(Hydro)stratigraphy of the Upper Cretaceous to Danian Chalk Group of South Limburg, the Netherlands

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Societal problem

The Upper Cretaceous to Danian Chalk Group of South Limburg is an important aquifer. Groundwater quality in this aquifer has declined in recent years due to a **high concentration of nitrate**. Current geological models, required to manage the aquifer appropriately, cannot accurately simulate **groundwater flow**. This inability is partially caused by inadequate facies characterization and stratigraphic correlation of the reservoir unit.

Stratigraphic problem

Little is known about the relationship of the Chalk Group lithostratigraphic subdivisions with the groundwater reservoir properties in South Limburg. The existing subdivisions are unlikely to encompass the heterogeneities of the reservoirs and to be representative of the subsurface architecture of the aquifer.

Take-home message

Our preliminary results show that there are three (hydro)stratigraphic units in the uppermost Chalk Group in South Limburg: the Gulpen Formation and the kunrade and maastricht 'facies' of the Maastricht Formation. The best reservoir is in the maastricht 'facies', which is exclusively located in the western part of South Limburg.

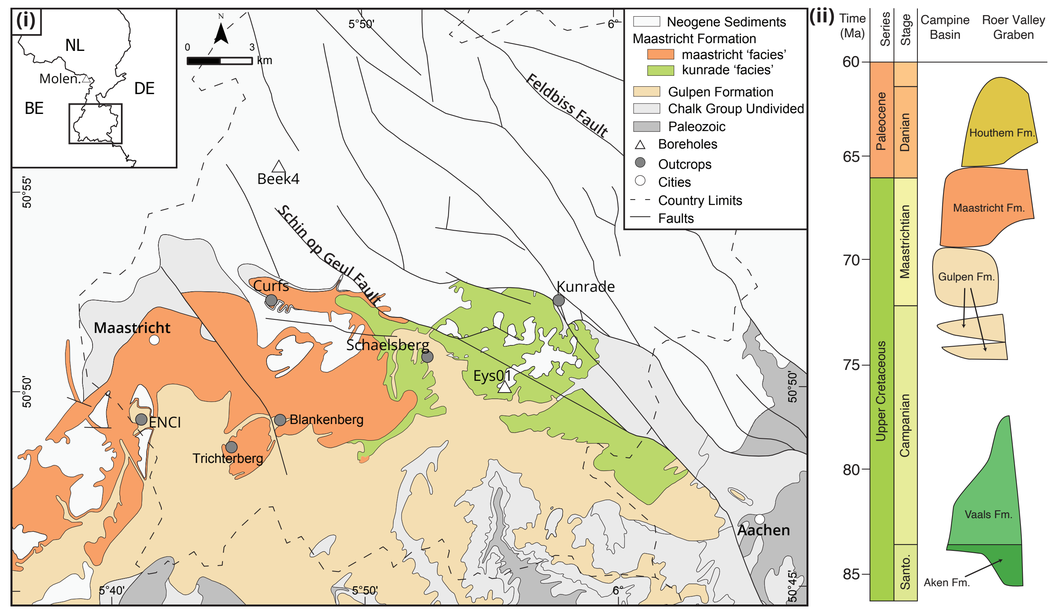

Figure 1 | **(i)** Geological map of South Limburg. The Maastricht Formation has been subdivided into a maastricht 'facies' in the west and a kunrade 'facies' in the east of South Limburg. **(ii)** Chronostratigraphic diagram of the Chalk Group in South Limburg.

