical simulations were used to predict the evolution of the wellbore closure with time for various drilling fluids and analyze several technically feasible alternatives of casing capable of supporting salt creep. The methodology has been used successfully to design the drilling of three deep wells in the Campos Basin. The risk of casing collapse and stuck pipe due to salt creep was minimized and drilling costs were reduced in these holes.

CONSTITUTIVE EQUATION OF SALT BEHAVIOR

Salt rocks exhibit relatively quick time-dependent deformation when subjected to any level of shear stress, due to their crystalline structure. This creep behavior, slow deformation under constant stress, is influenced by the thickness of the layer of salt, formation temperature, mineralogical composition, water content, presence of impurities, and the extent to which differential stresses are applied to the salt body.

The Brazilian continental margin basins have, in general, high geothermal gradients, a thick sediment column on top of salt layers, neo-tectonics inducing salt movement and evidence that salt diapirs are still moving, indicated by mapping of salt faults in Campos and Santos Basins. Information from wells drilled through deep salt sections shows that salt closure can reach high velocities (0.05 in/h) [7].

Starting from the beginning of the 1990´s, creep constitutive laws based on deformation mechanisms, have been recommended by the international technical literature, to represent the intrinsic behavior of the material [8-10].

The law describing the deformation mechanisms due to moment was developed by Munson [8-9]. The constitutive equation of Munson's creep law considers the following mechanisms: dislocation glide, dislocation climb and undefined mechanisms. The magnitude of contribution of one or other mechanism depends on the temperature conditions and differential stress that the salt is subjected to.

The constitutive equation corresponding to the creep law of double mechanism of deformation is a simplification of the equation developed by Munson (8-9), and it considers the dislocation glide and undefined mechanisms. The latter effect was recently identified as being creep in the contacts of the halite (salt) grains, provoked by the dissolution of the salt due to the increase of its solubility, under the high pressures that occur in the contacts between grains.

In this paper, halite is analyzed according to the elasto/viscous-elastic behavior, adopting the double mechanism creep law, as shown in *Equation 1*:

$$\varepsilon = \varepsilon_0 . \left(\frac{\sigma_{ef}}{\sigma_0}\right)^n . e^{\left(\frac{Q}{RT_0} - \frac{Q}{RT}\right)} \qquad (1)$$

where,

ε - Strain rate due to creep at the steady state condition

ε_0 - Reference strain rate due to creep (in steady state)

σ_{ef} - Creep effective stress

σ_0 - Reference effective stress

Q - activation energy (kcal/mol), Q = 12 kcal/mol [8]

R - Universal gas constant (kcal/mol.K), R = 1.9858 E-03

T_0 - reference temperature (K)

T - temperature of rock (K)

The steady-state creep parameters were based on the results of triaxial creep tests and applied in the numerical model, correcting the strain creep rate with the thermal activation factor.

SALT SAMPLES

All of salt samples were obtained from wells located in the northeast of Brazil (Sergipe State). The samples are stored in a room with temperature and humidity control, to preserve the character of the specimens, due to the sensitivity of the salt to both heat and water.

As a consequence of the sampling process, cracks could be induced in the sample, which could affect its mechanical behavior. These cracks and the larger or smaller presence of insoluble material such as clay and interbedded shale and anhydrite, reduce the compressional velocity. To avoid this effect, the samples were prepared (top and bottom are ground) and submitted to a quality control to verify its structural integrity by the measurement of compressional velocity using a PUNDIT instrument. Samples with compressional velocity below 4300 m/s were rejected.

The porosity of the halite is negligible, as its permeability is low. The compressional velocity can be considered a constant mechanical property independent of the depth, this fact can be observed in a sonic profile of an exploratory well that cross thick layers of pure halite.

Using the elastic theory the dynamic Young Modulus can be obtained. A dynamic Poisson's Ratio of 0.36, has been used in several works related with the mechanical behavior of the salt in the potash mine of Taquari-Vassouras - Northeast of Brazil. It was determined by measurements of compressional and shear velocity in the mine, for the application of seismic reflection techniques [11].

The creep tests were performed in specimens of salt with a width: height ratio of 0.5.

EXPERIMENTAL ASSEMBLY AND TESTS

A laboratory with six independents temperature, axial and confining pressure serval control units was built. *Figure 1* illustrates the scheme of one unit [12].

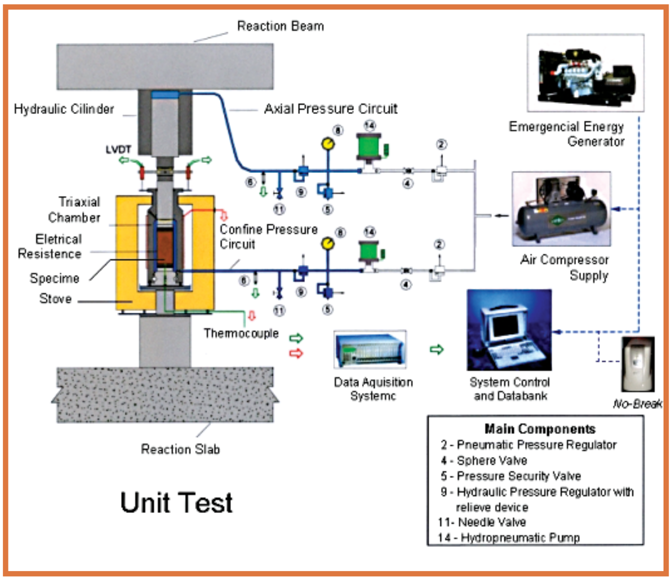

Figure 1: *Scheme of the experimental apparatus.*

The units are operated by hydraulic and pneumatic control systems (providing confining and axial pressure). Electrical resistance, heat, are determined by instruments like LVDT´s, pressure transducers and thermocouples. All instruments are connected in a data acquisition system MGC Plus (HBM), connected to a computer, that is controlled by code specially written in CatMan program (HBM) to control the tests, plot real time and store the data.

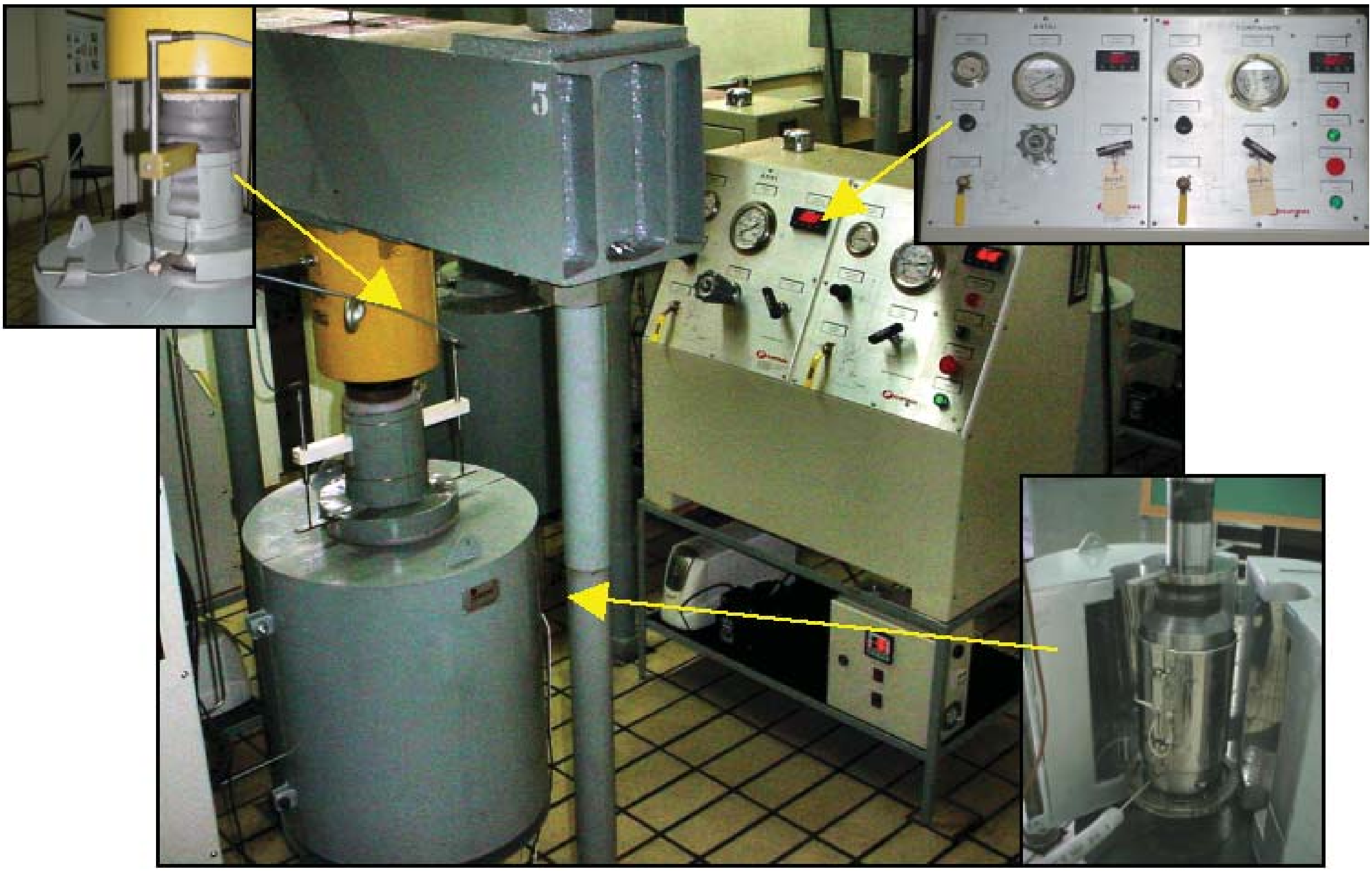

Figure 2: *Final assembly of the testing apparatus and hydraulic control system*

To guarantee that the creep tests would be performed without energy fluctuation and interruption, a UPS and generator was installed, as the creep tests could occur over hours or months.

