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AGE RANGE AND ORIGIN OF THE LIMESTONE CLASTS OF THE MALMEDY CONCLOMERATE (PERMIAN, ARDENNES, BELGIUM)

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ABSTRACT. - The Malmedy Conglomerate extends across the Stavelot Massif, in the eastern part of the Ardennes. It is deposited on older Palaeozoic formations and stretches in a NE-SW direction, from Xhoffraix to Basse-Bodeux.

Within the conglomerate three units were recognized by A. RENIER. The middle unit comprises mainly fossiliferous limestone clasts which were the main object of our study. Study of the faunal elements, mainly conodonts, stromatoporoids, tabulates, rugose corals and brachiopods, indicates that these limestone clasts were derived from Upper Emsian to Lower Carboniferous (Ivorian) formations.

Agė, lithofacies and biofacies of the limestone clasts, colour of the conodonts and direction of debris supply (as determined by size distribution of clasts), point to a mixture of sediments from different sources. One of these was probably the Devonian of the Eifel area. Other sources are also taken into consideration.

The Malmédy Conglomerate is generally regarded as a Permian formation. Study of the matrix has not yet provided microfossils to confirm this Permian age.

RESUME. - Le Poudingue de Malmédy repose sur des formations paléozoïques du massif de Stavelot. Il s'allonge de Xhoffraix à Basse-Bodeux, dans une direction NE-SO.

A. RENIER a divisé ce dépôt poudinguiforme en trois "assises".

L'assise moyenne est caractérisée par une abondance de galets calcaires et fossilifères qui font l'objet principal de cette étude.

L'étude détaillée de la faune de ces galets calcaires, des Conodontes, des Tabulés, des Stromatopores, des Rugueux et des Brachiopodes, indique que ces galets proviennent de formations d'âge Emsien supérieur à Carbonifère inférieur (Ivorien).

L'âge, le lithofaciès et le biofaciès des galets calcaires, la couleur des Conodontes et la direction de transport, suggèrent que les galets dérivent de plusieurs sources. Une est probablement les formations dévoniennes de l'Eifel. Des sources situées dans d'autres régions sont également considérées.

L'âge du Poudingue de Malmédy est controversé, mais selon l'opinion généralement admise, est Permien bien que la recherche de microfossiles dans la matrice n'a pas permis de confirmer cet âge permien.

KEY WORDS : Biostratigraphy, Conodonts, Tabulate and Rugose Corals, Stromatoporoids, Devonian, Carboniferous, Permian, Palaeogeography, Ardennes, Belgium.

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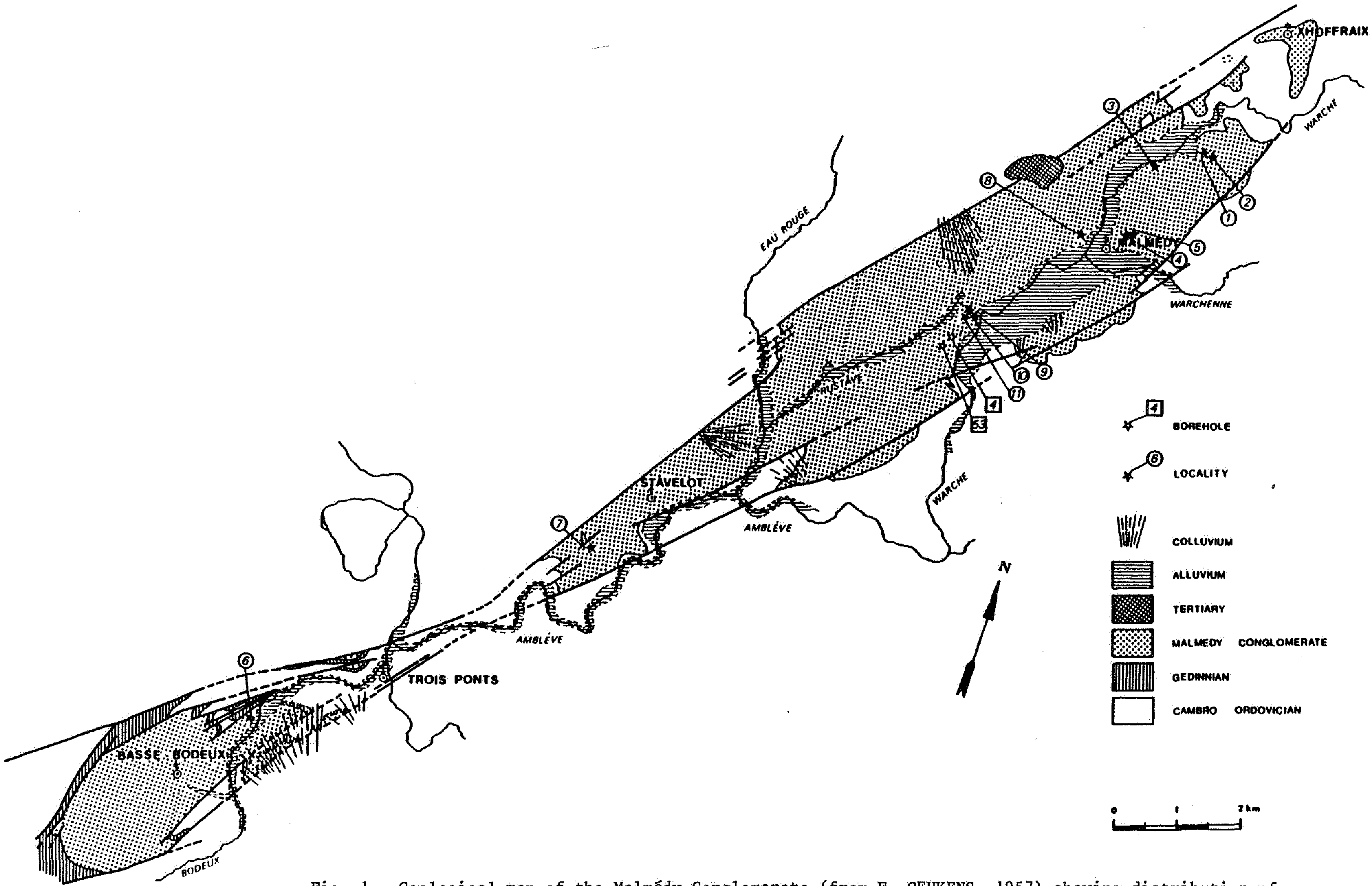


Fig. 1 - Geological map of the Malmédy Conglomerate (from F. GEUKENS, 1957) showing distribution of localities and boreholes.

1. INTRODUCTION.

The Malmédy Conglomerate extends across the Cambrian Massif of Stavelot. It stretches in a NE-SW direction, from Xhoffraix to Basse-Bodeux (see fig. 1).

According to F. GEUKENS (1956, 1957) the conglomerate was deposited in a graben. Subvertical faults define the northern and southern margins.

The conglomerate rests upon Lower Palaeozoic rocks. In the vicinity of Trois-Ponts the outcrop of the formation is interrupted by an anticline in Cambro-Ordovician formations.
At Basse-Bodeux Gedinnian rocks border the northern and western part of the outcrop while Salmian and Revinian formations border the southern and eastern parts respectively.
At Malmédy the conglomerate is in contact with Revinian formations along the northwestern margin, Salmian on the eastern side and Revinian and Devillian rocks in the southeastern extension.
The northern flank of the outcrop at Malmédy-Stavelot is partially covered with Tertiary and Cretaceous rocks.

A. RENIER (1902) subdivided the Malmédy Conglomerate into three units :

- Upper unit : a breccia with flags, phyllite and quartz fragments, lying in a red, argillaceous matrix. This unit is only represented at Malmédy where it attains 30 m.

- Middle unit : predominantly fossiliferous limestone clasts in a red, calcaro-argillaceous matrix, intercalated with sandstone lenses.

  The thickness of this unit decreases in a southwesterly direction. It attains 150 m at Malmédy and only 30 m at Stavelot. At Basse-Bodeux the conglomerate is restricted to this unit. In the same direction the sandstone lenses become more important while the size and number of limestone clasts decrease.

- Lower unit :
  - a breccia formed by sandstone and slate debris at the base, followed by
  - an alteration of micro-conglomeratic sandstone lenses, flags and lenticular conglomerates with well-rounded clasts.

  This unit has a thickness of 60 m at Malmédy, diminishes towards Stavelot (15 m) and is absent at Basse-Bodeux.

The main object of this study lies in the determination of the age range of the limestone clasts based on their fossil content, namely of conodonts, tabulates, rugose corals, stromatoporoids and brachiopods.

A second point of interest is to determine the provenance of the clasts. Criteria for this are :

- age, faunal and lithological features of the limestone clasts;

- size distribution of the clasts;

- colour alteration index (CAI) of the conodonts in the limestone clasts and the organic metamorphism of organic spots in the matrix.

The final aim of the study is to determine the period during which the conglomerate was deposited by examination of the microfossils in the matrix.

2. HISTORICAL REVIEW.

Many authors have contributed to the study of the Malmédy Conglomerate. Opinions differ as to the age of the formation, the source area and age of the included limestone clasts, and the origin of the depression in which this heterogeneous conglomerate is preserved.

The first information on the fossil content of the limestone clasts was given by A. DUMONT (1832) who considered the deposit to be of Permian age. Among the fossils he enumerated the following species were assigned an Upper Couvinian or Givetian age : "*Stromatopora concentrica, Heliolithes porosa, Phacellophyllum caespitosa, Favosites gotlandica*" and "*Favosites polymorpha*". A. DUMONT also reported "*Spirifer attenuatus*" and "*Spirifer rotundatus*", suggesting a Dinantian age. According to E. MAILLEUX (1931), however, the latter determinations were not correct.

G. DEWALQUE (1868) assumed that the Malmédy Conglomerate had been deposited in an existing depression during Triassic times. He published a list of fossils that he collected but did not discuss their stratigraphic implications. In 1931 E. MAILLEUX reviewed this list and considered that the fauna indicated a Lower Emsian to Givetian age range. G. DEWALQUE noted that the bed thickness as well as the number and size of the clasts decrease from Malmédy to Basse-Bodeux. He proposed that a river coming from the Eifel area in W-Germany transported the clasts to Malmédy.

J. GOSSELET (1888) proposed another origin. He thought that the source area was located in the region of Marche and Rochefort, and that the river which transported the eroded material towards Malmédy flowed into the Triassic sea at Zulpich.

In 1902 A. RENIER made a detailed study of the conglomerate, which he thought to be a lacustrine deltaic deposit filling up two depressions of glacial origin. He distinguished three "assises" within the formation, the middle one of which contained mainly limestone clasts. He also recognized that bed thickness, the size of the clasts and the number of limestone clasts increase in northeasterly direction from Basse-Bodeux towards Malmédy. This suggested to A. RENIER that the debris was supplied from the northeast. He mentioned that the Malmédy Conglomerate was deposited in post-Hercynian pre-Cretaceous times.

E. HOLZAPFEL (1911) believed that the Malmédy Conglomerate was related with the Triassic conglomerates of the Rur-Urft area. He recorded that the clasts of the Malmédy Conglomerate comprise Cambrian quartzites, Lower Devonian sandstones and also red and yellow, fossiliferous limestones. According to their fauna, these limestone clasts seem to be derived from the "*Cultrijugatus* Stufe" of the "Sötenicher Kalkmulde". The Lower Devonian sandstones also suggest a provenance from this area. Like H. GREBE (1899), E. HOLZAPFEL assumed that the conglomerate had been deposited in a graben.

A. RENIER (1919) argued that the Malmédy Conglomerate is of post-Hercynian pre-Cretaceous age because it is unaffected by the Hercynian orogenesis and overlain by Cretaceous sediments. More specifically, based on the previous studies of P. KRUSCH (1908), P. KUKUK (1908, 1913) and W. VAN WATERSCHOOT VAN DER GRACHT (1909, 1913), A. RENIER concluded that sedimentation of the conglomerate took place during Early Permian times. He disagreed with E. HOLZAPFEL's (1911) idea of linking the Malmédy Conglomerate with the Triassic conglomerates of the Rur-Urft area, where no limestone clasts were deposited. He reiterated that the size of the clasts decreases from Malmédy to Stavelot. He added, however, that the largest clasts are not found at the northeastern extremity of the deposit, but 1 km southwest of Malmédy.

E. MAILLIEUX (1931, 1933) car out the only systematic, paleontological study of the fossils in the clasts of the Malmédy Conglomerate. Like A. RENIER (1902, 1919), he assumed that this Permian formation was a lake deposit, filling up a depression due to glacial activity. The "Poudingue de Malmédy" contains Cambrian and Devonian clasts. To determine the origin of the latter, E. MAILLIEUX studied their faunal and lithological features and compared them with rocks of the same age in neighbouring areas. He recognized limestone clasts derived from formations ranging in age from the Lower Emsian ("Koblenz Schichten") to the top of the Givetian ("Schönecker Dolomit") and probably even the Frasnian ("Ooser Kalk"). E. MAILLIEUX situated the source area of the Devonian clasts in Germany, in an area between the Schnee-Eifel, the Hunsrück and the Hohe-Eifel.

