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INGEOKRING NIEUWSBRIEF

April 1988

NIEUWSBRIEF INGEOKRING

april 1988

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Nieuwsbrief van de Ingenieursgeologische Kring
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Zonder energie staan we stil.

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Van de redaktie

Voor u ligt het eerste nummer van 1988.
De Nieuwsbrief van de Ingeokring zal vanaf dit jaar viermaal per jaar verschijnen.
De volgende nummers kunt u in juni, september en december verwachten. Wij hopen dan ook, dat de leden van de Ingeokring voor een grotere bijdrage, in de vorm van artikelen, zullen gaan zorgen. Ook willen wij het bedrijfsleven wat nauwer gaan betrekken bij de Nieuwsbrief, daar wij van mening zijn dat publicaties uit het bedrijfsleven de kwaliteit van de Nieuwsbrief zullen verhogen.
Uiterste inleverdata van de kopij zijn: 18 mei, 17 augustus en 16 november.

Verder willen wij u erop attent maken dat het Symposium "Milieu en Aardwetenschappen" op 19 mei zal plaats vinden in de Aula van de Technische Universiteit Delft. Dit symposium, dat georganiseerd zal worden door het Dispuut Ingenieursgeologie, in samenwerking met de Mijnbouwkundige Vereeniging, het K.I.V.I. en de Ingeokring, heeft drie onderwerpen:

- Geologische berging
- Bodem bescherming
- Mijnbouw, vervuiler of verschoner?

Hierbij willen wij alle leden van de Ingeokring oproepen dit symposium bij te wonen.

F. Bisschop
E. Zwerver.

VAN HET BESTUUR........

De Ingeokring bestaat nu al een respectabel aantal jaren. Dit betekent in ons geval niet dat ouderdomsverschijnselen zich gaan openbaren. In tegendeel, verjonging en verandering komen tot uiting in verhoogde activiteiten en praktische initiatieven.
Denk maar aan het komende symposium in mei!

Vanuit deze levendige belangstelling is ook het initiatief geboren het (verouderde) logo van de Ingeokring een grondige opknapbeurt te geven en een poging te doen onze Niëuwsbrief van een pakkende naam te voorzien.
Een folder over de Ingeokring is in voorbereiding en mede hiervoor zal een beter reproduceerbaar en moderner aandoend logo op zijn plaats zijn.
Dit heeft ons doen besluiten alle leden te betrekken bij deze activiteit door een tweeledige prijsvraag uit te schrijven:

1. Ontwerp een logo voor de Ingeokring, bij voorkeur in een kleur, wat bovendien eenmaal gedrukt goed reproduceerbaar moet zijn met de bestaande copieermachines.
2. Bedenk een passende naam voor onze Nieuwsbrief, representatief voor het vakgebied en (verniëuwde) inhoud.

De gekozen inzending mag rekenen op een paar flessen uit een prima jaar en van een interessant kasteel.
Zowel voor het logo als voor de naam van de Nieuwsbrief worden een paar van zulke flessen beschikbaar gesteld.

Wij verwachten een grote respons en een moëilijke keuze procedure.
Mogen wij op u rekenen?

J.E. Hageman.

<u>INGENIEURSGEOLOGISCHE KRING</u> <u>Jaarverslag 1987</u>

In 1987 vonden de volgende activiteiten plaats:

11 februari: Een symposium over het gebruik van de personal computer in de aardwetenschappen, georganiseerd in samenwerking met het KIVI, het Dispuut Ingenieursgeologie van de TU-Delft en de Mijnbouwkundige Vereeniging van de TU-Delft. Het symposium werd gehouden in Delft en trok ruim 250 belangstellenden, waaronder ruim 100 studenten. Er werden 22 korte voordrachten gehouden, terwijl 24 bedrijven en instituten uit binnen- en buitenland demonstraties gaven van hun automatiseringsontwikkelingen.

19 maart: Een themadag gericht op het gebruik van mergel in de bouwwereld en stabiliteitsproblemen en onderzoek in mergelgrotten. Lezingen werden gehouden door Ir.F.J.M.Backbier (directeur Grondzaken O.W. Valkenburg), Ir.A.M.Alkemade (directeur Ankersmit) en Drs.P.N.W. Verhoef (TU-Delft). Een excursie naar de Valkenburgse grot was gericht op stabiliteitsproblemen. De themadag werd bijgewoond door ca. 70 belangstellenden.

23 april: Voorafgaande aan de jaarvergadering, werden drie lezingen gehouden over het thema Ingenieursgeologische kaarten van Nederland. Het onderwerp ontleende zijn actualiteit aan de start van het project voor ingenieursgeologische kaarten van Amsterdam. Deze kaarten zullen op het IAEG-congres in 1990 in Amsterdam gepresenteerd worden. De bijeenkomst vond plaats bij de Dienst Openbare Werken te Amsterdam. De sprekers waren L.Kok (Bureau Grondmechanica, Amsterdam), Drs.R.Hillen (R.G.D.) en mevrouw C.E. Mak (Grondmechanica, Delft). Er waren ca. 35 belangstellenden.

7 juli: Lezing door Dr.C.Davenport (Strathclyde University U.K) over Earthquake hazards in North-West Europe. De lezing werd gehouden in Delft en werd door ca. 17 belangstellenden bijgewoond.

Het bestuur van de kring is zeer nauw betrokken bij de organisatie van het IAEG-congres 1990 in Amsterdam en de vorderingen verlopen volgens plan.
Op de jaarvergadering van 23 april 1987, die door 25 leden werd bijgewoond, traden de heren Oele (voorzitter) en Haakmeester (secretaris) statutair af en traden de door het bestuur voorgedragen heren Maurenbrecher en Hartevelt tot het bestuur toe. Het bestuur heeft zich in zijn nieuwe samenstelling als volgt geformeerd:

Drs.J.E.Hageman	- voorzitter
Dr.J.J.A.Hartevelt	- secretaris
Ir.J.G.Bakker	- penningmeester
Prof.Ir.H.P.S.v.Lohuizen	
P.M.Maurenbrecher M.Sc.	
Prof.D.G.Price	
Dr.N.Rengers	- vertegenwoordiger ISRM.

Het bestuur kwam gedurende 1987 zevenmaal bijeen.

Om de studenten in de Ingenieursgeologie nauwer bij de activiteiten van de Kring te betrekken, zal het bestuur voorstellen een vaste vertegenwoordiger van het Dispuut Ingenieursgeologie van de TU-Delft in het bestuur op te nemen.
Het ledental van de Kring bleef gelijk en bedroeg per 31 december 1987 154, hiervan zijn 73 eveneens lid van de IAEG en 21 tevens lid van de ISRM. Het aantal studentenleden bedroeg 18. In 1987 waren er 19 leden met een of meer jaren contributie achterstand.
De Ingeokring Nieuwsbrief is in 1987 tweemaal verschenen en wel in april en december.

Jaarverslag Dispuut IngenieursGeologie februari '87 - februari '88:

- 17-02-'87 Bestuursovername van het Dispuut
- 26-02-'87 Vergadering met staf
- 24-03-'87 DIG-borrel in 'het Noorden'
- 26-03-'87 Bezoek Symposium Geoplan
- 01-05-'87 Start truienverkoop
- 25/27-03-'87 Bezoek Symposium on Coastal Lowlands
- 26-05-'87 DIG-borrel in 'het Noorden'
- 04-09-'87 Vergadering met staf
- 29-09-'87 Vergadering met staf
- 02-10-'87 Ingeokringvergadering - Aanstelling DIG-bestuurslid
  - Redactie-overname Nieuwsbrief
- 07-10-'87 Aanstelling van redactie van de Nieuwsbrief
- 13-10-'87 DIG-borrel in 'het Noorden'
- 10-11-'87 Kennismakingsdiner op ITC
- 18-11-'87 Ingeokringvergadering
- 19-11-'87 Bezoek aan RIVM, Bilthoven
- 27-11-'87 Excursie naar bruinkoolmijn, Duitsland
- 15-12-'87 Start 2e maal truienverkoop
- 17-12-'87 Vergadering met staf
  DIG-kerstborrel in 'het Noorden'
- 11-02-'88 Aanstelling van het nieuwe DIG-bestuur
- 12-02-'88 Bezoek aan Heidemij, Arnhem
- 22-02-'88 Afscheidsborrel in 'het Noorden'.

Op 11 februari 1988 heeft het oude DIG-bestuur zijn taken aan een volgend bestuur overgedragen. De samenstelling van het nieuwe bestuur is als volgt:

M.W. Reinking	President
J. Kootstra	Secretaris
S. Clements	Thesaurier
E. Zwerver	Commissaris.

Bij deze wens ik hen namens het oude bestuur veel succes.

R. Vreugdenhil,
oud-secretaris DIG.

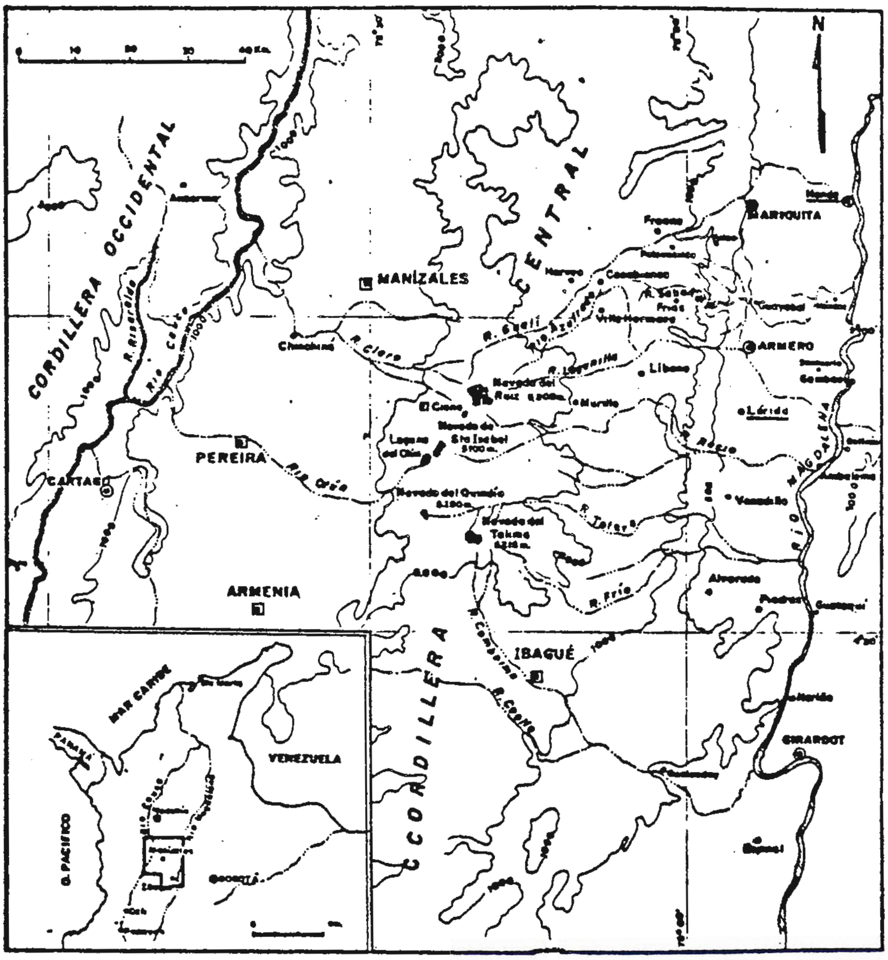


FIG. 1. LOCATION

NEVADO DEL RUIZ ERUPTION AND MUDFLOW OF ARMERO (COLOMBIA)

By Escobar J.A.E. Instituto Geografico `Agustin Codazzi'. Subdireccion Docencia e Investigacion, CIAF. Colombia.

