A subsurface record of the Lower Jurassic of Flanders, Roer Valley Graben, Belgium

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Background

The Jurassic of Flanders, Belgium, lies buried in the subsurface in the **Kimmerian Basins**, which are basins that underwent subsidence during a protracted (Anisian–Ryazanian) interval of extensional tectonics related to the opening of the Atlantic Ocean. Posteriorly, it experienced tectonic inversion and erosion leading to a discontinuous Jurassic record.

The area of study is located in the **Roer Valley Graben** (RVG), a mid-Mesozoic asymmetric system. After the extensional pulse, a **marine transgression** occurred, establishing the **Laurasian epeiric Sea**, that connected the Boreal Sea to the North and the Tethys Ocean to the South. The transgressive regime persisted into the Early Jurassic.

This study

We studied the **Molenbeersel** borehole, in northeast Belgium, recovered 36 m of core of an approximately 500 m thick **Upper Triassic – Lower Jurassic** succession deposited in the RVG (Figure 1). The succession consists of dark argillaceous **mudstones** with red ironstones and carbonate concretions. Here, we present the **first facies characterization of the Lower Jurassic of Flanders**, as well as a set of data that includes total organic carbon (TOC) and sulfur. This study will enable an approximation of a reconstruction of the missing link between the Lower Jurassic outcrops of Great Britain and Germany.

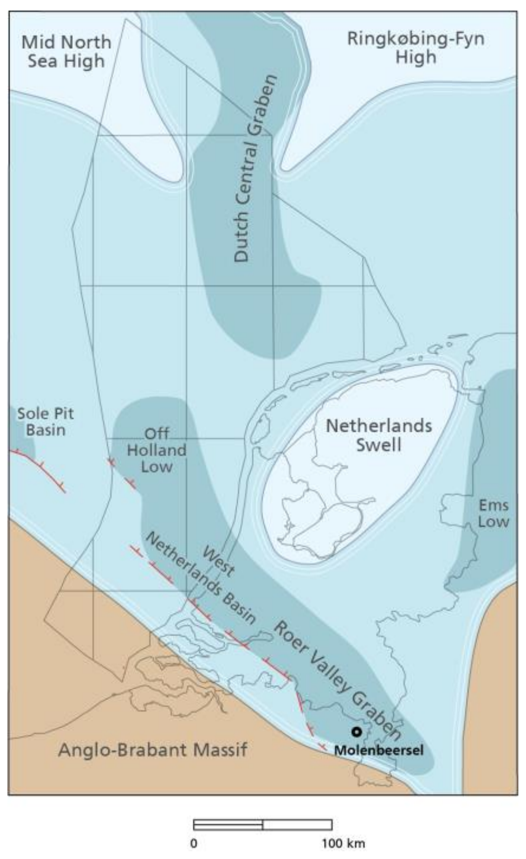

Figure 1 | Paleogeographic map of the Lower Jurassic of the area where the Molenbeersel borehole was drilled. The borehole is located in the Roer Valley Graben in Flanders, Belgium (source: João P. Trabucho Alexandre).

Take–home message

The Lower Jurassic of Flanders, Belgium, is characterized by mudstones with ironstones and carbonate concretions. Two formations have been identified: Aalburg Fm. (Hettangian to Pliensbachian) and Sleen Fm. (Rhaetian). They present different mineralogy, TOC, and sulfur trends. Six microfacies have been described according to grain size, bioclast content, lamination, and bedding planes.

Next Steps: With the results obtained I will attempt a paleoenvironmental reconstruction. These data will contribute to a better understanding of the link between the Lower Jurassic of Belgium and the outcrops of Great Britain and Germany.

