Characterization of the maastricht and kunrade ‘facies’ of the late Maastrichtian to Danian Maastricht Formation in South Limburg

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Stratigraphic context

The late Maastrichtian to Danian Maastricht Formation constitutes an **important aquifer** in South Limburg. The Maastricht Formation has been informally subdivided into a **maastricht and kunrade ‘facies’** based on the style and degree of cementation of the rocks. Little is known, however, about the (primary) characteristics and heterogeneity of both facies, including porosity and permeability, as well as their distribution. The aim of our project is to **characterize the maastricht and kunrade ‘facies’ of the Maastricht Formation and their influence on the quality of South Limburg’s aquifer.**

Take-home message

The maastricht ‘facies’ is coarser, more bioclastic, and contains horizons of flint nodules. The kunrade ‘facies’ is finer, less bioclastic, and contains dm thick cemented layers. Porosity is generally higher in the maastricht facies. **Thus, the quality of the Maastricht Formation as an aquifer declines towards eastern South Limburg due to an increase in cementation and consequent decrease in the porosity of the rocks in that direction.**

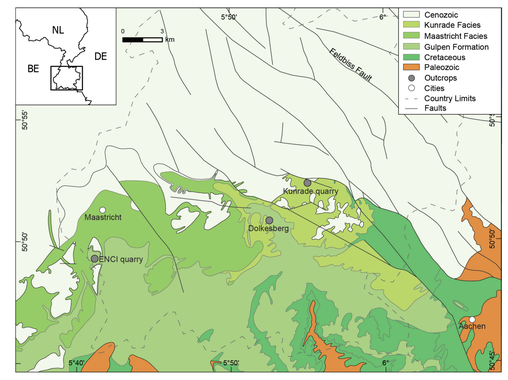


Figure 1 | Geological map of South Limburg. The maastricht ‘facies’ occurs in the west and the kunrade ‘facies’ in the east.

West **East**

maastricht ‘facies’

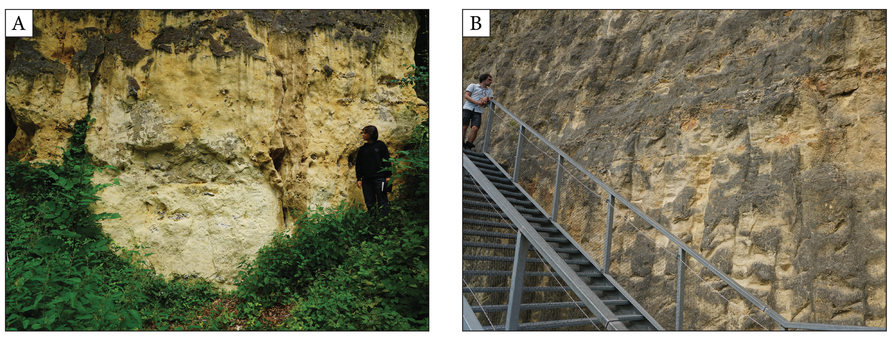


Figure 2 | The maastricht ‘facies’ is characterized by poorly cemented fine- to coarse-grained bioclast-dominated calcarenites with flint horizons and <3% siliciclastic grains. This ‘facies’ can be subdivided into a lower and an upper maastricht ‘facies’. **A** Lower maastricht ‘facies’. Poorly cemented fine-grained bioclast-dominated calcarenites with flint horizons. **B** Upper maastricht ‘facies’. Poorly cemented fine- to medium-grained bioclast-dominated calcarenites with fossiliferous beds.

Figure 3 | **A** Poorly cemented brown fine-grained bioclast-dominated calcarenite with a centimetre-thick flint horizon. **B** Poorly cemented brownish-orange bioclast-dominated calcarenite with a centimetre-thick fossiliferous bed. **C** Poorly cemented brown bioclast-dominated calcarenite with oriented annelid tubes.

