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INGEOKRING NIEUWSBRIEF

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INHOUDSOPGAVE

VAN DE REDAKTIE

Voor u ligt het winternummer van de IngeoKring Nieuwsbrief. In dit nummer aandacht voor de rol die Ingenieursgeologie speelt of kan spelen in milieuvraagstukken. Wij hopen dat dit artikel een aanzet kan zijn voor meer artikelen over dit zeer actuele onderwerp.

Verder aandacht voor de ontwikkeling van ondergrondse ruimten en de NOVA TERRA foundation. Ook in dit nummer maar liefst drie verslagen over verschillende Ingenieursgeologische excursies.

Tot slot een lijvig artikel over de methyleen-blauw test van de heer Verhoef en een uitgebreide symposiumagenda.

Binnenkort viert de IngeoKring haar derde lustrum. Uiteraard willen wij hier niet aan voorbijgaan. Het volgende nummer van de Nieuwsbrief zal dan ook in het teken staan van dit lustrum. Wij wensen u veel leesplezier en houden ons zoals altijd ten zeerste aanbevolen voor interessante artikelen en eventuele op- of aanmerkingen.

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DE ROL VAN DE INGENIEURSGEOLOGIE BIJ MILIEUVRAAGSTUKKEN

door drs. F.M. Taselaar, verbonden aan GEOFOX BV, adviesbureau voor geologie en milieu.

Inleiding

Het "milieu" is een dermate breed begrip dat de laatste tien jaar een veelvoud aan verschijnselen onder deze noemer is geplaatst. In de loop van de tijd heeft zich echter een schifting voorgedaan. Een aantal zaken, die werkelijk als serieus probleem zijn erkend, worden inmiddels aangepakt.

In een aantal geïndustrialiseerde landen zijn strikte milieu-eisen in wetten vastgelegd als randvoorwaarden voor de samenleving (bijv. de V.S., Duitsland, Frankrijk, Japan, Denemarken en Nederland). In andere landen zijn voorschriften in de maak. Tegelijkertijd zijn verschillende disciplines, zoals juristen, economen, bestuurskundigen, natuurwetenschappers en ingenieurs zich uitgebreid in deze milieuvraagstukken gaan verdiepen. In vrijwel elk vakgebied zijn raakvlakken met de milieu-problematiek te vinden. Het "milieu" is een verschijnsel waar geen burger en geen vakgebied meer omheen kan. Zo ook (en niet in de laatste plaats) de Ingenieursgeologie. Aan de ene kant dient de Ingenieursgeoloog op de hoogte te zijn van de milieuaspecten van de werkzaamheden die hij uitvoert of ontwerpt, anderzijds kan de Ingenieursgeoloog werkzaam zijn bij het aanpakken van milieuproblemen. Een groot aantal milieuvraagstukken kan genoemd worden waaraan de Ingenieursgeoloog kan bijdragen ze op te lossen. De bodem-verontreiniging is hiervan het meest actuele en wordt hieronder toegelicht.

Bodemverontreiniging

Op vele plaatsen is de kwaliteit van de bodem (grond, grondwater, etc.) aangetast. Met de kwaliteit van de bodem wordt in dit verband bedoeld de mate waarin verontreinigde stoffen aanwezig zijn. Dat wil zeggen dat zij niet meer gelijk is aan de originele geologische situatie. Dat dit tot problemen kan leiden is eenvoudig met een paar voorbeelden toe te lichten. In de eerste plaats kan het gebruik van grondwater als drinkwater worden genoemd. Een aantasting van de kwaliteit van de bodem kan in ongunstige geologische situaties ook de kwaliteit van het soms schaarse drinkwater bedreigen. Een ander voorbeeld is de situatie waarbij verontreinigde stoffen in de grond onder woonhuizen terecht kunnen komen en de leefbaarheid schaden (Lekkerkerk). Daarnaast wordt in dit soort situaties doorgaans de ondergrondse infrastructuur aangetast, waarbij met name de waterleiding een kwetsbaar punt is (Perrier). Ook het bij bouwwerkzaamheden vrijkomend grond(water) levert, als deze verontreinigd blijkt, problemen op voor de aannemer en de omgeving. De strikte eisen die aan de kwaliteit van de bodem worden gesteld, maken dat in Nederland en de ons omringende landen geen terrein van betekenis meer gekocht wordt, zonder dat daarvan eerst de kwaliteit van grond en grondwater zijn onderzocht. Dit wordt ook gedaan voorafgaand aan nieuwe investeringen op een terrein (bijv. bouwactiviteiten) of ter bewaking van een terrein tegen verontreinigingen die van buren kunnen komen.

Bodemonderzoek

In eerste instantie gaat het om het opsporen en vaststellen van bodemverontreinigen. In landen als de V.S., Duitsland en Nederland is onafhankelijk van elkaar een methodiek ontwikkeld om dit soort bodemonderzoek uit te voeren. Desondanks komen de methoden in hoofdlijnen op hetzelfde neer. In eerste instantie wordt een bureaustudie naar de mogelijke bronnen uitgevoerd, het zgn. historische onderzoek. Er wordt onderscheid gemaakt tussen diffuse en lokale bronnen. Diffuse bronnen zijn bijvoorbeeld zure regen, meststoffen en bestrijdingsmiddelen die over grote gebieden verspreid worden. Lokale bronnen zijn meestal afkomstig van bedrijfsactiviteiten, zoals lekkende vaten, ondergrondse opslagtanks, stortplaatsen, kapotte rioleringen, etc.

Op basis van het historisch onderzoek wordt een boorcampagne opgezet, waarbij het doel is met minimale kosten alle (eventueel) aanwezige verontreinigingen aan te boren. Belangrijk hierbij is de omgekeerde vraagstelling, wanneer er niets aangetroffen wordt mag er in het hele gebied ook geen verontreiniging zijn. Al in dit stadium is de Ingenieursgeoloog qua kennis in het voordeel. Bij het ontwerp van de boorcampagne zijn zaken als de keuze van de boormethode en de te plaatsen filters, monstername, toepassing van veld- of in situ metingen, technisch inzicht met betrekking tot ligging van ondergrondse infrastructuur in combinatie met inzicht in de te verwachten bodemopbouw en grondwatersituatie van belang om de vraagstelling zo goed mogelijk op te lossen.

Nadat vast is te komen staan dat zich daadwerkelijk een milieuschade in de zin van bodemverontreiniging op het terrein voordoet, zal verder onderzoek moeten worden gedaan om de totale verspreiding in horizontale en verticale zin vast te stellen. Ook hierbij is uiteraard een kennis van geologie, hydrologie en bodemonderzoekstechnieken van essentieel belang. Zodra de totale verspreiding goed is uigekarteerd, kan men zich een oordeel vormen over de ernst van de situatie. Dit oordeel is ook vandaag de dag nog een onderwerp van grote discussie, hoewel hiervoor in Nederland in tegenstelling tot andere landen zeer starre richtlijnen zijn gegeven (de zgn. A, B en C-waarden). De hierop gebaseerde oordeelsvorming, de zgn. risico-evaluatie, is een deel van het probleemveld waar geen enkel vakgebied voldoende dekking biedt tot een eenduidige oplossing te komen. Hier zijn kennis van zaken als de oorspronkelijke geologische situatie, technisch haalbare saneringsmethoden, normen en richtlijnen, praktijk ervaring en onderhandelingsvaardigheid belangrijke ingrediënten om tot een goed resultaat te komen.

Bij bovengenoemde werkzaamheden is de Ingenieursgeoloog met name bezig met grond(water)onderzoek en de interpretatie en presentatie daarvan. Een mogelijk nog interessanter deel is de fase waarin oplossingen moeten worden gezocht om een verontreinigingssituatie op te heffen of onschadelijk te maken.

Saneringen

Vele alternatieven zijn denkbaar wanneer het gaat om opheffen of onschadelijk maken van verontreinigingen. Een eerste vereiste is een goed inzicht in de ondergrondse verontreinigingssituatie op basis van boorgegevens en kennis van de civiele technische (on)mogelijkheden. Een gemis van een van beide is helaas nog steeds een belangrijke reden waarom saneringsprojecten zo vaak uit de hand lopen.

In het merendeel van de gevallen wordt (nog) gekozen voor ontgraving van de verontreinigde grond en vervanging door schone grond, waarna veelal het verontreinigde grondwater wordt opgepompt en gezuiverd. De verontreinigde grond wordt vervoerd naar een lokatie waar deze gereinigd kan worden. Bij deze relatief eenvoudige en weinig elegante methode treden overigens nog vaak aanzienlijke complicaties op, zoals ontgraven onder gebouwen, kabels en leidingen, weglichamen, zettingsproblemen omdat men droog wil ontgraven en dergelijke.

Mooiere, maar technisch veel moeilijkere oplossingen zijn de in situ saneringstechnieken. In veel gevallen zijn deze nog in een experimenteel stadium en is het moeilijk vooraf te voorspellen wat het rendement en dus de kosten zullen zijn. Bij de in situ saneringen speelt nog sterker het belang van een goed inzicht in de heterogene opbouw van de ondergrond. Het spreekt daarom voor zich dat ook hier een interessant werkterrein voor de Ingenieursgeologie is weggelegd.

Slot

Hierboven is in vogelvlucht aangegeven waar raakvlakken liggen tussen de Ingenieursgeologie en de bodemverontreinigingsproblematiek. De markt, en daarmee de werkgelegenheid, voor milieukundig onderzoek is inmens. Bovendien is op het brede terrein van milieuvraagstukken nog veel meer denkbaar dan alleen bodemverontreiniging. Dit geldt niet alleen voor Nederland, maar ook voor alle westerse, voormalige oostblok en derde wereldlanden. Het idee dat de milieuproblematiek van voorbij gaande aard is, is inmiddels al lang achterhaald. De Ingenieursgeologie heeft goede mogelijkheden hierop in te spelen.

ENGINEERING GEOLOGY INSTRUMENTAL FOR INNOVATION OF UNDERGROUND SPACE DEVELOPMENT.

by P.M. Maurenbrecher

lecture at the yearly meeting of the Belgian Committee of Engineering Geology (BCIG) at 17 December 1991

Dreams and realities

Early initiatives existed to make more use of underground space. Many imaginative ideas in the past can be found in the literature and art. A recent example is the Phantom and the Opera where the underground of Paris is made to look like the Bois de Boulogne. The first edition of Tunnels in 1971 shows a grandiose scheme, also in Paris, to put huge complexes underground, such as cinemas, sport and shopping centre all leading stepwise toward an underground transport system. Paris in the meantime has done much to further extend its underground infrastructure and has good examples, such as the new entrance to the Louvre, of underground structures.

What these schemes lack are any mention of the geology and the difficulties that this may cause. Despite taxing the imagination of the architects and planners involved the schemes all singularly lack one aspect of underground space develop-ment: to adapt the spaces to the geological environment. Urban planners often lack any imagination when taking the surface environment into account; often changing the landscape to suit their schemes (infilling streams, levelling sites) rather then attempting any harmony between landscape and design. This becomes even more evident when going underground: the assumption is made that it is one isotropic mass in which any shape or form can be carved out. Urban underground planners are beginning to realize there is a need for "*a total map in three dimensional underground information should be drawn which specifically shows what is buried under the ground.*" This is a quote from the recent keynote lecture given by Emiritus Prof. Dr. Eika Takayama, the doyen of architecture and urban planning in Japan at the TRI-U (Urban Underground Utilization) 4th International Conference on Underground Structures and Earth Sheltered Buildings.

Environment, nature & mankind

We, as engineering geologists, regard ourselves as the communications centre between the more basic science of Geology on the one hand and the applied sciences of engineering in general (Civil, Mechanical, Electrical, Mining and Chemical) on the other hand. I always like to quote the definition of the Civil Engineer (which I regard as the matriarch of all engineering disciplines): *to harness the forces of nature for the benefit of man-kind*. To harness these forces we must understand nature and geology is a science devoted to understanding the nature of the sub-surface. Hence, through the definition of Civil Engineering we can, as engineering geologists, justify our leading role in understanding the nature of the underground for the benefit of mankind.

Mankind benefits in numerous ways from the underground; principally as a source of materials and as a medium to secure to his great variation of structures. Early mankind also used natural spaces in the underground as shelters for living, worshipping and storage. In this way the early cave dwellers must have used nature not only for the benefit of mankind but also for the benefit of his environment. The surface environment was left undisturbed as construction material and sources of fuel were kept to a minimum and hence he could devote his time to the gathering of food leaving ample time to devote towards art as many cave drawings attest.

This harmony has long since gone when we consider our modern civilization. Yet we can still profit from some of its attributes; underground spaces saves space on the surface and saves our skyline being obliterated by high rise building which at most are monuments of twentieth century civilization defiance of everything that represents nature. They amplify the wind, they need extra heat to reduce the heat they trap from the sun, they need extra heat when exposed to winter winds, windows cannot open so that climates consist of artificial stale air through a system of ducts are efficient distributers of coughed out bacilli: sick-building syndrome. In summer high rise urban areas trap the hot moist air expelled by the air-coolers which are mixed with the fumes of the street traffic. Our quality of life bears little resemblance to that of the cave-dweller. In one hot summer in south Limburg tourists found relief in the underground building stone mines of Valkenburg.

The principal argument for underground space is that we have to a great extend starved the surface for space. The alternative is further urban sprawl or more sick buildings pointing towards the sky and making open areas at street level increasingly unpleasant to occupy.

