

news



letter

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ROCK EDITION



- **Goethe en Goethiet**
- **Rock mass characterization with 3D laser scanning**
- **Symposium in honour of Dr. Niek Rengers**
- **Van rots tot natuursteen, kei of tegel**



Objective of the Newsletter

The objective of the Newsletter is to inform the members of the Ingeokring, and other interested parties, on topics related to engineering geology and the developments in this field. The Newsletter wants to make engineering geology better known by improving the understanding of the different aspects of engineering geology.

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Notes for the authors

- Manuscript can be written both in Dutch and English and sent to the editorial board (address provided on the left column).
- Authors are free in choosing the subject of their contribution with the following restraints:
 - The subject is related to engineering geology.
 - The manuscript is not a commercial advertisement (announcements are allowed).
- Layout
 - The article should be written in MS Word or in plain Text, without any formatting or layout-codes. Submissions must be made both in electronic form on floppy or to the e-mail address provided on the left column and as printed hard copy send to the editor.
 - Figures, drawings, and pictures should be produced in one of the common image formats: GIF, TIFF, JPEG, WMF or as Word drawing objects.
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 - Each article must include the author(s) name(s), affiliations and address, and a short abstract of preferably less than 100 words.

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Editorial

Beste lezers,

Na themanummers als Offshore, Line infrastructure en Environment hebben we nu eindelijk de Newsletter het thema gegeven dat we uiteraard vanaf het begin voor ogen hadden, namelijk "Rock". Het is nog overwogen om de Nederlandse term "Rots" of "Gesteente" te gebruiken. De redactie heeft bij "Rots" echter te veel associaties met de branding en de term "Gesteente" klinkt wellicht wat te officieel. Daarom is er toch voor gekozen om ook voor dit themanummer de vertrouwde Engelstalige term "Rock" te gebruiken.

Zoals verwacht heeft het thema "Rock" de nodige interessante artikelen opgeleverd. Van het op afstand laser scanning van gesteentewanden tot het bij wijze van sportbeoefening van dichtbij analyseren van een *rock face*. Van dr. Robrecht Schmitz is de interessant bijdrage "Goethe en Goethiet". Uiteraard is dit niet zijn enige, met Michiel Maurenbrecher worden de handmatige stereografische projecties besproken. Een andere invalshoek op het "Rock" wordt gegeven door Bert Verstraeten in het artikel over het gebruik van natuursteen in de openbare ruimte.

In dit nummer is ook uitgebreid aandacht voor Dr. Niek Rengers, het erelidmaatschap van de Ingeokring en het afscheidsymposium dat op ITC ter ere van zijn pensionering is gehouden. De profesoren column is afkomstig uit Zuid-Afrika en de *Engineer Abroad* bevindt zich in de Kaspische Zee. Richard Rijkers heeft het verslag geschreven van het succesvol verlopen EurEnGeo2004 congres. Daarnaast zijn de vertrouwde rubrieken als de M.Sc. Abstracts, de Ingeokring en studenten activiteiten.

Deze uitgave is mede mogelijk gemaakt door Van Oord. Van Oord heeft zich bereidt getoond om het binnenwerk van de Newsletter te drukken, zodat de kosten voor de vereniging gedrukt kunnen worden. Indien andere bedrijven interesse hebben voor een dergelijke wijze van sponsoring houden wij ons uiteraard van harte aanbevolen. Adverteren in de Newsletter behoort ook tot de mogelijkheden. De opbrengst van de advertenties komt geheel ten goede aan het Dispuut IngenieursGeologie. Bij het adverteren en sponsoren van de Newsletter hoort ook een link op de website van de Ingeokring (www.ingeokring.nl). Dat dit een nuttig reclamemiddel is, blijkt wel uit de resultaten van zoekacties in google, waarbij het mij opvalt dat de site van de Ingeokring altijd hoog in de resultatenlijst staat.

De lay-out van dit nummer heeft een lichte wijziging ondergaan. Deze inspanning is met name door Robert Vuurens gepleegd en heeft naar mijn mening een prettig leesbare Newsletter opgeleverd.

In de bezetting van de redactie van de Newsletter zijn ook enkele wijzigingen opgetreden. Gerben Groenewegen en Bart Fellingma hebben het stokje namens de DIG overgedragen aan Albert van der Horst. Bart en Gerben hebben zeer veel werk verzet, met name op lay-out gebied, waarvoor namens de Ingeokring nog hartelijke dank. Xander van Beusekom, werkzaam bij Fugro Engineers, vond zijn inzet bij de Newsletter steeds lastiger te combineren met de regelmatige uitzending over de wereld. Gelukkig is in Gerhard Wibbens een goede vervanger gevonden. Xander bedankt voor de prettige samenwerking in de redactie. Tenslotte rest ons niets meer dan uw, namens de redactie, veel leesplezier met deze Ingeokring Newsletter te wensen.

Jacco Haasnoot, Robert Vuurens, Gerhard Wibbens, Albert van der Horst.

Dr. Niek Rengers erelid van de Ingeokring

Op dinsdag 12 april 2005 vond bij het TNO-NITG in Utrecht een bijzondere Ingeokring lezingenavond plaats. Het bestuur van de Ingeokring heeft het Erelidmaatschap van de Ingeokring, in de vorm van een beeldje, overhandigd aan dr. Niek Rengers. De reden voor het overhandigen van het erelidmaatschap is de buitengewone bijdrage die Niek Rengers geleverd heeft aan het vakgebied Ingenieursgeologie.

Naast deze feestelijke ceremonie zijn op deze avond twee lezingen gehouden voor een twintigtal geïnteresseerde Ingeokring leden. Ten eerste is door Peter Vos van TNO-NITG een lezing over Geokartering en Archeologie gegeven. Deze interessante en leuke lezing ging over een onderwerp wat niet direct met Ingenieursgeologie geassocieerd wordt. Toch waren er verrassende raakpunten zoals bijvoorbeeld het gebruik van geologische kennis om zoneringskaarten te maken en de veelvuldige toepassing van geodata integratie. Na enige algemene informatie over geo-archeologie en de geologische kartering van Nederland werden twee 'sleutel sites' beschreven, de IJzertijd Kano van Uitgeest en een Romeins schip in de Oude Rijn.

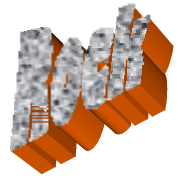
Vervolgens gaf Niek Rengers een presentatie over Bhutan, waarin een stortvloed van mooie plaatjes met landschappen, gebouwen en mensen uit Bhutan te zien was. Niek omlijstte deze beelden, op kenmerkende wijze, met opmerkelijke en verrassende anekdotes.



Erelid dr. Niek Rengers

Rock mass characterization with 3D laser scanning

Never again struggling with geologic compass and measuring tape?



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Introduction

Most engineering disciplines that deal with discontinuous rocks require a proper understanding of the character and behaviour of the rock mass under consideration. Rock mass description and characterisation is therefore an important first step in the design process. When dealing with discontinuous rock masses, the properties of discontinuities (joints, bedding planes and fractures) in the rock becomes of prime importance, since this will determine, to a large extent, the mechanical behaviour of the rock mass [2].

One of the most important inputs to existing descriptive- and characterising classification systems is therefore information on the rock mass's discontinuities [7]. This can vary between the description of block form and size [4] to the incorporation of RQD values and joint conditions in the more recent rock mass classification systems, such as: RMR system [2], Q-system [1] and MRMR [10].

Discontinuity properties of a rock mass can be measured in the field using standardized methods, such as scan line surveys or cell mapping [11], [12]. Both systems have their respective advantages and disadvantages, but all manual field survey methods have several disadvantages in common [9]:

- Erroneous data are introduced due to sampling difficulties, e.g. choice of sampling method, human bias, instrument error, etc.
- Safety risks are often considerable. Often field measurements are carried out at the base of existing slopes or during quarry, tunnelling or mining operations or along busy highways.
- Direct access to rock faces is often diffi-

cult or impossible.

- Apart from these practical problems, manual field survey methods are also time-consuming, labour-intensive and therefore costly.

What is 3D laser scanning?

3D terrestrial laser scanning is a relatively new, but already revolutionary, surveying technique. Different laser scanning systems exist, but the technique used outdoors for geodetic surveying or for measuring large civil engineering structures is the *time-of-flight* or *laser range finding* technique. The time-of-flight or ranging scanners have a laser diode that sends a pulsed laser beam to the scanned object. The pulsed laser beam moves through a rapidly changing elevation and azimuth angle of a mirror inside the instrument. The pulse is diffusely reflected by the surface of the scene or object and part of the light returns to the receiver. The time that light needs to travel from the laser diode to the object surface and return is very precisely measured. Knowing the speed of light, the distance from the scanner to the object and the azimuth and angle of the beam, the position of each point where the beam is reflected can be calculated.

The survey yields a digital data set, which is essentially a dense *point cloud*, where each point is represented by a coordinate in 3D space (X, Y and Z, relative to the scanner's position) and the reflected intensity (I) of the laser beam. With this data, the 3D shape of any object or environment can be determined and analysed. A new generation of ranging laser scanners also yields for each point the passive colour (i.e.: red, green, and blue reflection values). Very large and complex objects can also be scanned from different positions. Most soft-

ware used to capture the survey data allow to merge different surveys into a single point cloud. In this way, the *shadow* areas of surveys



Figure 1. Photograph of the scanned rock face. The box highlights the area that is used in this example to demonstrate the method. This particular rock face is popular for rock climbing. The location is near Dave, a village close to the city of Namur in Belgium. The rock consists of Carboniferous limestones, the bedding is oriented almost vertical.

can be complemented with scans where the laser beam can 'see' the previously hidden areas.

The most important advantage of the method is that a very high point density can be achieved, in the order of 5 to 10 mm resolution. Therefore, the shape of the surveyed object or scene can be modelled at a very high detail and accuracy in three dimensions. The method can measure objects and scenes at a distance of nearly 200 meters under ideal conditions. In real-world situations however, 50-100 meters is more usual. The method is also rapid: a full 360° scan can be carried out with the latest models in less than 4 minutes. The laser scan-

ner fits on a regular surveying tripod and has a normal laptop attached to operate the scanner and to store the survey data. Most of the software used to operate the scanner also allow the user to instantly geo-reference the scanned (X,Y,Z) data to a local or global reference grid. Currently, a number of 3D laser scanning devices are already on the market that use the ranging principle. The most important manufacturers are at the moment: Leica, Riegl, Optech and Mensi. The underlying principles of the different laser scanners are essentially the same, but the quality of the generated data (for instance: resolution, accuracy, precision, scanning speed, and laser beam divergence) may vary between manufacturers and models.

Automated discontinuity analysis

From point cloud to surface

The 3D laser scan survey of a rock face, yield therefore a dense 3D 'point cloud'. This point



Figure 2. The 3D laser scanner (Riegl 3D Imaging Sensor LMS-Z420i) in action. You can see that the point cloud data that has just been generated can be visualised in real-time. Note the high resolution digital camera mounted on top. The laser is slightly tilted to accommodate the entire slope in one scan.

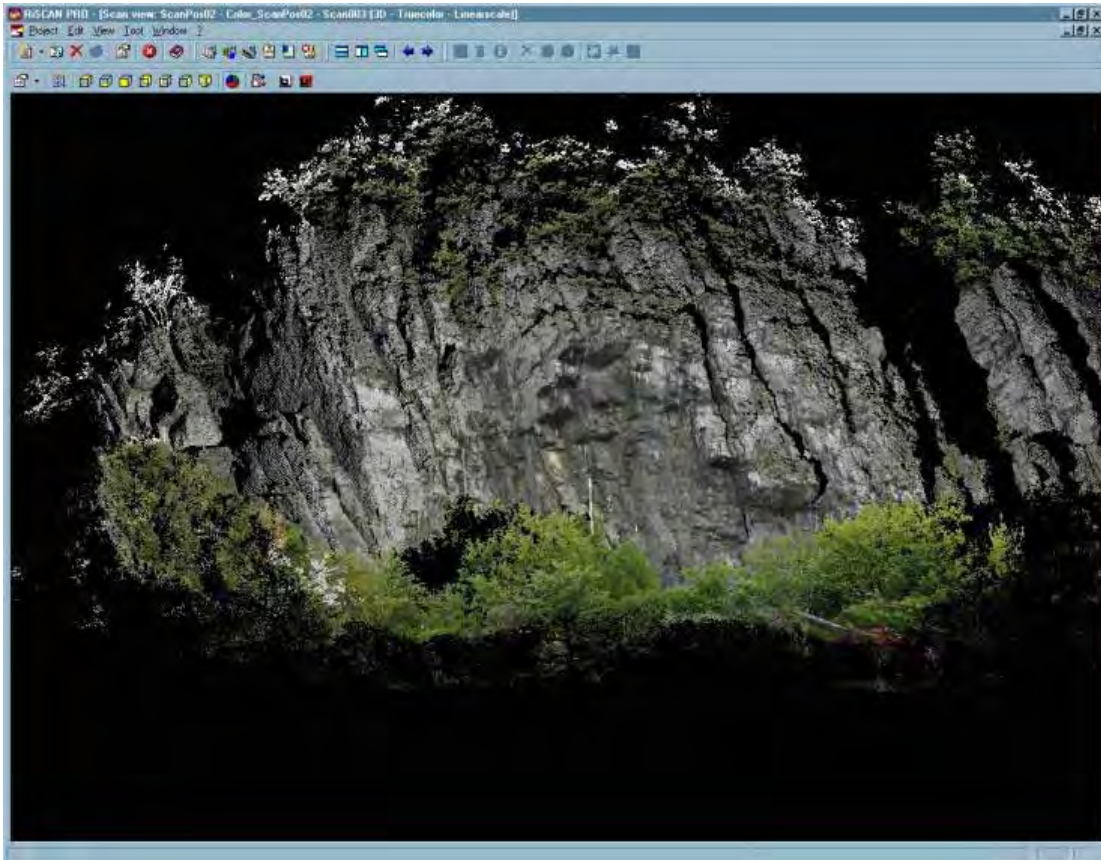


Figure 3. This is a screendump of a 3D view of the original point cloud generated by the laser scanner. Note that this is not a digital photograph! Each individual point has been given a colour based on the imagery taken by the digital camera mounted on top of the Riegl LMS-Z420i laser scanner.

cloud is merely data, but does not yet contain any information on the rock surface itself. To be able to view and analyse the surface that the points represent, a 3D virtual surface has to be generated (see Figure 5 and Figure 6). This can be done using so-called surface reconstruction techniques. Different techniques exist for this, but all yield a gridded or triangulated surface, where the entire surface is represented by tens of thousands to millions of small triangles or *facets*. Since each facet is uniquely defined in 3D Euclidean space, it can also be described in terms of orientation: dip angle and dip direction. With this we now have in fact a very powerful way of describing the original rock surface, not only in terms of geometry, but also in terms of orientation.

Plotting the facets in a stereoplot

We now have to assume that most surfaces in a discontinuous rock outcrop are actually formed by the internal discontinuous structure of the rock mass. In that case each facet represents in

fact a single orientation measurement, comparable to an individual manual orientation measurement made for each discontinuity set in a traditional way with a geological field compass. By hand we are only able to measure and plot a limited number of orientations, but we have tens of thousands, if not millions of

...tens of thousands, if not millions of facets...

facets in our virtual slope from which to calculate the orientation. Therefore, by simply plotting the orientations of all individual facets in a stereo or polar plot we can easily test whether our assumption is valid. It is shown in Figure 7, that the discontinuities in the laser scan data can indeed be visualized and recognized in the form of clusters. Following the assumption made earlier, each cluster should therefore represent a different discontinuity set.

Identifying the discontinuity clusters

Even though the different discontinuity sets can be recognized visually, in order to do an objective and automated analysis, we have to carry out a cluster analysis. For the automatic clustering of discontinuity sets, the adjusted fuzzy k-means clustering method can be used, suggested by Hammah and Curran [8]. This results in a ‘soft’ classification scheme where each individual facet is to be classified to a (pre-defined) number of discontinuity clusters (see Figure 7). The 3D virtual rock surface can subsequently be classified or coloured according to the discontinuity cluster it belongs to (see Figure 8). This allows for a rapid visual verification of the validity of the clustering procedure.

Delineating the discontinuity clusters

Not all facets are however part of a ‘real’ cluster. If, for instance, surfaces in the outcrop are formed by fractures through intact rock, or if the surfaces have been affected by weathering, these surfaces are not characteristic for a specific discontinuity. This all will pollute the data and introduces ‘noise’. Introducing a ‘hard’ cluster classification scheme can filter out this noise in the data. A simple form of F-test [3] [5] is being used as a first pragmatic approach to delimit the cluster boundaries. All approaches that can lead to a proper delineation of cluster boundaries are based on the assump-

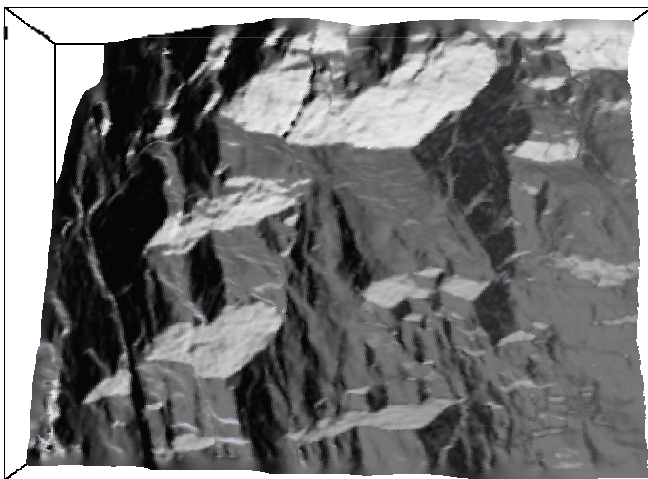


Figure 5. The reconstructed 3D surface model. This surface is basically composed of a large number of small facets or triangles. In this case artificial illumination effects have been added using digital rendering techniques to highlight the morphology.



Figure 6. This is the same 3D rendered surface model as Figure 3. Instead of using artificial illumination, in this case each facet in the 3D surface has been coloured using the colour information from the point cloud.

tion that the distribution pattern is that of a so-called ‘Fisher distribution’ [6], i.e.: a circular concentration around the mean. Fisher’s k-value can be used in an iterative process of increasing sub-cluster size. Since a higher Fisher’s k or concentration parameter κ corresponds to relatively dense distribution, the highest value found for any subset should mark the boundary of the entire cluster.

Discontinuity set spacing

Another very important aspect in rock mass characterization is the determination of discontinuity set spacing and spacing distribution. Together with the orientation of the discontinuity sets, this determines the variation in size and shape of the blocks that make up the fabric of the rock mass. For most engineering applications dealing with rock masses, this is crucial information. By separating the individual discontinuity sets and surfaces from the data, it becomes possible to analyze these surfaces in 3D space and subsequently derive the orthogonal distances (spacings) between them. By simplifying the surfaces as planar equations it would also become possible to export information on individual discontinuities to external numerical rock mass modelling programs for example (see Figure 9).

