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CORRELATION OF THE 83W421 KORTRIJK (SINT-ANTONIUS) AND 83W44 KORTRIJK (LUST) BOREHOLES WITH ACRITARCHS (LATE AERONIAN-EARLY TELYCHIAN, SILURIAN, BELGIUM)

Bastien WAUTHOZ

(5 figures, 1 plate)

Université de Liège, Paléontologie, Bat. B18, Sart-tilman, B-4000 Liège 1, Belgique, E-mail: acritarche@yahoo.fr.

ABSTRACT. 25 samples from the 83W421 Kortrijk (Sint-Antonius) and 83W44 Kortrijk (Lust) boreholes are investigated. Acritarchs provide a more reliable and precise correlation of these two boreholes than graptolites and chitinozoans because of large barren and/or not indicative intervals. Based on this correlation, two subzones of the *Dactylmofusa estillis* Biozone are proposed around the Aeronian-Telychian boundary (Llandovery, Silurian). The two subzones are also found in sections from the Midlands platform and Welsh Basin and thus provides a tool to correlate shallower and deeper facies, at least on a regional scale.

KEYWORDS. Acritarchs, Belgium, biostratigraphy, Llandovery, Silurian

RESUME. Corrélation des sondages 83W421 Courtrai (Saint-Antoine) et 83W44 Courtrai (Lust) par les acritarches (Aéronien supérieur-Télychien inférieur, Silurien, Belgique). Les acritarches sont étudiés dans 25 échantillons provenant des sondages 83W421 Courtrai (Saint-Antoine) et 83W44 Courtrai (Lust). Ils permettent une corrélation de ces deux sondages plus précise et plus fiable que ne le permettent les graptolites ou les chitinozoanires. Sur base de cette corrélation, une biozonation affinée des acritarches est proposée pour l'Aéronien supérieur et le Télychien inférieur. Cette biozonation est également trouvée dans des sections de la plateforme des Midlands et du bassin du Pays de Galles. Dès lors, les acritarches peuvent être utilisés pour corréler les faciès de faible et de grande profondeurs, au moins à l'échelle régionale.

MOTS-CLEFS. Acritarches, Belgique, biostratigraphie, Llandoverien, Silurien

1. Introduction

The 83W421 Kortrijk (Sint-Antonius) and the 83W44 Kortrijk (Lust) boreholes were drilled in subsurface Silurian deposits of Belgium. They record Llandovery (Silurian) mudstone deposition with interbedded thin to thick sandstones on the southwestern Brabant Shelf (as defined by Verniers, *et al.*, 2002). These deposits may be interpreted as mass-wasting ones, perhaps due to turbidity currents as envisaged by Van Grootel (1990).

Since the boreholes are very close (586 m, see Fig. 1), it would be expected that they can be correlated on a lithological basis. This is not the case, because Legrand (1962, 1981) does not give sufficiently detailed lithological descriptions of the boreholes, neither does he indicate the presence of marker beds. Moreover, since the whole cores are not stored in the Geological Survey of Belgium core library, but only fragments, such a study can no longer be conducted.

Thus, it appears that only biostratigraphical tools can provide a correlation. The recent revision of the stratigraphic distributions of graptolites and chitinozoans in these boreholes (Van Grootel *et al.*, 1998) shows that none of these two fossil groups can accurately correlate them.

This is why we investigate here the stratigraphic distribution of acritarchs in 25 samples in order to find an accurate correlation of the boreholes.

2. Geological context

In the Brabant Massif, Silurian depositional settings can be divided into two different areas separated by the Ronse-Veurne line (Verniers *et al.*, 2002). The southwestern Brabant Shelf is located south-west to this line while the central and

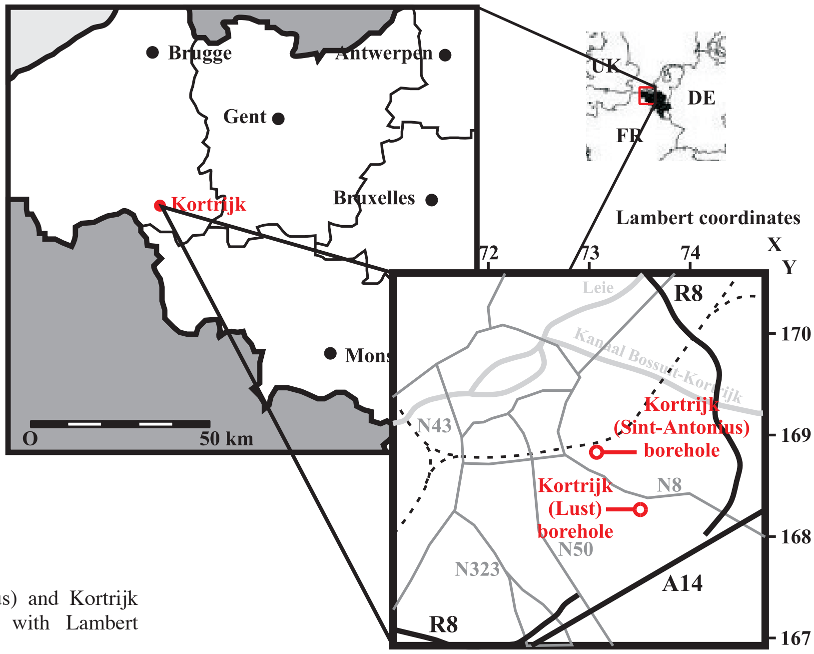

Figure 1. Localisation of the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes. The Kortrijk map is displayed with Lambert coordinates.

northern Brabant Basin lies north to it. Due to the lack of surface exposure, the shape of the shelf, basin and turbidite system are still largely unknown (Verniers & Van Grootel, 1991). For example, Rhuddanian, Aeronian and lower Telychian strata are present in several boreholes in southern Flanders, but they are not observed elsewhere in the Brabant Massif (Verniers & Van Grootel, 1991). However, contemporaneous Silurian deposits are most probably present very near the surface south to Lessines as indicated by Vanguestaine & Wauthoz (2004).

