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Observations on the Pliocene sediments exposed at Antwerp International Airport (northern Belgium) constrain the stratigraphic position of the Broechem fauna

Supplementary material

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ABSTRACT. Detailed observations at a large temporary outcrop south of Antwerp International Airport (northern Belgium) reveal the complexity of a thin interval of fossil-rich Pliocene sediments found on top of the upper Miocene Diest Formation. Based on the lithological characteristics and mollusc faunas, several units were tentatively attributed to the Kattendijk Formation and the Luchtbal and Oorderen Members of the Lillo Formation. Concretions containing characteristic preserved molluscs dominated by large paired bivalves and that are informally known as the Broechem nodules were observed in situ between the Kattendijk Formation and Lillo Formation, and in reworked position in the base of the latter, indicating a late Early Pliocene age. The role of extensive reworking in the formation of Pliocene units is shown and implications for stratigraphic framework of Pliocene deposits from northern Belgium are discussed.

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Characterisation of samples

Sample BB01 (Fig. 3a) – Grey to grey-reddish quartz sand with dark green-black rounded glauconite grains, fine gravel and shell fragments covered in iron oxide dirt. Gravel composed of phosporite, quartz and some lithoclasts. Shells and shell fragments common but strongly decalcified (softened). Some shells contain phosphatised infill. The sample consists of a single fauna in terms of species composition and preservation. Severe dissolution complicates assessment of taphonomic properties such as wear. Most material has intermediate to very strong bioerosion (microboreholes). Common species are *Laevastarte omalii*, *L. basteroti* s.l., *L. ovatacostata*, *Laevastarte bipartita* forma *acuminata*, *Digitariopsis obliquata*, *A. incerta* and *Turritella* cf. *incrassata*. Other species are *Yoldia semistriata*, *Ostrea edulis*, *Palliolum gerardi*, *Digitaria digitaria*, *Cyclocardia scalaris*, *Spisula* cf. *triangulata*, *Arctica islandica*, *Pygocardia rustica* forma *tumida*, *Mya* sp., *Varicorbula gibba*, *Callista chione*, *Turritella* cf. *vanderfeeni*, *Neptunea angulata*, *Euroscaphella* sp. and also worn shark teeth are present.

Sample BB02 (Fig. 3b-c) – Sandstone nodules collected from the outcrop floor deriving from Unit 3. The brown to dark red-grey nodules are typically 6–12 cm in diameter, have a rounded to ovate outline and when broken open almost all contain single or pairs of large species. The sediment consists of strongly indurated, well-sorted fine-grained quartz arenite with very little fine grained rusty-coloured matrix. No sedimentary structures or small faunal elements are present. Shells are decalcified to various degree, sometimes only reddish imprints remain, others retain parts of the original aragonite shell. Remarkable is the almost sole occurrence of large shelled species, mostly bivalves, and absence of shell grit. Part of the species is found paired, indicative of in situ preservation. The imprints of the outer shells in the nodules typically show very fine surface structures also in line with in situ preservation. Dominant species (as collected and observed during the site visits also from other collectors): *Acanthocardia* aff. *aculeata*, Cardiidae indet. (sensu Wesselingh in van Bakel et al., 2003), *Arctica islandica*, *Cyrtodaria angusta*, *Callista chione*.

Sample BB03 (Fig. 3d) – Admixture of abundant yellowish shell fragments and some shells dominated by *Palliolum gerardi*, coarse-grained sand dominated by quartz and including strongly worn glauconite, and some fine gravel (largest diameter 8 mm) containing quartz, flint and phosporite. Two fauna types with differential composition and preservation occur.

Type 1 fauna (dominant fraction) – Yellow to yellow-grey fragments and some shells. Calcitic species dominate (*Palliolum gerardi*, *Aequipecten opercularis*, Pectinidae spp., *Ostrea edulis*). Aragonitic species do also occur, mostly of larger species that have relatively thicker shells. Shells and shell fragments are observed to be strongly softened due to decalcification. Abrasion levels are variable but in general edges and umbones are clearly worn. Bioerosion levels (with predominant microboreholes) are high to very high. This type 1 fauna is dominated by *Palliolum gerardi* and *Aequipecten opercularis*. Other

less common species include *Aequipecten wagenaari*, *Pecten* cf. *grandis*, *Ostrea edulis*, *Laevastarte* sp., *Astarte incerta*, *Digitariopsis obliquata*, *Pygocardia rustica* forma *tumida*, *Arctica islandica* and *Turritella* cf. *incrassata*.

Type 2 fauna (rare fraction making up at most a few % of the sample) – Grey to grey-white, variably preserved mostly aragonitic species. Wear variable, from absent to intermediate high but in general low to intermediate. No incompatible ecological or stratigraphic species. Bioerosion levels are variable from absent to high and consist mostly of microboreholes. Dissolution levels are low and shells are firm (not softened). Wear is very variable: in various shells fine surface details are preserved, but also some intermediate strongly worn fragments occur. This type 2 fauna is diverse and common species are *Ennucula laevigata*, *Yoldia semistriata* (including a umbonal fragment of a paired specimen), *Cyclocardia scalaris*, *Goodallia triangularis*, *Astarte incerta*, *Spisula* cf. *triangulata*, *Varicorbula gibba*, *Timoclea ovata* and *Turritella incrassata*. Rare species are *Laevastarte* cf. *ovatocostata*, *L. basteroti*, *Digitaria forbesi*, *Scacchia oblonga*, *Pygocardia rustica* forma *tumida*, *Lentidium complanatum*, *Tornus belgicus*, ?*Cingula inusitata* and a fragment of a sinistral coiled species that we attribute with some hesitation to *Limacina atlanta*.

