欧洲白垩纪非海相软体动物及其地层分布①

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摘 要：本文综述了欧洲白垩纪非海相软体动物群, 列出了主要产自英格兰南部、法国和西班牙早白垩世的 16 个不同沉积层的 59 个分类单元。淡水动物群以珠蚌类双壳类和田螺类腹足类为主, 但在有些地点也存有肺螺类腹足类。这些化石类群与现代类型很相似, 说明白垩纪淡水中的水草、氧气与营养环境良好。在欧特里沃期和巴列姆期, 淡水与边缘海环境中的动物群组成都发生了显著的变化。欧洲的淡水生物群落早在巴列姆期就已存在, 此时的有些类群, 如著名的 *Margaritifera* (s.l.) *valdensis* 在欧洲西部有着广泛的分布。英格兰南部的早白垩世韦尔登群被认为是欧洲最连续的非海相白垩纪地层, 其上部的生物群可与西班牙的 Las Hoyas 动物群和法国的 Wassy 动物群相对比。这 3 个动物群, 以及法国侏罗(汝拉)和英格兰南部波倍克的侏罗纪-白垩纪的过渡生物群——Purbeck 动物群, 是了解欧洲白垩纪淡水动物群的关键动物群。

关 键 词：生物地层学, 双壳类, 腹足类, 非海相软体动物, 白垩纪, 英格兰, 法国, 西班牙, 欧洲
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REVIEW OF THE CRETACEOUS NON-MARINE MOLLUSCA AND THEIR STRATIGRAPHICAL DISTRIBUTION IN EUROPE

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Abstract Non-marine mollusc faunas from the Cretaceous of Europe are listed and reviewed. Fifty-nine taxa are recorded from sixteen different deposits. The majority of sites are Early Cretaceous, principally from southern England, France and Spain. The freshwater fauna is dominated by unionid bivalves and viviparid gastropods, however pulmonate gastropods are also present at a number of localities. Analogous modern taxa indicate that Cretaceous freshwater habitats were well weeded, oxygen and nutrient-rich environments. Major change occurred in the composition of the fauna in both freshwater and marginal marine settings during the Hauterivian and Barremian. Some taxa, notably *Margaritifera* (s.l.) *valdensis* were widely dispersed across western Europe by the Barremian, when a European freshwater community had developed. The Early Cretaceous Wealden Group of southern England is considered to be the most continuous non-marine Cretaceous sequence in Europe, and the fauna in its upper parts provides links with Las Hoyas (Spain) and Wassy (France). These three faunas along with the Jurassic-Cretaceous transitional Purbeck faunas of the French

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Jura and Purbeck (southern England) are considered key to understanding the European Cretaceous freshwater fauna.

Key words biostratigraphy, bivalves, gastropods, non-marine mollusc fauna, Cretaceous, England, France, Spain, Europe

1 Introduction

Despite almost two hundred years of study, European Cretaceous non-marine mollusc faunas remain poorly documented and those that have been documented are only now being revised since their original descriptions in the early 19th century. A generalised pattern of marine transgression throughout much of the Cretaceous means that non-marine faunas occur principally in Early Cretaceous strata in northern Europe and Iberia. With much of Europe covered by sea in Late Cretaceous times, the few non-marine settings are in southern Europe and Spain. Non-marine deposits have also tended to have poor stratigraphic resolution, with widespread application of the term 'Wealden' throughout Europe for Late Jurassic and Early Cretaceous non-marine strata. Imprecise correlation, certainly in much 20th century literature adds to the fog which obscures our knowledge of these deposits and their faunas.