Strata from the Kortrijk (Sint-Antonius) boreholes belong to the Deerlijk Formation. In the Kortrijk (Lust) borehole, strata from -191.00 m to -255.50 m belong to the Deerlijk Formation while overlying strata belong to the Lust Formation, of which the stratotype is defined in the Kortrijk (Lust) borehole between depths of -150 m to -191 m (Verniers *et al.*, 2001).

2.1. The Kortrijk (Sint-Antonius) borehole

The Kortrijk (Sint-Antonius) borehole was drilled in 1971. Cores, 63 mm in diameter, were extracted from -200.00 m to -303.00 m. This borehole is situated 586 m northwest of the 83W44 Kortrijk (Lust) borehole (Legrand, 1981). The eight studied samples were collected in the interval ranging from -244.10 m to -200.00 m. The lithological description of this borehole can be found in Legrand (1981) who divides it into eight units labelled with letters (a to h).

2.2. The Kortrijk (Lust) borehole

The Kortrijk (Lust) borehole was drilled in April 1961 (Legrand, 1962). Cores, 135 mm in diameter, were extracted from -148.30 m to -225.50 m. The 17 collected samples cover the whole interval. The strata display a gentle dip from 6° to 15° with a mean of 9.6° and a mode of 10°. The upper part displays a more gentle dip than the lower part. No folding or slaty cleavage is observed in the borehole. The lithological description of this borehole can be found in Legrand (1962).

3. History of biostratigraphical research

Three fossil groups were previously studied in the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes. Graptolites were studied by Legrand (1962, 1981) and Van Grootel *et al.* (1998). Chitinozoans were studied by Van Grootel (1990) and Van Grootel *et al.*, (1998). Acritarchs were studied by Martin (1966, 1969a), Stockmans & Willière (1963), Wauthoz (1997) and P. Steemans in an unpublished report to the Geological Survey of Belgium. A summary of the results of the latter author can be found in Vanguestaine *et al.* (1989).

3.1. Graptolites

Legrand (1962) studied graptolites in the Kortrijk (Lust) borehole. He recognised the *sedgwickii* and *turriculatus* Biozones of Elles & Wood (1913). He indicated that the *sedgwickii* Biozone ranges from -203.50 m to -198.80 m and the *turriculatus* Biozone ranges from -190.80 m to -159.00 m (see Fig. 2).

Legrand (1981) studied graptolites in the Kortrijk (Sint-Antonius) borehole. He recognised the *gregarius*, *convolutus*, *sedgwickii* and possibly the *turriculatus* Biozones of Elles & Wood (1913). In the interval of interest here, he indicated that the *sedgwickii* Biozone ranges from -251.50 m to -205.00 m and the ?*turriculatus* Biozone ranges from -205.00 m to -200.00 m (see Fig. 2).

Graptolites were revised in several boreholes of the Brabant Massif by Zalasiewicz (in Van Grootel *et al.*, 1998), including the two boreholes of interest here. They use the graptolite biozonation scheme of Loydell (1992, 1993).

In the Kortrijk (Lust) borehole, graptolites indicate

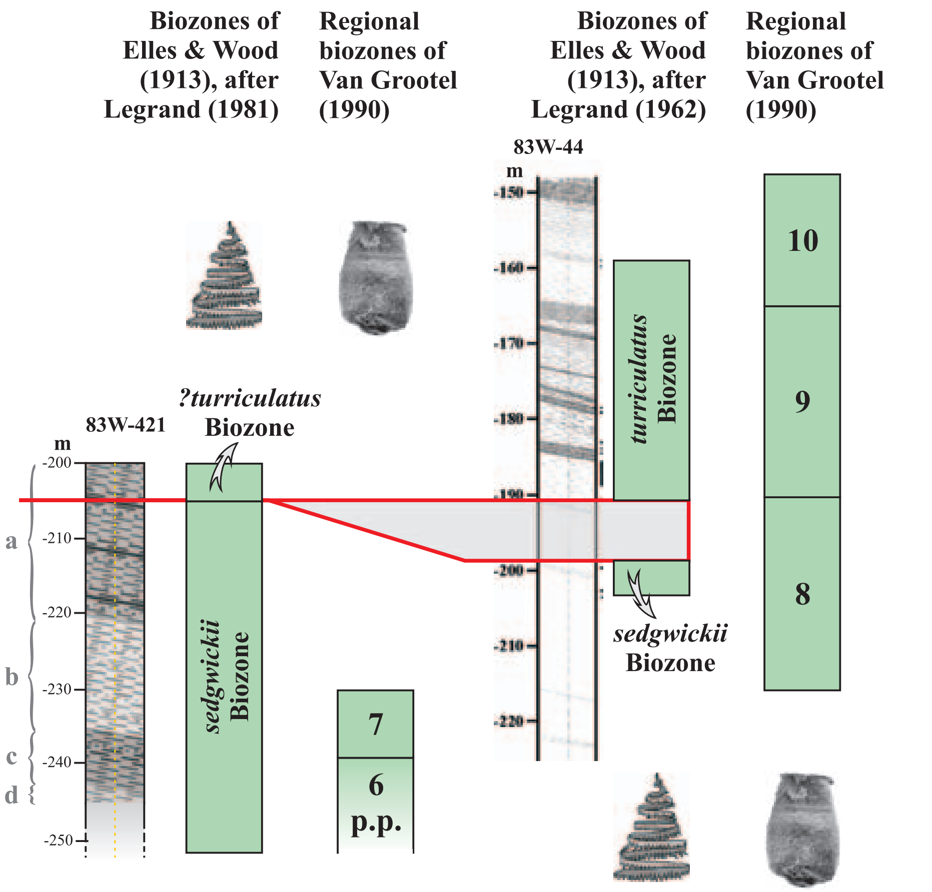

Figure 2. Correlation of the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes proposed by Van Grootel (1990) on the basis of the graptolite biozonation (Legrand, 1962, 1981) and regional chitinozoan biozonation of Van Grootel (1990). The letters a-d indicate the lithological divisions of Legrand (1981).

an early *turriculatus s.l.* Biozone, i.e. a *guerichi* Biozone (Van Grootel *et al*., 1998). The lower part (from -203.50 m to -190.00 m) is considered as the *gemmatus* Subzone while the upper part from -190.00 m upwards probably belongs to the *renaudi* Subzone. An impoverished assemblage at -160.00 m indicates a probable *utilis* Subzone, but with little evidence (see Fig. 2).

