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The Callovian and Oxfordian of the Boulonnais area in northern France: new biostratigraphic data

ABSTRACT: New exposures north of Marquise (Boulonnais, France) of "Montaubert Clays" (Upper Callovian) and "Coquillot Clays" (Lower Oxfordian) allowed to describe precisely: (*i*) detailed lithological succession of these formations; and for the first time: (*ii*) succession of ammonite faunas; (*iii*) succession of biohorizons. These outstanding sections indicate that all deposits from the Late Callovian to the Lower Oxfordian (Mariae Zone) of Western Europe can now be correlated at the horizon scale.

INTRODUCTION

Late Callovian and Lower Oxfordian deposits are often absent in Western Europe. Where they do occur they are always thin (rarely more than about 10 m thick). They are either marly sediments containing crushed fossils or clays featuring pyritic fossils. The only known exception occurring as an outcrop is the "Terres Noires" series in the basin of south-eastern France where deposits of this period can be over 300 m thick. Lengthy studies of the succession of ammonite faunas of this region, along with data collected *in situ* on the Isle of Skye (Scotland) either by TURNER (1966, 1970) or by MARCHAND (1986), mainly in the Praecordatum subzone, resulted in establishing of six new biohorizons for the Mariae Zone alone (FORTWENGLER & MARCHAND 1994).

The sections at Uzelot, 3 km north of Marquise (Boulonnais) fill the gap in data between these two regions (*see* Text-fig. 1). It is a clay series with a wealth of small pyritic fossils but is often interspersed by more carbonate beds containing larger ammonites so a link can be made between the pyritic ammonites, which are always small, and the larger-diametered ones.

The detailed biostratigraphy is mainly based on the Cardioceratinae. However, the study of a few rare species that have a limited vertical range and the detailed analysis of changes in the faunal spectra have confirmed chronostratigraphic divisions deduced from the study of the Cardioceratinae.

LITHOLOGY OF THE UZELOT SECTIONS

Les marnes de Belle (The "Belle Marls")

These are only exposed in section No 2 (*see* Text-fig. 2). This formation is represented here by 20 cm of sandy clay with ferruginous nodules succeeded by a bed of ferruginous oolite pebbles and rolled fossils and then by 10 cm of purplish clay with plant debris.

Les argiles de Montaubert (The "Montaubert Clays")

This formation consists of a 9 m thick alternating pattern of very fine bioclastic clay beds which become increasingly carbonate as one moves upwards. The first three meters are almost azoic although crocodilian remains have been found at around 1 m from the base. Above, the fauna is scarce and represented by a few bivalves and brachiopods; cephalopods, which only appear at+4 m, remain rare throughout except in the top part of the clays where a small fauna of ammonites, largely dominated by Kosmoceratinae, was collected under a perforated surface colonized by bivalves (*Gryphaea*) and brachiopods.

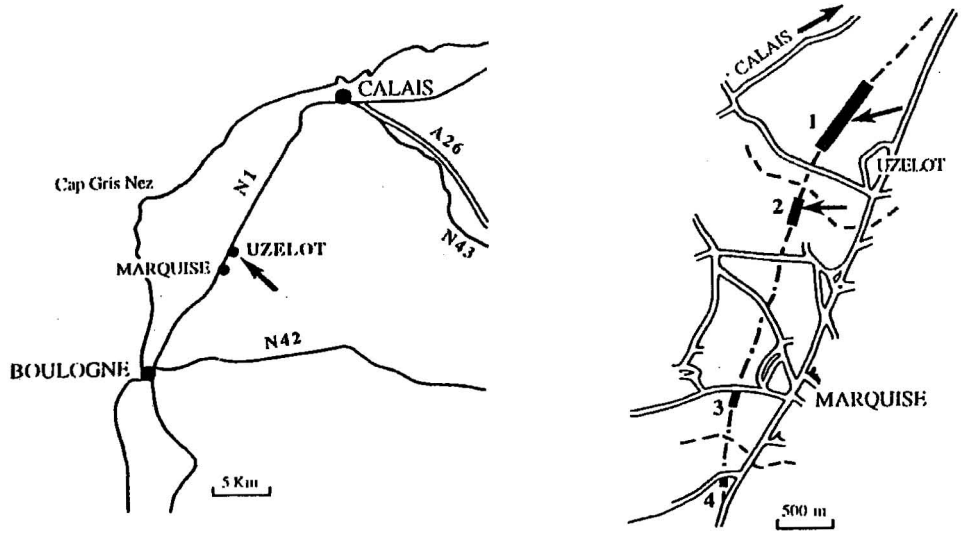


Fig. 1. Geographic situation of the studied area near Uzelot in Boulonnais

Section 1: Upper part of "Argiles de Montaubert" and "Argiles de Coquillot"; Section 2: "Argiles de Montaubert"

The "Montaubert Clays" finish with two beds of marly limestone (beds *10* and *20*) which are rich in carbonate fossils with a black patina, separated by a thin clay band that bears few fossils. These two beds were called "Calcaires marneux fissiles du Waast" by PELLAT (1878).

Les argiles du Coquillot (The "Coquillot Clays")

This formation is visible over about 11 m and corresponds to a clay series rich in pyritic fossils interspersed by marly limestome beds (intervals are named as *IT*, and marly limestone as *beds*).

The formation starts with 180 cm of clay (*IT 20-30*) which form a three-fold subdivision. At the base is a thin band (30 cm) of black plastic clay that is rich in crushed and often incomplete fossils (beds *21/22*). The next 50 cm above (beds *23/24*), not so black, contain numerous *Avicula*

and the first numerous pyritic fossils. The last meter of clay (beds *25/27*) has yielded many pyritic ammonites but also belemnites, bivalves (*Gryphaea*) and abundant plant remains.

