

# GEOTOP

## 3D MODELLING OF THE SHALLOW SUBSURFACE

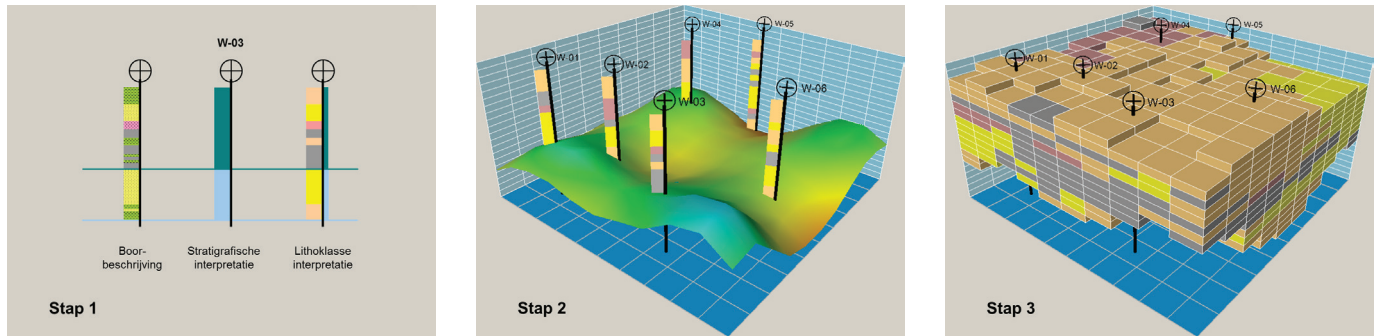


Figure 1. From borehole to model.

Step 1: Interpretation of borehole logs.

Step 2: Modelling the base of the lithostratigraphical units.

Step 3: Modelling lithoclasses.



### INTRODUCTION

Knowledge about the composition and properties of the subsurface rock layers is vital to using and managing the subsurface safely and sustainably. The Geological Survey of the Netherlands supplies this information by geological subsurface models. GeoTOP is a detailed three dimensional model of the shallow subsurface up to a depth of 50 m below NAP (Dutch Ordnance Datum). That depth range is the most intensively used part of the shallow subsoil. This fact sheet provides general information about the construction and workflow of GeoTOP. We consider the lithostratigraphical framework, the modelled lithological classification (lithoclasses) and the interrelated physical and chemical parameters. In addition, an example is presented of the model uncer-

tainties. GeoTOP models individual regions that roughly correspond to provinces. At present, GeoTOP models are available for Zeeland, Zuid-Holland, Noord-Holland, Rijn - Maas gebied (the Rhine–Meuse area), West Wad and Oost Wad. Results of the models are available via the website [www.DINOloket.nl](http://www.DINOloket.nl).

### 3D VOXEL MODEL

The 3D voxel model GeoTOP schematises onshore Netherlands in millions of voxels (grid cells), each measuring 100 x 100 x 0.5 m, to a depth of 50 m below NAP (Dutch Ordnance Datum). Each voxel in the model contains information on the lithostratigraphy and lithological classes (lithoclasses), including the probability of occurrence for each lithoclass. Other parameters, such as hydraulic conductivity and chloride content can also be linked to the voxels in the model. Using the lithostratigraphical framework as a base for physical and chemical parameters,

GeoTOP provides the user with a reliable image of the spatial variability of those parameters.

### BASIC DATA

GeoTOP has been constructed per region from the available digital borehole descriptions stored in the DINO database, which contains some 430,000 borehole descriptions. Each borehole description provides detailed information about the layering of the subsurface at one particular location. The borehole data have been supplemented with data from cone-penetration tests and from digitised geological maps. For the model of the Rhine–Meuse area, additional borehole data from Utrecht University's Department of Physical Geography have been used.

The modelling procedure involves the following steps (Fig. 1). The first step is the geological schematisation of the boreholes into units that have uniform sediment characteristics using lithostratigraphical and lithological class (lithoclass)

**Lithostratigraphical units ▼**

- Anthropogenic deposits
- Nieuwkoop Formation, Hollandveen Member
- Echteld Formation
- Bortel Formation, Wierden Member
- Bortel Formation
- Kreftenheye Formation
- Drente Formation
- Ice-pushed deposits
- Urk Formation
- Sterksel Formation
- Peize-Waalre Formation
- Fluvial channel generations, Echteld Formation

**Lithoclasses ▼ ▶**

- Anthropogenic deposits
- Peat
- Clay
- Sandy clay and clayey sand
- Fine sand
- Medium grained sand
- Coarse sand
- Gravel
- Model area Zuid-Holland

information. Subsequently, the 2D top and base surfaces of lithostratigraphical units are constructed. These interfaces represent the bounding surfaces of the units at Formation or Member level. Each voxel in the model can now be placed within the correct lithostratigraphical context. In the third step stochastic interpolation

techniques are used to assign a lithoclass to the voxels.