In the Kortrijk (Sint-Antonius) borehole, graptolites can be well-preserved, provided they do not have too delicate features, and they probably include the earliest known septograptids (Van Grootel *et al*., 1998). Graptolites from -300.00 m to -252.70 m indicate the *gregarius* graptolite Biozone and some subzones can be identified. From -252.70 m to -250.00 m the *sedgwickii* Biozone is recognised. The *turriculatus s.l*., probably *guerichi* Biozone is recognised from -220.00 m to -200.00 m.

3.2. Chitinozoans

Chitinozoans were extensively studied in Silurian rock-bearing boreholes by Van Grootel (1990). He recognised 10 local biozones of which several were defined in the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes (see Fig. 2). This biozonation scheme was never formally published though it is shortly cited and illustrated in Verniers & Van Grootel (1991, p. 171 and Fig. 4). In order to build this scheme, Van Grootel (1990) correlated the two boreholes at the base of the *turriculatus* Biozone defined by Legrand (1962, 1981).

The chitinozoan biozones recognised by Van Grootel *et al*. (1998) refer to the global chitinozoan biozonation for the Silurian (Verniers *et al*., 1995). In the Kortrijk (Lust) borehole, chitinozoans indicate that *Eisenackitina dolioliformis* is present, although quite rare, from -215.50 m to -148.30 m (Van Grootel *et al*., 1998). The dominance of *Conochitina candoris* from -215.50 m to -190.50 m indicates a low position in the *dolioliformis* Biozone (see Fig. 2). From -163.00 m to -148.30 m, chitinozoans are not indicative.

In the Kortrijk (Sint-Antonius) borehole, chitinozoans indicate that the *maenlii* Biozone starts at -296.10 m (Van Grootel *et al*., 1998). The base of the *alargada* Biozone is situated at -285.25 m. The *dolioliformis* Biozone is present from -240.10 m upwards (see Fig. 3). The chitinozoans are inconclusive from -253.10 to -240.10 m with no determinable specimen (Van Grootel, 1990). This interval corresponds to his biozone 6, an interval zone which does not show any proper characteristic features, except the lack of identifiable chitinozoans and the low chitinozoan yield (Van Grootel, 1990).

3.3. Acritarchs

Stockmans & Willière (1963) described the first Silurian acritarchs from Belgium in level -188.50 m from the Kortrijk (Lust) borehole. This pioneering work principally focused on specimens belonging to the genera *Micrhystridium*, *Multiplicisphaeridium* and *Veryhachium*. The recent revision of this work by Mullins (2002) gives better descriptions and illustrations of the type specimens of Stockmans & Willière (1963). These two studies do not discuss the biostratigraphy and are not of much interest here.

The classical work on Ordovician and Silurian acritarchs by Martin (1966, 1967, 1969a) was the first to provide stratigraphical information on these fossils for Belgium. In addition to the descriptions of acritarch species, including data on their variability whenever possible, Martin (1969b) gives a complete table with the relative proportion of every species (Figs XXXV to XXXIX) and genera (Fig. XXXIV) in the studied samples. These tables give the stratigraphic range of each species (or genera) through the Ordovician and Silurian of Belgium, with the relative stratigraphical position of samples based on graptolites and lithostratigraphy. She already recognised the stratigraphic potential of *Domasia* species and other Silurian acritarchs

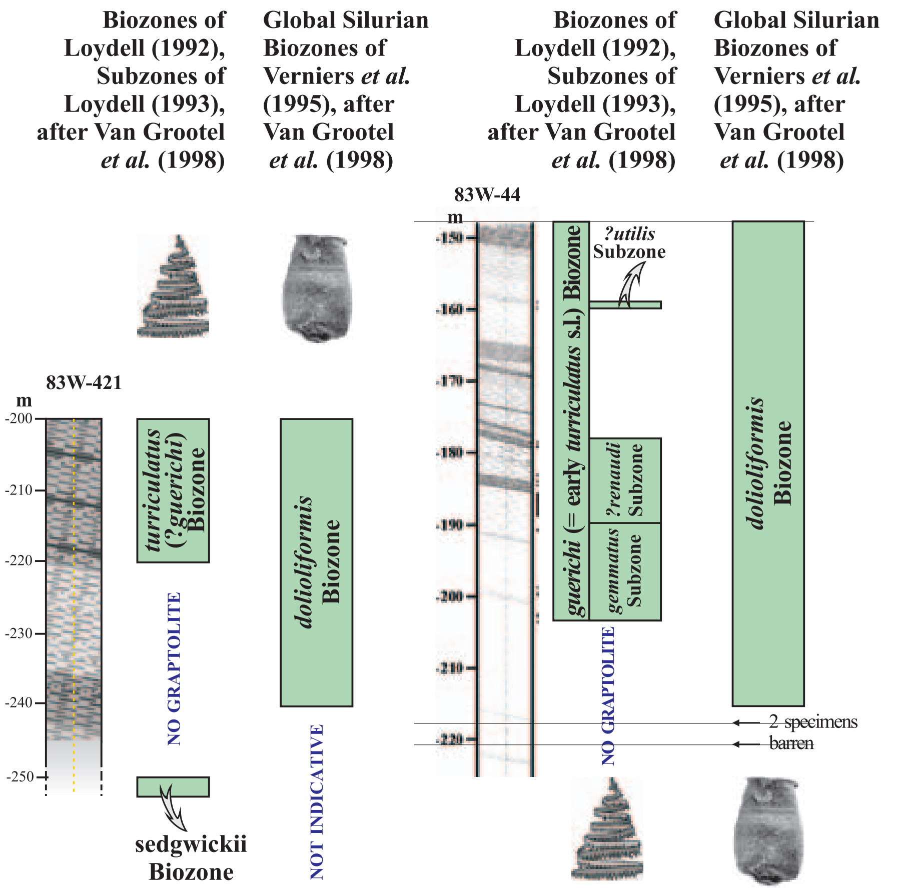

Figure 3. Graptolite and chitinozoan biozonations of the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes based on Van Grootel *et al.* (1998).

although she did not present any formal biozonation scheme.

