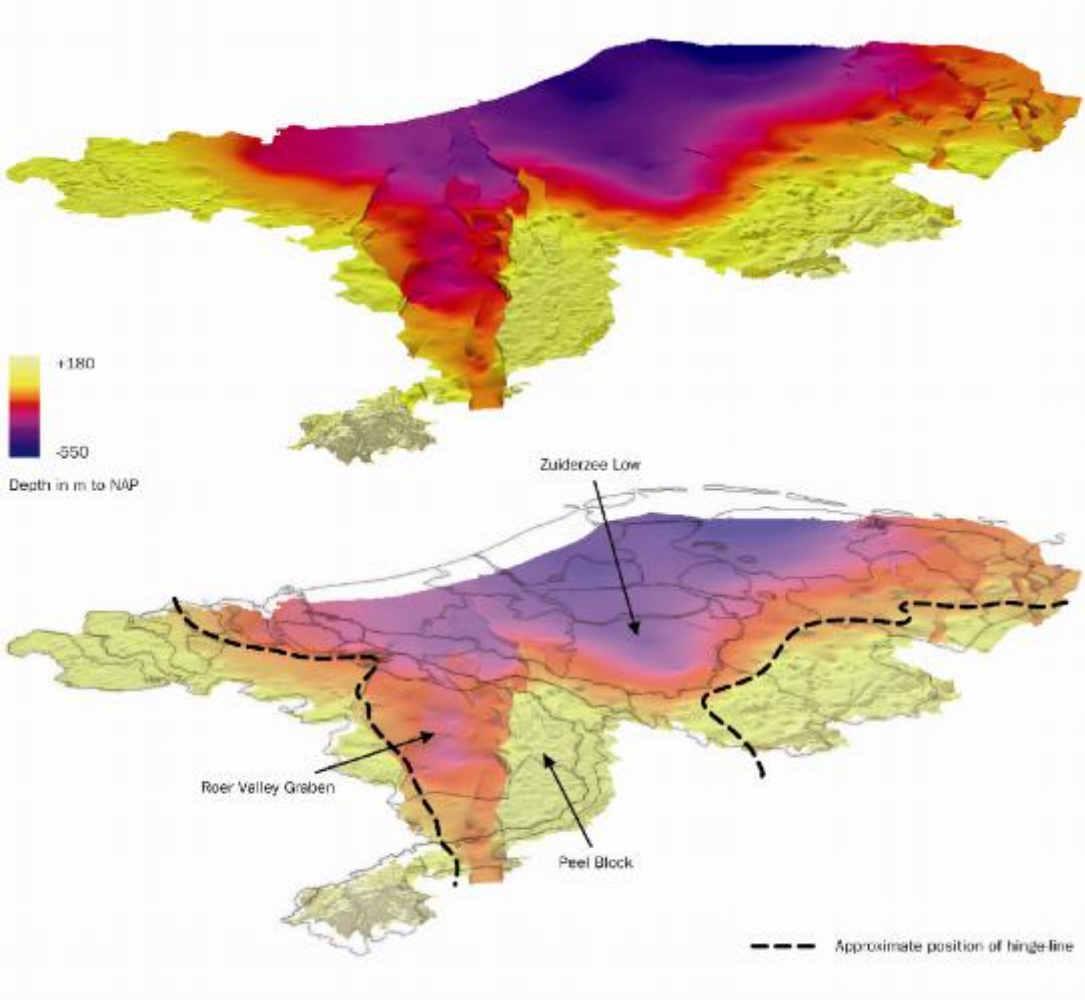
TAGUNGSBAND
EXKURSIONSFÜHRER



76. Tagung Arbeitsgemeinschaft Norddeutscher Geologen

2. – 5. Juni 2009 Utrecht (NL)

University Utrecht

Geological Survey of the Netherlands

TNO
Geological Survey of the Netherlands

Faculty of Geosciences
Utrecht University

Tagungsband
und
Exkursionsführer

76. Tagung der

Arbeitsgemeinschaft Norddeutscher Geologen

Vom 2. – 5. Juni 2009
in Utrecht

Tagungsorganisation & Tagungsort

TNO - *Geological Survey of the Netherlands*
Princetonlaan 6
3584 CB Utrecht

W.E. Westerhoff & M.L. Elsing (eds.)
76.Tagung der Arbeitsgemeinschaft Norddeutscher Geologen
Tagungsband und Exkursionsführer
TNO - *Geological Survey of the Netherlands* (GSN)
Utrecht 2009.
Report nr.: 034.99000
Cover: Map showing depth position Quaternary deposits in the Netherlands

Vorwort/Preface

Dear Colleagues,

TNO Geological Survey of the Netherlands and the Faculty of Geosciences of the University Utrecht are pleased that they can host the 76. Tagung der Arbeitsgemeinschaft Norddeutscher Geologen (ArGe NDG)). This year's *Tagung* has a special character because despite long lasting contacts between German and Dutch geoscientist it is the first time that the ArGe NDG has its venue in the Netherlands.

The present volume contains the abstracts of oral and poster presentations as well as the excursion guides.
The topics comprise a wide range of subjects form basal geological mapping and modelling to various examples of applied geoscientific studies. Bringing together practitioners of multiple disciplines is already a since long proven approach of the ArGE NDG *Tagungen*.

The programme offers subjects form geomapping and modelling of the subsurface from Northern Germany and the Netherlands. Examples of groundwater, environmental and geochemical studies will be presented. They will undoubtedly show that in both countries geoscientist are working on similar questions. A number of contributions address Quaternary geological questions. During this epoch the impact of climate variations on geological played a major role. Studying Quaternary processes, time constraints and cross-correlations forms a strong catalyst in the cross-border relationship between Germany and the Netherlands has been developed over the last generations. The *76. Tagung* reconfirms the common interests of geoscientists in both countries. We do hope that the 2009 meeting in Utrecht re-establishes existing relationships and also serves as a base for future exchange of ideas and knowledge. We wish you a good and productive meeting and much reading pleasure with the here presented volume.

Dr. M.J. van Bracht
Dr. W.E. Westerhoff
(TNO - *Geological Survey of the Netherlands*)

Inhaltsverzeichnis Seite

Vorwort / Preface 3
Inhaltsverzeichnis 5

Kurzfassungen der Vortrage 7
Subsurface geology and groundwater quality 7
Drs. Bas van der Grift
Karstifikation on top of salt diapirs in Schleswig-Holstein 8
Dr. Alf Grube
Regional mapping of the deep subsurface in the Netherlands and some remarks on particular phenomena 9
Duin, E.
MDI-DE Marine Daten-Infrastruktur Deutschland –Metadaten, Gazetteer und Internet Dienste 10
Dr.-Ing. Rainer Lehfeldt
Geopotenzial Deutsche Nordsee – Ein neues Gemeinschaftsprojekt 12
Anke Krüger
Marine landscape mapping of the Duch North Sea 14
Dr. Sytze van Heteren
Der Salzstock von Scharhörn und seine Bedeutung für die litorale Morphologie der Inneren Deutschen Bucht 15
Dr. Gerhard Linke
Development of the Wadden area in time and space: towards a geoscience knowledge agenda for the Wadden area 16
Hanneke Verweij
3D subsurface characterization of Zeeland and Zuid-Holland 17
Jan Stafleu
Verbreitung von Elster-Grundmoräne und Lauenburger Ton in NW-Niedersachsen – Leithorizonte für die 3D-Modellierung? 19
Röhm, H.
Climate coupling of terrestrial and marine Miocene 21
T.H. Donders
Grundwasserbeschaffenheit in Niedersachsen: Ermittlung geogener Hintergrundwerte 23
D. Budziak
REGIS II, A hydrogeological model of the Netherlands 25
Ir. Ronald W. Vernes
Case-study brook valley system of the Dwingelderstroom, Drenthe, the Netherlands. 26
A quaternary geological study as a base for geoconservation and nature development.
E.P.H.Bregman, MA
Registration and dating of human-induced landscape changes at Messchenveld (Drenthe, the Netherlands) 27
Dr. Jeroen Schokker
Environmental geochemical characterisation of the Netherlands 28
Dr. Jasper Griffioen
Implications of Soil Heterogeneity on differential rest-settlement 29
Ir. Stephan H.L.L Gruijters
Plio-Pleistocene Stratigraphy of the Southern Lower Rhine Embayment 30
H.A. Kemna
Das plio- pleistozäne Flusssystem im nördlichen Oberrheingraben 31
Christian Hoselmann
Middle Pleistocene proglacial lakes in the southern North Sea area: sedimentary and chronological insights from the Dutch sedimentary record 33
Drs. Freek S. Busschers
The occurence of Late Weichselian pingo remnants in the Netherlands and neighbouring Germany. 35
Wim Z. Hoek
Accurate dating of fluvial deposits in the Lateglacial Niers Valley system (Germany) using a multiple dating strategy 36
Drs. Jan Peeters

Kurzfassungen der Poster 38
Environmental response to rapid climatic oscillations in northwest Europe during Greenland Interstadial 1 38
Nelleke van Asch
Abrupt climatic events during OIS-3 recorded in terrestrial sediments in the Netherlands: a multi-proxy approach 39
Bos, J.A.A.
400 years of environmental change documented in sediments of a deep dike-burst lake in the Rhine-Meuse Delta in the Netherlands 41
Holger Cremer
Das geologische 3D-Untergrundmodell der Subrosionssenke des „Heiligen Feldes“ (nördliches Münsterland, Nordwestdeutschland) 42
Manfred Dölling
Petroleum Geological Atlas of the Southern Permian Basin Area - Project overview 44
J.C. Doornenbal
3-D-Modellierung quartärzeitlicher Ablagerungen im Deutschen Nordsee-Sektor 46
Elbracht, J.
New results from the Upper Rhine-Meuse delta 47
G. Erkens
3D subsurface mapping of the Dutch Continental Shelf: seismic interpretation and geological modelling. 48
S.F. van Gessel
Zur Geologie des Himmelmoores bei Quickborn (Schleswig-Holstein) 52
Grube, A.
Westward extension of Rhine-Meuse delta maps 54
M.P. Hijma
Tertiary dinocyst research at TNO Geological Suvey of the Netherland 55
Dirk K. Munsterman
Sesshaft im Netz. Die neue Domain der Arbeitsgemeinschaft Norddeutscher Geologen unter www.arge-ndg.de. 56
Konrad Schuberth
Mapping of marine channels from digital elevation data (AHN) using Topographic Position Index 58
Drs. Tamara J.M. van de Ven
Uncovering physical and chemical properties of the shallow subsurface of the Netherlands 59
Ronald Vernes
Pleistocene ice margins and glaciotectonics in Saxony-Anhalt 60
Stefan Wansa
Hydrogeologische Typstandorte und Grundwasserneubildung ein Aspekt des Klimafolgenmanagements 62
Tina Wixwat

Halbtagsexkursionen
Exkursion A1: Denkmäler aus Werksteinen und Gestein im Stadtbildt vom Utrecht
Wim Dubelaar
Exkursion A2: Vom holozänen Rhein bis zur saalezeitlichen Stauchmoräne und Findlingen (30 km Fahrrad-Exkursion)
H.J.T.Weerts & J. Schokker
Exkursion A3: Römer-Zeit und Mittelalter in Boden und Landschaft im Utrechter Raum
Dr. J. Renes

Ganztagsexkursionen
Exkursion B1: Upper Pliocene and Lower Pleistocene Rhine-Meuse deposits in the Tegelen-Reuver type area
Dr. Wim E. Westerhoff
Exkursion B3: Von der Stauchzone durch das Poldergebiet bis zur Nordseeküste; Geologie, Hydrologie und Landschaft des Westlichen Hollands
Drs. Roelof J. Stuurman

Kurzfassungen der Vorträge

Subsurface geology and groundwater quality

Drs. Bas van der Grift
Deltares / TNO Geological Survey of the Netherlands
Postbus 85467, 3508 AL Utrecht
Tel.: 030 - 256 47 20, Email: bas.vandergrift@deltares.nl

The quality of groundwater demands attention: anthropogenic contamination of groundwater is a recurring problem, groundwater is the raw material of drinking water, and wetlands and some other ecosystems partly depend on the quality of groundwater. There is strong relation between the geology setting and the 'natural' quality of ground- and surface water and the way in witch the water system reacts to anthropogenic pressures. Knowledge of subsurface processes is therefore essential for sustainable management of groundwater body. In the field of groundwater quality we are working on sustainable management and use of groundwater and the subsurface; geochemistry of the subsurface and groundwater; monitoring and modelling transport of substances in the water system; interaction of groundwater, surface water and ecology and innovative measures in the water system.

An example of an area that covers the items as described above is the Kempen area situated at the border of Belgium and the Netherlands. Historic emissions from ore smelters located in this area typically caused regional soil contamination. Trace metals like Cd and Zn are transported in soil and caused a threat for the groundwater and surface water quality. For this area we developed a regional approach using reactive transport models, which addresses geochemical and hydrological controls on subsurface transport of the trace metals Cd and Zn. The requisites to the approach are to assess and predict: (1) metal binding processes in the subsurface in relation to geological build up (2) temporal and spatial trends in Cd and Zn concentrations in shallow and deeper groundwater, (3) long term developments in groundwater contribution to the surface water contamination in relation to the geology, hydrology and land-use. With the knowledge learned from the groundwater model we developed a monitoring network for groundwater quality in the contaminated area. Innovative measures were developed to improve the situation.

Karstifikation on top of salt diapirs in Schleswig-Holstein

Zur Verkarstung und Erdfallbildung auf Salzstöcken in Schleswig-Holstein (Strukturen Elmshorn, Quickborn und Lägerdorf-Krempe)

Alf Grube
Geologischer Dienst, Landesamt für Landwirtschaft, Umwelt und Ländliche Räume des Landes Schleswig-Holstein, Abt. Geologie und Boden, Hamburger Chaussee 25, 24220 Flintbek, alf.grube@llur.landsh.de

Im Vortrag werden Zwischenergebnisse aktueller Untersuchungen zur Verkarstung im Deckgebirge der Salzstrukturen Elmshorn, Krempe-Lägerdorf und Quickborn dargestellt. Diese Untersuchungen stehen teilweise im Zusammenhang mit Erdfällen der letzten Jahre im Bereich Münsterdorf. Neben Bohrungen, DGM-Auswertungen und Aufschlussaufnahmen wurden ergänzend pollenanalytische Datierungen von H. USINGER (Kiel), B.-H. RICKERT (Ökologie-Zentrum der Christian-Albrechts-Universität zu Kiel) sowie J. STRAHL (Landesamt für Bergbau, Geologie und Rohstoffe Brandenburg, Cottbus) durchgeführt.

Bei den drei vorgestellten Salzstrukturen handelt es sich um Doppelsalinare (Rotliegend und Zechstein). Dabei bilden die Rotliegend-Gesteine den Kern der Strukturen. Zechstein-Ablagerungen finden sich an den Strukturflanken sowie in einzelnen Bereichen der Salzstöcke. Während die Gesteine der Strukturhochlagen Elmshorn und Quickborn die Quartärbasis mit nur geringmächtiger Überdeckung bilden, bedecken im Bereich Lägerdorf Schreibkreide-Sedimente die dortige Struktur.
Die Oberflächen der Salzstockgesteine der Strukturen Elmshorn und Quickborn sind generell stark bewegt. Neben der Verkarstung sind sie durch differentielle Salzstockhebung, Salzstocktektonik i.e.S. und durch glazigene und periglaziäre Prozesse geprägt worden.
Das Deckgebirge der drei Strukturen besteht neben lokal auftretenden Resten tertiärer Ablagerungen vorwiegend aus Gesteinen der Elster- und Saale-Kaltzeit. Weichselkaltzeitliche Ablagerungen sind meist geringmächtig, örtlich treten intensive periglaziäre Überprägungen auf. Spätglaziale bis holozäne Sedimente finden sich bevorzugt in häufig durch Subrosion entstandenen Hohlformen.

Als verkarstungsfähige Gesteine der Strukturen Elmshorn und Quickborn sind Kalke bzw. Kalksteine des Zechsteins, Gipse des Rotliegenden und des Zechsteins sowie Ablagerungen der Oberkreide - letztere aufgeschleppt an den Salzstockflanken - zu nennen. Im Bereich der Struktur Lägerdorf-Krempe sind dies flächenhaft vorhandene Schreibkreide-Ablagerungen, die u. a. örtlich durch glazitektonische und periglaziäre Prozesse stark überformt sein können.

Die Zusammenhänge von Verkarstungserscheinungen (Form, Größe, Orientierung, Vergesellschaftung, Alter, Füllung usw.) und den unterschiedlichen Bedingungen ihrer Entstehung werden diskutiert. Beispielhaft werden an einigen Stellen Zusammenhänge mit Kluftsystemen in der Oberkreide, der unterschiedlichen Verbreitung von verkarstungsfähigen Gesteinen des Rotliegenden und des Zechsteins sowie der petrographischen Zusammensetzung des jeweiligen Deckgebirges hergestellt. Die vorwiegend eemzeitliche Anlage der Hohlformfüllungen wird interpretiert.

Regional mapping of the deep subsurface in the Netherlands and some remarks on particular phenomena

Duin, E.

Since the mid-eighties of the 20th century regional mapping projects have been carried out in the Netherlands. Maps of the geological structure of the deep subsurface of the Netherlands onshore, on a scale of 1:1,100,000, have been being released by TNO in the Geological Atlas of the Subsurface of the Netherlands - onshore (2004). The data used to produce the maps originate from exploration and production activities that started in the Netherlands in the beginning of the 20th century. The geological maps were made for E&P companies active in the Netherlands territory and to enhance research in applied geological subjects, such as CO_2 sequestration and geothermal prospects.

In a subsequent mapping project regional maps of the offshore area were compiled using existing seismic interpretations. These maps were combined with the onshore maps and presented in an article by Duin et al. (2006). The last phase of the regional mapping projects, scheduled from 2006 to 2010, consists of a more detailed interpretation of the offshore area, using all available well and 2D and 3D seismic data.
Depth and thickness maps are created for the Upper-Rotliegend Group, the Zechstein Group, the Lower and Upper Germanic Trias Groups, the Altena Group, the Schieland-Scruff-Niedersachsen Groups, the Rijnland Group, the Chalk Group, and the Lower and Upper North Sea Groups. In addition to these maps regional profiles and structural element maps are created.
The depth maps are used to develop a 3D model for the entire Dutch on- and offshore. This model encompasses a detailed 3D structural framework of the deep subsurface including the 10 major units and an associated 3D fault network.
From the mapping projects a number of remarkable geological features can be observed.

Examples of these phenomena are:

- relations between paleo- and neotectonics
- dramatic lateral Zechstein salt movements
- numerous indications for shallow gas
- indications in Pliocene sediments for a mega paleo gravity slide

MDI-DE Marine Daten-Infrastruktur Deutschland – Metadaten, Gazetteer und Internet Dienste

Dr.-Ing. Rainer Lehfeldt
Bundesanstalt für Wasserbau – Dienststelle Hamburg, Wedeler Landstraße 157, 22559 Hamburg, Tel.: 040.81908.312, Email: rainer.lehfeldt@baw.de

Mehrwert einer marinen Informationsinfrastruktur

Die Marine Dateninfrastruktur Deutschland MDI-DE entsteht in Zusammenarbeit von Bundes- und Landesdienststellen, die in der deutschen Küstenzone für Küsten- und Naturschutz, Meeresschutz und Raumordnung zuständig sind. Diese Dienststellen sind für die Erfüllung der Berichtspflichten, die sich aus den Vorgaben der EG-Richtlinien zur Wasserpolitik, zum Hochwasserrisikomanagement, zur Meeresstrategie sowie zu den Natura2000 Schutzgebieten ergeben, zuständig. Mit den technischen und inhaltlichen Vorgaben der INSPIRE-Richtlinie soll aus den sektoralen Datenbeständen der EG-Mitgliedsländer eine Gesamtübersicht mit interoperablen Geobasisdaten sowie Geofachdaten erzeugt werden. Durch eine geeignete Vernetzung der Datenquellen wird es zukünftig möglich, in einem ökonomisch vertretbaren Aufwand die umfassende Bereitstellung von Fachdaten und Informationen aus dem Küsten- und Meeresbereich für Wissenschaft, Planung, Öffentlichkeit, Politik und Verwaltung gemäß den Anforderungen an eine integrierte europäische Meerespolitik umzusetzen. Für die deutsche Küstenzone werden die technischen Voraussetzungen dazu mit der MDI-DE geschaffen, die die Vorarbeiten aus dem KFKI Forschungsprojekt NOKIS – Nord- und Ostsee-Küsten-Informationssystem www.nokis.org und dem Internet-Portalzugang GeoSeaPortal vom Bundesamt für Seeschifffahrt und Hydrographie www.geoseaportal.de zusammenführt.

In den letzten Jahren haben sich Standards und Technologien im Umfeld von Informationssystemen etabliert, die eine Kommunikation zwischen heterogenen und verteilten Datenhaltungen unterstützen. Dazu gehört der ISO19115-Standard für Metadaten, der ISO19119-Standard für Services, die CS-W-Schnittstelle für Katalog-Dienste zur Kommunikation zwischen Metadaten-Servern und die OGC-konformen Darstellungs-Dienste WMS, WFS und WCS für Daten aus Geoinformationssystemen. Diese Grundlagen werden in allen nationalen und internationalen Informations-Systemen angewandt. Als Beispiele seien hier die Nationale Geodateninfrastruktur GDI-DE und das Umweltportal des Bundes PortalU genannt.

Metadaten

Speziell für die Dokumentation von Daten aus der Küstenzone ist in NOKIS aus dem Metadatenstandard ISO19115 ein überschaubares Küstenzonenprofil abgeleitet worden. Es kann durch standard-konforme Erweiterungen für alle Fragestellungen im Küstenraum verwendet werden und umfasst insbesondere das Profil der GDI-DE. So können die Metainformationssysteme PortalU und GDI-DE auf Bundes- wie auf Länderebene ohne besonderen Aufwand gleichermaßen bedient werden. Das zwischen allen Behörden abgestimmte Küstenzonenprofil hat drei weitere Ausprägungen, mit denen sich Forschungsprojekte, Zeitreihen sowie Simulations-Szenarien von Daten und Modellen beschreiben lassen.

Die Metadatenerfassung und -pflege erfolgt mit dem browserbasierten NOKIS Metadaten-Editor, der bei allen Datenlieferanten im Einsatz ist. Mit diesem mehrsprachigen Werkzeug können auch automatisch erfasste Metadaten, die während des Datenverarbeitungsprozesses entstehen, gesichtet und ergänzt werden. Die Mehrsprachigkeit bezieht sich nicht nur auf die Bedienelemente und Beschriftungen der Anwendung, sondern auch auf die Metadateninhalte, die überall dort, wo es sinnvoll ist, mehrsprachig gepflegt werden können. Dadurch wird es möglich, die Arbeitsumgebung auch in internationalen Kooperationen zu verwenden.

Gazetteer
Ortsnamen sind ein wichtiger Bestandteil von Metadaten zur räumlichen Einordnung der zu dokumentierenden Daten. In einem Gazetteer werden räumlichen Einheiten Koordinaten zugeordnet, die bei der Suche in Internet-Portalen verwendet werden können. Der in NOKIS in Zusammenarbeit mit dem Bundesamt für Kartographie und Geodäsie BKG entwickelte Gazetteer für die deutsche Küstenzone stellt die geographischen Namen in den deutschen Küstengewässern digital zur Verfügung.

Dabei berücksichtigt das zugrundeliegende Datenmodell zwei Eigenschaften von Objekten, die üblicherweise nicht Bestandteil von Gazetteer-Modellen sind. Mit einer Historienverwaltung, ohne die keine sachgerechte Dokumentation von morphodynamisch sich verändernden Strukturen im Wattenmeer möglich ist, werden Umring-Polygone aus verschiedenen Jahren erfasst, die einzeln ausgewertet werden können. Die Mehrsprachigkeit des Gazetteers ermöglicht es, alle Objekte mit mehreren Namen, die ebenfalls mit einer Gültigkeitsdauer versehen sind, in verschiedenen Sprachen zu benennen, und so die vorhandene Namensvielfalt entlang der deutschen Küsten digital zu erfassen.

Der Gazetteer der deutschen Küstenzone ist als Web Feature Service WFS online verfügbar. Er wird in Web-basierten Werkzeugen eingebunden, um entweder zu vorhandenen Koordinaten die naheliegenden geographischen Namen zu liefern, oder den Bildausschnitt auf vorgegebene Namen zu fokussieren.

Internet Dienste
Innerhalb der MDI-DE werden umfangreiche Metadaten gepflegt, die neben einer Text-basierten Suche auch eine Karten-basierte Recherche mit geometrischen Informationen, die aus dem Gazetteer bezogen werden, unterstützen. Für die Nutzer von Informationsinfrastrukturen sind die online verfügbaren Dienste von Interesse, mit denen nach einer Metadaten-gestützten Recherche auf die nachgewiesenen Quellen zugegriffen werden kann.

Zurzeit kann über das GeoSeaPortal Portal nach Daten und Informationen gesucht werden, die dann auf verschiedene Arten kombiniert und in einem interaktiven Web-GIS dargestellt werden können. Dazu wurden für eine Vielzahl von Fachsystemen Web-Kartendienste eingerichtet, die im Internet als OGC-konforme WMS verfügbar sind.

Für Daten mit Raum- und ausgeprägtem Zeitbezug wie z.B. Zeitreihen skalarer und vektorieller Größen und deren statistischen Auswertungen, sind bisher keine standardisierten Web-Services verfügbar. Gerade die hydrologischen Messungen gehören zu diesem Datentyp, so dass hier ein Defizit im Web-basierten Datenmanagement besteht. In dem Projekt kfkiGIS wurde erfolgreich gezeigt, dass unter ausschließlicher Verwendung von Standards auch GIS-untypische georeferenzierte Daten aus dem Küsteningenieurwesen verarbeitet und publiziert werden können.

Geopotenzial Deutsche Nordsee – Ein neues Gemeinschaftsprojekt

Geopotential of the German North Sea – A new joint project

Anke Krüger (Landesamt für Bergbau, Energie und Geologie)
Dr. Jochen Erbacher (Bundesanstalt für Geowissenschaften und Rohstoffe)

Die Deutsche Nordsee stellt einen einzigartigen Naturraum dar. Ein Antragsverfahren auf Unterschutzstellung des Wattenmeeres als Weltnaturerbe läuft derzeit bei der UNESCO-Kommission. Gleichzeitig handelt es sich bereits heute um einen intensiv genutzten Wirtschaftsraum, der weitere Zukunftsperspektiven für die wirtschaftliche Entwicklung der nördlichen Bundesländer, insbesondere von Niedersachsen bietet.

Das Niedersächsische Wirtschaftsministerium setzt einen Aktionsplan um, durch den die innovative, sichere und Klima schonende Gewinnung, Erzeugung und Speicherung von Energie sowie eine langfristige Versorgungssicherheit gewährleistet werden soll. Dabei steht zunächst der niedersächsische Küsten- und Nordseeraum im Mittelpunkt, der besondere Potenziale bietet. Das Bundesministerium für Wirtschaft und Technologie hat im Rahmen der fünften Nationalen Maritimen Konferenz das vorrangige Ziel deutlich gemacht, die erfolgreiche Entwicklung der maritimen Wirtschaft weiter abzusichern.

Die o. g. Initiativen greifen das Landesamt für Bergbau, Energie und Geologie (LBEG), die Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) und das Bundesamt für Seeschifffahrt und Hydrographie (BSH) mit dem Projekt „Geopotenzial Deutsche Nordsee“ auf.

Ziel des Projektes ist es, bis zum Jahr 2013 Wirtschaft und Wissenschaft grundlegende Geoinformationen über die heute noch weitgehend unbekannte Entstehungsgeschichte und den strukturellen Aufbau des Nordseeraumes zugänglich zu machen. Dieses Wissen ist für die nachhaltige Entwicklung des maritimen Wirtschaftsraumes Nordsee unerlässlich, da Planung und Umsetzung von Maßnahmen in den Bereichen Wirtschaft und Umwelt darauf aufbauen.

Das Vorhaben umfasst sechs Projektmodule, die parallel und aufeinander aufbauend Geodaten aus der Nordsee gewinnen und aufbereiten. Wesentlich für den Erfolg ist das koordinierte Zusammenwirken der verfügbaren Kräfte. Das umfassende und spezifische Know-how der Projektpartner BGR, LBEG und BSH kann dabei von der wissenschaftlichen Grundlagenermittlung über die Dateninterpretation und Aufbereitung bis zur anwenderbezogenen Produktgestaltung Kompetenz unter einem Dach bereitstellen und bietet daher hervorragende Voraussetzungen zur Umsetzung eines solchen Projektes.

Künftig interessante Bereiche für die Energiewirtschaft sollen identifiziert werden, so dass sich Technologieentwicklungen und Kraftwerksplanungen darauf einstellen und Anforderungen des Umweltschutzes rechtzeitig beachtet werden können. Potenziale liegen insbesondere in der Verfügbarkeit der Energierohstoffe, insbesondere Erdöl, Erdgas, aber auch Windenergie sowie der Energiespeicherung und der geografischen Position im Energienetzwerk, die für Pipelines, Leitungstrassen, neue Kraftwerke und die Möglichkeit der CO_2-Speicherung besonders interessant sind.

Die 6 Fachmodule lauten:

Geopotenzial Deutsche Nordsee	
• **Modul A**	**Geologisches Strukturmodell Nordseeraum**
• **Modul B**	**Ablagerungen, Baugrundverhältnisse, mineralische Rohstoffe**
• **Modul C**	**Geologische Grundlagen und Meeresspiegelentwicklung**
• **Modul D**	**Abschätzung des Erdöl-/ Erdgaspotentials**
• **Modul E**	**Speicherkapazitäten im Nordseeraum**
• **Modul F**	**Geoinformationssystem Nordsee**

Im Projektverlauf wird die bestehende Systemplattform Niedersachsens um den Bereich der Nordsee erweitert und durch die in den unterschiedlichen Modulen des Projektes erarbeiteten Datenbestände ergänzt.

Auf dieser Plattform ist vorgesehen, alle für das Projekt notwendigen Daten über die Nordsee nach einheitlichen Kriterien zu archivieren und zu integrieren, dies umfasst auch die im Projektverlauf entwickelten 3D-Modelle.

Das Informationssystem wird über das Internet einer großen Zahl von Akteuren aus Industrie, Wissenschaft und Forschung bereitgestellt, die dieses Wissen – jederzeit erreichbar - für ihre Projekte nutzen können.

Der europäische Kontext wird in einigen Projektmodulen bereits aufgezeigt. Für die nähere Zukunft ist hier eine internationale Zusammenarbeit mit anderen Anrainerstaaten der Nordsee anzustreben.

Marine landscape mapping of the Duch North Sea

Dr. Sytze van Heteren
Deltares, Marine and Coastal Systems Unit, PO Box 85467, NL-3508 AL Utrecht, the Netherlands

During the past five years, geological mapping of the Dutch North Sea has focused increasingly on improving spatial and temporal resolution and on integrating abiotic and biotic databases. Traditional printed maps at scales of 1:250,000 or 1:100,000 are gradually being replaced by digital grids that enable the end user to zoom in when sufficient data points are available, particularly near the shoreline where human impact is the highest. Grids are made not only for the top and base of stratigraphical units, but also for various associated abiotic and biotic parameters.
Spatial resolution is highest where 3D-seismics or dense grids of 2D-seismics are available. Although 3D-seismics is shot for hydrocarbon-exploration purposes, shallow time slices provide full-coverage information even for the shallow subsurface, provided that the water depth is more than 30 meters. For the Dogger Bank, time slices show meandering and dendritic drainage patterns (Figure 1) and ice-pushed ridges in the upper 10 meters of the subsurface. In shallower water, gridding 3D-seismic data does not produce satisfactory results and acquisition of 2D-seismic data at 1 km x 1 km grids is more effective. Using this latter approach, kilometer-scale sedimentary systems, such as channel fills, can be mapped with accuracy.

Temporal resolution refers to changes caused by seabed dynamics, which affect primarily the uppermost units present at or near the seabed. The Dutch marine territory forms a highly dynamic underwater landscape, with migrating sand waves and tidal channels. Knowledge on changes in unit thickness and bedform migration helps interpret and understand core and seismic information.
Integration of abiotic and biotic databases is used to identify and quantify relationships among various parameters. Biological seabed analyses such as macrozoobenthos counts are expensive and scarce. Using abiotic parameters as habitat proxies, interpolation between biological data points is improved, resulting in better habitat maps. This so-called marine-landscape approach is a powerful tool in the development and validation of spatial-distribution models of marine habitats, providing spatial planners and policy makers with tailor-made grids.

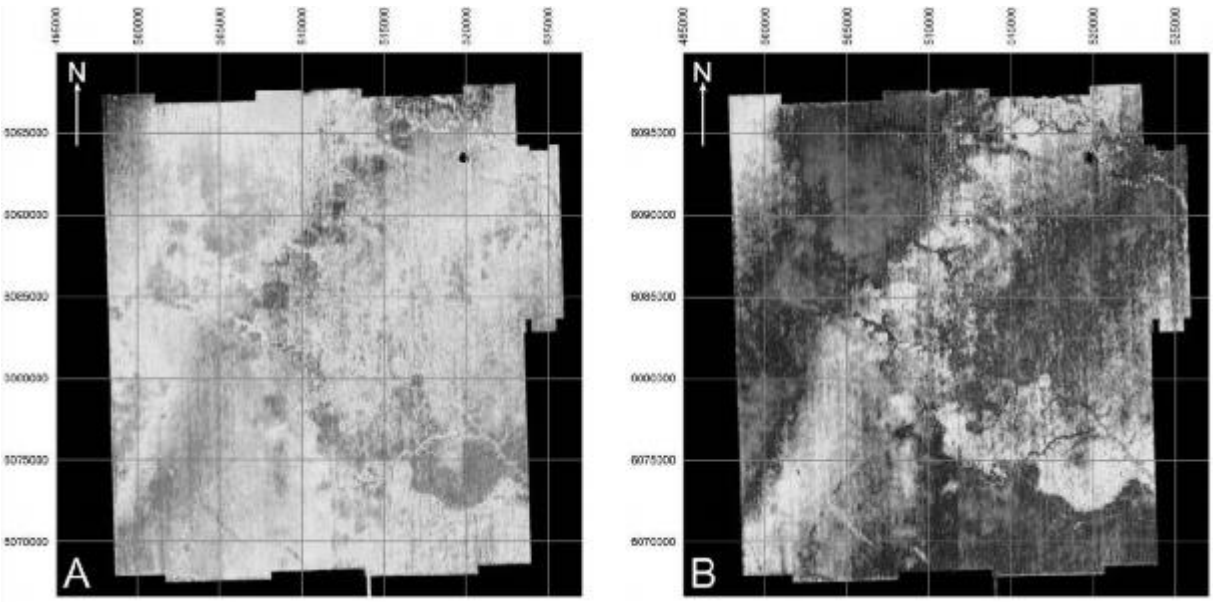


Figure 1. (A) Time slice at 40 ms after suppression of large-scale structures; (B) Same as A but with a different grayscale palette. Grid is 5 x 5 km.

Der Salzstock von Scharhörn und seine Bedeutung für die litorale Morphologie der Inneren Deutschen Bucht

Dr. Gerhard Linke, Hamburg

Die Nordsee ist hydrographisch gesehen ein Randmeer des Atlantik. Sie hat keine eigenständigen sondern nur Mitschwinggezeiten. Ihre Anregung erfolgt durch einen Impuls aus dem Nordatlantik. Die dabei entstehende Tidewelle wird bei ihrer Ausbreitung nach Süden auf Grund der Erdrotation an die englische Ostküste abgedrängt und umläuft das Nordseebecken als linksdrehende Gezeit, also entgegen dem Uhrzeigersinn. Ohne dieses Tidegeschehen ist die holozäne Situation an der südlichen Nordseeküste nicht zu verstehen, denn hieraus resultiert z.B. eine west/-östlicher Sedimenttransport, sei es als Schwebstoff, sei es als bodennaher Sandtransport, letztlich sogar Inselverlagerung.

Hierauf nahm Gripp, 1944, Bezug, als er das Fehlen von Inseln in der Inneren Deutschen Bucht zu erklären versuchte. Für ihn lag die Ursache darin, daß der erwähnte Materialtransport in diesem Gebiet noch zu keinem reifen Watt, als Voraussetzung einer Inselbildung, geführt hat. Er postuliert ihre Entstehung für die Zukunft. mit ausgeglichenen Bogenküsten, zunächst von Langeoog nach Amrum, und später von Norderney nach Westerland. Im Hinblick auf den ausgeglichenen Verlauf der seeseitigen Wattkante, nahmen aber weder er noch spätere Bearbeiter Anstoß daran, daß im Elbmündungsbereich die Watten und Sände diesem Konzept nicht entsprechen: offensichtlich, weil sich hierfür keine plausible Erklärung anbietet.

Auch der Aufbau des Neuwerk-Scharhörner Wattes, das der Autor in den 60er und 70er Jahren engmaschig abbohrte, bot keine Anhaltspunkte. Stets ergab sich bei der Erkundung die zu erwartende Sedimentabfolge: mächtige, holozäne Wattsedimente über Saale-glaziale Sande. Erst als 1974 eine Trasse von der Küste bis Scharhörn Riff erkundet wurde, enthüllte sich das Rätsel. Die Bohrung 1/74 auf Scharhörn, am Südende der Robbenplate traf bei -30.6 mNN auf harten, rotbraunen Ton des Rotliegend.

Naturgemäß mußte zunächst geklärt werden, ob es sich hierbei um eine glaziale Scholle älteren Materials handelte. Durch Seeseismik konnte diese Möglichkeit ausgeschlossen werden. Es ergab sich vielmehr der nach dem damaligen Kenntnisstand unerwartete Befund einer Hochlage des nördlichen Endes der Salzstruktur Mellum - Knechtsand - Scharhörn bis in relative Oberflächennähe. Die erbohrte Tiefe von -30.6 mNN dürfte nicht die höchste Stelle des Salzstocktops bedeuten, denn es gibt einen hierzu passenden, früher nicht beachteten Hinweis. In einer alten Landschaftsbeschreibung der Unterelbe (Linde, R.,1908) heißt es nämlich: Es hat den Anschein, daß Scharhörn Felsengrund hat. Alte Wattläufer versichern auf das bestimmteste, daß bei hohlster Ebbe nach der Westertill zu ein roter muschelbewachsener Felsen sich zeige, den man mit dem Ruder von dem Boot aus noch weiter verfolgen könne.

Demnach scheint es sich hier um eine Helgoland vergleichbare Situation gehandeln zu haben, nur mit dem Unterschied, daß bei Scharhörn der obertägige Fels komplett abradiert wurde und die alte Brandungsplattform heute im holozänen Wattsand begraben ist.

Als Konsequenz ergibt sich die Hochlage einer Salzstruktur bis in das NN-Niveau und eine Insellage bei Scharhörn Riff, selbst noch während der holozänen Transgression. Diese Insel wirkte mit ihrer exponierten Lage im küstennahen, west-östlichen Materialtransport als Hindernis, das in seinem Strömungsschatten zur Sedimentation führte. Das Ergebnis ist der auffällige seewärtige Vorbau der Wattaußenkante über den ausgeglichenen Küstenverlauf hinaus, der im Umkehrschluß als Argument für die Hochlage der Struktur zur interpretieren ist.

(als Manuskript eingereicht bei *Probleme der Küstenforschung im südlichen Nordseegebiet*)

Development of the Wadden area in time and space: towards a geoscience knowledge agenda for the Wadden area

Hanneke Verweij
TNO Built Environment and Geosciences, Princetonlaan 6, PO Box 80015,
3508 TA Utrecht, the Netherlands

The Dutch-German-Danish Wadden Sea forms the largest unbroken system of tidal sands and mudflats worldwide with natural dynamic processes proceeding in a widely unimpaired natural state. At this time the Wadden Academy, in close cooperation with researchers and stakeholders, is preparing a geoscience knowledge agenda for the area.

The Wadden Academy is a new research institute of the Royal Netherlands Academy of Arts and Sciences (KNAW). An important task of the Academy is to increase the knowledge, and the integration of knowledge, with respect to the natural and socio-economic development of the Dutch Wadden area (the Wadden Islands, Wadden Sea, and the coastal zone of the main land). For this purpose the Wadden Academy is compiling an integrated knowledge agenda for the Wadden area. This agenda will integrate geoscience knowledge concerning the Wadden area in close relation with other knowledge in the domains relevant for a sustainable development of the area, such as climate change, ecology, cultural history, social and spatial economics.

With respect to geosciences the focus is on the development of the Wadden area on different time and spatial scales. The Wadden area, the most important elements of which are the Wadden islands, the Wadden Sea beyond and the coastal zone of the mainland, is characterised by strong spatial and temporal dynamics. The present state and dynamic features of the Wadden system are the joint result of processes deep in the earth, near and at the surface and in the atmosphere, which take place on various temporal and spatial scales. Changes at the surface of the Wadden system are caused by natural processes and by recent human activity.

Three related themes can be identified in the development of the Wadden area in time and space. These are the Subsurface of the Wadden area, the Evolution of the Wadden area and the Morphodynamics of the Wadden Sea. Within these themes knowledge gaps and research questions have been identified for the purpose of research that contributes to the sustainable development of the Wadden area. The Subsurface of the Wadden area theme is concerned with the geological constitution and structure of the subsurface and the physical and chemical properties of rocks and fluids in the subsurface, the processes that occur on geological temporal and spatial scales, and the relatively rapid processes in the subsurface that are connected to its use. The Evolution of the Wadden area theme concerns mainly the natural development and dynamics of the Wadden area on time scales ranging from years to thousands of years. It includes the strong anthropogenic influence on the system during the last few centuries. The Morphodynamics of the Wadden Sea theme concerns mainly the short-term morphodynamics of the Wadden Sea under influence of natural development and human interferences. Here short-term means an ‘engineering’ time scale (up to decades).

This paper will present information on the tasks and organisation of the Wadden Academy and outline the approach used to develop the geoscience knowledge agenda for the Wadden area.

3D subsurface characterization of Zeeland and Zuid-Holland

Jan Stafleu, Denise Maljers, Jan L. Gunnink, Freek S. Busschers.
Deltares/TNO Geological Survey of the Netherlands
Postbus 85467, 3508 AL Utrecht

The Geological Survey of the Netherlands aims at building a 3D geological model of the upper 30 m of the subsurface of the Netherlands in order to provide a sound basis for subsurface related questions on groundwater extraction and infrastructural issues. The Province of Zeeland (SW Netherlands, covering an area of approximately 70*75 km) was chosen as the starting point for this model due to an excellent dataset of 23,000 stratigraphically interpreted core descriptions. A model of the Province of Zuid-Holland (70*65 km), with major cities like Rotterdam and Den Haag, is currently under construction.

Zeeland is positioned at the southern rim of the North Sea rift basin. The shallow subsurface geology mainly consists of gently N-S dipping Tertiary and Quaternary strata that were formed under shallow marine, estuarine and fluvial sedimentary settings. The upper sequence in the area is formed by Holocene deposits consisting of tidal channel, tidal flat and lagoonal sediments that alternate with peat beds and coastal dune deposits. In contrast, the Holocene deposits of Zuid-Holland are characterized by complex fluvial channel systems of the Rhine and Meuse rivers.

The modelling procedure involved a number of (iterative) steps. During the first model step, 2D bounding surfaces were constructed that allowed placing each 3D grid cell (100*100*0.5 m) within a correct lithostratigraphical context at formation and member level. Secondly, the lithological data from each core was transferred into a lithofacies code using newly developed, Python-based software. Examples of lithofacies zones include tidal channels, tidal flats and coastal dune sands. The combination of the lithostratigraphical model and the lithofacies zonations, allowed us to perform a final interpolation procedure in which a 3D, 50 million cell lithofacies model was constructed. In addition, the use of stochastic techniques such as Sequential Gaussian Simulation and Sequential Indicator Simulation, allowed us to compute probabilities for both lithostratigraphy and lithofacies for each grid cell, providing a measure of model uncertainty.

The procedures described above resulted in the first fully 3D regional-scale facies model of Tertiary, Quaternary and Holocene strata in the Netherlands. The model provides important new insights on spatial connectivity of sediment units like for example patterns of sandy Holocene tidal and fluvial channel systems (Figure 1). Our results represent a major step forward towards a cell based, 3D model of the Netherlands that should eventually replace the existing 2D models.

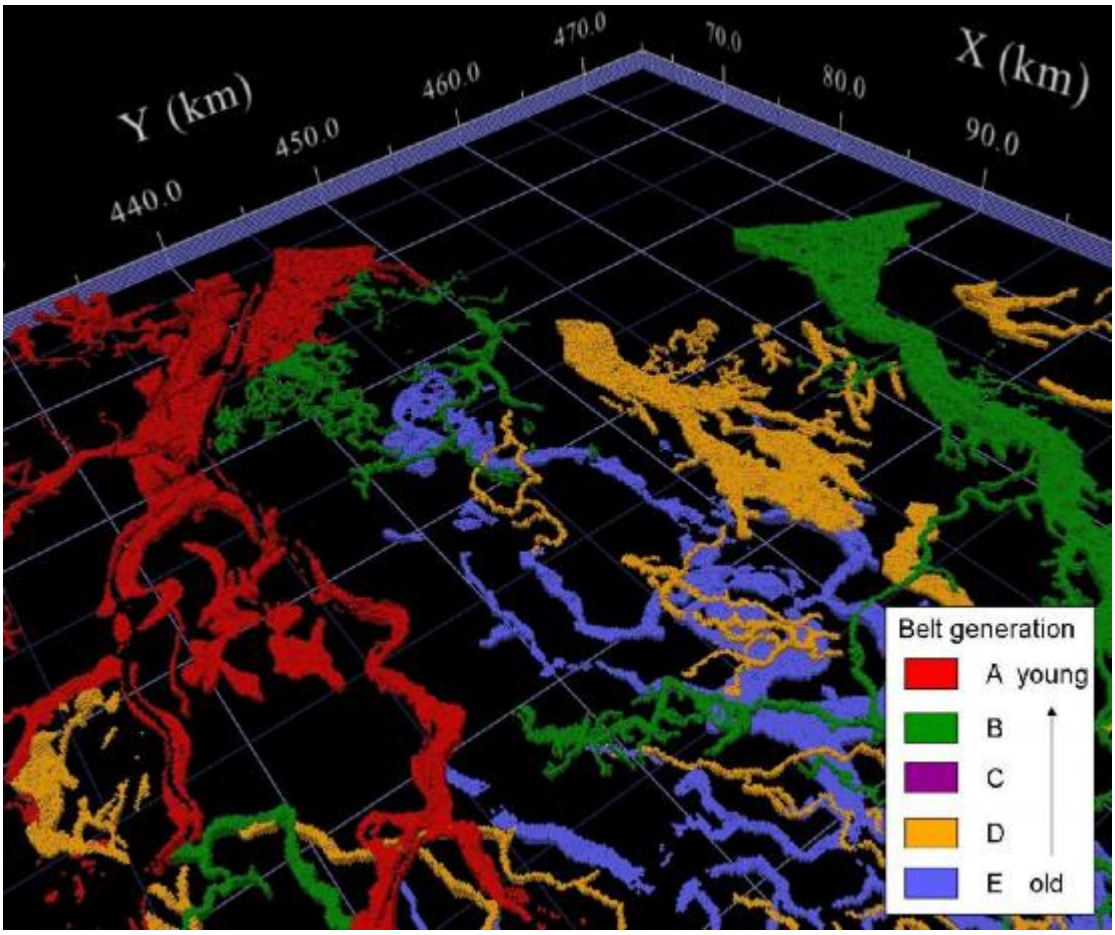


Figure 1 – Holocene channel systems in Zuid-Holland. Colours refer to belt generations.

Verbreitung von Elster-Grundmoräne und Lauenburger Ton in NW-Niedersachsen – Leithorizonte für die 3D-Modellierung?

Röhm, H. & Witthöft, M.
Landesamt für Bergbau, Energie und Geologie, Hannover

Um flächendeckende Informationen zum Aufbau des Untergrundes bereit zu stellen, ist es erforderlich, geologische 3-D-Modelle zu erarbeiten. Für den tieferen Untergrund von Niedersachsen wird beim Landesamt für Bergbau, Energie und Geologie (LBEG) derzeit der Geotektonische Atlas von Nordwest-Deutschland und dem deutschen Nordsee-Sektor (Baldschuhn et al. 2001) zu einem 3D-Modell weiter entwickelt. Um die besonders für hydrogeologische Fragestellungen interessanten quartärzeitlichen Schichten detaillierter darzustellen wurde am LBEG begonnen, ein „Quartär-3D-Modell“ zu bearbeiten. Die ersten Arbeiten wurden im Bereich der Oldenburgisch-Ostfriesichen Geest bei Aurich durchgeführt.

Im Rahmen von Arbeiten zur Umsetzung der Europäischen Wasserrahmenrichtlinie (EG-WRRL) entstanden zur Beschreibung der geologisch-hydrogeologischen Verhältnisse der Grundwasserkörper und ihrer Grundwasservorkommen geologisch-hydrostratigrafischer Schnitte (Budziak et al. 2006, Röhm 2007, 2009), die eine wesentliche Grundlage für ein „Quartär-3D-Modell“ darstellen. Weitere Arbeitsgrundlagen sind die vorhandenen Daten wie

Schichtenverzeichnisse von Bohrungen,
sonstige Profilschnitte,
geologische Karten und
sonstige Unterlagen.

Die im Modellgebiet vorkommenden Ablagerungen bzw. Gesteine wurden nach stratigrafisch-genetischen Gesichtspunkten untergliedert bzw. zusammengefasst und als Baueinheiten für das 3D-Modell definiert (s. Tab. 1).

Tabelle 1: Baueinheiten des 3D-Modelles auf TK100 Aurich

geol. Kürzel	Lithologie	Stratigrafie	geologische Einheit
qh//	Torf, Ton, Schluff, Sand	Holozän	Moor, marin - brackische Ablagerungen, fluviatile Ablagerungen, Flugsande, Dünen
qw//f	Sand, Kies	Weichsel-Eiszeit	Talsand, Niederterrasse
qw//b	Ton, Schluff	Weichsel-Eiszeit	Beckenablagerungen
qD//Mg, Lg	Geschiebemergel, -lehm	Drenthe-Stadium	Grundmoräne
qD//b	Ton, Schluff	Drenthe-Stadium	Beckenablagerungen
qD//gf	Sand, Kies	Drenthe-Stadium	Schmelzwasserablagerungen
qL//b	Ton, Schluff, Feinsand	Elster-Eiszeit	Beckenablagerungen
qe//Mg, Lg	Geschiebemergel, -lehm	Elster-Eiszeit	Grundmoräne
qe//b	Ton, Schluff	Elster-Eiszeit	Beckenablagerungen
qe//gf	Sand, Kies	Elster-Eiszeit	Schmelzwasserablagerungen
t//	Ton, Schluff, Sand, Kies	Tertiär	ungegliedert

Zur Gliederung der quartärzeitlichen Schichten ist es erforderlich, Leithorizonte festzulegen. Ein Leithorizont sollte Eigenschaften besitzen, die ihn von den umgebenden Schichten deutlich unterscheiden. Darüber hinaus sollte er hinreichend genau datierbar sein, ausreichend mächtig und weit verbreitet sein und auch unter ungünstigen Randbedingungen erkennbar sein. Warmzeitliche humose Ablagerungen lassen sich zwar gut datieren, besitzen aber nur eine geringe Verbreitung und geringe Mächtigkeit und wurden nur selten tatsächlich untersucht. Vergleichbares gilt für feinkörnige Beckensedimente (ausgenommen Lauenburger Ton, s.u.). Die größte vertikale und horizontale Verbreitung besitzen die verschiedenen eiszeitlichen Schmelzwasserablagerungen. Da man in Bohrungen i.d.R. Elster-zeitliche Schmelzwasserablagerungen nicht von solchen des Drenthe-Stadiums unterscheiden kann, bleiben nur noch die Grundmoränen und der Lauenburger Ton als potenzielle Leithorizonte übrig. Sie können auch in Bohrungen (Druckspülbohrungen) mit hinreichender Sicherheit petrografisch erkannt werden, besitzen eine weite Verbreitung und sind aufgrund ihrer Lagebeziehung stratigrafisch zuordenbar.

In der Ostfriesisch-Oldenburgischen Geest steht die Grundmoräne des Drenthe-Stadiums an der Oberfläche bzw. oberflächennah an. Für tiefere Bereiche ist sie als Leithorizont nicht geeignet. Ausgehend vom Modellierungsraum Aurich wurde daher versucht, für das ganze Gebiet NW-Niedersachsens die Vorkommen von Lauenburger Ton und Elster-Grundmoräne zu erfassen und damit auf ihre Eignung als Leithorizonte zu überprüfen. Dazu wurde begonnen, flächendeckend für das Gebiet westlich der Weser alle vorhandenen Daten und Unterlagen durchzusehen. Dazu gehören Gutachten, Karten, Berichte und Veröffentlichungen sowie insbesondere das vom LBEG geführte Bohrarchiv von Niedersachsen. Die Angaben zu den Vorkommen wie Bohrung oder Aufschluss, Koordinaten und Teufen-/Höhenangaben, Mächtigkeitswerte, Bearbeiter, Grund der stratigrafisch/genetischen Einstufung sowie weitere Angaben einschließlich der eigenen Beurteilung bzw. Einstufung werden in einer Datenbank gesammelt und stehen damit für GIS-gestützte Auswertungen wie z.B. Verbreitungskarten und schließlich für die 3-D-Modellierung zur Verfügung.

Literatur:

BALDSCHUHN, R.; BINOT, F.; FLEIG, S. & KOCKEL, F. (2001): Geotektonischer Atlas von Nordwest-Deutschland und dem deutschen Nordsee-Sektor. - Geol. Jb., **A 153:** 3 – 95, 3 CD-ROMs; Hannover.

BUDZIAK, D.; FRANKE, B.; KORN, M.; MERZBACH, G. & RÖHM, H. (2006): Erfassung, Aufbereitung und Darstellung geologischer und hydrogeologischer Daten zur Umsetzung der EG-Wasserrahmenrichtlinie. In: FORKER, A.; FRIEDEL, C.-H. & WANSA, S. [Hrsg.]: 73. Tagung Arbeitsgemeinschaft Norddeutscher Geologen, vom 6. bis 9. Juni in Halle (Saale), Tagungsband und Exkursionsführer; Halle (Saale).

Grobkonzept (2005): Grundwassermonitoring chemischer und mengenmäßiger Zustand für Grundwasserkörper in Niedersachsen/Bremen (Stand: Mai 2005). - Hannover (unveröffentlicht).

RÖHM, H.; BUDZIAK, D.; ELBRACHT, J.; FRANKE, B.; HAUSCHILD, S.; KORN, M. & MERZBACH, G.; (2007): Grundwasser-Monitoring : Erstellung geologischer und hydrostratigrafischer Schnitte zur Umsetzung der EG-WRRL, Teil 1, Landesamt für Bergbau, Energie und Geologie; Hannover (unveröffentlicht).

RÖHM, H.; KORN, M.; RICHTER, M. & WITTHÖFT, M. (2009): Grundwasser-Monitoring : Erstellung geologischer und hydrostratigrafischer Schnitte zur Umsetzung der EG-WRRL, Teil 2, Landesamt für Bergbau, Energie und Geologie; Hannover (unveröffentlicht).

Climate coupling of terrestrial and marine Miocene

T.H. Donders[1,3*], J.W.H. Weijers[2,4], D.K. Munsterman[3], R.D. Pancost[4], S. Schouten[2], J.S. Sinninghe Damsté[2], and H. Brinkhuis[1]

[1)] Palaeoecology, Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands
[2)] Department of Marine Organic Biogeochemistry, NIOZ Royal Netherlands Institute for Sea Research, PO Box 59, 1790 AB Den Burg – Texel, The Netherlands
[3)] TNO B&O, Geological Survey of The Netherlands, P.O. Box 80015, 3508 TA Utrecht, The Netherlands
[4)] Organic Geochemistry Unit, Bristol Biogeochemistry Research Centre, School of Chemistry, Cantock's Close, Bristol University, Bristol BS8 1TS, UK

Summary:
A detailed land-sea correlation on the basis of a Miocene palynological record from the North Sea Basin reveals a coupled climate system between the NW European marine and terrestrial realms. Both palynological and organic geochemical methods reveal the general long term cooling trend for the mid to late Miocene.

