Mesozoic Oceanic Anoxic Events: Records from India and future scope

Abha Singh[1]* & Prem Raj Uddandum[1]

[1]Birbal Sahni Institute of Palaeosciences, 53-University Road, Lucknow-226007, U.P., India.

*Corresponding author e-mail: abha.maurya@gmail.com

ABSTRACT

This paper presents a assessment of the Mesozoic Oceanic Anoxic Event (OAE) studies, carried out from India. It also provides a summary of the researches pursued on biostratigraphic, isotopic, and organic geochemical proxies for establishing Oceanic Anoxic Events (OAEs) from the Mesozoic sedimentary sequences of the Indian subcontinent. From Indian sedimentary basins, studies are available on OAE-1a, OAE-1b, OAE-1d, OAE-2, and OAE-3. From the Cauvery Basin records of OAE-1b, OAE-1d, OAE-2, and OAE-3 are available. From the Spiti Valley records are present of OAE-2 (Chikkim Formation) only, and the possibilities of late Valanginian Weissert Event (W-OAE), latest Hauterivian Faraoni Event (F-OAE) and OAE-1a are expected to be present in Giumal Formation. Nonetheless, the Black shale from Rudramata Shale, Jhuran Formation from Kutch basin indicate possible late Jurassic OAE, based on the character of sedimentary facies and organic geochemical results. There is also, possibility of OAE-1a and OAE-1b in the Ukra and Upper member of the Bhuj Formation. This paper aims to provide a comprehensive introduction on global and regional OAEs records from the Indian subcontinent and a significant window on available knowledge of these events in India and supply significant attention for the future research possibilities from the Indian landmass.

Key words: Oceanic Anoxic Event, Mesozoic, Black Shale, Spiti Himalaya, India.

INTRODUCTION

The Mesozoic Era (time span approx. 186 Ma) is an important and remarkable time period in the Earth's history as it witness the rifting of the Pangaea Supercontinent and the opening-spreading of the Atlantic and Indian oceans. Mesozoic era brackets the time interval sandwiched between two extreme events of biodiversity crisis i.e., the end Permian mass extinction (~ 252 Ma) marking the base of the Triassic period (start of the Mesozoic Era) and the Cretaceous-Paleogene mass extinction (around 66 Ma) marking the end of the Cretaceous period (end of Mesozoic Era). Each of extinction events record major change in atmosphere and ocean composition and it's impact on bio-diversity (extinction-adoptation-radition) provide crucial information in understanding of anthropogenic climate change. The climate-environment may influence by several factors including volcanic eruption, sea-level rise, ocean acidification, and anoxicity. However, it is difficult to record the sedimentalogical-geochemical-paleontological data sets from a specific time frame at same tune throughout the globe, but study over geological time scale identified few catastropic events from isolated basin to quasi-global scale.

The CO_2 increase in the atmosphere affect the composition of ocean and atmosphere which reflect in sedimentary basin as changes in sediment dynamics-pattern, paleo-redox, pH of ocean, nutrient supply etc. These events are recognized as deposits of dark colored laminated shale, highly rich in organic carbon content and sulfides (Jenkyns, 2010). These events are Known as Oceanic Anoxic Events (OAEs) are widely documented from a single isolated basin to quasi-global scale and from shallow coastal zones to the deepest parts of the open ocean (Jenkyns, 2010; Schlangerand Jenkyns, 1976).

In pelagic and neritic habitats, during periods of extreme greenhouse temperatures, three global OAEs (Toarcian-OAE, OAE 1a and OAE 2) are marked by a carbonate crisis. (Weissert et al., 1998; Cobianchi and Picotti, 2001; Herrle and Mutterlose, 2003). In comparison with current populations, the excess CO_2 released from volcanoes during OAE prevented biocalcification in reef communities (Langdon *et al.*, 2000), along with planktonic foraminifers (Barker and Elderfield, 2002) and calcareous Nannoplankton (Riebesell *et al.*, 2000). After surplus CO_2 was drawn down by accelerated weathering and burial of organic matter, carbonate sedimentation restarted, and possibly the rate of nutrient delivery also slowed down.

OAEs affected nannofossil productivity in different ways. Certain OAEs, have led to speciation events whereas others have caused extinction events. The Toarcian OAE and OAE1a, which are both preceded by a speciation event and do not exhibit extinctions, showing similar nannofossil evolutionary trends. Conversely, nannofossil assemblages during OAE2 are characterised by a turnover, in which new species emerge after a set of species vanished. Therefore, calcareous nannoplankton benefited from the environmental changes that occurred during the Aptian and Toarcian, which in turn encouraged diversification. Perhaps nannofloras suffered from far more harsh conditions during OAE2.

The concept of the oceanic anoxic event was first introduced by Schlanger and Jenkyns (1976) and Jenkyns (1980). Total of nine episodes of global and regional OAEs are recorded during the Mesozoic era (Jenkyns, 2010; Leckie *et al.*, 2002; Erba, 2004). The intense effect of climate change on global oceans has been studied from the geochemical signatures in carbon-rich dark black shale sequences deposited under an anoxic condition and representing a reducing environment (Schlanger and Jenkyns, 1976). These OAEs events recognized as intervals in the geological timescale which lasted for about a few 100-1000 years (Jenkyns, 2010).

During an extensive volcanic eruption high concentrations of carbon dioxide released in the atmosphere and caused extreme warming effect. Due to the warm environment the solubility of oxygen in ocean water dropped and caused enhanced stratification (Leckie *et al.,* 2002; Hesselbo *et al.,* 2000; Beerling *et al.,* 2002). This long term intense warming also caused huge continental weathering (Jenkyns, 2010; Jenkyns, 2003). The long term depletion of oxygen in the ocean and high concentration of carbon dioxide, caused extinction of calcareous microorganisms in the oceans which lead to mass extinction events of calcareous phytoplanktons and zooplanktons in the geological past such as during K/Pg boundary (Keller et al., 2011 and references therein). Hence, a better understanding of the past catastrophe with the future prediction of climate and oceans could be achieved from OAE studies (Arthur and Schlanger, 1979; Jenkyns, 1999; Bottjer *et al.,* 2001; Huber *et al.*, 2002; Takashima *et al.,* 2006; Bralower, 2008).

Several studies have demonstrated plenty of evidence of global and regional OAE's in the Mesozoic sediments (Jenkyns, 2010; Leckie *et al.,* 2002; Erba, 2004). These events are early Toarcian (Posidonienschiefer event, T-OAE, ~ 183 Ma); early Aptian (Selli event, OAE-1a, ~ 120 Ma; early Albian (Paquier event, OAE-1b, ~ 111 Ma) first recognized in the Vocontian Trough of southeast France (Bréhéret, 1985) and Cenomanian-Turonian (Bonarelli event, C/T OAE, OAE-2, ~ 93 Ma). Some events are recognized from the Tethyan realm (OAE-1c, OAE-1d (Toolebuc event, late Albian Breistroffer event, (Arthur *et al.*, 1990), the late Cretaceous Valanginian Weissert event (W-OAE) and latest Hauterivian Faraoni Event (F-OAE) also demonstrated from the various Tethyan and Atlantic domain regions (Lini *et al.*, 1992; Erba *et al.*, 2004; Bornemann and Mutterlose, 2008; Brassell, 2009; Rodríguez-Tovar and Uchman, 2017) and Coniacian-Santonian (OAE-3) (Arthur *et al.*, 1990; Wagner *et al.*, 2004). In addition Late Jurassic anoxic event (Nozaki *et al.*, 2013; Arora *et al.*, 2015; Carmeille *et al.*, 2020; Rogov *et al.*, 2020) and an Oxfordian-Kimmeridgian OAE (Martinez and Dera, 2015) also identified (Fig. 1).