The first bed (No *30*) is thin (10 cm) and yields a similar fauna. It is overlain by 50 cm of clay (*IT 30-40*) with few bioturbations; in this level, the authors found some pyritic ammonites of large diameter (more than 40 cm).

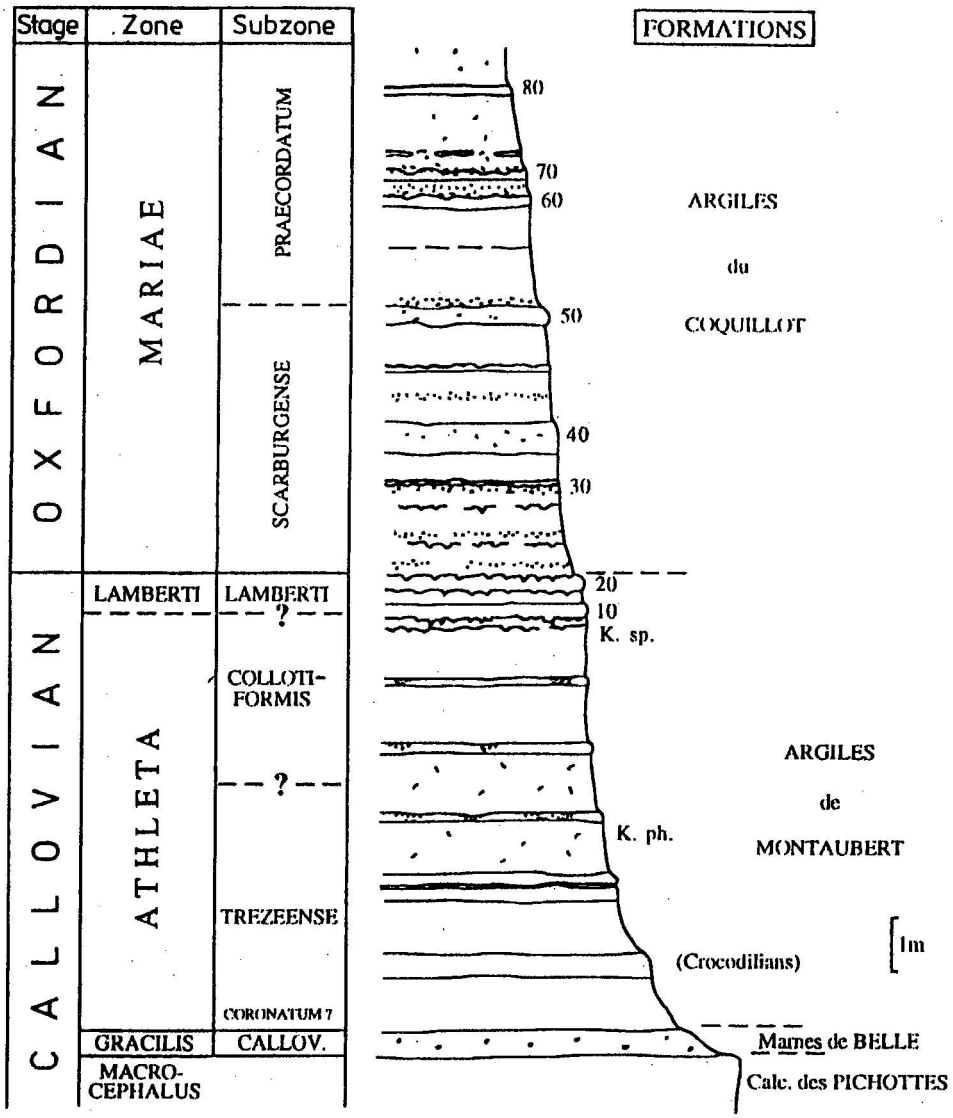


Fig. 2. Lithological succession and biostratigraphic interpretation of the two Uzelot sections

10 to 80: Number of marly limestones interbedded in clays

K. ph. — *Kosmoceras phaeinum* BUCKMAN (Athleta Zone, lower part of the Trezeense Subzone);
K. sp. — *Kosmoceras* sp.

The second bed (No *40*) which is thicker (40 to 60 cm) and more carbonate, yields a poor fauna. It is overlain by 2 m of clay (*IT 40-50*) which are rich in pyritic ammonites. Around the middle of this level (+ 110 cm) lies a more indurated level (10 cm) showing signs of bioturbation with abundant brachiopods (*Thurmanella*) on the surface.

The third bed (No *50*) is pinkish, thinner (40 cm) and rich in fauna that is variably pyritized (ammonites, bivalves, *Thurmanella*). Above it lie 2 m of clay (*IT 50-60*) which is rich in pyritic ammonites. Once again, towards the center of the level (+ 110 cm) lies a slightly more indurated level (10 cm) featuring numerous *Thurmanella*.

The fourth bed (No *60*) is a thin one (20 cm) and ammonites are fairly scarce. It is overlain by 40 cm of clay (*IT 60-70*) which is fairly rich in pyritic ammonites. There are large ammonites and belemnites whose rostra can exceed 20 cm in length; abundant lignitic debris appear at this level. This is interpreted as a sudden continental signal, probably associated with a discontinuity, as recorded by the ammonite fauna.

The fifth bed (No *70*) is thin (20 cm) and has sparse fauna. The overlying clays (*IT 70-80*), which are 140 cm thick, are rich in belemnites at the base and have yielded numerous pyritic ammonites but also larger specimens (more than 20 cm).

The final carbonate bed that is visible (No *80*) is no more than 20 cm thick and forms a poor outcrop (part of section affected by plant life).