But do we need engineering geologists to argue this aspect? We are closer to understanding nature than the engineer and we should make him more aware of his increasing disregard for harnessing the forces of nature for benefiting mankind. Today the maxim is abusing the forces of nature for the benefit of mankind's overindulgence in fleeting and superficial materialistic experiences.

Environmental aspects of underground space

Before we start abusing the underground as we do the surface we must understand the underground. We must create spaces which blend harmoniously with the underground geology. A whole environment exists which can be irreparably disturbed: aquifers polluted or drained, aquicludes pierced, surface subsidence and flooding. The environment can be hostile: poisonous or radioactive gasses can accumulate, groundwater can corrode and previous workings can seldom be ruled out. An understanding of the processes underground should influence the design of underground spaces rather then underground spaces be influenced by an architect's monumental desires.

When we create spaces underground two possible objectives are at work: creating a space we require for some form of occupation (usually for storage, power plant, conveyance, or defence shelter) or for the extraction of material for use in industry.

Today one increasingly talks about designing the myriad of industrial products not only to serve its function but also to consider its "after-life", how it can be efficiently disposed of once its function has ceased such as ease of dismantling for recycling.

This approach should also be used in underground space development. If we create spaces underground as primary object to extract minerals, then we should consider possible occupational use of such a space once it is created. Such consideration may require that an ore body may be either under or over extracted. It may also be that extraction is financially feasible as the space once created will continue to act as a source of income. Conversely creating a space for occupation should consider exploiting the material to be excavated. Hence the excavation should be adapted to quarry or mining methods to ensure all the material can be used industrially: clay, sands, gravels and peats always have a market. In this way the geology could influence the shape and size of the space and also the logistics of excavation. To use this "conservationist-friendly" approach, for want of a better word, requires thorough investigation by the engineering geologist who not only communicates subsurface information to disparate engineering disciplines such as architects, mining engineers and civil engineers but also to offer a communications bridge between the different engineering disciplines.

The second more traditional role of engineering geologists with respect to underground spaces is to determine the effects of an excavation on its environment; the stability of an excavation, potential for subsidence due to collapse of existing spaces or due to ground water lowering, inflow of groundwater into an excavation. Unlike surface structures engineering geologists are also much more concerned with reinforcement of excavations too weak to support themselves as the surrounding mass forms part of the structure of an excavation. This aspect requires a sound understanding of hydrogeological, geotechnical and geo-mechanical processes which is essentially the interaction between the walls, roof and floor of a space and the mass of material radiating from these boundaries. Creating a space influences the stress field. The reorientation of the stress field is such that these stresses will possibly exceed the material strength causing excessive displacements which are regarded as failure. The shape of the space boundaries (floor, walls and roof) influence the re-distribution. Hence concentration can be avoided by adopting rounded shapes or concentrations can be used to aid excavation to a shape which becomes relatively stable.

Carboniferous cinema

Once a year the TU Delft first year students from the Faculty of Mining & Petroleum visit a quarry site in the Meuse/Maas valley eastern flank 3 km north of Dinant: the St. Anne quarry in the lower Carboniferous calcareous mudstones. It is a favourite with the petroleum geologists as they claim it to be a possible source rock. If the rock is freshly broken a typically organic odour somewhere between oil and sulphur can be smelled. The rock has been quarried for ornamental window sills (which can be admired at the faculty building in Delft). The bedding dips about 25° to 30° towards the south. As the quarry progressed the overburden thickness increased so that underground extraction favoured open quarry excavation. Now a deserted large sloping gallery follows the bedding of the excavated limestone. Though roof slabs have fallen in, the gallery remains remarkably stable despite the slender pillars. Place rows of seats along the strike lines and a screen at the lower end of the excavated quarry and you have a cinema; and an example of a space created for a dual purpose space which also had regard for the nature of the geology.

ICUSESS '92

Many additional aspects of underground space will be addressed at the 5th International Conference on Underground Space and Earth Sheltered Structures. The themes will cover planning, possible uses, lighting, ventilation, orientation ergonomics, safety, legal aspects, and economics of underground space. Previous conferences were held in the USA, Australia, China and Japan. This is the first time the conference is held in Europe. As 1992 is a significant year for Europe the intention is towards the conclusion of the conference to set up initiatives for the establishment of a European Underground Space Centre. Its principal aim is to encourage more use of underground space in Europe. The conference is organised by the Nova Terra Foundation and is hosted by the University of Technology, Delft as part of the university's 150 anniversary celebration. Brochures will be provided before or after the presentation or one can request one from Congress Office ASD, PO Box 40, NL-2600 AA Delft. (tel 31 15 120234, fax 31 15 120250).

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SYMPOSIUM MIDDAG - 28 APRIL 1992

GIS - GEOSTATISTIEK - PATTERN RECOGNITION

Interpretatie van geologische en geotechnische data en de daarbij voorkomende problemen zullen centraal staan op deze middag. Verwerking van data in Geologic Information Systems en mogelijkheden van pattern recognition zullen door de verschillende sprekers worden behandeld zowel theoretisch als aan de hand van praktijk voorbeelden.

sprekers op deze middag zullen zijn:

Dr.Ir. S. Spierenburg	-	Delft Geotechnics
Prof. Andrea Fabbri	-	ITC, Int. Inst. for Aerospace Survey and Earth Sciences
Ir. Pieter Swart	-	Koninklijke Boskalis Westminster
4de spreker	-	nader aan te kondigen

De middag wordt gehouden in het gebouw van Delft Geotechnics, Stieltjesweg, Delft op 28 april 1992, 14:00 uur. De kosten zullen F 15.- bedragen.

Deelname aan deze middag gaarne opgeven doormiddel van onderstaande antwoordcoupon of telefonisch bij: Robert Hack, Secretaris Computerra, ITC, Int.Inst.for Aerospace Survey and Earth Sciences, Kanaalweg 3, 2628 EB Delft, tel. 015 569226.

Antwoordcoupon
Ik wil GIS - GEOSTATISTIEK - PATTERN RECOGNITION bijwonen.

Naam: ....

Adres: .... Postcode: .... Plaats: ....

Sturen aan: Robert Hack, Secretaris Computerra, ITC, Int.Inst. for Aerospace Survey and Earth Sciences, Kanaalweg 3, 2628 EB Delft.

NOVA TERRA Foundation

Underground space, an introduction.

Energy and raw materials conservation and its influence on the environment is the main concern of our present civilization. The Club of Rome issued a disturbing report in 1972 in response to the Arabic oil embargo and the subsequent high energy prices and shortages caused by the embargo. The report examined conservation and environmental aspects which to this day are still not resolved. Since the establishment of the Nova Terra Foundation in January 1985 research is being promoted on the possibilities of underground construction to help settle some of the more pressing problems identified by the Club of Rome.

Underground space as a building concept, more so then high-rise or low-rise building concepts, is based on conservation: energy-conservation, space-conservation and maintenance and exploitation-costs conservation. Energy conservation is a principal focal point for the Netherlands. Not only does less fuel consumption improve the atmosphere but it also reduces the cost of living and prolongs our existing natural energy reserves.

Underground construction can be characterized into three main categories, which could both occur in level ground or in sloping ground situations. The three categories are earth sheltered buildings, partially buried and subterranean. The negative image the public has on occupying underground space results from lack of knowledge and experience of underground spaces. Preconceptions, such as, damp, dark and daylight-less spaces are bolstered by claustrophobia owing to lack of windows to outside vistas. As a result of these prejudices, an important task of the Nova Terra Foundation activities is aimed at providing information on and about research for underground-housing and underground-utilities design.

The advantages of underground-space

The stabilising effect of the ground

The ground acts as a stabilizer of seasonal temperature variations. A surface house is exposed to temperature changes, which in the Netherlands can fluctuate between the extremes of -20°C. in the winter to +30°C. in the summer. A constant temperature of 11°C. persists at about fifty meters depth. Underground spaces are, thereby, relatively cool in the summer and warm in the winter.

The thermal mass of the earth

The ground has a very large thermal capacity. This thermal capacity acts as an energy buffer: it absorbs energy during the day and radiates this during the night. This control of temperature differences during the day and night can result in a large saving in energy costs.

Shield.

Underground spaces act as a shield against dust, storms, vibrations, fire-transmission, house-breakers, vandalism, radiation and lightening. Protection against influences of wind is of particular significance: in modern buildings one of the main causes of energy loss is due to wind induced draughts. With underground spaces the earth layer acts as a sealant preventing unwanted infiltration of (cold) outside air.

Landscape and surroundings

In more and more areas the presence of man is made manifest through buildings. In some instances it is undesirable and results in a definite intrusion in the character of such an area (horizon pollution), but also sometimes it is not allowed by legislation (conservation areas). Underground space can overcome these objections as it is hidden by a vegetation covered earth layer which blends into the landscape.

Space conservation

The total of unused roof area in the Netherlands is considerable. In this densely populated country use of such roof space should have more than the one purpose of keeping out the weather. Underground structures makes it possible to have a garden on the roof. This results in more efficient spacial use of the ground, allowing an increase in population density per hectare without using up green areas.

Underground space and monuments

Through the use of underground it is possible in urban areas to make use of the space under squares and parks. Such an increase in building density allows preservation and avoids architectural despoliation of historical buildings. In cities costly real estate can become more profitable through more intensive use of the available space. Underground extension of heritage buildings can, in this context, produce a valuable gain in space and quality, without negatively influencing the historical value of the building.

Noise abatement/containment barrier

The mass of earth over an underground space acts as an effective shield for either containing internal sound or keeping out external sound. High noise levels along traffic routes, railways and airports prevents traditional construction in the adjoining areas. In the Netherlands up to 25,000 hectares cannot be built on due to the effects of transportation noise. Underground space concepts would allow construction in such areas.

Conversely, internal sound sources from, say, some especially noisy activities which had previously been designated to industrial areas could revert back to urban housing areas near the homes of employees.

Underground space through the years

Underground space is as old as mankind. The oldest civilizations often used the underground for residential purposes. Some of the merits of ancient underground architecture are very relevant to twentieth century aspirations: to be less dependent on energy sources and technology so as to have a closer bond with nature. Examples of modern applications of underground space often are found in western countries such as Japan and USA. It is, however, in developing countries that traditional ways of living could show our western culture how to successfully live underground before it is too late. Large scale applications of traditional underground space are found in the northern provinces of the People's Republic of China (Shansi, Shensi, Kansu and Henan).

10,000,000 underground space houses in China

In November 1985 and in September 1988 the Nova Terra Foundation attended conferences on underground space in Beijing and Shanghai respectively. These conferences were followed by excursions into the hinterland of China where ten million houses of the semi-buried are located and give shelter to forty million people. The semi-buried house, known locally as *Yao-Dong*, is an ancient and, yet, contemporary Chinese building form. The building form conserves agriculture land. The sunken courtyards, besides allowing daylight to penetrate, are used for storage, as farm animals enclosures and for fruit trees. These homes are ideally suited to moderating the outside temperature extremes of central China which fluctuate from -30°C in the winter to +35°C in the summer. Inside temperatures remain close to 16°C all year round! Such an airconditioned house is simply constructed by excavating with a spade a square atrium into the ground. From there one tunnels chambers laterally into the exposed walls of the atrium. The size of the *Yao-Dong*, which may vary somewhat in size and shape, is often 6 metre deep and 8 to 10 metre square. The various chambers are 5.5 metre wide and 8 to 10 metre deep. The application of the *Yao-Dong* in the Netherlands will present problems in the West and in the North of the country as a result of the high water tables. In the eastern, southern and central (Veluwe) parts of the country this type of housing, which would resemble Spanish patio-bungalows, could be realised.

Underground space in the United States of America

The national centre for underground space of the USA is housed underground in Minneapolis. The centre, known as the Underground Space Center, has had an enormous influence in the explosive growth in the USA in underground space development ensuring yet another H.G. Wells prophesy may become reality. In his film back in 1935 the following was said:

"The Everytown of the year 2054 will be dug into hills, it will not be a skyscraper city, the old familiar hill contour is in the background and quite recognisable, but the old town itself under the open sky has disappeared and given place to a few terraces and external structures, grass slopes and formal trees. It is very tranquil and beautiful, the apotheosis of Everytown".

The cold war and atom-bomb anxieties of the 1950s looked to underground space as a solution for personal safety against a nuclear attack. At the 1964 World Fair in New York a totally radio-active free underground house was exhibited, of which a number were sold. However it remained until the 1970s before underground space was regarded as an important possibility of building. The principal reason was not fear of nuclear attack but to reduce energy costs and conserve the natural landscape.

The present knowledge on underground space combines geology, passive solar energy technology and civil engineering. Recent research investigated energy performance of underground space buildings. Results have shown that such spaces have many advantages over above-ground buildings. The research, furthermore, is used to increase understanding of energy conservation in conventional buildings. The largest growth rate in American underground space development has moved from residential buildings to commercial/industrial buildings as a result of energy conservation. Other factors also influence this trend as modern high technology industry demands the advantages offered by underground space: low vibrations, sealed environments, and constant temperatures.

The many tens of thousands of underground space buildings resulting from the construction boom of the 1980s have emanated to a large degree from the activities of the Underground Space Center. Examples are found all over the USA. The effect of these activities are a great stimulant for the policies of the Nova Terra Foundation.

