Energy, Mines and Resources Canada — Énergie, Mines et Ressources Canada

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Canada Centre for Mineral and Energy Technology — Centre canadien de la technologie des minéraux et de l'énergie

6TH ISRM CONGRESS PROMOTION AND SOUTH AMERICAN LECTURE TOUR

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6TH ISRM CONGRESS PROMOTION AND SOUTH AMERICAN LECTURE TOUR

by

G. Herget*

SUMMARY

A two week lecture tour was conducted from May 5 to May 19, 1987 to improve awareness of the International Congress for Rock Mechanics scheduled for August 30 to September 3, 1987 in Montreal, Canada. At each location a lecture was presented on: "Stress determinations and stress monitoring in Canada", followed by details on the congress and handouts.

The following cities were visited: Santiago-Chile; Buenos Aires-Argentina; Rio de Janeiro, Sao Paulo, Belo Horizonte-Brazil; and Caracas-Venezuela. Arrangements which were made through the respective National Groups of the International Society for Rock Mechanics, proved very effective. As a result it is expected that an additional 20 delegates will attend from South America. Discussions during the trip established that a number of National Groups and interested regional centres had not received the second bulletin. All lectures were well attended with 30-55 participants.

On the basis of question raised during discussion periods, it was evident that regional centres with the greatest in depth awareness of rock mechanics were found at Santiago, Chile and at Sao Paulo and Belo Horizonte, Brazil. At the time of writing this report 8 registrations had been received.

KEYWORDS: Stress determination, stress monitoring, microseismic activity, Rock Mechanics Congress.

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PROMOTION DU 6e CONGRÈS DE LA SIMR ET TOURNÉE DE CONFÉRENCES EN AMÉRIQUE DU SUD

par

G. Herget*

RÉSUMÉ

Une tournée de conférences a eu lieu du 5 au 19 mai 1987 afin de promouvoir le Congrès international sur la mécanique des roches qui aura lieu du 30 août au 3 septembre 1987, à Montréal au Canada. À chaque endroit, on a présenté une conférence sur "La détermination des contraintes et la mesure des contraintes", fourni des détails sur le congrès et distribué des dépliants.

Les villes suivantes ont été visitées : Santiago au Chili, Buenos Aires en Argentine, Rio de Janeiro, Sao Paulo et Belo Horizonte au Brézil et Caracas au Vénézuela. Les dispositions prises par l'intermédiaire des groupes nationaux respectifs de la Société internationale de la mécanique des roches ont été très efficaces. Par conséquent, 20 autres délégués de l'Amérique du Sud sont attendus au congrès. Les échanges lors du voyage ont permis d'apprendre que bon nombre de groupes nationaux et de centres régionaux intéressés n'avaient pas reçu le deuxième bulletin. Les conférences ont attiré de nombreuses personnes, c'est-à-dire entre 30 et 55 participants.

D'après les questions posées lors des périodes de discussion, il était évident que les centres régionaux possédant le plus de connaissances sur la mécanique des roches étaient situés à Santiago au Chili et à Sao Paulo et à Belo Horizonte au Brésil. Au moment de la rédaction de ce rapport, huit inscriptions avaient été reçues.

MOTS-CLÉS: détermination des contraintes, mesure des contraintes, activité microsismique, congrès sur la mécanique des roches.

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INTRODUCTION

From the submission of papers for printing in the 6th ISRM Congress proceedings and pre-registration it was evident that South American attendance at the 6th ISRM Congress could expected to be low. At the March 31, 1987 meeting of the Canadian organizing committee, the decision was made to support a two week trip by G. Herget to six centres in South America to promote the International Congress for Rock Mechanics in Montreal.

All visits, which were arranged through the National Groups of the International Society for Rock Mechanics, proved very effective.

SCHEDULE AND OBSERVATIONS

At each site a 45 minute lecture on "stress determination and stress monitoring in Canada" was given. Following the discussion period, which was at times very lively, the 6th ISRM Congress was introduced as a subject. Ten to 15 bulletins and a number of registration forms were distributed at each location. Quite a number of individuals and agencies had not seen the second bulletin and were not aware of the costs of attending the Congress.

May 6, 1987 - Santiago, Chile

After 24 hours of airports and plane rides G. Herget arrived in Santiago at 12 noon. The lecture was scheduled for 6 p.m. the same day at the Instituto de Engineros de Chile, Santiago. Thirty people were in attendance with president (Eugenio Retamal) and secretary (Luis Valenzuela) of the national rock mechanics group of Chile. Chilean engineers have done a considerable amount of stress determinations and are very interested in ground stress monitoring in relation to block caving operations. Chilean engineers not only face challenges of a technical nature in their work, but the terrain often forces them to use oxygen at high altitudes, e.g. Andina mine, located about 150km from Santiago, has open pit and block caving operations taking place at 4,300m.

May 7, 1987 - Buenos Aires, Argentina

A presentation was given at the Centro Argentino de Ingenieros with simultaneous translation into Spanish. The major power companies and highway departments were represented. About 30 people were present. The next day a number of companies and agencies were visited. The visits were organized by Dr. D. Moretto, former vice president of ISRM for South America, and D. Vardé Associates working with the Canadian Embassy in Buenos Aires. The list of agencies is given below:

May 8, 1987 - Buenos Aires, Argentina

09:00	Mr. Denis Thibault, Commercial Counsellor CANADIAN EMBASSY Suipacha 1111 - 25o (1368) Buenos Aires Tel.: 312-9081/88
10:00	Lic. Alberto Enrique Devoto Presidente (President) AGUA Y ENERGIA ELECTRICA L. N. Alem 1134, 9th floor (1001) Buenos Aires Tel.: 311-3467/5281/6364
12:00	Dr. César Garcia Puente Presidente (President) Eng. Jacques Lagrange Vicepresidente (Vicepresident) HIDRONOR Av. L. N. Alem 1074, 6th floor (1001) Buenos Aires Tel.: 312-6031/39/8269, line 226

15:00 Dr. José Arcuri
Jefe Depto. Tecnologia (Mngr. Technical Dep.)
DIRECCION DE VIALIDAD NACIONAL
Av. Comodoro Py 2002
(1104) Buenos Aires
Tel.: 312-6931

18:30 Eng. Osvaldo Canillas
Gte. Gral. de Estudios, Proyectos y Obras
(General Mngr. Studies, Projects and Works)
OBRAS SANITARIAS DE LA NACION
Marcelo T. de Alvear 1840, 1st floor
(1122) Buenos Aires
Tel.: 44-6926

Dr. Herget was accompanied on his visits
by Mr. Oreste Moretto, affiliators, and
Mr. Bill Perkins, Senior Commercial Officer
CANADIAN EMBASSY

The visits were very effective. The president of Agua y Energia Electrica, Lic. Devoto, has already decided to send five of his employees to the Congress.

Buenos Aires and environs are located on soft soils. Thus there is very limited use of rock mechanics in the vicinity of Buenos Aires. Rock mechanics was used extensively during the construction of the Chilean/Argentinian high way tunnel through the Andes and during the present construction of the binational Vacyreta Hydro Power project on the Parana river (Ing. R.A. Cappucci).

May 12, 1987 - Rio de Janeiro, Brazil

Dr. Vargas, Professor of Civil Engineering at the Pontificia Universidade Catolica do Rio de Janeiro (PUC) organized the lecture in the main auditorium of the University. PUC has 8,000 students and is supported by the Church and as such classified as a private university. The Civil Engineering Department has good connections with the Department of Civil Engineering of the University of Alberta, Edmonton. Twenty-eight people attended the lecture.

Brazil has a very rugged topography which is very suitable for hydro power development. In many cases the tropical climate has weathered the rock to a depth well below 60m. Inflation is severe, 21% in April 1987. One consequence is frequent strikes which cripple the country. Brazil now has 135 Million inhabitants.

May 13, 1987 - Sao Paulo, Brazil

A visit was made to the Instituto de Pesquisas Tecnologicas do Estado de Sao Paulo, a provincial research organization with 3,000 people. There are 400 people in the section devoted to mining and applied geology. The state of Sao Paulo contains most of Brazil's manufacturing capabilities, in particular with respect to car and plane production. A very strict industrial policy is in place to ensure Brazilian development of new technology where there is a substantial home market. Severe restrictions are in place with respect to the importation of technology in the following areas: biotechnology (drugs), fibre optics, and microcomputers. Brazil has produced IBM clones for universities, offices and research organizations. The geomathematics groups of IPT was in the progress of modifying existing IBM software and Basic programs to run on Brazilian IBM clones.