BIOSTRATIGRAPHY AND AMMONITE FAUNAS

Bed *10*

This bed is characterized by its wealth in ammonites. From a sample of 271 individuals, the Cardioceratinae (genus *Quenstedtoceras*) and the Hecticoceratinae dominate (41.6% and 31.4%), with the Kosmoceratinae (11.4%) and the Perisphinctidae (11.8%) making up virtually all the remaining fauna.

The species *Q. lamberti* (SOWERBY) is, as ever, chiefly represented by the thin morph (morph *lamberti*). It should be noted that this population already includes individuals that cannot be distinguished from *C. paucicostatum* LANGE. Among the Hecticoceratinae, the species *H. paulovi* DE TYST and *H. punctatum* (STAHL) occur most frequently; among the Perisphinctidae, species such as *O.* (*Poculisphinctes*) *poculum* (LECKENBY) or *O.* gr. *orion* (OPPEL) always occur.

All of these species, associated with *K. duncani* (SOWERBY) and *K. spinosum* (D'ORBIGNY) mark the top part of the Lamberti Zone (Lamberti Subzone, Lamberti horizon). Compared with the Swabian Jura studied by DIETL, this level would seem to be the equivalent of the marl level that is found above the "Schwarzen Knollen Bank".

Bed *20*

This bed is also characterized by the wealth of ammonites it contains. Out of a sample of 429 individuals, the Cardioceratinae (genus *Cardioceras*) dominate by far (61.1%); in contrast the Hecticoceratinae are less abundant (13.1%) while the Perisphinctidae account for 14.7% of individuals. The Aspidoceratinae (genus *Euaspidoceras*) become fairly numerous (9.1%) and the genus *Microsphinctes* appears (1.7%). The Taramelliceratinae are absent and the Kosmoceratinae have disappeared.

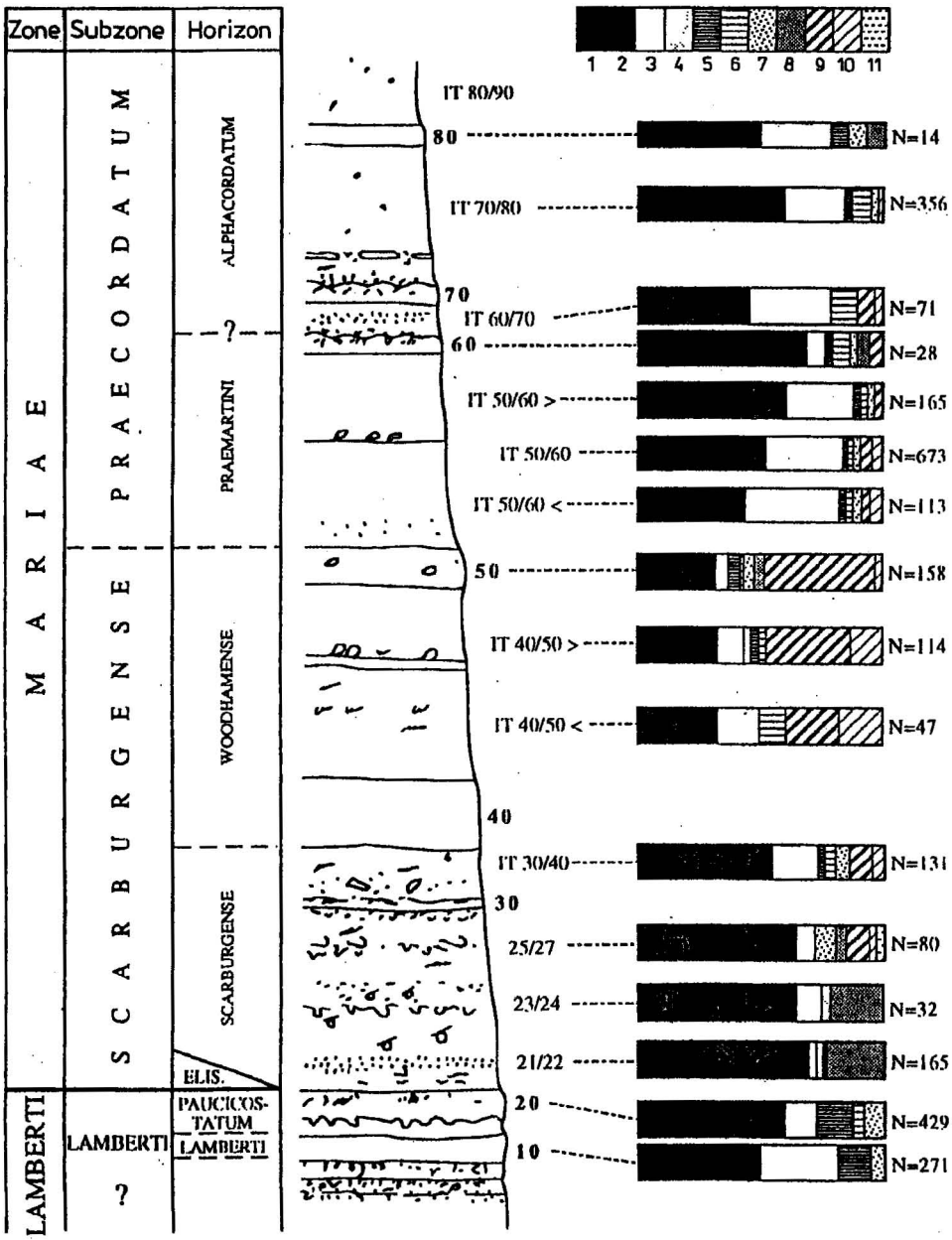


Fig. 3. Lithological succession, biostratigraphic interpretation and ammonites faunas at Uzelot (section *1*)

1 — Cardioceratinae, 2 — Kosmoceratinae, 3 — Hecticoceratinae, 4 — *Fehlmanites* and *Eochetoceras*, 5 — Perisphinctidae, 6 — *Mirosphinctes*, 7 — Euaspidoceratinae, 8 — Peltoceratinae, 9 — Taramelliceratinae, 10 — *Creniceras*, 11 — ?*Lissoceras*

The Cardioceratinae are dominated by the species *C. paucicostatum* LANGE and the "*lamberti*" variants are rare. The thin morph is still very common; medium to thick morph individuals are found but are indistinguishable from those of the underlying bed *10*. In comparison with the cardioceratid fauna of the "La Guerche" deposits (DEBRANDT-PASSARD & *al.* 1978), those of Uzelot would seem to be slightly more evolved if all ecophenotypic variations are rejected.