In particular, the Devonian rocks of the valleys of the Kyll, Prüm and Nims show close affinities with the clasts. In this region the whole series of rocks dating from the Lower Emsian ("Lower Koblenz Schichten") to the Upper Givetian ("Schönecker Dolomit") is exposed.
MAILLEUX considered that the debris supplied from this area was transported towards the northwest. He did not, however, exclude other sources.

P. ANTUN (1954) described the Malmédy Conglomerate as the remaining part of an alluvial fan, built up by an ephemeral stream. He ascribed the red colour of the formation to sedimentation in semi-arid conditions. On this interpretation the top of the alluvial fan was situated 1 km southwest of Malmédy where the largest clasts had been deposited.

After H. GREBE (1899) and E. HOLZAPFEL (1911), F. GEUKENS (1956, 1957) asserted that the conglomerate had been deposited in a graben. This view was based on the vertical faults delimiting the outcrop of the conglomerate to the north and the south.
According to F. GEUKENS the Malmédy Conglomerate was one of the first formations to be formed by erosion of the Hercynian belt. Sedimentation took place in a basin which was formed during a late Hercynian phase and covered the region of Stavelot. At that time, or later, a series of faults deformed the region and dilimited a graben in which the conglomerate has been preserved. GEUKENS noted that limestones clasts are abundant in the upper part of the conglomerate. He suggested that they have their origin in the Dinant Basin and the Vesdre Massif or were derived from the Eifel Synclines.

In 1963 F. GEUKENS pointed to the fact that the diameter of the clasts diminishes from the borders towards the centre of the deposit. This supports the hypothesis of the simultaneous formation of the graben and the sediments.

A. OZER and P. MACAR (1968) seemed to be convinced that the conglomerate had been deposited during a period of cold climate. They supported the view that the depression, in which the conglomerate is preserved, was of glacial origin rather than tectonic (graben). They asserted that the contact between the conglomerate and the substratum might well have a gentle slope for a considerable distance and that the borders of the conglomerate outcrop were not linear everywhere. According to OZER and MACAR, transport of the sediments was mainly accomplished by a glacier. Their argument is based on the fact that the clasts consisting of limestone or quartz with marcasite were not resistent enough to be transported along with harder fragments over long distances in humid conditions. Limited fluviatile transportation could have caused the rounding of the clasts. The clasts and the cement were thought to have been coloured red before sedimentation took place.

A. OZER (1979) studied the karstic phenomena in the Malmédy Conglomerate. He described the formation as a Permian conglomerate of continental origin. Following A. RENIER (1902) he distinguished three lithological units. The middle unit, comprising limestone clasts in a calcaro-argillaceous matrix, shows solution features such as dolines, stream sinks, shafts, dry valleys, caves and karst pinnacles.

According to A. OZER and A. PISSART (1983) the Malmédy Conglomerate gives evidence of fluvio-lacustrine conditions under an arid climate. They also distinguished three lithological units but noted that many faults intersecting the conglomerate make it difficult to follow them laterally. The authors indicate that the conglomerate contains elements of Devonian and Visean age, but they do not present any paleontological arguments for these ages.

3. SAMPLED SECTIONS.

The Malmédy Conglomerate was sampled along the axis of the graben in 11 sections and 2 boreholes. The distribution of localities is shown in figure 1. Detailed locality maps are presented in figures 2, 9, 10 and 11. Figures 3-8 and 12-17 show cross-sections at the localities studied; megafossil localities and position of conodont samples are also indicated.

LOCALITY 1 (figs 2, 4).

The outcrop is located in the southeastern part of Malmédy Bevercé, south of the Warche. It comprises a 7 m thick section of conglomerate overlying a bed or lens of sandstone.
The conglomerate contains a few grey and brown clasts of quartzite, with a diameter of 20 to 30 cm, but most of the clasts have diameters varying between 5 and 10 cm. The limestone clasts (maximum 7 cm) can easily be recognized by their pale yellow alteration colour.
The matrix is composed of a fine red sandstone and small angular rock fragments.

CONODONT SAMPLES :

C1, C3a : brown, fine-grained limestone.
C2 : brown, coarse-grained, shelly limestone.
C3b, C5, C6 : grey, fine-grained limestone.
C4 : ochre-grey limestone.

LOCALITY 2 (figs. 2, 5).

Locality 2 is situated 120 m southeast of section 1.
The conglomerate attains a thickness of 16 m and has an apparent dip of 13°S. The constituent clasts vary greatly in size ; their diameter ranging from 2 to 50 cm. The boulders and cobbles (after F.J. PETTIJOHN *et al.*, 1972) have a lower sphericity than the pebbles. The limestone clasts, also varing widely in size, are very abundant. They contain many tabulates and stromatoporoids and also a few rugose corals. The matrix is mainly formed by granules ; finer material being rather scarce.

CONODONT SAMPLES :

C1, C2, C3b, C6b, C7a, C9, C10a, C10b : grey, fine-grained limestone.
C3a, C4, C7b : red-grey, fine-grained limestone.
C5a, C8a : light-grey, fine-grained limestone.
C5b, C8b : dark-grey, fine-grained limestone.
C6a : grey, coarse-grained limestone.
C8c : grey limestone with yellow calcite veins.

LOCALITY 3a (figs 2, 6)

The conglomerate is well exposed behind the generating station in Malmédy Bevercé. In locality 3a, 100 m west of the generating station, the thickness of the exposed section is about 20 m. Only the lowest 10 m have been sampled.

A thin sandstone bed, with an apparent dip of 7°W, intersects this outcrop. The mean diameter of the clasts in the conglomerate below the sandstone bed is about 10 cm. The conglomerate consists of sandstone, shale, quartzite and quartz pebbles and cobbles : limestone clasts are less abundant.
Above the sandstone bed the conglomerate appears to be stratrified. Beds of clasts with maximum diametres of 15 cm alternate with beds composed of coarser (25 cm) clasts. Sandy material forms the matrix.

CONODONT SAMPLES :

C1 : ochre-grey limestone.
C2a : ochre-grey, coarse-grained, shelly limestone.
C2b, C3b, C4, C6a : grey, fine-grained limestone.
C3a, C5, C6 : brown, coarse-grained, shelly limestone.
C3c : light-grey, fine-grained limestone.

LOCALITY 3b (figs. 2, 7).

In locality 3b, 50 m west of the generating station, a vertical section of 25 m was sampled. The conglomerate is strongly weathered and much of the sandy matrix is eroded, which simplified the sampling. A gentle dip of 12°W can be recognized. The component clasts, mainly quartzite, sandstone, quartz and limestone, have low sphericity and are well rounded (after M. C. POWERS, 1953). Their diameters vary between 2 and 30 cm.

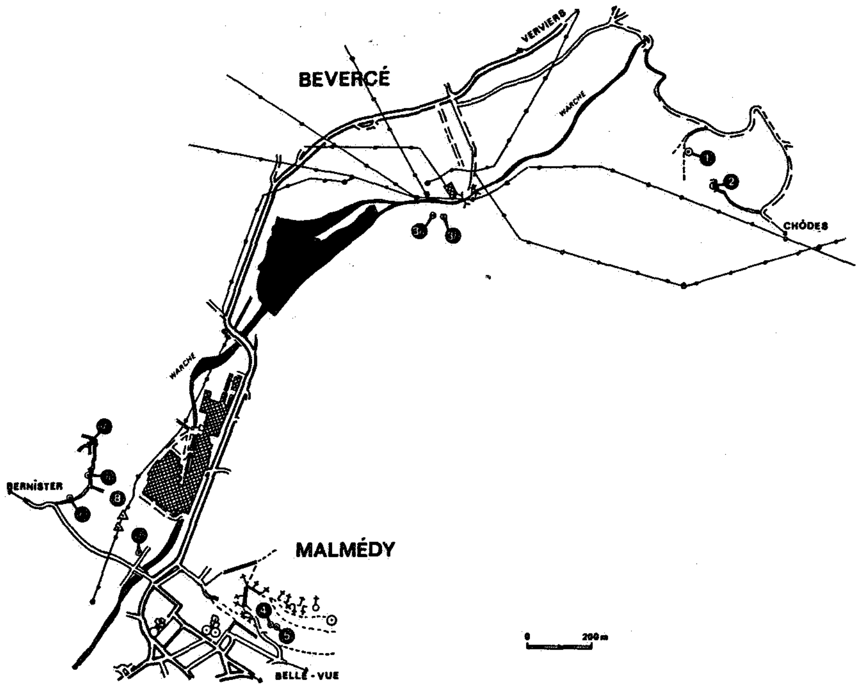


Fig. 2 - Index map showing localities 1-3b at Malmédy-Bevercé and localities 4-5, 8a-8d at Malmédy.

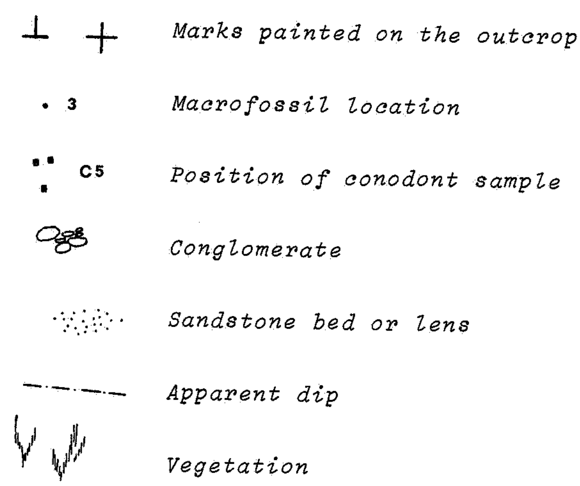


Fig. 3 - Symbols for figures 4-9, 13-14.

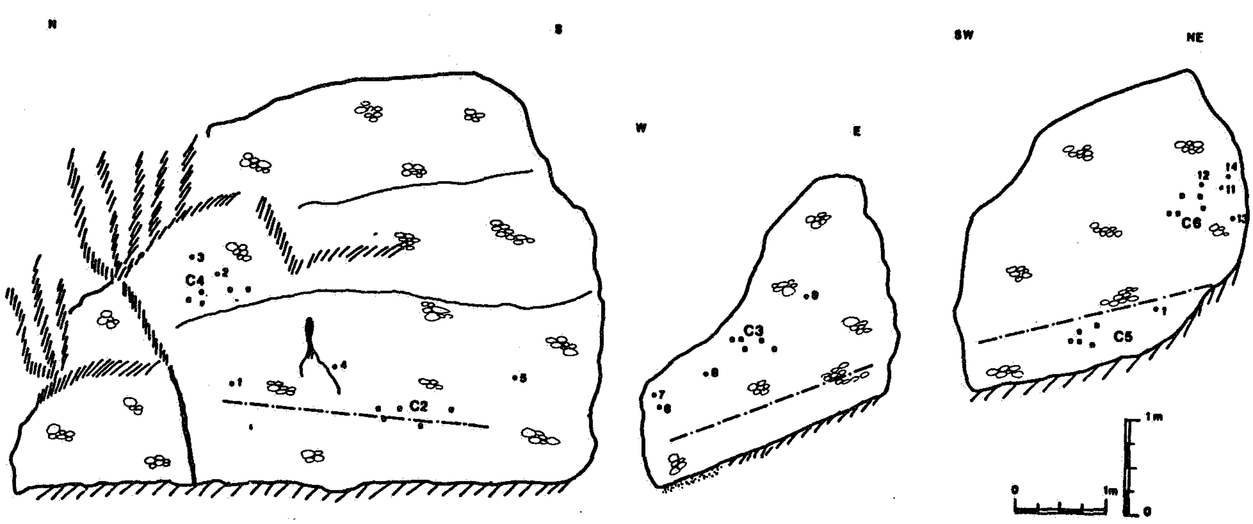


Fig. 4 - Schematic drawing of Malmédy-Bevercé section, locality 1.