A special session was held with IPT professionals on stress and deformation monitoring in potash mines. Arrangements for the lecture at the Institute of Engineering were well prepared by Dr. Dinis da Gama. There were 32 attendees.

May 14, 1987 - Belo Horizonte, Brazil

Belo Horizonte (2 Million inhabitants) is the capital city of the State of Minas Gerais (General Mines) which has very rich Iron ore deposits. On May 15 an MBR iron ore deposit grading better than 68% Fe was visited. The ore can be excavated without the use of explosives but is blasted using 9in holes to ensure better product size. Consultants are used to carry out slope stability work. Production is about 40kt/day or 12Mt/year and only size screening is done before shipment to its customers: Japan (50%), Far East (25%), Europe (25%). There is so much iron ore in this area that 50Mt of iron ore were immobilized at the city limits of Belo Horizonte to protect landscape. One hundred year old gold mine is operating near Belo Horizonte. It has reached a depth of 2,500m and is subject to rockbursting. Apart from use in mining, rock mechanics is extensively used by CEMIG (Centrais Eléctricas de Minas Gerais, S.A.) in the design and construction of dam foundations, slopes and power houses. They have built more than 31 hydroelectric complexes with a total generating capacity of 4,500MW. CEMIG organized a special session for G. Herget to address their consultants and project engineers on stress determination and stress monitoring. The evening lecture, organized by B. Vioti took place at the Minas Engineering Society, and was well attended with 55 participants.

May 18, 1987 - Caracas, Venezuela

Because of an unscheduled emergency stop at Brazila the overnight flight from Rio arrived at Caracas at 4 a.m. A meeting was held with Professor Tinoco ISRM, Vice president. The meeting topic was the significance of rock mechanics to Venezuela. Their rock mechanics problems and interests are primarily concerned with steep slopes, foundations and road tunnels in deeply weathered rock. The presentation at 18:00 took place at the Colegio de Engenieros de Venezuela. Thirty-two attended the lecture. The 1987 Panamerican conference on soil mechanics and foundation engineering in Carthagena, Colombia, (Aug. 16-21), will be strong competition for the 6th ISRM Congress in Montreal.

CONCLUSIONS

The visits indicated the importance of rock mechanics at all centres visited, especially those located in Chile and Brazil. The monitoring of stress changes was a subject of considerable interest to those concerned with mining (block caving near Santiago and underground mining near Belo Horizonte).

The visits increased South American awareness of the 6th International Congress, organized in Montreal, significantly. Due to personal contacts during the visits, additional delegates have decided to attend the conference. As a result, 29 South American delegates are expected to attend with the following distribution: Chile 5, Argentina 8, Rio de Janeiro 2, Sao Paulo 2, Belo Horizonte 3 and Venezuela 4. The minimum attendance will be 10.

APPENDIX A: STRESS DETERMINATION AND STRESS MONITORING IN CANADA

Mr. Chairman, thank you very much for the introduction, Ladies and Gentlemen.

It is indeed a great pleasure to be here, first as a researcher to talk about my work on rock stresses, that is the work I do for the Federal Government of Canada within the Department of Energy, Mines and Resources. I work in the Mining Research Laboratories located in Ottawa, which are a part of the Canada Centre for Mineral and Energy Technology.

Following this technical presentation I would like to address you as the Chairman of the International Congress of Rock Mechanics which is organized for August-September 1987 in Montreal, Canada.

Work on ground stresses is important if we intend to assess the stability of any engineering structure. It is also important for the geologist and geophysisist if a refined understanding of tectonic processes in the earth crust is to be achieved. In regard to engineering structures, stresses have to be known so that load assumptions can be made. We can determine the strength of rocks and soils reasonably well but it is far more difficult to determine the stresses existing in rock. The procedure for stress determinations are not difficult, however, they require a certain amount of skill and are very expensive. Therefore, it is advisable to maintain a database and compile results over the years for particular regions in regard to ground stress determinations.

The Government of Canada has been involved in ground stress determinations for over 20 years and now 54 ground stress tenors are available for the Canadian Shield. The Canadian Shield covers a large part of Ontario, Manitoba and Quebec and extends into the centre of the United States (Figure 1). The youngest orogenic event is the Grenville Orogeny which occurred 955 millions years ago. Therefore we are dealing with Archean and Proterozoic rocks which consist of volcanics, metamorphosed sediments and granites. The Canadian Shield has the advantage that we are dealing with very strong rock with an elastic range up to 130 MPa and we can therefore use overcoring methods to depths of 2,200 meters.

Most of the ground stress determination have been carried out in the vicinity of mine sites and the values reported here are considered free from the influence of mine openings. The methods which have been used are overcoring methods and they involve the biaxal United States Bureau of Mines meter, the South African door stopper, the triaxal South African system and the Australian CSIRO triaxal hollow inclusion cell.

For those not familiar with overcoring, the next figure (Figure 2) explains the concept. When a piece of rock is drilled out of its environment by diamond drilling, it shows elastic rebound because the stresses acting before on the piece of rock have been removed by drilling. The elastic rebounds which occur during drilling are minute and are measured most often by strain gauges.

From the ground stress determinations, which we carried out in the Canadian Shield, we found that all stresses are compressive, sigma 1 is the highest compressive stress with an orientation of east-west to ENE-WSW and nearly horizontal. Sigma 3 is the minimum principal compressive stress which is in most cases oriented vertical and can be equated to overburden load. With this orientation of the principal axes of the stress tensor, we can treat horizontal stress components and vertical stress components as principal stresses independently from each other.

1. <u>Vertical Stress Components With Depth</u>

In Figure A-3 the crosshatched area shows the vertical stress component which should be observed if the vertical stress component is due to overburden alone. For a range of densities of 2,650kg/m^3 for acidic rock and 3,300kg/m^3 for basic rock, the gradient should be 0.0260 MPa/m to 0.0324 MPa/m, respectively. One can see that most of the observations follow this trend, however, there are a number of values which do not follow this trend and are considerably higher than what is to be expected from gravity alone.

If one uses the highest density of rocks found, plus three times the standard deviation of the usual measuring error for ground stress determinations, we obtain a gradient of 0.0407 MPa/m. Any value of sigma vertical above this gradient must be influenced by additional effects than by gravity only. These values are called extreme vertical stress components and a relationship is given in Figure A-3 under 2. This relationship for the extreme vertical stress component equals (0.0602 ± 0.0035)MPa/m, with a correlation coefficient of 0.97.

During field testing, nothing extraordinary was observed at the site where these extreme vertical stress components were obtained. Of course, with the benefit of hindsight in some cases there was a higher than usual frequency of quartz veins, a shear zone more than 50m away, and in some other case measurements were made close to a healed contact of metamorphic rock types with a change in elastic modulus of about 20%. In other cases there was no explanation for the higher than usual strain recovery in vertical direction.

These extreme vertical stress components however, are of limited significance, or better said, they exist over very limited areas. This is deduced from the seismic activity found around hydro electric facilities during filling of reservoirs. This seismic activity shows that the earth crust maintains a delicate balance in the vertical direction. The Russian researcher Artiyushkov calculated a value of 0.5 to 1MPa as being critical for seismic events occuring during adjustments in the earth crust.

2. Average Horizontal Stress With Depth

Figure A-4 shows a very complex distribution of data points. This is due in part to the more complex boundary conditions which we find for the horizontal stresses in the earth crust. It is, however, interesting to know that the average horizontal stress component is high for the tensors which have shown high vertical stress components. On this basis the horizontal stress components which belonged to stress tensors with high vertical stress components, were treated separately and a linear relationship was fitted as relationship 3 in Figure A-4. This yielded an extreme horizontal stress component of 14.45MPa + 0.0563MPa/m with a correlation coefficient of 0.97.

The remainder of the data show that the horizontal stress gradient is not constant with depth. Probably a curved relationship could be fitted, however it was chosen to put a break at a depth of 800 to a 1,000m and partition the average horizontal stress component with depth into two separate linear relationships. Relationship 1, (0.0581MPa/m) is valid from a depth from 0 to 800m, and relationship 2, (35.79MPa + 0.0111MPa/m) is valid from 800 to 2,200m.