Applications of underground space in the Netherlands

Historically a relatively small underground space building tradition exists in the Netherlands . The tradition is found, almost exclusively, in the south of the province of Limburg. Though underground activities can be traced to the Neolithic age (4000 year BP), actual underground living is represented by underground houses in limestone which were still inhabited up to about forty years ago. For the remainder of the country examples can be found of earth-covered fortifications which have played an important role in the defense of the country.

The increasing rate of urban population growth in the last century in cities like Amsterdam caused a severe housing shortage. Speculators saw opportunities to convert existing cellars and basements into homes. As such conversions were based purely on a quick profit, little thought was given to ensuring proper use of building materials and design. Most sub-surface homes were damp, badly ventilated and poorly lit which did little for the health of the people occupying them. In the 20th century such homes became less popular as increasing prosperity meant people sought better homes above ground level, despite the fact that improvements in technology would have made underground living more feasible. One example where underground space use has made recent strides are the metro lines of Amsterdam and Rotterdam.

Considering the combination of the high population density in the Netherlands and the small size of the country, then underground space would be an important addition to solving the space problem. The use of the underground, sometimes referred to as the 3rd dimension, is not formally considered in any urban or industrial planning procedures for making more effective use of existing, remaining space or space for redevelopment. Hence the question in the Netherlands is: do we use our space efficiently? What are the possibilities; technically, financial, legal and the general public attitudes to working and living underground? These questions are of primary importance for the cities in the Randstad area (zone covering Amsterdam, Haarlem, Leiden, The Hague, Delft, Rotterdam, Gouda and Utrecht) and south Limburg enclave zone which extends into Belgium and Germany (Cologne, Aachen, Heerlen, Maastricht and Liège) where the greatest shortage of space exists. Developments outside urban areas must, however, not be overlooked as these too must be critically considered for placing underground.

Since the Club of Rome report we are slowly but increasingly developing new insights towards assuring the natural environment and our quality of living. As with any assurance policy we are prepared to pay the extra premium for situating a space underground if this should conserve the environment and enhance the quality of living. The science of underground space construction and design is gaining momentum. New building methods have been evolved that makes underground space financially feasible, frequently, even despite the extra premium.

Sub-surface soil description and the groundwater regime

Design factors which increasingly are found to influence building concepts are changing trends for residential neighbourhood lay-outs, home comforts, home amenities, new materials, areal space and, significantly but unseen, subsoil constraints. Good examples exist world-wide of situations where the subsurface is central in influencing the other design factors. For the Netherlands some geological maps depict the country having one subsurface unit (the Quaternary). Luckily examples of different subsurface situations exist and their influence on design and construction of buildings. The bulk of the population resides below sea-level in the polders of the Randstad where the ground is very weak and the water table from 0.1 m to 1 m below ground level. Most examples of underground space in these areas are infrastructural development such as tunnels for transport.

For these areas the simplest example for housing would be earth-covered structures. Owing to the extensive network of canals and channels in the polders house-boats are a very popular form of living. Why not excavate channels to float a basement into position, build a second floor to sink the basement to its foundation (bed of the channel) and then cover the remainder of the structure with the surplus earth from the channel?

Industrial and commercial buildings development would depend on each individual project. The high investment required to put such building underground would be profitable in areas where ground value are very high, if its situation in the 3rd dimension would reduce its hindrance (noise or too overbearing in scale to its neighbouring buildings), and the energy saving is substantial.

The higher ground (above sea-level) consists of the coastal dunes, the ice-pushed ridges in central and eastern Netherlands and large glacial wind sand deposits of the northeastern, eastern and southern Netherlands. In some more localised areas older rock does come to the surface such as south Limburg and Winterswijk on the centre eastern border with Germany. Here the water table is much lower so that underground space of the three types can be achieved without undue high investment costs. In fact in south Limburg extensive underground space exists due to coal and limestone mining activities. Limestone has been mined in the dry for building stone over ten centuries and the spaces of these mines are now used for storage, as museums and even for horticulture (mushrooms).

Characterisation of underground space

The application possibilities in the Netherlands occur both for residential and commercial/industrial purposes. To change to underground space requires assessing the advantages of underground space with respect to conventional buildings. The advantages lead to several applications possibilities, of which a few have been realised in the Netherlands. Buildings, which have restricted demand for daylight or for outside views, can obviously be developed as underground space structures. Examples of such buildings are theatres, museums, garages, hotels, warehouses, shopping centres, television and recording studios, churches, cinemas, gymnasia, factories, libraries and concert halls. Even offices and housing can be realised underground on the condition that daylight can penetrate and views are possible. Often window views in town centres extend no further then across an atrium or a few meters across a street. Such "open spaces" can be realised as easily underground as open shafts as modern high-rise seem to create above ground.

Extensions to old historical buildings usually degrade the buildings' original architectural merit. The modern municipal legislative auditorium, The Hague, is now intended for demolition so as to reinstate the adjoining historical town hall and create extra open green space. Had the auditorium been situated underground this problem and extra expense would not have occurred. The error has been repeated in the nearby recently completed Dutch Parliament's 2nd Chamber auditorium. The auditorium could have been better situated underground, its modernity and scale overwhelming the historical traditional parliament buildings. Increasingly open "green oasis" such as gardens, parks and squares in city centres are sacrificed for short term financial accounting. This does very little to improve our environment. Making more use of space underneath parks and squares and beneath old buildings which could be extended laterally underneath pavements and roads is an obvious solution without compromising modern demands for space and sacrificing our environment to achieve these demands. Residential underground space, especially as earth covered and partially buried buildings would create space for more peaceful, almost rural environment and conserve energy.

Underground space in all areas of the Netherlands is possible

Underground space for different purposes is possible

Underground space has perspectives with a creative challenge.

The NOVA TERRA Foundation

The name is based on the acronym in Dutch *Nationaal Onderzoek- centrum Vernieuwend Aardgebruik* meaning National Research Centre for In<u>nova</u>tive Use of the Ground. Fortuitously the Latin word *Nova* appears embedded in the English translation. The Foundation originated from research on underground space in January 1985 at the University of Technology, Delft. Initially little was known in the Netherlands on underground space so that the research first concentrated in collecting information. The investigation looked at both historical and modern applications of underground space which resulted in assimilating a large amount of information and contacts with institutions and people involved with underground space outside the Netherlands.

The objective of the Nova Terra Foundation is the collection and examination of information which provide knowledge on a wide spectrum on underground space use. Subsequently the knowledge is disseminated to a wider public to encourage the development of underground space in the Netherlands. Information acquisition focuses on subjects such as energy conservation, space conservation, construction methods, design, noise abatement, water-tightness, construction and exploitation costs, psychological effects, architectural aspects and town planning considerations of underground space. The examined and assimilated knowledge is then disseminated by lectures, conferences, publications and audio-visual presentations to make known to a broad a public as possible.

ICUSESS '92 Conference & European Underground Space Centre

The Nova Terra Foundation, after seven and a half years existence, is now organising the 5th International Conference on Underground Space and Earth Sheltered Structures ICUSESS '92 appropriately being hosted by the University of Technology, Delft. ICUSESS '92 is one of the events commemorating an anniversary twenty times older then Nova Terra, the 150th anniversary of the founding of the university. The conference is from 2nd to 7th August, 1992.

1992 is supposed to be also the year the European Community countries allow unhindered travel across their borders. In the spirit of European cooperation the intention of the Nova Terra Foundation is to set up a European Underground Space Centre on the lines of the centres in Minneapolis, in Shanghai, in Tokyo and in Sydney.

The centre should increase awareness of underground space possibilities as an information centre, an exhibition centre and centre for encouraging research and development. This signifies an important impetus for the development of underground space in the Netherlands and Europe.

Address

Technische Universiteit Delft
Faculteit der Civiele Techniek
Vakgroep Utiliteitsbouw

Postbus 5048
2600 GA Delft

Telefoon (015) 782844/783958
Telefax (015) 786993

Office address Stevinweg 1, 2628 CN Delft

ICUSESS '92

5th International Conference on Underground Space & Earth Sheltered Structures
2nd to 5th August 1992 Delft University of Technology, The Netherlands

This conference is organized by the Netherlands National Research Centre for Innovative Use of Underground Space, the NOVA TERRA Foundation, which will be part of the 150th anniversary of Delft University of Technology.
Active participation from engineering geologists in both the scientific and organisation committees by Professor David Price and Michiel Maurenbrecher ensures that the conference will be of interest to all earth scientists and technologists. The engineering geology section has partaken in the two previous conferences: in Shanghai 1988 (see articles Chronicle of a Trip to China) and in Tokyo 1991. Both David Price and Michiel Maurenbrecher look forward to seeing you in August at TU Delft.

Aim
Underground construction is a logical planning and development consideration for both large cities and inter-city areas associated with infrastructure, spaces for human use and storage. Multi-functional use of the ground is possible through underground space construction which is especially suited to densely populated countries such as the Netherlands and provides an extra dimension to the possibilities for solving problems in the field of environmental planning. Improved insight in this third dimension is provided through the means of this conference and is directed towards government administrators, legislators, financiers, clients, builders, architects, contractors and suppliers. These varied disciplines can collectively offer competent solutions towards major community concerns with respect to infrastructure, storage, work, recreation, and living, without further sacrificing the environment by surface construction.

The conference is open to all with interest in the use of underground space and it is expected that delegates will come from the fields of civil engineering, architecture, geology, planning, economics, politics, law, medicine and environmental science.

Main subjects
The proceedings of the conference will fall under five main subjects. These are:

Planning The use of underground space and earth sheltered structures within urban, national and environmental development planning.

Economy The economy, marketing and financing of the use and development of underground space and earth sheltered structures, in particular in contrast to the continuing exploitation of surface space. The economy of mining/quarrying with a view to creating underground space.

Law and Politics The present situation and developments in national and international law, standards and political opinion with regard to the use of underground space and earth sheltered structures. The use of underground space and earth sheltered structures as a factor in the development of policies for environmental protection.

Design and Use Architectural and social design of underground space with regard to function, safety, natural light, comfort, health and utilisation, in accordance to specific uses and possibilities of underground space.

Construction General problems relevant to the construction of new underground spaces and the use of existing underground space and earth sheltered structures. Environmental impact of the construction process.

Scientific Committee

Prof.Ir.H.P.S. van Lohuizen Chairman
Ing. A.Jonker, Secretary
Ir.G.Chr. Bouquet
Prof.L.Boyer
Prof.Ir. A.Glerum
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Main sponsors
-Association of the Netherlands Cement Industry
-Foundation Technics Verstraeten B.V. Fundex
-Geological Survey of the Netherlands

Co-operating Institutions
-Ass. of Consulting Engineers in the Netherlands (ONRI)
-Civil Engineering Services Department /Geotechnical Service
-IAEG Int.Ass. of Engineering Geology
-ITC Inst. for Aerospace Survey and Earth Sciences
-Institution of Civil Engineers
-ISSMFE International Society for Soil Mechanics and Foundation Engineering
-Royal Inst. of Dutch Architects (BNA)
-Royal Inst. of Engineers (Netherlands)
-Ruhr Universität Bochum
-The Geological Society
-University of Cambridge
-Urban Underground Space Centre of Japan

Committee of Recommendation

-J.G.M. Alders,
Minister of Housing, Physical Planning and Environment

-Prof. S.Itoh,
Professor of Architecture, University of Tokyo

-Mr. S.Patijn,
Queens's Commissioner for the Province of Zuid-Holland

-M.I. Platschorre,
Chairman of Association of the Netherlands Cement Industry

-Prof.Drs.P.A. Schenck,
Rector Magnificus of Delft University of Technology

-Mr. H.V. van Walsum,
Mayor of Delft

Keynote Speakers
Keynote speakers will present critical reviews within the main subjects.

Ir. J.W. Bosch	Amsterdam: building an underground public transport interchange
Drs. A.P. Buur	Building underground: not only an economical problem
T.H. Douglas, FICE CEng	Underground space construction-problems, limitations and opportunities
Prof. S. Itoh	General overview on planning
Drs. F.C. Stam	The underground: an option for environmental policy
Prof. Dr. R. Sterling	General overview on design and use: safety and psychological aspects of underground space
Ir. A.W.G. Thijsse	To dig or not to dig; chances and possibilities for underground building in the Netherlands

Papers
Selected authors will present their papers, and in addition all authors have the opportunity to present posters.
Proceedings
All accepted papers will be published in the proceedings and will be available during the conference.

Organisation of the conference: Sunday 2 August 1992 to Wednesday 5 August 1992
In contradiction to the First Announcement the date of the conference has been slightly changed from 2 August to 7 August. On Sunday 2 August there is an excursion and the opportunity to register. The excursion is included in the conference fee.

Thursday 6 August 1992 - Post Conference Tour
The Organising Committee are arranging a post conference tour for 6 days to visit underground space sites in the Netherlands, Belgium and France. Those who would wish to participate in the excursion should complete the box in the reply card. The excursion requires a minimum of 20 persons to proceed.

6 August, 1992 Den Bosch and Maastricht, The Netherlands

7 August, 1992 Maastricht, the Netherlands

8 August, 1992 Departure Maastricht to Brussels, Belgium

9 August, 1992 Departure Brussels to Paris, France

10 August, 1992 Paris, France

11 August, 1992 Paris, France

Social Event
Monday, 3 August, 1992
-Reception at Delft University of Technology
Tuesday, 4 August, 1992
-Reception at Old Town Hall, Delft followed by Conference dinner
Wednesday, 5 August, 1992
-Farewell party

Partner Programme
Monday, 3 August, 1992 Visit Delft:
-The Porceleyne Fles, the Delft Blue Pottery and museum
-Guided tour through Delft with lunch included.