Conclusions

Laser scanning in combination with an auto-

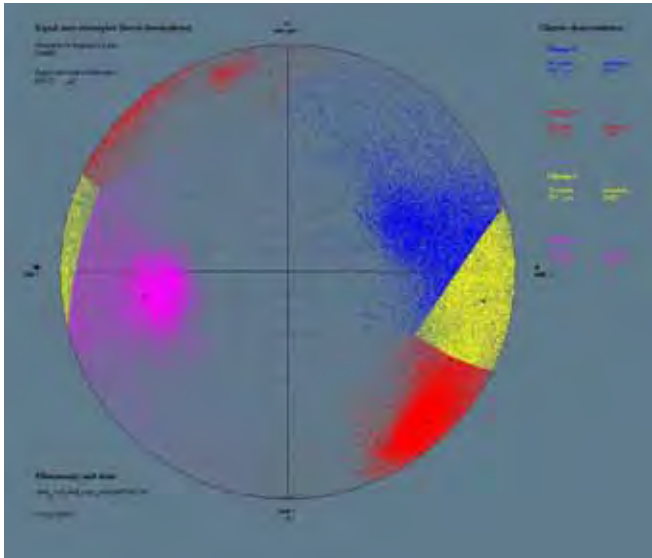


Figure 7. Through geometric analysis of all individual facets that make up the 3D reconstructed surface, it is possible to compute and plot the orientations is a stereoplot. Fuzzy K-means clustering allows subsequently to outline the different discontinuity sets in an automated way.

ated discontinuity analysis, has potentially a number of important advantages over the traditional manual field survey methods:

- Laser scanning can be used as a cheaper, more objective and more precise and accurate method to determine discontinuity orientations.
- Laser scan surveys can be carried out rapidly (in minutes) and at some distance (from 4 up to 800 meters) away from the actual site in a controlled environment, so that safety risks are minimized. Some laser scanners can even be operated by remote control via an infrared or wireless ethernet link.
- Laser scanning can reach rock faces up to several hundreds of meters away from the operator, so that discontinuity properties of inaccessible spots can be obtained, which was previously impossible to do.

If this method can be worked out further as a routine fieldwork tool, we will never again have to struggle under a steep and treacherous slope with the old field compass and measuring tape. However, the Engineering Geologists remains the essential and key figure in the whole rock mass characterisation process. This

method is not meant to replace any of our engineering judgement, just to make our life a little bit easier.

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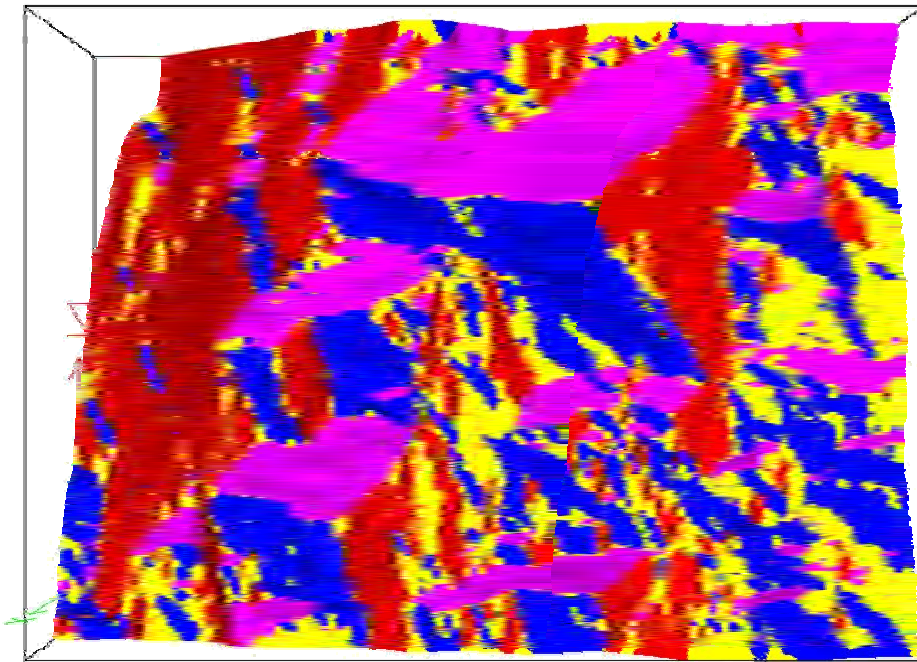


Figure 8. Using the clustering results (shown in Figure 6) the different facets of the 3D surface are coloured according to the discontinuity set they fall within. It is evident that the most important discontinuity sets are indeed recognised. The red surfaces are the (almost) vertical bedding planes. The blue and purple are the 2 orthogonal joint sets. The yellow 'set' is probably not a real joint set, but composed of weathered or fractured surfaces.

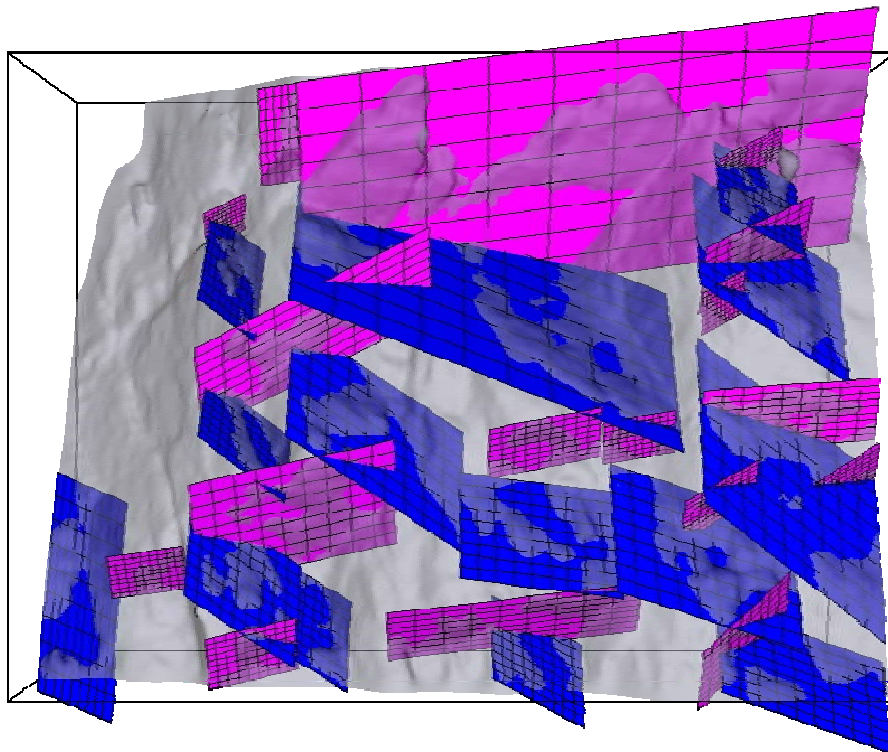
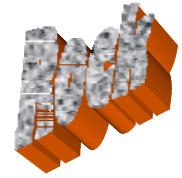


Figure 9. Each individual plane of each discontinuity set is subsequently simplified and represented by a single planar trend surface. This allows calculation of spacing and exchange to for example a Distinct Element Modelling program. In this view only the "blue" and the "purple" joint sets are shown and the bedding is left out.

Goethe en Goethiet



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*Habe nun, ach! Philosophie,
Juristerei und Medizin,
Und leider auch Theologie
Durchaus studiert, mit heißem Bemühn.
Da steh ich nun, ich armer Tor!
Und bin so klug als wie zuvor;
[Doctor Faust in Faust I]*

Dit is het wel bekende begin van Faust I. Hier zou men aan kunnen toevoegen:

*Warum hab ich den Fehler gemacht,
und bei meinen Studien nicht an Bergbau
gedacht?*

Dat heeft Goethe (1749-1832) inderdaad ingehaald en wel toen hij op later leeftijd in de dienst trad van de Hertog van Weimar om onder andere de mijnbouw in de streek Thüringen weer leven in te roepen. Toen hij deze baan aannam gaf hij ook toe dat hij niets van mijnbouw wist. Dit was trouwens een tijdperk waar de systematische mineralogie pas begon (Goethe was een tijdgenoot van Abraham Gottlob Werner die te Freiberg onderzoek verrichtte en doceerde) en het nieuwe vakgebied der geologie nog verdeeld was tussen Neptunisten en Plutonisten (dus toen er nog over de drijfveren getwist werd die van de puur descriptieve geologie een wetenschap moesten maken, ook nu is er

...zijn onderzoek werd belachelijk gemaakt...

trouwens nog een ondergrondse strijd gaande tussen plaattektoniek aanhangers en expansie theorie aanhangers).

In het algemeen wordt Goethe weliswaar gezien als groot dichter maar zijn eigen natuurwetenschappelijk onderzoek werd toentertijd, in de 20ste eeuw en in mindere mate tegenwoordig belachelijk gemaakt (behalve zijn ontdekking van de Zwischenkieferknochen bij een menselijke schedel (Lippert 1993) die hij als bewijs zag

Maar hoe zit het met zijn werk op het gebied van de mijnbouw? Als politicus heeft hij veel moeite gedaan om de mijnbouw in Thüringen weer op gang te krijgen.

Daarvoor leerde hij veel over de mijnbouw, ook op studiereizen naar mijn technisch interessante streken zoals de Thüringer Wald (foto 3) en de Harz (bekend door de Mijnbouwuniversiteit te Clausthal-Zellerfeld). Hij had goede contacten met de bekende mijnbouwuniversiteit te Freiberg (Werner doceerde en Alexander von Humboldt leerde aldaar, deze laatste heeft ook veel gedaan voor de mijnbouw in Thüringen, zie foto 1).

Goethe heeft bovendien zijn kennis Johann Georg Lenz te Jena tientallen jaren



Foto 1. Humboldtsche Verbruch, Grube Morassina, Schmiedefeld, Thüringen. Aluin schist werd voor het bezoek van Humboldt aan deze mijn door pijlerwinning gedolven. Op aanraden van Humboldt (11/07/1792), kennis en tijdgenoot van Goethe en student van de Mijnbouwuniversiteit Freiberg, werd op de kamerwerk wijze over gegaan (Foto van de auteur).

ondersteund bij het aanleggen van de toentertijd grootste systematische mineralen verzameling ter wereld (Salomon 1990).

Goethe heeft zich dus serieus en intensief met de mijnbouwkunde bezig gehouden (foto 2).



Foto 2. Net als Humboldt (zie foto 1) hield Goethe zich bezig met het onderzoek naar ondergrondse instabiliteit van mijnen zoals hier zijn persoonlijke 2d schets van de open drainage steengang genoemd de Martinrodaer Stollen (beneden) die verstopt raakte (links) door de breuk van een neerhouw (Wagenbreth 1983).



Foto 3. Jagdhuys op de Gabelbach richting Kickelhain, vaak door Goethe bezocht voor en tijdens zijn Natuurwetenschappelijke studies in de Thüringer Wald, nog op zijn laatste verjaardag in 1831 (Foto van de auteur).

Hij werkte in een periode waar nieuwe deeldisciplines van de mijnbouwkunde, de geologie en de mineralogie ontwikkeld werden. Als hij al niet zelf in deze disciplines werkte dan had hij kennissen in deze vakgebieden die later wereldberoemd zouden worden. Bij deze achtergrond kan men de vraag stellen (zie ook de zeer gemakkelijke autobiografie van Sacks

- Ja als we op internet bronnen afaan (bijvoorbeeld Wikipedia bij het trefwoord Goethiet).
- Nee, volgens de meeste andere bronnen (menig mineralen boek en ook Wikipedia bij het trefwoord Goethe).

Hoe zit het dan? Als hij het mineraal niet zelf ontdekt heeft wie heeft het dan naar hem vernoemd? Nog tijdens zijn leven als verantwoordelijke voor de mijnbouw? Na zijn leven?

1805-1806

Johann Daniel Engels, mijningenieur te Siegen dacht in een nabije mijn te Eiserfeld een nieuw mineraal gevonden te hebben. Dit mineraal was echter al bekend in de 17^{de} eeuw onder de naam Rubinglimmer, een variëteit van Nadeleisenerz.

1806

Samen met zijn kennis, Henrich Adolph Achenbach (priester en hobby-aardwetenschapper aldaar) noemde hij dit uit eerbied voor Goethe, "Goethit". Ze waren beide lid van het natuurkundig genootschap van Lenz (waar Goethe lange tijd voorzitter van was) en deze nam de naam "Goethit" van Engels en Achenbach over in zijn catalogus uit 1806. Omdat de mineralen verzameling van Lenz toentertijd dermate compleet en groot was en constant groeide, hadden zijn catalogi



veel invloed. 1806 is ook de datum dat als

Foto 4. Goethiet mineralen (donkere stengels) Mineralenmuseum Marburg. De naalden zijn enkele mm lang (Foto van de auteur).



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“ontdekkingsjaar” op menig webwerf staat. Daarom wordt Lenz tegenwoordig vaak foutief als naamgever geciteerd.

1808

In 1808 hebben Achenbach en Engels hun ontdekking gepubliceerd (Jahrbuch für Berg- und Hüttenleute, Siegen; Schmid 1940).

1820

Goethe bedankt zich heel laat voor de naamgeving van het mineraal en wel in 1820. Achenbach was toen al dood en Engels wordt door Goethe nog niet eens genoemd (Schmid 1940).

Door dit late en foutieve bedankje door Goethe wordt ook 200 jaar later per abuis vaak Lenz als ontdekker geciteerd maar zelden Achenbach en bijna nooit Engels (Achenbach wordt wel door Murawski (1992) genoemd maar hij vergeet Engels).

Tot nu toe ben ik ook nog niet veel tegengekomen dat er op duidt dat Goethe zelf erg trots was op Goethiet, waarschijnlijk omdat hij het niet persoonlijk ontdekt heeft. Over andere zaken waar hij zelf naar onderzoek gedaan had (kleurenkeer, de oerplant, het bekende botje en de anti-plutonistische houding) heeft hij heel veel ophef gemaakt.

1832

In het sterftejaar van Goethe, publiceert Breithaupt (1832) de intussen derde editie van zijn toonaangevende mineralenboek. Volgens Murawski (1992) heeft Breithaupt Goethiet als eerste in de wetenschappelijke literatuur opgenomen. In de derde editie komt Goethiet echter niet (meer?) voor (net zomin als Rubinglimmer trouwens), maar enkel Nadeleisenerz. Dit is ook vrij logisch als men de mening van Breithaupt aangaande mineraalnaamgevingen in de vierde editie van zijn boek leest.

1836

Breithaupt (1836) is het in de vierde editie van zijn boek zo zat dat er mineralen enkel uit hoffelijkheid naar beroemdheden (zoals Humboldt die intussen beroemd geworden is, of Werner) genoemd worden (het geval Goethe?) dat hij schrijft dat zulke “Gevatterschaften gehören in das Gespräch, während dessen man Thee brauet” maar niet in de wetenschap.

Is Goethiet daarom toen weer uit de literatuur verdwenen?

20^{ste} en begin 21^{ste} eeuw

Goethiet is weer terug van weggeweest maar nu in tegenstelling tot voorheen, als synoniem van Nadeleisenerz (min-web.de, webmineral.com, DANA (1966)). In de loop van de 20^{ste} en 21^{ste} eeuw neemt de mystificatie van Goethe toe. Zelfs zover dat tegenwoordig Goethe als ontdekker van Goethiet geldt (zie bijvoorbeeld Bertaux et al 2000 en Wikipedia onder Goethiet juli 2004).

Tegenwoordig is Goethiet dus synoniem met Nadeleisenerz (a-FeOOH) (een zeer doeltreffende naam, zie foto 4) en Rubinglimmer van Lepidokrokit (g-FeOOH). Omdat de naam Goethiet door Engels en Achenbach oorspronkelijk werd ingevoerd voor een mineraal dat al bekend was als Rubinglimmer komt ook deze nog als synoniem van Goethiet voor zoals in LIB (1979).

Ook Goethiet is waarschijnlijk onderhevig aan het fenomeen dat men zoveel met Goethe in verbinding probeert te brengen omdat men zoveel over Goethe weet (hier heeft Goethe zelf sterk aan bijgedragen) en wil weten. Dit fenomeen leidt tot publicaties als: Goethe en de Wiskunde en Goethe de schaatser en andere bizarre titels ook al heeft Goethe zelf over deze thema's nauwelijks een woord gerept of iets mee te maken gehad (volgens Donat 1999; die per abuis Goethiet een steen noemt).

Afgezien van Goethiet, welke:

- niet door Goethe ontdekt werd
- al bekend was onder de andere doeltreffende naam Rubinglimmer
- tegenwoordig synoniem is Nadeleisenerz heeft Goethe direct of indirect invloed op de mijnbouw gehad maar ook andersom: “War Goethes amtliche Tätigkeit von 1776-1796 von entscheidener Bedeutung für den ... Bergbau, so hatte dieser wiederum großen Einfluß auf Goethes Schaffen als Dichter und Wissenschaftler” (Wagenbreth 1983). Een mooi voorbeeld is het volgende fragment uit Faust II:

*Als Felschirurgen wohlbekannt;
Die hohen Berge schröpfen wir,
Aus vollen Adern schöpfen wir;*

Dus Goethe was een fan van de mijnbouwkunde en is en was een goede ambassadeur van deze tot op heden, zoals uit het volgende compliment gericht aan Mijnbouwkundig Ingenieurs blijkt:

*In Bergesadern, Mauergründen
Ist Gold gemünzt und ungemünzt zu finden,
Und fragt ihr mich, wer es zutage schafft:
Begabten Manns Natur- und Geisteskraft.
[Faust II]*

Referenties:

Faust I en II: Gutenberg project op het internet.
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70 jaar ontdekkingsreis door de delta



- 2004
- 2003 dijkdorbraak Wilnis
- 1980 bodem-voontreiniging Lekkerek
- 1953 watersnood-ramp
- 1934 oprichting GeoDelft
- 1918 treinramp Weesp

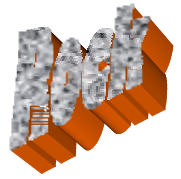
GeoDelft is als Groot Technologisch Instituut al zeventig jaar actief in het vakgebied van de geo-engineering en slaat daarbij dagelijks een brug tussen wetenschap en praktijk.

Geo-engineering heeft vele aandachtsgebieden, zoals funderingstechniek, geo-ecologie en grondmechanica waarmee het allerlei maatschappelijke en infrastructurele ontwikkelingen raakt. Een fascinerend en relevant vakgebied, waarin nog dagelijks ontdekkingen worden gedaan die een belangrijke meerwaarde hebben.

Nationaal Instituut voor geo-engineering



Stereographic (graphical=non-computer) methods in Geomechanics into the 21st century



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¹ Delft University of Technology

² Université de Liège

R.J. Lisle is well known in the field of structural geology. Lisle has made much use of stereographic methods to both analyse stress fields and ensuing geological structures from compass measurements of discontinuities in the rock mass (Ramsay and Lisle, 2000). The failure of the Malpasset Dam in 1959 resulted in the use of stereographic plots by Londe et al. (1969 & 1970), though Richard Goodman (1963- in the very first edition of the first rock mechanics journal) and Klaus John (1968) had been involved in attempting application of recently popular techniques being adopted in structural geology to rock mechanics. The methods of Londe et al. (loc cit) appear to be little understood but are very similar to the “Block Theory” developed by Goodman & Shi (1985).

The use of stereographic methods for slopes, underground openings and foundations has not become standard in rock mechanics practice as much as one would have hoped. This is possibly because much of the subject matter dealing with slopes has been published in textbooks dealing with ‘foundations’ such as the one by Bell (1978), which precedes the reference used by the Lisle in *Géotechnique*. When dealing with essentially foundations (dam abutments) Londe et al. (loc cit) use the word ‘slope’ in the titles of their papers. Another clue is a reaction to Maurenbrecher (1994) paper for an Institution of Civil Engineers conference on retaining structures in which R. Fernie (1994) introduced the session to which the paper was placed “..it reminds us that FEM is not the only elegant modelling available to Engineers.” Fernie then continues “For most practicing engineers stereo-nets are useful for 3D introductions to rock slope problems, but they have insufficient regular “hands on” experience to use them confidently.” He concludes, “we salute the theory but rely on engineering geologists practicing it”.