Within this fauna the following two facts are noteworthy: (*i*) the last Pseudoperisphinctinae are contemporaneous with *C. paucicostatum* LANGE; (*ii*) the Hecticoceratinae still have Callovian morphologies with numerous thick but not sharp, broad ribbed variants; the characteristic forms of the Elisabethae horizon (first horizon of the Oxfordian) are absent.

The fauna as a whole therefore points to the Paucicostatum horizon, as redefined by FORTWENGLER & MARCHAND (1994), *i.e.* the final Callovian horizon.

Interval *IT 20-30*

The marl unit that lies between beds *20* and *30* may be subdivided into three levels on the basis of its lithology and fauna.

Levels *21/22*

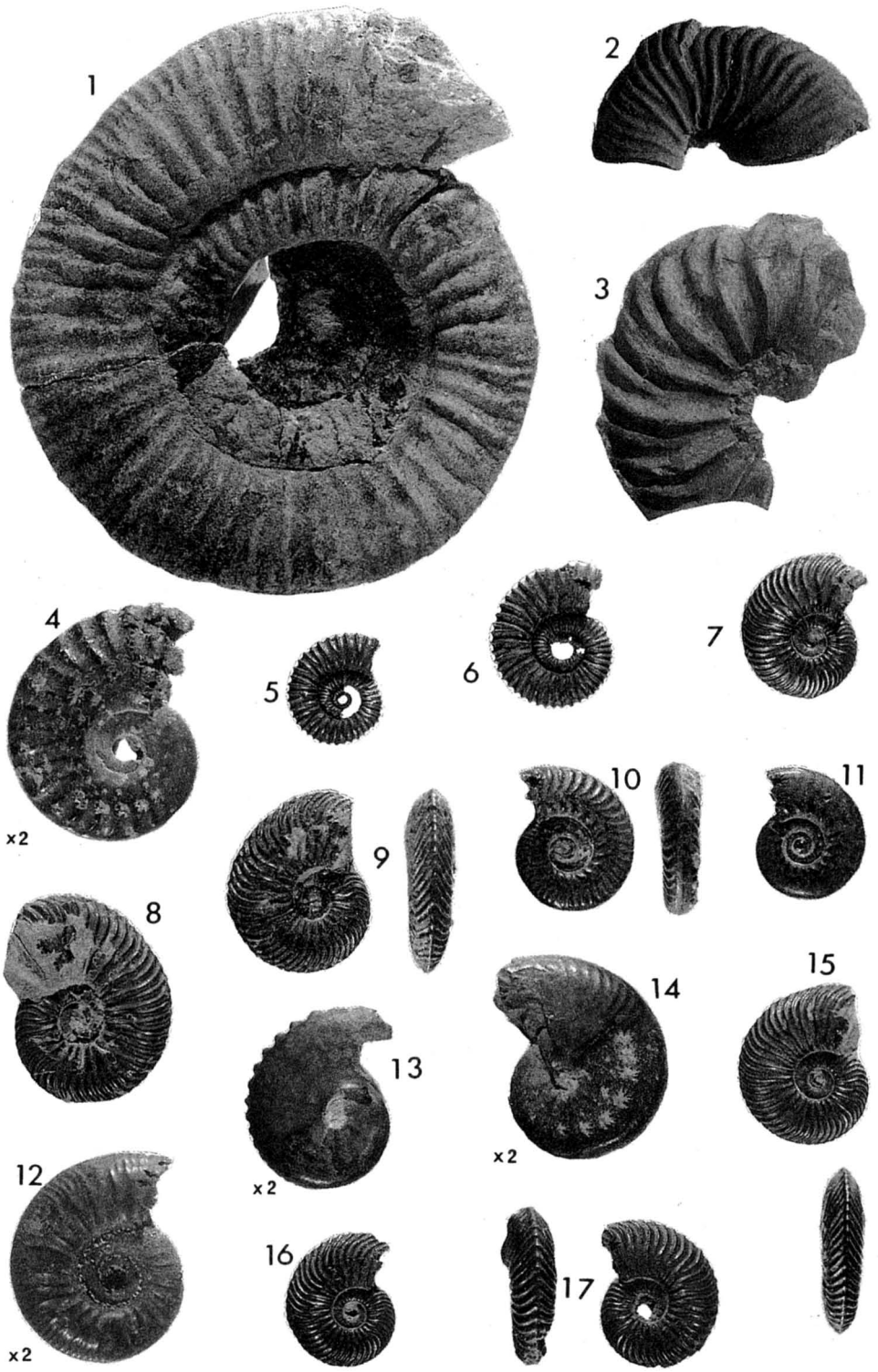
These are plastic clays rich in crushed non-pyritic fossils that are incomplete. The fauna (N=165) is dominated by the Cardioceratinae (70.9%) and the Aspidoceratidae (genus *Peltoceratoides* 22.4%). The Hecticoceratinae are rare (genus *Hecticoceras* 4.3%, *Eochetoceras* and *Fehlmanites* 1.8%) as are the Perisphinctidae (0.6%).