Sample BB04 – Admixture of grey to light brown strongly worn shell fragments in quartz/lithoclast sand with common gravel (mostly flint, small quartz and few phosphorite and lithoclasts). One limonitised burrow with shell fragments (diameter 70 mm). Two fauna types with differential composition and preservation occur.

Type 1 fauna (dominant fraction, c. 99%) – Very strong to worn grey to light brown shell fragments and some shells. Bioerosion levels variable, shells often worn out by amongst others, *Entobia*, microboreholes and naticid predation. Dissolution levels low but variable, some material softened by decalcification. Presence of stratigraphic strongly incompatible (Eocene and Pliocene) species indicates reworking and mixing. Common are *Palliolum gerardi*, *Aequipecten opercularis*, *Talochlamys harmeri*, *Heteranomia squamula*, *Varicorbula gibba*, *Turritella incrassata*, barnacles, abraded shark and fish teeth. Several specimens of strongly worn Eocene *Nummulites* and *Haustator solanderi* were observed.

Type 2 fauna (rare fraction, c. 1%) – Slightly worn to well-preserved light grey to light brown-grey shells. Low levels of bioerosion (micro boreholes). Wear absent or low level, often apparent wear next to sharp edges suggesting pseudowear due to dissolution. Dissolution levels low but with some variation. No ecological or stratigraphic incompatible species. Common are *Heteranomia squamula*, *Astarte incerta*, *Digitaria digitaria*, *Hemilepton nitidum*, *Spisula* cf. *triangulata* and *Gastrana laminosa*. Also *Cerithiopsis* cf. *subulata*, *Tornus belgicus* and *Pyramidella laeviuscula* were found.

Sample BB05 (Fig. 3d) – Admixture of reddish-grey strongly worn shell fragments and common gravel and very small component of reasonably well-preserved shells with fine surface details, but some corrosion. The sand fraction is dominated by quartz and contains lithoclasts. Gravel consists of flint, small quartz and phosphorite (largest diameter 17 mm). Two fauna types with differential composition and preservation occur.

Type 1 fauna (dominant fraction, c. 99%) – Very strong to strongly worn reddish-grey shell fragments and rare shells. Bioerosion levels variable, but often very high (*Entobia*, micro boreholes). Wear strong to very strong. Dissolution levels low but variable, some grain imprinting, some material softened. Common species are *Palliolum tigerinum*, *P. gerardi*, *Aequipecten opercularis*, *Laevastarte* sp., *Astarte incerta*, *Varicorbula gibba*, *Turritella incrassata*, barnacles, shark and fish teeth.

Type 2 fauna (rare fraction, c. 1%) – Slightly worn reddish-grey shells lacking or with very low bioerosion levels (micro boreholes). Common preservation of fine surface details, even though some apparent wear occurs next to sharp edges suggesting pseudowear due to dissolution. Dissolution levels low but variable (some softening). No ecological or stratigraphic incompatible species. Common are *Heteranomia squamula*, *Hemilepton nitidum*, *Venerupis* cf. *senegalensis*, *Turritella incrassata*, *Amyclina labiosa*, *Odostomia conoidea*. Furthermore one fragment of *Mya arenaria lata* was found and *Goodallia triangularis*, *Astarte incerta*, *Tornus belgicus* and *Epitonium clathratulum minutum* were found.

Sample BB06 – Admixture of coarse-grained quartz arenite, including worn glauconite grains, gravel dominated by phosphoritic sandstone pebbles and some flint/lithoclasts and grey strongly worn shell fragments and shells. Also variably preserved but mostly worn to strongly worn fish- (including shark) teeth. Two mollusc fauna types with differential composition and preservation occur.

Type 1 fauna (dominant fraction, c. 99%) – Very strong to somewhat worn shell fragments and shells, grey-coloured with some tendency to grey-yellow in few very strongly worn *Palliolum gerardi* fragments. Bioerosion levels variable, often high (mostly micro boreholes). Dissolution levels variable, some material softened to strongly softened. Type 1 fauna is dominated by (fragments of) *Aequipecten opercularis*, *Palliolum gerardi*, *Ostrea edulis*, *Laevastarte* sp., *Varicorbula gibba*, *Turritella incrassata*. A single strongly worn nummulite has been found. This fauna is interpreted as a strongly reworked assemblage.

Type 2 fauna (rare fraction, c. 1%) – Slightly worn to very well preserved shells but with softening occurring. Dominant colour grey-white, some faint colour banding on *Astarte*. Some bioerosion (micro boreholes). Wear is absent or at very low levels. Dissolution levels low but some variation (some softening). No ecological or stratigraphic incompatible species. Common species are juvenile *Astarte* spp., *Hemilepton nitidum*, and juvenile *Spisula* cf. *triangulata*. Also occurring are *Digitaria digitaria*, *D. forbesi*, *Goodallia triangularis*, *Gastrana laminosa*, *Turritella incrassata* and ?*Cingula inusitata*.