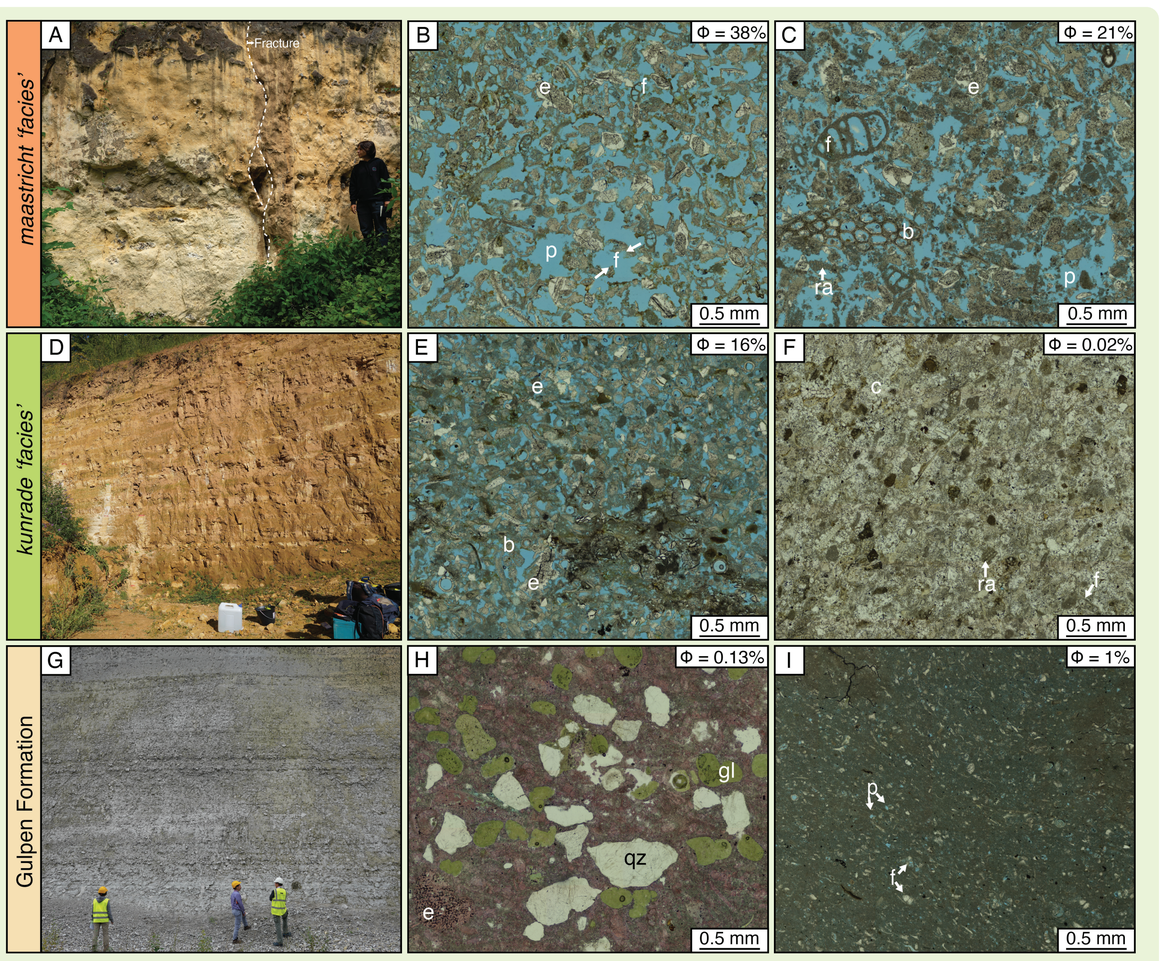

Figure 2 | Outcrops and thin sections of the uppermost Cretaceous units of the Chalk Group in South Limburg. **(A–C)** The maastricht 'facies' of the Maastricht Formation is characterized by poorly cemented bioclastic grainstones with high porosity. **(D–F)** The kunrade 'facies' of the Maastricht Formation is characterized by an alternation of highly **(F)** and poorly **(E)** cemented bioclastic pack- and grainstones. The porosity in the packstones is usually high (~15 %) and in the cemented layers ~0 %. **(G–I)** The Gulpen Formation is characterized by white to light grey carbonate mudstones and sandstones, with varying amounts of detrital grains (lithoclasts, quartz, and glauconite). The porosity is usually low and consists mostly of intraparticle pores. Blue = porosity; f = foraminifera; e = echinoderm; b = bryozoan; ra = red alga; qz

