Ingenieurs Geologische Kring
Netherlands Section of Engineering Geology
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INGEOKRING NIEUWSBRIEF

November 1988

NIEUWSBRIEF INGEOKRING

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Inhoud: pag.

Van de redaktie

Voor u ligt alweer het derde nummer van 1988.
Tot onze spijt is de uitgave van dit derde nummer enigszins vertraagd.
Door het ontbreken van voldoende kopij waren wij genoodzaakt de nieuwsbrief een maand later te laten verschijnen.
Het volgende nummer kunt u eind december verwachten.
Hierin zal een uitgebreid verslag staan van de jaarvergadering van de Ingeokring.
De nummers van 1989 zullen in maart, juni, oktober en december verschijnen.

Nieuwsbrief van de Ingenieursgeologische Kring
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LANDGEBRUIK

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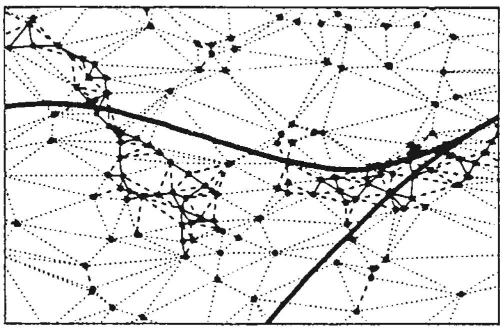

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Summary of results of doctoral-thesis on

THE INFLUENCE OF DISCONTINUITIES WITH RESPECT TO THE GROUNDWATER FLOW IN THE LIMESTONE AQUIFERS OF SOUTH LIMBURG

by Ir. R.G. de Wit, September '88
Section of Engineering Geology
Delft University of Technology

Introduction

In behalf of provincial groundwater management, a plan had been drawn up recently by order of the Hydrological Department of the province of Limburg. The plan recognized that the influence of faults and joint systems on the permeability of the limestone aquifers was not well understood. To enable the provincial government to evaluate regional groundwater flow by means of computer models a quantification of these influences was required.

Within the general framework of a co-operation between the province of Limburg and the Section of Engineering Geology at the Delft University of Technology a study was carried out with relation to the influence of discontinuities on the permeability of aquifers in the Maastrichtian limestones.

The thesis quantifies the influence of discontinuities with respect to the permeability, based on an extensive literature study, field surveys and laboratory measurements.

It contains a qualitative description of the hydrology of rock masses, especially of limestone aquifers. The quantitative description of the permeability of rock masses is based upon the homogeneous model. Furthermore attention is given to anisotropy and heterogeneity, with specific reference to the analysis of pumping tests in rock masses. In addition the influence of discontinuities was tested with models based on the finite element method. Dispersion of contaminants in rock masses is also under discussion. Furthermore, an inventory of the geohydrology of South Limburg has been made. Finally, on basis of the homogeneous model, the permeability of the limestone aquifer is derived from the results of field and laboratory measurements. This calculated permeability is compared to the measured local and regional permeabilities of the aquifer.

In the following a summary of results is presented. The report (written in Dutch language) is available from the Section of Engineering Geology at the Delft University of Technology. In view of my interest for this subject I would readily give further information to those who are interested.

The address: Jegerinkhorst 33, 7531 VP Enschede, the Netherlands

An aquifer characterized as a rock mass

A rock aquifer can be characterized as a rock mass: massive rock material divided by more or less open discontinuities.

Rock material is build up of intergranular pores up to 50 % of the total volume (porosity). The pores which are of importance for the flow and storage of groundwater must be connected to each other (effective porosity). The porosity depends on grainsize-distribution and diagenesis of the original sediment. Discontinuities can be distinguished into different types: bedding, jointing, foliation and faulting.

The space in a rock mass incorporated by the pores in the grain matrix and the discontinuities is referred to as primary and secondary porosity respectively. The secondary porosity constitutes only 0.1 - 0.4 % of the total porosity in a rock mass. As far as the primary porosity is far less than the secondary porosity, the primary porosity is responsible for the storage of the groundwater, whereas the secondary porosity is responsible for the permeability in an aquifer.

The flow of groundwater in a rock mass is mainly controlled by open faults and joints; bedding and foliation are mostly of secondary importance. If the aperture of such discontinuities is sufficiently large, the permeability of the rock mass will increase in the direction parallel to these discontinuities. Therefore the permeability of a rock mass is much higher than the hydraulic conductivity[1] of the rock material. However, the permeability in a rock mass may vary as a result of karst processes, changes in lithology and different tectonic stresses. Consequently it is not correct to assume one value to be valid for the permeability of a rock mass as a whole.

The rock material can exhibit an anisotropic hydraulic conductivity as a result of the non-uniform characteristics of the grain matrix. Also the permeability of a rock mass will mostly exhibit an anisotropy under the influence of joints which are concentrated in one direction.

The anisotropy of an aquifer such as the Formation of Gulpen, which is one of the water bearing limestone formations in South Limburg, is totally dependent on the characteristics of the network of discontinuities in the aquifer. An analysis of a pumping test with 4 piezometers at Caberg by the Hantush method and the exact method[2] showed that the main axis of anisotropy could be approximately related to the direction of discontinuities as were detected on aerial photographs. It became evident however that the limestone formation at Caberg has to be regarded as an anisotropic and heterogeneous aquifer.

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[1] In this report, '(hydraulic) conductivity' refers to rock material or individual discontinuities, whereas 'permeability' refers to the rock mass as a whole.

[2] Developed by the author.

Homogeneous model of permeability of a rock mass

The groundwater flow in a rock mass can be described by a homogeneous model. Although the groundwater flow in the limestone aquifers of South Limburg, strictly speaking, is related to inhomogeneous models the application of homogeneous models is allowed when a radial flow condition to the well is established or when large scale regional groundwater flow is considered.

Application of the homogeneous model requires the aquifer (rock mass) to be divided into homogeneous parts with more or less identical characteristics such as joint density. With the help of friction laws it is possible to calculate the permeability of those parts.

The friction laws relate the viscosity of the fluid and the aperture and wall roughness of the fissure to the flow velocity of water in fissures. Therefore the hydraulic conductivity of joints can be calculated, based on this 'parallel-plate' model.

The groundwater flow in joints is divided into several flow conditions: laminar and turbulent, parallel and non-parallel flow. These conditions lead to several friction laws for groundwater flow in joints. It can be shown that in joints with apertures $2a_i$ up to 0.1 mm laminar flow conditions prevail, even for hydraulic gradients over 1000. This means that in most aquifers the groundwater flow in joints with apertures less than 1 mm is in laminar state.

The friction law for laminar parallel flow with smooth walls:

$$k_{sv} = g \frac{(2a_i)^2}{12\ \mu}$$

in which k_{sv} = hydraulic conductivity of the joint [m/s]; g = gravity acceleration [m/s²]; $2a_i$ = aperture [m] and μ = kinematic viscosity [m²/s].

This formula illustrates that the hydraulic conductivity of a joint is mainly controlled by its aperture. A minimum of 4 μm is necessary for groundwater to be able to flow through a joint. Generally spoken such apertures are not encountered below a depth of approximately 200 m.