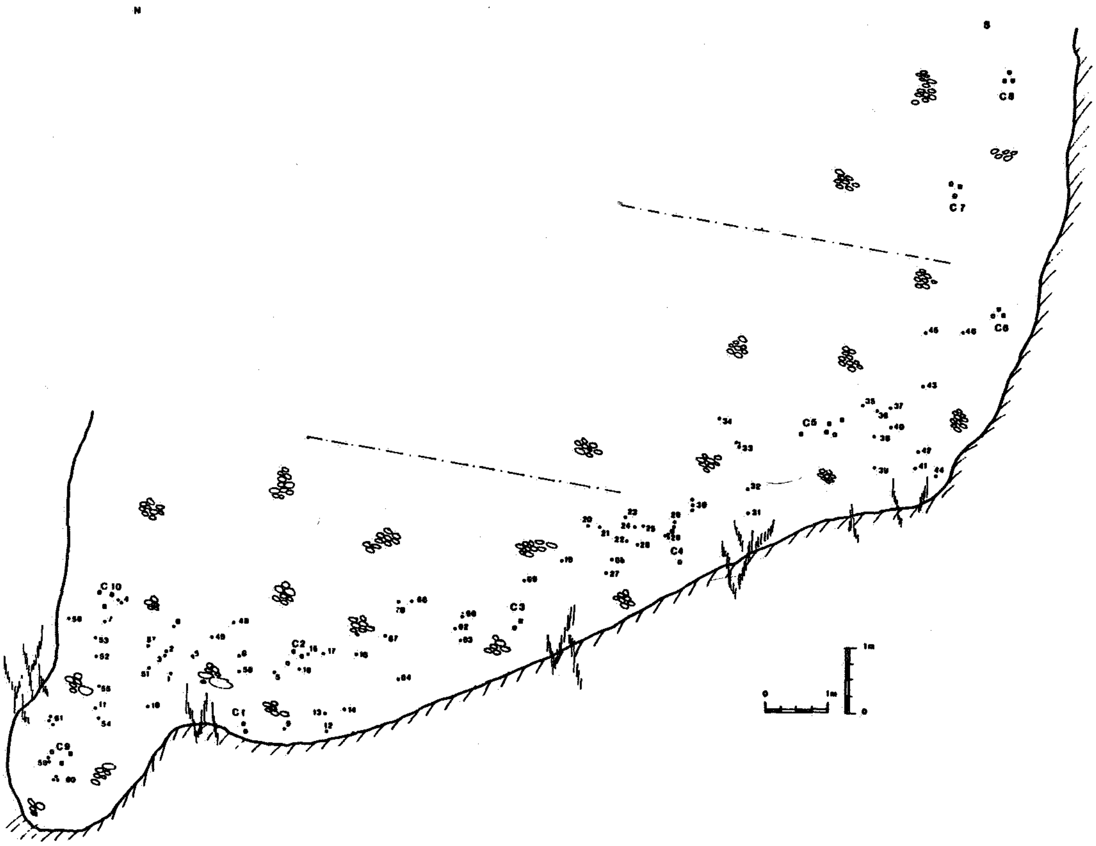


Fig. 5 - Schematic drawing of Malmédy-Bevercé section, locality 2.

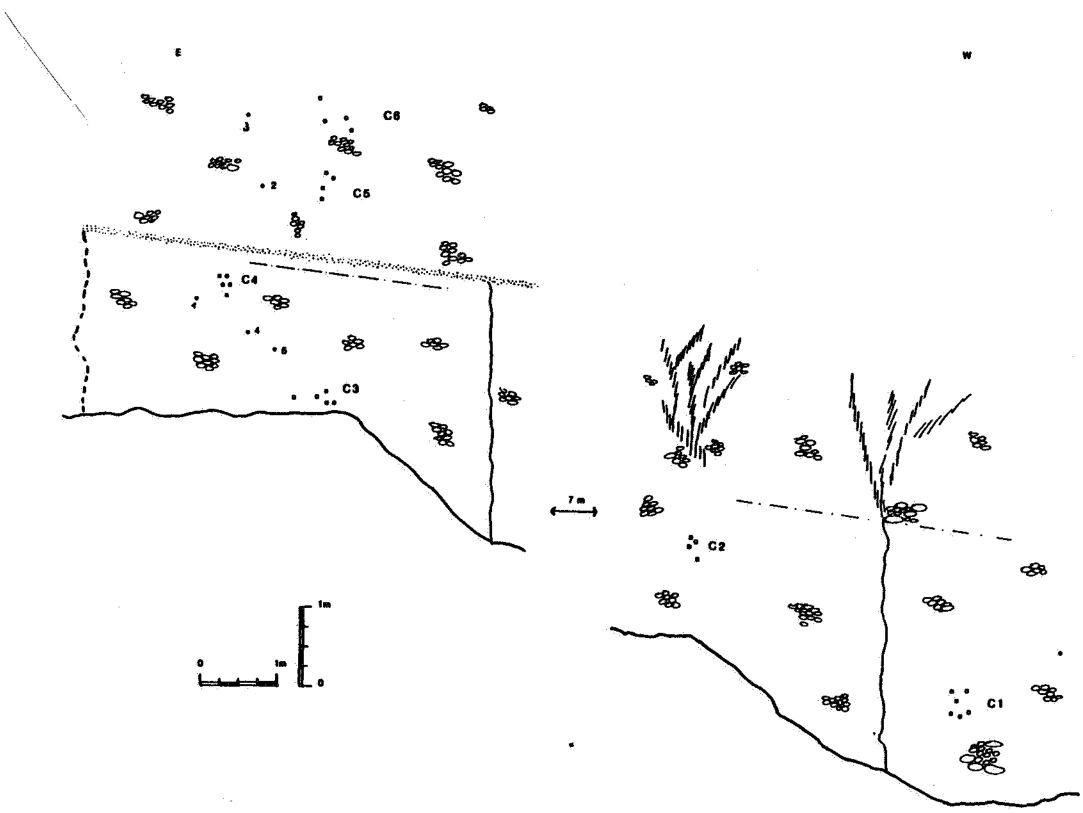
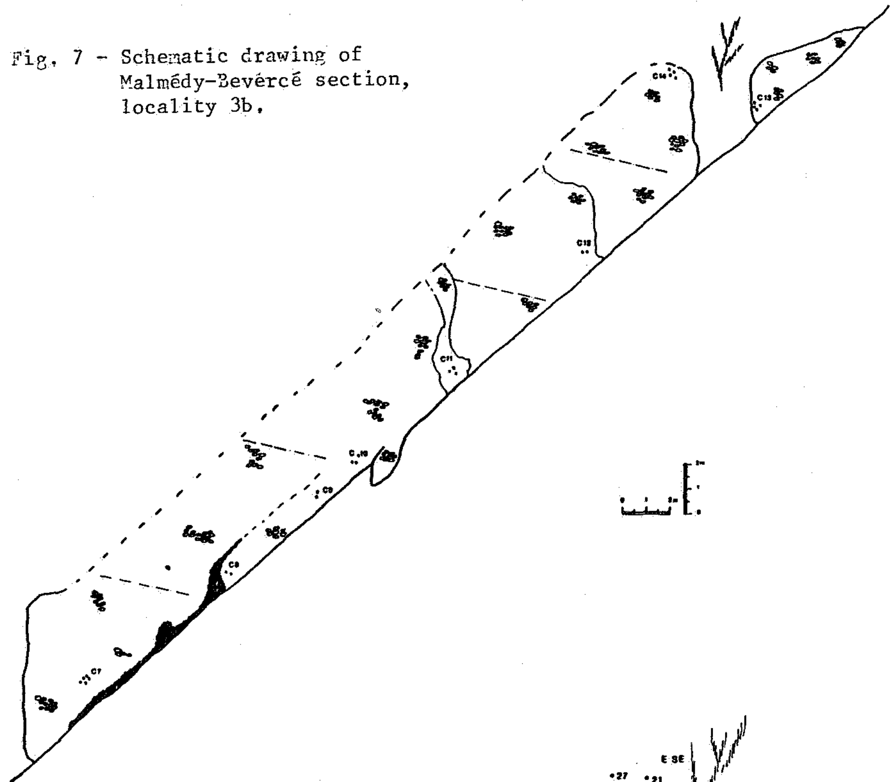


Fig. 6 - Schematic drawing of Malmédy-Bevercé section, locality 3a.

Fig. 7 - Schematic drawing of Malmédy-Bevércé section, locality 3b.



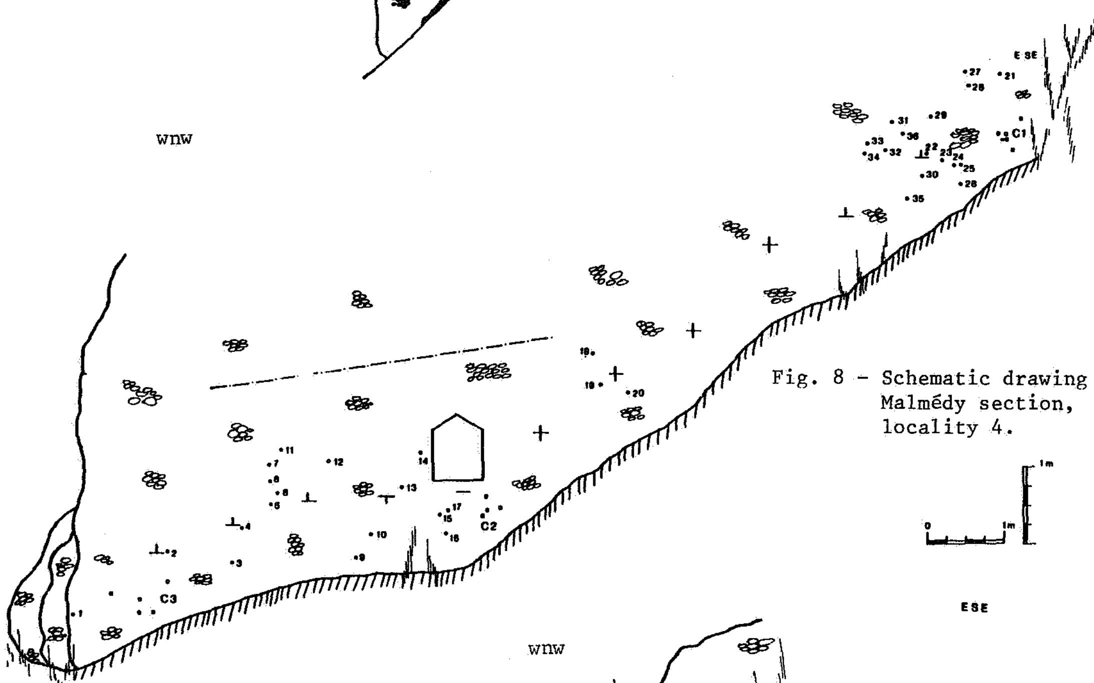


Fig. 8 - Schematic drawing of Malmédy section, locality 4.

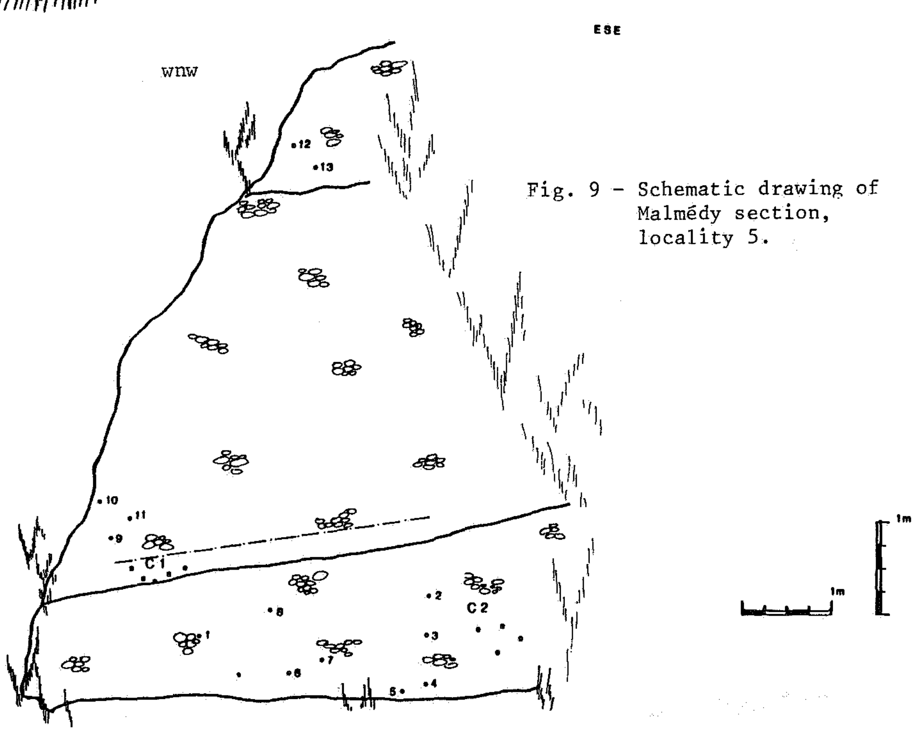


Fig. 9 - Schematic drawing of Malmédy section, locality 5.

CONODONT SAMPLES :

C7a : brown, coarse-grained, shelly limestone.
C7b : light-grey, fine-grained limestone.
C7c, C8a, C10b, C11b, C12, C13a : grey, fine-grained limestone.
C8b : red limestone with yellow calcite veins.
C9a : grey, coarse-grained limestone.
C7a : ochre-yellow, coarse-grained, shelly limestone.
C9b : light-grey, coarse-grained limestone.
C10a, C13b : brown, fine-grained limestone.
C11a : ochre-grey limestone.
C12 : brown, coarse-grained limestone.

LOCALITIES 4 and 5 (figs 2, 8, 9).