After completion the experimental assembly (*Figure 2*), confining pressure is applied, followed by the temperature and finally the axial pressure, inducing the differential stress to the specimen .

Specimen strains were then measured at one second intervals while the confining pressure, differential stress, and temperature were held constant for the duration of the test.

EXPERIMENTAL RESULTS

Three important stages of behavior must be handled appropriately when material model parameters are evaluated in the laboratory to characterize salt creep.

A typical creep curve for salt comprises of two or three creep stages. Following the application of the stress difference, the strain rate is very high. This rate then decreases monotonically with time until a constant rate of strain is observed. These two stages are called transient and steady state creep stages, respectively. A third stage called tertiary creep stage then becomes evident. This is characterized by acceleration of the creep rates that cause dilation and an increase in volume through micro fracturing, leading to failure.

Figure 3 shows a typical behavior of salt creep. In this test, halite is submitted to a 16 MPa differential stress at 86°C [13]. The first stage termed primary creep is observed up to 200h. Between 200h and 1600h, secondary creep is observed, with strain rate 7.7673E-05. After 1700h, the tertiary creep begins. The differential pressure of 16 MPa is about 45% of the rupture stress of the sample, (obtained by a simple compression test).

Figure 4 shows the strain rate for different differential stress ranges (6-20 MPa) from halite creep tests at 86°C.

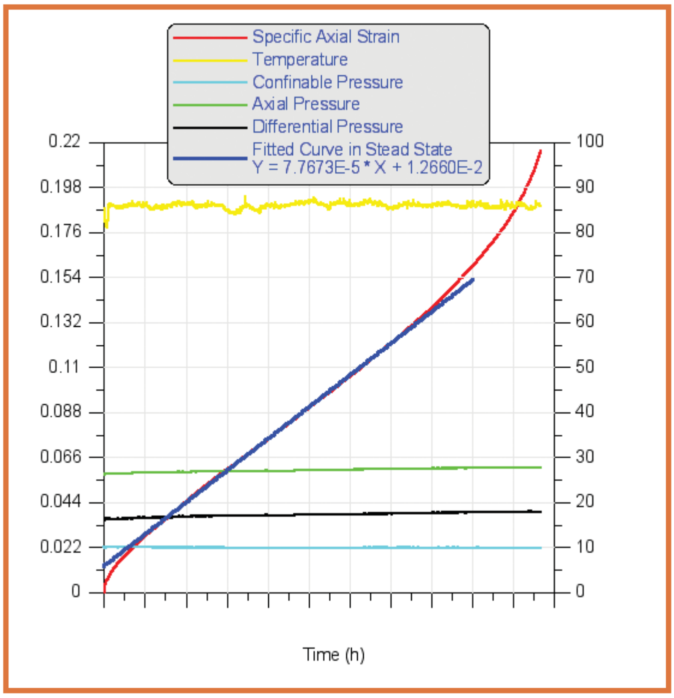

Figure 3: *Typical behaviour of salt creep test.*

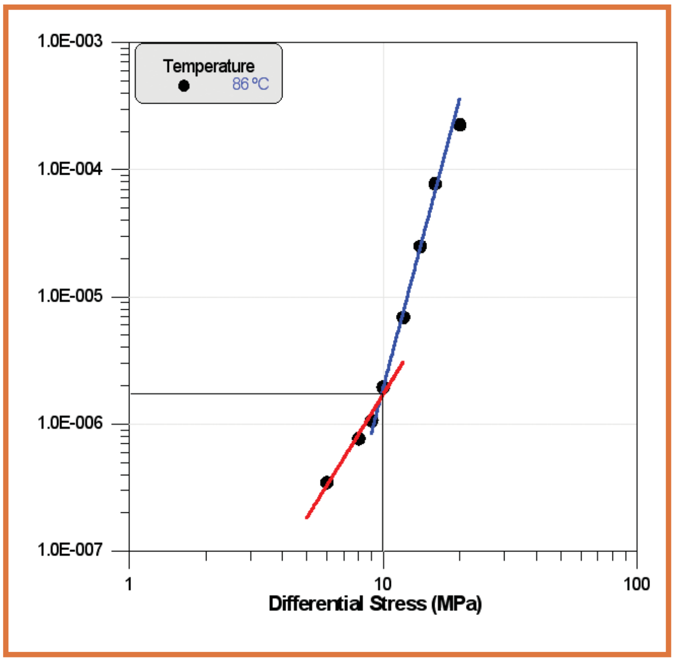

Figure 4: *Strain rates results from salt creep test in the stead state condition.*

At 86°C, σ_0= 9.91 and ε_0 = 1.880E-06

Therefore the constitutive equation becames:
ε = 1.880E-06 * $(\sigma_{efet}/10)^n$

Where:

n = 3.36 when $\sigma_{efet} < \sigma_0$

n = 7.55 when $\sigma_{efet} \geq \sigma_0$

Figure 5 shows the comparison of the strain rates versus the differential stress from the experimental tests at 86°C. The constitutive equation was evaluated and the parameters back-analyzed from the behavior of the potash mine excavations corrected for the temperature of 86°C, with the thermal activation factor ($e^{(Q/RT_0 - Q/RT)}$).

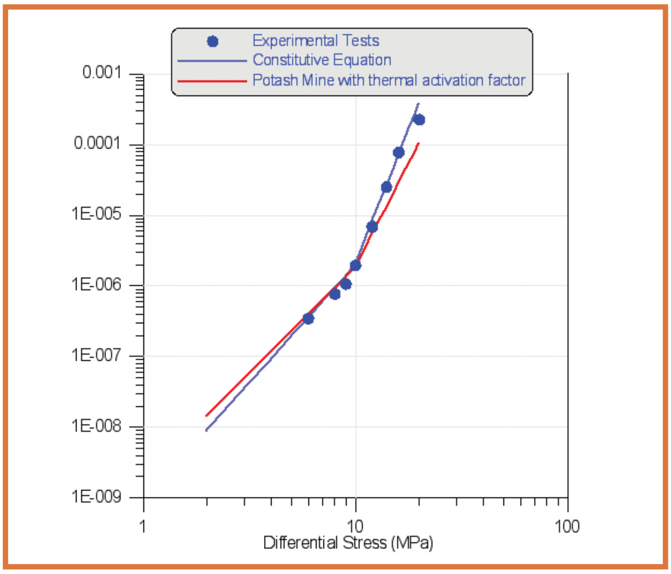

Figure 5: *Comparrison of the strain rates as a function of the differntial stress in the steady state condition.*

NUMERICAL SIMULATION OF THE CREEP TESTS

The parameters that define the constitutive equation, corresponding to the creep law of double mechanism of deformation, were isolated for different levels of differential stress defining a basic relationship of strain rate in steady-state conditions with the applied differential stress for the temperature of the tests.

As the first stage of creep parameters validation, the numerical simulation of the creep tests which would be used in a subsequent phase for prediction of the evolution of well closure with time, was compared with the measured caliper results.

For pre and post processing of the finite element model, the SIGMA system is used [14].

The numerical simulations have been done through the application of the finite element method being used the code ANVEC [3]. Both of these are PETROBRAS property.

We employed 2000 quadratic isoparametric elements (with 8 nodes) and 6241 nodal points in the finite element model, being used an axisymmetric two-dimensional structural model, as shown in *Figure 6a* to represent the specimens tested, *Figure 6b*. The program ANVEC considers the non-linear physical elasto/visco-plastic behavior with constitutive law of double mechanism of deformation for creep.

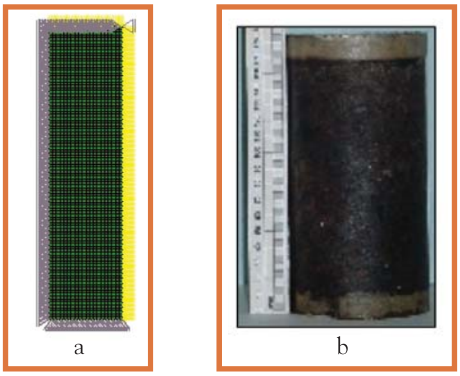

Figure 6: *a) Discreet model of simulation and b) Specimen.*

The model considers the axisymmetric axis of the specimen by restraining the horizontal displacement on this axis. At the top and base of the model the horizontal displacement is restricted to represent the strong restriction to the lateral strain of the specimen induced by the boundary conditions of the triaxial chamber.