Joint-walls usually have a rough surface. The roughness of the walls is described by the 'relative roughness': the quotient of absolute roughness k [m] and hydraulic diameter D_h [m]. This factor is introduced in the several friction laws. In practice the aperture of discontinuities can be only be approximated.

The friction laws as mentioned above are valid for one-dimensional flow. These laws however can be simply translated into a two-dimensional groundwater flow-system. The hydraulic conductivity in joints therefore is a two-dimensional tensor whereas the permeability of the rock mass is a three-dimensional tensor.

By means of tensors it is possible to add up the hydraulic conductivity of several hydraulic components such as joint sets and rock material. In this way a three-dimensional expression is obtained for the permeability of the rock mass as a whole.

It is important to note that the strike direction of the joints does not necessarily coincide with the direction of the hydraulic gradient. Therefore the joint set hydraulic conductivity depends upon the orientation of the joints in relation to the direction of the hydraulic gradient. This aspect is allowed for by the homogeneous model.

The aperture of discontinuities plays an important role in the homogeneous model. The joints in the limestone aquifers in South Limburg exhibit very small apertures. Therefore a reliable estimation of apertures of discontinuities is very difficult. A promising method however is to adapt the rock mechanics approach, based on the Joint Roughness Coefficient.

This method relates JRC of a given joint to its initial mechanical aperture by means of an empirical formula (eventually corrected for scale effects). Subsequently the hydraulic aperture can be derived from a formula based upon a trend analysis of mechanical and hydraulic apertures. With help of both types of apertures it is possible to pre-estimate the flow condition in the specific joint. The method accounts for the combined effects of joint-wall roughness, undulating joint planes and the influence of non-continuous apertures.

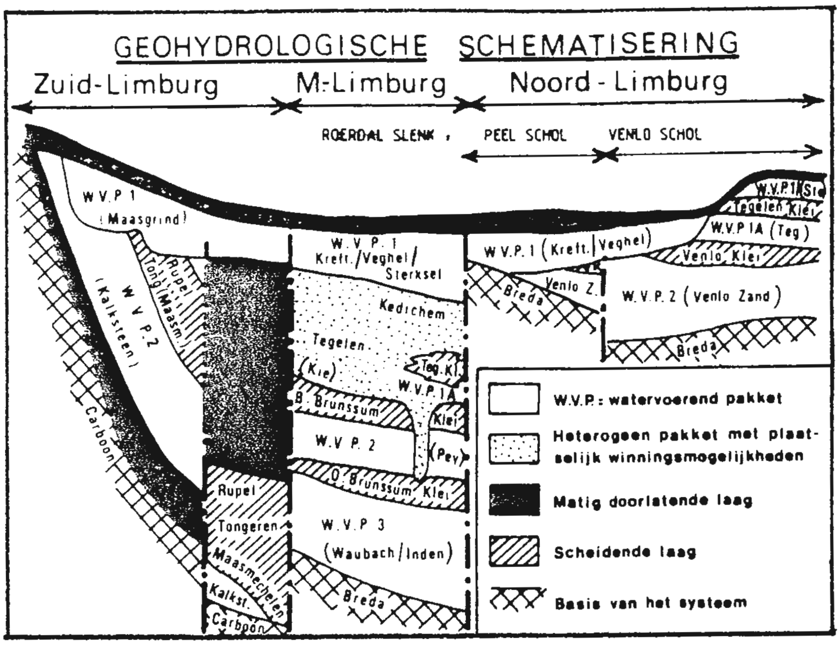
Geohydrology of the limestone aquifers in South Limburg

The geology of South Limburg is characterized by large faults (Feldbiss and Heerlerheide fault) and the presence of geologically old formations near to the earth's surface.

As a result of an overall dip to the north west, increasingly older formations are to be found in a southern direction. These formations are covered by Quaternary loess layers and river terrace deposits. The most important geohydrological units are:

- Carboniferous
  (shales and sandstone);
- Formations of Aken and Vaals
  (clayey sands and sandy clays);
- Formations of Gulpen, Maastricht and Houthem
  (limestone);
- Formations of Tongeren, Rupel and Breda
  (clay and clayey sands);
- Oölitic-gravel Formation and Formation of Heksenberg
  (sands with brown coal), and
- Pleistocene deposists of the river Maas
  (terrace gravels) and the loess.

The relative position of these units is given in the following cross-section.



The main water bearing formations are the Formations of Gulpen, Maastricht and Houthem, the Formation of Heksenberg and the Pleistocene river terrace deposists in the Maas-valley. The Formations of Tongeren, Rupel and Breda are considered as poorly permeable layers between the aquiiers mentioned above. The hydrological base of the system consists of Carboniferous deposits.

The first aquifer consists of terrace gravels of the river Maas, covered by loess layers. Below the bottom of this aquifer Miocene sands are to be found. This sequence extends north of the line Heerlen - Maastricht, where the second aquifer (limestone formations) is separated from the first aquifer by the clayey Oligocene deposists. The groundwater in these formations therefore is semi-confined. South of the line the layer between the second and the first aquifer is not present anymore. Therefore both aquifers are to be considered as one aquifer.

The Formations of Houthem, Maastricht and Gulpen are hydrologically combined to one aquifer. However, these formations are lithologically spoken not homogeneous at all. Furthermore it has been found that the limestone aquifers in South Limburg show different features such as bedding, joints and faults. Besides the limestones in South Limburg (more than 90 % $CaCo_3$) are especially prone to karstification. Therefore the geohydrology of these aquifers is affected by karst processes, which may result in stream flows in the aquifer.

In general it is assumed that the groundwater flow in the Formations of Maastricht and Houthem takes place in the porous matrix as well as along fissures in the harder parts of the rock. The groundwater flow in the Formation of Gulpen is believed to be concentrated along fissured hard rock zones as well as along joints associated with fault zones.

Results of field survey and laboratory measurements

A field survey in the ENCI-quarry near Maastricht was carried out to determine the groundwater flow patterns with respect to the geology and to the application of the homogeneous model. The survey was concerned with the investigation of the characteristics of the material and of the discontinuities such as bedding, joints, faults and flint layers. Furthermore the material hydraulic conductivities and the local and regional rock mass permeabilities were determined.

The survey was restricted to the Lixhe-formation as this was in the water bearing part of the Formation of Gulpen. See lithostratigraphical profile on the following page. This formation consists of a calcarenite build up of loosely packed grains and is porous. The overall lithology of the rock mass consists of massive calcarenites with irregular flint layers. There is strong evidence that (a part of) the groundwater flow takes place along these flint layers. The formation shows a slight tilting (1 - 2°) to the north.

The material hydraulic conductivity of the Lixhe-formation varies between 0.0144 m/d for yellow oxidized limestone and 0.0565 m/d for grey limestone. These hydraulic conductivities are rather low when compared to other limestones. The material hydraulic conductivity appeared to be slightly anisotropic.

The primary porosity varies between 42 % for yellow and 45 % for grey limestone. This porosity is rather high when compared to other rock types which normally show porosities ranging from 5 to 25 %. It has been found that the primary porosity of the yellow limestone is reduced by the formation of secondary calcite crystals as a result of solution processes. The combination of a low hydraulic conductivity with a high porosity leads to a high storage coefficient for this limestone.