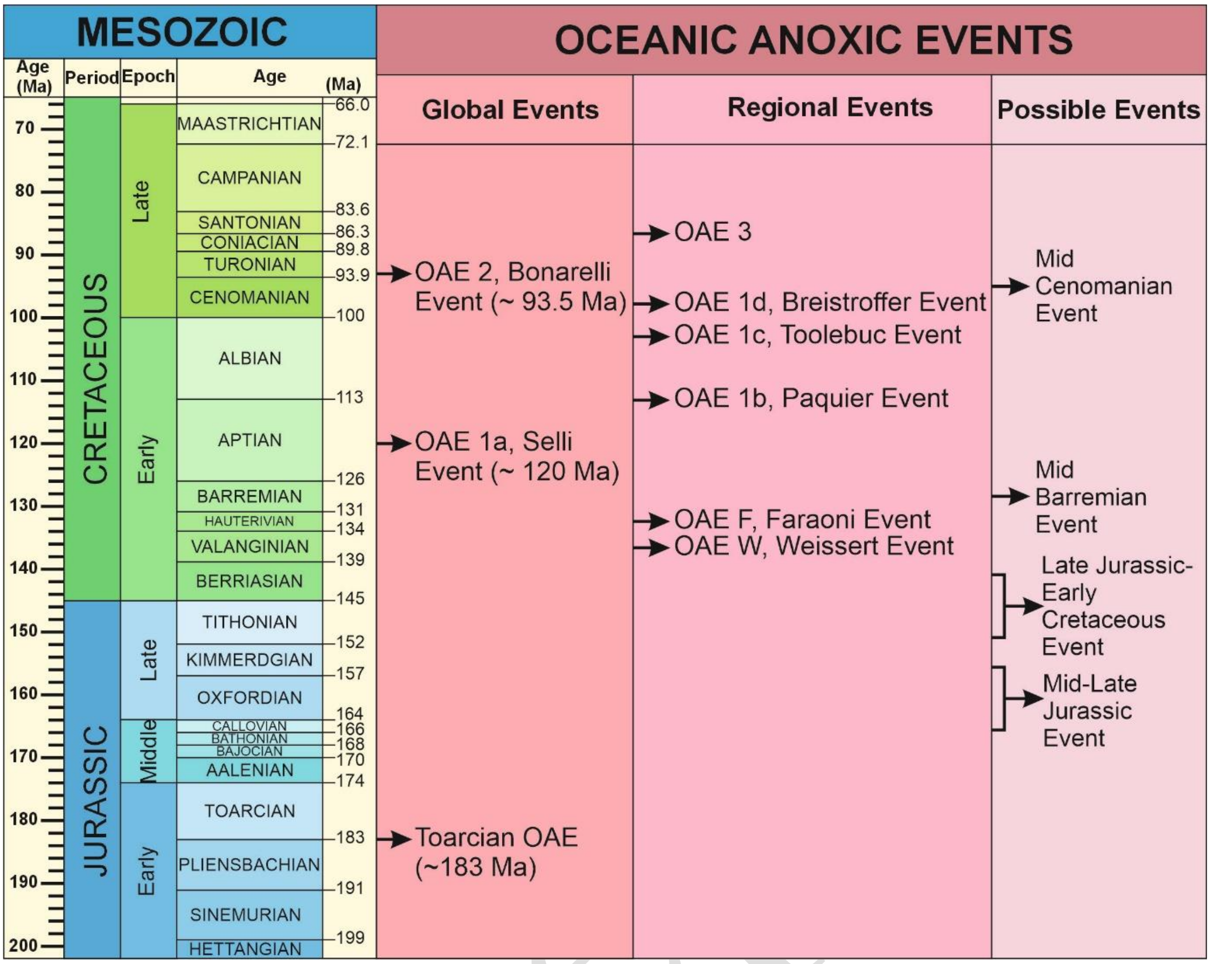


Figure 1. Mesozoic Oceanic Anoxic Events plotted against geological time scale.

During the Mesozoic time three global OAEs (i. Toarcian OAE or Jenkyns Event, ii. OAE 1a or Selli Event, iii. OAE 2 or Bonarelli Event) and six regional OAEs (OAE-W or Weissert Event, OAE-F or Faraoni Event, OAE 1b or Paquier Event, OAE 1c or Toolebuc Event, OAE 1d or Breistroffer Event and OAE3 Coniacian-Santonian) are recorded. The global OAEs are associated with the warm conditions due to the high carbon dioxide levels related to the various volcanic activities. T-OAE has been attributed to the warming due to the excessive carbon input into the atmosphere potentially caused by volcanism from the Karoo-Ferrar Large Igneous Province, the thermogenic emission of ^{12}C via intrusion of Karoo-Ferrar sills in Gondwanan coal deposits (McElwain *et al.*, 2005; Svensen *et al.*, 2007), and/or the dissociation of methane gas hydrates (Hesselbo *et al.*, 2000, Hesselbo *et al.*, 2007; Kemp *et al.*, 2005).

OAE 1a has been attributed to the warm conditions resulted from the increased CO_2 levels in the atmosphere which could possibly resulted from the volcanic activity on the the Ontong Java Plateau (OJP) in the Mid-Pacific. Studies also suggests volcanic activity in the Songliao Basin and northeast Asia possibly played an important role (Wang *et al.*, 2016a).

OAE-2 was linked to the high global temperatures associated with large igneous province (LIP) emplacements (Leckie *et al.*, 2002) and elevated volcanic degassing (Arthur *et al.*, 1985; Huber *et al.*, 1995; Jones *et al.*, 2021; Kuroda *et al.*, 2007; Larson, 1991), and thus increased atmospheric CO_2 concentrations (Forster *et al.*, 2007; O’Brien *et al.*, 2017; Robinson *et al.*, 2019; Sinninghe-Damsté *et al.*, 2010).

Regional OAEs are comparatively less studied for the causative mechanisms. While the role of volcanic activity is not established for the all regional OAEs, sea level changes, climate change could have played a key role in the formation of regional OAEs.

The present paper contributes on the synthesis of various studies made Oceanic anoxic events (OAEs) recognized from the Indian sedimentary record. The OAEs recorded from the Indian basins are OAE-1b (Paquier event); OAE-2 (Bonarelli event); OAE-1d (Breistroffer event) and OAE-3 (Coniacian-Santonian). The paper also demonstrates the possible time slices and sediment succession from where OAE studies can be persued from Indian sub-continent.

INDIAN MESOZOIC SEQUENCES AND OAE RECORDS

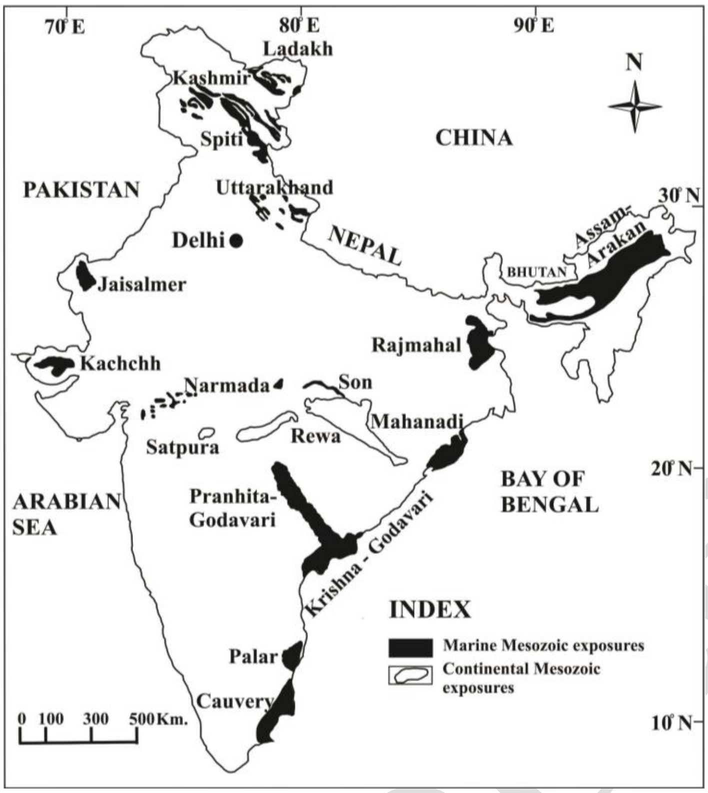


Figure 2. Marine and continental Mesozoic exposures in India (Modified after Chopparapo and Rajanikanth, 2018 ; Krishna, 2017).

In India, Mesozoic sequences are well developed and sought great attention of the stratigraphers and the palaeontologist from worldwide (Medlicott, 1872; Matley, 1921; Brookfield and Westermann, 1982; Jadoul *et al.,* 1990; Oloriz and Tintori, 1990; Fürsich *et al.,* 2018; Garzanti, 1992; Premoli Silva *et al.,* 1992; Cariou *et al.,* 1996; Fürsich, 1998; Whatley and Bajpai, 2000; Whatley *et al.,* 2002; Bertle and Suttner, 2005; Alberti *et al.,* 2019; Hart *et al.,* 2001; Lukeneder *et al.,* 2013; Galeet *et al.,* 2019; Chopparapu and Rajanikanth, 2018; Krishna, 2017). These sequences in India are exposed in the northern (Laddakh, Spiti, Uttarakhand); western (Jaisalmer, Kutch); eastern (Rajmahal Basin and Assam-Arakan); central (Narmada-Son, Satpura and Rewa basins); and southern parts (Cauvery, Krishna-Godavari, Palar, Mahanadi and Pranhita–Godavari basins) (Chopparapu and Rajanikanth, 2018; Krishna, 2017). However, the marine exposures comprising OAEs can be only found in

Ladakh and Spiti Himalaya, Kutch, Jaisalmer and Cauvery basins (Fig. 2). The areas from which OAE studies are available and the possible areas for these studies are discussed below and complied in figure 3.