3. Elastic Modulus

For the calculation of the magnitude of ground stresses, the elastic modulus is an important influence on the magnitude as the strain recovery itself. The effect of possibly wrong elastic moduli can be removed by calculation of the ratio of the measured horizontal stress component divided by the measured vertical stress component as shown in graphs published by Brown and Hoek in 1978. Plots of such ratios with depth are very useful. A number of functions can be explored, but for simplicity in this case, the ratio of the horizontal stress to vertical stress was plotted as the inverse of depth. This is of course a very rigid relationship but if one rejects values at a depth less than 50 meters, very interesting results are obtained.

In Figure A-5 one can see that the plot of the maximum horizontal stress to the vertical stress is defined as 357 divided by the depths in meters plus 1.46. Subjecting the maximum horizontal stress to vertical stress ratio, the average horizontal stress to vertical stress ratio, and the minimum horizontal stress to vertical stress ratio to a least square analysis, provides a good family of curves which is given in Figure A-6. These curves are very helpful for the Canadian Shield when stress or loading assumptions have to be made. We consult these curves, to identify whether for a given site ground stresses could pose problems for a particular engineering structure.

4. Structural Geology and Ground Stresses

When we observe rocks in the field, we notice very often that they are heavily cracked and thus have been loaded beyond their peak strength during geological history. From the testing of rock samples we know what orientation of fractures to expect in relation to loading direction. We also know which faults or what type of orientation faults will have in relation to the surface of the earth, depending on the orientation of the principal stresses.

In Elliot Lake, N. Ontario, we have found a very strict relationship between the direction of maximum strain recovery and the orientation of joints, Figure 7 (Bielenstein et al. 1969). Therefore, on this basis one can carry out a kinematic analysis for observed tectonic (geologic) elements and deduce the principal stress directions which formed certain tectonic features like faults and extension fractures such as joints. Of course other means exist to deduce a possible orientation of ground stresses such as analyzing seismic events and plotting the breakout in deep boreholes.

Using the information from geology, geophysics, borehole behaviour at depth, and overcoring has provided a very good basis for compiling a map of present day stresses in North America. Figure A-8 was provided by Zoback, a professor of geophysics at Standford University in California.

5. Stress Monitoring

So far I have talked about obtaining the absolute stress levels in rock. However, very often in engineering structures the need arises to determine the change in stresses to verify assumptions being made. Monitoring stress changes in rock or soil is a very difficult task because stress changes manifest themselves in the elastic range only as rather minute deformations or strains. These deformations are especially small in hard rock because of the high elastic modulus. We need, therefore, very sensitive detectors. Commonly, resistance strain gauges made of metal wire or foil elements or flatjacks filled with fluid are used. Flatjacks can fail because of plumbing problems and resistance strain gauges, which are mounted on rock, can fail because of creep in the glue bond or moisture infiltration causing a change in resistance. Therefore, resistance strain gauges have very poor long term stability. The vibrating wire principle provides very accurate readings over the long term because the resonant frequency is very stable for this type of sensor. However, for the purpose of monitoring the change of stresses in hard rock no suitable unit was commercially available. Therefore, we built a cylindical ring which contains vibrating wires to measure the change of diameter in a drill hole. Our instrument has a total range of 0.25mm and can read down to 3 microstrain in a 15cm diameter drill hole.

To show the results from this vibrating wire monitoring unit, I have reproduced here the changes in borehole diameter, which we measured at a mine north of Montreal during the development of rooms close to the instrumented borehole locations (Figure A-9). Calculations, which we carried out on the basis of the monitored values, show that horizontal stresses were relieved almost totally during the removal of the confinement for these excavation walls. The vertical stress components changed very little. In these instrumented boreholes, ground stress determinations have been carried out prior to installation of the vibrating wire monitoring unit.

6. <u>Microseismic Monitoring</u>

The previous description restricted the monitoring of stress changes to the observation of minute deformations or strains. However, for engineering structures we must be able to predict failure. As mines in the Canadian Shield are extending to greater depth, the danger of excavation collapse becomes more real. A number of cases have been observed in northern Ontario where damage to excavations was accompanied by violent seismic shocks resulting not only in excavation damage but also in the loss of life. Many mines in Ontario are experiencing these violent failures of rock, which are also called rockbursts. Rockbursts release so much energy that they are measured on the Richter Scale like earthquake events and alone in Ontario in the years 1984-85 there were 217 rockbursts observed of magnitude 1.5 to 4 on the Richter Scale. These rockbursts occured either in supporting pillars, walls of openings or along faults. Due to the large extent of some of these faults, rather large amounts of energy can be released when failure occurs.

Brittle rock is most prone to violent failure but no mine is really safe from rockbursts. They can occur in potash, salt, and coal mines, if harder strata, like sand stone beds, concentrate stress during mining. In the Sudbury basin, close to the Great Lakes in North America, mining in the hard rock of the Canadian Shield extends to 2km depths (6,600ft). For these large operations the ability to predict rockbursts has become on important objective.

We know from testing small samples in the laboratory that at the moment we exceed 50% of the peak strains, small microseismic events do occur and that the frequency of events generally increases as the load on the sample gets closer to failure (Figure A-10). On the basis of this effect, 13 mines in Ontario have now installed microseismic monitoring systems which are based on geophones which measure velocity or acceleration of seismic events. On-line multi-channel processing is needed because the frequency of events is such that manual interpretation is impossible.

The information one requires is the frequency of events, their location, and their magnitude.

To monitor the magnitude, only first arrivals of shock waves are monitored which are above a given magnitude. For the determination of location, a time-window is set, such as 100 milliseconds. An event will be processed if within this time-window, five geophones record events which are above the selected magnitude. If this condition is met, the calculation of location is triggered. The size of the time-window is equal to the time for a wave-front to pass diagonally through the monitored volume past the monitoring sensors.

Microseismic monitoring has provided significant warning but accurate predictions of failure is difficult. One of the disadvantages is that only the first arrivals of shock waves are used, although the wave-train is fully recorded by sensors. Therefore, the present microseismic system as shown in Figure A-11 does not allow the study of the mechanisms of failure which produces different wave forms for different conditions. Real time monitoring would provide more meaningful answers.

Another disadvantage is that the present processing methods cannot handle large events. During large rockbursts, a number of several large tremors occur which saturate the total system. In these cases most of the information is lost completely. In such cases we must still rely on the study of regional seismic networks which use the well known drum recorders and are processed by Earthquake stations.

7. Conclusion

This short summary has given you an overview of the work we, at CANMET, are doing in regard to ground stress determinations and ground stress monitoring. This work has identified that the increase of vertical stresses with depth follows two relationships and that more complex relationships exist for the increase of the horizontal stress with depth. The work is now in a mature state and will soon provide a map of the orientation of the maximum principle compressive stresses in North America.

In addition I have shown you where we stand in regard to the monitoring of stresses and the prediction and monitoring of rockbursts in the deep mines of northern Ontario in Canada.