If the hydraulic head in this aquifer decreases very rapidly, the water in the pores of the rock will take up the increased grain-pressure. Therefore the storage in the pores will almost remain constant, favoured by the low material hydraulic conductivity. In that case the following expression for storage is valid:

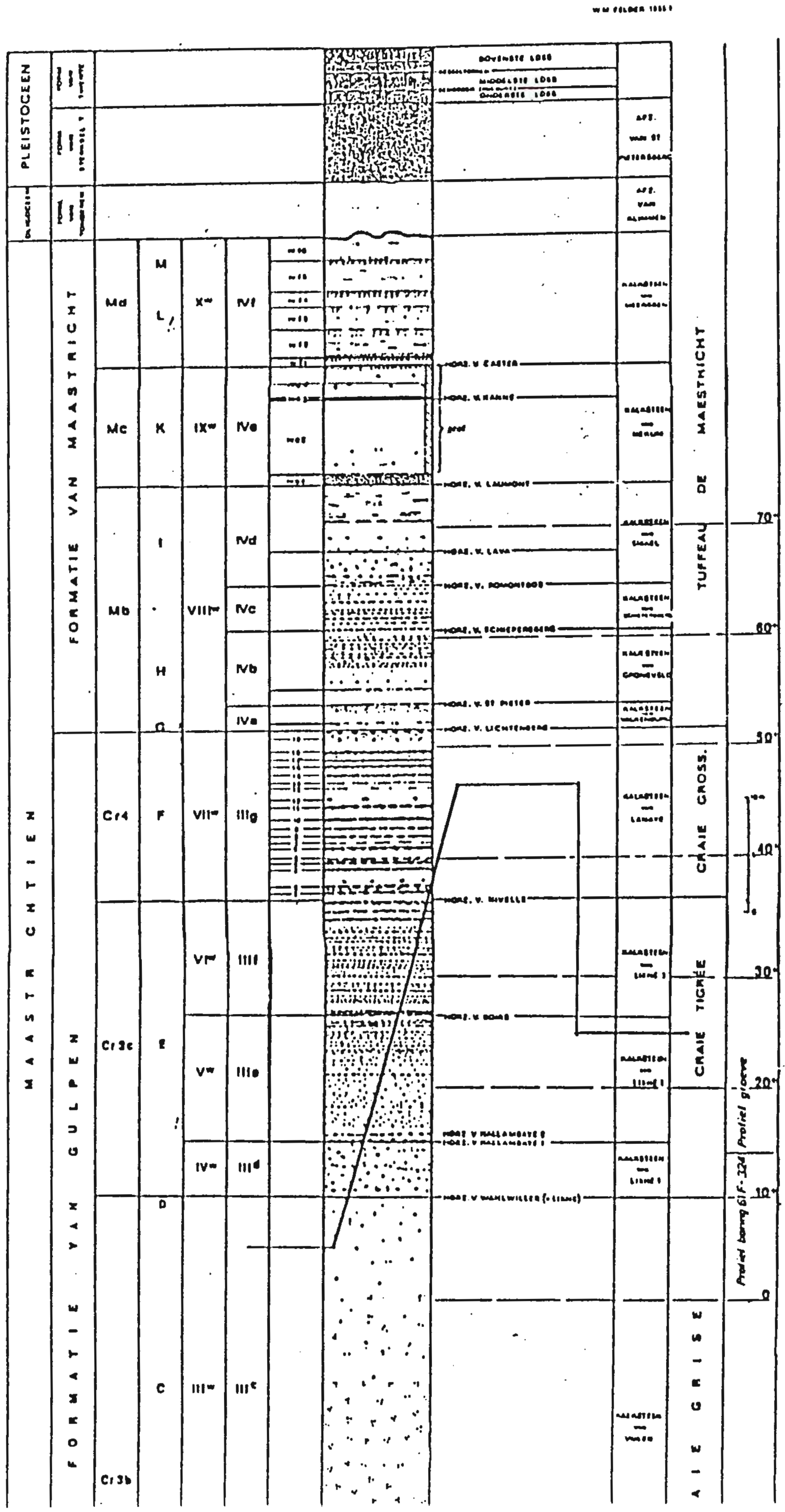
$$S_{SV} = \tau \; g \; 1/K_W \; 2a_i \; 1/d$$

in which S_{SV} = storage coefficient of a (semi-)confined undeformable non-porous rock mass [1/m]; τ = density of water [kg/m^3]; g = gravity acceleration [m/s^2]; K_W = compression modulus of water [N/m^2]; $2a_i$ = aperture of the discontinuities [m], and d = spacing between discontinuities [m].

A microscopical study of thin sections revealed that the rock matrix is build up of calcite that had been in solution and precipitated again, indicating a high degree of recrystallization. The very small joints in the sample (almost invisible with bare eye) appear to be intragranular. The apertures vary between 0.025 and 0.0375 mm and the joints are undulating. They may not be continuous: especially very small apertures show an irregular

LITHOLOGISCH PROFIEL

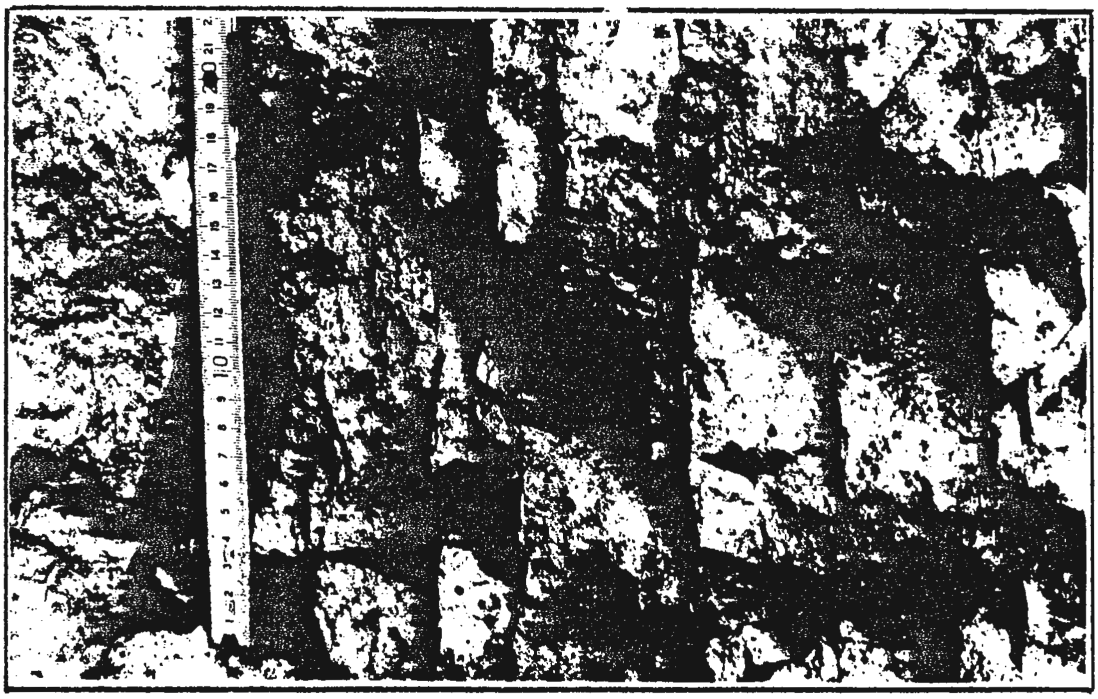
GROEVE ENCI (61F 19) SINT PIETERSBERG
MAASTRICHT



aperture. In that case the groundwater flow is concentrated in an 'effective flow area'. This phenomenon is mainly due to varying stresses across the joints. Along the wall of the joints very small secondary calcite crystals are to be found as a result of the flowing of groundwater in the joint. Furthermore the porosity in the material near to joints is slightly increased by 1 - 5 %.