1. INTRODUCTION.

A rough statistics of volcanoes around the world shows that more than 760 volcanoes are active and most of them have caused large damage and many people have lost their lives. One of these cases was registered on 18 may 1980. The north slope of 'Mount' St. Helen (USA), collapsed catatrophically, triggering the movement downslope of several blocks from the mountain, gouging up to 2.8 billion cubic meters of debris at 350 Km/h. It did not stop until it had covered 50 square kilometers. The loss of lives reached about 60. The deadliest eruption registered in this century, occurred in Martinique, where the mount Pelee volcano killed 28000 people in 1902. The worst second disaster caused by eruption of a volcano occurred in Nevado del Ruiz (Colombia) on November 13 1985, where mudflows coming down the slopes of the central mountain range, burried the town of Armero (Province of Tolima) and semi-destroyed the municipality of Chinchina (Province of Caldas). Official statistics showed that approximately 22000 people died.

2. LOCATION.

Nevado del Ruiz belongs to a group of volcanoes distributed along the central mountain chain of Colombia (the most north-west country of South America.) It is situated 150 Km west of the capital Bogota and it has an elevation of 5200 m. Ruiz is situated in the Ruiz-Tolima volcanic complex, which is a series of volcanic cones running along 60 km in the middle sector of the central cordillera. (Fig.1) This volcanic complex is a part of the Nevados National Park.

The Ruiz volcano has an eliptical shape, 12 -15 km in its largest diameter, and 200 square kilometers of surface area. The summit is relatively flat and the crater is in the north-cental zone. The crater itself has a diameter of 700 meters and a depth of 240 m and is not covered by ice due to the fumarolic activity. Around the volcano there are two parasit cones, Olleta in the west and Pirana in the east, both of them being inactive. (Alvarado E. & Paniagua P. 1986)

The country in general, is located in a tectonically active and complex area, where the oceanic crust and the continental plate, due to subduction processes are developing faults and volcanism on the surface. (Fig.2) These geological features are affecting densely populated areas causing loss of human life and property. (Popayan earthquake 1983 and eruption of the Ruiz volcano 1985).

3. GEOLOGY.

In accordance with several geological surveys and reports (eg. Butler 1942, Thompson 1966, Kassen & Arango 1974 and Barrero & Vesga 1976) the area may be divided in two main geological elements:

3.1 Igneous and metamorphic rocks: The east versant of the central mountain chain is limited by an inverse fault system running from South to North, close to Mariquita, Armero and Lerida. (Fig. 3) This area is mainly composed of

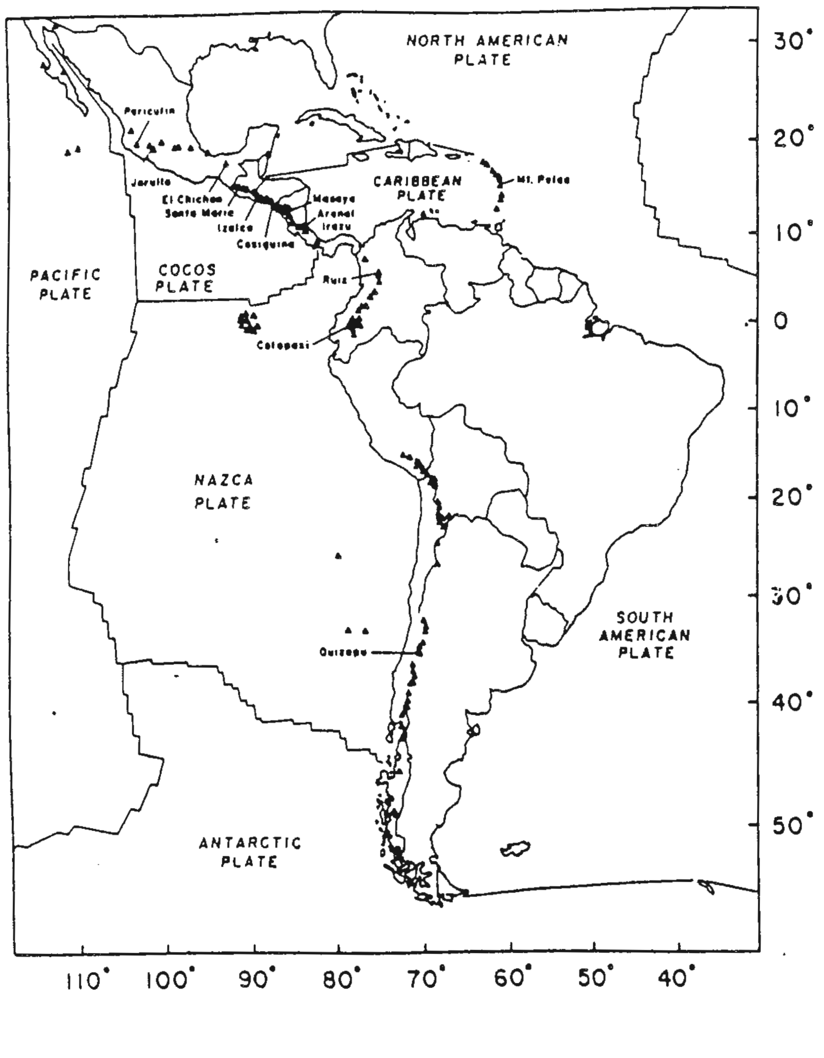


FIG. 2. TECTONIC PLATES IN SOUTH AMERICA

metamorphic rocks of Precambrian to Paleozoic age (Amfibolites and greenish grey schist), Mesozoic plutonic rocks (Mariquita stock and Ibague batolite) and Jurassic volcano-clastic rocks (Saldana formation). On the upper slopes dioritic intrusions and volcanic materials from the volconoes are predominant, although there are some scarce remanents of Tertiary rocks.

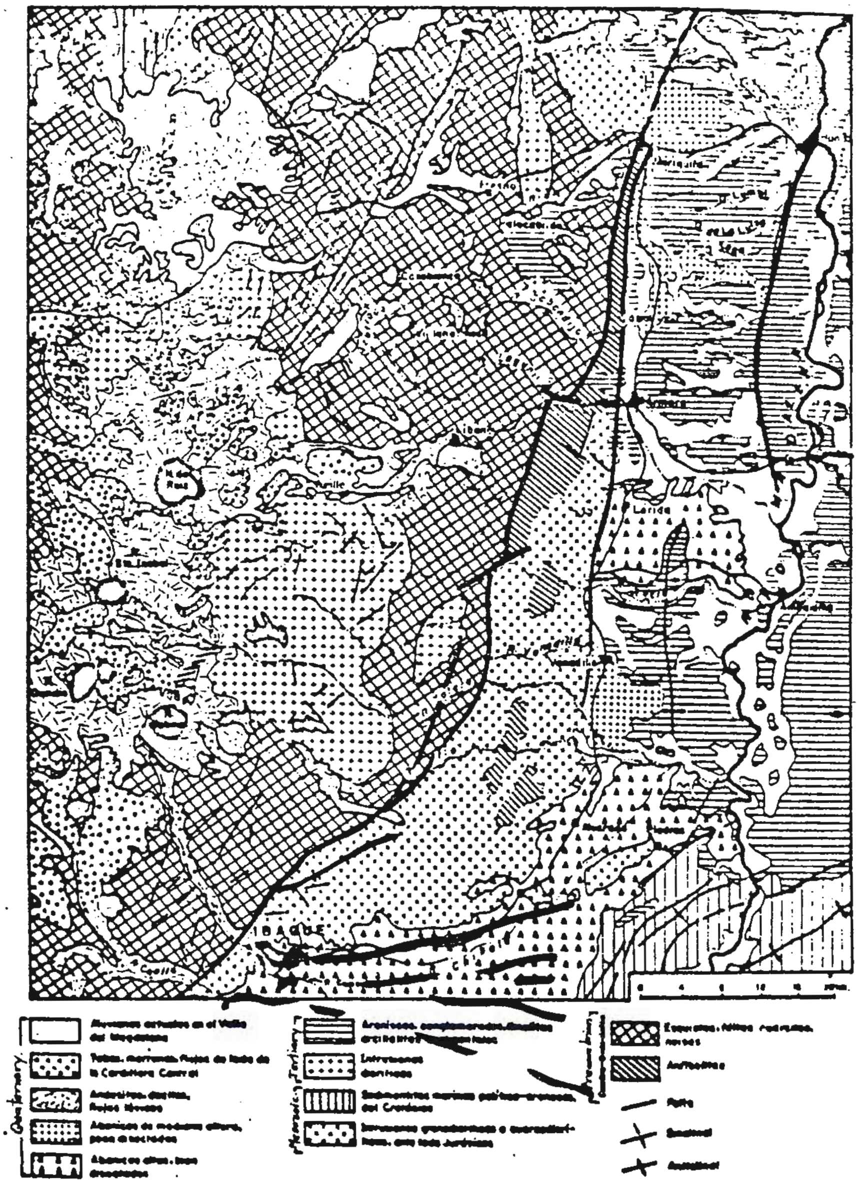
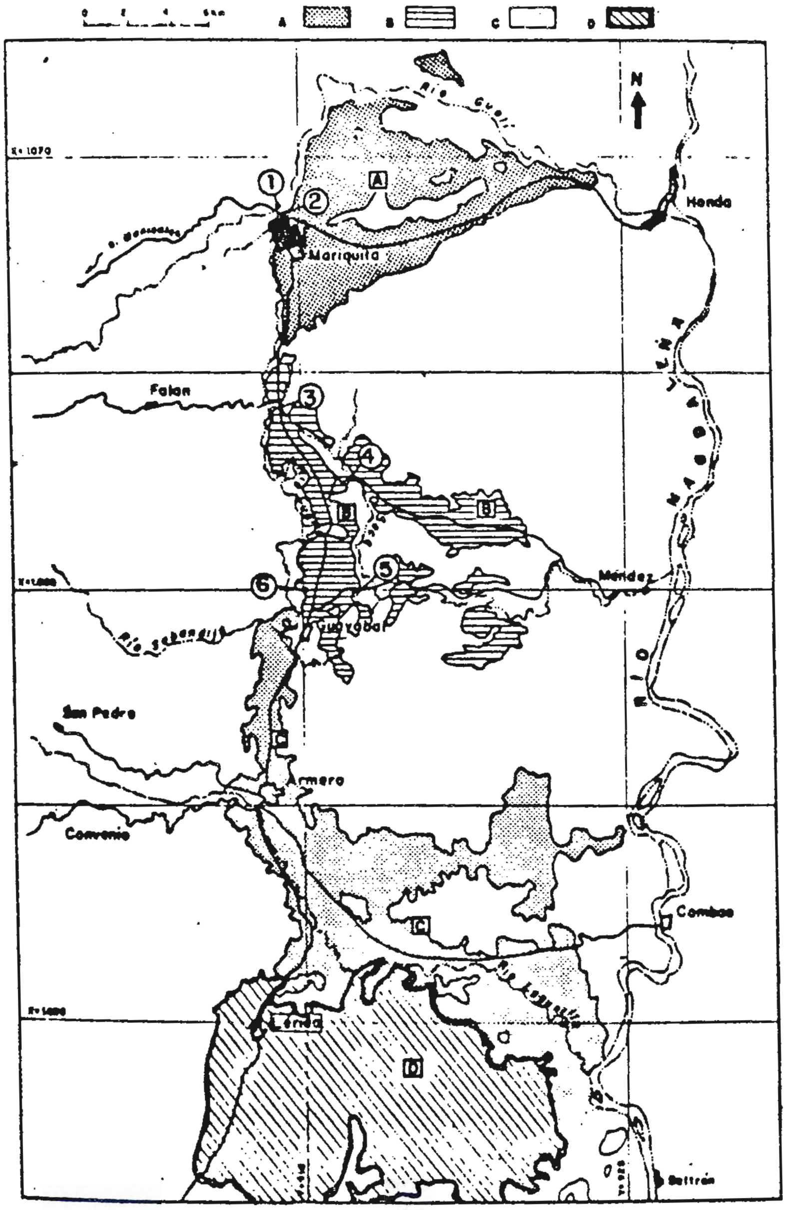


Fig. 3. GENERAL GEOLOGICAL MAP



A Alluvial fan of Mariquita.
B Alluvial fan of Guayabal-El Rhin.
C Armero's alluvial fan.
D Lerida's alluvial fan.

