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The literature on Triassic, Jurassic and earliest Cretaceous dinoflagellate cysts: supplement 4

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ABSTRACT

Since the publication of four compilations issued between 2012 and 2019, 93 further published contributions on Triassic, Jurassic and earliest Cretaceous (Berriasian) dinoflagellate cysts from Africa, North America, South America, the Arctic, Australasia, East Europe, West Europe, the Middle East and Russia have been discovered in the literature, or were issued in the last 12 months (i.e. between February 2018 and January 2019). Of these, 55 were published during 2018 and 2019, making this period a very productive one. These studies are mostly on the Late Triassic and Early Jurassic of Europe. All the 93 items are listed herein with digital object identifier (doi) numbers where available, as well as a description of each item as a string of keywords. Publications on West Europe comprise 31.2% of the total, and items on Africa, the Arctic, Australasia, East Europe and Russia are also significant (15.1, 6.5, 7.5, 9.7 and 14.0%, respectively). The least well-represented regions are North America, South America and the Middle East (2.2, 1.1 and 1.1%, respectively).

KEYWORDS
dinoflagellate cysts; earliest Cretaceous (Berriasian); Jurassic; literature analysis and compilation; Triassic; worldwide

1. Introduction

The literature on Triassic to earliest Cretaceous (Berriasian) dinoflagellate cysts is extensive, and was listed and reviewed by Riding (2012, 2013, 2014, 2019). These four papers cited 1347, 94, 89 and 266 publications, respectively, with each citation followed by keywords detailing the scope of each of the 1796 studies. The reviews provided by Riding (2014, 2019) were substantially more interpretive than those in Riding (2012, 2013); the former two papers reviewed and summarised each of the major publications listed. During the 12 months since the completion of Riding (2019), i.e. between February 2018 and January 2019, the author has compiled a further 93 relevant articles. Of these, 55 are recently published papers; the other 38 were previously overlooked. Thirty of the 93 items are considered to be of substantial scientific significance. The total of 55 articles published between February 2018 and January 2019 makes this one of the most productive periods on this topic in recent years.

The 93 articles are largely on the Late Triassic and Early Jurassic of Europe (Tables 1, 2), and are listed in Appendix 1 of the Supplementary material. Papers on West Europe are most numerous (29), and comprise 31.2% of the overall total (Table 1). By contrast, Riding (2012, 2013, 2014, 2019) noted a substantial bias towards the Late Jurassic of Europe. Publications on Africa, the Arctic, Australasia, East Europe and Russia are also numerous (15.1, 6.5, 7.5, 9.7 and 14.0% respectively; Table 1). Finally, relatively low proportions of articles are on North America, South America and the Middle East (2.2, 1.1 and 1.1% respectively; Table 1). In this compilation, six formally unpublished PhD theses are listed (e.g. Ruckwied 2009; Baranyi 2018; Correia 2018); these are all freely available online and the respective web addresses are quoted.

2. Regional review and synthesis

In this section, brief commentaries/reviews of selected articles from the 93 publications listed in Appendix 1 of the Supplementary material are presented. These items are from nine of the 14 geographical subdivisions in Riding (2019). In the present compilation, there are no relevant single-region publications from Central America, Antarctica, Southeast Asia, China or the Indian subcontinent. Each contribution in Appendix 1 of the Supplementary material is referred to at least one of these 14 regions; furthermore, 'multi-region' and 'no geographical focus' are also options (Table 1).

The publication by Mangerud et al. (2019) is a good example of the latter two categories. This article is a global synthesis of the available literature on Triassic dinoflagellate cysts; it reviewed data from Arabia, the present Arctic region, Europe, Oceania and South America. It is clear that, with the exception of *Sahulidinium ottii* in one well in offshore Australia, dinoflagellate cyst body fossils first appeared during the Late Triassic. The Norian–Rhaetian genus *Rhaetogonyaulax* appears to be a cosmopolitan pioneer taxon. There was migration into many formerly landlocked regions during the Rhaetian, and most Triassic dinoflagellate

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Table 1. A breakdown of the 93 publications on Triassic to earliest Cretaceous dinoflagellate cysts compiled herein, based on the nine relevant geographical regions (i.e. Africa, North America, South America, the Arctic, Australasia, East Europe, West Europe, the Middle East and Russia) and the initial letter of the family name of the first author.

Initial letter of the first author's family name	Total number of studies	Total number of highly significant studies	Total number of single-region studies	Africa	Central America	North America (sub-Arctic)	South America	Antarctica	The Arctic	Southeast Asia	Australasia	China	East Europe	West Europe (sub-Arctic)	The Indian subcontinent	Middle East	Russia (sub-Arctic)	Multi-region studies	Studies with no geographical focus
A	3	2	3	1	…	…	…	…	…	…	…	…	…	…	…	…	2	…	…
B	6	1	3	…	…	…	…	…	…	…	…	…	1	1	…	…	1	2	1
C	8	3	8	…	…	…	…	…	…	…	…	…	…	8	…	…	…	…	…
D	5	1	5	1	…	1	…	…	…	…	1	…	…	1	…	…	1	…	…
E	1	1	1	…	…	…	…	…	…	…	…	…	…	…	…	1	…	…	…
F	2	…	2	…	…	…	…	…	1	…	…	…	…	1	…	…	…	…	…
G	4	1	4	2	…	…	…	…	…	…	…	…	…	…	…	…	2	…	…
H	5	3	5	1	…	…	…	…	…	…	…	…	…	4	…	…	…	…	…
I	2	…	2	2	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
J	3	1	3	1	…	…	…	…	…	…	1	…	…	1	…	…	…	…	…
K	2	…	2	…	…	…	…	…	1	…	…	…	…	1	…	…	…	…	…
L	2	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	1	1
M	6	5	5	3	…	…	…	…	…	…	…	…	…	…	…	…	2	1	…
N	3	1	3	…	…	…	…	…	3	…	…	…	…	…	…	…	…	…	…
O	1	…	1	…	…	…	1	…	…	…	…	…	…	…	…	…	…	…	…
P	8	1	7	…	…	…	…	…	…	…	1	…	2	2	…	…	2	…	1
Q	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
R	2	2	2	…	…	…	…	…	1	…	…	…	1	…	…	…	…	…	…
S	14	3	13	1	…	…	…	…	…	…	…	…	5	4	…	…	3	1	…
T	3	1	2	2	…	…	…	…	…	…	…	…	…	…	…	…	…	1	…
U	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	..	…	…	…
V	5	2	4	…	…	1	…	…	…	…	…	…	…	3	…	…	…	1	…
W	7	2	6	…	…	…	…	…	…	…	3	…	…	3	…	…	…	…	1
X	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Y	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Z	1	…	1	…	…	…	…	…	…	…	1	…	…	…	…	…	…	…	…
Totals	93	30	82	14	0	2	1	0	6	0	7	0	9	29	0	1	13	7	4
Percentag-es	100	32	88.2	15.1	0.0	2.2	1.1	0.0	6.5	0.0	7.5	0.0	9.7	31.2	0.0	1.1	14.0	7.5	4

The number in the geographical region cell refers to the number of relevant published items on that area alone. An ellipsis (…) indicates a zero return for that particular parameter.

Table 2. A breakdown of the 93 publications on Triassic to earliest Cretaceous (Berriasian) dinoflagellate cysts compiled herein, subdivided into Triassic, Early Jurassic, Middle Jurassic, Late Jurassic, Jurassic–Cretaceous transition, investigations comprising three or more of the previous intervals and studies with no stratigraphical focus, and reworking.

Initial letter of the first author's family name	Total studies	Total highly significant studies	Triassic	Early Jurassic	Middle Jurassic	Late Jurassic	Jurassic/ Cretaceous transition (Tithon. and Berrias.)	Three or more of the previous intervals/ no focus	Reworking
A	3	2	…	…	…	…	2	1	…
B	6	1	3	…	…	1	1	1	…
C	8	3	…	8	3	…	…	…	…
D	5	1	1	…	…	…	2	1	1
E	1	1	1	…	…	…	…	…	…
F	2	…	2	…	…	…	…	…	…
G	4	1	…	2	…	…	1	1	…
H	5	3	1	…	1	…	…	2	1
I	2	…	…	…	…	…	…	2	…
J	3	1	2	…	1	1	…	…	…
K	2	…	1	1	…	1	1	…	…
L	2	…	1	1	…	1	1	…	…
M	6	5	1	1	3	2	1	1	…
N	3	1	…	…	…	…	…	3	…
O	1	…	…	…	…	…	1	…	…
P	8	1	2	2	1	1	2	1	…
Q	…	…	…	…	…	…	…	…	…
R	2	2	1	1	…	…	…	1	…
S	14	3	2	3	2	3	6	3	…
T	3	1	…	…	…	2	2	1	…
U	…	…	…	…	…	…	…	…	…
V	5	2	3	3	…	…	…	2	…
W	7	2	1	1	2	3	1	1	…
X	…	…	…	…	…	…	…	…	…
Y	…	…	…	…	…	…	…	…	…
Z	1	…	1	1	…	…	…	…	…
Totals	93	30	23	24	13	15	21	21	2

Some latitude and pragmatism are used in this compilation; for example, if a publication is on the Berriasian and Valanginian it is classified as covering the Jurassic–Cretaceous transition. One item may be counted twice (e.g. if it spans the Oxfordian to Berriasian), but not three times. An ellipsis (…) indicates a zero return for that particular parameter.

cyst taxa became extinct at the end-Triassic event. Other examples of 'multi-region' and 'no geographical focus' papers include Boersma et al. (1987), Lindström et al. (2017), Londeix (2018) and Penaud et al. (2018). All dinoflagellate cysts and other palynomorph taxa at and below species level mentioned in this paper are listed in Appendix 2 of the Supplementary material with full author citations.

2.1. Africa

This compilation includes 14 single-region contributions from East and North Africa, including five that are deemed especially significant (Appendix 1 of the Supplementary material). The highlights of this research are outlined in the next two subsections.

2.1.1. East Africa

In this synthesis, four single-region contributions on Ethiopia and Tanzania in East Africa are considered. Msaky (2008) is a thesis on the Bajocian to Cenomanian palynology of coastal Tanzania, and is available online. The thesis was published as Msaky (2011a, 2011b), and these major publications were reviewed by Riding (2019).