Both outcrops are located along the slope behind Malmédy church. The top of outcrop 4 corresponds with the lower part of section 5. The conglomerate reaches a total thickness of 15 m. Most of the clasts have diameters of 10 cm, but some beds composed of 20 cm clasts occur. Limestone clasts, mostly pebbles, are rather scarce. No sandstone beds occur in these sections. The matrix comprises a mixture of small, angular clasts and red sand.

CONODONT SAMPLES :

4 C1 : grey, fine-grained limestone.
4 C2a, C3 : brown, coarse-grained, shelly limestone.
4 C2b : red, fine-grained limestone.
4 C2c : red-grey, fine-grained limestone.

5 C1a, C2 : brown, coarse-grained shelly limestone.

5 C1b : light-grey, coarse-grained limestone.

LOCALITY 6 (fig. 10).

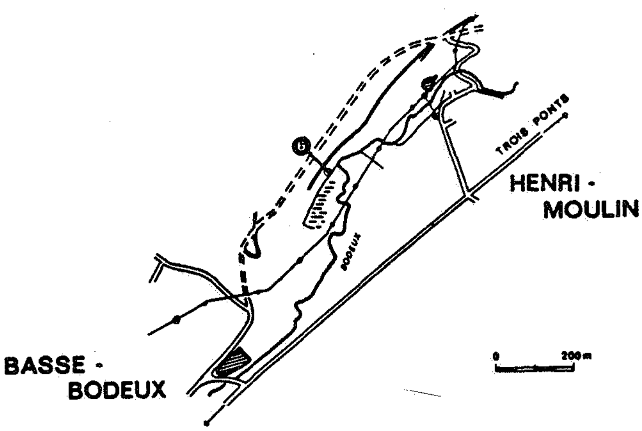


Fig. 10 - Index map showing locality 6 at Basse-Bodeux.

In locality 6, in Basse-Bodeux, sandstone beds alternate with fine- and coarse-grained rudites.

The clasts lie in a red, sandy matrix. They reach a maximum diameter of 7 cm in the coarse-grained beds and 2 to 3 cm in the fine-grained ones. The samples yielded no conodonts. Fossiliferous clasts are very scarce; only one was found among the fallen debris at the foot of the section.

CONODONT SAMPLES.

G1 : grey, fine-grained limestone.
C2 : red limestone with yellow calcite veins and red-grey, fine-grained limestone.

LOCALITY 7 (fig. 11).

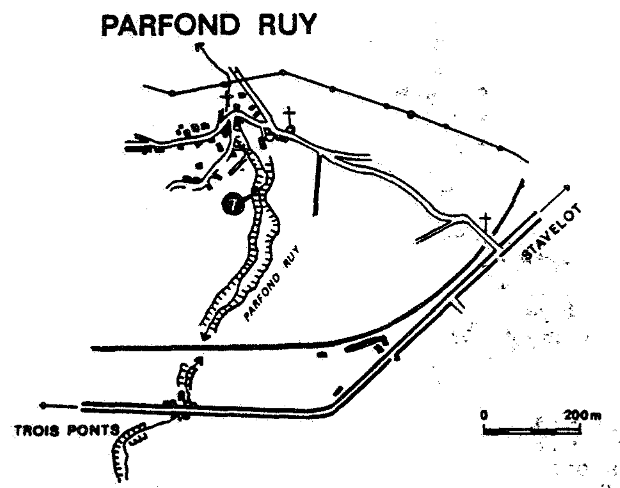


Fig. 11 - Index map showing locality 7 at Stavelot-Parfond Ruy.

A small exposure of conglomerate, with an apparent dip of 8°N, is exposed in the bed of the stream Parfond Ruy in Stavelot. The constituent clasts are quartzite, sandstone, shale and quartz : limestone clasts are scarce. The diameter of these clasts generally varies between 2 and 4 cm, although the largest attain 10 cm. The matrix consists of a mixture of small, angular granules and sand. Strongly weathered sandstone beds are exposed in the bottom of the stream.

CONODONT SAMPLE.

C1 : red-brown limestone.

LOCALITIES 8a, 8b, 8c and 8d (fig. 2).

West of Malmédy and the Warche sampling was carried out in outcrops occurring along a small path.

Locality 8a is situated at the southern side of the path, just before the bifurcation. The main elements of the conglomerate are limestone, quartzite, sandstone and quartz pebbles or cobbles. These clasts are well rounded and have moderate sphericity. The conglomerate is clast-supported, only sand and a few granules occur between the clasts.

Locality 8b lies south of 8a (figure 2). The conglomerate is strongly weathered and has an apparent dip of 5°N.

The size and the nature of the constituent clasts are the same as in section 8a.

75 m from the road to Bernister, in front of a newly built house, stratified conglomerates overlie a sandstone layer apparently dipping 6°W (locality 8c). In the first conglomerate layer above the sandstone bed, clasts (3 to 4 cm) lie in a matrix of sand and small, angular rock fragments. The overlying bed is coarser and contains less matrix. The clasts generally measure 8 to 10 cm, with a maximum of 15 cm. The largest have a lower sphericity than the smaller ones. The composition of the conglomerate is the same as in sections 8a and 8b.

Locality 8d forms the rear wall of a garage, situated 35 m along a small side street on the road to Bernister, just west of the Warche. A sandstone bed interrupts the conglomerate and dips 6° to N30°E. The mean diameter of the pebbles varies between 5 and 7 cm. The clasts are well rounded and most have a moderate sphericity, only few having low sphericity. 1 m above the sandstone bed a thin conglomerate layer comprising clasts of 2 to 3 cm diameter is exposed. Coarse, red sand forms the matrix.

CONODONT SAMPLES

8a C1a : grey, fine-grained limestone.
8a C1b : red-brown, coarse-grained limestone.
8b C1 : brown and grey, coarse-grained limestone.
8c C1 : grey, coarse-grained limestone.
8d C1 : grey, fine-grained limestone.

LOCALITY 9 (figs. 12, 13)

This outcrop is located on the east side of the new motorway in Malmédy Hausta, just south of the railway crossing.
The conglomerate has an apparent dip of 8°N. The clasts generally vary between 1 and 10 cm in diameter, but exceptionnally there are cobbles of 20 cm. The well-rounded pebbles have low sphericity. Limestone clasts are abundant ; quartzites, sandstone and quartz clasts are common. The conglomerate is clast-supported, the matrix being formed of small rock fragments and red sand. Limestone clasts (samples A-F) sampled by Professor F. GEUKENS and K. VAN DE PUT in 1981-1982 yielded no conodonts.

CONODONT SAMPLES.

C1a, C : light-grey, coarse-grained limestone.
C1b : brown, coarse-grained limestone.
C1c, C2b, A, B : grey, fine-grained limestone.
C2a : brown, coarse-grained, shelly limestone.
D, F : light-grey, fine-grained limestone.
D, E : red-grey, fine-grained limestone.
F : brown, fine-grained limestone and grey, coarse-grained limestone.

LOCALITIES 10 AND 11 (figs. 12, 14).

These localities are situated near the bridge where the new motorway crosses the railway. Outcrop 10 is located on the southwestern side of the bridge, outcrop 11 on the northeastern side.
In both sections sandtone lenses alternate with conglomerate beds. The sandstone lenses pass gradually into conglomerate units composed of quartz, quartzite and limestone clasts lying in a red, sandy matrix. The diameter of the clasts varies from 0,2 to 10 cm. The limestone clasts are well-rounded and have low sphericity.

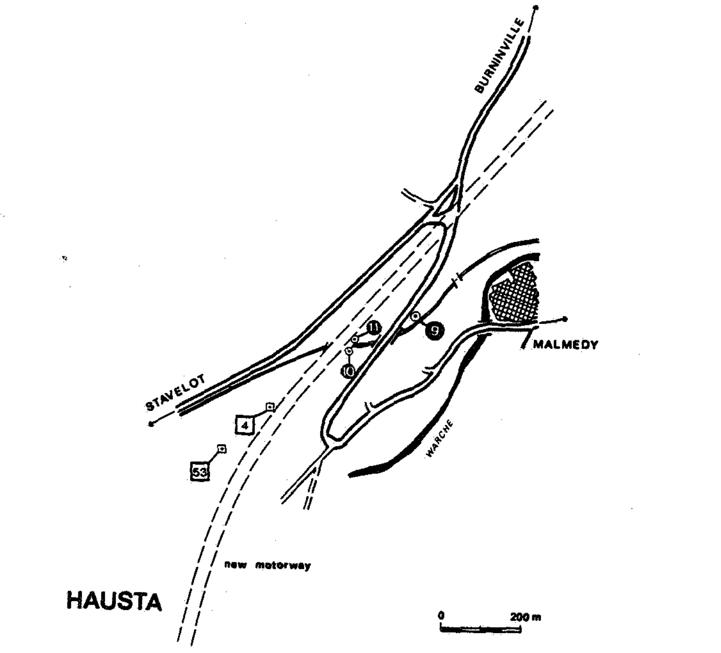


Fig. 12 - Index map showing localities 9-11 and boreholes F4 and F53 at Malmédy Hausta.

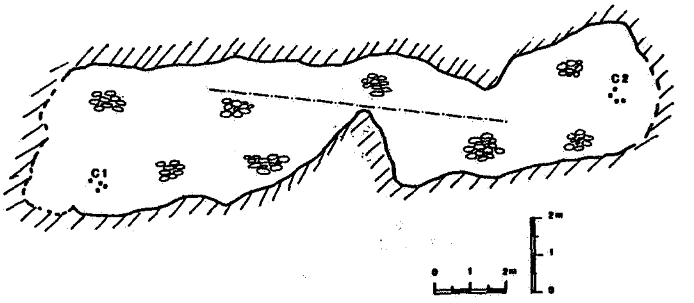


Fig. 13 - Schematic drawing of Malmédy-Hausta section, locality 9.

CONODONT SAMPLES.

10C1, C2 : grey, fine-grained limestone and red-grey, fine-grained limestone.
11 C1a : grey, coarse-grained limestone.
11 C1b, C2 : grey, fine-grained limestone.

BOREHOLES F4 and F53
(figs 12, 16, 17)

During preliminary work for the Malmédy-St Vith motorway section boreholes were drilled in the vicinity of Malmédy Hausta.
Only samples of boreholes F4 and F53 yielded conodonts and are described in figures 16 and 17.

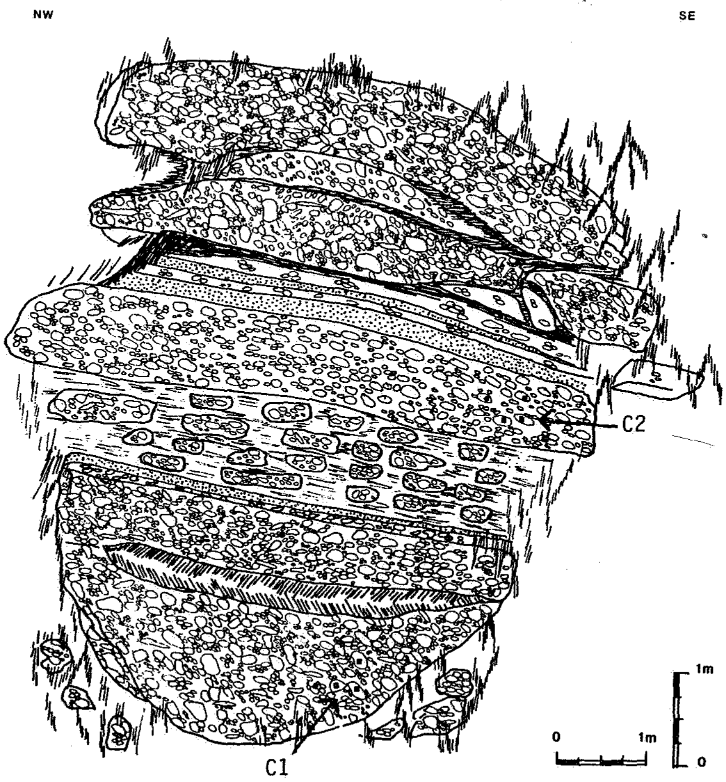


Fig. 14 - Schematic drawing of Malmédy-Hausta section, locality 10.

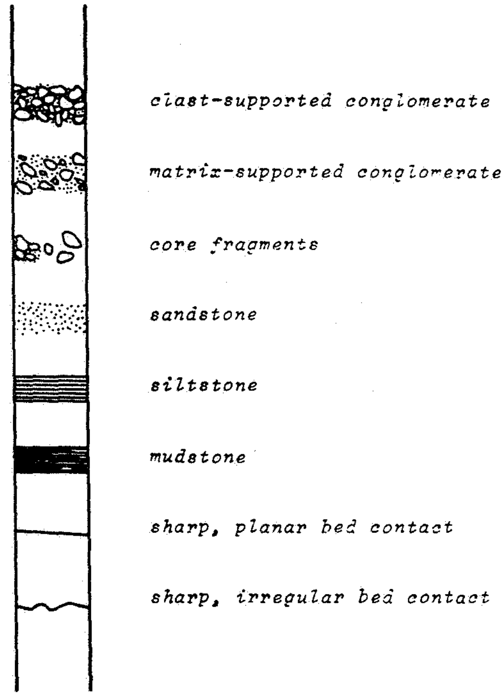


Fig. 15 - Symbols for figures 16-17.

