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Turonian ammonites from northwestern Aquitaine, France

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The position of the Cenomanian-Turonian boundary is established for the first time in Charente-Maritime, northwestern Aquitaine (France), on the basis of ammonite occurrences and the $\delta^{13}C$ isotope curve, corresponding to Oceanic Anoxic Event 2, that straddles the boundary. The earliest Turonian ammonites recognised are a monospecific occurrence of the early early Turonian pseudotissotiine *Bageites bakui* Zaborski, 1998, previously known only from northern Nigeria. Newly collected material and well-preserved specimens from existing collections supplement previous records, and include species of *Placenticeras*, *Morrowites*, *Kamerunoceras*, *Romaniceras* (*Romaniceras*), *Spathites* (*Jeanrogericeras*), *Mammites*, *Fagesia*, *Neoptychites*, *Choffaticeras* (*Leoniceras*), *Collignoniceras* and *Lecointriceras*. These confirm the presence of the upper lower Turonian *nodosoides* Zone and the lower middle Turonian *turoniense* and *kallesi* zones/subzones of authors.

1. Introduction

Turonian ammonites from Charente and Charente-Maritime in northwestern Aquitaine were first described and illustrated by Alcide d'Orbigny in the cephalopod volume of *Paléontologie Française*, *Terrains Crétacés* (1840–1842). Further species were recorded, but not illustrated, by d'Orbigny (1850, 1856) and Coquand (1859, 1860). Of the latter some types have not been traced and others are *nomina dubia*. One of Coquand's species, *Ammonites Ganiveti*, was figured for the first time by Pervinquière (1904). A few others were illustrated in connection with revisions of the ammonite faunas of Touraine (Kennedy & Wright, 1979a, b; Kennedy, Wright, & Hancock, 1980a, b) and in the revision of the cephalopod volume of *Paléontologie Française* (Gauthier, 2006). Details of the distribution of a number of species was clarified by the work of Moreau (1982) and Platel (1989). In 1979–1980, excavations for the A10 Autoroute traversed the Turonian outcrop east of Taillebourg in Charente-Maritime and revealed sections across the lower/middle Turonian boundary that yielded hundreds of ammonites; the great majority collected were not *in situ*. Amédro and Hancock (1985) were, however, able to piece together a sequence of three successive faunas, as noted below. The material they figured was poor and fragmentary. Our own researches have investigated the position of the Cenomanian/Turonian boundary in the classic Porte-des-Barques section on the south bank of the Charente, opposite Île Madame (Fig. 1), on the basis of new ammonite records, and the $\delta^{13}C$ curve. We also illustrate and describe material in the Arnaud Collection in the Sorbonne collections, housed in the Université Pierre et Marie Curie (Paris VI), and material in the Université de Poitiers, both historic collections, and material collected by our colleague Pierre Moreau. Some of the specimens described below, especially those in the Arnaud collection, come from long-vanished localities, the position of some of which is no longer precisely identifiable.

2. The base of the Turonian Stage

There is international agreement on the base of the Turonian Stage which is defined by the first occurrence of the ammonite *Watinoceras devonense* Wright andKennedy, 1981 , at the base of bed 86 of the Bridge Creek Member of the Greenhorn Limestone Formation in the Rock Canyon anticline east of Pueblo, Colorado (Kennedy, Walaszczyk, & Cobban, 2005). In the absence of faunal or floral evidence, the boundary can be placed in the carbon stable isotope excursion that straddles it, as shown in Fig. 2.

3. Turonian substages and ammonite zones

The lower/middle Turonian boundary as used here is defined by the first occurrence of the ammonite *Collignoniceras woollgari* (Mantell, 1822) (Robaszynski (compiler), 1982; Bengtson (compiler), 1996). Fig. 3 shows the lower and middle Turonian

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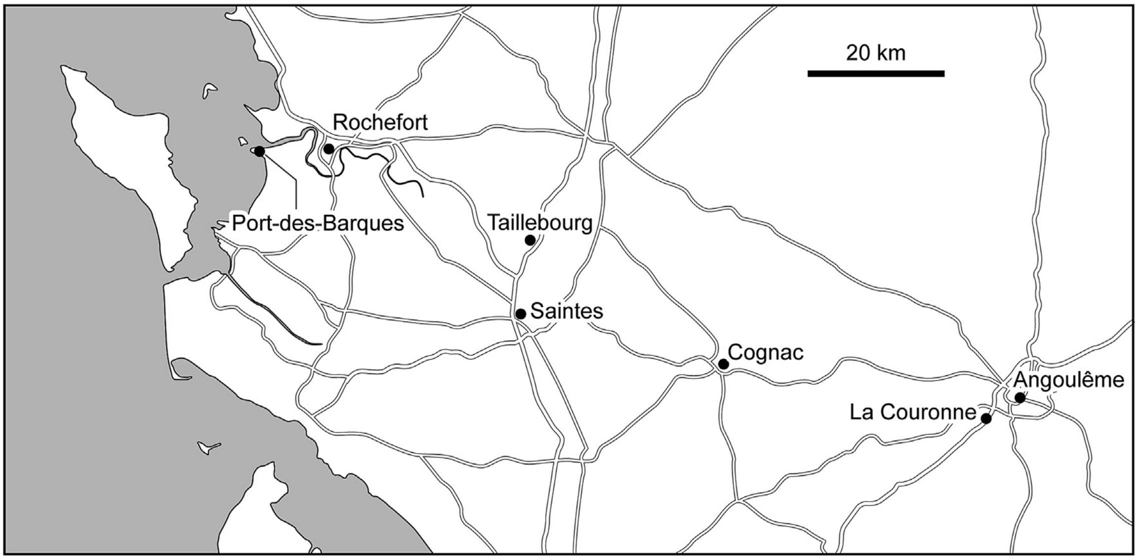