Background:
During the Cenozoic the central North Sea Basin has gradually been filled up with over 3 km of siliciclastic sediments providing an expanded record of global and regional climate and sea level evolution from both marine and terrestrial environments. Despite the potential wealth of this record, there is a general lack of directly measured data on the Paleogene and Neogene of the NW European shelf. Particularly the knowledge of Neogene paleoenvironmental evolution is poor at best.

New results
A new palynological and organic geochemical record from a shallow marine paleoenvironmental setting in SE Netherlands documents the coupled marine and terrestrial climate evolution from the late Burdigalian (~17 Ma) through the early Zanclean (~4.5 Ma) (Donders et al., 2009). Proxy climate records show several coeval variations in both relative sea surface (deduced from percent cool dinocysts) and terrestrial (subtropical vs. cool temperate pollen) temperature indices. The terrestrial climatic trend is confirmed by a quantitative reconstruction of annual mean air temperature based on the distribution of fossil branched glycerol dialkyl glycerol tetraethers, showing a cooling from ~27 ^{o}C to ~14 ^{o}C between 17 and 5 Ma punctuated by short-term variations. Decreases in sea surface temperature broadly correlate to inferred third-order sea level variations and correspond to isotope glacial events Mi-3 through Mi-7. An additional strong SST decrease occurs around ~8.4 Ma, coincident with a strong reduction and regional disappearance of subtropical pollen types. This cooling phase seems associated with lowered sea levels, but it has not yet been described from the deep sea ^{18}O record.

Pollen grain of Taxodium typical for "Cypress swamp" conditions of the European Miocene, equivalent of environments in subtropical Florida today

Outlook

The record shows the potential, through quantitative palynological and organic geochemical analyses, of integrated terrestrial and marine records for both paleoclimatic and stratigraphical purposes from the North Sea Basin. An initiative is therefore underway to set up a drilling project within the Integrated Ocean Drilling program (IODP) to recover shallow marine Cenozoic successions of the North Sea Basin shelf. We target a first-time complete recovery of Cenozoic shallow marine sediments in NW Europe in an effort to provide a regional integrated stratigraphic framework with detailed paleomagnetic and biostratigraphic data that currently is not available.

Grundwasserbeschaffenheit in Niedersachsen: Ermittlung geogener Hintergrundwerte.

D. Budziak
Landesamt für Bergbau, Energie und Geologie, Stilleweg 2, 30655 Hannover

Im Zusammenhang mit den Anforderungen der EG-Wasserrahmenrichtlinie (EG-WRRL) sind die EU-Mitgliedsstaaten dazu verpflichtet, das Grundwasser zu schützen und gegebenenfalls seine Qualität zu verbessern. Nur wenn sowohl der mengenmäßige als auch der chemische Zustand eines Grundwasserkörpers als "gut" eingestuft wird, entspricht dieser den Anforderungen der Richtlinie.

Laut Grundwasser-Tochterrichtlinie (GWTR) werden für die qualitative Beurteilung der Grundwasserbeschaffenheit verschiedene Kriterien, unter anderem natürliche Hintergrundwerte, genannt. Als Grundlage der Beurteilung schreibt die GWTR eine Mindestliste von 7 Stoffen (Chlorid, Sulfat, Ammonium, Arsen, Blei, Cadmium und Quecksilber) vor, die sowohl natürlichen als auch anthropogenen Ursprungs sein können. Für diese Stoffe sind Hintergrundwerte zu berechnen und bei Überschreitungen der ausgewiesenen Geringfügigkeitsschwellenwerte zu berücksichtigen. Die Art der Berechnung sowie die Zusammenfassung der Analysenergebnisse zu auswertbaren Bezugseinheiten werden hingegen nicht vorgegeben.

In Niedersachsen werden zur Bestimmung von Hintergrundwerten Grundwasseranalysen von Messstellen des niedersächsischen Monitoring-Messnetzes entsprechend der hydrogeologischen Räume des Landes zusammengefasst. Nach Morphologie, Bodenbeschaffenheit und Geologie des Untergrundes werden insgesamt 11 hydrogeologische Räume unterschieden (5 im Locker- und 6 im Festgestein) (Elbracht et al., 2007). Die diesen Bezugseinheiten zugeordneten Analysenergebnisse werden dann statistisch ausgewertet.

Mittels Wahrscheinlichkeitsnetzen wird versucht, über eine iterative Anpassung aus einem gemischten Datenkollektiv die Normalpopulation durch Ausschluss von Daten herauszufinden (Walter, 2005). Basis dieses Verfahrens ist die Überführung von Summenkurven eines Parameters in eine Gerade durch Transformation der Ordinatenskala in Summen-Prozent-Angaben (Lozán & Kausch, 1998). Der statistischen Auswertung liegt die Annahme zugrunde, dass das anthropogen unbeeinflusste Datenkollektiv eines Parameters einer Bezugseinheit normal- bzw. lognormal verteilt ist. Aus den ermittelten Kennzahlen (Perzentilen) der angepassten Verteilungen können darum Konzentrationsbereiche der natürlichen Grundwasserbeschaffenheit für diese Bezugseinheiten abgeleitet werden.

Ein Vergleich von regional mit überregional ermittelten Hintergrundwerten bundesweiter Studien (z.B. Kunkel et al., 2004) zeigt zum Teil erhebliche Unterschiede. Am Beispiel Ammonium wird der regionale Einfluss besonders deutlich. In den hydrogeologischen Räumen der 'Marschen' und 'Niederungen im nord- und mitteldeutschen Lockergesteinsgebiet' sowie in den Geestrandbereichen Niedersachsens weichen die Hintergrundwerte stark von den überregional ermittelten ab. Diese Gebiete werden einerseits landwirtschaftlich genutzt, sind aber auch geprägt durch Moore und Torfablagerungen. Unter reduzierenden bzw. sauerstoffzehrenden Bedingungen können diese eine natürliche Quelle für Ammonium sein, die in großräumigen, überregionalen Bezugseinheiten bei der Ermittlung von Hintergrundwerten jedoch kaum ins Gewicht fallen.

Literatur

ELBRACHT, J., MEYER, R. & REUTER, E. (2007): Hydrogeologische Räume und Teilräume in Niedersachsen. – Geoberichte des Landesamtes für Bergbau, Energie und Geologie, **3**; Hannover.

LOZÁN, J. L. & KAUSCH, H. (1998): Angewandte Statistik für Naturwissenschaftler. – 2. Aufl.; Berlin (Parey).

KUNKEL, R., VOIGT, H.-J., WENDLAND, F. & HANNAPPEL, S. (2004): Die natürliche, ubiquitär überprägte Grundwasserbeschaffenheit in Deutschland. – Schriften des Forschungszentrums Jülich, **47**; Jülich.

WALTER, T. (2005): Implementation of the Water Framework Directive in Saarland (Germany): Identification of groundwater bodies and installation of a new monitoring network. – Hidrogeología y Aguas Subterraneas, **21**; Spanien.

REGIS II, A hydrogeological model of the Netherlands

Ir. Ronald W. Vernes
Deltares/TNO Geological Survey of the Netherlands
Postbus 85467, 3508 AL Utrecht

Up to the late 1980s of the past century, hydrogeological information of the Dutch subsoil used to be presented in the form of paper maps as part of the "Grondwaterkaart van Nederland" (Groundwater Map of the Netherlands). In the early 1990s, a first set of digital subsoil models and maps were developed for groundwater management as part of the so-called REgional Groundwater Information System (REGIS I). However these digital subsoil models suffered from inconsistencies as well as from the early digital mapping techniques.

With this in mind a fully revised mapping concept was developed which resulted in the release in 2005 of REGIS II, comprising of:

- a hydrogeological model of the Dutch subsoil, describing the geometry and hydraulic properties of so-called hydrogeological units;
- 11 regional, so-called geohydrological models describing the geometry and hydraulic properties of aquifers and aquitards in each participating province.

Hydrogeological units, rock bodies with more or less uniform hydraulic properties play a key role in this new concept. Different types of units are defined based on their primary lithology and hydraulic properties. A hydrogeological model is simply defined as a spatial interpretation of the subsoil into hydrogeological units.

The hydrogeological model is based on the new lithostratigraphical scheme as well as the new Digital Geological Model of the Netherlands. The current hydrogeological model covers 132 units. Maps of the geometry and hydraulic properties are available in the form of grids.

A big advantage of this new concept is that schematizations of the subsoil in aquifers and aquitards (so called geohydrological models) can easily be derived from this hydrogeological model by combining the digital maps of the units. Depending on the goal for which the data are needed, f.e. a groundwater model, a coarse or highly detailed geohydrological model can be created for any area, still ensuring consistency between the data.

REGIS is being used in geohydrological studies, ranging from the design of well fields, where REGIS provides the user with a global picture of the hydrogeology of the area, to supra-regional and national groundwater models, like NHI (Netherlands Hydrological Modeling Instrument).

DINOLoket (www.dinoloket.nl) enables the users to view and download the maps and models through the internet. REGIS is updated; REGIS II.1 was released in April 2009.

Case-study brook valley system of the Dwingelderstroom, Drenthe, the Netherlands. A quaternary geological study as a base for geoconservation and nature development.

E.P.H.Bregman, MA, province of Drenthe/ Utrecht University
M.Nijhuis, MSc, Utrecht University
R.Quak, MSc, Utrecht University

Incomplete knowledge of the quaternary history of Drenthe provides a missing link in landscape planning, the protection of geoheritage values and nature development. That is one of the conclusions of a recent paleogeographical study in the brook valley system of the Dwingelderstroom.
Digital terrain analyses suppose an ancient river pattern, in the western part connected to an overridden push-moraine and opposite to the southern direction of the recent stream. The supposed change of the course of the river may be caused by a number of processes: e.g. down-cutting by changes of the base-level, proglacial reactivation of faults as a result of forbulging or postglacial uplift in an area with salt domes after the retreat of the land ice. To test all these possibilities a field study was performed in the autumn of 2008 to get more information about the quaternary geological history of the area. Results of the field study are discussed in relation to results of regional analyses of deep subsurface geological structures, glacial subsurface features of till deposits and geomorphological features and topography. We present the first results of the study which is nearly completed. These include a reconstruction of the paleo-sub-surface landscape, leading to our conclusion that glaciers followed existing pro-glacial valley systems. Effects of uplift or updoming in the postglacial period after the Saalian glaciation had no direct influence on subsequent landscape forming processes. On the other hand, pro-glacial reactivation of older faults cannot be excluded, because of a lineament formed by faults, the boundary of Elsterian deposits and Saalian till, which are also reflected in the actual topography of the surface. The western part of the brook valley fill (west of the village Uffelte) comprises till deposits at the base and is less deeper than the eastern part. The absence of till in the upstream area of the Dwingelderstroom, the deepening of the riverbed, sedimentation within this basin and peat formation all support the hypothesis that drainage of the eastern part of the Dwingelderstroom area is obstructed by coversand deposits that resulted in the formation of a lake. A breach and a lower base level during the end of the Saalian changed to our opinion the brooks' course. This conclusion is based on borings on top of a delta where we found completely reworked sediments and organic matter deposition throughout the whole profile just to the base of the newly formed SW-oriented drainage system. Erosion deepened the former lake area, because of an unsteady state due to the change of base level which led to till erosion in the eastern part of the Dwingelderstroom area. Sediments filled up the basin and due to climate change peat was formed. Just where we suppose the presence of this former lake, the topographic map of 1920 indicates a flat extended marsh, which could never have existed in the well drained gentle sloping delta area. Finally, we relate our conclusions to recent plans to protect a town (Meppel) against rising water (climate change and bad upstream natural storage conditions) and to nature development plans just on (top of) the delta. Based on the conclusions of our study and from a quaternary geological point of view we suggest to locate these activities at an other less contradictory but more natural place. More knowledge about the genesis of landscapes contributes to better protection of (subsurface) geoheritage values and to provide a better instrument for a sustainable environmental planning.

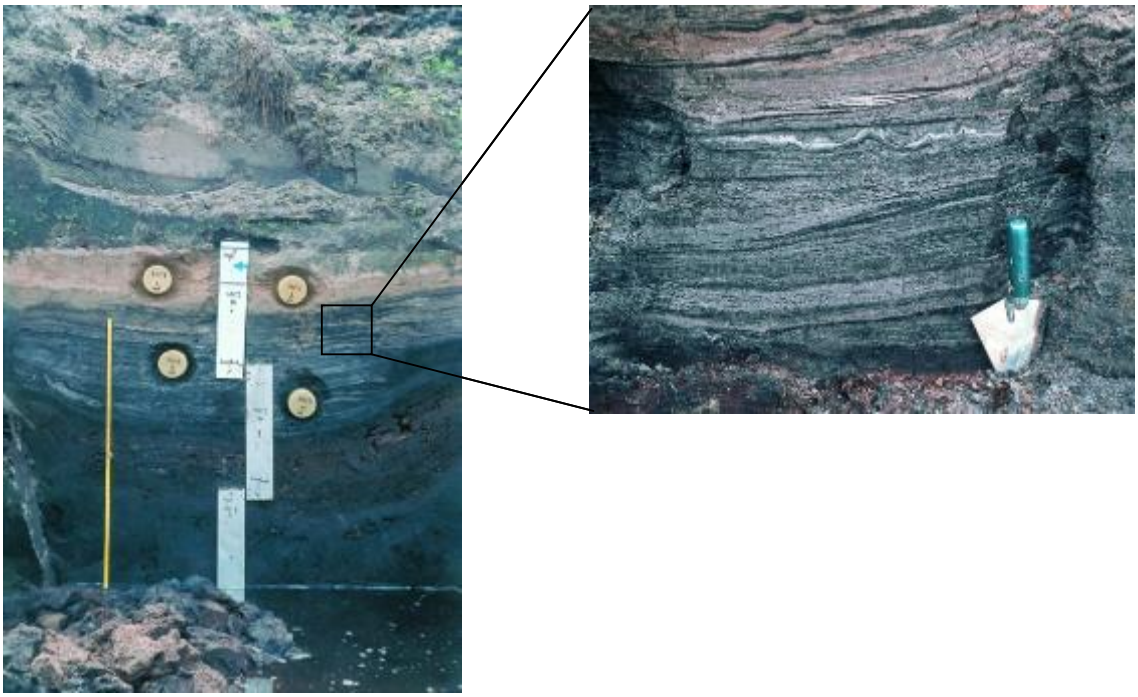
Registration and dating of human-induced landscape changes at Messchenveld (Drenthe, the Netherlands)

Schokker, J.[1], Woldring, H.[2] & Cleveringa, P.[3]

[1] Deltares/TNO - Geological Survey of the Netherlands, Princetonlaan 6, NL-3508 TA Utrecht, The Netherlands, jeroen.schokker@deltares.nl
[2] Groningen University, Groningen Institute for Archaeology, Poststraat 6, NL-9712 ER Groningen, The Netherlands
[3] WMC Kwartair Consultants, Clarissenhof 15, NL-1115 CA Duivendrecht, The Netherlands

Despite a hive of activity already during Mesolithic times the pollen record of an undrained depression situated in the upper part of the drainage area of the Drentse Aa river (Assen, The Netherlands) does hardly show any early human impact on the landscape. The pollen content of the peaty fill shows a typical Holocene vegetation succession, reflecting local peat growth and regional vegetation development, but without a clear influence of man. Based on a combination of proxy data and absolute dating (^{14}C and optical dating), we show that from the beginning of the Late Middle Ages agricultural practice dramatically transformed the natural landscape, resulting in heather growth at the site. In the 16th century overgrazing by sheep and peat cutting led to degradation of the heather and the development of sand drifts. The undrained depression was covered by an 80 cm-thick sand layer. It kept the natural deposits and its pollen record intact and gave it a hidden status up to the present-day.

The unusual way of filling of the closed depression and subsequent preservation of the fill is a result of the interaction between natural processes (the difference between precipitation and evapotranspiration) and increasing land use by man. It shows us that natural archives with archaeological remains from several different periods, which might be present near so-called palimpsest sites, can occur at unexpected, nowadays hidden locations in the landscape.



Environmental geochemical characterisation of the Netherlands

Dr. Jasper Griffioen,
Deltares/TNO Geological Survey of the Netherlands
Postbus 85467, 3508 AL Utrecht

TNO recently initiated a national characterisation of the environmental geochemistry of the geotop. Here, the geotop comprises the first 15-30 m below surface where anthropogenic influence is largest and most dynamic interaction between water and soil systems happen. This characterisation should facilitate sustainable environmental management of soil and groundwater. The national geochemical characterisation covers three aspects:

1. chemical composition of groundwater and its geogenic controls;
2. the reaction capacity of sediments as buffer for contamination;
3. typical elemental composition of geological formations and the association between trace elements and major minerals.

For groundwater, historical analyses are classified on the geological formation in which the well screens are situated. For sediment, historical as well as new analyses are interpreted.
The geotop of the Netherlands is divided into 27 regions, each having a unique geological and hydrogeological build-up of the shallow subsurface. These regions are statistically characterised on their geochemical composition where the geogenic controls on the composition are also indicated. The characterisation methodology will be presented and illustrated using various examples. Applications of the geochemical characterisation will also be presented, as the characterisation is e.g. used in establishing natural background levels for groundwater and parameterisation of groundwater transport models. An important application is, for example, the evaluation of the Dutch Manure Act, that is related to the European Nitrate Directive.

Implications of Soil Heterogeneity on differential rest-settlement

Ir. Stephan H.L.L Gruijters
Deltares/TNO Geological Survey of the Netherlands
Postbus 85467, 3508 AL Utrecht

In the design process of building new roads, predicting settlement is a main issue. This settlement is dominated by the thickness and characteristics off Holocene deposits (i.e. clay, peat). In the Netherlands, like in most low land delta areas around the world, these Holocene clay and peat deposits are very thick (up to 15 meters) and cover about 50% of the entire country. Road design is based on predicting the settlement at certain locations along the trace and to force about 90% of this settlement before the actual construction of the road e.g. by applying an overburden. By doing so, the expected settlement during the life cycle of the road (rest-settlement) is minimized. Road designers and constructors in the Netherlands have build up a great expertise in the last decennia to shorten the time needed for the overburden and to minimize this rest settlement. However, they are now faced with a new design restriction: the roughness of the road. They have to make a design that will fit strict rules on roughness during the life cycle of the road. The question changes form “how to minimize the rest settlement at a certain location” to “how to minimize the difference in rest settlement between two locations” and even “how to predict the chance of not applying to the roughness rules”. This means that spatial heterogeneity in both the characteristics and the parameters of Holocene deposits has to be incorporated in the design process.

The aim of this research is to predict the roughness (i.e. the differential settlement being the difference of the rest settlement between two locations along the road trace) of a new road using soil investigation data, geological expertise and geo-statistical modeling tools. A Artificial Neural Network technique was used to predict lithology classes from cpt data. We used sequential indicator simulation with varying local mean based on the cpt interpretation to simulate 100 equiprobable realizations of the subsoil up to about 10 meters below surface level. The settlement calculations are based on Koppejan. We chose a location in the centre of the Netherlands, where the Holocene deposits have a thickness of about 8 meters, and is partly eroded by the river Vecht, leaving more sandy deposits. Furthermore, at this location a large scale road reconstruction is carried out, which generated soil investigation data, settlement predictions and field measurements of actual settlement.

Plio-Pleistocene Stratigraphy of the Southern Lower Rhine Embayment

H.A. Kemna, Ucon Geoconsulting, Moritzstr. 18, D-47803 Krefeld,
Email: ha.kemna@ucon4d.com

The Pliocene and Lower/Early Pleistocene succession of the Lower Rhine Embayment (LRE) has been studied extensively since the beginning of the 20th century. Stratigraphy of this area has gained validity in a large part of northwestern Europe. However, the existing chrono- and lithostratigraphic subdivision of the Plio-Pleistocene has suffered from inconsistencies, unclear terminologies, local concepts, and even contradictions between the results of different methods applied. Furthermore, the systems used in the Netherlands on the one hand, and in Germany on the other, have never been conceptually harmonized.

Recent research has resulted in the set up of a new lithostratigrahic system in the Netherlands. As a side effect of these studies, severe doubt has been evoked concerning the chronostratigraphical subdivision of northwestern Europe based on pollen-analysis. It is now evident that the time-wise resolution possible by means of this method is by far too broad to subdivide especially the Early Pleistocene at the scale that was used in the past few decades.

At the same time, the succession in the German part of the area was studied in the type area near Brüggen and Venlo (northern LRE) and in the large-scale lignite pits (Tagebaue) in the southern LRE. The Plio-Pleistocene boundary is located at the top of the so-called Oebel beds, called horizon 11 in the local, hydrogeology-based system of RWE-Rheinbraun. Both the location of the Gauss-Matuyama boundary and dating of this horizon by means of mammal paleontology show that the Rhine gradually shifted its course eastward during Late Pliocene and Early Plesitocene times, obviously induced by tectonic movement of the Erft block. Lower Pleistocene deposits in the southern LRE comprise of deposits of the Rhine (inofficially called Frechen beds), the East-Maas (Holzweiler Formation), as well as a local river coming from the Eifel mountains in the south (”Paleo-Erft”, inofficially called Hambach beds).

As a result, a valid lithostratigraphical framework of the Lower Rhine Embayment has been set up which is now consistent with that of the Netherlands. Future research should be based on this approach and attempt to re-establish a valid chronostratigraphy for the area, making use of more suitable and advanced methods which are currently becoming available.

Das plio- pleistozäne Flusssystem im nördlichen Oberrheingraben

Christian Hoselmann*, Dietrich Ellwanger**, Gerald Gabriel***, Tobias Lauer***, Joachim Wedel* & Michael Weidenfeller****

Der nördliche Oberrheingraben – und hier speziell das Heidelberger Becken bildet im Pliozän und Pleistozän eine der größten fluviatilen Sedimentfallen Mitteleuropas mit einem hohen Erhaltungspotenzial der Ablagerungen. Allein aus dem Unterpleistozän sind mehre Hundert Meter Sedimente überliefert.
Ausgehend von kontroversen Diskussionen rund um die geologische Einstufung der Radium Sol Therme Bohrung, die 1913 bis 1918 im Stadtzentrum von Heidelberg abgeteuft worden ist, haben die geologischen Dienst von Baden-Württemberg, Hessen und Rheinland-Pfalz sowie das Leibniz-Institut für Angewandte Geophysik (LIAG – vormals Institut für Geowissenschaftliche Gemeinschaftsaufgaben, GGA-Institut) das Bohrprojekt „Heidelberger Becken“ initiiert. Dabei bilden die geologische Entwicklung des nördlichen Oberrheingrabens mit Fragen zur Steuerung durch Klimaveränderung und Tektonik sowie die Korrelation der alpinen mit der nordeuropäischen Vereisungsgeschichte Schwerpunkte der Untersuchungen.

Neben den eigentlichen Forschungsbohrungen in Heidelberg und Viernheim kommen drei Kernbohrungen aus Ludwigshafen hinzu, die dankenswerterweise von der Wasserwirtschaft zur Verfügung gestellt wurden. Diese drei Bohrlokationen bilden mit dem westlichen Rand des Beckens, dem Zentralbereich sowie dem östlichen Beckenrand auch unterschiedliche Faziesräume ab. Im hessischen Anteil des nördlichen Oberrheingrabens (Hessisches Ried) wurden in den letzten Jahren zusätzlich sieben weiter Kernbohrungen durch das Hessische Landesamt für Umwelt und Geologie abgeteuft, die die pleistozäne Grabenfüllung sowie Teile des Pliozäns aufschließen. Durch zusätzlich Bohrungen aus Projekten zur ICE-Trassenerkundung, Wasserwirtschaft sowie Geothermieprojekten kann mittlerweile ein neues Bild der geologischen Entwicklung des Raums skizziert werden.
Ausgangspunkte für die überregionalen Betrachtungen sind aber die Bohrungen in Heidelberg, Ludwigshafen und Viernheim, an deren Kernen in den letzten Jahren detaillierte wissenschaftliche Untersuchungen zur Sedimentologie, Sedimentpetrographie, Paläobotanik, Lumineszenzdatierung, Geomagnetik sowie Paläontologie durchgeführt wurden. Hinzu kommen die Ergebnisse der seismischen Voruntersuchungen in Heidelberg und Viernheim und der Bohrlochgeophysik.

Erste Resultate wurden 2008 im:

- Netherlands Journal of Geosciences: The Rhine – a major fluvial record. – Vol. 87, No.1: 1-125

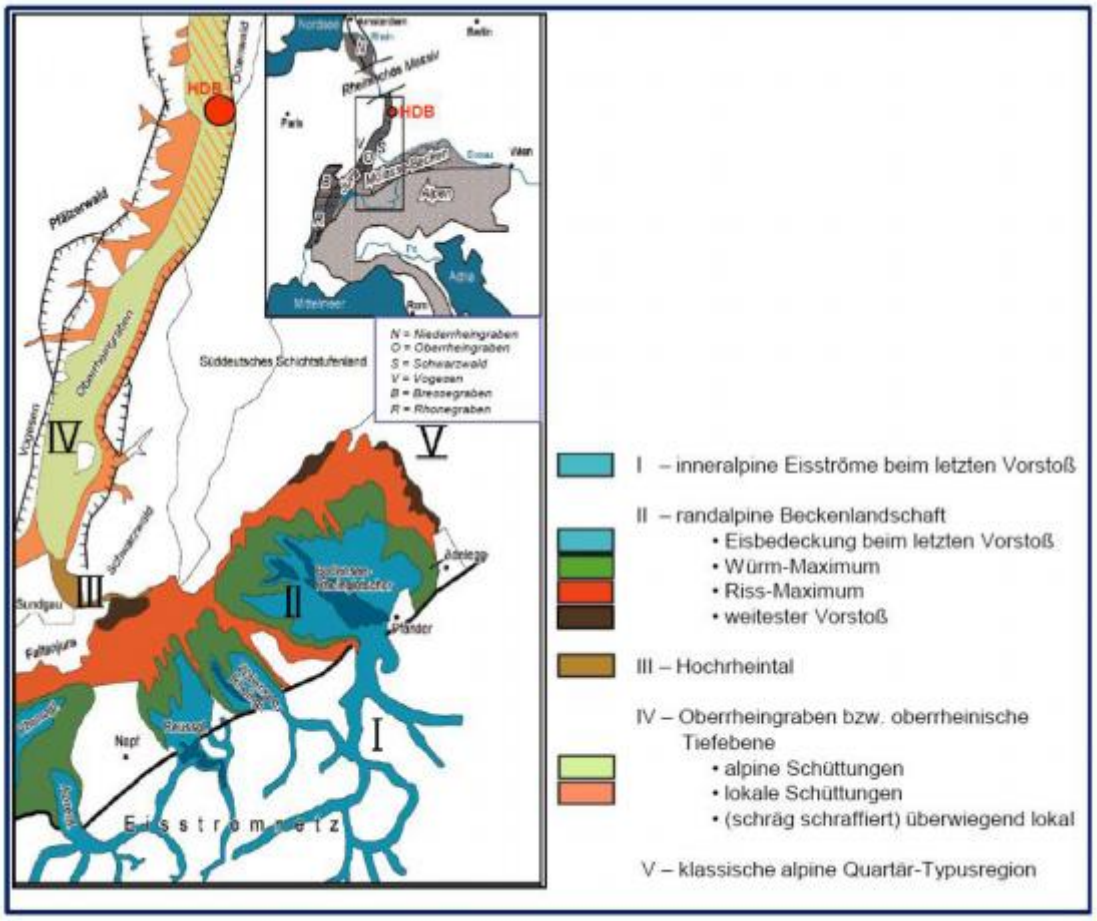
sowie kürzlich im:

- Quaternary Science Journal (Eiszeitalter und Gegenwart): The Heidelberg Basin Drilling Project. – Vol. 57 No. 3/4: 253-432

veröffentlicht.
Die bisher erzielten Ergebnisse bieten somit eine gute Basis, um die geologische Entwicklung im überregionalen Kontext zu betrachten. Außerdem ist es geplant verschiedene Forschungsansätze im Rahmen eines bei der Deutschen Forschungsgemeinschaft eingereichten Antragspakets weiterzuentwickeln.

* Dr. Christian Hoselmann, Joachim Wedel, Hessisches Landesamt für Umwelt und Geologie, Rheingaustraße 186, D 65203 Wiesbaden; E–Mail: christian.hoselmann@hessen.hlug.de
** Dr. Dietrich Ellwanger, Landesamt für Geologie, Rohstoffe und Bergbau im Regierungspräsidium Freiburg, Albertstraße 5, D 79104 Freiburg i.Br.
*** Dr. Gerald Gabriel, Dipl.-Geogr. Tobias Lauer, Leibniz-Institut für Angewandte Geophysik, Stilleweg 2, D 30655 Hannover
**** Dr. Michael Weidenfeller, Landesamt für Geologie und Bergbau Rheinland-Pfalz, Emy-Roeder-Str. 5, D 55129 Mainz

Abb.: Das Heidelberger Becken (HDB) im Geosystem „Rhein“ (nach Ellwanger et al. 2003, 2005 und Gabriel et al. 2008).
Kleine Karte: Der Oberrheingraben als Hauptsedimentfalle des Rheins zwischen Alpen und Nordsee.
Große Karte: Verschiedene Landschaftstypen entlang des Rheins von den Alpen bis zum Oberrheingraben.



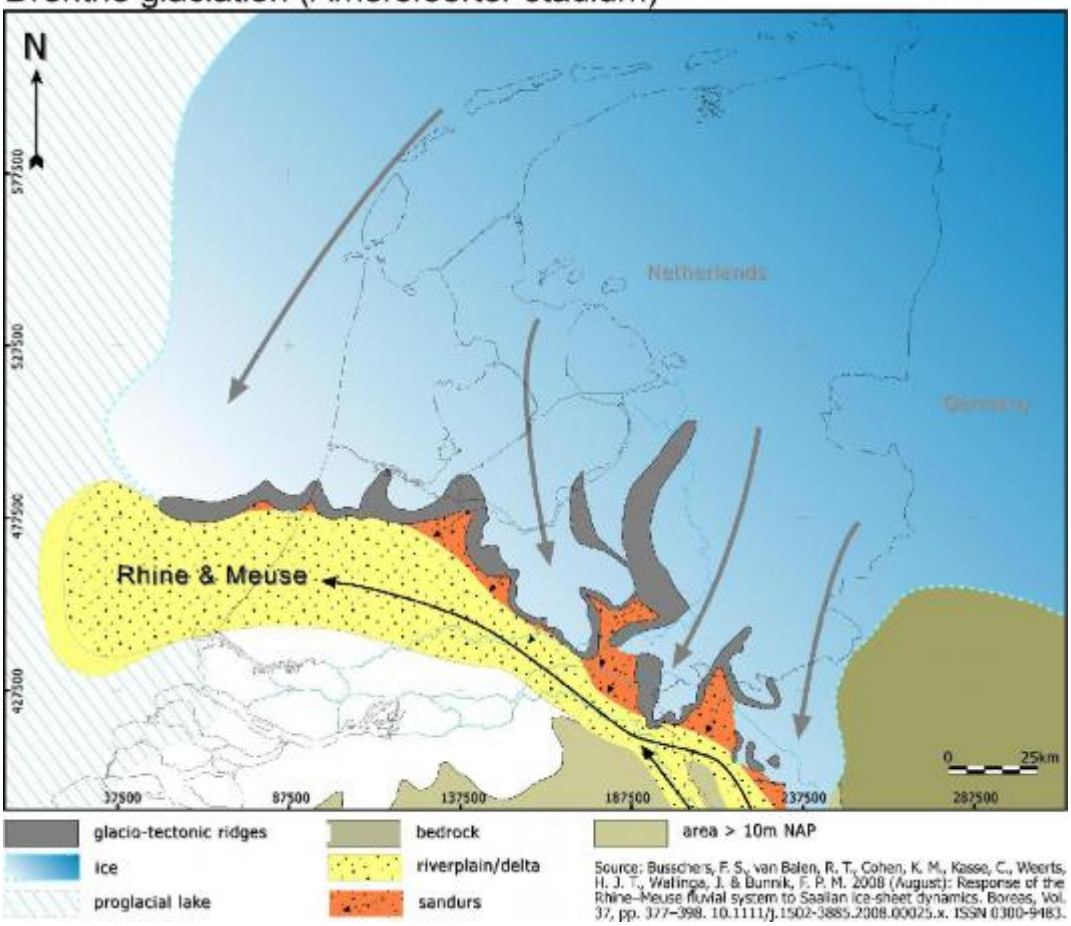
Middle Pleistocene proglacial lakes in the southern North Sea area: sedimentary and chronological insights from the Dutch sedimentary record

Busschers, F.S.[1], Cohen, K.M.[3,1], van Balen, R.T.[2], Kasse, C.[2], Bosch[1], J.H.A. & Wallinga, J.[4]

[1]Deltares/TNO Geological Survey of the Netherlands, P.O. Box 85467, 3508 AL Utrecht, the Netherlands
[2]Department of Paleoclimatology and Geomorphology, Faculty of Earth and Life Sciences, Vrije Universiteit, Amsterdam, the Netherlands.
[3]Utrecht Centre of Geosciences, Department of Physical Geography, Faculty of Geosciences, Utrecht University, Utrecht, the Netherlands.
[4]Netherlands Centre for Luminescence dating (NCL), Delft University of Technology, Faculty of Applied Sciences, Delft, the Netherlands.

Sedimentary and chronological data from the Dutch subsurface show that in the southern North Sea area, the Saalian and Elsterian glaciations were characterised by the development of proglacial lakes. The lakes formed between a former drainage divide to the southwest of the North Sea Basin (Strait of Dover and Southern Bight; Jurassic, Cretaceous and Palaeogene strata) and a northerly ice-front of confluent Norwegian and British ice-sheets.
Enigmatically elevated proglacial Rhine-Meuse sediments suggest that during the late Middle Pleistocene Drenthe glaciation (MIS6), the Rhine-Meuse fluvial system entered a proglacial lake that existed in the southern North Sea area south of the coalescing Scandinavian and British ice-sheets (figure).

Drenthe glaciation (Amersfoorter stadium)



The lake covered the entire southern North Sea area and had shoreline positions close to the current sea-level. We postulate that lake level position to be indicative for coeval palaeo-drainage divide elevation to the southwest of the North Sea Basin. The subsequent development of a deeply incised valley during the terminal phase of the Drenthe glaciation signals erosion of the palaeo-divide, and first establishment of a Rhine-Meuse valley through the Southern Bight and Strait of Dover. The Rhine-Meuse floodplain was situated well below interglacial sea level, allowing exchange of marine waters between the English Channel and North Sea during Late Pleistocene sea-level high stands - in contrast to interglacial situations before MIS-6.

New data from the northern Netherlands shows that during the Middle Pleistocene Elsterian glaciation a similar proglacial lake existed south of the ice front. The elevation of Elsterian lake-attributed fines is significantly higher than identified for MIS6, in support of hypothesised polycyclic spillway-scour driving progressive lowering of the English Channel - North Sea drainage divide. Currently collected OSL and palynological data and occurrence of an argon-argon dated augite-marker should give new insights in the age of the Elsterian and as well as its (non)correlation to the British Anglian glaciation.

The occurence of Late Weichselian pingo remnants in the Netherlands and neighbouring Germany.

Wim Z. Hoek[1], Sjoerd J.P. Bohncke[2], Kim. M. Cohen[1], Nelleke van Asch[1], Koen Volleberg[1], Harm-Jan Pierik[1]& Menno Nijhuis[1]

[1]Department of Physical Geography, Faculty of Geosciences, Utrecht University,
[2]Faculty of Earth and Life Sciences, Vrije Univerrsiteit Amsterdam
correspondence to: w.hoek@geo.uu.nl

The occurrence of permafrost related phenomena, in combination with radiocarbon and OSL dates of these phenomena, indicate that permafrost was present during the Pleniglacial, Early Lateglacial and Younger Dryas in The Netherlands. The most typical phenomena that indicate the presence of permafrost are the numerous remnants of Pleniglacial pingo's that can be found in particularly the Northern Netherlands (De Gans, 1982). They appear as circular depressions with or without a rampart, a diameter of 50-300 meters and depth of several meters at present partly or completely filled with organic deposits.

Pingo's are known from present day permafrost regions in Alaska, Canada and Siberia and occur under conditions with sufficient groundwater, leading to the formation of ice lenses. The presence of these pingo remnants with a depth varying between 5 meters in the southern Netherlands to 20 meters in the northern Netherlands indicates a minimum thickness of permafrost in the order of those values. The pingo's presumably originated as a result of hydrostatic pressure, under conditions of discontinuous permafrost during the Weichselian Pleniglacial. As temperature rose at the onset of the Lateglacial interstadial (GI-1, round ca. 12,500 ^{14}C BP or 14,700 cal BP), permafrost most likely started to disappear from that time onward. Melting of the permafrost layer that was several meters thick, presumably lasted several hundreds of years. Implications for the disappearance of permafrost during the Lateglacial in The Netherlands are given by the basal organic infilling of pingo remnants, dated to begin between 12,500 and 11,900 ^{14}C BP (Hoek & Bohncke 2002). Some of these depressions are filled with calcareous gyttja, implying that hydrostatic pressure and groundwater exfiltration continued after the decay of the ice-body.

Remarkably, no pingo remnants have been described in German literature, and it seems that the distribution stops at the Dutch German border while other landscape features do seem to extent further into Germany.

In this presentation, characteristics and distribution of pingo remnants in the Netherlands and adjacent Germany are presented. We describe previously unknown pingo remnants in the central and southern Netherlands that are revealed by the detailed digital elevation maps (AHN) that are now available in combination with detailed coring transects and core analyses. A comparison is made with circular depressions that are presents in Niedersachsen east of the province of Drenthe. Based on the characteristics and the position in the landscape it is concluded that, like in the Netherlands, numerous pingo's must have existed in this part of Germany during the Late Pleniglacial. During the Lateglacial and Early Holocene, the hydrological conditions, however, were different from those in the Netherlands leading to a fill which is only partly comparable to that of the pingo-remnants in the Netherlands.

References:

De Gans W. 1982. Location, age and origin of pingo remnants in the Drentsche Aa valley area (The Netherlands). Geologie & Mijnbouw 61, 147-158.

Hoek, W.Z. & S.J.P. Bohncke 2002. Climatic and environmental events over the Last Termination, as recorded in The Netherlands: a review. Geologie & Mijnbouw/The Netherlands Journal of Geosciences 81, 123-137.

Accurate dating of fluvial deposits in the Lateglacial Niers Valley system (Germany) using a multiple dating strategy

Peeters, J.[1,2,3,*], W.Z. Hoek[1,*], J. Wallinga[2] and C. Kasse[4]

[1] Utrecht University, Faculty of Geosciences, NL.
[2] Netherlands Centre for Luminescence dating, Delft University of Technology, NL.
[3] TNO/Deltares, Geological Survey of the Netherlands, NL.
[4] Vrije Universiteit, Faculty of Earth and Life Sciences, NL.
[*] Corresponding authors: w.hoek@geo.uu.nl, jan.peeters@tno.nl

The River Rhine occupied the Niers Valley (Germany) from the Saalian Glaciation (MIS 6) until the Early Holocene (Kasse et al., JQS 2005). The fluvial landscape of the time of abandonment has been exceptionally well preserved, leaving a series of cut-off meanders and residual channels (Figure 1). This unique preservation provides the possibility to investigate Late Weichselian fluvial dynamics of the River Rhine. We combined several dating techniques to accurately determine the age of the deposits. We developed a sampling strategy based on detailed field survey and cross sectioning. 1) The geomorphological relationships of the cut-off meanders gave a relative age for the successive stages of meandering. 2) The occurrence of Laacher See Pumice in the point bar deposits gave a maximum age for these deposits. 3) Optically Stimulated Luminescence (OSL)-dating on sandy point bar and channel-fill deposits yielded absolute ages for active meandering and channel abandonment. 4) AMS-14C dates on terrestrial macrofossils from the basal fills of the residual channels yielded minimum ages for abandonment. 5) Biostratigraphy of the organic channel fills using palynology gave a relative chronology, which could be linked to the well-dated regional biostratigraphy of the nearby Netherlands and is cross-checked by additional AMS-14C dates.

By combining these dating techniques we obtained a firm chronological framework (Figure 2) that allows linkage to climate records and above the cross-validation of the different dating techniques. All techniques gave consistent ages that confirm the Lateglacial age and Early Holocene abandonment of the Niers Valley by the River Rhine. Palynology and 14C-dating on the channels fills supported the relative chronology indicated by the cross-cut relationships. The presence of the Laacher See Pumice in the point bar deposits, which has an unambiguous age of 12.9 ka cal. BP concurs with the organic channel fill ages. Because OSL signals in some grains of the fluvial deposits were not completely reset at the time of deposition, advanced statistical methods were used to determine the burial dose from the equivalent dose distribution. We conclude that by combining several dating techniques we increase insight in the dynamics of the fluvial system during its last stages of activity and during abandonment.

Reference:

Kasse, C., W.Z. Hoek, S.J.P. Bohncke, M. Konert, J.W.H. Weijers, M.L. Cassee & R.M. Van der Zee (2005). Late Glacial fluvial response of the Niers-Rhine (western Germany) to climate and vegetation change. Journal of Quaternary Science 20(4), 377-394.

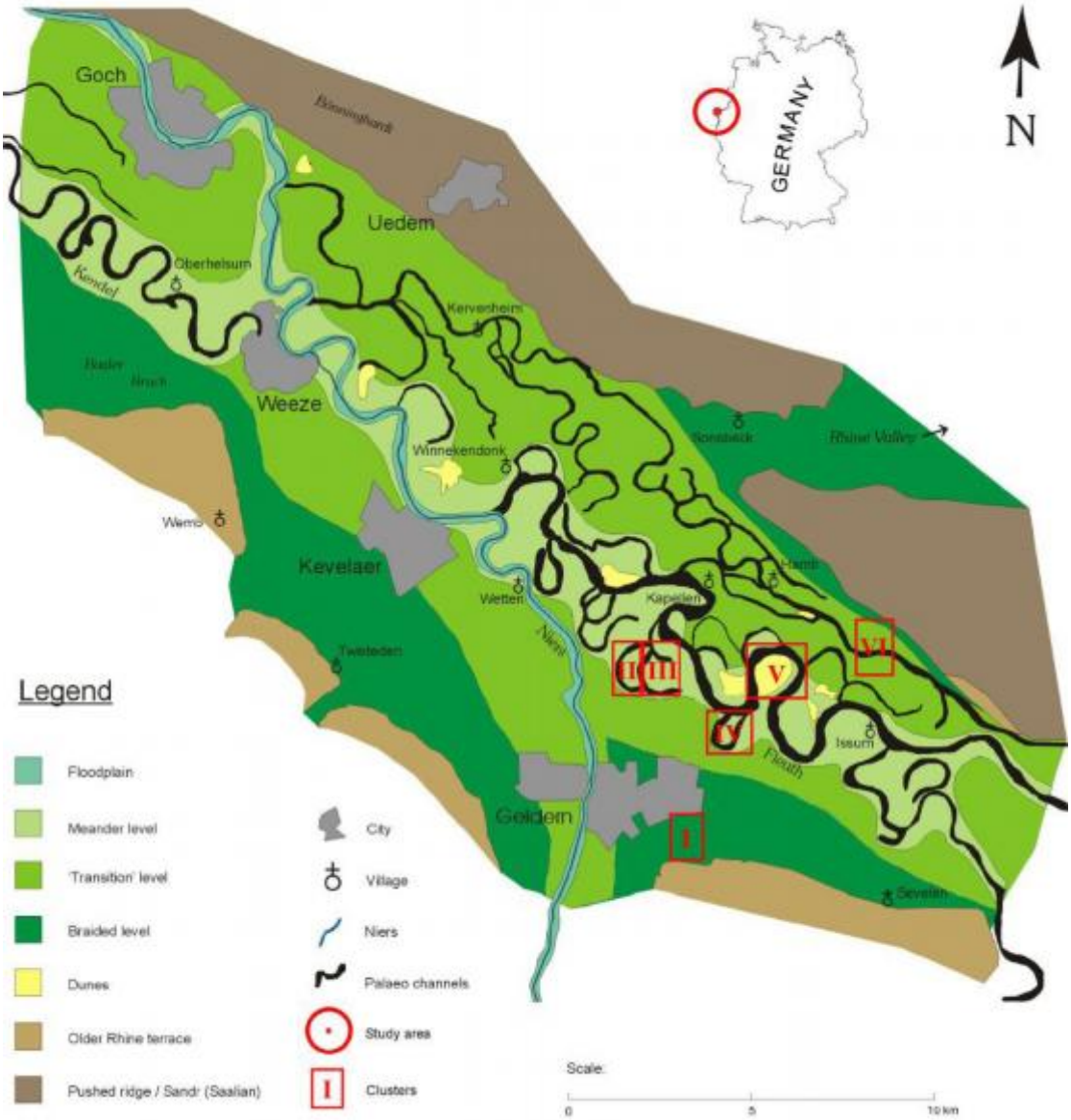


Figure 1. Niers Valley system research locations.

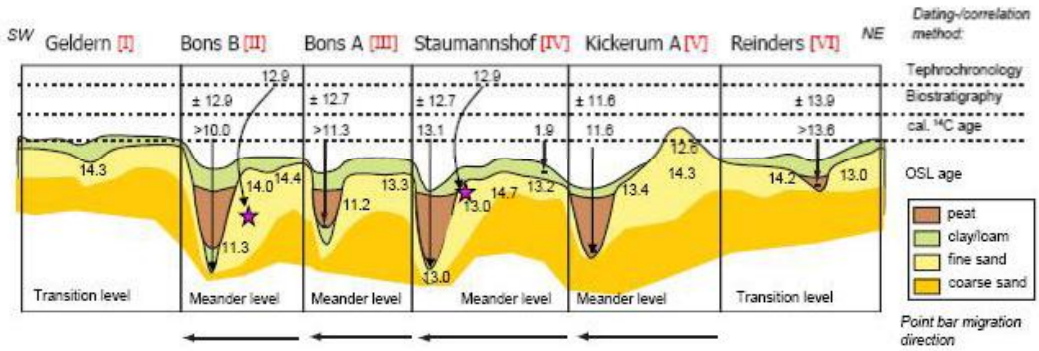


Figure 2. Schematic cross-section of the Niers Valley system. All ages are ka cal BP.

Kurzfassungen der Poster

Environmental response to rapid climatic oscillations in northwest Europe during Greenland Interstadial 1

Nelleke van Asch[1], Wim Z. Hoek[1] and Oliver Heiri[2]

[1] Department of Physical Geography, Faculty of Geosciences, Utrecht University, The Netherlands
[2] Palaeoecology, Institute of Environmental Biology, Faculty of Science, Utrecht University, The Netherlands
Correspondence to: N.vanAsch@geo.uu.nl

Rapid climatic oscillations are recorded in the Greenland oxygen isotope records. During Greenland Interstadial 1 (comparable to Bølling-Allerød or Lateglacial Interstadial), two distinct cold phases, GI-1b and GI-1d, occurred (Lowe et al., 2008). How did this affect the terrestrial environment? A west-east transect through northwest Europe will reveal the impact of these climatic changes on the environment in time and space. High-resolution multi-proxy analyses will be carried out on selected calcareous lake deposits in Ireland, Britain, The Netherlands and Germany. The multi-proxy analyses comprise pollen (regional and local vegetation), oxygen isotopes of bulk carbonates (qualitative climate reconstruction; correlation with NGRIP) and chironomids (quantitative temperature reconstruction).

Here we present results from our first site, which is located in southwest Ireland. Chironomid and oxygen isotope results provide evidence for the occurrence of short-lived cold events that are comparable to GI-1b and GI-1d. Comparison with the pollen record shows the impact of these cold events on the vegetation.

Reference

Lowe J.J. et al., 2008. Synchronisation of palaeoenvironmental events in the North Atlantic region during the Last Termination: a revised protocol recommended by the INTIMATE group. Quaternary Science Reviews 27, 6-17.

Abrupt climatic events during OIS-3 recorded in terrestrial sediments in the Netherlands: a multi-proxy approach

Bos, J.A.A.[1], Bohncke, S.J.P.[1], Kasse, C.[1], van Huissteden, J.[2], Schokker, J.[3], Bunnik, F.P.M.[4], Wallinga, J.[5]

[1] Section Climate Change & Landscape Dynamics, Department of Earth Sciences, Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, NL-1081 HV Amsterdam, The Netherlands, hanneke.bos@falw.vu.nl
[2] Department of Hydrology and Geo-environmental sciences, Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, NL-1081 HV Amsterdam, The Netherlands
[3] Deltares/TNO - Geological Survey of the Netherlands, Princetonlaan 6, NL-3508 TA Utrecht, The Netherlands
[4] TNO - Geological Survey of the Netherlands, Princetonlaan 6, NL-3508 TA Utrecht, The Netherlands
[5] Netherlands Centre for Luminescence Dating, Delft University of Technology, Faculty of Applied Sciences, NL-2629 JB Delft, The Netherlands

Abrupt climatic changes during Oxygen Isotope Stage 3 (OIS-3 or Weichselian Middle Pleniglacial) are revealed in the oxygen isotope records of the Greenland ice cores and in the North Atlantic marine cores. In the Greenland ice cores, these so-called Dansgaard/Oeschger (D/O) cycles start with a rapid warming of 5-10˚C within a few decades, followed by a phase of gradual cooling over several hundreds to more than a thousand years and finally resulting in a temperature regime equivalent to cold, stadial conditions again. On the European continent, climatic variability during this time interval is poorly known. High-resolution terrestrial records are scarce and the discontinuous nature of sedimentation and repeated erosion on the continent combined with poor dating control often hamper a detailed study of the vegetation and climate development.

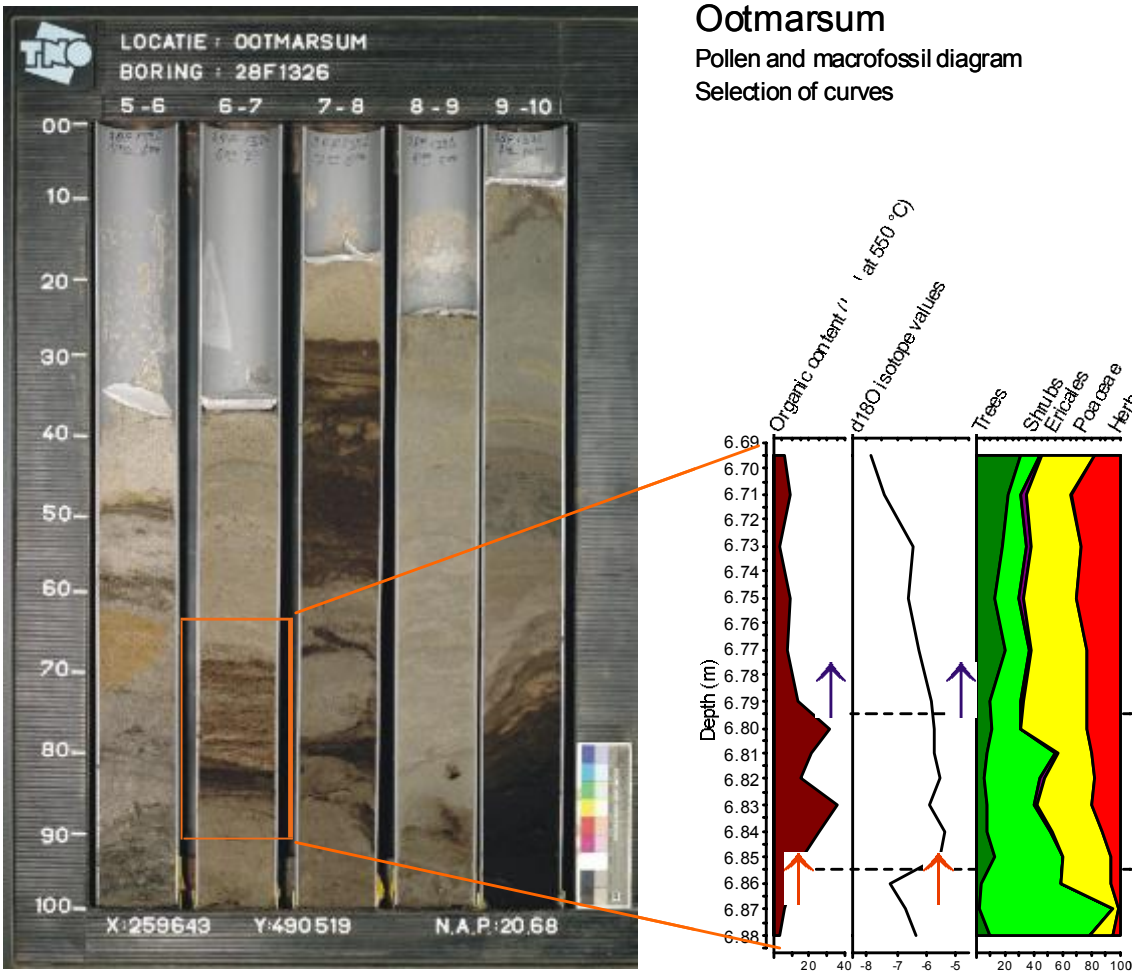
In this contribution, a Middle Weichselian sequence from the Netherlands is presented, consiting of shallow lacustrine deposits, intercalated with fluvial sediments with permafrost features. Within this Middle Weichselian sequence, rapid warming events are assumed to have given rise to thawlake formation and/or deposition of organic-rich lacustrine sediments, while the extreme cooling events of the D/O cycles are probably represented in the sequences by clastic intervals during which periglacial features developed.

In the sixties of the last century, two warming events or 'interstadials' were first recognized and described from terrestrial Middle Weichselian sequences from the Hengelo basin in the Netherlands, the Hengelo- and Denekamp interstadials, respectively. The shifts from a polar desert to shrub tundra (i.e. Hengelo interstadial) and tundra to shrub-tundra (i.e. Denekamp interstadial) that are visible in the pollen diagrams of this area were interpreted as a temporary ameliorations of the climate and were therefore given the names of interstadials. In time the Hengelo- and Denekamp interstadials were also correlated with D/O cycles 12 and 8, respectively, in the oxygen isotope records. However, in the oxygen isotope records of the Greenland ice cores and in the North Atlantic marine cores many more D/O cycles are present that are not recognized in terrestrial deposits from NW Europe.

In this new study the locality of the Denekamp and Hengelo interstadials in de Hengelo basin was re-visited and relatively new methods were employed (e.g., OSL- and AMS ^{14}C dating, $\delta^{18}O$ and $\delta^{13}C$ analyses on terrestrial calcareous deposits), which were not available during the 1960s. This new high-resolution multi-proxy study includes analyses of botanical and zoological remains, measurements of organic matter (LOI) and determination of stable isotopes ratios of oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$). A more accurate absolute chronology of the sediment sequence will be obtained by the

combination of a large number of AMS ^{14}C dates from the organic intervals and OSL dates from the clastic intervals. With this new study the following questions can probably be answered:

- Does the combined evidence from the Denekamp- and Hengelo interstadials show a rapid warming signal followed by a gradual cooling?
- Are these well-known interstadials a reflection of D/O cycles and with which D/O events can they be correlated?
- Was the formation of these organic deposits not influenced by climatic factors but by local hydrological factors?



400 years of environmental change documented in sediments of a deep dike-burst lake in the Rhine-Meuse Delta in the Netherlands

Holger Cremer, Frans Bunnik, Timme Donders
TNO Built Environment and Geosciences, Geological Survey of the Netherlands, Utrecht, The Netherlands

A 400-year sediment record from a deep water scour hole near the Meuse River in the Netherlands (Haarsteegse Wiel) was investigated for past changes in water quality, flooding regime and landscape change using a combined geochemical and micropaleontological (diatom and pollen analyses) approach. The results are highly significant for determining natural water quality, the impact of (atmospheric) pollution on the (aquatic) flora and the study of the impact and signals related to river floods. The sediment was dated by combining ^{137}Cs activity measurements and historically documented floodings indicated by the magnetic susceptibility of the sediments. The first flooding event is indicated in the sediment at AD 1610 when the lake was created by water masses bursting through a dike. The extent of large historical river floods are well described in historical chronicles and present an opportunity to study how a flood signal is represented in the lake catchment and provide an additional age calibration point. The resulting chronology is highly accurate and show that sedimentation rates decrease sharply with the widespread change from wheat cultivation to pasture land from around AD 1875 as a direct result of falling wheat prices and intensified cattle farming.

