

# Pithonellid blooms in the Chalk of the Isle of Wight and their biostratigraphical potential

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**ABSTRACT** Five pithonellid blooms recognised in the Chalk Group of the Isle of Wight are correlated via foraminiferal biostratigraphy to regional and global events. Blooms were recognised in the Holywell Nodular Chalk to basal New Pit Chalk formations (foraminiferal zones BGS7 to BGS9); *M. guerangeri* to *Mytiloides* standard macrofaunal zones); middle Lewes Chalk (questionably foraminifera Zone BGS12; *S. plana* standard macrofaunal Zone); basal Seaford Chalk (BGS14; base *M. coranguinum* standard macrofaunal Zone); lower Newhaven Chalk (base BGS18; base *U. socialis* standard macrofaunal Zone); and uppermost Newhaven to basal Culver formations (BGS19-20; *O. pilula* to low *G. quadrata* standard macrofaunal zones). The blooms appear to be coeval with oceanographic change and the general trend towards an increase in the proportion of planktonic taxa may suggest upwelling and/or dysaerobic bottom waters.

Key words: Pithonellids; Late Cretaceous; stratigraphy; Isle of Wight

## 1. Introduction

During recent surveying of the Chalk Group of the Isle of Wight by the British Geological Survey, samples were collected from pits, quarries and other exposures along the chalk outcrop (Fig. 1). Biostratigraphical control was provided principally by

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foraminifera (Wilkinson, **herein**), but during analysis, pithonellids (or ‘calcispheres’), were observed in abundance at several discrete horizons, whilst at other levels these microfossils were rare or absent. Blooms have been observed in Upper Cretaceous deposits on most continents and Bignot and Leuzaud (1964) suggested that their abundance could be used biostratigraphically. This notion that was confirmed by Villain (1977), although he was more circumspect, opining that this method of biostratigraphy was only applicable at a local scale. In order to determine their stratigraphical usefulness in the Isle of Wight, the pithonellid-rich chalks were confined biostratigraphically (on the basis of the associated microfaunal content) and stratigraphically (within the established lithostratigraphical framework of the Chalk Group) in an attempt to correlate horizons on the island with those elsewhere in Britain. Induration of the Chalk varies considerably across the Isle of Wight, such that investigation of the microfossils in the harder chalks was carried out by thin sections, while softer chalks were disaggregated and microfossils examined in 3-D. All samples are deposited in the Biostratigraphical Collection of the British Geological Survey, Nottingham, under the prefix ‘MPA’. All National Grid References (N.G.R.) are within 100 km square SZ.

## 2. ‘Calcispheres’ and pithonellids

Pithonellids form simple, hollow, calcareous spheroids up to 0.5 mm in diameter, varying from spherical to ovate and subcylindrical, and some are ornamented with striations. There is some evidence that they originally had granular to acicular aragonitic walls (Marszalek, 1975), arranged in one or two (and very rarely three) layers. The crystals comprising the wall were disposed obliquely (Keupp, 1987) resulting in linear, spiral or ‘parquet-like’ arrangement on the wall surface. An apical aperture (‘archaeopyle’) is also preserved in some specimens (e.g. Streng et al., 2004).

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There has been much debate as to the biological affinities of ‘calcspheres’. The earliest work was by Kauffman (1865) who considered them to be foraminifera, placing them into the genus *Lagena*. Others have considered them to be foraminifera, protozoan, spores of dasyclad algae or nannoplankton (e.g. Colom, 1955; Adams et al., 1967; Banner, 1972; Masters and Scott, 1978; Tappan, 1980). The view that has found most favour, however, is that they were calcareous dinoflagellates (Subfamily Calciodinelloideae Fensome et al., 1993), a concept postulated by Fütterer (1976). However, Fensome et al. (1993) and Streng et al. (2004) questioned this and Wendler and Willems (2004) concluded that “... microfossils of the genus *Pithonella* are most probably calcareous dinoflagellate cysts..... [but] .... they are taxonomically very problematic and evidence is needed to evaluate their affinity with the dinoflagellates.”

### 3. Distribution of pithonellid blooms in the Late Cretaceous

There are many examples of pithonellid blooms within Cretaceous successions, in some cases creating pithonellid wackestones and packstones, e.g. in France (Dufaure, 1959; Bignot and Lezaud, 1964; Villain, 1977; Robaszynski et al 2005), Iran (Adams et al.,1967), India (Bertle and Suttner, 2005), S. England (Banner, 1972; Hart 1991; Gale et al 2000; Mortimore et al., 2001), Israel (Bein and Reiss, 1976), Poland (Olszewska-Nejbert, 2004), Portugal (Hart et al., 2005), Germany (Niebuhr, 2005), USA (Tew, 2000), Mexico (Aguilera-Franco, 2003) and Antarctica (Fütterer, 1990).