Fig. 1. Locality map for northwestern Aquitaine.

zonal sequence that finds widespread use in northern Europe, while Fig. 4 illustrates the subzonal division of the middle Turonian that can be applied in northern Europe, together with the middle Turonian zonation proposed for southern Europe by Robaszynski and Amédro in Robaszynski, Amédro, Devalque, and Matrion (2014). It is important to note, however, that *Kamerunoceras turoniense* (d'Orbigny, 1850) first occurs in the upper lower Turonian, in association with *Mammites nodosoides* (Schlüter, 1871) in Tunisia (Chancellor, Kennedy, & Hancock, 1994) and in New Mexico in the United States Western Interior (Cobban & Hook, 1983). The upper limit of *C. woollgari* is also problematic. In the southern part of the United States Western Interior, the *regulare* Subzone of the *woollgari* Zone is succeeded by a *Prionocyclus hyatti* Zone (Kennedy, Cobban, & Landman, 2001), which, in New Mexico and northern Mexico, occurs with *Romaniceras* (*R.*) *mexicanum* Jones, 1938, a species recently recognised in the Uchaux Massif in Vaucluse (Amédro and Devalque in Robaszynski et al., 2014, p. 139, pl. 21, figs. 1 and 2; pl. 22, figs. 1 and 2; pl. 23, fig. 1; pl. 24, fig. 1), where it co-occurs with *C. woollgari regulare* (Haas, 1946) and *Prionocyclus hyatti* (Stanton, 1894) (Amédro and Devalque in Robaszynski et al., 2014, text-fig. 36), the implication being that the last occurrence of *C. woollgari regulare* in the United States preceded that in Europe. There is also a record of co-occurring *C. woollgari* and *Romaniceras* (*R.*) *deverianum* (d'Orbigny, 1841) together with *Suprionocyclus neptuni* (Geinitz, 1850) in the section at Clos du Hamelet, Troyes, in Aube (Amédro, Colleté, Pietresson de Saint-Aubin, & Robasynski, 1982).

The *woollgari* Zone can be divided into two subzones in northern Europe (Fig. 4). In southern Europe, Robaszynski and Amédro (in Robaszynski et al., 2014) have replaced the *woollgari* Zone and divided the middle Turonian into four zones, as shown in Fig. 4; the *turoniense*, *kallesi* and *deverianum* zones/subzones had previously been recognised in Touraine and northern Aquitaine.

4. The sequence in northwestern Aquitaine

4.1. Lithostratigraphy

The complex evolution of lithostratigraphic nomenclature in Charente and Charente-Maritime beginning with the work of d'Archiac (1851), was comprehensively reviewed by Platel (1989), and summarised in his table 1 (opposite p. 24). Relevant to the present account, as we have studied his collections, is the work of Arnaud, in an extensive suite of papers between 1887 and 1892. The units, yielding ammonites, are his divisions D and E:

E: 'Calcaire gélif à Ammonites' (also referred to as the 'Calcaire à Ammonites') (youngest).

D^2: 'Marnes et Calcaires à *Exogyra*'.

D^1: 'Calcaires noduleux vert à *Terebratella*' (oldest).

In contemporary terms, D^1 corresponds to the calcaires marneaux à lumachelles à "Exogyres", unité G of Platel (1989; see summary in his text-figure 41) and others. D^2 corresponds to the 'marnes verts à "Exogyres"', the lower part of unit TA2 of Platel and others. It attains a thickness of 5 m on the 1:50,000 Rochefort sheet (Bourgueil & Moreau, 1972). E corresponds to the 'calcaires crayeux', the upper part of TA2 of Platel and others. It attains a thickness of 8–10 m on the Rochefort 1:50,000 sheet.

4.2. The Porte-des-Barques section

The succession exposed in the low cliffs and foreshore at Portes-des-Barques in Charente-Maritime is shown in Fig. 5. It is made up of approximately 13 m of mixed carbonate and terrigenous-clastic sands. The lowest unit corresponds to G1 of Moreau, Francis, and Kennedy (1983), and consists of nearly 4 m of yellow-brown fine sands with abundant calcitic shell debris, and includes some five lumachelles of large oysters (*Rhynchostreon*). The lowest 0.5 m exposed include a nodular horizon surmounted by a glauconitic omission surface. A specimen of *Neolobites vibrayeanus* (d'Orbigny, 1841) from this section, collected by Hébert, in the Sorbonne Collections, and described by Moreau et al. (1983, p. 319, fig. 10) is inferred to be from G1 on the basis of its preservation.

Unit G2 comprises 2 m of nodular and intensely indurated limestones, which include two hardground surfaces. The lowest one (hg1), at the 4.5 m level, has a flat to gently hummocky unmineralised surface which is encrusted with oysters. The hardground contains idiomorphic *Thalassinoides* full of calcarenite. An omission surface is present at 0.3 m above the lower hardground, and a concentration of the brachiopod *Terebratella carentonensis* is present on the surface. The overlying 1.2 m of hard nodular limestone is surmounted by a further hardground (hg2), full of the