In the Kortrijk (Sint-Antonius) borehole, acritarchs were first studied by P. Steemans in an unpublished report to the Geological Survey of Belgium later published in Vanguestaine *et al*. (1989). His results were presented at the international meeting on the Caledonides of the Midlands and the Brabant Massif Vanguestaine *et al*. (1989). Moreover, the collected data were used to draw the subcrop geological map of the Brabant Massif (De Vos *et al.,* 1993).

Wauthoz (1997) largely confirmed and expanded Steeman's taxonomic list and allowed the dating of the acritarch assemblage as the upper Aeronian-lower Telychian (corresponding to levels with the *sedgwickii* to *turriculatus s.l.* graptolite biozones), principally on the presence of *Beromia rexroadii* (Pl. 1B), *Dactylofusa estillis* (Pl. 1C) and *Dilatisphaera williereae* (Pl. 1I). He also showed the scarcity of information given by acritarchs below -244.10 m due to bad preservation of the particulate organic matter.

4. Methodology

Eight samples from the Kortrijk (Sint-Antonius) and seventeen samples from the Kortrijk (Lust) borehole were investigated for acritarchs (see Fig. 4 for the position of samples). Palynomorphs were extracted in the Liège palynology laboratory following the method described in Streel (1965). We investigated one slide per sample or rarely two slides when samples were less productive. The slides were investigated using a Zeiss Axiolab microscope with Achroplan lenses (50x and 100x, for a total magnification of 500X and 1000x). Each slide was surveyed twice to ensure the taxonomic comparability and reliability of results.

5. Results

All the 25 samples are productive and display moderately to well preserved acritarchs, although reflected light is needed to study specimens with a thicker vesicle wall. 122 previously defined species of acritarchs and 61 informal species (or lower taxonomic level) of acritarchs, of which 50 can be spotted many times, were recognised. The samples display a moderate to quite high diversity. 36 to 56 species are recognised during a 250 specimen survey in a given slide and the total diversity of a slide ranges from 54 to 76. This is comparable to the figures given for the Llandovery of England (Downie, 1984) and it is representative of the early Silurian high acritarch diversity (Strother, 1996). Only one sample (level -225.50 in the Kortrijk (Lust) borehole) displays a lower diversity with 24 species recorded during a 250 specimen survey and a total diversity of 27 species. This sample is dominated by ?*Helosphaeridium echiniforme* (22.8%, see Pl.1E) and leiospheres (35.6%). This assemblage is interpreted as a bloom assemblage (Wauthoz, 2003) since ?*H. echiniforme* has a mean proportion of 1,5% and a modal proportion of 0,8% in the 24 other samples.

Ammonidium microcladum (Pl. 1A), *Beromia rexroadii* (Pl. 1B), *Dactylofusa estillis* (Pl. 1C), *Dilatisphaera williereae* (Pl. 1I), *Domasia limaciformis* (Pl. 1J) and *Salopidium granuliferum* are recorded throughout the two boreholes (see Fig. 4). Thus, the acritarch assemblage can be attributed to the *D. estillis* Biozone corresponding to a latest Aeronian to early Telychian age (Davies *et al*., 1997; Dorning & Bell, 1987; Hill & Dorning, 1984), consistent with the age interval given by graptolites and chitinozoans.

5.1. Acritarch species used for correlation purposes

A few species seem to have their First Appearance Datum (FAD) in these boreholes and may therefore be used for correlation. They are *Crassiangulina variacornuta*, *Dictyotidium faviforme*, *Helosphaeridium clavispinulosum* and *H. latispinosum*, *Schismatosphaeridium guttulaferum* and *S. perforatum*.

Schismatosphaeridium guttulaferum only appears in the Kortrijk (Sint Antonius) borehole and, thus, is not useful for the correlation of the two boreholes. *Helosphaeridium latispinosum* is known in older strata of the Hillend Farm section in Shropshire (Wauthoz, 2003). These are of late Aeronian age, as indicated by brachiopods, conodonts and (indirectly) by graptolites (Aldridge, 1972; Ziegler *et al*., 1968). It is interesting to note that the relative proportion of this species increases simultaneously with the incoming of *Crassiangulina variacornuta* in the Sheinton Brook section (Wauthoz, 2003). Whether this increase corresponds to a stratigraphic acme of this species or to more favourable environmental conditions is not understood by now. In Belgium and prior to this increase, it seems possible that this species is not recorded because it is present in such low amounts that it is not recorded during the palynological survey of one slide.

Crassiangulina variacornuta is recorded in the Kortrijk (Sint-Antonius) borehole at -204.20 m and -200.00 m and in the Kortrijk (Lust) borehole from -202.00 m to -158.00 m (Fig. 4). Note that the record of *C. variacornuta* in strata attributed to the *guerichi* graptolite Biozone in these boreholes represents an older FAD than that provided by Wauthoz *et al*. (2003). Moreover, the record of *C. variacornuta* in the Kortrijk (Lust) borehole is contradictory to Wauthoz *et al*. (2003), since they assess not to record it in the Kortrijk (Lust) borehole.

Schismatosphaeridium perforatum is recorded in the Kortrijk (Sint-Antonius) borehole at -223.90 m, -204.20 m and -200.00 m and in the Kortrijk (Lust) borehole from -217.00 m to -162.50 m. *Helosphaeridium clavispinulosum* is recorded at -223.90 m in the Kortrijk (Sint-Antonius) borehole and at -217.00 m, -197.50 m, -192.50 m and -148.30 m in the Kortrijk (Lust) borehole.

6. Correlation of the two boreholes

On the basis of Legrand (1962, 1981), one could correlate the Kortrijk (Sint-Antonius) borehole with the Kortrijk (Lust) borehole using the boundary between the *sedgwickii* and *turriculatus* graptolite Biozones (see Fig. 2). This limit is well defined in the Kortrijk (Sint-Antonius) borehole but it is not satisfactorily addressed in the Kortrijk (Lust) borehole where a 8.8 m thick barren interval separates the highest level with a *sedgwickii* Biozone from the lowest level with a *turriculatus* Biozone Legrand (1962, 1981).