The cause of the blooms has been ascribed to favourable palaeoenvironmental conditions, although the environmental requirements of pithonellids are not fully understood. The distribution of Cretaceous pithonellids suggests that they favoured low palaeolatitudes and appear to be at their northern limit in Yorkshire, England (Thomas 1932), Southern North Sea Basin (Kennedy, 1987) and Lägerdorf and Isle of Rügen,

1 northern Germany (Villain, 1977; Willems, 1992) and Stevns Klint, Denmark  
2 (Wendler and Willems, 2002). It has been suggested that they showed a preference for  
3 open-ocean (e.g. Adams et al., 1967; Bishop, 1972) and outer shelf (Villain, 1981)  
4 environments, but they have also been reported in carbonate-rich inter-reefal deposits  
5 (Bein and Reiss, 1976) and back-reef lagoonal environments (Masters and Scott,  
6 1978). Wendler et al. (2002) showed that it was possible to characterise the  
7 Cenomanian oceanic, outer shelf and marginal shelf milieu on the basis of  
8 Calciodinelloideae. The blooms in the Cretaceous of the Isle of Wight all took place in  
9 outer shelf conditions (in the sense of Wendler et al., 2002), but generally at times of  
10 high sea levels (Fig.2).

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24 Robaszynski et al. (1993) and Hart (1991) suggested that the sudden ‘floods’ of  
25 *Pithonella* were due to oceanographic change such as the early phase of transgression  
26 during sea-level fluctuations. Although this is the case for some transgressive events  
27 (Fig. 2), others (particularly those in the lower to middle Cenomanian and early to mid  
28 Campanian) lack blooms suggesting that the trigger was not sea level change alone.  
29 Other palaeoceanographic changes must have play a part. For example, rhythms of  
30 chalky marl (foraminiferal and nannofossil wackestones with abundant clastic  
31 material) and indurated limestone (calcisphere wackestones and packstones with little  
32 terrigenous clastic detritus) during the Campanian of the USA, may indicate periodic  
33 reductions in turbidity, leading to palaeoceanographic conditions favourable for  
34 blooms (Tew, 2000). Hart et al. (2005) suggested that the sudden influx of late  
35 Cenomanian-early Turonian pithonellids may be related to the Bonarelli Oceanic  
36 Anoxic Event. It also seems plausible that the cause for the blooms was related to  
37 phases of upwelling, resulting in the nutrient enrichment of the photic zone by, for  
38 example, nitrates and phosphates. The source of the nutrients may have been the  
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1 reworking of the black shales during the opening of the Atlantic, sea-level change or  
2 variability in deep water ocean circulation.  
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#### 5 **4. Pithonellid blooms in southern England**

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9 Banner (1972) was the first to document blooms of *Pithonella* in the Cenomanian of  
10 the Isle of Wight. He stated that the ‘floods’ occurred in Bands 2 and 3 of the “Chalk  
11 Marl” (in the sense of Kennedy, 1969) at Culver Cliff and considered them to be of *M.*  
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13 *mantelli* zonal age. However, he went on to list the associated foraminifera  
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15 (*Praeglobotruncana stephani*, *Arenobulimina anglica* and *Pseudotextulariella*  
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17 *cretosa*), the concurrent range of which would place the faunas in the *costatus* Subzone  
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19 (*rhomagense* standard macrofaunal Zone). In modern lithostratigraphical terms, this  
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21 would place the ‘floods’ of *Pithonella* within the Zigzag Chalk Formation. Similar  
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23 blooms were observed in borehole material from the English Channel (Curry and  
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25 Smith, 1975) with foraminifera including (by original designation) *Pseudovalvulineria*  
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27 *globosa*, *Gavelinopsis turonica*, *Hedbergella portsdownensis*, *Eouvigerina stormi* and  
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29 *Heterohelix* sp.; the assemblages were considered to be early Turonian in age based on  
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31 the flood of *Pithonella*.  
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41 Hart (in Hart et al., 2005) recorded the appearance of common *Pithonella* in the  
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43 *gerangeri* zone (Zigzag Chalk Formation) at Eastbourne, although they became more  
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45 abundant in the Plenus Marl, reaching ‘flood’ proportions in the *juddi* zone at the base  
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47 of the Holywell Nodular Chalk (Dover Chalk Formation sensu Hart et al., 2005) at  
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49 which point they began to decline in numbers again (Fig. 3). Similar ‘floods’ are  
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51 known from this stratigraphical level elsewhere in southern England, including the  
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53 lower Turonian at Hooken Cliff, Beer (basal Connet’s Hole Member of the Seaton  
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55 Chalk Formation sensu Hart, 1991), Dover (in the Shakespeare Cliff Member sensu  
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Jarvis et al., 1988; Hart, 1991) and at Membury (the *Mytiloides* spp. macrofaunal zone at the base of the Holywell Nodular Chalk Formation) (Hart 1991; Mortimore et al., 2001). Gale et al. (2000) also recorded the presence of pithonellids in the *guerangeri* macrofaunal Zone of the Zigzag Chalk Formation (their Grey Chalk Member) and the *M geslinianum* macrofaunal Zone (Plenus Marl) of Eastbourne, Sussex. However, the major increase in abundance took place in “couplet E6” in the uppermost *M. geslinianum* macrofaunal Zone (at the base of Ballard Cliff Member, sensu Mortimore et al., 2001) and the decline began in the *W. devonense* Zone (= low in the *Mytilioides* spp. Zone herein) during the early Turonian (Fig. 3).