COMPARISON BETWEEN NUMERICAL AND LAB RESULTS

Figure 7 presents a comparison of the results obtained by experimental test and numerical simulation. The strain creep rate in the steady-state condition obtained by numerical simulation reproduces the experimental results faithfully (less than 1% difference) proving that the methodology used is correct.

Figures 8a and 8b are a visualization of numerical simulation (with half volume rendering) and the experimental specimen after the creep test respectively.

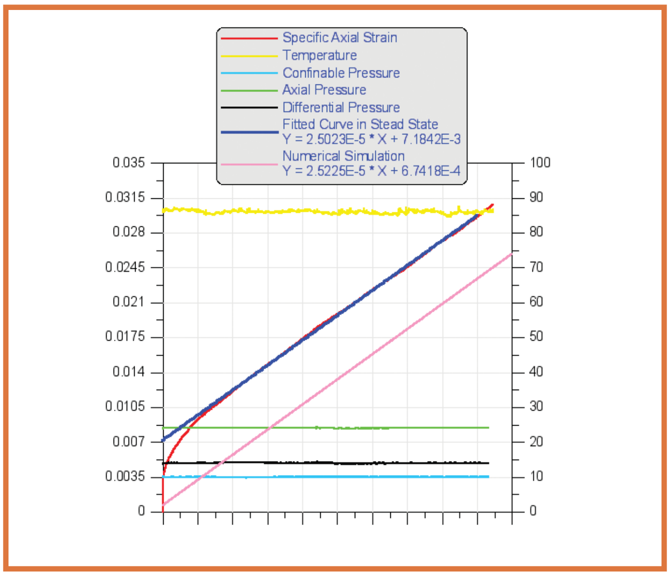

Figure 7: *Experimental versus numerical results.*

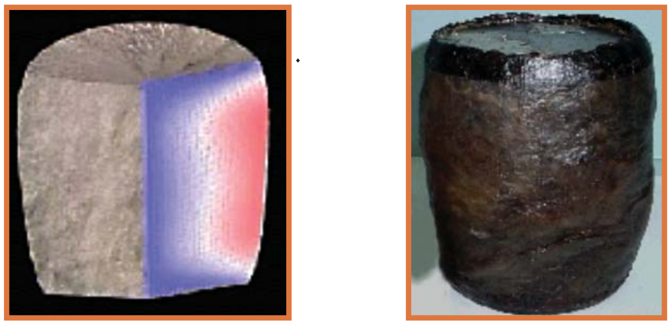

Figure 8: *a) Vizualization of numerical simulation and b) Experimental specimen after test. Note that these are of similar shape and proportions.*

NUMERICAL PREDICTION OF WELL CLOSURE

Numerical simulations based on these tests were performed to investigate the well closure rate during drilling of the salt zone. Several drilling fluids weights were tested, but results for two drilling fluids weight, 12.6 kN/m^3 (10.5lb/gl) and 14.4 kN/m^3 (12.0lb/gl) are presented. To guide drilling through the salt zone the behavior of salt creep as a function of drilling progress was simulated using an axisymmetric model in a rock assumed to be pure halite.

The evaporite zone of the chosen scenario for the study is a thick pure halite layer to be drilled at the interval of 2324 m to 3034 m below the sea bottom, or 3720 to 4430 m in relation to the drilling rig. *Figure 9* illustrates the geological profile used in the analysis.

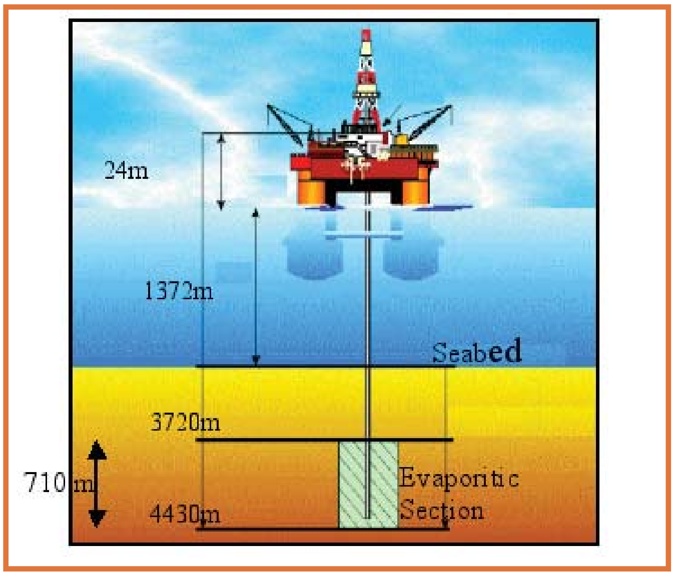

Figure 9: *Simplyfied geological pofile used in the analysis.*

The hard rocks with fragile behavior, above and below the salt, are analyzed according to a elasto/plastic model being adopted from the plastic flow criteria of Mohr-Coulomb for the multi-axial state of stress. For the stratigraphic column the average specific weight of 22.56 kN/m^3 and a horizontal thrust coefficient equal to 1 are used. *Table 1* summarizes the elastic properties and shear strengths of the rocks of interest to the analysis.

Table 1: *Elastic Properties and shear strength.*

Material	E(KPa) x 10^7	ν	C (MPa)	ϕ
Halite	2.04	0.36	3.0	43
Fine Limestone	3.10	0.30	0.9	37

The temperature gradient was considered in two ways. First we used data of several wells, to obtain a temperature for the well being analyzed, that resulted in 81.3° C and 109° C (at the top and bottom of the salt layer). Second we considered the experience accumulated in the project of potash mine of Taquari-Vassouras [3-7], where the evaporitic basin presents a geothermal gradient of 40° C/km, obtaining the temperature of 97.9° C and 126.3° C. The temperature measured of the seabed is 4° C. On the simulation, we adopted the temperatures of second case (worse case scenario) for evaluating the halite properties as function of depth. *Figure 10* illustrates the salt layer topology and the well location.

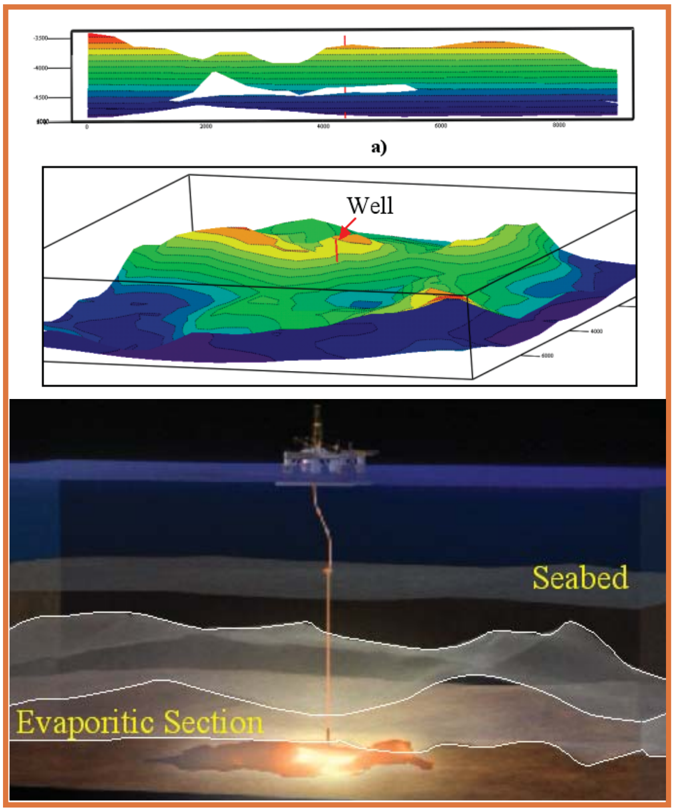

Figure 10: *Top and bottom of the salt layer topology.*

As the creep tests were conducted at a temperature of 86°C it was necessary to correct the creep constants by the thermal activation factor ($e^{(Q/RT_0 - Q/RT)}$).

FINITE ELEMENT MODEL

The axisymmetric model, about the longitudinal axis of the well, comprises 710m of evaporite interval and 200m of thick hard rock, below and above the salt layer to represent the boundary condition. We used 40880 quadratic isoparametric elements with 8 nodes and 125617 nodal points in the finite element model, (*Figure 11*). To consider the temperature variation with depth, different layers were built.

NUMERICAL SIMULATION RESULTS: DRILLING FLUID DESIGN

The behavior of the well is simulated in the time domain, considering the viscous-plasticity of the halite.