2 History of Research

The discovery of dinosaurs in southern England in the early 19th century, plus the proximity to London of the sites are perhaps the most important factors why non-marine molluscs were first described in British scientific literature. Mantell (1844, 1847), J. Sowerby (1826-1829), J. Sowerby & J. de C. Sowerby (1812-1846) & J. de C. Sowerby (1836) are the primary sources for both bivalves and gastropods. From Germany Koch and Dunker (1837) and subsequently Dunker (1846) re-described taxa first described by the Sowerby's from the UK (refs above) and Roemer (1836-39), as indeed did d'Orbigny (1844, 1850) when listing unionid taxa from the Cretaceous. However, Cornuel (1874) subsequently described the important fauna from Wassy (France), a key fauna in linking the European fauna. González-Linares (1878), Palacios and Sánchez (1885) and Palacios (1890) described the 'Wealden' of Spain and named new taxa. Coquand (1865) described some molluscs in his monography about Aptian fossils from Spain. Vilanova y Piera (1858, 1863) cited and figured some molluscs from the Lower Cretaceous of Spain. Newton (1910) described new discoveries and summarised knowledge of the English Wealden unionid, in the process being first to recognise the links with other European forms.

Arkell (1942) revised gastropods from the Jurassic to Cretaceous Purbeck Group providing the first serious revision of the gastropod taxa. Huckriede (1967) undertook a major revision of the German Wealden molluscs, critically resolving nomenclatural problems arising from early naming of *Viviparus* spp. from the English Wealden. Some of Huckriede's work was subsequently revised by Bandel (1991) based upon fossils from the Jura Mountains. Yen (1966) based upon the Spanish fauna undertook a largely overlooked review of the European fauna, the conclusions of which are eccentric but thought- provoking as to the origin of the faunas. Mongin (1961) revised the large freshwater mussel *Margaritifera valdensis*, first described by Mantell (1844) in response to newly discovered diverse freshwater mussels from the modern waterways of North America. Mongin expanded on Newton's earlier observations recognising links spreading beyond Europe into Africa. Unfortunately it was not until Morter (1978) that the significance of the Wassy fauna was first recognised. This work influenced Barker et al. (1997) and subsequently Radley et al. (2006) to explore the palaeobiogeographical links of the Early Cretaceous non-marine mollusc fauna with the first substantive recognition of links with Asiatic faunas. These links, speculated upon by Yen (1966), are currently being worked on by the authors, Sha (2007, 2010) has linked new data from western Europe on the distribution of trigonioidids with that from Asia. Munt et al. (in press), Delvene & Araujo (2009a, 2009b), Delvene & Munt (2011) and Delvene et al. (2011) present modern revisions of the English and Spanish Wealden faunas.

The marginal marine Cassiopidae (Gastropoda) dis-

tributed across northern Europe and Iberia, were revised by Cleevely & Morris (1988), Mennesier (1984) and Mennesier & Calzada (1985). There is an extensive list of references about molluscs, especially gastropods from the transitional facies from the east of Spain, among them we could name Bataller (1946-47, 1949) and Calzada (1973, 1975, 1976, 1977, 1985). Mongin (1966, 1978) reviewed the 'Wealden' bivalves of Spain, however little exists documenting faunas outside of southern England, the Late Jurassic of Germany and Cretaceous of Spain. Despite growing interest in dinosaur sites in Eastern Europe and more recently Denmark and long established knowledge of sites such as Bernissart (Belgium) the molluscs remain unreported. Recent work on Purbeck age vertebrate rich sediments at Cherves-de-Cognac (Colin et al., 2003) has expanded the range of existing genera summarised by Radley (2002).

3 Cretaceous non-marine environments

The European Cretaceous records a diversity of non-marine facies of subtropical or 'Mediterranean' aspect (Allen, 1975, 1989a). Ruffell & Batten (1990) presented evidence from across Western Europe for an arid phase during the Barremian to Aptian. Bivalves and gastropods locally abound in the freshwater basins of southern England (Wealden facies) and the Iberian Peninsula. Whereas there were extensive 'Wealden' environments in the Paris Basin, Belgium and Germany the fauna seems to have been less abundant. Habitats ranged from freshwater lakes, ponds and channels to coastal lagoons of fluctuating freshwater to brachyhaline salinity (Allen et al., 1973; Allen, 1975, 1981). Brackish lagoons such as the Vectis Formation lagoon of southern England were rich habitat for specialised bivalves, characterised by high abundance but low diversity, with frequent shell beds.