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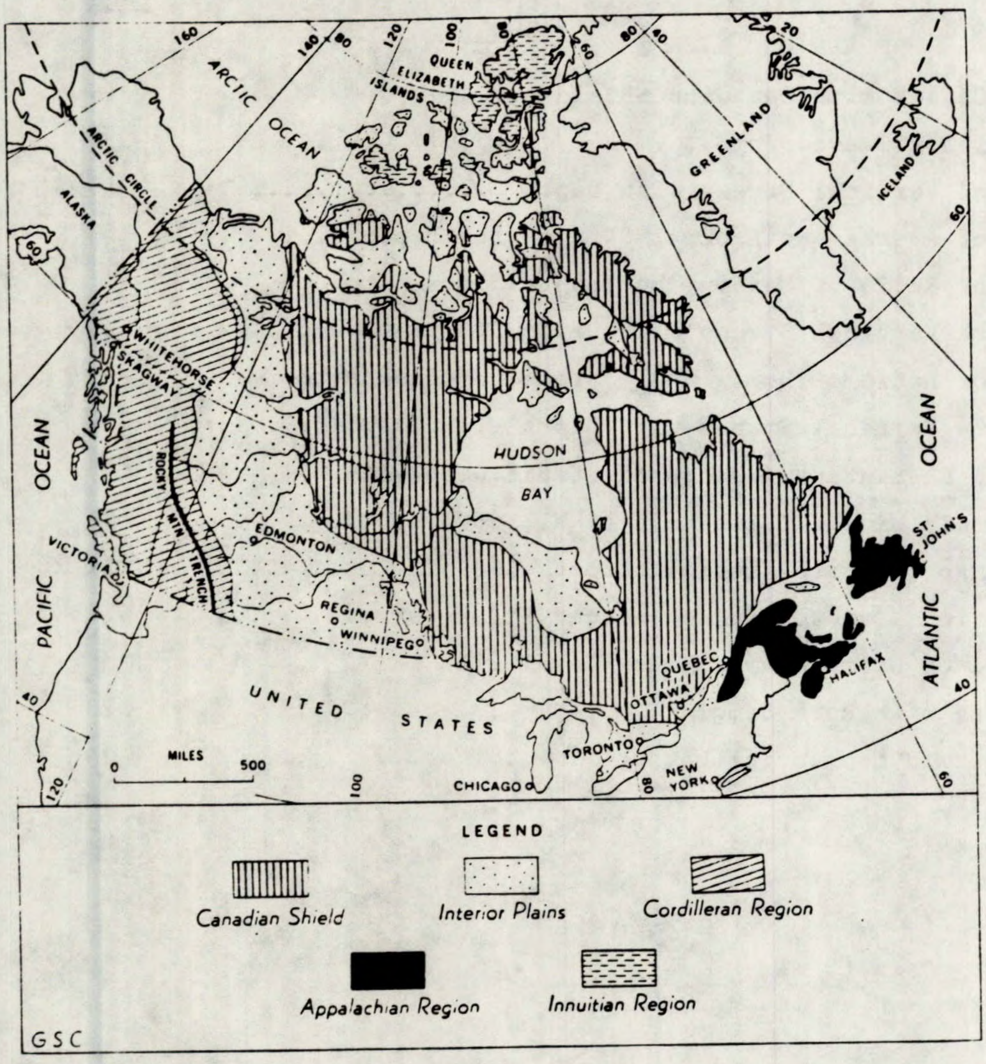
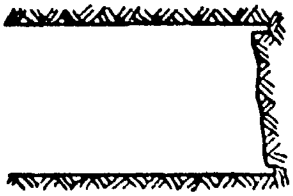
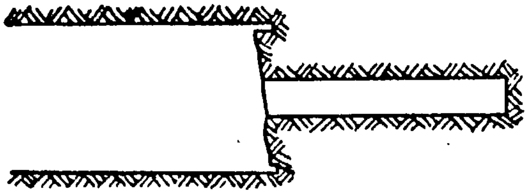


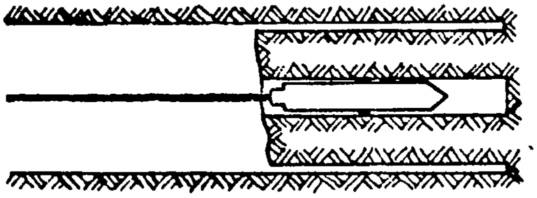
Fig. A-1 - Map of Canada with Canadian Shield



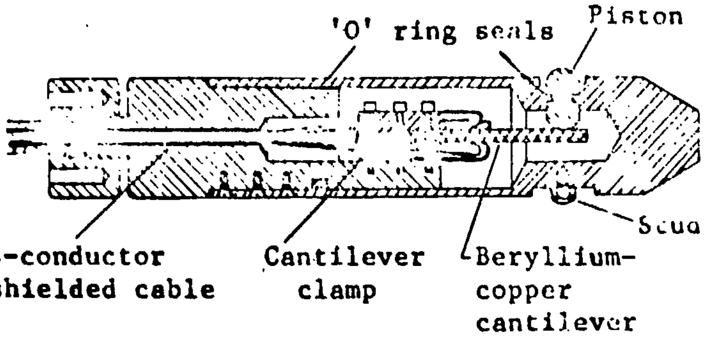
a) 15 cm hole drilled to required depth.



b) EX hole drilled 30 cm beyond (diam. 0.038 m)



c) Deformation meter overcored.



U.S. Bureau of Mines Borehole Deformation Gauge.

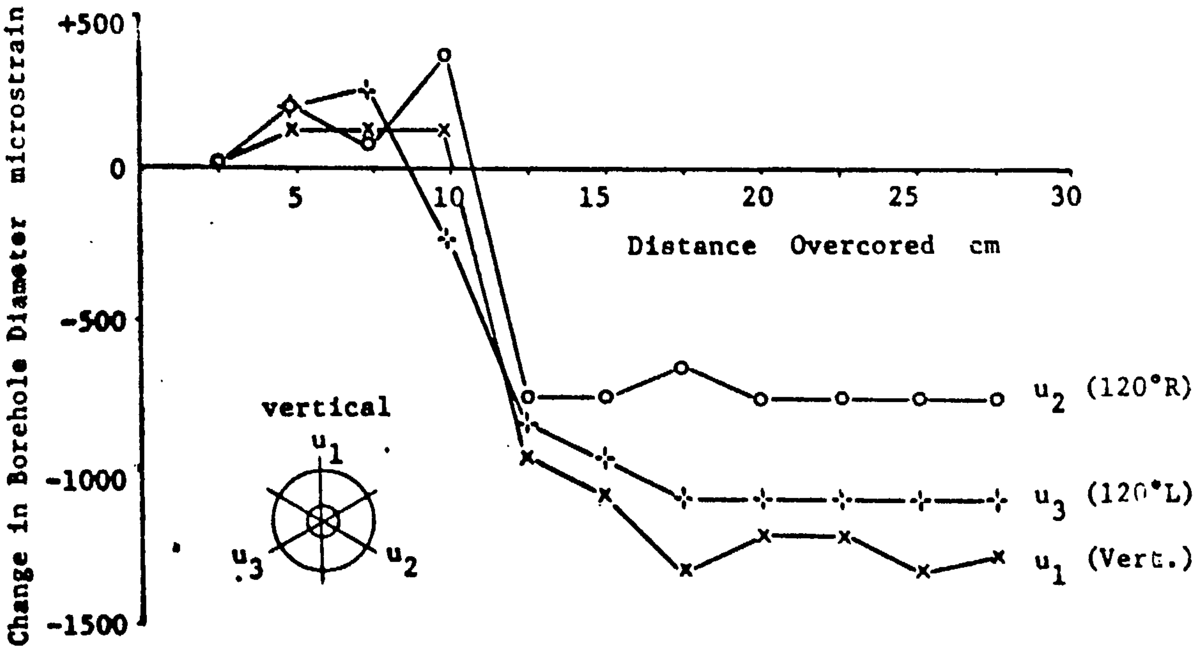
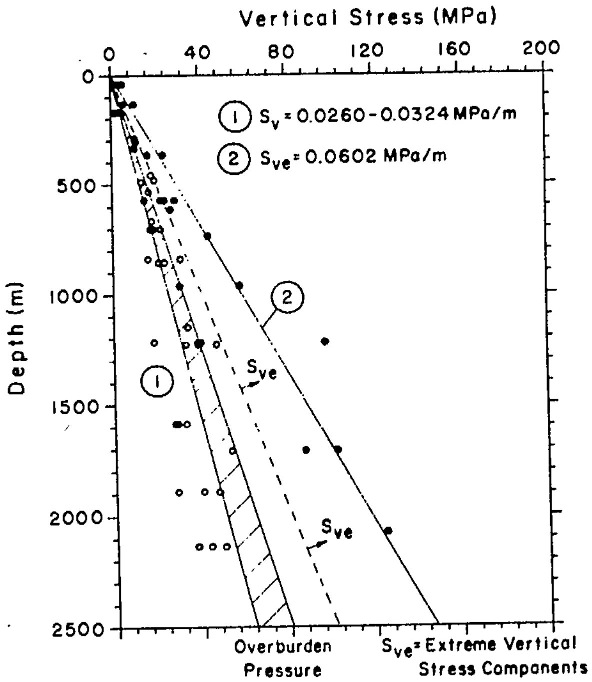
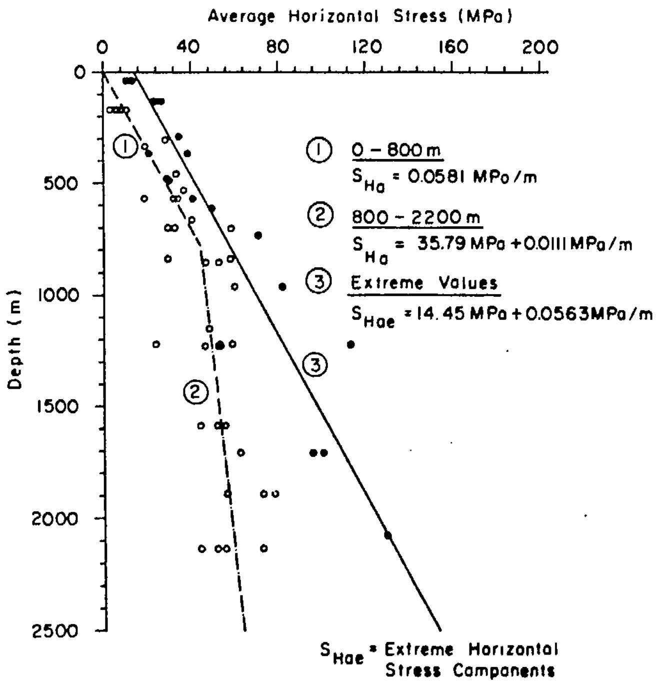