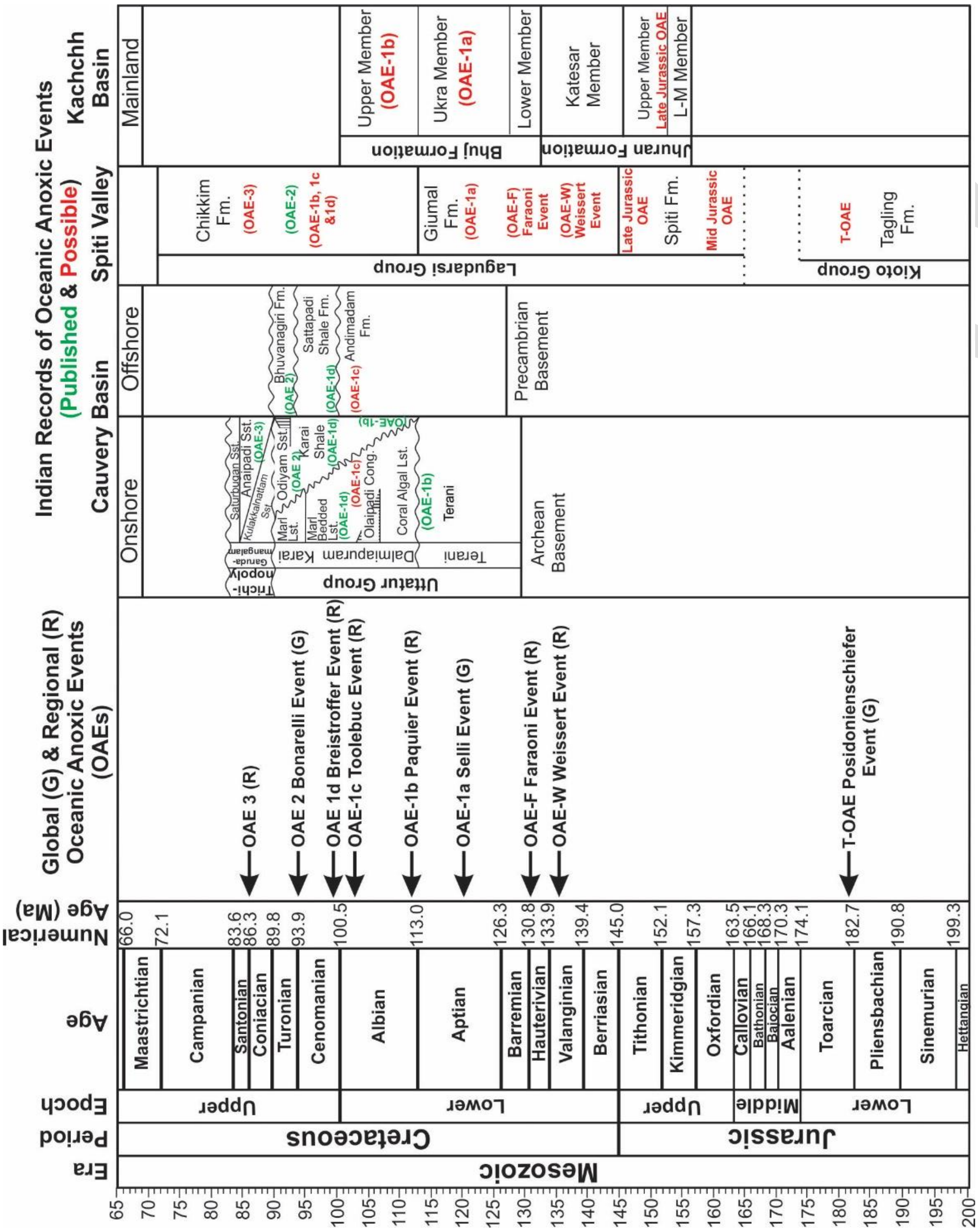


Figure 3. Established Global and Regional Oceanic Anoxic events (OAEs) and records from Indian Basins (Published events- green colour; Possible events- red colour).

Cauvery Basin

The Cauvery Basin is a pericratonic rift basin along the eastern continental margin of the Peninsular India (Rangaraju *et al.*, 1993; Madhavaraju *et al.*, 2015). It comprises more than 6000 m thick well preserved sediments ranging from Cretaceous to Paleocene. The sediments were deposited during two phases- (1) syn-rift phase which predominantly contains fluvial and lacustrine deposits and (2) post-rift phase consisting of shelf carbonates and marine shale (Reddy *et al.*, 2013). Post-rift phase sediments are well exposed in the Ariyalur area (Madhavaraju *et al.*, 2015). The Cretaceous and early Paleogene sediments are exposed in disconnected outcrops (Govindan, 2017); dipping towards east from bounding nonconformity with Archaean charnockitic crystalline basement (Sundaram *et al.*, 2001). Mainly exposed in three areas: in the Ariyalur, Vriddhachalum and Pondicherry districts.The complete succession is well represented in the Ariyalur area. A total thickness of 2.5 km of the Cretaceous sediments are well preserved in the Ariyalur area (Sundaram *et al.*, 2001). Blanford (1862) classified the Cretaceous sedimentary rocks of the Ariyalur area and divided them into three groups, the Uttatur, Trichinopoly, and Ariyalur groups. The Uttatur Group overlies the Archean basement. It comprises terrestrial, paralic and shallow marine strata (Sundaram *et al.*, 2001). Nagendra and Reddy (2017) divided the Uttatur Group into three formations- Terani, Dalmiapuram and Karai formations (Fig. 4).

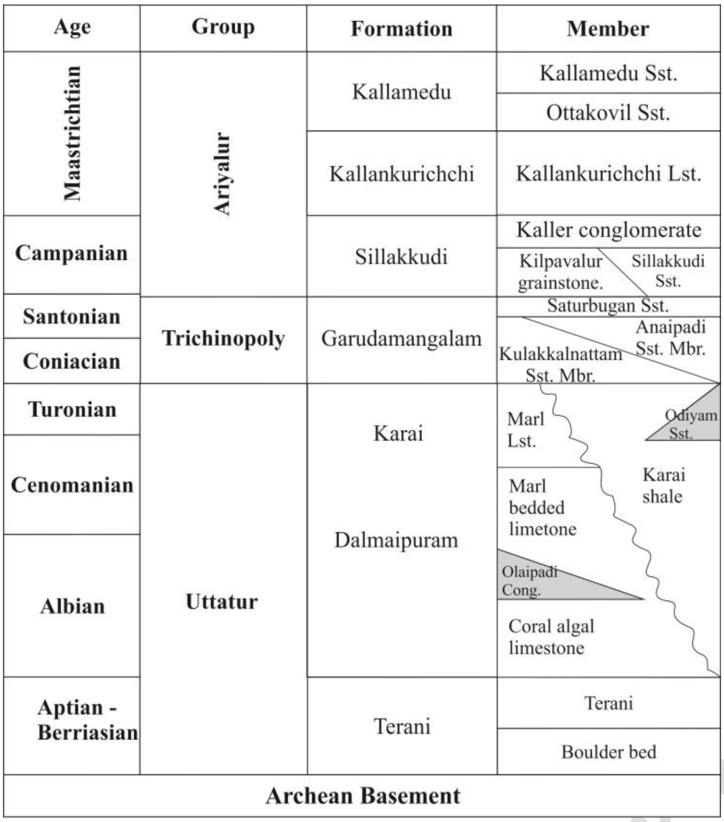


Figure 4. Mesozoic stratigraphy of the Cauvery Basin (modified after Nagendra and Reddy, 2017).

The Trichinopoly Group comprises Garudamangalam Fm., which is further divided into three members- Kulakkalnattam Sandstone, Anaipadi Sandstone and Saturbugan Sandstone members (Fig. 4).

The Ariyalur Group is divided into three formations- Sillakkudi, Kallankurichchi and Kallamedu. The Sillakkudi Fm. is further divided into three members- Kilpavalur Grainstone, Sillakkudi Sandstone and Kaller Conglomerate members. The Kallankurichchi Fm. Comprises Kallankurichchi Limestone Mb. The Kallamedu Fm. Is divided into two members-Ottakovil Sandstone and Kallamedu Sandstone (Reddy *et al.*, 2013) (Fig. 4).

In the Uttatur Group, the Terani Fm. (Berriasian-Aptian) comprises fluvial and marine sediment deposits during the first marine worldwide transgression inlate Aptian to early Albian during the Cretaceous period (Reddy *et al.*, 2013, Govindan, 2017, Sundaram *et al.*,2001, Blanford, 1862; Nagendra and Reddy, 2017). It comprises bedded sandstone contains local boulder conglomerates with bleached, kaolinitic claystone and micaseous shale, which is interbbeded with a siltstone and sandstone of 0.5 m and well cemented with calcareous material.

It is overlain by the Dalmiapuram Fm. (Albian to middle Turonian) comprising grey, fossiliferous, poorly lithified shale, calcareous mudstone, irregularly bedded to massive, fine-grained coralline micritic and algal limestone, coquinite and calcareous sandstone with rounded quartzite pebbles locally grading to beds of granule and pebble conglomerate. The internal facies mosaic of this unit is complex but in the type section, limestone interbedded with calcareous mudstone overlies a thick unit (>30 m) of grey shale (Sundaram *et al.*, 2001).

The time equivalent Karai Shale Fm. consists of ammonites, belemnites, and worm tubes (Madhavaraju *et al.*, 2015). Lithologically, it contains grey-brown, gypsiferous, glauconitic mudstone and marl which is black and gypsum free when freshly deposited, with sporadic thin, interbeds of siltstone, calcareous sandstone and coquinite particularly in its upper part. Sporadic calcareous, sideritic and phosphatic concretions and concretionary horizons occur in some intervals. Scattered macrofossils, predominantly molluscs, are typical of the formation (Sundaram *et al.*, 2001).

The Garudamangalam Fm. (Coniacian-Santonian) of Trichinopoly Group unconformably overlies the Karai Shale Fm. and comprises burrows in sandstone. Cross laminations are preserved in the upper portion indicating presence of the fluvial system and a sea level drop in the basin (Nagendra and Reddy, 2017). This formation is devoid of foraminifera but contains nannoplanktons and ammonite fossils (Reddy *et al.*, 2013). The Sillakkudi Fm. (Campanian) overlies the Garudamangalam Fm.It comprises glauconite pellets and calcareous nodules (Rasheed and Ravindran, 1978). The Kallankurchchi Fm. (early Maastrichtian) overlies the Sillakkudi Fm.and consistsof limestone beds dominated by the benthic foraminifera. The Kallamedu Fm. (late Maastrichtian) comprises ferruginous limestone, a lower arenaceous limestone, and *Gryphaea* limestone overlies the Kallankurchchi Fm. (Reddy *et al.*, 2013, Nagendra and Reddy, 2017).

