

## A Neogene succession in the city centre of Antwerp (Belgium): stratigraphy, palaeontology and geotechnics of the Rubenshuis temporary outcrop

### Supplementary data

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#### ABSTRACT

A temporary outcrop near the “Rubenshuis” in the centre of Antwerp (northern Belgium) facilitated the study of the Neogene glauconitic sand of the Berchem and Kattendijk formations, west and south of their respective stratotype sections. In contrast to the latter sections, the exposed Kiel Member of the Berchem Formation contains a relatively silty interval in its upper part, which is also reflected in Cone Penetration Tests. This silty interval is rich in molluscs, including the subspecies *Glossus lunulatus* cf. *lunulatus* and *Ennucula haesendoncki haesendoncki*, previously unknown from this member. Dinoflagellate cysts indicate that the main body of the Kiel Member was deposited during the middle Burdigalian, while only the upper part was deposited during the late Burdigalian. The Kiel Member is covered by the shell-rich, silty sand of the Langhian Antwerpen Member (Berchem Formation). Both members display soft-sediment deformation structures, probably caused by differences in silt content between and within these units. The Antwerpen Member is incised by the Lower Pliocene Kattendijk Formation, which reduced the thickness of the former to only 1.1 m, compared to 7 m in northeastern Antwerp. As a result, the basal gravel of the Kattendijk Formation contains many fossils reworked from the Antwerpen Member, in addition to autochthonous molluscs and *Ditrupea*. The Zanclean fauna resembles associations known from the highest part of the Kattendijk Formation in the former Oosterweel outcrop north of Antwerp, while it differs from the fauna of the lowermost Kattendijk Formation near Doel and Kallo. Hence, the palaeontological observations corroborate the regional depositional model of this unit, suggesting that only the youngest gully sequence of the Kattendijk Formation was deposited across the city of Antwerp.

#### KEYWORDS

Kiel Member,  
Antwerpen Member,  
Kattendijk Formation,  
molluscs,  
dinoflagellate cysts,  
Miocene,  
Pliocene,  
Cone Penetration Tests

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## 1. Samples in public repositories

The samples (>200 g) were coded in the field. Samples Ru 1–13 were taken on 6 July 2022. Samples Ru A–C on 16 August 2023, when the construction pit was excavated to its final depth. All layer numbers were harmonised with letters to maintain the uniformity of the paper (Table S1).

## 2. Full lithological and palaeontological description of the Rubenshuis outcrop

Field description of the observed layers, from bottom (-2.7 m TAW) to top (+7.3 m TAW):

**Layer A:** 100–110 cm of relatively pale grey, fine to medium-fine grained, very glauconitic sand with bioturbations. Some very rare, small, dispersed whitish sandstone patches occur.

**Layer B:** Ca. 5 cm of grey, fine to medium-fine grained, very glauconitic sand with a higher concentration of whitish sandstone patches (generally cross sections of lithified, subhorizontal *Ophiomorpha*) than in the surrounding sediment. Locally, the sand is enriched with coarser quartz grains, also containing some rounded pebbles, rare brown-grey phosphatic concretions, fish remains, some shark teeth and bone fragments. These concentrations are sometimes associated with small, slightly sloping lenses (<50 cm wide) with partially decalcified, very fragile shells, probably belonging to *Glycymeris obovata baldii*. All disarticulated valves are convex-up oriented, some are stacked.

**Layer C:** Ca. 70 cm of grey, fine to medium-fine grained, very glauconitic sand with a heterogeneous appearance. The sand is bioturbated (*Ophiomorpha* and *Macaronichnus segregatis*; Uchman, pers. comm., 2022). Some parts of the interval show an irregular distribution of more or less silty patches within the sand, laterally transitioning by a sharp

boundary into clean sands. Thin clay (mud) streaks can be present. Also in this interval, some whitish sandstone patches rarely occur with diameters of <3 cm.

**Layer D:** 20–30 cm of dark grey, fine to medium-fine grained, very glauconitic sand with a more silty admixture than the underlying sediment. This change is reflected in a duller colour of the sediment. Dispersed *Glycymeris* can be present in the upper 20 cm. The sand is bioturbated.