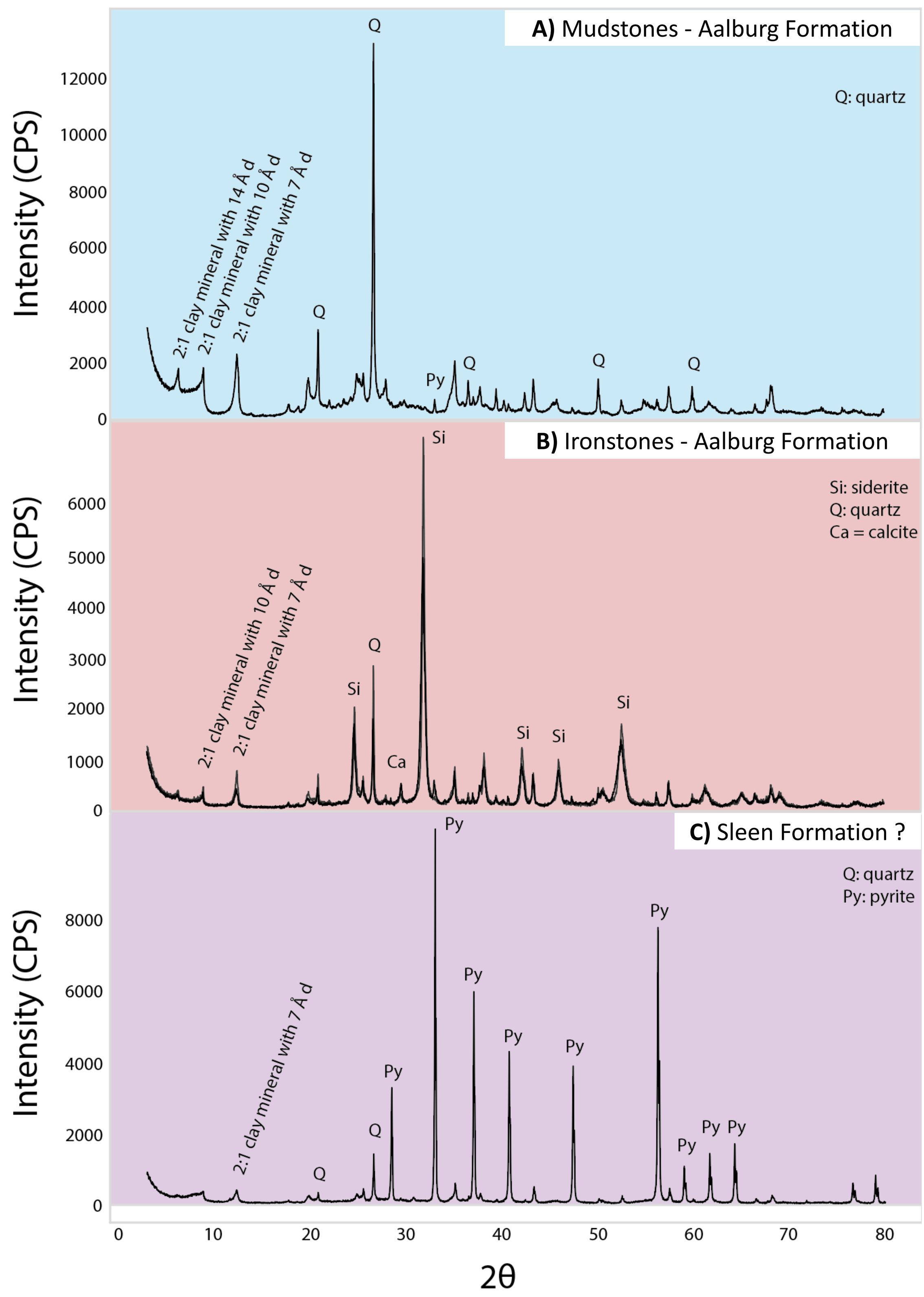

Figure 2 | XRD results of the Molenbeersel borehole. **A)** XRD data from the mudstones of the two uppermost intervals of the core, representing the Aalburg Formation. Three different families of clay minerals can be identified, along with quartz and pyrite. **B)** Ironstones of the Aalburg Formation. The dominant mineral is siderite, with minor quartz and clay mineral content. **C)** Lowermost interval, interpreted as the Sleen Formation, where pyrite is the dominant mineral. Quartz and clay minerals are present in minor percentages.