OAE records

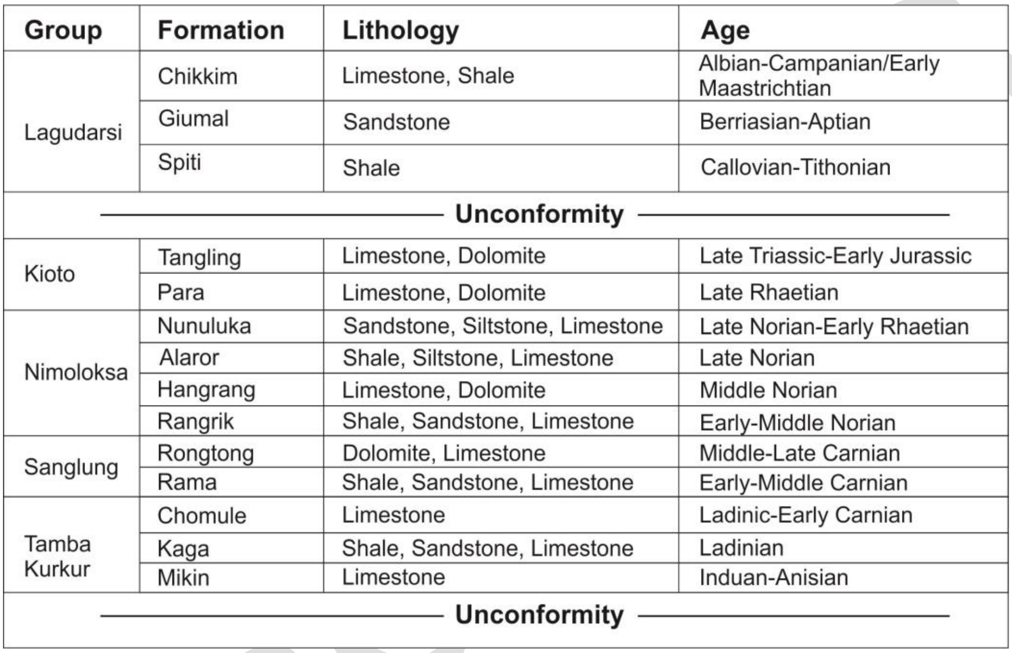
A number of significant OAE events has been demarcated from the Cauvery Basin. The OAE-1b has been marked at the Aptian-Albian boundary from the organic-rich shale deposits of the Terani Fm. (Nagendra and Reddy, 2017). The OAE-2 (Cenomanian-Turonian) and OAE-3 (Coniacian-Santonian) has recorded from Karai Shale Fm. and Garudamangalam Fm. respectively (Fig. 3). Later on, Bansal *et al.* (2019) provided more precise age of the OAE by ^{40}Ar / ^{39}Ar study from the glauconite occured at the lower part of the Karai Shale Fm. The age, ranging from 100.3 ± 0.7 to 92.6 ± 0.6 Ma correlates to the OAE-1d and OAE-2. Govindan (2017) and Nagendra and Reddy (2017) recorded OAE-1c, OAE-1d and OAE-2 from the Andimandam, Sattapadi Shale, and Bhuvanagiri formations from the organic-rich shale containing up to 6% TOC.

Madhavaraju *et al.*,(2015) carried out the petrographic, carbon, and oxygen isotopic studies from the Dalmiapuram Fm.exposed in the Vadugarpettai. He reported the positive shift of 0.8% in carbon isotopic values from the lower portion of the Coral algal Limestone. The shift coincided with the initiation of OAE-1d. The carbon isotopic value increases in the middle portion of the limestone coincided with the upper limit of the OAE-1d.

Tewari *et al.*(1996) correlated the significant evolution of the Planktonic foraminifera assemblages and planktonic/benthonic (p/b) ratio with the OAE-1dand the OAE-2.

Spiti Valley

The Spiti valley is considered as the deformed remnants of the northern continental margin of the Indian subcontinent. It consists of dominant limestone, shale, siltstone, and dolomite. The sequence of 12,000 meters of Paleozoic–Mesozoic sediments is well preserved in this synclinoria basin in the Tethyan Himalaya. The succession was first referenced by Gerard (1827); subsequently worked by Hayden (1904, 1908) and Diener (1912). Further, detailed work was done by many workers (Srikantia, 1981; Bagati, 1990; Gaetani and Garzanti, 1991; Bhargava and Bassi, 1998; Srikantia and Bhargava, 1998; Myrow *et al.*, 2003). The detailed lithostratigraphic framework of the Spiti valley was proposed by Bhargava (2008). The Mesozoic Tethys sediments were classified into Tamba Kurkur Group, Sanglung Group, Nimoloksa Group, Kioto Group, and Lagudarsi Group; lies disconformably in ascending order shown in figure 5.



Group	Formation	Lithology	Age
Lagudarsi	Chikkim	Limestone, Shale	Albian-Campanian/Early Maastrichtian
	Giumal	Sandstone	Berriasian-Aptian
	Spiti	Shale	Callovian-Tithonian
Unconformity			
Kioto	Tangling	Limestone, Dolomite	Late Triassic-Early Jurassic
	Para	Limestone, Dolomite	Late Rhaetian
Nimoloksa	Nunuluka	Sandstone, Siltstone, Limestone	Late Norian-Early Rhaetian
	Alaror	Shale, Siltstone, Limestone	Late Norian
	Hangrang	Limestone, Dolomite	Middle Norian
	Rangrik	Shale, Sandstone, Limestone	Early-Middle Norian
Sanglung	Rongtong	Dolomite, Limestone	Middle-Late Carnian
	Rama	Shale, Sandstone, Limestone	Early-Middle Carnian
Tamba Kurkur	Chomule	Limestone	Ladinic-Early Carnian
	Kaga	Shale, Sandstone, Limestone	Ladinian
	Mikin	Limestone	Induan-Anisian
Unconformity			

Figure 5. Mesozoic stratigraphy of Spiti Valley, Himachal Pradesh (modified after Bhargava 2008; Bertle and Suttner, 2005; Lukeneder*et al.*, 2013; Pandey and Pathak, 2015; Pathak, 2007; Cariou *et al.*, 1996).

OAE records:

Pandey and Pathak (2015) carried out a preliminary study on ammonoids from the early Cretaceous Giumal Fm. of the Spiti Valley, Himachal Pradesh. He suggested an age of Berriasian to early Aptian to the Gimual Formation based on the ammonoids. Also, showed the presence of all the stages from Berriasian to early Aptian in the Giumal Fm. The age range of

Gimual Fm. and presence of dark grey to black shale layers in between sandstone beds enhances the possibility of the presence of late Valanginian Weissert Event (W-OAE), the latest Hauterivian Faraoni Event (F-OAE), and OAE-1ain the Giumal Fm. succession. The area has potential for the study of early Cretaceous OAEs.

Bertle and Suttner (2005) carried out a detailed biostratigraphyof the Chikkim Fm. based on planktonic foraminifera. They have given an age ranging from late Albian to early Maastrichtian? to the Chikkim Fm. The age of the Lower Chikkim Fm. is from late Albian to Santonian and contains Cenomanian age sediments also, evidence by the presence of FO of *Rotalipora globotruncanoides*. In the upper portion of the Lower Chikkim Fm. presence of the single thin pinkish colored bed, suggests a change towards an oxygenated water column and presence of possible OAE-2, documented by the occurence of *Whiteinella archaeocretacea* Zone (Bertle and Suttner, 2005).

Kutch Basin

The Kutch Basin is a pericratonic rift basin in the Western Continental Margin of India, Gujarat. It comprises more than 25,000 m of synrift middle Jurassic to early Cretaceous sediments and post-rift late Paleocene to Pliocene and Quaternary sediments distributed in the northern, eastern, and the southern part of the basin (Biswas, 2016). The Mesozoic rocks are exposed in the uplifted areas especially islands (Wagad, Pachchham, Khadir etc.) and Kachchh mainland whereas the lowlying areas of Kachchh mainland are enclosed by Tertiary to recent marine and fluvio-deltaic sediments. Biswas (2016) classified Mesozoic successions of Kutch Basin into three lithostratigraphic Groups-Mainland Group, Pachchham Group, and Eastern Kutch Group. The Mainland sequences are divided into four formations-Jhurio, Jumara, Jhuran, and Bhuj in ascending chronological order shown in figure 6.

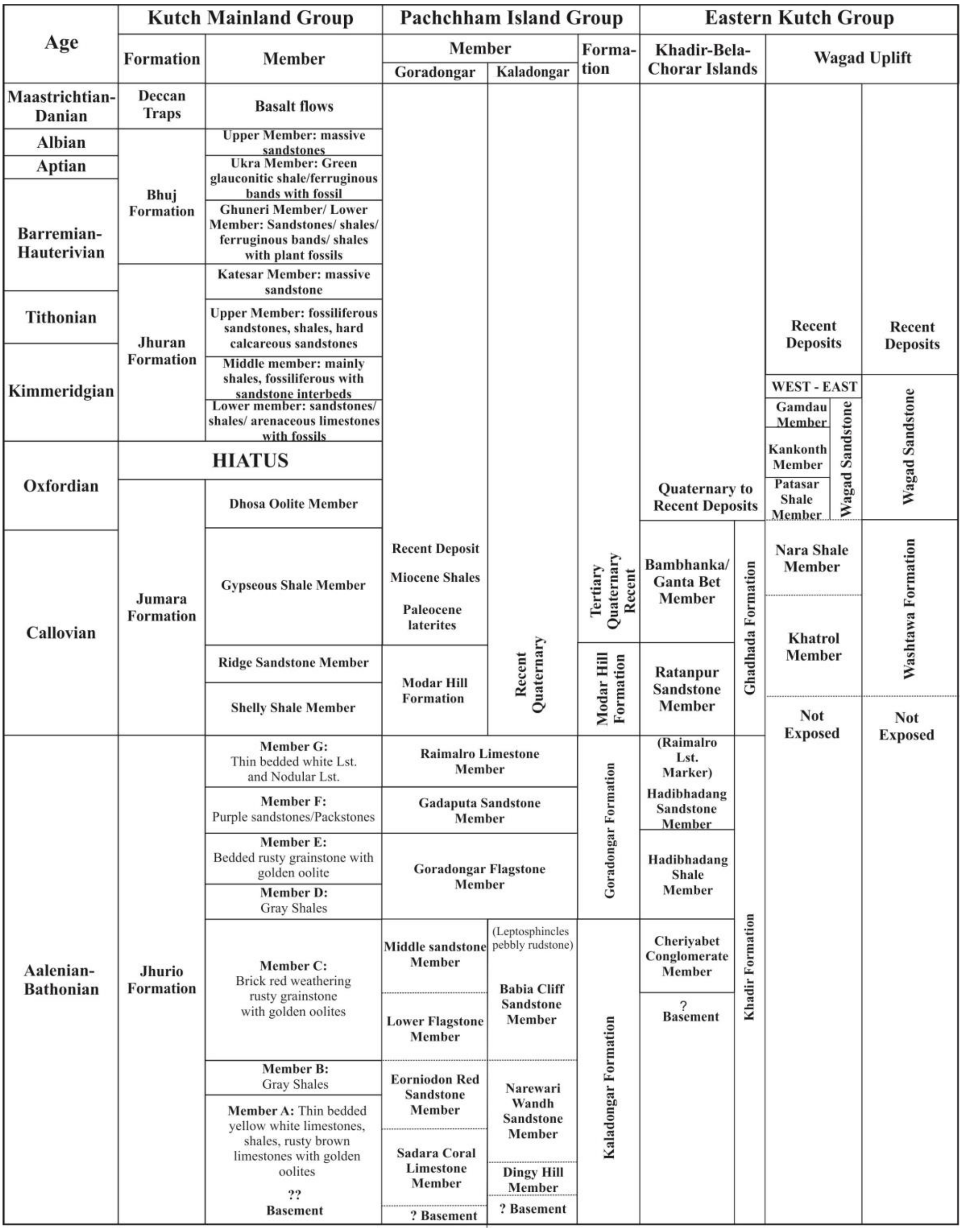


Figure 6. Mesozoic stratigraphy of Kutch Basin (modified after Biswas, 2016).