The bedding in the Formation of Gulpen is not very distinctive and therefore it does not contribute to the regional groundwater flow. It may only be of importance by diverting the regional groundwater flow direction.

In the field extensive scanline surveys were carried out to determine joint frequency, orientation and persistence. Together with the inter-connection of joints in a rock mass they greatly affect the development of permeability in a rock mass. Flowpaths will be concentrated in the direction in which most joints occur. The photograph below illustrates the joint system in the Lixhe-formation.



Joint system in Lixhe-formation.

The joints were found to be concentrated along N020E/90 on the stereo-net. The orientation of the joints approximately corresponds to that of the fault direction so they may be a result from the same tectonic stresses which caused the faulting. Besides the direction of the joints is parallel to the hydraulic gradient across the quarry to the river Maas. The quarry is to be mined to a depth below the watertable of the river Maas, probably resulting in an intensified inflow from the river by means of the joint-system. The average spacing is 0.13 m, the length of the joints is about 0.72 m with a maximum persistence of 4.50 m. Most joints are straight and show very small apertures. They are intersecting with one or more horizontal flint layers.

It has been found that large zones in the formation show a distinctive yellow colouring. This yellow oxidation discolouring has also been observed along faults. The yellow colouring is attributed to intensified oxidation of the limestone, caused by the increased permeability. In the large zones an increase in joint density as well as in length of the joints been proven, indicating an increased permeability indeed.

The faults in the formation are relatively small: throws vary between 0.05 and 1.75 m.The orientation of the faults is about N220E/70. In general the fault planes are undulating. The width of the fault zone varies as does the number of joints in these zones. A small (0.10 m) very strong weathered zone is present in many fault zones. The characteristics of the fault zones are very diverse, even within a small distance in the same fault. This indicates that the hydraulic conductivity can vary significantly along the faults. Infilling of the fault plane by breccia or mylonite may warrant them as hydraulic conductors and hydraulic barriers respectively. Brecciated or open faults probably act as drains for flow in the rock mass joint system. The persistence of the faults is relatively small (< 200 - 300 m) so the regional groundwater flow is not strongly affected.

The horizontal flint layers in the Lixhe-formation are rather irregular. The mean diameter of the flintstones is about 0.20 m. Sometimes Liesegangrings (spherical diffusion) can be encountered near to the flint layers. The importance of flint layers for the groundwater flow in this formation is emphasized by the fact that joints, which are not in direct contact to each other, can communicate through the conductive flint layers. It is not clear yet to which degree the vertical permeability in the aquifer is affected by the presence of the flint layers.

The local permeability of the Lixhe-formation was estimated by means of rising head tests. These tests mainly reflect the horizontal permeability. Application of three different methods yields permeabilities varying from 0.07 to 0.27 m/d. This variation is probably a result of a strongly decreasing permeability with increasing depth.

The permeability-tensor K for the Lixhe-formation was derived. The derivation of the following expression is given in the thesis and essentially was derived from a combination of joint survey, joint roughness classification, laboratory hydraulic conductivity tests and field permeability tests (rising head tests as well as a large scale pumping test). The method of derivation involves statistical analysis of joint characteristics. The method is to be published in due course in english in a technical note.

In a three-dimensional coordinate-system, with the x-axis horizontal parallel, the y-axis vertical parallel and the z-axis perpendicular to the strike direction, it follows:

$$K \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0.685 & 0 & 0 \\ 0 & 0.695 & 0 \\ 0 & 0 & 0.056 \end{bmatrix} \ m/d$$

This K-tensor suggests a very strong anisotropy of about 1:12.

An estimation of the rock mass-permeability based on the pumping for dewatering in the quarry yields a permeability of 0.10 - 0.12 m/d.

Conclusions

- The limestone aquifers in South Limburg can be divided into 4 successive zones:
  - an unsaturated zone in which vertical flow of infiltrate (precipitation) takes place;
  - a zone with seasonal fluctuations of the groundwater level, resulting in intensified karstification;
  - a zone in which the drainage is controlled by the local net-work of discontinuities, and
  - a zone of deep groundwater flow, unaffected by local systems of discontinuities.

- The material hydraulic conductivity of the limestone is much lower than the measured permeabilities. This indicates that the permeability of the formation is greatly influenced by the presence of joints and flint layers, despite the very small apertures of most joints. Especially the yellow parts of the formation may contribute to the permeability of the formation. The resulting solution and precipitation processes of calcite account for the low hydraulic conductivity and porosity of the yellow limestone.

- The Formation of Gulpen has to be considered as anisotropic with regard to the (regional) permeability. This anisotropy may be weakened by the horizontal conductive flint layers. It is likely that on a regional scale the heterogeneity will decrease in importance.

- Due to the very low permeability of the Formation of Gulpen it cannot be regarded as an important water-supply aquifer. The presence of faults could give a favorable production. However, the high flow velocities in these fault zones may considerably reduce the filtering capacity of the aquifer. An eventual dispersion of a contaminant may take place at a very high rate due to the presence of joints. This is promoted by the occurrence of karst phenomena just below the covering layer on top of the limestone, in which turbulent flow conditions prevail.

- Comparison of the calculated permeability with the measured permeabilities of the Lixhe-formation indicates a discrepancy. However, regarding the order of magnitude, the results indicate that an application of the homogeneous model to regional groundwater flow is possible.

REGLEMENT VAN DE INGENIEURS-GEOLOGISCHE KRING

van het Koninklijk Geologisch Mijnbouwkundig Genootschap (K.N.G.M.G) en van de met het K.N.G.M.G. samenwerkende verenigingen.

Artikel 1: Oprichting en doel

1.1. De Ingenieurs-Geologische Kring is opgericht op 24 april 1974 en gevestigd te 's-Gravenhage.

1.2. Het doel van de Kring is:
  a. de toepassing van de geologie bij de voorbereiding, uitvoering en instandhouding van civieltechnische werken te bevorderen;
  b. het bieden van een forum, waar ingenieurs en geologen elkaar leren verstaan;
  c. het bevorderen van de uitwisseling tussen geologen en ingenieurs van opgedane ervaring en kennis zowel in nationaal als internationaal verband.

Artikel 2: Wijze hoe doel te verwezenlijken

2.1. De Kring tracht dit doel te bereiken door:
  a. het organiseren van lezingen en excursies;
  b. het beleggen van vergaderingen;
  c. de bevordering van de communicatie tussen zijn leden;
  d. het onderhouden van contacten met binnenlandse en buitenlandse organisaties met een verwant doel;
  e. alle andere wettige middelen.