Water quality changes and absolute phosphorous concentrations are reconstructed using a diatom-based transfer function. Results show that the currently nutrient rich lake water has mostly been in a mesotrophic state prior to AD 1920, with the exception of several sharp eutrophication events. These events generally occur in sediments deposited during river floods. The river flooding also impacts the vegetation composition by importing allochthonous components and indirectly by the deposition of nutrients which have a clear impact on vegetation composition and richness.

Lake Haarsteegse Wiel. The white arrows indicate to flooding directions of the dike bursts in 1610 and 1740, respectively. The yellow square indicates the coring location of core HA07-05/06/07 at 17.10 m water depth.

Das geologische 3D-Untergrundmodell der Subrosionssenke des „Heiligen Feldes“ (nördliches Münsterland, Nordwestdeutschland)

Manfred Dölling
Geologischer Dienst Nordrhein-Westfalen, De-Greiff-Str. 195, D-47803 Krefeld

Im Subrosionsgebiet des „Heiligen Feldes“ (nördliches Münsterland, Nordwestdeutschland) entstanden spätestens seit dem Pliozän durch Auslaugung salinarer Serien innerhalb des Münder-Mergels (Malm/Unterkreide) im Untergrund zahlreiche Subrosionstrichter. Ein rezenter Erdfall vom 14. April 1913 beweist ihren Fortgang bis in die heutige Zeit. In der Senkunsgszone des Heiligen Feldes sammelten sich während des Tertiärs und Quartärs verschiedenartige Lockergesteine - Sande, Schluffe, Tone und Torfe -, die hier vor Erosion geschützt waren. Palynologische Datierungen erbrachten den Nachweis, dass sich in den Senkungszonen warmzeitliche Sedimente des Cromer-Komplexes, des Holsteins und des Eems erhalten haben. Die Absenkungsbeträge im Bereich der Subrosionssenke belaufen sich auf rund 60 bis 70 m.

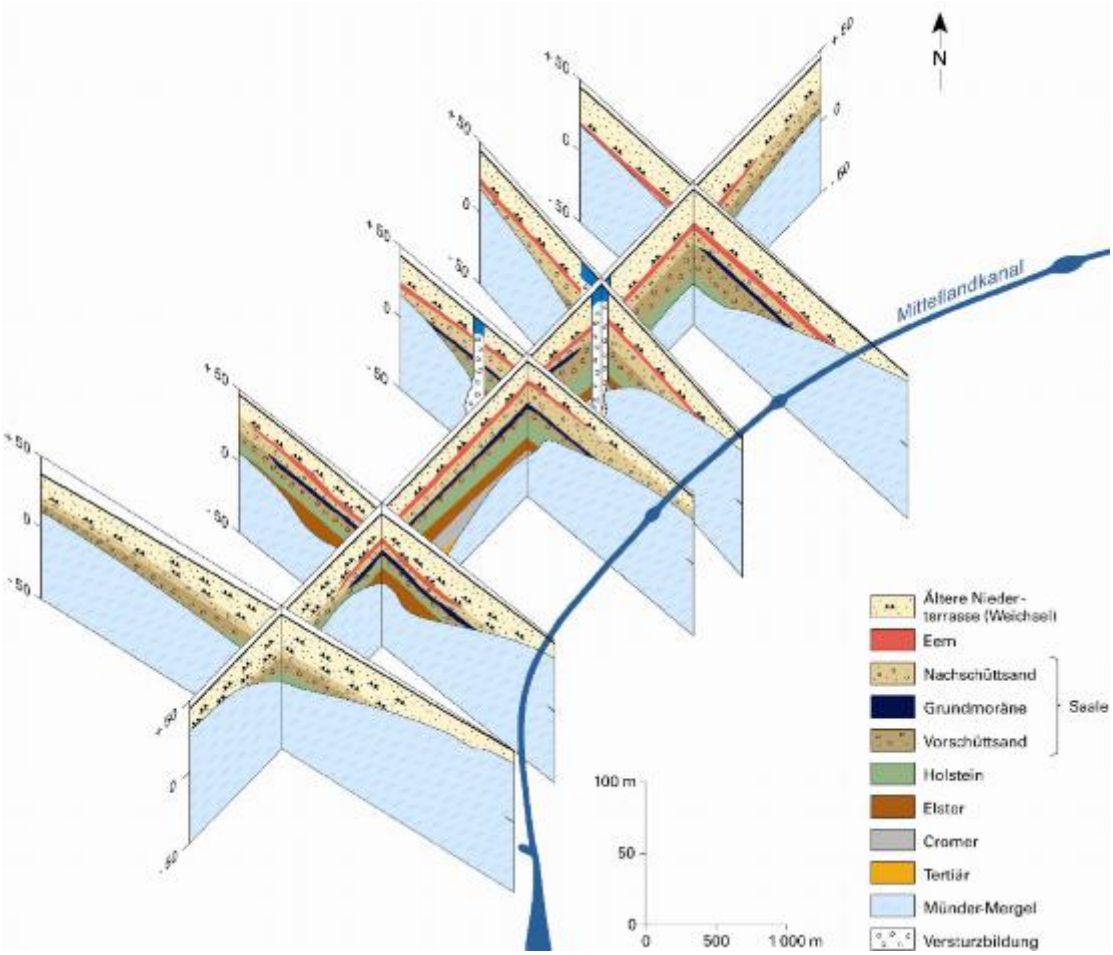


Abb. 1: Vernetzte Schnitte im Bereich der Subrosionssenke des „Heiligen Feldes“.

Das Subrosionsgebiet des „Heiligen Feldes“ wurde durch den Geologischen Dienst Nordrhein-Westfalen im Zeitraum von 2005 bis 2008 umfangreich geowissenschaftlich untersucht (DÖLLING & STRITZKE im Druck) Das Ziel dieser Untersuchungen war die Klärung von Stratigrafie, Genese sowie Mächtigkeit der im Subrosionsgebiet vorkommenden quartär- sowie untergeordnet tertiärzeitlichen Lockergesteine. Durch eine Vielzahl von niedergebrachten Bohrungen in Kombination mit bohrlochgeophysikalischen

Messungen konnte dadurch ein dichtes Netz von Informationen geschaffen werden, die es gestatten, in einem weitergehenden Arbeitsschritt eine 3D-Modellierung des Untergrundes vorzunehmen.
Als fachliche Grundlage für den Aufbau des digitalen 3D-Modells diente die Konstruktion vernetzter Profilschnitte. Dafür wurden alle verfügbaren Daten aus 250 Bohrungen im räumlichen Kontext nach stratigrafisch-genetischen Kriterien interpretiert. Daraus wurde ein lückenloses und konsistentes dreidimensionales Modell mit GOCAD entwickelt, welches die Lage und Verbreitung der wichtigsten quartärzeitlichen sowie im tieferen Untergrund auch tertiärzeitlichen Ablagerungen im „Heiligen Feld“ wiedergibt. Als Endergebnis steht ein widerspruchsfreies 3D-Modell des Subrosionsgebietes des „Heiligen Feldes“ für anwendungsorientierte und wissenschaftliche Fragestellungen zur Verfügung.

Insbesondere die 3D-Raummodelle verdeutlichen den komplexen Aufbau der quartärzeitlichen Sedimente im Bereich der Senkungszone. Sie geben wiederum Auskunft über die Entwicklung und das Alter der Subrosionsprozesse. Vor allem die Interglazial-Ablagerungen des Cromer-Komplexes, des Holsteins und des Eems dokumentieren die Existenz und Entwicklung von fossilen Subrosionsstrukturen im Bereich des „Heiligen Feldes“.

Literatur:

DÖLLING, M. & STRITZKE, R. (im Druck): Geowissenschaftliche Untersuchungen im Subrosionsgebiet des „Heiligen Feldes“ (nördliches Münsterland, Nordwestdeutschland).- Geol. u. Paläont. Westf.; **72**: 31 – 70, 24 Abb.; 3 Tab.; Münster.

Petroleum Geological Atlas of the Southern Permian Basin Area - Project overview.

J.C. Doornenbal
TNO Built, Environment and Geosciences, Geological Survey of the Netherlands,
hans.doornenbal@tno.nl

Introduction

The Atlas reviews the entire Southern Permian Basin (SPB) area, covering the British, Dutch, German, Danish and Polish sectors. The area extends from eastern England to the Belarussian-Polish border and is situated between latitudes 50.5 and 56 degrees North (figure 1).

Figure 1 Location map showing the areas covered by the Southern Permian Basin Atlas and the Millennium Atlas

The Southern Permian Basin Atlas (SPBA) Project, which was initiated by Ken Glennie, officialy started in March 2005. The presentation of the Atlas is foreseen in June 2009 at a special Event to celebrate the 50 years Groningen gas field, which boosted exploration for gas and oil in the Southern Permian Basin Atlas (SPBA) area.

A key objective of the Atlas is to stimulate the petroleum E&P industry to continue their activities in this mature basin. As the Southern Permian Basin gas and oil province continues to mature and with field sizes inevitably decreasing, more and more careful data integration and geoscientific effort is required to discover new reserves and to augment the recovery of proven hydrocarbon accumulations. The large volume of data that is or will be made available publicly allows the production of an authoritative compilation to support the E&P industry in their efforts to fully develop the basin; efforts which will likely take place in the coming decades. At the same time, easy and inexpensive access to the accumulated knowledge held by educational bodies will lead to a better understanding of the Southern Permian Basin area and the documentation of this knowledge will assist in the training of the next generation of petroleum geologists.

Contents Atlas

The Atlas addresses the geologic evolution and hydrocarbon potential per stratigraphic interval. The paleogeographic and tectonic evolution has been covered within the framework of the principal stratigraphic intervals, from the pre-Cambrian basement to the Holocene. The various structural and stratigraphic settings are elucidated by a thorough set of hydrocarbon field examples, overview maps, and illustrations. In addition, petroleum generation, migration, trapping, and production as well as the history of exploration and licensing in the basin has been covered, together with a summary of resource assessments. Other potential options for use of the deep subsurface such as gas and CO_2 storage and geothermal aspects have been also addressed. The content of the Atlas has been generated through contributions from authoritative international experts, survey material, and data from petroleum exploration companies.

Activities of the project

The Atlas actually got off the ground as a four year project in March 2005 when the steering committee was established consisting mainly of representatives from the National Geological Surveys and from E&P industry sponsors. TNO has exercised overall

management of the project (i.e. technical, secretarial, and financial) and the British Geological Survey (BGS) has supervised the editing of the Atlas.
In the first year, chapter-author teams were formed and the Project website has been set up. Work was started on GIS mapping and writing of the chapters, which continued also in the second and third year. Special software was used with great success for submitting, exchanging and sharing kinds of information via a shared environment.
About eleven Technical Meetings were held with the project team and the chapter-author teams, discussing preliminary tectonic evolution maps, tectonostratigraphic correlation charts, depth and isopach maps, log correlation panels, draft text and illustrations. Currently all GIS h maps have been compiled (see figure 2). Finally most of the Chapters have entered the review and final editing stage.

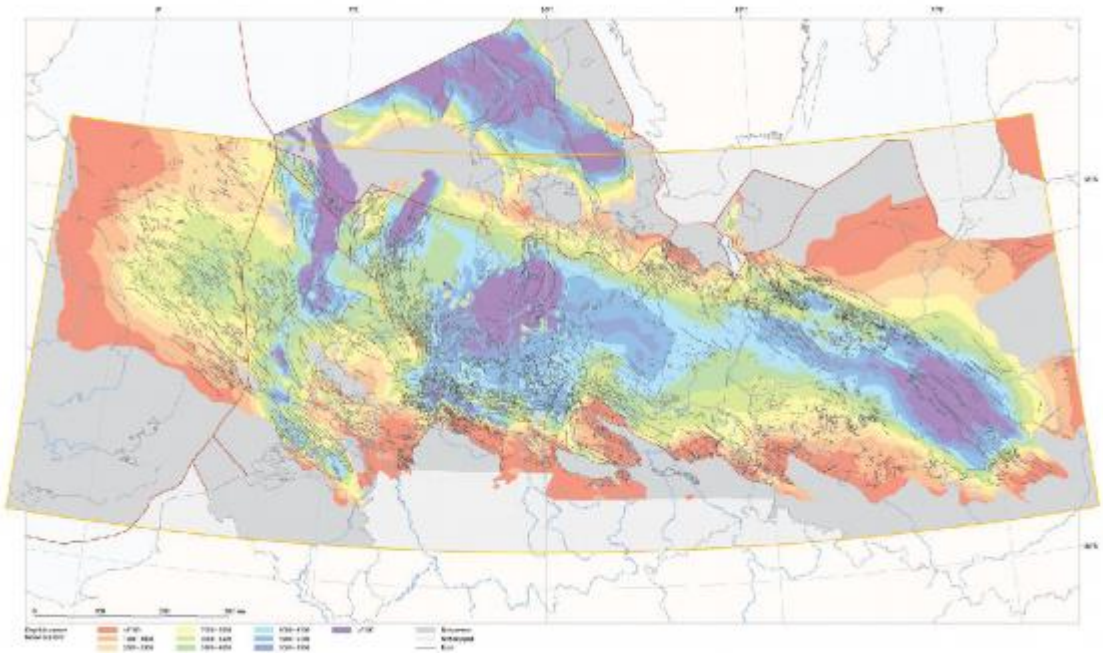


Figure 2 Depth map of the base of the Zechstein

Deliverables
The EAGE has been selected as the publisher for the Atlas and they will be responsible not only for the production, printing, and the binding of the Atlas, but also the marketing and the sales service. The Atlas will be available on printed paper (A2 size) and on CD in an interactive PDF format (figure 3). The maps (print scale 1: 3.000.000) will also be offered as a separate GIS product on DVD, at an application scale of 1: 1.000.000. This will greatly increase the utility and accessibility of the maps, and will allow their integration with other, perhaps more detailed data sets. It will also enable an invaluable training tool for postgraduate students and for new graduates employed by the petroleum industry.

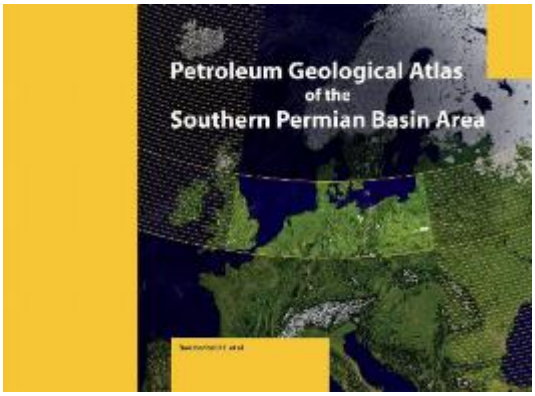


Figure 3 Cover of the Atlas, expected publication date is December 2009.

3-D-Modellierung quartärzeitlicher Ablagerungen im Deutschen Nordsee-Sektor

Asprion, U., Ertl, G., Lange M. & Elbracht, J.
Landesamt für Bergbau, Energie und Geologie
GeoZentrum Hannover, Stilleweg 2, 30655 Hannover
ulrich.asprion@lbeg.niedersachsen.de

Quartärzeitliche Ablagerungen in der Nordsee wurden im Wesentlichen durch die Vereisungen Nordeuropas gebildet. Die komplexen Zusammenhänge und der Wechsel von Eisvorstoß- und Eiszerfalls-Phasen prägten diesen Bereich nachhaltig. Bei den Sedimenten herrschen glazifluviatile und subglaziale Abfolgen vor. Ferner kann davon ausgegangen werden, dass mächtige Diamikte während der einzelnen Eisbedeckungsphasen gebildet wurden.
Wichtige morphologische Elemente sind die in diversen Publikationen bereits diskutierten subglaziale Rinnensysteme (z.B. Huuse (2000), Lutz et al. (2009)) und Eisbergmarken. Die sedimentäre Abfolge dürfte lokal in erheblichem Maße durch glazitektonische Prozesse modifiziert worden sein. Dies wird für den dänischen Bereich beispielsweise in Larsen und Andersen (2005) beschrieben.

Die wissenschaftlich bislang nur wenig bearbeiteten quartärzeitlichen Ablagerungen in der Deutschen Nordsee rücken mehr und mehr in das Interesse von Wirtschaft und Forschung. Die zunehmenden Aktivitäten in Bereichen wie Offshore Windparks, deren Anbindung an das Festland, oberflächennahe Rohstoffe, Pipeline- und Leitungsbau, aber auch das Schließen von Lücken im Verständnis um die Entstehung und zeitliche Einordnung dieser Sedimente, zeigen die Notwendigkeit einer exakteren, modernen Analyse für die Ablagerungen dieses geologischen Zeitabschnittes. Aus diesem Grund wird in den kommenden Jahren ein geologisches 3-D-Modell quartärzeitlicher Ablagerungen im Deutschen Nordsee-Sektor am Landesamt für Bergbau, Energie und Geologie (LBEG) entwickelt.
Ein zentraler Punkt dieses Teilprojektes aus dem Projekt „Geopotentiale deutsche Nordsee“ und wesentliche Grundlage für die Erstellung eines geologischen 3-D-Modells wird die Korrelation der onshore- mit der offshore-Stratigraphie sein. Die in den Niederlanden, Großbritannien und Dänemark bereits erarbeiteten möglichen Korrelationen stellen hierbei wichtige Ausgangpunkte dar.

Literatur:

Huuse, M. & Lykke-Andersen, H.(2000). "Overdeepened Quaternary valleys in the eastern Danish North Sea: morphology and origin." Quaternary Science Reviews, 19(12): 1233-1253.

Lutz, R., Kalka, S., Gaedicke, C., Reinhardt, L. & Winsemann, J. (2009): Pleistocene tunnel valleys in the German North Sea: spatialdistribution and morphology. - Z. dt. Ges. Geowiss., 160/*: in press

Larsen, B. & Andersen, L. T.(2005). "Late Quaternary stratigraphy and morphogenesis in the Danish eastern North Sea and its relation to onshore geology." Netherlands Journal of Geoscienses, 84(2): 113-128.

New results from the Upper Rhine-Meuse delta

G. Erkens, M.J.P. Gouw, K.M. Cohen, E. Stouthamer, W.Z. Hoek*
Utrecht University | Dept. Physical Geography | www.geo.uu.nl/fg/palaeogeography
PO Box 80.115, 3508 TC Utrecht, the Netherlands | w.hoek@geo.uu.nl

The 'Berendsen & Stouthamer (2001)' map of the Rhine-Meuse delta, produced at Utrecht University, has become the reference map for channel belt age in the Netherlands. Research projects over the last decade have added further data. In the eastern Netherlands recently completed and ongoing projects comprise:
1. Five SN cross-sections including time lines (Gouw & Erkens, 2007 NJG)
2. History of sediment delivery to the Holocene delta (PhD thesis Erkens)
3. Mapping and dating Rhine deposition in the Gelderse IJssel valley (Cohen)
4. Late Glacial/Holocene landscape change in the Oude IJssel- and Niers-valley (Hoek)

The Dutch-German border region became part of the Rhine delta only 3000 years ago. In times before it was a lower valley region, just like the Lower Rhine Embayment still is today. The transition from valley to apex-delta is associated with dramatic increase in delivery of suspended sediment: from the iron-age onward the delta received and trapped double the amount of fines it had done in previous time and the apex of the delta is the depocentre for this sediment. This finding links human impact in central and southern Germany (clearing of forest, agricultural revolutions) with the developments in the delta such as the annexation of the IJssel valley by a major Rhine branch in early medieval times. The developments in the upper delta have nothing to do with sea-level rise 100 km further downstream at the coast.

The Late-Glacial – Early Holocene landscape evolution over a large width of Pleniglacial floodplain is a story of absence of the main Rhine. Combined OSL, ^{14}C and palynological dating studies reveal the adaption of rivers to the changed climate and vegetation.

Selected publications:

Berendsen, H.J.A. & **Stouthamer, E.** (2001). Palaeographic development of the Rhine-Meuse delta. Assen: Koninklijke van Gorkum., 268 pp., 3 folded maps + CD-ROM.

Busschers, F.S., Kasse, C., Balen, R.T. van, Vandenberghe, J., **Cohen, K.M.,** Weerts, H.J.T. & Wallinga, J. (2007). Late Pleistocene evolution of the Rhine in the southern North-Sea Basin: imprints of climate change, sea-level oscillations and glacio-isostacy. Quaternary Science Reviews, 26, 3216-3248.

Erkens, G., Cohen, K.M., Gouw, M.J.P., Middelkoop, H. & **Hoek, W.Z.** (2006). Holocene sediment budgets of the Rhine Delta (The Netherlands): a record of changing sediment delivery. In Rowan, J.S., Duck, R.W., Werritty, A. (Ed.), Sediment Dynamics and the Hydromorphology of Fluvial Systems (IAHS Publication, 306), pp. 406-415.

Gouw, M.J.P. & Erkens, G. (2007). Architecture of the Holocene Rhine-Meuse delta (the Netherlands) – A result of changing external controls. Netherlands Journal of Geosciences, 86 (1), 23-54

Hoffmann, T., **Erkens, G., Cohen, K.M.,** Houben, P., Seidel, J. & Dikau, R. (2007). Holocene floodplain sediment storage and hillslope erosion within the Rhine catchment. The Holocene, 17(1), 105-118.

Kasse, C., **Hoek, W.Z.,** Bohncke, S.J.P., Konert, M., Weijers, J.W.H., Cassee, M.L. & Zee, R.M. van der (2005). Late Glacial fluvial response of the Niers-rhine (western Germany) to climate and vegetation change. Journal of Quaternary Science, 204(4), 377-394.

3D subsurface mapping of the Dutch Continental Shelf: seismic interpretation and geological modelling.

S.F. van Gessel, E.J.T. Duin, J.W. Verbeek, N. Witmans, M. den Dulk, J.C. Doornenbal

TNO is commissioned by the Ministry of Economic Affairs to provide free access to public domain information and knowledge of the subsurface in order to stimulate the exploration of oil and gas reserves in the Dutch sector of the North Sea. To this perspective a comprehensive 3D subsurface model is being developed which encompasses a detailed 3D structural framework including essential stratigraphic units, reservoirs and related faults. Special attention is being paid to the reliability of the structural model.

Duin et al., (2006) published a first regional reconnaissance mapping (NCP-1) of the offshore based on available (predominantly 2D) seismic interpretations. This model is currently being enhanced using public domain 3D seismic surveys and additional well logs (NCP-2 model). Interpretation and modelling is carried out per region, following the configuration of the Mesozoic structural elements.

Figure 1 gives an overview of 3D seismic surveys in the Netherlands, on- and offshore. The blank regions are covered by 2D seismic surveys. The interpretation involves the identification of 10 major lithostratigraphic units and related faults from the Permian Upper Rotliegend Group up to the Neogene Upper North Sea Group. All faults are consistently integrated into a 3D fault model and - together with all horizons - converted from time domain to depth domain. Time – depth conversion uses a layer cake velocity model constructed in the joint industry project VELMOD. Biostratigraphically validated interpretation and correlation of available well logs is used to aid the identification and correlation of the seismic horizons, the calibration of the converted depth model and the modelling of important reservoir layers. An example of the stacked seismic horizon model for the northern Dutch offshore is shown figure 2.

Seismic interpretation, surface interpolation, fault modelling and velocity modelling are recognized as important contributors to the overall uncertainty in the structural model. The individual uncertainties of each contributor are recorded in probability distributions. (e.g. the uncertainty in picking a horizon on a 2D or 3D seismic survey is represented as a range of possible values in stead of one exact pick). Monte Carlo analysis is performed in order to determine how these uncertainties propagate into the final model. Figure 3 shows an example of the uncertainties in the base of the Chalk Group from both the NCP-1 model and the current NCP-2 model.

References

Duin, E.J.T., Doornenbal, J.C., Rijkers, R.H.B., Verbeek, J.W. & Wong, Th.E. [2006]. Subsurface structure of the Netherlands – results of recent onshore and offshore mapping. Netherlands Journal of Geosciences 85(4), 245-276.

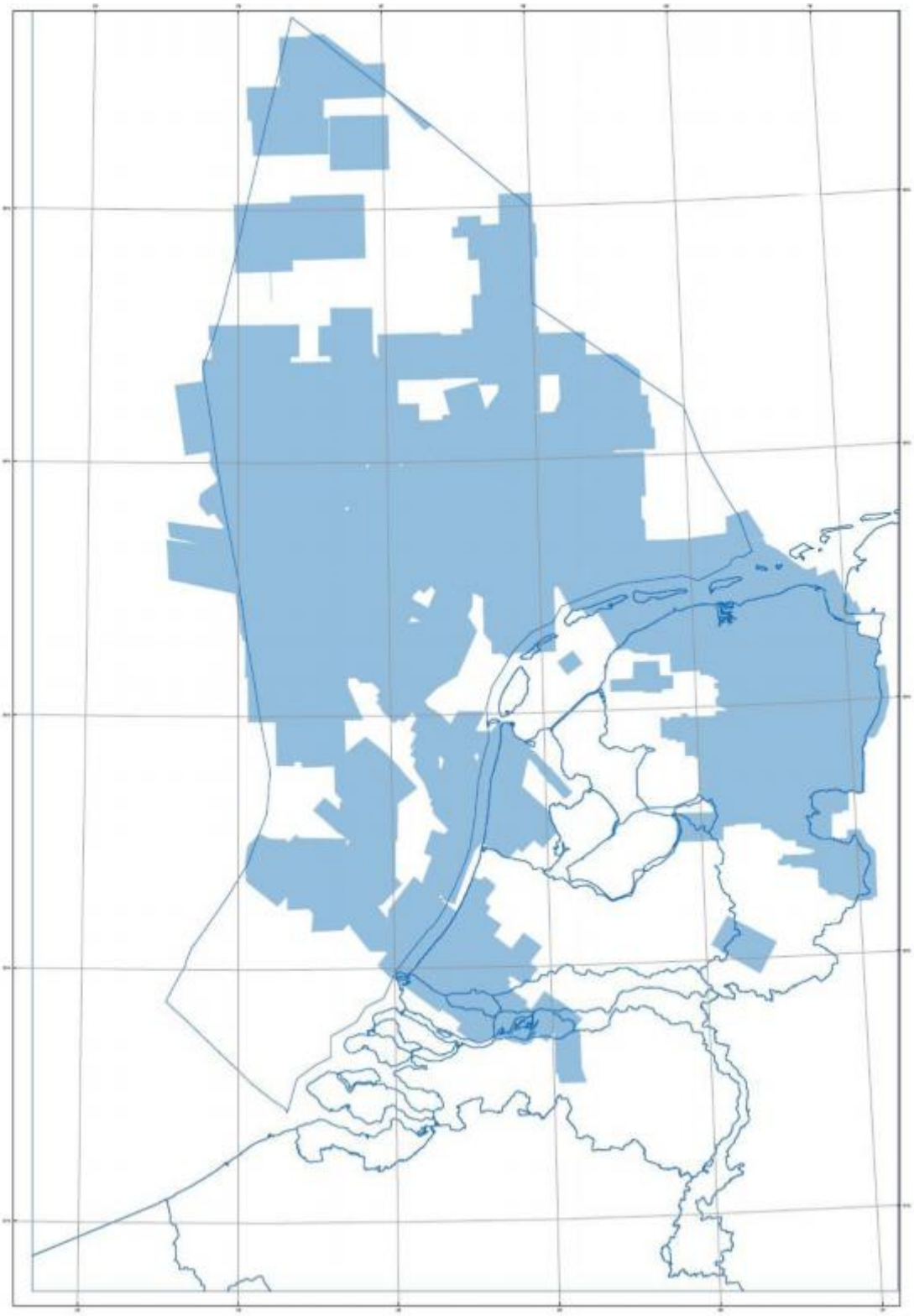


Figure 1: Location of 3D seismic surveys in the Netherlands, on- and offshore

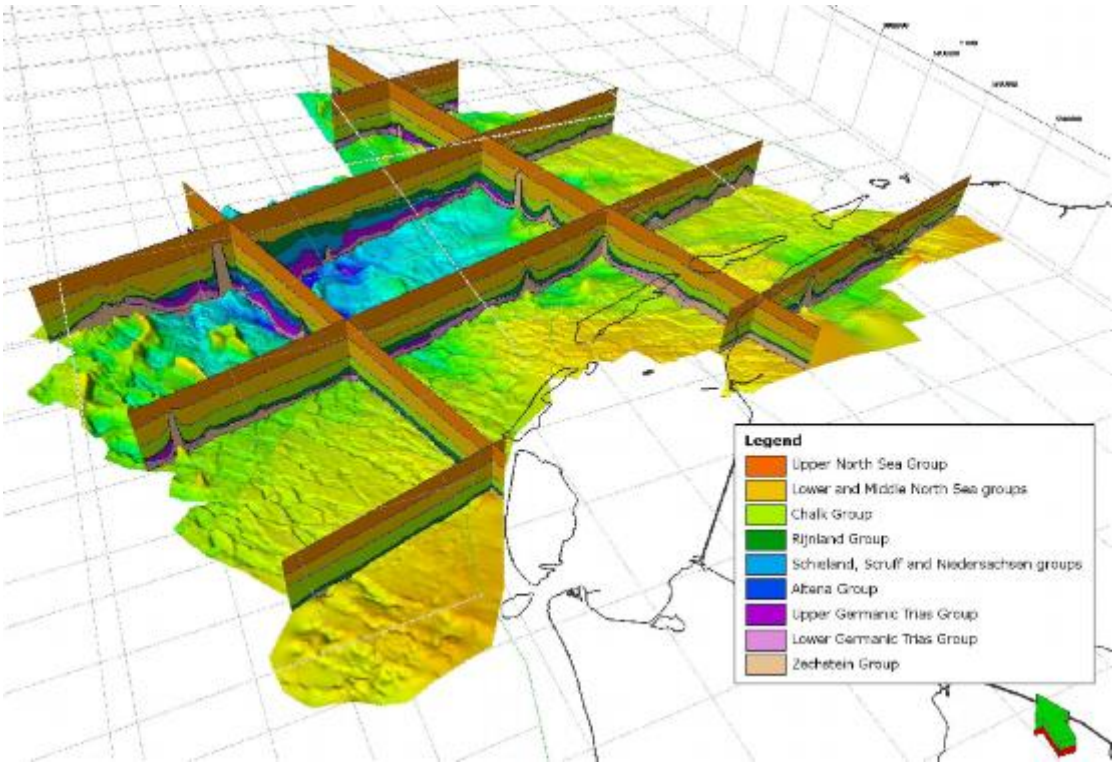
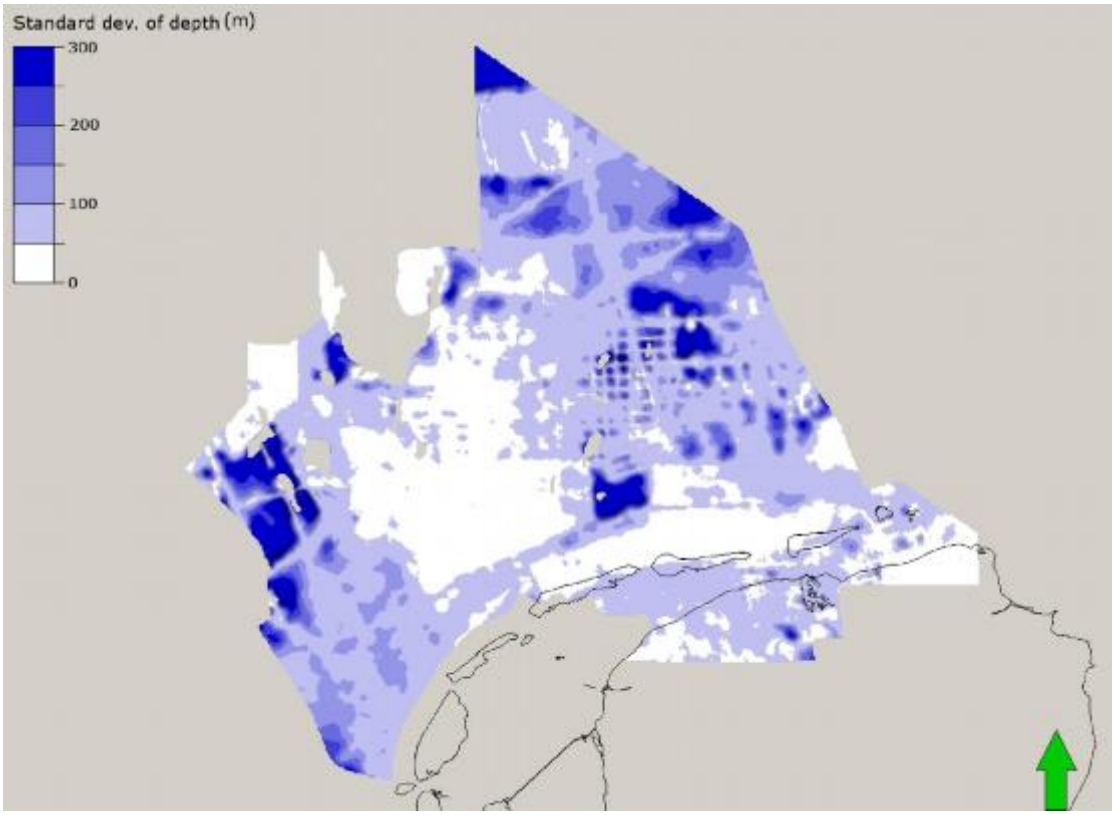


Figure 2: Example of the NCP-2 model with the base Zechstein surface and overlying units in mapping areas NCP-2A, B and E. The upper layer in the cross sections represents the Upper North Sea Group. Legend:



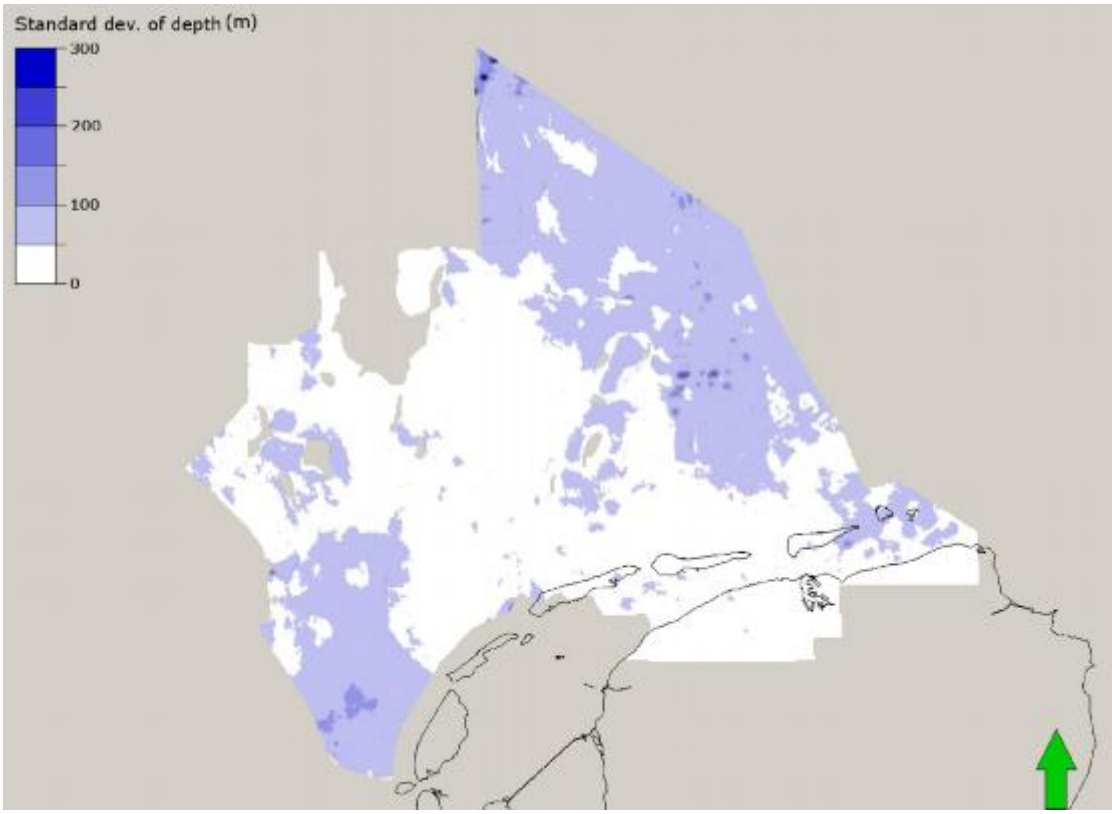


Figure 3: Comparison of uncertainties in the base Chalk Group between the NCP-1 (a) and NCP-2 (b) mapping project. The reduction of uncertainties in the NCP-2 model is predominantly due to the incorporation of 3D seismic surveys.

Zur Geologie des Himmelmoores bei Quickborn (Schleswig-Holstein)

Fuest, T., Menzel, P. & Grube, A.

Das Untersuchungsgebiet liegt nordwestlich von Hamburg im Kreis Pinneberg. Mit etwa 6 km^2 Moorfläche ist es eines der größten Hochmoore Schleswig-Holsteins. Davon werden 1,3 km^2 industriell für den Torfabbau genutzt. Dabei wird vor allem der Weißtorf zur Bodenverbesserung im Gartenbau verwendet. Da im Himmelmoor nicht mehr viel Weißtorf abgebaut werden kann, wird er aus dem Baltikum importiert, und mit hier gewonnenem Schwarztorf vermengt. Bis 2020 ist der schrittweise Rückzug aus dem Abbaugebiet vorgesehen. Im Zuge des industriellen Torfabbaus wurden umfangreiche Drainiermaßnahmen innerhalb des Moores durchgeführt. Landeseigene Moorflächen (ca. 410 ha) werden durch den Werksinhaber (Torfwerk Carl Hornung, Neumünster) während der laufenden Abbauarbeiten umfangreich renaturiert und wiedervernässt. Die Entwässerung erfolgt über die beiden Vorfluter Pinnau und Bilsbek und schließlich in die Elbe. Durch diese Entwässerung kam es zu Sackungen innerhalb des Moorkörpers, welche heute bis zu 40 % der ehemaligen Mächtigkeit ausmachen können. Eine kleine Fläche des Himmelmoores wird durch eine ursprüngliche Hochmoor-Oberfläche eingenommen.

Die umgebende Landschaft in der Barmstedt-Pinneberger Geest ist geprägt durch häufig bindige saalezeitliche Ablagerungen. Das Himmelmoor entstand im Bereich einer Randsenke westlich des Salzstocks Quickborn. Die die doppelsalinare Struktur maßgeblich aufbauenden Rotliegendgesteine steigen seit dem Jura auf und durchstießen im Untermiozän das Deckgebirge. Über dem abwandernden Salz entstand eine Senkungszone, der Pinneberger Trog als Teil des Hamburger Supertrogs. Tertiäre Sedimente bilden in diesem Trog mächtige Ablagerungen, die Braunkohlensande sind aus wasserwirtschaftlichen Gesichtspunkten von besonderer Bedeutung. Während der Elstervereisung wurde im heutigen westlichen Bereich des Himmelmoores die NNW-SSE-streichende, ca. 300 m tiefe Ellerbeker Rinne bis in die tertiären Sedimente angelegt. Sie wurde anschließend mit Schmelzwassersanden, Tonen und Geschiebemergeln verfüllt. Überlagert werden diese Schichten von saalezeitlichen Tills sowie saale- und weichselzeitlichen Schmelzwassersanden. Im Holozän bildeten sich an verschiedenen Stellen des ehemaligen weichselzeitlichen Abflusssystems Stillgewässer, in denen Mudden zur Ablagerung kamen. Durch eine zunehmende Verlandung erfolgte ein Wechsel des Ablagerungsgeschehens. Es bildete sich Phragmites-Carex-Torf, welcher später von einem Birken-Bruchwaldtorf abgelöst wurde. Im Atlantikum führten erhöhte Niederschläge und ein gestiegener Grundwasserspiegel zum Absterben der Waldvegetation und zur Verbreitung des Torfmooses Sphagnum.

Im Zuge einer Diplomkartierung wurde das Himmelmoor mit Hilfe von Sondierungen, tieferen Rammkernsondierungen (bis 25 m Teufe) und Schürfen untersucht und die Ergebnisse hinsichtlich des Aufbaus und der Entstehung des Moorkomplexes interpretiert.

Der jüngste im Untersuchungsgebiet angetroffene Till konnte aufgrund seiner grauen Farbe, seiner feinkörnigen Zusammensetzung (schluffreich) und einem signifikanten Kreideanteil der Mittleren Saale zugeordnet werden. Er kommt außerhalb des eigentlichen Moorgebietes flächenhaft in geringer Tiefe (> -5 m GOK) vor, unterhalb des Moorkörpers ist er lückenhaft ausgebildet, was möglicherweise auf schmelzwasserbedingte Erosionsprozesse zurückzuführen ist. Die außerhalb des Himmelmoores gelegenen Tills flankieren als höher gelegene Bereiche eine Senkungsstruktur, in der sich das Moor bildete. Die Senke liegt zwischen den Vorflutern Bilsbek im Nordwesten und Pinnau im Osten und zeichnet den Verlauf der heutigen Bilsbek (NE – SW) nach. Die durchgeführten Bohrungen zeigten, dass die Senke mit Dekameter mächtigen, vorwiegend sandigen Ablagerungen verfüllt ist. Hierbei handelt es sich um schlecht bis gut sortierte, glazifluviatile Mittel- und Feinsande. Äolische

Sedimente konnten in den Bohrungen nicht nachgewiesen werden, jedoch sind im Moorgebiet zwei exponierte Bereiche mit fehlender bzw. nur geringer Torfbedeckung angetroffen worden. Diese sind aus gut sortierten Feinsanden aufgebaut und können als Dünen interpretiert werden. Der Moorkörper des Himmelmoores konnte grob in drei Einheiten unterteilt werden: Mudden, Schwarztorfe und Weißtorfe. Mudden, meist Torfmudden, wurden an der Basis des Moores nachgewiesen, jedoch ist ihre Verbreitung nicht flächenhaft. Im nördlichen Teil des Moores sind sie recht stark und in größeren Mächtigkeiten (bis zu 2 m) vertreten, während im südlichen Teil nur sporadisch geringmächtige Mudden (< 0,7 m) erbohrt wurden. Mit 6,90 m NN liegt die Moorbasis im Norden auch auf dem niedrigsten Level. Diese Tatsachen lassen den Schluss zu, dass die durch Verlandung initiierte Moorentstehung in diesem Teil begann. Der hangende Schwarztorf, welcher durch seinen hohen Zersetzungsgrad vom Weißtorf zu unterscheiden ist, kommt im gesamten Moor flächendeckend vor. Innerhalb des Schwarztorfes konnten Reste von Sphagnum, Eriophorum und Gehölzen nachgewiesen werden. Es zeigte sich, dass der Schwarztorf Mächtigkeiten von max. 2,20 m erreicht. Im Hangenden der Schwarztorfe (scharfer Kontakt - SWK) bildeten sich Weißtorfe, die durch ihren geringen Zersetzungsgrad und ihre fast ausschließlich auf Sphagnum basierende Zusammensetzung zu identifizieren sind. Heute finden sich Weißtorfvorkommen nur noch im Norden und Nordosten des Himmelmoores. Auf dem „Knust“, einem nicht torfwirtschaftlich genutzten Bereich des Moores, wurde mit 3,80 m (bei einer Gesamttorfmächtigkeit von 7,85 Metern) die größte Weißtorfmächtigkeit innerhalb des Himmelmoores festgestellt. In einigen Bohrprofilen wurde umgelagerter Weißtorf in größerer Tiefe angetroffen, was darauf zurückzuführen ist, dass seit mehr als 200 Jahren Torf als Brennmaterial gewonnen wurde, und der Weißtorf auf Grund seines geringeren Brennwertes flächenhaft in bereits abgebaute Gebiete verbracht worden ist. Somit ist die Stratigraphie des Moorkörpers zum Teil anthropogen überprägt.

Tobias Fuest, cand. geol., Universität Hamburg, MIN Fakultät, Department Geowissenschaften, Geibelstraße 43, 22303 Hamburg, tobias.fuest@gmx.de

Philip Menzel, cand. geol., Universität Hamburg, MIN Fakultät, Department Geowissenschaften, An der Moorkuhle 9, 22145 Braak, PhilipMenzel@gmx.de

Dr. Alf Grube, Geologischer Dienst, Landesamt für Landwirtschaft, Umwelt und Ländliche Räume des Landes Schleswig-Holstein, Abt. Geologie und Boden, Hamburger Chaussee 25, 24220 Flintbek, alf.grube@llur.landsh.de

Westward extension of Rhine-Meuse delta maps

M.P. Hijma, I.J. Bos, K.M. Cohen*, E. Stouthamer, W.Z. Hoek
Utrecht University | Dept. Physical Geography | www.geo.uu.nl/fg/palaeogeography
PO Box 80.115, 3508 TC Utrecht, the Netherlands | k.cohen@geo.uu.nl

The 'Berendsen & Stouthamer (2001)' map of the Rhine-Meuse delta, produced at Utrecht University, has become the reference map for channel belt age in the Netherlands. Research projects over the last decade have added new data, improving our insight in development of the natural environment.

We are now updating the map (2009-2010), extending coverage seaward, to include the river mouth, lagoonal fringe and coastal barrier. The covered area is now extended:

1. Westward to the North Sea barrier coast (PhD thesis Hijma; Rotterdam-Leiden)
2. Northward to the Zuiderzee lagoon (PhD thesis Bos; Utrechtse Vecht).

We have synchronized these mapping and dating activities, with efforts by TNO B&O / Deltares / | Geological Survey of the Netherlands to construct 3D subsurface models.
We are in frequent exchange with archeological prospectors and engineers involved in numerous ongoing infrastructural projects and marine geologists to connect our mapping to seismic data from the shallow offshore.

Improved resolution has allowed to detail the palaeogeography of the Early, Middle and Late Holocene landscapes in the western Netherlands. The exercise highlights the interrelations of evolution of 'coastal barrier' and 'back-barrier Rhine delta'. Linking these two in sequence stratigraphic schemes opens new ways to use the Holocene Rhine-delta as a modern analogue / facies model archetype in ancient reservoirs.

Coastal, lagoonal and river landscape reconstruction at last is connected!

Selected publications:

Berendsen, H.J.A. & **Stouthamer, E.** (2000), Late Weichselian and Holocene palaeogeography of the Rhine-Meuse delta, The Netherlands. Palaeogeography, Palaeoclimatology, Palaeoecology 161 (3/4), p. 311-335

Berendsen, H.J.A. & **Stouthamer, E.** (2001). Palaeographic development of the Rhine-Meuse delta. Assen: Koninklijke van Gorkum., 268 pp., 3 folded maps + CD-ROM.

Cohen, K.M. (2005). 3D geostatistical interpolation and geological interpolation of palaeo-groundwaterrise within the coastal prism in the Netherlands. In L. Giosan & J.P. Bhattacharaya (Eds.), river Deltas: Concepts, models, and examples (SEPM Special Publication, 83) pp. 341-364.

Cohen, K.M. & Hijma, M.P. (2008). De ontwikkeling van het Rijnmondgebied in het Vroeg Holoceen: inzichten uit een diepe put bij Blijdorp (Rotterdam). Grondboor & Hamer, 2008-3/4, 64-71.

Hijma, M.P., Cohen, K.M., Hoffmann, G., Van der Spek, A.J.F., **Stouthamer, E.** (2009) From river valley to estuary: the evolution of the Rhine mouth in the early to middle Holocene (western Netherlands, Rhine-Meuse delta). Netherlands Journal of Geosciences — Geologie en Mijnbouw | 88 (1), pp. 13-53.

Tertiary dinocyst research at TNO Geological Suvey of the Netherland

Dirk K. Munsterman and Roel C.M.H. Verreussel

Dinocysts of a cored Plio-Pleistocene transition from the central North Sea
A set of discrete core and side-wall core samples consisting of soft silts and clays from two closely spaced wells of the Netherlands Continental Shelf (southern North Sea) have been studied for dinoflagellate cysts. The high resolution study aims at the interval associated with the onset of northern Hemisphere glaciations, coinciding with the basal part of the Matuyama Chron. The Sea Surface Temperature (SST) signal extracted from the dinocyst distribution reveals a strong correlation with the cyclic pattern of the Gamma Ray log (GR). Warm phases (dominated by Operculodinium israelianum and/or Lingulodinium machaerophorum) correspond with low GR readings (predominantly silts), cold phases (dominated by the genera Filisphaera, Habibacysta, Bitectatodinium and/or Brigantedinium) correspond with high GR readings (predominantly clays). The Marine/Terrestrial ratio (M/T) also displays a strong correlation with the GR: low GR readings correspond with high M/T ratios, high GR readings with low M/T ratios. Reworked dinocysts are most abundant in the cold intervals. These results indicate that the coarsest sediments correlate with the warmest phases and the highest sea levels, while the finest sediments correlate with the coldest phases and the lowest sea levels. The distribution curves for the outer neritic to oceanic taxa Amiculosphaera umbracula and Nematosphaeropsis lemniscata support that conclusion. The strong climate signal expressed by the dinoflagellate cysts is interpreted to reflect the 40.000 obliquity signal. Through extrapolation of the Gauss-Matuyama boundary, pin-pointed in one of the two wells, the displayed warm-cold cycles could be correlated to the marine isotope stages 103 to 95.

Integrated stratigraphical study emphasizing Miocene dinocyst distribution
Recent drilling of relatively well-developed marginal marine Miocene successions from the Dutch Southern North Sea Basin provided an opportunity to establish a first-ever dinocyst zonation for this region (SE part of the Netherlands). Recognition of consistent dinocyst events between multiple boreholes allow to propose fourteen zones for the Miocene. By combining information from calcareous microfossils, sequence stratigraphic analysis, and previous dinocyst studies, a meaningful age-model has been developed.

Eocene-Oligocene boundary Zeeuws-Vlaanderen (E-W profile)
The Eocene/Oligocene boundary can be traced through a number of wells in the Zeeuws-Vlaanderen area (SW Netherlands). Because of distinct differences in lithology, classic lithostratigraphical correlation fails. The application of dinocyst stratigraphy allows accurate correlations and reveals that the grainsize trends, expressed in the GR log, are synchronous over considerable distances.

The Woensdrecht borehole, Southeastern North Sea: Upper Paleocene-Lower Eocene strata
The Paleocene-Eocene thermal maximum or PETM represents a geological brief time interval characterized by a global warming and associated environmental change. In proximal Dutch wells (SW Netherlands) we report a dramatic response of Apectodinium (>90 %) replacing the late Paleocene dominance of “open-marine” Spiniferites and Areoligera gippingensis. During Eo-1 HST the lagoonal setting is affected by subaerial exposure, while the more distal borehole Raalte shows increasing lagoonal influence at Eo-1 HST. Sequence Eo-2 is characterized by an overall marine flooding (Spiniferites dominance) followed by a return to lagoonal conditions in the near coastal areas such as Woensdrecht. This second acme of Apectodinium might be associated with an Early Eocene climatic optimum recently described as the Elmo event. Overall open marine conditions are reached during sequence Eo-3.

Sesshaft im Netz. Die neue Domain der Arbeitsgemeinschaft Norddeutscher Geologen unter www.arge-ndg.de.

Konrad Schuberth
Landesamt für Geologie und Bergwesen Sachsen-Anhalt, Köthener Straße 38, 06118 Halle (Saale), Deutschland.
E-Mail: schuberth@lagb.mw.sachsen-anhalt.de, Tel.: (0345) 5212-135

Die Erfolgsgeschichte der Arbeitsgemeinschaft Norddeutscher Geologen (Arge NDG) währt nun schon 82 Jahre. Teilnehmerzahlen von 150 und mehr belegen das ungebrochene Interesse an den jährlich stattfindenden Exkursionstagungen mit ihrem breiten wissenschaftlich-praktischen Spektrum und der Möglichkeit zur intensiven fachlichen Kommunikation der Teilnehmer an Aufschluss und Biertisch.

Wer einmal dabei war, kommt alljährlich gern wieder und mobilisiert nicht selten auch Kollegen oder Bekannte zur Teilnahme an der in ihrer Art einzigartigen Gemeinschaft. Tagungsankündigungen und -berichte in Fachzeitschriften und Regionalzeitungen tragen die Aktivitäten der Arge NDG seit jeher in die Öffentlichkeit und sorgen für einen ständig nachwachsenden Teilnehmerkreis.

Mit der Etablierung eigener Internetauftritte haben die jeweils verantwortlichen Geologischen Dienste (GD) seit knapp 10 Jahren eine weitere Plattform, um auf speziellen, temporär eingerichteten Webseiten Vorbereitung und Durchführung der Tagungen zu begleiten und neue Teilnehmer zu werben. Während das regionale Rotationsprinzip (zwischen den beteiligten GD) ein Gewünschtes ist, hat die damit verbundene mediale Karussellfahrt durchaus ihre Schattenseite: Die Auffindbarkeit der jeweils aktuellen Tagungsinformationen ist auch bei Benutzung von Suchmaschinen umständlich, die Programme und Vorträge vergangener Veranstaltungen sind nur in Bruchstücken recherchierbar.

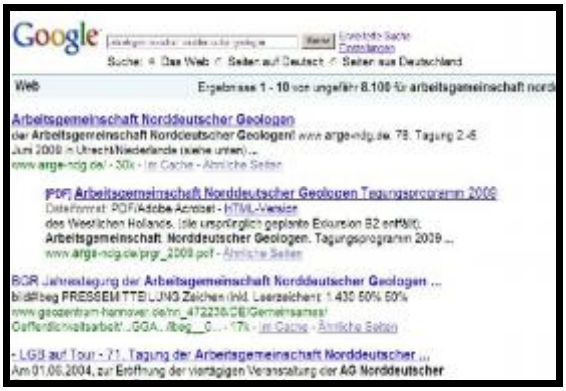


Abb. 1: Screenshot einer Suche mit Google nach „Arbeitsgemeinschaft Norddeutscher Geologen“. Die Webseite www.arge-ndg.de ist u. a. mit den Internetauftritten von www.deuqua.de und www.geo-aktuell.de verlinkt und wird von vielen Suchmaschinen als erster Treffer aufgelistet. Aufwändiges Forschen nach den aktuellen Tagungsinformationen hat damit ein Ende.

Dem Rechnung tragend, wurde am 06.09.2008 mit der Domain www.arge-ndg.de eine zentrale Anlaufstelle geschaffen, die das Aufspüren aktueller Informationen erleichtern und die Darstellung des von den Mitgliedern der Arge Geleisteten verbessern soll (Abb. 1 u. 2).

Wichtigstes Anliegen war die Bereitstellung neuester Daten zur jeweils kommenden Tagung und zu den hiermit verbundenen Formalitäten (Anmeldung, Programm, Autorentermine usw.).

Die Rubriken „Wir über uns“, „Persönlichkeiten“ und „Literatur“ machen mit dem Selbstverständnis der Arge NDG bekannt und geben einen knappen Überblick über ihre spannende historische Entwicklung.

Der vorerst nur spärlich gefüllte Bereich „Downloads“ soll vor allem der online-Publikation der Tagungs- und Exkursionsführer dienen. Die nur in Kleinstauflagen erschienenen Bände sind als „graue Literatur“ sämtlichst vergriffen und nur selten in Bibliotheken archiviert. Als pdf-Dateien bereit gestellt, werden Sie nicht nur einem breiten Interessentenkreis zugänglich gemacht, sondern werben zugleich für die Arge und ihre Autoren.

Abb. 2: Screenshot der Startseite www.arge-ndg.de.

Die schnörkellose, unkompliziert strukturierte Seite zielt auf schnelle und kompakte Information. Eine optische, vor allem aber inhaltliche Aufwertung bedarf der aktiven Mitwirkung aller.

Folgende Vorschläge für die Weiterentwicklung der Webseite stehen zur Diskussion:

- Die bisher privat finanzierte Domain www.arge-ndg.de wird als offizieller Internetauftritt der Arge NDG anerkannt. Die jährlich beim Provider „1 & 1 Internet AG“ anfallenden Kosten von 35,88 EUR (monatlich 2,99 EUR) werden zukünftig aus dem Etat der Arbeitsgemeinschaft finanziert.
- Die Einstellung aktueller Mitteilungen (Einladung, Zirkulare usw.) übernehmen der Autor oder einer seiner Kollegen am Landesamt für Geologie und Bergwesen Sachsen-Anhalt in Halle (Saale). Selbstverständlich können die jeweils verantwortlichen Geologischen Dienste unabhängig davon weiterhin Informationen zur jeweiligen Tagung auf ihren Webseiten veröffentlichen. Links von der Arge-NDG-Webseite auf die der Geologischen Dienste sichern auch diesen eine verbesserte Auffindbarkeit.
- Tagungsprogramme, Tagungsbände/Exkursionsführer und Tagungsberichte werden im download-Bereich als pdf-Dateien zum Nachlesen und Ausdrucken zur Verfügung gestellt.