PLATE 1

Ammonites from the Uzelot section; Collection I.S.T., Dijon

All photos in natural size, unless otherwise stated

1 — *?Alligaticeras* sp.; bed *20*; Upper Callovian, Lamberti Zone, Lamberti Subzone, Paucicostatum horizon
2 — *Cardioceras paucicostatum* LANGE (M?); bed *20*, age as above
3 — *Cardioceras* cf. *scarburgense* (Y. & B.) (m) *in* WRIGHT, Pl. 18, Fig. 4; IT *20/30*, levels *22/23*; Lower Oxfordian, Mariae Zone, Scarburgense Subzone, Scarburgense horizon
4 — *Eochetoceras coelatum* (COQUAND) (m); IT *20/30*, level *22*; age as above; taken ×2
5 — *Peltoceratoides athletoides* (LAHUSEN); *in* LAHUSEN, Pl. 10, Fig. 6; IT *20/30*, levels *23/24*; age as above
6 — *Peltoceratoides arduennense* (D'ORBIGNY); *in* LAHUSEN, Pl. 7, Fig 3; IT *20/30*, levels *23/24*; age as above
7 — *Cardioceras scarburgense* (Y. & B.); IT *20/30*, levels *25/27*; age as above
8 — *Cardioceras* cf. *scarburgense* (Y. & B.); IT *30/40*, upper part of Scarburgense horizon
9 — *Cardioceras* cf. *scarburgense* (Y. & B.); *in* LEBERT & MARCHAND (1982, Pl. 1, Fig. 2); IT *30/40*, age as above
10 — *Hecticoceras kautzschi* NOETLING; IT *30/40*, age as above
11 — *Hecticoceras* cf. *bonarellii* DE LORIOL; IT *30/40*, age as above
12 — *Mirosphinctes bonjouri* (DE LORIOL); IT *40/50*; Lower Oxfordian, Mariae Zone, Scarburgense Subzone, lower part of Woodhamense horizon; taken ×2
13 — *Taramelliceras* aff. *richei* (DE LORIOL); *in* DE LORIOL (1900); IT *40/50*, age as above; taken ×2
14 — *Taramelliceras* cf. *dupasquieri* (DE LORIOL); IT *40/50* (upper part), age as above; taken ×2
15 — *Cardioceras woodhamense* ARKELL; IT *40/50*, age as above
16 — *Cardioceras woodhamense* ARKELL; IT *40/50* (upper part), age as above
17 — *Cardioceras woodhamense* ARKELL; thick specimen; IT *40/50* (upper part), age as above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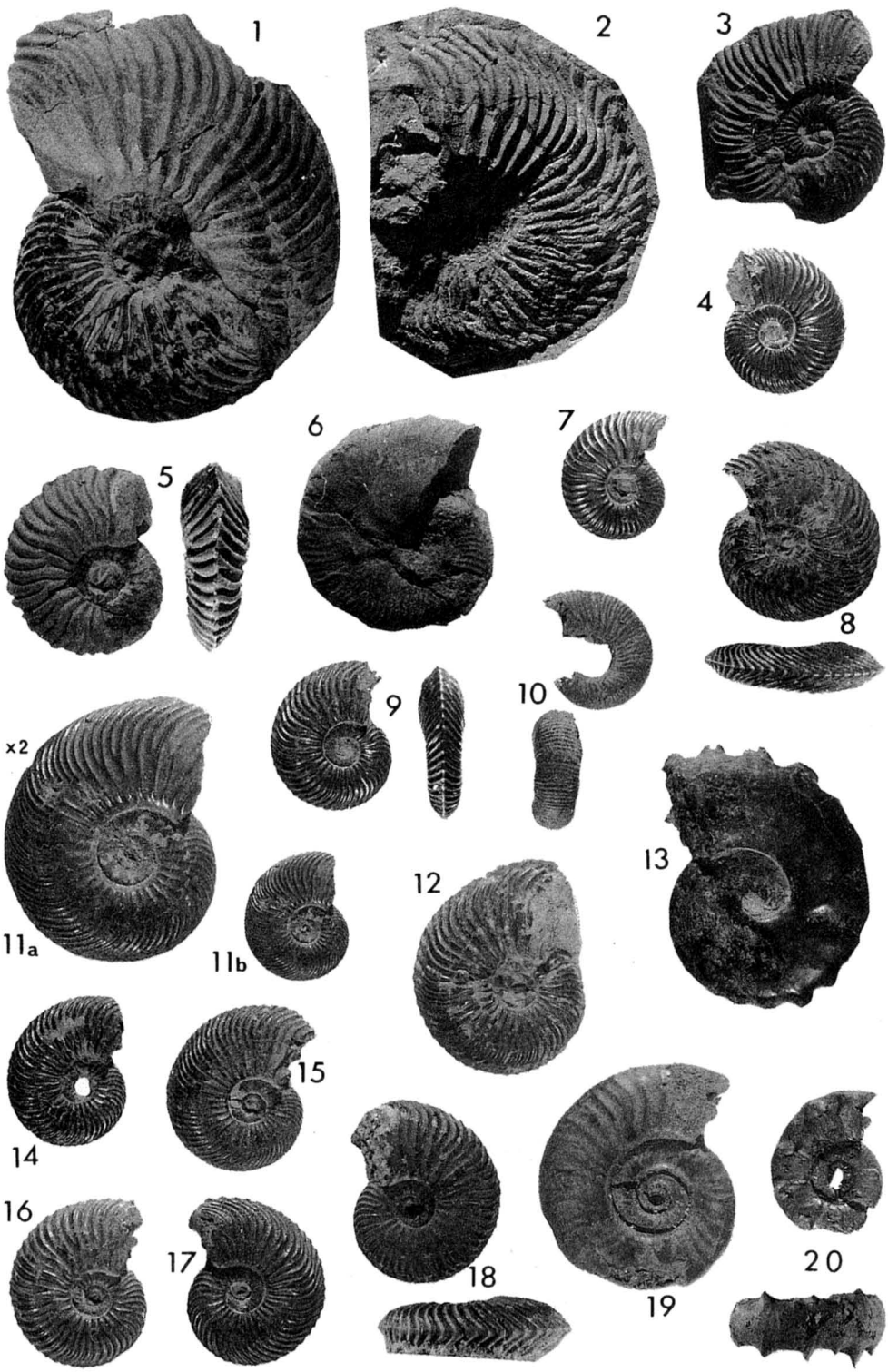
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Levels *23/24*

These levels contain fairly numerous *Avicula* associated with fairly numerous pyritic ammonites (N=32). The faunal composition is similar to that of levels *21/22*.