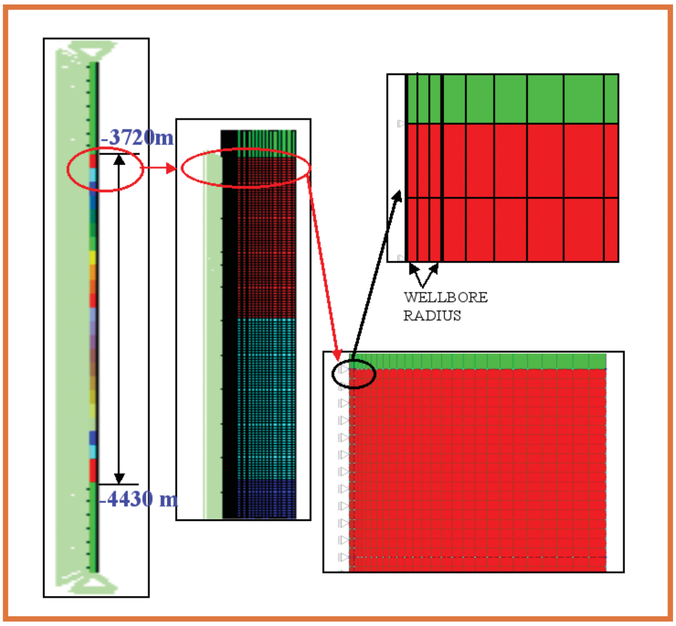

Figure 11: *Finite element model.*

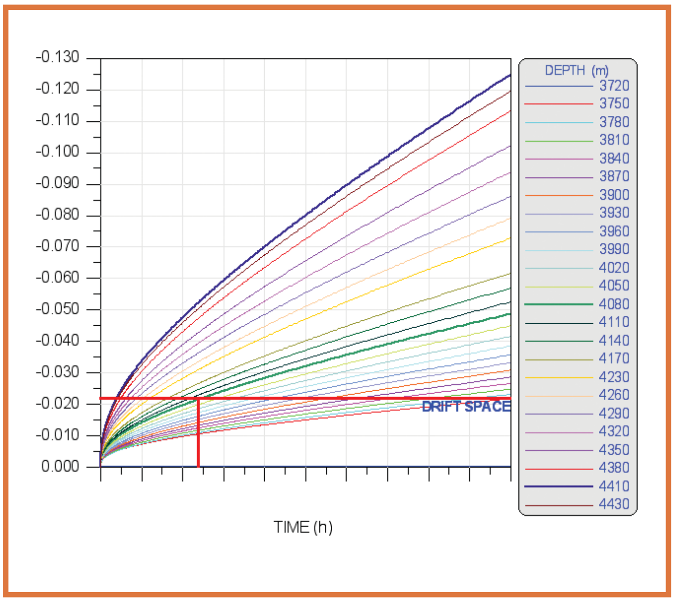

Figure 12: *Closure curve in 24 different depths drilled within a single excavation stage, 10.5 ppg mud weight.*

The objective of the numerical simulation was to predict the evolution of the well closure with time along its longitudinal axis, during the progress of the drilling column.

To simulate the structural behavior of the well, we adopted two procedures. On the first it was considered that salt layer was drilled in a single excavation stage and on the second it was considered that the salt layer (710m) was drilled in 71 excavation steps, simulating the bit progress at 10 m/h.

Figure 12 shows the evolution of the well radial closure with time in a single excavation stage, a 10.5 ppg mud weight. It is observed that the largest closure of the well (of the 24 depths numerically monitored) occurs at a depth of -4410 meters (relative to the rotary table), in a section located 20 meters above the base of the halite. The layer of halite that crosses the well would be drilled with a bicentric bit (maximum diameter of 14 $^{3}/_{4}$" and minimum diameter of drift of 12 $^{1}/_{4}$"). If irregularities during the drilling are considered in the analysis model, a nominal diameter of 14" is used. Therefore, there is an acceptable closure of 1.75" (0.022m), for drift of 12 $^{1}/_{4}$ ".

In the graph the acceptable closure is compared with the evolution curves with time of the well radial closure. It is observed that for depths greater than 4080m the acceptable limit for the radial closure is reached early (125h). This model considered the simultaneous excavation of all intervals. Therefore, it is a conservative simulation procedure but serves as reference for a preliminary definition of the mud weight. The simulation in a single stage is faster, allowing the evaluation of a larger number of alternatives of drilling fluid weights.

Figure 13 shows the evolution of the well radial closure with time being considered over 71 excavation steps, simulating the bit progress at the rate of 10 m/h, when a mud weight of 10.5 ppg is adopted. The curves of radial closure with the time of each depth begin when the excavation, (that is the bit), reaches the respective depth.

For example, notice that the curve of radial closure in the depth of 4410 m begins around t = 75 hours, which is when the bit reaches that depth *(Figure 13)*. The radial closure at that depth reaches the acceptable value around t = 120 hours, about 45 hours after the bit has reached that depth. Adding this time to the necessary time to reach the salt base, (about 75 hours), it shows that 120 hours

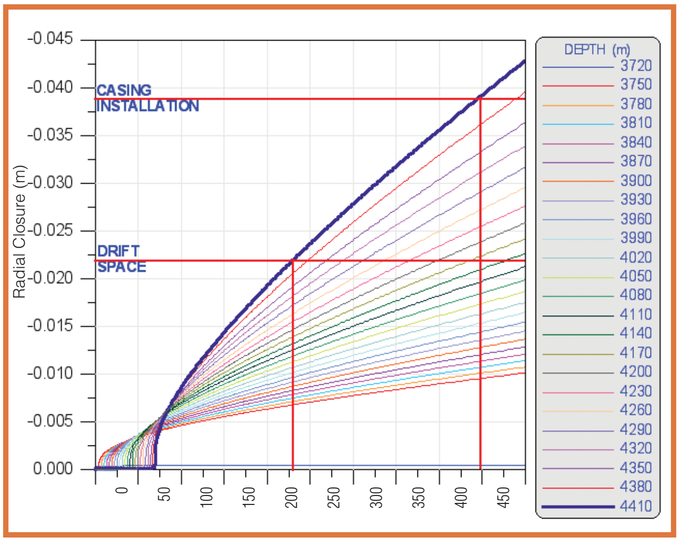

Figure 13: *Closure curve in 24 different depths drilled with 71 excavation steps, 10.5 ppg mud weight.*

after the beginning of drilling the salt layer the radial closure at a depth of 4410 meters would cause a stuck drill rod. Comparing this result to *Figure 12*, it is seen that for the same depth when considering the simultaneous excavation of the whole salt interval, the radial closure happens faster. In the specific case of the depth of 4410 m, the radial closure of the well reaches the acceptable value earlier, after only 25 hours.

Even with the more realistic approach of the simulation model (gradual progress of the bit with the time) it is verified that the mud weight of 10,5 ppg could not keep the wellbore open for long enough for concluding the drilling operation without the risk of a stuck rod. At the same time, the wellbore would not be open for a long enough time to set the casing.

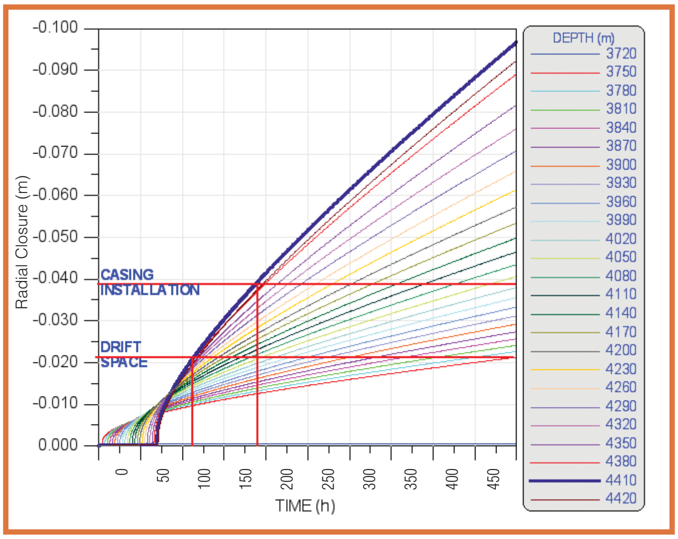

Figure 14: *Closure curve in 24 different depths drilled with 71 excavation steps, 12.0 ppg mud weight.*

Based on that result, we decided to increase the mud weight to 12.0 ppg and redo the simulation of the behavior of the well in stages, in a total of 71 stages, with a bit progress of 10 m/h.

Figure 14 shows the evolution of the well radial closure with time in function of the bit progress. The curve of radial closure at the depth of 4410 m, shows that the closure of the wall of the well begins around t = 75 hours, that is when the excavation reaches that depth. The radial closure at that depth reaches the acceptable value around t = 225 hours, about 150 hours after the bit has reached that depth. Added to this, the time necessary for the excavation to reach the salt base of about 75 hours, it is concluded that 300 hours elapsed after the beginning of drilling the salt layer the radial closure at the depth of 4410 meters would cause the drill string to get stuck.

The adoption of a mud weight of 12.0 ppg provide a length of time of about 12.5 days (400 hours) before the drill string got stuck. That was considered enough time for drilling the salt layer and running and setting the casing. These curves have being used during the drilling in order to guide the operations, so that well closure above the bit does not cause the drill string to get stuck.

CONCLUSION

In this work we presented a methodology developed by Petrobras R&D for mud weight and casing design and also to define the strategy to drilling sub salt prospects. An apparatus with temperature, axial and confining pressure control was built. Triaxial creep tests in salt rocks were performed to evaluate and isolate reological properties to represent the creep behavior of salts under different differential stresses and temperature. Computer modeling to evaluate the creep behavior of salt rocks submitted to high differential stress and high temperature was then applied.