Unionids are the most frequently occurring bivalves in Cretaceous freshwater habitats. Modern unionids generally need long lasting water bodies to exist in, clean well-oxygenated water with a regular supply of nutrients is essential, along with the presence of fish to act as hosts to the parasitic juveniles (Good, 2004). Bermúdez-Rochas et al. (2009) describe the association of *Margaritifera* and *Lepidotes* (semionotiform fish remains) developing the hypothesis of a palaeoecological relationship of these taxa from the Lower Cretaceous of Spain. Extant pulmonates such as the planorbid *Hippeutis complanatus* are found on weeds in ponds, canals, ditches and marshes and *Planorbarius corneus* is found in ponds, canals, marshes and rivers, *Physa fontinalis* occupies similar habitats (Ellis, 1926). Plaziat & Younis (2005) recorded that *Gyraulus* in the tributaries of the Shatt al Arab typically lives on the submerged portions of rooted plants. Extant *Viviparus* from Europe live in hard water areas with slight to moderate current and appear to thrive in water where there is a considerable amount of particulate matter in suspension. They are however, extremely sensitive to any increase in salinity above 3‰ (Fretter & Graham, 1962). Based upon the modern analogues above we can therefore postulate that the Lower Cretaceous freshwater pond and lake habitats were well weeded, and rivers were well oxygenated with a good supply of nutrients, the rivers may also have been well weeded. Palaeobotanical evidence from the Wealden of southern England indicates that emergent vegetation was dominated by *Equisetites* (Allen, 1989b).

4 Taxonomy of the Cretaceous non-marine Mollusca

Class GASTROPODA
Order ARCHITAENIOGLOSSA
Viviparus infracretacicus Huckriede
Viviparus cariniferus (J. de C. Sowerby)
Viviparus wassiacensis (Cornuel)
Viviparus bulimoides (Cornuel)
Viviparus inflatus (Sandberger) *sensu* Arkell.

Subclass CAENOGASTROPODA
Paraglauconia fittoni (Morter)
Paraglauconia shipbornensis (Mennessier)
Paraglauconia tricarinata (J. de C. Sowerby)
Theodoxus fisheri Arkell
Promathilda microbinaria Arkell

Subclass HETEROSTROPHA
Order ALLOGASTROPODA
Provalvata helicoides (de Loriol)
Ptychostylus harpaeformis (Koch & Dunker)

Order PULMONATA
Gyraulus sp.
Gyraulus loryi Coquand
Gyraulus choffati (Maillard)
Prophysa sp.
Prophysa bristovii (de Loriol)

Suborder ARCHAEOPULMONATA
Juramarinula sp.
Juramarinula cf. *durlstonense* (Arkell)

Class BIVALVIA
Order MYTILOIDA
Modiolus aequalis (J. Sowerby)

Subclass PTERIOMORPHIA
Order PTERIOIDA
Isognomon lyelli (J.de C. Sowerby)

Order OSTREOIDA
Praexogyra cf. *distorta* (J.de C. Sowerby)

Subclass PALAEOHETERODONTA
Order UNIONOIDA
'*Unio*' *aduncus* (J.de C. Sowerby)
'*Unio*' *antiquus* (J.de C. Sowerby)
'*Unio*' *cochlearella* Cornuel
'*Unio*' *compressus* (J.de C. Sowerby)
'*Unio*' *cornueliana* d'Orbigny
'*Unio*' *elongatus* Cornuel
'*Unio*' *mantelli* (J.de C. Sowerby)
'*Unio*' *martini* (J.de C. Sowerby)
'*Unio*' *porrectus* (J.de C. Sowerby)
'*Unio*' *scutellus* Cornuel
'*Unio*' *semirectus* Cornuel
'*Unio*' *subovalis* Cornuel
'*Unio*' *subsinuatus* (J.de C. Sowerby)
'*Unio*' *subtruncatus* (J.de C. Sowerby)
'*Unio*' *turgidulus* Cornuel
'*Unio*' *ventricosus* Cornuel
Protelliptio gualteri (J.de C. Sowerby)
Proparreysia cordiformis (J.de C. Sowerby)
Protopleurobema numantina (Palacios & Sánchez)
Anodonta becklesi Newton
Protoanodonta conchae Delvene & Araujo
Margaritifera idubedae (Palacios & Sánchez)
Margaritifera valdensis (Mantell)
Margaritifera (*Margaritana*) *menkei* Koch & Dunker
Subnippononaia fordi Barker *et.al.*
Nippononaia (*Paranippononaia*) *camerana* Delvene & Munt
Iberanaia iberica Delvene & Munt