Higher in the succession, blooms are less well known, although *Pithonella*-rich, nodular chalk has been recorded from the late Turonian Lewes Tubular Flints (*S plana* Macrofaunal Zone) in the Lewes Nodular Chalk Formation in Sussex (Mortimore et al., 2001, page 13) (Fig. 3). Here, both *Pithonella sphaerica* and *P. ovalis* were illustrated, although no details of the vertical distribution of the bloom were given. This ‘flood’ appears to correlate with the Turonian “calcisphere and flaser chalk” which are situated as high as the Lewes Tubular Flints south-east of Paris (Robaszynski et al., 2005).

Pithonellid blooms have not been recorded in stratigraphically higher chalks of southern England, although they have been recorded in the Middle to Upper Campanian and Upper Maastrichtian of Mainland Europe.

## 5. Pithonellid blooms on the Isle of Wight

Although pithonellids were rare or absent in the majority of samples examined from the Isle of Wight, they were common and abundant at several distinct horizons (Fig. 3).

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*The West Melbury Marly Chalk Formation* contained only very rare or rare pithonellids throughout the unit, the foraminiferal association being characterised by numerous agglutinated benthonic foraminifera of Foraminiferal Zones BGS1- BGS4i (for an overview of the foraminifera of the Chalk of southern England and their biostratigraphical distribution, see Wilkinson, [herein](#)).

*The Zigzag Chalk Formation* of the Isle of Wight contains a characteristic foraminiferal fauna. Long ranging Cenomanian taxa are accompanied by species with a more restricted distribution such as *Rotalipora cushmani*, *Lingulogavelinella globosa*, *Gavelinella tourainensis*, *Plectina cenomana* and *Pseudotextulariella cretosa*. *Pithonella* is generally rare in the lower part of the Zigzag Chalk Formation, but in the upper part (particularly foraminiferal zones BGS5 and BGS6 sensu Wilkinson, [herein](#), which equate to the *A. jukesbrownei* and *C. guerangeri* macrofaunal zones) they become more frequent. A thin section from the indurated Upper Zigzag Chalk Formation at Bembridge Down (MPA57102; N.G.R.62630 85687) has yielded abundant *Pithonella sphaerica* and a foraminiferal assemblage (including *Lingulogavelinella globosa*, *Plectina cenomana* and *Gavelinella cenomanica*) characteristic of BGS6. The Zigzag Chalk Formation to the NE of Yaverland Manor Farm (MPA57090; N.G.R. 61583 86163) contained very rare, long-ranging Cenomanian benthonic foraminifera and frequent, simple, non-keeled planktonic species (e.g. *Hedbergella delrioensis*). Floods of *Pithonella sphaerica* accompanied these foraminiferal assemblages, together with rare *Pithonella ovalis* and very rare, questionable *Orthopithonella*, although other species recorded from Escalles, Northern France (Wendler et al., 2002), such as *Cubodinellum renei* and *Pentadinellum vimineum* Keupp, 1987, were not observed.

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**The Holywell Chalk Formation** on Cheverton Down, NW of Shorwell, Mottistone Down and Luccombe Down contained Pithonella-rich chalks dating to foraminiferal zones BGS8 and BGS9. At Cheverton Down, foraminifera tended to be sparse and of low diversity, but *Gavelinella berthelini*, *Gavelinella tourainensis*, *Lingulogavelinella globosa*, *Tritaxia jongmansii*, *Hedbergella planispira* and *Helvetoglobotruncana helvetica*. indicate a position within foraminiferal Zone BGS9 (sensu Wilkinson, **herein**).