In order to build his regional chitinozoan biostratigraphical scheme, Van Grootel (1990) correlates the two boreholes at the base of the *turriculatus* Biozone. He is not able to confirm this correlation using independent data as chitinozoans (Van Grootel, 1990).

Indeed, his Biozone 7 (association zone) which is defined in the Kortrijk (Sint-Antonius) borehole by the first appearance of 5 chitinozoan species at -240.10 m is not recognised in the Kortrijk (Lust) borehole. The Biozone 8 (*Conochitina candoris* nomen nudum abundance zone) is recognised in the Kortrijk (Lust) borehole but not the Kortrijk (Sint-Antonius) borehole where this species does not show any clear abundance interval. Biozone 9 (concurrent range zone of *Eisenackitina brabantium* nomen nudum, *Conochitina tenuis* and *Cyathochitina novempopulanica*) is defined in the Kortrijk (Lust) borehole but is not recognisable in the Kortrijk (Sint-Antonius) borehole.

Van Grootel *et al*. (1998) recently provided another possible correlation. It appears from their work that a correlation based on graptolites would be quite coarse and unreliable due to large barren intervals below the proposed base of the *guerichi* Biozone in both boreholes (see Fig. 3).

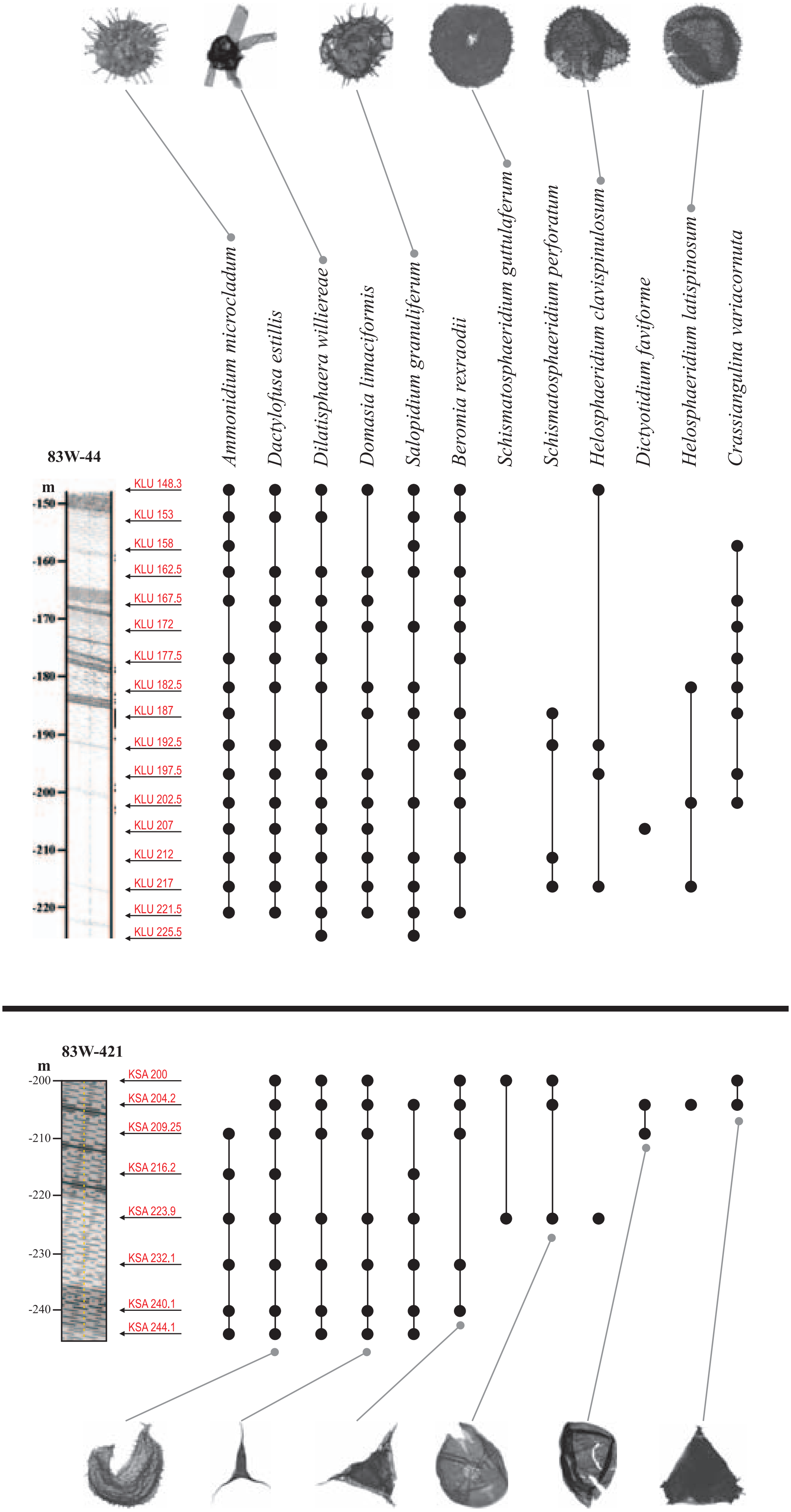

Figure 4. Stratigraphic distribution of 12 chosen acritarch species in the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes. Note that no stratigraphic continuity is implied by the vertical succession of the boreholes, as indicated by the horizontal line.

In the Kortrijk (Sint-Antonius) borehole, there is a 30 m barren interval between the established top of the *sedgwickii* Biozone and the bottom of the *turriculatus s.l.* (?*guerichi*) Biozone. In the Kortrijk (Lust) borehole, the first graptolitic level follows a 22 m wide barren interval at the base of the borehole.

Chitinozoans provide an apparently better correlation (see Fig. 3) based on the first stratigraphic appearance of *Eisenackitina dolioliformis* (Van Grootel *et al*., 1998). However, this point may not be reliable enough in the Kortrijk (Lust) borehole since sample -220.00 m yielded only two poorly preserved chitinozoans that could not be identified to the species level and sample -223.00 m is barren.