Levels *25/27*

Ammonites (N=80) are still dominated by the Cardioceratinae (68.8%). However, the composition of associated fauna is different: *Peltoceratoides* are now rare (3.8%) while *Euaspidoceras* reappears (7.5%); the Taramelliceratinae, which were absent hereto, now become abundant (11.2%). The Perisphinctidae are absent.

The fauna of the interval *IT 20-30* is, on the whole, characteristic of the Scarburgense horizon through: (*i*) the appearance of *Eochetoceras* (*Eochetoceras*) *coelatum* (COQUAND) which is unknown in the Elizabethae horizon; (*ii*) the mid-flank bifurcation point of the ribs in *Peltoceratoides*; (*iii*) the presence of the Cardioceratinae which in their inner whorls (under 3 cm) are close to *C. scarburgense* (YOUNG & BIRD) but which are indistinguishable beyond there from *C. paucicostatum* LANGE.

It is noted, though, that from level *25* upwards the Cardioceratinae appear which have secondary ribs that slope increasingly forward, sometimes sharply so, as they approach the venter; these morphological changes are

PLATE 2

Ammonites from the Uzelot section; Collection I.S.T., Dijon

All photos in natural size, unless otherwise stated

1 — *Cardioceras woodhamense* ARKELL var. *normandiana* SPATH; common specimen; bed *50*, Lower Oxfordian, Mariae Zone, Scarburgense Subzone, upper part of Woodhamense horizon
2 — *Cardioceras* aff. *praemartini* SPATH; rare specimen; bed *50*, age as above
3 — *Cardioceras woodhamense* ARKELL var. *normandiana* SPATH; common specimen (m?); bed *50*, age as above
4 — *Cardioceras woodhamense* ARKELL; bed *50*, age as above
5 — *Cardioceras woodhamense* ARKELL; thick specimen; bed *50*, age as above
6 — *Taramelliceras* gr. *dupasquieri* (DE LORIOL); bed *50*, age as above
7 — *Cardioceras woodhamense* ARKELL; IT *50/60*; Lower Oxfordian, Mariae Zone, Praecordatum Subzone, lower part of Praemartini horizon
8 — *Cardioceras praemartini* SPATH; IT *50/60*, age as above
9 — *Cardioceras praemartini* SPATH; specimen close to *C. woodhamense* ARKELL; IT *50/60* (upper part), age as above
10 — *Mirosphinctes marsyas* (BUKOWSKI); IT *50/60* (upper part), age as above
11a-11b — *Cardioceras praemartini* SPATH; rare specimen, with very thin ribs (natural size and taken ×2); IT *50/60*, age as above
12 — *Cardioceras* cf. *praemartini* SPATH; bed *60*; Lower Oxfordian, Mariae Zone, Praecordatum Subzone, boundary Praemartini/Alphacordatum horizon
13 — *Creniceras renggeri* OPPEL; IT *60/70*; Lower Oxfordian, Mariae Zone, Praecordatum Subzone, lower part of Alphacordatum horizon; taken ×2
14 — *Cardioceras* cf. *praemartini* SPATH; *in* SPATH (1939, Pl. 7, Fig. 2); IT *60/70*; Lower Oxfordian, Mariae Zone, Praecordatum Subzone, lower part of Alphacordatum horizon
15 — *Cardioceras* cf. *praemartini* SPATH; IT *70/80*; Lower Oxfordian, Mariae Zone, Praecordatum Subzone, lower part of Alphacordatum horizon
16 — *Cardioceras* aff. *suessiforme* SPATH; *in* LEBERT & MARCHAND (1982, Pl. 1, Fig. 11); IT *70/80*, age as above
17 — *Cardioceras* aff. *alphacordatum* SPATH; IT *70/80*, age as above
18 — *Cardioceras suessiforme* SPATH; *in* LEBERT & MARCHAND (1982, Pl. 1, Fig. 11), age as above
19 — *Mirosphinctes kobyi* (DE LORIOL); IT *70/80*, age as above
20 — *Euaspidoceras armatum* (DE LORIOL); IT *70/80*, age as above

concomitant with the massive arrival of the Taramelliceratinae. It is therefore likely that a change in environment occurred at this time (deepening?).

Bed *30*: Ammonites are scarce at this level.

Interval *IT 30-40*

This thin band has provided numerous pyritic ammonites, some of which are large in size. The faunal composition, based on 131 individuals is as follows: Cardioceratinae (53.4%), Hecticoceratinae (18.3%), Taramelliceratinae (*Taramelliceras* 13%, *Creniceras* 2.3%) for the three main groups. The Perisphinctidae (3.1%) and Aspidoceratidae (genus *Euaspidoceras* 4.6%) are also found. From this level onwards, the genus *Mirosphinctes* becomes constant (5.3%).

The Cardioceratinae are close to those of levels *25/27* even though individuals with sometimes markedly forward bending secondaries seem more abundant. This population is still to be thought of as characteristic of the Scarburgense horizon.