Artikel 3: Verhoudingen tot K.N.G.M.G. en andere verenigingen

3.1. De handelingen van de Kring mogen niet in strijd zijn met de Statuten en Reglementen van het K.N.G.M.G. en de erkende met het K.N.G.M.G. samenwerkende verenigingen, die in artikel 4.1 worden genoemd.

3.2. Het K.N.G.M.G. en elk der in artikel 4.1 genoemde samenwerkende verenigingen, gezamenlijk of afzonderlijk, kunnen de Kring volmacht verlenen als haar vertegenwoordiger op te treden bij daarbij aan te wijzen buitenlandse organisaties.

3.3. Veranderingen in de lijst der in artikel 4.1 genoemde met het K.N.G.M.G. samenwerkende verenigingen vereist een door het Hoofdbestuur goed te keuren reglementswijziging.

3.4. De Ingenieurs-Geologische Kring vertegenwoordigt het K.N.G.M.G. in de "International Association of Engineering Geology" (I.A.E.G.); de Kring fungeert hierbij als nationale afdeling van de I.A.E.G.

Artikel 4: Lidmaatschap

4.1. Als lid van de Kring kunnen toetreden - door aanmelding bij de secretaris -: alle leden resp. buitengewone leden van het K.N.G.M.G. en alle leden van de met het K.N.G.M.G. samenwerkende verenigingen, te weten:
het Koninklijk Instituut voor Ingenieurs (K.I.V.I.);
the International Association of Engineering Geology (I.A.E.G.);
de Nederlandse Ingenieursvereniging N.I.R.I.A.;
de Nederlandse Bodemkundige Vereniging (N.B.V).

4.2. De contributie, die door de jaarvergadering op voorstel van het Kringbestuur wordt vastgesteld, dient uiterlijk in de maand juni voldaan te zijn en door hen die later in het jaar toetreden, bij aanvaarding van het lidmaatschap.
Opzegging van het lidmaatschap ontheft het lid niet van de verplichting contributie te betalen over het jaar waarin wordt opgezegd.

4.3. Alle leden hebben actief en passief stemrecht.

4.4. Het lidmaatschap eindigt door:
a. schriftelijke opzegging bij de secretaris uiterlijk een maand voor het einde van het kalenderjaar;
b. royement bij besluit van het Kringbestuur wegens wanbetaling dan wel wegens houdingen of gedragingen in strijd met de belangen van de Kring, met de mogelijkheid van beroep op de ledenvergadering;
c. beeindiging van het lidmaatschap van het K.N.G.M.G. en/of de in art. 4.1 genoemde met het K.N.G.M.G. samenwerkende verenigingen;
d. overlijden van het lid.

Artikel 5: Kringbestuur

5.1. Het Kringbestuur bestaat uit tenminste drie en ten hoogste vijf gewone leden, waarvan tenminste twee lid zijn van het K.N.G.M.G. waarvan een stemgerechtigd.

5.2. In het Kringbestuur bestaan de funkties van voorzitter, secretaris en penningmeester.

5.3. Het Kringbestuur is belast met de dagelijkse leiding en vertegenwoordiging van de Kring in en buiten rechte.

5.4. De leden van het Kringbestuur worden gekozen voor een tijdvak van drie jaar uit en door de Kring en zijn direkt herkiesbaar, met dien verstande, dat men ten hoogste gedurende twee opeenvolgende driejaarlijkse perioden zitting kan hebben; zij treden af volgens een roulerend systeem.

5.5. Bestuursverkiezingen vinden plaats in een jaarvergadering op voordracht van het aftredende Kringbestuur. Tegenkandidaten kunnen door minstens vif stemgerechtigde leden schriftelijk worden voorgedragen aan de secretaris tot 21 dagen voor de passende jaarvergadering.

5.6. In de tussentijdse vacatures wordt voorzien op de eerstvolgende ledenvergadering van de Kring; een tussentijds gekozen bestuurslid treedt af op het tijdstip dat zijn voorganger zou zijn afgetreden.

Artikel 6: Jaarstukken

6.1. Het verenigingsjaar is gelijk aan het kalenderjaar.

6.2. De secretaris en de penningmeester brengen tijdig voor de jaarvergadering schriftelijk verslag uit over het voorafgaande verenigingsjaar ter goedkeuring door de jaarvergadering.

6.3. Een kascommissie, die uit twee leden bestaat, wordt jaarlijks benoemd door de jaarvergadering. De commissie controleert de boekhouding van de penningmeester en brengt schriftelijk verslag uit aan de eerstvolgende jaar vergadering en aan het Hoofdbestuur van het K.N.G.M.G.

Artikel 7: Afvaardigingen

7.1. Een van de bestuursleden, die tevens stemgerechtigd lid is van het K.N.G.M.G., wordt door het Kringbestuur aangewezen als lid van de Genootschapsraad.

Artikel 8: Ledenvergadering

8.1. Algemene ledenvergaderingen worden tenminste eenmaal per jaar gehouden, bij voorkeur in combinatie met wetenschappelijke bijeenkomsten.

8.2. Een algemene ledenvergadering kan voorts bijeengeroepen worden zo dikwijls het Kringbestuur of tenminste vijf leden dit verlangen, met vermelding van het agendapunt en de eventuele voorstellen die zij behandeld wensen te zien. Een verzoek voor een algemene ledenvergadering door tenminste vijf leden dient aan de secretaris schriftelijk te worden gedaan; deze vergadering dient binnen een maand na ontvangst van dit verzoek gehouden te worden.

8.3. De convocaties met agenda voor alle vergaderingen worden tenminste 14 dagen van te voren aan alle in Nederland wonende leden van de Kring toegezonden.

8.4. In een algemene ledenvergadering worden besluiten bij meerderheid van stemmen van de aanwezige leden genomen, behoudens het bepaalde in artikel 9.

8.5. De voorzitter van het Kringbestuur leidt de algemene ledenvergaderingen; zijn stem is beslissend bij staking der stemmen.

8.6. Introductie door het Kringbestuur tot de wetenschappelijke bijeenkomsten is toegestaan.

8.7. De jaarvergadering stelt de jaarstukken zoals omschreven in artikel 6.2 vast; voorstellen tot contributieheffing vergezeld van een begroting zullen ter goedkeuring worden overgelegd. Goedkeuring der jaarstukken door de jaarvergadering strekt het bestuur tot decharge.

<u>Artikel 9</u>: Reglementswijziging en ontbinding van de Kring

9.1. Voor reglementswijziging van de Kring is een algemene ledenvergadering vereist, waarbij geldige besluiten een tweederde meerderheid behoeven. De voorgestelde wijzigingen dienen op de convocatie te zijn vermeld.

9.2. Ontbinding van de Kring kan slechts geschieden door een algemene ledenvergadering indien:
a. het aantal leden gedaald is beneden het door het K.N.G.M.G. of het door de met het K.N.G.M.G. samenwerkende verenigingen vastgestelde minimum;
b. het bestuur een voorstel daartoe heeft ontvangen van tenminste 10 leden van de Kring dan wel het Hoofdbestuur van het K.N.G.M.G.