Subclass HETERODONTA
Order VENEROIDA
Nemocardium (*Pratulum*) *ibbetsoni* (Forbes)
Superfamily ARCTICOIDEA
Neomiodon spp.
Neomiodon sublaevis (Roemer)
Neomiodon latoovatus (Dunker)
Neomiodon medius (J. de C. Sowerby)
Neomiodon angulata (J. de C. Sowerby)
Neomiodon fasciatus (Roemer)
Myrene angulatus (Roemer)

Superfamily CORBICULOIDEA
Filosina gregaria Casey

Order MYOIDA
Cuneocorbula cf. *arkelli* Casey

5 Stratigraphical distribution of the Cretaceous non-marine Mollusca

5.1 Berriasian

5.1.1 Purbeck Limestone Group, southern England

The most recent review of the Purbeck Mollusca is that of Radley (2002). In its lowest parts, the Purbeck Limestone Group is late Jurassic. The fauna listed below is that found in the Cinder Bed Member and above and is therefore representative of the Berriasian (probably not including the lowest Berriasian). The Purbeck Limestone Group is characterised by periodic marine incursions (Morter, 1984) and therefore the mollusc fauna has a distinct brackish aspect along with typical freshwater taxa such as *Viviparus* and *Prophysa* with both autochthonous and allochthonous assemblages.

Fauna: *Viviparus* sp., *Hydrobia* sp., *Provalvata helicoides*, *Ptychostylus harpaeformis*, *Theodoxus fisheri*, *Prophysa bristovii, Paraglauconia tricarinata*,

Promathilda microbinaria, *Juramarinula* cf. *durlstonense*, *Gyraulus loryi, Neomiodon sublaevis*, *Neomiodon* latoovatus, *Neomiodon medius*, *Neomiodon angulatus*, *Neomiodon fasciatus*, *Myrene angulata*, *Cuneocorbula* cf. *arkelli*, *Isognomon lyelli*.

5.1.2 The Purbeckian strata of Cherves-de-Cognac, Charente, south-west France Brackish and freshwater limestone-marls, sometimes stromatolitic and with gypsum layers. (Colin et al., 2003).

Fauna: *Protocardia* sp., '*Corbula*' sp.

5.1.3 Jurassic-Cretaceous transition French Jura Bandel (1991) described 23 species of gastropods from freshwater and marginal-marine deposits. However, the position of the Jurassic-Cretaceous boundary has not been determined. Taxa are con-specific with Purbeck Limestone Group fossils including *Prophysa bristovii, Ptychostylus harpaeformis, Juramarinula* cf. *durlstonense*, *Gyraulus loryi.* As the age is uncertain the full fauna is not provided.

5.2 Berriasian to Valanginian

Jydegård Formation, Bornholm, Denmark

Deposition in a low salinity lagoon, sediments consisting of sands, clays and clay ironstones (Noe-Nygaard et al., 1987).

Fauna: *Viviparus cariniferus, Neomiodon angulatus*.