The Pachchham Group is divided into two formations- Lower Kaladongar, and Upper Goradongar formations. They are exposed in the northern Kaladongar and southern

Goradongar hill ranges. The Eastern Kutch Group is divided into four formations- Khadir, Ghadhada, Washtawa, and Wagad Sandstone which are exposed in the disconnected rock units outcroped in the Khadir, Bela, Chorar 'Island' and Wagad Highland. The middle Jurassic to late Jurassic sediments were deposited inthe marine transgressive phase during the syn rifting stage whereas late Cretaceous to recent sediments deposited after post-rift stage which indicates deltaic to marginal shelf depositional environment.

OAE records:

The sedimentary facies and organic geochemical analysis carried out by Arora *et al.* (2015) on the organic rich black shale of the Middle Member (Rudramata Shale) of the Jhuran Fm. They divided lower portion of the Rudramata Shale into five lithofacies-

Facies A: Black shale,

Facies B: Black shale with siltstone inter-bedding,

Facies C: shale and siltstone alternations with minor sandstones,

Facies D: siltstone-sandstone alternations, and

Facies E: plane laminated and hummocky cross-stratified sandstone.

The Total Carbon Content (TOC), oxygen index (OI), hydrogen Index (HI), T_{max} and trace elemental composition study records show significant variations. The TOC content decreases from Facies A (av. TOC- 3.4%) to Facies D (av. 0.6%). The black shale of Facies A and B have high TOC values and indicates deposition in possibly oxygen minimized zone developed at that time. Also, a significant shift was recorded in the Ni/Co ratio and V/(V+Ni) ratio plot represents an anoxic and sulfidic conditions in the depositional setting. Whereas the V/Cr ratio plot represents an oxic condition which might be due to diagenetic redistribution of the elements. The presence of the pyrite framboids of size ranging from 7 to 20 µm also correlated with an anoxic and sulfidic conditions within the depositional setting. These suggest sub-oxic to anoxic conditions prevailed during the Late Jurassic and it could be signature of Late Jurassic Oceanic Anoxic Event.

Pandey and Pathak (2016) discussed the presence of OAE-1a in the Ukra Member (early Cretaceous) of Bhuj Fm., Kutch Basin.

DISCUSSION

Apart from the globally recorded oceanic anoxic events (Three: T-OAE, OAE-1a and OAE-2 several regional or local anoxic events are also reported from the different parts of world (Jenkyns, 2010; Leckie *et al.,* 2002; Erba, 2004) (Table 1).

Table 1. Global, Regional and Possible Oceanic Anoxic Events and their records from the different regions of the world.

Sl. No.	Oceanic Anoxic Events	Records
Global Oceanic Anoxic Events		
1.	OAE 2, Bonarelli Event (~ 93.5 Ma)	**Western Tethys**, **Southern Tethys**, **USA, North African Continental margin, Canadian Arctic , Alaska , Mexico Japan** (Tiwari et al. 1996; Bertle and Suttner, 2005; Govindan, 2017; Nagendra & Reddy, 2017; Boulila et al., 2020; Sooraj et al. 2024)
2.	OAE 1a Selli Event (~120 Ma)	**Northern Tethys** (Zhang et al. 2021 and references therein) **Western Tethys** (Midtkandal et al., 2016; Tedeschi et al., 2020; Giraud et al., 2018; Castro et al., 2021; Giraldo-Gomez et al., 2022) **Southern Tethys** (Lowrie et al., 1980; Coccioni et al., 1987, 1990; Erba, 1994; Baudin et al., 1998; Erba & Larson, 1998; van Breugel et al., 2007; Bottini et al., 2012; Hu et al., 2016; Karakitsions et al., 2018; Talbi et al., 2021) **Pacific** (Thiede et al., 1981; Sliter, 1989; van Breugel et al., 2007; Bottini et al., 2012; Erba et al., 2015; Matsumoto, 2024)
3.	Toarcian OAE (Jenkyns Event) (~183 Ma)	**Arctic** (Suan et al., 2011 and references therein) **Panthalassic Ocean** (Kemp et al., 2019; Kemp et al., 2022; Chen et al., 2023 and references therein) **Northern Tethys** (Huang et al., 2024; Nie et al., 2023; Jin et al. 2020 and references therein) **Western Tethys** (Reolid et al. 2021; Peti & Thibault, 2017; Chen et al., 2021; Fernández-Martínez et a., 2021;

		Galasso et al., 2021; Müller et al., 2020; Boulila et al., 2019; Satolli et al., 2018; Mattioli et al., 2009) **Southern Tethys** (Han et al., 2022; Kemp et al., 2022 and references therein)
Regional Oceanic Anoxic Events		
1.	OAE 3	**Boreal** (Jenkyns et al., 1994; Jarvis et al., 2006; Pugh et al., 2014; Thibault et al., 2016; Eldrett et al., 2021; Grasby et al., 2024) **Northern Tethys** (Chamberlain et al., 2013; Wang et al., 2016b; Jones et al., 2018 and references therein) **Western Tethys** (Arthur & Fischer, 1977; Jenkyns et al., 1994; Stoll & Schrag; 2000; Wagreich & Krenmayr, 2005; Lamolda & Paul, 2007; Locklair et al., 2011; Frijia et al., 2015) **Southern Tethys** (Clark & Jenkyns, 1999; Tur & Wagreich, 2005; Li et al., 2006; Wendler et al., 2011; Petrizzo et al., 2017; Huber et al., 2018; MacLeod et al., 2020; Mansour et al., 2020b) **Eastern Tethys** (Navidtalab et al., 2020; Razmjooei et al. 2020 and references therein) **Pacific** (Perez-Infante et al., 1996; Alberdi-Genolet & Tocco, 1999; Rey et al., 2004; Takashima et al., 2010; Ando et al., 2013; Machado et al., 2016; Tessin et al., 2019) **Atlantic** (Huber et al., 2002; Bottcher et al., 2006; Beckmann et al., 2008; Sachse et al., 2012, 2014; Aquit et al., 2017; Junium et al., 2018; Luft de Souza et al., 2018)
2.	OAE 1d, Breistroffer Event	**Boreal** (Mitchell et al., 1996; Bornemann et al., 2017; Bornemann et al., 2023 and references therein) **Northern Tethys** (Melinte-Dobrinescu et al., 2015 and references therein) **Western Tethys** (Erbacher and Thurow, 1997; Gale et al., 1996; Stoll and Schrag, 2000; Strasser et al., 2001; Bornemann et al., 2005; Reichelt, 2005; Sprovieri et al., 2013; Gambacorta et al., 2015; Giorgioni et al., 2015; Bąk et al., 2016; Gyawali et al., 2017; Bottini & Erba) **Southern Tethys** (Govindan, 2017; Nagendra & Reddy, 2017; Yao et al., 2018; Mansour et al., 2020a; Madhavaraju et al., 2021) **Eastern Tethys** (Vahrenkamp, 2013; Zhang et al., 2016; Wohlwend et al., 2016; Hennhoefer et al., 2018; Navidtalab et al., 2019) **Atlantic** (Wilson and Norris, 2001; Nederbragt et al., 2001; Watkins et al., 2005; Petrizzo et al., 2008; Ando et al., 2010; Rodríguez-Cuicas et al., 2020) **Pacific** (Takashima et al., 2004; Robinson et al., 2008; Navarro-Ramirez et al., 2015; Rodríguez-Cuicas et al., 2019, 2020)