Mapping of marine channels from digital elevation data (AHN) using Topographic Position Index

Tamara van der Ven
Deltares/TNO - Geological Survey of the Netherlands, Princetonlaan 6,
NL-3508 TA Utrecht, The Netherlands

Abstract: A detailed digital elevation model of the Netherlands (AHN) based on laser-altimetry data can be used to aid the mapping of shallow geological features. In the Provence of Zeeland a semi-automatic method using Topographical Position Index (TPI) has been developed to extract geological features in the Walcheren Member of the Naaldwijk Formation. Former marine tidal channels with a sandy fill are visible as small ridges because of compaction of the surrounding peat and clay. In the past channels in this member were mapped based on boreholes and visible elevation differences. However, the current resolution of the AHN enables to map even the slightest difference in elevation not visible for the human eye in an efficient way using the TPI.

TPI is a measure for the relative elevation of a point compared to its surroundings. TPI is scale-dependent; the same point on a levee might be considered as a high point in the local environment or as a low point viewed from the entire incised river valley. The result of the TPI is a classification with ridges and low areas. Taking into account human interference like excavation of peat, the ridges can be considered as channels in the Walcheren Member.

Uncovering physical and chemical properties of the shallow subsurface of the Netherlands

Ronald Vernes
Deltares/TNO - Geological Survey of the Netherlands, Princetonlaan 6,
NL-3508 TA Utrecht, The Netherlands

The current geological and hydrogeological models DGM and REGIS describe the subsoil of the Netherlands at a regional scale. Most hydrogeological, environmental and geotechnical research however requires more detailed knowledge of the upper part of the subsoil. In 2006 a new project TOPINTEGRAAL was launched by Deltares/TNO Geological Survey of the Netherlands. The goal of this project is to create a detailed 3D lithofacies model of the shallow subsurface, up to a depth of about 30 meters, with associated property models. The collection, interpretation and publication of grain size, hydraulic, geochemical and geotechnical data and characteristics of the (facies) units that are present in the shallow subsurface is part of TOPINTEGRAAL. Over the years around 300 new cored wells will be drilled. From each of these wells samples are taken and tested/analysed to determine their physical and chemical properties. The results are interpreted per region, not only creating a unique dataset for the parameterization of the 3D-model but also providing researchers with information on the physical and chemical characteristics of the units present.

In the spring and summer of 2009 the analyses and interpretation of data collected from the three Northern provinces Groningen, Friesland and Drenthe will take place. Publication of the first results is expected in the second half of 2009.

Pleistocene ice margins and glaciotectonics in Saxony-Anhalt

Stefan Wansa
Landesamt für Geologie und Bergwesen Sachsen-Anhalt
Pf. 156, D-06035 Halle, Germany
E-Mail: wansa@lagb.mw.sachsen-anhalt.de

Saxony-Anhalt is mainly covered by glacial sediments from the Elsterian and Saalian glaciations and is a part of the type region of the Elsterian Cold Stage and the Saalian Complex.

The Elsterian is represented by sedimentary cycles consisting of meltwater deposits and tills of two ice advances (Zwickau Glacial Formation and Markranstädt Glacial Formation in the Saale-Elbe area, Eissmann 1975, 1997, Litt & Wansa 2008). The first Elsterian glaciation was most extensive and reached up to the foot of the Thuringian and Saxonian mountains (300–500 m a.s.l.) as indicated by the so called “flint line”. Large ice-dammed lakes were developed in front of the ice shield and the ice ingressed rapidly without disturbing the subsurface (600–900 m/a in the Leipzig Lowland, Junge 1998). The maximum extent of both Elsterian ice advances is not represented by distinct end moraines, but subsequent oscillations formed thrust moraines farther to the East in Saxony (southern Dübener Heide and Dahlener Heide) (Ehlers et al. 2004).

The Saalian was different when compared to the Elsterian glaciations. Two main sedimentation sequences can be distinguished connected with the Drenthe Stadium and the Warthe Stadium. In the Saale-Elbe area the Drenthe Stadium is subdivided in two advance phases, which are documented by two or three sedimentary cycles (Zeitz Glacial Formation and Leipzig Glacial Formation, Eissmann 1975, 1997, Litt & Wansa 2008). During the first or Zeitz Phase, the Saalian ice sheet reached its maximum extent but, because of the absence of end moraines, the course is not very clear in most areas. The Zeuchfeld outwash plain is one of the important points for indicating the Saalian outer margin. The ice advanced quickly, overriding varved clay and silt of the ice-dammed lakes. The following downwasting stopped a few kilometres north of Halle and Leipzig. The ice retreat, as well as the re-advance during the Leipzig Phase, were accompanied by oscillations of the ice margin and the creation of end moraines.

New results from geological mapping demonstrate that the first stop of ice melting after the maximum extent (accompanied with a short re-advance) is probably represented by the Langeneichstädt end moraine not far behind the outermost margin south west of Halle (Meng & Wansa 2008). The Leipzig Phase is correlated with the Petersberg end moraine, which consists partly of deposited material and partly of thrust moraine. This end moraine can be followed from the Magdeburg area to Halle and farther to the end moraines north of Leipzig. Afterwards the inland ice probably retreated to the Baltic Sea basin and then re-advanced in the Warthe Stadium to the Colbitz-Letzlinger Heide and the Fläming area. In these regions the Warthe maximum position cannot be delineated exactly, because of the close connection with older landforms and with partial superposition on Drenthe end moraines. The Planken-Calvörde end moraine was formed during the Drenthe glaciation and was not reached by the Warthe ice. To the north, a group of several rather indistinct end moraines occurs that were overridden by the Warthe ice. Of this group the Letzlingen end moraine may be regarded as the maximum position of the Warthe ice in this area (v. Poblozki 1995). A Warthe ice advance beyond the present Elbe valley up to the Schmiedeberg end moraine seems likely (Knoth 1995, Eissmann 1997). This thrust moraine is characterised by very intensive disturbances (folding, shearing) of the underlying Quaternary and Tertiary beds down to more than 100 m. The ice lobe was at least 20 km wide and reached the area from NE.

In general in the Saale-Elbe region the first ice advances of both the Elsterian and the Saalian progressed, with short oscillations, rapidly towards the south without causing major disturbances of the subsurface. In contrast, the later ice advances in some areas have caused deep-reaching glaciotectonic deformations. The cause for this effect may have been a strongly reduced or totally lacking permafrost in the later glaciation phases (Eissmann 1987).

New infrared radiofluorescence ages (IR-RF) from the Leipzig Lowland and the Niederlausitz provide evidence that the non-glaciated Saalian lasted here at least from about 300 ka to about 150 ka. Therefore the Saalian glaciations (Drenthe and Warthe) are confined to the period between 150 ka and 130 ka (end of MIS 6) (Krbetschek et al. 2008).

Finally, the landscape of Saxony-Anhalt is superimposed by periglacial processes of the Weichselian cold stage. The Weichselian ice (Brandenburg Stadium) reached Saxony-Anhalt in the very north east only (Kamern Hills).

Literature:

Ehlers, J., Eissmann, L., Lippstreu, L., Stephan, H.-J. & Wansa, S (2004): Pleistocene Glaciations of North Germany. – In: Ehlers, J. & Gibbard, P. L. (eds.): Quaternary Glaciations – Extent and Chronology, Part I Europe. – Developments in Quaternary Science, vol. 2a: 135–146; Amsterdam (Elsevier).

Eissmann, L. (1975): Das Quartär der Leipziger Tieflandsbucht und angrenzender Gebiete um Saale und Elbe. – Schriftenr. geol. Wiss., 2: 1–263; Berlin.

Eissmann, L. (1987): Lagerungsstörungen im Lockergebirge. Exogene und endogene Tektonik im Lockergebirge des nördlichen Mitteleuropa. – Geophysik u. Geologie, III: 7–77; Berlin.

Eissmann, L. (1997): Das quartäre Eiszeitalter in Sachsen und Nordostthüringen. – Altenburger naturwiss. Forsch., 8: 1–98; Altenburg.

Eissmann, L., Litt, T. & Wansa, S. (1995): Elsterian and Saalian deposits in their type area in central Germany. – In: Ehlers, J., Kozarski, S. & Gibbard, P. (eds.), Glacial deposits in North-East Europe, 439–464; Rotterdam (Balkema)

Junge, F. W. (1998): Die Bändertone Mitteldeutschlands und angrenzender Gebiete. – Altenburger naturwiss. Forsch., 9: 1–210; Altenburg.

Knoth, W. (1995): Sachsen-Anhalt. – In: Benda, L. (Hrsg.), Das Quartär Deutschlands, 148–170; Berlin (Bornträger).

Krbetschek, M. R., Degering, D. & Alexowsky, W. (2008): Infrarot-Radiofluoreszenz-Alter (IR-RF) unter-saalezeitlicher Sedimente Mittel- und Ostdeutschlands. – Z. dt. Ges. Geowiss., 159/1: 133–140; Stuttgart.

Litt, T. & Wansa, S. (2008): 4.13 Quartär. – In: Bachmann, G., Eichner, R., Knoth, W. & Schwab, M. (Hrsg.), Geologie von Sachsen-Anhalt, 293–325; Stuttgart (Schweizerbart).

Meng, S. & Wansa, S. (2008): Sedimente und Prozesse am Außenrand der Saale-Vereisung südwestlich von Halle (Saale). – Z. dt. Ges. Geowiss., 159/2: 205–220; Stuttgart.

Poblozki, B. v. (1995): Quaternary geology of the Altmark region. – In: Ehlers, J., Kozarski, S. & Gibbard, P. (eds.), Glacial deposits in North-East Europe, 473–484; Rotterdam (Balkema).

Stottmeister, L., Poblozki, B. v. & Reichenbach, W. (2008): 5.2 Altmark-Fläming-Scholle. – In: Bachmann, G., Eichner, R., Knoth, W. & Schwab, M. (Hrsg.), Geologie von Sachsen-Anhalt, 348–369; Stuttgart (Schweizerbart).

Hydrogeologische Typstandorte und Grundwasserneubildung ein Aspekt des Klimafolgenmanagements

Tina WIXWAT[1] & Herbert RÖHM [2]
Landesamt für Bergbau, Energie und Geologie, Stilleweg 2, 30655 Hannover,
[1]tina.wixwat@lbeg.niedersachsen.de, [2] herbert.roehm@lbeg.niedersachsen.de

Im Rahmen des Verbundprojektes „Regionales Management von Klimafolgen in der Metropolregion Hannover-Braunschweig-Göttingen-Wolfsburg“ werden im Teilprojekt „Wasserwirtschaft“ unter anderem die möglichen Auswirkungen des Klimawandels auf den Grundwasserhaushalt untersucht. Nach Nakicenovic & Swart (2000) soll es zu einer Verschiebung der Niederschläge von den Sommer- in die Wintermonate kommen. Es soll nun ermittelt werden, wie groß der Einfluss dieser Verschiebung in der Metropolregion sein wird. Neben Veränderungen der Grundwasserneubildungshöhe sollen die Einflüsse auf den Grundwasserstand bzw. seine innerjährlichen Schwankungen abgeschätzt werden. Da in Niedersachsen 86 % des Trinkwassers aus dem Grundwasser stammen (Reutter, 2005), ist es im Sinne einer nachhaltigen Grundwasserbewirtschaftung von großer Bedeutung diejenigen Bereiche zu identifizieren, in denen es zu Einflüssen auf die Grundwasserneubildungshöhe und Veränderungen des Grundwasserspiegels kommen kann.

Zur Auswertung von Wasserstandstandsdaten (Grundwasserstandsganglinien) im geologisch-hydrogeologischen Kontext wurden zunächst Hydrogeologische Typstandorte definiert. Zu diesem Zweck wurden auf Basis der HÜK500 „Hydrogeologische Einheiten“ (LBEG, 2008) und HÜK500 „Hydrogeologische Räume und Teilräume“ (LBEG, 2009) das Projektgebiet in die folgenden Hydrogeologischen Typstandorte unterteilt:

- Lockergestein
  - Ia Lockergestein des Niedersächsischen Tieflandes (Geest)
  - Ib Lockergestein des Niedersächsischen Tieflandes (Niederung)
  - Ic Lockergestein im Bergland und Bergvorland, tertiäre Sedimente
- Festgestein
  - IIa Festgestein, karbonatisch
  - IIb Festgestein, silikatisch
  - IIc Festgestein ungegliedert
  - IId Harz

Für jeden Hydrogeologischen Typstandort sollen durch statistische Auswertung die für diesen charakteristische Grundwasserganglinie hergeleitet und in Relation zu den Niederschlägen gebracht werden. Einerseits können damit Rückschlüsse auf die standorttypische Amplitude der Wasserstandsschwankungen gezogen und zum anderen sollen Aussagen über die innerjährliche Verteilung der Grundwasserneubildungsmenge gemacht werden.

Im Weiteren Verlauf des Projektes sollen die ermittelten prozentualen monatlichen Grundwasserneubildungsanteile mit den Klimaszenariodaten des regionalen Klimamodells „CLM“ (Hollweg et al., 2008) in das Grundwasserneubildungsmodell GROWA06v2 (Lemke & Elbracht, 2008) eingehen, um eine mögliche Veränderung der Grundwasserneubildungshöhe und die Änderung im Jahresgang durch den Klimawandel zu erkennen.
Im Rückschluss soll aus der Veränderung der zukünftigen innerjährlichen Grundwasserneubildungsverteilung wiederum auf mögliche Änderungen der Amplitude der Grundwasserganglinie geschlossen werden. Damit könnten dann Bereiche benannt werden, in denen größere Grundwasserstandsschwankungen zu erwarten sind.

Dazu wurden im Gebiet der Metropolregion bisher ca. 260 Grundwassermessstellen ausgewertet. Die Auswahl erfolgte nach folgenden Kriterien:

- Distanz zu Förderbrunnen,
- Lage des Filters und
- Distanz zu einem Vorfluter.

Die bisherige Auswertung hat gezeigt, dass in den Festgesteinsgebieten Niedersachsens nicht genügend Grundwassermessstellen vorhanden sind, um gesicherte Aussagen zu erhalten.

Literatur:

HOLLWEG, H.-D., BÖHM, U., FAST. I., HENNEMUTH, B., KEULER, K, KEUP-THIEL, E., LAUTENSCHLAGER, M., LEGUTKE, S., RADTKE, K., ROCKEL, B., SCHUBERT, M., WILL, A., WOLDT, M., WUNRAM, C. (2008): Ensemble Simulations over Europe with the Regional Climate Model CLM forced with IPCC AR4 Global Scenarios, Technical Report No. 3 – Max-Planck-Instiut für Meteorologie, 152 S.; Hamburg.

LEMKE, D. & ELBRACHT, J. (2008): Grundwasserneubildung in Niedersachsen. Ein Vergleich der Methoden Dörhöfer & Josopait und GROWA06V2. – Geoberichte 10, 61 S., 19 Abb., 24 Tab., Anh.; Hannover.

NAKICENOVIC, N. & SWART, R. (Hrsg.) (2000): IPCC Special Report on Emissions Scenarios. – Univ. Press Cambridge, 612 S.; Cambridge.

REUTTER, E. (2005): Hydrostratigrafische Gliederung Niedersachsens. - Geofakten 21. Niedersächsisches Landesamt für Bodenforschung, 9 S., Hannover.

LBEG (2008) – LANDESAMT FÜR BERGBAU, ENERGIE UND GEOLOGIE (Hrsg.): HÜK500 – Hydrogeologsiche Übersichtskarte von Niedersachsen und Bremen 1 : 500 000, Hydrogeologische Räume und Teilräume, Stand: August 2008.; Hannover.

LBEG (2009) – LANDESAMT FÜR BERGBAU, ENERGIE UND GEOLOGIE (Hrsg.): HÜK500 – Hydrogeologsiche Übersichtskarte von Niedersachsen und Bremen 1 : 500 000, Hydrogeologische Einheiten, Stand: März 2009; Hannover.

Link zum „Klimafolgenmanagementprojekt“: http://www.klimafolgenmanagement.de

Exkursion A1

Denkmäler aus Werksteinen und Gestein im Stadtbildt vom Utrecht -

A walk along monument stones in the City of Utrecht

Wim Dubelaar, Deltares, Utrecht

1. Introduction

As the Netherlands hardly have any building stones available in the subsurface nearly all natural stones have to be imported. In Utrecht the Romans built a fortification, a castrum, and used volcanic tuff from the Laacher See area as a building stone. In the Middle Ages tuff stone remained the most important natural stone for churches and castles. Fine examples of Romanesque tuffstone churches are St. Peter's church and St. Johns Church (both from the 11th century) in the historical center of Utrecht. In the 13th and 14th century other types of building stones were imported from Germany such as the Drachenfels trachyte and red sandstones from the Buntsandstein Formation. Slates from, among other places, Mayen in the Eifel, were used as a roofing material on some of the old churches. In the course of time tolls on the Rhine drove the cost of the tuff, trachyte and red sandstone still higher, making the Lower Cretaceous Bentheim Sandstone from Westfalen an attractive alternative stone for masonry. At the same time a cream coloured very durable sandstone from Obernkirchen in the Bückeberge, west of Hannover, was introduced in the Netherlands. In the 16th and 17th century blue limestone from the Carboniferous in Belgium were transported in great amounts to the Netherlands. Due to the tight and compact structure, and the very low porosity, the blue limestones mainly were used in plinths while the facades were made of sandstones from Bentheim and Obernkirchen. Igneous rocks like granite and basalt and metamorhpic rocks, like Carrara marble, are subordinate stones in the spectrum of building stones in Utrecht. It is obvious that in twentieth century buildings a wide range of natural stone from all over the world has been used.
A geological walk, starting from the 14th century bell tower at Dom Square, illustrates the history of the City and the different varieties of natural stone applied in historical buildings of Utrecht.

2. The geological walk

Utrecht as a Roman fort

Apart from the incidental use of glacial boulders in prehistoric times, the use of building stones in the central Netherlands starts with the Romans. Emperor Claudius declared in the year 47 AD that the river Rhine between the North Sea and Bonn would form the northern boundary of his empire. A road was built on the southern bank of the Rhine and to provide safe shelter for the soldiers a large number of forts, known as castella, were built at set distances.
The Utrecht fort (now hidden below Dom Square) was called Trajectum, meaning river crossing, and it was situated on a levee near the bifurcation of the river Vecht from the river Rhine. At about the year 200 AD the fort had a stone wall and a building of sandstone and tuff stone. The stones were imported by ship along the river Rhine.The tuff, now known as Römer tuff, comes from the Laacher See area. Part of the sandstone presumably comes from Nivelstein, a hamlet near Herzogenrath, along the present border between Germany and the Netherlands.

Middle Ages: tuff and red sandstone (Buntsandstein)

In about the year 275 AD the Romans gave up the Rhine frontier and the castella were abandoned. In the following period the Franks and the Frisians inhabited the Utrecht area, but we do not know any remnants of stone buildings from that time. In the 7th century the English missionary Willibrord launched a conversion offensive among the Frisians. Willibrord was appointed as archbishop by the pope in 695. He recontructed the castellum walls and he had two new churches built (De Bruin et al. 1999). We do not know much about the building material of this churches. Most probably they were partly made of tuff, the recycled material from the former Roman buildings.
From the 10th to the 14th century Utrecht was the most important city in the area north of the river Rhine in the Netherlands. Archbishops reigned and trade brought prosperity to the growing

city. The archbishops built a new church in the castellum area (the present Dom Square) and also four churches in the city centre situated near Dom Square.
One of these churches, St. Peters, is very well preserved. It was built between 1040 and 1080 and shows fine examples of the use of tuff. Different sizes of the tuff can be observed, pointing to the original dimensions of the volcanic ash layers. Besides the Römer tuff from the Laacher See eruption, also tuff from the Riedener caldera, known as Weibern tuff, was imported.

The old Romanesque church in the center of Dom Square, St. Martins Cathedral, that was built in 1023, was demolished in the 14th and 15th century. We presume that a lot of the original building blocks were re-used in the new Gothic cathedral, built on the same place from 1254 onwards. Blocks of red sandstone from the Buntsandstein Formation, are clearly visible in the columns and in the apsis of the present gothic church (Fig.1).

Fig. 1. Column at Dom Church exposed in the open air after the devastation of part of the nave caused by the thunderstorm in 1674. Red sandstone (Buntsandstein) and grey patinated Bentheim sandstone.

In the Dom Tower (built from 1321-1382), originally connected to the cathedral, besides bricks and Buntsandstein use was made of other types of sandstone and limestones. The cornerstones of the tower are made of tight, bluegrey Carboniferous (Visean) limestone from Namur in Belgium. However, one has to be aware of the fact that a large amount of the limestones dates from renovations in the 19th and 20th century.
Up to the present day it is not known from which outcrops in the Buntsandstein Formation the red sandstones were derived. It is reasonable to suggest that they may have been excavated from the Buntsandstein outcrops in the Moesel area near Trier. We suggested a possible origin from Miltenberg in Spessart for the red columns in St. Peters Church (Dubelaar et al. 2007). Dr. Jochen Lepper (personal comment, 2007) had a look at some of the red sandstones and thought an origin from the Miltenberg area on geological reasons as unlikely. It is known that red sandstones from the Weser area, south of Porta Westfalica, had been imported to the Netherlands too in the Middle Ages. Geochemical fingerprints might be helpful, and in some cases conclusive, in finding the origin of the material but it takes a lot of samples to get reliable outcomes.

Drachenfels trachyte

Following the same transportroute as the tuff, trachyte from the Drachenfels along the Rhine in the Siebengebirge, was brought into the Netherlands during the Middle Ages. It has been used for cladding of houses that belonged to important, rich people in the community's government. Due to the large feldspath cystals, the stone was easy to cut. Durability under normal, not salt polluted circumstances is high, although spalling and blistering occasionly do occur. Nice examples of the Drachenfels trachyte can be observed in the Pandhof beside the Dom Church (Figs. 2A and 2B).

Fig.2A. Corner stones at Dom Church (Pandhof). Pink coloured Römer Tuff, grey Bentheim sandstone and Drachenfels trachyt.

Fig. 2B Detail of Figure 2A. Drachenfels trachyte with sanidine crystals showing flow orientation.

Calcareous sandstone and limestone from Belgium

For the facades of new Gothic Cathedral at Dom Square, beside tuff and sandstone from Germany, use was made of Eocene calcareous sandstone and limestone from quarries near Gent and Brussels in Belgium. These so called *Ledesteen* and *'Pierre de Gobertange'* were deposited in shallow marine environments. The Ledesteen, a calcareous sandstone, contains macrofossils, e.g. gastropods, foraminifera (Nummulites) and shark tooths. The stone quarried near the village of Gobertange is a white limestone, characterized by a fine lamination and many ichnofossils: tracks and burrows also known as bioturbation structures.

In particular the Ledesteen show strong weathering features, such as blistering and spalling of large flakes (Figs. 3A, 3B and 3C). The conversion of carbonate into sulfate in the course of time has resulted in thick, black-sooted crusts of gypsum that depart at last from the stone behind.

Fig. 3A. Dom Church with facade of bricks and natural stone.

Fig. 3B Detail of Figure 3A. Waterdrip of Lower Carboniferous Namur limestone and severely weathered calcareous sandstone (Ledesteen) from the Eocene in Belgium

Fig. 3C. Detail of Figure 3A showing Römer tuff above Ledesteen and Namur limestone

Bentheim sandstone and Obernkirchen sandstone

The introduction of tolls on the Rhine in the Middle Ages drove the cost of transporting tuff still higher. That made the sandstone from Bentheim, east of Oldenzaal just across the border in Germany, an attractive alternative. It was easy to transport this stone to the city of Utrecht via the River IJssel, the Zuider Zee and the River Vecht.

Bentheim sandstone is a well-sorted, medium-grained, cream-coloured sedimentary rock of Lower Cretaceous age. It consists of sand grains deposited in shelf sea and nearshore areas. The sandstone contains a quartz content of about 95 vol.%, with accessory feldspars and only very little clayminerals (kaolinite) and carbonate (Grimm, 1990).

The Cretaceous (Wealden) Obernkirchen sandstone from the Bückeberge near Hannover, is also cream coloured but with finer grainsizes than the Bentheim sandstone. Obernkirchen sandstone has 10-15% cement, mainly quartz and clayminerals (kaolinite/illite). Remains of small mollusc shells can be observed in some of the building stone blocks.

Especially the Bentheim sandstone shows intense black weathering. The outer layers contain, among others, gypsum, organic carbon (soot), airborne particles such as fly ash, iron (hydr)oxides and remnants of algae and fungi (Dubelaar 1992; Nijland et al. 2003). The removal of the relatively dense weathering layers will change the hygric characteristics of the sandstones. It also might remove historic information of old coating systems. Therefore the consequences of cleaning are diverse and should be taken into account in the decision making (Nijland et al. 2003).

Bentheim sandstone was used e.g. at Dom Church and in the Pandhof of the Dom, situated between Dom Church and the University's Academiegebouw (Figs. 1, 2A). Obernkirchen sandstone was used e.g at the large office building at Drift 9.

Udelfangen sandstone

Micaceous Udelfangen sandstone from the Triassic (Lower Muschelkalk) near Trier, was used in the west portal of the Pandhof (1893), where a hundred years of weathering have clearly exposed the different sedimentary layers in the sandstone (Fig.4).

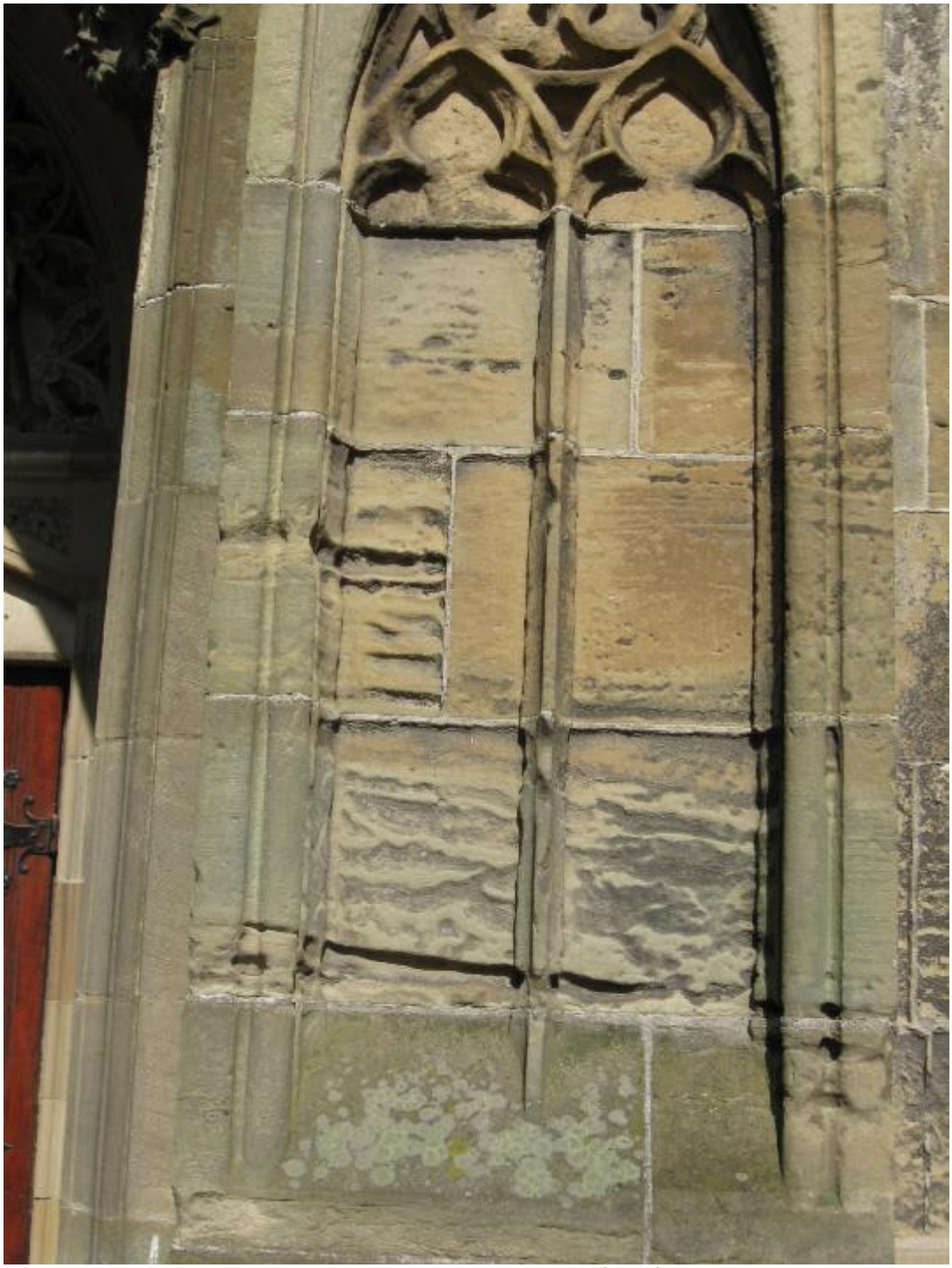


Fig. 4. Weathering phenomena revealing the sedimentary layering of Udelfangen sandstone. Lower blocks show growth of fungi and algae.

Due to the mica and carbonate content, and the well developed layering the durability of the Udelfangen sandstone is less than that of the Bentheim sandstone and Obernkirchen sandstone (Dubelaar, 2004).

Blue limestones from Belgium

Belgian blue limestones from the Lower Carboniferous, known as *Hardsteen* or *'Petit granit'* (but it has nothing to do with an igneous rock!) are excavated nowadays in large open pits near the town of Soignies in the province Henegouwen (Hainault). In the 14th to 17th century blue limestone was imported from two main areas; one is situated along the banks of the river Scheldt in Doornik (Tournai) and the stone extracted was called Doornik limestone. The other area is in

the vicinity of the cities of Huy and Namur along the Meuse and the limestone was named *'Namense steen'* by the stonemasons.
A supreme example of the application of *Doornikse steen* is the memorial grave, in the Dom Church, of Guy d' Avesnes, who died in 1317. It has been carved in dark-grey to black coloured limestone, known as *'Tournai marble'*. Guy d' Avesnes, originating from the province of Hainault, became bishop in Utrecht and granted Amsterdam its privileges in 1306. The tomb has been damaged during the iconoclastic fury in 1580.
An example of Namur Limestone can well be observed at Dom Church, south of the main entrance (Fig. 3B). The layering in the waterdrip is the result of the deposition of lime particles by several generations of algae. Nowadays a variety of Namur Limestone, the Vinalmont Limestone is still being quarried north of Huy.

Limestones from France

From the second half of the 19th century onwards Jurasssic limestones from the eastern part of the Paris Basin were imported and became popular in the neo-styled architecture. The Euville encinite can be seen in the Donkers monument opposite St. Johns Church, and the well-known Savonnieres limestone, excavated in the Meuse Departement, can be observed e.g. in the sculptures of the Academy building at Dom Square (Fig. 5).

Fig.5 Sculpture made of French limestone (Savonnieres) at the Acadamy building at Dom square.

Nowadays building stones from all over the world have been applied in the facades of the shopping centers. A nice example of a light coloured granite-gneiss with red garnets, imported from Scandinavia, is the stone used at Lange Elisabethstraat 25.

References

Bruin, R. de , T. Hoekstra & A. Pietersma, 1999. The city of Utrecht through twenty centuries, 1999.

Dubelaar, C.W. 1992. A geological view of the Royal Palace, Amsterdam, The Netherlands, In: Engineering Geology of Ancient Works, Monuments and Historical Sites (Eds. P.G.Marinos and G.C. Koukis), pp. 2057-2066

Dubelaar, C.W. 2004. Mineralogy, petrophysical properties and durability of the Udelfangen sandstone (Muschelsandstein, Lower Muschelkalk, Germany). In: Prikryl, R. (ed.). Dimension Stone 2004.New perspectives for a Traditional Building Material, Proceedings of the International Conference on Dimension Stone 2004, 14-17 June, Prague, Czech Republic,p. 23-28.

Dubelaar, C. W, Nijland, Timo. G., Tolboom, H.J., Kipp, F, Overeem, G., & D. J. de Vries, 2007. Utrecht in steen. Historische bouwstenen in de binnenstad. Matrijs, Utrecht, 192 p.

Grimm, W.D, 1990. Bildatlas wichtiger Denkmalgesteine der Bundesrepublik Deutschland. Bayerische Landesamt für Denkmalpflege, Arbeitsheft 50.

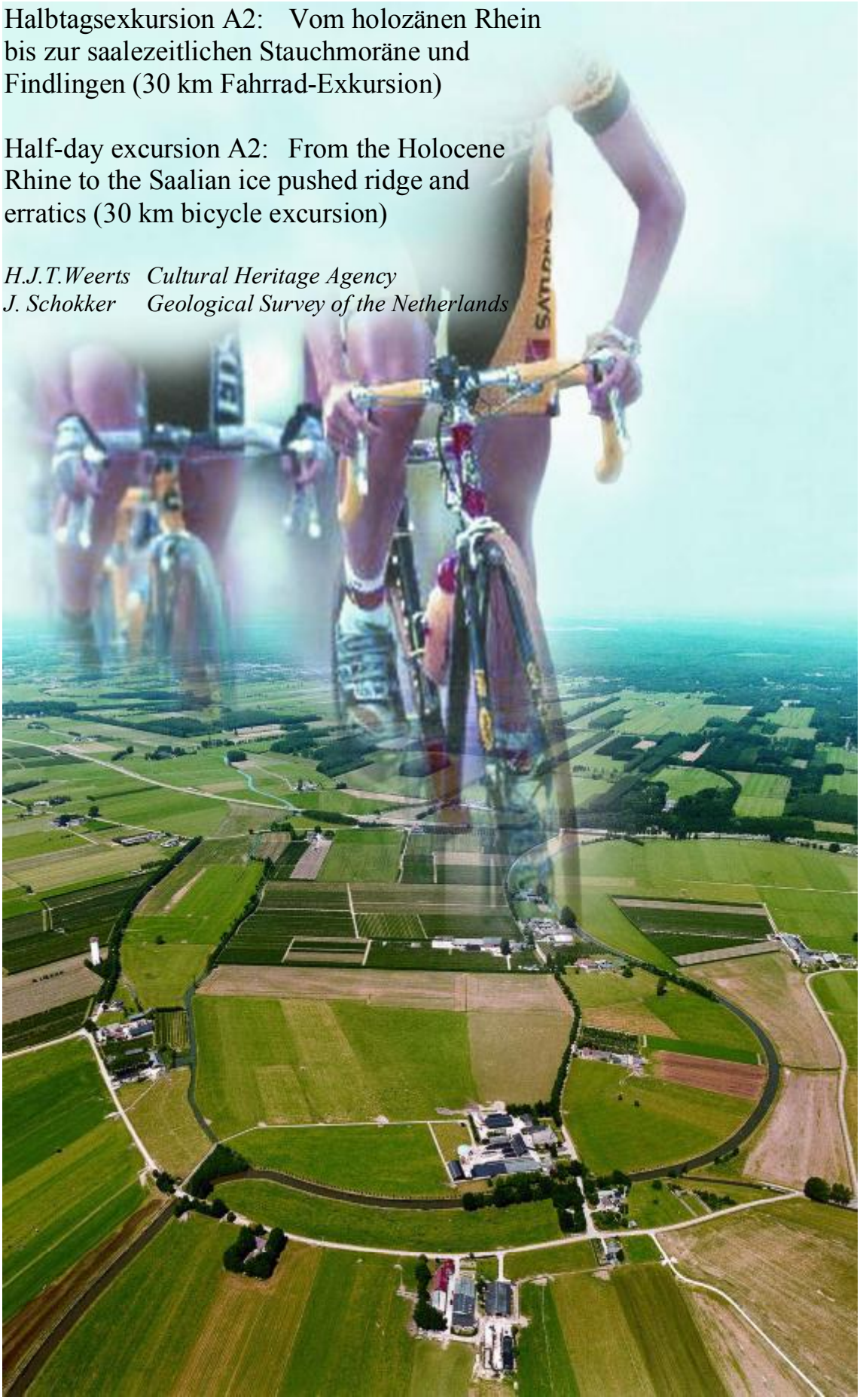
Nijland, T.G., C.W. Dubelaar, R.P.J. van Hees & T.J.M. van der Linden, 2003. Black weathering of Bentheim and Obernkirchen sandstone. HERON, Vol.48, No. 3, p.179-206.

Exkursion A2

Halbtagsexkursion A2: Vom holozänen Rhein bis zur saalezeitlichen Stauchmoräne und Findlingen (30 km Fahrrad-Exkursion)

Half-day excursion A2: From the Holocene Rhine to the Saalian ice pushed ridge and erratics (30 km bicycle excursion)

H.J.T.Weerts Cultural Heritage Agency
J. Schokker Geological Survey of the Netherlands



The genesis of the landscapes of the Utrechtse Heuvelrug and the Kromme Rijn area.

Pleistocene

A large part of the Pleistocene deposits of the Netherlands consists of sand and gravel that was deposited by major river systems: the precursors of the Rhine and Meuse, the so-called Belgian river system and a no longer existing Baltic river system (Eridanos). A smaller part of the Pleistocene sediments was deposited in shallow seas, by land ice or by wind. In the vicinity of Utrecht the total stack of Pleistocene deposits is 100-150 m thick. The transect of Figure 1 schematically shows the upper 40 meters of the subsurface near Utrecht. For this excursion, deposits from the Late-Saalian (MIS 6) onward are of importance.

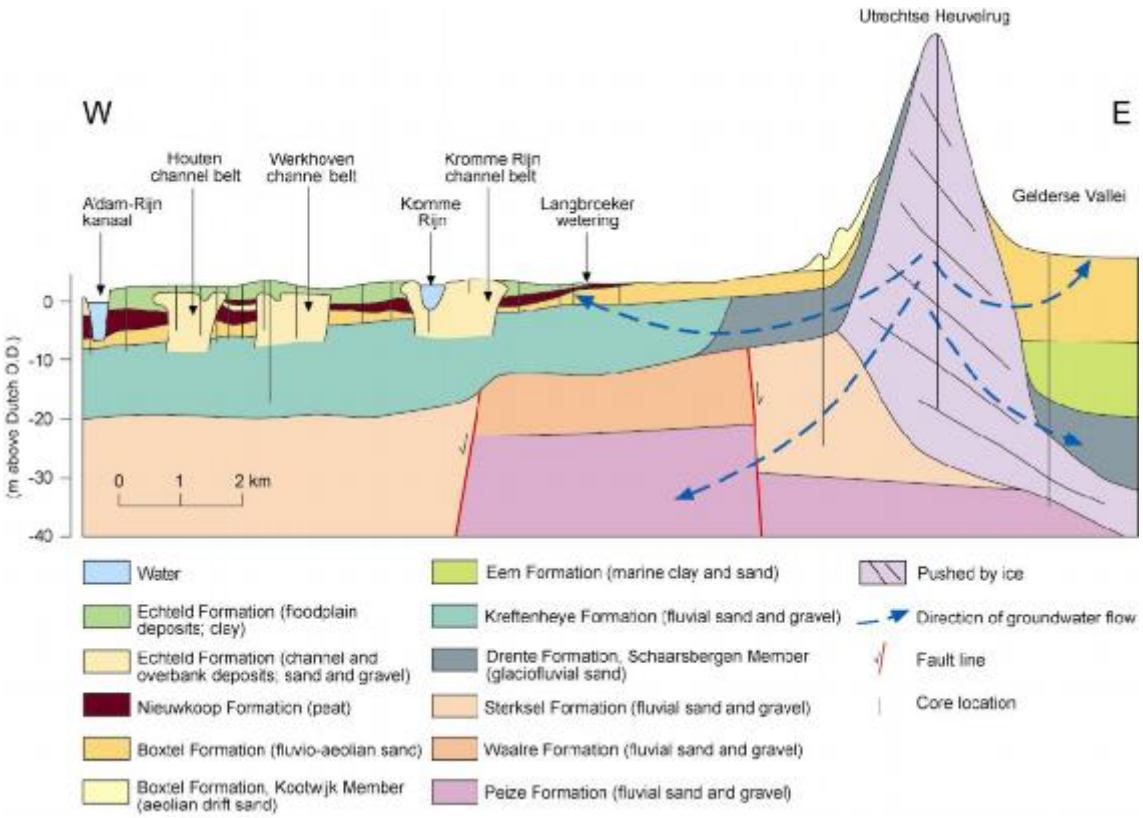


Figure 1. Schematic west-east geological cross section through the Kromme Rijn area and Utrechtse Heuvelrug. See Fig. 2 for the location of the cross section.

Saalian

Around 160.000 years ago, the ice of the Fennoscandian ice sheet reached the Netherlands. After the ice had melted, a widespread glacial till cover was left behind in the northern half of the Netherlands. The southernmost ice limit is characterised by the occurrence of up to 150 m deep glacial basins, surrounded by large push moraines (Figure 2). In the vicinity of Utrecht these moraines consist of faulted and folded Early and Middle Pleistocene river deposits that had been pushed up in front of the -probably surging- ice (Figure 3). The Utrechtse Heuvelrug is one of the large push moraines. Its highest points still reach 70 m above sea level. The push moraines are intermittently covered by erratics from Scandinavia, Finland and the Baltics. This suggests that the ice that formed these moraines had a northeasterly origin. The moraine has a relatively steep eastern slope and a gentle western slope. The latter is caused by the presence of a large sandur plain that formed on the outward sides during the melting of the ice sheet. During melting, meltwater flowed to the west and south, thereby carving large valleys into the moraine.

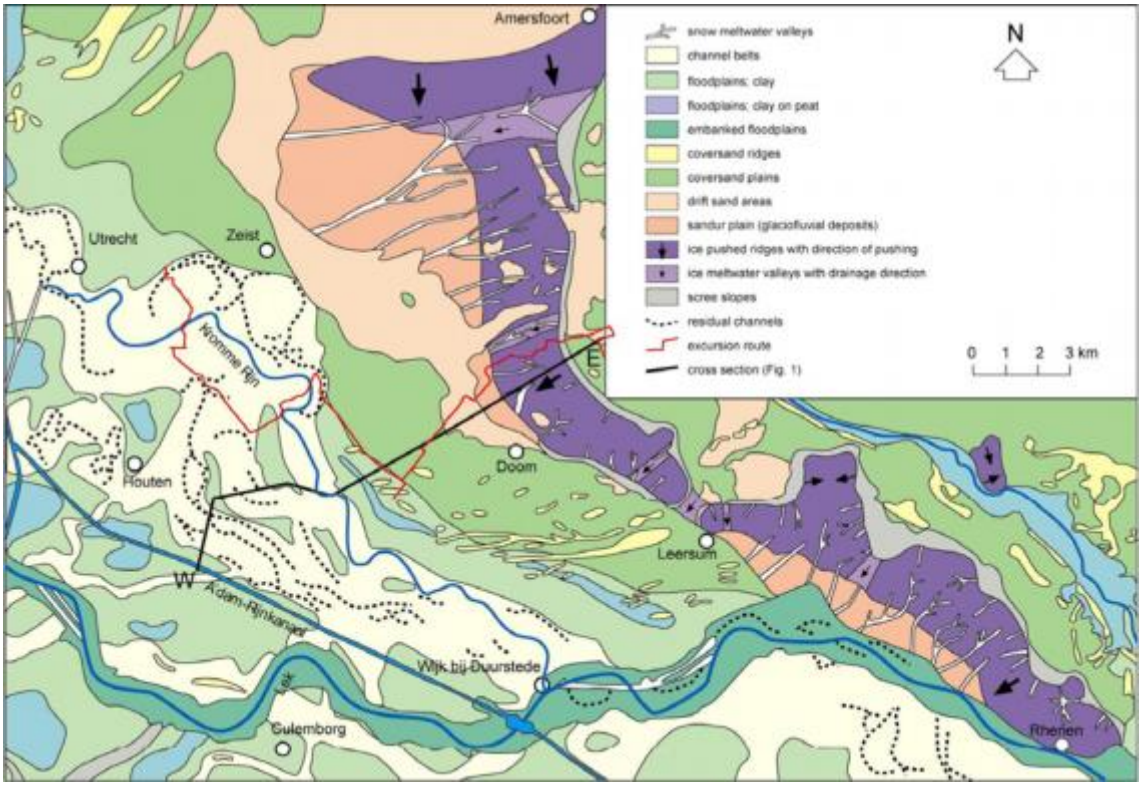


Figure 2. **Geomorphological map of the south-east of the province of Utrecht (after Berendsen *et al.*, 1985).**

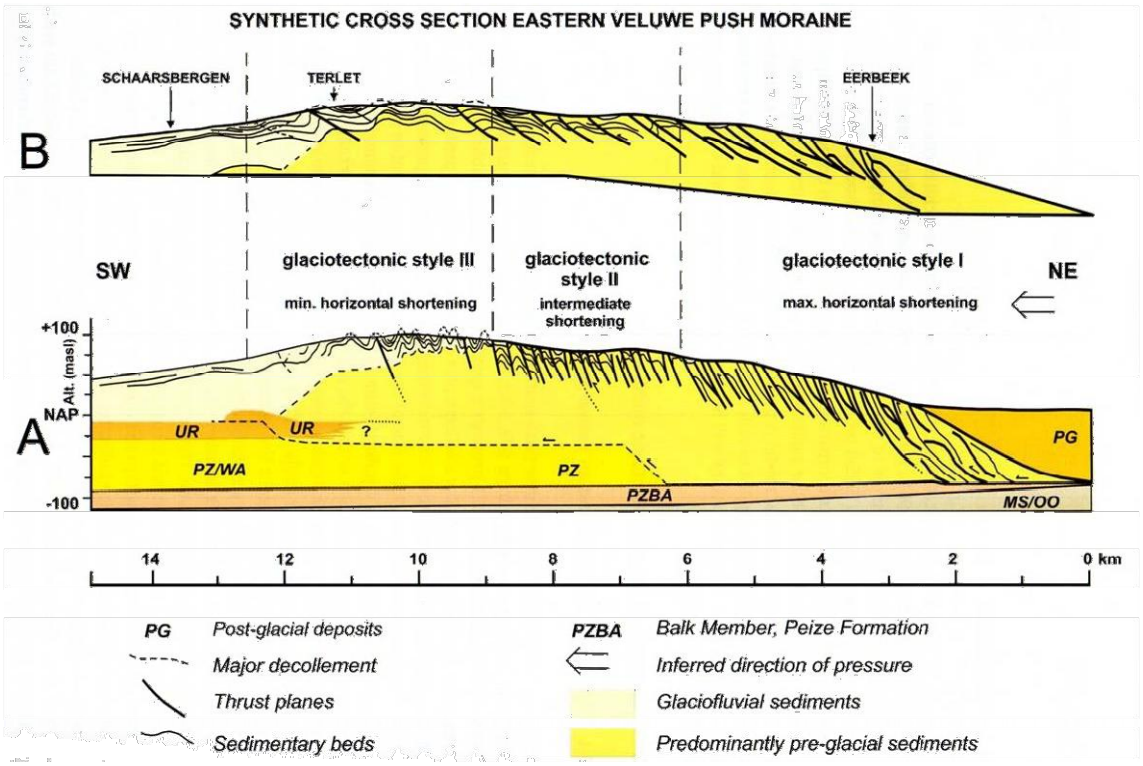


Figure 3. **Synthetic cross section showing the different glaciotectonic styles to be found in the push moraines of the central part of the Netherlands (Bakker, 2005).**

The sediment that was eroded in the valleys or had directly melted out of the ice was deposited immediately to the west of the moraine. Along the eastern side, much less meltwater deposits formed. Therefore this side of the moraine ridge remained steep.

Eemian
The interglacial climate of the Eemian led to a closed vegetation cover and meandering rivers like we see today. The lower course of the river Rhine however did not follow its present route, but flowed northbound between Wesel and Zwolle, before diverting west towards the North Sea. The lower course of the river Meuse flowed in the same area as the present-day Rhine and Meuse. The exact coastline west of the Utrechtse Heuvelrug during the Eemian is not known. However, the presence of reworked marine shells in Early to Middle Weichselian Rhine deposits suggests that a shallow marine bay extended at least to the east of Rotterdam. East of the Utrechtse Heuvelrug another marine bay occupied the deep glacial basin of the Gelderse Vallei (Figure 1). The Dutch palaeobotanist prof.dr. Waldo Zagwijn and others investigated marine deposits in this basin from several sediment cores that were taken in Amersfoort near the River Eem (Figure 4). The small river has formally given the Eemian Stage its name.

Weichselian
During the Weichselian, the Fennoscandian ice sheet did not reach the Netherlands. In the coldest parts of the Weichselian, there was no closed vegetation cover and the soil was permanently frozen. Rhine and Meuse were braided river systems with a highly variable discharge. Due to the combination of a permanently frozen soil and freeze-thaw processes, small valleys were carved out in the Saalian push moraines. Nowadays, these valleys are dry valleys because rainwater can easily infiltrate the generally coarse, sandy soils. The morphology of the moraines was further modified by solifluction processes. The present morphology of the push moraines is therefore a combination of ice-pushing in the Saalian and modification by surface processes during the Weichselian. In the Late Weichselian, large parts of the landscape became covered by aeolian coversands. Along the valleys of the Rhine and Meuse large aeolian dune complexes formed that are still partly visible in the landscape today.

Holocene
11.000 years ago the Holocene interglacial period started. Under a generally closed vegetation cover soil formation became the dominant geological process. The now meandering Rhine and Meuse rivers continually had to adjust their gradient to the rapidly rising base level caused by the rising sea level. Around 8.000 years ago this caused the ground water level to rise to the surface in the westernmost part of the Kromme Rijn area. Peat formation began and spread further to the east in the course of time. Around 5.600 years ago it had reached the present Langbroeker Wetering (excursion stop 10). Peat formation was now the most important geological process in the area west of the Utrechtse Heuvelrug. From around 4.100 years ago, fluvial sedimentation by the river Rhine became dominant in the excursion area. Sedimentation continued until 1122 AD when the Kromme Rijn was finally dammed at Wijk bij Duurstede. From that moment onward, the land became quickly cultivated.

During the Middle ages man became the dominant landscape-forming factor on the Utrechtse Heuvelrug also. Due to overgrazing by sheep and large-scale removal of the topsoil for use as plaggen-soil near the hamlets and villages, the vegetation cover was partly removed. Because the groundwater table was far below the surface, wind got a grip on the dry, sandy soil. Human-induced drift sands became common on the Utrechtse Heuvelrug. Only after artificial fertiliser became widely available in the second part of the 19th century, sheep and plaggen soils were no longer necessary for successful agricultural practice. The Utrechtse Heuvelrug was reforested Nowadays, most of the push moraines are covered with forest, both coniferous and deciduous.

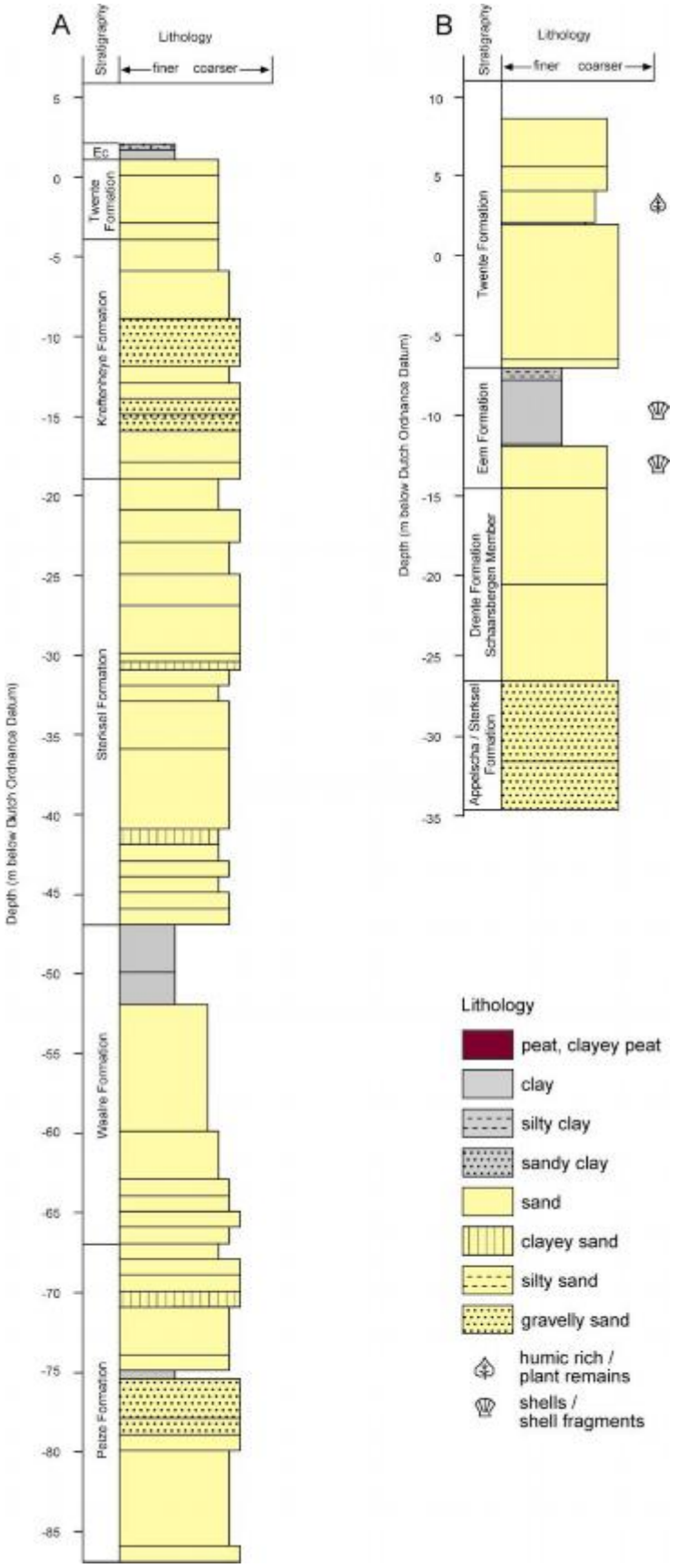
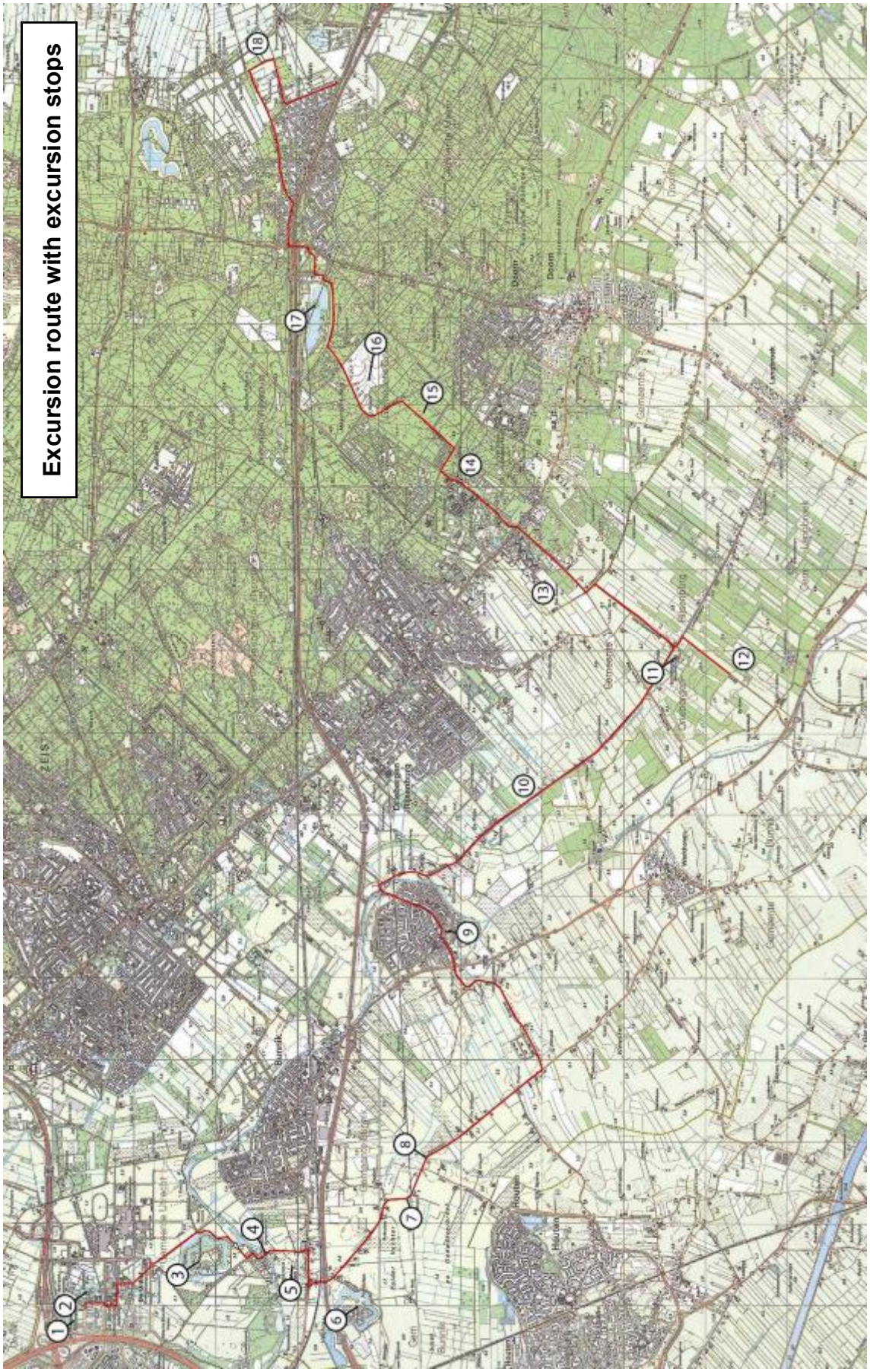


Figure 4. **A) Sediment core near De Uithof. B) Sediment core near Amersfoort.**


Excursion route with excursion stops
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Excursion stops (see also excursion route)

1. The building of the *Geological Survey of The Netherlands* (Fig. 5)

Since the 1990s it has become policy of Utrecht University to house the faculties and research institutes on its campus "De Uithof" in buildings of outstanding architecture. The building of the *Geological Survey of The Netherlands* is only one of the examples as we shall see further on.