Lisle (2004) uses a plot (figure 2) first developed by Markland (1972) (figure 1), which, despite its simplicity and ease of use, has remained relatively obscure. The popular book *Rock slope engineering* 3rd edition (Hoek and Bray, 1981) does not describe this method but it does finally appear in the most recent edition under the authorship of Wyllie & Mah, (2004) see further review in this NewsLetter (Schmitz and Maurenbrecher 2005).. This was preceded by Wyllie’s (1999) book, *Foundations on rock!* In both of Wyllie’s books, (figure 3) the daylight envelope has been truncated for planar sliding to a zone corresponding to the difference between the dip direction of the planar joint and the dip of the slope. When the difference in direction exceeds 20° the resulting

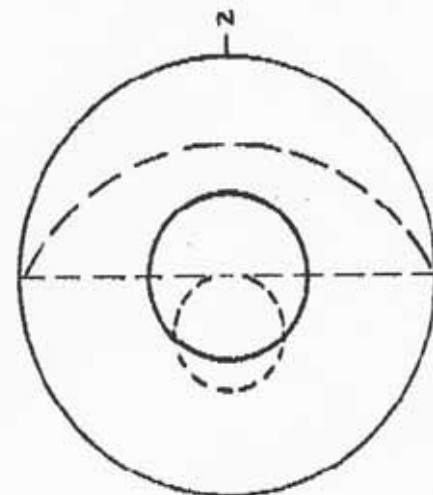


Fig 6 The friction cone for joint poles.

Figure 1: Markland 1972 Daylight envelope for a slope of about 40° facing North with friction circle (solid line) of about 30°

block will be thicker at one end than the other and therefore will mobilize sufficient strength to resist sliding. An increasing thickness would indeed mobilize more frictional resistance but in tandem the weight component parallel to the sliding direction also increases cancelling out any gain in stability for a plane of “ ϕ ” friction only.

Planar sliding assumes either an infinitely wide slope, release joints or side slopes allowing the block to slide on one plane. A 20° difference in alignment will require at least a second joint set to release the sliding block and hence the block

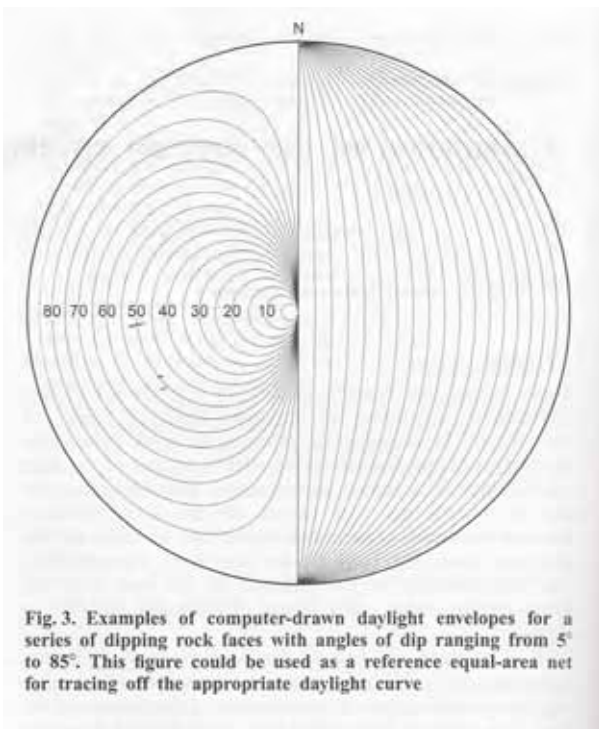


Figure 2: Slopes all face East, Lisle 2004

will slide as a wedge rather than a planar slide. The more rigorous ‘block theory’ by Goodman and Shi (1985) deals with a commonly occurring group of three discontinuity sets producing eight possible blocks shapes of which a number are removable depending on the orientation of the free surfaces (which can be anything from a floor, wall, slope or underground roof). Nevertheless for field surveys, the simpler ‘Markland’ daylight envelope has withstood the test of time and essentially remains a useful preliminary aid to assess slopes. One strange inconsistency remains: why Hoek and Bray did not adopt Markland’s polar daylight envelope? Markland was a student at Imperial College when Evert Hoek was professor of Rock Me-

chanics. (Other non-polar plots involving great circles only- from Markland are included in the book). The polar method was initially popularized by workers at Golder Associates in Canada, where, even more strangely, Hoek for a number of years after Imperial College was a partner! Furthermore the contributors in Bell’s books, and Wyllie are or have been associated with Golders.

As can be seen in figure 2 (and also present in Richards et al. (1978,1987) is a ‘toppling’ envelope. This toppling envelope is originally attributed to Goodman and Bray (1976). This has little to do, in fact, with ‘kinematic analysis’ as steep joints into the slope will not allow for movement. Strange as it may seem the criteria for potential failure does seem to work if one analyses the stress equilibrium at the slope surface (Maurenbrecher 1994). The poles of planes having an alignment more than 10° as shown in figure 3 has a history of variation from 15° in 1976, decreases to 10° in 1978 rises to 30° in Goodman, 1989 (a footnote in the book states ‘the 15°, previously recommended by Goodman and Bray (1977), has been found too small). then decreases in stages of 10° in Wylle (1999) to 20° and ending up at 10° in Wylle and Mah (2004) (figure 3)! Theoretically,

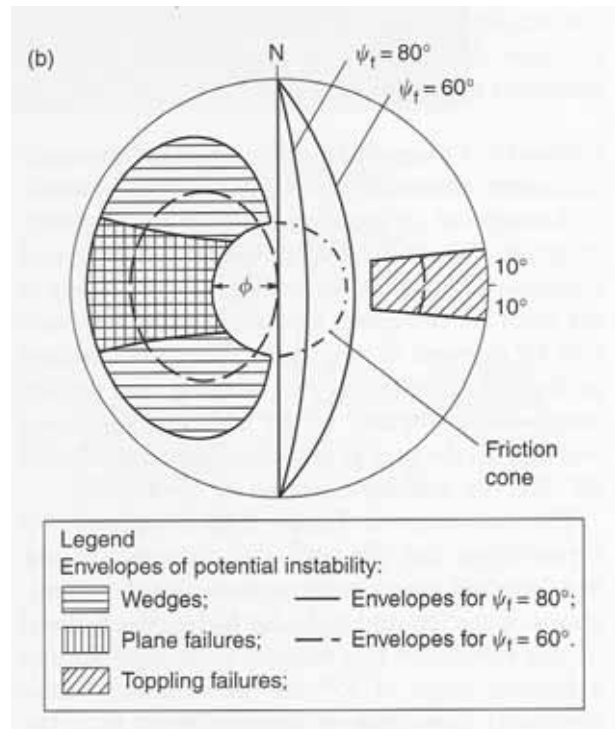


Figure 3: Wyllie and Mah 2004 Failure envelope slopes (two) facing East with toppling envelope.

using Goodman and Bray's initial analyses it can be shown that the angle can be much larger than 30° depending on the value of ϕ , dip of discontinuity and steepness of slope.

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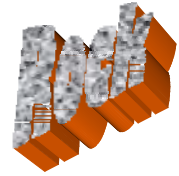
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Famous rock outcrops in the Dutch (Limburg)-Belgian (Liège) frontier region

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ir. Claude Polo-Chiapolini - Université de Liège

Prof.Dr.ir. Christian Schroeder - Université de Liège



1 Introduction

In the Netherlands and most of the frontier regions, rock outcrops are uncommon. Although very rare, these few outcrops are world famous because they represent unique:

- i) Geological highlights: the Maastrichtian and the Visean type localities (discussed in section 3)
- ii) Palaeontological highlights: the “first dinosaur”, the Mosasaur(us) (discussed in section 4)
- iii) Mining and Petroleum engineering highlights: a 6000 year old silex mining tradition, the underground “Mergel”/“Tuffeau de Maestricht” quarries with hundreds of kilometres of galleries, the geomechanical link with the Ekofisk hydro-carbon field, and diverse open pit mines in the Maastrichtian deposits (discussed in section 5)
- iv) Engineering geological highlights: the 65m deep unsupported Caster trench and the infamous Palaeokarst encountered recently during excavation of the Soumagne tunnel (discussed in section 6)

2 Sites

The information found in several outcrops will be used in this article (N° refers to figure 1):

- Maastrichtian calcarenite: open pit - N°2
- Maastrichtian calcarenite: underground quarries - next to N°2 and between N°2 and N°4
- Maastrichtian chalk: open pit - N°5
- Visean (karstified) limestone: former quarry - N°9
- Visean (karstified) limestone: during construction of the Soumagne tunnel - Soumagne (not on map)
- Contemporary silex mine - N°11
- Large excavation at Caster - N°4
- Stone-age silex mine near Ryckholt - N°10



Figure 1. Map showing the location of the different outcrops described in this article: 1) Museum of Natural History, Maastricht next to the Jeker/Geer; 2) Open pit mine in Maastrichtian calcarenite of the Sint Pietersberg/Montagne Saint Pierre; 3) Topographic maximum of the Sint Pietersberg (Observant) is a spoil heap next to the mine; 4) The Caster trench 5) Chalk open pit mine near Lixhe; 6) Borehole where Phtanite was encountered during site investigation of the pipeline Oostende/Ostende-Germany; 7) Visé/Wezet; 8) Point from which the Visean outcrop (9) and the Lixhe open pit mine (5) can be seen; 9) Visean Outcrop; 10) Ryckholt stone age silex mining district; 11) Eben-Ezer present-day silex

3 Geological highlights: Dumont and two type locations

Dumont

The city of Liège/Luik has been site of mining and metallurgy for a thousand years. The centre of the city is constructed on coal (coal from the Westphalian, figure 2), the metal ore arrived on the rivers Maas/Meuse and Vesdre/Wezer. Therefore Liège became one of the earliest and last remaining sites for metallurgy



Figure 2. Liège is built on coal (Westphalian) as these (hand sized) specimen, excavated during the construction of the new Guillemins TGV station, show (photo summer 2004).

André Hubert Dumont (1809-1857) (GE 1971) was trained as mine-surveyor (remember that William Smith was a surveyor as well). To learn something about the geological composition of the southern provinces of the “Kingdom of the united Netherlands” (at that time the present day: The Netherlands, Belgium and Luxemburg were unified into this Kingdom), the “Académie royale des sciences et belles-lettres de Bruxelles” offered price money for treatises on geology. Prices were given to the treatise of the geology of the province of: Hainaut/Hengouwen in 1821, Namur/Namen in 1824, Luxemburg/Luxembourg in 1828 and Liège/Luik in 1830. André Hubert Dumont won the latter price. According to Dumont (1849) himself, this was the first detailed geological map of any Belgian province.

Thereafter Dumont was given permission by the government to participate in the preparation of a detailed geological map of the entire Kingdom. This project was brought to an end by the Belgian independency wars of 1830 (Dumont 1849). But work continued when in 1836, the Belgian government requested and

paid for the preparation of detailed geological maps of the abovementioned provinces. This task was given to Dumont. In 1837 Dumont was asked to map the remaining provinces (Brabant, Antwerpen/Anvers, Vlaanderen/Flanders and Limburg/Limbourg) as well. Dumont worked at the Université de

...the first detailed geological map of Belgium...

Liège (although he must have been mainly walking outdoors mapping outcrops) towards a Doctor degree in Sciences. Later he became Professor of Geology and Mineralogy and rector at this university. Because, eventually, he prepared the first detailed geological map of Belgium (1849; GE 1971) and another map of Belgium and neighbouring regions (one of the reasons he visited the Sint Pietersberg) he is considered to be the godfather of geology in Belgium (www1). His statue stands in front of the central building of the Université de Liège, place de XX août (figure 3). It was André Hubert Dumont who gave the Visean and the Maastrichtian their names. A few years later another Professor André Dumont, Léon André Dumont (1847-1920), mining engineer, achieved fame by predicting in 1877, the presence of hard coal in the underground of the Kempen/Campine (region in the Belgian province Limburg). The presence of hard coal, which led to an enormous industrialisation of the Kempen, was finally proven in 1901 by drillings (The telegram of the drill team was submitted in Maastricht to Professeur Dumont,



Figure 3. Photo of Dumont in front of the main building of the Université de Liège. Upper box: Note the hammer and chisel and the pit lamp at his feet. Lower box: Dumont squints at the café au Delft. Can this be coincidence? (photo summer 2003).

Maastrichtian

“Le terrain crétacé ayant été, cette année, le sujet de mes études, je crois devoir dire quelques mots sur sa classification et sur sa composition. Je le divise en système aachenien, nervien, senonien et maestrichtien“, so Dumont spoke (1849) and the Maastrichtian was born.

Hubert André Dumont gave the Maastrichtian formation its name in 1849 (Murawski and Meyer 2004) and appointed the outcrop beneath de “Hoeve Lichtenberg” on the Sint Pietersberg near Maastricht as type locality of the Maastrichtian (Felder and Bosch 2000).

The Maastrichtian of the Sint Pietersberg

The Maastrichtian calcarenites of the Sint Pietersberg are world-famous. Dumont’s type locality is not far from the open pit mine shown in the upper photo in figure 4. For Dutch standards the Sint Pietersberg (St. Peter’s Mountain) is a mountain (see figure 4 to be amazed



Figure 4. Above: The open pit mine in the Sint Pietersberg, just south of Maastricht (point 2 in figure 1). Below: The spoil heap, located on the Sint Pietersberg, "towers" above the alluvial deposits of the river Maas (photos: summer 2004 and autumn 2004, looking from point 3i to 3, in figure 1).

about its size).

The Maastrichtian in Lixhe

Maastrichtian chalk can be found in a chalk, “Craie de Lixhe”, open pit mine near Lixhe, a village opposite to Visé on the other side of the



Figure 5 (left). Chalk outcrop in the Carrière de Lixhe (located at point 5 in figure 1). The upper two photos were taken from point 8 (autumn 2004). The two thereafter in the quarry (point 5, 2002), the lowest image on a sample of Lixhe chalk in the laboratory (the diameter of the coccolite is 10 micrometer).

The Viséan

Just south of the frontier town Visé, an outcrop can be found: the type locality of the Viséan. It was again Dumont who gave this formation its name in 1832 (Murawski and Meyer 2004). This outcrop (figure 6) is not only famous for its Viséan but as well for its Palaeokarst (discussed in section 6). Ingeokring members visited this Palaeokarst during the Karst excursion (Schmitz and Schroeder 2004) in October

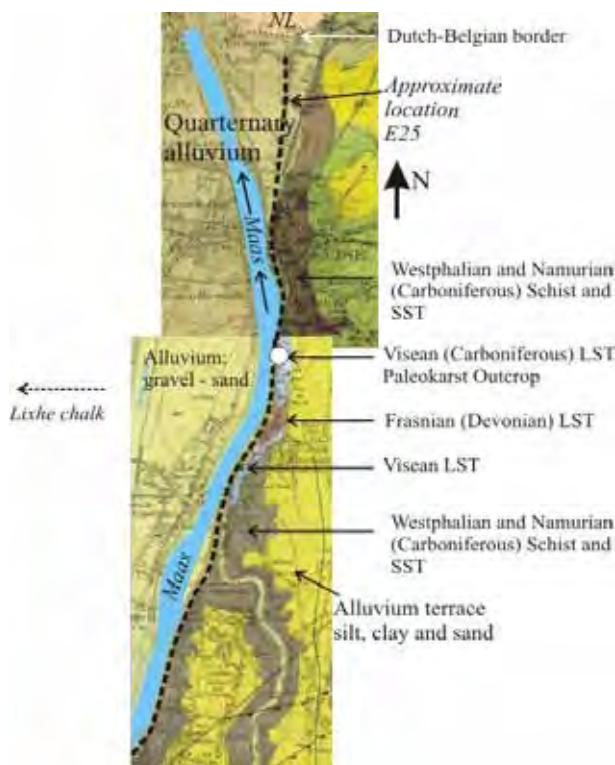


Figure 6. The outcrop south of Visé shows that the Viséan limestone outcrop is only a small island surrounded by Westphalian, Namurian, Frasnian and Quaternary deposits (www2).

4 Paleontological highlights:

The “first dinosaur”

In many old cultures dragon legends exist. Are these legends based on coincidental discoveries

of fossils and more specifically of dinosaurs? In the Middle Ages fossils were dismissed as a “delusus naturae” a joke of nature. The idea that they were exactly what they seemed to be, proved extremely hard to accept (Wade 1998). When in 1770 the large skull of a Mosasaurus (Maas lizard, for purists: not a dinosaur) was discovered by miners in the Maastrichtian deposits of the Sint Pietersberg (Faber 1926) everything changed. After Maastricht fell to Napoleon, the famous skull, was “borrowed” and transported to Paris where it was analysed by the expert: the famous scientist Kuefer (known as Georges Cuvier). Kuefer interpreted the



Figure 7. Above: The discovery of the first Mosasaurus in 1770 (Faber 1926). Middle: The new “Mosasaurus” (actually a: Prognathodon saturator) found in Maastrichtian calcarenites in 1998. Below: A replica of a Mosasaurus in action.

skull as giant extinct marine lizard (www3) and named it Mosasaurus. Thereby, the Mosasaurus was one of the first to be classed as prehistoric animal and not as the recent remains of a contemporary monster. The skull is still in Paris (at least in 1994, the last time the authors checked) placed in a small box in a corner of the main building of the “Muséum national d'Histoire naturelle”. The “Natuurhistorisch Museum Maastricht” had to do with a plastic copy until in 1998 a new (bigger!) “Mosasaurus” skeleton was found (figure 7). See Dortangs (et al 2002) for information about its classification.

5 Mining and Petroleum engineering highlights: Roman building stones - Ekofisk oil field - 6000 years silex mining

Maastrichtian: Calcarenite underground quarries

The Maastrichtian “mergel” or “Tuffeau de Maestricht”, in fact calcarenite, has been mined since Roman times. The word “mergel”, as the rock is known in the region, is derived from the mediaeval latin “margila” which has even older Celtic roots. Celts were the first who used the soft limestone and used it as fertilizer (de Vries and de Tollenaere 1983) and it was still used as such in this region in the 20th century.

First the material was mined in surface quarries. Later the material was mined under-

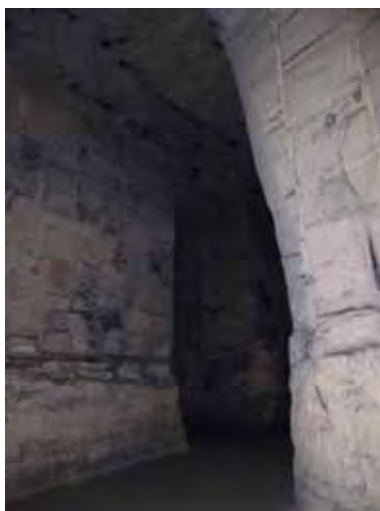


Figure 8. The old room and pillar mines (actually underground quarries) in the Sint Pietersberg (Photo summer 2004). The highest excavation galleries are 12-15m high (Schaik 1938).

ground (see figure 8). This led to the creation of extensive subsurface galleries (a thousand kilometres; before modern open pit mining started excavating them). Nowadays the material is (still) mined for cement production instead of building-blocks and in open pit mines (outcrop N° 2, figure 1) instead of underground quarries



Figure 9. Shovel loading the dump truck in the calcarenite, open pit south of Maastricht (N° 2, figure 1). (Photo: Courtesy of ENCI, Maas-

In the largest open pit in the Netherlands the calcarenite, of the Maastrichtian is mined. The calcarenite is used in the cement production. The following steps are taken to produce cement (www4):

- stripping of the 15m thick overburden (gravel, sand and loam)
- blasting
- separation of silex (used for road construction) and calcarenite
- loading of the calcarenite by hydraulic shovels into 60ton dumpers (see figure 9)
- 2 stage crushing of the calcarenite
- mixing of different qualities of Maastrichtian rocks (formation of Maastricht and formation of Gulpen)
- Drying (removal of 15% moisture)
- addition of Quartz sand (SiO₂), fly ash (Al₂O₃), and additives containing iron (iron oxide)
- mixing and milling
- burning and sintering in a 180m long, 5.5m diameter rotary kiln
- cooling

After these steps the Maastrichtian calcarenite has been turned into Portland clinker.