Tuesday, 4th August, 1992 Visit Floriade Zoetermeer
-Guided tour through the world of flora, video presentation and exhibitions, lunch included

Wednesday, 5th August, 1992 Visit Amsterdam
-Boat trip through the canals
-Rijksmuseum: Rembrandt's Nightwatch
-Shopping, Lunch included.

General Information
All correspondence should be sent to the Conference Bureau which is:
Congress Office ASD, P.O.Box 40,
2600 AA Delft, The Netherlands;
Tel. 31 15 120234; Fax 31 15 120250.

Dates
Conference:
August 2 - 5*, 1992.
Post Conference Tour:
6 - 11* August 1992,
* inclusive

Location of conference
Delft University of Technology, Aula Building, Mekelweg 5, Delft, The Netherlands.

Registration fee
The registration fee includes: coffee and tea during breaks
lunches, receptions, conference dinner and proceedings
- if received before June 1, 1992
  Dfl. 950,--; ± $ 550,--.
- if received after June 1, 1992
  Dfl. 1.100,--; ± $ 650,--.

Post Conference Tour
The costs will be Dfl 1100.- with room sharing
Supplement for a single room is Dfl 300
This programme needs a minimum of 20 persons.

Social Event
The social event for accompanying persons will be Dfl. 150.-. This includes the reception on 3 and 4 August, the conference dinner on 4 August and also the farewell party on 5 August, 1992.

Partner Programme
The costs will be Dfl. 200 A quorum of 10 persons required to proceed.

Hotel accommodation
Zeehage Hotel, Kijkduin, The Hague
Single: Dfl. 145.-
Double: Dfl. 165.-
Excludes breakfast.

Pullman Hotel, City Centre, The Hague
Single: Dfl. 200.-
Double: Dfl. 225.-

Atlantic Hotel, Kijkduin, The Hague
Single: Dfl. 200.-
Double: Dfl. 225.-
Excludes breakfast

Europa Hotel, The Hague (Coast)
Single: Dfl. 195.-
Double: Dfl. 245.-
Excludes breakfast

Bus transfer from and to the hotel will be arranged.

All requests for accommodation should be accompanied by a deposit of Dfl. 250.- before June 1, 1992. Without this deposit room reservations after this date will be cancelled.

Registration Form

Delft University of Technology, Delft, The Netherlands 2-5 August, 1992
Please use typewriter or CAPITAL LETTERS

5th International Conference on Underground Space and Earth Sheltered Structures

Surname : Initials: Mrs./Mr.

Affiliation :

Address : Postal Code:

City : Country:

Telephone: Telefax:

I definitely will participate in the 5th International Conference on Underground Space and I will be accompanied by the following person(s).
If your children will join you please fill in their ages.

Mrs./Mr.

• **Hotelaccommodation**

Date of arrival: Date of departure:

Zeehage Hotel	Atlantic Hotel	Pullman Hotel	Europa Hotel
☐ Single: Dfl. 145,-	☐ Single: Dfl. 200,-	☐ Single: Dfl. 200,-	☐ Single: Dfl. 195,-
☐ Double: Dfl. 165,-	☐ Double: Dfl. 225,-	☐ Double: Dfl. 225,-	☐ Double: Dfl. 245,-
Excluding breakfast	Excluding breakfast	Including breakfast	Excluding breakfast

All requests for accommodation should be accompanied by a deposit of Dfl. 250,- before 1 June, 1992.

• **Registration**

☐ Interested in the Post Conference Tour If you are interested special information will be send to you.	Dfl. 1.100,-
☐ If received before 1 June, 1992	Dfl. 950,-
☐ If received after 1 June, 1992	Dfl. 1.100,-
☐ Social Event ... accompanying persons x Dfl. 150,-	Dfl. ....
☐ Partner programme ... persons x Dfl. 200,-	Dfl. ....
☐ Hoteldeposit (before 1 June, 1992)	Dfl. 250,-
	+
Total	Dfl. ....

• **Way of payment**

☐ Please make an Eurocheque payable to:
Congress Office ASD, Delft, The Netherlands

☐ Or by direct bank transfer to:
Rabobank, Pijnacker, The Netherlands
Accountnumber 35 44 12 388, quoting: ICUSESS, and the name of the participant(s)

• Please note: A credit card is not accepted by Congress Office ASD.

Signature: Date:

Return this form to: Congress Office ASD, P.O. Box 40, 2600 AA Delft, The Netherlands

Note: reverse side of ICUSESS'92 form, adress provided: fold into envelope and seal with sticking-tape or place in appropriate window envelope.

STAMP

ICUSESS'92 Conference Bureau
Congress Office ASD
Postbus 40
2600 AA DELFT
The Netherlands

DE INGENIEURSGEOLOGISCHE EN BOUWTECHNISCHE ASPECTEN VAN HET AFZINKEN VAN EEN CAISSON VOOR EEN SLUIS IN DE VERBREDE ZUID-WILLEMSVAART.

door Anita Kos, Linda Vader en Brigitte Meibos, VU Amsterdam.

Dit is het verslag van de excursie van 1 oktober jl. naar Nuenen die de IngeoKring gezamenlijk met het Belgisch Comite' voor Ingenieursgeologie (BCIG) heeft georganiseerd.

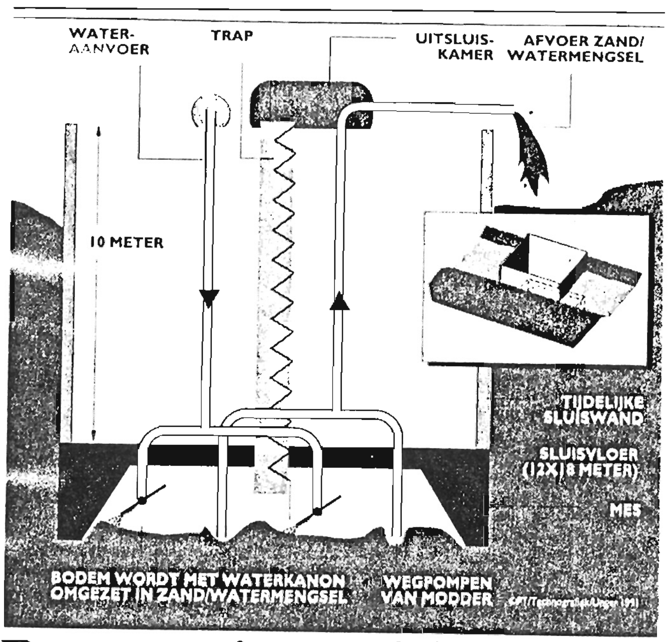
De excursiedag werd ingeluid met wat algemene informatie over de Zuid-Willemsvaart en de toekomstige verbreding ervan door dhr. R. ten Broeke, Directie Noord Brabant van Rijkswaterstaat. Verbreding is noodzakelijk om de vaart toegankelijk te maken voor grotere schepen (tot 1350 ton). De Zuid-Willemsvaart is nu ongeveer 23 meter diep en 2,40 meter breed, maar zou tot 48 meter verbreed moeten worden en uitgediept tot 4 meter. Ook zou het aantal sluizen verminderd moeten worden en de meeste sluizen zijn aan vervanging toe. Door vermindering van het aantal sluizen zullen de sluizen een groter hoogteverschil moeten kunnen overbruggen, waardoor peilverhogingen in het gebied aan de stroomopwaartse kant en peilverlagingen in het gebied aan de stroomafwaartse kant kunnen gaan optreden. Dit kan schadelijk zijn voor de landbouw en voor funderingen van gebouwen.

Vervolgens werd ons verteld over de ondergrond van de Zuid-Willemsvaart door dhr. F. den Lang, Rijks Geologische Dienst. Met behulp van boorgatmetingen en geo-elektrische methoden is een profiel van de ondergrond geconstrueerd.

Hierna gingen we naar Schijndel, waar het caisson in aanbouw is. Hier kregen we informatie over de geotechnische aspecten van de sluisbouw van dhr. C. Treve van het bureau CFE in Brussel, waarna ons een broodmaaltijd werd aangeboden.

Na de lunch ging dhr. S.J. de Visser van de Bouwdienst Rijkswaterstaat nog verder in op de afzinkmethode voor het caisson. Deze afzinkmethode bleek goedkoper dan andere methoden en het grote voordeel is dat er geen bemaling nodig is. Het caisson wordt bovengronds gebouwd, waarna men het laat afzinken. Door een speciale constructie wordt ervoor gezorgd dat het caisson verticaal afzinkt. Bij een bepaalde diepte treedt evenwicht op tussen opwaartse en neerwaartse krachten. Dan kan nog extra ballast toegevoegd worden (meestal water), waardoor het caisson nog verder afzinkt. Het komt echter ook wel voor dat het caisson blijft hangen en dan ineens naar beneden zakt of dat het caisson scheefzakt. De methode is ook niet ongevaarlijk voor de mensen in de werkkamer onder het caisson.

Aansluitend kon de werkkamer bezichtigd worden. Er was juist begonnen met het laten afzinken van het caisson. Dit afzinken duurt ongeveer twee weken.



Pneumatisch afzinken

ENGINEERING GEOLOGY FIELD EXCURSION TO SWITZERLAND

by Jenco de Groot, TU Delft

The excursion is part of the MSc. course in engineering geology at Imperial College in London, and was organised by dr. M.H. de Freitas (april 1991).

The Dutch delegation (Mr. Maurenbrecher and myself) didn not spend money on a plane ticket but took the opportunity to travel by train through the impressive rifting system of the Rhine graben. The system follows the rhine up till Basel, it continues towards the south-west where it coincides with the Saone and eventually with the Rhone graben. It started only 30 my ago.
At Basel the tertiary Molasse Plateau started. We left the graben to continue our trip through the Jura Plateau to end in the Molasse basin at Zürich.

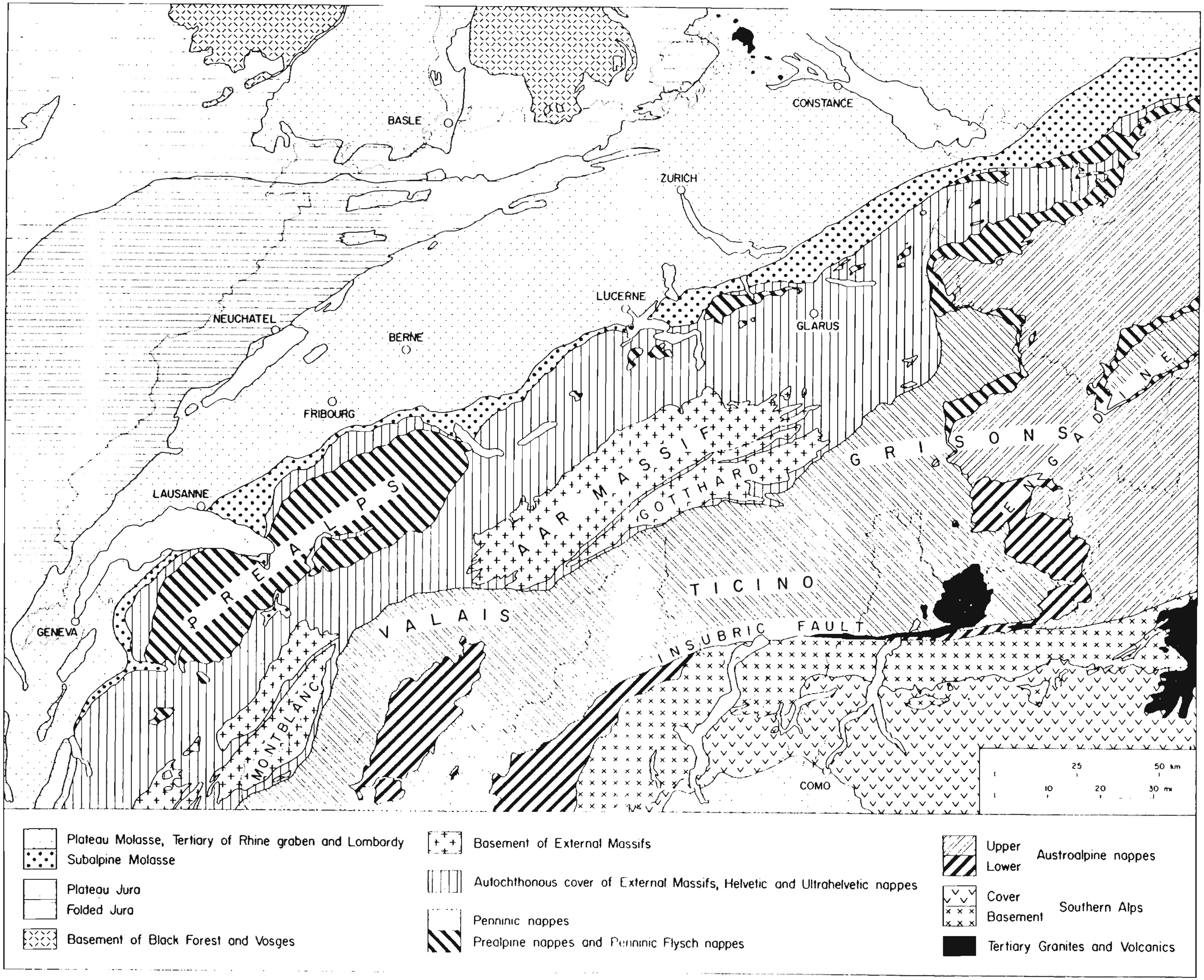
This fieldreport is not representing a complete description of the excursion but just giving a general impression of the Swiss geology and a description of one visited site, the NAGRA nuclear waste repository site. For a complete review the reader is referred to Maria Strong 1991[1].