2. Fortress Hoofddijk (Figs. 6, 7)

This is one of the fortresses of the "Nieuwe Hollandse Waterlinie", a huge 19th-century defence line that aimed to protect Holland and the city of Utrecht against invasions from the east. Several fortresses can be recognised along the first part of the excursion route. The original defence line was constructed in the 1820s. It was reinforced in the 1860s and 1870s, during World War I and again just before the World War II. The defence line never saw any battle. Fortress Hoofddijk was added to the original defence line between 1877 and 1879. The idea of the Nieuwe Hollandse Waterlinie was to inundate low-lying areas by means of a system of sluices and ditches, thus preventing the enemy from passing them. Fortresses were built at regular distances. On higher grounds that were difficult to inundate, the density of fortresses is much higher. At present, Fortress Hoofddijk hosts the Laboratory of Palaeomagnetism of Utrecht University. The extremely thick brick walls make it an excellent location for this laboratory.

3. Fortress Rhijnauwen

This is the largest fortress of the Nieuwe Hollandse Waterlinie. It is situated on the high grounds of a former Rhine course that could not be inundated. It was built between 1868 and 1871, when the Hollandse Waterlinie to the east of Utrecht was reinforced.

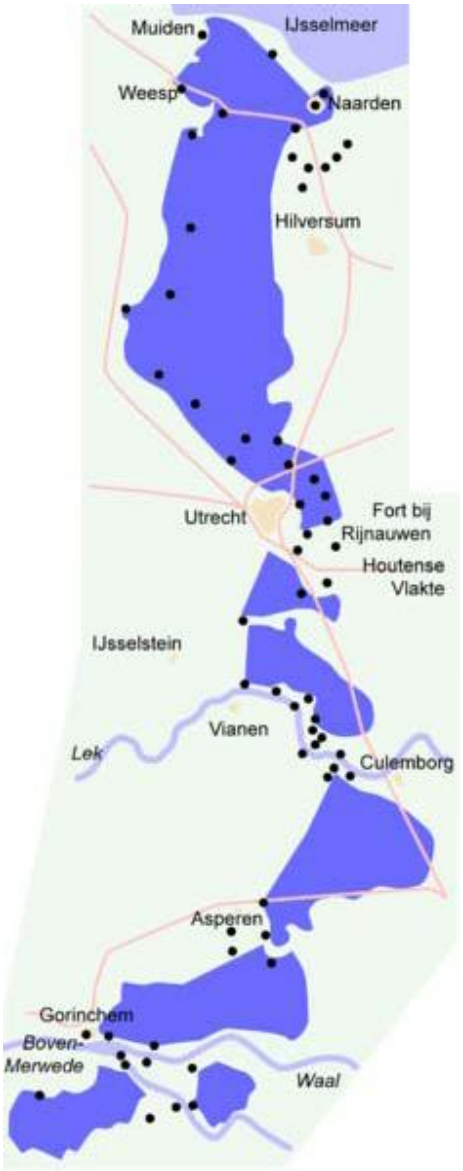


Figure 5. ▲ **The building of the *Geological Survey of The Netherlands* on Utrecht University campus De Uithof. (website.hurksvanderlinden.nl)**

Figure 6. ▼ **Outline of the defence line Nieuwe Hollandse Waterlinie. Black dots indicate fortresses, the blue areas could be inundated. (www.wikipedia.org)**

Figure 7. ▲ **Inundation of the Nieuwe Hollandse Waterlinie during World War I. (www.wikipedia.org)**

Figure 8. ▲▲ **River Kromme Rijn near Rhijnauwen.**

Figure 9. ► **Reconstructed Roman boundary post alond the *limes*, the boundary of the Roman Empire in the first century AD.**

4. River “Kromme Rijn” (Fig. 8)

At this stop, we are looking at the remains of the Roman Rhine. The small residual channel resides in a 100 m wide depression that indicates the width of the river before it was dammed at Wijk bij Duurstede in 1122 AD. At this point we enter the former Roman Empire (Germania Inferior).

5. Small group shelters of the Nieuwe Hollandse Waterlinie

To our right we can see many small concrete group shelters that are situated on the high grounds of the Roman Rhine. These shelters were placed between the forts Rhijnauwen and Vechten in 1939 and could house 4 to 10 soldiers each. They mainly functioned as protection shelters for the soldiers.

6. Fortress Vechten

This is the last fortress of the Nieuwe Hollandse Waterlinie on our route. It was built between 1867 and 1870. Remarkably it is situated roughly at the same location as the Roman fortress Fectio, one of the fortresses along the Roman *limes*.

7. “Reconstruction” of a Roman boundary post (Fig. 9)

Along the road we cycle on, several “reconstructions” of Roman boundary posts have been put in place. The Roman road between the fortresses of Fectio and Levefanum (near the present Wijk bij Duurstede) is believed to have been situated close to where we are now. The actual boundary was probably somewhat further to the east along the course of the Kromme Rijn, an active branch of the river Rhine at the time.

8. Residual channel near Houten

The small ditch we see here is actually a remnant of a former course of the river Rhine. This course is called the Houten System and was active between 3.795 and 2.560 years BP. A drilling near this former course actually proves that the shallow subsoil consists of Holocene fluvial deposits. Underneath a clay layer that was deposited during later flood stages, calcareous river sand of the Houten System is present.

9. Odijk (Fig 10)

The village of Odijk was built on the southern bank of the river Rhine and dates back to the 8th or 9th century AD. However, farms were already present here in the Roman age. Since the 11th century there has been as church at the location of the present white church (“Witte kerkje”). 12th-century remains of the foundations of a church are still present near the present church. As we leave Odijk we soon cross the Kromme Rijn, leave the former Roman Empire and enter the land of the Barbarians (Germania).

Figure 10. Witte Kerkje in Odijk. (www.plaats.nl)

Figure 11. **Langbroekerwetering near Odijk.**

Figure 12. **Castle Sterkenburg.**

10. De Langbroeker Wetering (Fig. 11)

We are now cycling along the Langbroeker Wetering. This is not a natural water course. The straight canal was dug in 1126, soon after the Kromme Rijn was dammed. By then, the whole area was an uninhabitable low-lying swamp. After having completed the Langbroeker Wetering, ditches were dug at regular intervals perpendicular to the wetering. Thus, the swamp was drained and turned into agricultural land. This was done throughout the whole river delta after dike-building had started in the 11th and 12th century. Completing the river dikes meant that the low-lying areas were no longer prone to flooding.

11. Castle Sterkenburg (Fig 12)

This castle was originally built in 1196 and became a loan to the noble family Sterkenburg. In 1536, it became a "Ridderhofstad", a regional term that could be translated as "Knight's Homestead". The mighty Sterkenburg family were given the right to loan land to lower nobility by the Bishop of Utrecht. In return they had to collect taxes and handing them over to the Bishop, after receiving their proper share. The present form of the castle dates from the 18th and 19th centuries.

12. Drilling in the polder

If a handdrilling is performed in the fields somewhat to the south of castle Sterkenburg, it becomes clear that the composition of the subsoil strongly differs from that near stop 8. First a layer of stiff non-calcareous clay is found. This layer was deposited by floods of the Rhine and her precursors. Underneath the clay we find a thin peat bed that was formed before ~5.660 years BP, when fluvial clay deposition by the Werkhoven System started. The peat bed is the result of drowning of the landscape due to a rising ground water level. At the time, no Rhine courses were present near the area, so no clay was deposited here yet. Below the peat we encouter fine-grained aeolian coversand that was deposited at the end of the Weichselian.

13. Coversand ridge near Doorn

Although pretty hard to notice, we leave the Holocene landscape at this point. The trained eye sees that the landscape becomes slightly undulating. Here, Weichselian coversand occurs at the surface. This area has been in agricultural use since the Middle Ages. In many places, an anthropogenic "plaggen soil" is found on top of the coversand. The plaggen were obtained from higher, dry Pleistocene grounds that were not suitable for agriculture.

14. Recent drift sands in an old landscape

Due to repeated removal of the topsoil for plaggen and due to overgrazing by large sheep herds, the barren sandy soil started to drift again from the 15th century onwards. Huge modern-time drift sand areas were formed. The drift sand areas were fixed by large-scale forest planting at the end of the 19th and the beginning of the 20th century.

15. Drilling on the sandur plain

We now have started to "climb" the Saalian ice-pushed ridge. We have not reached the ridge itself yet. Instead, we have been cycling on the sandur, covered with a thin veneer of Weichselian coversand and locally also modern-time drift sand. Below these sandy deposits, horizontally bedded coarse-grained sand and fine gravel of the sandur is present.

16. Weichselian dry valley near the top of the ice-pushed ridge

The subsoil of the ice-pushed ridge mainly consists of coarse-grained fluvial deposits of Early to Middle Pleistocene age. Clay layers occur only locally. As a consequence, surface water infiltrates very easily and the groundwater table is far below the surface here. The groundwater table has been further lowered by groundwater pumping as a source of drinking water from the end of the 19th century onwards. The morphology of the valley we see here was formed in the coldest periods of the Weichselian when permafrost was present, prohibiting surface water from infiltrating.

17. Erratic boulders in a sandpit (Fig. 13)

To our left is a huge pit from which sand and gravel has been dug since 1910. The water level of the pond in the pit corresponds to the actual groundwater level. On the island in the pond, many erratic boulders that were found in and around the pit have been collected. Most of them have a Scandinavian origin and have been brought here by the Fennoscandian ice sheet during the Saalian. Surprisingly, some of the boulders have a much more southern origin (Schiefergebirge, Ardennes). The presence of these boulders is explained by assuming ice-rafted debris transport by the Rhine and the Meuse in ice ages preceding the formation of the ice-pushed ridge. The boulder island is now a geological monument.

18. Coversand plain in a former glacial basin

After the Saalian ice sheet receded, the glacial basin to the north and east of the ice-pushed ridge was flooded by the sea during the Eemian. At 15 m below the surface, shallow marine deposits of Eemian age occur. They are covered by sandy fluvio-periglacial deposits and aeolian coversand of Weichselian age. The sandy road we see here is a former “sheep-road” that sheep herds followed from their houses to the heathlands on the ice-pushed ridge.

Figure 13. Monumental outline of glacial and southern erratics in the Maarn sand pit. (www.aardkundigewaarden.nl)

Further reading

This bicycle excursion stands in a long tradition. We have used several sources from literature to arrive at its present form. The most important sources are listed below in chronological order of appearance.

Berendsen, H.J.A., 1982, De genese van het landschap in het zuiden van de provincie Utrecht. Utrechtse Geografische Studies 25, Vakgroep Fysische Geografie, Rijksuniversiteit Utrecht.

Berendsen, H.J.A., R.J. de Boer, M.I.J.G. Cortenraad & E.E.J. Weiss, 1985, Utrechtse Heuvelrug en Kromme-Rijngebied – een verkenning per fiets. Utrechtse Geografische studies 17, Vakgroep Fysische Geografie, Rijksuniversiteit Utrecht.

Dijkmans, J.W.A. & H.J.T. Weerts, 2000, Aardkundige Fietsexcursie Zuid-Oost Utrecht. Nederlands Instituut voor Toegepaste Geowetenschappen TNO, Utrecht.

Berendsen, H.J.A. & E. Stouthamer, 2001, Palaeogeographical development of the Rhine-Meuse delta, The Netherlands. Koninklijke Van Gorcum, Assen.

De Mulder, E.F.J., M.C. Geluk, I. Ritsema, W.E. Westerhoff & Th.E. Wong, 2003, De ondergrond van Nederland. Geologie van Nederland, deel 7. Nederlands Instituut voor Toegepaste Geowetenschappen TNO, Utrecht.

Bakker, M.A.J., 2005, The internal structure of Pleistocene push moraines. A multidisciplinary approach with emphasis on ground-penetrating radar. TNO Built Environment and Geosciences, *Geological Survey of the Netherlands,* Utrecht.

Busschers, F.S., 2008, Unravelling the Rhine. Response of a fluvial system to climate change, sea-level oscillation and glaciation. Ph.D. Thesis, Vrije Universiteit Amsterdam – Geology of the Netherlands 1.

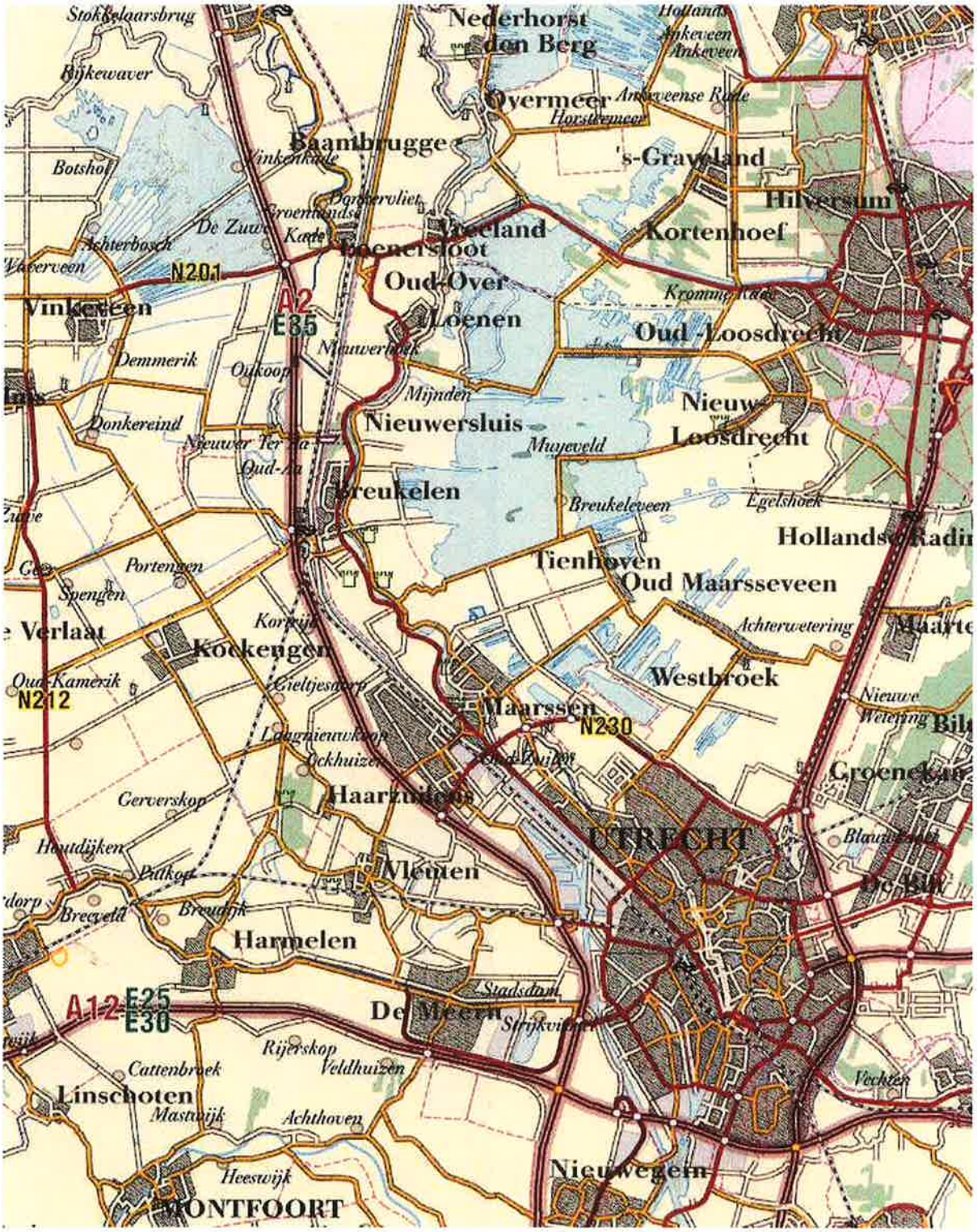
Exkursion A3

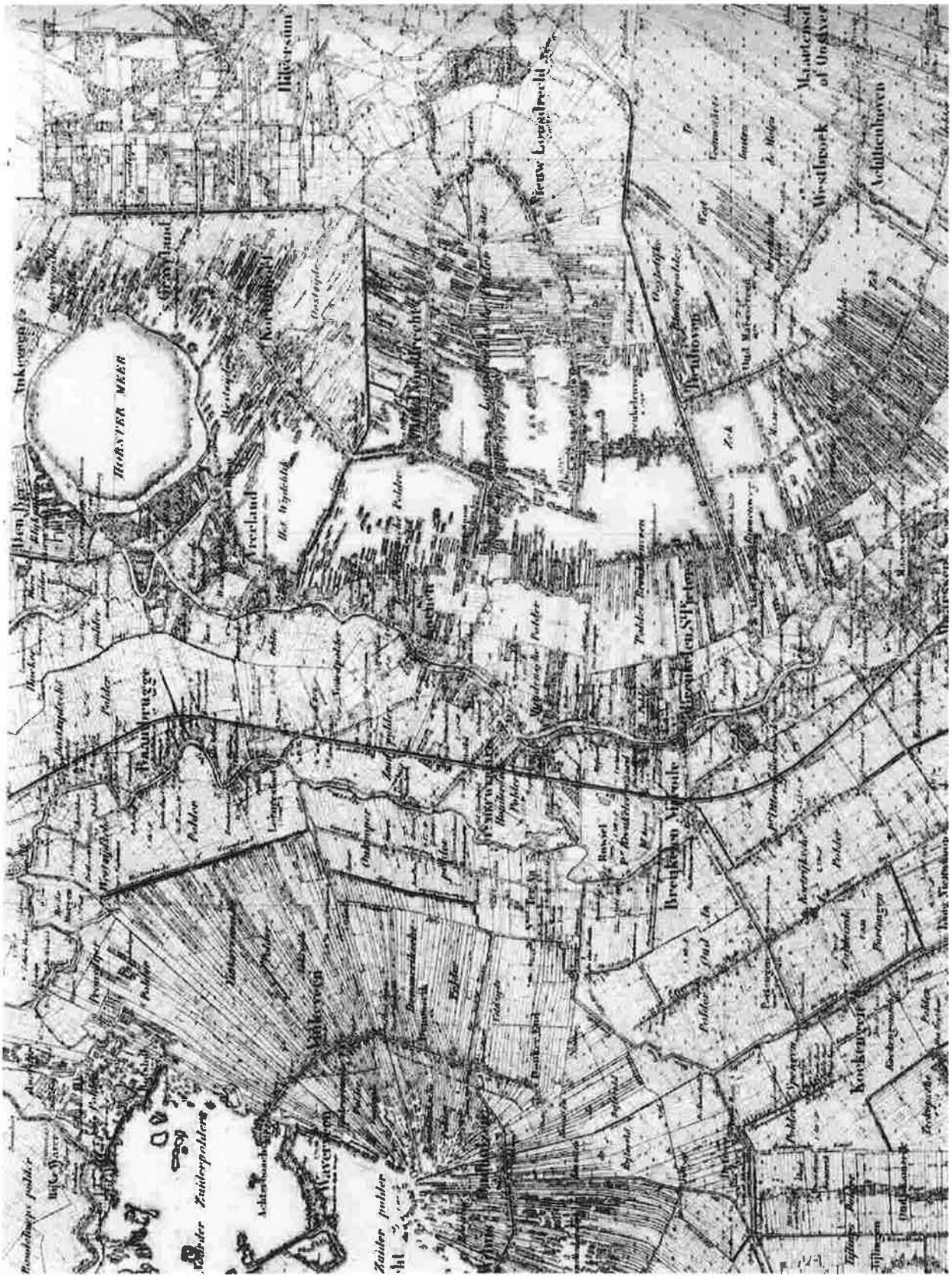
76. Tagung der Arbeitsgemeinschaft
Norddeutscher Geologen

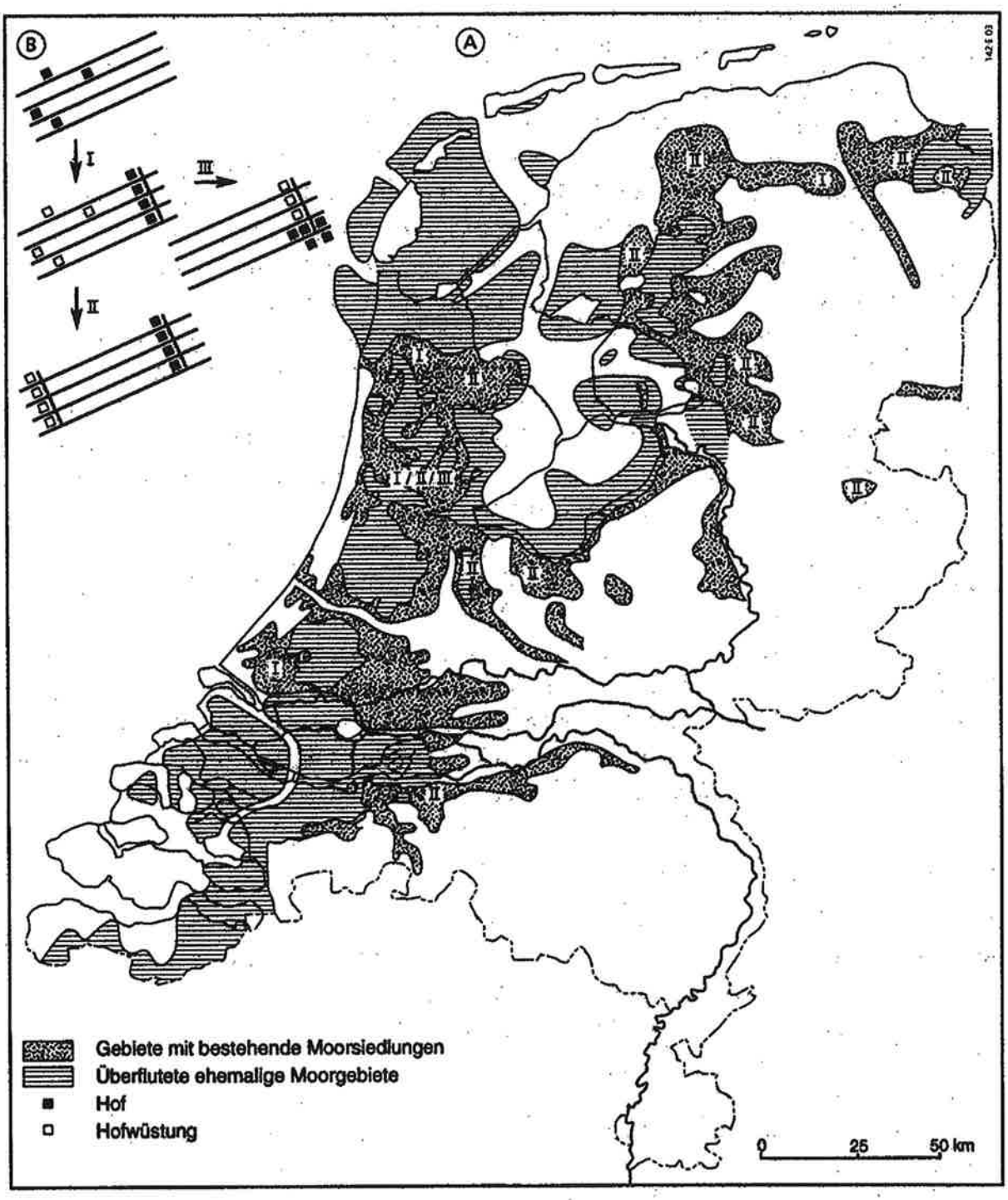
Exkursion A3
Donnerstag 4. Juni 2009

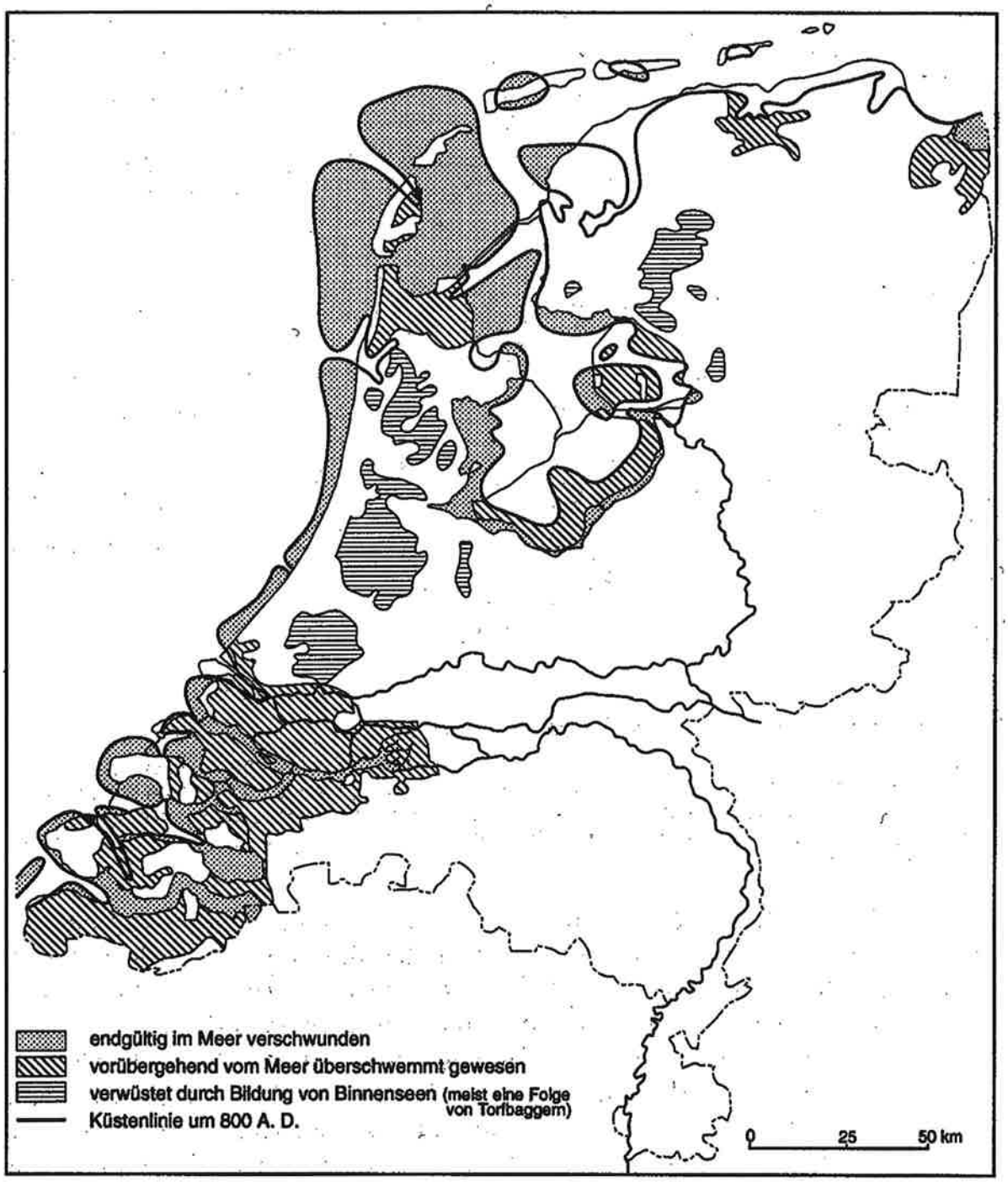
Die Flusslandschaften und Moorgebiete nördlich und westlich der Stadt Utrecht, Niederlande

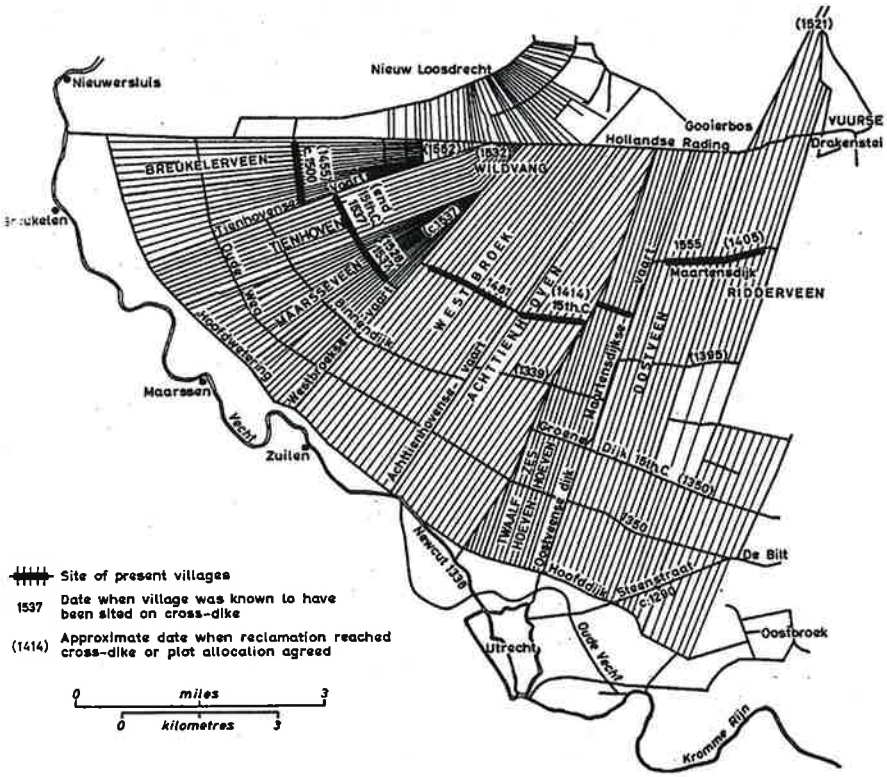
Führung: Dr Hans Renes


Nederhorst den Berg
Overmeer
Baambrugge
's-Graveland
Hilversum
Kortenhoef
Vreeland
Loenersloot
Oud-Over
Loenen
Oud-Loosdrecht
Nieuwersluis
Nieuw-Loosdrecht
Breukelen
Tienhoven
Oud Maarsseveen
Westbroek
Maarssen
Kockengen
Haarzuilens
UTRECHT
Vleuten
Harmelen
De Meern
Linschoten
Nieuwegein
MONTFOORT
Vinkeveen
Demmerik
Donkereind
Portengen
Spengen
Verlaat
Gerverskop
Houtdijken
Breeveld
Breudijk
Rijerskop
Veldhuizen
Cattenbroek
Mastwijk
Achthoven
Heeswijk
Stadsdam
Strijkvijver
Vechten
Groenekan
Nieuwe Wetering
Achterwetering
Egelshoek
Breukeleveen
Muyeveld
Mijnden
Oukoop
Nieuwerbroek
Kromme Rade
Ankeveense Rade
Horsteemeer
Ankeveen
Hollands Radin
Maarte
Bilt
De Bilt
Blauwkapel
Stokkelaarsbrug
Rijkewaver
Botshol
Achterbosch
Vaverveen
De Zuwe
Groenlandse Kade
Donkervliet
Vinkenkade
Oud-Aa
Nieuwer Ter Aa
Oud-Kamerik
Gieltjesdorp
Langnieuwkoop
Ockhuizen
Oud Zuilen
Putkop
Breeveld
Stadsdam
N201
N212
N230
A2
E35
A12
E25
E30

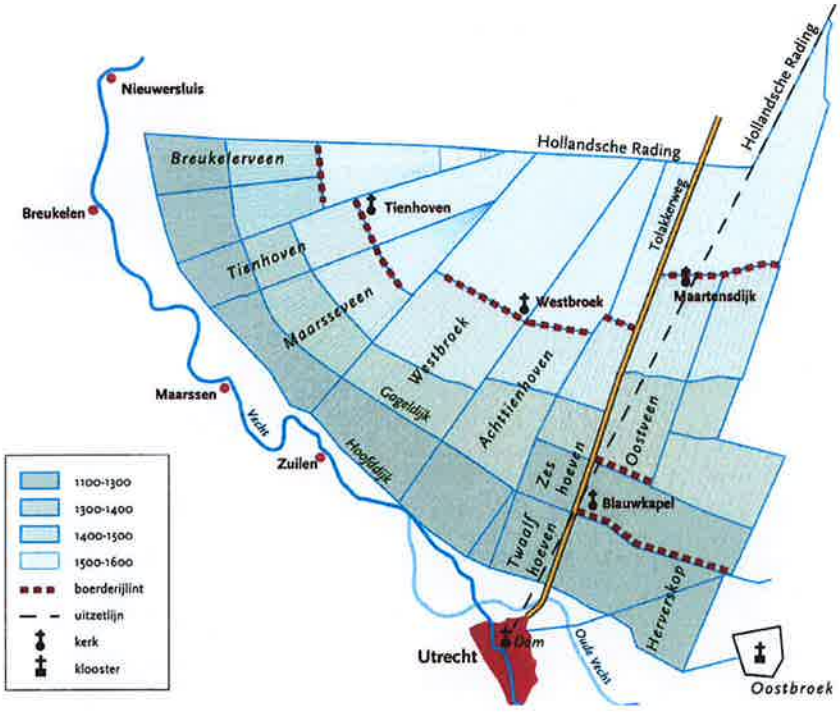

HORSTER MEER
Vreeland
Hilversum
Nieuw Loosdrecht
Westbroek
Achttienhoven
Zuiderpolder

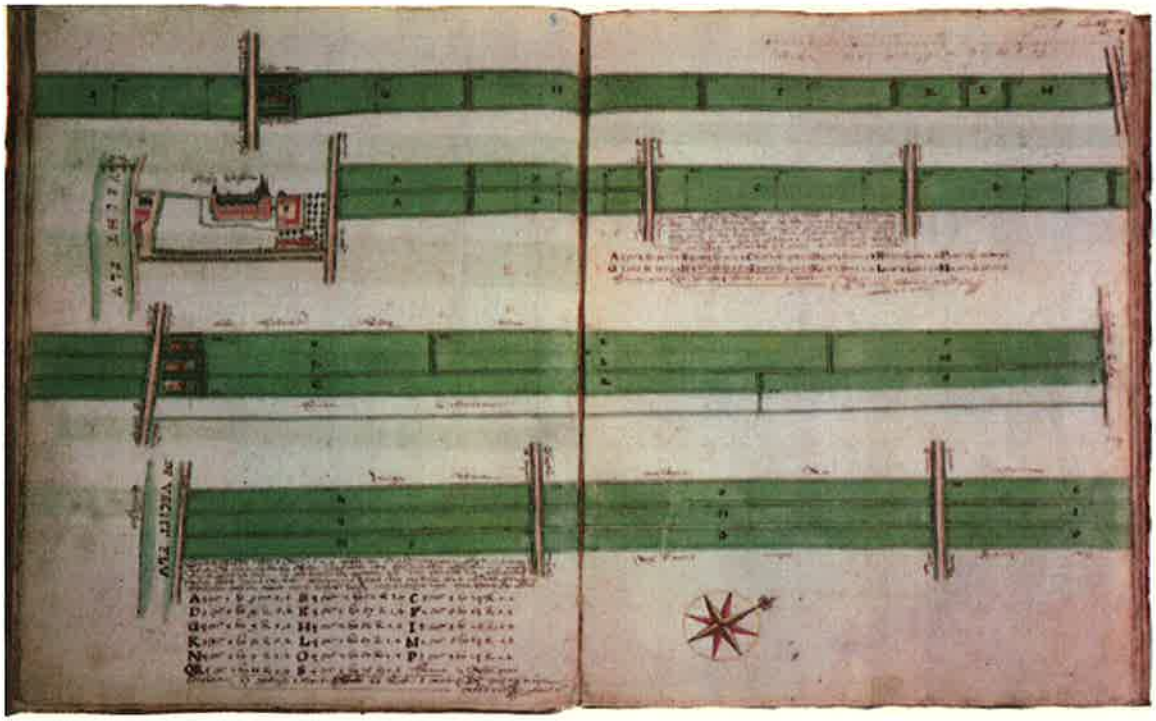

B
A
I
II
III
I / II / III
Gebiete mit bestehende Moorsiedlungen
Überflutete ehemalige Moorgebiete
Hof
Hofwüstung
0
25
50 km


endgültig im Meer verschwunden
vorübergehend vom Meer überschwemmt gewesen
verwüstet durch Bildung von Binnenseen (meist eine Folge von Torfbaggern)
Küstenlinie um 800 A. D.
0
25
50 km

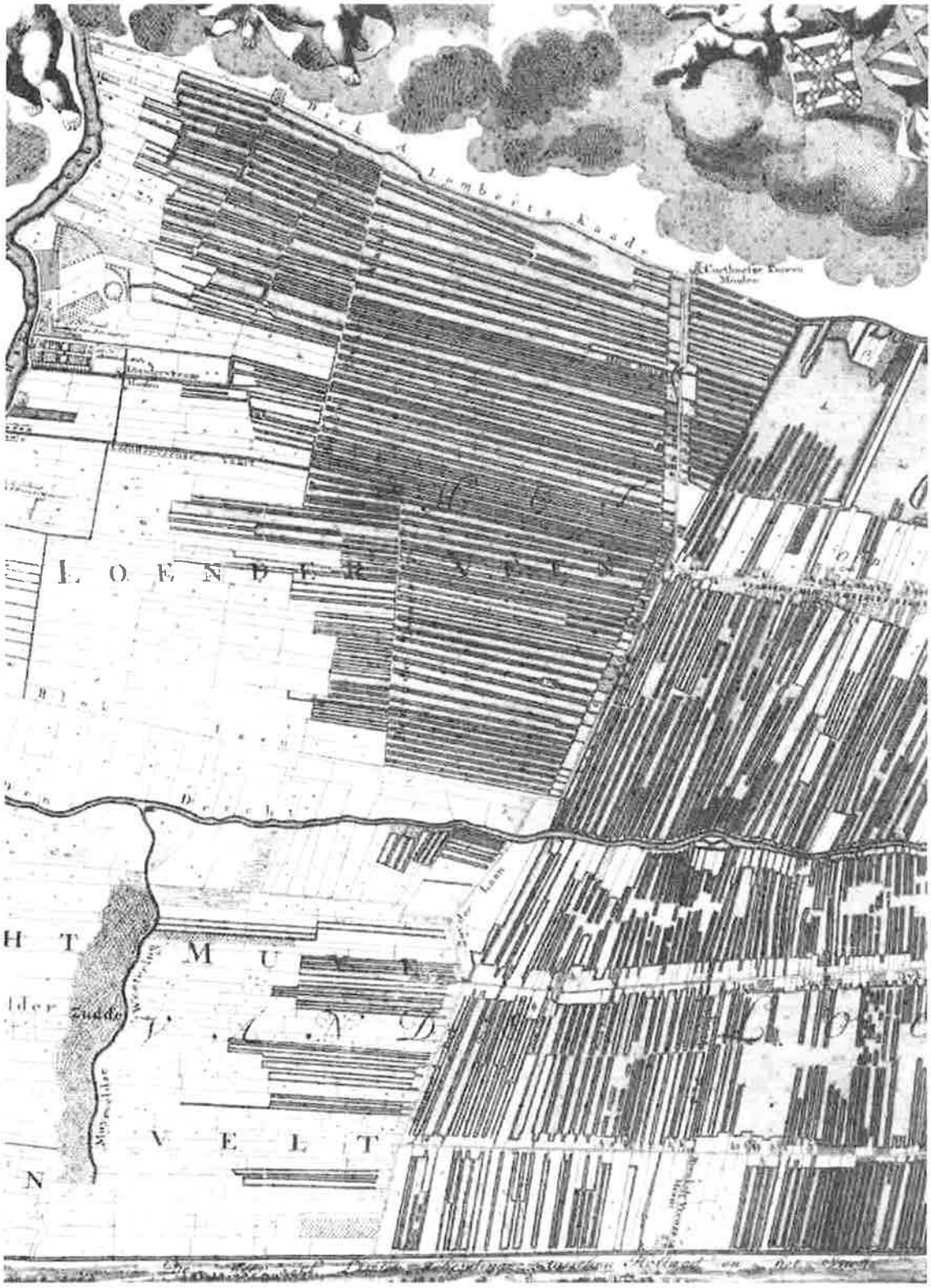


Lambert, 1971, p. 105, naar Gottschalk, 1956.

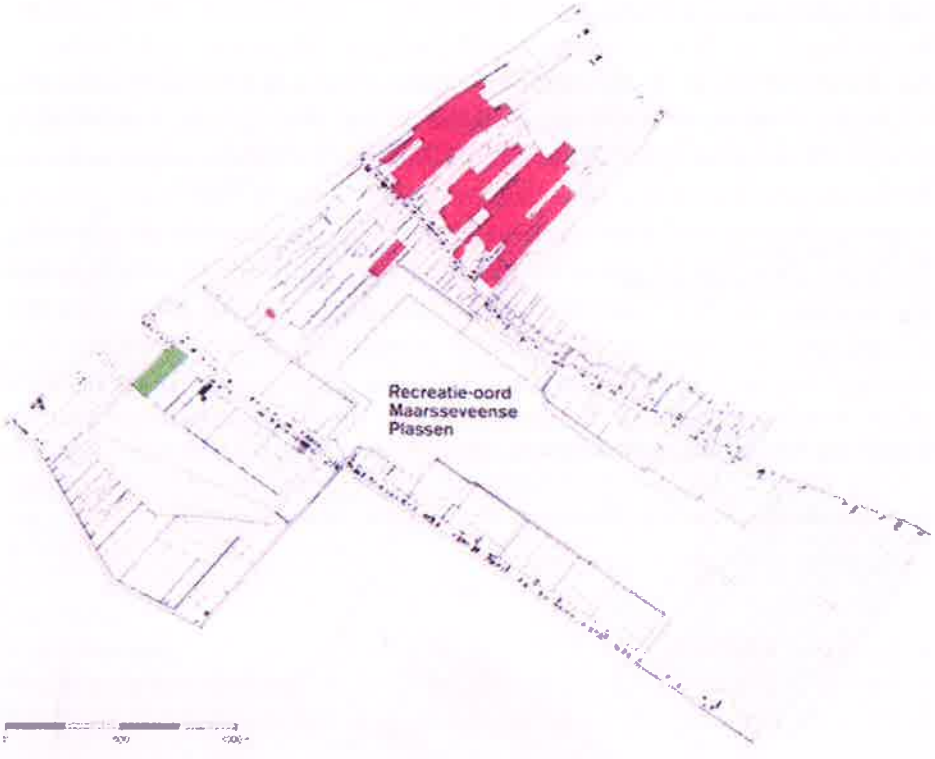


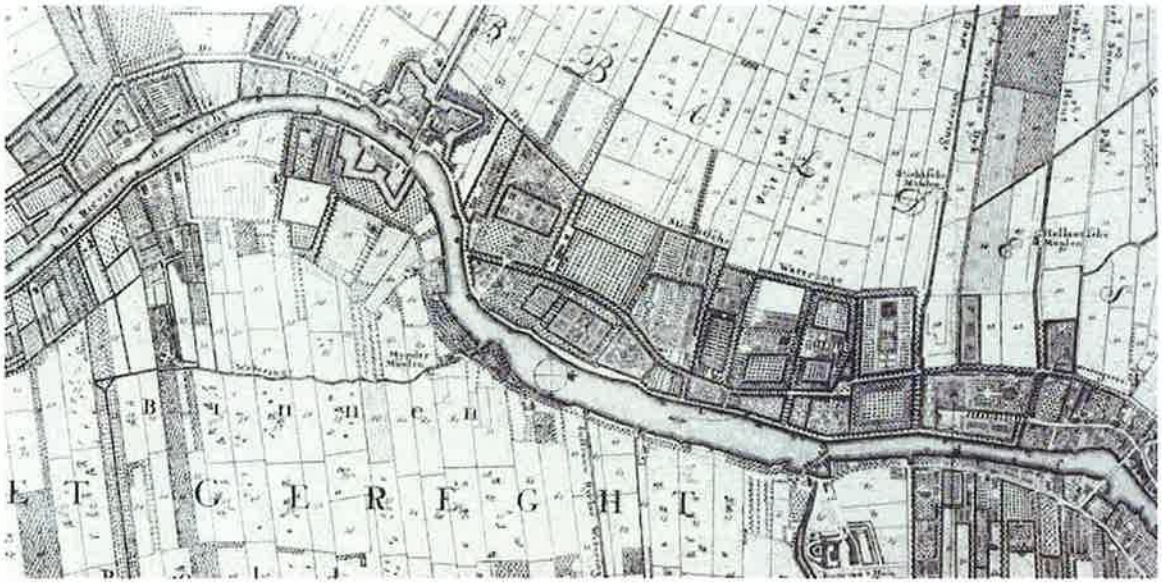


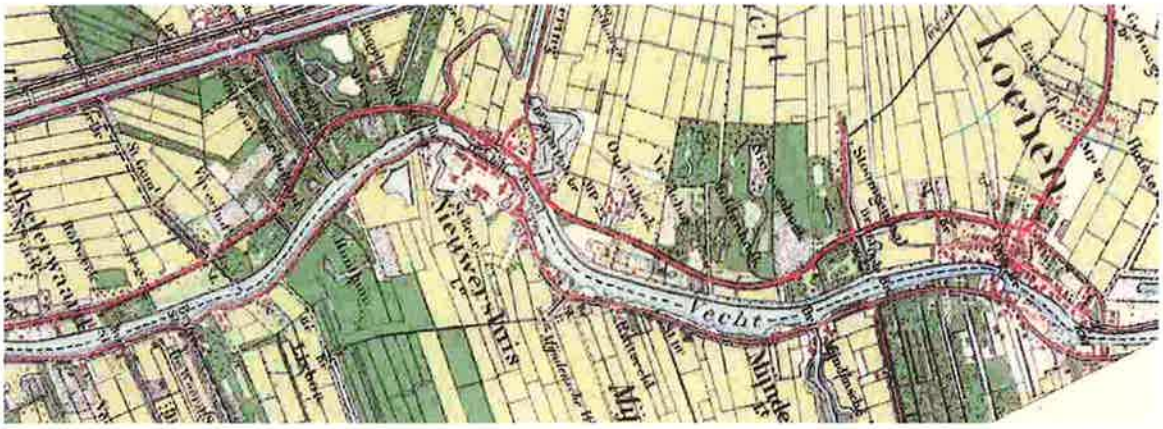
Maarsseveen


L O E N D E R
V E L T

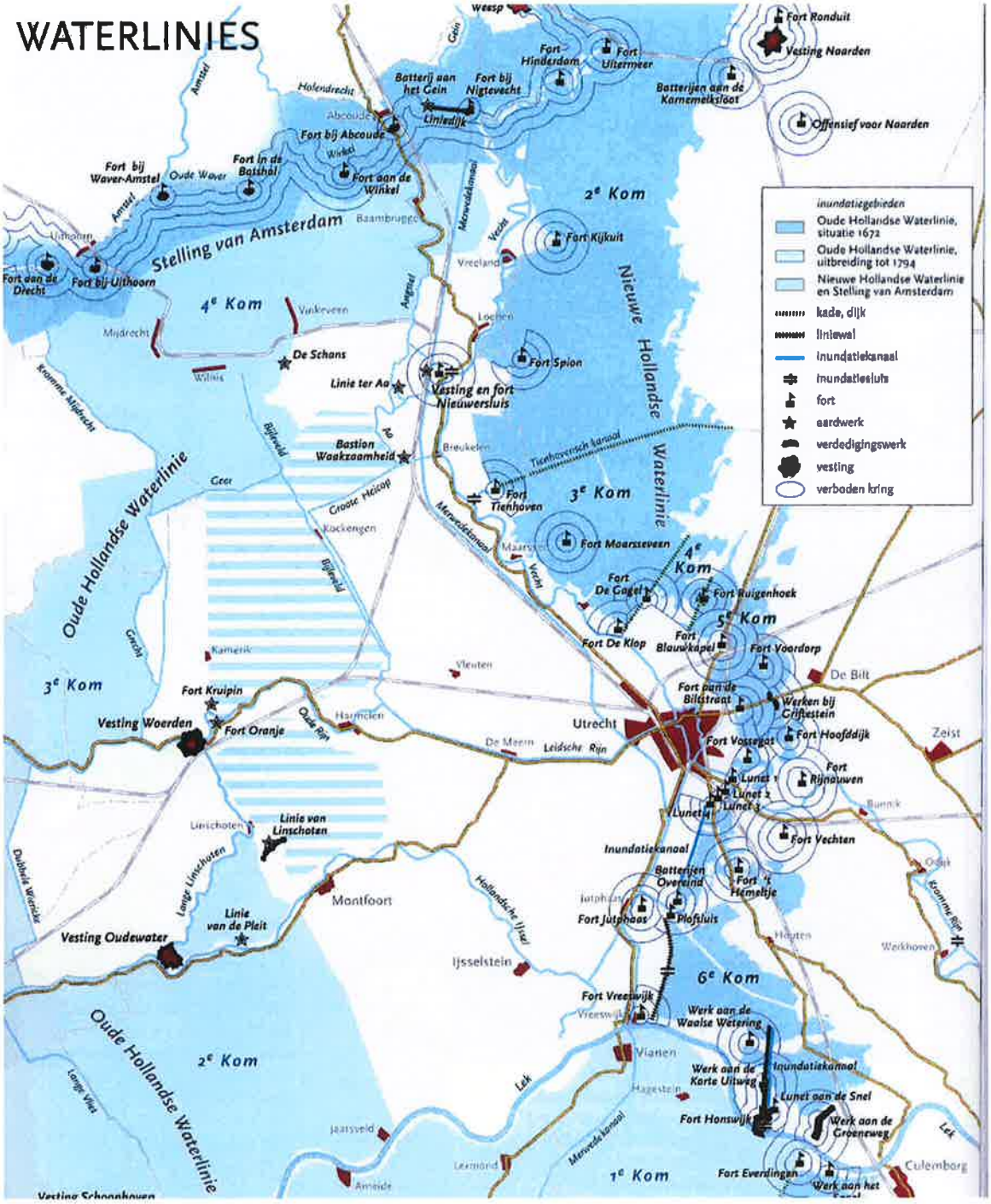
Maarsseveense Plassen

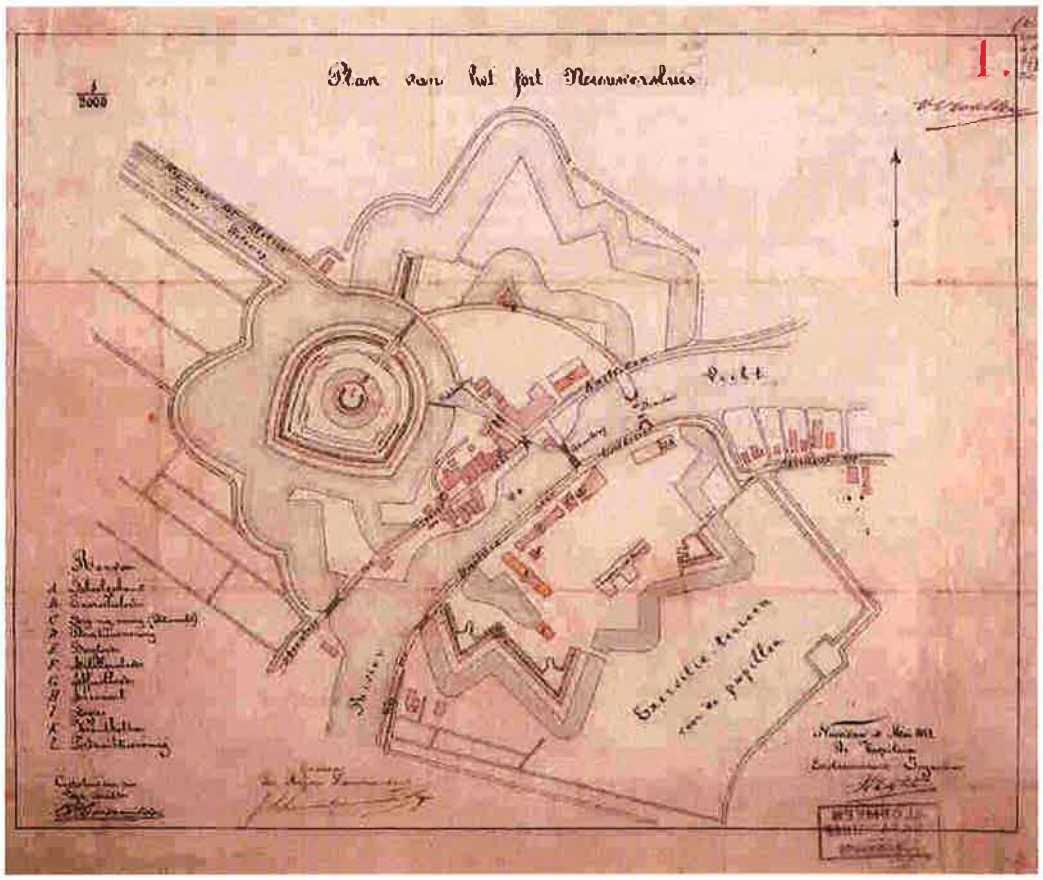


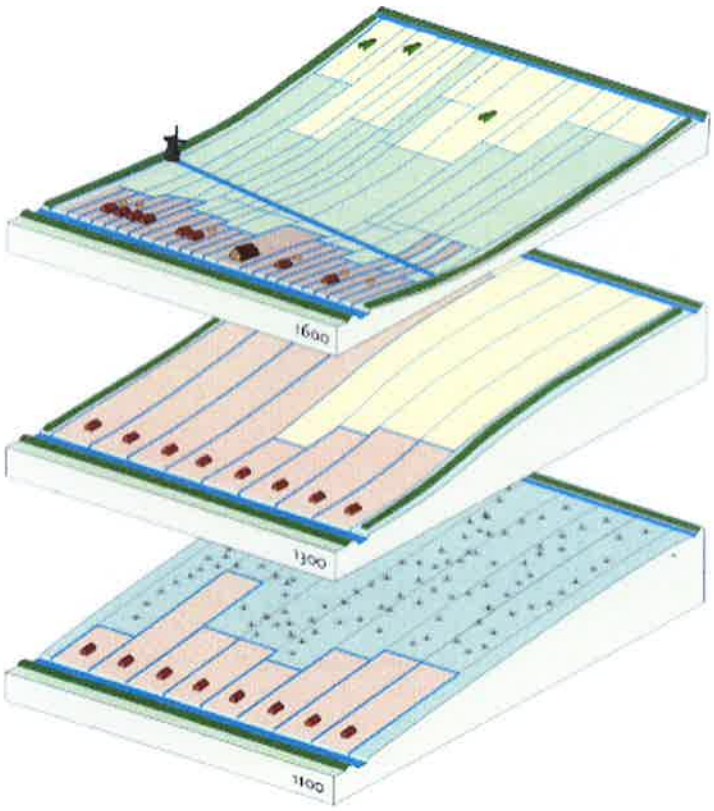

T G E R E G H T


Loenen
Nieuwersluis
Vecht

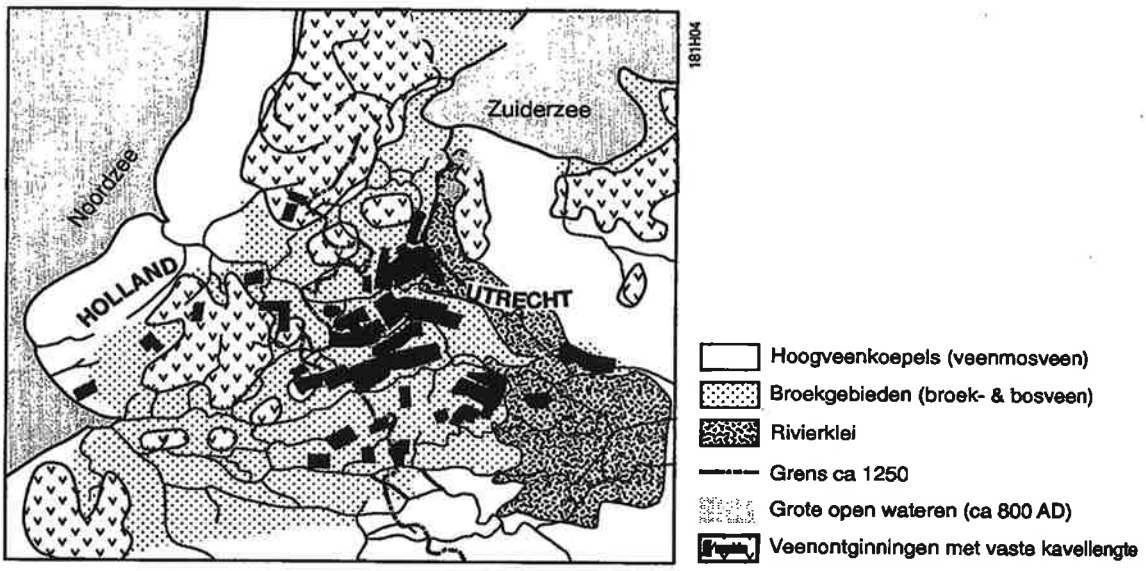
WATERLINIES

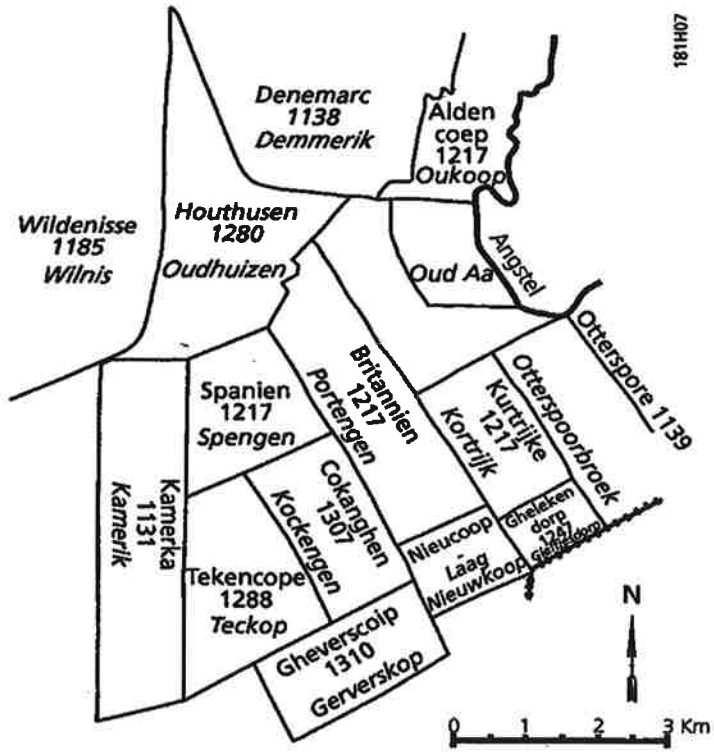



Plan van het fort Nieuwersluis
1.