The palynofloras of the Pindiro Group (Triassic to Lower Jurassic) of southern Tanzania were studied by Hudson and Nicholas (2014). These authors reported the dinoflagellate cysts *Dapcodinium priscum*, *Sahulidinium ottii*, *Scriniocassis* sp. cf. *S. weberi* and *Sverdrupiella* sp. from the Mbuo Formation (Hudson and Nicholas 2014, p. 59). This assemblage was interpreted as being Late Triassic in age. The presence of *Dapcodinium priscum* and *Sverdrupiella* sp. is consistent with this age determination. However, *Sahulidinium ottii* and *Scriniocassis* sp. cf. *S. weberi* are indicative of the Middle Triassic and the late Pliensbachian to Aalenian, respectively (Helby et al. 1987; Riding and Thomas 1992). If confirmed, this report would be the first record of *Sahulidinium ottii* since this species was first described by Stover and Helby (1987). *Nannoceratopsis pellucida* was recorded from the Mihambia Formation by Hudson and Nicholas (2014, p. 65). The Mihambia Formation was interpreted as being Toarcian to Aalenian in age. Either the interpreted age or the identification of *Nannoceratopsis pellucida* appears to be erroneous, because the range base of this species in both hemispheres is Bathonian (Riding et al. 1985, 2010). It should be noted that the 'probable reworked dinoflagellate' figured by Hudson and Nicholas (2014, fig. 3.5M) is an indeterminate palynomorph, and has no demonstrable dinoflagellate affinity.

Smelror et al. (2018) is a relatively short paper on the Upper Jurassic and Lower Cretaceous palynostratigraphy of the Kipatimu, Mitole, Nalwehe and Kihuluhulu formations of the onshore Mandawa Basin in southeastern coastal Tanzania. The authors concluded that the four formations span the Oxfordian–Tithonian to Aptian–Albian interval. Jurassic and earliest Cretaceous dinoflagellate cysts were recorded only from the Mitole Formation, and these were interpreted as being of Oxfordian to Berriasian age. They include *Canningia reticulata*, *Circulodinium distinctum*, *Cribroperidinium* spp., *Dingodinium jurassicum*, *Kaiwaradinium scruttinum* and *Systematophora areolata*. This assemblage is significantly reminiscent of the Late Jurassic and Early Cretaceous of Gondwana (Helby et al. 1987; Riding et al. 2010). Sample WP232-5-14 from the Mitole Formation contains a marine palynoflora reminiscent to the *Dingodinium jurassicum–Kilwacysta* assemblage of Schrank (2005), and is indicative of a correlation with the *Trigonia smeei* Bed of Tendaguru Hill in southeastern Tanzania.

2.1.2. North Africa

Ten single-region contributions on North Africa are included herein. Nine of the articles are on northern Egyptian material, which reflects the intense hydrocarbon exploration and production activity in this region. One contribution (Jaydawi et al. 2016) is a study of Moroccan material.

Aboul Ela and Tahoun (2010) documented the stratigraphical palynology of the Middle Jurassic to Lower Cretaceous (Bathonian–Callovian to Albian) of the Mango-1 and Til-1 offshore wells, northern Sinai, Egypt. Based on 174 samples of ditch cuttings, the authors established 11 informal dinoflagellate cyst zones which were correlated with other successions in Egypt and surrounding Tethyan areas. Five of these zones cover the Bathonian–Callovian to ?Berriasian interval. A major depositional hiatus between the late Kimmeridgian and the ?Berriasian was identified, and was attributed to a major sea-level fall associated with the Cimmerian orogenic event (Aboul Ela and Tahoun 2010, figs 2, 3). The samples yielded diverse and rich marine and terrestrial palynofloras. This paper focuses entirely on biostratigraphy, and the ranges of all the palynomorphs were given in non-quantitative range charts (Aboul Ela and Tahoun 2010, p. 90–98). The Jurassic dinoflagellate cyst associations appear to be substantially similar in content and distribution to their European counterparts; for example, *Cribroperidinium*? *longicorne*, *Ctenidodinium continuum*, *Gonyaulacysta jurassica*, *Korystocysta pachyderma* and *Systematophora areolata* were recorded.

Ied and Ibrahim (2010) studied the Jurassic and Early Cretaceous palynology of the Almaz-1 well in northern Egypt. This contribution focused mostly on miospores, but some dinoflagellate cysts were recorded from the Bajocian–Callovian to the Barremian. These include *Ctenidodinium sellwoodii*, *Gonyaulacysta jurassica*, *Pareodinia ceratophora* and *Systematophora penicillata* (see Ied and Ibrahim 2010, p. 10). A very similar biostratigraphical paper on the Middle Jurassic to Early Cretaceous (Callovian–Albian) of the Kabrit-1 well drilled west of Cairo in northeastern Egypt was published by Ied and Lashin (2016). They recorded dinoflagellate cysts from the entire succession examined, including *Cribroperidinium* spp., *Dichadogonyaulax*? *pannea*, *Gonyaulacysta jurassica*, *Lithodinia jurassica*, *Pareodinia prolongata* and *Systematophora areolata* (see Ied and Lashin 2016, fig. 2). This assemblage is similar to floras from eastern North America and Europe.

Tahoun et al. (2012) undertook a study of the Middle Jurassic to Upper Cretaceous succession of the Alamein-IX well in northern Egypt. In this study, zone 5, which comprises the Masajid Formation, was interpreted as being of Callovian to possibly Kimmeridgian age (Tahoun et al. 2012, p. 68, fig. 3). This interpretation was based on the presence of *Acanthaulax* sp. cf. *A. crispa*, *Amphorulacysta*? *dodekovae*, *Epiplosphaera reticulospinosa*, *Lithodinia jurassica*, *Meiourogonyaulax reticulata* and *Sentusidinium* spp. This assemblage appears to be somewhat biostratigraphically ambiguous; however, the presence of *Amphorulacysta*? *dodekovae* and *Epiplosphaera reticulospinosa* strongly suggests a late Oxfordian to early Kimmeridgian age (Feist-Burkhardt and Wille 1992, fig. 2).

Gentzis et al. (2018) published a study on the petroleum prospectivity of the Matruh Basin, North Western Desert, Egypt. The dinoflagellate cysts *Ctenidodinium sellwoodii*, *Korystocysta gochtii*, *Mancodinium semitabulatum*, *Nannoceratopsis gracilis Rhynchodiniopsis cladophora* and *Systematophora penicillata* were recorded from the Wadi Natrun, Khattatba and Masajid formations. The two discrete intervals represented by these formations were interpreted as being of Toarcian–Aalenian and ?late Bathonian–Oxfordian age (Gentzis et al. 2018, fig. 4). Some photographs were presented, although the images purportedly of *Nannoceratopsis gracilis* (Gentzis et al. 2018, pl. 1/1, 2) are not clearly of that species.

The stratigraphical palynology of the Middle and Upper Jurassic (Bathonian–Oxfordian) strata of the South Sallum well, North Western Desert, Egypt, was studied by Mostafa et al. (2018). This interval yielded relatively diverse dinoflagellate cyst asssociations, and these were comprehensively illustrated (Mostafa et al. 2018, pls 2–5). Two dinoflagellate cyst biozones were recognised. These are the *Dichadogonyaulax sellwoodii–Wanaea acollaris–Wanaea digitata* Assemblage Zone, interpreted as Bathonian–Callovian in age, and the *Amphorula dodekovae* Interval Zone which was deemed to be Callovian–Oxfordian. Note that the species *Amphorula dodekovae* is now questionably accommodated in *Amphorulacysta*? (see Williams and Fensome 2016, p. 139). Included in the *Dichadogonyaulax sellwoodii–Wanaea acollaris–Wanaea digitata* Assemblage Zone were *Ctenidodinium ornatum*, *Impletosphaeridium varispinosum*, *Korystocysta* spp., *Mendicodinium groenlandicum*, *Pareodinia prolongata* and *Wanaea digitata*. By comparison with Europe, this interval is most likely to be entirely Callovian in age (e.g. Poulsen and Riding 2003). The index taxon for the *Amphorula dodekovae* Interval Zone was first described from the Kimmeridgian and its range was determined as late Oxfordian to early Kimmeridgian (Zotto et al. 1987; Feist-Burkhardt and Wille 1992, fig. 2). Mostafa et al. (2018) interpreted this biozone as being of Callovian–Oxfordian age. However the presence of *Amphorulacysta*? *dodekovae*, *Compositosphaeridium*? *polonicum*, *Endoscrinium galeritum*, *Gonyaulacysta jurassica* and *Neuffenia willei* strongly suggests that it is entirely of Oxfordian age (Riding 1984a; Riding and Thomas 1992). The biostratigraphical significance of selected Berriasian dinoflagellate cysts from northern Egypt was discussed in a review paper by Tahoun and Ied (2018). Sparse and low diversity dinoflagellate cyst associations were recorded from the Tithonian to Albian strata penetrated by the Minqar-IX well, northern Egypt, by Mahmoud et al. (2019).

The paper by Jaydawi et al. (2016) is a major and well-illustrated contribution on the Callovian to Kimmeridgian dinoflagellate cyst biostratigraphy of the petroliferous Essaouira Basin in the Marrakesh–Safi region of central-western Morocco. These authors examined three boreholes. An early Callovian assemblage which includes *Ctenidodinium combazii*, *Ctenidodinium cornigerum* and *Impletosphaeridium varispinosum* was encountered in the MKL-110 borehole. Further material was studied from the NDK-2 and NDK-3 boreholes. A rich late Callovian flora containing *Ctenidodinium continuum*, *Ctenidodinium ornatum* and *Wanaea thysanota* was recovered in the latter borehole. The NDK-2 well yielded established marker species such as *Cribroperidinium*? *longicorne*, *Egmontodinium polyplacophorum*, *Gonyaulacysta centriconnata*, *Scriniodinium crystallinum*, *Systematophora areolata* and *Trichodinium scarburghense*, indicative of the interval from the Callovian–Oxfordian transition to the Kimmeridgian.

2.2. Sub-Arctic North America

The only relevant single-region publication on sub-Arctic North America issued between February 2018 and January 2019 is that by Dodsworth and Eldrett (2018). These authors recorded the reworking of low numbers of *Chytroeisphaeridia chytroeides*, ?*Gonyaulacysta jurassica*, ?*Rhynchodiniopsis cladophora* and *Scriniodinium* spp. into the Upper Cretaceous (Cenomanian–Turonian) Bridge Creek Member (Greenhorn Formation) near Pueblo, Colorado, USA. These Middle to Late Jurassic forms are part of an extensive suite of allochthonous palynomorphs of Carboniferous to middle Cretaceous age (Dodsworth and Eldrett 2018, p. 9, 10).

Additionally, one older single-region contribution was also discovered. This is by van Helden (1987), and comprises a short article in a newsletter designed to encourage research on the Jurassic palynology of Alberta and Saskatchewan in western Canada. This author reported that the Nordegg, Poker Chip and Rock Creek formations of Alberta, and the Shaunavon and Vanguard formations in Saskatchewan, contain abundant and diverse Jurassic dinoflagellate cyst assemblages. It was noted that detailed study of these floras would help the understanding of both the biostratigraphy and palaeoecology of the region. Van Helden (1987) expressed surprise that the palynology of these lithostratigraphical units had not been studied by contemporary palynologists in Canada, and recommended that this open field of research be advanced.