**Layer E:** 10–15 cm thick, continuous shell bed in a matrix of dark grey, fine to medium-fine grained, very glauconitic sand with a silty admixture. The molluscs are strongly dominated by *Glycymeris obovata baldii*, these are often articulated. Disarticulated valves also occur, predominantly stacked and convex-up. The sand within the articulated specimens is coarser than the sand between the shells, with less silt. In addition to *Glycymeris*, also *Cyrtodaria angusta*, *Glossus lunulatus* cf. *lunulatus* and the gastropod *Ptychidia eryna* are frequent. Barnacles are extremely common. The shell bed has a strongly undulating course due to load casting.

**Layer F:** 10–20 cm of dark grey, fine to medium-fine grained, very glauconitic sand with a slightly silty admixture and bioturbations.

**Layer G:** 40 cm of grey, fine to medium-fine grained, very glauconitic sand with few silt. Some small spots with higher concentrations of quartz were noted. The sand is bioturbated. In the upper 30 cm, some dispersed lithified burrows of *Ophiomorpha* occur, visible in cross-section as scattered small, round whitish patches.

**Layer H:** 15–20 cm of dark green to blackish, fine-grained, silty, very glauconitic sand with some rare, dispersed shells. The boundary with the underlying layer was often somewhat disturbed (irregular). In dry conditions, there is a distinct colour difference with the paler, underlying layer. In wet conditions, the boundary is poorly visible. This layer has experienced load casting along with the overlying shell bed.

**Layer I:** 10 cm thick, continuous shell bed within dark green to blackish, fine-grained, silty, very glauconitic sand. The shells are dominated by stacked valves of *Glycymeris obovata baldii*, mostly in convex-up orientation. Also articulated specimens are common. *Cordiopsis polytropa nysti* regularly occurs. The shell bed has an undulating course (max. amplitude 50 cm), almost parallel with the load casts of layer E.

**Layer J:** 40 cm of dark brown, fine-grained, silty, very glauconitic sand with some rare, dispersed shells.

**Layer K:** 5 cm thick uncrowded accumulation of more fine shells, including fragile pectinids of *Korobkovia woodi*, *Aspalima decussata* and the gastropod *Ptychidia eryna*. Also larger bivalves occur, such as *Glossus lunulatus lunulatus* and *Glycymeris obovata baldii*. Most bivalves are disarticulated with a convex-up orientation, but convex-down also occurs. Besides, also articulated specimens are present. The matrix of the shells consists of dark brown, fine-grained, silty, very glauconitic sand. Some dispersed, dark phosphatic concretions are present with an irregular surface (up to 3 cm).

**Layer L:** 5–10 cm of dark brown, fine-grained, silty, very glauconitic sand with some rare dispersed shells, including a specimen of *Panopea kazakovae* in life position.

**Layer M:** 5 cm thick accumulation of shells, almost identical to layer K. The shell concentration is still markedly lower compared to layer I, sometimes too low to trace layers K–M as separate layers across the temporary exposure. A large coral of *Flabellum tuberculatum* was found within the interval of layers L–M.

**Layer N:** 30 cm of dark brown, fine-grained, silty, very

**Table S1.** Samples per layer, available in the Geotheek of the Flemish department of the Environment (VPO) and the Geological Survey of Belgium (BGD).

Layer (description)	Sample code on bags (repositories)	Dinocyst samples
Layer A	Ru A	/
Layer B	Ru B	Ru-B
Layer C	Ru C	/
Layer D	Ru 1	/
Layer E	Ru 2	Ru-E
Layer F	Ru 3	/
Layer G	Ru 4	Ru-G
Layer H	Ru 5	/
Layer I	Ru 6	Ru-I
Layer J	Ru 7	/
Layer K	Ru 8	Ru-K
Layer L	Ru 9	/
Layer M	Ru 10	/
Layer N	Ru 11	/
Layer O	Ru 12	/
Layer P	Ru 13	Ru-P

glaucinitic sand with some rare dispersed shells, including some *Panopea kazakovae* in life position.