		Western Interior Seaway (North America) (Gröcke et al., 2006; Gröcke and Joeckel, 2008; Scott et al., 2013; Richey et al., 2018) **Indian Ocean** (Madhavaraju et al., 2015 and references therein)
3.	OAE 1c, Toolebuc Event	**Boreal** (Strasser et al., 2001; Wójcik-Tabol & Ślączka 2015 and references therein) **Southern Tethys** (Coccioni and Galeotti, 1993; Tiwari et al. 1996; Galeotti et al., 2003; Luciani et al., 2004; Govindan, 2017; Nagendra & Reddy, 2017; Madhavaraju et al., 2021) **Pacific** (Meyers et al., 2006; Scott et al., 2020 and references therein) **Austral** (Bralower et al., 1993; Haig and Lynch, 1993; Alibrahim, 2016 and references therein)
4.	OAE 1b, Paquier Event	**Boreal** (Herrle et al., 2015; Bodin et al., 2023 and references therein) **Northern Tethys** (Ando and Kakegawa, 2007; Suarez et al., 2018; Gavrilov et al., 2019 and references therein) **Western Tethys** (Breheret and Crumiere, 1989; Strasser et al., 2001; Grocke, 2002; Heimhofer et al., 2003; Mutterlose et al., 2003; Herrle et al., 2004; Follmi et al., 2007; Millan et al., 2014) **Southern Tethys** (Coccioni et al., 2014; Li et al., 2016; Ben Chaabane et al., 2019) **Atlantic** (Bralower et al., 1999; Erbacher et al., 2001; Wagner et al., 2008; Huber and Leckie, 2011; McAnena et al., 2013; Peybernes et al., 2013; Phelps et al., 2015; Caetano-Filho et al., 2017; Huber et al., 2018; Matsumoto et al., 2023) **Pacific** (Price, 2003; Robinson et al., 2004; Ludvigson et al., 2015; Navarro-Ramirez et al., 2015; Matsumoto et al., 2020)
5.	OAE F, Faraoni Event	**Western Tethys** (Baudin, 2005; Baudin & Riquier, 2014; Rodríguez-Tovar & Uchman, 2017) **Southern Tethys** (Ammar & Layeb, 2021) **Atlantic** (Stein et al., 1989) **South Africa** (Brown et al., 1996) **North Sea** (Mutterlose & Ruffell, 1999) **Pacific** (Baudin et al., 1995; Jenkyns, 1995) **Argentina** (Tyson et al., 2005; Guler et al., 2013)
6.	OAE W, Weissert Event	**Southern Tethys** (Bottini et al., 2018; Ammar & Layeb, 2021) **Western Tethys** (Moller et al., 2020) **Atlantic** (Moller et al., 2020)
Possible Oceanic Anoxic Events		
1.	Mid Cenomanian	**Western Tethys** (Coccioni & Galeotti, 2003)

	Event	
2.	Mid Barremian Event	**Southern Tethys** (Talbi et al., 2021)
2.	Late Jurassic-Early Cretaceous Event	**Boreal sea** (Rogov et al., 2020) **Panthalassic Ocean** (Nozaki et al., 2013) **Southern Tethys** (Arora et al., 2015) **Northern Tethys** (Carmeille et al., 2020)
3.	Mid-Late Jurassic Event	**Western Tethys** (Martinez & Dera, 2015)

Leckie *et al.* (2002) has given an overview of additional possible oceanic anoxic events. These additional possible anoxic events are recorded from the black shale units deposited worldwide during the late Aptian (~116 Ma), latest Aptian–early Albian (OAE-1b; ~113– 109 Ma), late Albian (OAE-1c and OAE-1d; ~102 and ~99.2 Ma, respectively), mid Cenomanian (~96 Ma), an event in the late Aptian, between OAE-1a and OAE-1b (Arthur *et al.*, 1990; Weissert and Lini, 1991; Bralower *et al.*, 1993, 1999; Bréhéret, 1994; Erbacher *et al.*,1996; Weissert *et al.*, 1998; Wilson and Norris, 2001). The multiple black shales of OAE-1b are mostly restricted to Mexico and the North Atlantic basin (western Tethys) and the Mediterranean (eastern Tethys) region (Bralower *et al.*, 1993, 1999; Arthur and Premoli Silva, 1982; Bréhéret *et al.*, 1986; Premoli Silva *et al.*, 1989). OAE-1b time interval is linked with cooling and sea level fall in the latest Aptian and following sea level rise during the early Albian (Weissert and Lini, 1991; Weissert *et al.*, 1998). OAE-1c (lower upper Albian) has been identified from the central Italy, the U.S. western interior, and Australia (Bralower *et al.*, 1993; Erbacher *et al.*, 1996; Pratt and King, 1986; Coccioni and Galeotti, 1993; Haig and Lynch, 1993). Conversely, OAE-1d is widely preserved as a black shale across Tethys with patchy occurrences in the South Atlantic, southern Indian, and eastern Pacific Ocean basins; it is primarily linked with marine organic matter enrichment due to increased primary productivity (Bréhéret, 1994; Erbacher *et al.*, 1996; Wilson and Norris, 2001; Bréhéret and Delamette, 1989). The cause of the OAE-1d is explained from the ODP Site 1052. The Cyclic black shales in the uppermost Albian sequence are correlative to OAE-1d and correspond to an interval manifested by collapse of upper water column stratification which was caused by the intensification of mixing during winters and reduced stratification during summers (Petrizzo *et al.*, 2008).

The global and regional OAE records from India are very limited. Only one global Oceanic Anoxic Event, OAE2 is recorded from the Indian successions. It is recorded from the two areas, i. Chikkim Formation, Spiti Valley, ii. Karai Shale Formation and Bhuvanagiri Formation, Cauvery Basin. In India the published records on regional OAEs (OAE 1b, OAE 1d and OAE 3) are available only from the Cretaceous successions of Cauvery Basin.

Possible OAEs and possible horizons in India

Possible OAE occurs in the mid-Cenomanian of the Tethys where it is associated with a positive carbon excursion (~1%), deposition of marine organic matter, and an extinction event in the radiolarian (Erbacher *et al.*, 1996; Stoll and Schrag, 2000; Coccioni and Galeotti, 2003). Within the same time period, benthic calcareous micro-organisms exhibit a steady reduction in both species diversity and faunal density (Coccioni et al., 1995).

Apart from the above OAE, a Mid Barremian anoxic event (Talbi *et al.*, 2021), a Late Jurassic-Early Cretaceous anoxic event (Nozaki *et al.*, 2013; Arora *et al.*, 2015; Carmeille *et al.*, 2020; Rogov *et al.*, 2020) and an Mid-Late Jurassic OAE event (Martinez & Dera, 2015;) are also possible. For ascertaining their regional or global extent more studies are needed from the suitable sucessions around the world.

In Indian sedimentary sequences the marine Mesozoic black shale, dark grey or glauconitic deposits falling in the additional possible OAEs time slice are mainly deposited in Spiti, Kutch and Cauvery basins. From the Kutch Basin, Pandey and Pathak (Pandey and Pathak, 2016) showed the possible presence of early Aptian based on the ammonoid genera *Deshayesites* and *Australiceras* in the Ukra Mb. of the Bhuj Formation. These ammonoids were recorded from the green shales which is characterstic deposit of OAE in Shallower depths. For ascertaining the presence of OAE-1a in the Ukra Mb. geochemical studies and other marine fossil group studies are required from the green shales, which is key lithology to shows presence of OAE in an extreme marginal location. OAE-1b can be demarcated in Upper Mb. of the Bhuj Fm. due to its age range and marine nature of deposits (Darji and Solanki, 2017). Predominantly, Rudramata shale Member of Jhuran Fm. contains dark grey to black shales which could be a possible horizon to study the Late Jurassic OAE (Arora *et al.*, 2015) (Fig. 3).

The Tagling Fm. (Lias) of Kioto Group, Spiti Valley mainly contains limestone with black shaley bands and ranges in age from Late Triassic to Early Jurassic. In this view the possibility of T-OAE in Tagling Fm. could not be denied. The Spiti Fm. (Callovian-Tithonian) mainly comprises black shale and remarks the presence of Late Jurassic OAE. Overlying Guimal Fm. (Berriasian-Aptian) mainly comprises sanstone with intercalations of black shales and these black shales can give signatures of Weissert event, Faraoni event and OAE-1a. Also OAE-1b, OAE-1c, OAE-1d, OAE-2, and OAE-3 can be traced out in the Chikkim Fm. (Cenomanian-early Maastrichtian) (Fig. 3).

From the Cauvery Basin OAE-1b, OAE-1d, OAE-2 and OAE-3 are already studied but the possibility of OAE-1c from Onshore and Offshore organic rich shaley successions still present and can be distinguish in the Karai Fm. (Albian to middle Turonian) of Uttatur Group on Onshore and from Andimadam Fm. on Offshore. Still detailed study is required of the previously recorded oceanic anoxic events from the Cauvery Basin (Fig. 3).

CONCLUSION

Within the previous few years, in India, researches on oceanic anoxic events have been carried out utilizing detailed biostratigraphy, stable isotopic studies, organic geochemistry, and sedimentary facies studies of the geochemically significant organic-rich laminated black shales from the Mesozoic successions exposed in different basins. But, the integrated approach for

OAE characterization from individualsection is lacking. The purpose of this review paper is to provide a comprehensive introduction to Oceanic anoxic events and records of OAEs from the varied parts of India and findout the probable horizons from which these studies can be taken up in future. The review highlights the potentiality of the various regions from where the increasing number of studies would offer a much better understanding of the OAEs from Indian basins.The holestic approach for establishing OAE events from Indian sections is totally lacking. A few studies have been taken from the Cauvery Basin upto some extent but from the other areas the OAE studies are in nascent stage. It is an authors hope that the work, comprehensively presented in this overview has paved the ground for more research on OAEs from Indian sediments.

Acknowledgements

Authors are gratefully acknowledge Director, Birbal Sahni Institute of Palaeosciences for continuous support and permission to publish this work (Permission No. BSIP/RDCC/Publication No.79/2020-21). Ms. Nazim Deori is acknowledged for arranging the pertinent literature from different sources. The authors are grateful to the reviewers whose constructive comments and suggestions greatly improved the manuscript.

REFERENCES

Alberdi-Genolet M & Tocco R 1999. Trace metals and organic geochemistry of the Machiques Member (Aptian-Albian) and La Luna Formation (Cenomanian-Campanian), Venezuela. Chemical Geology 160: 19-38.

Alberti M, Fürsich FT & Pandey DK 2013. Deciphering condensed sequences: a case study from the Oxfordian (Upper Jurassic) Dhosa Oolite member of the Kachchh Basin, western India. Sedimentology 60: 574–598.

Alibrahim A 2016. Micropaleontology and Isotope Stratigraphy of the Upper Aptian to Lower Cenomanian (~114-98 Ma) In ODP Site 763, Exmouth Plateau, NW Australia. University of Massachusetts Amherst (Thesis).