FIG. 4. DISTRIBUTION OF THE QUATERNARY ALLUVIAL FANS

3.2 Sedimentary rocks: Consist of the Tertiary and Quaternary sediments in the Magdalena valley. The Tertiary rocks are referred to as the Honda group and the Mesa, the Quaternary consist of alluvial fans formed during the Pleistocene (Lerida fan), early Holocene (Mariquita and Guayabal fans), and Holocene (Armero fan). The Honda group is divided in two series; the inferior one is without volcanic rocks, has a thickness of 1600 m. The superior is of mainly andesitic volcanic origin, an has a thickness of 2400 m. The latter comprise a sequence of poligenetic conglomerates, sandstones and shales. The Mesa formation is characterized by its "top flat" hills that give them the aspect of a table. This lithology can be Miocene-Pliocene, (De Porta, 1974) but the latest investigations have shown that the age is mainly Pliocene (Duenas y Castro, 1981). Van Houten (1976) has considered these sediments as the result of volcanic activity in the central mountain range. They are composed of andesites, sandstones with high amount of volcanic components and montmorillonitic clays. Its thickness is about 1000 m. Geologically, the fans have been considered as formations with their correspondent stratigraphic name.

3.2.1 Lerida Formation. According to De Porta (1974), this alluvial fan is overlaying the Mesa formation extended to both sides of the Recio River. Its composition is basically of arkosic deposits full of pebbles and rounded blocks (Andesites, amfibolites, granites and quartz). In the stratigraphic profile is possible to detect its characteristic of torrencial deposit. Van Houten (1976) mentioned that Lerida conglomerate breccia and sandstone is the result of volcanic activity and the consequent flows. He also found, through radiometric investigations, topographical height and degree of dissection, that the Lerida fan is the oldest in the area. It is probably related with the Pleistocenic Glaciation. (Fig. 4)

3.2.2 Guali Formation: Proposed by Buttler in 1942 to designate the younger and less lithified deposits as the Mesa Formation, that are lying on the Gualis banks. They are composed of conglomerates with quartz and chert pebbles (blocks) up to 1 m of diameter. Intercalations of tuffaceous layers and agglomerates are also part in its lithologic characteristics. De Porta (1966) expresses that the Mariquita and Guayabal fans must be classified as Guali Formation. The thickness of the formation is variable , as a matter of fact, thicker than the one described by Butler, but close to some 75 m given by Van Houten (1976). The most recent fans are those filling the Lagunillas and Recio valleys. They are lightly dissected forming a flat surface available for the agrarian industry. According to historic evidence this area has been flooded and covered by mudflows several times. Most of them related with fast thawing in Nevado del Ruiz. In the northern part of Armero three previous mudflows can be distinguished. One of them has fragments of Indigenous ceramics from a Pre-Columbian culture (1100-1200 a.c.). (Mojica, J., Brieva, J., Villarroel, C., Colmenares, F. & Moreno, M. 1986) The presence of older mudflows has been confirmed in different places around the Armero fan. Ramirez (1968), has compiled all the historic events related with the activity of the Ruiz Volcano between 1595 to 1985. (Fig. 4)

4. HISTORIC ACTIVITY

At least 10 major eruptions have occurred at Ruiz volcano during the last 10000 years, about every 160 to 400 yr. on average. The volcano was quiet most of this century, therefore it has not had a major eruption since 1595 A.D. On 12 march 1595, (at 11:00) three tremors shook the surrounding area, (Cieza De Leon, 1595). The telluric movements were accompanied with emission of volcanic ash and lapilli. As a consequence a big mass of mud moved down into the Guali and Lagunilla rivers dragging materials from their banks. No mention is made of lost of lives, but the destruction of crops and devastation of the zone is described. The activity of the volcano was also observed during the 1600s and the description of a red glow and plume was registered in 1623, (Ramirez,1968). In the 1700s the volcano had an apparently dormant state and in the 1800s it gained activity. In 1805 an ash eruption was reported, a plume was observed intermittently between 1826 and 1833, accompanied by weak eruptions in 1828 and 1829. Between 1831 and 1833 the volcano had fumarolic activity, (Schaufelberger, 1944; Von Humbolt , 1958; Hnatke & Parodi, 1966; Herd, 1974). A large earthquake and/or phreatic eruption occurred on February 10 or 19, 1845 (There is a discrepancy between Ramirez 1968 and Darrell, G.,1986), triggered a lahar that swept down the Lagunillas River, killing at least 1000 persons. Mud, trees and ice were carried more than 70 km to the Magdalena river, probably overrunning the modern site of Armero (Ramirez, 1975). In 1916 a phreatic eruption showered the nearby city of Manizales (230.000 inhabitants), with fine ash. The town of Armero was built upon consolidated mudflows (Lahars) and on November 13 1985, it was totally destroyed by a similar event as 143 years ago.

5. PRECURSORY EVENTS AND ERUPTION.

Since November 1984, the population settled on the surroundings of Santa Isabel and Ruiz Volcanoes, felt a serie of tremors followed by an explosion that gave a yellowish colour to the snow. At that time mountain climbers reported increase of fumarolic activity in the Arenas Crater, a small (500 m diameter), circular crater enclosed by ice on the north-east edge of the ice cap.

On december 22, 1984, three earthquakes (one of magnitude 3-4) were felt within a radius of approximately 20 Km of the volcano. The earthquakes were accompanied by small explosions in Arenas Crater that spewed sulfurous mud and lithic ash onto the surrounding ice fields. (Tombling, 1985; Instituto Nacional de Investigaciones Geologico-Mineras, INGEOMINAS; Colombia's geological survey).

The earthquakes and abnormal fumarolic activity persisted into 1985. In February the first report about this unusual activity was presented by INGEOMINAS. In March a seismologist from UNDRO (United Nations Disaster Relief Coordinator) accomplished a brief investigation of the volcano, concluding that the abnormal activity could be precursory to an eruption of magnitude and recommending the installation of seismographs on the volcano at the earliest possible date. In July, INGEOMINAS began installation of a network of five portable seismographs at distances between 2 and 14 Km from Ruiz's crater. The first seismographic records confirmed an abnormally high level of earthquake activity near Ruiz. About five to twenty countable earthquakes were occurring each day, with ocassional harmonic tremor and earthquake sequences of as many as 40-80 events (INGEOMINAS, 1985). That August INGEOMINAS warned that the earthquakes could be precursory to a large volcanic eruption and noted that in about 25% of similar cases in other parts of the world, the earthquake activity had ended in an eruption of magnitude. (El Tiempo, 1985).

The earthquake and fumarolic activity intensified in early September 1985, with heavy fume from the summit crater. Between September 6 and 11, episodes of high-amplitude tremor (4 Hz), each lasting about 15 min, recurred at remarkably regular intervals of about every 1-3 hours. (INGEOMINAS, 1985). The tremor episodes culminated on September 11 in a strong phreatic eruption from Arenas Crater. Large steam explosions fired lithic ash and blocks from the throat of the volcano, deepening and steepening the walls of the crater. Numerous boulder-sized blocks were hurled up to more than 1 km from the crater. A rain of fine lithic ash began to fall on the cities of Manizales and Chinchina; more than 25 Km northwest of the volcano. The ash emission was accompanied by lightening and thunderous detonations and it ceased after 6 hours. Approximately 5 cm of ash was deposited at a distance of 2.4 Km from the crater. There were no human casualities.

The strong shaking associated with the eruption triggered an avalanche of ice and rock from the headwall of the Rio Azufrado valley on the northeast side of Nevado del Ruiz. The avalanche mobilized into a rapidly moving debris flow that swept at least 27 Km down the valley, damaging the high mountain road on the north side of the Ruiz that links Manizales and Murillo. A second smaller, debris flow occurred on September 15 in the Rio Guali. (INGEOMINAS, 1985). On September 17 the mayor of Armero told to the authorities that a landslide-dammed lake in the Lagunillas River threatened his town with inundation. A rockslide in 1984 had blocked the Lagunillas River in the Canon de la Vereda Cirpe, 15 Km west of Armero. By September 1985, a lake approximately 1.5 Km in length, 20 m wide, and about 25 m deep had formed behind the landslide dam; the lake's volume was estimated at about 1.3 Million cubic meters (El Tiempo, 1985). INGEOMINAS also reported that the occurrence of the landslide dam on the Lagunillas River was unrelated to the activity at Ruiz. They conclude that the landslide dam at La Vereda Cirpe canyon did not appear to be in danger of inminent failure, and the agency doubted that the Lagunillas River, under normal conditions, could erode the landslide dam. (Herd, E.G. EOS, may 1986)

6. THE ERUPTION DAY AND CONSEQUENT MUDFLOW.

On 13 November 1985, at 13:00 L.T. a smaller eruption ejected fine lithic ash that as falling on Armero two hours later. The phreato-magmatic eruption threw up pumice stones of several centimeters of diameter as far as 10 km from the crater, while ash reached Venezuela, 550 km north-east. Pyroclastic flows and surges were deposited onto the summit ice cap causing its partial fusion (3.5-10%). The flows and surges flattened the vegetation and destroyed the Refugio ski hut. The melted and scoured ice developed streams of meltwater ice blocks and debris that ran from the summit down the volcano's west, north and east flanks. The runnoff was channelized into rapidly moving debris flows that surged down the Las Nereidas, Molinos, Guali, Azufrado and Lagunillas rivers. The lahars scoured the canyon walls as they passed, sweeping up trees, brush, rocks and soil. Then a Plinian column rose thousands of meters into the air. A regional ash fall ocurred northeast of the volcano.

Four big mudflows can be distinguished. The two largest ones came down through Azufrado and Lagunilla rivers and became one in their confluence. At this point the lahars reached 44 m above the normal water level. (Fig 5). The mudflows apparently originated as separate lahars and reached at different times the land-slide dammed lake on the Lagunillas River causing obviously its failure. 80-100 Mm^3 of mud and water reached Armero, (Mojica et al., 86)

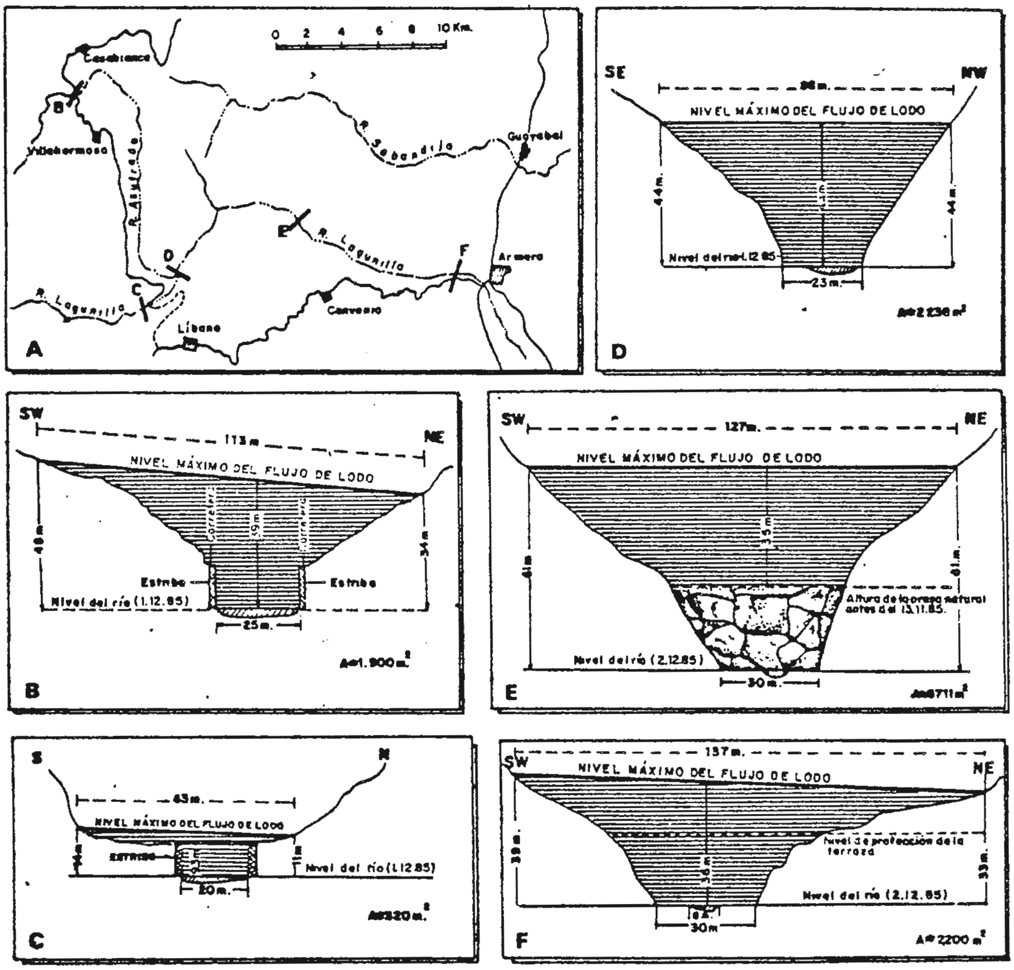


FIG. 5. CROSS SECTIONS ALONG LAGUNILLAS AND AZUFRADO RIVERS.
(After mudflow Nov. 13 1985)

Mudflows originated in the headwaters of the Molinos and Las Neridas rivers that surged through Chinchina (9 Mm^3). The last one descended taking the course of Guali River towards the Magdalena River. (About 15 Mm^3). In the surroundings of Armero, 34.5 Km^2 were affected and the mud layer (a heterogenous mix of blocks, gravel, sand silt, clays and vegetal remains) reached a maximum thickness of 2.5 m while the water level rose more than 5 m. The mud was divided in 3 branches at the mouth of the canyon.