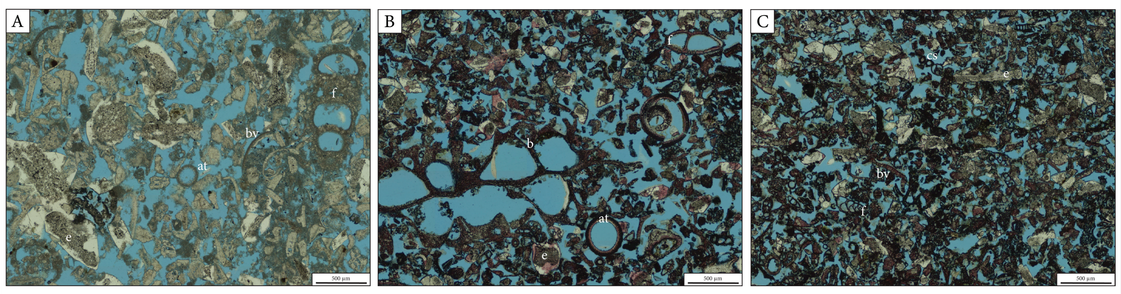


Figure 4 | The maastricht ‘facies’ is composed of 90% of bioclasts, <5% of carbonate cement, 5% clay, and <3% siliciclastic grains. The blue epoxy represents porosity. **A and B** Poorly cemented fine- to medium-grained bioclast-dominated grainstone (B, stained with alizarin red-S and potassium ferricyanide). **C** Poorly cemented fine-grained bioclast-dominated grainstone (stained with alizarin red-S and potassium ferricyanide). bv = bivalves; b = bryozoan; e = echinoid; f = foraminifera; cs = calcisphere; at = annelid tube.

kunrade ‘facies’

Figure 5 | The kunrade ‘facies’ is characterized by an alternation of friable and hard layers of fine- to medium-grained bioclast-bearing calcarenites without flint horizons and <5% siliciclastic grains. In the Kunrade quarry, towards the top of the section, grain size and diversity of bioclasts increase.

Figure 6 | **A** Lower part of the Kunrade quarry. Alternation between poorly cemented brownish-orange very fine-grained bioclast-bearing calcarenite and cemented brown fine-grained bioclastic-bearing calcarenite. **B** Cemented brown fine-grained bioclast-bearing calcarenite. **C** Upper part of the Kunrade quarry. Contact between poorly cemented brownish-orange fine-grained bioclast-bearing calcarenite and cemented brown fine-grained bioclast-bearing calcarenite.

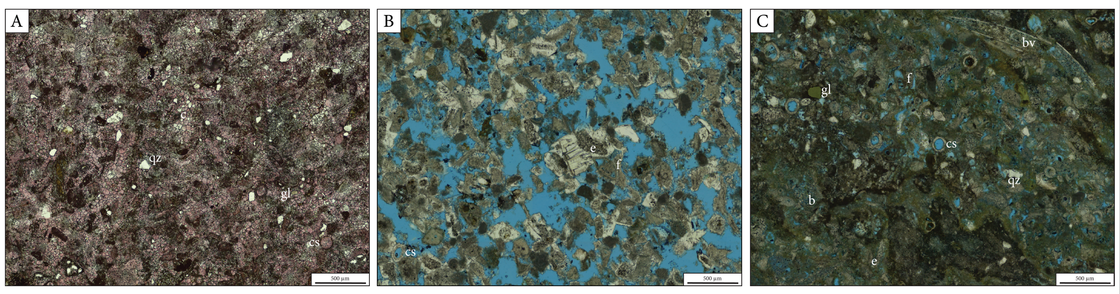
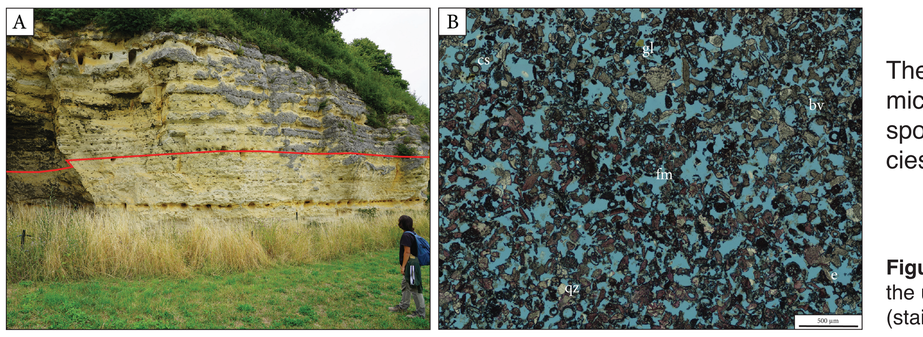