5.3 Valanginian

Wealden Group, southern England (Ashdown, and Wadhurst formations, Grinstead Clay, Lower and Upper Tunbridge Wells formations)

The early Valanginian Ashdown Formation contains poorly-preserved neomiodontids and unionoideans, alluvial clays contain unionoideans. The overlying Wadhurst and Grinstead clays were deposited in dysaerobic lacustrine and lagoonal facies. Molluscan diversity is low with monospecific shell beds dominated by neomiodontids. Bivalve resting/escape traces are present in the succeeding Lower Tunbridge Wells Sand Formation (Munt et al., in press).

Fauna: *Viviparus cariniferus*, *Neomiodon* sp., *Margaritifera* (*Margaritana*) *menkei*, *Protelliptio gualteri*, '*Unio*' *aduncus*, '*Unio*' *antiquus*, '*Unio*' *compressus*, *Proparreysia cordiformis, Anodonta becklesi*, '*Unio*' *mantelli*, '*Unio*' *martini*, '*Unio*' *porrectus*, '*Unio*' *subsinuatus*.

5.4 Hauterivian

Wealden Group, southern England.

During the deposition of the Lower Weald Clay significant salinity excursions occurred as indicated by the presence of the corbiculid *Filosina* (replacing *Neomiodon* of Valanginian times) described by Casey (1955). These 'brackish-marine bands', contain mesohaline-brachyhaline oysters, corbulid and cardiid bivalves, and cassiopid gastropods. Thin limestones composed of either *Filosina* or *Viviparus* are traditionally termed '*Cyrena*' and '*Paludina*' limestones respectively (Munt et al., in press).

Fauna: *Viviparus infracretacicus*, *Viviparus cariniferus*, *Paraglauconia shipbornensis*, *Filosina gregaria*, *Nemocardium* (*Pratulum*) *ibbetsoni*, '*Unio*' *antiquus*, '*Unio*' *compressus*, *Protelliptio gualteri*, *Margaritifera* (s.l.) *valdensis*.

5.5 Hauterivian to Barremian

5.5.1 Viviparus Bed Member (Vega de Pas Formation), Basque-Cantabrian Basin, northern Spain. Interpreted as having been deposited in a lacustrine environment (Pujalte, 1981, 1982; Delvene & Araujo, 2009a).

Fauna: *Viviparus* sp., *Protoanodonta conchae* Delvene & Araujo.

5.5.2 Urbión Group, Cameros Basin, northern Spain. Fluvial sediments (Barrenechea, 1993; Delvene & Araujo, 2009a, 2009b).

Fauna: *Margaritifera idubedae*, *Protopleurobema numantina*, *Viviparus* sp.

5.5.3 Mirambel Formation, Teruel Province, south-east Spain Non-marine possibly deltaic, Lower Hauterivian (Calzada, 1976).

Fauna: *Glauconia gaudry* (Vilanova)

5.5.4 Coastal system, possibly subdeltaic, Hauterivian (Calzada , 1985).

Fauna: *Confusiscala mirambelensis* (Vilanova)

5.5.5 Bauxitic Formation, Cornet, Oradea, north-west Romania Cerithid gastropods in brackish-water limestones (Benton et al., 1997).

5.6 Barremian

5.6.1 Weald Clay, southern England The Upper Weald Clay, Barremian and is separated by a marker bed BGS 5. The Weald Clay is dominated by muds but

with frequent sandstones, '*Paludina*' limestones occur throughout.

Fauna: *Viviparus infracretacicus*, *Viviparus cariniferus*, *Paraglauconia shipbornensis*, *Filosina gregaria*, *Nemocardium* (*Pratulum*) *ibbetsoni*, *Modiolus aequalis*, '*Unio*' *compressus*, *Protelliptio gualteri*, *Margaritifera valdensis*.