Acritarchs provide two possible ways to correlate the Kortrijk (Sint-Antonius) and the Kortrijk (Lust) boreholes (see Fig. 4). On the one hand, the correlation may be based on the first stratigraphic occurrence of *Crassiangulina variacornuta* (Pl. 1H). On the other hand, it may be based on the first stratigraphic occurrences of *Schismatosphaeridium perforatum* (Pl. 1G) and *Helosphaeridium clavispinulosum* (Pl. 1L).

In the Kortrijk (Sint-Antonius) borehole, *S. perforatum* and *H. clavispinulosum* appear 19.7 m below the first stratigraphic appearance of *C. variacornuta*. In the Kortrijk (Lust) borehole, this interval is 14.5 m wide. This 5.2 m difference is roughly equivalent to the sample mesh in the boreholes (approximatively 5 m in the Kortrijk (Lust) borehole and 7 m in the relevant part of the Kortrijk (Sint-Antonius) borehole). Thus, provided there are no faults between the boreholes, it can be considered that both options are geometrically equivalent since the boreholes are geographically close (586 m) and no important difference is expected in their sedimentation rate.

The first stratigraphic appearance of *Crassiangulina variacornuta* is considered to be more reliable because its range seems limited to the Telychian stage in Balonia (Wauthoz *et al*., 2003). Moreover, the stratigraphic ranges of *Schismatosphaeridium perforatum* and *Helosphaeridium clavispinulosum* do not appear sufficiently addressed to confidently use them as stratigraphic markers. In addition, *C. variacornuta* is more frequently recorded than the other two species and its characteristic morphological features are easier to spot, especially in the thermally altered samples of the Kortrijk boreholes. Thus the first appearance of *C. variacornuta* is chosen for the correlation.

7. Discussion

The revision of graptolites and chitinozoans (Van Grootel *et al*., 1998) in the Kortrijk (Sint-Antonius) and the Kortrijk (Lust) boreholes shows that neither fossil group provides an accurate and/or reliable correlation of the two boreholes. This is due to the presence of barren and/or inconclusive samples below the defined base of the *guerichi* graptolite Biozone and that of the *dolioliformis* chitinozoan Biozone. Moreover it invalidates a possible correlation based on older graptolite data gathered by Legrand (1962, 1981).

In both boreholes, the first stratigraphic appearance of *Crassiangulina variacornuta* occurs within the interval dated as early Telychian (*guerichi* Biozone) by Van Grootel *et al*. (1998). However, according to the proposed correlation

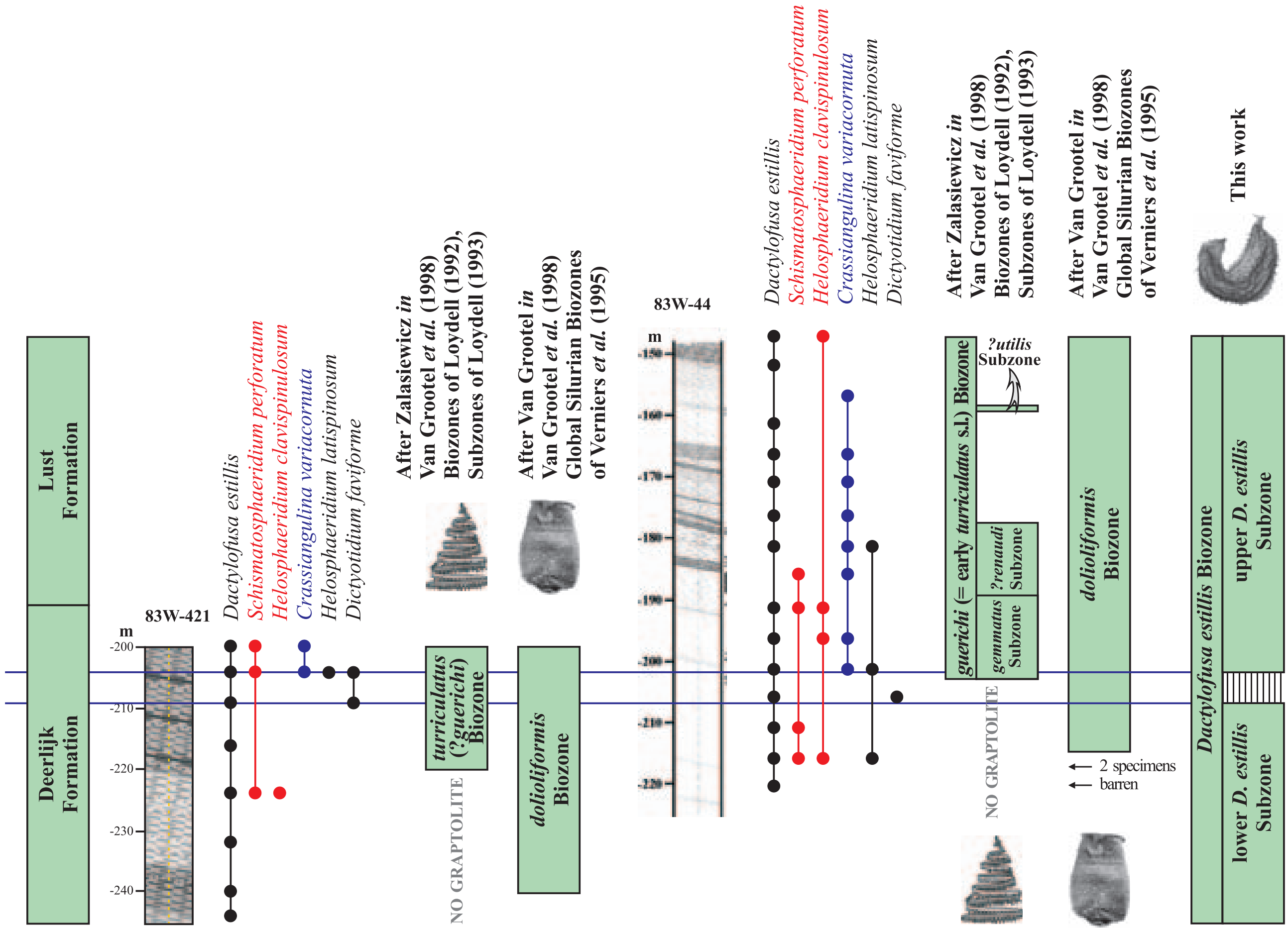

Figure 5. Correlation of the Kortrijk (Sint-Antonius) and Kortrijk (Lust) boreholes based on the first stratigraphic occurrence of *Crassiangulina variacornuta* and relation to the graptolite and chitinozoan biozonations (Van Grootel *et al*., 1998) together with the refined acritarch biozonation proposed herein.