Ammar SB & Layeb M 2021. Updated geochemical insights on the Weissert and Faraoni events in the southern Tethyan margin (northern Tunisia). Arabian Journal of Geosciences 14: 2379. https://doi.org/10.1007/s12517-021-08669-w.

Ando A & Kakegawa T 2007. Carbon isotope records of terrestrial organic matter and occurrence of planktonic foraminifera from the Albian stage of Hokkaido, Japan: ocean-atmosphere d13C trends and chronostratigraphic implications. Palaios 22(4): 417-432.

Ando A, Huber O & MacLeod KG 2010. Depth-habitat reorganization of planktonic foraminifera across the Albian/Cenomanian boundary. Paleobiology 36(3): 357-373.

Ando A, Woodard SC, Evans HF, Littler K, Herrmann S, Macleod KG, Kim S, Khim B-K, Robinson SA & Huber BT 2013. An emerging palaeoceanographic ‘missing link’: multidisciplinary study of rarely recovered parts of deep-sea Santonian-Campanian transition from Shatsky Rise. Journal of the Geological Society 170: 381-384.

Aquit M, Kuhnt W, Holbourn A, Chellai E-H, Lees JA, Kluth O & Jabour H 2017. Complete archive of late Turonian to early Campanian sedimentary deposition in newly drilled cores from the Tarfaya Basin. SW Morocco. Geological Society of America Bulletin 129: 137-151.

Arora A, Banerjee S & Dutta S 2015. Black shale in late Jurassic Jhuran Formation of Kutch: Possible indicator of oceanic anoxic event? Journal of the Geological Society of India 85(3):265−278.

Arthur MA & Schlanger SO 1979. Cretaceous “oceanic anoxic events” as causal factors in development of reef-reservoired giant oil fields. American Association of Petroleum Geologists Bulletin 63: 870−885.

Arthur MA & Fischer AG 1977. Upper Cretaceous–Paleocene magnetic stratigraphy at Gubbio, Italy, I. Lithostratigraphy and sedimentology. Geological Society of America Bulletin 88: 367-371.

Arthur MA & Premoli Silva I 1982. Development of widespread organic carbon-rich strata in the Mediterranean Tethys. *In* Schlanger, S.O. & Cita, M.B. (eds.): Nature and origin of Cretaceous carbon-rich facies. Academic Press, London 7−54.

Arthur MA, Brumsack HJ, Jenkyns HC & Schlanger SO 1990. Stratigraphy, geochemistry, and paleoceanography of organic carbon-rich Cretaceous sequences. *In* Cretaceous resources, events, and rhythms, Springer, Dordrecht 75-119.

Arthur MA, Dean WE & Schlanger SO 1985. Variations in the Global Carbon Cycle During the Cretaceous Related to Climate, Volcanism, and Changes in Atmospheric CO_2. In: Sundquist ET, Broecker WS (eds), The Carbon Cycle and Atmospheric CO_2: Natural Variations Archean to Present, Volume 32: 504-529. doi.org/10.1029/GM032p0504.

Bagati TN 1990. Lithostratigraphy and facies variation in the Spiti basin (Tethys), Himachal Pradesh, India. Himalayan Geology 1(1): 35−47.

Bąk K, Fabiańska M, Bąk M, Misz-Kennan M, Zielińska M, Dulemba P, Bryndal T & Naglik B 2016. Organic matter in upper Albian marine sediments in the High-Tatric units, central western Carpathians related to Oceanic Anoxic Event 1d–Geochemistry, microfacies and palynology. Palaeogeography Palaeoclimatology Palaeoecology 454: 212-227.

Bansal U, Pande K, Banerjee S, Nagendra R & Jagadeesan KC 2019. The timing of oceanic anoxic events in the Cretaceous succession of Cauvery Basin: Constraints from 40Ar/39Ar ages of glauconite in the Karai Shale Formation. Geological Journal 54(1): 308−315.

Barker S & Elderfield H 2002. Foraminiferal calcification response to glacial–interglacial changes in atmospheric CO_2. Science 297: 833- 836.

Baudin F & Riquier L 2014. The late Hauterivian Faraoni ‘oceanic anoxic event’: an update. Bulletin de la Société Géologique de France 185(6):359-377.

Baudin F 2005. A Late Hauterivian short-lived anoxic event in the Mediterranean Tethys: the ‘Faraoni Event.’ Comptes Rendus Geoscience 337(16):1532-1540.

Baudin F, Deconinck J-F, Sachsenhofer RF, Strasser A & Arnaud H 1995. Organic geochemistry and clay mineralogy of Lower Cretaceous sediments from Allison and Resolution Guyots (Sites 865 and 866), Mid-Pacific Mountains. In: Winterer EL, Sager WW, Firth JV, Sinton JM (eds), Proceedings ODP, Scientific Results 143: 173-196.

Baudin F, Fiet N, Coccioni R & Galeotti S, 1998. Organic matter characterisation of the Selli Level (Umbria-Marche Basin, central Italy). Cretaceous Research 19: 701-714.

Beckmann B, Hofmann P, Marz C, Schouten S, Sinninghe Damste JS & Wagner T 2008. Coniacian-Santonian deep ocean anoxia/euxinia inferred from molecular and inorganic markers: results from the Demerara Rise (ODP Leg 207). Organic Geochemistry 39: 1092-1096.

Beerling DJ, Lomas MR & Gröcke DR 2002. On the nature of methane gas-hydrate dissociation during the Toarcian and Aptian oceanic anoxic events. American Journal of Science 302(1): 28−49.

Ben Chaabane N, Khemiri F, Soussi M, Latil J-L, Robert E & Belhajtaher I 2019. Aptian-Lower Albian Serdj carbonate platform of the Tunisian Atlas: development, demise and petroleum implication. Marine and Petroleum Geology 101: 566-591.

Bertle RJ & Suttner TJ 2005. New biostratigraphic data for the Chikkim Formation (Cretaceous, Tethyan Himalaya, India). Cretaceous Research 26(6): 882−894.

Bhargava ON & Bassi UK 1998. Geology of the Spiti-Kinnaur, Himachal Himalaya. Memoris of the Geological Survey of India 124: 1−210.

Bhargava ON 2008. An updated introduction to the Spiti geology. Journal of Palaeontological Society of India 53(2): 113−128.

Biswas SK 2016. Mesozoic and Tertiary stratigraphy of Kachchh–A review. *In* Thakkar, M.G. (ed.): Recent Studies on the Geology of Kachchh.Geological Society of India, Special Publication 6: 1−24.

Blanford HF 1862. On the Cretaceous and other rocks of the South Arcot and Trichinopoly districts. Memoirs of the Geological Survey of India 4: 1−217.

Bodin S, Charpentier M, Ullmann CV, Rudra A, Sanei H 2023. Carbon cycle during the late Aptian-early Albian OAE 1b: A focus on the Kilian–Paquier levels interval. Global and Planetary Change 222: 104074. doi.org/10.1016/j.gloplacha.2023.104074.

Bornemann A & Mutterlose J 2008. Calcareous nannofossil and δ^{13}C records from the Early Cretaceous of the Western Atlantic Ocean: evidence for enhanced fertilization across the Berriasian–Valanginian transition. Palaios 23(12): 821−832.

Bornemann A, Erbacher J, Blumenberg M & Voigt S 2023. A first high-resolution carbon isotope stratigraphy from the Boreal (NW Germany) for the Berriasian to Coniacian interval-implications for the timing of the Aptian–Albian boundary. Frontiers in Earth Science 11: 1173319. doi: 10.3389/feart.2023.1173319.

Bornemann A, Erbacher J, Heldt M, Kollaske T, Wilmsen M, Lübke N *et al.* 2017. The Albian-Cenomanian transition and oceanic anoxic event 1d - an example from the boreal realm. Sedimentology 64: 44–65. doi:10.1111/sed.12347.

Bornemann A, Pross J, Reichelt K, Herrle JO, Hemleben C & Mutterlose J 2005. Reconstruction of short-term palaeoceanographic changes during the formation of the late Albian 'Niveau Breistoffer' black shales. Journal of the Geological Society of London 162: 623-639.

Bottcher ME, Hetzel A, Brumsack H-J & Schipper A 2006. Sulfur-iron-carbon geochemistry in sediments of the Demerara Rise. In: Mosher DC, Erbacher J, Malone MJ (eds), Proceedings of the Ocean Drilling Program Scientific Results 207: 1–23.

Bottini C & Erba E 2018. Mid-Cretaceous paleoenvironmental changes in the western Tethys. Climate of the Past 14: 1147-1163.

Bottini C, Cohen AS, Erba E, Jenkyns HC & Coe AL 2012. Osmium-isotope evidence for volcanism, weathering, and ocean mixing during the early Aptian OAE 1a. Geology 40: 583-586.

Bottini C, Dieni I, Erba E, Massari F & Weissert H 2018. The Valanginian Weissert Oceanic Anoxic Event recorded in central-eastern Sardinia (Italy) Rivista Italiana di Paleontologia e Stratigrafia 124(3): 617-637.

Bottjer DJ, Droser ML, Sheehan PM, McGhee GR & Allmon WD 2001. The ecological architecture of major events in the Phanerozoic history of marine invertebrate life. *In* Allmonand, W.D. & Bottjer, D.J. (eds.): Evolutionary Paleoecology: the Ecological Context of Macroevolutionary Change.Columbia University Press, New York 35−61.

Boulila S, Charbonnier G, Spangenberg JE, Gardin S, Galbrun B, Briard J & Le Callonnec L 2020. Unraveling short-and long-term carbon cycle variations during the Oceanic Anoxic Event 2 from the Paris Basin Chalk. Global and Planetary Change 186: 103126.