The largest, swept off Armero continuing the old course of the Lagunilla river (Rio Viejo) and stopped at 18 Km towards the east. At that point the thickness of the mudflow was 1.3 - 1.5 m.

The second was directed 8 Km northwards through the valley of Santo Domingo, reaching and damming temporary the Sabandija River.

The smallest one was guided by the bed of Lagunilla river over 10 Km towards the SE.

In the itself of the Lagunilla river itself, the flow had a cross section of 2200 m2 with an average height of 35 m. (Fig. 5). The average velocity of the mudflow was estimated to be 40 Km/h. (Mojica et. al., 1986).

A detailed description of the eruption day was compiled by Darrel G. Herd (1986).

7. INSTRUMENTATION AND MONITORING.

Since July 1985, Ingeominas in cooperation with U.S.G.S. (U.S. Geological Survey) and UNDRO (United Nations Disaster Relief Coodinator) established a monitoring system for Ruiz Volcano. It consist of a net work of five portable seismographs installed at 2 - 14 Km from Ruiz's crater. Until October 8, 1350 earthquakes had been recorded, with an average of about 15 events per day.

On October 1985, the ground deformation Survey began with three mechanic and electronic tiltmeters. They were installed N, S, and West of the summit, and 11 days of data (Before November 5), suggest that some deflation was occurring. After the eruption of November 13th, six telemetered seismographs, four telemetered tiltmeters and geodetic lines were added to the network. Data from the telemetered instruments are transmitted, in real time, by radio to the Ruiz Volcano Observatory in Manizales, 30 Km northwest of the volcano. The geodetic lines and dry tilt arrays are remeasured periodically. The E.D.M. (Electronic distance measurement) was useful to monitor inflation and deflation events of the volcano and therefore to aid eruption forecast. (Banks et. al., 1986). Systematic radial line shortening of 5-10 cm/day was recorded in December for targets on the summit plateau surface near the head of the Azufrado River; (SEAN Bulletin, v. 10, No. 12).

On February 1986, a program of geotechnical monitoring was developed to determine if there was appreciable downward and outward movement of the bedrock mass under the cap of glacial ice. This program involved the adaptation of the already established EDM-base geodetic net, (Fig. 6)

As a result of that program it was found that motions of ice and bedrock are decoupled on the summit plateau at the head of the Azufrado canyon. The steady outward motion of the summit deposits reflects motion in ice, not rock, and the rate of ice movement had systematically decreased during the period of measurements. It was also found that ice avalanches of small to moderated size (100000 to 1 Mm^3) might be expected periodically, due to collapse of cantilivered ice blocks at the Azufrado headwall rim. Finally the possibility of massive gravitational failure of the Rio Azufrado headwall seems to be unlikely unless loading conditions change. (Voight, B., Calvache M., Ospina, O., 1986).

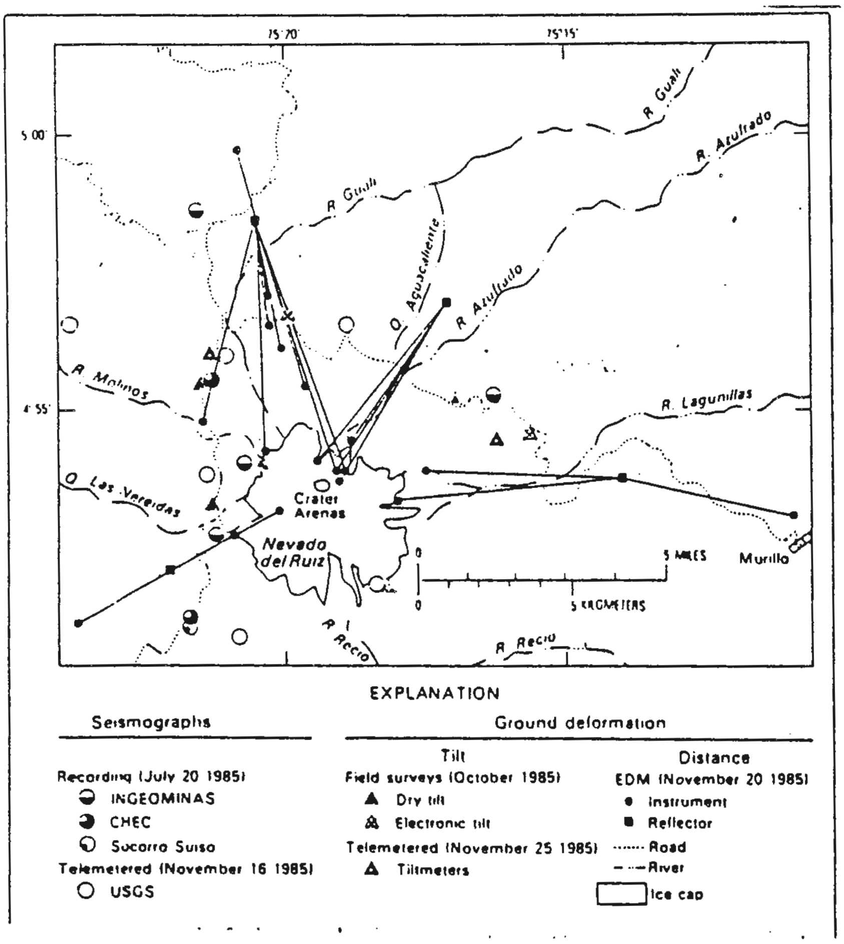


FIG. 6. INSTRUMENTATION

8. CONCLUSIONS.

Although it is impossible to avoid natural disasters, it is viable to diminish their consequences. To do that it is indispensable to know the behaviour of volcanoes and the risk zones associated with them. Volcanic behaviour is studied through volcanic observatories distributed all around the world even though every volcano has its own way of conduct.

On the other hand, volcanic hazard maps as the one developed by Miller et al, (Map of Cotopaxi Volcano, Ecuador, 1978) or by by Thouret and INGEOMINAS (Potential Volcanic hazards of Ruiz, 1985) will serve as a guide to urban planning and long term land use planning. Also they would be useful for evacuation planning in case of eruption. Monitoring is proved, once more, to be an important tool in determining the highest state of excitation and therefore the possibility of eruption forecast.

"Approach to mechanics on swelling soil media" by Prof.Dr. R.K. Katti.

From 6 to 20 February 1988 Prof. Katti of the Institute of Technology in Bombay visited ITC.
On 16 February he held in Delft a guestlecture about swelling soils. The following text is a very short summary of this lecture, in which all the formulas have been left out.

Almost 1/3 of the surface of India consists of expansiye soils, often called "black cotton soils". The high swelling pressure of these soils has caused a lot of damage to civil engineering projects, e.g. linings of irrigation canals, bridges, sluices, etc. Prof. Katti was facing the problems due to this soils for the first time in the early fifties. Soon it was realised that a solution had to be found through the theoretical basis of soil mechanics.

A new theoretical basis for expansive soils

The basic assumptions of Karl Terzaghi about the behaviour of soils describe reasonably the behaviour of sands, but less that of clays and even less than that the behaviour of expansive soils. Some of the typical aspects of expansive clayey soils are:
-saturation from dry to saturated conditions leads to heave
-can excert a swelling pressure up to 500 kPa
-in the upper 1 to 1.5 m the coefficient of lateral earth pressure at rest Ko can be 15 to 20 (in normally consolidated soils Ko = 0.4 to 0.6).
The typical behaviour of these clays is caused by:
-the clay minerals, especially montmorillonite
-the dipolar nature of water.
The interaction between the clay particles and water results in cohesion, and the value depends on the radius of the pores. Next to the forces due to weight as taken into account by Terzaghi it is necessary to regard also the internal forces due to the interaction of clay particles and water. This

interaction is the result of the electric charges on the crystals of the clay minerals and the Van der Waals forces.

From mathematical derivations follows that for a given void ratio there exists a unique relation between swelling pressure, cohesion and pressure of saturated expansive soil systems.

Next a model was used on micro-scale which involves the soil particles, the adsorbed waterfilm, and the water entering in the particles and causing swelling. In this way the cohesion needed to balance the swelling pressure is found for a given void ratio. At a depth of 1 to 1.5 m the expansive soil system is in equilibrium.

Expanding soils show a very high lateral pressure on a vertical wall. This can also be expressed in a (complicated) formula, showing that the lateral pressure depends amongst others on the radius of the pores and the void ratio of the soil.

Engineering treatment of expanding soils

The electric charges can be neutralised by chemical stabilization.

Another important solution for the problem of expansive soils is the use of so-called CNS (cohesive non-swelling soil). The thickness of a CNS layer on top of the swelling soil is chosen in such a way that it counteracts the swelling and swelling pressure characteristics of the underlying expansive soil.

Between a vertical wall and the swelling soil also a layer of CNS can be placed.

During large scale experiments for the different parameters a reasonable to good agreement with the theoretical values was found.

At the end Prof. Katti showed slides and a video tape, which gave a number of examples of the application of CNS-layers. The soil improvement with CNS normally has a thickness of at maximum 1 m. The CNS is used below the linings of canals and near the toe of high embankments, which mainly are constructed with expansive soil. Besides it has been used below the footings of rigid concrete bridges and aquaducts. From the pictures taken 14 years after construction it became clear that none of these structures showed any damage, despite the only 1 m thick layers of CNS below the footings.

From the foregoing text it will be clear that after 30 years of study and engineering practice the problems for the construction of several hundreds of kilometers of irrigation canals caused by the swelling soils in India have been solved.

Literature: Cohesion Approach to Mechanics of Saturated Expansive Soil Media, R.K. Katti, Civil Engineering Department, Indian Institute of Technology, Bombay, India, 6th International Conference on Expansive Soils, 1-4 December 1987, New Delhi, India.

Ir. Wolter Zigterman,
ITC-Delft.

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IngeoKring Nieuwsbrief will be publishing a number of articles written by I.T.C. engineering geology students about engineering geology in their home countries; the first two are by M.J. Ahmed from the Geological Institute of India and by S. Manoharan from the Irrigation Department, Sri Lanka.

EXPERIENCE OF AN INDIAN ENGINEERING GEOLOGIST

by M.J. Ahmed.
Geological Survey of India.