Tot zodanig besluit is een meerderheid van tweederde der geldig uitgebrachte stemmen vereist.
Convocaties tot een ontbindingsvergadering worden tenminste een maand tevoren aan alle leden van de Kring toegezonden.

<u>Artikel 10</u>: Gevallen waarin het reglelment niet voorziet

10.1. In gevallen waarin de reglementen niet voorzien, wordt door het Kringbestuur beslist.
Bekrachtiging van deze beslissing door de eerstvolgende ledenvergadering is vereist.
De beslissing van het Kringbestuur wordt tot op het tijdstip der eerstvolgende vergadering nageleefd.

1500 KM NOORD, VAN 0 TOT 815 METER DIEPTE

Dit is globaal de plaats waar ik, als 4e-jaars student ingenieursgeologie, mij afgelopen zomer bevond. Op stage in de LKAB ijzermijn Malmberget, circa 80 km boven de poolcirkel in Zweden.
In januari 1988 werd door het IAESTE (International Association for the Exchange of Students for Technical Experience) een nominatie voor deze stageplaats aangeboden.
Ik reageerde hierop om een tweetal redenen.
Ten eerste leek dit mij een unieke gelegenheid om veel van wat ik afgelopen jaren op het gebied van de ingenieursgeologie en gesteentemechanica geleerd heb in praktijk te zien.
Ten tweede leek het mij leuk om ook eens in een mijn gewerkt te hebben, per slot van rekening staat er op de bul van een Delfts ingenieursgeoloog nog altijd "mijn-ingenieur".
En zo reisde ik begin juli, samen met een 3e-jaars student ingenieursgeologie naar het verre noorden.
De eerste twee weken (van in totaal twee maanden) heb ik in het ertsverwerkings research laboratorium doorgebracht. Alhoewel dit gedeelte van mijn stage niets met ingenieursgeologie van doen heeft, was het een nuttige ervaring om in een slechts drie jaar oud research lab te werken. Overigens zijn het soort proeven die in het lab gedaan werden nauw verwant met grondmechanische proeven. Zo maakte ik onder andere zeefcurves (zeven, cyclosizer en Malvern, hiermee konden we zeefcurves maken van 1 um). Ook werden dichtheids- en permeabiliteitsmetingen gedaan.
In de drie weken die daarop volgden heb ik in de mijn gewerkt. Daar volgde een introductie in het gehele mijnproces. Dit hield in dat ik steeds een paar dagen in een bepaald team werkte, steeds eeen gehele werkcyclus. Wel werd er nadruk gelegd op de voor mij interessante werk-momenten. Een van de meeste interessante teams is bijvoorbeeld het 'drifting-team'. Deze ploeg maakte de transporttunnels en de toegangstunnels naar en in het ertslichaam.
Een voorbeeld van zo'n komplete cyclus: de mijnmeet-ploeg zet uit waar de tunnels moeten komen en markeert waar geboord moet worden. Dan komt het drifting-team, dit team boort de schietgaten, laadt deze boorgaten met springstoffen, schiet het gesteente en rijdt het gebroken gesteente uit. Vervolgens wordt eerst het dak geinspecteerd, zwakke plekken gemerkt en wordt los gesteente omlaag geschoten (eerst met de hand, dan met een scalingmachine). Als laatste stap in de cyclus komt het reinforcing-team, dit team brent rockbolts en spuitbeton aan. Met werk als 'scaling' leer je zwakke plekken in het gesteente en onveilige gedeelten in een tunnel herkennen, voor mij een nuttige ervaring.
De laatste drie weken van mijn stage heb ik met de geoloog en de gesteentemechanicus samengewerkt. De geoloog hield zich bezig met het karteren van het gesteente type en discontinuiteiten in het gesteente. Ook vertelde hij waarom de tunnels op bepaalde plaatsen gemaakt zijn en liet ons die gedeelten van de mijn zien waar in het verleden stabiliteits problemen zijn opgetreden (hoe deze zwakke plekken wel, dan wel niet tijdig ontdekt zijn en de gevolgen daarvan). Met de gesteentemechanicus deed ik onder andere deformatie metingen (distometer, extensometer), boven en naast de holruimten in de mijn (een van de open-stopes waar het hier om ging had de volgende afmetingen: 100 m lang, 70 m breed,

100 m hoog). Er bestond hier onder andere gevaar voor chimney-caving. In de tijd dat ik met de gesteentemechanicus werkte kwamen een aantal docenten gesteente-mechanica van de universiteit Lulea naar de mijn. Zij waren met een onderzoek bezig naar deze chimney-caving. Het was zeer leerzaam om met deze mensen de mijn in te gaan. Om een overzicht te krijgen van de deformaties in de tijd, heb ik een computer programma geschreven dat de diverse meetwaarden aan elkaar koppelt en deze grafisch weer geeft

Een gedeelte van de metingen van de gesteentemechanicus werd aan de oppervlakte gedaan, nu om de vibraties ten gevolgde van de blastings te meten. Van de gemeten vibratie intensiteiten moest een kaart worden gemaakte. De bedoeling was om deze kaart te correleren met de subsidence kaart.

Het gesteente waarin de mijn zich bevindt bestaat voor een helft uit "extremely strong, fresh, coarse grained Granite, Pegmatite and fine grained Quartzite, widely spaced joints". Een schitterend gesteente om tunnels in te maken. Het enige probleem met dit gesteente waren de hoge tektonische restspanningen die in het gesteente aanwezig waren. De tweede kategorie gesteenten was een "moderately strong to very weak, fresh to heavely weathered medum grained Biotite-Chlorite Schist with narrow to extremely narrow spaced joints". Dit gesteente was dus van een beduidende mindere kwaliteit. In dit gesteente waren de joints gedeeltelijk watervoerend en was plaatselijk een groot gedeelte van Biotiet en Chloriet omgezet naar kleimineralen.

Gedurend mijn stage heeft LKAB diverse excursies georganiseerd naar onder andere: Aitik (Europa's grootste open-pit mijn), Kiruna (de zuster van Malmberget) en de universiteit van Lulea. LKAB steekt veel geld in research. In het bedrijf wordt met veel moderne technieken/materialen gewerkt. Voorbeelden hiervan zijn het glasfiber-reinforced shotcrete, cablebolts (een rockbolt met variabele lengte), het gebruik van televisie-camera boorgatinspectie en crosshole seismics Voor onderzoek naar blasting damage). Veel machines ondergronds zijn computer en/of robot gestuurd.

Ik hoop een beeld te hebben geschetst van wat ik gedurende twee maanden heb gezien en geleerd. Mede door de goede begeleiding van LKAB is de uitdaging om naar het noorden van Zweden te gaan voor mij uitgemond in een zeer rijke ervaring, die ik elke student, die er tijd voor heeft/maakt een stage te lopen, van harte kan aanbevelen.

W.O. Molendijk
student ingenieursgeologie
TU-Delft

BOOK REVIEW: "Ground mechanics in hard rock mining", by M.L. Jeremic (1987). A.A. Balkema, Rotterdam, pp. 537. Hfl. 175,--.