Results

For the Lower Jurassic of the Molembeersel borehole, **three lithofacies** and **six microfacies** have been characterized (Table 1). Based on the data shown in Figures 2, 3, 4, and 5, two formations can be recognized: the upper one is the **Aalburg Formation**, comprised between (1227.01 – 1313.9 mbsf; 1510.01 – 1511.82 mbsf), deposited during the Hettangian to Pliensbachian (Lower Jurassic). The lower one is the **Sleen Formation,** comprised between (1717.6 – 1720.37 mbsf), deposited during the Rhaetian (Upper Triassic).

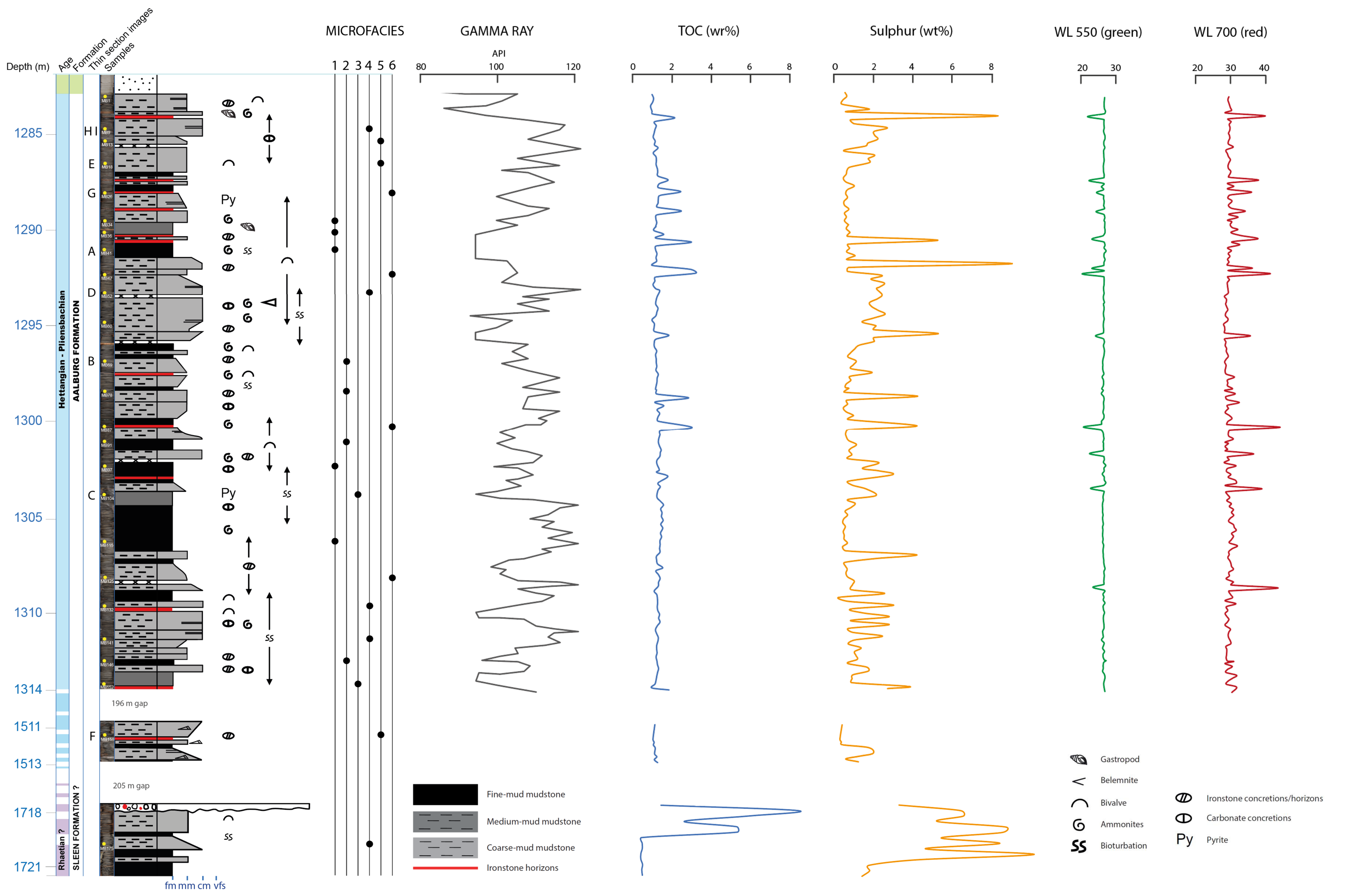

Figure 3 | Stratigraphic column of the Lower Jurassic of the Molenbeersel borehole. The deposits consist mainly of dark argillaceous mudstones (clay to silt grain size) with red ironstones. The TOC data presents lower values (~ 1.3 wr%) throughout the core with the exception of the ironstones, and the interval between 1717.6 – 1720.37 mbsf, where the TOC values can reach up to 8 wr%. The sulfur data presents a more heterogeneous pattern, with higher values in the ironstone concretions and an increase in the lowermost interval where the values start rising before the TOC increases. The color data throughout the Molenbeersel borehole is represented by the W550 (green) and WL700 (red), we observe an increase in the WL700 and a decrease in the WL550 in the ironstone horizons.