Starting up

In 1975 I gained my Master of Science degree in Geology followed by a lectureship in Geology before joining the Geological Survey of India (G.S.I) in the year 1977 as a Geologist concerned with class I services. As the result of having a special paper for my masters on Engineering Geology the GSI deployed me in the Engineering Geology Division. The policy of the GSI is to have all newcomers follow a nine month in-service orientation training. During this period I became acquainted with the GSI methods of geological mapping, petrological studies, photo-geology / photo-interpretation, mineral prospecting, geotechnical evaluation of sites for dams, roads, and bridges. Field visits were often made to examine geological problems first hand in different areas having different geological environments.

Brief geology of India

The peninsular India has considerable diversity in its geomorphological, geological, tectonic, climatic and social aspects. Perhaps these diversities have taught us to live with unity in diversity. India is characterised by the mighty snow clad Himalayan range in the north, the eastern and western mountain ranges along the peninsular coasts, the Vindhyan and Satpura range on the heart, the deserts on the extreme west and agriculturally flourishing Indo-Gangetic plains at the foot of the Himalayan range. The geochronological time-scale has registered its presence in India from the oldest Archaean basement (3800 m.yrs) in the south to the well developed Holocenes (quarternaries) on the sub-Himalayas.

The complete range of stratigraphy is also reflected in the diverse lithology; ingeneous, metamorphic and sedimentary rocks, of the country. These rocks host economically viable minerals for the production of iron-ore, manganese, copper, lead, zinc, tin, tungsten, uranium, thorium, gold, diamond, mica, coal, lignite, petroleum, halite, phosphorous, potash.

The mighty rivers like the snow fed Ganga, Bhramaputra, Jamuna, Sindh, Jhelum in the north and Narmada, Cauveri, Krishna, Godavari with their tributaries in the south have vast potentials for water resources management by construction of dams, powerhouses, tunnels, canals for irrigation and hydro-electric power. The topography has potential for the construction of 300 m high (mega)dams. In fact where such a dam exists, its reservoir is connected to an 18 m diameter tunnel and to a 35 m wide 120 m long underground powerhouse. The humid tropical climate with varied geological conditions pose at times acute foundation problems for the dams, bridges and allied problems for the underground excavations. The tectonically active Himalayan zone pose challenging geotechnical and design problems for the engineering geologists and civil engineers.

Geological Survey of India

The diverse geological setting with associated mineral resources and its associated potential for wealth has resulted in the Geological Survey of India having a multi-task and flexible articles of association. The basic responsibilities of the organisation is to prepare geological maps and carry out scientific studies in the fields of offshore geology and mineral resources. Furthermore the GSI engages in projects involving geothermal energy, air-borne mineral surveys, glaciology. environmental studies, geological surveys in Antarctica and mineral surveys. Such projects involve prospecting and providing consultancy services in engineering geology, geotechnics. The organisation has about 3000 geologists of which the scientific roll has 300 engineering geologists, 300 geophysicists and 100 geochemists. The Geological Survey of India has the testimonial honour of being the third largest and second oldest organisation of its kind in the world (Est. in 1851).

Engineering Geology at the GSI

I started my professional career in engineering geology with the given understanding that an engineering geologist speaks about geology for the engineers and engineering for the geologists (which at the start I found difficult, much to my discomfort, with my lack of experience to back me up). I started handling the geotechnical investigation works for minor and medium irrigation and hydro-electric projects in parts of central India covered by sedimentary, igneous and metamorphic rocks showing typical humid tropical weathering. Much of this work was performed under the guidance of supervisory authorities. During this period, I investigated for the foundation conditions for dams (earth and gravity of about 45 m height), tunnels and bridges. Despite supervision one is expected to work independently which I did for the preparation of the reports. After five years I had enough experience to organise the investigation works with respect to the site conditions. I was also associated with some of the major construction projects and managed to learn what to speak of geology for engineers and engineering for geologists. (Such occassions certainly became much more comfortable).

In the year 1982 I was made the resident geologist of the World Bank sponsored Bodhgat hydro-electrical project. I was engaged on its site investigation (preconstruction stage) and during this period attended to investigation works of some projects near by. The Bodhghat project envisages the construction of a 100 m high composite dam comprising a gravity section with central spill-way flanked partly by earth fill and partly by rock fill sections. Additional structures had to be investigated for such as a 9 km long water conductor system comprising of a 3 km long 14 m diaheadrace tunnel, three 600 m long 6 m dia pressure shafts, a 55 m deep pit powerhouse and a 6 km long tail race channel, with a maximum excavation depth of up to 45 m. The investigation for the project was completely reviewed during the visit of the world bank experts appraisal mission. It was my privilege to handle the complete investigation works of the project at site. The statistics of the site investigation ensures keeping an engineering geologist fully employed: about 3500 m of diamond core drilling, 200 m of adit/drifts, besides a number of pits and trenches, geophysical surveys and in-situ shear and modulous tests were carried out.

The dam site is located on the Archaean basement migmatites with basic intrusives cut by a braided shear zone across the base width of the dam. The shear zone with a zonal influence of about 75 m is sympathetic to a regional shear zone having a strike extension of over 200 km (picked up on satellite imagery). The headrace tunnel cuts across the proterozoic meta-sediments such as phyllites and schists with basic intrusive. The rockmass was classified for the tunnelling grades. In 1984-85 the geo-technical report of the dam, water conductor system, reservoir competency was prepared independently and submitted to the World Bank for review. The report received commendations from the World Bank experts on engineering geology, Dr. J. Newberry from England, Chairman South East Asia for power and transport from World Bank and Prof. O.J. Rescher, Dept. of Civil Engineering, Vienna University. This came as a moral booster for me; I was learning the language of engineering geology.

By the end of 1987 I had interpreted about 9000 m of cores for geotechnical investigations, analysed some geophysical and rock-mechanics data, prepared geological maps, wall maps on different scales and 3 D geological maps of underground excavations to advise on rockmass character interaction with the support system. This work covers 38 unpublished reports with my department and 6 publications / papers of which one is in the IAEG bulletin 1982 and one in the International Tunnelling Authority (ITA) publication of 1988. Rockmass characterisation with applications to dam foundations and underground excavations is the area of interest to me.

Incompatability Geologist/Engineer

Last but not least, I would like to mention clash of communication and priorities between the geologists and the engineers, which perhaps is not the problem in developing countries only. Any project is an integrated work of the various disciplines of science. Some authorities are in the execution of such a project and some are involved in an advisory capacity. These capacities are ultimately in the interest of the well-being of mankind. The ego should find no place in the spectrum of scientific development and progressive thought. Concerted decisions are to be taken which suits best to the scientific problem. Perhaps this approach with time will bridge the widening gap between the interests of civil engineers and engineering geologists.

OBJECTIVES OF ADVANCED STUDY IN ENGINEERING GEOLOGY

by S. Manoharan, Irrigation Department, Sri Lanka

Mr. Manoharan is a civil engineer with the Sri Lanka Irrigation Department. He joined the irrigation department as irrigation engineer after obtaining the B.Sc.(Hons.) degree in Civil Engineering, engaged in design, construction & water management of irrigation works for the past ten years in various capacities as counterparts to the consultants of many donor agencies. Previous to coming to ITC he was attached to the engineering geology division. He has also been resident engineer for the Kiridioya Irrigation and Settlement project. He uses this project as an example of the type of work he has been involved with.

REQUIREMENT IN GENERAL

The satisfactory design and construction of an engineering structure can be accomplished only when the character of the soil or rock, on which or within which it is to be built, is known. For this knowledge to be obtained, the ground must be carefully studied by investigations conducted in-situ and in laboratories. Engineering structures such as roads, dams, buildings, tunnels and other underground works, are normally constructed according to the requirements of a specific design and from selected construction materials. To obtain comparable information about the soil and rock against which the structure will react, it is necessary to understand the geological processes which formed the soils and rocks, this being the only way to reveal their design and the nature of the materials of which they are composed.

In locating a dam site, for instance, good foundations are highly desirable, but when they are questionable or poor, it becomes an exercise in locating areas where either the rocks and soils can best be improved or the dam design most easily adapted to compensate for this deficiencies of the ground. Considerable economics can be achieved in the design and construction of engineering works if the ground on site can be improved, and supported where necessary. Even a knowledge of the geology of the ground to be excavated is most desirable and considered essential for ensuring the safety of personnel who will work below ground level. Hydrogeological investigations should be performed to predict the influence of groundwater upon engineering works.

Engineering geology is not just a branch of the science of geology as it uses all branches of science to obtain an equable solution to the practical problems of engineering. Physiography, historical geology, stratigraphy, structural geology, petrography, economic geology, groundwater hydrology and even palaeontology have important applications in civil engineering.

It is only with comparatively recent years that the engineering geologist is being recognised as an essential part of an organisation engaged in investigation, planning and construction of large civil engineering projects. This change has resulted primarily due to the large and growing demand of the civil engineering profession for a better understanding of the geological factors involved in building of dams and allied hydraulic structures and due to the increasing ability of the geologist to apply the other sciences in terms of engineering requirements. With this change the demand for professional geological services has grown from an occassional call for advise to the full time utilisation of a geological team composed of personnel trained and equiped for service in the civil engineering organisation.

REQUIREMENT OF THE NATION

The island of Sri Lanka has a geographical area of 65,585 sq.km. of which 90% of this area encloses 103 distinct river basins. Agriculture,consisting mostly of tea and rubber, and small industries form the economic base of the country. Until a few years ago the country was not self-sufficient in food production and had to arrange imports. Recently irrigation projects have been developed to ensure self-sufficiency in food products and generate power for industrialisation. The water resources of the country are estimated to be 41.6 million ac.ft. (51 billion cubic metres) out of which only 40.5 percent has been harnessed. The agricultural land forms 61.4 percent of the geographical area.

The water potential which can be technically and economically harnessed would be adequate to provide irrigation facilities to 80 percent of agricultural land. A proper assessment can only be achieved by proper planning and utilisation of water resources. This can only be accomplished by hydrological and geological studies. The irrigation now has a programme of obtaining geological data through observations, collection and processing. The methods, however, need improvement and refinement, as experience is gained and as a result of increasing use of modern techniques.

Reconnaisance level geological maps of the country exist, but there is very limited data on geology. Since Sri Lanka is moving from "hunting and gathering stages to the husbanding and cultivating stages", there is an increasing demand for experts to assist in exploring and formulating high standard records of geology of the country.

KIRIDIOYA IRRIGATION AND SETTLEMENT PROJECT

The geology of Sri Lanka is relatively uncomplicated. Few examples exist of earthquakes, and volcanic activity has never been recorde. A typical example of the type of geology that one can expect is that of that obtained from the geological investigation of the Kiridioya Irrigation And Settlement Project. The geomorphology of the river basin consists of three major physiographic regions a, b, and c.

a. The Highland Zone where elevation changes from 305-1829 m.

b. The Hilly Upland Zone where the elevation is intermediate,and

c. A Lowland Zone where the elevation changes from 0-183 m.

The most widespread land-forms, however, are those associated with the weathered bedrock plain in the Lowland Dry Zone. Thus more than 50% of the catchment is mantled plain, and another 10% is under valleys, valley bottoms and alluvial plains.

Geologically the rocks of the river basin can be classified primarily as cristalline, metamorphic and granitic rocks of the Pre-Cambrian age. They include a variety of metamorphosed sediments such as quartzites, crystalline limestones, granulites, garnetiferous quartzofeldspathic gneisses, charnockites, pyroxene garnet gneisses and an association of biotite hornblende gneisses, potash migmatites, pegmatites and augen gneisses. Soils of the basin fall mainly into the category of eluvial reddish brown earths and they show strong correlation with local geomorphological features.

The objective of the scheme is to ensure sufficient irrigation water storage for year-round cultivation. Hence the dry season water deficit has to be met as well as ensuring supplementing erratic rainfall and stream flow during the wet season.

REQUIREMENT OF THE IRRIGATION DEPARTMENT

The irrigation department is the government organisation responsible for the major irrigation schemes of Sri-Lanka. It is engaged on

(a) development of land and water resources for irrigated agriculture, hydropower and flood control and

(b) provision of irrigation and drainage facilities for cultivable land in irrigation and drainage projects.

