



## **Lithological properties of sedimentary environments in the shallow subsurface of the Northern Netherlands**

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Society has an increasing demand from the subsurface, which in the Dutch shallow subsurface (upper 30 to 40 meters) mainly focuses on natural aggregate resources, groundwater, infrastructure and dike safety. This stimulates the demand for knowledge about the composition and heterogeneity of the subsurface and its physical and chemical properties, including the uncertainties involved.

Physical and chemical properties of sediments in the subsurface have been under investigation for decades; however, the usefulness of this data for applied research and the understanding of these properties is limited. This is due to several factors: studies consist mainly of separately collected datasets, targeted at a limited amount of parameters, focused on a small number of geological units, distributed unevenly with depth and usually collected from clustered drillings with limited spatial extent or are analysed with different techniques and methods, often on disturbed samples. These factors result in a heterogeneous and biased dataset not suitable to function as a reference dataset or to statistically determine regional characteristics of geological units.

To overcome these shortcomings, the Geological Survey of the Netherlands is establishing a nation-wide reference dataset for physical and chemical properties. In 2006, a drilling campaign was started using cone penetration tests, cored drillings and geophysical well logs, choosing the sites for a good geographical distribution. The lithological properties of the undisturbed cores are visually described and interpreted for lithostratigraphy and inferred sedimentary environment based on lithofacies. The location of the samples in the cores are chosen based on this description and interpretation, resulting in an evenly distributed dataset of in situ samples with respect to geological units as well as an adequate number of samples suitable for statistical analysis. Analyses are uniformly performed for grain size distribution, permeability (both high and low permeable lithologies) and geochemical methods (X-Ray Fluorescence, Thermo-Gravimetric Analysis, Total Carbon, Total Sulphur and Total Organic Carbon). These analyses result in a large number of lithological, hydrological and geochemical parameters, i.e. clay content, sand median, vertical and horizontal permeability and  $\text{CaCO}_3$ -content.

We present the results from the analysis of lithological properties for the Northern Netherlands. Besides geology, these properties can be applied directly in studies concerning (amongst others) groundwater, natural aggregates and dike safety. We demonstrate the use of sedimentary environments based on lithofacies as a useful tool for comparison between lithostratigraphic units and lithofacies. These lithofacies match distinct parts of the marine, fluvial, glacial, eolian or organogenic environment, i.e. tidal channel sand, floodbasin clay and subglacial till. This results in lithological properties illustrating the heterogeneity within a geological unit and between equal depositional environments in different lithostratigraphic units.

The acquired data have so far been used in several applied studies, i.e. improving parameterisation of 3D models leading to increased accuracy in groundwater models and dike safety studies concerning dike failure due to undermining. Recently, grain size distributions measured with different methods were recalibrated into a homogeneous dataset using this reference set, which greatly enlarged the dataset to be incorporated in the parameterisation of a 3D voxel model.