*Pithonella*-rich samples in the lower part of the Holywell formation on Mottistone Down (MPA58133; N.G.R.44081 84508) contain sparse foraminifera including *Tritaxia tricarinata* and *Arenobulimina* sp. cf. *preslii*. Although equivocal a position within BGS8 is suggested. Foraminifera (including rare *Gyroidina praestans* and *Gavelinella cf. tourainensis*) were sparse at N.G.R. 45827 84169 (MPA57150), to the north of Shorwell, and on Luccombe Down MPA57162 (N.G.R. 57551 79805), although in contrast, *Pithonella* blooms comprised abundant *Pithonella sphaerica* and rare *P. ovalis*.

**The New Pit Chalk Formation** contains a bloom of very small (less than 125 microns) *Pithonella sphaerica* in its lower part, west of Culver Cliff (MPA57103; N.G.R. 62960 85576). The planktonic foraminiferal assemblage here comprises essentially long-ranging species (but no lower than BGS 10), including *Helvetoglobotruncana helvetica* and *Dicarinella canaliculata*. The former is confined to the *Mytiloides* and *T. lata* macrofaunal zones, and is associated particularly with the Holywell and New Pit chalk formations, although it ranges up into the lower Lewes Chalk. The latter species first appears near the base of the *T. lata* macrofaunal Zone in the lower New Pit Chalk. *Pithonella* becomes rare towards the top of the formation.



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**The Lewes Chalk Formation of the Isle of Wight** generally contains only rare specimens of *Pithonella*. However, a thin section from Brading Down (MPA57084; N.G.R. 59920 86705) contained abundant, very small specimens of *Pithonella sphaerica* together with a sparse assemblage of indeterminate benthonic foraminifera with unkeeled, long-ranging planktonic taxa such as *Hedbergella* and *Heterohelix* and very rare, keeled *Marginotruncana marginata*. It is not possible to confine the stratigraphical position of the sample accurately, but the Lewes Tabular Flints in the *S. plana* macrofaunal Zone contains a bloom of *Pithonella* (cf. Mortimore et al., 2001).

**The Seaford Chalk Formation** generally yields only rare assemblages of *Pithonella*, although raised numbers have been found on the Isle of Wight. A thin section from the northern side of Bembridge Fort (MPA57097; N.G.R. 62394 86179) contains the foraminifera *Gavelinella ammonoides*, *Reussella kelleri*, *Eouvigerina aculeata*, *Osangularia cordieriana*, *Stensioeina* sp. cf. *granulata*, *Globorotalites michelinianus* and a specimen of *Gavelinella* tentatively assigned to *G. cristata*. If the last named is correctly identified, a position in foraminiferal zone BGS18 the highest Seaford Chalk can be suggested. *Reussella kelleri* is normally absent through much of the Seaford Chalk although it is present towards the base of the unit and above the Whitaker 3” Flint and lateral equivalents.

A similar assemblage was found in the basal part of the unit on Mersley Down (MPA57074; N.G.R. 56080 87282), although *Stensioeina* sp. cf. *granulata* was also present. The genus *Stensioeina* first appears consistently in the English chalk at the base of Foraminiferal zone BGS14. *Pithonella* is common in the sample from Bembridge Fort and frequent on Mersley Down, and although it does not constitute a ‘flood’, their raised frequency takes place at a horizon that has not previously been noted in the English Chalk.

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**The Newhaven Chalk Formation** generally contains rare *Pithonella*, but *P. sphaerica* is frequent to common at East Afton Down, Little Down, Brighstone Down, Mottistone Down, Newbarn Down and Mersley Down. Foraminifera in the lower part of the formation at East Afton Down (MPA59667; N.G.R.36297 85801) included *Gavelinella cristata*, *G. stelligera*, *Reussella szajnochae praecursor* and *Stensioeina granulata perfecta* (although species of *Bolivinooides* were absent), and placed in foraminiferal zone BGS18ii. Although *Pithonella* did not occur in ‘flood’ proportions, they were common at this locality, notably in the 72-125 micron sieve fraction. On Little Down (MPA59609; N.G.R. 4350 8619), Brighstone Down (MPA59605; N.G.R. 4271 8484) and Mottistone Down (MPA59600; N.G.R. 4067 8518), frequent *Pithonella* occurred with *Gavelinella cristata*, *G. stelligera*, *Reussella szajnochae praecursor*, *R. kelleri* and *Stensioeina granulata incondita*. A specimen of *S. granulata granulata* was also present, a species that is very rare in the upper part of its range, but appears to go into extinction in the late Santonian. Foraminiferal zone BGS18iii is indicated.