Samples were taken from the following depth intervals :

Borehole F4 :
8.00-8.20 m; 9.00-9.25 m; 12.80-13.00 m; 14.00-14.55 m; 14.80-15.00 m; 15.00-15.20 m; 17.00-17.40 m; 17.50-18.00 m.

Borehole F53 :
6.00-6.50 m; 7.30-8.00 m; 13.10-13.50 m; 14.00-15.00 m.

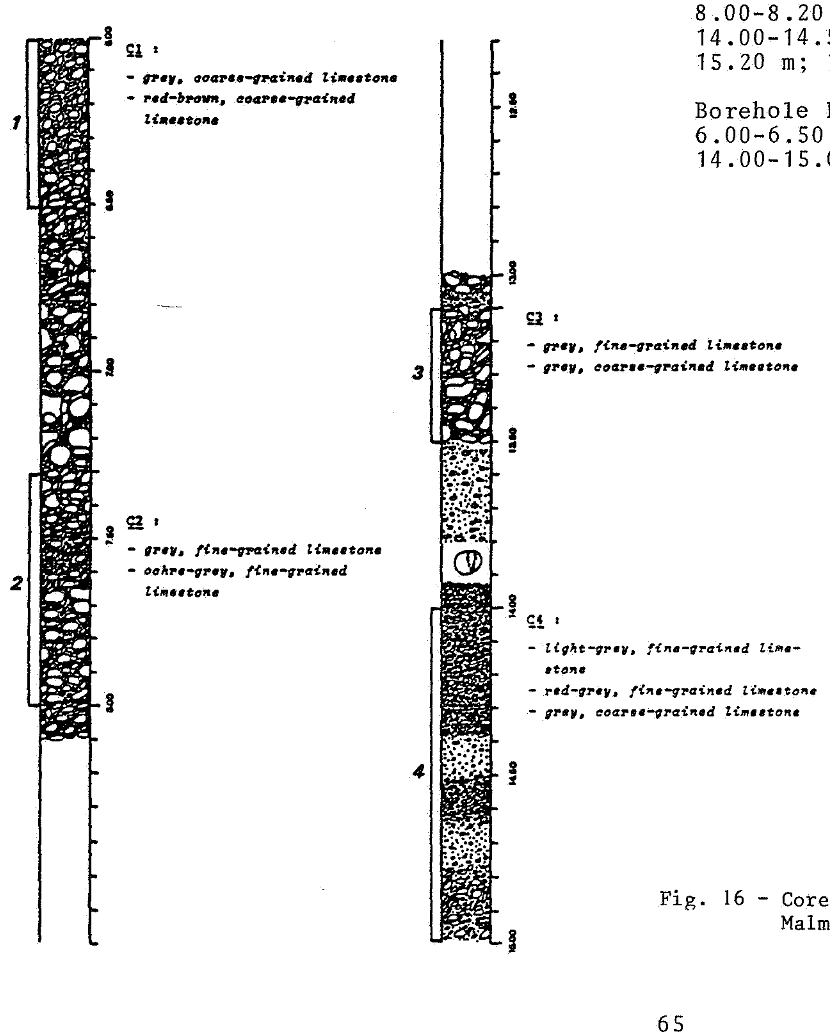


Fig. 16 - Core description of borehole 53 at Malmédy Hausta.

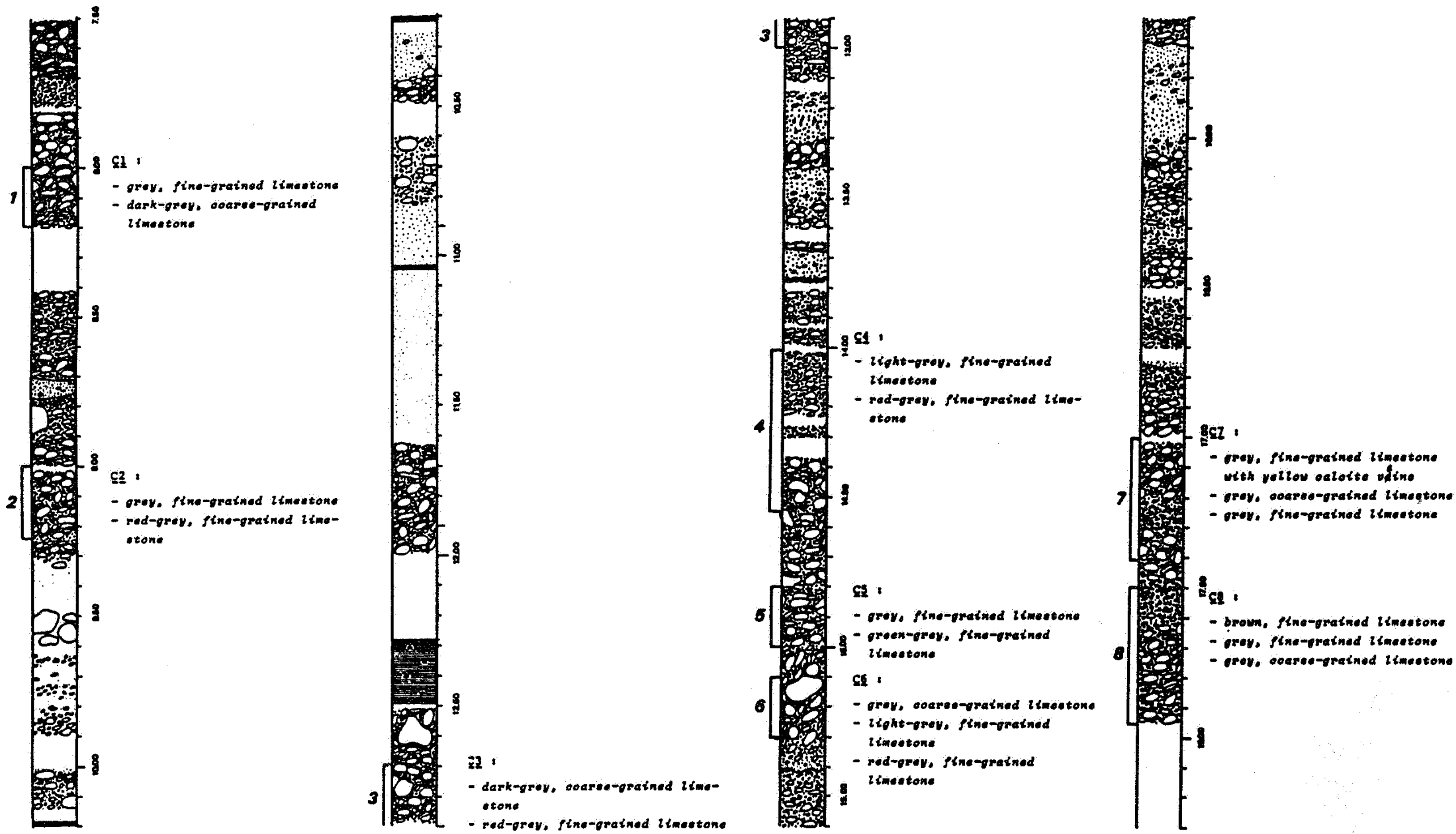


Fig. 17 - Core description of borehole F4 at Malmédy Hausta.

4. FAUNA AND AGE OF THE LIMESTONE CLASTS.

4. 1. CONODONTS.

For the first time conodonts have been recovered from the limestone clasts, included in the Malmédy Conglomerate. This provides new information on the age and origin of the limestone clasts.

In tables 1-6 the detailed stratigraphic distribution of the conodonts is represented for each locality. The stratigraphic position of the samples in the conglomerate is respected.

Conodont numbers are low. The collections are too small to permit apparatus reconstruction.

When a sample containing several small limestone granules is dissolved, mixture of the conodont faunas of the separate clasts occurs. Sometimes, therefore, the stratigraphic extensions of the conodonts in the sample are discontinuous and do not overlap (e.g. sample C2 of borehole F53).

Most of the conodont recovered from the samples are of Eifelian/Couvinian age. However, three species : *Icriodus corniger corniger* WITTEKINDT, H. P., 1966, *Icriodus corniger rectirostratus* BULTYNCK, P., 1970 and *Icriodus culicellus* (BULTYNCK, P., 1976), have their lowest occurrences in Emsian strata.

Sample C2a of locality 4 yielded *Icriodus corniger corniger* and *Icriodus culicellus*. Specimens of *Icriodus corniger corniger* have been recorded from Emsian strata in Spain and Morocco. In the Ardennes and in the Eifel area, however, the earliest known occurrence is in Couvinian formations. Taking into account a source area situated in the latter areas, we may assume that the specimens of *Icriodus corniger corniger*, and therefore also the specimens of *Icriodus culicellus* from the same sample (C2a), have a Couvinian age.

In sample C3 of locality 4 *Icriodus rectirostratus* and *Icriodus culicellus* occur together with *Icriodus struvei* WEDDIGE, K., 1977, a species that is restricted to the Couvinian. This limits the stratigraphic age of the other two species to the Couvinian.

Other conodonts of Couvinian age are : *Icriodus retrodepressus* BULTYNCK, P., 1970, *Icriodus werneri* WEDDIGE, K., 1977, *Icriodus obliquimarginatus* BISCHOFF, G. & ZIEGLER, W., 1957, *Polygnathus zieglerianus* WEDDIGE, K., 1977, *Polygnathus linguiformis linguiformis* HINDE, G. I., 1879 and *Polygnathus costatus costatus* KLAPPER, G., 1972. *Polygnathus linguiformis linguiformis* and *Icriodus obliquimarginatus* extend into the Givetian. The other listed species are restricted to the Couvinian.

Polygnathus linguiformis klapperi CLAUSEN, C. D. & LEUTERITZ, K. & ZIEGLER, W., 1979 ranges from the top of the *ensensis* Zone to the *varcus* Zone (Givetian). The species does not reach the top of the latter zone.

Eognathodus bipennatus bipennatus (BISCHOFF, G. & ZIEGLER, W., 1957) ranges from the middle part of the *ensensis* Zone (Lower Givetian) to the lower *varcus* Zone (middle Givetian).

Conodont number	Locality	Sample	COUVINIAN 2c	2d	GIVETIAN			FRASNIAN			FAMENNIAN								TOURNAISIAN			
			kockelianus	ensensis	varcus	hermanni cristatus	disparilis	asymmetricus	Ag. triangularis	gigas	Pa. triangularis	crepida	rhomboidea	marginifera	trachytera	postera	expansa	praesulcata	Siphonodella	communis carina	anchoralis	Conodont Zones
2	1	C6		—	—																	*I. obliquimarginatus*
21	1	C5a							—	—												*A. cf. nodosa*
									—	—												*Ag. triangularis*
									—	—												*P. decorosus*
7	1	C5c		—	—																	*E. bipennatus bipennatus*
13	1	C2															—	—	—	—		*P. communis carina*

Table 1 - Stratigraphic distribution of conodonts. Malmédy Bevercé, locality 1.
A. = *Ancyrodella* *E.* = *Eognathodus* *P.* = *Polygnathus*
Ag. = *Ancyrognathus* *I.* = *Icriodus* *Pa.* = *Palmatolepis*

Conodont number	Locality	Sample	COUVINIAN 1: patulus	2a - 2b: costatus costatus	2a - 2b: australis	2c: kockelianus	2d: ensensis	GIVETIAN: varcus	GIVETIAN: hermanni cristatus	GIVETIAN: disparilis	FRASNIAN: asymmetricus	FRASNIAN: Ag. triangularis	FRASNIAN: gigas	FAMENNIAN: Pa. triangularis	FAMENNIAN: crepida	FAMENNIAN: rhomboidea	FAMENNIAN: marginifera	FAMENNIAN: trachytera	FAMENNIAN: postera	FAMENNIAN: expansa	FAMENNIAN: praesulcata	TOURNAISIAN: Siphonodella	TOURNAISIAN: communis carina	TOURNAISIAN: anchoralis	Conodont Zones
1	3	C 12a					—	—																	*I. obliquimarginatus*
7	3	C 10a	—	—																					*I. werneri*
				—	—	—																			*I. struvei*
89	3	C 8a																	—	—	—	—	—	—	*P. communis communis*
																—	—	—	—	—					*P. semicostatus*
																	—	—	—	—	—	—			*"Sp." stabilis*
																	—	—							*P.* cf. *nodoundata*
																			—	—					*P. obliquicostatus*
12	3	C 7a	—																						*I. retrodepressus*
			—	—																					*I. corniger corniger*
				—	—	—																			*I. struvei*
16	3	C 6b		—	—																				*P. costatus costatus*
				—	—	—																			*I. struvei*
				—	—	—	—	—	—	—															*P. linguiformis linguiformis*
2	3	C 2b	—	—																					*I. werneri*

Table 2 - Stratigraphic distribution of conodonts. Malmédy Bevercé, locality 3.
Ag. = *Ancyrognathus* *P.* = *Polygnathus* *Sp.* = *Spathognathodus*.
I. = *Icriodus* *Pa.* = *Palmatolepis*

Conodont number	Locality	Sample	EMSIAN: gronbergi	EMSIAN: inversus	EMSIAN: serotinus	COUVINIAN 1: patulus	2a-2b: costatus costatus	2c: australis	2c: kockelianus	2d: ensensis	GIVETIAN: varcus	Conodont Zones
10	4	C2a		—	—							*I. culicellus*
				—	—	—						*I. corniger corniger*
2	4	C2b				—	—					*P. costatus* subsp. indet.
16	4	C3		—	—	—						*I. culicellus*
				—	—	—						*I. corniger rectirostratus*
							—	—	—	—		*I. struvei*
4	5	C2					—	—	—	—		*I. struvei ?*
				—	—	—						*I. culicellus*
1	9	C1b				—	—					*I. corniger corniger* → *I. struvei*

Table 3 -
Stratigraphic distribution of conodonts.
Malmédy, localities 4-5.
Malmédy Bevercé, locality 9.