An Outline of the Geology of Switzerland

During the mid carboniferous the climax of the Hercynian (Variscan) orogeny took place and pre pennsylvanian Switzerland has been strongly metamorphosed and deformed.
This continental pre pennsylvanian metamorphic basement complex consists of gneisses, granites, amfiboles, few marbles and some ultra mafic rocks. Radiometric research indicates even an older affection of deformation namely the Caledonian orogeny.
Continental Pennsylvanian and Permian formations were furthermore affected by late Variscan ('Saalic') faulting combined with granite emplacement. Their tectonic role is intermediate between that of the basement complex and that of the Mesozoic cover rocks.
Shallow seas transgressed during the Trias partly from the north (Germanic Basin) but mainly from the SE Paleo Tethys. Subsidence in some parts of the Alps was quite considerable, but sedimentation remained of carbonate platform type with anhydrites.

Break up of this carbonate platform started in early and Middle Jurassic time, with the opening of the Afro-North Atlantic and of the partly oceanic basins of the western Tethys. Continental margins (Helvetic belt, Austro-Alpine belt and Southern Alps and the interspersed platforms of the Penninic belt) were differentiated. Epicontinental seas covered the future Jura mountains and part of the Molasse basin.
Sedimentation became more rapid during the Lower Cretaceous, both in the Penninic Eugosysncline and the Helvetic margin, coinciding with tension and wrench action. The northernmost part of the country including the Molasse basin emerged for some time.
In the mid-Creteceous Albian epoch compressional movements set in. First in the Austroalpine, then in the southern part of the Penninic belt. Ophiolite procuction ceased and flysch sedimentation began. The deformations are associated with high pressure metamorphism. The Helvetic margin subsided more strongly and received pelagic sediments.
By the end of the Cretaceous, the Jura and Molasse Basin emerged and became part of an extensive, lowlying landmass. Paleocene and Eocene Flysch was laid down in several troughs of the Penninic and southernmost Helvetic belt. In the Helvetic Zone, a sequence of shallow-water limestones and sandstones, pelagic shales, flysch becomes progressively younger towards the northwest. Alpine compression starts from now on from the south.

The climax of the main Alpine orogeny occured at the end of the Eocene. It was accompanied by basaltic and andesitic volcanism and followed by metamorpism. At this time the rifting of the foreland in the Rhine graben stated. During the Oligocene the Alps were uplifted; emplacements followed by the main deformation. The southern swiss part becomes continental, this means the end of deepsea environment with flysch deposits. The distance between Basel and Lugano became half of what is was.
Thick Middle Oligocene to Middle Miocene detrital formations, mainly of continental origin, accumulated in the Molasse basin and on the southern foot of the Alps.
The Jura mountains were folded at the end of the Miocene. The Pleistocene is marked by renewed uplift and strong glaciations affecting almost the entire country. The Alpine uplift still continues nowadays at a rate of 1-2 mm/year.



BASLE
CONSTANCE
ZURICH
LUCERNE
GLARUS
NEUCHATEL
BERNE
FRIBOURG
LAUSANNE
GENEVA
PREALPS
AAR MASSIF
GOTTHARD
MONTBLANC
VALAIS
TICINO
GRISONS
ENGADINE
INSUBRIC FAULT
COMO
25
50 km
10
20
30 mi
Plateau Molasse, Tertiary of Rhine graben and Lombardy
Subalpine Molasse
Plateau Jura
Folded Jura
Basement of Black Forest and Vosges
Basement of External Massifs
Autochthonous cover of External Massifs, Helvetic and Ultrahelvetic nappes
Penninic nappes
Prealpine nappes and Penninic Flysch nappes
Upper
Lower
Austroalpine nappes
Cover
Basement
Southern Alps
Tertiary Granites and Volcanics

NAGRA, Radioactive Waste Disposal in Switzerland

The NAGRA group was founded in 1972 by electrical supply companies, involved or to be involved in future, with nuclear power, together with the Eidgenossenschaft [the committee which take care of the radioactive waste from industry, research and hospitals]. NAGRA = Nationale Genossenschaft für lagerung Radioaktiver Abfälle. They are responsible for all the radioactive waste disposal in Switzerland. Different site investigations are being undertaken, some waste locations are chosen. The timespan of the investigations and the constructions is about 30 years.

Deposition Requirements

According to the Swiss Authorities all radio active waste should be disposed in suitable geological formations. The sites are restricted by safety requirements of the government; safety guideline R-21 1980. This guideline requires:

Isolation; the yearly radiation of nuclides into the biosphere may not exceed 0.1 mSv (or 10 mrem), which is about 3% of the country its total radiation a year.

Stability; after closure and monitoring stop, the site may not lead to unsafely conditions.

Low level wastes are stored both in crystalline and sedimentary rocks, accessible by inclined rift. Crystalline (Piz Pian Grand), Anhydrite (Bois de la Glaivaz), Valanginien Marl (Oberhauenstock)

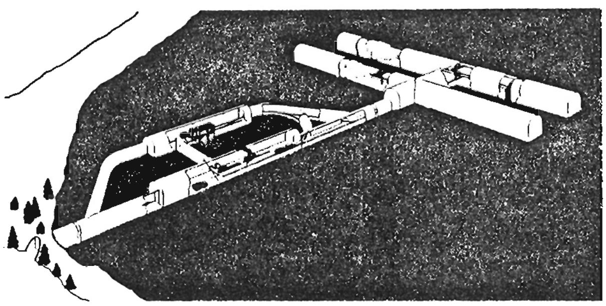


Figure 1:Low Level Waste: Storage tunnels are treated with shotcrete. Prefabricate concrete shields are placed are installed, inside this blocks of cement in which the waste is sealed are placed.

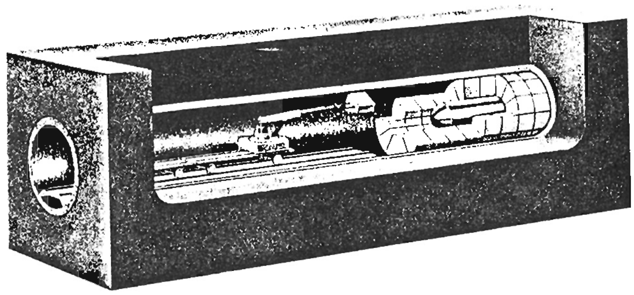


Figure 2. Middle Level Waste: In cement or bitumen bedded waste is placed in concrete silo's.

High Level Waste: the waste bedded in a leaching resistant glass matrix is put in a steel cone. The cone is isolated by hardened blocks of bentonite (see figure 2.A), which are placed in the with shotcrete threatened tunnel.

Site Investigation

At Oberhausenstock both a high and a low level waste site are planned. 150 million SF is being used for all the site investigations. Comparing the following construction costs of about 300 million SF it is about 30% of the complete project costs. Compared to the situation in the UK with site investigation costs of about 5% this is very high.

Progress of Site Characterization

This huge investigation project is rather complex because different specialists have to cooperate (see the scheme in figure 3). About 500 people, the university included, are involved. The main aim of all is to produce a reliable safety report.

Modelling data and geotechnical parameters are used by the desk geologist in order to design a characterization plan. His indications are used by the field geologist to set up a field program which is performed by contractors.
Data output is used by the different specialists to adapt their input theses. The desk geologist has to change his geological maps, and so his characterization plan, the field geologist modifies his field program, etc. Like this cooperation, evaluations, modifications continue and shift untill

the safety report is produced.

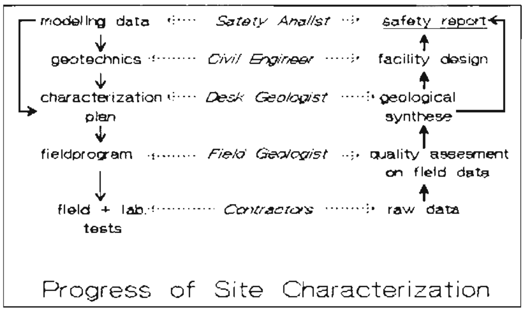


Figure 3 Progress of Site Characterization

Field investigation

Field investigation implies: the making of a geological map on a 1 : 10.000 scale, spring inventory, survey of (possible) sliding areas, survey of soil gas, seismic monitoring, geophysical investigations as refraction, refraction and geoelectrical surveys.

Subsurface investigations

These investigations imply exploration boreholes (up to 750 m), exploration drifting, and the construction of a rock laboratory. Remarkable is that it's not tolerated to penetrate into the planned host rock. No boreholes at the cavern site. It could increase the permeability, which in any case should be avoided thinking about possible environmental impact in the future.

Hydrology

Hydrological investigations are worked out both on a regional and a local scale. They contain:

Hydrological Mapping; the monitoring of springs and the groundwater in shallow aquifers.

Drilling Fluid Monitoring; tracers, quality and quantity monitoring with aid of chemical and physical methods and fluid balances.

Hydraulic Parameters; flow checks, packers tests, fluid logging

Long Term Monitoring of Deep Groundwater; packer complation and nested piezometers.

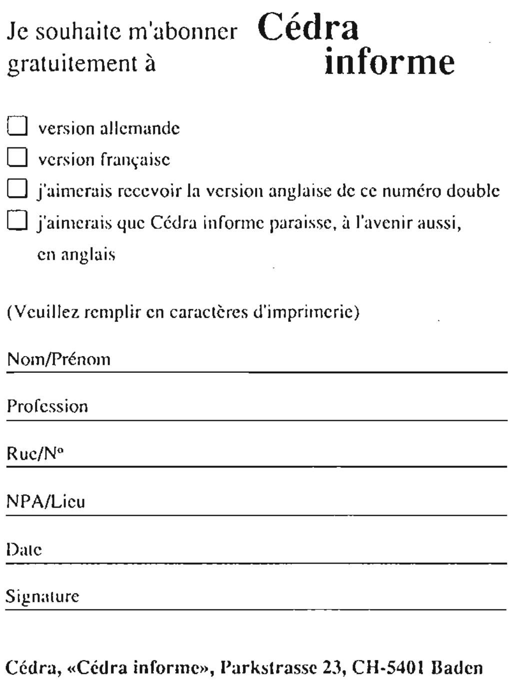
Groundwater Sampling; pumping, downhole sampler, hydrochemical, isotope analyses.

Each time when there is a fluid gain or loss during drilling, drilling is stopped to do a single packer test and to take a water sample. Gas influxes of 40 l/min have been measured.

Endremarks

The planning is to construct a safe deposition site for at least 100.000 years. It is very difficult to predict the safety for such a timespan and to say something about the future conditions. Risk analysis have to be made but on what assumptions and how to interpret it. Geology an thus the safety factors are not stationary.

Late tectonic movements of the Alpine orogeny still push the Alps against Germany and cause besides a decreasing Switzerland an uplift of the Alps which is measured in between 1 and 2 mm a year. If this rate continues for the stated 100.000 years, the site will be on a level which is 100 - 200 m higher! What are the site conditions by then? That's the question.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1. Reference: Maria Strong, RSM London MSc Course in Engineering Geology, Field Excursion to Switzerland, April 7th to 14th, 1991 (available at Mr Maurenbrecher and Jenco de Groot)

the Engineering Geological students Dispute (DIG) presents:

EECO -Eastern Europe Committee

Study-tour Eastern Europe 1992

Times of Change

Decades of heavy industrialisation have strongly affected the environment in Central and Eastern Europe. Problems, which also exist in Western European countries. Rapid political and economic changes have recently taken place. This has led to more openness and removal of the 'iron curtain', which offers opportunities to establish and improve economic relationships and personal contacts. Hopefully these developments may lead to a solution of the environmental problems in a united Europe of the future.

Study-tour

The EECO has been founded to organise a study-tour through the countries of Czechoslovakia, Hungary and Poland and establish an exchange program with students of the Moscow University. During this study-tour attention will be paid to the environmental problems and to find out how Engineering Geology can help solving these problems.

The study-tour is scheduled from 31 August to 14 September 1992. The number of participants are 18; 15 students and 3 staff members.

Theme

The main theme of the study-tour is *environmental geology*. Some subjects related to this theme are:
•problems associated with waste disposal, pollution of ground and groundwater.
•environmental aspects of large infrastructural works like dams, tunnels and bridges.
•environmental problems due to natural hazards like landsliding or avalanching.
•environmental consequences of (open pit) mining and quarrying.

Objectives

Summarised, the main objectives of the study-tour are:
•determining the role of Engineering Geology in Central and Eastern Europe and what role it plays or can play in the environmental care.
•finding out to what extent Dutch Engineering Geologists can collaborate and exchange information with their Eastern European colleagues.
•establish contacts with fellow students, future colleagues, institutions and companies in the visited countries.
•broaden the view of the Dutch Engineering Geological students
•visiting interesting sites, both cultural and technical.

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THE METHYLENE BLUE ADSORPTION TEST APPLIED TO GEOMATERIALS.

by Peter N.W. Verhoef, Delft University of Technology.

This paper is an excerpt of a report prepared for Rijkswaterstaat, Dienst Weg- en Waterbouwkunde, as part of the study "Rock Materials Characterisation and Testing".