A bloom of *Pithonella sphaerica* was observed at Newbarn Down (MPA59607; N.G.R. 4306 8581), Mersley Down (MPA57076; N.G.R. 56224 87549), and Little Down (MPA59610; N.G.R. 4355 8639). The foraminifera association included *Gavelinella crista*, *G. stelligera*, *Reussella kelleri*, *Stensioeina granulata incondita* and *Bolivinooides culverensis* with *Stensioeina pommerana* on Mersley Down (MPA57076 N.G.R. 56224 87549) indicating foraminiferal zone BGS19 (approximately equivalent to the standard *O. pilula* macrofaunal Zone).

**The Culver Chalk Formation** at the western end of the island also yielded common pithonellids, examples being noted at West High Down, the western end of Pay Down and Newbarn Down. The Lower Culver Chalk at Newbarn Down (MPA59603; N.G.R. 4265 8559) contained frequent pithonellids together with a characteristic foraminiferal

1 assemblage including *Gavelinella usakensis*, *Bolivinooides culverensis*, *Gavelinella*  
2 *thalmanni*, *Stensioeina granulata incondita* and *Neoflabellina rugosa*, which is  
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4 considered to be indicative of BGS20i. Frequent pithonellids (all of very small  
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6 dimensions) were identified from west of the Coastguard Station, West High Down  
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8 (MPA59619; N.G.R. 29794 84839) where a sparse foraminiferal association included  
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10 *Gavelinella usakensis*, *G. trochus* and *Stensioeina pommerana* and although several  
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12 key indices were not observed, the assemblage is placed in foraminiferal zone BGS 20  
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14 (probably subzones BGS20ii or BGS20iii). An assemblage, characterised by  
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16 *Gavelinella usakensis*, *Bolivinooides culverensis*, *Stensioeina granulata incondita* and *S.*  
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18 *pommerana* was found on Pay Down, 650 m SE of Shalcombe Manor (MPA59598;  
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20 N.G.R. 4001 8524) and is of a similar age to that at West High Down. Here common  
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22 pithonellids were observed in the 72-125 micron sieve fraction. A similar fauna was  
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24 recorded in a thin section of indurated Culver Chalk Formation at Ashey Down  
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26 (MPA57080; N.G.R. 57700 87929), north west of Brading. *Gavelinella usakensis* and  
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28 *Bolivinooides* sp. (with an outline closer to *B. culverensis* than the more kite-shaped *B.*  
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30 *decoratus*) were present, characteristic of BGS20. Specimens of *Pithonella sphaerica*  
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32 were common at this horizon, but accompanied by rare *Pirumella krasheninnikovi*,  
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34 which is known to range between the late Campanian and early Maastrichtian in the  
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36 north Atlantic (Pflaumann and Krasheninnikov, 1978). A thin section from Culver  
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38 Down NW of the gun emplacement (MPA57108; N.G.R. 63357 85695) also contains  
39  
40 *Gavelinella usakensis*, together with *Globotruncana linneiana* and frequent *Pithonella*  
41  
42 *sphaerica*. The influx of pithonellids at this stratigraphical horizon may be related to  
43  
44 the bloom at about the mid-late Campanian boundary interval recognised in mainland  
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46 Europe (Villain, 1977; Willems, 1992) and France (Bignot and Lezaud, 1964; Villain  
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48 1977).  
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**The Portsdown Chalk** to the west of Carisbrook on the northern edge of Bowcombe Down (MPA57125; N.G.R. 4715 8826) at the western end of Arreton Down (MPA 57727; N.G.R. 5281 8759) and in Scratchells Bay (N.G.R. 29354 84855 – 29660 84797) yielded foraminiferal assemblages including *Gavelinella monterelensis*, *G. usakensis*, *G. voltziana*, *G. trochus*, *G. clementiana*, *Bolivinoidea decoratus* and *B. laevigatus pustulatus* characteristic of BGS21i. However, pithonellids were very rare throughout the formation.

## 6. Conclusions

*Pithonella* is generally rare or very rare in the Chalk Group of the Isle of Wight, although five blooms can be recognised: Holywell Nodular Chalk to basal New Pit Chalk (foraminiferal zones BGS7 to BGS9; *M. guerangeri* to *Mytiloides* standard macrofaunal zones), middle Lewes Chalk (questionably foraminifera Zone BGS12; *S. plana* standard macrofaunal Zone), base Seaford Chalk (BGS14; base *M. coranguinum* standard macrofaunal Zone), lower Newhaven Chalk (base BGS18; base *U. socialis* standard macrofaunal Zone) and uppermost Newhaven to basal Culver formations (BGS19-20; *O. pilula* to low *G. quadrata* standard macrofaunal zones). The blooms appear to correlate with the larger maximum flooding surfaces when widespread oceanographic change took place. The blooms of pithonellids and the general trend towards an increase in the proportion of planktonic, compared to benthonic, foraminifera at these events, may suggest upwelling and/or dysaerobic bottom waters.