The department also carries out research in hydraulics, hydrology, soil mechanics, engineering geology, engineering materials and land use as applied to water resources development projects. The functions of the Engineering Geology Division of the department include:

a. regional and area geology for irrigation projects.

b. drilling with diamond core drills, tube well rotary rigs and percussion rigs for subsurface explorations for dams, tunnels, structures etc. including water sampling, logging, and providing geologic profiles and interpretations of same.

c. geophysical surveys for foundation explorations.

d. various types of pressure grouting for foundation treatment.

e. provision of rock anchors and other methods specialised for improvement of foundation conditions.

f. instrumentation operations on dams etc.

g. maintenance operations for strengthening existing structures such as dams, spillways, bridges etc.

INDIVIDUAL ROLE

At this juncture, it will be relevant to relate one of the latest geological aspects typical of my experience. A project funded by three international lending agencies was designed in a dry zone to irrigate 15.000 ha, at a cost of about US $ 1000 million. The scheme was designed by the department checked, revised and re-revised by the consultants of the financers on various issues on geological problems and finally approved by the financers. During constructions of the spillway foundations (70 m deep & 100 m wide) a wedge of massive rock mass dipping downstream of the dam axis was intercepted at a depth of 15 m with shear zones upstream of the dam axis tracing half of the width.

A number of alternative solutions were proposed for the stability of the spillway foundation. Ultimately rock anchoring, grouting, installation of additional piezometers, drainage gallery modifications, and shotcreting was suggested by a world reknown expert to be carried out for the entire foundation to ensure its stability. The job was performed by a civil contractor from West Germany and the complete computerised monitoring system was installed by the consultants early 1986. Within one year of installation of rock anchors, 15% of them had ceased to function and the instrumentation system is completely out of order. The performance of the balance anchors is very unsatisfactory. This project has been my incentive to embark on further studies in which one aspect would be to have the opportunity to have a state-of-the-art understanding of the behaviour of rock anchors supporting a heavy weight of concrete.

FUTURE ROLE

After returning to Sri Lanka I would be entrusted with the engineering geological aspects of planning, design and construction of irrigation projects. For this an advanced knowledge of geology would improve my performance as an irrigation engineer and would fulfill the longfelt need for improvement in observation and analysis of geological data. An advanced course in geology will therefore provide me technical background and training to deal with the more significant or unexpected problems in the department. Using these techniques would assist the department in evolving better geological and hydrological designs for projects under planning stage and in achieving better performance of projects already completed.

Let me take this unique chance to thank the ITC which has provided the opportunity to introduce me and my country to you, the engineering geologists of today.

S. Manoharan

Book Review: " Proceedings of the Sixth International Congress of Rockmechanics", Montreal, Canada, 1987.

3 vol.s, vol 1 + 2, 1362 pp.
Editors: G.Herget and S.Vongpaisal. Balkema, Rotterdam. Price Hfl. 551,20 (vol.3 will contain the invited lectures presented at the Conference and still has to appear).

The 6th.International Conference of the ISRM (International Society of Rock Mechanics) occurred at the 25th. anniversary of the society. The two large volumes show that the science of rock mechanics applied to civil- and mining engineering indeed has grown up. What had been mainly an "art" some twenty-five years ago has grown into a discipline which allows a systematic approach of rock mechanic problems using geology, laboratory- and in-situ testing, computer- and physical modelling and monitoring techniques, which, if used skillfully (and together!), should lead to a more economic and safer practice of rock engineering. Today we may have reached the point where one is not allowed anymore to say: "We could not have foreseen this" after some failure of an engineered structure in rock. Such an excuse may have been given a quarter of a century ago after huge full-scale geomechanical experiments, such as the failure of the rock slope of Vajont-reservoir in Italy, or the failure of Malpasset Dam in France. Nowadays failures are often anticipated and timely warnings by monitoring techniques can prevent fatal accidents (e.g. N.A.T.M. high-speed railway tunnel construction in Germany). Of course rock engineering or rock mining remains a very risky business and fatalities are likely to occur at present and in the future. However, low budget site investigations and incapable management or research will be the cause of many of the problems and the phrase: "We could not have foreseen problems with the geology at the site" must be regarded with high suspicion.

The large format (A4 size) set of books (vol 1 + 2) contain 253 papers grouped into the four themes of the conference:

Theme 1: Fluid flow and waste isolation in rock masses (53 papers)
Theme 2: Rock foundations and slopes (55 papers)
Theme 3: Rock blasting and excavations (30 papers)
Theme 4: Underground openings in overstressed rock (115 papers)

The huge amount of contributions to the fourth topic do not reflect an increasing amount of underground construction taking place. (Although in Finland, for example, construction of a sports hall underground may be cheaper than above ground with the present-day excavation techniques and design- and support methods). Most papers concern themselves with mining problems, since in mining overstressing and failure commonly occurs.

It is not wise to attempt to summarize the enormous content of the proceedings. In general the proceedings cover most of the work going on in applied rock mechanics all over the world. Every researcher or worker in the field should have access to these books, and will have a fair chance to find something of interest.

Apparently the papers were prepared copy-ready by the authors without much (if any) editing. The national groups of the ISRM were responsible for the content of the papers from their own country. There are some papers which would have improved much with some editing, also with regard to language. The bulk of the papers is in English, but there are also contributions in French and German. All abstracts are in these 3 languages. In general much effort has been given to presentation by most of the authors; very few did not respond to the instructions regarding lay-out and letter-type but these were nevertheless printed. This book should be in the library of any institution concerning itself with civil and mining engineering in rock.

Delft, P.N.W. Verhoef.

Review:

Groundwater effects in Geotechnical Engineering,

Proc. of the 9th European Conf. on Soil Mech. and Found. Eng.,
Dublin 31st Aug. - 3 Sept. 1987,
Published by A.A. Balkema, Rotterdam 1987.

Two Volumes: Volume 1, Sessions 1-4, 114 papers, 1-530
Volume 2, Sessions 5-9, author index, 95 papers, pp 530-936
Cost: *f* 551.20 incl 6% BTW

Engineers have always been aware that water could have an effect on earth structures. Soil mechanics dates back to the time when Karl Terzaghi derived a very simple equation based on that of Coulomb from the previous century; the shear strength is dependent on the pore water pressures in the soil:

$$t' = c' + (\sigma_n - u) \cdot \tan \phi'$$

Ever since this equation was developed back in the 1920's engineers concerned with earth structures, ground water resources, excavations and foundations have been estimating the value of "u", the pore water pressure. The reduction in shear stress is only one aspect; for reduction in pore water pressures also occurs when water or fluids (one thinks of oil and gas) are extracted from the ground for dewatering excavations or for obtaining water as a resource. In the Netherlands such extraction can have serious consequences and claims for damages from such extraction are not un-common.

Review of conference proceedings can be done in two ways: either by critically examining the contents of each paper or, as often happens with conference papers by assessing the proceedings as a whole as a useful up-to-date state-of-the-art reference manual in relation to the reader's own work and experience. The first questions that come to mind are:

a -Are there arbitration or cost/damage case histories with respect to de-watering ?
b -Are there papers on contaminated ground and groundwater including case histories on cleaning operations?
c -Are there case histories on sealing dangerous chemical and nuclear wastes from contaminating the groundwater?
d -Are there papers on the consolidation and groundwater flow mechanisms in carbonate sediments?

The first volume contains four sessions:

1. Field and Laboratory Testing
2. Groundwater control
3. Environmental problems and seepage
4. Groundwater problems in embankments, dams and natural slopes

1st session: Some of the papers provide satisfactory answers to the list of questions. An example is that of Hansen et al (paper 1.12) which dealt with tunnelling in Danian chalk in Copenhagen. The paper does not mention variation of permeabilities with direction but did indicate fissures/ faults appear to influence inflows. Another paper by Toledo and Acevedo (paper 1.22) almost used the title of the symposium; "Groundwater in geotechnical engineering" but fell short in providing examples of processed test values based on their method for measuring degree of fissuring using down hole seismic methods.

The second session papers would have been better served had answers been provided to the amount of damages (or for that matter the costs) caused by dewatering systems due to tunnelling, excavations and ground water resource extraction. Why engineers always have to prove to others their analytical techniques and design dexterity (of which there are plenty of very interesting papers) without ever mentioning the economics involved is possibly a reason that engineering works are always more expensive than what they initially set out to be. The paper by Brink et al (paper 2.4) on the dewatering of a construction pit excavation did not indicate if settlements took place and lacked proper geotechnical descriptions of the aquifer soils, demonstrating that engineering geology is still an unknown subject for most civil engineers in the Netherlands. The other papers in the session give a satisfactory insight in the geological conditions of their respective sites and the settlements that the dewatering systems cause.

The third session papers are worth a separate publication consisting of only sixteen papers, all worth reading. Bergado et al (paper 3.1) are experiencing at first hand the effects of groundwater extraction as their campus (the Asian Institute of Technology) is settling in much the same as that of Bangkok (mentioned in a later paper -No. 3.10 by Prinzl and Nutalaya). Further examples of either swelling or settlements are given as a result of ground water changes in places as far afield as London, Stockholm and South Africa. A paper (No. 3.6) by Janbu considers the extraction of oil as well as groundwater but little mention is given on the distinction between extraction from sandstone reservoirs and carbonate reservoirs. The few papers on groundwater contaminant containment or cleaning suggest that this problem only exists in the Netherlands, West Germany and Denmark. The papers are useful and would help somewhat to answer questions b and c. What is obvious is that only a few geotechnical engineers are actively involved in ground water pollution problems.

The theme of the fourth session is well trodden territory for the geotechnical engineer for which their was no shortage of papers. Some papers appear to re-invent the wheel providing better than before analyses. One conclusion that can be made is that the analyses and theories one uses today should not be used for fear that tomorrow will bring something better and more accurate. Dutch articles are instantly recognizable by the way they distort dyke emankments by using different vertical and horizontal scales on their crossections. For readers outside Holland this Alpinisation of the Dutch topography could be quite disturbing.

The second volume contains the folowing sessions:

5. Special problem soils
6. Dynamic effects
7. Groundwater in foundations and excavations
8. Groundwater modelling
9. Filters

Session 5 covers a wide spectrum of problem soils such as swelling clays, collapsing sands, glacial clays, muds -with gas production, ash (tailings sediment) and suffusion soils (gypsiferous). This despite only thirteen papers. In this category partially saturated soils have also been placed, though these do not necesarily give problems except in analyzing/ determining relevant pore water/air pressures. Under- consolidated river and lake sediments can have problems in supporting dumped fill. A paper from Poland (No 5.13) investigates this aspect for an ash-tailings lagoon; quite useful reading for Dutch engineers.