Maastrichtian: Chalk open pit

In the open pit (point 5; figure 1) the Maastrichtian chalk is mined for cement production

as the calcarenite described above. Because of the presence of chalk instead of calcarenite, white cement can be produced which is used in special (ornamental) applications in civil engineering.

Maastrichtian: Silex mines

Silex has been mined in the Maastrichtian for a 6000 years (discontinuously?). Marcel de Puydt (former student at Université de Liège) discovered in 1881 the old mining district of Ryckholt (N° 10, figure 1) (Engelen 1998).

The mining method consisted of room and pillar mining, occasionally with stowing and (partial) pillar extraction. The maximum overburden was 12m, the shaft diameter 1m. No support was used except for temporarily installed wooden struts (Felder 1998). Other stone-age mines were sliced by a road cut just north of Valkenburg, west of the Geul. Recent rediscovery and removal of vegetation resulted in a presentation of the mines in a 1:1 cross-section. The exploitation of the mining district of Ryckholt started 4000BC and continued for a 500years (Felder and Bosch 2000). Even in the stone-age there was a competition between the different mining districts. Analysis (Weisgerber 1993) of the distribution of tools made of silex originating from the Lousberg in Aachen (in the stone age the next mines east of the Ryckholt district) demonstrated that the competition of the Ryckholt and other mines located in what is at present Belgium, was tough: the silex tools of the Lousberg are found far in the east (>600km) but less in the west.

Silex mining and (manually) chiselling of the silex into "bricks" is still practised today in two quarries (see figure 10). One of them is the "Carrière du Pach Laaw" (firm Garcet), south of the village Eben-Ezer (point 11, figure 1). The silex blocks are used as silex tube mill liner. According to Taggart (1927) silex lining is composed of blocks or bricks of hard flint. Uniformity in thickness is the important requirement, considerable variation in length and width are allowable. They are cemented into the mill with cement. Joints are staggered to prevent circumferential grooving. Today the chief reason to apply silex (or porcelain, Al_2O_3 , rubber or PVC liners) and silex pebbles as grinding material is not to reduce wear but to avoid iron contamination of the product that has to be ground. For example: during grinding of minerals like barite and feldspars and others



Figure 10. Modern silex exploitation. The silex is mined near Eben-Ezer (N° 11, figure 1). The silex is chiselled by manual labour into prism shaped brick. These bricks (masonry) are used as silex tube mill liner. Length: 14cm to 13.5cm; width: 9.5 to <9cm; height: 6.5 to 6.7cm. In the 20th century the silex was still mined underground in galleries. Today the silex is provided by the open pit (N°5; figure 1). (Photo: Autumn 2004)

in the glass, ceramic, chemical-industry and during paint and pigment production.

Maastrichtian: Lixhe chalk, Ekofisk hydro-carbon field

The outcrop of Maastrichtian chalk in Lixhe, called “Craie de Lixhe”, has besides economic value to the region (cement production) a very special geomechanical significance: the same formation can be found in the North Sea at 3000m depth. In this region the chalk is a hydro-carbon reservoir rock. The reservoir is exploited from the Ekofisk platform which was built in 1971 (see figure 11). During hydro-carbon production the platform, with seafloor foundations, experienced ongoing settlements. What happened, which counteractions could be taken?

In terms of the Mohr-Coulomb model and the Terzaghi effective stress model one can reason as follows:

- i) hydro-carbon production causes:
 - ii) decrease of pore pressure, which causes:
 - iii) increase of effective stress, which causes:
 - iv) failure of chalk, which results in:
 - v) settlement (3m were attained in 1984).
- To prevent further settlement one started to inject seawater in 1987 based on the idea that:
- vi) injection of sea water would stimulate hydro-carbon production (it did)
 - vii) injection of sea water would cause a decrease of effective stresses (at least no further increase) which should prevent failure of the chalk and further settlement (it did not)

What actually happened was a further increase of the settlement, after (and in fact due to) the injections, up to a total of 8 m.

To study the problematic in more detail several geomechanical research projects were started. Because sampling in a drill hole at 3000m depth is very expensive, alternatives were sought. Looking on geological maps one found out that the chalk outcropping in Lixhe resembled the one in the Ekofisk field (same formation). Suddenly geomechanical engineers from all over Europe were interested in the quarries near Lixhe. The research project resulted in two theses in Liège (Schroeder 2003, Collin 2003) and other thesis will follow in Trondheim.

6 Engineering geological highlights: The Caster trench and Palaeokarst

Maastrichtian: The Caster trench

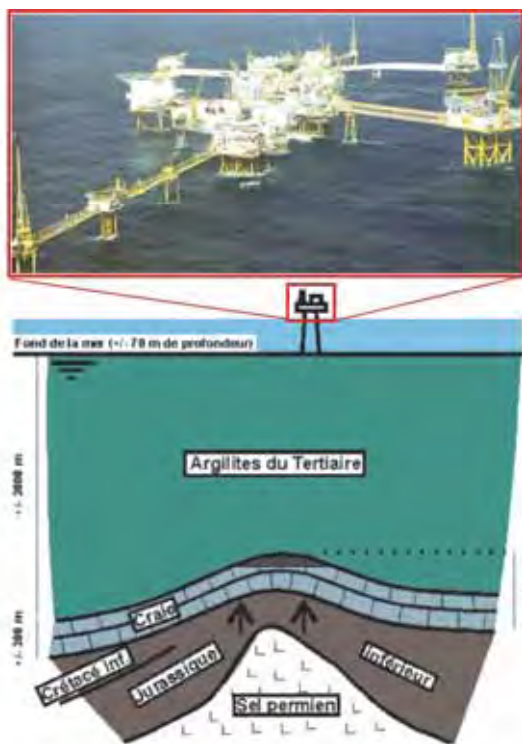


Figure 11. Above: Photo Ekofisk platform (Photo: courtesy of P.P.Co). Below: This section through the Ekofisk reservoir shows the location of the chalk reservoir rock (modified after Masson et al 1980).



Figure 12. South of Maastricht one can see these impressive Maastrichtian outcrops bordering the Albert canal (Caster, Lanaye) excavated in 1932 (Photo from point 4i to 4 in figure 1, winter 2004).

On the way south from the Maastrichtian type locality to the Visean type locality, the Maastrichtian has been dissected by an enormous excavation (figure 12). This trench was constructed in the 1930th as part of the Albert canal, which links the industrial basin of Liège to the North Sea (according to Delmer (1939) one of the reasons to construct the canal here, was as line of defence).

This 1300m long section of the Albert canal is known as the “tranchée de Caster” (the dig-out or trench of Caster). At this point the Albert canal, starting north of Liège, leaves the Maas valley. When leaving a natural drainage pattern obstacles are often encountered. In this case the obstacle was the Sint Pietersberg described above. To keep the number of ship locks low it was decided to cut the Sint Pietersberg down to the level of the Albert canal at its starting point in Liège: this meant that the Sint Pietersberg had to be cut down by 65m. Between 1930-1933 (Delmer 1939, Costes 2000, figure 13):

- 1200 men worked at the excavation process
- 20.000 m³/day, 30.000 t/day were excavated
- the excavated material was used as fill of the constructed dikes. The rest was transported to the cement quarries nearby (see note 1)
- 16 steam shovels and spoon dredgers were used as well as 1000 tip wagons and 63 locomotives
- 65km of rail were installed
- the blasting cycle took place at the end of the day
- galleries and shafts were constructed to remove the muck from the level of excavation via the interior of the Sint Pietersberg to the tip wagons and locomotives operating at the level of the future canal
- the benches are 10m high, 1.5m (southern slope) to 1m wide (northern slope); the inclination is 76° (southern slope) to 72° (northern slope)
- no reinforcement was needed

As stated above the trench is very steep and high and still no reinforcement was applied.

How is this possible?

Maastrichtian calcarenites have very good rock mass properties, although the strength of the intact rock material, the UCS (unconfined compressive strength), is comparably low (general range of UCS of calcarenites, formation of Maastricht, Maastricht facies: dry: 1.5-5.5 MPa, saturated: 1.0-4.5; Bekendam 1998). The low UCS is advantageous for underground and surface excavation. An additional advantage is that on the surface of the calcarenite a recrystallisation occurs which produces a protective layer (calcin protecteur, recrystallisation du carbonate de chaux) (RWCB 1992). Impressive examples of the very good rock mass qual-



Figure 13. On top: The entry to the muck tunnels in the Sint Pietersberg. These were constructed and used only during the excavation of the Caster trench. In the middle: Steam shovels at work in the Caster trench. Below: Muck trains in the Caster trench on the level of the canal, in the distance: the river Maas (Photos modified after Delmer 1939).

Note 1: The main open pit in the Sint Pietersberg (N°2, figure 1) just south of Maastricht even stopped exploitation of the rock in the pit during the excavation of the stretch next to the Caster trench. The miners were sent from the quarry to the construction site to help excavate the canal. The excavated material was transported and stored in the open pit. The open pit was filled much muck that the cement mills could be fed for another three years after the excavation of the canal ended without even touching the own reserves (www4).

ity are the underground quarries and kazemat-ten which have a proven unsupported stand-up time of hundreds of years. These properties allowed to construct the Caster trench:

- with very steep slopes
- without support
- using an ingenious mucking technique by driving additional muck tunnels and shafts

These excellent properties of the Maastrichtian calcarenites should be born in mind during any future tunnelling in the region.

Visean: Palaeokarst in Visé and the Soumagne tunnel

Palaeokarst in Belgium

An overview of karst in Belgium has been given by Schmitz and Schroeder (2003): Karst in Belgium is dominantly related to the karst of Palaeozoic limestone. The Palaeozoic limestone is of Carboniferous age, in Wallonia rep-

Palaeokarst can be found where the Visean meets the Namurian

resented by e.g. the Visean, Namurian and Westphalian (see note 2). The contact between the Visean and the Namurian, stratigraphically a normal contact, corresponds on the regional scale to an old erosional surface with important karstification of the limestone of the Visean. The karst is filled in by Namurian sediments. The geotechnical properties of the infill material of the Palaeozoic karst on the contact Visean - Namurian is very heterogeneous: silt, sand, weathered shale, clays, breccias etc. (Calembert 1975). The Westphalian, Namurian and Visean were extensively folded and faulted during the Variscan/Hercynian orogeny (Bouhenni 2003). The Palaeozoic limestone and dolomite were karstified during the erosion of the Variscan/Hercynian mountain range (Calembert & Monjoie 1970). This Palaeokarst can therefore be found at any level where the Visean meets the Namurian. And where do these two meet? In an outcrop (Souvre-Argenteau, N°9 in figure 1) just south of Visé. The type locality of the Visean is thus not only

of academic/geological interest but as well interesting for engineering geologist because the same type of karst was encountered during the construction of the Soumagne tunnel discussed below.

Palaeokarst in the outcrop next to Visé

The quarry of Souvre-Argenteau (N°9, figure 1) offers an interesting outcrop of the top of the Carboniferous in a zone located in the North-east of the Brabant massif. Following the nomenclature of the new geological map of Wallonia 1:25.000, N° 42-3-4 "Dalhem-Herve" (Barchy and Marion 2000), one distinguishes (nomenclature following the new geological maps (www2)) from top to bottom along the outcrop (figure 16):

- 1) Quarternary (T): silts, alluvial gravels, river Maas terraces
- 3) Cretaceous (Campanian) (Sm): "Smectite de Herve" = "Vaalser Groenzand". In fact, this is not a Smectite but a marl containing: Carbonate, Quartz, Smectite, Illite, Illite-Chlorite mixed layers and pillared Smectite and Glauconite bands. This formation was deposited during the Campanian transgression on the Hercynian/Variscan peneplain. When outcropping the Carbonate in the "Smectite de Herve" is dissolved. Thereby the originally very good rock mass (RQD >90%, as cores below the Halambaye landfill have shown) is transformed into a weak soil. This causes many problems if houses or roads are founded on this material.
- 4) Carboniferous (Namurian): Souvré (Sou) formation: siliceous shale and siltified limestone

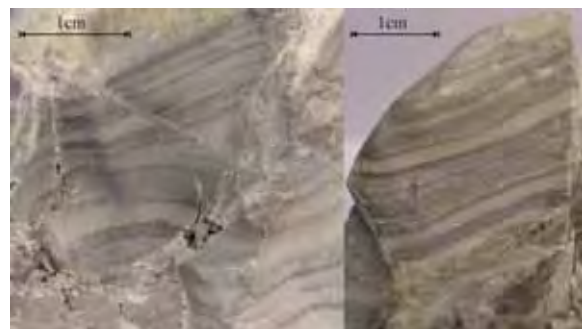


Figure 14. Phtanite encountered in a borehole west of the Visean outcrop in the plane between the Maas and the Albert canal (approximately at point 6 in figure 1).

Note 2: The coal seams of the Westphalian have been exploited in, around and underneath Liège for ages. Namurian coal seams have never been mined because they are too thin.

(“Phtanites”, see figure 14).

5) Carboniferous (Visean): (V) Sedimentary calcareous breccias, massive (dm to m) thick limestone banks, bioclastic massive limestone.

The Visean outcrop shows (figure 16):

- Palaeokarst

Post-Carboniferous karst which provoked the formation of large cavities at the contact with the “Houiller” (= Namurian and Westphalian). The cavities have been filled with collapse breccias (Phtanite, shales and clays). Examples of this Palaeokarst can be found in an outcrop just north to the quarry (figure 16 left column) and in the quarry itself (figure 16 middle column).

- Reactivation of Palaeokarst:

The presence of discontinuities (filled with Maas terrace sediments) and the reactivation of Palaeokarst result in progressive upward failure (figure 16 right column).

Palaeokarst in the Soumagne tunnel



Figure 15. Tunnel front during the construction of the Soumagne tunnel (radius 5.5m) showing the Palaeokarst on the Namurian-Visean interface (Photo: Courtesy of S.M. Soumagne Tunnel).

7 Summary

In this article we have shown that although rocks and rock outcrops are scarce in the Netherlands and the frontier region, the few outcrops that can be found are very spectacular and represent highlights in terms of:

- Geology: two type localities: Maastricht and Visé can be found close together in the frontier region between the Netherlands and Belgium because they are located in the working terrain of the active

mine-surveyor, later professor of geology and mineralogy at the Université de Liège: André Hubert Dumont, creator of the first detailed geological map of Belgium and neighbouring regions

- Mining and petroleum engineering: Maastrichtian chalk is sampled and tested to understand the behaviour of hydro-carbon host rock in the North Sea; Maastrichtian calcarenites were quarried underground for building blocks during many centuries leaving hundreds of kilometres of galleries; modern open pit mining continues to excavate Maastrichtian deposits for the cement industry (largest open pit mine in the Netherlands).
- Palaeontology: The skull of the Mosasaurus found in Maastrichtian deposits of the Sint Pietersberg played an important role in the public acceptance of extinct prehistoric life.
- Engineering geology: The presence of Palaeokarst can be predicted on the basis of knowledge of Visean-Namurian contacts; Steep and very deep excavations, tunnels and shafts can be constructed without support and without major difficulty in Maastrichtian calcarenites due to the good rock mass quality with at the same time, a low uniaxial strength of the rock.

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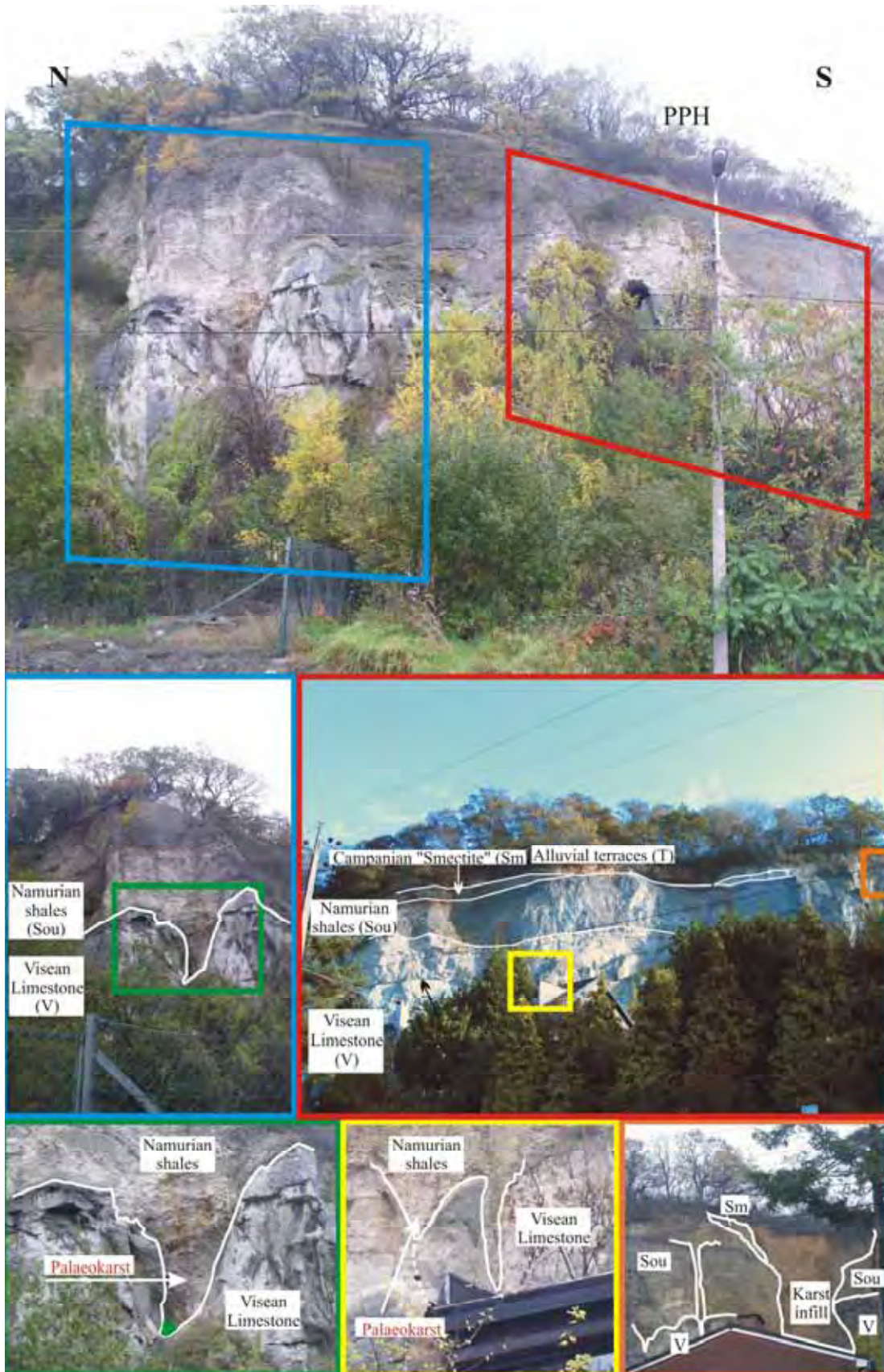


Figure 16. Outcrop showing the Palaeokarst on the Namurian-Visean interface. The outcrop is located just south of Visé (Visé is point 7 in figure 1; the outcrop point 9 has been photographed from point 8). PPH = post hercynian peneplain.

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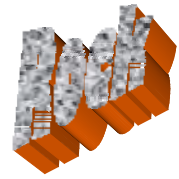
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Van rots tot natuursteen kei of tegel

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In de laatste tachtig jaar is de praktische kennis over het ontwerpen en uitvoeren van werken in de openbare ruimten met natuursteen drastisch verminderd. Kennis en vaardigheden met het straten van keien en kennis van kwaliteiten natuursteen in de groeven is niet overgedragen door de generaties. In het verleden wisten de architecten, handelaren en opzichters precies welke lagen in de lokale groeven voldoende kwaliteit hadden. Nu worden er over de hele wereld natuursteen blokken gewonnen en meestal elders bewerkt tot platen. Het centrum van de natuursteenhandel is nog Carrara in Italië, maar de landen met goedkope arbeidskrachten in Azië zijn aanzienlijke concurrenten geworden. De blokken worden gezaagd in platen en daarna weer bewerkt met technieken als boucharderen, polijsten, vlammen of in stroken gehakt voor het maken van keien.