Microfacies

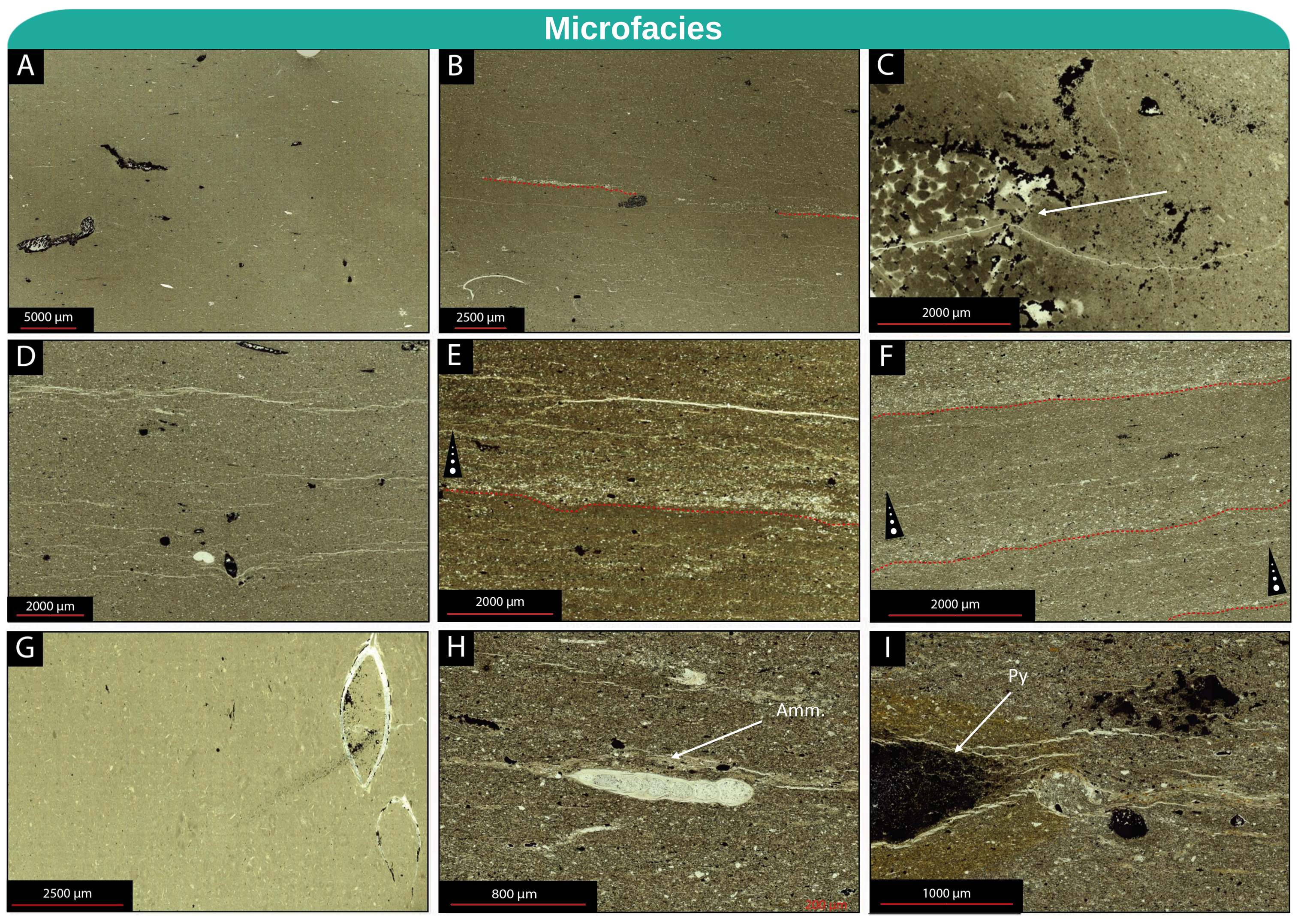

Figure 4 | Plane-polarized-light optical micrographs of the Lower Jurassic in the Molenbeersel borehole and microfacies characterization. **A)** Example of MF1 with poor lamination development in fine-mud mudstones. (MB41, 1291.15 mbsf) **B)** Example of MF2 with erosive bed surface with detrital quartz and bioclast silt-size grains (red dashed lines) and bioclasts. (MB69, 1296.75 mbsf) **C)** Example of MF3, showing a burrow with fecal pellet accumulation (white arrow). (MB102, 1303.94 mbsf): **D)** Example of MF4, coarser grain size compared to the prior microfacies can be observed with a discontinuous lamination. Pyrite is larger in aggregates and framboidal forms. (MB52, 1293.25 mbsf) **E)** Example of MF5 with a bed surface with an accumulation of quartz and bioclast detrital grains (red dashed lines). Normal grading can be observed (symbol). (MB18, 1286.55 mbsf) **F)** Example of MF5 where three bed planes can be observed (red dashed lines), the lower and central planes present a normal grading trend (symbol). The upper bed plane presents a change to coarser grain size. (MB158, 1511.50 mbsf) **G)** Example of MF6. Ironstone