2.3. South America

Only one publication is included here on South America. This is Olivera et al. (2018), which is a report of the pollen grain *Shanbeipollenites proxireticulatus* from the Vaca Muerta Formation of the Neuquén Basin, Argentina, and its associated palynomorphs, including dinoflagellate cysts. *Shanbeipollenites proxireticulatus* was previously reported from the Upper Jurassic of Tanzania (Schrank 2004). The material in this study was interpreted as being of ?Berriasian–Valanginian age based on the overall palynoflora which includes *Meiourogonyaulax bulloidea*, *Sentusidinium villersense* and *Systematophora penicillata* (Olivera et al. 2018, figs 4, 5).

2.4. The Arctic

Six recent single-region contributions from the Arctic are considered in this subsection. Four of these are from Arctic Russia, one of which (Nikitenko et al. 2018a) is considered to be especially significant (see Appendix 1 of the Supplementary material).

The Lower Jurassic through Upper Cretaceous (Hettangian–Turonian) biostratigraphy and lithostratigraphy of the New Siberian Islands and adjacent areas of continental Arctic Siberia was studied by Nikitenko et al. (2017), who defined three depositional series with important reference sections. These strata have been substantially deformed. Despite the substantial structural complications, however, Nikitenko et al. (2017) demonstrated the applicability of these successions for correlation in the continental shelf east of the Laptev Sea and in the west of the East Siberian Sea. These authors used ammonites, bivalves, foraminifera, miospores and ostracods, in addition to dinoflagellate cysts. Nikitenko et al. (2018b) is a closely related study and involves an investigation of the same sections that were studied by Nikitenko et al. (2017). Nikitenko et al. (2018b) comprises a detailed examination of the micropalaeontology (dinoflagellate cysts, foraminifera, miospores and ostracods) and Hettangian and Pliensbachian organic geochemistry of the Hettangian to Turonian reference sections of the New Siberian Islands. A scheme of Boreal standard biozones was erected that have regional applicability in northern Siberia. Kashirtsev et al. (2018) involves a study based on organic geochemistry on the Oxfordian to Valanginian succession of the Nordvik Peninsula, western Anabar Bay, Arctic Russia. A comprehensive biostratigraphy has been developed for this succession including seven dinoflagellate cyst zones (Kashirtsev et al. 2018, fig. 2).

By far the most significant publication on the Arctic region in this review is that by Nikitenko et al. (2018a). This work details the biostratigraphy, geochemistry ($\delta^{13}C_{TOC}$), palaeoecology and sedimentology of the Middle Jurassic to Lower Cretaceous (Bathonian–Valanginian) succession of the Olenek section in the Anabar-Lena region of Arctic Russia. The emphasis is on the uppermost Jurassic and Lower Cretaceous (Tithonian [= Volgian] to Valanginian) Buolkalakh and Iaedaes formations (Nikitenko et al. 2018a, fig. 3). Detailed range data was gathered for ammonites, dinoflagellate cysts, foraminifera and miospores (Nikitenko et al. 2018a, figs 6–9). Five 'dinocyst local zones' were recognised: 1 – the *Cometodinium whitei*, *Epiplosphaera gochtii*, *Gonyaulacysta eisenackii* 'dinocyst local zone'; 2 – the *Bourkidinium* sp.

'dinocyst local zone'; 3 – the *Gochteodinia villosa* 'dinocyst local zone'; 4 – the *Batioladinium varigranosum*, *Occisucysta tentorium* 'dinocyst local zone'; and 5 – the *Cyclonephelium cuculliforme*, *Batioladinium reticulatum* 'dinocyst local zone' (Nikitenko et al. 2018a, fig. 7). Numbers 1 to 4 of these 'zones' cover the ?uppermost Kimmeridgian–Lower Volgian to uppermost Tithonian/Volgian–lower Boreal Berriasian interval. The ages of the five 'dinocyst local zones' from the Olenek section were calibrated to the current geological time scale via correlations with 11 coeval studies throughout the northern and southern hemispheres (Nikitenko et al. 2018a, fig. 11).

The only other single-region publications on the Arctic reviewed herein are those by Felix and Burbridge (1977) and Rismyhr et al. (2019). Felix and Burbridge (1977) established a new species of pteridophytic spore, *Ricciisporites umbonatus*, from the Upper Triassic (Carnian–Norian) of the Sverdrup Basin, Arctic Canada. This comprehensive study included details of the associated palynomorphs, including common occurrences of the dinoflagellate cysts *Sverdrupiella baccata*, *Sverdrupiella manicata*, *Sverdrupiella ornaticingulata*, *Sverdrupiella septentrionalis* and *Sverdrupiella usitata* in the borehole successions that were examined. Dinoflagellate cysts proved absent in the outcrop samples that were studied (Felix and Burbridge 1977, table 1). *Sverdrupiella usitata* is the most prominent species throughout the borehole sections studied. The genus *Sverdrupiella* is therefore highly characteristic of the Norian of boreholes drilled in the Canadian Arctic (Bujak and Fisher 1976).

Rismyhr et al. (2019) provided a major study of the palynology, sedimentology and sequence stratigraphy of the Carnian to Callovian strata of western central Spitsbergen, Svalbard. Ten composite assemblage zones (CAZs) were established, of which the six for the Norian to Callovian interval are based on dinoflagellate cysts (Rismyhr et al. 2019, fig. 3). The principal focus of this study was the Knorringfjellet Formation (Wilhelmøya Subgroup), in which three sequences were identified. Sequence 1 is Norian, and is characterised by the *Rhaetogonyaulax arctica* and *Heibergella* spp. CAZs. *Nannoceratopsis senex* gives its name to a Toarcian CAZ which is equivalent to Sequence 2. The Brentskardhaugen Bed is a highly condensed deposit of late Toarcian–early Aalenian age. It is assigned to the *Phallocysta eumekes* CAZ, and was assigned to Sequence 2 by Rismyhr et al. (2019).

2.5. Australasia

Seven single-region contributions from Australasia are listed in Appendix 1 of the Supplementary material in this review. Zhang Wangping and Grant-Mackie (2001) described the palynology of the Late Triassic and Early Jurassic (Norian–Sinemurian) of New Zealand. This paper is chiefly on miospores, although the authors also reported undifferentiated acritarchs and dinoflagellate cysts from various lithostratigraphical units of the Hokonui Hills and southwestern Kawhia.

The remaining six single-region studies are from Australia. Jones and Nicoll (1984) and Dixon et al. (2012) are short papers on the Late Triassic (Carnian–Norian) of the North West Shelf of Australia. Both mention dinoflagellate cysts briefly. Dixon et al. (2012) worked on the Upper Mungaroo Formation from the offshore Carnarvon Basin. These authors recorded *Dapcodinium* spp. from marginal marine to tidally influenced facies, and *Hebecysta balmei* and *Rhaetogonyaulax* spp. from open-marine settings. The paper by Paumard et al. (2018) is also on material from the North West Shelf of Australia. In this multidisciplinary study the authors examined the sedimentary architecture and sediment partitioning in the Barrow Group (Tithonian–Valanginian) of the Northern Carnarvon Basin. Offshore well data were integrated to establish a seismic stratigraphy of this economically important unit. The authors related seven third-order seismic sequences to the eustatic and tectonic history of the depocentre, and calibrated these sequences using the *Pseudoceratium iehiense* to *Systematophora areolata* dinoflagellate cyst zones of Helby et al. (1987).

However, the most significant Australasian contribution listed herein is by Wainman et al. (2018a). This paper is on the latest Jurasssic (Tithonian) palynology of the Indy 3 well in the western Surat Basin, Queensland, southeastern Australia. These authors discovered low-diversity dinoflagellate cysts and colonial algae in the Walloon Coal Measures (Injune Creek Group). The Walloon Coal Measures were previously believed to be entirely nonmarine. The study showed that either a brief marine transgression is represented by this unit, or that these planktonic palynomorphs were freshwater forms and thus represent a rare report of pre-Cretaceous nonmarine dinoflagellate cysts. These records are coincident with an interval of high global sea level; hence, the former scenario appears to be the best explanation. The new dinoflagellate cyst species described by Wainman et al. (2018a) are *Moorodinium crispa* and *Skuadinium fusum*, and they also described the colonial alga *Palambages pariunta* as new. *Moorodinium crispa* and *Skuadinium fusum* are small, thin-walled proximate cysts from a thin (ca. 2 m) unit interpreted as a possible upper estuarine deposit (Wainman et al. 2018a, pls 1, 2). This interpretation, together with the high dominance and low species richness nature of the assemblage, is consistent with a freshwater setting. Wainman et al. (2018a) provided the palynological basis for a wider study of the Middle–Upper Jurassic Walloon Coal Measures of the Surat Basin (Wainman and McCabe 2018; Wainman et al. 2018b).

2.6. East Europe

None of the nations generally considered to comprise this region are in the Arctic Circle, so the prefix 'sub-Arctic' is superfluous in this case. Nine single-region items concerning Bulgaria, Hungary, Poland and Slovakia in East Europe are listed in Appendix 1 of the Supplementary material. Two of these publications are deemed to have substantial significance.

Three multi-authored papers written in Bulgarian detail the Jurassic (Sinemurian–Tithonian) lithostratigraphy of northeastern Bulgaria (Sapunov et al. 1985, 1986a, 1986b). Specifically, the Dobrič, Drinovo, Esenica, Ginci, Javorec, Kalojan, Ozirovo, Polaten, Provadija, Sultanci and Tiča formations were considered in this set of contributions, all in the same journal. The material studied is from numerous deep, continuously cored, boreholes drilled as part of a partially successful petroleum exploration campaign throughout northern Bulgaria. In Sapunov et al. (1985), the four formations considered are treated separately in ascending stratigraphical order. By contrast, in Sapunov et al. (1986a, 1986b) the lithostratigraphy was described borehole by borehole. Throughout each of these three papers, integrated biostratigraphy based on brachiopods, calpionellids, molluscs and palynomorphs was included. Selected occurrences of dinoflagellate cysts, especially in Sapunov et al. (1986a), were provided by the late Lilia Dodekova, who was one of the co-authors. No photographs or range charts were provided.

The paper by Bóna (1995) is a major work on the Upper Triassic palynostratigraphy of a large coal-bearing basin around Pécs, in the Mecsek Mountains of southern Hungary. Only 'dinoflagellate indet.' was recovered from the lowermost Mecsek Coal formations (Rhaetian) (Bóna 1995, table 2, pl. 8/17). This specimen is very poorly preserved, but appears to be referable to *Rhaetogonyaulax rhaetica*. This author also reported questionable specimens of *Hystrichosphaeridium magnum* from the Karolinavölgy Sandstone and the lowermost Mecsek Coal formations, which are of Norian and Rhaetian age, respectively (Bóna 1995, table 2, pl. 8/16, pl. 9/2, 3, 6). The original authorship of the spinose species *Hystrichosphaeridium magnum* was not provided by Bóna (1995) and was not located by the present author. Only one of the two specimens illustrated of *Hystrichosphaeridium magnum* appears to have possible dinoflagellate cyst affinity (Bóna 1995, pl. 8/16). This specimen is a chorate form with an apparent apical archaeopyle and may be referable to *Beaumontella*.

