Ministry of Economic Affairs, Agriculture and Innovation

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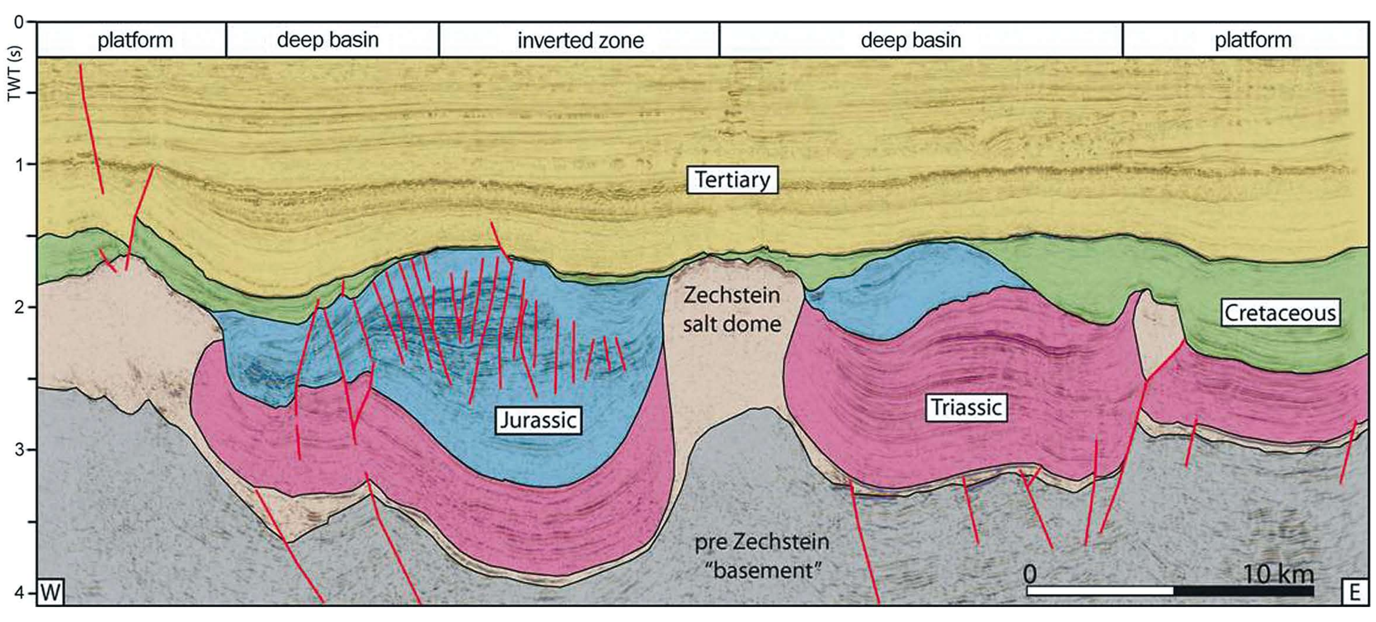
3D-Subsurface mapping
of the Netherlands

Geological interpretations
The structural 3D model facilitates the reconstruction of the tectonostratigraphic development of the Netherlands.