**Layer O:** 10–15 cm thick, dense bed with rather randomly oriented shells, phosphatic concretions, rounded pebbles, driftwood, shark teeth and cetacean bones in a matrix of fine-grained, grey to ochre-coloured, slightly glauconitic sand. Some rusty patches are observed. The mollusc fauna is diverse, including *Glycymeris obovata baldii*, *Pygocardia rustica tumida* (forma *solida*), *Laevastarte omalii*. Most valves are disarticulated, but articulated specimens also occur. Other invertebrates include frequent tubes of *Ditrupa*

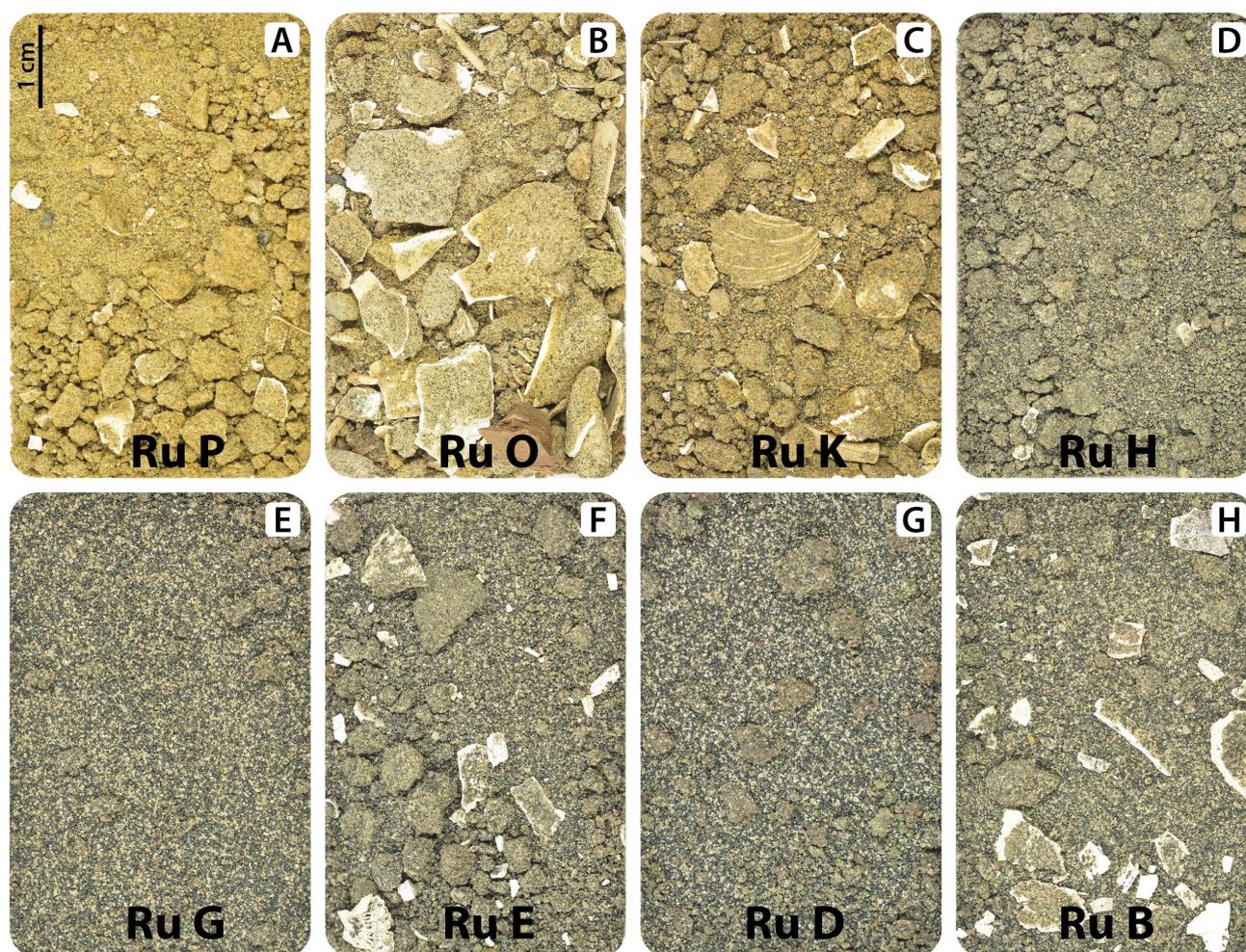
and some spines of sea urchins.