with acritarchs, the established base of the *guerichi* graptolite Biozone in the two boreholes does not exactly correlate (Fig. 4). This is not deemed significant due to the barren intervals below the base of this biozone, moreover so since the graptolites were studied on the stratification plane of cores 63 mm or 135 mm in diameter. A perfectly accurate and reliable correlation is hampered by these uncertainties.

The proposed correlation with acritarchs does not coincide with the possible correlation based on the lowest stratigraphic occurrence of the chitinozoan *Eisenackitina dolioliformis*. However, this latter base does not appear accurately defined in both boreholes where it follows intervals containing no or no determinable chitinozoans (Fig. 3).

Due to these barren or inconclusive intervals, both the correlation based on graptolites and chitinozoans cannot reach the accuracy of that based on acritarchs. This accuracy corresponds to the largest interval between the sample where *C. variacornuta* first appears and that just below it, i.e. 5.05 m in the Kortrijk (Sint-Antonius) borehole.

7.1. Refinement of the acritarch biostratigraphic scheme for the early Silurian

The first stratigraphic occurrence of *Crassiangulina variacornuta* may be used to refine the current acritarch biozonation scheme for the uppermost Llandovery and lowermost Telychian. It allows the division of the *Dactylofusa estillis* Biozone in two subzones. The lower Subzone is an interval zone. The base is defined at the lowest stratigraphic occurrence of *Dactylofusa estillis* and the top is defined at the lowest stratigraphic occurrence of *Crassiangulina variacornuta*. *Helosphaeridium clavispinulosum* (Pl. 1L) and *Dictyotidium faviforme* (Pl. 1D) first appear within this Subzone (Fig. 4).

The upper Subzone is the concurrent-range biozone of *Dactylofusa estillis* and *Crassiangulina variacornuta*. It is defined by the lowest stratigraphic occurrence of *C. variacornuta* and the highest stratigraphic occurrence of *Dactylofusa estillis*. *Helosphaeridium latispinosum* (Pl. 1F) has its last occurrence within this Subzone. Note that in the 50E134 Steenkerke borehole, the range of *C. variacornuta* is known to extend higher up than that of *D. estillis* (Wauthoz, 2003; Wauthoz *et al*., 2003).

The subdivisions of the *Dactylofusa estillis* Biozone can also be recognised on the Welsh Borderland platform in the Sheinton Brook section (Shropshire, England), although observation lacunes in the outcrop do not allow to pinpoint the boundary between both subzones (Wauthoz, 2003). In the Claerwen Reservoir section (Rhayader County, Wales), *Dactylofusa estillis* and *Crassiangulina variacornuta* are found together in strata belonging to the *turriculatus* graptolite Biozone (*proteus* and *carnicus* Subzones, Davies *et al*., 1997), as shown by Wauthoz (2003).

Thus, it appears that this refined biozonation scheme with two subzones may be applied at least regionally in two areas of the Avalonia Microplate. Moreover, since there is a good correspondence between the acritarch assemblages from this plate and the Baltica Plate (Le Hérissé & Gourvennec, 1995), it may be applicable on a wider scale. On the other hand, since this scheme is recognisable in shallow platform (Sheinton Brook section), deep platform (Belgian boreholes) and basin environments (Claerwen Reservoir section), it may be used to correlate shallow facies where graptolites are scarce and biozonation is generally based on brachiopods to deeper facies where graptolites are more abundant and brachiopods rarer.

Finally, it may prove that the boundary between the lower and upper *Dactylofusa estillis* Subzones lies quite close to the Aeronian-Telychian boundary and, thus, the former may provide an estimate of the position of the latter in sections where other indications lack. However, this may only be true in Balonia, since *C. variacornuta* was found in Aeronian strata of the Lipéon Formation in Argentina (Rubinstein & Toro, in press). These strata are dated by graptolites (*convolutus* and ?*sedgwickii* Biozones, Rubinstein & Toro, in press).

8. Conclusion

The investigation of acritarchs in eight samples from the Kortrijk (Sint-Antonius) borehole and seventeen from the Kortrijk (Lust) borehole allows their precise correlation (Fig. 5). This is based on the first stratigraphic occurrence of *Crassiangulina variacornuta*. This datum point allows to correlate level -204.20 m in the Kortrijk (Sint-Antonius) borehole to level -202.50 m in the Kortrijk (Lust) borehole. This correlation is further supported by the first stratigraphic appearance of *Helosphaeridium clavispinulosum* and *Schismatosphaeridium perforatum*. This datum point may be considered a geometric equivalent of the proposed correlation. It correlates level -223.90 m in the Kortrijk (Sint-Antonius) borehole to level -217.00 m in the Kortrijk (Lust) borehole.

Correlations of the Kortrijk boreholes based on graptolites and chitinozoans appear less accurate and less reliable than that proposed with acritarchs. This is principally due to the presence of barren or inconclusive intervals between biozone boundaries. However, the proposed correlation with acritarchs is not inconsistent with the biostratigraphical data gathered with either graptolites or chitinozoans.

The first stratigraphic appearance of *Crassiangulina variacornuta* allows dividing the *Dactylofusa estillis* Biozone (which is a total range zone) into two subzones. The lower *D. estillis* Subzone is an interval zone of which the base is defined at the lowest stratigraphic occurrence of *Dactylofusa estillis*. The top of this Subzone is defined at the lowest stratigraphic occurrence of *Crassiangulina variacornuta*.