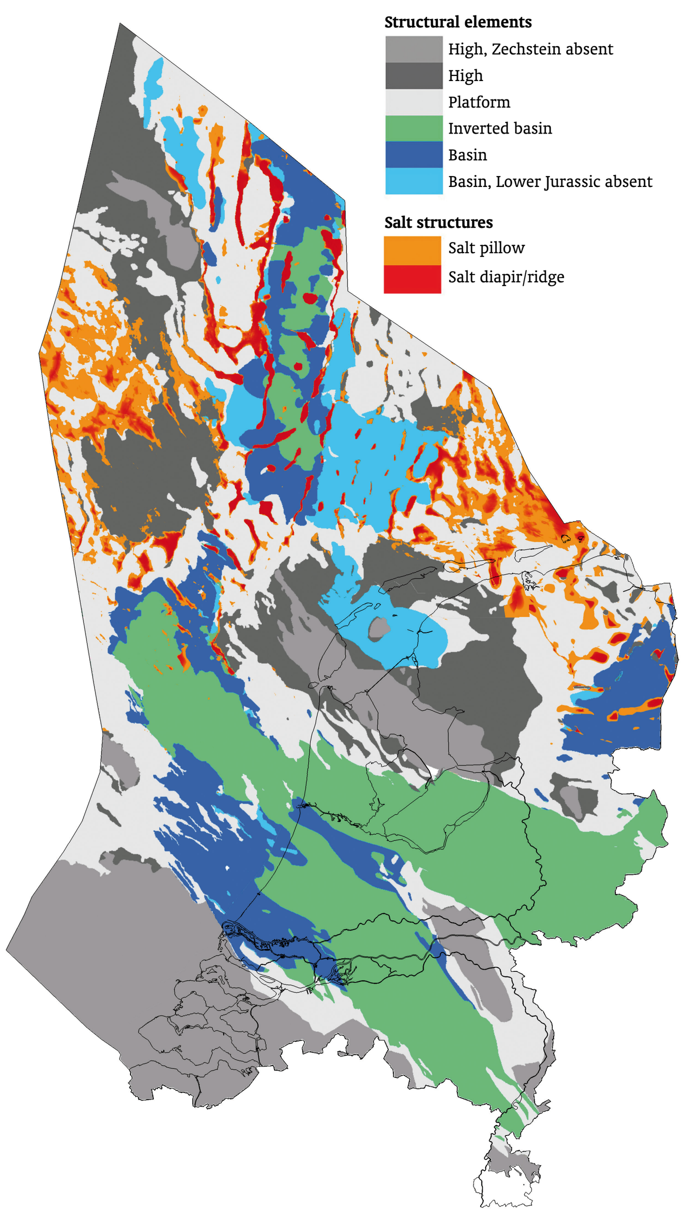
Structural elements
Structural element maps have been constructed from the depth and present-day thicknesses of the different stratigraphic layers in the 3D model (figure on the right). The elements are divided in structural highs, platforms and basins. Most basins are inverted during the Alpine orogeny.

Tectonostratigraphic observations include:
- Platforms and highs experienced less structural deformation during the major phases of rifting. Halokinesis in the platform areas is thin-skinned in the sense that it is decoupled from subsalt faulting.
- In the rift basins salt diapirs and walls are almost exclusively linked to major subsalt faults. Halokinesis in the basin areas is thick-skinned, i.e. importantly controlled by subsalt deformation.

Salt tectonics
The presence of Zechstein salt is greatly influenced by the post-Permian structural and sedimentary development of the area (figure below). The 3D model allows us to:
- Asses the distribution of Zechstein salt thickness and its relation to salt flow;
- Map the salt deformation styles (ridges, pillows, lateral intrusions) in relation with fault styles and orientations;
- Map the regional outlines of the timing of salt deformation phases using back-stripping analysis.

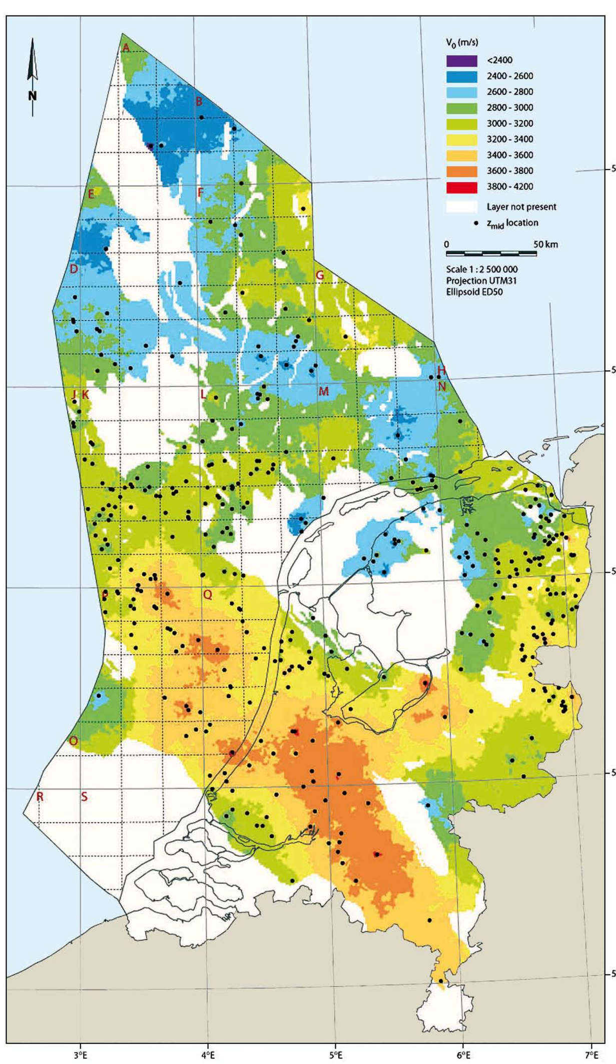


Interpreted E-W seismic section in the Dutch offshore. Back-stripping analysis corroborates that peak salt flow occurred during Jurassic rifting (204 - 140 Ma) and Late Cretaceous-Tertiary inversion (80 - 20 Ma) of the Central Graben and resulted in the formation of large salt diapirs, rimsynclines and multiple internal unconformities.