Introduction

In recent years it has become clear that the methylene blue adsorption test is a reliable and simple method to obtain information on the presence and properties of clay minerals in soils and rock. The test was first described in the fifties (Fairbairn and Robertson, 1957). Several methods have been used to measure the adsorption of methylene blue by hydrophillic and cation-exchanging substances, some of which have been rather complicated. For example, Orchard (1976) describes how the test was done in the School of Highway Engineering in Australia. A suspension of finely ground rock or soil was mixed with a solution of methylene blue, left over for a few days, and then on a diluted solution the optical density was measured by a spectrophotometer, from which the amount of methylene blue adsorbed by the clay was determined. Because this method is quite involved and despite the fact that one could determine the MB adsorption by comparing the colours of the test solution with a standard set of solutions of varying MB concentration, this method was not universally accepted.

In many papers where the method is applied, no mention is made of the concentration of the methylene blue solution used, and the adsorption is given in ml MB taken up by the soil. Without knowing the MB concentration used, nothing can be done with such data. Possibly also for this reason the method has not gained widespread popularity. In most geotechnical literature the concentration is reported in grams MB adsorbed by 100 g of soil. Also this way of reporting the concentration is basically incorrect; it should be reported in milli-equivalents per 100 g of soil [meq/100g], because the molecular weight of MB is dependent on its water content (it is hygroscopic).

The "spot method" developed by Jones (1964) was applied in the oil industry, to check the quality of bentonite drilling mud. This method is essentially a titration technique which determines the amount of MB adsorbed by a suspension of fines. The "spot method" is very simple, convenient and sufficient for the purpose of estimating geotechnical properties of geomaterials. The spot method has been applied both to rock and soil materials. The Laboratoire Central des Ponts et Chaussées (LCPC) has done a continuous investigation of the method over the past 15 years and applied it on soils, rocks and aggregates. Much of this research is summarized in the report "Essai au bleu de méthylène" (LCPC, 1990). One of the important conclusions that can be drawn from this report is that with help of the methylene blue method a more convenient way is available to obtain information on the nature and activity of clay substances in soil and rock and probably the method may be even more reliable than the traditional geotechnical tests performed.

LCPC has found that:

1. There are good correlations between the methylene blue adsorption (MBA) and plasticity index and liquid limit of soils. The method is easier to perform and probably more accurate than the classical determination of Atterberg limits.
2. Clay activity can be expressed by MBA values.

Method used	Specific surface (m^2/g)			Type of surface measured
	kaolinite	illite	montmorillonite	
BET	22	113	82	external
Ethylene-glycol	45	90	750 800	external - internal
MBA	48	74	860	external - internal

Table 1: Specific surface of clay minerals (Denis et al, 1980)

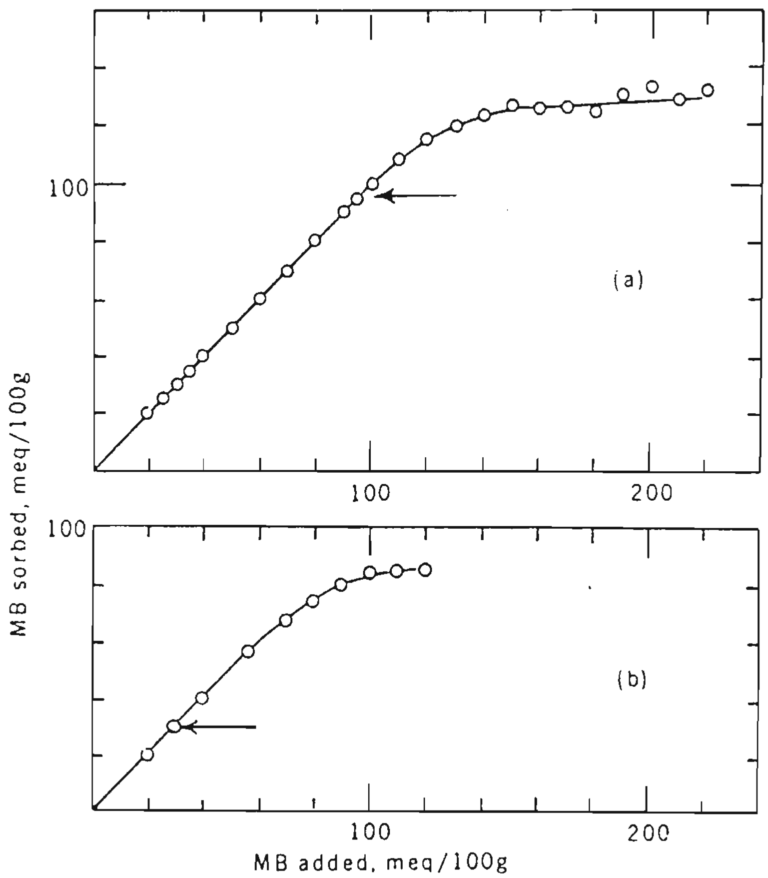


Figure 1. Methylene blue adsorption by (a) Na-montmorillonite, (b) Ca-montmorillonite. Arrows indicate conditions for optimum flocculation and probably mark the end point of the spot test (Hang and Brindley, 1970).

3. MBA can be used conveniently in soil classifications.

Both in soils and rock a good idea of the nature of the clays present may be obtained using methylene blue in the characterisation phase of geomaterial investigations. From our own findings we may add:

4. MBA is a reliable method to identify potential deleterious swelling clay in rock and an educated guess of the nature of the clay present in the rock can be made.

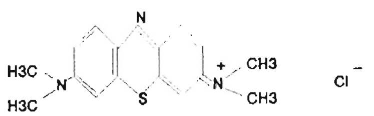
It appears that for geotechnical engineering purposes the MBA method gives sufficient information on the nature of clay minerals present in soil or rock.

Methylene blue adsorption: theory.

Methylene blue (3.9 bis Dimethylamino phenazothium chloride) is an organic molecule which is built up of benzene rings.

Molecular formula: $C_{16}H_{18}N_3ClS$

Structural formula:



Looking at the structural formula it can be seen that the molecule actually contains a negatively charged (Cl^-) ion and a large positively charged ion.

It can be regarded as a rectangular volume of dimensions 17.0x7.6x3.25 $Å^3$. The projected area of the molecule is about 130 $Å^2$ (= 17.0x7.6). The molecular weight is 319.9. Methylene blue hydrochloride (trihydrate) has a molecular weight of 373.9.

Hang and Brindley (1970) have investigated the mechanisms by which MB is adsorbing on the clay minerals kaolinite, Na- and Ca-montmorillonite and illite. X-ray diffraction was used to clarify the adsorption behaviour in Na- and Ca- montmorillonite. Their study was specifically undertaken to examine the determination of surface areas and cation exchange capacity (CEC) by methylene blue adsorption.

Careful experimenting with clay suspensions showed that the clay suspensions started to flocculate at a specific concentration of MB. This point was interpreted as the amount of MB needed to cover the clay surfaces with MB cations. The specific surface area could be calculated as follows:

$$S_s = M_f \times A_m \times 6.02 \times 10^{-2} \quad [m^2/g] \qquad (1)$$

S_s = specific surface
M_f = amount of MB adsorbed per 100 g clay [meq/100g]
A_m = area per molecule on the surface = 130 $Å^2$

Specific surface areas calculated this way are compared with other methods to determine specific surface area in Table 1.

Maximum adsorption of methylene blue, corresponding to complete exchange of the inorganic by the organic ions, occurs with larger amounts of MB than required for optimum flocculation. The results of the MB adsorption experiments on montmorillonite are given in Figure 1. Here the arrow indicates the optimum flocculation point, the plateaux give the CEC for Na- and Ca-montmorillonite respectively.

In Figure 1 is shown that the optimum flocculation point occurs in the region where the curve begins to deviate from the initial 45° slope, i.e., where adsorption is no longer 100 %. This corresponds to the end point given by the spot test in the interpretation of Hang and Brindley (op. cit.).

From the work of Hang and Brindley we may conclude:

1. For determination of specific surface, the amount of MB leading to optimum flocculation of the clay should be used. This point is determined by the spot test.
2. The maximum amount of MB adsorbed corresponds to the "effective" CEC, i.e. the cation capacity also available for water molecules.

Summarizing, the mechanism seems rather simple. When a methylene blue solution is added to a watery clay mixture the positive methylene blue ion will drive away the cations of the diffuse-ion-interlayer of the clay minerals. This process will continue until all the removable cations have been expelled. Up to that point all the methylene blue will attach to the clay mineral surfaces. From then on the remaining methylene blue ions will stay in solution. There is a distinct point in the process, the point where the clay minerals become electroneutral. This point can also be measured by electrophoresis techniques (Figure 2). Further adsorption gives the clay molecules a positive charge. Maximum adsorption corresponds with the CEC (cation exchange capacity).

Another way of interpreting the process can be found in the LCPC reports: As there are actually two surfaces in clay minerals, the external and the internal, there are also two stages in the attachment process: a fast and a slow one. Methylene blue will first attach to the external surface, the fast process, and then slowly attach to the internal surface. According to LCPC the spot test measures the total exchange capacity of the clay and attaches both on the internal and external clay surfaces. In this view the result of the spot test corresponds to the CEC

Test methods.

Two methods have been used extensively at the Laboratoire des Ponts et Chaussées (LCPC 1990); the "spot method" and the "turbimetric method". The spot method is a simplified titration technique. A certain concentration of MB solution is used (normally 10 g/l trihydrate or 3 g/l dry MB), which is added in definite volumes (5 or 2 ml) to a suspension of fine grained soil or ground rock particles. About 2 g of particles suspended in 20 ml water is sufficient. Drops of the suspension are placed on filter paper. When MB is adsorbed, the fluid migrating in the filter paper from the droplet outwards is colourless. MB is added to the suspension again, while the suspension is thoroughly shaken (by a magnetic rod stirrer, for example). Another droplet is placed on the filter paper and the migrating halo around the droplet is examined. This process is continued until the migrating fluid is blue coloured by the excess MB resting in solution when all MB is adsorbed. It was found that, when using this method, the MB that is adsorbed by the clay minerals corresponds with total coverage of the surface areas of the clay layers. When titrating a pure clay suspension the amount adsorbed would relate to the cation exchange capacity of that clay. (Otherwise it would relate to the CEC of the soil or rock under study).

The methylene blue adsorption value is calculated in grams MB adsorbed by 100 g of sample:

$$MBA = (c \times p) / (A/100) \quad [g/100\ g], (2)$$

MBA = methylene blue adsorption value (V_B in French literature)
c = concentration methylene blue solution [g/ml]
p = amount of MB adsorbed [ml]
A = weight of soil or rock powder [g]

The adsorption expressed in milli-equivalents (M_f; see equation 1) can be calculated as follows:

$$M_f = (100 \times N \times p)/A \ [meq/100\ g] \qquad (3)$$

N = normality of the MB solution [meq/l]

In the reports of LCPC and the papers of the French authors the results of the adsorption tests are always reported in MBA values (noted as "V_B"; la valeur de bleu), with the units g/100g or g%. This is not really good practice, because of the fact that methylene blue turns out to be hygroscopic. Because of this its molecular weight may vary. As has been noted above, the molecular weight of dry MB is 319.9, that of trihydrate 373.9. To determine the hygroscopic water content of the MB, a sample of the crystalline dye is dried at 105 °C and the loss of the weight determined (a typical weight loss is about 12.34 %). The normality of a MB solution can then be calculated:

$$N = (c \times 1000)/319.9 \times (100.00 - 12.34)/100 \quad [meq/l] \qquad (4)$$

When dried methylene blue crystals are used to prepare the MB solution, M_f = 3.13 MBA [meq/100g]; when saturated trihydrate is used, M_f = 2.67 MBA [meq/100g]. It is desirable to report MB test results in meq/100g, to prevent misunderstanding. For the experiments in Delft always dried MB was used to prepare the solutions. The French values relate to MB solutions prepared from trihydrate. Since the LCPC has already assembled a large data base, we have chosen to follow the procedures adopted by LCPC. The MBA value will be given in g/100g or g%, based on the result of a determination with a solution of pure MB trihydrate. The data assembled in Delft using solutions of dry MB have been corrected with a factor of 373.9/319.9 = 1.17. The more correct usage of giving the data in meq/100g is advocated, however. Therefore M_f, when possible, is given as well. As will be discussed, M_f is nearly equal to the CEC. The French "V_B" data should be multiplied with 2.67 [meq] to obtain M_f.

The turbimetric method was developed by LCPC, because it was found necessary to have a more precise test method available, to measure very minute contaminations of clay, for example in sands used for concrete manufacture. The second reason given was that the spot method would measure the total, external and internal, surface adsorbing MB and cannot distinguish the two. Tourenq and Tran Ngoc Lan (1990) think that this distinction may, in some cases, be of geotechnical significance. A distinction between short-term and long-term geotechnical behaviour is made. An analysis of quite a number of studies seems to indicate that:

1. In the long term it is the total specific surface (internal and external) of clays that determines the maximal risk (here the result of the "spot test" is significant).
2. In short term only the external surface may determine the mechanical behaviour of clays. This may relate to laboratory tests with a duration of less than 7 days.

The turbimetric method allows one to determine adsorption only on the external surface.

It appears that, also in France, the turbimetric method is only rarely used (Mishellany, 1990). The latter author notes some drawbacks of the turbimetric method: the sample preparation is delicate and the cleaning of the glasswork takes a long time, while the glasswork is also tinted blue. The latter may influence the results of the measurements.