As part of an unpublished PhD thesis mainly focussed on miospores from southwestern England, Hungary and the southwestern USA, Baranyi (2018) analysed borehole material from the the Veszprém Marl Formation (Carnian) of the southern Transdanubian Range, western Hungary, and recorded 'dinocyst indet.' and *Heibergella* sp. (see Baranyi 2018, pl. 12/10, 11). These records are within the Carnian Pluvial Episode, and are highly unusual in that most Triassic dinoflagellate cyst occurrences are Norian–Rhaetian (Mangerud et al. 2019, fig. 2).

The dissertation by Ruckwied (2009) on the palynology of the Rhaetian and Hettangian strata of the northwestern Tethyan Realm of Hungary and northern Slovakia aimed to investigate biostratigraphy, palaeoclimate and palaeoecology. The principal thrust of this contribution is on miospores. However, Ruckwied (2009) reported *Dapcodinium priscum* and *Rhaetogonyaulax rhaetica* from the Rhaetian and Hettangian of the Furkaska section in the Tatra Mountains of northern Slovakia (see also Ruckwied and Götz 2009). Ruckwied (2009) did not record dinoflagellate cysts from the successions investigated in Hungary.

The prominent Hungarian palynologist Mária Sütőné Szentai produced a compilation of all the genera and species of Silurian to Holocene organic-walled microplankton reported from Hungary since 1957 (Sütőné Szentai 2018). This compendium was an alphabetical listing of all published post-Silurian records of palynomorphs excluding miospores. By far the largest section of this book is on dinoflagellate cysts (Sütőné Szentai 2018, p. 11–111). Every species recorded from Hungary is included; the holotype and the stratigraphical range are also given. The main papers on Triassic and Early Jurassic dinoflagellate cysts from Hungary included in this compilation are Bóna (1995), Bucefalo Palliani et al. (1997) and Baranyi et al. (2016).

2.7. Sub-Arctic West Europe

A total of 29 single-region contributions on the Triassic, Jurassic and earliest Cretaceous of sub-Arctic West Europe are covered in this review, and 12 of these are considered to be considerably impactful (Appendix 1 of the Supplementary material). This section is divided into three subsections based on the stratigraphical coverage of the items.

2.7.1. Triassic and early Jurassic

Seven articles summarised here are focused on the Triassic and Early Jurassic interval. The paper by Karle (1984) involves a detailed study of the palynology of the Triassic–Jurassic boundary at Fonsjoch, western Austria. This author recorded *Rhaetogonyaulax rhaetica* from the Rhaetian. This species is especially common in the middle and upper Rhaetian, and the range top is immediately below a prominent limestone bed which underlies the Pre-Planorbis Beds at the Triassic–Jurassic transition (Karle 1984, fig. 3).

The published PhD dissertation by Holstein (2004) details the palynofacies, palynology and sequence stratigraphy of the Kössen Beds (Upper Triassic, Norian–Rhaetian) of the Eiberg and Mörtlbachgraben sections in the Northern Calcareous Alps of northern Austria. The palynofloras are dominated by miospores, but the dinoflagellate cysts *Dapcodinium priscum* and *Rhaetogonyaulax rhaetica* were recognised. This author asserted that *Dapcodinium priscum* preferred high-energy, shallow-water settings, and that *Rhaetogonyaulax rhaetica* had a preference for deep-water, low-energy palaeoenvironments.

A wide-ranging and multidisciplinary study on the Triassic–Jurassic boundary by Lindström et al. (2017) includes descriptions of palynofloras from several localities in Austria, Denmark, England and Germany. The range top of the last, last common and last consistent occurrences (LO, LCO and LCON, respectively) of *Rhaetogonyaulax rhaetica* were used as reliable regional markers. The LCO and LCON of this prominent and cosmopolitan species are consistently within, or immediately below and above, the extinction phase in the late Rhaetian. However, *Rhaetogonyaulax rhaetica* apparently became extinct (LO) during the post-extinction phase in Austria and England (Lindström et al. 2017, fig. 12).

Juncal et al. (2018) involves a multidisciplinary study of the Permian and Triassic of the Paris Basin in central France. These authors reported *Dapcodinium priscum* and *Rhaetogonyaulax rhaetica* from the uppermost Rhaetian of the Sancerre-Couy 1 borehole, within their SC-4 assemblage. Schneebeli-Hermann et al. (2018) provided a very detailed study of the palynology of the Norian, Rhaetian and Sinemurian strata of northern Switzerland, distinguishing five informal palynomorph associations. The main emphasis was on miospores, but nine dinoflagellate cyst taxa were recognised from the Rhaetian and Sinemurian (Schneebeli-Hermann et al. 2018, figs 2, 5). These include *Beaumontella langii*, *Dapcodinium priscum*, *Rhaetogonyaulax rhaetica* and ?*Suessia swabiana*; the greatest dinoflagellate cyst diversity is in the Rhaetian (Schneebeli-Hermann et al. 2018, figs 2, 5).

As part of a major multidisciplinary paper on the cores recovered by the Schandelah Scientific Drilling Project in northern Germany, van de Schootbrugge et al. (2018) investigated the palynology of an important Rhaetian to Toarcian succession. Full details of the palynomorphs recovered were not given, but these authors illustrated major bioevents and figured significant dinoflagellate cyst, miospore taxa (van de Schootbrugge et al. 2018, fig. 3, pl. 1). The authors recognised the Early Jurassic *Dapcodinium priscum*, *Liasidium variabile* and *Nannoceratopsis* dinoflagellate cyst zones.

Several contributions on the Early Jurassic palynology of the Lusitanian Basin in western Portugal were published recently by Vânia Correia and her co-authors (Appendix 1 of the Supplementary material). These are all associated with the author's PhD thesis (Correia 2018), and the most significant is Correia et al. (2018). This paper is on the palynostratigraphy of the Lower Jurassic strata of this important Iberian depocentre. Correia et al. (2018) documented the Sinemurian to Toarcian palynomorph biostratigraphy based on six localities, with the principal emphasis being on dinoflagellate cysts. The Sinemurian proved devoid of dinoflagellate cysts. By contrast the Pliensbachian and Toarcian are characterised by the presence of the genera *Luehndea*, *Mancodinium*, *Mendicodinium*, *Nannoceratopsis* and *Scriniocassis*. *Luehndea* was apparently made extinct by the Toarcian Oceanic Anoxic Event (T-OAE). This event proved substantially more intense in the Lusitanian Basin than elsewhere in southern Europe, and the recovery of phytoplankton was protracted in this basin. Correia et al. (2018) proposed a biozonation for the late Pliensbachian and Toarcian, comprising the *Luehndea spinosa* and *Mendicodinium microscabratum* dinoflagellate cyst zones. The zones were divided into subzones (Correia et al. 2018, fig. 15).

2.7.2. Middle Jurassic

In this subsection, four items focused on the Middle Jurassic are documented. A major study on the palynology of the Middle Jurassic Ravenscar Group, from the Cleveland Basin, northeastern Yorkshire, northern England, was undertaken by Hogg (1993). This unpublished PhD thesis focussed on outcrops of the Cloughton, Scarborough, Scalby and Cornbrash formations (Bajocian–Bathonian) in the Scarborough area of North Yorkshire. The emphasis was on miospores, but diverse dinoflagellate cyst floras were also recovered and 30 genera were recognised (Hogg 1993, p. 121–137, fig. 4.6, pls 17–23). Three new species were informally introduced. Furthermore, *Ambonosphaera calloviana* and *Tabulodinium senarium* were reported from the UK for the first time. Hogg (1993) determined that much of the Long Nab Member of the Scalby Formation is of latest Bathonian (*Clydoniceras discus* ammonite zone) age. This work refined the biostratigraphical results of Riding and Wright (1989), who reported a Bathonian (undifferentiated) age. Hogg (1993, p. 179–190) discussed the dinoflagellate cyst biostratigraphy of the Scarborough and Scalby formations in some detail, comparing his results with previous studies such as those by Riding and Wright (1989) and Gowland and Riding (1991). The sequence stratigraphy of the successions investigated was also analysed.

Powell et al. (2018, Appendix B in Supplementary material) documented the palynology of two samples from the Kellaways Sand Member (Lower Callovian) of Burythorpe Sand Quarry, North Yorkshire, UK. Sample 2 was relatively rich in dinoflagellate cysts and five specimens were illustrated (Powell et al. 2018, fig. 12).

The early Mesozoic phytoplankton radiation was investigated by Wiggan et al. (2018). The coccolithophores and dinoflagellates radiated substantially during the Bajocian (∼170–168 Ma). Wiggan et al. (2018) described and interpreted a dominance of the genus *Dissiliodinium* in the mid-latitudes, followed by the explosive evolutionary expansion of the dinoflagellate family Gonyaulacaceae. The latter phenomenon was viewed as being strongly influenced by increases in sea level and changes in ocean gateways, and possibly related to the Mesozoic Marine Revolution. The key dinoflagellate cyst data in Wiggan et al. (2018) were from an important borehole succession in southern Germany initially published by Wiggan et al. (2017).

Correia et al. (2019) presents part of the senior author's PhD study (Correia 2018), providing an account of the palynostratigraphy of the Cabo Mondego and Póvoa de Lomba formations (uppermost Toarcian–Bathonian) at Cabo Mondego and São Gião in the northern Lusitanian Basin. The succession at Cabo Mondego includes the Global Stratotype Section and Point (GSSP) for the Bajocian. The samples from Cabo Mondego were by far the most palynologically productive. Here the uppermost Toarcian to lowermost Bajocian succession produced low-diversity dinoflagellate cyst associations dominated by *Nannoceratopsis*. Within the *Witchellia laeviuscula* ammonite zone, the assemblages become markedly more diverse, reflecting the intra-Bajocian global evolutionary explosion of dinoflagellates. This predominantly involved the family Gonyaulacaceae, and was apparently strongly linked to sea-level rise (Wiggan et al. 2017, 2018). The upper part of the Lower Bajocian and much of the Upper Bajocian were not sampled by Correia et al. (2019, fig. 2); however, the trend of increasing dinoflagellate cyst diversity continued through the Bajocian–Bathonian transition. It is clear from Correia et al. (2019) that the Middle Jurassic dinoflagellate cyst species richnesses in the Arctic region and the Boreal Realm are substantially higher than in southern Europe. This may be because more northerly palaeolatitudes were a phytoplankton-diversity hotspot during the Mesozoic, that the recovery from the T-OAE was more protracted in the Iberian region, or that regional palaeogeographical factors controlled dinoflagellate diversity in the Lusitanian Basin.