5.6.2 Wessex Formation, Wealden Group, southern England The Wessex Formation was deposited in an organic-rich floodbasin preserving autochthonous and flood-generated allochthonous assemblages. The latter often preserve shells retaining ligaments, etching scars, traces of periostracum and gill supports. Channel/overbank sandstones occasionally yield unionoideans, viviparids and associated trace fossils. The Wessex Formation provides the strongest palaeobiogeographic evidence with unionoideans conspecific with France, Spain and the Middle East, notably the margaritiferid *Margaritifera valdensis* distributed from southern England to the Middle East (Mongin, 1961). The trigonioidid *Subnippononaia fordi* indicates links with freshwater environments in the Far East (Barker et al., 1997; Munt et al, in press). Brachyhaline cassiopid gastropods imply connections with Tethys, in tropical latitudes to the south (Cleevely & Morris, 1988).

Fauna: *Viviparus infracretacicus*, *Viviparus cariniferus*, *Paraglauconia fittoni*, *Paraglauconia shipbornensis, Gyraulus* sp., *Prophysa* sp.nov., '*Unio*' *compressus*, '*Unio*' *cornueliana*, '*Unio*' *elongata*, '*Unio*' *subtruncatus*, '*Unio*' *turgidula*, *Protelliptio gualteri*, *Margaritifera valdensis, Subnippononaia fordi*.

5.6.3 The La Huérguina Formation, Las Hoyas, Spain Las Hoyas is famous for its exceptionally preserved vertebrates. Deposited in a lacustrine setting, the molluscs comprise unionids, viviparid, air breathing pulmonates and the gastropod *Juramarinula*, which is considered to have been terrestrial. Bivalves are commonly found preserved in "butterfly position" indicating that the dead shells were lying on the surface for some time prior to burial. Pulmonate gastropods suggest that the fauna may be autochthonous or para-autochthonous Sweetman & Insole (2010). The fauna contains links to that of France southern England and the Jura. The fauna has been described by Delvene & Munt (in press).

Fauna: *Viviparus inflatus, Viviparus* sp., *Juramarinula* sp., *Gyraulus loryi*, *Gyraulus choffati*, *Prophysa* sp. '*Unio*' *elongatus*, '*Unio*' cf. *turgidulus*, '*Unio*' *semirecta*, *Subnippononaia fordi*

5.6.4 Cameros Basin, La Rioja, southeast Spain Fresh to brackish water system (Calzada, 1977).

Fauna [sic]: *Eomiodon cuneatus*, *Unio vicentei*, *Elliptio galvensis*, *Cerithium vidalinum*

5.6.5 Freshwater Beds of Wassy, Haute-Marne, France Fauna comprising unionids and viviparids re-corded by Cornuel (1874). Lapparent & Stchepinsky (1968) record Barremian 'red-beds' overlying iron oolites, the latter being the source of the mollusc fauna. The red beds are succeeded by deposits attributed to the Aptian marine transgression.

Fauna: *Viviparus wassiacensis, Viviparus bulimoides*, *'Unio' cochlearella* Cornuel, *'Unio' cornueliana*, *'Unio' elongata*, *'Unio' scutella*, *'Unio' semirecta*, *'Unio' subovalis*, *'Unio' turgidula*, *'Unio' ventricosa*.

5.7 Aptian

5.7.1 Vectis Formation, Wealden Group, Isle of Wight, southern England The Vectis Formation comprises two lagoonal mudstones separated by cross bedded sandstone. Frequent low diversity shell beds occur throughout the muds, including storm generated coquinas in the upper mud dominated member. These have been described by Radley & Barker (1998) and Stewart et al. (1991). Some of the molluscs found in the Vectis Formation are also present in the marine Lower Greensand and were described by Casey (1961).

Fauna: *Viviparus infracretacicus*, *Viviparus cariniferus*, *Paraglauconia fittoni*, '*Unio*' *compressus*, '*Unio*' *cornueliana*, *Modiolus aequalis*, *Praexogyra* cf. *distorta*, *Filosina gregaria, Cuneocorbula* cf. *arkelli*.

5.7.2 Enciso Group Cameros Basin, northern Spain Lacustrine sediments (Mas et al., 2005 ; Delvene & Araujo, 2009a; Delvene & Munt, 2011).

Fauna: *Paraglauconia* sp., *Margaritifera valdensis*, *Nippononaia* (*Paranippononaia*) *camerana*, *Neomiodon* sp.