The numerical simulations have been done through the application of an in-house developed computer code based on the finite element method. Numerical and experimental results and constitutive equations matched and have a good conformity. The experimental tests proved that the correction factor for thermal reactivation is represented by the exponential term ($e^{(Q/RT_0 - Q/RT)}$).

The program ANVEC, with extensive application in the simulation of the behavior of underground excavations, subject to the elasto/visco-plastic phenomenon, demonstrated excellent stability and convergence to predict the creep phenomenon in conditions of high temperature levels and differential stresses. The procedure of simulating the behavior of the well with time as a function of the bit progress, through the technique of automatic mesh rezoning is constituted in a differential advantage of the program providing valuable information for the drilling operation. In function of the bit position, the field engineer has tools to evaluate what is happening above the position of the bit and hence the potential of risk of stuck pipe.

Results obtained by the numerical simulations were used to predict the evolution of the well closure with time for various drilling fluids and analyze several technically feasible alternatives of casing capable of supporting salt creep. The methodology has been used successfully to design three deep wells in the Campos Basin (through 290, 400 and 710 meters of salt), [15,16]. The risk of casing collapse and stuck pipe due to salt creep was minimized and drilling costs were reduced. The news challenges are drilling through very thick layers of salt (2000 to 3000 meters) and adjacent to salt diapers, in the Santos and Campus Basins looking for light oil in deep reservoirs.

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Kyoto 2004 ISRM

Contribution of Rock Mechanics to the New Century

The 2004 ISRM International Symposium: 3rd ARMS (Asian Rock Mechanics Symposium), "Contribution of Rock Mechanics to the New Century", chaired by Professor Yuzo Ohnishi at Kyoto University, was successfully held on November 30 – December 2, in Kyoto International Conference Hall, Kyoto, Japan. This International Symposium was jointly organized by JGS (Japanese Geotechnical Society), ISRM and ISRM National Group - Japan. About one thousand and three hundred pages of proceedings from this symposium were published. The proceedings contain a collection of seven excellent Keynote lectures, two excellent Special lectures, one Rocha Medal Lecture and 230 technical papers from 26 countries. There were 469 participants including more than two hundred and ten overseas participants from 31 countries.

The organizing committee thought that, whether a symposium was a success or not, could be judged by if it had fulfilled some factors. One of the important factors is what kinds of themes and observing keynote lectures we could propose and arrange. This symposium especially proposed and covered the following themes;

- Visualization in Rock Engineering
- Risk and Hazard Management in Rock Engineering
- Energy Development and Environment Preservation

Fortunately, our three proposed themes were satisfied with excellent keynote lectures. We understood that one of the highlights within this symposium was the introduction of keynote lectures and special lecturers, which were considered as the heart of the symposium.

Opening Address

Traditional opening of the Saki keg at the start of the banquet.

All seven keynote lectures and two special lecturers have spent an enormous amount of time and energy preparing truly outstanding masterpieces of their works and also for presenting them in such a beautiful and fascinating manner.

The efforts of the keynote lecturers and the special lecturers are a distinct contribution to the success of 3rd ARMS.

There were many excellent technical presentations in 3rd ARMS. In 2003, the ARMS council meeting established the ARMS Outstanding Paper Award. This symposium was the first time to present the ARMS award. The first ARMS Outstanding Paper Award was conferred to Mr. S. Shirasagi, Kajima Co., Japan, who is the first author of the paper titled *"Evaluation system of rock property for tunnels by the seismic reflective survey and the TBM excavation"* with co-authors T. Yamamoto, I. Kuronuma, E. Ogura, Y. Mito, K. Aoki.

The recipient of this award was given a certificate, a memorial plaque and cash prize of US$ 1,000.

Apart from the ARMS Outstanding Paper Award, the Organizing Committee also decided to present the 3rd ARMS Excellent Paper Award to the first author of the paper orally presented in this symposium.

The recipient of the 3rd ARMS Excellent Paper Award received an award certificate, a memorial plaque and a cash prize of US$1,000, which was donated by Professor Chung-In Lee of Seoul National University.

The award was given to Professor Koji Matsuki, Tohoku University, Japan, who was the first author of the paper "*Estimation of regional stress for heterogeneous rock mass by FEM*" with co-authors T. Kato, N. Kimura, S. Nakama, T. Sato.

Before opening the symposium, the council meeting, five workshops, one special session and the welcome reception were held on 29 November, 2004. More than two hundred participants closely discussed and exchanged excellent ideas and information.

Kyoto is an ancient capital of Japan. Many historical sightseeing points can be easily found. We believe all participants enjoyed their stay in Kyoto. In the welcome reception, Kyo-dance (Maiko and Geiko dance) was performed.

Before and after performing Kyo-dance, Maiko and Geiko stayed in the banquet room and the participants took photos with them.

On behalf of JGS, ISRM and ISRM National Group, we, the 2004 ISRM International Symposium: 3rd ARMS organizing committee, would like to extend our sincere appreciation to all the participants and the exhibitors.

ISRM REGIONAL SYMPOSIUM – RUSSIA JANUARY 2005

ISRM Regional Symposium on Rock Mechanics for Underground Environment and 10th ACUUS Conference on Underground Space: Economy and Environment Regional Symposium held in Russia, January 2005

The ISRM Regional Symposium on Rock Mechanics for Underground Environment together with the 10th ACUUS Conference on Underground Space: Economy and Environment took place at the Moscow State University of Civil Engineering, Russia, in the warm atmosphere traditionally attributed in Russia to such scientific events.

The Rock Mechanics Symposium provided the scientific and practical basis for the development of underground spaces, whereas the event the Associated Research Centres for the Urban Underground Space (ACUUS) promoted the international cooperation and exchange amongst the world community of planners, researchers, builders, investors and other parties involved in the use and development of urban underground space.

The two general themes concerning underground space and environment made the two events inseparable.

More than 150 participants from 16 countries participated actively in both events and a volume was published with 52 excellent papers from authors belonging to 18 countries.

The Second International Exhibition Underground City 2005 was joined in venue with the events following the success and the previous exhibition held in 2004.

News from the Board

Council meeting at the ISRM International Symposium in Kyoto.

The ISRM Board met at the Kyoto International Conference Hall on 28 November 2004. The meeting took place in conjunction with the ISRM International Symposium on "Contribution of Rock Mechanics to the New Century" (3rd ARMS).

The meeting was chaired by the President of the ISRM, Prof. Nielen van der Merwe, and was attended by all the Vice Presidents of the respective geographical areas and by the two Vice Presidents at Large.

Matters such as finances, budget for 2005, ISRM website, co-operation with sister societies, progress in the organisation of the 11th Congress to be held in Portugal in 2007, selection of Symposia to be endorsed by the ISRM, activity of ISRM Commissions and of the Interest Groups, ISRM News Journal, as well as other matters of interest to the Society, were dealt with.

ISRM COUNCIL MEETING 2004

The International Society for Rock Mechanics held its Council meeting in Kyoto, Japan, in conjunction with the 3rd Asian Rock Mechanics Symposium, organised by the Japanese Committee for Rock Mechanics. In the Council meeting 26 of the 46 National Groups were represented.

ACCOUNTS OF 2003 AND BUDGET FOR 2005

The ISRM accounts of 2003 and the Budget for 2005 were unanimously approved. With the development of the new Website, where most of the information is posted, and the issuing of only one paper issue of the News Journal per year, balancing of the accounts is expected to be reached.

NEW FEE STRUCTURE

A new scale of fees, proposed by the Board and approved by the Council, aims at reducing fees of smaller countries, which currently pay a considerably higher fee per member than larger countries. Instead of the current USD 150 basic fee for all National Groups, the basic fee for countries with 10 members or less will be USD 40 and for countries with 10 to 40 members will be calculated by the formula: USD 3.67 x number of members + USD 3.33. The individual fee will remain unchanged.

ELECTRONIC DISTRIBUTION OF THE NEWS JOURNAL

The Council approved a proposal of the Board for distribution of the ISRM News Journal electronically, via the Website. From the 3 issues published every year, one will continue to be published in paper. This will enable ISRM to considerably reduce the expenses and therefore to use the available resources in a more rational and useful way.

ROCHA MEDAL 2005

The Board, acting as the Rocha Medal Award Committee, selected the prize-winning Ph.D. thesis for 2005 from among the nine outstanding shortlisted theses for that year. The winning thesis *"Wave Interaction with Underground Openings in Fractured Rocks"* was submitted by Dr Mark Hildyard and had been presented to the University of Liverpool in the United Kingdom. The award will be conferred at the ISRM International Symposium "Impact of the Human Activity on the Geological Environment" (EUROCK 2005) to be held in Brno Czech Republic from the 18th to 20th May 2005.

ISRM SPONSORED MEETINGS

The following list of conferences sponsored by the ISRM was presented:

- 25-28 January 2005, Moscow, Russia – Rock Mechanics for Underground Environment: an ISRM Regional Symposium.
- 18-20 May 2005, Brno, Czech Republic International Symposium on Impact of the Human Activity on the Geological Environment (EUROCK 2005): the 2005 ISRM International Symposium, where the ISRM Council and Board meetings will take place.
- 8-10 November 2005, Singapore – Rock Mechanics for Underground Construction (4th ARMS): approved by the Council, in Kyoto, as the 2006 ISRM International Symposium.
- July 2007, Lisbon, Portugal – The Second Half Century of Rock Mechanics: the 11th ISRM International Congress.