**LITHOSTRATIGRAPHY AND LITHOCLASS**

Lithostratigraphy, the logical ordering of rock units, is based on lithological properties that discerns a rock unit from other

rock units above, below or lateral from the observed unit. In GeoTOP lithological properties are described in lithoclasses, combining lithology and sand grain-size classes in one legend. As an example the lithostratigraphy and the lithoclasses of the Gelderse Vallei GeoTOP area is presented in Figure 2. The lithoclass model

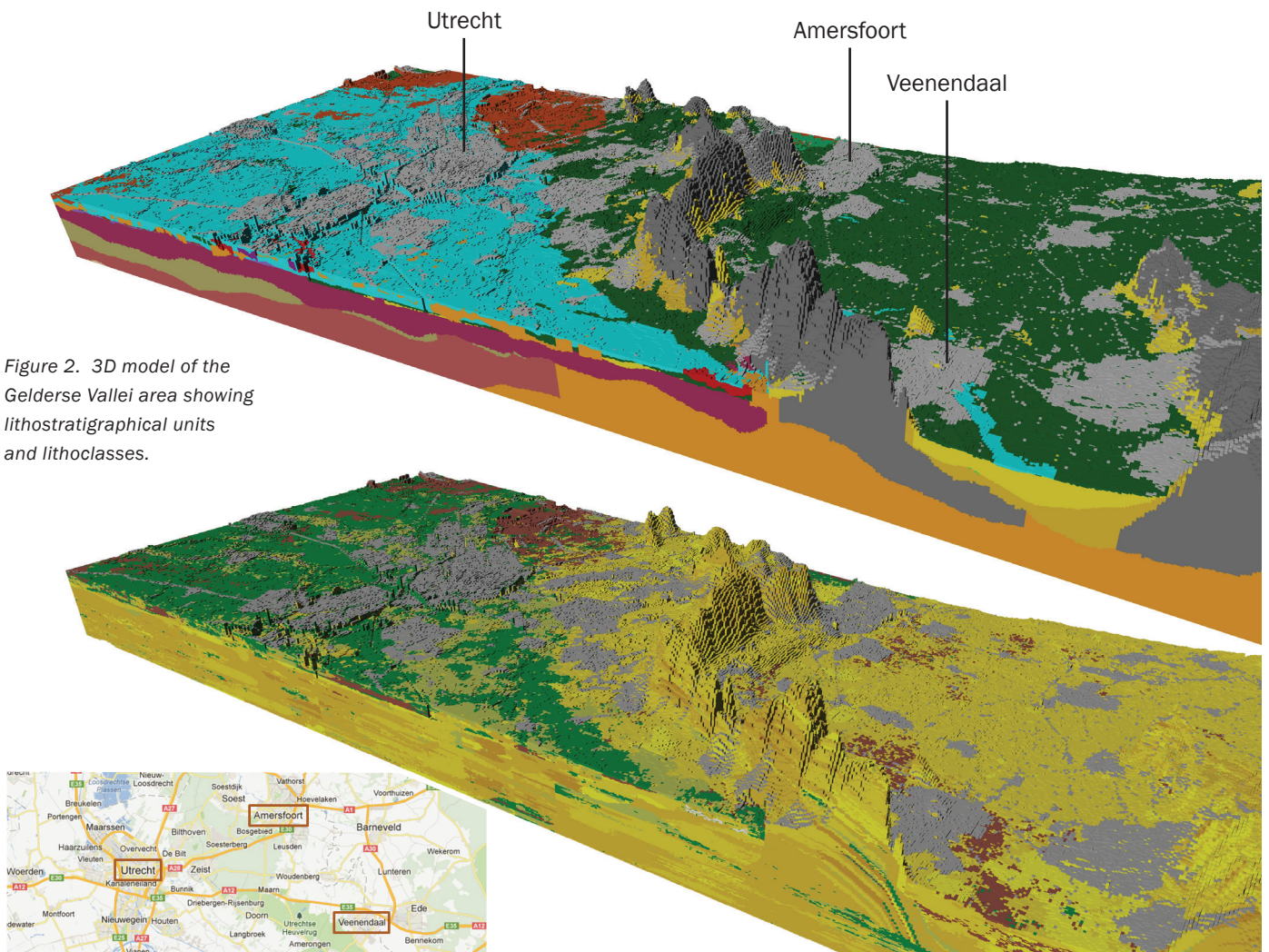


Figure 2. 3D model of the Gelderse Vallei area showing lithostratigraphical units and lithoclasses.