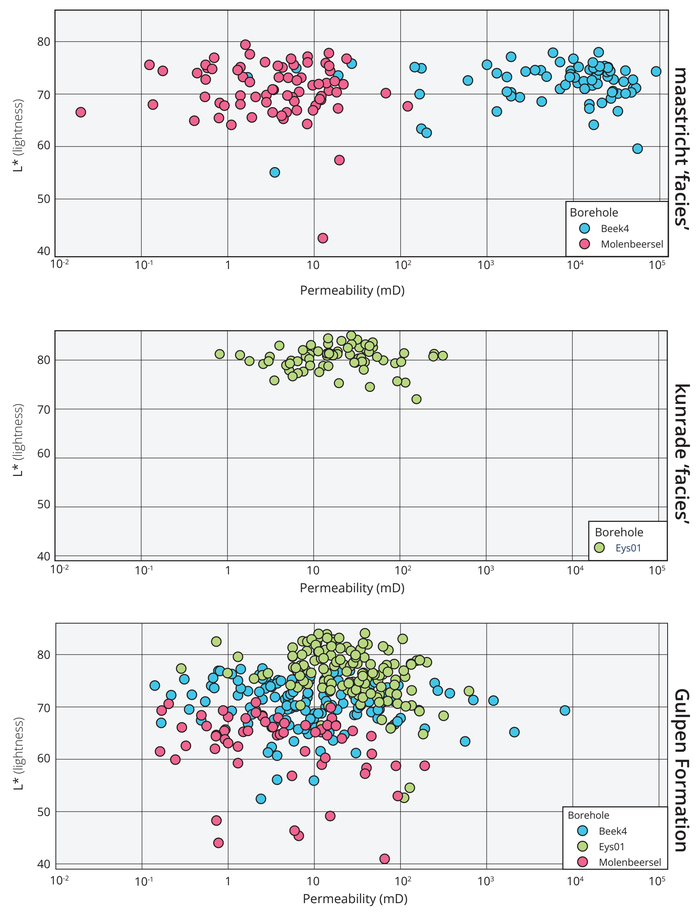

Figure 3 | Scatter plots comparing lightness (spectrophotometric colour) to permeability. Lightness is a proxy for carbonate cement (lighter) or mud content (darker). The permeability of the maastricht 'facies' in borehole Beek4 is higher than in borehole Molenbeersel. The Gulpen Formation and the kunrade 'facies' have similar permeability, but the kunrade 'facies' presents higher L* values due to cementation.