Figure 7 | The kunrade ‘facies’ is composed of 30% bioclasts, <50% cement, <15% clay, and <5% siliciclastic grains. The blue epoxy represents porosity. **A** Fine-grained bioclast-bearing and cement-bearing grainstone (stained with alizarin red-S and potassium ferricyanide). **B** Poorly cemented fine-grained bioclast-bearing grainstone. **C** Fine-grained bioclast-bearing and clay-bearing packstone. qz = quartz; gl = glauconite.

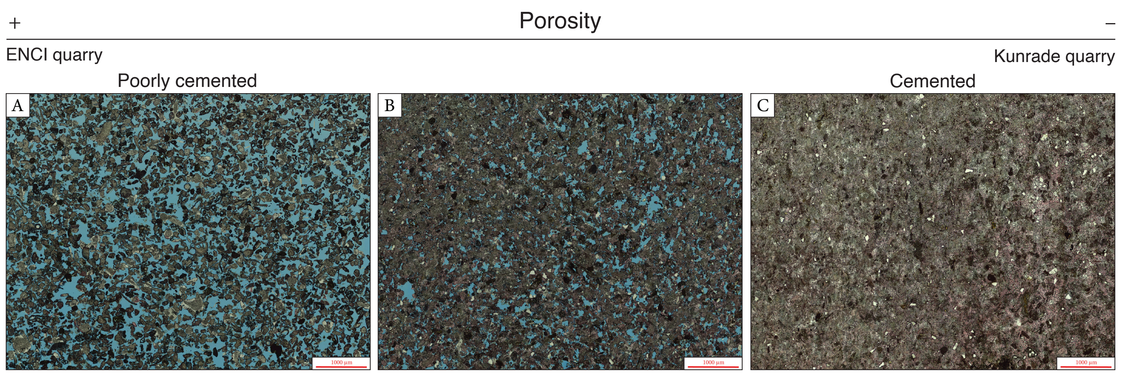
Dolkesberg: transition between the two ‘facies’?



The outcrop of Dolkesberg is considered to be the transition between the maastricht and kunrade ‘facies’ (Figure 8A). The microfacies analysis of a more prominent layer (Figure 8B) reveals that this type of layer is poorly cemented and corresponds to the fine-grained bioclast-dominated poorly cemented grainstones of the maastricht ‘facies’. As the kunrade ‘facies’ is not present, the outcrop of Dolkesberg cannot be considered the transition between the two facies.

Figure 8 | **A** The red line divides the outcrop into a lower and an upper part. The lower part is similar to the maastricht ‘facies’ in the ENCI quarry; the upper part is apparently similar to the kunrade ‘facies’ in the Kunrade quarry. **B** Fine-grained bioclast-dominated poorly cemented grainstone (stained with alizarin red-S and potassium ferricyanide; the blue epoxy represent porosity).

Figure 9 | Plane polarized light micrographs of representative microfacies of the Upper Cretaceous of South Limburg. The thin sections are stained with alizarin red-S and potassium ferricyanide. **A** Poorly cemented, high porosity maastricht ‘facies’ in the westernmost ENCI quarry. **B** Higher porosity kunrade ‘facies’ in the Kunrade quarry farther east in South Limburg. **C** Well-cemented kunrade ‘facies’ with very low porosity from Kunrade quarry. From A to C a decrease in porosity can be observed. The kunrade ‘facies’ alternates between higher porosity and little to no porosity layers on a decimetre scale.



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