2.7.3. Middle Jurassic to Early Cretaceous, inclusive

In this subsection, the six remaining substantial papers exclusively on West Europe are discussed. The works involved range from the Middle Jurassic to Early Cretaceous. Heunisch and Luppold (2018) present an important study of the Middle Jurassic to earliest Cretaceous (Callovian–Berriasian) micropalaeontological biostratigraphy of two boreholes drilled in the Lower Saxony Basin of northern Germany. It is a technical report with the micropalaeontology of selected intervals in the Eulenflucht-1 and Wendhausen-6 boreholes described one by one. In the palynology subsections, age-diagnostic dinoflagellate cysts such as *Compositosphaeridium*? *polonicum*, *Dingodinium tuberosum*, *Gonyaulacysta jurassica*, *Hystrichosphaerina*? *orbifera*, *Muderongia simplex* subsp. *microperforata*, *Nannoceratopsis pellucida*, *Pareodinia brevicornuta*, *Systematophora areolata* and *Systematophora penicillata* are mentioned (Heunisch and Luppold 2018, pl. 3).

An overview of the Middle Jurassic to Early Cretaceous (Bathonian–Barremian) basin evolution in the Central Graben area of the North Sea (representing the Danish, Dutch and German sectors) was presented by Verreussel et al. (2018). This study was entirely based on the correlations of wells that have been analysed for palynology (Verreussel et al. 2018, fig. 2). These authors recognised four intervals that they termed tectonostratigraphical megasequences (TMS). Each TMS represents a distinct phase of basin evolution; for example, TMS-1 reflects the onset of basin rifting, and the rift climax occurred during this phase. It was characterised by thick mud deposition.

A study focussed on the Oxfordian/Kimmeridgian boundary beds in the Flodigarry Shale Member (Staffin Bay Formation) of the Isle of Skye, northwestern Scotland, was undertaken by Barski (2018). This unit is notable because it includes a proposed GSSP for the base of the Kimmeridgian. Barski (2018) studied seven samples from the *Ringsteadia pseudocordata* and *Pictonia baylei* ammonite zones, and presented quantitative data (Barski 2018, table 1). The author recognised a eutrophication event in the lowermost Kimmeridgian. Furthermore, Barski (2018) noted that the range bases of sparse *Emmetrocysta sarjeantii*, *Perisseiasphaeridium pannosum* and *Senoniasphaera jurassica* can be used as markers for the base of the Kimmeridgian.

Turner et al. (2018) is a major study on the comprehensive stratigraphy of the Upper Jurassic and Lower Cretaceous of the Arctic and Europe, and includes palynological analysis of the Kimmeridgian to Berriasian of the Norwegian Continental Shelf. These authors integrated carbon isotope, cyclostratigraphical, dinoflagellate cyst and gamma ray data to effect interregional correlations throughout this important interval. Turner et al. (2018, fig. 2) calibrated the palynological data from the Barents and North seas to the current geological time scale using ammonite-dated dinoflagellate cyst studies such as Riding and Thomas (1992) and Poulsen and Riding (2003).

Schneider et al. (2018) undertook a detailed study of the micropalaeontology and palynology of the Jurassic–Cretaceous transition (Tithonian–Berriasian) in the Lower Saxony Basin of northern Germany. This study is based mainly on miospores, but the authors noted the regional correlative significance of the range bases of *Batioladinium pomum*, *Cantulodinium speciosum*, *Muderongia simplex* subsp. *microperforata*, *Muderongia simplex* and *Pseudoceratium pelliferum* in the Berriasian (Schneider et al. 2018, fig. 2).

Stanley Duxbury continued his extensive research into dinoflagellate cysts from the Lower Cretaceous of the North Sea and surrounding areas that began with Duxbury (1977). Duxbury (2018) is a major study of the Berriasian to lower Hauterivian marine palynostratigraphy of the Speeton Clay and Valhall formations of the Central North Sea and northeastern England based on 1131 samples. The biozonation of Duxbury (2001) is substantially refined. Duxbury (2018) is dominated by a systematics section with taxonomic novelties including one new genus and 21 new species.

2.8. The Middle East

The one single-region contribution on the Middle East herein is the article by Eshet (1990). This author studied the Permian and Triassic successions of 11 boreholes drilled throughout Israel. Eshet (1990) erected seven interval zones for the Early Permian to Late Triassic. Only one dinoflagellate cyst zone, the *Rhaetogonyaulax rhaetica* Zone (VII; Norian–Rhaetian), was established. The base of this zone was defined by the range bases of post-Carnian miospores, and the top by the range top of *Rhaetogonyaulax rhaetica* and other dinoflagellate cysts (i.e. *Heibergella asymmetrica*, *Noricysta fimbriata*, *Suessia swabiana* and *Sverdrupiella* spp.). Two distinct palynofacies are present in this zone, one with dinoflagellate cysts and the other devoid of these marine palynomorphs. The *Rhaetogonyaulax rhaetica* Zone is restricted to the coastal plain in the extreme west of Israel; elsewhere, the Norian–Rhaetian has been cut out by a regional unconformity. Its reference section is within the Shefaiym Formation, between 4860 and 4495 m in the Ga'ash 2 Borehole, northwestern Israel (Cousminer 1981; Eshet 1990, fig. 1). The age interpretation of Norian–Rhaetian is based on the ranges of the dinoflagellate cysts *Rhaetogonyaulax rhaetica* and *Suessia swabiana* (see Visscher and Brugman 1981) and foraminifera.

2.9. Sub-Arctic Russia

Twelve single-region articles on sub-Arctic Russia are compiled in this review, six of which are deemed to be highly significant (Appendix 1 of the Supplementary material). Three of these are on sub-Arctic West Russia, i.e. west of the Ural Mountains, and the remaining nine are on southwestern Russia. The most significant of these contributions are detailed below in two subsections.

2.9.1. Sub-Arctic west Russia

The unpublished PhD thesis by Smith (1999), available online, details the palynostratigraphy of the Tithonian (Volgian) to Valanginian strata of the important Volgian lectostratotype successions at Gorodische and Kashpir, near Ulyanovsk, southwestern Russia. The key findings were later incorporated into Harding et al. (2011). Another noteworthy article based on the Upper Kimmeridgian and Tithonian strata of Gorodische is Pestchevitskaya (2018). This author focussed on the distinctive camocavate dinoflagellate cyst genus *Dingodinium*. The genus was emended, with the archaeopyle interpreted as of combination type (apical/anterior intercalary), and the tabulation partiform (Pestchevitskaya 2018, fig. 2). Pestchevitskaya (2018) thus placed *Dingodinium* into the family Cladopyxiaceae. She compiled the Middle Jurassic to the latest Cretaceous stratigraphical ranges of the genus worldwide, and discussed the morphologies of 12 species of *Dingodinium* (Pestchevitskaya 2018, figs 1, 3). Pestchevitskaya (2018) identified *Dingodinium albertii*, *Dingodinium jurassicum* and *Dingodinium tuberosum* from Gorodische, and established the new species *Dingodinium nequeas*. In another publication Dzyuba et al. (2018) discussed the ranges of dinoflagellate cysts, mainly identified only at the generic level, from the Tithonian–Berriasian (Volgian–Ryazanian) of a fossiliferous succession exposed on the banks of the Maurynya River in the Northern Ural Mountains of West Siberia.

2.9.2. Southwestern Russia (the Caspian Sea, the Caucasus Mountains and Crimea)

The discussion of articles on the Caspian Sea, the Caucasus Mountains and Crimea is placed in the subsection on sub-Arctic Russia herein for purely geographical and pragmatic reasons. This strategy has absolutely no political significance whatsoever.

The remaining nine items from sub-Arctic Russia, all recently published, are based on material from southwestern Russia. Arkadiev et al. (2018) is a biostratigraphical and magnetostratigraphical synthesis of the Jurassic–Cretaceous boundary beds of the Crimean Mountains. Tithonian and Berriasian strata are well developed and highly fossiliferous throughout this region. The authors summarised research on ammonites, calpionellids, dinoflagellate cysts, foraminifera and ostracods from Tithonian to lowermost Valanginian strata across Crimea, and correlated these fossil records with magnetostratigraphy. Two subdivisions based on dinoflagellate cysts were recognised. These are the ‘beds with *Amphorula expirata*’ (now *Amphorulacysta*? *expirata*) and the ‘beds with *Phoberocysta neocomica*’ of latest Tithonian–earliest Berriasian and earliest Berriasian–latest Berriasian age, respectively. The range bases of *Ctenidodinium elegantulum*, *Phoberocysta neocomica* and *Spiniferites* spp. define the boundary between these two informal biozones; these bioevents are within the *Tirnovella occitanica* ammonite zone (Arkadiev et al. 2018, fig. 21).

The short paper by Goryacheva and Ruban (2018) is on the Pliensbachian and Toarcian palynology of the Sjuk River valley in the northwestern Caucasus, where the authors identified *Nannoceratopsis senex*. Another short article by Goryacheva et al. (2018) is on the palynology of a sandstone representing a reportedly deep marine setting in the upper part of the Bagovskaja Formation from the River Belaja, south of Guzeripl in the northern Arkhyz-Guzereplskaja area, Western Caucasus region. This unit is Toarcian in age, based on ammonites recovered from its lowermost beds. Goryacheva et al. (2018) reported a dinoflagellate cyst assemblage dominated by *Nannoceratopsis*. The most abundant species is *Nannoceratopsis spiculata*. Less common forms include *Nannoceratopsis plegas*, *Nannoceratopsis senex*, *Phallocysta eumekes* and *Susadinium faustum*. Goryacheva et al. (2018) interpreted this association as being of late Toarcian age.

Mitta et al. (2017) provided an integrated palaeontological study of the Middle Jurassic (Bajocian–Bathonian) of the Bolshoi Zelenchuk River Basin in the Northern Caucasus region. Samples were collected from the uppermost Bajocian and lowermost Bathonian (*Parkinsonia parkinsoni* and *Zigzagiceras zigzag* ammonite zones) part of the Djangura Formation from localities 8, 11, 12 and 25 of Mitta et al. (2017, fig. 2). The authors examined ammonites, dinoflagellate cysts, foraminifera, miospores and ostracods from this succession. The five productive samples yielded moderately diverse dinoflagellate cyst associations. Prominent species recorded throughout include *Aldorfia aldorfensis*, *Chytroeisphaeridia chytroeides*, *Ctenidodinium sellwoodii*, *Korystocysta gochtii*, *Meiourogonyaulax caytonensis*, *Nannoceratopsis gracilis*, *Nannoceratopsis spiculata* and *Valensiella ovulum*. Mitta et al. (2017) recognised two informal zones. The uppermost Bajocian was termed ‘beds with *Rynchodiniopsis*? *regalis*’, the nominate species being confined to this interval. The most prominent dinoflagellate cysts are *Ctenidodinium sellwoodii* and *Dissiliodinium* spp. The presence of *Acanthaulax* aff. *crispa* (as *Cribroperidinium* aff. *crispum*) is indicative of the late Bajocian (Wiggan et al. 2017). However, Mitta et al. (2017) also recorded *Nannoceratopsis dictyambonis* from this interval. This species, characteristic of the latest Toarcian to early Bajocian interval (Riding 1984a, 1984b; Wiggan et al. 2017), may thus be reworked. The overlying lowermost Bathonian was assigned to ‘beds with *Ctenidodinium sellwoodii*’, named after one of the dominant species. The dinoflagellate cysts of this interval are substantially similar to those from the underlying interval. Only six range bases were observed in the ‘beds with *Ctenidodinium sellwoodii*’, including that of *Ctenidodinium continuum*.