Table 2 gives values obtained for clay minerals. The table gives also the M_f value and the specific surface derived from the MBA result.

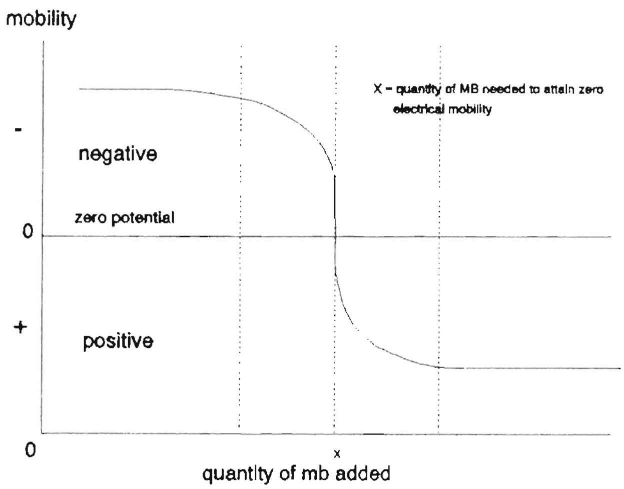


Figure 2. Electrophoresis diagram showing mobility of clay particles as function of the quantity of methylene blue present in the suspension. The change of electro-negative to -positive charge of the clay molecules is clearly related to MB addition (Lautrin, 1990)

Mineral	MBA [g/100g]	M_f [meq/100g]	S_s [m^2/g]
Li-montmorillonite[1]	12.9	29.4	230
Na-montmorillonite	11.1	26.1	204
Na-montmorillonite[2]		126.0[2]	
K- montmorillonite	26.8	62.6	490
Rb-montmorillonite	13.3	31.1	243
Cs-montmorillonite	5.5	12.9	101
Mg-montmorillonite	25.7	60.2	471
Ca-montmorillonite	24.8	57.8	452
Ca-montmorillonite[2]		90.0[2]	
Sr-montmorillonite	23.8	55.4	434
Ba-montmorillonite	20.5	47.8	374
Montmorillonite[3]		64.3	503
Palygorskite	17.1	39.9	312
Chlorite	0.7	2.0	16
Illite	2.9	6.7	52
Oswego Illite[2]		13.2[2]	
Kaolinite	2.8	6.6	52
Florida kaolinite[2]		7.2[2]	
Serpentine	1.4	3.3	26
Halloysite	1.5	3.4	27
Ball clay[3]		12.3	96
London clay[3]		25.2	197

[1] homoionic fractions of montmorillonite were prepared from Wyoming bentonite
[2] data from Hang and Brindley (1970), CEC (maximum adsorption) obtained by spectrophotometer measurements (see Fig. 1).
[3] data from Kühnel (Delft)

Table 2: MBA values of some clay minerals (Stapel & Verhoef, 1989).

Interpretation of MBA adsorption data.

There are two problematic issues related to the interpretation of MBA data.

1. Does the spot test actually measures cation exchange capacity (CEC)?
2. The units of measure of MBA

The first point is related to Figure 1. If we follow the interpretation of Hang and Brindley (1970), the MB spot test would indicate the concentration at which some MB remains in solution. This relates to the flocculation point for pure clays. It appears that the clay is capable of adsorbing more MB, the maximum amount is the cation exchange capacity (Fig. 1). As noted earlier, it depends on the chemical composition of the clay, i.e. the type of cation, how much exchange can occur. Table 2 and data in literature show that CEC values vary also for the same clay mineral, even with identical chemical composition. According to the above, the MBA spot test probably underestimates CEC. There is ample evidence, however, that MBA results (M_f) correlate very well with, and are near to, CEC values measured with other methods (e.g. Sweere and Galjaard, 1987; LCPC, 1990). In fact, "cation exchange capacity" is a term which should be regarded in relation to the method by which it is determined. How much exchange will take place is a function of the environment (pH, type of clay, type of exchanging cation etc.). If the method by which CEC is determined is given, there is no objection to replace "M_f" by "CEC".

Specific surface can be determined without problem from the MBA spot test data. The accuracy of the spot method can be illustrated with the minimum surface area that can be determined, which is 2 to 3 m^2. This would correspond with 0.1 % kaolinite or 0.002% montmorillonite present in the rock or soil. The calculated S_s values in Table 2 are generally lower than theoretically possible (compare with Table 1). This may relate to a systematic underestimation by the MBA test, but probably also is a real effect. As for CEC, also specific surface will be dependent on experimental conditions and method of determination used.

More important than the fact whether the MBA method gives theoretically correct values of CEC and S_s is its relationship with chemical activity and water adsorption, which both determine geotechnical properties (swelling and shrinking, shear strength etc.). Figure 3 shows the results of a comparative study on homoionic fractions of Wyoming Bentonite, where the methylene blue adsorption has been compared with the result of Foster's swell test (Foster, 1953; Stapel and Verhoef, 1989).

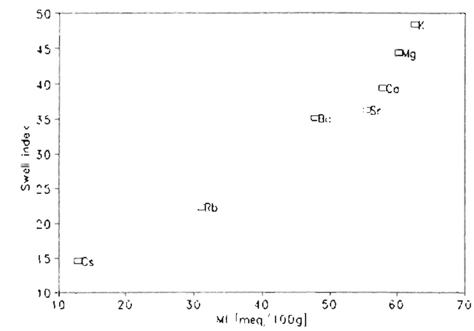


Figure 3. Swell capacity of different montmorillonite clays and MB adsorption

MBA and durability of rock.

The MB test can also be performed on crushed rock aggregate or stone. This requires crushing the rock to a size where the clay particles become exposed. Normally a size < 100 μm will be sufficient. From a batch of aggregate commonly 1 kg is crushed and the test is performed on 2 g of the finely ground rock. Wimpey Laboratories (UK) has given guidelines to assess soundness of rock aggregate (Table 3).

The MBA values determined on

Class	MBA [g/100g]	M_f [meq/100g]
Acceptable	< 0.7	< 1.9
Marginal	0.7 - 1.0	1.9 - 2.7
Unsound	> 1.0	> 2.7

Table 3. Indication of rock durability (Wimpey Laboratories, UK)

Clay mineral	range MBA [g/100g]	range M_f (CEC) [meq/100g]
Kaolinite	2 - 5	5 - 15
Illite	5 - 15	20 - 40
Montmorillonite	15 - 40	40 - 100

Table 4. Typical range of adsorption values for the common clay minerals

Sample No.	M_f [meq/100 g]	Sample description
1	6.6	Laminated Calcilutite, stained clay in layers + patches
1	6.1	
2	1.9	stained clay highly dispersed
3	0.9	local stained parts, in high concentrations
3	1.9	
4	0.9	

Table 5. Results of MBA test on limestone blocks from Lake Tunis rip rap.

rockaggregate are a function of clay mineral content and clay type. If the percentage of clay present is known, the clay type may be inferred. Typical values for the three major clay types are given in Table 4.

To appreciate the effect of swelling clay in rock, two examples of deterioration that can occur in practice are given.

1. Limestone from a rock quarry near Tunis was used as rip-rap to protect the slopes of Lake Tunis. The quarry is in strong limestone, locally layered and laminated. The climate in the area is arid. When the rock blocks became exposed to wetting and drying conditions, about 30% of them deteriorated to rock powder within a few months of time. Four rock samples were provided for study. The rocks were partly crushed and the MBA test was performed on the rock powder. Four thin sections were prepared for microscopic study. These were stained in a MB solution. By staining, the adsorbing minerals are coloured blue. The results of the MB test are given in Table 5.

Parts of the rocks were ground and the clay fraction was concentrated, to perform an X-ray examination. The following minerals were identified in the clay-size fraction: quartz, kaolinite, montmorillonite and possibly chlorite.

It is obvious that the swelling clay montmorillonite was the cause of the problem. When wetting and drying of the rock occurs, the layers and laminae of clay will act as small pumps: expanding when wet and shrinking when dry. This may lead to crack growth, with resulting enlargement of the areas in the interior of the rock that will be wetted and disintegration of the blocks.

2. Another way that rock may disintegrate for the same reason is possibly less obvious. If rock which contains some swelling clay (for example argillaceous mudstones) is used for road base aggregate, which - when the road is well constructed - is normally well drained and dry, deterioration has been reported by the following mechanism. Due to the dynamic loading by the traffic, pressure differences within the rock particles cause water to migrate from pore to pore. If swelling clay comes into contact with this water it will start to expand and may cause crack growth. It is known that swelling pressures up to 2 MPa can occur due to clay swelling (Fookes et al, 1988). Due to this mechanism the rock particles start to degrade and fines may concentrate between the road base and black top, with subsequent failure of the road structure.

The two examples given above illustrate that, when swelling clay is present, the following factors determine the durability of the rock.

1. clay activity (MBA and percentage of clay present)
2. microstructural position of the clay
3. a wetting- and drying mechanism.

The above made us suspicious that probably not only the MBA value of the crushed rock is sufficient to predict durability, but the microstructural position had to be evaluated as well. Therefore microscopic examination is recommended.

A suite of rock aggregate used as ballast for railway tracks was examined this way. Apart from determining MBA also the percentage of stained mineral in the rock was obtained by estimating volume percentage present in thin section. The following formula allows one to obtain an impression of the MBA of the "adsorbing mineral" (this will be an average value for all adsorbing mineral types present).

$$MBA_{min} = \frac{MBA_{rock}}{vol.\%} \cdot \frac{\rho_{min}}{\rho_{rock}} .100 \quad (5)$$

If we would know the density difference between mineral and rock, the MBA_{min} can be derived. Table 6 gives a list of common densities of minerals. From the table we can deduce that commonly the clay minerals have more or less the same density as the minerals in the rock powder used for the MBA_{rock} determination.

Mineral	Density [Mg/m^3]
Kaolinite	2.6 - 2.7
Illite	2.6 - 2.9
Smectites	1.7 - 2.7
Serpentinites	2.4 - 2.7
Chlorites	2.6 - 3.3
Muscovite	2.8 - 2.9
Biotite	3.0 - 3.1
Quartz	2.5 - 2.8
Plagioclase	2.6 - 2.8
Kalifeldspar	2.5 - 2.6

Table 5. Densities of minerals

However, when smectites are present, they will be present in the expanded state and will have a low density. If this is the case, the ρ_{min}/ρ_{rock} ratio will be about 1.7/2.6 = 0.7. This means that the derived estimate of MBA_{min} will be lower if a swelling clay mineral occurs. If we assume that the densities of rock and mineral are equal, we have a conservative guess of the MBA of the mineral (i.e. the values will be high).

Apart from the microscopic examination and the MBA test, also the wet Deval

rock type	Vol.% stained	MBA (g%)	MBA min (g%)	0.7*MBA min (g%)	Deval (wet)
andesite *	1	0.35	35.1	24.6	9.7
andesite *	1	0.59	58.5	41.0	9.1
andesite *	5	1.29	25.7	18.0	6.0
andesitic basalt *	1	0.35	35.1	24.6	9.6
andesitic basalt *	1	0.82	81.9	57.3	9.0
basalt	5	0.35	7.0	4.9	14.9
dacite *	20	2.11	10.5	7.4	7.8
granite	3	0.35	11.7	8.2	14.6
granite *	4	0.70	20.1	14.0	12.1
granite *	18	0.94	5.2	3.6	8.7
granodiorite	10	0.59	5.9	4.1	15.0
quartz diorite	22	0.35	1.6	1.1	20.1
dolomite *	1	0.35	35.1	24.6	18.2
limestone *	1	0.23	23.4	16.4	6.2
limestone *	1	0.23	23.4	16.4	10.3
limestone	5	0.35	7.0	4.9	9.3
limestone	15	0.59	3.9	2.7	5.9
quartz arenite	10	0.35	3.5	2.5	10.5
quartz arenite *	1	0.47	46.8	32.8	6.2
quartz arenite *	15	0.82	5.5	3.8	7.4
graywacke	8	0.70	8.8	6.1	10.6
metabasalt	5	0.47	9.4	6.6	13.7
metagabbro *	45	1.17	2.6	1.8	5.5
gneiss *	1	0.35	35.1	24.6	9.3
gneiss *	1	0.59	58.5	41.0	21.5

*Table 6. Results of petrographic examination, MBA test and Deval test on railway ballast aggregate. Rocks indicated by * were considered suspect after petrographic examination of MB stained thin sections.*

attrition test has been carried out (Table 6). It can be seen that using formula (5), and applying a density ratio of 1, unrealistically high values of MBA_{min} are obtained. Using the above mentioned ratio of 0.7, the estimated MBA_{min} values approach realistic values for smectite. In this example, the following criteria were used to indicate potential durability problems with regard to swelling clays:

1. MBA > 0.7 g/100g for the aggregate
2. MBA_{min} > 10 if present in vol.% > 5 *(MBA_{min} determined with eq. 5; ρ_{min}/ρ_{rock} = 1)*
3. MBA_{min} > 20

If either of these criteria were met, the rock was considered suspect. These rocks are indicated in Table 6, and are plotted as filled squares in Figure 4. In Figure 4 the results of the MBA test and the wet Deval test are plotted. It is thought that the wet Deval test indicates also degradation due to the action of the clay. The result shows that most of the rocks considered suspect performed badly in the Deval test, including rocks which would pass the MBA < 0.7 criterion (sound rock; Table 3). Only by this staining test minute amounts (around 1 vol.% or less) of smectites can be detected and potentially deleterious rock indicated. It is thought that this method should be included in the routine petrographic examination of rock construction materials, because swelling clays can occur in any weathering grade of rock, including fresh. Figure 4 also shows four rocks that were suspect, but performed well in the Deval test. Most of these have 1 vol.% (or less) clay. It should be noted that petrographic examination has the function of indicating potential hazard. In this example only vol.% and MBA values were considered, not microstructural position. The one sample which was considered sound, both by the MBA test and the petrographic MBA test, but with Deval coefficient 5.9, is a limestone with 15 % clay, were the clay is surrounding the calcite grains. This rock shows microstructural weakness, which also bears out in the Deval test.