Normen en Richtlijnen

In Nederland werkt de CROW (kennis centrum voor verkeer, vervoer en infrastructuur) te Ede al jaren aan de



ontwikkeling van civiele kennis in vele tientallen werkgroepen. De laatste drie jaren zijn twee werkgroepen actief bezig om de kennis van natuursteen voor de civiele toepassing te verhogen. Het doel is een publicatie uit te brengen in 2005/2006 om architecten, ingenieurs, opdrachtgevers en leveranciers meer basis kennis te geven over de toepassing van natuursteen.

In deze publicatie worden o.a. de volgende onderwerpen besproken: historie en voorgeschiedenis, het materiaal natuursteen, ontwerp, functionele eisen, verkeersbelasting, funderingen, elementenverhardingen, voegmaterialen, uitvoering, beheer etc. Het probleem is dat er weinig kennis aanwezig is in Nederland zodat via buitenlandse voorschriften (Duitse en Belgische) en publicaties de kennis wordt verzameld. Er is wel op individuele vakgebieden veel kennis aanwezig, maar een integrale kennis van het ontwerpen van natuursteen in openbare ruimten ontbreekt in Nederland. Geologen, ingenieurs, handelaren en natuursteenleggers hebben ieder op zich wel veel kennis en vaardigheden op deelgebieden.

Opvallend is dat de kennis van het aanleggen van (natuursteen)tegels in vloeren bij de utiliteitsbouw wel verder is ontwikkeld en vastgelegd in voorschriften gedurende de laatste eeuw.

In Europees verband zijn een aantal normbladen ontwikkeld met voorwaarden waaraan tegels, keien en banden moeten voldoen, respectievelijk de NEN EN 1341 t/m 1343.

Deze normbladen bevatten voorschriften en beproevingen zoals: toleranties van de afmetingen, vries- dooi weerstand, druksterkte, slijtvastheid, slipweerstand, waterabsorptie, petrografische beschrijving en monster name. In de voorschriften zijn er keuze mogelijkheden te maken in diverse klassen van kwaliteiten en

toleranties. De voorschriften in deze normen zijn door de bescherming van de Europese belangen zeer ruim genomen, waardoor de opdrachtgever in feite scherpere eisen moet stellen om goed werk te kunnen krijgen.

In de CROW werkgroep worden praktische richtlijnen en inzichten opgesteld zodat de opdrachtgevers of adviseurs zelf in staat zijn om functionele eisen te formuleren. In een tweede werkgroep van de CROW (Aanbevelingen Straatwerk RAW 2005) worden standaard besteksteksten voor natuursteen toepassingen gemaakt. De afkorting RAW staat voor Rationalisering Automatisering Wegenbouw, welke al vele jaren geleden standaard besteksteksten voor de civiele bouw heeft gemaakt. De bestekken hebben nu eenduidige, juridische sluitende teksten en systematiek voor alle gebruikers. Voor de aanleg van wegen wordt in de RAW het hoofdstuk 31 paragraaf 41 straatwerk verbeterd inclusief de nieuwe eisen voor natuursteen verhardingen.

In de praktijk zijn er vele interessante raakvlakken tussen de civiele techniek, geologie en chemische technieken, een paar hiervan worden hierna besproken.

Fundering

In het ontwerp van natuursteen bestratingen spelen een aantal vraagstukken een belangrijke rol zoals: zettingen in ondergronden, stijfheden van daken van parkeergarages, vochttransport door constructie, flexibele of stijve funderingsconstructie, betrouwbaarheid etc.

Een algemene regel is dat stijve constructies stijve voegen vragen en flexibele constructies



flexibele voegen. Maar hoe zit de mechanisch in elkaar bij een dak van parkeergarage die door (vracht) auto's wordt bereden en niet stijf is ontworpen.? De belangen van de constructeur zijn een zo gering mogelijke constructie hoogte en een zo hoog mogelijke ligging ten opzichte van het maaiveld wegens de opwaartse krachten door het grondwater.

Voor een wegebouwer geldt dat een dikkere goed opgebouwde en verdichte fundering de zettingen en levensduur van een weg verlengen. De spreiding van mobiele belasting wordt verbeterd door een dikkere fundering, maar de statische belasting neemt evenredig toe. Dan is men geneigd weinig ruimte over te laten voor het aanleggen van een natuursteen verharding. De vraag blijft echter welke constructie en voegmiddel toe te passen. Er zijn starre voegmiddelen zoals cement- of epoxy gebonden producten met E-modulus 6.400- 20.000 N/mm² voor epoxygebonden met druksterkten 40 -117N/mm² en flexibele voegmiddelen zoals LD-Mix of brekerzand.

Voor een goede berijd- en beloopbaar van natuursteen verharding is eigenlijk een starre voeg nodig wegens de zware belastingen tot 50 ton die worden toegelaten. De civiele belangen staan haaks op de exploitant/eigenaar van de parkeergarage.

Oorsprong van het gesteente

Een ander probleem te achterhalen waar het natuursteen vandaan komt. In de ijver om een zo laag mogelijke prijs te krijgen worden er wel eens certificaten gekopieerd waarbij alleen materiaal aanduidingen in de kop van de tekst verschillend zijn. Veelal geeft dat aanleiding



tot klachten omdat het geleverde materiaal slechter is dan in bestek voorgeschreven stond. De klachten gaan meestal over vocht, uitbloeien, verkleuring etc. Om te bewijzen dat de juiste stenen geleverd zijn kunnen slijpplaatjes van de geleverde en gewenste materialen worden vergeleken d.m.v. een microscopisch onderzoek.

Vocht

Bij een vochtprobleem in natuursteen, waar de oorzaak niet duidelijk is ten gevolge van bijvoorbeeld een lekkage, kan men gebruik maken van petrografisch en fluorescentiemicroscopisch onderzoek. Dit vochtverschijnsel kan optreden bij vloeren die worden schoongemaakt met machines/water en onbekende schoonmaak middelen. De bovenlaag van het natuursteen kan hierdoor dichtzitten en geen water verdampen.

De 20mm dikke slijpplaatjes worden door een polarisatiemicroscop op door en opvallend licht bestudeerd. De plaatjes worden onder

vacuüm geïmpregneerd met een fluorescentiehars, waardoor een beeld wordt verkregen van de porositeit en waterdoorlatendheid.

Ontwikkelingen

Betonstraatstenen, klinkers en natuursteen bestratingen worden door vocht, kauwgom en vuil aangetast. Op weinig beloopbare plaatsen ontstaat algenvorming. Nieuwe ontwikkelingen om (natuur)steen te impregneren tegen vochtaantasting en algenvorming zijn het behandelen met een nieuw impregneer middel op basis van teflon/fluor. Door nano technologie worden de poriën bekleed met de werkzame stof. De oppervlaktetenspanningen van de materialen worden verlaagd van normaal 83 naar 10×10^{-9} . De oppervlakte van de (natuur)steen wordt hierdoor waterafstotend gemaakt door het aanbrengen via airless spuiten of sproeien. Het middel kan op vochtige ondergronden worden aangebracht en heeft hierdoor minder beperkingen bij het aanbrengen. Voor de toepassing op bestaande wegen en pleinen voorkomt het teleurstellingen bij verkeerde keuze of toegepaste kleur van materiaal. Het middel wordt minimaal 10 jaar gegarandeerd, maar zijn nog veel langer werkzaam. In het verleden waren er wel middelen op basis van silanen of siloxanen. Dit nieuwe middel is een cocktail van een aantal werkzame stoffen en kan op maat worden gemaakt voor diverse toepassingen. Nu is er eindelijk een goed voorbeeld van prestatie verbeterend middel in de handel door middel van een cocktail zonder dat er een straf van een bond of vakorganisatie opstaat.

INGEOKRING PRIJSVRAAG juli 2005

Robrecht Schmitz – Université de Liège

Michiel Maurenbrecher – Technische Universiteit Delft

On October 22nd and 23rd the Ingeokring organised an engineering geological excursion to the Ardennes. One of the points of interest during the first day was the visit to the Sainte Anne's limestone room and pillar mine. A vivid discussion started on the stability of the mine with respect to the thickness of the slim pillars and their fairly large inclination.

On the basis of:

(quantitative) explanation how these thin, inclined pillars contribute to the stability of the mine.

The most complete and correct solution (deadline 2 months after publication of the newsletter) will be rewarded with a genuine Walloon hand chiselled silex brick.

Please send your results to



- these photographs,
 - the indicated inclination
 - a UCS of 108MPa determined with the point load test on samples collected during the excursion
 - and other details the participants surely noted during the visit,
- we would like to hear from you a reasoned

schmitz.robrecht@vdi.de

or P.M.Maurenbrecher@CITG.TUdelft.NL

or

EurEnGeo2004 conferentie in Luik

Richard Rijkers

(IAEG Secretary Organising Committee EurEnGeo2004)



De conferentie

“Het 1st European Regional IAEG Conference in Luik (4-7 mei 2004) is zeer succesvol verlopen”. Deze kwalificatie klinkt natuurlijk als een klok, maar laten we bij het begin beginnen: EurEnGeo2004 is het resultaat geworden van de gezamenlijke inspanning van drie ingenieurs-geologische verenigingen: CBGI, INGEOKring en DGG. Deze verenigingen zijn de nationale secties van de IAEG (is de International Association Engineering Geologists), resp. van België, Nederland en Duitsland. De conferentie is georganiseerd om een platform te bieden voor Europese professionals die internationaal willen communiceren over de toekomst van hun vak: (1) voor infrastructurele werken en de ondergrond, (2) innovatie in de ingenieursgeologie, (3) (nieuwe) onderzoekstechnieken en (4) geologische risico's.

Hoofdthema:

Professional Practices and Engineering Geological Methods in European Infrastructure Projects

Onderwerpen:

Topic 1: Professional Practices

Topic 2: Engineering Geological Methods

Topic 3: Case studies of Infrastructure Projects

Open work shops:

- Hazardous geological processes in Civil Engineering
- New Developments in risk evaluation

Geologische processen en Geo-risico

Dinsdag, de eerste dag, was geheel gevuld met open workshops over geologische processen en risico in het ontwerp en uitvoering van infrastructuur. Het was druk en de zaal liep vol. Dat beviel me. Chris Bremmer beet de spits af met een 'key note' lezing over de variatie van geomechanische en geologische eigenschappen en hoe daar mee om te gaan in

het geotechnisch ontwerpproces. De beoogde discussie kwam op gang en na een aantal andere presentaties over risico-analyse was de zaal het erover eens dat voor Risico-Analyse geen strakke 'blauwdruk' te hanteren is, maar voor de aanleg van complexe infrastructuur projecten wel degelijk uitgevoerd dient te worden.

Hilariteit bracht de lezing van Jorge Hanisch die “stalen tennisballen” - gevuld met elektronica - gebruikte om grote modderstromen te monitoren. Hanisch had in de veldexperimenten er nog nooit één teruggevonden om gegevens uit te lezen. Vanaf dat uur waren “the (empty) Balls of Jorge” niet van de lucht. Bij de lunch van vandaag stonden Belgische gehaktballen op het menu. Die smaakten sowieso niet.

Ingenieursgeologie en de Europese agenda

Woensdagmorgen schetste (de secretaris van) Philippe Busquin -Director Research&Development van de Europese Commissie- een beeld van mogelijkheden voor financiering van innovatief onderzoek. Dit gaf voor de ondergrond overigens weinig concrete aanknopingspunten. Interessanter was de discussie over de betekenis van Engineering Geology en haar positie tussen Geology en Civil Engineering. Aanscherping van deze vakgebieden en het takenpakket is noodzakelijk om bijvoorbeeld projectrisico's van de ondergrond effectiever te kunnen analyseren (zie kader). De sessies over normering (ISO en NEN) van geotechnische grondeigenschappen hadden die ochtend ook mijn aandacht. De presentaties vestigde de aandacht op de noodzaak tot meer specifieke definitie van geotechnische termen, data en uitwisseling te bevorderen en te vereenvoudigen. Aleid Bosch brak in zijn presentatie een lans voor het gebruik van XML bij digitale uitwisseling van geologische gegevens.

Sporen en tunnels

Donderdag stond in het teken van nieuwe

(veld-)technieken en de concrete betekenis voor de aanleg van infrastructuur (tunnels en spoorwegen). Tunnels werden in Nederland afgezonken en worden tegenwoordig geboord. Tunnels onder de Alpen worden veelal geboord, maar ook (machinaal) afgegraven (NATM methode). Er passeerde die dag veel projecten en vooral veel grondonderzoek. Vooruitgang is vooral geboekt bij de numerieke berekening van deformatie van grond en gesteente. Een groot aantal lezingen gaf aan dat grondonderzoek veelal niet integraal en volledig wordt uitgevoerd. Daarom is bij het opsporen van (verborgen) ondergrondse obstakels, karstgaten en geologische breuken weinig vooruitgang geboekt. Innovatie ligt deze jaren vooral bij onderzoek naar zwakke (verbroken) gesteenten en deformatie van slappe sedimenten.

Horizontale regen

Op vrijdag werd de Conferentie afgesloten met excursies naar de Soumagne-tunnel (HSL verbinding tussen Luik en Aachen), de Rheinbraun pit (bruinkoolwinning nabij Aachen) of het Maastrichtien Krijtkalk van Zuid-Limburg. Het was zeer slecht weer. De tunnelbezoekers hadden daarom vandaag mazzel. Horizontale regen is waarschijnlijk

normaal voor Liègeois, maar Spaanse, Italiaanse en Griekse congresgangers worden sacherrijng van horizontale regen. Ik besloot naar huis te gaan en nam afscheid van bezoekers, collega's en mede-organisatoren. De conferentie was geslaagd, en daar deed de horizontale regen niets aan af.

De kengetallen

De karakteristieke getallen van EurEnGeo2004 waren:

- 180 deelnemers
- 24 verschillende Europese landen
- 89 wetenschappelijke presentaties
- 15 Nederlandse presentaties
- 4 presentaties door TNO-NITG (Divisie Geologie)
- 11 commerciële stands
- 1 diner banquet
- 1 borrel bij de burgemeester van Luik

HACK, R., R. AZZAM & R. CHARLIES 2004. Engineering Geology for Infrastructure Planning in Europe – A European Perspective. Lecture notes in Earth Sciences 104, Springer-Verlag (ISBN 3-540-21075-X), pp. 803





Engineering Geology (revisited)

Definition

'Engineering Geology' is a discipline that studies the interaction between 'ground' and any possible use of 'ground' for engineering purposes, either during the design, construction or maintenance phase of an engineering work. 'Ground' consists of any material that is found at the earth's surface or within its subsurface and includes rock, soil or a combination of both materials.

The understanding of the interaction between ground, water and engineering works is based on combining various disciplines in geology and engineering sciences. Geological disciplines include, but are not limited to, structural geology, sedimentology, mineralogy, geomorphology and geophysics. Engineering sciences include soil and rock mechanics, foundation and construction engineering, and geohydrology. Geology is an elementary science used to approach engineering works.

Engineering geology is usually applied to civil engineering works such as roads, railways, bridges, tunnels, buildings, dams, waterworks, pipelines, off-shore structures, dredging, underground construction works and construction materials.

Key Elements

Key elements in Engineering Geology are Geology, Soil/Rock Mechanics and construction fundamentals of engineering works. The former allows the Engineering Geologist to understand site (terrain) and ground features in relation to the proposed engineering works. The latter gives the necessary tools to comprise the mechanical behaviour of the ground under influence of engineering works and vice-versa.

An Engineering Geologist generally performs a site investigation to explore the site conditions

for future engineering works. A sound knowledge of site investigation methods and techniques to efficiently determine the ground composition, structure and engineering properties is hereby of prime importance. Examples of site investigation techniques include drilling, sampling, geophysics and remote sensing.

The site investigation results together with laboratory test data and desk study information are the necessary input for the creation of a geological, geotechnical and/or geohydrological (material) model of the subsurface (= Engineering Geological Model). This model is the basis for analyses of interactions between the subsurface and the planned engineering works. Advanced engineering-geological analyses comprise of numerical ground mass modelling, geostatistics and comparative studies. Geostatistics and geographical information systems (GIS) are often necessary in making these models and are therefore prominent elements in Engineering Geology.

In some projects Material Science for ground as a construction material and Environmental sciences are supporting elements.

A new field of expertise to Engineering Geology is (geo-)hazard and risk assessment. This discipline considers potential hazards for a specific engineering project. Potential (geo-) hazards include, amongst others, slope instability, seismic risk, shallow gas trapped in the subsurface, flooding, subsidence, or site contamination by pollutants.

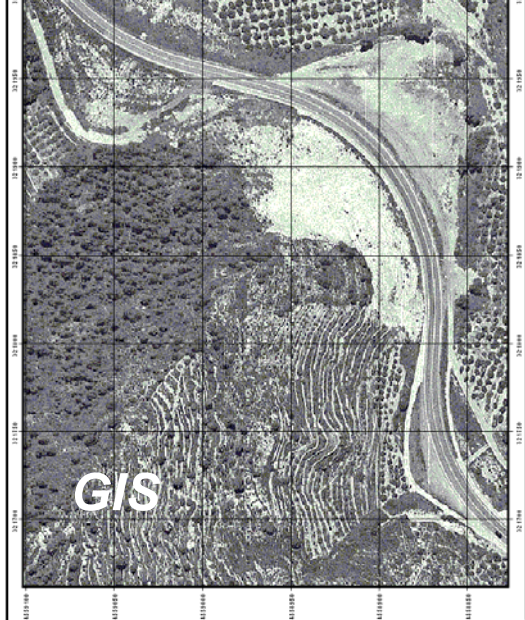
Naschrift Redactie:

In de vorige Newsletter is abusievelijk de publicatie met betrekking tot het RandstadRail project te Rotterdam van Robert Berkelaar en Melinda van den Bosch (beide Gemeentewerken Rotterdam) aan het EurEnGeo2004 vergeten te vermelden.

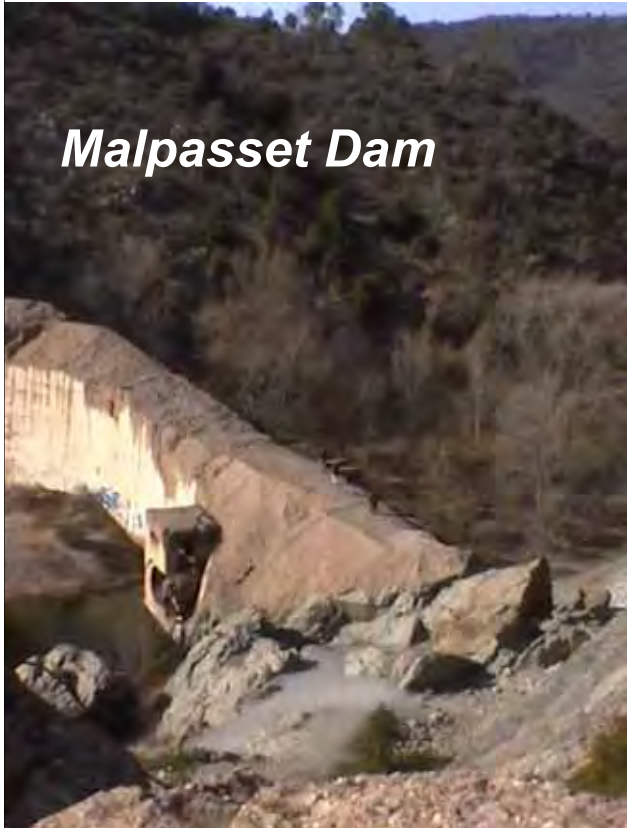


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PROFESSORS' COLUMN

Engineering Geology in a Developing Country

J. Louis van Rooy, Senior lecturer in Engineering Geology, Department of Geology, University of Pretoria, South Africa

After the discovery of diamonds and gold in the late 1880s infrastructure development, especially railway lines, started and linked the mines, in the central parts of the Southern Africa, with the ports of Cape Town and Durban. This was the origins of the present modern infrastructure in the country.