The two species of *Pithonella* that bloomed during the Cretaceous of the Isle of Wight, *P. sphaerica* and *P. ovalis*, have a broad temporal and spatial distribution. Questionable specimens of *P. sphaerica* were recorded from the Barremian of

1 Indonesia (Vogler, 1941), although it was not until the Albian that the species became  
2 geographically widespread with further expansion during the Cenomanian –Turonian  
3  
4 (Dias-Brito, 2000 and references therein). *Pithonella ovalis* first appeared in the Albian  
5  
6 and very rapidly migrated into Europe, North Africa, the Americas and Asia (Dias-  
7  
8 Brito, 2000 and references therein). Both species range throughout the Late  
9  
10 Cretaceous. These long-ranging species have little biostratigraphical significance,  
11  
12 except where there are sudden blooms. The use of these blooms for correlative  
13  
14 purposes appears be possible at least between France, Germany and the UK, but the  
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16 larger events (e.g. that during the late Cenomanian-Turonian) can be recognised on a  
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18 global scale.  
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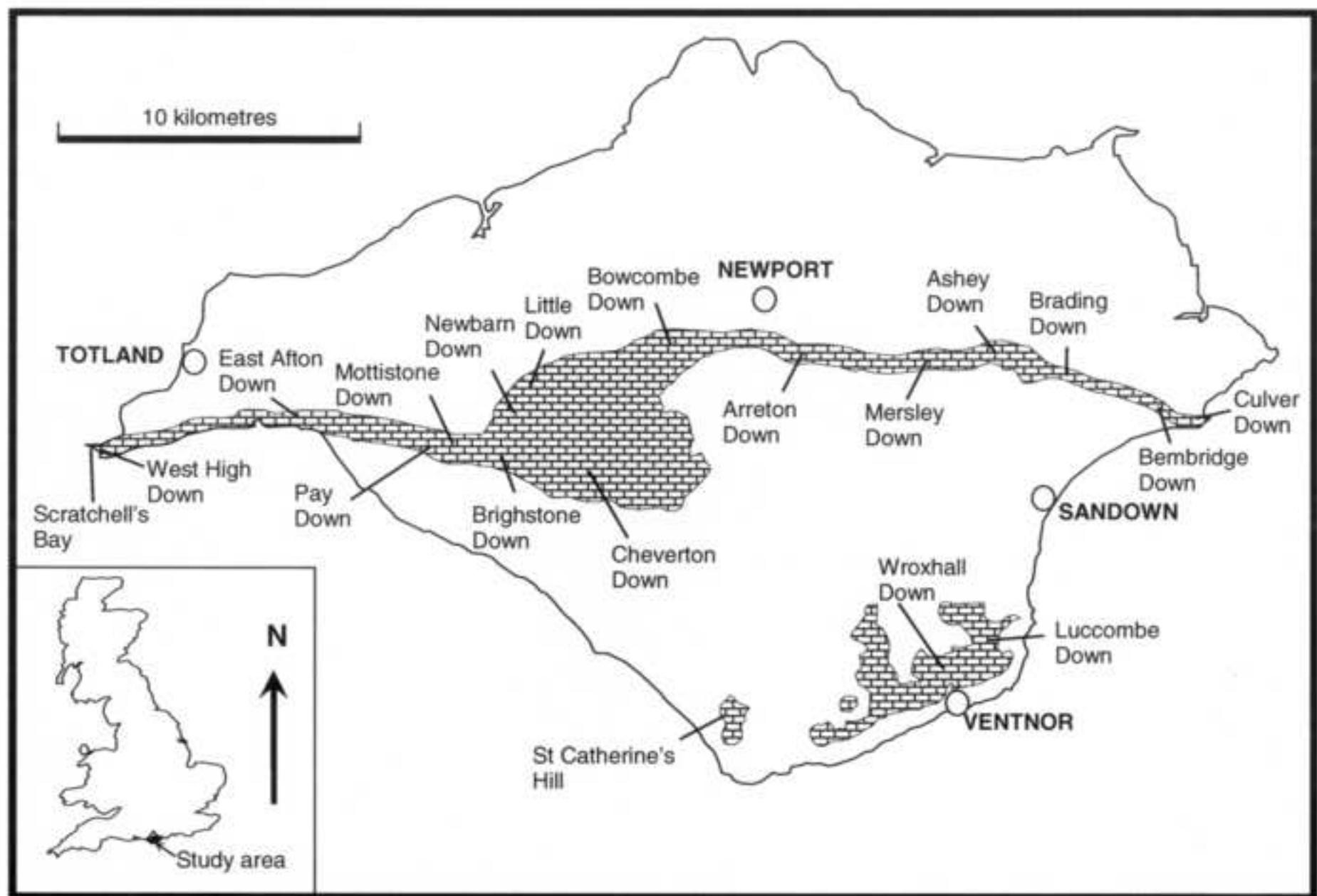
## Figure captions