Conclusion.

This survey has shown that the methylene blue method is a very useful aid in the study of geotechnical properties of geomaterials. The MBA test gives direct information of the activity of clays present in the soil or rock. MBA is directly related to swelling potential of clays, which is the property that determines mechanical behaviour. The experience of LCPC shows that MBA can reliably and comfortably be used for geotechnical classification of soils. Also in the study of rock intended for construction purposes MB is very valuable. If the spot test on ground rock is done in combination with a study of stained thin sections, a very good impression can be gained of the potential soundness of the rock.

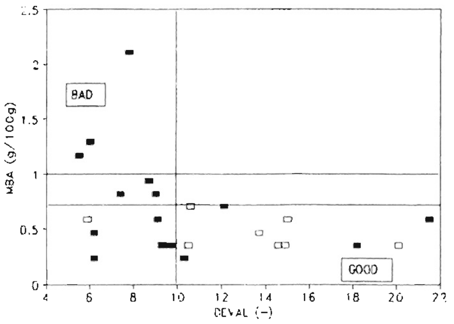


Figure 4. The filled squares indicate rock considered suspicious after petrographic examination of stained thin sections and the MBA test. The wet Deval coefficient < 10 indicates poor attrition resistance.

A source of error lies in the different ways that methylene blue adsorption is reported. The best way of reporting MB adsorption is in milli-equivalents adsorbed by 100 g of soil or ground rock [meq/100g]

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CHUNNELEXCURSIE

door ir. Edwin Smits en ir. Freek van Eijk, verbonden aan OMEGAM, Onderzoeksdienst voor Milieu en Grondmechanica Amsterdam.

Dit is het verslag van de excursie die het Dispuut IngenieursGeologie afgelopen zomer heeft georganiseerd naar het channel tunnel project in Folkestone, G.B.

Tweeduizend jaar nadat de Romeinen het Britse Rijk binnenvielen deed het DIG het dunnetjes over. Het bedrijfsleven, waaronder vertegenwoordigers van OMEGAM, TERRAWARE, GEOCOM en BKH, volgden hen op de voet. Een van de laatste mogelijkheden om de kanaaltunnel te bezoeken lag aan dit alles ten grondslag.

De overtocht stond in het teken van tax-free shops en internationale betrekkingen. De gezelligheid compenseerde ruimschoots het lange wachten op de DIG-bestuurders bij de douane-controle. Nadat intrek was genomen in uiterst rustiek gelegen onderkomens aan de befaamde krijtrotsen, werd de avond in typisch Britse omgeving doorgebracht met innemende discussies tussen eerdergenoemde vertegenwoordigers en studenten. De gezelligheid en het hoge niveau van die avond gevoerde gesprekken compenseerde ruimschoots het wachten op de vertegenwoordigers van de TU-Delft.

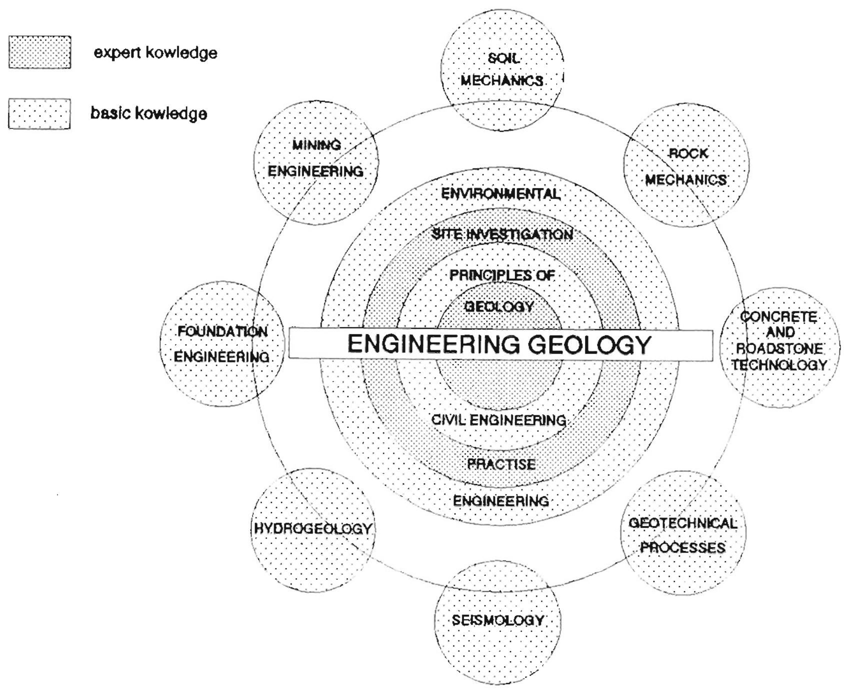
Eenmaal aangekomen op de site vond kennismaking plaats met de hoofdverantwoordelijke voor het geotechnisch ontwerp van de terminal aan Britse zijde. Het eerste aandachtspunt van de excursie betrof de hernivellering van de dal waar de tunnel uitmondt in de terminal. Teneinde voldoende ruimte te kunnen creëren voor de twaalf sporen van de terminal stonden twee opties open, ontgraven dan wel aanvullen van het dal. Omdat bij ontgraven gevaar bestond voor reactivering van bestaande instabiliteitsvlakken in de valleihellingen is deze optie verworpen. De aanvulling is door Hollandse inbreng gerealiseerd. Vooral de wijze van transport van het voor de kust gewonnen zand over grote afstand was nog niet eerder vertoond. De zetting van de overgeconsolideerde Gault-clay ten gevolge van het aanbrengen van plaatselijk meer dan 7 meter zand bleef beperkt tot maximaal 0,15 meter. Op een aantal locaties langs de valleiwanden bestond gevaar voor hellinginstabiliteit. Na een fase van monitoring werden enkele locatie-specifieke oplossingen toegepast zoals diep-drainage en de toepassing van Terre Armée.

Interressant om te vernemen was dat het ontwerp van de Britse terminal een veel massiever karakter had dan het ontwerp aan de Franse zijde. Nationale veiligheidsoverwegingen liggen hieraan ten grondslag. Na een bezoek aan de terminal werd via een nu nog prachtige landelijke route een bezoek gebracht aan de op de tunnel aansluitende motorway richting Londen. De met klei opgevulde oplosholten in het kalkgesteente vormden een probleem bij de dimensionering van de boorpalen ten behoeve van de kunstwerken over de motorway. De M-way naar Londen bevat tevens een aantal tunnels. Hoewel technisch niets nieuws inbrengend was de grote schaal van de verbindende motorwaytunnel indrukwekkend. Voor berging van de bij het tunnelproject vrijkomende grond werd een oplossing gevonden door het maken van een landfill voor de krijtrotsen (Shakespeare's cliff) waarop veel tunnel-aanverwante activiteiten werden geconcentreerd.

Of het het gevaar voor IRA aanslagen was, of het ietwat ludieke gedrag van de mijnbouwstudenten de avond ervoor, is niet duidelijk, een feit was dat de "chunnel" zelf die dag niet kon worden bezocht. Na afloop van de excursie moesten de representanten van het bedrijfsleven zich weer haasten om marktconform te gaan werken. De heren studenten bleven nog iets langer om bij te komen van de opgedane ervaringen.

Deze door het DIG georganiseerde excursie was, ondanks de nagevorderde Poll-tax van Michiel Maurenbrecher voor herhaling vatbaar (aanleg tunnel in Japan?).

Engineering geologists, multidiscipline specialists:



Institutes where engineering geology courses are given in the Netherlands:

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CONFERENCES, SEMINARS AND SYMPOSIA

1992

Sixth International Symposium on Landslides.
February 10-14,
Christchurch, New Zealand
Topics: Landslide investigations, Stability analysis techniques, Stabilisation and remedial works, Landslide hazard assessment, Seismicity and landslides, Landslides and reservoirs, Open pit mine slopes, Slope instability in tropical areas. Excursions related with the symposium are being organized.
Info: ISL 1992 Secretariat, c/-Guthreys Pacific Ltd., P.O. Box 22255 Christchurch, New Zealand. Fax: (64-3) 790-175. Tls: NZ 4243 Guthrys.

Grouting, Soil Improvement and Geosynthetics
February 25-28,
New Orleans, Louisiana, U.S.A.
Topics: Soil reinforcement, densification and stabilisation; Applications of geosynthetics, Grouting and grout materials; Environmental technology.
Info: Dr. Ilan Juran, Dept. of Civil Engineering, Louisiana State University, Baton Rouge, LA 70803 U.S.A. Tel. 504/388-8699. Fax: 504/388-5990.

International Symposium on Soil Improvement and Pile Foundations
March 25-27
Nanjing, China
Topics: Design & techniques of ground deep treatments; Highways & runway soil improvements; Geosynthetics & reinforced earth; Building underpinning & restoration; Pier foundation design & construction; Pile integrity testing; Stress-wave theory applications to piles; Field instrumentation & monitoring; and case histories.
Info: Mr. Zhu Cun-Fu, Secretariat of ISSIPF, Nanjing Civil and Architectural Engineering Society, 288 Chang Jiang Hou Jie, Nanjing, 210018 China.

Fractured and Jointed Rock Masses
June 3-5
Lake Tahoe, California, U.S.A.
Topics: Analytic and numerical models of discontinuous systems; Characterization of jointed media; Electromagnetic and seismic properties; Hydrology and transport; Coupled hydromechanical processes.
Info: Lawrence Berkeley Laboratory, Attn: Larry Myer, MS 50E, 1 Cyclotron Road, Berkeley, CA 94720, U.S.A.

33rd U.S. Symposium on Rock Mechanics
June 8-10
Santa Fe, New Mexico, U.S.A.
Topics: Origin of stresses in the lithosphere; Rock mass monitoring; Blasting; Reservoir completion and stimulation; Fluid and contraminant transport; Fault mechanics; Subsidence and ground motions; In-situ storage and sealing; Geothermal energy.
Info: Dr. Wolfgang R. Wawersik, Geomechanics Division 6232, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185, U.S.A. Tel. (505)844-4342. Fax: (505) 844-7354.

International Symposium: Engineering Geology of Karst
July 6-8
Perm, U.S.S.R.
Topics: Influence of karst processes on engineering geological properties of rocks; Karst territory stability; Surface and subsurface water interaction with soluble rocks; Forecast methods of karst processes development under industrial, civil and hydrotechnical construction; Rational territory use and environmental protection in karst areas.

Info: I.A. Pechorkin, Perm State University, Bukirev St., 15, Perm, 614600, GSP, U.S.S.R.

5th International Conference on Undergrond Space and Earth Sheltered Structures
August 2-7
Delft, The Netherlands
Topics: The use of underground space and earth sheltered structures within urban, national and environmental development concerning: Planning; Design and use; Construction; Economy; Law and politics.
Info: Congress Office ASD, P.O. Bos 40, 2600 AA Delft, The Netherlands, Tel. 015-120234, Fax 015-120250.

Eurock '92 ISRM International Symposium on Rock Characterisation
September 14-17
Chester, U.K.
Topics: Site investigation; Input to design; Rock engineering and the environment; Rock properties; Monitoring and back analysis.
Info: Professor J.A. Hudson, Eurock '92, Department of Mineral Resources Engineering, Imperial College, London U.K. Fax: (44) 707 375912.

4th International Conference on the Application of Stress-Wave Theory to Piles
September 21-24
The Hague, The Netherlands
Topics: Soil mechanics aspects of stress-wave propagation and/or pile installation; Influence of driving or vibrating piles on the environment; New developments in dynamic testing equipment and vibrators during pile installation; Reliability of predictions based on measurement and interpretation of stress-wave propagation.
Info: Stress-wave Conference, c/o KIVI, P.O. Bos 30424, 2500 G.K. The Hague, The Netherlands. Fax: 070-391840, Tel: 070-3919890.

1993

19th General Assembly of the ITA
April 18-22
Amsterdam, The Netherlands
Topics: Soft ground tunnelling (cut-and-cover methods, underground methods, immersed tunnels and comparative case studies); Rock tunnels (conventionally driven, mechanically driven and comparative case studies); Submerged floating tunnels; General topics (cost optimisation of the total tunnel project, private financing of tunnels, research).
Info: Congress Office KIvI, P.O. Box 30424, 2540 GK The Hague, The Netherlands. Tel. 070-3919890. Fax 070-3919840.

International Symposium on Hard soils-Soft Rocks
September 20-24
Athens, Greece
Topics: Geological features; Mechanical properties and behaviour; Foundation, excavations and retaining structures; Slope stability and protection; Fills and embankments; Tunnelling and underground openings.
Info: Dr. N. Kalteziotis, HS-SR Symposium, P.O. Box 20034 GR, 11810 Athens, Greece.