In this book the author tries to integrate "theoretical principles, natural phenomena and practical mining engineering". This is in his own words, "a very difficult task". The book contains the following chapters: 1. Concept of stress and strain. 2. Deformation of rocks. 3. Failure of rocks. 4. Strength of rocks. 5. Monitoring of rock structures. 6. Ground conditions. 7. Ground stresses. 8. Mine pillar structures. 9. Open stoping. 10. Artificially supported stope structures. 11. Caving and drawing methods. 12. Combined open/filled structures. 13. External ground support. 14. Internal ground support. 15. Ground stabilization.

In his preface, the author states that he addresses specifically people in ore mining practice. These apparently have been reluctant to accept rock mechanics and still have difficulties with the acceptance of numerical modelling. According to this: "There is still a gap between the results of numerical models and the practical mining situations." The author tries to win the professional mining engineers for rockmechanics, by showing how theoretical principles have been applied to observed, problematic underground stability phenomena. The author does not mention students. His book seems, nevertheless, the result of lectures given by him to students: he is a professor of rock mechanics and mining engineering at the Laurentian University in Sudbury, Ontario. However, I would not recommend the book as a textbook for students. For this purpose the usage of theory is not evolved enough; the background of derived formula's is often not explained. In many occasions formula's just fall "from the air", and are being applied without any justification of their usage. Nowadays textbooks exist, like Brady and Brown's "Rock Mechanics for underground mining", which are much better suited to introduce students to modern rock mechanics.

As a geologist, I am not completely happy with the treatment of the geology in the book. In chapter 7 ("Ground conditions"), descriptions of some types of ground mass are given, stressing the structural complexity of many ore deposits. The illustations are the best part, the definitions and explanations of the geological structures and discontinuity types are not free from conceptual mistakes. But since the author is not a geologist himself, I think he even has to be complimented for his efforts to stress the importance of geology for mining engineering.

The strength of the book appears to be in the presentation of examples of cases of the application of rock mechanic theories. Each chapter promises to be interesting, but closer inspection leaves the reader a bit disappointed. The mere quantity of subjects chosen does not leave enough space for thorough treatment. Often the author gives a summary of facts about the ground conditions, the mining method used, the rock mechanics theory applied and the solution chosen. The book may be regarded as a first reference book on the type of rock mechanics solutions that have been chosen in the past in ore mining. The author has given us a glimpse of his own experience in the field; he would have done better to treat the interaction between geology, mining and rock mechanics more methodically, supplemented with some well chosen and extensively treated case histories.

Peter N.W. Verhoef, Delft.

Some comments on Maurenbrecher's review of the 9th European Conference on Soil Mechanics and Foundation Engineering in Dublin.

J.D. Nieuwenhuis, Grondmechanica Delft.

During and after reading Maurenbrecher's review in the first Nieuwsbrief of 1988 I could not suppress the feeling that something was definitely wrong either with the reviewed conference or with Maurenbrecher or with both. The review is extremely negative on nearly all elements of the conference: the scope of work, groundwater effects, seems outdated and irrelevant; elements like damage due to groundwater extraction or contaminated groundwater were not considered; the Dutch contributions are only outstanding by their geometrically distorted pictures of dike embankments; the participation of para-statal research institutes and universities seems most regretful and fees for the conference were out of all reasonable bounds.

Having not participated in the conference myself I questioned attendees from Delft Geotechnics whether they felt also that it was all that bad. The general answer was that most conference contributions fitted well within the prescribed scope of work of the different sessions, that other conferences treat subjects like damage assessment and polluted groundwater, that all papers considering dikes or dams contain distored pictures (not just the Dutch ones) and that the conference fees were not excessive compared to comparable conferences.

Without believing that I performed an exhaustive enquiry on the quality of the Dublin Conference I must however state that all conclusions of Maurenbrecher are considered nonsense by our collaborators. I furthermore regret that the reviewer is not mentioning the contribution of Prof. Frans Barends as the Dutch general reporter at the conference.

Reply by P.M. Maurenbrecher (Delft, University of Technology)

I could not suppress the feeling that something is definitely wrong with Jan Nieuwenhuis' comments. His commentary shows, indeed, a lack of enquiry let alone an exhaustive enquiry. For this reason it is hardly worth replying to considering the subjective and ill-conceived statements it harbours. Firstly the review was a review of the proceedings and not a review of the conference. Secondly, the proceedings do not contain the Dutch general report from Prof.F.Barends.

As for the remainder of Jan Nieuwenhuis' comments it suggests a typical angry reaction to a few home truths. He knows as well as I do that the government has laid down the big stick "Publish or Perish". So long as publications appear and are accepted at recognised conferences or periodicals the research finance is secure. In the last eight years more has been published than all the publications that went before (Michelis et al, 1988). Part of this growth in publication stems from "Publish or Perish" directives. Part stems also from institutions and persons wanting, understandably, to advertise their expertise. Both tend to produce a huge amount of duplication, at least, partial duplication. It were these papers that I had regarded negatively, though in themselves they are all of high callibre. I did however mention a large number of papers as genuine contributions towards groundwater effects in geotechnical engineering.

Alas, I cannot accept Jan Nieuwenhuis' rather superficial statements such as being "extremely negative on nearly all elements of the conference". He should, judging by his own comments, level the accusation at himself.

Ref.: Michelis, P.N.; Toratzidis L.P. & Loumos, B.G. (1988) "Database use for geotechnical studies related to ancient structures". Eng.Geol. of Ancient Works Monuments & Historical Sites, p. 575-578, Balkema.

CONFERENCES, SEMINARS and SYMPOSIA:

1988:

23 November	Rock Seminar Meeting: Mathematical simulation of the severely converging galleries at "Les Houilleres de Blanzy, France" by A.M. McConell and Electron microscopy in rock deformation studies by B.K. Smith. 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.
28- 2 December	Symosium on Geotechnical Aspects of Restoration and Maintenance of infra-structures and Historical Monuments. Bankok, Thailand. Prof. A.S. Balasubramaniam, Division of Geotechnical and Transportation Engineering, Asian, Institute of Technology, GPO Box 2754, Bangkok, Thailand.
8- 9 December	1st Indian Geotextiles Conference. Bombay, India. Dr. J. N. Mandal, Organising Secretary, FIGC-88, Civil Engineering Dept. I.I.T., Powai, Bombay-400 076, India.
12-14 December	2nd Int. Conf. on Geomechanics in Tropical Soils. Singapore. Topics: Characterisation, indentification and classification of tropical soils; Engineering properties; stability of slopes and excavations; Foundations of buildings; Construction of dams, roads, airfields, harbours and land reclamation Engr. John S. Y. Tan, 2 ICOTS Conference, 150 Orchard Road 07-14, Orchard plaza, Singapore 0923.
14 December	Rock Mechanics Seminar: The collapse of an ancient building stone mine in Valkenburg, Limburg by Prof. D.G. Price. 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.