1600
1300
1100

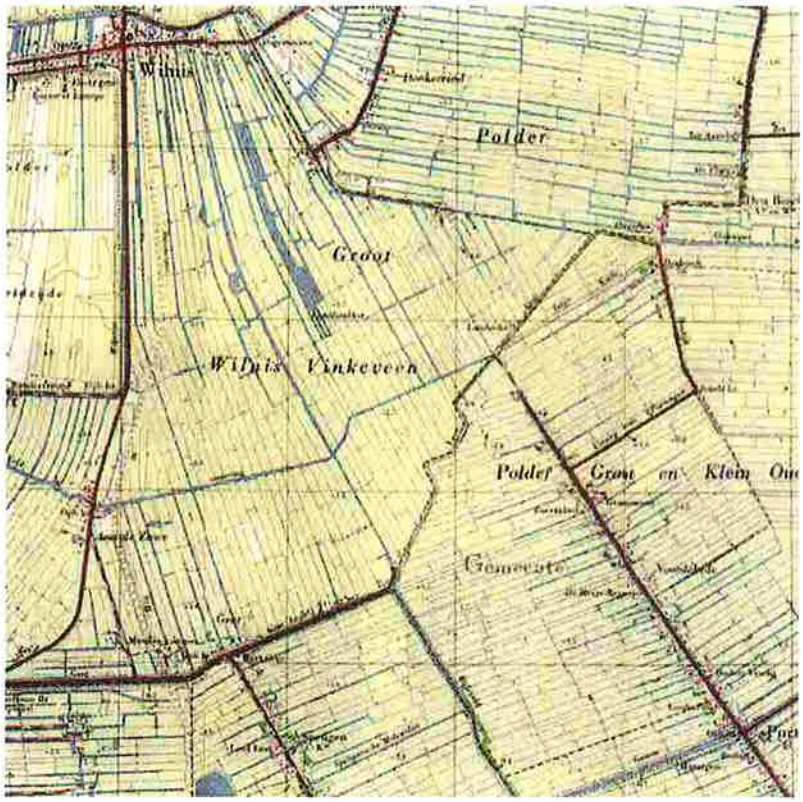
Klein
Oud-Aa
Noordeinde
Oostenburgh
Portengense Brug
N401
Portengen
Polder
Zuideinde
Kockengen
Portengen
Kockengen
Gerverscop

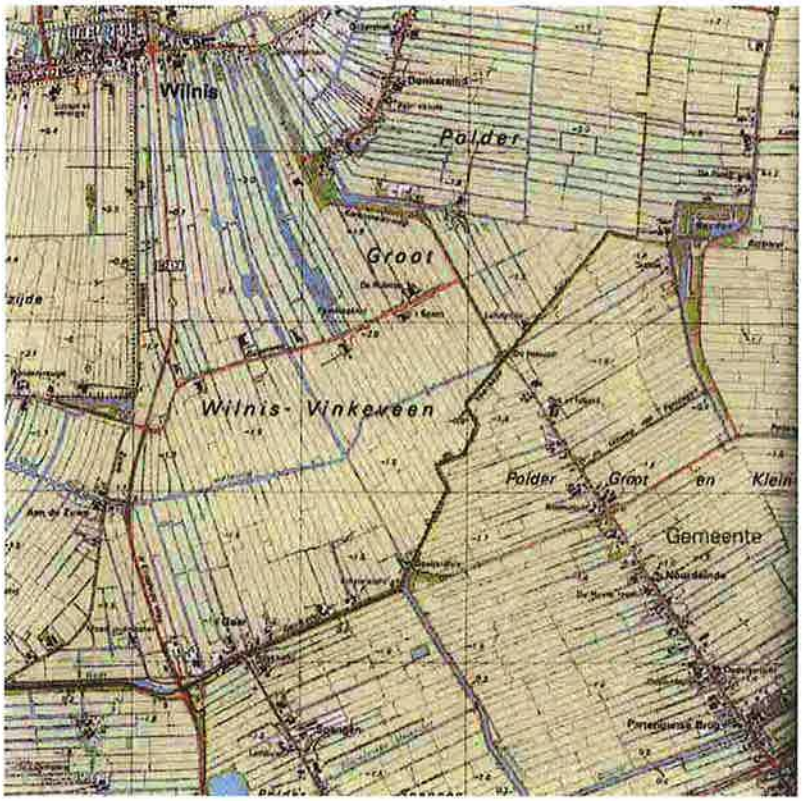




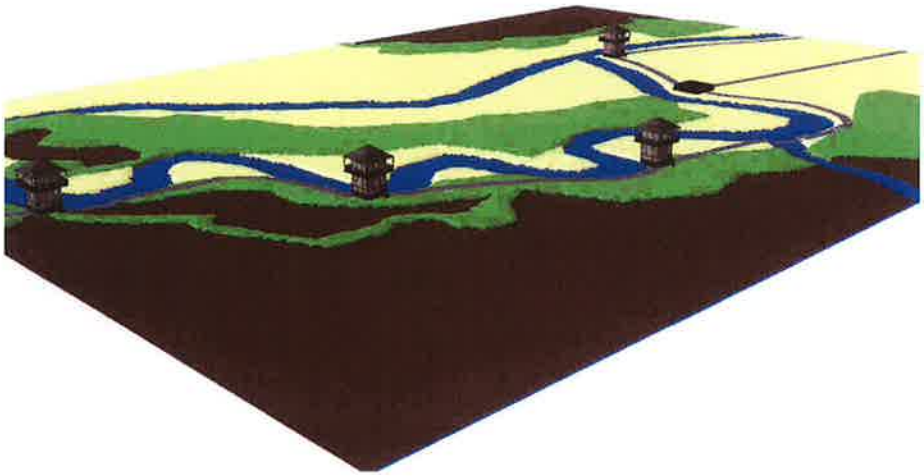
Legenda

- Blokgrens
- Rivier
- Wetering


Wilnis
Polder
Groot
Wilnis Vinkeveen
Polder Groot en Klein
Gemeente

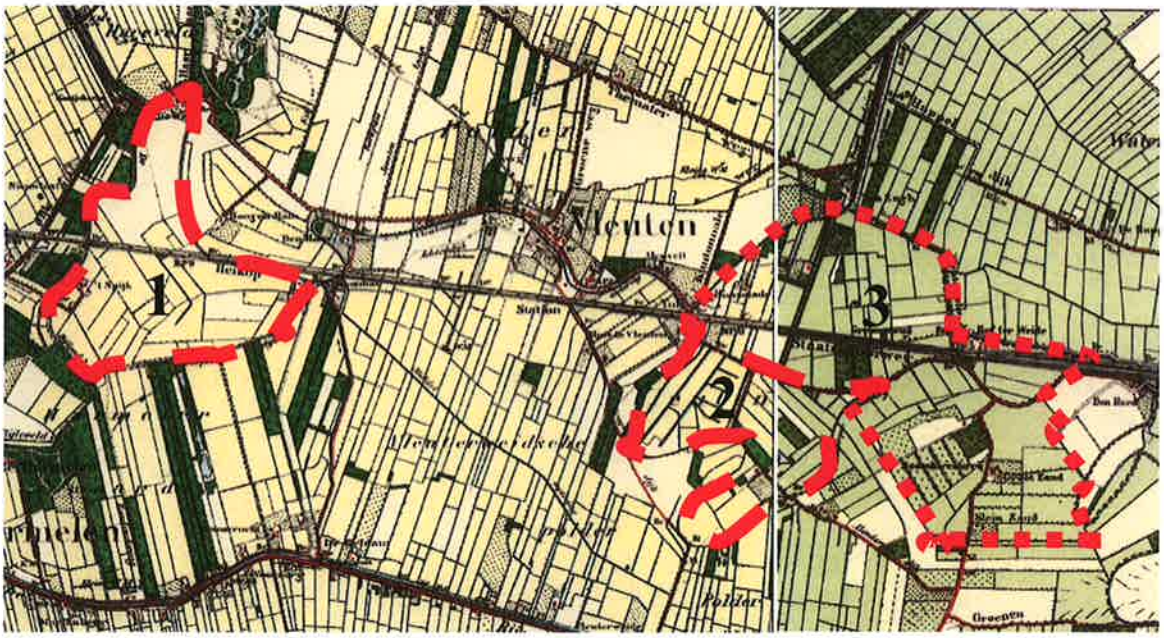

Wilnis
Polder
Groot
Wilnis- Vinkeveen
Polder Groot en Klein
Gemeente

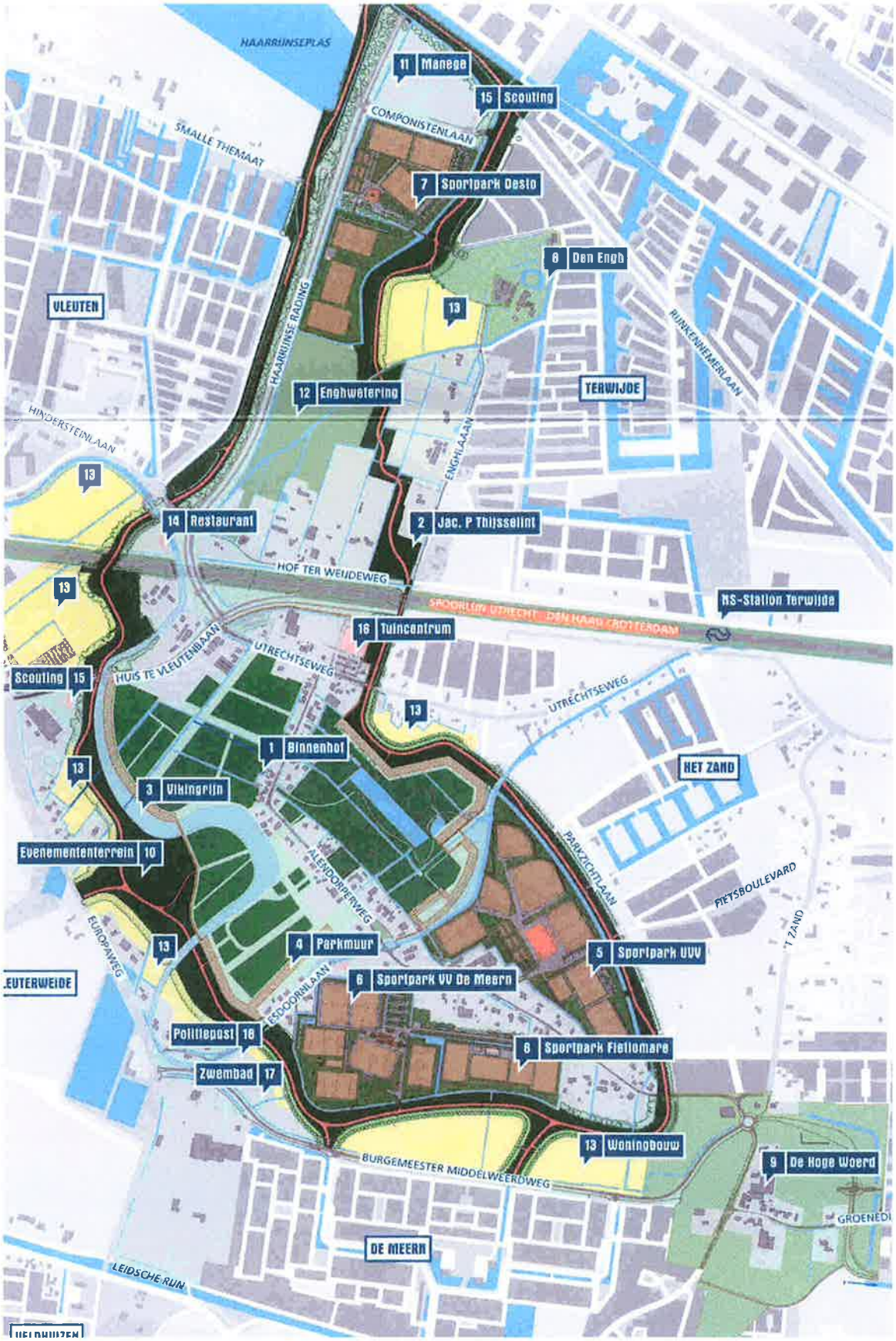
Leidsche Rijn



de Rijn
Vleuten-
De Meern
Utrecht
TRAJECTUM
Woerden
LAUR(I)UM
Maurik
MANNARIC
Lek
Wijk bij Duurstede
LEVEFANUM

Vleuten
Vleuterweidsche Polder
De Meern
Langerak


Vleuten
1
2
3


HAARRIJNSEPLAS
11 Manege
15 Scouting
COMPONISTENLAAN
SMALLE THEMAAT
7 Sportpark Oesto
8 Den Engh
VLEUTEN
13
HAARRIJNSE RADING
RIJNSKENNEMERLAAN
12 Enghwetering
TERWIJDE
HINDERSTEINLAAN
ENGHLAAN
13
14 Restaurant
2 Jac. P Thijsselint
HOF TER WEIDEWEG
13
SPOORLIJN UTRECHT - DEN HAAG - ROTTERDAM
NS-Station Terwijde
16 Tuincentrum
UTRECHTSEWEG
HUIS TE VLEUTENLAAN
Scouting 15
UTRECHTSEWEG
13
1 Binnenhof
HET ZAND
13
3 Vikingrijn
PARKZICHTLAAN
Evenemententerrein 10
ALENDORPERWEG
FIETSBOULEVARD
EUROPAWEG
13
4 Parkmuur
5 Sportpark UVV
LEUTERWEIDE
6 Sportpark VV De Meern
ESDOORNLAAN
Politiepost 18
8 Sportpark Fietsmare
Zwembad 17
13 Woningbouw
BURGEMEESTER MIDDELWEERDWEG
9 De Hoge Woerd
GROENEDI
DE MEERN
LEIDSCHE RIJN

Exkursion B1

EXCURSION B1

Upper Pliocene and Lower Pleistocene Rhine-Meuse deposits in the Tegelen-Reuver type area

76. Tagung der Arbeitsgemeinschaft Norddeutscher Geologen 5. Juni 2009

TNO / **Deltares** Subsurface and Groundwater systems
Geological Survey of the Netherlands
Princetonlaan 6, Utrecht.
P.O. Box 85467
3508 AL Utrecht
The Netherlands

Contents

1. **GENERAL INTRODUCTION** **3**

1.1 Tectonic framework 3

2. BRIEF REVIEW OF FORMER GEOLOGICAL AND PALAEOBOTANICAL RESEARCH **9**

2.1 Lithostratigraphy 9
2.2 Palaeobotanical research 14

3. THE ÖBEL PIT (Near Brüggen) **16**

4. THE PIT BRACHTER TON ABBAU **21**

5. THE PIT HOHER STALL **25**

1. GENERAL INTRODUCTION

1.1 Tectonic framework

The south-eastern part of the Netherlands forms the continuation of the LRE which is the most south-easterly extension of the North Sea basin. To the south the LRE is bounded by the Palaeozoic rocks of the Rhenish Massif (Fig.1). The subsurface structure is determined by a SE- to NW-orientated fault pattern. The faults define individual tectonic blocks of which the subsidence rate may show considerable differences. The area forms part of the European Rift System (Vinken, 1988; Ziegler, 1994; Geluk et al., 1994; Michon et al., 2003; Van Balen et al., 2005; Sissingh, 2006). One of the main tectonic features is the RVG (Rurscholle in Germany, Fig. 1). This subsiding area is confined by major fault systems, i.e. the Feldbiss Fault Zone and Gilze Rijen fault to the south and the Peel Boundary fault to the north (Fig.1). Due to the NE-SW-orientated extension an overall subsidence of the RVG of about 1200 m is recorded since the Late Oligocene (Geluk et al., 1994). The overall subsidence of the adjacent Peel Block amounts to about 200 m. The higher subsidence rate of the RVG provides a more suitable preservation potential for the Rhine-Meuse deposits in this area.
The sediment fill of the LRE consists of thick marine strata in the deepest part that were deposited during the Oligocene, Miocene and Pliocene (Schäfer et al., 2005). Up to 100 m thick brown coal or lignite seams occur in the southern part of the LRE (Gliese & Hager, 1978; Zagwijn & Hager, 1987). They interdigitate with the marine deposits. The upper part of the sediment fill consists of fluvial deposits that started to develop above the lignite as a result of increased uplift of the Rhenish Massif. The onset of the fluvial deposition is thought to have taken place in the Late Miocene (Gliese & Hager, 1978; Boenigk, 1978[a], 1978[b]; Hilden, 1988; Van den Berg & Van Hoof 2001; Schäfer et al., 2005). The fluvial domain progressed gradually north-westwards and reached the southern part of the Netherlands during the Pliocene. Concurrently the coastline shifted in the same direction (Zagwijn, 1989). This process continued in the Early Pleistocene and eventually resulted in a shift of the marine area far into the present North Sea.

The subsurface tectonic framework of the southern North Sea Basin (including the LRE) strongly controlled the Quaternary depositional record. The pattern of regional Quaternary tectonic movement is well-expressed by the base of the Quaternary deposits. Two areas of maximum subsidence are shown in the onshore part of the Netherlands: the RVG and the so-called Zuiderzee Low) situated at the centre of the present Lake IJssel (Van Adrichem Boogaert & Kouwe, 1993). Between them the SE-NW orientated area of the Peel Block is situated (Fig. 1). The south-western part of the Netherlands (i.e. the area west of the RVG) shows an undulating north-eastward dipping base-Quaternary surface. A similar surface is present in the eastern part of the country north of the Peel Block. This surface is disturbed as a result of updoming salt structures and deeply incised (sub)glacial valleys in the north-eastern part of the country. The hinge-line of the basin runs more or less parallel to the southern and eastern state boundaries but is situated further to the southeast in the LRE. The pattern of the hinge-line is clearly expressed in the models of the regional subsidence during the Quaternary (Kooi et al., 1998). Its position may have shifted basinwards during the last few millions years, but it is assumed that the overall pattern can be compared to the present-day situation. However, an exception must be made for the area of the Peel Block. It is assumed that the hinge line here was situated south of the present-day situation as a consequence of the remnants of Lower Pleistocene fluvial deposits on this tectonic unit. The Quaternary deposits in

the RVG are about 235 m thick, increasing up to 400 m or more in the Zuiderzee Low (Zagwijn, 1989), while values of over 1000 m can be reached in the Central Graben of the North Sea Basin.

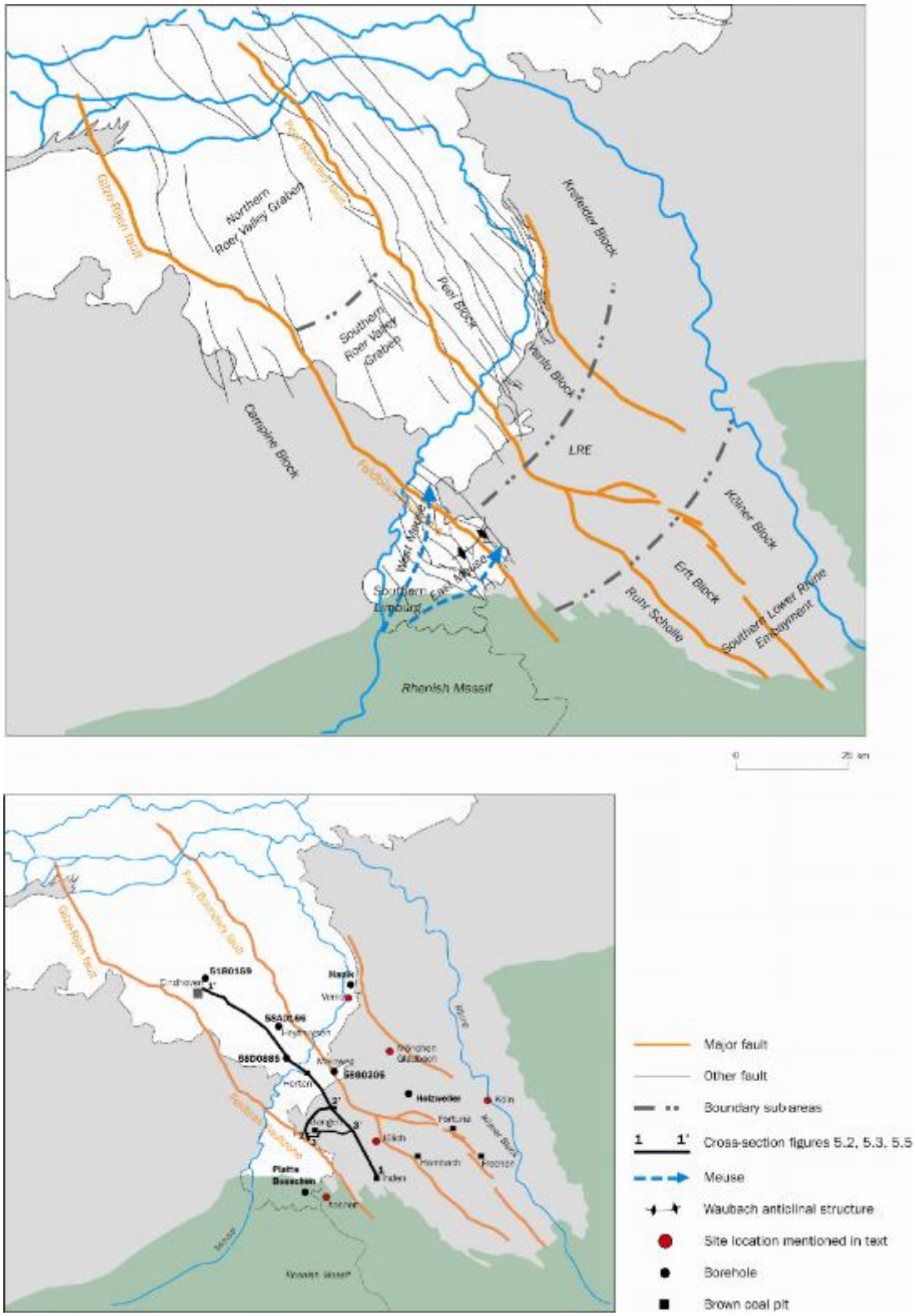


Figure 1. Tectonic framework of the Lower Rhine Embayment and the SE-Netherlands

Within the RVG/Rurscholle the thickness of the preserved depositional sequences is increasing from SE to NW. This indicates that subsidence rates increase accordingly in the same direction (Van Balen et al., 2005; Michon & Van Balen, 2005). The generalised thickness of the various lithostratigraphical units in each of the three compartments of the RVG (i.e. Rurscholle in Germany, southern and northern RVG in the Netherlands) shows a more or less constant ratio in thickness of the Pliocene, Lower Pleistocene, and Middle to Upper Pleistocene deposits. This observation indicates that the subsidence rates may have been more or less constant during Pliocene and Early Pleistocene times, while a slight increase might have occurred during the Middle and Late Pleistocene (Van Balen et al., 2005). Detailing these figures is extremely difficult in the absence of reliable age-control and (relative) height markers. Moreover, it is complicated because of the interfingering of the deposits of the Rhine-Meuse and Belgian river systems. A similar complication results from the intercalations between the fluvial and marine deposits. Considering the scale of the North Sea Basin, it should be noted that the sediment storage capacity of the RVG is restricted and that the major part of the sediment supplied by the Rhine-Meuse system by-passed the area and was deposited further northwards in the Zuiderzee Low and central part of the North Sea (Van Balen et al., 2000; Schäfer et al., 2005).

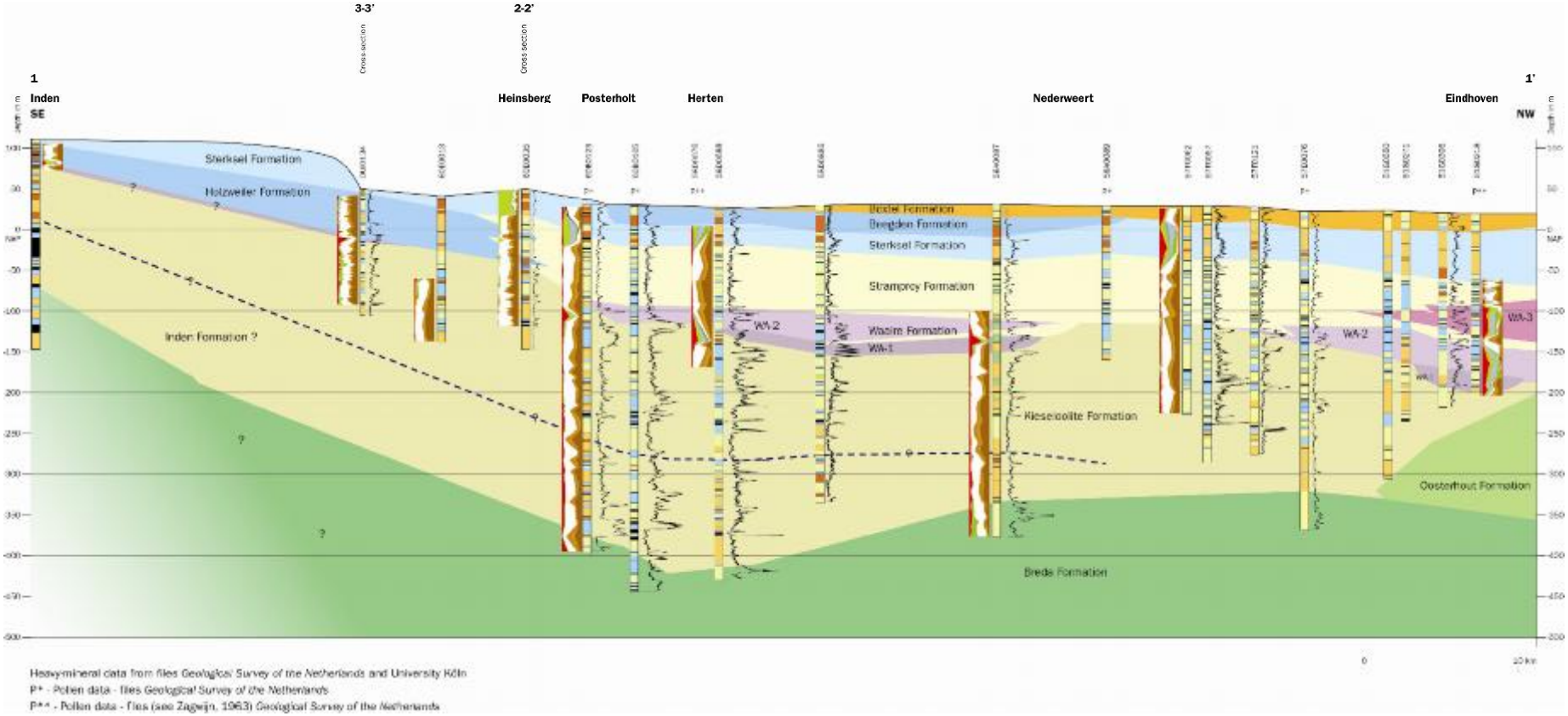


Figure 2. SE-NW cross-section in the Rurscholle/Roer Valley Graben showing the Pliocene and Quaternary lithostratigraphic units. See Table ! for description of main characteristics.

The deposits found in the excursion area all form part of lithostratigraphically well mapped units in The Netherlands. In Table I a brief description is given of the units and their characteristics in the excursion area.

Table I. Comprehensive overview of main lithostratigraphic units in the excursion area

Litho-stratigraphic unit	Depositional characteristic	age	lithology
Boxtel Formation	aeolian and periglacial deposits. < 2 m	Late Pleistocene	coversand and loess-like deposits, locally reworked by wind during the Holocene
Sterksel Formation	Coarse grained fluvial sand and gravel, locally with clay-layers ± 20 m	Early Middle Pleistocene (Cromerian)	heavy minerals: unstable association dominated by epidote (Weert zone). Erosional lower boundary.
Stramproy Formation	Fluviatile and periglacial medium grained sandy deposits. Locally soil horizons, cryoturbation and frost wedges. 0 - 5 m	late Early Pleistocene	heavy minerals: stable association. Only locally as erosional remnants.
Waalre Formation	Fluvial sand and gravel with extended and often thick clay layers. 10- 25 m	Early Pleistocene	heavy minerals: unstable associations, often with considerable garnet content.
Kiezeloolite Formation	Fluvial sand with thick clay layers and intercalated browncoal seams in the top. 10 - 60 m	Pliocene	heavy minerals: stable associations. The finer top part is dominated by zircon. The uppermost part shows a gradual change to unstable mineral associations.
Breda Formation	fine grained glauconite bearing - marine sands and clay. > 100 m	Miocene	heavy minerals: dominated by stable associations but generally 20 - 30% unstable minerals.

In the excursion area, which comprises the Elmpter and Brachter Wald areas a series of active and abandoned excavations can be found which initially were mainly used for clay digging (figure 3). Especially in the pits near Tegelen geological research has taken place for more than 100 years. In the beginning this research concentrated predominantly on palaeontological aspects but since halfway the last century investigations of the a-biotic components of the exposed deposits became gradually more important.

It is generally believed that the name Tegelen is derived from the Latin word Tegula. From archaeological studies it is known that already during Roman Times clay digging has taken place for the production of pottery, roof-tiles, and bricks. Originally the exploitation of the clay started in small excavations that where dug out along the terrace escarpment. Later on, clay digging was also started on the higher part of the terrace. Large scale excavation began around the end of the nineteenth century and culminated during the 1950s. After about 1960, many excavations were abandoned but since the mid-eighties an increase of clay- and sand-mining activities has taken place. Nowadays, the exploitation is concentrated in a few relatively large excavations.

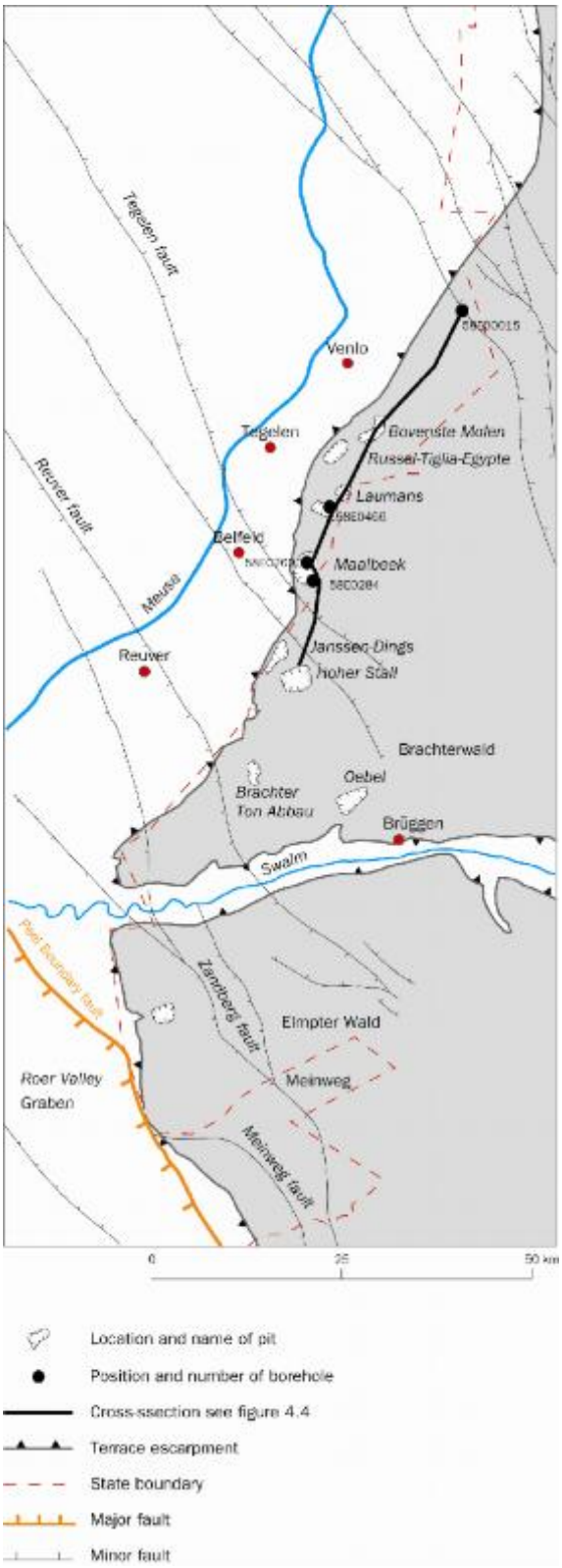


Figure 3. Detailed map of the Meinweg-Tegelen area. Name of faults and excavations are indicated. Some of the pits will be visited during the excursion

2. BRIEF REVIEW OF FORMER GEOLOGICAL AND PALAEOBOTANICAL RESEARCH

2.1 Lithostratigraphy

The Dutch-German border area, east of Tegelen, has a long history of geological research and includes a number of Late Pliocene and Early Pleistocene 'type-sites' (for extended References see: Zagwijn, 1998; Meijer, 1998). As a result of its position on the Peel Block, Late Pliocene and Early Pleistocene deposits are situated at or near the surface. The area is marked by a pronounced terrace escarpment formed by the Meuse which, reinforced by tectonic movements, has undergone a major shift eastwards across the Peel Block since the second half of the Middle Pleistocene. Lower Pleistocene deposits occur only as erosional remnants, west of the escarpment. The main lithostraigraphical subdivision is shon in figure 4.

A discontinuous record of Lower Pleistocene deposits has been preserved in the Netherlands-German border area east of the terrace escarpment. An overview of the general lithostratigraphy in this area is shown in the N-S orientated cross-section (Fig. 5). The section is based on borehole data, cone penetration tests (CPT), field observation in excavations and the results of regional mapping. All units show a NE-orientated tilting on the tectonic blocks. The sequence comprises five lithostratigraphical units which are listed below:

1 The base is formed by the Breda Formation, consisting of fine-grained and glauconite-bearing marine deposits of Miocene age.
2 The Kieseloolite Formation unconformably overlies the Breda Formation. The unit consists of up to 30 m thick medium to coarse-grained fluvial deposits which grade into a several metre thick clay deposit towards the top. The latter is assigned to the Reuver Bed. (Zagwijn, 1960; Boenigk, 1970; Westerhoff, 2004; Kemna, 2005, 2008) that normally contains two characteristic peat or browncoal strata in its uppermost part. The sand is typified by a dominant stable heavy-mineral content (Fig.4). The unit is of Pliocene (Piazencian) age.
3 The Waalre Formation consists of a sequence of fluvial deposits up to 25 m of the Early Pleistocene Rhine-Meuse system. The basal part consists of coarse-grained gravel and sand that grades upwards into fine-grained and clayey deposits. An erosional boundary marks the transition into the underlying Kieseloolite Formation. The heavy-mineral content is typified by a dominance of unstable minerals, with a clear presence of garnet, that often culminates in and around the clayey deposits. Two subunits can be recognised within the Waalre Formation. Firstly, deposits near Hoher Stall (southern part of the section, Fig. 4) are assigned as subunit WA-1. They are characterised by an unstable heavy-mineral association and form part of the so-called Oebel Beds (Boenigk, 1970; Kemna, 2005, 2008; Boenigk & Frechen, 2006; Heumann & Litt, 2002; Westerhoff, 2004). The uppermost part of subunit WA-1 consists of a clay deposit that lithologically resembles the Reuver Bed and yields typical Late Pliocene pollen assemblages (e.g. presence of 'Tertiary elements', Zagwijn, 1974[a]; Westerhoff, 2004). However, the lithology (mica-rich) and the predominance of an unstable heavy-mineral association of this subunit bears all the characteristics of an 'Alpine-influenced' Rhine deposit and therefore it forms part of the Waalre Formation. North of the fault that separates the Hoher Stall area from the Maalbeek-Tegelen area (Fig. 4), gravel, sand and clay deposits of the Waalre Formation overly the Reuver Bed and are assigned to

the Tegelen Member. This member of the Waalre Formation comprises all the deposits of the formation that occur on the Peel Block.

4 The Stramproy Formation overlies the Waalre Formation and consists of preserved sediments only a few metres thick. The unit consists of medium-grained sand with a dominant stable heavy-mineral content and often shows the clear occurrance of periglacial phenomena (Van Straaten, 1956; Zagwijn, 1963[a]; Kasse & Boncke, 2001).

5 The uppermost deposits in the section are formed by coarse-grained gravel-bearing deposits of the Sterksel Formation. The lower boundary forms an erosional contact with the underlying deposits. The formation is about 20 m thick and forms part of the so-called upper terrace series (UT) in Germany. Its heavy-mineral content is characterised by unstable (Rhine) associations in which epidote dominates.

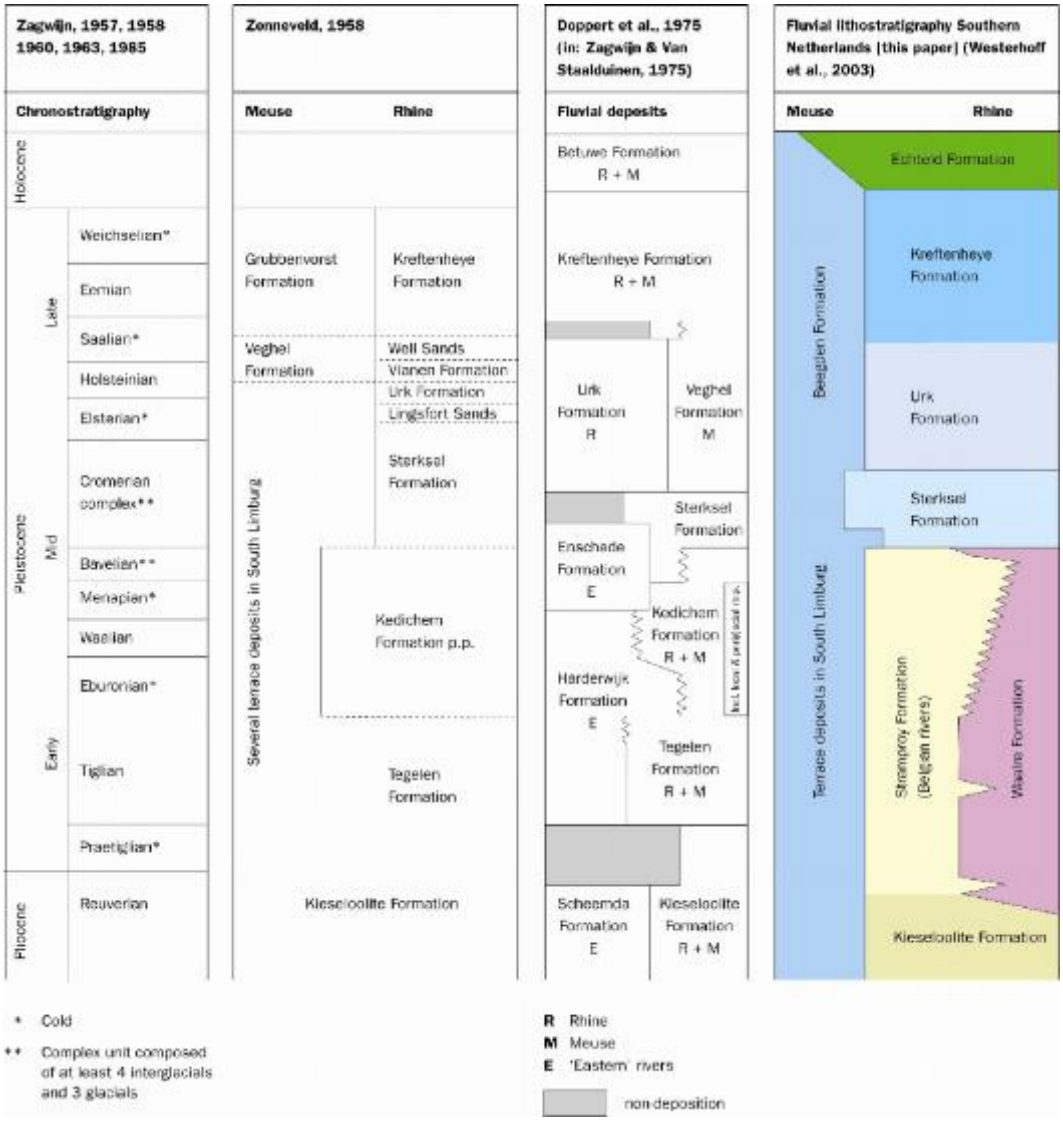


Figure 4. (litho)stratigraphy of Late Pliocene and Early Pleistocene deposits in the southern part of the Netherlands. The table of Zonneveld (1958) was the first lithostratigraphical schemewith a Pleistocene chonology based on de pollen-defined subdivision introduced by Zagwijn (1957). The recently revised scheme is shown in the leftmost column (Westerhoff, 2009).

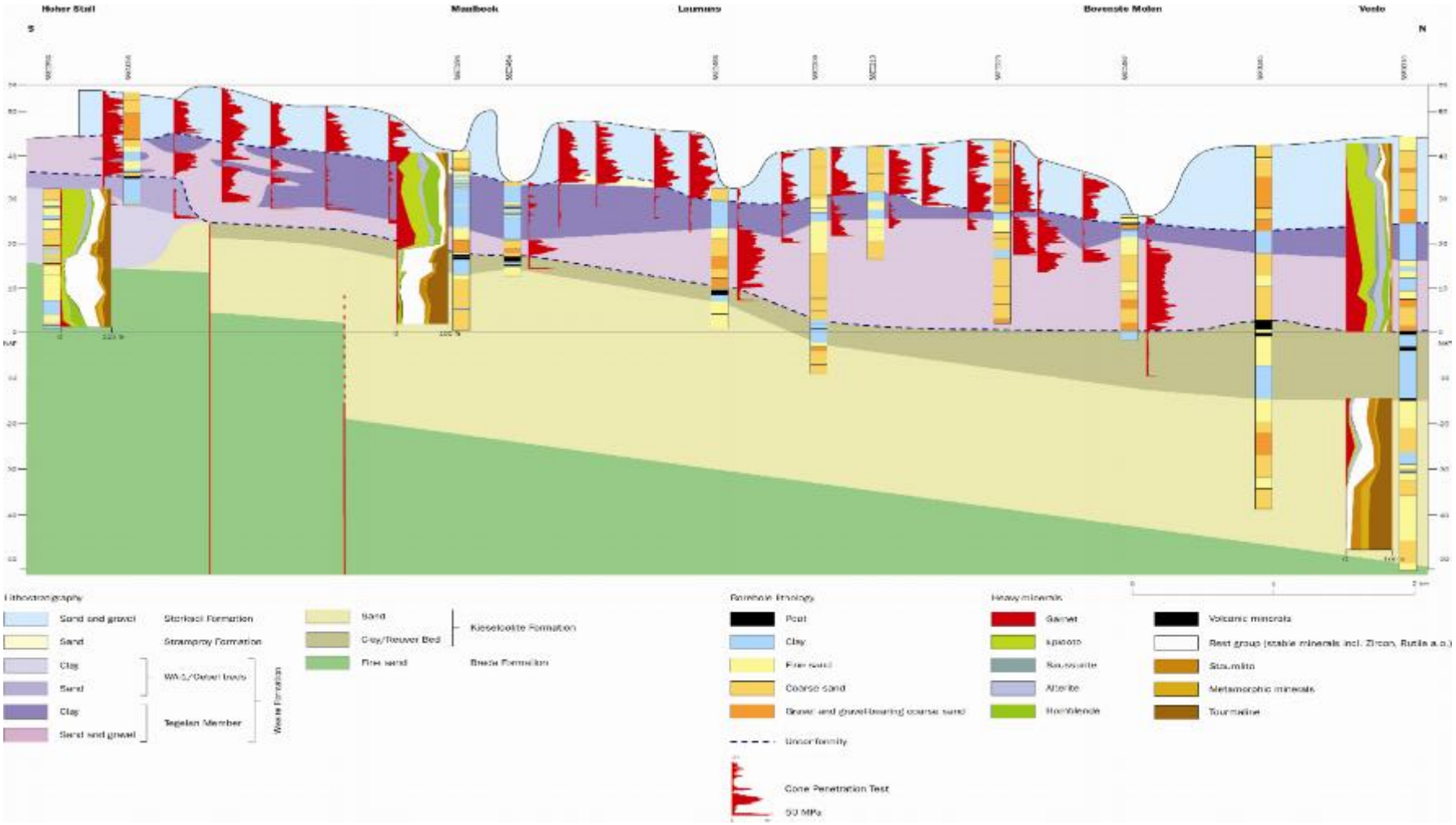


Figure 4. Cross-section along the Dutch-German border in the Tegelen-Maalbeek area (location indicated in Fig. 3). The position of the lithostragraphical units is based on field observations, borehole data and cone penetration tests. The heavy-mineral data from three boreholes clearly show the differences between the pre-Rhine (stable) and 'Alpine-influenced (unstable) Rhine-Meuse deposits. The northward dipping of the main lithostratigraphical units results from the generally NE orientated tilting of the main tectonic blocks in the area.

The deposits in the Dutch-German border area south of Venlo have drawn interest of geologists already for more than one century. Apart from the rather easy access because of a great number of exposures this is mainly caused by geoscientific reasons. The transitional period form Pliocene to Pleistocene is of great interest for studying climate change and related fluvial processes. It is also a key area for understanding the geological history and stratigraphic development of the Lower Rhine Embayment and the southern North Sea basin. The tectonic overprint on the sedimentary record however still hinders a full and comprehensive picture. Several authors have tried to reconstruct the sedimentary record of this area by compiling geological cross-sections. In the next figures some of the sections are shown. All sections run more or less parallel to the state boundary in a direction from south to north. Striking is the through time increasing number of lithostratigraphic units. A second matter of interest is formed by the number and position of faults.

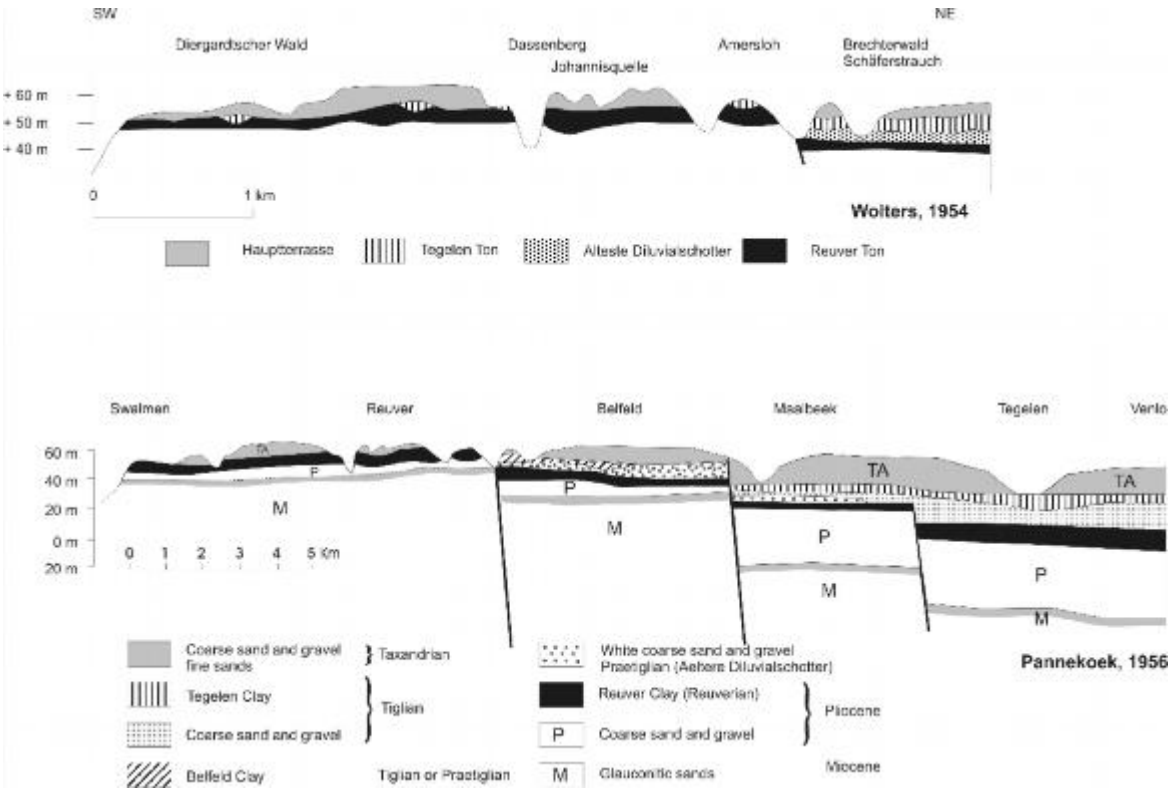


Figure 5. S-N cross-sections of the Dutch-German border area near Tegelen. The upper one is reconstructed by Wolters (1954). The lower one is published in the book: The Geology of The Netherlands by Pannekoek (1956).

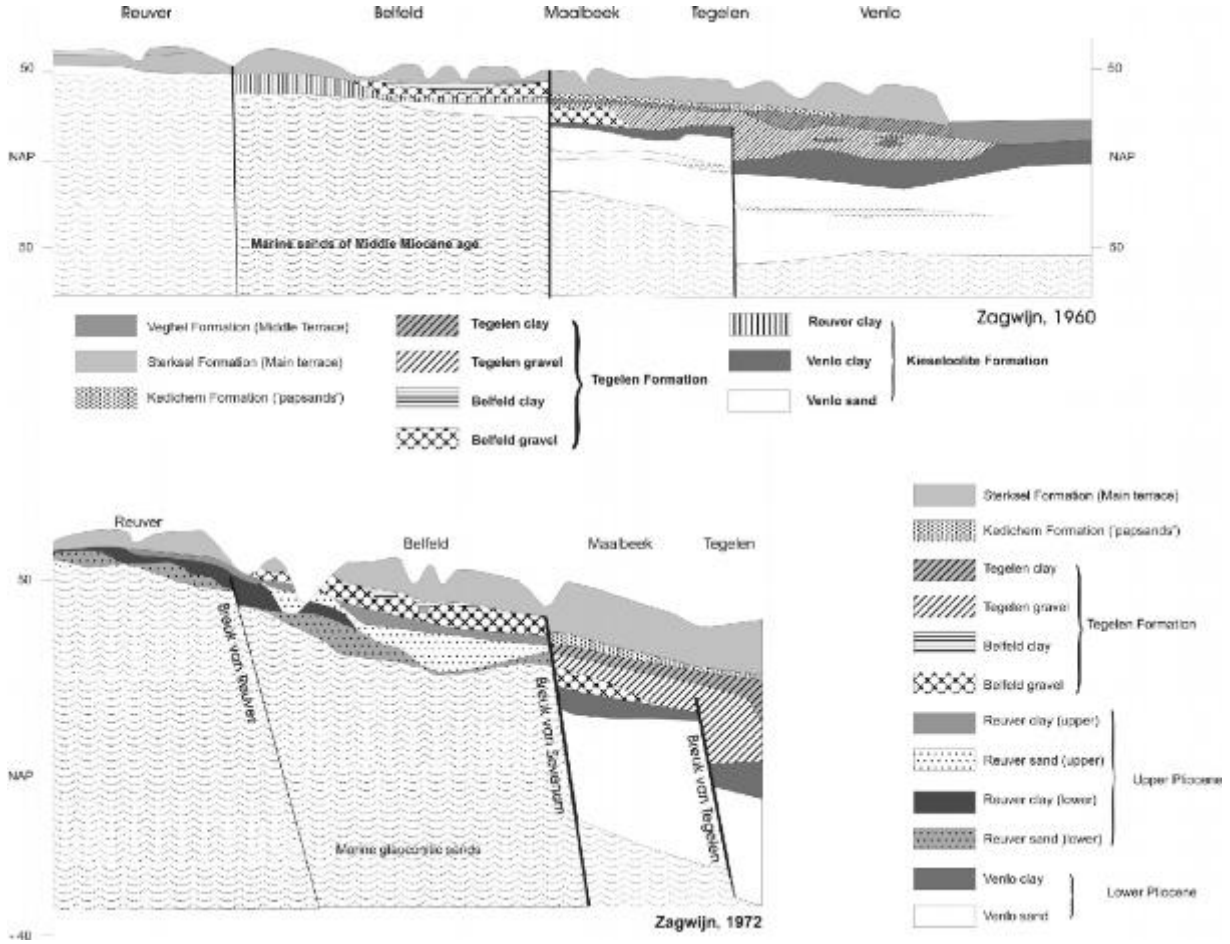


Figure 10. Cross-sections published by Zagwijn (1960, 1972 –excursion guide).