The upper *D. estillis* Subzone is the concurrent-range biozone of *Dactylofusa estillis* and *Crassiangulina variacornuta*. It is defined by the lowest stratigraphic occurrence of *C. variacornuta* and the highest stratigraphic occurrence of *Dactylofusa estillis*. Since these subzones can be recognised on the Welsh Borderland platform (at Sheinton Brook) and possibly in the Welsh Basin (at Clearwen Reservoir), it appears that acritarchs may provide the most successful way to correlate shallow facies to basin where a graptolite biozonation is often established.

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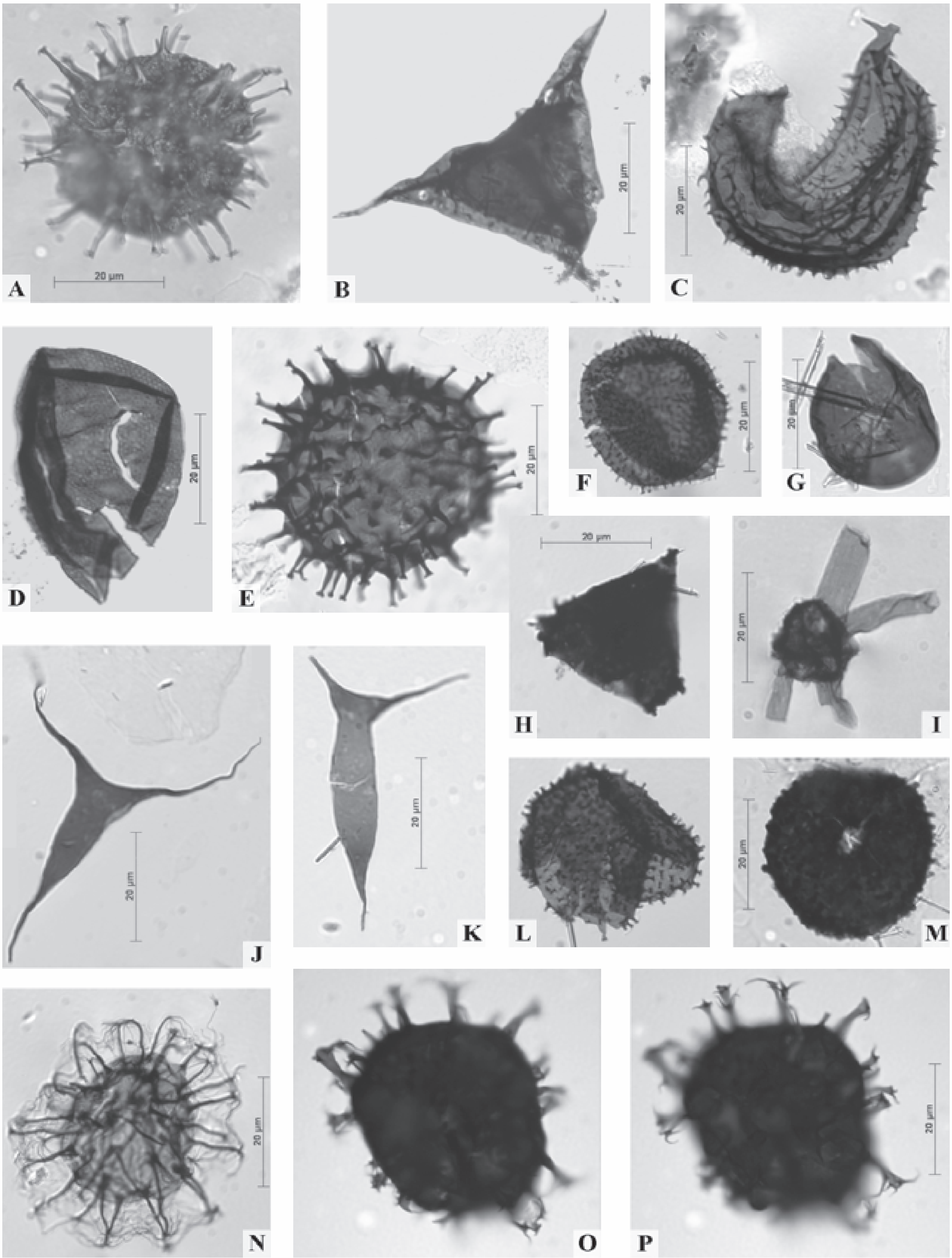

Plate 1. Some acritarchs from the 83W-421 (KSA) and 83W-44 (KLU) boreholes. Specimens are given, the level and borehole in which specimens are found, together with their England Finder reference. All specimens x1000.
A. *Ammonidium microcladum*, level -232.10 m (KSA), N52/1 (combined transmitted and reflective light). – ***B.*** *Beromia rexroadii*, level -216.80 m (KLU), U55/2. – ***C.*** *Dactylofusa estillis*, level -232.10 m (KSA), R50-51. – ***D.*** *Dictyotidium faviforme*, level -216.20 m (KSA), H53/3 – **E.** ?*Helosphaeridium echiniforme*, level -216.20 m (KSA), H54/0 – ***F.*** *Helosphaeridium latispinosum,* level -182.50 m (KLU), G36/4 – ***G.*** *Schismatosphaeridium perforatum,* level -223.90 m (KSA), T56/1 – **H.** *Crassiangulina variacornuta,* level -167.50 m (KLU), Q40/1 – **I.** *Dilatisphaera williereae,* level -232.10 m (KSA), M41/0 – **J.** *Domasia limaciformis,* level -148.30 m (KLU), W56/3 – **K.** *Domasia elongata,* level -200.00 m (KSA), R58/3 – **L.** *Helosphaeridium clavipinulosum,* level -148.30 m (KLU), Y54/3 – **M.** *Schismatosphaeridium guttulaferum,* level -200.00 m (KSA), R59/4 – **N.** *Tunisphaeridium tentaculaferum,* level -244.10 m (KSA), C40/3 – **O, P.** *Visbysphaera brevifurcata,* level -158.00 m (KLU), L47/2