1989:

25 January	Rock Mechanics Seminar. 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.

7-10	February	Int. Conf. on Tunneling and Micro-Tunneling in Soft Ground. Paris, France. Topics: Recent soft soil tunneling techniques; Micro-tunneling techniques; Instrumentation and field observation; Model and design methodes. Colloque International "Tunnels et Micro-tunnels", ENPC/DFCAI - Department International, 28 rue des Saints-Peres 75007, Paris, France.
22	February	Rock Mechanics Seminar. 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.
13-17	March	Int. Symp. on Frost in Geotechnical Engineering. Helsinki, Finland. Finnish Geotechnical Society-FGE89, Seppo Saarelainen, c/o VTT, Geotechnical Lab., SF-021150 Espoo, Finland.
22	March	Rock Mechanics Seminar. 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.
3- 5	April	Conf. of Geotechical Instrumentation in Civil Engeneering Projects. London, England. Topics: Earthworks and retaining walls; Buildings, Landslides and slopes; Offshore; Tunnels and underground chambers; Buried services; Dams. Instution of Civil Engineers, 1-7 Great George Street, London SW1 P 3AA England.
19	April	Rock Mechanics Seminar. 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.
15-17	May	2nd. Int. Symp. on Environmental Geotechnology. Shanghai, China. Topics: Effect of toxic and nucular wastes on soil/rock; Soil-water-gas interaction; Landslides, subsidence and sinkhole; Landfill contol systems; Ground improvement techniques; Groundwater contamination; Expert systems; Sampling and testing; Durability and protection of pavements and geostructural members in hazardous conditions. Prof. Sibel Pamukcu, Dept. of Civil Engineering, Lehigh University, Bldg 13, Bethlehem, Pennsylvania 18015 USA, Tel: 215 758-3220.

22-26 May	8th. Int. Strata Control Conference. Dusseldorf, F.R. Germany 8. IGDT, Stein kohlen bergbauverein, 4300 Essen 13, F.R. Germany.
25-28 June	Int. Conf. on Storage of Gasses in Rock Caverns. Trondheim, Norway. The Norwegian Institute of Technology, Studies Administration, N-7034 Trondheim, Norway.
26-28 June	Int. Conf. on Engineering Geology in Tropical terrains. Selangor Darul Ehsan, Malaysia. **Topics:** Various eengineering geologic aspects and problems specifically related to tropical terrains. Dept. of Geology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Darul Ehsan, Malaysia.
13-18 Agust	12th. Int. Conf. on Soilmechanics and Foundation Engineering. Rio de Janeiro, Brazil. Dr. L.J. de Moraes, 12th ICSMFE, Caixa Postal, 1559, 20.001-Rio de Janeiro, R.J. Basil.
30- 2 September	Symposium on Rock at Great Depth. Pau, France. **Topics:** Mechanical behaviour; Laboratory and in-situ testing; Methods of Analysis. ELF Aquitaine, CSTCS-Bat.LS, F. 64018 Pau Cedex, France.
4- 7 September	Int. Chalk Symposium. Brighton, England. **Topics:** General; Costruction; Hydrology; Petroleum Engineering. Dr. R.N. Mortimore, Int. Chalk Symposium, Dept. of Civil Engineering, Brighton Polytechnic, Brighton BN2 4GJ, U.K.
10-14 September	Conf. on Quaternary Engineering Geology. Edinburg, Scotland. Dr. J.A. Little, Dept. of Civil Engineering, Heriot-Watt University, Edinburg EH14 4AS, Scotland.

<u>1990:</u>

6-10 August	6th. Int. Congress of the IAEG. Amsterdam, The Netherlands. Dr. L. Primel, Secretary General IAEG, Laboratoire Central des Ponts et Chausees, 58 Boulevard Lefebre, 75732 Paris Cedex 15,France. Tlx: LCPARI 200361 F.

ICS 89

INTERNATIONAL CHALK SYMPOSIUM

INTERNATIONAL CHALK SYMPOSIUM
Brighton Polytechnic, 4 - 7 September 1989

In 1966 the Institution of Civil Engineers held a major conference on Chalk Earthworks and Foundations. This was followed by key papers on foundations (Ward, Burland and Gallois, 1968; Wakeling, 1970) and then in the 1970's the problems of Chalk Earthworks received considerable attention. In France, where similar Chalk engineering problems had been encountered, two multidisciplinary meetings were held, La Craie, 1973 and 1975. Also in 1975, Jenner and Burfitt presented a significant paper at the Southern Association of the ICE meeting held at Brighton. For earthworks in Chalk several specifications have been devised and developed reflecting the difficulty in both identifying and predicting behaviour of different types of Chalk. During this same period a major review on piling in Chalk has been undertaken by CIRIA.

Despite the apparent wealth of publications on the Chalk the view expressed at the 1966 Conference still holds good.

"... it was a dangerous assumption among many people, including engineers that the Chalk was a uniform material... even geologists tended to view Chalk as one material, apart from the basic classification of Upper, Middle and Lower..." Mr. D.C. Heath, Chief Resident Engineer, High Wycombe By-pass, 1966. p.94).

In the 1970's and 80's research by geologists has identified a new stratigraphy capable of a high degree of resolution allowing analysis of engineering properties within and between projects. Research has also provided a new understanding of how the Chalk formed and new methods of analysing texture in relation to physical properties. Much new information comes from the exploration of Chalk reservoirs in the North Sea (Ekofisk, Hod, Tor and Dan Fields) and the techniques and lessons learnt have yet to be widely considered in the context of onshore engineering.

Chalk hydrogeology has also been developing through the 1970's and 80's to the point where a major publication is required to summarise the advances. Again, many of the techniques of investigation will have a wider application to engineering.

It has become abundantly clear that the time is ripe for a symposium to review the state of the art and this multidisciplinary Chalk Symposium was conceived to allow an exchange of ideas and practices across the disciplines. Brighton is chosen as the venue as it is within easy access of well exposed and recently researched Chalk in sea-cliffs, quarries and engineering works including the Channel Tunnel and major new trunk roads through the Chalk and these will be visited during the Symposium.

An underlying common thread to all the areas of investigation is the need to identify and explain the variations in material and rock mass properties. The great variety of research information generated in the last two decades and the coincidence of some major engineering projects on the Chalk makes it an appropriate time to hold this Symposium.

Conference Chairman:
J. B. Burland DSc(Eng) FEng FICE MIStructE

BRIGHTON POLYTECHNIC
4th-7th SEPTEMBER 1989

Co-sponsored by:
Institution of Civil Engineers
Institution of Geologists
British Geotechnical Society

CALL FOR PAPERS

Topics

Original papers are invited from both researchers and practitioners on the following topics:

General

(i) Material and mass properties
(ii) Ground and reservoir investigation
(iii) Laboratory and in-situ testing
(iv) Methods of classification

Construction

(i) Foundations
(ii) Geotechnical processes
(iii) Underground excavations
(iv) Surface excavations
(v) Earthworks
(vi) Groundwater (soakaways etc.)

Hydrogeology

(i) Characteristics of chalk aquifers
(ii) Water resources
(iii) Pollution

Petroleum Engineering

(i) Characteristics of chalk reservoirs
(ii) Identification of chalk types and properties from wire-line logs
(iii) Specialist testing

The topics listed are not intended to be exclusive, others will be considered.

ABSTRACTS

Prospective authors are asked to submit two copies of an abstract in English (no more than 250 words) and indicate within which topic area the proposed paper is intended.

The last date for receipt of abstracts is 1st September 1988 and papers would be expected by 1st March 1989.

COMMERCIAL EXHIBITION

A commercial exhibition will be held at the venue where there is space for both inside and outside demonstrations.