I. = *Icriodus*.
P. = *Polygnathus*.

Conodont number	Locality	Sample	GIVETIAN		FRASNIAN			FAMENNIAN								
			hermanni cristatus	disparilis	asymmetricus	Ag. triangularis	gigas	Pa. triangularis	crepida	rhomboidea	marginifera	trachytera	postera	expansa	praesulcata	Conodont Zones
24	10	C1			—	—	—									*Pa. subrecta*
							—									*Ag. asymmetricus*
								—	—	—	—					*I. alternatus*
								—	—	—	—	—				*Pa.* cf. *minuta minuta*

Table 4 – Stratigraphic distribution of conodonts.
Malmédy Hausta, locality 10.
Ag. = *Ancyrognathus*
I. = *Icriodus*
Pa. = *Palmatolepis*

Conodont number	Locality	Sample	COUVINIAN 1	COUVINIAN 2a-2b	COUVINIAN 2c	COUVINIAN 2c	COUVINIAN 2d	GIVETIAN			FRASNIAN →	FAMENNIAN		
			patulus	costatus costatus	australis	kockelianus	ensensis	varcus	hermanni cristatus	disparilis	asymmetricus	Pa. triangularis		Conodont Zones
1	F4	C1									— →	—		*Ancyrodella* sp. indet.
4	F4	C4		—	—	—								*I.* cf. *struvei*
4	F4	C5		—	—	—								*I.* cf. *struvei*
			—											*I.* cf. *retrodepressus*
17	F4	C7	—											*I. retrodepressus*
				—	—	—								*I. struvei*
				—										*P. ziegleri anus*

Table 5. – Stratigraphic distribution of conodonts.
Malmédy Hausta, borehole F4
I. = *Icriodus*
P. = *Polygnathus*
Pa. = *Palmatolepis*

Conodont number	Locality	Sample	COUVINIAN 2c	COUVINIAN 2d	GIVETIAN			FRASNIAN			FAMENNIAN								TOURNAISIAN			
			kockelianus	ensensis	varcus	hermanni cristatus	disparilis	asymmetricus	Ag. triangularis	gigas	Pa. triangularis	crepida	rhomboidea	marginifera	trachytera	postera	expansa	praesulcata	Siphonodella	communis carina	anchoralis	Conodont Zones
	F53	C1			—																	*P. linguiformis klapperi*
	F53	C2						—														*A. rotundiloba rotundiloba*
														—	—	—	—	—	—			"*Sp.*" *stabilis*

Table 6 – Stratigraphic distribution of conodonts.
Malmédy Hausta, borehole
A. = *Ancyrodella*
Ag. = *Ancyrognathus*
P. = *Polygnathus*
Pa. = *Palmatolepis*
Sp. = *Spathognathodus*

Typical Frasnian forms are : *Ancyrodella nodosa* ULRICH, E. O. & BASSLER, R.S., 1926, *Ancyrodella rotundiloba rotundiloba* BRYANT, 1921), *Ancyrognathus triangularis* YOUNGQUIST, W. L., 1945 and *Polygnathus decorosus* STAUFER, C. R., 1938.

The sample collected in outcrop 10 yielded the following conodonts : *Palmatolepis subrecta* MILLER, A. K. & YOUNGQUIST, W., 1947, *Ancyrognathus asymmetricus* (ULRICH, E. O. & BASSLER, R. S., 1926), *Palmatolepis* cf. *minuta minuta* BRANSON, E. B. & MEHL, M. G., 1934 and *Icriodus alternatus* BRANSON, E. B. & MEHL, M. G., 1934. The two latter species are known as Famennian conodonts. *Ancyrognathus asymmetricus* is restricted to the Upper *gigas* Zone (upper Frasnian). The lowest occurrence of *Palmatolepis subrecta* is in the uppermost part of the Middle *asymmetricus* Zone (lower Frasnian) and the species ranges to the Lower *Palmatolepis triangularis* Zone (top of the Frasnian).

Polygnathus communis communis BRANSON, E. B. & MEHL, M. G., 1934, *Polygnathus semicostatus* BRANSON, E. B. & MEHL, M. G., 1934, *Polygnathus nodoundata* HELMS, J., *Polygnathus obliquicostatus* ZIEGLER, W., 1962 and *Spathognathodus stabilis* (BRANSON, E. B. & MEHL, M. G., 1934) were recovered from sample C8a of locality 3.

Polygnathus semicostatus ranges from the Lower *rhomboidea* Zone (lower Famennian) to the Lower *praesulcata* Zone (upper Famennian), *Polygnathus nodoundata* from the Upper *marginifera* Zone (upper Famennian) to the Lower *trachytera* Zone (upper Famennian) and *Polygnathus obliquicostatus* occurs at the base of the *postera* Zone (upper Famennian) into the Upper *expansa* Zone (upper Famennian).

Spathognathodus stabilis and *Polygnathus communis communis* are already present in the Famennian but they are also known from younger, Lower Carboniferous, formations. Because of their occurrence with exclusively Famennian conodonts, these specimens are probably of Famennian age.

The conodont collection of sample C2 of locality 1 comprises seven specimens of *Polygnathus communis carina* HASS, H., 1959 and four bars and blades which are too broken for a specific assignment.

H. HASS (1959) first described *Polygnathus communis carina* from the Chappel Limestone of Texas, and noted its occurrence in the " *Gnathodus punctatus*" Zone ("Upper Kinderhookian" = Lower Carboniferous, Tournaisian). He also recognized a few specimens in the overlying *"Bactrognathus communis"* Zone (probably Lower Osagean).

T. L. THOMPSON & L. D. FELLOWS (1969) defined the Kinderhookian-Osagean boundary on the first appearance of this short-lived subspecies and used *Polygnathus communis carina* as an index species for a Lower Carboniferous (Osagean) zone that overlies the highest *Siphonodella* Zone. In Belgium, E. GROESSENS (1974) also recognized a *Polygnathus communis carina* Zone within the Tournaisian. According to these workers *Polygnathus communis carina* seems to be restricted to the Carboniferous. However, C. A. SANDBERG & R. C. GUTSCHICK (1978) mention this subspecies from shallow water formations as low as the "Upper *Styriacus*" Zone (= Lower *expansa* Zone) and in most of the intervening zones of the Famennian and Lower Carboniferous. Only two badly-preserved and broken specimens of the Lower *expansa* Zone were illustrated by C. A. SANDBERG & W. ZIEGLER (1979). In their collection the number of the *Polygnathus communis carina* specimens was low as compared with the total conodont counts. Their specimens also differ from typical Lower Carboniferous *Polygnathus communis carina* forms, in that they are much more curved and have different ridges along the carina.

The specimens we collected show more resemblance to typical Lower Carboniferous forms. Moreover, they are abundant in the Malmédy samples. We thus conclude that the *Polygnathus communis carina* forms of the Malmédy Conglomerate are Lower Carboniferous (Ivorian) in age. They represent the youngest fossils observed in the limestone clasts of the Malmédy Conglomerate.

4.2. TABULATES, STROMATOPOROIDS AND RUGOSE CORALS.

Tables 7 and 8 show the stratigraphic extension of the megafossils which have been studied. Only fossils with a relatively restricted stratigraphic distribution are included in the tables.

Identification and stratigraphic ranges of tabulate corals and stromatoporoids are mainly based on the work of M. LECOMPTE (1939, 1951-1952). M. LECOMPTE's material was collected from Devonian rocks of the Dinant Synclinorium. The stratigraphic distribution of corals and stromatoporoids is generally considered to be facies-dependent. Since the limestone clasts were not necessarily derived from the Dinant Synclinorium, the stratigraphic extension of the Malmédy fossils may differ slightly from those proposed by M. LECOMPTE.

Tabulates are very abundant in the clasts. Usually tabulate species have restricted stratigraphic ranges. For example, *Rhapidopora magna* (LECOMPTE, M., 1939) only occurs in the Couvinian "Co 2d".

Other Couvinian "Co 2" species collected are *Caliapora chaetetoides* LECOMPTE, M., 1939, *Rhapidopora lonsdalei* (ETHERIDGE, R. & FOORD, A. H., 1884) and *Thamnopora ? vermicularis* (MC COY, F., 1850). *Heliolites porosus* GOLDFUSS, G. A., 1826 appears in the lower Couvinian "Co 1" and extends into the Lower Givetian.

Species restricted to the Lower Givetian are : *Caliapora battersbyi* (MILNE-EDWARDS, H. & HAIME, J., 1851), *Crassialveolites crassus* (LECOMPTE, M., 1939), *Crassialveolites cavernosus* (LECOMPTE, M., 1933), *Thamnopora cervicornis* (DE BLAINVILLE, H. M. D., 1826) and *Thamnopora proba* DUBATOLOV, V. N., 1952.

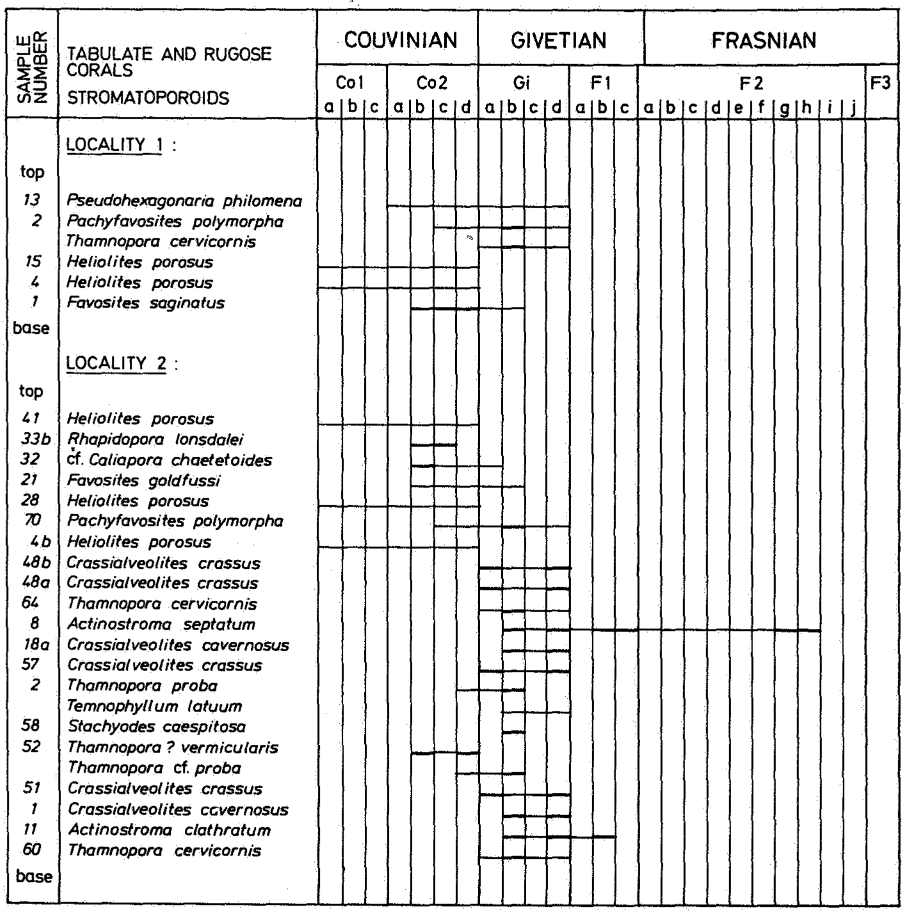


Table 7 - Stratigraphic distribution of tabulates, rugose corals and stromatoporoids, Malmédy Bevercé, localities 1-2.