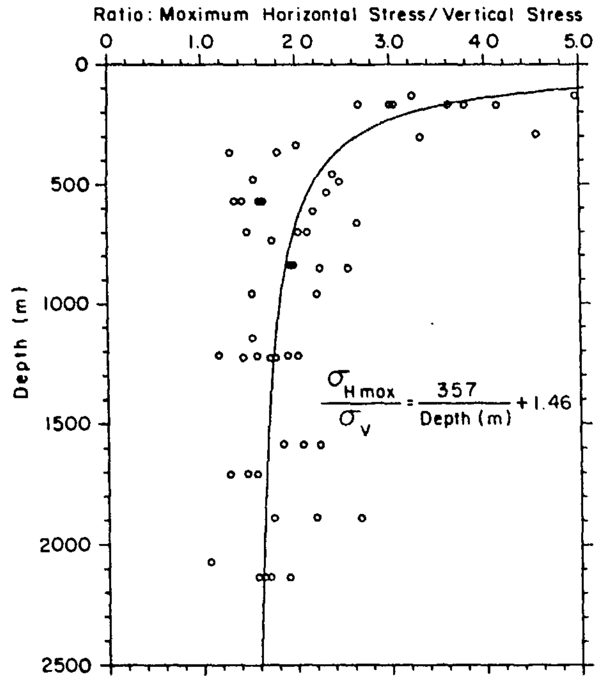
Fig. A-2 - Overcoring technique and example of measurements with the deformation meter



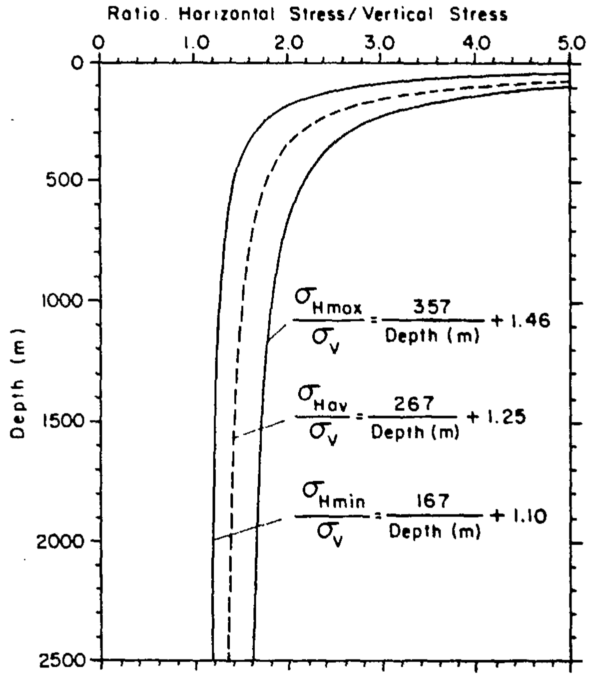
A-3 - Change of vertical stress components with depth



A-4 - Change of average horizontal stress components with depth



A-5 - Cnange of ratio of maximum horizontal stress/vertical stress witn depth



A-6 - Change of ratio of horizontal stress/vertical stress with depth

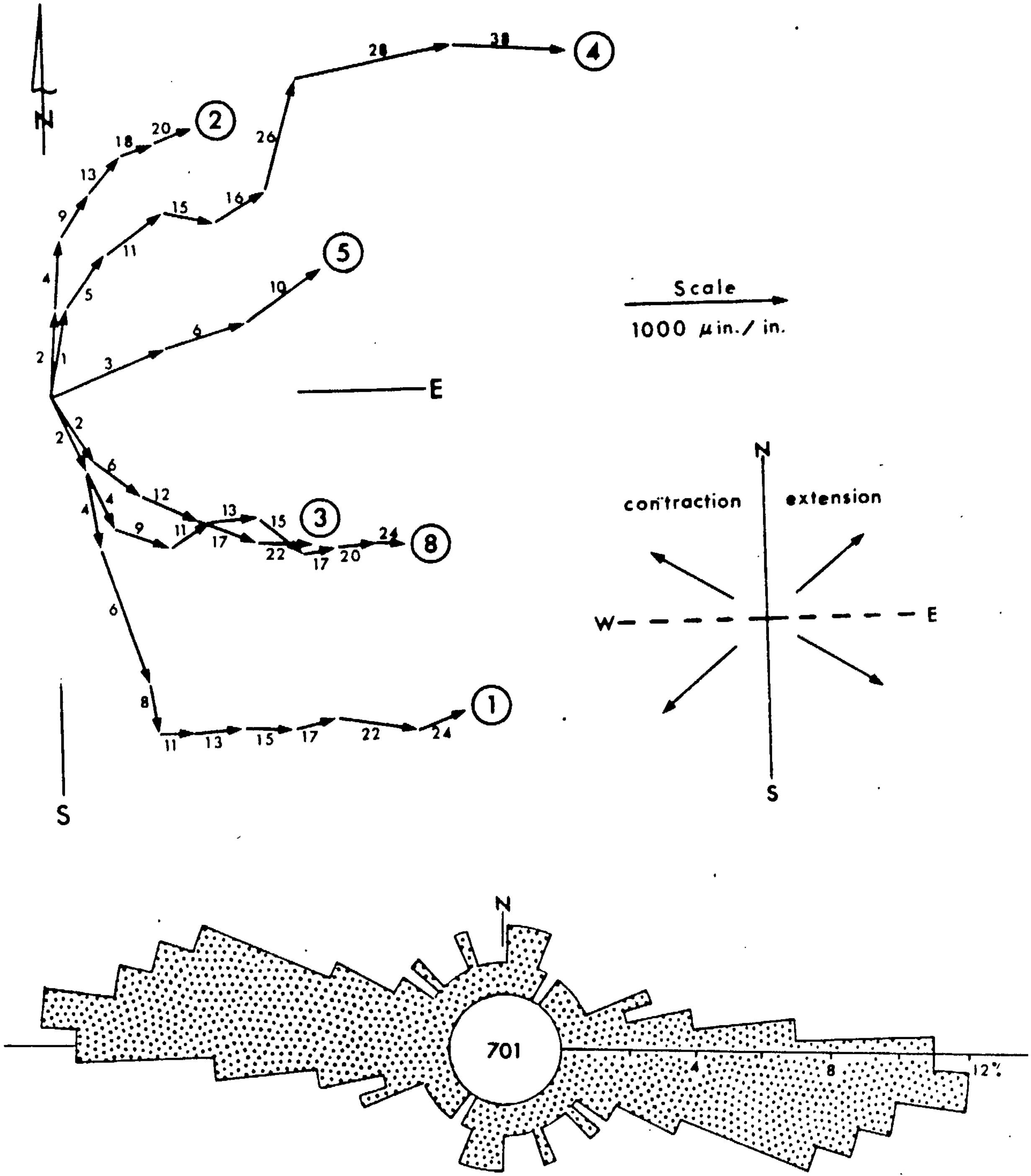


Fig. A-7 - Tectonic Elements and Measured Strain Recoveries at Nordic Mine (Bielenstein et al 1969)