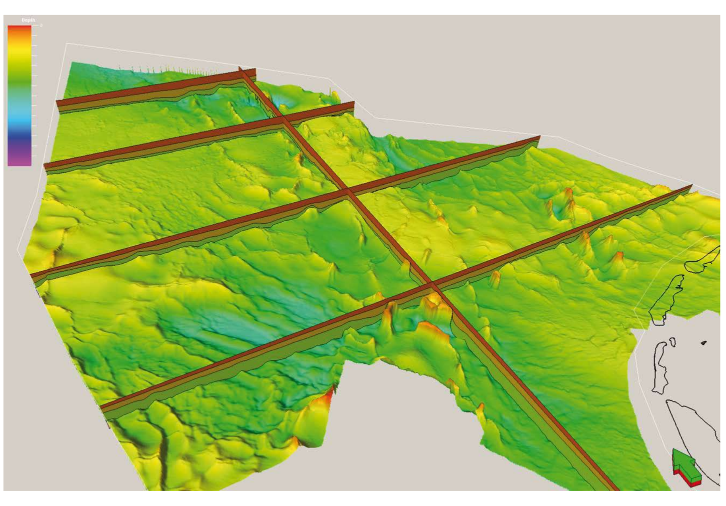
Structural elements map of the Netherlands. Inversion of the Mesozoic basins mainly occurred during the Late Cretaceous Alpine orogeny.

Time depth conversion

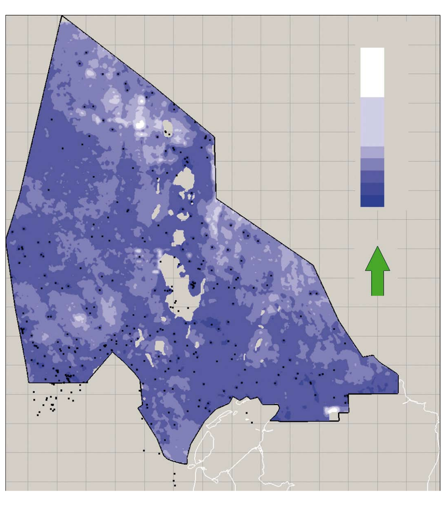


Map of the V0 distribution of the Lower and Upper Germanic Trias groups. High values of V0 in the central and southern parts of the Netherlands coincide with areas of strong structural inversion.
(see also Figure 5.)

Uncertainty assesment



Perspective view of the base of the Upper Cretaceous in the northern offshore.



Associated standard deviation of the Upper Cretaceous Chalk Group in the northern part of the offshore.

Time-to-depth conversion
The compiled time horizons and faults are converted to depth using a regional velocity model consisting of 10 layers. Except for the layer of the Zechstein Group, which contains multiple salt levels, it is assumed that for each layer velocities increase linearly with depth under the influence of compaction: $V(x,y,z) = V0(x,y) + k \cdot Z$
The regional compaction coefficient k is determined from the linear least squares relation between the interval velocity (Vint) and mid-depth (Zmid) at boreholes. The location dependent parameter V0(x,y) is determined at borehole locations and interpolated, using a kriging method, to grids. An example of a gridded V0 map is given in figure on the left. Major variations in the distribution of V0(x,y) values often coincide with regions of structural inversion (relatively high velocities) and regions where overpressured conditions are present within layers (relatively low velocities). For the Zechstein Group a grid of interval velocities was used.

Uncertainty assessment
The modeling workflow includes an assessment of uncertainties of depth and thickness of the stratigraphic layers. Errors can be introduced by the following processes:
- Seismic interpretation,
  - 2D or 3D data,
  - 2D data: paper or digital ,
  - structural complexity,
  - resolution,
- Interpolation of interpretations,
- Velocity model used for T-D conversion,
  - Number of wells,
  - Distance to well

For information on Exploration and Production issues and E&P data see the Netherlands Oil and Gas Portal www.nlog.nl & www.ebn.nl