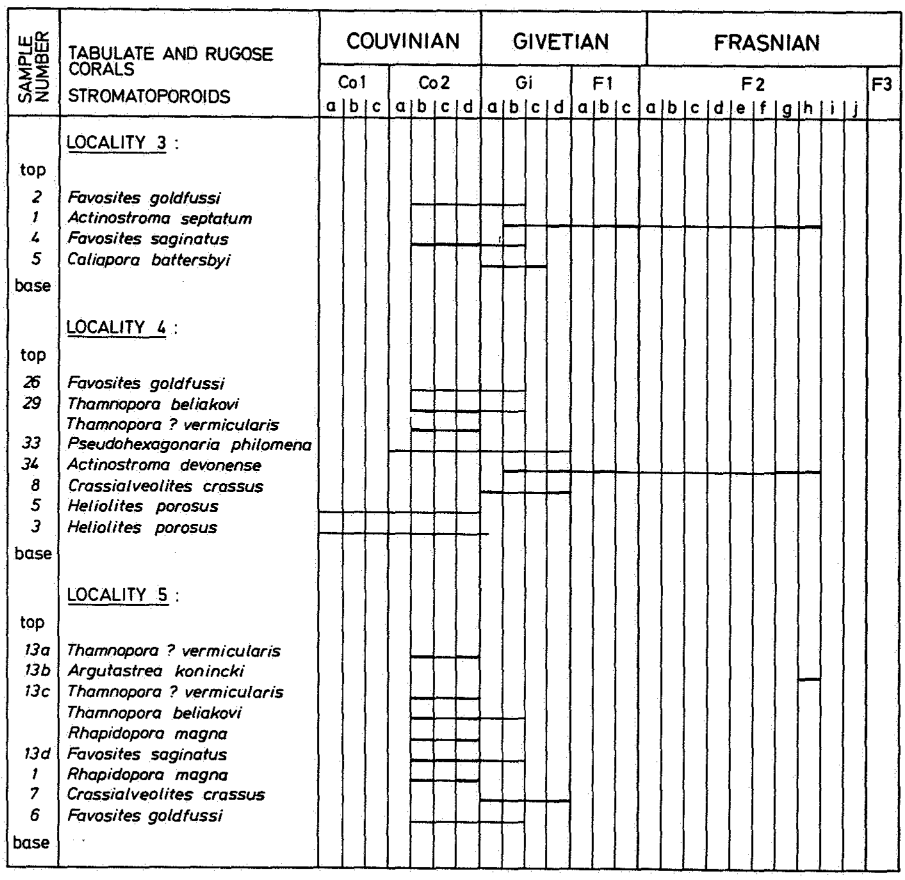


Table 8 - Stratigraphic distribution of tabulates, rugose corals and stromatoporoids. Malmédy Bevercé, locality 3. Malmédy, localities 4-5.

Other species, like *Pachyfavosites polymorphus* (GOLDFUSS, A., 1826), *Favosites saginatus* LECOMPTE, M., 1939 and *Thamnopora proba* DUBATOLOV, V. N., 1952, *Thamnopora beliakovi* DUBATOLOV, V. N., 1955, *Favosites goldfussi* d'ORBIGNY, A., 1850, occur in both Couvinian and lower Givetian stages.

Stromatoporoids are also common. These recovered from the clasts have the following ranges.

Stachyodes caespitosa LECOMPTE, M., 1951 and *Actinostroma clathratum* NICHOLSON, H. A., 1886 only occur in the lower Givetian.

Actinostroma septatum LECOMPTE, M., 1951 and *Actinostroma devonense* LECOMPTE, M., 1951 are present in the lower and upper Givetian (Fromelennes Formation) and also in the Frasnian.

As only generic assignment was possible for the other stromatoporoids collected, *Actinostroma, Atelodictyon, Amphipora, Hermatostroma* and *Stromatoporella*, they are not included in the tables. The genera *Stromatoporella, Actinostroma* and *Atelodictyon* appear in the Upper Couvinian "Co 2". The youngest *Atelodictyon* forms are known from the lower Givetian. *Actinostroma* and *Stromatoporella* extend into the Frasnian. Both *Hermatostroma* and *Amphipora* range from the lower Givetian to the Frasnian.

Well-preserved specimens of Rugosa are scarce. Specific assignment was possible for only four specimens : *Pseudohexagonaria philomena* (GLINSKI, A., 1955) (2 specimens), *Temnophyllum latuum* WALTHER, C., 1941 and *Argutastrea konincki* (ROEMER, F.A., 1855).

Temnophyllum latuum and *Pseudohexagonaria philomena* are known from Givetian formations. *Argutastrea konincki* is Frasnian.

Other genera present (but not included in the tables) are *Disphyllum, Dohmophyllum* and *Mesophyllum*. According to W. A. OLIVER & A.E.H. PEDDER (1979) *Dohmophyllum* ranges from the Couvinian into the lower Givetian, *Disphyllum* from the Couvinian into the upper Givetian, and *Mesophyllum* is restricted to the lower Givetian.

4.3. BRACHIOPODS.

A single pebble, lying among the loose debris at the foot of the exposure at locality 3a, contains brachiopods, namely *Arduspirifer arduennensis arduennensis* (SCHNUR, J., 1853). This clast, a red-brown, calcareous, fine-grained sandstone, shows features typical of the "Wiltzer Schichten" facies.

Arduspirifer arduennensis arduennensis occurs in the lower part of the Upper Emsian.

4.4. AGE RANGE OF THE LIMESTONE CLASTS.

Conodonts have extended the information concerning the age of the limestone clasts, formerly based mainly on the stratigraphic distribution of megafossils. Nevertheless, megafossils proved to be useful, especially in establishing the lower age limit of the limestone clasts.

The specimens of *Arduspirifer arduennensis arduennensis* are the sole Upper Emsian representatives.

In contrast with the results obtained by G. DEWALQUE (1868) and E. MAILLIEUX (1931), this study did not reveal fossils indicating a Lower or Middle Emsian age.

The presence of Couvinian, Givetian and Frasnian elements in the conglomerate is well documented from the known stratigraphic ranges of the corals, stromatoporoids and conodonts they contain.

An upper Famennian age for some limestone clasts is proved only by conodonts.

The youngest limestone clasts of the Malmédy Conglomerate were probably derived from Lower Carboniferous (Ivorian) formations as indicated by the occurrence of *Polygnathus communis carina*.

5. SOURCE AREA OF THE LIMESTONE CLASTS.

Based on the study of lithofacies and biofacies E. MAILLIEUX (1931) considered the Devonian synclines of the Eifel (W-Germany), more specifically the Prüm Syncline, to be the source area of the limestone clasts of the Malmédy Conglomerate. This source area is situated southeast of Malmédy.

In repeating A. RENIER's (1919) observations, P. ANTUN (1954) emphasized the importance of size distribution of the clasts in relation to the transport direction of the sediments which was considered to be towards the northwest. The largest clasts were deposited 1 km southwest of Malmédy. From there the size of the clasts decreases southwestwards towards Basse-Bodeux and northeastwards towards Xhoffraix. Recent study of size distribution along the axis of the conglomerate confirms the latter observations (C. LANDUYDT, 1982).

In the present study three different methods of recognizing the source area have been used :

- colour alteration index of the conodonts;
- age range of the limestone clasts; and
- lithofacies and biofacies of the limestone clasts.

5.1. COLOUR ALTERATION INDEX (CAI) OF THE CONODONTS. ORGANIC METAMORPHISM.

The colour of conodonts may vary from pale yellow to brown, black, opaque white and crystal clear. This colour change is related to increasing thickness and deformation of overburden covering the formation from which the conodonts were collected.

A. G. EPSTEIN & J. B. EPSTEIN & L. D. HARRIS (1977) produced the same colour alteration in laboratory experiments by heating conodonts. On the basis of these changes they distinguished five colour intervals : CAI = 1 (pale yellow) to CAI = 5 (black) (A. G. EPSTEIN & J.B. EPSTEIN & L.D. HARRIS, 1977, fig. 5). To correlate the conodont CAI with other organic maturity indices, they measured palynomorph translucency and vitrinite reflectance. Table 9 shows the correlation of conodont CAI and vitrinite reflectance values derived from their work. Conodonts recovered from the clasts of the Malmédy Conglomerate generally have a CAI of 1 or 1.5, with a maximum 2. Their pale yellow colour indicates that burial has been slight. The organic metamorphism index of the conodonts deduced from their colour can be applied in the search for the source area of the limestone clasts. Accordingly, the CAI of Devonian conodonts of the Dinant and Namur Synclinoria, and the Vesdre and Eifel areas have been studied and compared. The existing conodont collections of P. BULTYNCK provided the necessary material.

Conodonts of Devonian rocks in the Dinant and Namur Synclinoria and of the Vesdre area are greyish black. This is ascribed to overburden of the thick mass of Carboniferous sediments. They differ distinctly from the conodonts derived from the Malmédy Conglomerate.

In areas around the Stavelot Massif, conodonts with a colour index as low as those of the Malmédy Conglomerate (CAI = 1 or 2) have only been found in Devonian rocks of some of the Eifel synclines. This region, with its pale yellow conodonts is thus a possible source area of the Malmédy conodonts.

A metamorphism index was also provided by reflectance measurements on the organic material in the matrix of the conglomerate. Samples were studied by Y. SOMERS at the I.N.I.E.X. in Liège.

From the results of the measurements three populations may be distinguished :

- population 1 with an average reflectance capacity R = 0.90;
- population 2 with R = 1.31; and
- population 3 with R = 2.05.

Some of the organic spots have a metamorphism index equal to that of the conodonts. Populations 1 and 2 correlate with a conodont CAI = 1.5-2. The third population, with much higher content of fixed carbon and thus a higher metamorphism index, points to supply of debris from another source area.
Mixture of transported debris from different sources probably occured.

5.2. AGE RANGE OF THE LIMESTONE CLASTS.

Most of the limestone clasts that were collected from the Malmédy Conglomerate have a Devonian (Upper Emsian-Famennian) age.

The Eifel Limestone Synclinorium is situated in a Devonian framework. The age of formations outcropping in the synclines ranges between the Lower Emsian ("Stadtfeld-Schichten") and Famennian (Nehdenian) : only the Prüm Syncline offers the complete sequence. Erosion in this part of the Eifel area probably provided the abundant Devonian debris of the Malmédy Conglomerate.

Among the Malmédy clasts, however, are representatives of Upper Famennian and Lower Carboniferous formations. At present, no rocks of that age are known in the Eifel and, judging from the low CAI of the Eifel conodonts (little overburden) were probably never deposited there. The clasts assigned an Upper Famennian or Lower Carboniferous age were therefore not derived from the Eifel Synclinorium. Other sources must be considered.

5.3. LITHOFACIES AND BIOFACIES OF THE LIMESTONE CLASTS.

Lithofacies and biofacies of a clast of known age may provide clues to the source of the clasts.

The clast 13c, collected in locality 5, consists of yellow-brown crinoidal limestone with scattered tabulates, namely *Rhapidopora magna, Thamnopora beliakovi* and *Thamnopora ? vermicularis*. The red, crinoidal limestone 52 from section 2 contains *Thamnopora ? vermicularis* and *Thamnopora* cf. *proba*. The stratigraphic distribution of these tabulates indicates an uppermost Couvinian "Co 2d" age for both pebbles.

This type of limestone is not known in Couvinian formations of that age in the Ardennes. Couvinian "Co 2d" limestones, deposited in the vicinity of the type locality Couvin, appear to be bituminous and are dark, bluish grey in colour (P. BULTYNCK, 1970). J. GODEFROID (1968) described light to dark, coral limestones in the vicinity of Wellin and Jemelles, east of Couvin.

The latter observations prove that these crinoidal limestone clasts were probably not derived from the Couvinian "Co 2d" formations of the Ardennes.

As corals are facies controlled, they also may be valuable guides to possible source areas.

Specimens of *Pseudohexagonaria philomena* are known from the "Rohrer Schichten" of the "Rohrer Mulde" and "Dollendorfer Mulde". These synclines are part of the Devonian Limestone Synclinorium of the Eifel. Givetian formations in the Ardennes also contain *Pseudohexagonaria philomena*.

This example shows that the Eifel area of W-Germany was a possible source of the Malmédy fossiliferous limestone clasts.

In locality 2 one specimen of *Temnophyllum latuum* was collected. This rugose coral species occurs in Givetian formations of the Dinant and Namur Basin and also in the "Schwelmer Kalk" (Givetian) of Sauerland (W-Germany). However, no specimens of *Temnophyllum latuum* have yet been recorded from the Devonian rocks of the Eifel Synclinorium. Thus, it cannot be assumed that all the clasts originated in the Devonian synclines of the Eifel. Other sources must also be considered.

6. STUDY OF THE MATRIX.

In order to find microfossils on which dating of the conglomerate can be based, thin sections of the matrix were made from a representative sample for each of the exposures studied.

The matrix is very heterogeneous both in grain size and composition. The detrital elements range in size from 200μ to a few cm. They include fragments of limestones, fine-grained sandstones, and calcareous shales as well as much detrital quartz. The cement is mainly calcitic.