Mitta et al. (2018) is a companion paper to Mitta et al. (2017). The former is an important biostratigraphical study of the Upper Bajocian Djangura Formation from the banks of the Kyafar River, a tributary of the Bolshoi Zelenchuk River, Karachay-Cherkessia, Northern Caucasus, southwestern Russia. The material is all from the *Rarecostites subarietis* ammonite subzone of the *Parkinsonia parkinsoni* ammonite zone. Ten samples were examined, and all yielded substantial proportions of dinoflagellate cysts in relatively diverse associations (Mitta et al. 2018, fig. 6). The samples are dominated by *Dissiliodinium* spp. Furthermore, the following species were found throughout: *Aldorfia aldorfensis*, *Chytroeisphaeridia chytroeides*, *Ctenidodinium continuum*, *Ctenidodinium sellwoodii*, *Durotrigia daveyi*, *Korystocysta* spp. , *Meiourogonyaulax caytonensis*, *Meiourogonyaulax valensii*, *Nannoceratopsis gracilis*, *Nannoceratopsis senex*, *Nannoceratopsis spiculata*, *Pareodinia ceratophora*, *Pareodinia prolongata*, *Rhynchodiniopsis*? *regalis*, *Sentusidinium* spp. , *Tubotuberella* spp. , and *Valensiella ovulum*. The following are also present, but rather less consistently: *Endoscrinium galeritum*, *Kalyptea stegasta*, *Leptodinium* sp. , *Nannoceratopsis dictyambonis*, *Nannoceratopsis raunsgaardii*, *Pareodinia halosa*, *Phallocysta elongata*, and *Wanaea acollaris* (see Mitta et al. 2018, fig. 6, pl. V). The authors assigned the entire succession that they studied to the 'beds with *Meiourogonyaulax valensii*, *Rhynchodiniopsis*? *regalis*' (Mitta et al. 2018, fig. 7). Many of the dinoflagellate cyst taxa recovered by Mitta et al. (2018) are entirely consistent with the latest Bajocian age determined by ammonites and other fossils. These marker taxa include *Aldorfia aldorfensis*, *Ctenidodinium continuum*, *Ctenidodinium sellwoodii*, *Dissiliodinium* spp., *Durotrigia daveyi*, *Kalyptea stegasta*, *Korystocysta* spp., *Leptodinium* sp., *Meiourogonyaulax caytonensis*, *Meiourogonyaulax valensii*, *Rhynchodiniopsis*? *regalis*, *Tubotuberella* spp. and *Wanaea acollaris* (see e.g. Riding and Thomas 1992; Wiggan et al. 2017).

As in Mitta et al. (2017), Mitta et al. (2018), identified apparent reworking of dinoflagellate cysts. The diversity of the species involved is considerable, comprising *Nannoceratopsis dictyambonis*, *Nannoceratopsis raunsgaardii*, *Nannoceratopsis gracilis*, *Nannoceratopsis senex* and *Phallocysta elongata*. The presence of these taxa is clearly stratigraphically incompatible with a latest Bajocian age and reflects stratigraphical recycling of Upper Pliensbachian to Early Bajocian strata. The range bases of *Nannoceratopsis gracilis* and *Nannoceratopsis senex* are late Pliensbachian, and these species are common throughout the Toarcian and earliest Bajocian interval (e.g. Morgenroth 1970; Poulsen 1996; Riding et al. 1999; Correia et al. 2018, 2019). The allochthonous species with the shortest ranges are *Nannoceratopsis dictyambonis* and *Phallocysta elongata*, forms that are characteristic of the latest Toarcian to earliest Bajocian (Riding 1984b, 1994).

The earliest Cretaceous (Berriasian) dinoflagellate cysts from the Uruh section in the North Caucasus, southwestern Russia, were reported in a short contribution in Russian by Shurekova (2018). The article is well-illustrated, and a semi-quantitative range chart is presented (Shurekova, 2018, p. 283–285). The author distinguished the *Phoberocysta neocomica* and *Systematophora* cf. *palmula* dinoflagellate cyst zones which are broadly equivalent to the *Tirnovella occitanica* and *Fauriella boissieri* ammonite zones. The species *Systematophora palmula* is now known as *Palaecysta palmula*.

3. Conclusions

In a literature search from February 2018 to January 2019, 55 new publications pertaining to Triassic to earliest Cretaceous dinoflagellate cysts were discovered, and are compiled herein together with 38 older items which were not covered by Riding (2012, 2013, 2014, 2019). These 93 papers are based on material from Africa, North America, South America, the Arctic, Australasia, East Europe, West Europe, the Middle East and Russia. Thirty of them are deemed herein to be significantly impactful and are asterisked in Appendix 1 of the Supplementary material. All 93 contributions are listed in Appendix 1 of the Supplementary material, and most are on the Late Triassic and Early Jurassic of Europe (Tables 1, 2). This may be due to substantial recent interest in the Triassic–Jurassic transition, and the situation differs from previous compilations which demonstrated greater focus on the Late Jurassic of Europe (Riding 2012, 2013, 2014, 2019). Papers based on West Europe comprise 31.2% of the total, and publications on Africa, the Arctic, Australasia, East Europe and Russia are also significant (15.1, 6.5, 7.5, 9.7 and 14.0%, respectively). The least well-represented regions are North America, South America and the Middle East (2.2, 1.1 and 1.1%, respectively; Table 1).

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Disclosure statement

The author has no potential conflict of interest.

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References

Aboul Ela NM, Tahoun SS. 2010. Dinoflagellate cyst stratigraphy of the subsurface Middle–Upper Jurassic/Lower Cretaceous sequence in North Sinai, Egypt. Fifth International Conference on the Geology of