During the apartheid years more and more money was spent on political ideologies and the war waged in the neighbouring countries and local terrorism to curb the expansion of communism and to keep the apartheid regime in power. With the abolition of the acts regulating where people may live and work and the first democratic election in 1994, the Government of National Unity adopted many of the goals of the ANC's Reconstruction and Development Programme.

One major goal is the provision of housing, electricity and water to the many millions of South Africans living in squatter camps under unhygienic conditions.

...to keep the gold mines dry in the karst area of the Far West Rand...

Now what could you ask have all this to do with engineering geology?

During the late 1940s and early 1950s Prof Jeremiah Jennings, a civil engineer, and Tony Brink, a young geologist, were responsible for the formalisation of the applied field of engineering geology in South Africa. Jennings was at the time a student of Karl Terzaghi.

Geologists and civil engineers have been working together on especially dam projects even prior to the 1940s in South Africa.

The geologic constraints on infrastructure development in the early years and the economic importance of developing large tracks of land around the mining areas, underlined the importance of the geologic factor in civil engineering.

Large parts of South Africa are underlain by expansive and collapsible soils. The shallow undermining caused surface subsidence and the waste products pollution of the environment.

But it was really the shallow undermining in the coalfields and the extraction of groundwater to keep the gold mines dry in the karst area of the Far West Rand that emphasised the importance of engineering geology.

The large-scale extraction of groundwater from the karst caused serious surface instability with sinkholes and dolines that caused certain areas to become virtually uninhabitable. Engineering geologists played and are still playing an important role in the evaluation of surface stability in karst areas.

During the last couple of years under the apartheid government very little money was spent on new infrastructure development as large sums of money was used to keep the political dispensation in place. The country also went through a dry cycle with roads, near the end of their design life, standing up fairly well with the low rainfall in the late 1980s and early 1990s.

The unbanning of the ANC as a political party changed the political scenario and after the 1994 elections the new government started to implement its policies regarding the provision of housing, water and electricity to the many millions of people who were still without these basic services.

This also caused an upsurge in geotechnical work and suddenly there were too few engineering geologists and geotechnical engineers.

In addition to this the mining companies started to sponsor students in engineering geology as they are regarded as very useful professionals, especially regarding the rock mechanics and the environmental input.

Due to this relatively new and increased demand from industry the engineering geology training at the University of Pretoria was changed to include an option in rock engineering. This meant that very few engineering ge-



ologists actually entered the construction geology field (soil mechanics) over the past 15 years.

The economic influence of black economic empowerment is suddenly also seen in the new emerging middle-class that are not comfortable staying in the so-called black townships and are moving into new areas where high density high security housing complexes are in great demand.

All new land for development must be investigated according to the National Department of Housing and National Home Builders Registration Council's guidelines, which include different stages of geotechnical investigations.

For many years the engineering geologists in the construction geology field worked on their own from small offices or rather from their homes to keep overheads down and to survive the slow infrastructure development times.

The present pressure on new housing developments is enormous and the pooling of the professional engineering geology resource is probably one way of managing the current shortage and work overloaded engineering geologist syndrome.

The upsurge in housing development will obviously only last as long as the local economic growth is sustained and this is one of those unknown factors.

The present profile of the practising engineer-

ing geologists outside of the mining industry is probably one of ageing white professionals, each working on his/her own.

This can be explained by a number of factors. The new professionals entering the market are looking for good salaries and job security. Very few new engineering geologists are trained and the numbers are only now increasing at tertiary education level.

The current increased demand for engineering geological services are due to the readjustment of the political and economic platform in South Africa as explained above, the decreased reliance on gold being replaced by the sudden increase in the demand for platinum and the establishment of the new middleclass without appropriate infrastructure to accommodate them.

I am very optimistic about the future of engineering geology in South Africa, and on the African continent as a whole. Hopefully the new initiatives on the continent in the political and economic fields will produce growth in infrastructure, mining and housing of which the rocks and soils of the Earth's crust is the foundation and construction materials. There is obviously a great challenge for the engineering geology profession to adjust to the new demands and to become more representative of the population composition of South Africa and the continent as a whole.

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MEETING THE CHALLENGE OF NATURE

INGEOKRING ACTIVITIES

Ingeokring members expedition to the Ardennes rock slopes

By Michiel Maurenbrecher

with advice and help from climbing fanatic Marco Huisman

Ingeokring excursions: an uphill climb?

The Ardennes tour was organised by Marco Huisman. Not only did we look at rock slopes and their stability. Some of them actually turned out not to be that safe: A rock slope near the slope we visited first near to Namen recently was subject of rock fall as can be seen on website of skynet (see the references).

Other unsafe slopes were the Citadel Slope at Dinant (which has been stabilised - see appendix 1 to this article) and after carefully inspecting the Roche du Bayard two months later in the Travel Section of the Telegraaf an announcement that this slope is to be stabilised! (Appendix 2 to this article).



Michiel interacting with rock, sky and rope.

As an extra diversion Marco organised a rock climbing experience. The safety issue became of some concern when Marco suddenly excused himself and went to Bhutan. Only Marco found to his frustration that in Bhutan rock climbing is discouraged so that we were obviously the great envy of Marco that day as he stared with deep unfulfilled longing at the great Himalayan cliffs.



Marco extolling the merits of rock climbing to the Bhutanese (in Bhutan)

Layman's experience to Rock Climbing

How safe are ropes? They depend on not slipping out of control and that has to do with devices such as an "air traffic controller" (ATC). Perplexed already? These are 'belay' devices and one can list quite a number of them from a simple 'figure 8' or 'Petit huit', via a 'tuber', to a 'grigri'. Not only are they for 'belaying' but also for 'rappelling'. You appreciate it is a wonder that no serious accidents happened as a result of this strange language spoken by rock climbers. Belaying is safeguarding an ascent with the assistance of a sort of anchor person known as a 'belayer' so if you slip and fall, chances are your belayer will keep you in place or let you fall a finite height. This also depends how the rope is hooked up. In the Ardennes the rope is pre-looped through a 'carabiner' attached to an anchor device which could be a permanently installed bolt either glued-in, or a mechanical gripping device. Attached to the bolt is a 'hanger', a bracket, to transfer the load from the carabiner to the bolt. The rope passes through the carabiner. The carabiner is a cleat ring and not dissimilar to what is used in the



sailing sport (more comparisons are coming). Now, as engineering geologists, the interest is the connection between the geology and the rope. Will the bolt hold? If you think rock climbers spend all day with a 'Black and Decker' or 'klop-boor' as many Dutch house-husbands spend their weekends then you are mistaken. They also have anchors they can insert in rock joints. In cliff-hanger language these devices are known as 'camalots' (nothing romantic), 'cams' if you are climbing a lot, 'zeros' (micro-camalots), 'technical friends', (these are rather devices one inserts into relatively large cracks or even gaps in the rock mass and then through a double cam together with a spring they jam giving the climber something to hang from). The climber also has at his/her disposal simpler items such as a 'talon', 'cliffhanger', 'bathook', or a 'grappling hook'. These are curved pieces of steel which one, presumably, inserts over a ledge. One wonders at their holding power as normally one would induce tension bending type stresses for which rock is not exactly the best material to resist. There are devices which the KU Leuven site recommend should be used instead of camalots as they are less expensive. These are tapered slithers of metal which wedge themselves in rock fissures. Vertical rock face buffs know them as as: 'Pitons', 'fifi hooks', 'peckers' and 'rurps' – the latter an abbreviation for 'Realized Ultimate Reality Pitons'. How does that description grab your imagination?

Engineering Geology Rock Climbing

The Ardennes engineering geology tourist group was spared this complicated and hidden side of rock climbing. Ideally this aspect of rock-face climbing would be most akin to engineering geology and one could consider it as a vertical fieldwork. The ideal excursion would start in the climber's shop, and then loaded up with *camalots*, *zeros*, *technical friends*, *cliffhangers*, *bathooks*, *grappling hooks*, *talons*, *pitons*, *fifi-hooks*, *peckers*, *rurps* and, not to mention various bolts, a rock drilling device one would then go off to conquer a rock face somewhere. Probably the whole exercise would be a case of destroy and conquer (rock climbing traditions vary from country to country so that making holes to glue in or jam in anchors is 'not the done thing' in the United Kingdom. In other countries it is done quite often, especially when rock fractures and cracks hardly exist such as in massive gran-

ite. Then again, UK climbers do have a reputation for their gung-ho attitude as well as their rather precarious belaying techniques).

The excursionists departed from engineering geology approach; this, after having examined

Engineering geology answers difficult climbing questions

at close quarters the Roche du Bayard (pronounced unsafe in de Telegraaf's article a few days later) and the stability (overkill?) works of the Dinant Citadel cliff (see Algemeen Dagblad cutting of 1996 concerning its instability). Here we could also examine the cliff intimately in relative safety. You have these days people communing with trees by embracing their trunks. Rock climbers have a similar much more ardent experience with one's body clinging to the rock face as our hands and feet groped the rock to find a niche or ledge to offer a modicum of support to move upward (the whole essence of the sport).

The other thrill no-one tried which on reflection would be the ultimate experience in rock climbing: the fall. No-one actually fell, which would have put to the test the ropes, anchors, skill of the belayer and the climber's reaction to the experience: heart seizure, cold sweat, shakes, near death feel etc. followed by some sort of bungee jump mode as the rope intercepts the fall (if the belayer is doing his/her job properly) Rock climbers have various terms for falls, like the self explanatory 'screamer' or a 'crater': if you fall all the way and nothing to stop you except terra firma when you body reaches a velocity corresponding to the force of gravity equalling the resistance force due to air. If the rope snaps, the belayer panics or the anchor dislodges you are bound to become a case history in the doomsday book of rock climbers¹.

So what happened? In exceptionally fine October weather, after a terrace lunch and after losing our way to locate the Adventure Centrum Ardennen at Ferme de Pont-a-Lesse we finally located the facility run by a Dutch recreational organisation called CAVE2.

Is climbing simple and its associated language even simpler?

Simply, climbing has to do with friction between rope and some sort of contraption attached to a harness, which in turn is secured to

ones body. The rope loops through a ring or strap attached to an *anchor* (bracket with two holes: one for the bolt and the other for the ring or a removable snap-ring called a *carabiner* in the climbing sport). Similarly one works with snap-rings if one climbs a steep path along a wire cable (*klettersteig/via ferrata*), attaching and re-attaching as one cannot slide past a cable bolt support. Make sure the *carabiner* is properly placed or it may accidentally open so you end up as a *crater*, in the *deck* (the usually unfriendly surface that welcomes you at the end of a *grounder* which can be accompanied, also usually with a bounce if from a great height (*Todessturz* in German speaking climbs)). Other ways of *falling* is known as a dynamic retreat from a climb.

Note that it is never the fall that kills, it's the landing and if intending to fall in other countries the following are the translations: (d) *Stuerzen*, (f) *Prendre un plomb / Voler / Tomber*, (nl) *Vallen*, (i) *Cadere / Volare*, (e) *Caer / volar*, (s) *Ramla, Falla*, (pl) *odpascare*). There are special falls such as a *zipper fall* which is a frictional fall by rubbing your body against the rock face 'unzipping' one's clothes. More special falls is a *whipper* or a *free-solo rappel* (which are self-explanatory). Going straight up, the *belayer* uses the rope and an air traffic controller, making sure to take up the slack in the rope as the climber goes up. If your finger or foothold gives the anchor person ensures the rope is jammed in the ATC. After reaching the top one then shouts down intention to come down, known as *rappelling* where the rope now does become a support as well as safety aid. One walks backward leaning out as if on a trapeze of a sailing boat ensuring the body is more or less normal to the slope. As one comes down both the climber and the anchor person feeds the taught rope through the figure eight ring or ATC. Simple, is it not?

Rock climbing to survey rock for rock stability?

Some measurements of the rock face cracks were made (-yes the compass came along-) and close observations were made of a 'Lessard' a local amphibian which uses suction pads to climb... (yet to be introduced for humans in the climbing sport). One then ventured to ask the CAVE instructors what did they do to ensure stability and safety with regard to the rock face.

Yearly before the season starts the rock face is closely inspected and loose or potentially loose rock is removed. As for the anchors not much was said, but one expects these are loaded to at least their design load which is well in excess of a free falling human through a height just short of the height of the slope. The charts below is the contribution of rock mechanics to rock climbing compiled by Marco Huisman (taken from his annual lectures on technical aspects of anchoring systems for rock climbers.)

The mechanical models can further be studied, appropriately on the KU Leuven website. One example of the physics of rock climbing is presented so that one can figure out the fall force.

$$F = \frac{mg + \sqrt{(mg)^2 + 4R \cdot f}}{2}$$

This is where F is the force on the rope, m the mass of the climber, R=EA, E is Young's modulus of rope and A cross-sectional area of rope, f=h/L, h is the fall height and L the length of rope.

There appears to be a small error in a statement made on the web-page: "The total amount of force on the rope and thus on the point of protection and also on the climber, F= etc". The 'last' point of protection is an anchor with some sort of ring through which the rope runs through. If the force on the rope is F one side of the ring and also F the other side of the ring (going down towards the belayer) then the total force on the ring is 2F. So if one has been only calculating for the ring to hold F then lets hope it has, at least, a factor of safety of 2! Furthermore, falling bodies are hardly static items, so elastic and perhaps even plastic deformation is also generated and should be accounted for. See websites in references on rock climbing 'physics' KULeuven. This is an excellent opportunity to introduce physicists to engineering geology (vertical) fieldwork. They can come along and see if the theory works. A useful paper on ropes is 'Rope System Analysis' by Stephen W. Attaway

Is it possibly to climb rock empirically?

Though the Ingeokring group have an engineering background none appeared to do any calculations before tackling the cliffs putting their trust blindly in the experts from the CAVE's Adventure Centre Ardenne. The Lesse has eroded locally the peneplane plateau

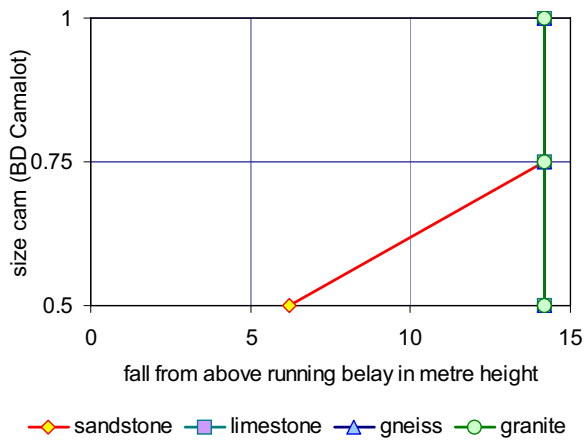


Figure 1: Holding power of camalots

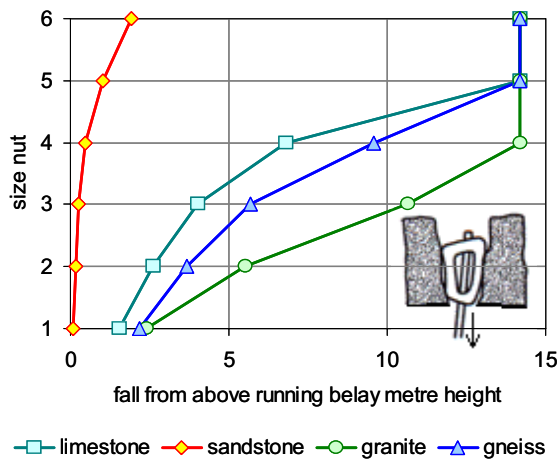


Figure 2: Holding power of nuts

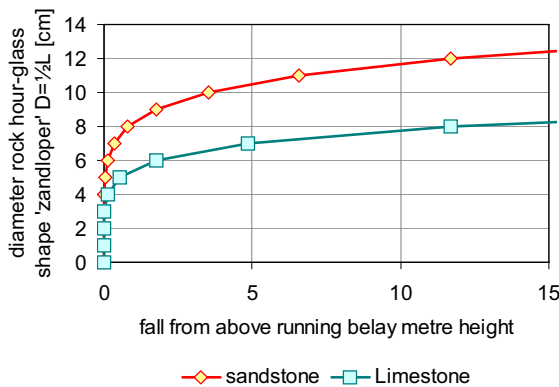


Figure 3: Holding power natural rock column

of the Ardennes leaving sufficient climbing possibilities on Carboniferous limestones cliff faces. The instructor assured one member of the party that at the beginning of the season all existing anchors, bolts “pitons” for the initiated

are tested as well as loose pieces of rock are removed. Suffice to say no anchors came loose as one abseiled back to terra horizontal (*rappelling*).

Going up the face one has to ensure there are foot and hand-holds in which the hand-holds become footholds if one succeeds in gaining height. If these holds, *ledges*, come in all sizes, known as *Crimper* for a very small hold that accepts only the finger tips. (d) *Kratzer / Pinchi*, (f) *Gratton*, (i) *Tacca*, (e) *Grieta de dedos* depending in which country you are. If *ledges* or *crimpers* are in short supply one can resort to *hang-dogging* by using the rope as a climbing aid, this usually happens at the crux the most difficult part of the climb: a good place to become *gripped* (extremely scared) with symptoms known as an *Elvis* (to do with Presley also known in climbing-speak as sewing machine leg) before embarking on a *zipper/whipper*. Strange the amount of terminology climber’s have for activities that last a few short seconds like the fall. It is difficult enough coming to terms with the vast selections of tools one needs to tackle climbs in relative safety. The next day at St. Annes Cave along climbing faces along the Ourthe River valley, Liège there was a memorial to a climbing victim. This was not because of a fall but being killed by a direct hit on the head by a falling rock. Helmets or *brain buckets*, in Belgium still occasionally referred to as *ketspet* (climbers have an alternative term for everything) are standard equipment now.

Is there an alternative climbing experience with less terminology?

It is just as well that the IngeoKring members were spared much of a climber’s standard equipment which could be a huge load of terms and equipment, not only consisting of rope, but the large assortment of contraptions which transfer the human load to rock the *nuts*, *hexen* (no not Dutch witches but *hexentrics* rock climbing talk for eccentric hexagonal nuts), *cams*, *camalots*, *schlinges* (which one loops around *hour glasses* (see the graphs) or in Dutch *zandlopers* rock pillars). The less weighty alternative both in terminology and equipment (and more challenging) is *crack* climbing. This is free climbing up a rock by wedging one’s hands and feet into a crack in the rock and pulling upward. The vocabulary for this climbing is less extensive but some of the terms just as arcane:

fingerlock: a crack climbing technique wherein the fingers are wedged (often painfully) into a crack for purchase on the rock, *fist jam*: similar to a fingerlock except that the entire fist is wedged into a crack and in case a *flapper* results from fist jam or fingerlock this can be field-repaired with Super Glue or duct tape. Definition of a *flapper*: a large piece of detached skin.

Anybody for a game of golf?

References

¹Schubert, P. (2001): Sicherheit und Risiko in Fels und Eis, Band 1, 6th edition. Bergverlag Rother, Munchen.