1  
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6 Fig. 1. Map of the Isle of Wight to show the distribution of the Chalk Group and  
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8 localities mentioned in the text.  
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14 Fig. 2. The distribution of pithonellid blooms (hashed lines) on a regional and global  
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16 scale in relation to global (dashed line) and North-west European (solid line) sea level  
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18 changes and major (long arrow) and intermediate (short arrow) maximum flooding  
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20 surfaces in North West Europe (after Oakman and Partington, 1998).  
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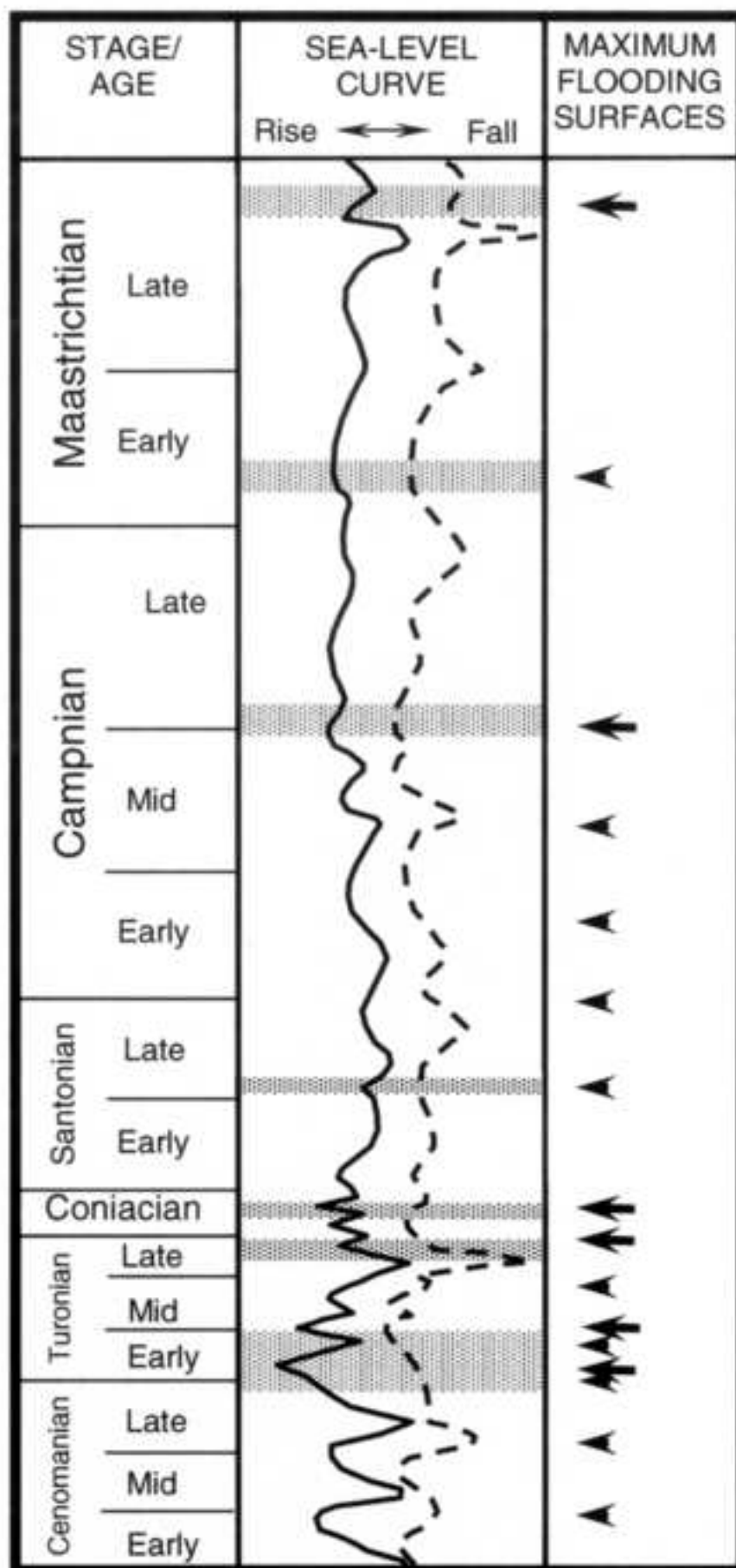
26  
27 Fig. 3. The distribution of pithonellids in the Chalk of southern England. Left side of  
28  
29 mid line = blooms recorded in southern England (see the text and reference for details);  
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31 right side of the mid line = blooms recognised in the Isle of Wight (see text for details).  
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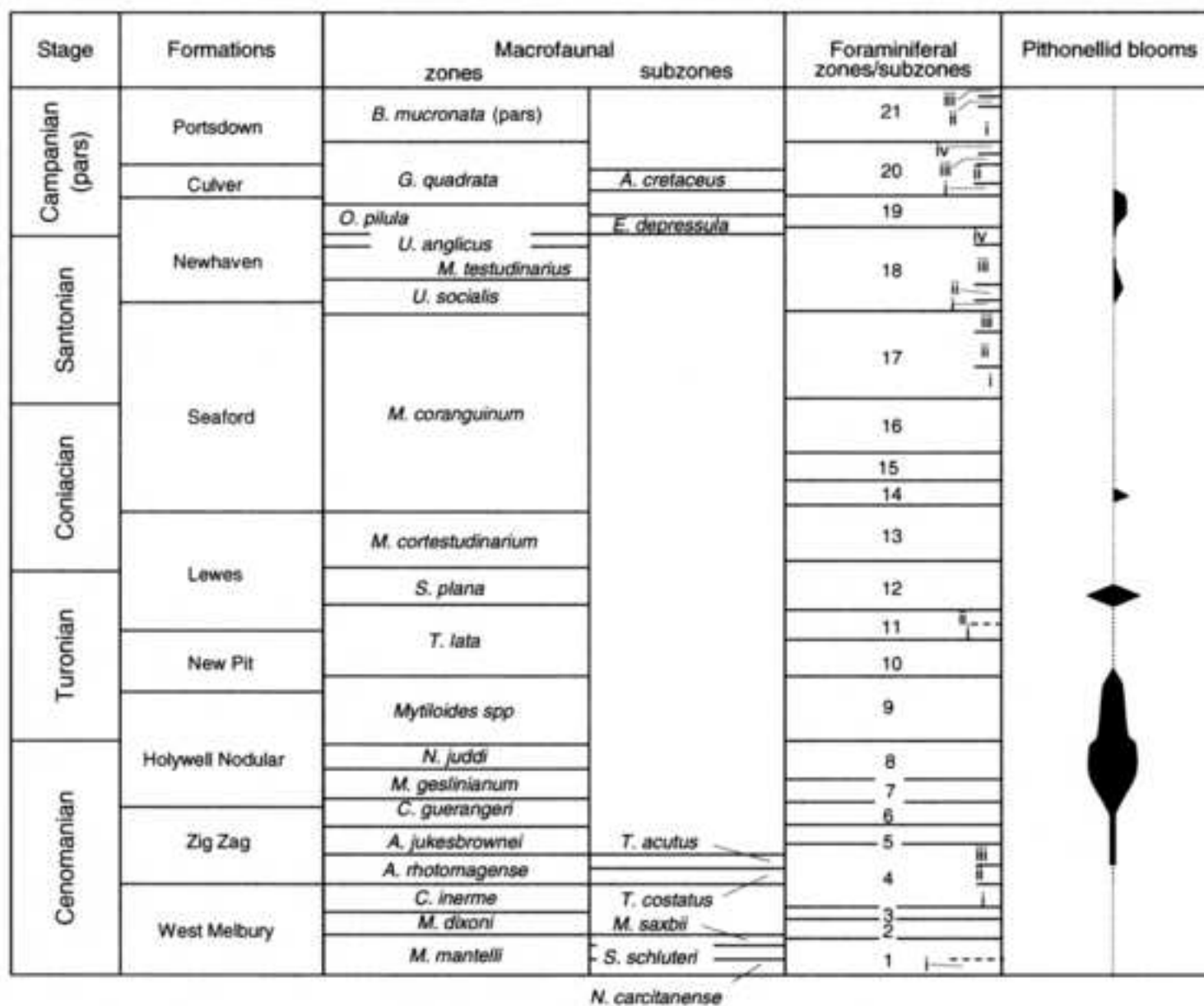
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Rare

Frequent

Common

Abundant