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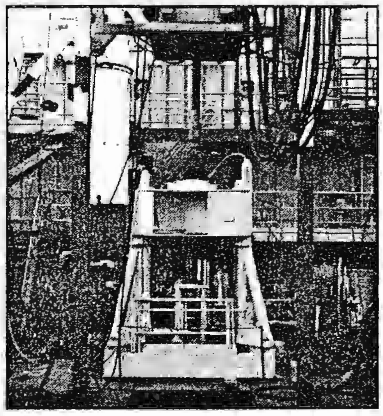

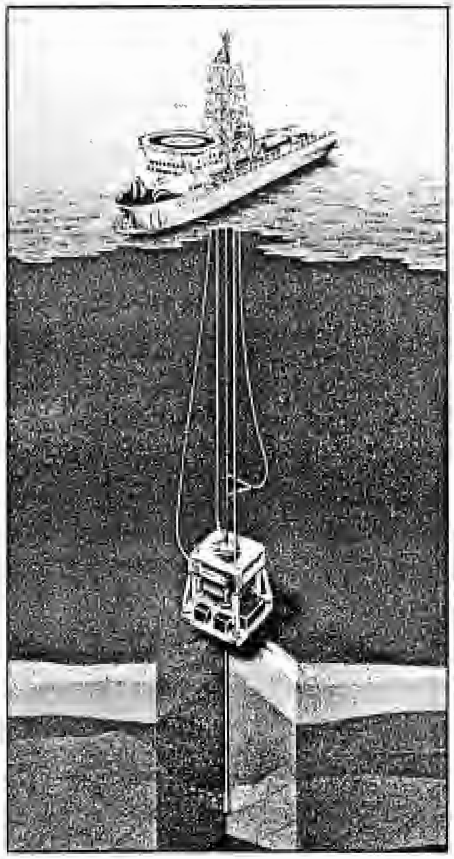

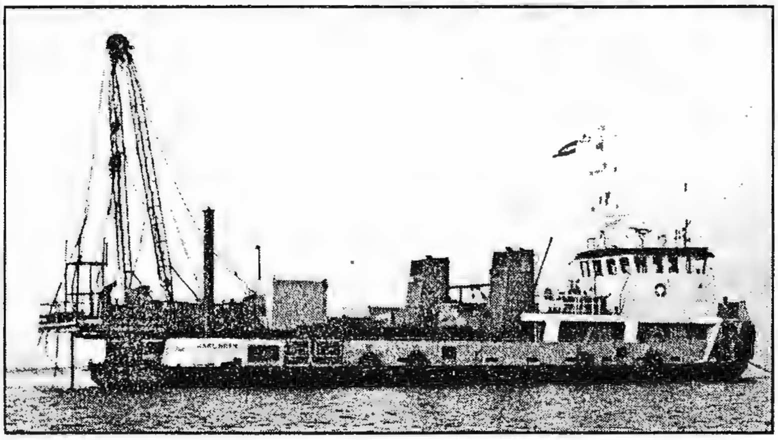

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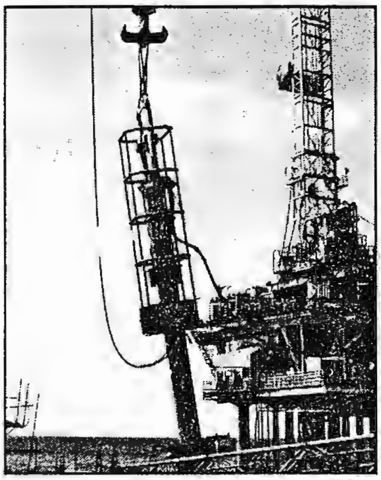

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In session 6 quite an assortment of papers constitute dynamic effects covering earthquake loading, tidal loading, cyclic sedimentation / dumping loading, pile driving and dynamic compaction. The various types of dynamic loading cause all forms of distress such as liquifaction, flow sliding, collapse settlement, changes in permeability (comapction?) and pore water pressure build up (cohesive soils). Little mention however is the cost of the damage caused by the different forms of dynamic loading.

Session 7 appears to be a more specific aspect of session 2, namely groundwater and excavations or foundations for which most of the papers covered case histories. This session proved again popular with geotechnical engineers judging by the number of papers submitted (26 papers). Of interest is one such case history concerning heave resulting from rising water tables caused by discontinuation of mining (from Hungary, paper 7.23). Such a paper could be relevant to south Limburg in the Netherlands where similar phenomena are taking place.

Finally a paper that could answer question 1; Hulsbergen and Carree (paper 7.15) presents the economics of settlement effects in an urban area in the Netherlands. The authors not only produce hypotheses for determining degrees of damage due to settlement for producing an areal distribution damage map but also go on to estimate the costs such damage causes. The usual papers appear in which better theories are produced. One such example is by Hansen et al (paper 7.12) on the design of foundations in the pore water pressure zone. Terzaghi's simple emperical design methods are just not good enough for some.

Not surprisingly,session 8's theme on groundwater modelling resulted in 32 papers of which only two came from independent firms the rest from para-statal research organisations and universities. One assumes from these statistics that a wide chasm exists between research and practice. Typical of these papers are the very complex equations of flow, slope stability and consolidation used to solve for situations having usually quite simple geological boundary conditions, or rather simplified boundary conditions. De Paz et al (paper 8.8) provides an analysis of flow coupled to stresses in jointed rock. To be able to do such an analysis, with the aid of finite element techniques the three dimensional model had to be reduced to two dimensions which is possible since they chose to analyse two boundary conditions: an isotropic condition and a horizontally bedded condition. Harr and Vedris (paper 8.14) attempt to determine the probability of exceeding a flow determined by analytical "method of sections". The analysis would be a usefull addition to Harr's book of 1962. The book hasn't dated much judging by analytical methods presented in this session. Slope stability since Bishop's method of slices back in the 50's is still having its spin-off effect; four papers rediscover slope stability. Similarly the papers on consolidation appear to offer little extra to analyses of twenty years ago. The only relevant analysis of the type of papers presented in this session would be a cost-effect analysis on the great deal of effort the authors seem to put into this subject matter.

Session 9 contrasts to a certain extent with its preceding session, there are only 11 papers which are very practical on methods of drainage. The session also demonstrates that for some in para-statal research organisations and universities would, after all, be cost effective. Practical examples are given of performance and design aspects of geo-textile drains, cemented gravel drains and traditional graded drains.

Conferences and their proceedings have since the first international conference on soil mechanics and foundation engineering back in 1936 experienced an explosive growth and one can now in geotechnics continually travel from one conference to another as professional tennis players travel from one competition to the next. Why such an explosive growth? This phenomena and its relevance to the practicing engineer has never been considered. It could possibly form a theme for the tenth E.C.S.M.F.E. An exchange of too much information and probably duplicated several times over in other conferences or publications with slight changes in nuance could form a barrier to information exchange.

Despite this explosion A.A. Balkema has consistantly produced high quality publications usually at far less cost than other publishers for similar conferences. The costs for publications has increased and it would be prudent if A.A. Balkema considered options such as paper back copies or producing separate editions of the sessions as incentive for the practicing engineer or the student to purchase these proceeding or parts there of.

P.M. Maurenbrecher
Sectie Ingenieursgeologie,
TU Delft

LEZING: PROFESSOR KEITH TURNER

Environmental Constraints effecting the construction of Interstate 70 in Colorado, USA

De lezing zal plaats vinden op Donderdag, 21 April 1988 in het gebouw van ITC Delft, Kanaalweg 3 en begint om 19.00 uur. Vooraf bestaat er de mogelijkheid tot het drinken van een borrel en te eten in het restaurant en bar van de DISH.

Keith Turner is verbonden aan de Colorado School of Mines als professor Ingenieursgeologie. Hij heeft bekendheid geworven als professor op het gebied van geo-informatie systemen. Voorlopig is Prof. Turner met studie verlof op uitnodiging van ITC en TNO DGV in Nederland.

REPORT OF THE 42th NGSMO CONGRESS

The "Nederlandse Geologische Mijnbouwkundige Studenten Organisatie" was founded on January 11 th. 1946. The aim of the organisation is to improve the contact between geology- and mining students.
The 42th NGSMO Congress was held in Delft on February 29th, organised by the Mijnbouwkundige Vereeniging.
The title of the Congress was "When things go wrong".
The theme was "The importance of geological view to avoid natural and mining disasters".
The following lectures have been presented:

- Safety and environmental aspects on a drilling rig (by Mr. A.M.M. Buysse, N.A.M.)
- Prediction of reservoir compaction and surface subsidence (by Dr.Ir.R.M.M. Smits, K.S.E.P.L.)
- Eruption of the Vesuvius in 1998 (by Drs.H.Helmers, V.U.-Amsterdam)
- Mis-interpretation of the geology for a road construction in Oman (by Mr. P.M.Maurenbrecher M.Sc., T.U.-Delft)
- Shallow Gas Detection by Seismics (by Mr.C.D. Green, S.I.P.M.).

Short abstracts of the lectures of Dr.Ir.R.M.M. Smits and Mr. P.M. Maurenbrecher M.Sc. are given below.

PREDICTION OF RESERVOIR COMPACTION AND SURFACE SUBSIDENCE
'OUTLINE OF PROCEDURES AND ECOFISK AS FIELD CASE'
(by Dr.Ir. R.M.M. Smits)

In an oil or gas reservoir the oil and gas are present in the pore space which exists between the quartz or calcite grains of the reservoir rock. The rock grains experience an overburden stress which is partly counteracted by the oil or gas pressure in the reservoir. During the oil or gas production the reservoir pressure decreases. Hence, the effective stress acting on the grains increases. This causes the rock to compact and this compaction can cause surface subsidence.
The amount of compaction and subsidence caused by oil or gas production depends on the compressibility and loading rate sensitivity of the reservoir rock, on depth, thickness and lateral extent of the reservoir and on the product scenario. The compressibility and loaded rate sensitivity have to be measured in the laboratory on representative core samples. The thus measuredd compaction behaviour has to be translated to field conditions by using several models developed at KSEPL in which the effects of loading rate, temperature, stress regime and pore content are taken into account. Subsidence is calculated from compaction using a poro-elastic theory.
The various experimental and theoretical procedures to arrive at accurate predictions of compaction and subsidence will be discussed. Particular attention will be paid to the abrupt compaction which sometimes takes place in carbonate reservoirs due to pore collapse, as e.g. in the Ecofisk field in the North Sea.

'MIS-INTERPRETATION OF THE GEOLOGY FOR A ROAD CONSTRUCTION IN OMAN'
(by Mr.P.M. Maurenbrecher M.Sc.)

Many examples exist where lack of understanding of geology and geotechnical processes has led to catastrophic failures. One cites the Vayont Dam disaster, the Aberfan mine tip disaster and more recently the Nevado del Ruiz mud-slide in Colombia or the Stava tailings dam failure in Italy. Many mishaps go un-reported unless significant loss of property or life occurs; the latter always exert promises from politicians that they will supply funds to prevent such calamities from occurring in the future, through in practice the publicity dies down quickly and conveniently the extra funding is forgotten.

What happens behind the scenes when mishaps do not reach publicity stage?
A typical case history is the construction of the main arterial freeway for the capital area of Oman. This road starts from the end of the coastal plain at Qurum to the interchange between Muscat's business center Ruwi and the port of Mutrah. Large road cuts were required through one prominent ridge and several minor ridges. In this case history the large road-cut was "designed" using rock-mechanics and structural geological principles.
The minor cut dimensions were made at very steep angles, the design criteria for these surmised at being:

- to save on excavation costs, and,
- if they fail, they are not so large and the failed material can be removed.

Failed they did, and it is of interest to compare the two approaches to rock cut design. The economics of very steep cuts can severely backfire. The example demonstrates the practival difficulty of trimming back a slope to its stable angle.

The extra costs are further compounded by the resulting road closure due to blockage of slipped material as these failures do not necessary occur during construction. In conclusion: there is no excuse for not using proper design principles for rock cuts which are like the viaducts, bridges, culverts, road embankments, the principles, codes of practice and standards.

J.W. Nijdam and E.Zwerver.

REPORT ON ROCK MECHANICS SEMINAR MEETING

Every month a seminar on rock mechanics is organised with different lectures. On February 17th. the following lectures have been presented:

- Ultrasonic measurements for crack detection during HAW experiment in the Asse mine. (by Ir.J.P.A. Roest)
- New models of salt diapirism. (by Drs. P.van der Gaag)

Short abstracts of the two lectures are given below.

Ultrasonic measurements for crack detection during High Active Waste (HAW) experiment in the Asse mine. (by Ir.J.P.A. Roest, TUD)

During the last decade a considerable amount of work has been carried out concerning the safe disposal of high level radio-active waste in salt formations. Although geological disposal in the Netherlands is still a matter of the far future, a contribution is given to a large scale demonstration test with HAW in the Asse mine in Germany (1985-1992). G.S.F., Munchen and ECN, Petten are testing in a one-to-one scale test facility the complete technical system of an underground responsitory, in order to improve the final concept for high level waste disposal.
The Delft University of Technology has installed a measuring system for the long term observation and recording of cataclastic effects around test borehole B1. This borehole is provided with an electrical heater. Possible macro- and microfracturing will be detected by means of so-called acoustic crosshole measurements. Preliminary results were shown of the measurements of the intact rocksalt before heating. The expected structural changes were explained by means of the results of field tests and model experiments.