2.2 Palaeobotanical research

Since the beginning of the 20th century geologists have shown interest in the clay-pits near Tegelen and Reuver (Southeast of Venlo). The earliest investigations mainly concerned the study of the mammal faunas and the macroplant remains. It was Eugene Dubois who carried-out studies on the remains of (mainly) the larger mammals. The director of the former Geological Survey Dr. P. Tesch (1908) published a monograph on the Pliocene fluviatile sediments in this region. In order to enlarge the knowledge about the Late Tertiary and Early Pleistocene stratigraphy, it was decided to start a study on the fossil plant remains found in the several clay layers of this area. Therefore the British researchers E. & CL. Reid were invited to investigate the area and to describe the fossil floras. As a result of their studies Reid and Reid (1907, 1908, 1910, 1915) made distinction between two different flora assemblages, namely:

1. **Reuver Flora:**
   dominated by species like *Sequoia, Taxodium, Nyssa, Aesclus, Liquidambar* and *Fagus*.
2. **Tegelen Flora:**
   with low percentages or near absence of the so-called tertiary relics and Tsuga, *Pterocarya, Carya, Eucommia, Phellodendron* and *Actinida.*

Reid and Reid already thought that the decrease in number and content of thermophilous species, which form the differences between the two floras, were caused by a climatic change. They sought the explanation in a gradual cooling which took place at the transition from the Tertiary to the Pleistocene. The disappearance of several species in their opinion could be caused by the existence of the W-E orientated alpine mountain belts in south and central Europe.

In the thirties Florschütz started pollenanalytical studies of the clay and browncoal layers in the same area. The results confirmed the assumed relationship between the palaeovegetations and climatic changes. Florschütz however, proposed that the deterioration of the climate at the Plio/Pleistocene transition could be connected with a cold period (the pre-Tiglian). He rejected the idea of a gradual change and thought that a more sudden deterioration of the climate had taken place. In his thesis, Zagwijn (1960) published a pollen diagram of the Meinweg which shows a clear decrease in thermophilous plants and an increase of herbs. This phase was assigned by Zagwijn to the Pretiglian and is generally seen as the onset of the Quaternary. A summary of the main vegetational development during the Pliocene and Early Pleistocene is given in Figure 5.

At the same time, sediment-petrological studies were carried-out in order to characterise the fluviatile sandy sediments on the basis of their heavy mineral composition. This gave more information about the provenance of the sediments and the changing patterns of the rivers. The first firm combination of the results from the palaeobotanical and sediment-petrological investigations was made by Doppert and Zonneveld (1955) and Zagwijn (1960,1963). In the end, this has led to the establishment of a stratigraphic system for the Quaternary in The Netherlands

Especially the outstanding pollen analytical work of Zagwijn (a.o. 1957,1960,1963, 1985, 1998) has resulted in a rather detailed subdivision of the Early Pleistocene (Figure 5). Key sites for this work are situated in the pits near Tegelen and Reuver and in several boreholes in the Roer Valley Graben. Some of the sites will be visited during the excursion and former as well as recently obtained research results from several, investigated sites will be discussed.

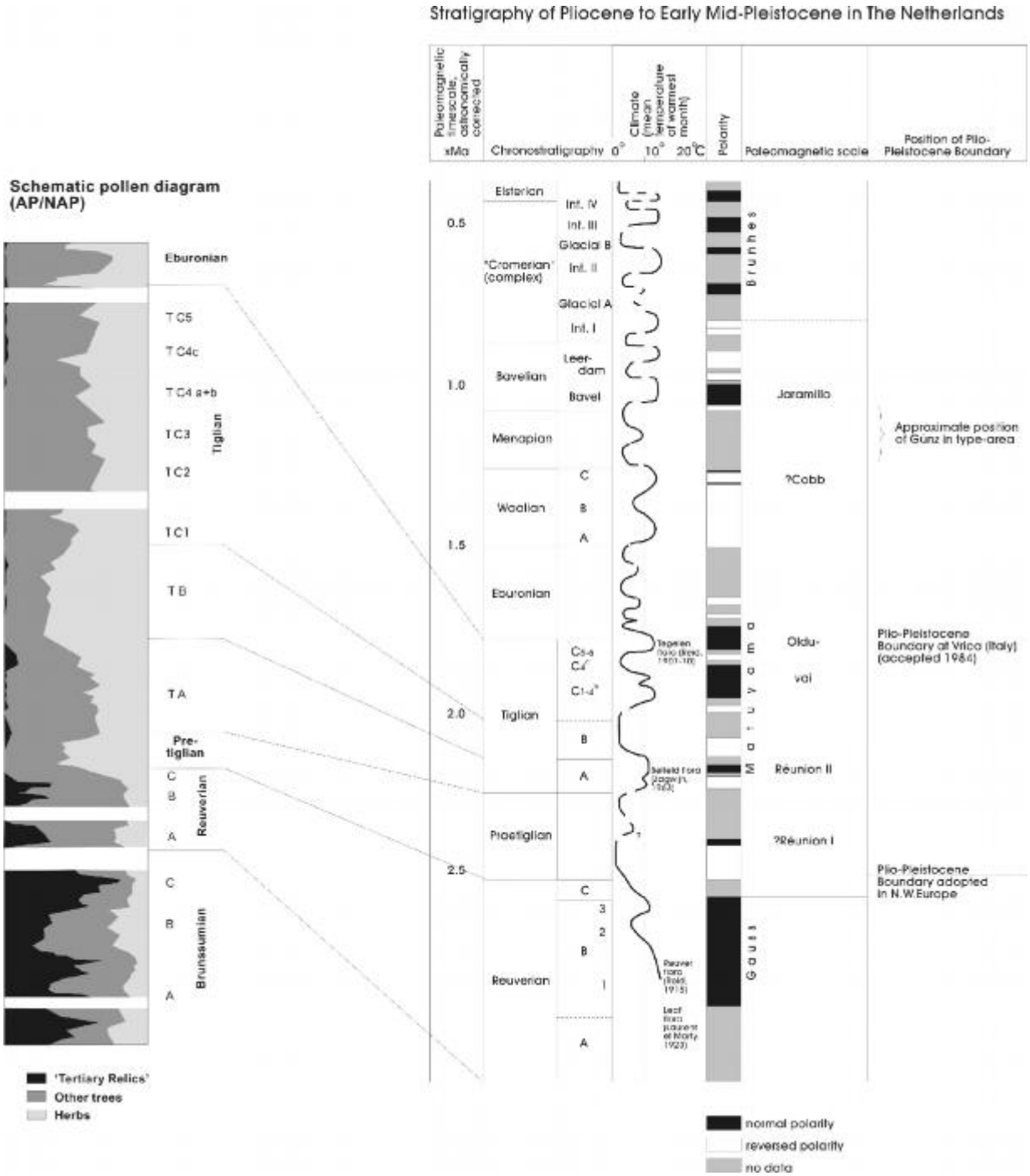


Figure 6. Late Pliocene and Early Pleistocene (bio- and chrono) Stratigraphy as defined by Zagwijn in several publications (see also Zagwijn, 1998).

3. THE ÖBEL PIT (Near Brüggen)

In the vicinity of Öbel (near Brüggen, Germany) several clay pits are already known for many years. Boenigk (1970) studied some of them of which pit number 85 & 83 are of special interest. In the 1990's a number of these pits were enlarged and connected to each other. The main pit is now known as the Deponie Viersen. However, this pit shows a gradual decrease in quality of exposure. During the excursion we will visit a pit with similar stratigraphy just at the north side of the main pit. The data shown here are merely derived from the main pit area but are still of value for discussing the sequences in nearby pits.
The general stratigraphy at Öbel shows the typical tripartion that is characteristic for this area. At the bottom a thick layer of Reuver Clay is exposed. It is overlain by gravel-bearing deposits and clay belonging to the Tegelen Member of the recently defined Waalre Formation. The latter is overlain by brown-colored sand of the Sterksel Formation. Locally some shallow channels occur at the base of the Sterksel Formation.

***Table II**:* general stratigraphy of the Öbel pit (see also figure 14, 17).

Sterksel Formation	coarse gravel bearing sand
Waalre Formation Tegelen member	clay, and channel fill with clay and browncoal layer sand, mica flakes coarse whitish gravel
Kieseloölite Formation	Reuver Clay, with browncoal horizons Reuver Sand

The basal clay deposit in the Öbel pits shows all characteristics of the Reuver Clay in the type area. It is a dense compact grey-blue coloured clay with two (sometimes three) browncoal horizons in its top part. The uppermost browncoal layer contains a lot of wood fragments and is a pure browncoal. The other browncoal layers contain mostly a clear clay component. The clay contains many rootlets, leaves and other organic material. Apart from the browncoal horizons there are other humic enriched layers in the clay.
Concentrations and sometimes nodules of carbonate, siderite and sulphate bearing compounds are common features. In some places thin lines with pyrite are found.

Remarkable is the by blue colours typified upper part of the clay. generally it overlies a brown coal or peaty layer and it is also overlain by a thin (0.5 m) brown coal layer.
The heavy mineral content of this particual layer is dominated by instable associations (garnet, epidote, saussurite/alterite, hornblende).

This uppermost part of the clay unit at the base of the pit is assinge as Oebel Beds (Boenigk, 2002; Boenig & Frechen, 2006). In the Netherlands the uppermost clay bed is stratigraphically assigned to the lowermost part of the Waalre Formation (WA-1). The stratigraphic significance of this clay bed has been disputed for a long time. The clay registers the major change in heavy mineral composition of the pre-Rhine system that supplied the deposits of the Kieseloolite Formation and the Alpine-connected Rhine system that supplied the deposits of the Waalre Formation.

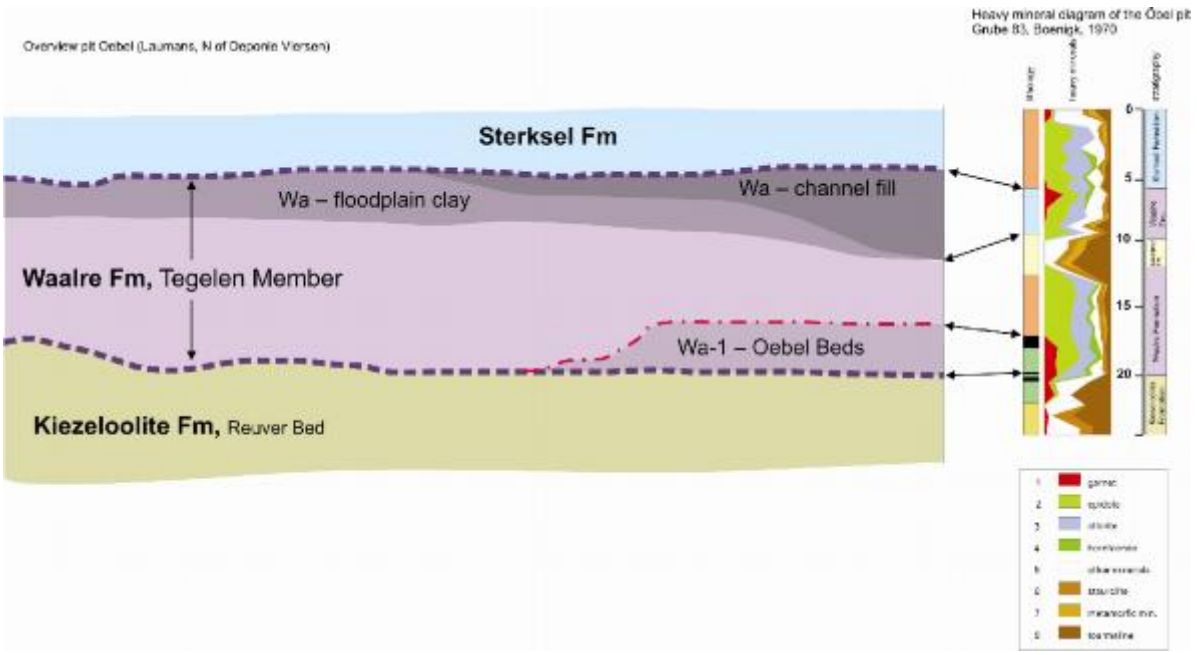


Figure 7. Overview of the general stratigraphy in the area of the Oebel pits. The two dashed lines mark the major hiatuses in the area

The heavy mineral composition of the exposed deposits show many interesting aspects that are characteristic for the Upper Pliocene and Lower Pleistocene deposits in this area.
In general the Pliocene sediments (Kieseloölite Formation) are characterised by a dominance of stable heavy mineral associations. These stable associations consist of *tourmaline, metamorphic minerals, staurolite* and *zircon* in the finer grained parts. Often they are referred to as the 'Tertiary' associations. On the contrary, the deposits of the Waalre Formation are dominated by unstable heavy mineral associations. Formerly, it was believed that this change marked the Plio/Pleistocene boundary. But according to the investigations of Boenigk (1970) it is demonstrated that this change already took place in the upper part of the Reuverian. As is shown in figure 7 the increase of a *garnet-epidote-alterite/saussurite-hornblende* association starts in the uppermost part of the basal clay deposit in the pit.

In the sequences studied by Boenigk (1970) an influx of white coloured sand deposits typified by stable heavy minerals cuould be demonstrated. Traditional this deposits were correlated to the (former) Dutch *Kedichem Formation*. As, by definition, this *Kedichem Formation* should post-date the Tiglian the position of this particlar deposit iat Oebel led to a longlasting discussion. It's clear that at Oebel this influx of by stable heavy minerals typified deposit occurs below a clay layer of Tiglian age. At the Oebel site this particular deposit has a irregular distribution pattern. Probaby as a result of erosion.

Gibbard et al. (1995) published a paper in which they describe deformational structures in the top of the Tegelen Clay along the northwestern face of the main Öbel pit. They also describe an ice-wedge cast in the sand and basal gravels of the Tegelen deposits. They discuss the possibility of correlating these phenomena to one of the colder stages of the Early Pleistocene. However, to the author's opinion it is very hard to use these particular data from Öbel for stratigraphical interpretations.

A striking fesature in the pit to be visited during the excursion is the clear erosion of a part of the Oebel Beds (figure 7, right corner). It demonstrates that severe erosion may have occurred (locally?) before deposition of the gravel-bearing sand of the overlying Tegelen Member.

Pollenanalytical studies indicate that the clay was deposited during the Reuverian-B pollenzone (figure 8). Characteristic palynomorphs like *Sequoia-type*, *Taxodium-type*, *Sciadopitys*, *Nyssa* etc. form a substantial part of the tree vegetation. Furthermore, *Quercus*, *Ulmus*, *Alnus* and *Pterocarya* are also important. In the browncoal seams, conspicuous high peaks of *Ulmus* are noticed. The upper part of the Reuver Clay between the two browncoal layers shows often a lack of pollen. It is assumed that soil formation and related chemical alterations affected the pollen conservation in this part of the clay.
The Reuver Clay in the Öbel pit is unconformably overlain by a fluviatile sequence. These sediments belong to the Tegelen Member of the Waalre Formation. The basal part consists of white, quartz-rich gravels (sometime referred to as Belfeld Gravel or deposits representng the Brüggen Kaltzeit) grading into sands which are covered by fine silts and clay. A small channel filled-in with 3 to 5 m of clay can be found in the south-western corner of the pit. A peat layer, with many wood fragments, is present in the uppermost part of the channel fill. The pollen diagram of the channel fill points to a Late Tiglian age of the deposit, pollenzone TC5 and possibly partly TC3-4 (interpretation according Zagwijn). The 'Tertiary' elements show very low percentages. The values of *Quercetum mixtum*, *Alnus*, *Pinus* and *Betula* are constantly low. *Pterocarya* is notably present.

The deposits of the Waalre Formation are unconformably overlain by Middle Pleistocene coarse-grained fluviatile sediments of the Sterksel Formation.

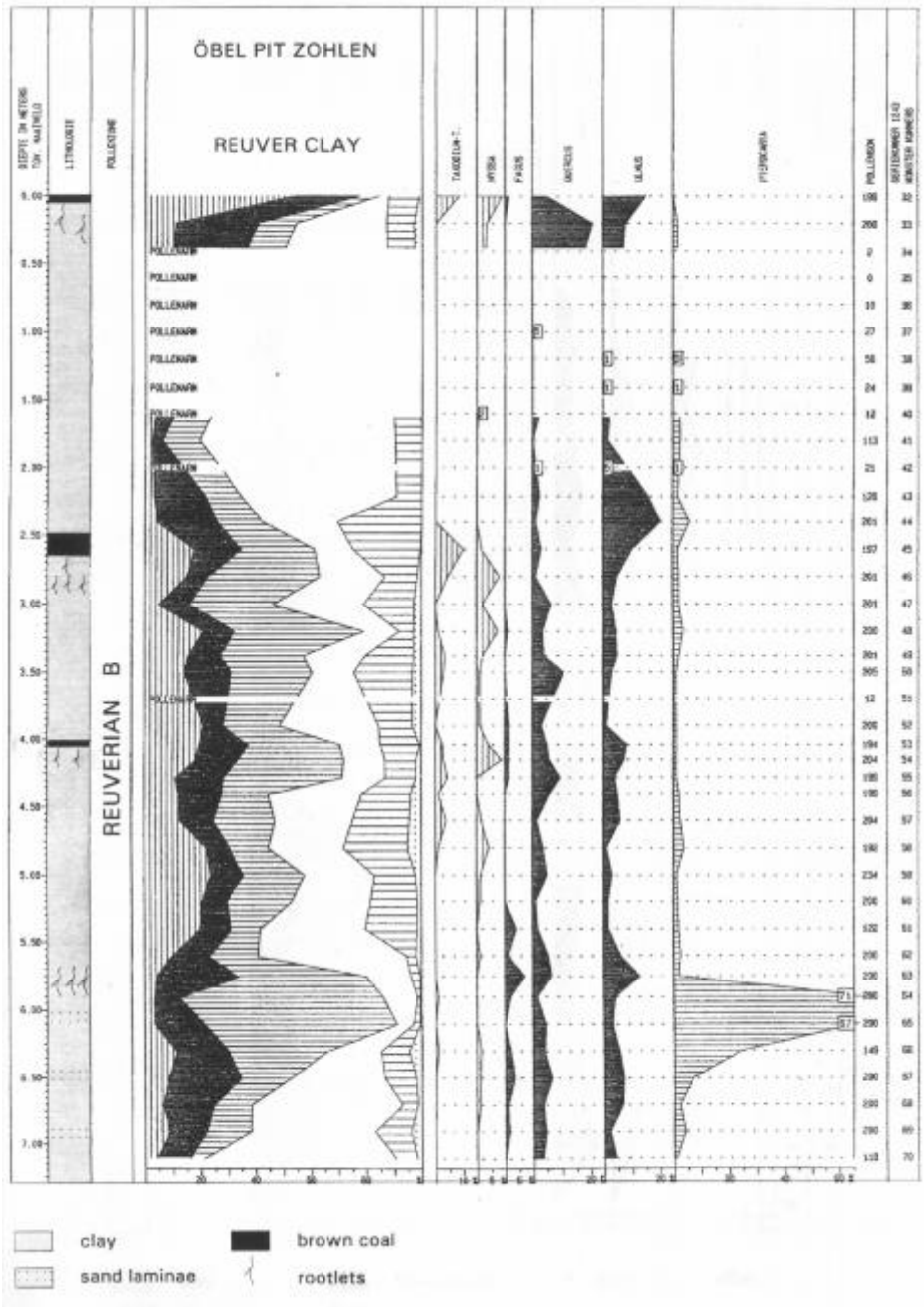


Figure 8. *Pollen diagram of Reuver Clay at Öbel (compiled by Zagwijn, internal files TNO-GSN)*

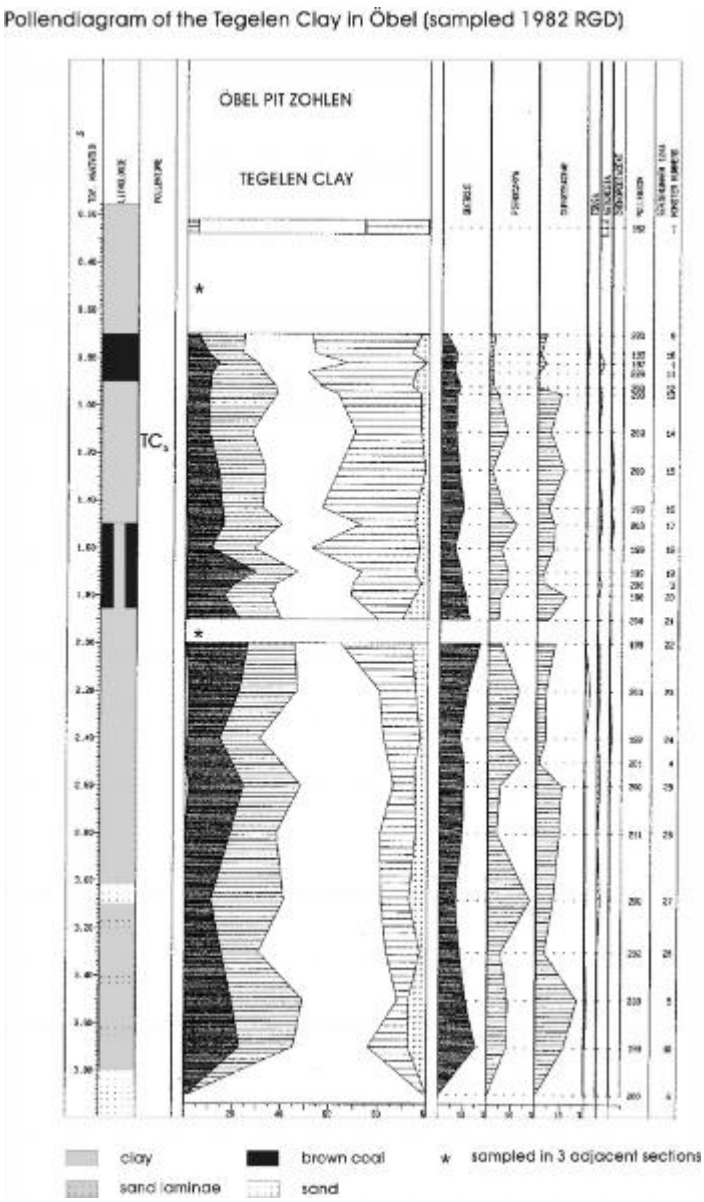


Figure 9. Pollen diagram of Tegelen Clay at Öbel (compiled by Zagwijn, internal files TNO-GSN)

References

Boenigk, W., 1970: Zur Kentnnis des Altquartärs bei Brüggen (westlicher Niederrhein). Sonderveröff. Geol. Inst. Univ. Köln 17, pp. 138.

Gibbard Ph. L., L. Krook & J. Vandenberghe,1995: Early Pleistocene depositional environments and stratigraphy at Öbel (Brüggen), Nordrhein-Westfalen, Germany. Meded. Rijks Geol. Dienst, 52, p. 83-96.

Monreal, W., 1959: Die Sedimentpetrographische Gliederung der Terrassen im Venloer aben und am Viersener Höhenrücken. Fortschr. geol. rheinld. u. westf., 4, pp171-177.

Zagwijn, W.H., 1974: Bemerkungen zur stratigraphischen Gliederung der plio-pleistozänen Schichten des niederländische-deutschen Grenzgebietes zwischen Venlo und Brüggen. Z. Deutsch. Geol., Bd.125, pp 11-16.

4. THE PIT BRACHTER TON ABBAU

The pit Brachter Ton Abbau, situated in between Öbel and Hoher Stall (fig. 3), is studied on pollen by Zagwijn (1960) and heavy minerals by Boenigk (1970). The site is nearby the so-called Icksberg where the original Reuverian is defined (Reid &Reid, 1915; Florschütz, 1948; van der Vlerk & Florschütz, 1953).

The stratigraphy of the exposure is rather simple. At the bottom of the pit a 6 – 7 m thick Reuver Clay is exposed (figure 18). One browncoal or peat horizon occurs at the top of the clay and a second peat layer is present some 2 m below the top. In between a thin peaty horizon, formed in a shallow depression is often observable.

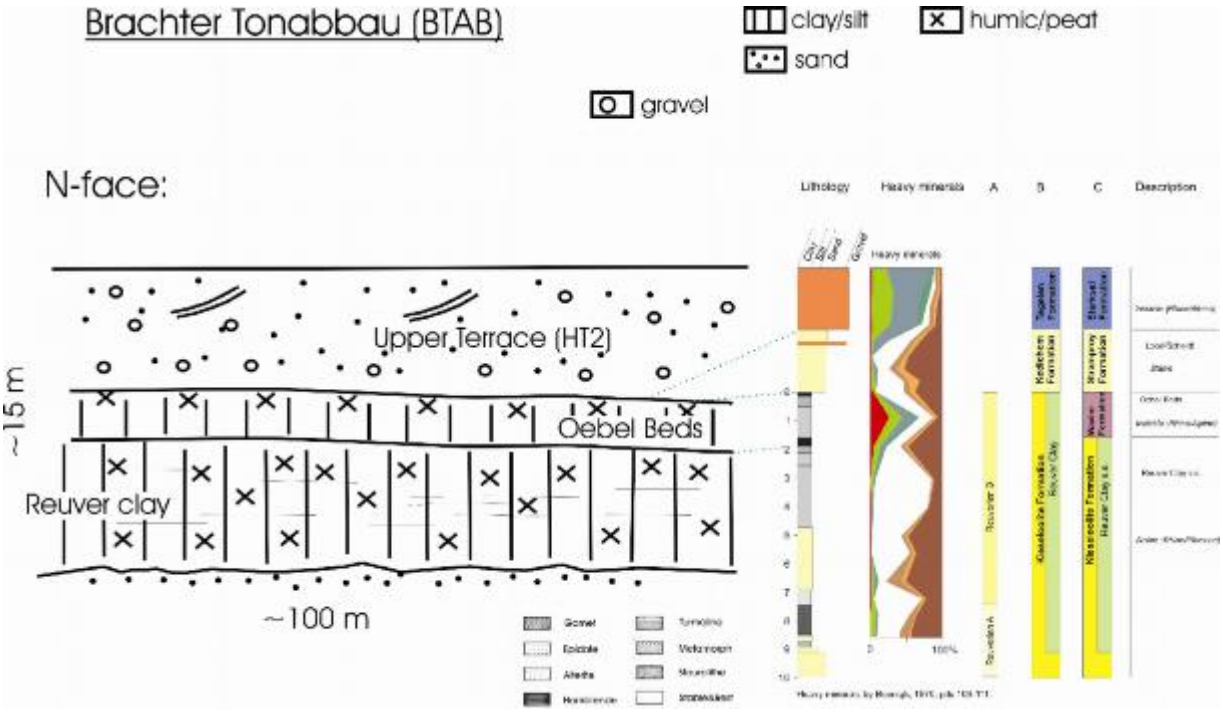


***Figure 10**. Overview of the exporue at the Brachter Ton Abbau (drawing by H.A. Kemna).*

Zagwijn (1960) produced a pollen diagram (figure 11) of the Reuver Clay here and he interpreted the lower part as Reuverian A , based on relative high values of *Sequoia-T.* and *Taxodium-T*. The upper part is interpreted as Reuverian B. *Sequoia-T.* is rather low while *Nyssa* is high in the upper spectra. Notable is the lack of pollen in several spectra of the diagram. Probably this is due to weathering after deposition.

The heavy mineral diagram (Boenigk, 1970 – pits 109-111; figure 10) shows the well-known increase of instable heavy minerals in the part between the two peat layers.
So, the uppermost clay deposits at BTAB can be positivetly correltad to the Oebel Beds or WA-1 unit of the Dutch Waalre Formation.

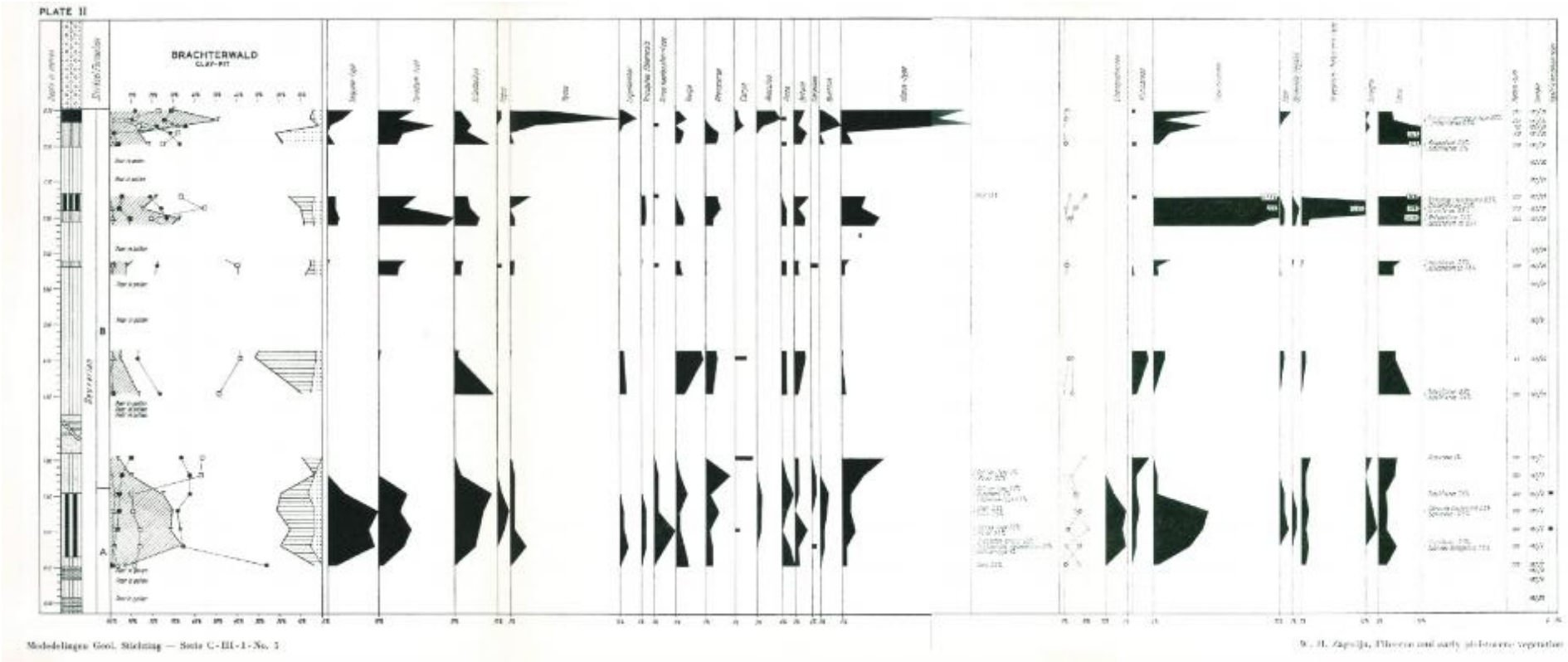


Figure 11. Pollen diagram of Reuver Caly at Brachter Ton Abbau (Zagwijn, 1960). Note that the uppermost part between the two peat layers lithostraigraphically forma part of the Oebel Beds.

Geochemical analysis and clay mineralogy has been studied by Huisman (1998; see figures 12, 13). The results show an enrichment of kaolinite just below the lower browncoal/peat horizon. This corresponds with a typical light or white-coloured clay. The idea is that a period of rather severe weathering has occurred before the peat horizon could be formed. The same whitish layer shows also a lack of pollen.
A clear increase of S (sulfur) is observed in the lower part of the peat layers. This is caused by relatively enrichment of pyrite in the sections. A possible explantion might be that the deposit here is during or after its formation regular flooded by saltwater.

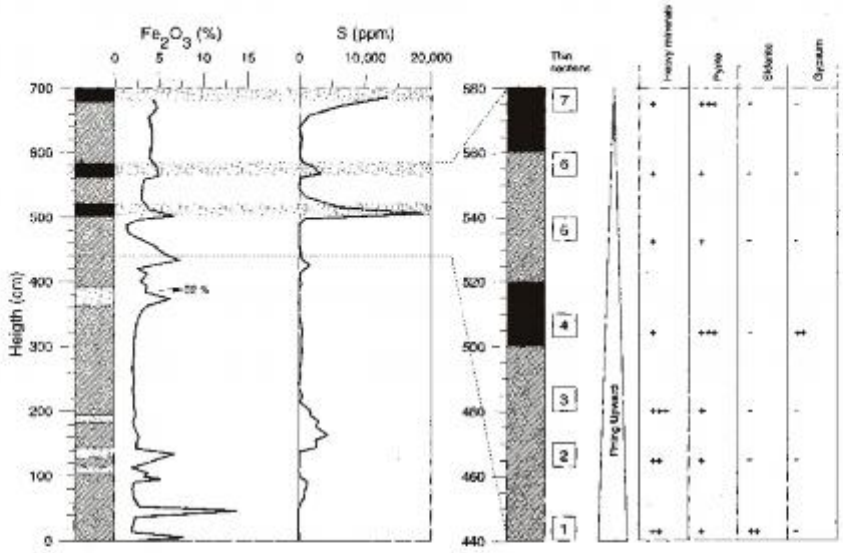


Figure 3.2.6 Depth profile of Fe- and S-contents (section BTAB). Part of the section is enlarged to indicate the and micromorphological observations. S-contents are elevated in the organic layers due to the presence of pyrite. Fe_2O_3-contents show a large amounts of local elevations, related to the presence of pyrite (in the organic layers) and (hydr)oxides.

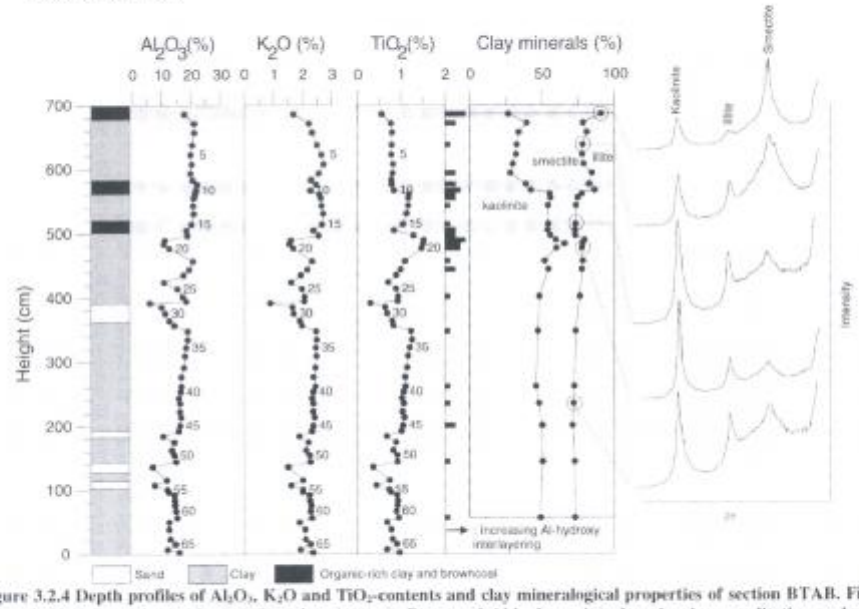


Figure 3.2.4 Depth profiles of Al_2O_3, K_2O and TiO_2-contents and clay mineralogical properties of section BTAB. Figures indicate sample numbers (referred to in text). Degree of Al-hydroxy interlayering is a qualitative scale. Clay mineral percentages are based on relative peak heights. The diffractograms of five representative samples are given, with "kaolinite", "illite" and "smectite" at 7, 10 and 14Å respectively. The clay above the middle organic-rich layer is smectite-rich, whereas the clay below it shows higher contents of kaolinite and TiO_2. TiO_2 and kaolinite contents are further elevated immediately below the lower organic-rich layer. K_2O-contents drop in all three organic-rich layers, and there is an increase in Al-hydroxy interlayering.

***Figure 12**. Some geochemical data of the Reuver Clay at BTA (Huisman, 1998)*

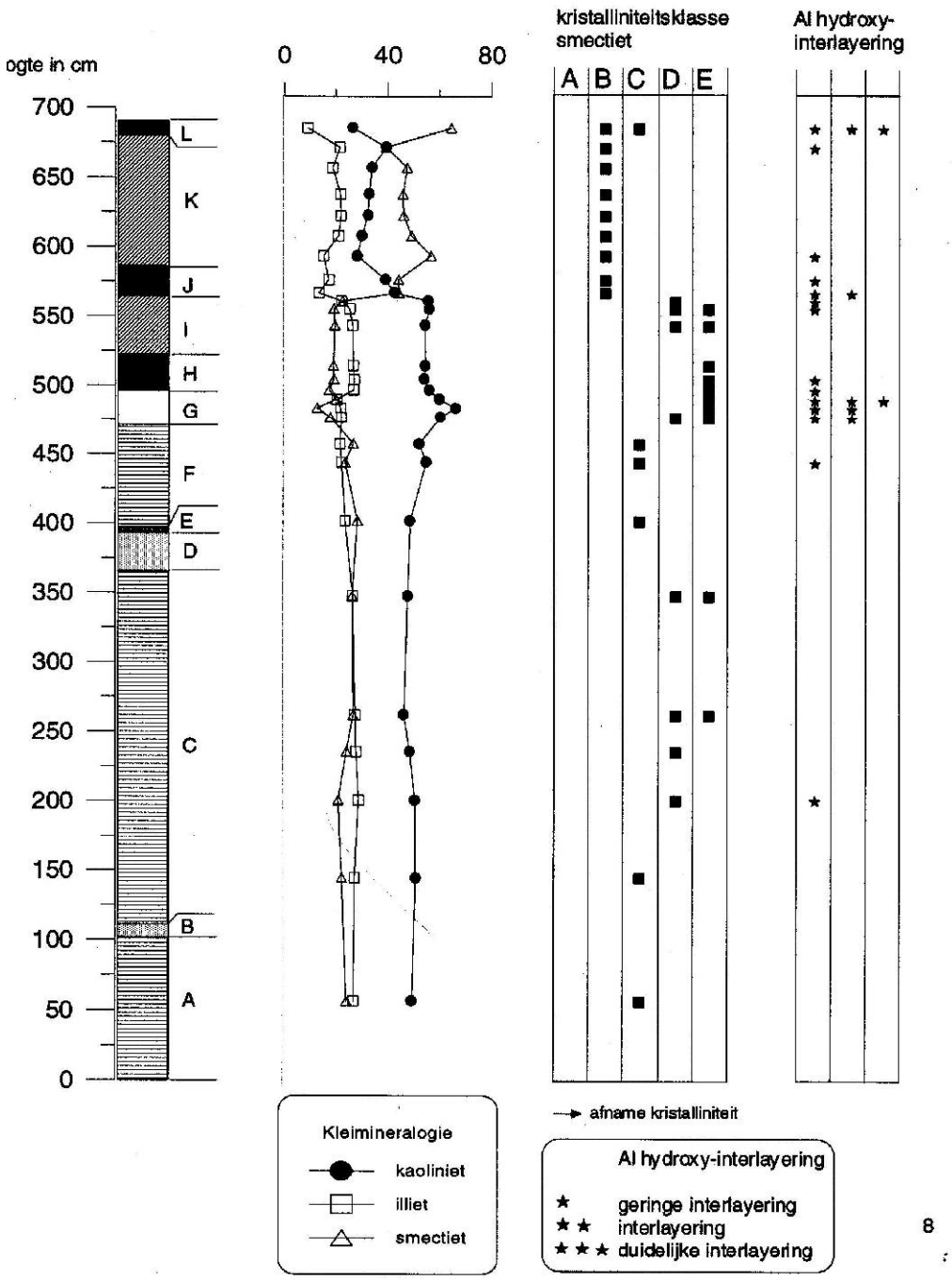


Figure 13. Distribution of kaolinite, illite and smectite along a section of the Reuver Clay in the BTA (data from internal report TNO-NITG).

References

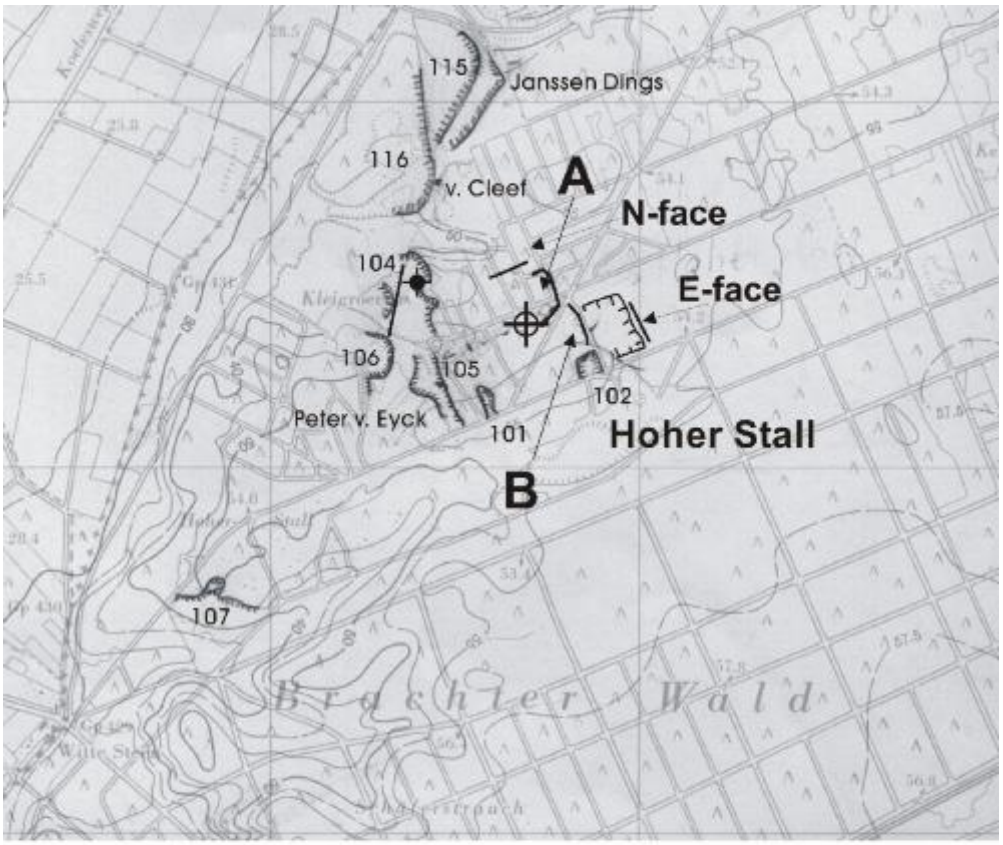
Boenigk, W., 1970: Zur Kenntnis des Altquartärs bei Brüggen (westlicher Niederrhein). Sonderveröff. Geol. Inst. Univ. Köln 17, pp. 138.

Huisman, D.J., 1998: Geochemical Characterization of Subsurface Sediments in the Netherlands. Thesis Wageningen University.

Zagwijn, W.H. (1960): Aspects of Pliocene and Early-Pleistocene vegetation in The Netherlands. Meded. Geol. St., ser. C-III-1, no 5.

5. THE PIT HOHER STALL

Since the 1990s a number of smaller pits at the Hoher Stall site have been enlarged and connected to each other (figure 14). The excavation is situated just east of Grube 104 - 106 (Boenigk, 1970) and nearly 1 km Southeast of the Janssen- Dings pit at Belfeld. This is well-known because of the so-called 'Belfeld-clay' (van der Vlerk & Florschütz, 1953; Zagwijn, 1963). Pollen analytical studies in some of the pits near Hoher Stall were carried out by Zagwijn (1974) and Urban (1978).



section Boenigk, 1970

Borehole Geological Survey of The Netherlands, 1996

A Section I + II, pollen diagram (Reuverian)

B Section I + II, pollen diagram (Tiglian)

E-face & N-face. Sections studied by H.A. Kemna (Uni Koeln)

Figure 14. Detailed map of the Hoher Stall area and location of the main investigated sites.

Since 1993 when the pits at Hoher Stall were enlarged and connected to each other regular field visits and survey's were carried out.

The general stratigraphy resembles that of the other pits in the area (figure 15). In general three main depositional units can be observed. The lowermost deposits resemble the Reuver Clay of the adjacent pits but at Hoher Stall the clay deposit as well as the underlying sands all are typified by instable heavy mineral association and can therefore be assigned to the Waalre Formation (lower unit WA-1 = Oebel Beds).
This unit of the Waalre Formation is overlain by a sequence of light coloured fluvial sand and gravel that fines up in an dark-grey floodplain clay. These sediments also form part of the Waalre Formation. An interesting feature is the sand wedge that is intercalated in the floodplain clay. In turn the Waalre Formation is overlain by coarse grained sand and gravel of the Sterksel Formation (Upper Terrace UT 2). Dependig on the state of the excavation one sometime can observe a relatively thin intercalation of quartzrich deposits of the Stramproy Formation (typified by stable heavy mineral associations).

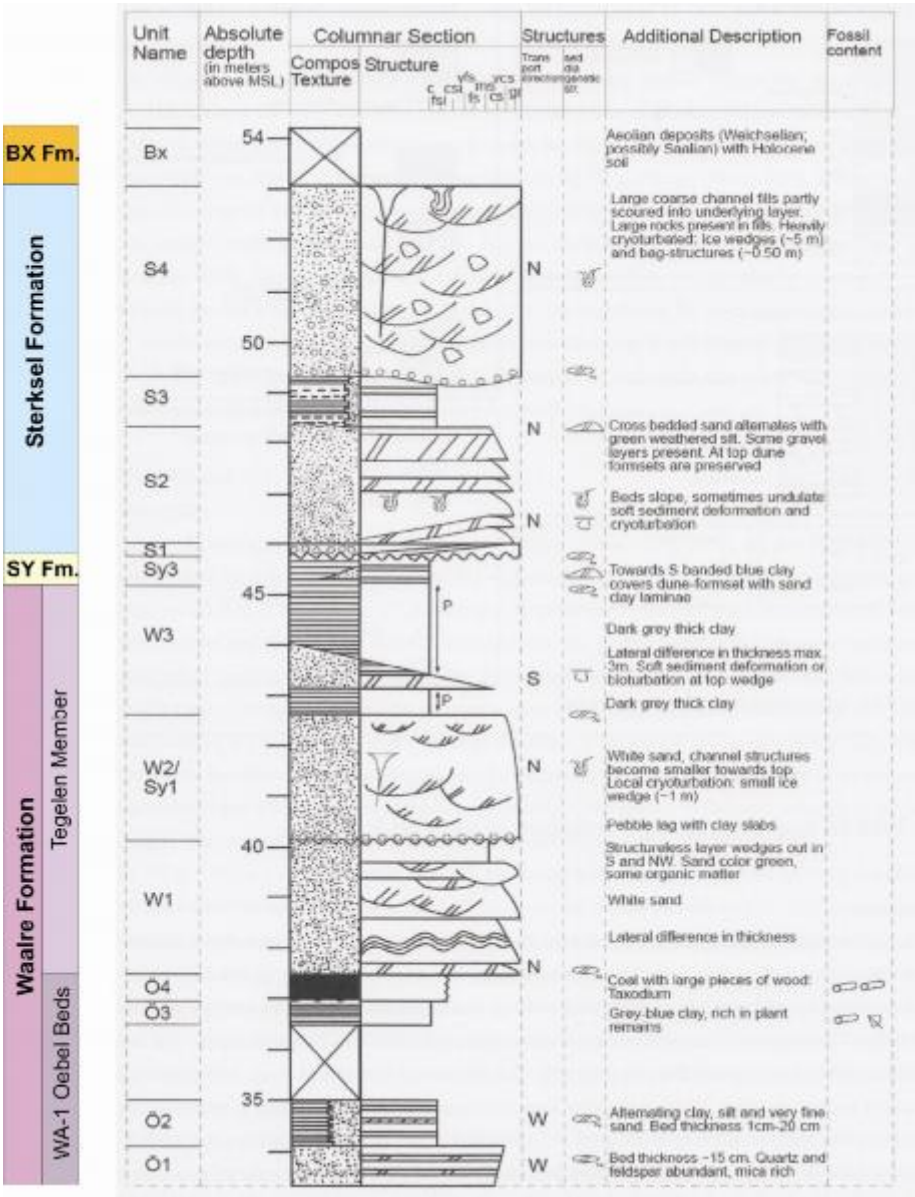


Figure 15. Composite stratigraphy and sedimentary log of the Hoher Stall site.

The heavy mineral content of the exposed deposits are well-studied by Boenigk (1970) and Kemna (2005).
The sometimes partly exposed sand deposits underneath the basal clay (Oebel Beds) is rich in mica flakes and grades gradually into the overlying clay.The heavy mineral content of this basal sand is dominated by an instable association with a.o. *epidote, alterite,* and *hornblende.* This phenomenon was already shown by Boenigk (1970). We iterprete this sandy deposits below the clay of the Oebel beds as the main stream belt which supplied the clay of the Oebel Beds. So, the Oebel Beds in this area can be seen as floodplain deposits formed on top of the Reuver Bed.

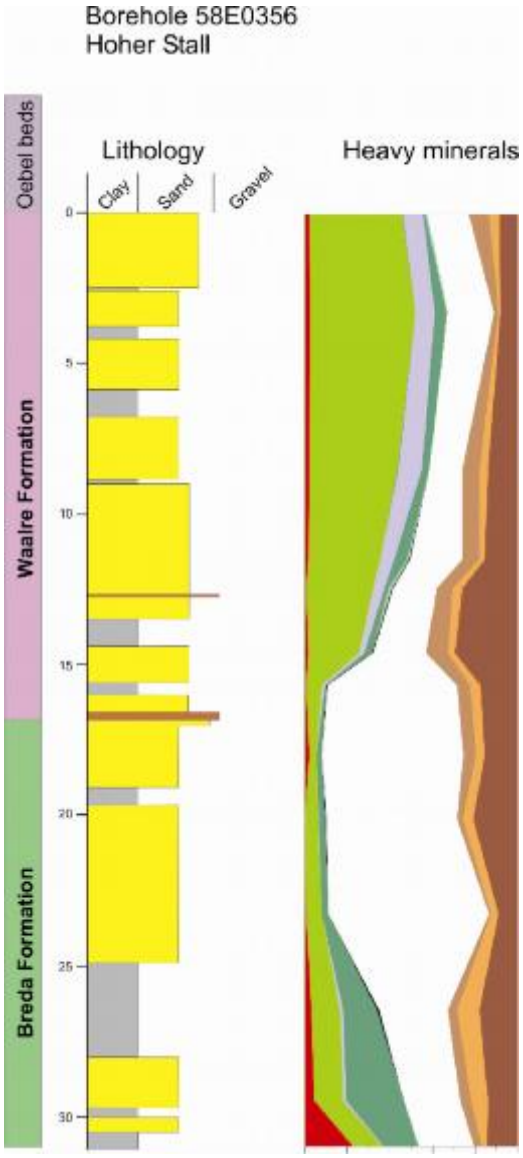


Figure 16. Lithology, heavy minerals and lithostratigraphy of a borehole that is lowered down form below the clay depoists of the Oebel Beds in the pit Hoher Stall.

The by instable heavy minerals characterised channel deposits are underlain by fine-grained marine sediments of the Breda formation (Miocene).

Palynological the Oebel Beds form part of the uppermost Pliocene. Therefore the existence of the instable heavy mineral associations (the so-called 'Pleistocene'-mineral association) in the uppermost part of the Kieseloolite Formation has led to intensive discussions about the interpretation of the Oebel Beds. (Boenigk, 1970; Klostermann, 1983, 1992; Zagwijn, 1974).

Nowadyas we are certain that the major change of the heavy mineral composition can be attributed to the capture of the Rhine to the Alpine drainage system. Lithostraigraphically, we now can make distinction between deposits suplied by the pre-Rhine and the Alpine-connected Rhine system. So, the major change in provenance is reflected directly in the lithostratigraphical units.

The clay of the Oebel Beds at the base of the excavation shows the typical blue-grey colors and two browncoal/peat horizons are exposed (figure 17). The clay lithology resembles much to that of the Reuver Clay and Oebel beds in the other pits of the area. The uppermost browncoal layer often contains a lot of compressed wood fragments and in the clay many rootlets can be observed.
Pollenanalytical results from the Oebel Beds at Hoher Stall, sampled in 1993 (figure 18), point to a late Reuverian age. There are differences with the pollen diagrams of the Reuver Clay at Öbel and Brachter Ton Abbau. The low values for the typical '*Tertiary'* elements form the main difference. Only *Nyssa* reaches high values. *Ulmus* shows conspicuous peaks in the browncoal layer. The upper part of the diagram shows a transitional vegetation. A gradual replacement to a more or less deciduous forest (bare in winter) takes place. This is also recorded in pollen analysis of some boreholes at the Meinweg area (a.o. Zagwijn, 1960; and recently carried out research). Therefore, we think it is likely to assume a Reuverian-C age of the clay deposits from the Oebel Beds in the Hoher stall pit.

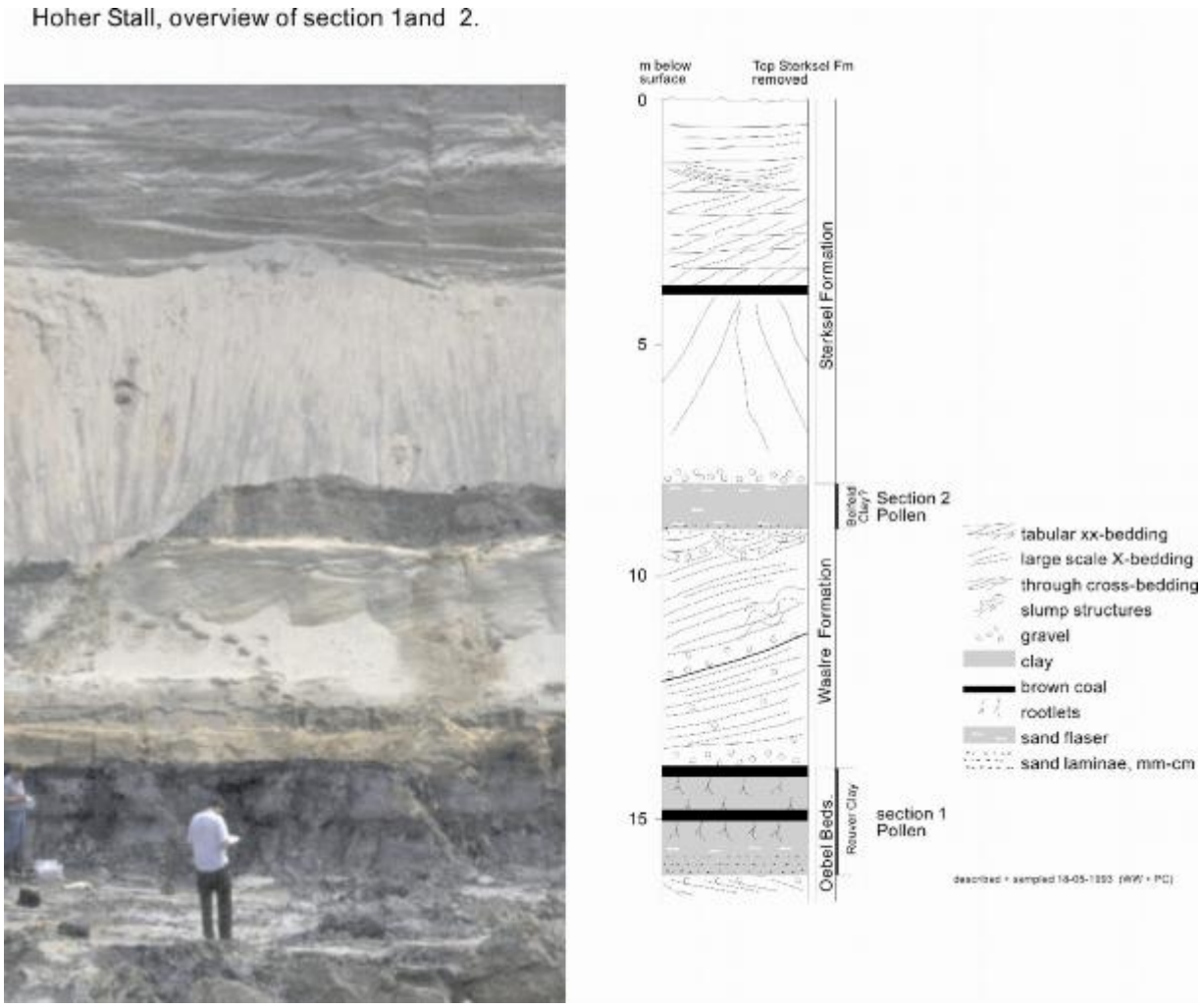


Figure 17. Lower part of the exposure Hoher Stall with Reuver Clay at the base.