Bed *40*: Ammonites are scarce at this level.

Interval *IT 40-50*

This marl interval has yielded numerous ammonites (N=838), some of which were found, with certainly, either below the *Thurmanella* bed located 110 cm from bed *40* (*IT 40-50*< with N=47) or above it (*IT 40-50*> with N=114). In both instances, the fauna is dominated by the Cardioceratinae (31.9% and 33.3%). But it is worthwhile noting that the upper fauna is close, in terms of quantity, to that of bed *50*: fewer Hecticoceratinae, *Mirosphinctes* and *Creniceras*, more Perisphinctidae and Taramelliceratinae. It should be noted that the genus *Euaspidoceras* is rare at this level while *Peltoceratoides* is completely absent.

In this population only the Cardioceratinae provide data on the age of the level. Compared with *C. scarburgense* (YOUNG & BIRD) they feature the following traits: (*i*) a more triangular overall cross-section; (*ii*) slightly swollen secondary rib endings, giving the venter, seen in profile, a slightly beaded appearance; (*iii*) ribs which sometimes slope forward on the venter but that never taper.

It should further be noted that the thick individuals cannot be distinguished from the underlyig thick individuals, and that the rare individuals of over 40 mm diameter do not show signs of revertion to a more ancient morphology.

This population has all the characteristics of the species *C. woodhamense* as ARKELL (1938) described it at Woodham and which characterizes the

woodhamense horizon. Compared with the fauna of the overlying level, this fauna is located at the base of the horizon.

Bed *50*

The ammonite fauna of this bed is characterized by the size of the ammmonites which does not exceed 80 mm which is exceptional in pyritic fossil clays. The fauna (N = 158) is accompanied by sparse *Thurmanella* and rare belemnites. It is largely dominated by the Taramelliceratinae (49.4%) and Cardioceratinae (33.5%), with the other groups only accounting 17.1% of individuals: the Hecticoceratinae (5.7%), Perisphinctinae (4.4%), Euaspidoceratinae (3.8%) and Peltoceratinae (1.3%). The genera *Mirosphinctes* (0.6%) and *Creniceras* (1.3%) do occur, but are rare.

The Cardioceratinae are characterized by their great intraspecific variability. The individuals which make up the ancient pole of the population have fairly coarse ribbing which slopes little as it approaches the venter; however, the keel is always crenulated, or beaded, unlike *C. scarburgense* (YOUNG & BIRD), as the ends of the secondary ribs tend to be raised as they near the ventral axis. There is a further difference with *C. scarburgense* (YOUNG & BIRD): it can be observed that beyond 5-6 cm in diameter, the "*woodhamense*" morphology of inner whorls persists. The individuals that form the evolved pole of the population are rarer: they are always narrow in cross-section and have clearly finer and more proverse ribbing; the secondary ribs are slender and straighten as they approach the venter where they end in a clear swelling. This morphologic pattern obviously heralds that of the species *C. praemartini* SPATH. The absence of even rudimentary tubercles on the primary ribs is noted.

This population should still be considered to belong to the species *C. woodhamense* ARKELL of which it represents an evolved population.

The Taramelliceratinae are characterized by seemingly little intraspecific variability which is arranged around *T. richei* DE LORIOL.

The Hecticoceratinae are not common and are arranged around *H. kautzschi* NOETLING *in* GYGI. The Euaspidoceratinae correspond to *E.* aff. *subbabeanum* SINTZOW and *E. babeanum* (D'ORBIGNY). The only *Mirosphinctes* collected is *M. frickensis* MOESCH; the two *Creniceras* correspond to *C.* aff. *renggeri* OPPEL.

By its fauna, bed *50* seems to represent the top half of the Woodhamense horizon (top of the Scarburgense Subzone).

Interval *IT 50-60*

The fauna, whether above or below the *Thurmanella* level, is pyritic and small in size. Quantitative analysis shows that the lower fauna (N = 113) is richer in the Hecticoceratinae (44.3% as against 29.7%) than the upper one

(N = 165) but that it is poor in the Cardioceratinae (43.4% versus 60%); the remaining fauna making up 12.3% and 10.3% of individuals. The sudden scarcity of the Taramelliceratinae (1.8% and 2.4%) compared with bed *50* should be noted. As quantitative analysis does not allow the two sets of fauna to be told apart, these will be considered as one and the same population.

The Cardioceratinae stand out from those of bed *50* in several points: (*i*) the evolved pole is represented by a far greater number of individuals (one third of the population); (*ii*) individuals with very fine and highly proverse ribs appear from 15 mm diameter onwards; (*iii*) rare individuals with clearly more quadrangular cross-section occur, which implies more marked ventral shouldering and a better individualized keel. The set of characters means that the population of level *IT 50-60* should be considered to belong to the species *C. praemartini* SPATH which characterizes the Praemartini horizon, the first horizon of the Praecordatum Subzone.

Among the Hecticoceratine, most individuals up to 20 mm in diameter are smooth as with *H. bonarellii* DE LORIOL. Some individuals are found with clearly marked ribs near the umbilical edge but which are virtually smooth on the top half of the flanks (*H. chatillonense* DE LORIOL); the species *H. kautzschi* NOETLING *in* GYGI is rare. The absence of individuals resembling *H. socini* NOETLING *in* GYGI, which always occur at this level in south-eastern France, is to be noted.

The other typological species collected are: *Euaspidoceras perisphinctoides* SINTZOW, *E. armatum* DE LORIOL, *Mirosphinctes bonjouri* DE LORIOL, *M. kobyi* DE LORIOL, *M. marsyas* BUKOWSKI, *Taramelliceras richei* DE LORIOL, and *Creniceras renggeri* OPPEL.