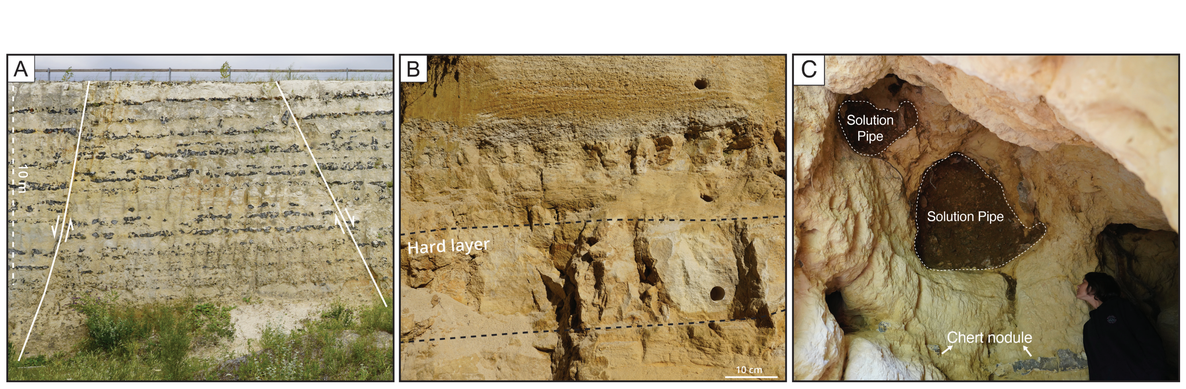

Figure 4 | Features that can impact primary reservoir properties. **(A)** Normal faults in the ENCI quarry creating secondary porosity and permeability (Gulpen Formation). **(B)** Alternation of hard and soft layers, forming baffles to vertical water flow. **(C)** Solution pipes developed due to karstification in rocks with primary porosity. When unfilled, solution pipes can significantly impact groundwater flow.

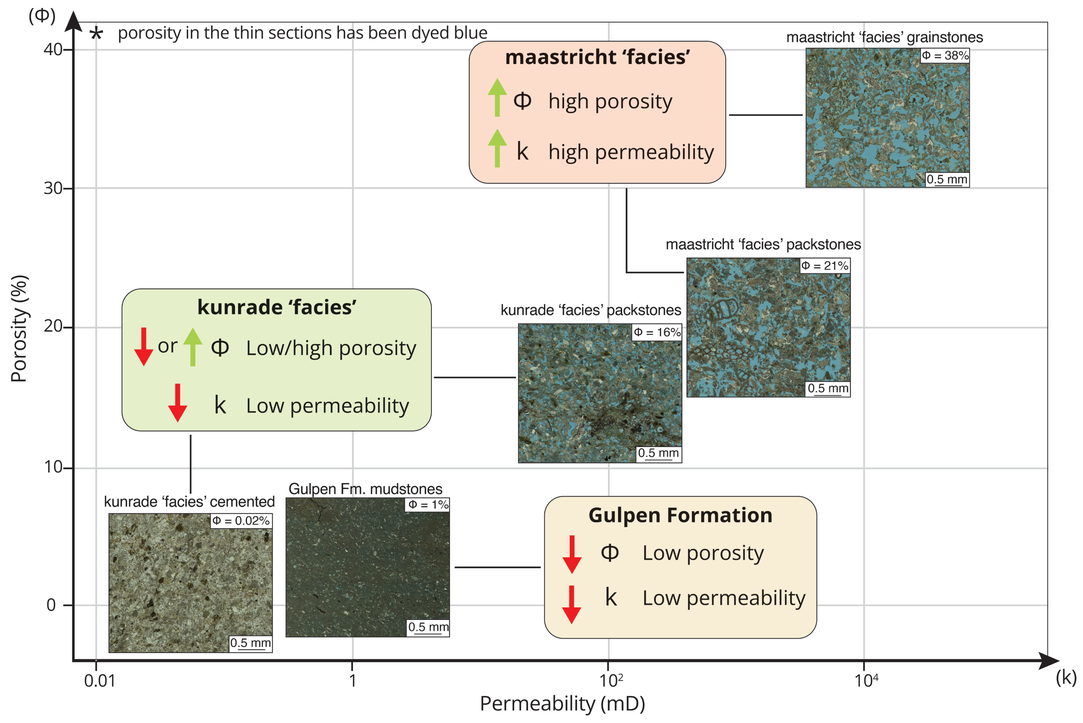

Figure 5 | Permeability versus porosity diagram. Three groups of rocks can be recognized: rocks of the Gulpen Formation and kunrade 'facies' with porosities ranging from 0 to 10 % and low permeability; rocks of the maastricht and kunrade 'facies' with porosities ranging from 10 to 25 % and moderate permeability; and rocks of the maastricht 'facies' with porosities between 30 and 40 % and high permeability. The best reservoirs are in the maastricht 'facies'. In the kunrade 'facies' and Gulpen Formation reservoir performance will depend on secondary porosity.

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