Reports were presented by the organizers of the 2005 and 2006 International Symposia and of the 2007 Congress. The following applicants to host the 12th ISRM International Congress, in 2011, presented their proposals: NG China and NG Singapore, in Beijing; NG Korea, in Seoul. A decision on the venue of the Congress will be taken in May 2005 in Brno.

COOPERATION WITH SISTER SOCIETIES

The President of ISRM reported on the meetings that took place during last year between the Presidents of the three Sister Societies (IAEG, ISRM and ISSMGE). In the first meeting, held in Lisbon in January, they appointed a task force, with three representatives of each society, in order to investigate the possibility of creating a federation of the three societies and to present a proposal for the scope of activities and structure of the future federation. A report, prepared by the task force in July 2004, presented recommendations for the creation of a Federation of International Geo-Engineering Societies - FIGS. A second meeting of the Presidents took place in Paris in September 2004 and it was decided to request the task force to further investigate the financial implications of the creation of FIGS.

The Council mandated the President to continue these negotiations with the Sister Societies. The President informed that any decision on this very important issue must be submitted for Council approval.

NOMINATIONS FOR PRESIDENT

The President of the ISRM, Professor Nielen van der Merwe, announced that 3 nominations for the office of President of the ISRM for the term 2007-2011 were received: Prof. John Hudson (UK), Dr Claus Erichsen (Germany) and Prof. Luís Ribeiro e Sousa (Portugal). All nominees were present at the Council meeting. Election took place during the Council meeting in Brno, in May 2005.

LAUNCHING OF THE NEW WEBSITE

The new ISRM Website was launched on 1 April 2005. Rock mechanics practitioners have a new tool where they can find all sorts of information about the Society, its organisation and history, conferences and meetings, commissions and interest groups, awards, corporate members, suggested methods and other publications. In a restricted area, ISRM members will find materials of their interest, such as the News Journal and a virtual library, or they may wish to participate in discussion forums. Board members will have access to working areas and new services that will facilitate their routine work.

It is hoped that this new system will be positively received by the rock mechanics community. Launching of the system will be followed by continuous improvements that will prove necessary. Feedback from the users is essential, so that the system may become a useful working tool for all those involved in rock mechanics or in the activities of the ISRM.

ISRM COMMISSIONS

The ISRM President, assisted by the Board, has appointed the following Commissions to study scientific and technical matters of concern to the Society:

- Commission on Case Histories in Rock Engineering:
  President – Prof. Fengsheng Shen (China)
  shenfengsheng@giwp.org.cn or
  shenfs@iwhr.com
- Commission on Environment:
  President – Dr John Gale (Canada)
  jgale@mun.ca
- Commission on Maintenance and Repair of Underground Structures in Rock Masses:
  President – Prof. Luís Ribeiro e Sousa (Portugal) – lsousa@lnec.pt
- Commission on Mine Closure:
  President – Mr Christophe Didier (France)
  Christophe.Didier@ineris.fr

and has reappointed the following ones that had been disbanded in accordance with provision 10.2a of the ISRM Statutes:

- Commission on Application of Geophysics to Rock Engineering:
  President – Prof. Koichi Sassa (Japan)
  sassa@mbox.kyoto-inet.or.jp
- Commission on Education:
  President – Prof. Meifeng Cai (China)
  caimeifeng@ustb.edu.cn
- Commission on Preservation of Natural Stone Monuments:
  President – Dr Chikaosa Tanimoto (Japan)
  tanimoto@ga.eng.osaka-u.ac.jp
- Commission on Testing Methods:
  President – Prof. John A. Hudson (UK)
  jah@rockeng.co.uk
- Joint Technical Committee with Sister Societies ISSMGE and IAEG on Landslides (JTC-1)
  President – Prof. Robin Fell (Australia)
  r.fell@unsw.edu.au

In December 2004, in Kyoto, the ISRM President and the Secretary General met the Chairmen of the different Commissions in order to discuss and approve a policy enabling the Commissions to successfully achieve the stated objectives along the term of office of the existing Board.

In accordance with the ISRM By-Law No. 3 "*Rules to be followed by Commissions*", ISRM Members wishing to participate in the work of any of them shall get in touch with the respective Chairman.

Joint Technical Committees

The ISRM, in conjunction with the ISSMGE and the IAEG, accepted the principle of Joint Technical Committees (JTC's) to address subjects of common interest to the three societies. Each JTC has a Core Group of six members. two from each of the Sister Societies. JTC-1, on the topic of landslides, was the first, and is responsible for organising the popular series of Internal Symposiums on Landslides, or ISL's. More JTC's are planned for the future and is expected that JTC-2 will be on the topic of visualisation of geotechnical data.

COMMISSION ON CASE HISTORIES

Membership

- Nielen van der Merwe – South Africa (ex officio)
- Jian Zhao – Singapore (ex officio)
- Eda de Quadros – Brazil
- Nick Barton – Norway
- Seokwon Jeon – Korea
- Mike Roberts – South Africa
- Martin Wittke – Germany
- Anthony Meyers – Australia
- Bingxu Zheng – China
- Zhongxiang Kuang – China
- Qian Qihu – China
- Dayong Zhu – China
- Yaojun Cai – China

Background

The establishment of ISRM Commission on Case Histories in Rock Engineering (CCHRE) is based on the understanding that development of Rock Mechanics depends not only on the advances of theoretical and experimental studies but also on feedback from practice. Monitoring and interpreting the performance of rock masses and structures, both successful and unsuccessful ones, is important work that the ISRM should focus on.

It is also understood that collecting and documenting case records is a very difficult undertaking. First, it requires a large amount of work that can hardly be rewarded by support from either government or private organizations. Second, people are always reluctant to report their failures, especially those that involve catastrophic loss of human lives. Third, documenting the information can sometimes be frustrating due to failure in obtaining permission from the owners. The success in documenting important case histories relies on a common effort made by our society.

Progress Report

(1) In September 2003, during the 10th ISRM International Congress, the Chinese Society for Rock Mechanics and Engineering (CSRME) submitted a preliminary proposal for establishing the Commission on Case Histories in Rock Engineering (CCHRE) under the ISRM. The preliminary proposal was discussed in the Board Meeting of the newly elected ISRM leadership and it was approved.

(2) After the approval by the ISRM Board, a working group that is responsible for the daily work of the CCHRE, was promptly established by the Chinese Society for Rock Mechanics and Engineering (CSRME). The main work of the working group is to contact ISRM Regional Vice Presidents to nominate commission members. Other work is concerned with the financial support. We highly appreciate a total of RMR 200,000 donations contributed by the Yangtze River Design Institute and Hongda Blasting Technology Company respectively, which greatly facilitate the CCHRE's work.

(3) During the ISRM-Sponsored International Symposium on Rock Mechanics (SinoRock 2004, May 18-21, 2004 Yichang China), the first nominal commission meeting was held at the Three-Gorge Dam site. At this meeting, Prof. Qian Qihu, the President of CSRME, introduced the progress and future work of CCHRE. A total of 16 persons participated in this meeting, including Prof. Nielen ven der Merwe, Dr Nick Barton, Dr. Eda f.d. Quadros, Dr. Seokwon Jeon, Dr Mike Roberts, Prof. Qian Qihu, Prof. Zuyu Chen, Professor Zhongkui Li, Professor Bingjun Fu, Prof. Gongchang Li (Proxy of Dr. Fengsheng Shen), Prof. Bingxu Zheng, etc. During this meeting, Prof. van der Merwe officially nominated Prof. Fengshen Sheng as the President of CCHRE.

(4) At the time of preparing this report, 15 commission members have been proposed, who need to be appointed by the ISRM President.

Proposed CCHRE Activities in the Near Future

Although some progress has been made, the development of CCHRE is still in its infancy. There are still many difficulties to be overcome by the joint efforts of the ISRM colleagues.

1. **Completing the commission membership.**
   So far, only the representatives from China, South America, Korea and South Africa are available. It is requested that the President and Vice Presidents of ISRM give some help in order to finalize the commission membership. Dr. Fengsheng Shen has nominated Prof. Zuyu Chen the secretary general of CCHRE.
2. **Finalizing the guidelines of CCHRE**
   A draft guideline of CCHRE has been prepared and will be subject to discussions and final approval from ISRM leadership.
3. **Establishing a homepage on ISRM website**
   Understanding that most of the commission work will be carried out through the Internet, it is planned to establish a CCHRE website. We hope that the ISRM homepage will allow a link that provides direct access to our website.
4. **Some activities CCHRE may undertake**

   (1) Establishing a rock engineering database

   Documenting the performance of rock masses and structures, both successful and unsuccessful ones, is by far the most important work CCHRE should undertake. However it is also very difficult work. In the First Commission Meeting held on November 29, 2004 in Kyoto, Prof. Zuyu Chen delivered a keynote lecture entitled 'The landslide and engineered slope inventory for China's water resources and hydropower development'. He describes a common effort the Chinese water resources community had undertaken, which resulted in a 3-volume inventory with 117 slope cases, totalling 1591 pages. A CD disk containing this database has also been made available. One of the features of this work is that the documenting work is carried out in strict compliance with a set of standard forms, so that important information would not be missing.