² www.cave.nl then carefully choose 'sporters individueel' (if you choose another you cannot return by pressing 'home'. Then ask for 'climbing education' in which page appears with the rock face conquered by the Ingeokring excursionists. Climbing Centre Ardenne is another entry but it takes a bit of "http://www.cave.nl/cookie.asp?level=4

Attaway, S.W. 1996 Rope System Analysis 13p from http://www.amrg.org/Rope_system_analysis_Attaway.pdf

³If you want to learn more about the technicalities see a useful site at: <http://www.student.kuleuven.ac.be/~m9916724/technique/rockpro.htm>

KU Leuven main page mountaineering: <http://www.student.kuleuven.ac.be/~m9916724/index.htm>

Les Awirs climbing face slide: <http://users.skynet.be/info-escalades/news/new.htm> (scroll to Les Awirs)

Climbing Glossary: <http://www.dwmorrison.com/dictionary.htm> (best glossary includes Dutch terms and, finally, translation for 'zandloper')

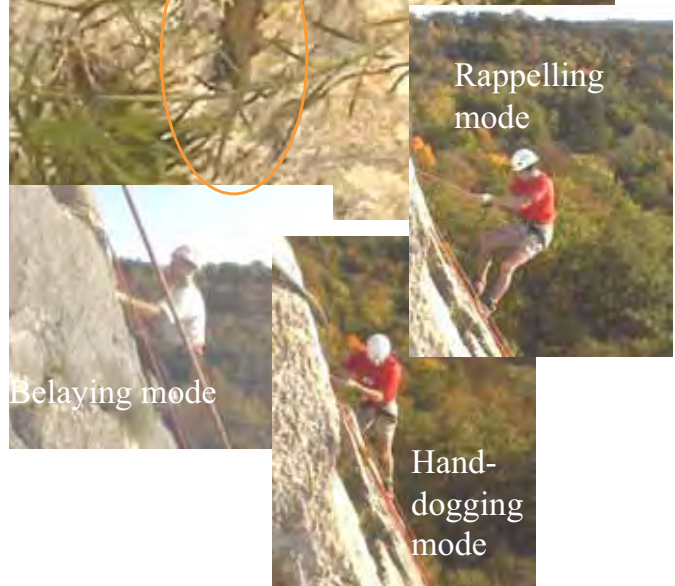
Other glossary's found (some illustrated)are:

A Climber's Glossary: <http://www.climber.org/Resource/glossary.html>

Appendices



Lessard: local amphibian showing how to climb with toe suction pads



Rappelling mode

Belaying mode

Hand-dogging mode

Photos of the climbing experience

AD 420310 300 7

Door onze correspondent
Jan Schilt

Dinant ruimt gevallen rotsblok op

Het Zuid-Belgische stadje Dinant raakt over een paar dagen een belangrijke toeristische trekpleister kwijt.

Het ruim driehonderd ton wegende blok dat vorig jaar met de rotswand van de Citadel loskwam en met een onoverdovende klap in de Rue Sous les Roches op een warenhuis en enkele auto's viel, wordt in stukken gehakt en afgevoerd. Het karwei moet op rij augustus klaar zijn.

Bijna een jaar lang heeft de rots van Dinant de bewoners van de straat bij woonwep geléven. Het blok versperde de weg. Desondanks legde de blokkade de restaurant- en cafebodez geen winderen. De rots zou het afgelopen jaar meer toeristen naar de Rue Sous les Roches en onmiddellijke omgeving hebben getrokken dan de betoemde Citadel, doorgaans de toeristische attractie van het stadje aan de Maas. Omdat ruzie ontstond over de vraag wie eigenaar is van het blok, dunde het lang voordat met de opruiming werd begonnen. Bovendien moest een gespecialiseerd Frans bedrijf eerst een steunruim loswien op de plek van de losgeraakte rots. Stalen netten werden aangebracht om vallende stukken steen op te vangen en de buurtbewoners kregen van de burgemeester het bevel om tijdens de werkzaamheden een helm te dragen.

Intussen zorgden de toegestroomde toeristen voor extra inkomsten omdat voor pakweg een tientje stukjes rots werden verkocht met een echtheidscertificaat. Die verkoop bracht ongeveer zestigduizend gulden op.

Het geld kwam de ingedeponeerde in de Rue Sous les Roches goed van pas, want noch de verzekeringsmaatschappijen, noch het Rampenfonds stonden te trappelen om met grid over de brug te komen.

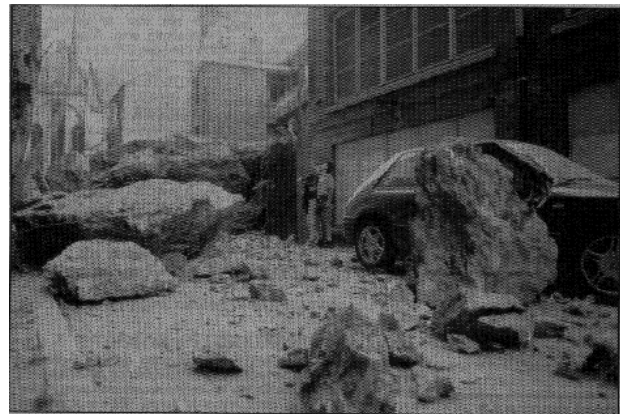
Terwijl Jean Beaumartige, restaurateurhouder van 'La ville de Bruxelles' snuppert over de afvoer van de kapoblaan van het blok veroorzaken, klaagt een collega dat hij veertien dagen lang zijn cafe-terras niet kan gebruiken. „Wie betaalt dat?“, jammert de man.

Zij kunnen zich troosten met de gedachte dat over een paar dagen de Rue Sous les Roches er weer normaal uitziet. Maar er zal een verschil zijn: een stuk van het rotablok blijft liggen op de plaats waar het gevaarte insloeg. Een gebrinkplaat herinnert de passant aan het voorval. Zo heeft burgemeester Richard Fourmuraas beslist.

Failure Cidatel (taken from Algemeen Dagblad one day in 1995)

‘Dinant clears up fallen rock-block’

The southern Belgian town Dinant will loose over a few days an important tourist attraction. The amply 300 tonne weighted block that the previous year dislodged from the rock face of the Citadel and with a ear-blasting impact landed on the Rue Sous les Roches, a department store and a number of cars. en from Algemeen Dagblad one day in 1995)



De Telegraaf

Dinant verstevigt rots

Van onze correspondent

DINANT — Het Belgische toeristenplaatsje Dinant gaat met grote spoed haar beroemde rots Bayard stutten en herstellen nu is gebleken dat de bekende toegangspoort tot het plaatsje forse scheuren en barsten vertoont.

De komende maanden zal de rots van het ook veel Nederlanders trekkende Maastradje fors worden verstevigd, waarvoor een flink bedrag van totaal 190.000 euro zal worden uitgetrokken.

Volgens een eeuwenoude legende is de 35 meter hoge rots ontstaan toen Karel de Grote het ros Beyaert (Frans: Bayard) van de vier Heemskinderen wilde afpakken. Maar het paard wist te ontsnappen en bij een van zijn sprongen langs de Maas doorkliefde het de rotsen en creëerde zo de rots Bayard.

Algemeen wordt er echter van uitgegaan dat de rots is ontstaan toen Lodewijk XIV zich in de 17e eeuw met explosieven een gangbare weg langs de Maas verschaftte.

• De beroemde rots wordt hersteld.

EIGEN FOTO

(taken from De Telegraaf, Saturday edition: ‘Reis’ section) on forthcoming stabilisation

Excursie naar de Belgische Ardennen

22-23 oktober 2004

Robert Vuurens

In de vroege ochtend van vrijdag 22 oktober 2004 vertrok een groep Ingeokring leden richting de Belgische Ardennen. De eerste stop werd gemaakt langs de rivier de Maas, net ten zuiden van Namen. Bij deze nagenoeg loodrechte wand van kalksteen (Rochers de Dave) vertelde Siefko Slob over zijn onderzoek naar het in kaart brengen van discontinuïteiten met behulp van LIDAR. Deze wand had als proefobject gediend in dit onderzoek en het afstudeeronderzoek van Bart van Knapen. De LIDAR techniek is een hoge resolutie 3D scan met een laser. Door zeer nauwkeurig de afstanden te meten tussen de gesteentewand en het observatiepunt, kan na verwerking in een 3D model gedetailleerde informatie worden verkregen van de orientatie van discontinuïteiten en textuur van het gesteente. Een mogelijke uitvoer van het model is bijvoorbeeld een stereoplot en met de



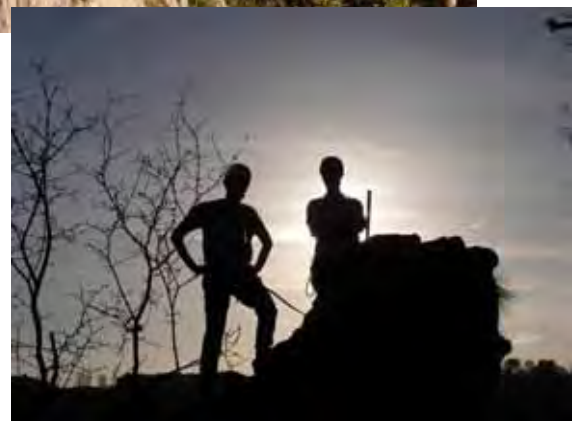
modernste apparatuur is het zelfs mogelijk kleurinformatie op te slaan, zodat over de puntenwolk een foto van de wand kan worden geprojecteerd. Het analyseren van gesteentemassa's op

afstand wordt met deze techniek eenvoudiger en sneller, voor meer info zie www.itc.nl.

De reis werd vervolgd door een landschap van hobbelende anticlines en synclines en er werden onderweg nog wat Utrechtse geologies gespot, die in een groeve de indrukwekkende structuren aan het bestuderen waren. Dit bracht ons in de gelegenheid een ongepland bezoek te brengen aan deze groeve, die ook wel bekend staat om zijn poreuze kalksteen. De volgende groeve was wel gepland: de St. Anne groeve nabij Dinant. Nu in gebruik als kleiduiven-shooting-range, is er weinig oog meer voor de zwarte klakstenen in de gecombineerde open-pit en room-and-pillar mijn. De Marbre Noir de Dinant is voor velen herkenbaar in de vensterbanken van het

De enthousiastste ingenieursgeologen konden het toch niet laten in de room-and-pillar mijn te klimmen voor een nader onderzoek. De stabiliteit van het geheel riep wel enige vragen op (zie voorblad en prijsvraag)...

Niet te missen is de Rocher Bayard! Deze doorkliefde bergkam langs de Maas is onderwerp in legendes en torent hoog boven het water uit. De verticale gelaagdheid is het resultaat van plooiing van de 350 MA oude kalksteen in de Hercynische Orogenese (ca. 300 MA geleden). Na een uitgebreide inspectie werd het tijd voor de lunch en nadat Michiel ook eindelijk weer in de bus zat vertrokken we richting "Le Chamonix" voor goede Belgische lunch. Dit was ook wel nodig om wat moed te verzamelen voor de volgende activiteit: rotsklimmen. Na een korte instructie in het zekeren van je medereisgenoot, kon men in 2 disciplines (klettersteig en vrij klimmen) de gesteentewand wat nader bekijken. Het prachtige weer maakte deze klimpartij de moeite waard.



de klimervaringen waren uitgewisseld bij het merkwaardige diner (in welk restaurant krijg je alle drank (aperitief, witte + rode wijn) al meteen geserveerd bij het voorgerecht?). Uiteraard werd het nachtleven van Namen nog verkend en de avond werd afgesloten in de Havana-bar, misschien omdat het publiek in de authentiek Belgische kroegen niet echt

...bos vol dolines, verdwijnende beekjes en illegale vuilstorten...

openstond voor een feestje die avond.

De excursie werd zaterdag voortgezet in de omgeving van Luik, onder leiding van Robrecht Schmitz en prof. Christian Schroeder. Het onderwerp betrof Kwartaire karstverschijnselen in het gebied van de Ourthe en paleokarstverschijnselen rond met name Visé. Een tocht van het universiteitsterrein langs de Ourthe naar het zuiden voerde langs verschillende oplosgaten en grotten.

De karst is hier het gevolg van een relatieve daling van de grondwaterstand (en insnijding van rivieren) door de stijging van de Ardennen vanaf het Pliocene (5-2 MA terug).

Na een stop ter plaatse van een gebroken anticline bij Grotte Sainte Anne (ja weer Saint Anne, dit is naast Barbara ook een beschermvrouwe voor o.a. mijnbouwers) reizen we verder naar een prachtig uitzichtpunt over een vallei met een meanderende Ourthe, Roche aux Faucons. Vanuit hier begint een wandeling door een bos vol dolines, verdwijnende beekjes en illegale vuilstorten, er werd zelfs een sixpack uitgelooft aan degene die het eerst een sinkhole signaleerde. Een laatste gevolg van recente oplossing is de doline bij Esneux in een weide, waar kort geleden van de een op de andere dag een krater ontstond. Tot slot bekenen we nog een vleugje Belgische mijnbouwhistorie in Cheratte op de route naar Maastricht. Als echte roadside-engineering-geologists zagen we nog net de paleokarstverschijnselen in Visé....



Doline in een weiland bij Esneux

Mini-symposium at ITC Enschede on January 21st, 2005 on the Occasion of the retirement from ITC of Niek Rengers

Siefko Slob



Na meer dan 30 jaar gewerkt te hebben voor het ITC, nam Niek Rengers op 21 januari j.l. afscheid van zijn professionele leven. Het was de wens van Niek dat dit afscheid luister werd bijgezet door middel van een mini-symposium. Het thema voor dit mini-symposium was: "New Developments in Geo-Information Handling for Engineering Geology". Een zeer groot aantal internationale gasten, collega's en vrienden zijn voor deze dag naar het ITC in Enschede afgereisd.

Gerennomeerde persoonlijkheden in de wereld van de Ingenieursgeologie, zoals Helmut Bock, Paul Marinos, Keith Turner, Martin Culshaw en Sergio Mora gaven een aantal zeer interessante lezingen. De wetenschappelijke presentaties werden afgewisseld met vooral veel dierbare persoonlijke herinneringen aan Niek door collegas, vrienden en oud-studenten zoals Joost van der Schrier. Zelfs Niek's eerste PhD student (Dr. Joseph Akinyede) was helemaal uit Nigeria overgekomen, wat een volslagen verrassing voor hem was.

Niek Rengers heeft duidelijk aan de wieg gestaan van het vakgebied Ingenieursgeologie in Nederland en mag ook al een van de "founding fathers" van de Ingeokring worden gezien. Niek heeft er ook voor gezorgd dat er een jarenlange vruchtbare samenwerking was tussen de TU Delft en het ITC op het gebied van Ingenieursgeologie. In zijn dankrede was het dan ook met een ietwat bittere bijmaak dat Niek juist op het einde van zijn carrière moest

Niek Rengers wordt erelid van Ingeokring!

constateren dat die samenwerking intussen wordt afgebouwd. Het was verassend dat juist Jacob Fokkema, als Rector Magnificus van de TU Delft, ook op het symposium aanwezig was en tevens een praatje hield over zijn persoonlijke ervaringen en die vruchtbare samenwerking met Niek.

Het Ingeokring bestuur had al in een eerder stadium besloten Niek erelid te maken van de Ingeokring. Deze dag was dan ook een goede gelegenheid om dit aan te kondigen. Als

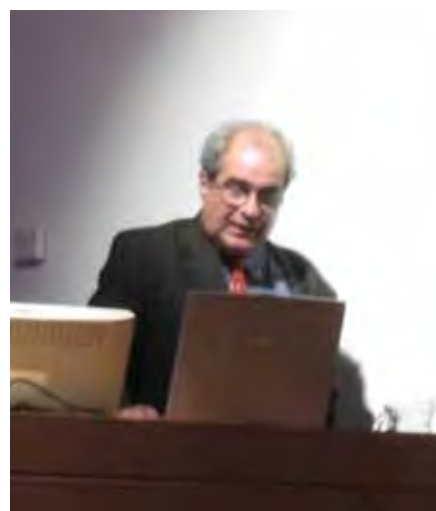


Figure 2. Paul Marinos talking about the Geological Strength Index.



Een zee van mogelijkheden

Ervaring in de bagger?



Van Oord is ontstaan uit het samengaan van Ballast Ham Dredging en Van Oord ACZ eind 2003. We voelen ons waterbouwer in hart en nieren door een meer dan honderdjarige, succesvolle traditie. Overal ter wereld voeren we projecten uit met respect voor de omgeving waarin we werken. Ons werk laat vakkennis, ervaring met lokale omstandigheden en innovatief vermogen zien. Van Oord beschikt over 2.800 goed opgeleide medewerkers en de grootste en modernste vloot ter wereld.

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Figure 1. View on the audience just after the lunch break.

voorzitter van de Ingeokring kondigde Chris Bremmer dit aan, wat voor Niek duidelijk een complete verassing was. Later in dit jaar zal er een speciale middag worden georganiseerd waar Niek zijn erelidmaatschap in ontvangst zal mogen nemen.

Na zijn pensionering zal Niek zal nog wel actief blijven als president van het IAEG. Niek

kennende, zullen we nog wel veel van hem horen. De artikelen die op het symposium zijn gepresenteerd worden teven gepubliceerd in een van de issues van het IAEG bulletin, later in dit jaar, dus hou het in de gaten.

THESIS ABSTRACTS

“Carbonate cementation of alluvial sediments caused by Gypsum influx in catchments”

A case study on cemented Quaternary deposits of Baix Camp district, NE Spain

Yohannes Belete, ITC

The occurrence of cementation in soils could be either in in-situ residual or transported soil. The geotechnical properties depend largely on the nature of the original host rock/soil and the extent and degree of cementation. Moreover, factors like climatic history of the area, hydrological and hydrogeological conditions, chemical constituents of the fluid and presence of organic matters would greatly influence both the mechanism and the occurrence of cementation in soils. The resulting cementation significantly influences the soils geotechnical properties.

The main objective of this research is to investigate the geotechnical property of the cemented Quaternary ‘clastic’ deposits of the Baix Camp coastal plane in terms of spatial distribution and the deposit source material. The material consists of the clasts (gravels and sands) and cementing agents, precipitated from the ground-water chemistry. Relationships are established based on data derived predominantly from the Catalunya government website (climate, water chemistry and water level monitoring data) (<http://www.gencat.net/mediamb/sig/bases-a.htm>) and the geotechnical data of the cemented samples collected and compiled from past joint TU Delft/ITC fieldwork reports.

The research investigated cementation from the micro-scale to macro-scale level. Use of thin section for Scanning Electron Microscopy and Optical fluorescent microscope and placing cored samples in X-ray -CT-scan to identify type of cement and void distribution at micro-scale level. On the macro scale GIS and remote sensing are used to investigate the extent and spatial distribution of cementation. Correlation of occurrence of cementation with distribution of drainage in the catchment was also used on a macro-scale level.

The effect of climate, hydrochemistry, geology and water level fluctuation on the occurrence of cementation was clearly shown from the data analysis. Gypsum input in the catchment is found to be the major cause for the calcite precipitation and for the occurrence of carbonate cementation particularly at the western side of the study area. As yet, little evidence has been found of organic influences causing cementation.

From the analysis of hydrochemistry, a correlation between calcite saturation with time is established; accordingly, samples located at the western part shows uniform calcite saturation through time. This could lead to a continuous cementation which has got a significant contribution in increasing the strength.

Determining the speed at which the cementation completes and attains its maximum strength requires further study.

Initial data on the slake durability analysis of the cemented material from the study area was obtained and results indicates the competency and stability of the cemented material which is clearly depends up on the quality and quantity of the influx element which is controlled by the solubility of the chemicals involved and the original parent rock from which they were leached.

Ultimately the study was also planned to examine the speed at which cementation processes occur. One possible scenario to investigate this is with a more detailed data base of the cementation in relation with the age of the clastic deposits generally assumed to become younger towards the coast.

“Two dimensional numerical modelling of the South Limburg abandoned room and pillar mines in weak limestones (“mergelgrotten”) to prepare a surface subsidence hazard map”

Nancy Ramirez, ITC

The study area is part of the abandoned room and pillar mines in Caestert Groeve zone located in the southern part of the city of Maastricht in the Netherlands. It presents a horizontal distribution where the shallowest section is at 3,0 meters below the ground level. The room and pillar mines height is 6,0 meters and the altitude of the floor is 87 meters above the Normal Amsterdam Peil (NAP) level.