5.7.3 "Capas rojas de Morella", Castellón Province, southeast Spain Marine with continental incursions, Lower Aptian (Calzada, 1973).

Fauna [sic]: *Glauconia pizcuetana*, *Glauconia studeri*, *Nerinea utrillasi*, *Cerithium fresqueti*, *Ampullina*

pradoana, *Confusiscala caneroti* (Calzada).

5.8 Albian

Barriada Member (Escucha Formation), Utrillas, Teruel (Spain) Deposited in a fluvial-palustral environment connected to a deltaic system (Pardo & Villena, 1979), Palynological data obtained by Villanueva-Amadoz (2009) indicates Late Albian date.

Fauna: *Iberanaia iberica* Delvene & Munt in Delvene et al. (in press).

5.9 Cenomanian−Maastrichtian

Late Cretaceous dinosaur sites including track ways are known throughout much of southern and central Europe, including France, Spain, Italy, Hungary and Romania (Weishampel et al., 2004). Some of these sites could potentially yield or have in the past yielded molluscs. The Natural History Museum, London has unionids from three localities in France. *Unio cuvieri* Matheron is recorded from the Upper Senonian of Ventabrien, Rhone, and from Bouches-du-Rhône, The third record is *Unio* sp. from the Senonian of Fuveau in the south of France. At this time most of northern Europe was submerged by the Chalk sea.

6 Additional records of uncertain date

The Natural History Museum has the following specimens: *Unio subsinuatus* from the Wealden near Hanover, this and specimens of *Viviparus roemeri* from near Obernkirchen, northern Germany. Both these sets of specimens are potentially Late Jurassic. In addition, a specimen of *Unio* sp. in a block also containing indeterminate small viviparids is recorded from the Wealden of Robbedck, Bornholm.

7 Overview and comments

Cretaceous freshwater habitats have been recorded from across much of Europe. However by their nature they tend to be sporadic in distribution, with the best and longest near continuous succession being that provided by the Purbeck-Wealden of southern England. This provides a sequence from (Tithonian?) Berriasian to Aptian freshwater and marginal marine deposits often rich in well preserved mollusc remains. The principal observations are:

1) Pre-Hauterivian, the dominant non-unionid bivalves are *Neomiodon* spp. which are particularly abundant in the Purbeck Limestone Group; these are replaced by *Filosina gregaria* through to the Aptian.

2) Where they occur, pulmonates (*Gyraulus* and *Prophysa*)are broadly consistent between the Berriasian Purbeck Limestone Group and the Barremian where they occur, with *Gyraulus* and *Prophysa*. They are however, generally rare but this may be due to the dominance of allochthonous assemblages post Purbeck Limestone Group times.

3) Both freshwater and marginal marine assemblages are structurally consistent where they occur throughout the Early Cretaceous with unionids and viviparids in freshwater, and cassiopids, cerithiids, oysters and corbiculids dominating marginal marine settings

4) The unionids undergo a major faunal change in the Hauterivian to Barremian, with cosmopolitan taxa such as *Margaritifera valdensis*, *'Unio' cornueliana* and *'Unio' elongata* coming to dominate assemblages. Replacing taxa such as *'Uni' antiquus*, *'Unio' aduncus, 'Unio' compressus*, *Proparreysia cordiformis*, *Anodonta becklesi*, *'Unio' mantelli*, *'Unio' martini*, *'Unio' porrectus*, *'Unio' subsinuatus.*

5) Trigonioidid bivalves, primarily of East Asian distribution are present in western Europe from at least the Barremian onwards, indicating palaeobiogeographical links between Asia and Europe.

6) Freshwater faunas are not preserved from northern Europe after the early Aptian, however they persist in the freshwater basins of Iberia and southern France.

7) The key European freshwater faunas are in the Purbeck of southern England and the French Jura, the Wealden Group of southern England, and Barremian strata of Wassy (France) and Las Hoyas (Spain).

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