   It is understood that similar work has been carried out elsewhere in the world. CCHRE expects to establish a platform by which people working in this area can share their experience and hopefully, a rock engineering database developed by ISRM can eventually be established.

   (2) The case study method in Geomechanics education

   In collaboration with the ISRM Commission on Rock Mechanics Education, also to be seated in CSRME, it is planned to establish a post-graduate course entitled 'Case Histories of Geotechnical Engineering' at Tsinghua University, Beijing, China. With this course we will explore the feasibility of the so-called 'case history educational method'. We hope our experience will be shared with our international peers and some day this course will be taught through the Internet under the support of ISRM.

   (3) Organizing an international symposium on monitoring and case studies

   As an important endeavor CCHRE propose to hold an International Symposium entitled 'Geotechnical monitoring: recent advances and case studies'. We hope that through this activity, people working on case history study will meet and discuss issues of common interest. The Yangtze River Academy of Sciences has submitted its proposal to CSRME for hosting the symposium in Wuhan, China.

Prof. Fengsheng Shen – President
shenfengsheng@giwp.org.cn or shenfs@iwhr.com

COMMISSION ON THE ENVIRONMENT

Membership

- Nielen van der Merwe – South Africa (ex-officio)
- François Heuzé – USA (ex-officio)
- Liu Hanlong - China
- Carlos Dinis da Gama – Portugal
- Eurípedes Vargas – Brazil
- Sergey Yufin - Russia

General Proposal

The mandate of the Commission is to create a Commission report, in this case focussing on guidelines to be followed by rock engineers/

mechanics in their activities to ensure that the environmental considerations receive the required attention, balanced by the need for progress, provision of energy, etc. We need to see man and the needs of humanity as part of nature, not in opposition to nature.

The "justification" for an ISRM Environment Commission is "The necessity of assuring the sustainable development of geomechanical structures constructed in rock masses".

Proposed objectives and tasks

The Commission will focus on engineering structures in rock and the question of sustainable development compatibility with the development of structures in rock when considered at the planning, design and operation stages. A tentative list of topics for consideration includes:

- Sustainable development and underground planning
- Underground space and groundwater problems
- Waste storage, transport of solutes through rock
- Risk assessment and management of rock construction
- Underground construction and interaction with surface and subsurface infrastructures
- Slope instabilities
- Large water reservoirs and the impact in the environment
- Exploitation of the subsurface
- Environmental remediation and protection
- Natural cavities in volcanic formations
- Abandoned mines
- Subsurface storage
- Dewatering of open pits in high permeability systems, and interaction with the environmental impact assessment process.

Schedule

The schedule of ISRM International Symposia is as follows:

1. Kyoto November 2004: Approval of concept by the ISRM Board and appointment of the President and first three members of the Commission. Discussion of the Commission's mandate and a review of topics and the proposed schedule.
2. December 2004 to February 2005. Finalize the membership of the Commission and outline potential working group topics. Initiate a fund raising activity to support some of the travel costs by members.
3. Approval of the final Commission membership by the ISRM Board. Full Commission meeting in Brno, May 2005, with report to the ISRM Board along with updated schedule and topics.
4. Activities and schedule for 2005 and 2006 to be decided.
5. Lisbon September 2007 (submission of final report).

Specific Activities

1. History of the development of Professional Guidelines as they relate to the environmental aspects of rock engineering in related professions.
2. Current guidelines in rock engineering practise. The EIA process in different countries.
3. Current progress in developing for "good mining practise".
4. Rock engineering developments in sensitive terrains subject to rapid environmental changes.
5. World wide examples of rock engineering with significant environmental impacts and how they might have been minimized or mitigated.
6. Objectives and scope of guidelines related to sustainability.
7. Concept of sustainability at it applies to Rock Engineering.
8. State-of-the-art in rock engineering practise and technology and associated environmental impacts.
9. Rock engineering practises, guidelines and procedures and their impact on:
   - long term stability
   - changes to excavated rock, ARD, etc.
   - changes to ecosystem, dewatering, etc.

10. Compatibility of current EIA processes in different jurisdictions with the need for energy and raw materials.

John Gale – Commission President
E-mail: jgale@mun.ca

COMMISSION ON MINE CLOSURE

Membership

The following list of names proposed initially has to be completed at international level especially from major countries involved in mining and post-mining (United States, Australia, South Africa, India, Russia, China):

- Nielen van Der Merwe - South Africa (ex officio)
- Claus Erichsen – Germany (ex officio)
- Semsa Canbulat - South Africa
- David Reddish - England
- Marc Bethournay - Canada
- Matthieu Veschkens - Belgium
- Jean-Pierre Josien - France
- Bojan Rezun - Slovenia
- P. Meier - Switzerland

Proposed objectives

The first aim of this Commission is to facilitate contact between experts in rock mechanics from different countries concerned with post mining management. This will create opportunities to exchange experiences, back-analyse case studies, scientific data, etc. It should be noted that there is little specialised and precise international literature available on documented back-analyses on accidents or disorders developing above abandoned mines.

Obviously, the objective will not be restricted to facilitating contact and mutual learning but also to setting up guideline methodologies. Therefore, the commission aims to produce a common guideline document which will, at least:

- present the relevance of post mining in the countries mainly represented in the commission,
- describe and explain basic mechanisms that may initiate disorders,
- describe and classify main disorders and their potential consequences on people and surface structures,
- create a methodology enabling experts to carry out diagnosis on the potential hazard generated by an old mine (e.g. this hazard may be determined by the crossing of the foreseeable intensity of disorder with its probability of occurrence),
- describe (with examples of successful cases) the existing solutions managing the identified risk. Those solutions may be treatment like reinforcement or backfilling and land use management like restrictions on construction or reinforcement of existing or future buildings.

These topics are obviously not exhaustive and will be complemented by others (e.g. possibility of re-mining an abandoned mine), depending, on particular, on the speciality and the interest of the Commission members.

The President of the proposed commission has been deeply involved in the establishment of a national guideline based on French regulations and experience. This guideline could be translated in order to provide a basis for this discussion.

Indeed, the final ISRM document will be a collective document, each member of the commission being in charge of a chapter or a part of the document. One efficient way to ease the work would be to constitute a group of complementary international experts (some of them specialists on underground and others on open pit, some of them specialists or risk analysis and other involved in remediation measures).

The opportunity of a devoted web site or a dedicated area in the new ISRM website to this topic will be discussed. The main objective would be to facilitate the constitution of an international network for scientific exchanges and for the initiation of an international database concerning post mining management (bibliography, congress announcement, back analysis).

Organisation and schedule

As other Commissions generally proceed, this Commission will try to hold an annual meeting at the time and place of the annual ISRM Council meeting. This should obviously remain flexible, depending on specific opportunities (multi-disciplinary international congresses on post mining for example). The commission will also encourage members to organise special meetings on the application of their national approaches illustrated by some in situ cases. It is to be underlined that France is going to organise an international colloquium on post mining, in November 16-18, 2005, in a very sensitive area relating to post mining problems, salt, iron, coal.

The commission meetings could be an opportunity to hold scientific seminars on specific topics (role of water on stability, how to integrate time in diagnosis, the specific case of salt mines). These seminars will be co-ordinated by a member of the commission. This will offer an opportunity to collect interesting international literature and state of the art on those topics.

Concerning the schedule, 2004 will be devoted to the constitution of the expert panel and to the translation of the French guidelines. We will then take the opportunity of the ISRM Council meeting in November 2004 to hold the first meeting of the Commission. This meeting will be devoted in particular to determine the framework of the Commission (do we integrate gas, how to take water into account?) and the distribution of tasks between volunteer members.

2005 and 2006 will then be dedicated to developing relationships and exchanges between members and other specialists, to hold seminars and meetings on specific topics that will be discussed and validated and to progress in the elaboration of common guidelines.

The document will then be finalised during the first semester of 2007 in order to be available and presented during the next ISRM Congress that will be held in Portugal in 2007.

Christophe Didier – Commission President
E-mail: Christophe.Didier@ineris.fr

COMMISSION ON TESTING METHODS

Report on the activities in 2004

I am pleased to report that there has been considerable Commission activity recently with ISRM Suggested Methods (SMs) having been published, being in preparation, and being planned.

The four ISRM Suggested Methods on Rock Stress Estimation were published at the end of 2003 in the Special Issue on Rock Stress Estimation, IJRMMS, 41,7-8. These SMs are:

ISRM SM - Part 1: Strategy for rock stress estimation by J.A. Hudson, F.H. Cornet and R. Christiansson

ISRM SM - Part 2: Overcoring methods by J Sjöberg, R. Christiansson and J.A. Hudson

ISRM SM - Part 3: Hydraulic fracturing methods by B.C. Haimson and F.H. Cornet

ISRM SM - Part 4: Quality control of rock stress estimation by J.A. Hudson and R. Christiansson

The contents of this Rock Stress Estimation Special Issue are given on the next page. The four SMs were supported by 17 papers which discuss the manifold aspects of in situ stress occurrence and its measurement. We invited Charles Fairhurst (former ISRM President) to write the introductory article because of his 1960s pioneering work in the stress measurement field. Thus, not only is guidance given through the SMs, but the SMs are supported by papers discussing the history of the subject, stress measurement experiences and associated issues. In this way, the ISRM provides engineers and researchers with a wealth of knowledge.