**Layer P:** 190 cm of light ochre-coloured, fine-grained, slightly glauconitic, homogeneous sand with dispersed shells, frequently including *Scalaricardita scalaris* and *Astarte corbuloides*.

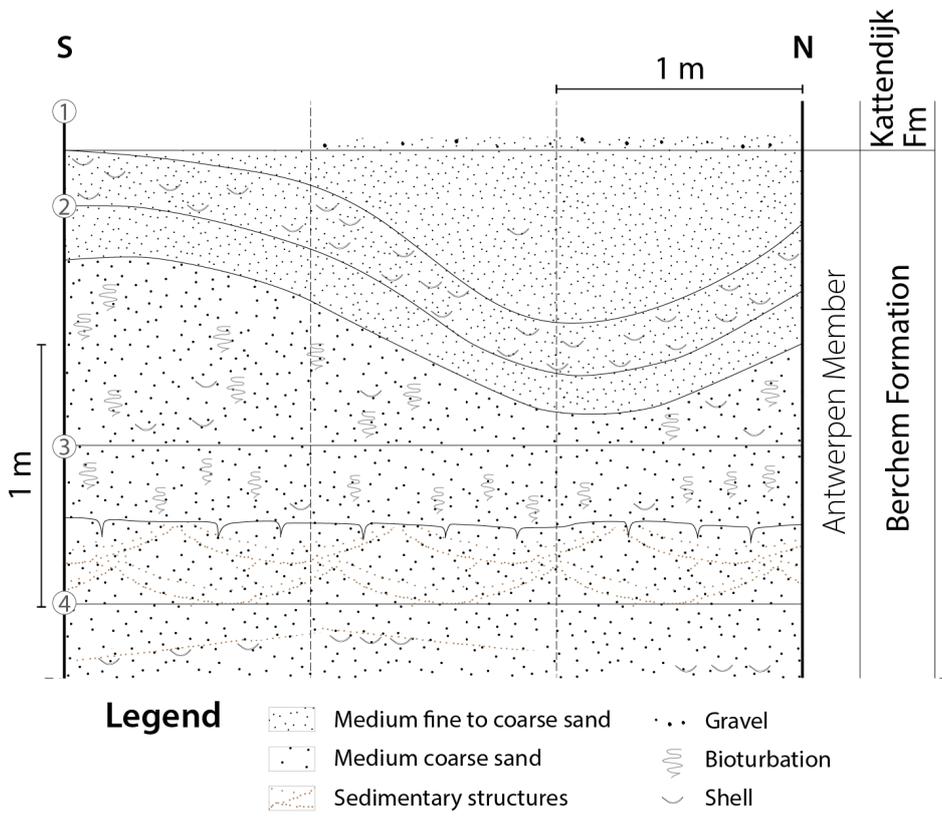
**Layer Q:** 15 cm thick horizon with a dense accumulation of shells. This part of the temporary exposure could not be studied, as the walls were already cemented.

**Layer R:** Ca. 350 to 400 cm of disturbed quaternary and anthropogenic sediment and filling up.

### 3. Additional figures



**Figure S1.** Sediment samples from the Rubenshuis section. **A.** Kattendijk Formation (Layer P). **B.** Basal gravel of the Kattendijk Formation (Layer O). **C.** Discoloured sediment of the Antwerpen Member (Berchem Formation) with shells (Layer K). **D.** Base of the Antwerpen Member (Berchem Formation) (Layer H). **E.** Top of the Kiel Member (Berchem Formation) (Layer G). **F.** Upper shell bed within the silty interval of the Kiel Member (Berchem Formation) (Layer E). **G.** Sediment just below the upper shell bed of the Kiel Member (Berchem Formation) (Layer D). **H.** Small lens with partially decalcified *Glycymeris*, shark teeth, pebbles and concretions in the Kiel Member (Berchem Formation) (Layer B). See lithological description in the Supplementary data for an estimate of the grain sizes.



**Figure S2.** Simple load casts within the higher parts of the Antwerpen Member (base of the litholog ca. 1 m above the central “*Glycymeris crag*”), exposed during the excavation of the motorway access ramp in Borgerhout on September 23rd, 1987. The undulating sediments were described as “*zwak slibhoudend*” (weakly silty). Section measured and drawn by Arie W. Janssen (NBC archive, Leiden).