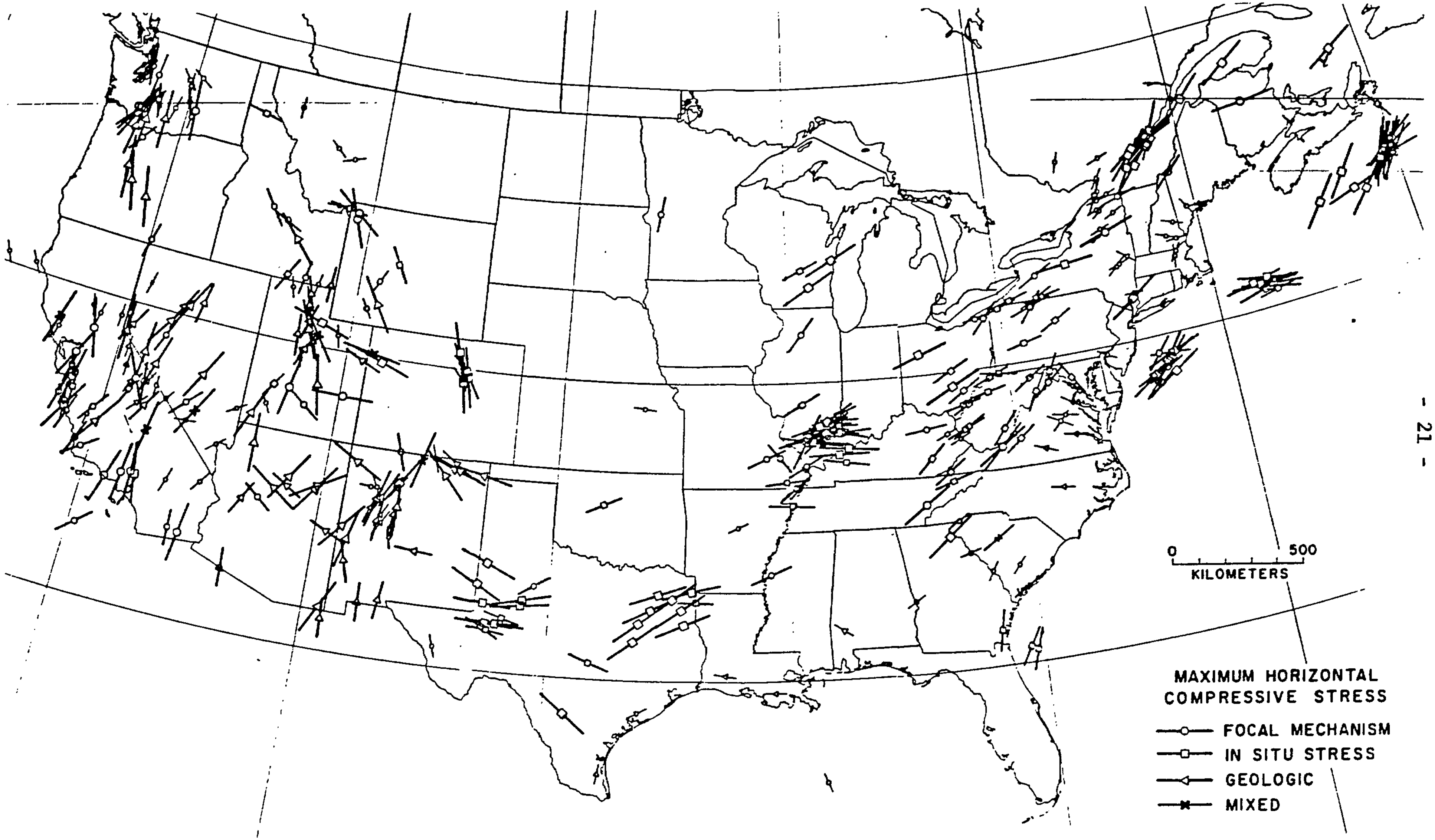


Fig. A-8 Stress Map of North America (Zoback 1987)