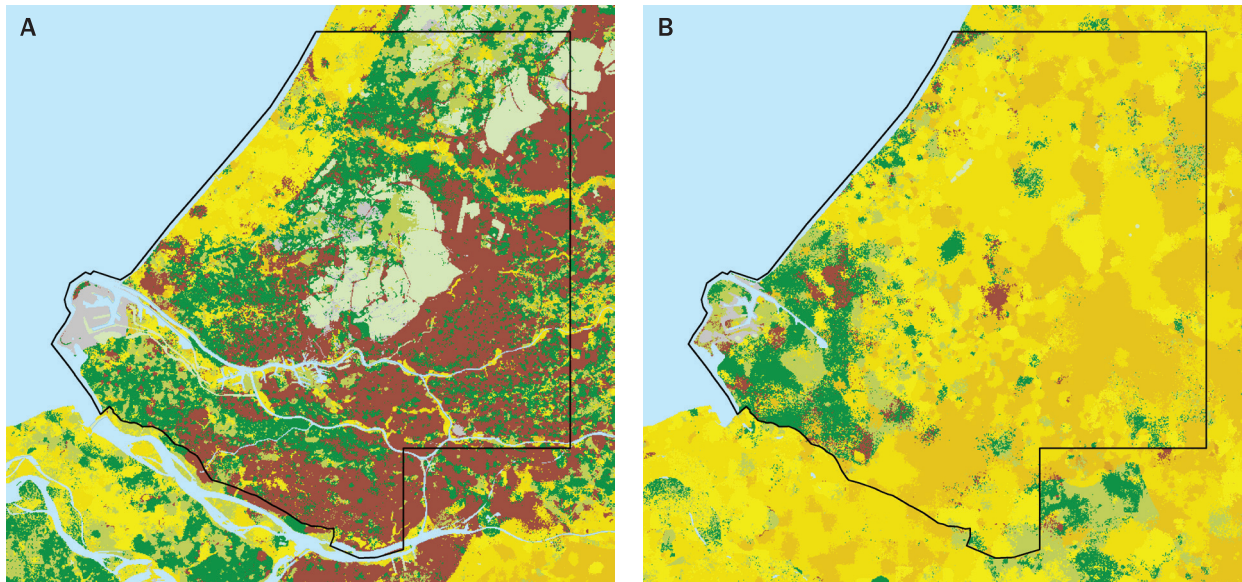


Figure 3. Depth slices of the Zuid-Holland model at 5 m (a) and 20 m (b) below NAP to show the variation in lithology and grain-size classes of Holocene and Late Pleistocene sediments.

shows, e.g., the coarse sands and the gravel content of the ice-pushed ridges around the Gelderse Vallei in the central part of the Netherlands. The 3D model also clearly shows the oblique position of the originally horizontally bedded sediments. Model depth slices provide insight into the variation in lithology at a chosen depth. Figure 3 shows two depth slices, one at a depth of 5 m below NAP (Dutch Ordnance Datum) and the other at a depth of 20 m below NAP in Zuid-Holland. The slices clearly show the differences in lithology and grain-size classes between the Holocene and the Late Pleistocene sediments.

**UNCERTAINTIES**

The use of stochastic interpolation techniques in modelling enables to compute the most probable occurrence of a lithoclass for each voxel. The probabilities are a measure of the model uncertainty. Figure 4 shows the results in case of the Rhine floodbasin deposits (Echteld Formation) near Wijk bij Duurstede. The colours indicate the probability of occurrence of the lithoclass clay in a voxel. At greater distances of the river courses the probability is high (red). Close to the river courses the blue and green colours reveal the low probability of occurrence of clay. The probability of occurrence of sand and clayey sand near the channels is much higher. The pattern of sandy sediments near the river courses and clay in the flood basins characterizes the Holocene fluvial deposits in the Netherlands.