Bed *60*

This bed has not yielded abundant ammonite fauna (N = 28): the Cardioceratinae largely dominate (67.8%) the Hecticoceratinae (10.9%) and the remainder of the fauna which is highly diverse despite the low sample numbers.

Among the Cardioceratinae, it can be seen that several individuals have a clearly quadrangular cross-section, due to marked shouldering around the top quarter of the flanks, and that fine-ribbed varieties seem infrequent. This population is therefore to be grouped with the species *C. praemartini* SPATH.

The associated fauna seems to be similar to that of the level *IT 50-60*.

Interval *IT 60-70*

Ammonite fauna is not abundant (N = 71) and is dominated by the Cardioceratinae (41.1%) and Hecticoceratinae (33.8%); the Taramelliceratinae (genus *Taramelliceras* 5.6% and *Creniceras* 2.8%) are relatively well represented. This level is distinctive in the absence of the Perisphinctidae and Aspidoceratidae and the relative abundance of the genus *Mirosphinctes* (12.7%).

The Cardioceratinae have numerous similarities with those of the level *IT 50-60*, although the following differences can be noted: (*i*) individuals with thin, strongly forward sweeping ribs now make up the majority of the population; (*ii*) several individuals have a clearly platycone shell which leads to a better individualized keel because of the more marked flattening of the venter.

This population has obvious affinities with that of bed *60* but includes a greater number of "evolved" morphologies. Despite the absence of individuals with small lateral tubercles, the fauna is considered to belong already (with some doubt) to the species *C. alphacordatum* SPATH and could characterize the base of the Alphacordatum horizon.

The other "typological" species collected are: *Euaspidoceras billodensis* DE LORIOL, *E. armatum* DE LORIOL, *Mirosphinctes frickensis* MOESCH, *M. kobyi* DE LORIOL, *Taramelliceras* gr. *episcopalis* DE LORIOL, *Taramelliceras richei* DE LORIOL, and *Creniceras renggeri* OPPEL.

Bed *70*: This level is almost azoic.

Interval *IT 70-80*

This interval has yielded an abundant pyritic ammonite fauna (N = 356) which is very largely dominated by the Cardioceratinae (61.2%) and Hecticoceratinae (25.8%). The remainder of the fauna is made up of the Perisphinctidae (3.7%), the genera *Mirosphinctes* (6.8%), *Euaspidoceras* (1.4%) and *Creniceras* (1.1%). It should be noted that a lot of euaspidoceratids are as molds badly preserved and not counted here. The genera *Peltoceratoides* and *Taramelliceras* are absent.

The Cardioceratinae have many similarities with the population of the level *IT 60-70* although there are several, sometimes subtle, differences to be observed: (*i*) the appearance of a very clearly quadrangular cross-section in some individuals; (*ii*) the appearance of a slight tendency to tubercles occurring on the primary ribs in a few individuals; (*iii*) the existence of a clearly individualized keel in a good number of specimens.

This population, which is original in its variability, is to be grouped with the species *C. alphacordatum* SPATH (appearance of individuals with tubercles) and could still characterize the base of the Alphacordatum horizon.

As for the accompanying fauna, it is observed that species like *H. kautzschi* NOETLING *in* GYGI still persist but that on the whole the Hecticoceratinae of this level tend to have ornamentation that is above all marked in the top half of the flanks and a more abrupt umbilical wall. The genus *Euaspidoceras* is still represented by *E. billodensis* DE LORIOL and *E. armatum* DE LORIOL, and *Mirosphinctes* by *M. bonjouri* DE LORIOL.

Bed *80*

Ammonite fauna is not very abundant (N = 14) and yielded seven Cardioceratinae which bear strong resemblance to the Cardioceratinae described by SASONOV as *C.* aff. *suessiforme* SPATH; among these forms one individual has clear tubercles as frequently occurs from the Alphacordatum horizon onwards. This small population indicates rather the Alphacordatum horizon than the base of the Praecordatum horizon through the absence of "*praecordatum*" morphology as described by MAIRE.

Interval *IT 80-90*

This level is exposed over about 1 m and is mostly highly distorted by pedogenesis. The rare ammonites collected are difficult to identify.

CONCLUSIONS

The new sections opened up in the Upper Callovian and Lower Oxfordian clays of the Boulonnais have yielded abundant ammonites studied bed-by-bed. The biozone pattern put forward in by FORTWENGLER & MARCHAND (1994) from samples collected *in situ* in the basin of south-eastern France and in Scotland (Isle of Skye) can be retraced.

These new sections have also provided some new recognitions. The gap of the Elisabethae horizon in the Boulonnais, as elsewhere on the NW European platform, but not in south-eastern France, reinforces the hypothesis of a lowstand on the Callovian/Oxfordian boundary.

The occurrence of fairly large ammonites in some more carbonate beds provides better understanding of the ontogeny of the Cardioceratinae of the Mariae Zone which is still poorly known because of the scarity of large specimens collected *in situ* at this level. These data confirm that the evolution of the subfamily have really occurred by paedomorphosis.

The study of faunal substitutions confirms that the genus *Peltoceratoides* is abundant at the base of the Scarburgense horizon, but absent or very scarce thereafter (until the Praecordatum horizon). This survey also shows that the species *Creniceras renggeri* OPPEL appears later on, at the top of the Scarburgense horizon, before more or less disappearing at the top of the Woodhamense horizon, and that the history of *Creniceras* is often separate from that of the Taramelliceratinae.

The study of ammonite spectra shows that quantitative changes do seem to match the sequential interpretation by which the boundary between bed *20* and interval *IT 20-30* (level *21*) is a sequence boundary, levels *IT 20-30* to *IT 40-50* correspond to a transgressive interval, bed *50* may be the equivalent of

the maximum flooding surface, and interval *IT 50-60* is the highstand before the start of a new sequence (or parasequence) above bed *60*.

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