Geological model of the Netherlands

October, 2005

TNO Build, Environment and Geosciences
Geological Survey of The Netherlands
The Netherlands

Area: 41.526 km²; population: 16.2 miljion
Modelling the subsurface of the Netherlands

• Geological modelling of the shallow subsurface (- 500m)

• The Netherlands is situated on the edge of the North Sea basin (“the sink of Europe”)

• The geological record is controlled by a number of processes:
  • Marine trans- and regressions
  • Fluvial sedimentation and erosion by 3 main large riversystems, i.e. Rhine, Meuse and the Eridanos (originating form the Baltic shield)
  • Glacial sedimentation from at least 2 major glacial events
  • Tectonics and Climate Change
  • Local sedimentation
Aim of geological modelling

• To construct a consistent and updatable stacked layer model of the subsurface
• lithostratigraphically based at the formation level
• Appropriate for use in applied geosciences at a regional scale (gridcells 250 * 250 meter)
Modelling process

At first the concept starts with a dream
Modelling process (2)

Combining borehole data (DINO) and lithostratigraphy provides a basic dataset of the layermodel.
The basic data set of the model is formed by ±14,300 lithostratigraphically classified borehole data, stored in RDBMS ORACLE.
Lithostratigraphic classification at the formation level forms a basic framework for the layer model; the lithostratigraphical information is stored in DINO; 18 formations are distinguished.
Geological “reference” cross-section aid the consistent labelling of individual borehole data
Geological profile in detail

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Modelling process (3)

Geological aspects to be used as steering instruments in the modelling

- Distribution
- Shape-assist
- Faults
Distribution of the extent of the formations is stored in GIS (ESRI software (ArcGIS etc.))
Geological reference surfaces are stored in contours and rasterized for modelling
Fault data stored in GIS and extracted for modeling
Modelling process (4)

Point information

- DINO
- Litho-stratigraphy

Data Processing

Layermodel point information

- Distribution
- Shape-assist
- Faults

layer = f(x, y)

the actual modelling starts when data and geological information are combined.
Assisting the interpolation

Erosion and thinning out near the distribution limit

Channel incision

Formation A
Formation B
Formation C

Distribution limit

additional data points at channel bottom are used for shaping the incision by Formation C
additional data points with Z=0 provide a smooth thinning out
Modelling process (5)

Layer = f(x, y)

Basic data
- ORACLE
- DINO
- Reference profiles
  - Lithostratigraphy
- SQL and Java-script
  - Processing
  - Xls-files
    - Layermodel point information
- GIS-grid
  - Distribution
  - Shape-assist
- GIS-lines
  - Faults
- VBA in xls
  - Workflowmanager
- Geostat software
  - (interpolation/gridcell conversions)
- Raster output
  - RESULTS
    - 3D Layermodel database

Modelling
- Raw data
- Geology
- GIS-grid
- GIS-lines
Salt Lake City, October 2005
Jan L. Gunnink; Geological Survey of The Netherlands

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Workflow in a nutshell

- The data is combined within the workflow manager;
- Interpolation is carried out with geostatistical software (Isatis) by means of a batch file that is created by the workflow manager;
- Block kriging is applied;
- The interpolation results are stacked in Isatis to construct a consistent geological model;
- The geological model is exported in raster format for display and inspection;
- New versions are created overnight.
Fault map and depth contours for base of Quaternary deposits, i.e. a combination of the base the Waalre -, Stramproy - and Maassluis Formations

The map is extracted from the layermodel by combining data from 3 different formations and presented as a so-called shade map
The 3D layer model can generate cross-sections along randomly chosen lines.
Detailed maps with fault patterns are reconstructed for the base of each formation.

Fault pattern
Kieseloolite Fm

Fault pattern
Stramproy Fm
Some examples of 2D sections derived from the model
Example of horizontally produced slices between 0 - 400 m below reference datum.

In this case, interval distances increase with depth.

Colors refer to formations present at the specified depth.
Application

- The geological framework is used for constructing a nationwide geohydrological model: REGIS
- Within the geological framework of the formations, aquifers and aquitards are modelled
- Hydraulic properties are assigned to these geohydrological layers, based on pumping tests and grain size information

Digital Groundwater model of the Netherlands
Future work

• Emphasis will be shifted to the “top-system”: the uppermost 30 – 50 meter
• Aim is to construct a 3D voxel model of smaller areas (typically 50 km2)
• Beyond lithostratigraphic subdivisions it will describe a detailed facies distribution and characterization
• The 3D voxel model will be suitable for a wide range of parametrisations that can be used in a more detailed modelling of hydrological, geomechanical and geochemical issues
Example of 3D-model
For every voxel the most likely facies is determined from geostatistical interpolation routines (indicator kriging and simulation)
The 2 approaches of modelling and their relation to the depositional domains

Hierarchy of micro- to megascale sediment characterisation

1. Particles
   - Transport dynamics
   - Geochemical composition

2. Strata
   - Depositional dynamics
   - Physical characteristics

3. Facies units
   - Geomorphologic dynamics
   - Geometry

4. Architectural elements
   - Environmental system dynamics
   - Lateral variability

5. Sequences
   - Sedimentary dynamics
   - Sequential variability

6. Basin Fill
   - Basin dynamics

2D Stacked Layer model

3D Voxel model

Lithostratigraphy

2D Stacked Layer model

Sample

Core

Outcrop

Shallow seisms / GPR

Core-logging

HRS seisms

3D Voxel model