with a very fine grain size that contains articulated bivalve shells. (MB26, 1288.15 mbsf) **H)** Example of an ammonite bioclast (white arrow), framboidal pyrite, and quartz silt-size grains from MF4 (MB9, 1284.75 mbsf) **I)** Example of a pyrite aggregate (white arrow) where an orange oxidation discoloration can be, calcite veins are present. MF 4(MB9, 1284.75 mbsf).

LF	Microfacies
LF 1	MF1 - laminated fine-mud mudstone
	MF2 - Fine to medium-mud mudstone, with lamination and bed surfaces
LF 2	MF3 - Bioclastic fine-mud mudstone
LF 3	MF4 - Homogeneous and/or laminated, medium to coarse-mud mudstone
	MF5 - Medium to coarse-mud mudstone, with lamination and bedding surfaces
MF6 - Ironstones	

Table 1 | Lithofacies (LF) and microfacies (MF) of the Lower Jurassic of the Molenbeersel borehole.

Lithofacies

Figure 5 | Aalburg Formation in the Molenbeersel borehole. **A)** Example of the mudstones with ironstones in the upper part of the core. Sometimes the ironstones present septarian carbonate veins (white arrow). (1288.72 – 1293.94 mbsf) **B)** Contact between the Lower Jurassic and the Cretaceous deposits (white arrow) (1283.15 mbsf).

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