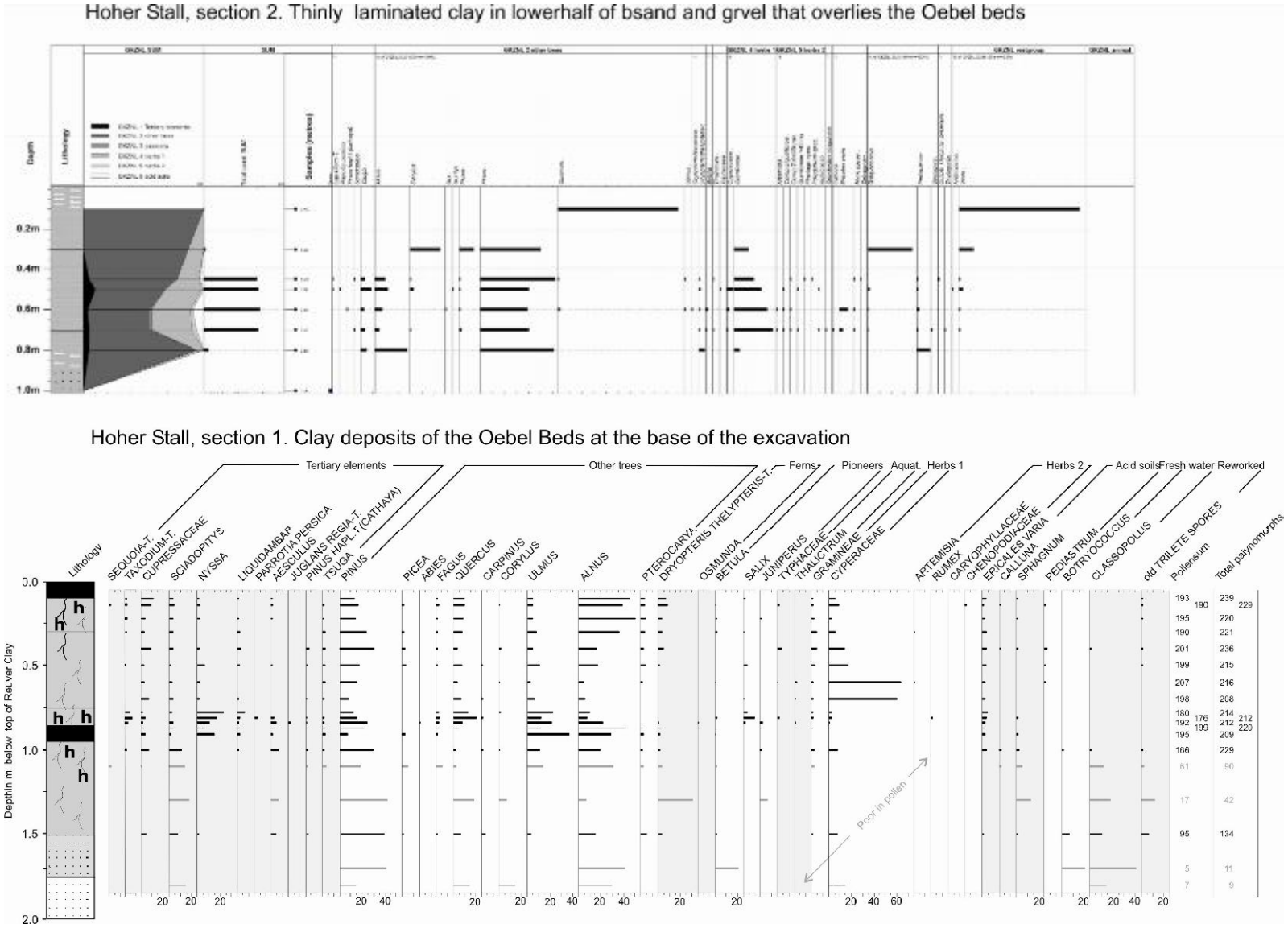


***Figure 18**. Pollen* diagrams of the Oebel Beds (section 1) and of a clay bed exposed in the lower hald of the overlying sand and gravel deposits(section 2).

The top of the Oebel Beds at Hoher Stall is unconformably overlain by coarse white gravel-bearing sands with gravel with a characteristic 'Pleistocene' -unstable heavy mineral composition (figure 28). With a relatively sharp boundary these sands are overlain by a light grey-coloured sandy clay (section 2 in figure 17). Initially it was thought that this relative thin clay layer could be correlated with the Belfeld Clay in the Janssen-Dings pit. The pollen diagram however, shows a local development and lacks the for the Belfeld Clay typical high values of *Fagus* (figure 18).

In 1993 a second profile (figure 19) was sampled in a pit adjacent to the one of section 1 & 2 (figure 17). Both faces are presently removed as a result of continuing excavation. In the second profile the two clay layers of the floodplain clay that shows an intercalated sand wedge were sample and described. The lower clay layer (section 5, figure 19) consists of a dark-blue coloured clay of about 50 cm thickness. The lower part of this clay is strongly affected by orange coloured Fe-oxides. The upper part is much darker because of humic enrichments and shows structures that resembles shrinkage or drying cracks. This clay layer is overlain by ± 1.80 m of sand which grades into an upper clay layer (section 4, figure 19). In the years after 1993, when the pits were enlarged, it has been observed that the intercalated sand layer wedges out between the two clay layers. A feature now visible in the eastern part of the excavation. The top part of the sand shows convoluted laminations and alternations with relatively thin clay laminae. Sometimes bioturbation has been observed. the sand wedge is interpreted as part of of crevasse splay that enters the floodplain from northen directions. At all sites in the Hoher Stall excavations, the Tegelen deposits are unconformably overlain by coarse gravel-bearing sediments which belong to the Sterksel Formation (Jüngere Hauptterrasse).

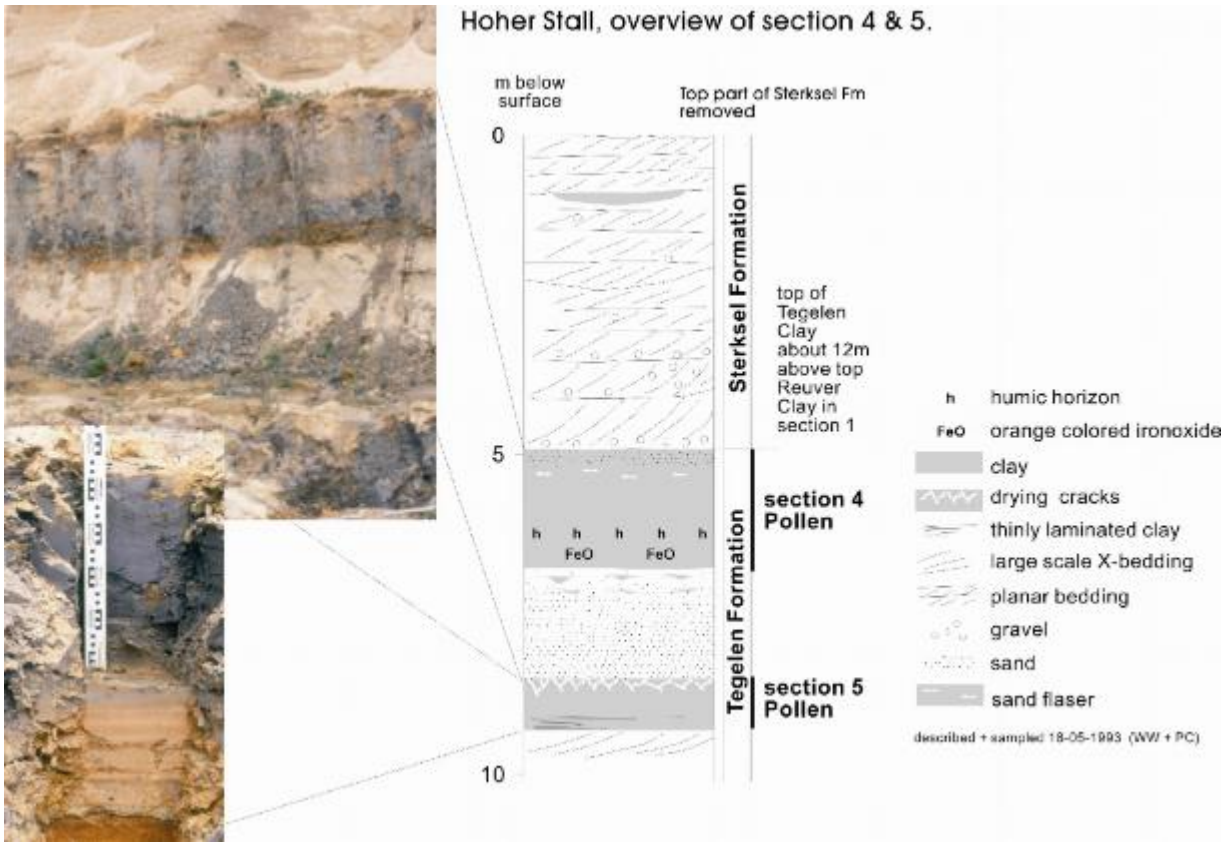
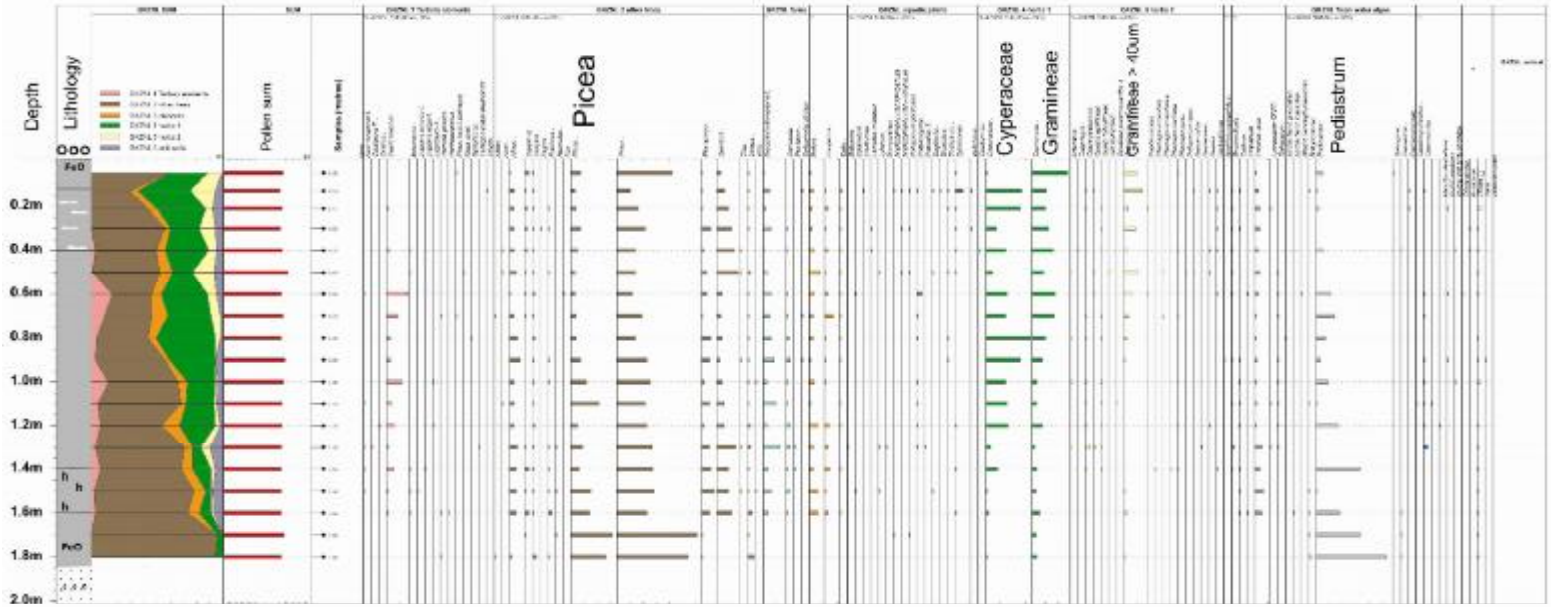


Figure 19. Schematic representation of the Tegelen Clay deposit in Hoher Stall (observed, 1993)

Hoher Stall section 4, Flood plain lay at top of Waalre Formation



Hoher Stall section 5, basal part of the flood plain clay which is overlain by sand deposit of a crevasse splay.

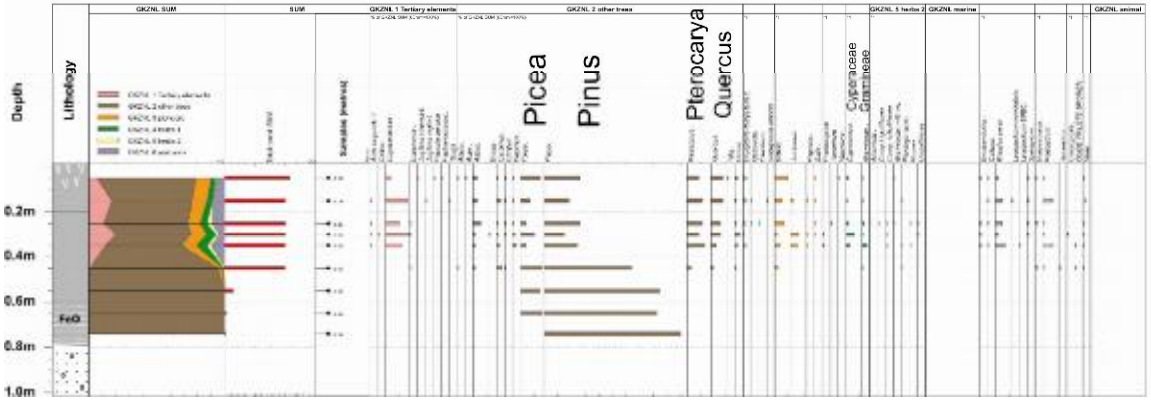


Figure 20 Pollen diagams of two clay layers in the upper part of the Waalre Formation (Tegelen Member) at Hoher Stall.

The pollendiagrams of the clays from section 4 & 5 are given in figure 20. The pollen results resemble the diagrams from nearby sites published by Urban (1978). Tree pollen, especially *Pterocarya,* are only present in low values but point to a Tiglian age. The relative high values of *Gramineae* > 40 µm may indicate wet conditions and confirm deposition in a floodplain basin. Urban (1978) assigned these type of pollendiagrams as the so-called 'Van Eyck-Interglazial'.

References

Boenigk, W., 1970: Zur Kenntnis des Altquartärs bei Brüggen (westlicher Niederrhein). Sonderveröff. Geol. Inst. Univ. Köln 17, pp. 138.

Klostermann, J., 1983: Die Geologie der Venloer Scholle (Niedrrhein). Geol. Jb., A66, pp3-115.

Klostermann, J., 1992: Das Quartär der Niederrheinischen Bucht. GLA Nordrhein Westf. Krefeld. pp 200.

Urban, B., 1978: vegetationsgeschichtliche Untersuchungen zur Gliederung des Altqurtärs der Niederrheinische Bucht. Sonderveröff. Geol. Inst. Univ. Köln 34, pp. 165.

Zagwijn, W.H., 1974: Bemerkungen zur stratigraphischen Gliederung der plio-pleistozänen Schichten des niederländische-deutschen Grenzgebietes zwischen Venlo und brüggen. Z. Deutsch. Geol., Bd.125, pp 11-16.

General references

Kemna, H.A., 2005. Pliocene and lower Pleistocene Stratigraphy in the Lower Rhine Embayment, Germany. Kölner Forum für geologie und Paläontologie, 14/2005: 1-121.

Kemna, H.A., 2008. A revised stratigraphy for the Pliocene and Lower Pleistocene deposits of the Lower Rhine Embayment. Netherlands Journal of Geosciences/Geologie en Mijnbouw 87: 91-106.

Westerhoff.W.E., Kemna, H.A. & Boenigk, W., 2008. The confluence area of Rhine, Meuse, and Belgian rivers: Late Pliocene and Early Pleistocene fluvial history of the northern Lower Rhine Embayment. Netherlands Journal of Geosciences/Geologie en Mijnbouw 87: 107-126.

Westerhoff, W.E., 2009. Stratigraphy and sedimentary evolution. The lower Rhine-Meuse system during the Late Pliocene and Early Pleistocene (southern North Sea Basin). [Ph.D. dissertation, Vrije Universiteit Amsterdam]

Exkursion B3

B3: Von der stauchzone durch Poldergebiet bis zur Nordseeküste

Geologie, hydrologie und Landschaft des Westlichen Hollands

1

B3: Von der Stauchzone durch Poldergebiet bis zur Nordseeküste; Geologie, Hydrologie und Landschaft

1. De Uithof: Urban hydrogeology (8.30-9.00),
2. Hollandsche Rading: Nature in the transition zone between glacial hills and polder landscape (9.30-10.30),
3. Landgoed Zonnestraal: geology, infiltration and international top architecture on glacial hill of Hilversum (10.45-11.15),
4. Large scale historical sand excavating and Huis De Trompenburgh (view from bus),
5. Subsidence/ground settlement (view from bus),
6. A small glacial hill in the polder landscape; tuff stone church & peat bore hole (11.45-12.30),
7. Lunch on a peat dike (12.45-13.30),

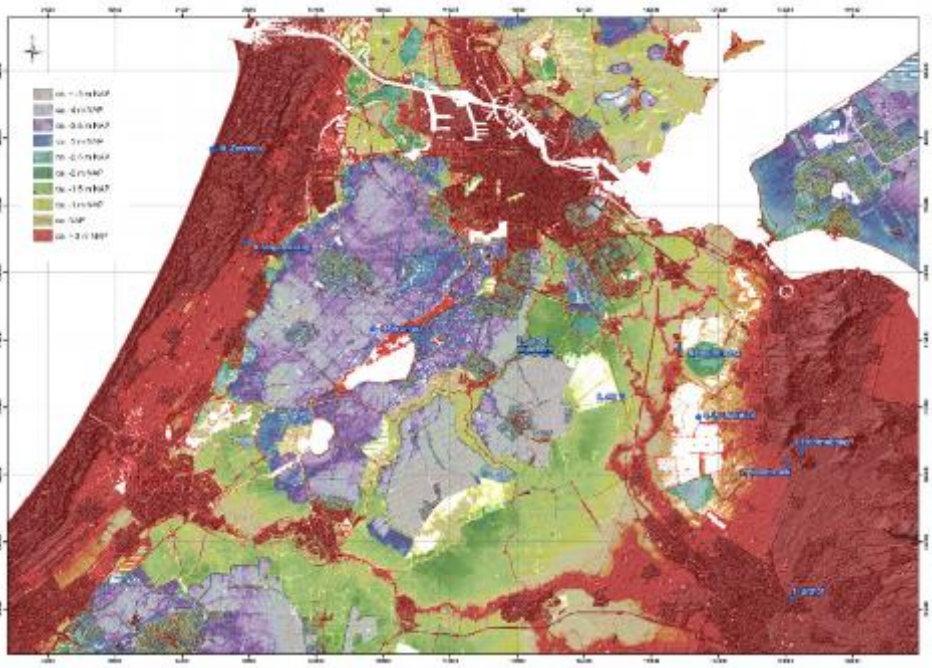
2

B3: Von der Stauchzone durch Poldergebiet bis zur Nordseeküste; Geologie, Hydrologie und Landschaft

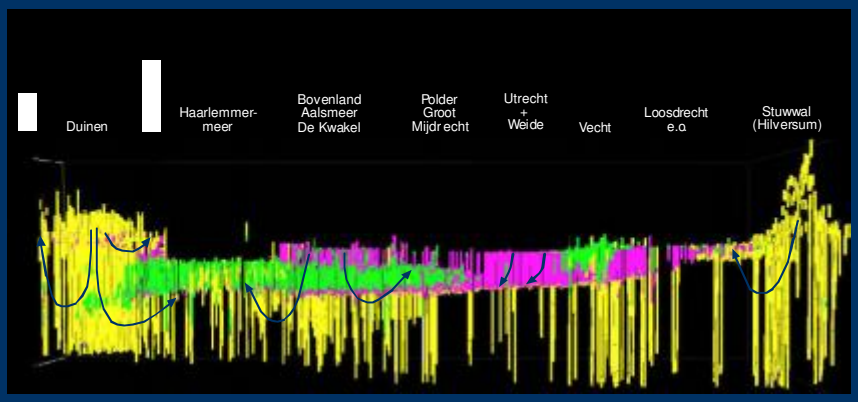
8. Polder Groot Mijdrecht; Why return it into water? (14.00-14.30),
9. Natural gas from shallow groundwater (view from bus),
10. Coastal barrier landscape and bulb area (15.15-16.15),
11. Return to Utrecht station (16.15-17.00/17.30),

3

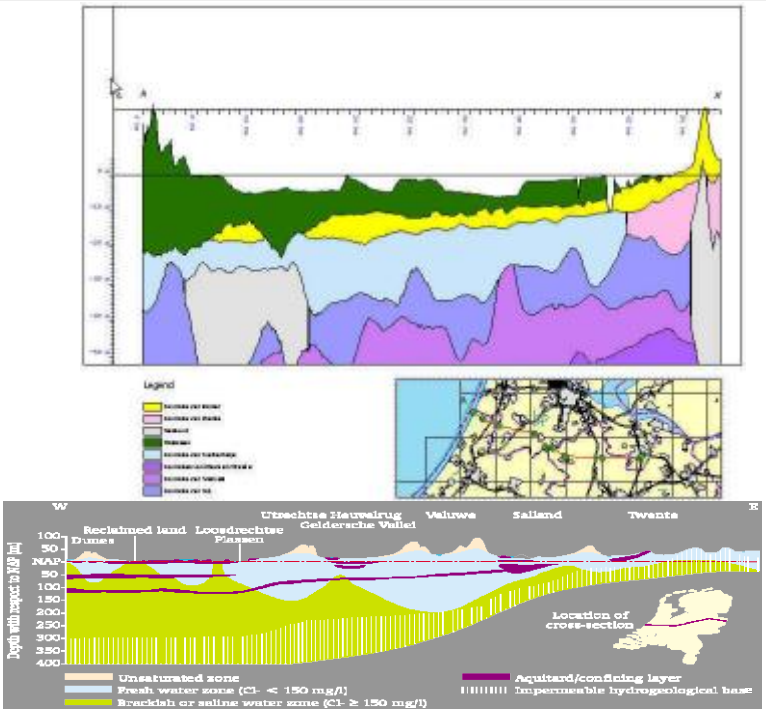
4



E-W profile using DINO bore holes

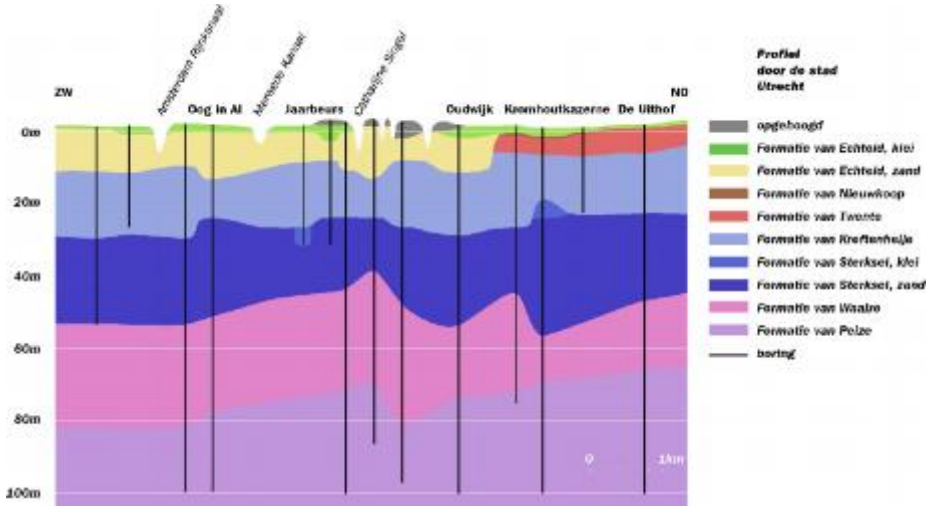


6


Legend
W
E
Reclaimed land
Dunes
Loosdrechtse Plassen
Utrechtse Heuvelrug
Gelderse Vallei
Veluwe
Salland
Twente
Depth with respect to NAP [m]
100
50
NAP
50
100
150
200
250
300
350
400
Location of cross-section
Unsaturated zone
Fresh water zone (Cl- < 150 mg/l)
Brackish or saline water zone (Cl- ≥ 150 mg/l)
Aquitard/confining layer
Impermeable hydrogeological base

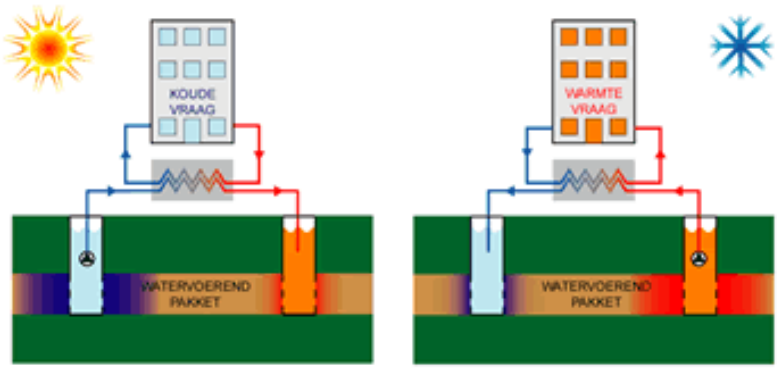
7

De Uithof


ZW
NO
Oog in Al
Jaarbeurs
Oudwijk
Koemhoutkazerne
De Uithof
0m
20m
40m
60m
80m
100m
1km
Profiel door de stad Utrecht
opgeboogd
Formatie van Echteld, klei
Formatie van Echteld, zand
Formatie van Nieuwkoop
Formatie van Twente
Formatie van Kreftenheije
Formatie van Sterksel, klei
Formatie van Sterksel, zand
Formatie van Waalre
Formatie van Peize
boring

8

De uithof
(heat & cold storage)



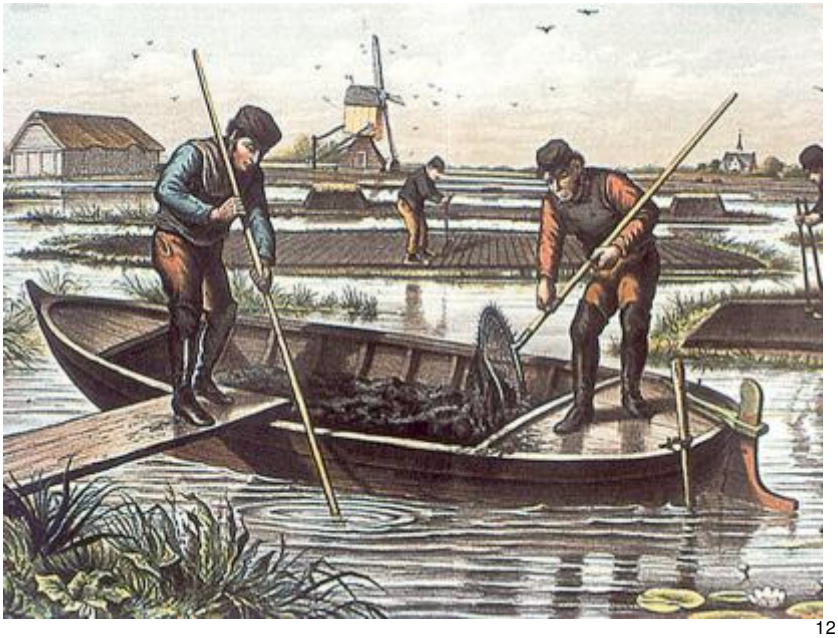
9

De uithof
(water defense inundation areas)

10

Hollandsche Rading
(Westbroek)
(transition zone polder area and glacial hills)

11

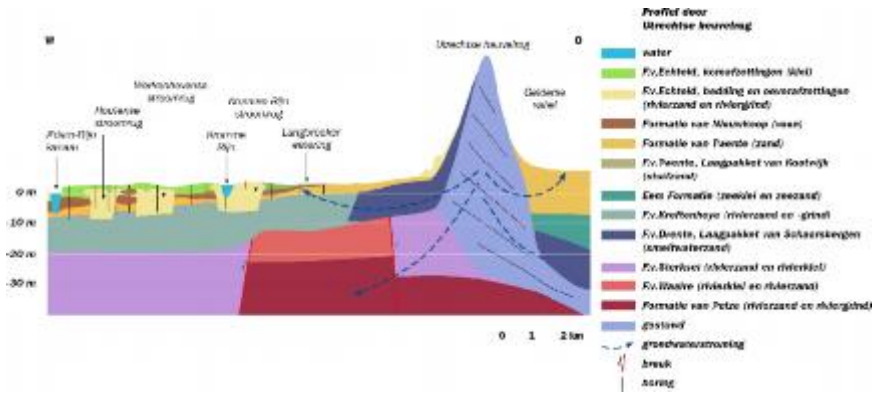


12

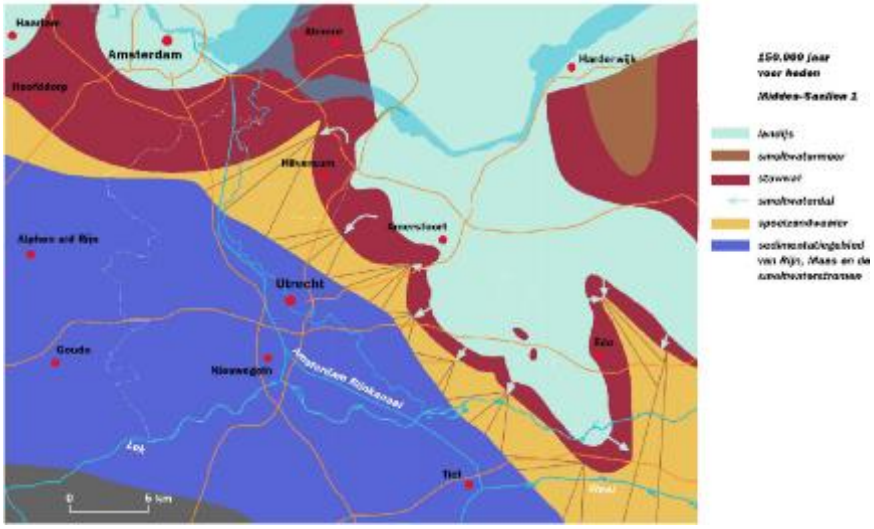
Equisetum fluviatile & Hottonia palustris (groundwater discharge)

13

Landgoed Zonnestraal (glacial hill, infiltration area)



14



Zonnestraal

- Design Jan Duiker (1925), “het nieuwe bouwen”,
- “Throw away” building. Now national monument!
- By “Algemene Nderlandse Diamant Arbeiders bond”,
- TBC sanatorium

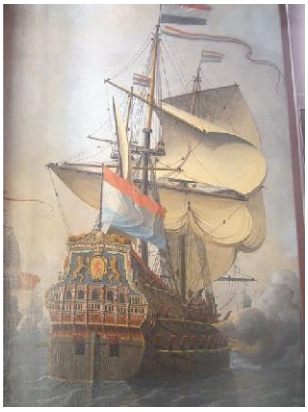
‘s-Gravenland

(17th century sand excavation for urban extension of Amsterdam)

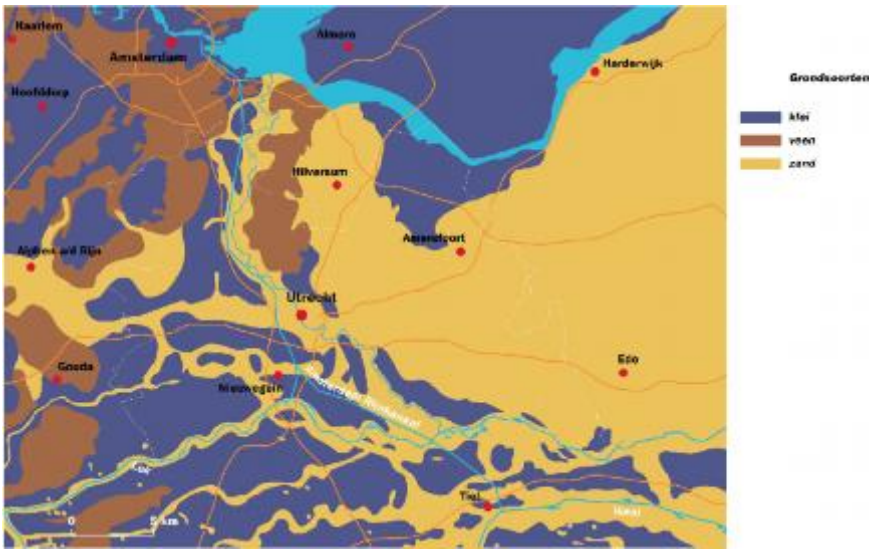
17

Huis De Trompenburgh

- House built(1675-1684) by Admiral Cornelis Tromp,
- German slate,
- Developed by Amsterdam investments



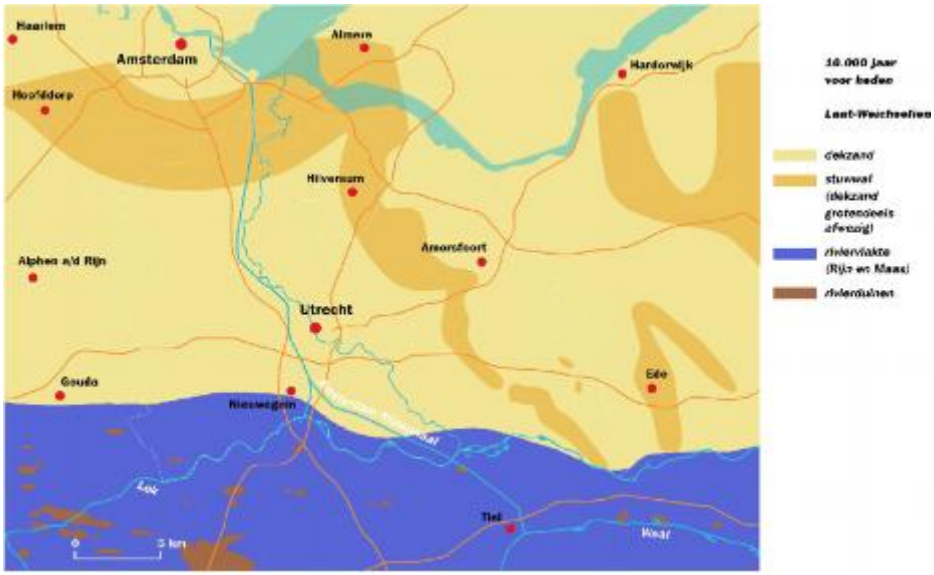
18



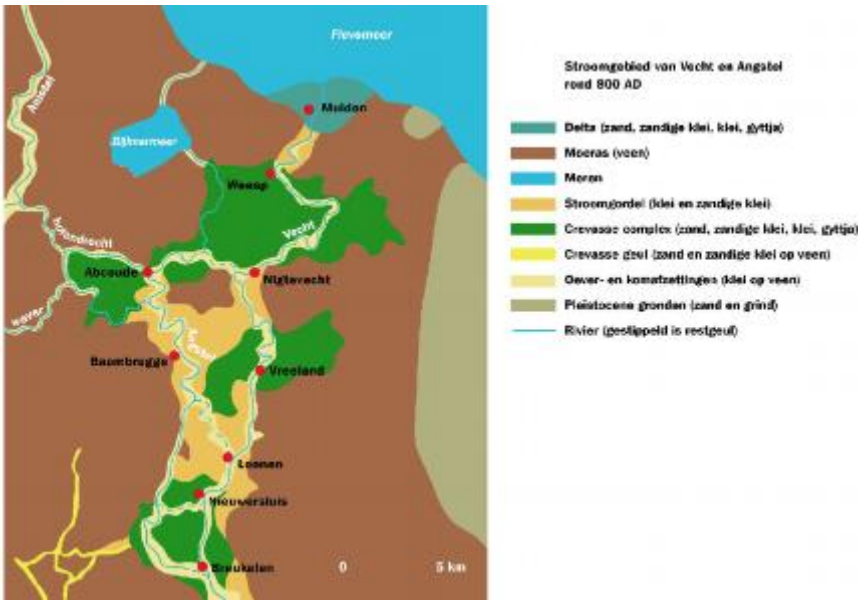
19

Nederhorst Den Bergh

20

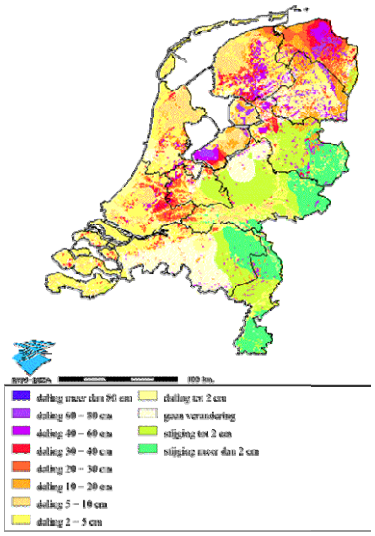

Haarlem
Amsterdam
Almere
Hardorwijk
Hoofddorp
Hilversum
Amersfoort
Alphen a/d Rijn
Utrecht
Goude
Nieuwegein
Eile
Tiel
Waal
0
5 km
10.000 jaar voor heden
Laat-Weichselien
dekzand
stuwwal (dekzand grotendeels afwezig)
riviervlakte (Rijn en Maas)
rivierduinen

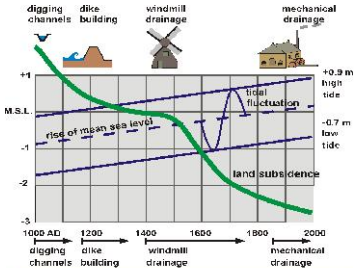
21

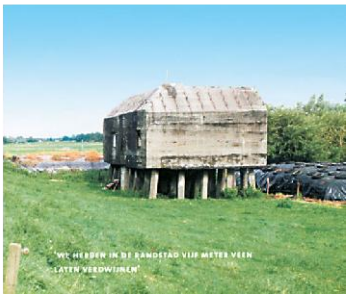

Flevemeer
Muiden
Weesp
Vecht
Abcoude
Nigtevecht
Baambrugge
Vreeland
Loenen
Nieuwersluis
Breukelen
0
5 km
Stroomgebied van Vecht en Angstel rond 800 AD
Delta (zand, zandige klei, klei, gyttja)
Moeras (veen)
Meren
Stroomgordel (klei en zandige klei)
Crevasse complex (zand, zandige klei, klei, gyttja)
Crevasse geul (zand en zandige klei op veen)
Oever- en komafzettingen (klei op veen)
Pleistocene gronden (zand en grind)
Rivier (gestippeld is restgeul)

22

Subsidence

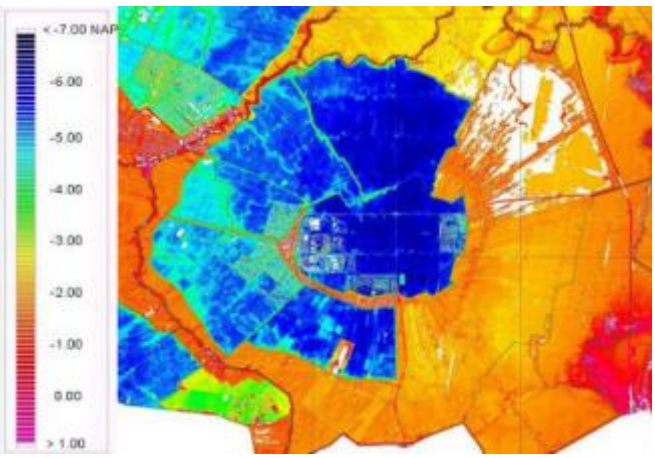






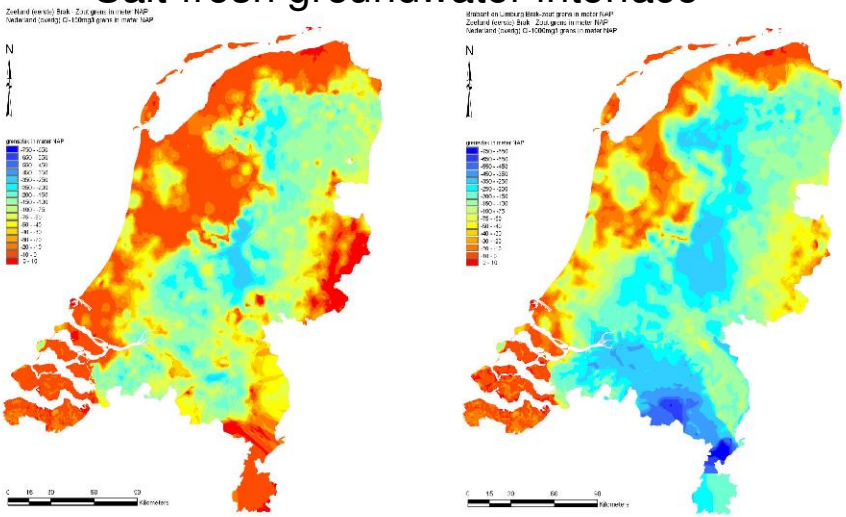
23

Polder Groot Mijdrecht



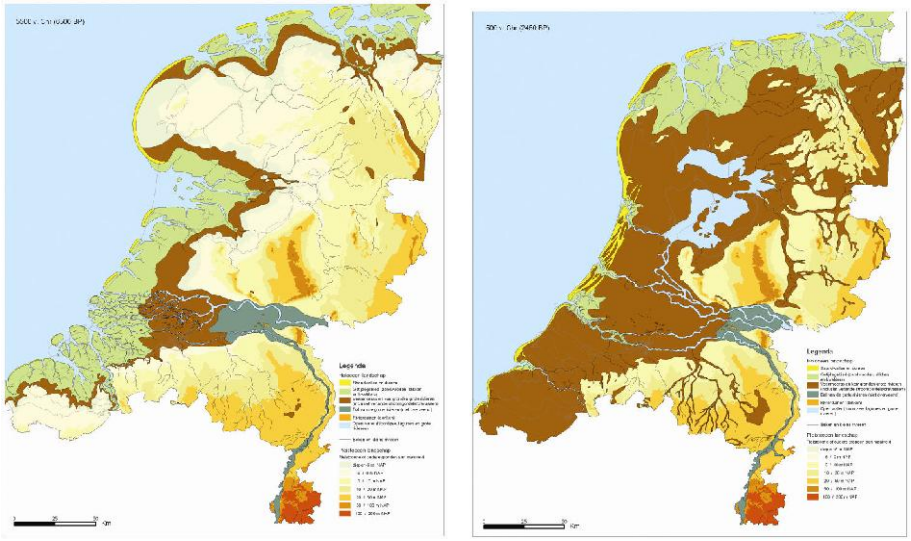
24

Salt-fresh groundwater interface

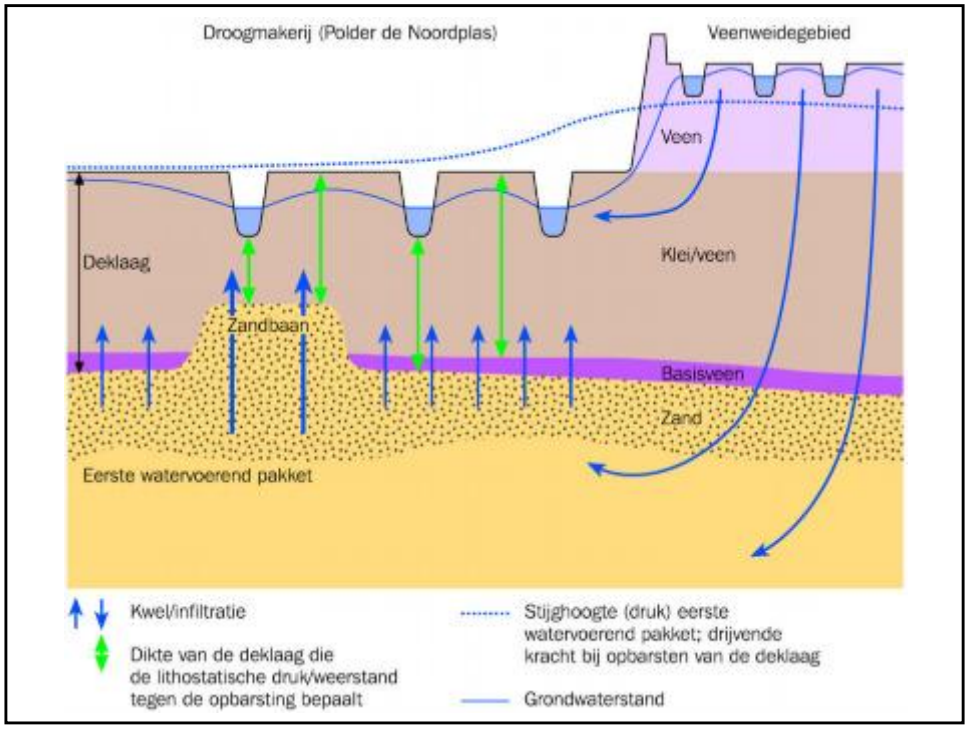


25

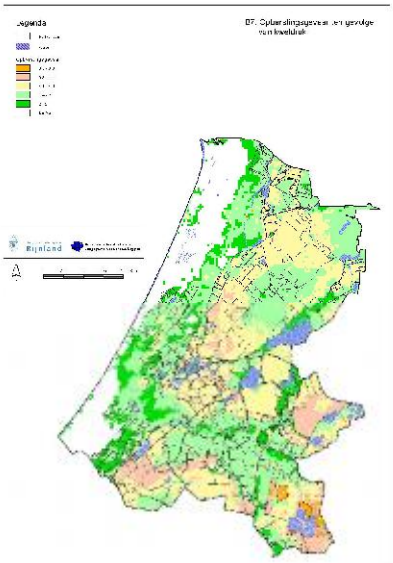
Holocene landscape

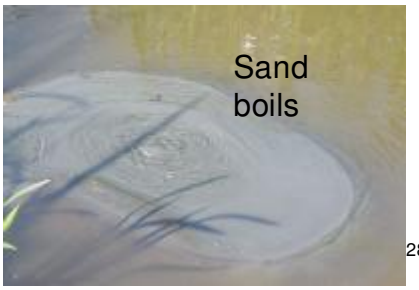


26



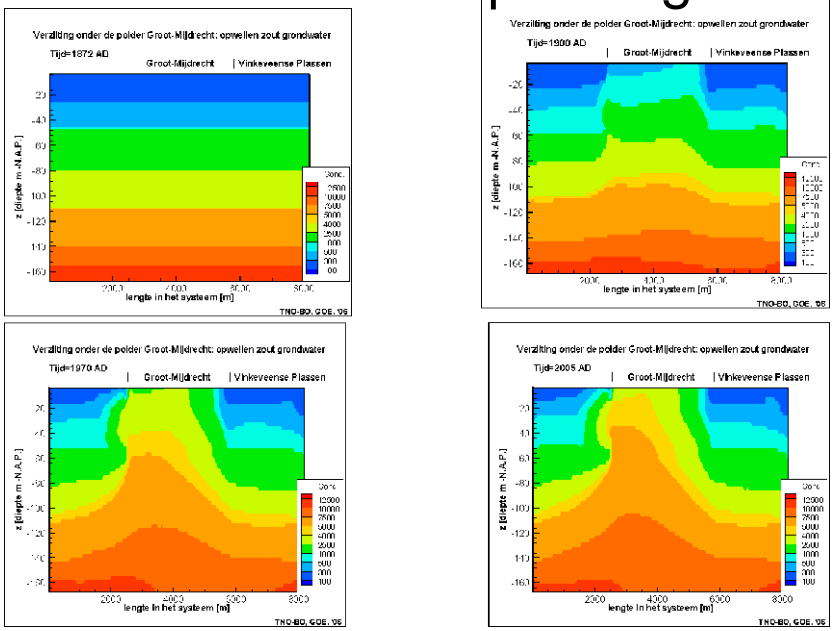
Bursting clay layers





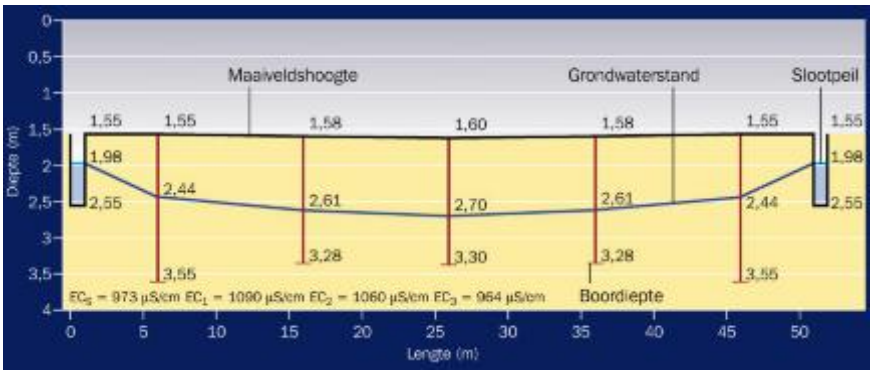
28

Salt water upconing

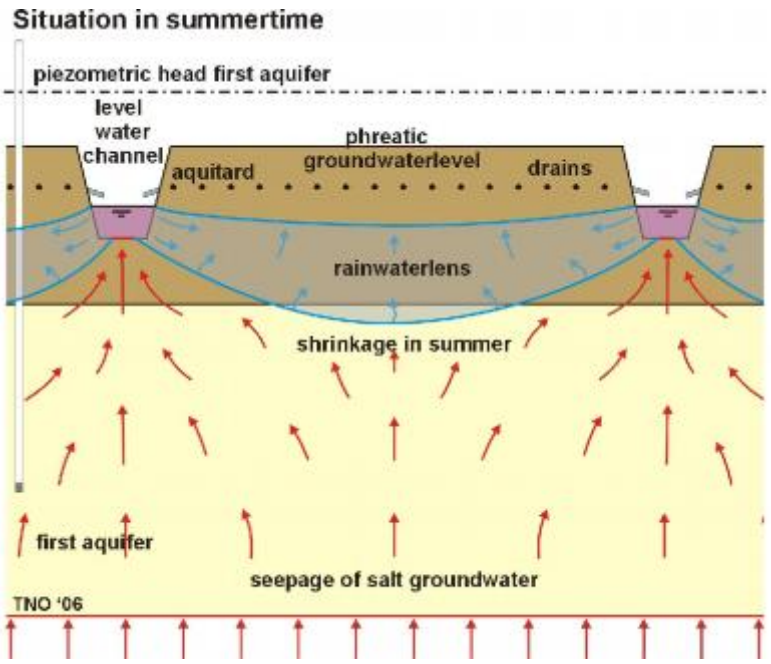


29

Hollow groundwater levels

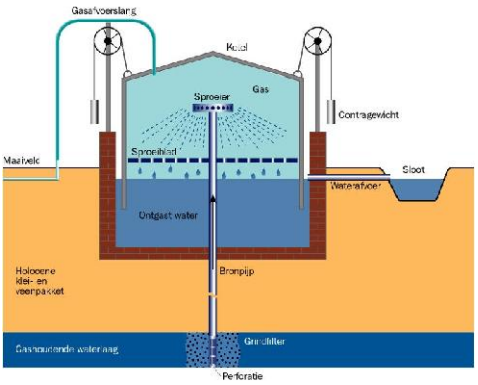


30



31

Shallow groundwater:source of natural gas

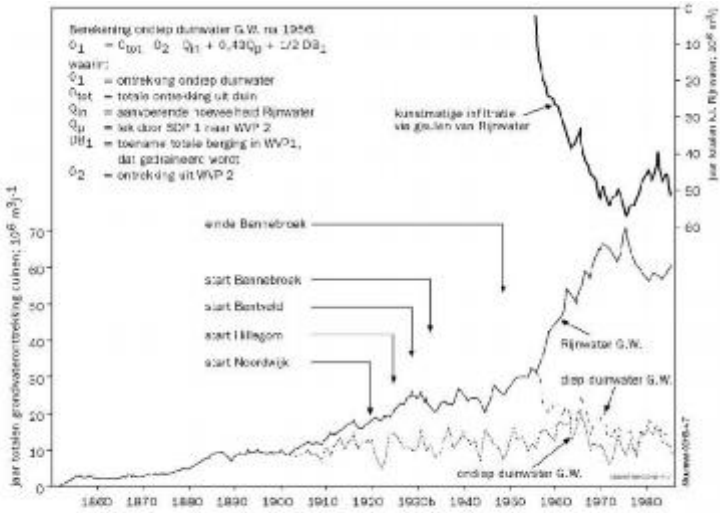


32

Coastal barrier landscape

33

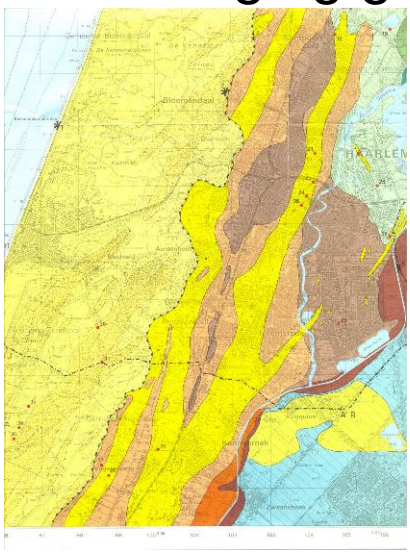
Groundwater pumping in the dune area

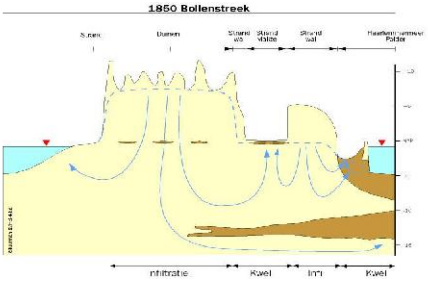


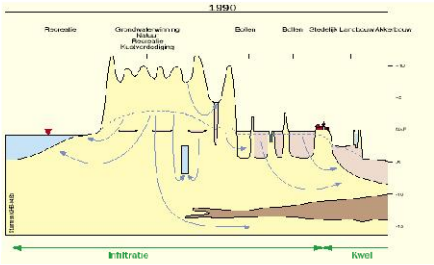
Figuur 4.7 Verloop in jaarlijkse ontrekkingen van water uit de duinen voor drinkwater producerende bedrijven afzonderlijk en gesommeerd, vanaf het begin, 1853, tot op heden. Het verloop van de jaarlijkse kunstmatige infiltratie van Rijnwater uit het Leekkanaal, in de duinen is tevens aangegeven. Voor details zie bijlage 4.

34

Changing groundwater flow







35

Deposition chronology

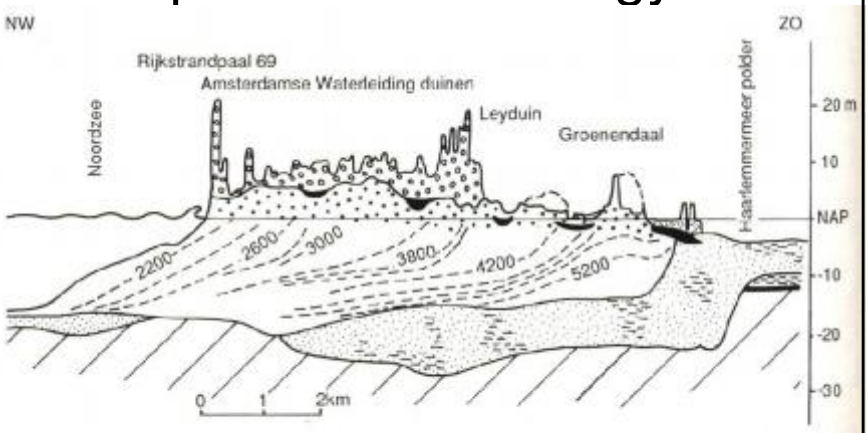


Fig. 15. Profiel ten zuiden van Haarlem. Naar Van der Valk (1992)

36