the Tethys Realm, 2nd–7th January 2010, South Valley University, Quena, Luxor, Egypt; p. 85–115.
Arkadiev V, Guzhikov A, Baraboshkin E, Savelieva J, Feodorova A, Shurekova O, Platonov E, Manikin A. 2018. Biostratigraphy and magnetostratigraphy of the upper Tithonian–Berriasian of the Crimean Mountains. Cretaceous Research. 87:5–41.
Baranyi V. 2018. Vegetation dynamics during the Late Triassic (Carnian–Norian): Response to climate and environmental changes inferred from palynology [Unpublished PhD thesis], University of Oslo, Norway, p. 164. https://www.duo.uio.no/handle/10852/61940.
Baranyi V, Pálfy J, Görög A, Riding JB, Raucsik B. 2016. Multiphase response of palynomorphs to early Toarcian (Early Jurassic) environmental changes in southwest Hungary. Review of Palaeobotany and Palynology. 235:51–70.
Barski M. 2018. Dinoflagellate cyst assemblages across the Oxfordian/Kimmeridgian boundary (Upper Jurassic) at Flodigarry, Staffin Bay, Isle of Skye, Scotland - a proposed GSSP for the base of the Kimmeridgian. Volumina Jurassica. 16:51–62.
Boersma M, Brugman WA, Veld H. 1987. Triassic palynomorphs: index to genera and species. Laboratory of Palaeobotany and Palynology (LPP) Special Services, No. 1987-02, Utrecht, The Netherlands. p. 228.
Bóna J. 1995. Palynostratigraphy of the Upper Triassic formations in the Mecsek Mts (Southern Hungary). Acta Geologica Hungarica. 38: 319–354.
Bucefalo Palliani R, Riding JB, Torricelli S. 1997. The dinoflagellate cyst *Luehndea* Morgenroth, 1970, emend. from the upper Pliensbachian (Lower Jurassic) of Hungary. Review of Palaeobotany and Palynology. 96(1–2):113–120.
Bujak JP, Fisher MJ. 1976. Dinoflagellate cysts from the Upper Triassic of arctic Canada. Micropaleontology. 22(1):44–70.
Correia V. 2018. Jurassic dinoflagellate cyst biostratigraphy of the Lusitanian Basin, west-central Portugal, and its relevance to the opening of the North Atlantic and petroleum geology [Unpublished PhD thesis] Universidade do Algarve, Portugal, p. 283.
Correia VF, Riding JB, Duarte LV, Fernandes P, Pereira Z. 2018. The Early Jurassic palynostratigraphy of the Lusitanian Basin, western Portugal. Geobios. 51(6):537–557.
Correia VF, Riding JB, Henriques MH, Fernandes P, Pereira Z, Wiggan NJ. 2019. The Middle Jurassic palynostratigraphy of the northern Lusitanian Basin, Portugal. Newsletters on Stratigraphy. 52(1):73–96.
Cousminer HL. 1981. Palynostratigraphy, thermal alteration index and kerogen characteristics of the Ga'ash 2 well sequence. Geological Survey of Israel Restricted Report P/2/81. p. 20 (unpublished).
Dixon M, Morgan R, Goodall J, van den Berg M. 2012. Higher-resolution palynostratigraphy of the Norian–Carnian (Triassic) Upper Mungaroo Formation, offshore Carnarvon Basin. APPEA 2012 Journal and Conference Proceedings, 13th–16th May 2012, Adelaide, South Australia, p. 3.
Dodsworth P, Eldrett JS. 2018. A dinoflagellate cyst zonation of the Cenomanian and Turonian (Upper Cretaceous) in the Western Interior, United States. Palynology. doi:10.1080/01916122.2018.1477851
Duxbury S. 1977. A palynostratigraphy of the Berriasian to Barremian of the Speeton Clay of Speeton, England. Palaeontographica Abteilung B. 160:17–67.
Duxbury S. 2001. A palynological zonation scheme for the Lower Cretaceous – United Kingdom Sector, Central North Sea. Neues Jahrbuch Für Geologie Und Paläontologie - Abhandlungen . 219(1–2): 95–137.
Duxbury S. 2018. Berriasian to lower Hauterivian palynostratigraphy, U.K. onshore and Outer Moray Firth. Micropaleontology. 64:171–252.
Dzyuba OS, Pestchevitskaya EB, Urman OS, Shurygin BN, Alifirov AS, Igolnikov AE, Kosenko IN. 2018. The Maurynya section, West Siberia: a key section of the Jurassic–Cretaceous boundary deposits of shallow marine genesis. Russian Geology and Geophysics. 59(7):864–890.
Eshet Y. 1990. Paleozoic–Mesozoic palynology of Israel. I. Palynological aspects of the Permian–Triassic succession in the subsurface of Israel. Geological Survey of Israel Bulletin. 81:73.
Feist-Burkhardt S, Wille W. 1992. Jurassic palynology in southwest Germany - state of the art. Cahiers de Micropaléontologie NS. 7: 141–156.
Felix CJ, Burbridge PP. 1977. A new *Ricciisporites* from the Triassic of Arctic Canada. Palaeontology. 20:581–587.
Gentzis T, Carvajal-Ortiz H, Deaf A, Tahoun SS. 2018. Multi-proxy approach to screen the hydrocarbon potential of the Jurassic succession in the Matruh Basin, North Western Desert, Egypt. International Journal of Coal Geology. 190:29–41.
Goryacheva AA, Ruban DA. 2018. New palynological data from the Lower Jurassic deposits of the northwestern Caucasus. Bulletin of Udmurt University Series Biology Earth Sciences. 28:321–324.
Goryacheva AA, Zorina SO, Ruban DA, Eskin AA, Nikashin KI, Galiullin BM, Morozov VP, Mikhailenko AV, Nazarenko OV, Zayats PP. 2018. New palynological data for Toarcian (Lower Jurassic) deep-marine sandstones of the Western Caucasus, southwestern Russia. Geologos. 24(2):127–136.
Gowland S, Riding JB. 1991. Stratigraphy, sedimentology and palaeontology of the Scarborough Formation (Middle Jurassic) at Hundale Point, North Yorkshire. Proceedings of the Yorkshire Geological Society. 48(4):375–392.
Harding IC, Smith GA, Riding JB, Wimbledon W. 2011. Inter-regional correlation of Jurassic/Cretaceous boundary strata based on the Tithonian–Valanginian dinoflagellate cyst biostratigraphy of the Volga Basin, western Russia. Review of Palaeobotany and Palynology. 167(1–2):82–116.
Helby R, Morgan R, Partridge AD. 1987. A palynological zonation of the Australian Mesozoic. Memoir of the Association of Australasian Palaeontologists. 4:1–94.
Heunisch C, Luppold FW. 2018. Mitteljura bis Unterkreide in den Bohrungen Eulenflucht 1 und Wendhausen 6 – litho- und biostratigraphische Ergebnisse. In Fischer K, Herrendorf G, Heunisch C, Luppold FW, Meinsen J, Possin W, Schwarz C, Thomas M. Neue Erkenntnisse zu Quartär, Jura und Unterkreide in Niedersachsen. GeoBerichte. Vol. 31. Hannover: Landesamt fur Bergbau, Energie und Geologie; p. 40–85.
Hogg NM. 1993. A palynological investigation of the Scalby Formation (Ravenscar Group, Middle Jurassic) and adjacent strata from the Cleveland Basin, north east Yorkshire [Unpublished PhD thesis]. University of Sheffield, UK, p. 233. http://etheses.whiterose.ac.uk/14604/1/576086.pdf.
Holstein B. 2004. Palynologische Untersuchungen der Kössener Schichten (Rhät, Alpine Obertrias). Jahrbuch Der Geologischen Bundesanstalt. 144:261–365.
Hudson WE, Nicholas CJ. 2014. The Pindiro Group (Triassic to Early Jurassic Mandawa Basin, southern coastal Tanzania): Definition, palaeoenvironment, and stratigraphy. Journal of African Earth Sciences. 92:53–67.
Ied IM, Ibrahim N. 2010. Jurassic – Early Cretaceous palynomorphs in Almaz-1 Well, north Western Desert, Egypt. Bulletin of the Faculty of Science Zagazig University Egypt. 32:115–133.
Ied IM, Lashin G. 2016. Palynostratigraphy and paleobiogeography of the Jurassic – Lower Cretaceous succession in Kabrit-1 well, northeastern Egypt. Cretaceous Research. 58:69–85.
Jaydawi S, Hssaida T, Benbouziane A, Mouflih M, Chakor Alami A. 2016. Datation par les kystes de dinoflagellés des formations jurassiques (Callovien–Kimméridgien) du bassin d'Essaouira (Marge atlantique marocaine). Bulletin de l'Institut Scientifique, Rabat. Section Sciences de la Terre No. 38:127–148.
Jones PJ, Nicoll RS. 1984. Late Triassic conodonts from Sahul Shoals. Ashmore Block, Northwestern Australia. BMR Journal of Australian Geology and Geophysics. 9(1):361–364.
Juncal MA, Bourquin S, Beccaletto L, Diez JB. 2018. New sedimentological and palynological data from the Permian and Triassic series of the Sancerre-Couy core, Paris Basin, France. Geobios. 51(6):517–535.
Karle U. 1984. Palynostratigraphische Untersuchung eines Rhät/Lias-Profils am Fonsjoch, Achensee (Nördliche Kalkalpen, Österreich). Mitteilungen Der Österreichischen Geologischen Gesellschaft. 77: 331–353.
Kashirtsev VA, Nikitenko BL, Peshchevitskaya EB, Fursenko EA. 2018. Biogeochemistry and microfossils of the Upper Jurassic and Lower Cretaceous, Anabar Bay, Laptev Sea. Russian Geology and Geophysics. 59(4):386–404.

Lindström S, van de Schootbrugge B, Hansen KH, Pedersen GK, Alsen P, Thibault N, Dybkjaer K, Bjerrum CJ, Nielsen LH. 2017. A new correlation of Triassic–Jurassic boundary successions in NW Europe, Nevada and Peru, and the Central Atlantic Magmatic Province: A time-line for the end-Triassic mass extinction. Palaeogeography, Palaeoclimatology, Palaeoecology. 478:80–102.

Londeix L. 2018. Quantitative biostratigraphical ranges of some late Cenozoic species of the dinoflagellate genus *Spiniferites* and taxonomic considerations. Palynology. 42(sup1):203–220.

Mahmoud MS, Deaf AS, Tamam MA, Khalaf MM. 2019. Revised (miospores-based) stratigraphy of the Lower Cretaceous succession of the Minqar-IX well, Shushan Basin, north Western Desert, Egypt: Biozonation and correlation approach. Journal of African Earth Sciences. 151:18–35.

Mangerud G, Paterson NW, Riding JB. 2019. The temporal and spatial distribution of Triassic dinoflagellate cysts. Review of Palaeobotany and Palynology. 261:53–66.

Mitta VV, Savelieva YN, Feodorova AA, Shurekova OV. 2017. Biostratigraphy of the Bajocian–Bathonian Boundary Beds in the basin of the Bolshoi Zelenchuk River (Northern Caucasus). Stratigraphy and Geological Correlation. 25(6):607–626.

Mitta VV, Savelieva YN, Fedorova AA, Shurekova OV. 2018. Ammonites, microfauna, and palynomorphs from the lower part of the Upper Bajocian Parkinsoni Zone of the basin of the Bolshoi Zelenchuk River, Northern Caucasus. Stratigraphy and Geological Correlation. 26(5): 552–570.

Morgenroth P. 1970. Dinoflagellate cysts from the Lias Delta of Lühnde/Germany. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen. 136:345–359.

Mostafa TF, El Soughier MI, Makled WA. 2018. Middle–Upper Jurassic Palynology of the South Sallum Well, North Western Desert, Egypt. Egyptian Journal of Petroleum. 27:1251–1263

Msaky ES. 2008. Middle Jurassic–earliest Late Cretaceous palynofloras, coastal Tanzania [Unpublished PhD Thesis]. University of Queensland, Brisbane, Australia, p. 198. https://espace.library.uq.edu.au/view/UQ:178439.

Msaky ES. 2011a. Middle Jurassic – earliest Late Cretaceous palynofloras, coastal Tanzania. Part One. Palaeontographica Abteilung B. 286:1–99.

Msaky ES. 2011b. Middle Jurassic – earliest Late Cretaceous palynofloras, coastal Tanzania. Part Two. Palaeontographica Abteilung B. 286: 101–209.

Nikitenko BL, Devyatov VP, Lebedeva NK, Basov VA, Goryacheva AA, Pestchevitskaya EB, Glinskikh LA. 2017. Jurassic and Cretaceous stratigraphy of the New Siberian Archipelago (*Laptev and East Siberian Seas*): facies zoning and lithostratigraphy. Russian Geology and Geophysics. 58(12):1478–1493.

Nikitenko BL, Pestchevitskaya EB, Khafaeva SN. 2018. High-resolution stratigraphy and palaeoenvironments of the Volgian–Valanginian in the Olenek key section (Anabar-Lena region, Arctic East Siberia, Russia). Revue de Micropaléontologie. 61(3–4):271–312.

Nikitenko BL, Devyatov VP, Lebedeva NK, Basov VA, Fursenko EA, Goryacheva AA, Peshchevitskaya EB, Glinskikh LA, Khafaeva SN. 2018. Jurassic and Cretaceous biostratigraphy and organic matter geochemistry of the New Siberian Islands (*Russian Arctic*). Russian Geology and Geophysics. 59(2):168–185.

Olivera DE, Martínez MA, Zavala C, Otharán G, Marchal D, Köhler G. 2018. The gymnosperm pollen *Shanbeipollenites proxireticulatus* Schrank from the Vaca Muerta Formation (Upper Jurassic–Lower Cretaceous), Neuquén Basin, Argentina. Cretaceous Research. 90: 120–130.

Paumard V, Bourget J, Payenberg T, Ainsworth RB, George AD, Lang S, Posamentier HW, Peyrot D. 2018. Controls on shelf-margin architecture and sediment partitioning during a syn-rift to post-rift transition: Insights from the Barrow Group (Northern Carnarvon Basin, North West Shelf, Australia). Earth-Science Reviews. 177:643–677.

Penaud A, Hardy W, Lambert C, Marret F, Masure E, Servais T, Siano R, Wary M, Mertens KN. 2018. Dinoflagellate fossils: Geological and biological applications. Revue de Micropaléontologie. 61(3–4):235–254.

Pestchevitskaya EB. 2018. Morphology, systematics, and stratigraphic significance of the dinocyst genus *Dingodinium*. Paleontological Journal. 52(6):682–696.

Poulsen NE. 1996. Dinoflagellate cysts from marine Jurassic deposits of Denmark and Poland. American Association of Stratigraphic Palynologists Contributions Series. 31:227.

Poulsen NE, Riding JB. 2003. The Jurassic dinoflagellate cyst zonation of Subboreal Northwest Europe. In Ineson JR, Surlyk F, editors. The Jurassic of Denmark and Greenland, Vol. 1. Copenhagen, Denmark: Geological Survey of Denmark and Greenland Bulletin; p. 115–144.