This Special Issue on Rock Stress Estimation has proved to be most successful and is a useful template for future subjects. For example, on 24 September 2004, a Fracture Mechanics Workshop convened by Ove Stephansson, and which I attended, was held in Potsdam, Germany, to discuss the generation of a new suite of fracture toughness SMs. This is to update the 1988 SM co-ordinated by Finn Ochterlony and the 1995 SM co-ordinated by Bob Fowell. The purpose of the Workshop was explicitly to formulate the group which will generate the new SMs and to consider how to develop supporting papers for a Special Issue on

Fracture Toughness in the same style as the Rock Stress Estimation Special Issue. The Potsdam initiative was well received and is going ahead. If anyone is interested in contributing to the fracture toughness SMs, please contact Ove Stephansson.

E-mail: ove@gfz-potsdam.de or *ove@stephansson.de*

A similar suite of new SMs on rock fracture is also planned to update the original 1978 one.

Special Issue of the IJRMMS:

Rock Stress Estimation

(*containing the new ISRM Suggested Methods and associated Supporting Papers*)

Guest Co-Editor: F. H. Cornet

Contents

John Hudson – Commission President
E-mail: jah@rockeng.co.uk

Forthcoming Events

2006 November 08-10 – Singapore SINGAPORE – 4th ARMS (Asian Rock Mechanics Symposium an ISRM-Sponsored Regional Symposium, organised by the ISRM NG Singapore, the Tunnellling and Underground Construction Society (Singapore) and the Protective Technology Research Centre of the Nanyang Technological University. Theme: Rock Mechanics in Underground Construction. ARMS-4 Organising Committee, c/o Underground Technology and Rock Engineering Program, Protective Technology Research Centre of the Nanyang Technological University, Block N1, Nanyang Avenue, Singapore 639789, Tel.: (+65) 6790 5268; Fax: (+65) 6792 1650, E-mail: tust@ntu.edu.sg, chybian@ntu.edu.sg, camhefny@ntu.edu.sg;
Website: www.ntu.edu.sg/home/cjzhao/arms

2007 July Lisbon PORTUGAL – ISRM 11th International Congress on Rock Mechanics, organized by the Portuguese Geotechnical Society (SPG) and the ISRM NG PORTUGAL. Sociedade Portuguesa de Geotecnia, LNEC, Av. do Brasil, 101, 1700-066 Lisboa, PORTUGAL; Tel.: (+351) 21844321; Fax: (+351) 218443021; E-mail: spg@lnec.pt, Website: http://www,isrm2007.org

2005 September 07-11, Zaragoza SPAIN – International Conference on Geomorphology, the 6th Quadrennial Conference of the International Association of Geomorphologists. Organizing Secretariat, Geomorfologia, Fac. de Ciencias, Univ. de Zaragoza, C/Pedro Cerbuna 12, E-50009 Zaragoza, SPAIN. Fax: 34/976/761106, E-mail: iag2005@posta.unizar.es
Website: wzar.unizar.es/actos/SEG/

2005 September 12-16, Osaka JAPAN – XVIth ICSMGE International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE). Prof. Masashi Kamon, The Japanese Geotechnical Society, Sugayama Building, 4F, Kanda Awaji-Cho 2-23, Chiyoda-Ku, J-11-0063 Toyoko, JAPAN. Tel.: 81/3/32517661, Fax: 32516688,
E-mail: secretary@icsmge2005.org or 16icsmge@jiban.or.jp
Website: www.icsmge2005.org

2005 September 13-15, Osaka JAPAN - International Young Geotechnical Engineer's Conference, Organized by The Japanese Geotechnical Society (the ISSMGE MS JAPAN), and sponsored by the ISSMGE, in conjunction with the 16 ICSMGE (September 12-16). Prof. Masashi Kamon, The Japanese Geotechnical Society, Sugayama Building, 4F, Kanda Awaji-Cho 2-23, Chiyoda-Ku, J-11-0063 Toyoko, JAPAN. Tel.: 81/3/32517661, Fax: 32516688,
E-mail: secretary@icsmge2005.org or 16icsmge@jiban.or.jp
Website: www.icsmge2005.org

2005 September 14-16, Hagerbach SWITZERLAND - IUT 2005 an exhibition and seminars held in an underground environment, with capability of live equipment demonstrations. Deltacom, Gesellschaft für Projektmanagement mbH, Stormarnstr. 477, D-22844 Norderstedt, GERMANY. Tel.: 49/3572320, Fax: 35723290
E-mail: info@deltacon-hamburg.de Website: www.iut.ch

2005 September 19-21, Perth AUSTRALIA - IS-FOG 2005 International Symposium on Frontiers in Offshore Geotechnics, organized by COFS - Centre for Offshore Foundation Systems, in association with TCI of the ISSMGE. Fax: 61 8 9380 1044, E-mail: monica@civil.uwa.edu.au
Website: www.cofs.uwa.edu.au

2005 September 28-30, Kathmandu NEPAL, 5th Asian regional conference on Engineering Geology for Major Infrastructure Development and Natural Hazards Mitigation. The President, Nepal Geological Society, P.O. Box 231, Kathmandu, NEPAL. E-mail: bnupreti@wlink.com.np or ngs@wlink.com.np

2005 October 10-12, Chambéry FRANCE – Tunnelling for a Sustainable Europe, organized by the French Tunnelling Association (AFTES) (the ITA NF FRANCE), the AETOS (the ITA NG SPAIN), the GTS (the ITA NG SWITZERLAND) and the SIG (the ITA NG ITALY). AFTES, c/o SNCF Infrastructure, 17, Rue d'Amsterdam, F-75008 Paris, FRANCE.
Tel.: 33/1/153429469, Fax: 153420820,
E-mail: contact@aftes.asso.fr Website: www.aftes.asso.fr

2005 October 13-14, Salzburg AUSTRIA - LIVth Geomechanics Colloquy, organized by the Österreichische Gesellschaft für Geomechanik (ÖGG) (the ISRM NG AUSTRIA). Österreichische Gesellschaft für Geomechanik Bayerhamerstr. 14, A-5020 Salzburg, AUSTRIA. Tel.: 43/662/875519, Fax: 886748,
E-mail: salzburg@oegg.at.at Website: www.oegg.at

2005 November 06-11, Houston Texas USA
Annual Meeting and International Exposition of The Society of Exploration Geophysists. Mr Steve Emery, 8801 S. Yale, Tulsa, OK 74137, USA. Tel.: 1/918/4975539.
E-mail: semery@seg.org Website: www.meeting.seg.org

2006 April 22-27, Seoul KOREA – World Tunnel Congress 2006, organized by the Korean Tunnelling Association and sponsored by the ITA. Congress Secretariat - ITA 2006, 5F Marine Centre New Building, #51 Sogong-Dong, Jung-Gu, ROK-100-770 Seoul, KOREA Tel.: 82/2/7265554, Fax: 7782514
E-mail: ita2006@hajinpco.com. Korean Tunnelling Association, 44-3 Bangi-Dong, Hyundai Topics #1914, Soongpa-Gu, ROK-138-050 Seoul KOREA.
Tel.: 82/2/22033442 Fax: 22033553
E-mail: krtna@chollian.net
Website: www.ita2006.com or www.tunnel.or.kr

2006 June 26-30, Cardiff UK - 5th International Conference on Environmental Geotechnique (5th ICEG), sponsored by the ISSMGE
E-mail summers@Cardiff.ac.uk
Website: www.grc.cf.ac.uk/45iceg/

2006 August 04-06 Hong Kong CHINA - International Conference on Physical Modelling in Geotechnics, Ms Shirley Tse, Geotechnical Centrifuge Facility, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong CHINA. Tel,: +852-2358 0216; Fax: +852-2243 0040
E-mail: gfc@ust.hk; Website:icpmg2006.ust.hk

2006 August 27-31, Curitiba (Paraná) BRAZIL - IIIrd Portuguese-Brazillian Congress on Geotechnique and XIIth Brazillian Congress on Soil Mechanics and Geotechnical Engineering, organized by the Associação Brasileira de Mecânica de Solos (ABMS) (the ISRM NG BRAZIL), and the Sociedade Portuguesa de Geotecnia (SPG) (the ISRM NG PORTUGAL). Prof Allessander Kormann, Curitiba, Paraná, BRAZIL. Fax: 55/41/3612436,
E-mail: cobramseg2006@cesec.ufpr.br
Website: www.abms.com.br

2006 September 14-17, Nottingham UK – 10th International Congress of the International Association of Engineering Geology and the Environment. Engineering geology for tomorrow's cities.
E-mail: info@iaeg2006.com; Website: www.iaeg2006.com

2006 September 18-22, Yokohama JAPAN – 8th International Conference on Geosynthetics
Website: www.8icg-yokohama.org

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http://www.geosyntheticssociety.org

ISSMGE – International Society of Soil Mechanics and Geotechnical Engineering
http://www.issmge.org

ITA – International Tunnelling Association
http://www.ita-aites.org

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