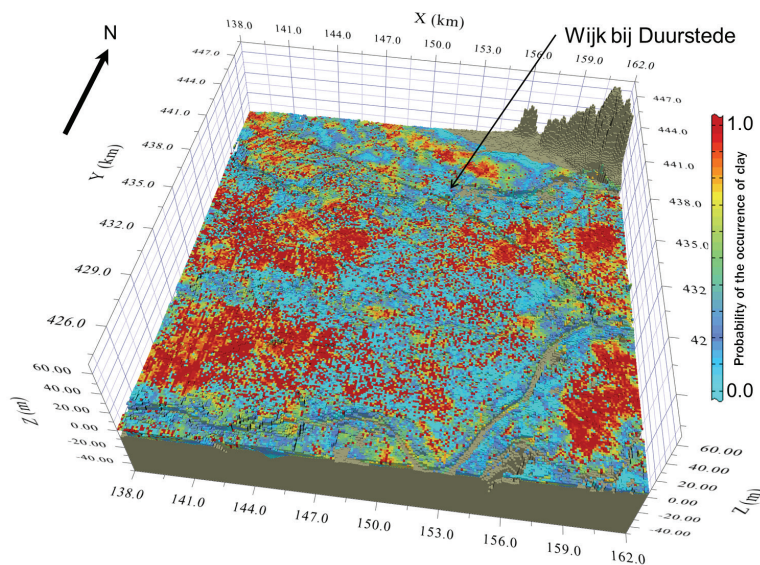


Figure 4. Probability of the occurrence of clay in the floodbasin areas south of Wijk bij Duurstede (Rhine–Meuse area).

**PHYSICAL AND CHEMICAL PARAMETERS**

Physical and chemical parameters are also included in GeoTOP. The measuring program has been organized in such a way that the results can be assigned to the lithostratigraphical and lithoclass model units. The outcome is a detailed 3D image of the spatial variation of the parameter values in the subsurface. Examples are the horizontal and vertical hydraulic conductivity, crucial parameters in groundwater studies, and the reactivity of sediments used in the modelling of contaminant plumes. The chosen parameters to include in the model are based on the needs and wishes of the users of GeoTOP.

# WWW.DINOloket.NL

## VISUALIZATION AND MODEL RESULTS

TNO and INSIGHT Geological Software Systems GmbH developed a Subsurface viewer to visualize the model data. The user can freely download both the viewer and the 3D datasets via [www.DINOloket.nl](http://www.DINOloket.nl). The viewer enables the construction of maps, cross-sections and 3D - images of the shallow subsurface (Figure 5). GeoTOP model results are available via [www.DINOloket.nl](http://www.DINOloket.nl). You can view the requested GeoTOP model data on your own computer in the Subsurface viewer and in ArcGIS. ArcGIS applications are available as grid files of the top, base and thickness of the model units in the layer model, and

as grid files of horizontal sections through the voxel model (both relative to ground level and to NAP). Future developments include the data storage directly in the DINO database through which the users can download the model results in selected areas.

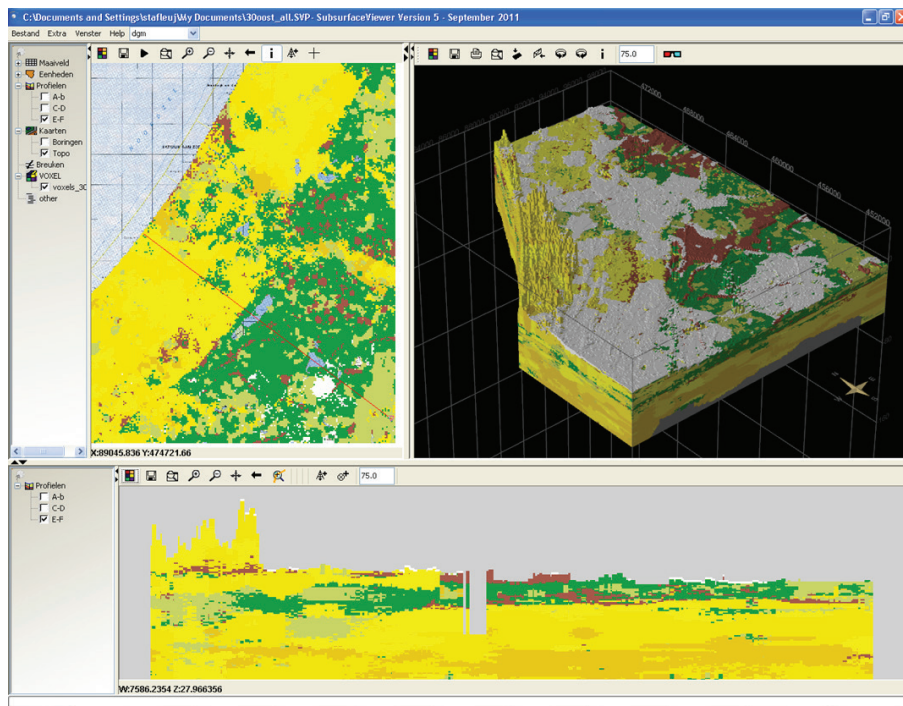


Figure 5. Examples of model results shown in the Subsurface viewer: lithoclasses, 3D image and cross-section (Zuid-Holland).

**TNO.NL**

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