Four geological formations are presented in the study area: The formation of Maastricht (specifically the Facies Nekum) where the room and pillar mines take place. Three meters of the formation of Tongeren continues the sequence. It is overlay by two meters of the deposits of the Maas River and the youngest unit is composed by Loess deposits.

A two dimensional numerical modelling is executed with the explicit Distinct Element Method-Universal Distinct Element Code (UDEEC) to asses the surface subsidence induced by unstable condition into the room and pillar mines. This analysis is applied to prepare a surface subsidence hazard map.

Because of the large scale consequences, pillar instability is considered the most significant type of deterioration which may occur into the room and pillar mines in South Limburg. Collapse will be the result of support system absence. Then, collapse is modelled by the extraction of the pillar structures from the geometry generated in the numerical model. The constitutive model used is the elastic-plastic Mohr Coulomb that permits the development of failure.

The surface subsidence hazard map is prepared based in the distribution of the maximum vertical strain values measured after the simulation of collapse into the abandoned room and pillar mines. These values correspond with the re-

sults obtained from the numerical modelling.

The main implication of modelling a three dimensional (3D) problem in two dimensional (2D) plane is that in 3D plane the bodies have limited dimensions, therefore reliability in the results obtained in the 2D representation will be completely dependent of the position of the cross sections into the 3D plane. Depending of each 2D geometry position evaluated, the result obtained will be actually estimation about what could be in reality.

Numerical model is a tool to make prediction. It is concluded that the numerical model developed in this research can be applied for future analysis being aware that the results will be a conceptualization about how that simulated scenario could it be.

“The measurement of anisotropic stiffnesses and stresses in the Pot Clay”

Marcel Remijn, TU Delft

The Pot Clay was deposited in deep glacial gullies in a glaciolacustrine environment at the end of the Elsterian glaciation. During the Saalian glaciation the formation was three times overrun by the ice sheet.

It is general believed that the dominant process causing overconsolidation of subglacial sediments is one dimensional consolidation due to the weight of the ice. The research of Schokking (1998) and Hegtermans (2003) provide evidence of horizontal anisotropic stress and stiffness conditions in the Pot Clay, which are related to the direction of Saalian glacial advance. This suggested that glacial shear might play a dominant role in the present stress state of the Pot Clay. This led to the research question whether the principal axes in the Pot Clay are rotated due to glacial shear and whether these principal stresses can be measured with the lateral stress oedometer.

To answer these questions two sets of tests were performed on the Pot Clay. The first series of tests is on vertical orientated sample, this to determine the direction of maximum and minimum horizontal stiffness. The orientation of maximum stiffness coincides with the direction of glacial advance; therefore the direction of minimum stiffness is the rotation axis and a minor principal axis. By trimming horizontal samples along the minimum stiffness axis in the horizontal plane the orientation of the other two principal axes could be determined. The tests were performed on three samples of Pot Clay from Marum taken between 14 to 25 m depth. The direction of maximum horizontal stiffness confirms with the stress directions found by Schokking (1998), the stiffness direction found by Hegtermans (2003) and the directions of Saalian glacial advance determined by Kluiving et al (1991).

It could be concluded that the principal axes of the samples from 20 and 25 m depth were rotated with 40 to 55 degrees against the direction of glacial advance and are due to glacial

shear. The principal axes of the sample from 15 m depth were rotated 32-38 degrees in the opposite direction. No explanation with supporting evidence could be given.

When evaluating the e -log p' curves from the lateral stress oedometer data it was observed that the curves were concave downwards of shape. Therefore the preconsolidation pressure depended highly on the maximum applied vertical load. The determined preconsolidation pressures were comparable to the values Hegtermans (2003) obtained, but much lower than the values Schokking (1998) determined at similar depths. This is because Schokking (1998) applied a much higher vertical load. When calculating the K_0 value from empirical correlation in the literature, the preconsolidation pressure is of major importance.

When comparing the obtained K_0 values (relative to stiffness) from the laboratory with the values calculated with the method of Mayne and Kulhawy (1982). It could be concluded that it compared reasonably well with the laboratory data. However when Schokking's (1998) preconsolidation pressures were used, the calculated K_0 values were much higher. This highlights the problem when determining the preconsolidation pressure from concave downwards curved e -log p' curves.

To be able to correlate the anisotropic stiffness findings of the laboratory with the insitu situation a load cell pressure meter (LCPM) was used to obtain insitu stress data. Due to rotation of the probe during insertion and extraction into the borehole the position of the probe, when it was into the ground, was not exactly known. However the measured orientation of maximum stress was very consistent.

When the field data was compared with the laboratory data there was a reasonable agreement between K_{0max} , K_{0min} in the field was generally lower. However when the LCPM data and the laboratory data was compared with the dilatometer data from Schokking (1998) it was observed that the K_0 values determined with the dilatometer were much higher, likely due to compaction of the soil by the dilatometer insertion.

To provide better insight in the behaviour of clay inside the lateral stress oedometer a load cell was placed under the lateral stress oedometer to measure the vertical load at the base of the sample. Any difference between the applied vertical load at the top and the measured verti-

cal load at the base is due to friction between the sample and the lateral stress oedometer ring. It could be concluded that during loading there is a 20-30% friction loss and during unloading a 3-20% gain in vertical load. When analyzing the e -log p' curves this results in lower preconsolidation pressures and higher K_0 values.

Pore water pressures were measured at the base of the soil specimen inside the lateral stress oedometer. From the results could be concluded that all pore water has dissipated when the lateral stresses are stable and that primary consolidation was completed. The system to measure pore water pressures must be improved to obtain a better instantaneous reaction upon the addition of a vertical load increment.

The obtained images from a computerized tomography scanner showed two sets of fissures, the first set in a SSW-NNE direction and the second set in a SSE-NNW direction, corresponding with the oldest and the youngest glacial advance.

“Deriving roughness characteristics of rock mass discontinuities from terrestrial laser scan data”

Md. Zillur Rahman

In this study, 3D terrestrial laser scan data have been used to quantify the surface roughness of rock mass discontinuities, to determine the roughness scale effect and to determine the influence of range precision. The Roughness-length method was applied to calculate fractal parameters (fractal dimension and roughness amplitude). The study showed that it is possible to calculate the fractal parameters from laser scan data of discontinuity surfaces. It has been found that the fractal dimension and roughness amplitude are very high for raw laser scan data, due to range measurement error of the used scanner.

The discontinuity surface has been reconstructed from the raw point data using a scattered data interpolation technique. The range measurement error can be removed using this data interpolation technique. The reconstructed surface visually resembles the actual discontinuity surface. The fractal parameters of the reconstructed surface have subsequently been

calculated. By subtracting the fractal parameters of the raw data from the fractal parameters of the reconstructed surface, the range error of the laser scan data can be estimated.

The fractal parameters have also been calculated using different sample sizes. The fractal parameters show an increase with increasing sample size. This means that the roughness complexity of the discontinuity surface is also increasing with increasing sample size. From this observation it can be concluded that the roughness of discontinuity surfaces has a significant scale effect.

The maximum resolution of the laser scan data used in this study is 5 mm (1 point per 5 mm). The laser scan data with 5 mm resolution can only acquire roughness information from roughness features larger than 5 mm. Consequently, small-scale roughness (roughness features smaller than 5 mm) can not be obtained from the data. Therefore the resolution of the laser scan data (point density) needs to be increased to quantify discontinuity surface roughness accurately as a smaller scale.



Meer camera's, meer ME of meer design?

Hoe maak je een stadion veiliger? En wie is er verantwoordelijk voor? De politie, de clubs, de KNVB? Ze hebben er allemaal mee te maken. Maar veiligheid begint al aan de basis. Bij de bouwtekeningen van het stadion. Want ruimtes communiceren met mensen. Een goede inrichting en het gebruik van hoogwaardige materialen kunnen zelfs vandalisme en agressief gedrag verminderen. Bouwen betekent dus niet alleen kijken naar constructies, kosten en kwaliteit. Maar ook rekening houden met de uitwerking ervan op de gebruiker. Of het nu gaat om een stadion, een fabriek, een winkelcentrum of een complete woonwijk. DHV is als internationaal advies- en ingenieursbureau actief in de markten Bouw en Industrie, Mobiliteit en Infrastructuur, Water, Telecommunicatie en Ruimtelijke Inrichting en Milieu. In een informele, open organisatie van ruim 3.800 professionals werken we aan innovatieve, veelal maatschappelijk relevante projecten. Bouw en Industrie is onder meer gespecialiseerd in flexibele kantoorconcepten, complexe bouwprojecten en de herontwikkeling van binnenstedelijke gebieden. Ontmoet ons op onze site www.dhv.nl.

www.dhv.nl



Altijd een oplossing verder



STUDENTEN ACTIVITEITEN

Dispuut Ingenieursgeologie DIG

The Annual Christmas dinner this year was a big success with many participants and lots of fun; a big gourmet was organized. Also invited were the international students and staff from the ITC (International Institute for Geo Information Science and Earth Observation). Engineering Geology students from the TU worked closely together with these international students and staff members during several courses and during our main fieldwork to Spain.

Furthermore, a “DIG-Sports-Day” has been organized in June, revealing the more or less prominent sporting characters of the Engineering Geologists. After a game of soccer, the participants could come back to old strength during a barbecue in order to, then, be able to follow the last game of the Dutch soccer team in the European Championships.

The last big trip organized by the DIG took place in October. This study trip was organized in association with the InGeokring. The goal of the excursion were the Ardennes in Belgium. The first stop during the excursion was used by Siefko Slob to explain more about the 3D characterization of rock and soil masses using high-resolution terrestrial and airborne remote sensing techniques. Siefko Slob and Bart van Knapen, MSc student of Engineering Geology at the TU Delft, laid out the technique of Lidar scans and the results, which can be achieved using this technique. During the next stop in an old mine (St. Anne’s Quarry), Michiel Maurenbrecher gave a further explanation about the classification of rock masses, especially regarding the prediction of in-situ block size distributions. After a “sightseeing”-stop at the Rocher Bayard in Dinant and an extended lunch break,

the rest of the day was filled by the climbing course. This course, organized by the CAVE-crew and at first started by a lot of doubtful and worried faces appeared to be a lot of fun in the end. The following and last day was then filled by a program with Robrecht Schmitz, concerning the karst features in the area.

Also the coming year will be accompanied by several actions organized by the Dispuut Ingenieurs Geologie. In addition to the regular drinks, there will be another sports day, this time with a game of tennis or volleyball- who knows?

A company visit might also be possible in the coming months, as well as a little pitch&putt-golf game.

But most attention of the DIG board is focused on the major project:

An excursion to the Gotthardt-Tunnel in Switzerland accompanied by several smaller stops along our way!

The quartet of Engineering Geology students forming the DIG of the season 2004-2005 has not been changed compared to the previous year and consists of four enthusiastic (partially international) members!

With warm regards,

The DIG Board of 2004-2005

Michiel Zandbergen— President
 Agnes van Uitert— Vice President
 Alfred van der Horst— PR
 Wiebke Tegtmeier— Treasurer

SURF SUGGESTIONS

Robert Vuurens

<http://www.covadenxoroi.com/>

If you want to rock in a rock, go to the island of Menorca. The Cova den Xoroi at Cala en Porter has to rate as one of the world's most unusual discos. Set high in the rocks, it's a cave bar with fantastic sea views by day. At night it's transformed into an ultra-modern disco with sophisticated light and sound systems and views of the sea and sunset via a hole in the rock!

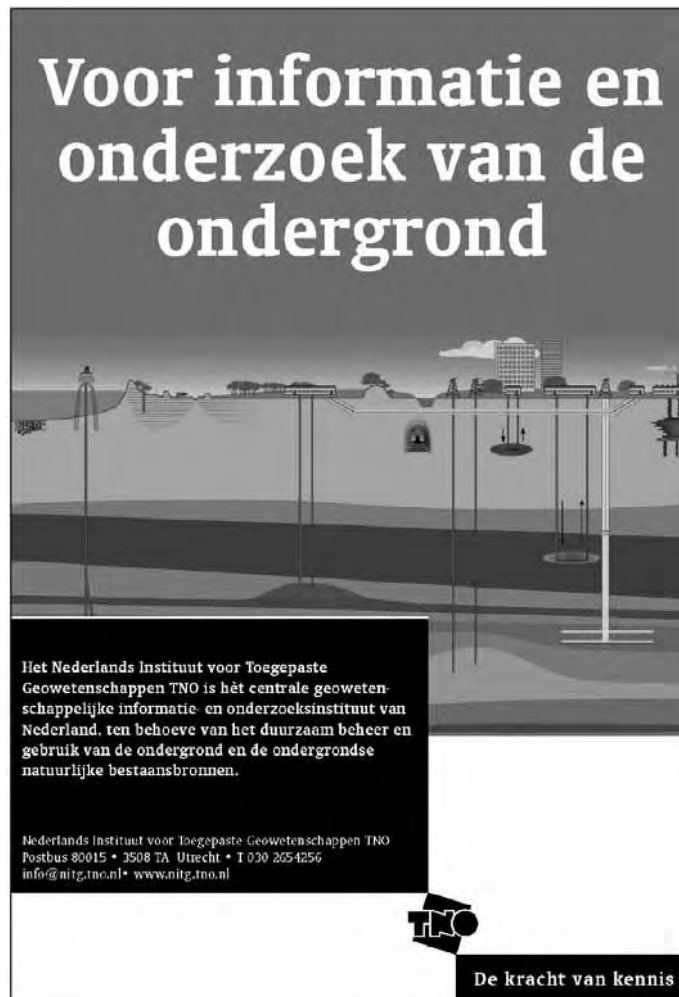
<http://www.geoengineer.org>

Very resourceful website including an online library, photo gallery, free software, links to papers and other geo-engineering websites.

A quality website like this can of course not lack famous sayings by Karl Terzaghi, such as: "...once a theory appears on the question sheet of a college examination, it turns into something to be feared and believed, and many of the engineers who were benefited by a college education applied the theories without even suspecting the narrow limits of their validity."

Last but not least: if you are really into rocks order a T-shirt at

<http://www.yuprocks.com/ourname.shtml>



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onderzoek van de
ondergrond**

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ENGINEERS ABROAD

Site investigation in Northern Caspian

“A lot of geologistics for a bit of geology”

Ir. Leon van Paassen, GeoDelft

In autumn 2004 I went for a nearshore site investigation in the Northern Caspian Sea of Kazakhstan. Autumn or actually late summer is a nice period for a site investigation in that area, because summers can be quite hot, up to 40°C., and in winters this part of the sea is covered by ice at temperatures as low as minus 40°C. In September and October temperatures are around 25°C and because of the dry land climate the sun shines practically every day. Spending time on the sea is enjoyable as the waving reeds and purple sea grass form a special landscape in which hundred types of birds fly over your head. In the deeper waters sea lions swim alongside your ship while you glance at the first oil exploration rigs on the horizon.

Although the scenery is nice, site investigation in the Northern Caspian proves most difficult, because of its logistics. Water depths range from 0 to 3 m over a distance of approximately 70 km off coast and depending mainly on the

...send two experts in a rubber boat with supplies for a few months ...

wind direction and speed this level can vary with a meter or two. This means that a large part of the area is inaccessible for any ship with any particular draft (not taking the risk to run aground when water level suddenly drops), not to mention the minimum depth for use of specific equipment as echosounders or subbottom-profilers.

So the survey cannot be considered as a standard offshore or nearshore job, but it is not a regular onshore survey either. From the onshore side, specialised equipment has to be used such as tracked vehicles and flatboats, but these are cannot operate in waters deeper than one meter or at heavy wave conditions and risk getting stuck in the reed beds or in the soft upper layer of mud. Performing CPTs or pushed

boreholes in the shallow zone (less than a meter) encounters difficulty as self elevating barges have too much draft and the lighter air-boats give not enough backpressure to penetrate layers of medium dense sand.

The remoteness of the working area, 20 km to the onshore base camp at the coastline and from there some 70 km from the nearest city, Atyrau, which is not accessible by any normal roads, results in transit times up to half a day and difficult communication, depending on satellite telephones, which are not always reliable, and radios with limited coverage.

Despite all the logistical challenges, we succeeded to get some valuable information from



Figure 1: Kazach way of transport

the shallow subsurface, although I sometimes thought it might be better to send two experts in a rubber boat with supplies for a few months and some handheld equipment in the summertime to get comparable results. At least it would be cheaper and a good way to spend your summer.

If you don't manage to get stuck in the reed beds here are a few tips to survive and make life more enjoyable in Atyrau (in addition to your lonely planet):

EAT&DRINK

Drink Guinness (local beers are quite good as well), eat pizza from a stone oven or chicken kebab at O'Neills Irish pub (next to the Chagala Hotel), while watching Premier League Football or Tri Nations Rugby. This is the meeting place for expats. Especially from AGIP personnel as their main office is next door. Drink Leffe Blond, Leffe Dubbel or Hoegaarden at the City Brew (in Europe), they have got good pepper steaks as well. Eat the best Indian or Mexican food (it is really good!) at Nomad, which turns out to be the La Cabana Disco after 10PM.



Figure 2: Tracked vehicle in action

SPORTS

Run the unofficial Atyrau half marathon, which brings you over the three bridges of the city two times from Europe to Asia and back again. Start and finish every one in two days at the pier just outside Chagala hotel at 7pm) ask the doctor at the back of O'Neills pub if you want to join in. Rent a bike at the River Palace Hotel (opposite to Chagala at the other side of the Ural river) and do the same round by bike. Be careful because cars don't know only the rule of the horn and there are no bike lanes.

Play football or go swimming in the Atyrau sports centre just next to Chagala hotel.

Go for a stroll or a short run along the Ural river bank, especially at sunset you'll see the boulevard is crowded.

CULTURE

Visit the mosque or the orthodox church, both in Europe and the two most eye-catching cultural buildings in town.

Visit the local paintings museum (in the walking area on the left of the main bridge in Asia) exhibits some local art, of which some paintings I suspect are done by a five year old. The museum of culture on the other side of the street

has some more to offer, including a real yurt and the golden armour of an ancient Kazakh warrior.

SHOPPING

Go shopping at the new nasiga bazar (HACIXA) or the real bazar just next to the modern shopping centre: cheap (fake) clothing, medicine and some suspicious food. Grocery shops are hidden in the basement of almost every old sovjetstyle apartment block or at busstops.

NIGHTLIFE

Join in the regular program on every Friday and Saturday night: from O'Neills at 7pm to La Cabana at 10pm and finish in the Renco Disco (the cellar of the River Palace Hotel) from 1am until 4am. You'll hear every night the same music (a multi culti mix of Britney, Tarkan and Ozone) and see the same people, but the more often you hear it the better the joke. If you don't like it you can always stay at Cabana's and play pool or bowling. Avoid BBARS, at the foot of the main bridge in Asia,



Figure 3: Transport by airboat

it is crowded with locals, who can show their aggressive nature if they drunk a bit too much of vodka and a lonely rich expat is then an easy target.

Go for the best rock in Atyrau to the Celtic Dragon Every Wednesday and Saturday there is a live performance. However, it is the same performance every night.

Join a local birthday party, eat real Kazakh food (Masle or Besparnak), dance in a Kazakh living room and drink Vodka at every time someone yells something to celebrate the occasion!

Advertising in the Newsletter

The Newsletter is a journal on engineering geology and related fields. It is distributed twice a year to the 200 members of the Ingeokring and several companies and institutes, active in the field of applied earth sciences.

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The Netherlands National Group of the International Association of Engineering Geology and the Environment (IAEG), The "Ingeokring" founded in 1974, is now the largest section of KGMG, the Royal Geological and Mining Society of the Netherlands. With over 200 members working in different organizations, ranging from universities and research institutes to contractors, from consultancy firms to various governmental organizations, the Ingeokring is playing a vital role in the communications between engineering geologists in the Netherlands.

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