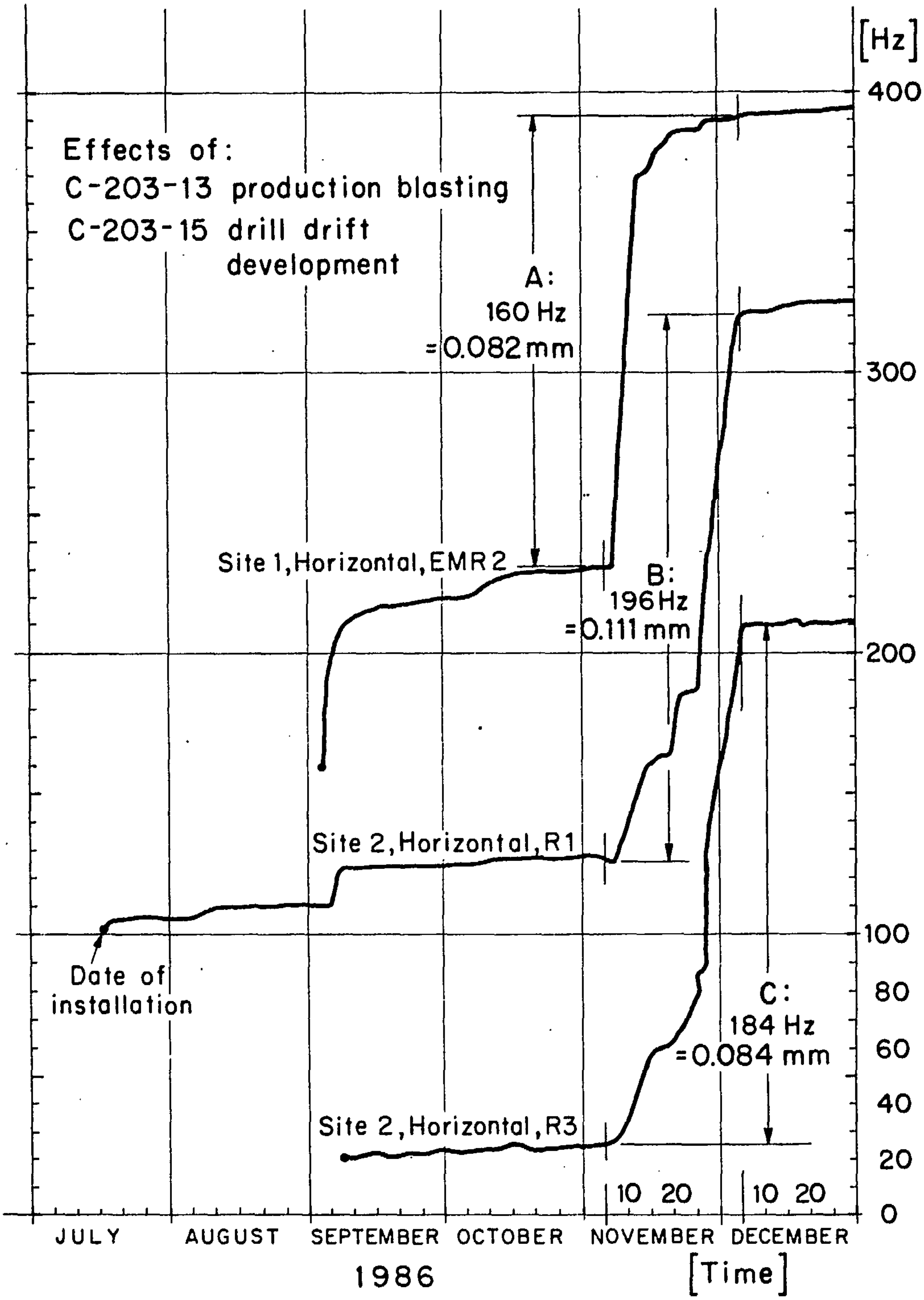


Fig. A-9 Deformations due to mining induced stresses

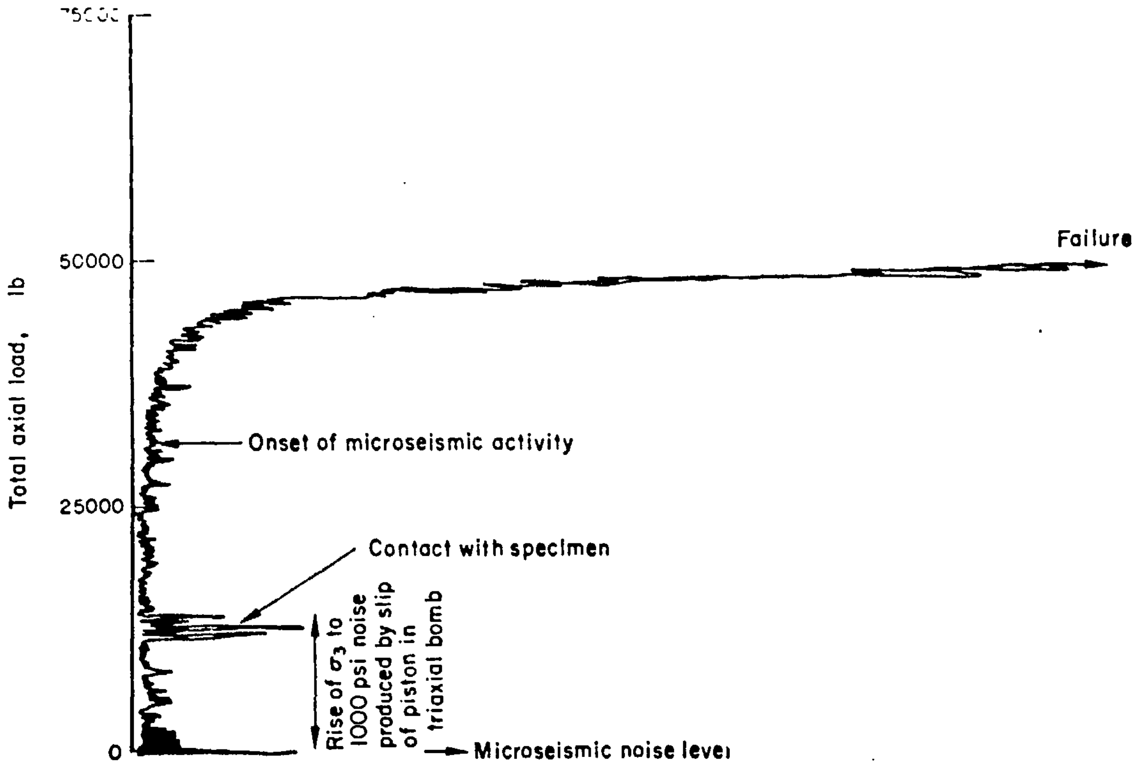


Fig. A-10 Increase of microseismic noise level with loading of a rock sample

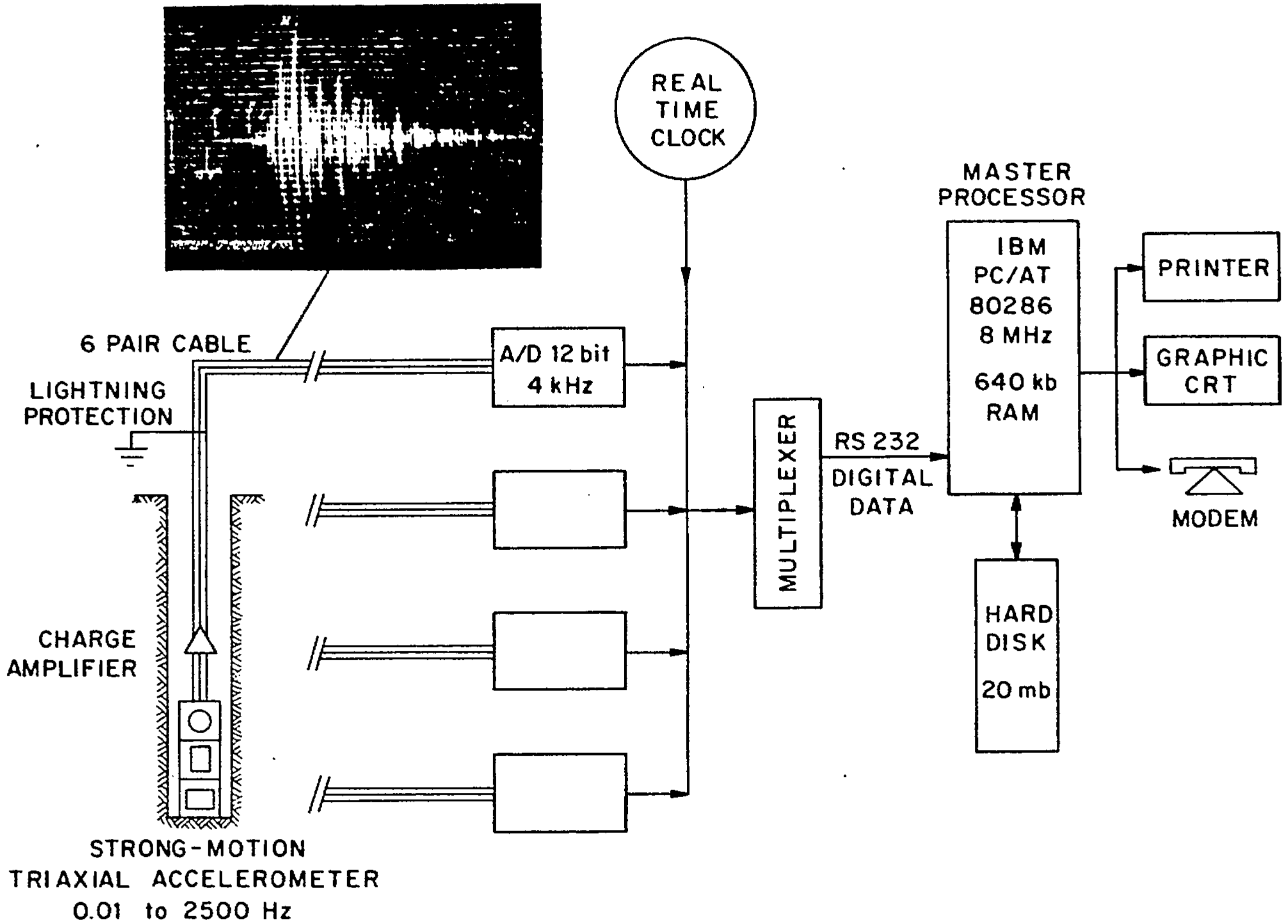


Fig. A-11 Microseismic monitoring layout

APPENDIX B: SUMMARY ON PREPARATION FOR THE 6TH ISRM CONGRESS IN MONTREAL

Mr. Chairman, Ladies and Gentlemen. I thank you very much for the opportunity to say a few words about the 6th International Congress on Rock Mechanics which is being organized for the end of August/beginning of September 1987 in Montreal, Canada. My name is Gerhard Herget and I am the General Congress Chairman and Chairman of the organizing committee.

Every four years this Congress is the most important event in rock mechanics and related engineering. We expect about 700 delegates and 34 nations have sent in a total of 253 publications for publication in the Congress proceedings (Figure B-1).

Sixty papers have been selected for oral presentation in the plenary sessions. The remainder of the contributions will be exchanged during discussion and poster sessions.

For the 4-day Congress we have organized four plenary sessions with discussions on the following themes: fluid flow and waste isolation, rock foundation and slopes, rock blasting and excavation, and underground excavations in overstressed rock (Figure B-2).

On Wednesday and Thursday workshops will be organized on the following topics (Figure B-3):

Tuesday (Sept. 1): swelling rock, constitutive laws for salt rock, numerical methods as a practical tool.

Wednesday (Sept. 2): failure mechanisms around underground openings, rock cuttability and drillability, rock testing and testing standards.

To allow a more informal and more up-to-date exchange of information, poster sessions are organized for the lunch period and after the technical sessions. A summary of the poster sessions as supplied by authors will be printed in the discussion volume after the Congress.

On the same level, where the plenary sessions are organized, we will be holding a tradeshow at the time of the Congress. Of the 70 booths already 55 are rented, and the booth space is available for $950 for three days.