Powell JH, Rawson PF, Riding JB, Ford JR. 2018. Sedimentology and stratigraphy of the Kellaways Sand Member (Lower Callovian), Burythorpe, North Yorkshire, UK. Proceedings of the Yorkshire Geological Society. 62(1):36–49.

Riding JB. 1984. Dinoflagellate cyst range top biostratigraphy of the uppermost Triassic to lowermost Cretaceous of northwest Europe. Palynology. 8(1):195–210.

Riding JB. 1984. Observations on the Jurassic dinoflagellate cyst *Nannoceratopsis ambonis* Drugg 1978. Journal of Micropalaeontology. 3(1):75–79.

Riding JB. 1994. A taxonomic study of the Mesozoic dinoflagellate cysts *Phallocysta elongata* (Beju 1971) comb. nov., emend nov. and *Wallodinium cylindricum* (Habib 1970) Duxbury 1983 emend nov. Palynology. 18(1):11–22.

Riding JB. 2012. A compilation and review of the literature on Triassic, Jurassic, and earliest Cretaceous dinoflagellate cysts. American Association of Stratigraphic Palynologists Contributions Series 46:116. plus CD ROM.

Riding JB. 2013. The literature on Triassic, Jurassic and earliest Cretaceous dinoflagellate cysts: supplement 1. Palynology. 37(2): 345–354.

Riding JB. 2014. The literature on Triassic, Jurassic and earliest Cretaceous dinoflagellate cysts: supplement 2. Palynology. 38(2): 334–347.

Riding JB. 2019. The literature on Triassic, Jurassic and earliest Cretaceous dinoflagellate cysts: supplement 3. Palynology. 43(1): 104–150.

Riding JB, Wright JK. 1989. Palynostratigraphy of the Scalby Formation (Middle Jurassic) of the Cleveland Basin, north-east Yorkshire. Proceedings of the Yorkshire Geological Society. 47(4):349–354.

Riding JB, Thomas JE. 1992. Dinoflagellate cysts of the Jurassic System. In: Powell AJ, editor. A stratigraphic index of dinoflagellate cysts. British Micropalaeontological Society Publications Series. London: Chapman and Hall; p. 7–97.

Riding JB, Penn IE, Woollam R. 1985. Dinoflagellate cysts from the type area of the Bathonian Stage (Middle Jurassic; south-west England). Review of Palaeobotany and Palynology. 45(1–2):149–170.

Riding JB, Fedorova VA, Ilyina VI. 1999. Jurassic and lowermost Cretaceous dinoflagellate cyst biostratigraphy of the Russian Platform and northern Siberia, Russia. American Association of Stratigraphic Palynologists Contributions Series. 36:179.

Riding JB, Mantle DJ, Backhouse J. 2010. A review of the chronostratigraphical ages of Middle Triassic to Late Jurassic dinoflagellate cyst biozones of the North West Shelf of Australia. Review of Palaeobotany and Palynology. 162(4):543–575.

Rismyhr B, Bjaerke T, Olaussen S, Mulrooney MJ, Senger K. 2019. Facies, palynostratigraphy and sequence stratigraphy of the Wilhelmøya Subgroup (Upper Triassic–Middle Jurassic) in western central Spitsbergen, Svalbard. Norwegian Journal of Geology. 99. doi:10.17850/njg001.

Ruckwied K. 2009. Palynology of Triassic/Jurassic boundary key sections of the NW Tethyan Realm (Hungary and Slovakia) [Unpublished PhD dissertation]. Technischen Universität Darmstadt, Germany, p. 95. http://tuprints.ulb.tu-darmstadt.de/1359/.

Ruckwied K, Götz AE. 2009. Climate change at the Triassic/Jurassic boundary: palynological evidence from the Furkaska section (Tatra Mountains, Slovakia). Geologica Carpathica. 60(2):139–149.

Sapunov IG, Tchoumatchenco PV, Dodekova LD, Černjavska SP. 1985. Contribution to the formal lithostratigraphic scheme related to the Middle Jurassic deposits from north-east Bulgaria. Review of the Bulgarian Geological Society. 46:144–152.

Sapunov I, Tchoumatchenco P, Baburkov I, Bakalova D, Dodekova L, Zheleva C, Nikolova M, Černjavska S. 1986a. The Jurassic System in the new boreholes in the area of Provadija. Review of the Bulgarian Geological Society. 47:103–120.

Sapunov I, Tchoumatchenco P, Bârdarov S, Vavilova M, Dodekova L, Kitov P, Černjavska S. 1986b. Stratigraphy of Jurassic rocks from the borehole sections between the villages of Resen, Veliko Târnovo area and Konak, Târgovište area. Review of the Bulgarian Geological Society. 47:26–42.

Schneebeli-Hermann E, Looser N, Hochuli PA, Furrer H, Reisdorf AG, Wetzel A, Bernasconi SM. 2018. Palynology of Triassic–Jurassic boundary sections in northern Switzerland. Swiss Journal of Geosciences. 111(1–2):99–115.

Schneider AC, Heimhofer U, Heunisch C, Mutterlose J. 2018. The Jurassic–Cretaceous boundary interval in non-marine strata of northwest Europe – New light on an old problem. Cretaceous Research. 87: 42–54.

Schrank E. 2004. A gymnosperm pollen not a dinoflagellate: a new combination for *Mendicodinium*? *quadratum* and description of a new pollen species from the Jurasic of Tanzania. Review of Palaeobotany and Palynology. 131(3–4):301–309.

Schrank E. 2005. Dinoflagellate cysts and associated aquatic palynomorphs from the Tendaguru Beds (Upper Jurassic–Lower Cretaceous) of southeast Tanzania. Palynology. 29:49–85.

Shurekova OV. 2018. The Berriasian dinocysts of the section Uruh (North Caucasus). In: Baraboshkin EY, Lipnitskaya TA, Guzhikov AY, editors. Cretaceous system of Russia and near abroad: problems of stratigraphy and paleogeography. Proceedings of the Ninth All-Russian Conference, Belgorod State National Research University, Belgorod, September 17th–21st, 2018. Polyterra Publishing House, Belgorod, 282–286.

Smelror M, Fossum K, Dypvik H, Hudson W, Mweneinda A. 2018. Late Jurassic–Early Cretaceous palynostratigraphy of the onshore Mandawa Basin, southeastern Tanzania. Review of Palaeobotany and Palynology. 258:248–255.

Smith GA. 1999. Palynology of the Jurassic/Cretaceous boundary interval in the Volga Basin, Russia [Unpublished PhD Thesis]. University of Bristol, p. 527.

Stover LE, Helby R. 1987. Some Australian Mesozoic microplankton index species. Memoir of the Association of Australasian Palaeontologists. 4: 101–134.

Sütőné Szentai M. 2018. Taxon-list of Silurian to Holocene organic-walled microplankton from Hungary (1957–2017). e-Acta Naturalia Pannonica. p. 18:203.

Tahoun SS, Ied IM. 2018. A Cretaceous dinoflagellate cyst palynozonation of northern Eygpt. Palynology. doi:10.1080/01916122.2018.1449029

Tahoun SS, Ibrahim MIA, Kholeif S. 2012. Palynology and paleoenvironments of Middle Jurassic to Cenomanian successions, Alamein-IX well, north Western Desert, Egypt. Revista Española de Micropaleontología. 44:57–78.

Turner HE, Batenburg SJ, Gale AS, Gradstein FM. 2018. The Kimmeridge Clay Formation (Upper Jurassic–Lower Cretaceous) of the Norwegian Continental Shelf and Dorset, UK: a chemostratigraphic correlation. Newsletters on Stratigraphy. doi:10.1127/nos/2018/0436

van de Schootbrugge B, Richoz S, Pross J, Luppold FW, Hunze S, Wonik T, Blau J, Meister C, van der Weijst CMH, Suan G, et al. 2018. The Schandelah Scientific Drilling Project: A 25-million year record of Early Jurassic palaeo-environmental change from northern Germany. Newsletters on Stratigraphy. doi:10.1127/nos/2018/0259

van Helden BG. 1987. Dinocysts from the Jurassic of Saskatchewan and Alberta: an open field for research. Canadian Association of Palynologists Newsletter. 10(1):12–14.

Verreussel R, Bouroullec R, Munsterman DK, Dybkjaer K, Geel CR, Houben AJP, Johannessen PN, Kerstholt-Boegehold SJ. 2018. Stepwise basin evolution of the Middle Jurassic–Early Cretaceous rift phase in the Central Graben area of Denmark, Germany and The Netherlands. In: Kilhams B, Kukla PA, Mazur S, McKie T, Mijnlieff HF, van Ojik K, editors. Mesozoic Resource Potential in the Southern Permian Basin. London: Geological Society. Special Publications No. 469,

Visscher H, Brugman WA. 1981. Ranges of selected palynomorphs of the Alpine Triassic of Europe. Review of Palaeobotany and Palynology. 34(1):115–128.

Wainman CC, McCabe PJ. 2018. Evolution of the depositional environments of the Jurassic Walloon Coal Measures, Surat Basin, Queensland, Australia. Sedimentology. doi:10.1111/sed.12548

Wainman CC, Mantle DJ, Hannaford C, McCabe PJ. 2018a. Possible freshwater dinoflagellate cysts and colonial algae from the Upper Jurassic of the Surat Basin, Australia. Palynology. doi:10.1080/01916122.2018.1451785

Wainman CC, Hannaford C, Mantle D, McCabe PJ. 2018b. Utilizing U–Pb CA-TIMS dating to calibrate the Middle to Late Jurassic spore-pollen zonation of the Surat Basin, Australia to the geological time-scale. Alcheringa. 42(3):402–414.

Wiggan NJ, Riding JB, Franz M. 2017. Resolving the Middle Jurassic dinoflagellate radiation: The palynology of the Bajocian of Swabia, southwest Germany. Review of Palaeobotany and Palynology. 238:55–87.

Wiggan NJ, Riding JB, Fensome RA, Mattioli E. 2018. The Bajocian (Middle Jurassic): a key interval in the early Mesozoic phytoplankton radiation. Earth-Science Reviews. 180:126–146.

Williams GL, Fensome RA. 2016. Fossil dinoflagellates: nomenclatural proposals in anticipation of a revised DINOFLAJ database. Palynology. 40(1):137–143.

Wangping Z, Grant-Mackie JA. 2001. Late Triassic–Early Jurassic palynofloral assemblages from Murihiku strata of New Zealand, and comparisons with China. Journal of the Royal Society of New Zealand. 31(3): 575–683.

Zotto M, Drugg WS, Habib D. 1987. Kimmeridgian dinoflagellate stratigraphy in the southwestern North Atlantic. Micropaleontology. 33(3): 193–213.