The limestones fragments are micritic, pelmicritic or pelsparitic (classification of R. L. FOLK, 1959), with scattered fossils and fossil fragments. This fauna consists of bryozoans, brachiopods, ostracods, crinoids and calcispheres. Fragments of corals, stromatoporoids and calcareous algae are also present.

The smallest calcareous elements in the matrix are broken bryozoans and micritic fragments with pellets. The fragments are angular, badly preserved and bioturbated. In many cases the bryozoan and limestone fragments are iron-impregnated and are therefore more resistant.

Study of the thin sections shows that the matrix materials were probably derived from the same rocks as the larger clasts.

No microfossils were discovered in this study and so no criteria have been found to date the sedimentation of the Malmédy Conglomerate.

CONCLUSIONS.

In the determination of the age and provenance of the limestone clasts of the Malmédy Conglomerate, the included fauna has produced most useful information.

The age range of the limestone clasts extends from the lower part of the Upper Emsian to the Lower Carboniferous (Ivorian). This age was deduced from the stratigraphic distribution of the fossils. For the first time the clasts were processed for conodonts. Additionally, stromatoporoids, brachiopods and rugose and tabulate corals were investigated.

Debris in the conglomerate was probably derived from more than one source area.

The Eifel Limestone Synclinorium (W-Germany) is likely to have been a source area for the Devonian (Upper Emsian-Lower Famennian) limestone clasts.

The following criteria support this view :

1. The pale yellow colour of the conodonts (CAI = 1, maximum 2) indicates a low organic metamorphism index. In the vicinity of Stavelot only the Eifel conodonts show such low CAI (1.5 or 2).
2. The biofacies of some of the limestone clasts show close affinities with Devonian formations of the Eifel area.
3. The age range of the Devonian limestone clasts (Upper Emsian-Lower Famennian) is now only represented in the Prüm Syncline of the Eifel area.
4. Previous studies have demonstrated that debris supply occurred towards the northwest, as deduced from the size distribution of the roundstones.

However, other sources providing Devonian as well as Lower Carboniferous debris, cannot be excluded.

Indications are :

1. Upper Famennian and Lower Carboniferous limestone clasts exist in the conglomerate but rocks of these time intervals are not known in the Eifel.
2. Some of the rugose corals of the Malmédy Conglomerate have affinities with those of Sauerland and the Ardennes.
3. Part of the organic matter in the matrix show higher organic metamorphism indices than those indicated by the Eifel conodonts.

Although the Malmédy Conglomerate is generally considered to be Permian, no confirmation for this age has been found in the study of the matrix. All fossils and fossil fragments in the matrix seem to be debris probably derived from the same formations as the limestone clasts. The limestone clasts representing the youngest formations are Lower Carboniferous (Ivorian). Because Tertiary and Cretaceous rocks partially cover the northern flank of the conglomerate in the vicinity of Malmédy and Stavelot, the Malmédy Conglomerate is of post-Ivorian, pre-Cretaceous age.

These are the first results of a study designed to provide a detailed and extended investigation of the Malmédy Conglomerate.

Work is in hand to deal with unsolved problems, such as the additional source areas of the pebbles, the age of deposition of the conglomerate, and its relation to equivalent formations in surrounding areas.

CONODONTS		VITRINITE	
CAI	Temperature in °C	Reflectance	Percent fixed Carbon
1	50-80	< 0,8	60
1,5	50-90	0,70-0,85	60-65
2	60-140	0,85-1,3	65-73
3	110-200	1,4 -1,95	74-84
4	190-300	1,95-3,6	84-95
5	300-400	+ 3,6	+ 95

Table 9 - Chart showing correlation of conodont CAI and vitrinite reflectance. From A.G. EPSTEIN & J.B. EPSTEIN & L. D. HARRIS, 1977, figure 11.

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PLATE I

(All figures X60)

Fig. 1 - 2 *Icriodus corniger corniger* WITTEKINDT, H. P., 1966.
1. upper view
   Malmédy, Loc. 4 sample C2a
2. lower view
   Malmédy Bevercé, Loc. 3b sample 7a

Fig. 3 *Icriodus culicellus* (BULTYNCK, P., 1976)
   upper view
   Malmédy, Loc. 4 sample C3

Fig. 4 - 5 *Icriodus werneri* WEDDIGE, K., 1977
4. upper view
   Malmédy Bevercé, Loc. 3a sample C2b
5. Lower view
   Malmédy Bevercé, Loc. 3b sample C10a

Fig. 6 *Polygnathus zieglerianus* WEDDIGE, K., 1977
   upper view
   Malmédy Hausta, Borehole F4 sample C7

Fig. 7 - 9 *Icriodus retrodepressus* BULTYNCK, P., 1970
7. upper view
   Malmédy Bevercé, Loc. 3b sample C7a
8. upper view
   Malmédy Hausta, Borehole F4 sample C7
9. lateral view
   Malmédy Hausta, Borehole F4 sample C7

Fig. 10 - 12 *Icriodus struvei* WEDDIGE, K., 1977
10. upper view
   Malmédy Bevercé, Loc3b sample C10a
11. lower view
   Malmédy Bevercé, Loc. 3b sample C7a
12. lateral view
   Malmédy, Loc.4 sample C3

Fig. 13 - 14 *Icriodus obliquimarginatus* BISCHOFF, G. & ZIEGLER, W., 1957
13. upper view
   Malmédy Bevercé, Loc. 1 sample C6
14. lower view
   Malmédy Bevercé, Loc. 3b sample C12

Fig. 15 *Icriodus* cf. *alternatus* BRANSON, E. B. & MEHL, M. G., 1934.
   upper view
   Malmédy Hausta, Loc. 10 sample C1

Fig. 16-17 *"Spathognathodus" stabilis* BRANSON, E. B. & MEHL, M. G., 1934
16. upper view
   Malmédy Bevercé, Loc. 3b sample C8a
17. lateral view
   Malmédy Bevercé, Loc. 3b sample C8a

Fig. 18-19 *Eognathodus bipennatus bipennatus* (BISCHOFF, G. & ZIEGLER, W., 1957)
18. upper view
   Malmédy Bevercé, Loc. 1 sample C5c
19. lateral view
   Malmédy Bevercé, Loc. 1 sample C5c

PLATE 1

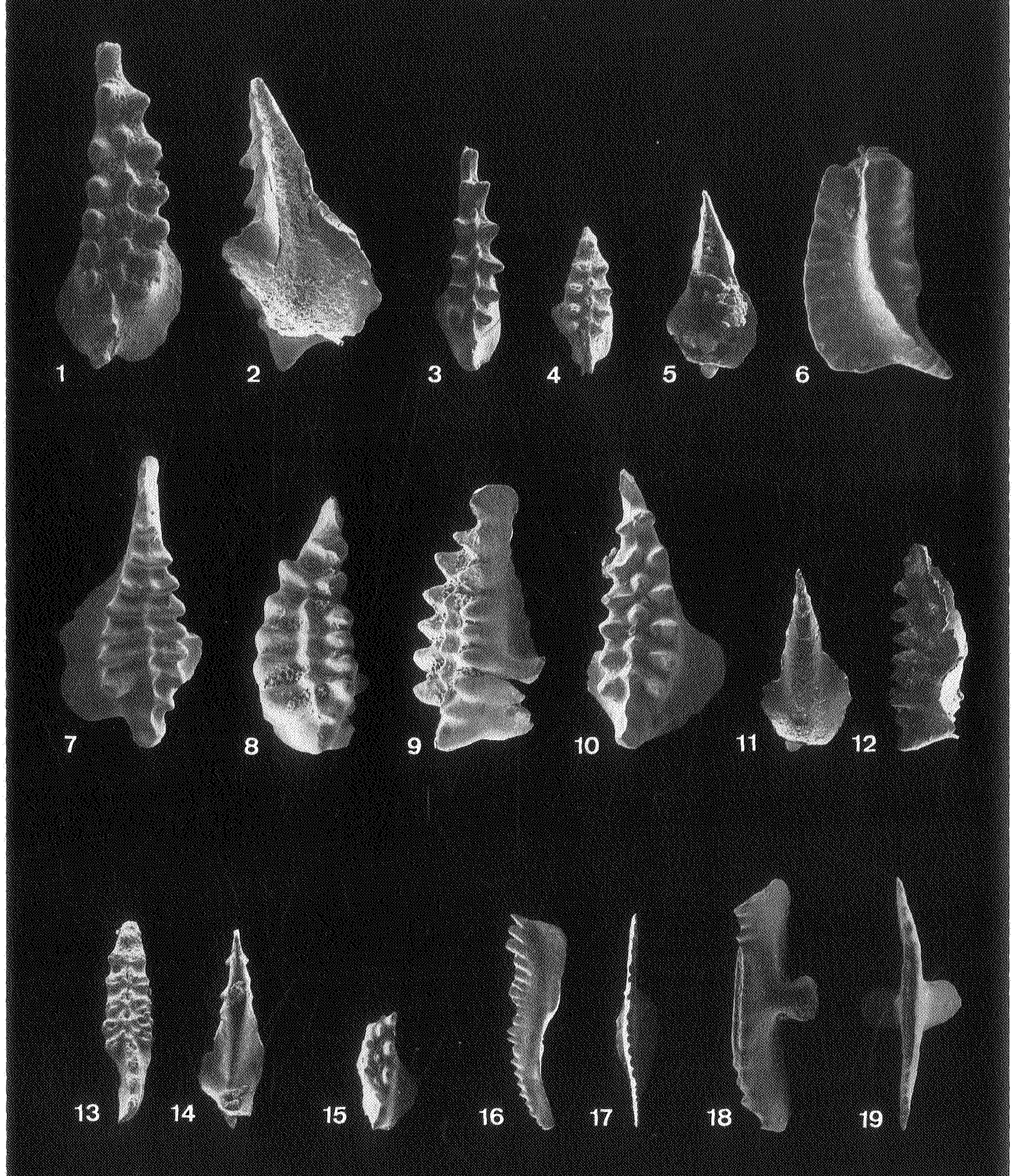

PLATE II

(All figures X60, except figure 10 X30)

Fig. 1 *Palmatolepis* cf. *minuta minuta* BRANSON, E. B. & MEHL, M. G., 1934
upper view
Malmédy Hausta, Loc. 10 sample Cl

Fig. 2 *Polygnathus linguiformis linguiformis* HINDE, G. I., 1879
upper view
Malmédy Bevercé, Loc. 3a sample C6b

Fig. 3 *Polygnathus linguiformis klapperi* CLAUSEN, C. D. & LEUTERITZ, K. & ZIEGLER, W., 1979
upper view
Malmédy Hausta, Borehole F53 sample Cl

Fig. 4 - 5 *Polygnathus decorosus* STAUFER, C. R., 1938
4. upper view
Malmédy Bevercé, Loc. 1 sample C5
5. lower view
Malmédy Bevercé, Loc. 1 sample C5

Fig. 6 - 9 *Polygnathus semicostatus* BRANSON, E. B. & MEHL, M. G., 1934
6. upper view
Malmédy Bevercé, Loc. 3b sample C8a
7. juvenile specimen, upper view
Malmédy Bevercé, Loc. 3b sample C8a
8. lower view
Malmédy Bevercé, Loc. 3b sample C8a
9. lateral view
Malmédy Bevercé, Loc. 3b sample C8a

Fig. 10 *Polygnathus* cf. *nodoundata* HELMS, J.
upper view
Malmédy Bevercé, Loc. 3b sample c8a

Fig. 11 *Polygnathus obliquicostatus* ZIEGLER, W., 1962
upper view
Malmédy Bevercé, Loc. 3b sample C8a

Fig. 12-13 *Polygnathus communis communis* BRANSON, E. B. & MEHL, M. G., 1934
12. juvenile specimen, upper view
Malmédy Bevercé, Loc. 3b sample C8a
13. upper view
Malmédy Bevercé, Loc. 3b sample c8a

Fig. 14-15 *Polygnathus communis carina* HASS, H., 1959
14. upper view
Malmédy Bevercé, Loc. 1 sample C2
15. lower view
Malmédy Bevercé, Loc. 1 sample C2

Fig. 16 *Ancyrodella rotundiloba rotundiloba* BRYANT, W. L., 1921.
upper view
Malmédy Hausta, Borehole F53 sample C2

Fig. 17 *Ancyrodella* cf. *nodosa* ULRICH, E. O. & BASSLER, R. S., 1926
upper view, outer lobe broken
Malmédy Bevercé, Loc. 1 sample C5

Fig. 18 *Ancyrognathus asymmetricus* (ULRICH, E. O. & BASSLER, R. S., 1926)
upper view
Malmédy Hausta, Loc. 10 sample Cl

Fig. 19 *Ancyrognathus triangularis* YOUNGQUIST, W. L., 1945
upper view
Malmédy Bevercé, Loc. 1 sample C5

Fig. 20 *Palmatolepis* cf. *subrecta* MILLER, A. K. & YOUNGQUIST, W., 1947
upper view
Malmédy Hausta, Loc. 10 sample Cl


PLATE 2
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