The registration fee is $575 Canadian which is at the current exchange rate about $440 U.S. This covers all events, the two receptions, the silver jubilee dinner, a performance by the Ballet Jazz of Montreal, Les Sortilèges a cultural dance group, and two volumes of the proceedings plus one discussion volume, which will be published after the Congress. All authors will receive 25 copies of their papers free of charge (Figure B-4).

If you want to spend more time and a bit more money in Canada, we have prepared a fairly extensive technical tour program. This program will give you the possibility to see the challenges which mining and civil engineers are facing in Canada. It will also give you a unique opportunity to see the geographic variety of Canada (Figure B-5):

<u>Pre-Congress tours</u>:

1) Rock Mechanics In Deep Underground Hard Rock Mines: the Sudbury nickel mines and the Elliot Lake uranium mines will be visited. Delegates will receive a good overview on the studies of rockbursts in the Sudbury area. In addition the Science Museum will be visited;

2) Underground Research Laboratory of AECL (Atomic Energy of Canada Limited) near Winnipeg, Manitoba: the underground research facilities will be toured and an atomic reactor will be visited. Laboratory and field work is directed to determine acceptable conditions for a nuclear waste repository.

3) Undersea Full Face Tunnel Boring: visit to Longwall coal mines and the coal research laboratory in Sydney, Nova Scotia;

Post-Congress tours:

They cover larger distances and the highlights are:

4) Mining In The Artic (September 4 to 7): two mines are being visited on northern Baffin Island with a side trip to Eskimo settlements. In addition a site for drilling in perma frost will be visited;

5) Niagara Falls Power Plants and Rock Cliff Stabilization, Ontario: one of the spectacular sites in Canada is the Niagara Gorge with its waterfall. Some of the water has been harnessed for generating electric power and some of the unstable rockcliffs have been stabilized by a number of means.

6) Railway Tunnels Through The Selkirk Mountains, British Columbia: the spiral tunnel and steep slopes will be toured and the Mount McDonald tunnel, which is under construction, will be visited;

I thank you very much for your attention and certainly hope to meet many of you in Montreal at the 6th International Congress for Rock Mechanics.

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INTERNATIONAL SOCIETY
FOR ROCK MECHANICS

SOCIETE INTERNATIONALE
DE MÉCANIQUE DES ROCHES

INTERNATIONALE GESELLSCHAFT
FÜR FELSMECHANIK

International Congress on Rock Mechanics
Congrès International de Mécanique des Roches
Internationaler Kongress der Felsmechanik

August 30th · Sept. 3rd, 1987
Montréal, Québec, Canada

CIM

C A R M A
Canadian Rock Mechanics Association

Figure B-1 Logo and Times of 1987 ISRM Congress

ISRM Congress 1987

Sunday, August 30	Monday, August 31	Tuesday, September 1	Wednesday, September 2	Thursday, September 3	
Pre-Congress Workshop: Young *(Canada)*: Monitoring and interpretation techniques for mining induced seismicity (extra charge) (8:30 - 18:00)	**OFFICIAL OPENING** Hoek *(Canada)*: Rock Engineering in Canada	THEME II: **Rock Foundations and Slopes** Chairman: Tinoco *(Venezuela)* Speaker: Panet *(France)* Reinforcement of rock foundations and slopes by active or passive anchors 4 Presentations	THEME III: **Rock Blasting and Excavation** Chairman: Tan Tjong-Kie *(China)* Speaker: McKenzie *(Australia)* Blasting in hard rock: Techniques for diagnosis and modelling for damage and fragmentation 4 Presentations	THEME IV: **U/G Excavations in Overstressed Rock** Chairman: Kidybinsky *(Poland)* Speaker: Wagner *(S. Africa)* Design and support of underground excavations in highly stressed rock 4 Presentations	08:30
	Coffee				10:00 10:30
	THEME I: **Fluid Flow and Waste Isolation** Chairman: Bjurstrom *(Sweden)* Speaker: Doe *(USA)* Design of borehole testing programs for waste disposal sites in crystalline rock 5 Presentations	9 Presentations	9 Presentations	9 Presentations	
	Lunch Break and Poster Sessions				12:00 13:30

Figure B-2 Technical Session Layout for the Mornings

ISRM Congress 1987					
Sunday, August 30	**Monday, August 31**	**Tuesday, September 1**	**Wednesday, September 2**	**Thursday, September 3**	12:00
	Lunch Break and Poster Sessions				13:30
	9 Presentations	Panel & Floor Discussions Moderator: Kovari *(Switzerland)* Panelists: MacMahon *(Australia)* Ribacchi *(Italy)* Yoshinaka *(Japan)*	Panel & Floor Discussions Moderator: Linqvist *(Sweden)* Panelists: Favreau *(Canada)* Gehring *(Australia)* da Gama *(Brazil)*	6 Presentations	14:30
		MODERATOR SUMMARY	**MODERATOR SUMMARY**	**Coffee**	15:00
	Coffee	**WORKSHOPS**		Panel & Floor Discussions Moderator: Whittaker *(UK)* Panelists: Sharma *(India)* Kaiser *(Canada)* Maury *(France)*	
	Panel & Floor Discussions Moderator: Barton *(Norway)* Panelists: Langer *(FRG)* Hudson *(UK)* Rissler *(FRG)*	Swelling Rock Constitutive Laws for Salt Rock Numerical Methods as a Practical Tool	Failure Mechanisms Around Underground Workings Rock Cuttability and Drillability Rock Testing and Testing Standards		16:00
				MODERATOR SUMMARY	16:30
	MODERATOR SUMMARY			**CLOSING ADDRESS:** Wittke *(FRG)*	17:00
	Poster Sessions				18:00

Figure B-3 Technical Session Layout for the Afternoons

ISRM Congress 1987

Time	Sunday, August 30	Monday, August 31	Tuesday, September 1	Wednesday, September 2	Thursday, September 3
17:00 - 18:00		Poster Sessions			
19:00 - 19:30	Reception by Congress Chairman	Reception ISRM President			Reception
19:30 - 20:30					Dinner
20:30 - 21:30		Ballet Jazz			Silver-Jubilee Addresses
21:30 - 22:00					Les Sortileges

Registration:	Sunday	14:30 - 22:00
	Monday, Tuesday	08:00 - 18:00
	Wednesday, Thursday	08:00 - 12:00

Trade Exhibition:	Monday, Tuesday	10:00 - 18:00
	Wednesday	10:00 - 16:30

Accompanying Persons Program will be organized concurrent with technical sessions.

Figure B-4 Evening Program

Figure B-5 Tour Locations in Canada

APPENDIX C: SOUTH AMERICAN CONTACTS

SOCIEDAD CHILENA
DE MECANICA DE
SUELOS E INGENIERIA
DE FUNDACIONES

ING. EUGENIO RETAMAL-SCHAFER
PRESIDENTE

Specialist on perma frost
Antarctica

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SANTIAGO, CHILE
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GEOLOGIA, GEOFISICA, INSTRUMENTACION GEOTECNICA

ICG
ingeniería

geotecnica
GC consultores

LUIS VALENZUELA PALOMO
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DIVISION ANDINA
CASILLA 253
LOS ANDES - CHILE

Chile

JOSE BLONDEL CAMPOS
JEFE DEPTO. GEOLOGIA MINAS

looking after
Chucicamata
El Teniente
Salvador

Andina 4300m high
block caving/openpit
36000t/day

CORPORACION NACIONAL
DEL COBRE DE CHILE
DIVISION ANDINA

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312-3204

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Consejero Comercial y Económico
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Oreste Moretto
Doctor Ingeniero Civil

VP of ISRM under Wittke

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yacyretá

May 8/87

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Evening visit
May 8/87
Sewage tunnels in soil

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Dr. Gerhard Herget
Congress Chairman
6th. ISRM CONGRESS

FRIDAY, MAY 8

09:00 Mr. Denis Thibault, Commercial Counsellor
CANADIAN EMBASSY
Suipacha 1111 - 25º
(1368) Buenos Aires
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10:00 Lic. Alberto Enrique Devoto
Presidente (President)
AGUA Y ENERGIA ELECTRICA
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Presidente (President)
Eng. Jacques Lagrange
Vicepresidente (Vicepresident)
HIDRONOR
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visit to open pit mine
anytime, May 15, 87

Júlio César Nery Ferreira
Ch. Seção de Engenharia de Mina

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SUELOPROYECTO S.R.L.

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