New models of salt diapirism. (by Drs.P.v.d.Gaag, consultant Groundcontrol, Rotterdam)

In this lecture two new models were proposed for the development of salt diapirs. Rapid heat advection to salt layers under certain conditions may trigger salt diapirism. Thermal expansion during the thermal recovering process after rapid salt accumulation in rift basins will produce salt ridges and salt walls in fault zones. In both models the difference in thermal properties between rock salt and other sediments is critical. Another factor of importance not yet incorporated in known models is the deposition rate of rock salt which may be 10-100 times higher than the deposition rates of other sediments.

J.W. Nijdam.

N.B.:
(If you want any information on the rock mechanics seminar: Please, contact Peter N.W. Verhoef, TUD)

CONFERENCES, SEMINARS and SYMPOSIA

1988:

11-15	april	6th International Conference on Numerical Methods in Geomechanics. - Innsbruck, Austria. (Kongresshaus Innsbruck, ICONOMIG 88,Rennweg 3, A-6020, Innsbruck, Austria.)
13	april	Rock Seminar Meeting. - Delft, The Netherlands. (Delft University of Technology, Faculty of Mining and Petroleum Engineering, Section Engineering Geology, Mijnbouwstraat 120, 2628 RX Delft, The Netherlands, phone 015-782543.)
15	april	Het kwartair in de Noordelijke Andes. - Amsterdam, The Netherlands. (Secretariaat INQUA Commissie Nederland, Mw. M.K. van Helden, KNAW, postbus 19121, 1000 GC Amsterdam, The Netherlands, phone 030-535052 of 020-222901.)
18-21	april	Tunneling 88, 5th International Symposium. - London, England. (The Conference Office, Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, England.)
23-24	april	Field weekend: Dams in North Country/Pennines. (Geological Society, Burlington House, Piccadilly, London W1V 0JU, England.)
25-27	april	Centrifuge 88. - Paris, France. (French Committee for Soil Mechanics, Mr. Jean-Francois Corte, LCPC, B.P. 19, F-44340 Bougenais, France.)
27-29	april	8th National Rock Mechanics Symposium. - Aachen, Germany. (DGEG, Kronprinzenstr. 35A, D-4300 Essen 1, Germany.)
29	april	Contactdag Deltagebied. - Veere, The Netherlands. (Koninklijk Nederlands Geologisch Mijnbouwkundig Genootschap, Secretariaat: Postbus 157, 2000 AD Haarlem, The Netherlands.)
11	may	Rock Seminar Meeting. - Delft, The Netherlands. (Delft University of Technology, Faculty of Mining and Petroleum Engineering, Section Engineering Geology, Mijnbouwstraat 120, 2628 RX Delft, The Netherlands, phone 015-782543 (to be put on mailing list).)
17	may	Engineering Geology and Groundwater in Land Reclamation. - Glasgow, Scotland. (Dr. M.S. Lawrence, Johnson Poole and Bloomer, Templeton Business Centre, Templeton Street, Glasgow G40 1DW, Scotland, phone 041-5548833.)

19	may	Symposium Milieu en Aardwetenschappen. - Delft, The Netherlands. (Delft University of Technology, Faculty of Mining and Petroleum Engineering, Section Engineering Geology, Mijnbouwstraat 120, 2628 RX Delft, The Netherlands, phone 015-785192.)
1- 3	june	2nd International Conference on Case Histories in Geotechnical Engineering. - St Louis, U.S.A. (Civil Engineering Dept., University of Missouri-Rolla, Rolla m.o. 65401-0249, U.S.A. .)
	june	Tunnels and Water. - Madrid, Spain. (Association Espagnola de Tuneles y Obras Subterranes (AETOS), Calle Martines Izquierdo, 53, 2, 3, E-28028 Madrid, Spain.)
13-15	june	16th Congress of the ICOLD. - San Francisco, U.S.A. (ICOLD '88, Mr. H.L. Blohm, Secretary, Bechtel Civil, P.O. Box 3965, San Francisco CA 94119, U.S.A. .)
13-15	june	Key Questions in Rock Mechanics. - Minneapolis, U.S.A. (Dr. Raymond L. Sterling, University of Minnesota, Dept. of Civil and Mineral Engineering, 500 Pillsbury, drive S.E. Minneapolis, U.S.A. .)
10-15	july	5th International Symposium on Landslides. - Lausanne, Switzerland. (Mr. Christophe Bonnard, Secretariat du 5eme Symposium International sur les Glisement de Terrain, Case Postale 83, CH 1015 Lausanne 15, Switzerland.)
22-26	august	5th Australia - New Zealand Conference on Geomechanics. - Sydney, Australia. (Mr. Michael J. Thom, c/o D.J. Douglas & Partners ltd., 322 Victoria Road, Rydalmere, NSW 2116, Australia.)
4- 9	september	24th Annual Conference: Field Testing in Engineering Geology. - Sunderland Polytechnic, England. (Dr. F.G. Bell, Engineering Group, The Geological Society, Burlington House, Piccadilly, London W1V 0JU, England.)
12-16	september	Rock Mechanics and Power Plants (I.S.R.M. symp.). - Madrid, Spain. (Sociedad Espagnola de Mechanica de las Rocas, Paseo bajo de la virgen del puerto 3, E-28005 Madrid, Spain.)

19-23 september Engineering Geology as related to the study, preservation and protection of ancient works, monuments and historical sites. - Athens, Greece. (Greek Committee of Engineering Geology, 1988 symposium secretariat, P.O. Box 19140, GR-11710 Athens, Greece. For more information: Dr. J.J.A. Hartevelt, P.O. Box 63, 2260 AB Leidschendam, phone: 070-111444.)

october International Geotechnical Symposium on the Theory and Practice of the Earth Reinforcement. - Kyusku, Japan. (Prof. N. Miura, Dept. of Civil Engineering, Fac. of Science and Engineering, Saga University, Saga 840, Japan.)

1989:

25-28 june International Conference on Storage of Gasses in Rock Caverns. - Trondheim, Norway. (The Norwegian Institute of Technology, Studies Administration, N-7034 Trondheim, Norway.)

10-14 september 25th Annual Conference - Quaternary Engineering Geology. - Edinburgh, Scotland. (Dr. J.A. Little, Dept. of Civil Engineering, Heriot-Watt University, Edinburgh EH14 4AS, Scotland.)

Storage of Gasses in Rock Caverns
The Norwegian Institute of Technology
Studies Administration
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Trondheim, Norway, June 25 – 28, 1989

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The 25th Annual Conference of the Engineering Group of the Geological Society is to be held at Heriot-Watt University, Edinburgh, from Sunday 10 to Thursday 14 September 1989. The Conference is to be held in association with the International Association of Engineering Geology.

The title of the Conference is:

QUATERNARY ENGINEERING GEOLOGY

It is intended that this Conference will cover all aspects of Engineering Geology relating to the Quaternary. An important feature of the Conference will be key thematic addresses on various aspects of the Quaternary and its engineering legacy.

▲ THEME

The theme of the Conference is deliberately broad so as to provide an international forum for all academic and practising engineering geologists whose area of work is in the Quaternary.

Both glacial and non-glacial aspects of the Quaternary will be covered, but particular emphasis will be placed on

(i) case histories of a regional engineering geological nature
(ii) constructional aspects of Quaternary sediments
(iii) engineering implications of Quaternary effects, eg. periglaciation, weathering etc.

THE ENGINEERING GROUP OF THE GEOLOGICAL SOCIETY

25th Annual Conference

▲ PROGRAMME

The four day programme will include main, discussion and poster sessions, as well as field excursions, a trade exhibition and a social programme.

▲ ABSTRACTS

The closing date for abstracts is 31 October 1988.

Papers will be refereed by the Engineering Group Editorial Committee. Papers accepted will be published in the Conference Proceedings. Prospective authors are invited to submit abstracts of their papers/technical notes, not exceeding 300 words, to:

Dr F G Bell
Engineering Group Editor
Geological Society
Burlington House
Piccadilly
London W1V 0JU.

▲ POSTER SESSIONS

The Organising Committee wishes to encourage Research Students to attend and contribute to the Conference and is providing Poster Sessions for this purpose. Authors of papers not selected for oral presentation may wish to take advantage of Poster Sessions. Posters accepted as Technical Notes will be published in the Conference Proceedings. There will be a special student's rate for the Conference. Enquiries regarding Poster Sessions to Dr J A Little, Organising Committee Secretary (Telephone 031-449 5111).

▲ EXHIBITING

An important aspect of the Conference will be a Products and Services Exhibition mounted by Consultants, Contractors, Publishers and Equipment Manufacturers. Companies requiring information on exhibiting at the Conference should contact Dr J A Little.

▲ ACCOMPANYING PERSONS

If sufficient demand exists, an accompanying persons programme will be available for wives/husbands of Conference delegates wishing to attend.

▲ VENUE

Edinburgh, the Scottish capital city is an administrative capital and international centre of finance, banking, commerce and tourism. Home of the famous International Festival, the city is well served by transport and communications by road, rail and air.

Heriot-Watt University is rurally situated on the western outskirts of Edinburgh on the 275 acre site of the Riccarton campus — an old estate of landscaped park and mature trees around a small loch.

Accommodation and full international conference facilities are available on the campus, including a bank, a medical centre, a sports centre and other amenities.

HERIOT-WATT UNIVERSITY

QUATERNARY ENGINEERING GEOLOGY

10-14 September 1989
Heriot-Watt University
Edinburgh, Scotland

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Please return to:

Dr J A Little
Department of Civil Engineering
Heriot-Watt University
Edinburgh EH14 4AS
Scotland.

"Milieu en Aardwetenschappen"

Op **19 mei 1988** zal onder auspicieën van de faculteit der Mijnbouwkunde en Petroleumwinning aan de Technische Universiteit te Delft, een symposium worden georganiseerd met het thema:

" Milieu en Aardwetenschappen "

Het symposium vindt plaats in de Aula van de Technische Universiteit Delft, Mekelweg 1.

De organisatoren van dit één-daagse symposium, het Dispuut Ingenieursgeologie (DIG) in samenwerking met de Mijnbouwkundige Vereeniging, het KIVI en de Ingeokring hebben tot doel studenten met enige kennis van de Geologie warm te maken voor het geologische aspect van het onderwerp milieu .

De dag zal bestaan uit vier sessies. De onderwerpen van de eerste drie sessies zijn achtereenvolgens:

- Geologiscne Berging
- Bodembeschermíng
- Mijnbouw, vervuiler of verschoner?

De vierde sessie zal een forumdiscussie bevatten waarin U in de gelegenheid wordt gesteld wat dieper op de onderwerpen in te gaan.

Vertegenwoordigers van verschillende bedrijven en instellingen krijgen 15 minuten de tijd om hun ervaringen, onderzoeken en meningen omtrent de genoemde onderwerpen naar voren te brengen. De sprekers maar ook bedrijven en instellingen zonder spreker wordt de mogelijkheid geboden middels posterstands de aandacht op zich te vestigen.

De inschrijving begint om 8.30 uur waarna om 9.30 uur het symposium zal worden geopend. De dag wordt om 16.30 uur besloten met een borrel. De kosten van deze dag bedragen:

Leden Kivi/KNGMG/ingeokring	fl 40,-
niet leden	fl 60,-
studenten	fl 15,-

Deze bedragen zijn inclusief lunch en afsluitende borrel en dienen op de dag zelf betaald te worden.

Voor meer informatie omtrent de betreffende onderwerpen en de posterstands kunt U zich vervoegen tot de organisatie:

Dispuut Ingenieursgeologie
Faculteit der Mijnbouwkunde en Petroleumwinning
Sectie Ingenieursgeologie
Mijnbouwstraat 120
2628 RX Delft
Tel.: 015-785192

Opgave voor het bijwonen van deze dag geschiedt middels het invullen van onderstaand registratieformulier.

Registratie formulier

Symposium: **"Milieu en Aardwetenschappen"**

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Een gereduceerd tarief geldt voor leden van de volgende instanties: KIVI, Ingeokring en KNGMG. Indien lid, Lidmaatschapno. ____________________

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Normaal	fl 60,-
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Studenten*	fl 15,-
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