Boulila S, Galbrun B, Sadki D, Gardin S & Bartolini A 2019. Constraints on the duration of the early Toarcian T-OAE and evidence for carbon-reservoir change from the High Atlas

(Morocco). Global and Planetary Change 175: 113-128. https://doi.org/10.1016/j.gloplacha.2019.02.005.

Bralower TJ 2008. Volcanic cause of catastrophe. Nature 454: 285−287.

Bralower TJ, CoBabe E, Clement B, Sliter WV, Osburn CL & Longoria J 1999. The record of global change in mid-Cretaceous (Barremian-Albian) sections from the Sierra Madre, northeastern Mexico. Journal of Foraminiferal Research 29: 418-437.

Bralower TJ, Sliter WV, Arthur MA, Leckie RM, Allard DJ & Schlanger SO 1993. Dysoxic/anoxic episodes in the Aptian-Albian (Early Cretaceous). In: Pringle MS, *et al.* (eds), The Mesozoic Pacific: Geology, Tectonics, and Volcanism: Geophysical Monograph Series 77. American Geophysical Union, Washington, D.C., pp. 5-37

Brassell SC 2009. Steryl ethers in a Valanginian claystone: Molecular evidence for cooler waters in the central Pacific during the Early Cretaceous? Palaeogeography, Palaeoclimatology, Palaeoecology 282(1-4): 45−57.

Bréhéret J-G & Crumiere J-P 1989. Organic-rich episodes in the mid-Cretaceous (Aptian to Turonian) pelagic realm of the Vocontian Basin (SE France). Geobios, memoire special 11: 205-210.

Bréhéret JG & Delamette M 1989. Faunal fluctuations related to oceanographical changes in the Vocontian basin (SE France) during Aptian-Albian time. Geobios. Memoirs Special publication 11: 267−277.

Bréhéret JG 1985. Indices d'un événement anoxique étendu à la Téthys alpine, à l'Albien inférieur (événement Paquier). Comptes-rendus des séances de l'Académie des sciences, Série 2, Mécanique-physique, chimie, sciences de l'univers, sciences de la terre 300(8): 355−358.

Bréhéret JG 1994. The mid-Cretaceous organic-rich sediments from the Vocontian zone of the French Southeast Basin. *In* Mascle, A. (ed): Hydrocarbon and Petroleum Geology of France, Springer-Verlag, New York 295−320.

Bréhéret JG, Caron M & Delamette M 1986. Niveaux riches en matière organique dans l'Albien vocontien; quelques caractères du paléoenvironnement essai d'interprétation génétique. *In* Bréhéret, J.G. (ed.): Les Couches Riches en Matière Organique et leurs Conditions de Dépôt. Documents BRGM 110: 141−191.

Brookfield ME & Westermann GE 1982. Mesozoic ammonites from the Spong Valley, Zanskar, NW India. Journal of the Geological Society of India 23: 263−266.

Brown LF Jr, Benson JM, Brink GJ, Doherty S, Jollands A, Junslager EHA, Keenan JHG, Muntingh A & Van Wyk NJH 1996. Sequence stratigraphy in offshore South African divergent basins. An atlas on exploration for Cretaceous lowstand traps by Soekor (Pty) Ltd. AAPG, Studies in Geology 41: 184 pp.

Caetano-Filho S, Dias-Brito D, Rodrigues R, de Azevedo RLM 2017. Carbonate microfacies and chemostratigraphy of a late Aptian–early Albian marine distal section from the primitive South Atlantic (SE Brazilian continental margin): record of global ocean-climate changes? Cretaceous Research 74: 23-44.

Cariou E, Enay R & Aimeras Y 1996. Newly discovered Callovian ammonite fauna in the Himalayan Spiti Shales at Spiti and compared chronostratigraphy of Middle and Upper Jurassic succession in Spiti and Central Nepal (Thakkhola) areas. Comptes Rendus de I’Academie des Sciences 322: 861−868.

Carmeille M, Bourillot R, Pellenard P, Dupias V, Schnyder J, Riquier L, Mathieu O, Brunet MF, Enay R, Grossi V, Gaborieau C, Razin P & Visscher PT 2020.Formation of microbial organic carbonates during the Late Jurassic from the Northern Tethys (Amu Darya Basin, Uzbekistan): Implications for Jurassic anoxic events. Global and Planetary Change 186: 103127. doi.org/10.1016/j.gloplacha.2020.103127.

Castro JM, Ruiz-Ortiz PA, de Gea GA, Aguado R, Jarvis I, Weissert H, Molina JM, Nieto LM, Pancost RD, Quijano ML, Reolid M, Skelton PW, López-Rodríguez C & Martínez-Rodríguez

R 2021. High-resolution C-isotope, TOC and biostratigraphic records of OAE 1a (Aptian) from an expanded hemipelagic cored succession, western Tethys: a new stratigraphic reference for global correlation and paleoenvironmental reconstruction. Paleoceanography and Paleoclimatology 36: e2020PA004004. https://doi.org/10.1029/2020pa004004.

Chamberlain CP, Wan X, Graham SA, Carroll AR, Doebbert AC, Sageman BB, Blisniuk P, Kent-Corson ML, Wang Z & Wang C 2013. Stable isotopic evidence for climate and basin evolution of the Late Cretaceous Songliao basin, China. Palaeogeography, Palaeoclimatology, Palaeoecology 385: 106-124.

Chen W, Kemp DB, He T, Huang C, Jin S, Xiong Y & Newton RJ 2021. First record of the early Toarcian oceanic anoxic event in the Hebrides Basin (UK) and implications for redox and weathering changes. Global and Planetary Change 207: 103685.

Chen W, Kemp DB, He T, Newton RJ, Xiong Y, Jenkyns HC, Izumi K, Cho T, Huang C & Poulton SW 2023. Shallow- and deep-ocean Fe cycling and redox evolution across the Pliensbachian–Toarcian boundary and Toarcian Oceanic Anoxic Event in Panthalassa. Earth and Planetary Science Letters 602: 117959. https://doi.org/10.1016/j.epsl.2022.117959.

Chopparapu C & Rajanikanth A 2018. Mesozoic woods from India: Nomenclature review and palaeoclimatic implications. Palaeoworld 27(2): 211−225.

Clarke LJ & Jenkyns HC 1999. New oxygen isotope evidence for long-term Cretaceous climatic change in the Southern Hemisphere. Geology 27: 699-702.

Cobianchi M & Picotti V 2001. Sedimentary and biological response to sea-level and palaeoceanographic changes of a Lower- Middle Jurassic Tethyan platform margin (Southern Alps Italy). Palaeogeography Palaeoclimatology Palaeoecology 169: 219- 244.

Coccioni R & Galeotti S 1993. Orbitally induced cycles in benthonic foraminiferal morphogroups and trophic structure distribution patterns from the late Albian “Amadeus Segment” (Central Italy). Journal of Micropaleontology 12(2):227−239.

Coccioni R & Galeotti S 2003. The mid-Cenomanian Event: prelude to OAE 2. Palaeogeography Palaeoclimatology Palaeoecology 190: 427-440

Coccioni R, Franchi R, Nesci O, Perilli N, Wezel FC & Battistini F 1990. Stratigrafia, micropaleontologia e mineralogia delle Marne a Fucoidi delle sezioni di Poggio le Guaine e del Fiume Bosso (Appennino umbro-marchigiano). Atti 2° Convegno Internazionale "Fossili, Evoluzione, Ambiente", Pergola, 25-30 ottobre 1987. Tecnostampa, p. 163-201.

Coccioni R, Galeotti S & Gravili M 1995. Latest Albianearly Turonian deep-water agglutinated foraminifera in the Bottaccione section (Gubbio, Italy) - Biostratigraphic and palaeoecology implications. Rev. Esp. Paleontol. no. Homenaje Al Dr. Guillermo Colom: pp. 135-152.

Coccioni R, Nesci O, Tramontana M, Wezel FC & Moretti E 1987. Descrizione di un livello-guida "radiolaritico-bituminoso-ittiolitico" alla base delle Marne a Fucoidi nell'Appennino umbro marchigiano. Bollettino della Società Geologica Italiana 106: 183-192.

Coccioni R, Sabatino N, Frontalini F, Gardin S, Sideri M & Sprovieri M 2014. The neglected history of Oceanic Anoxic Event 1b: insights and new data from the Poggio le Guaine section (Umbria–Marche Basin). Stratigraphy 11: 245-282.

Darji S & Solanki PM 2017. Facies and Ichnotaxonomy of Bhuj Formation near Godpar Village, Southwest of Bhuj, Kachchh, Western India. International Journal for Scientific Research and Development 4(11): 579‒583.

Diener C 1912. The Triassic of the Himalaya. Memoirs of the Geological Survey of India 36: 207‒358.

Eldrett JS, Vieira M, Gallagher L, Hampton M, Blaauw M & Swart PK 2021. Late Cretaceous to Palaeogene carbon isotope, calcareous nannofossil and foraminifera stratigraphy of the Chalk Group. Central North Sea. Marine and Petroleum Geology 124: 104789.

Erba E & Larson R 1998. The Cismon Apticore (Southern Alps, Italy): “Reference section” for the Lower Cretaceous at low latitudes. Rivista Italiana Di Paleontologia E Stratigrafia 104: 181-192.

Erba E 1994. Nannofossils and superplumes: the early Aptian ‘nannoconid crisis’. Paleoceanography 9: 483-501.

Erba E 2004. Calcareous nannofossils and Mesozoic oceanic anoxic events. Marine Micropaleontology 52: 85−106.

Erba E, Bartolini A & Larson RL 2004. Valanginian Weissert oceanic anoxic event. Geology 32(2): 149−152.

Erba E, Duncan RA, Bottini C, Tiraboschi D, Weissert H, Jenkyns HC & Malinverno A 2015. Environmental consequences of Ontong Java Plateau and Kerguelen Plateau volcanism. Geological Society of America Special Paper 511: 271-303.

Erbacher J & Thurow J 1997. Influence of oceanic anoxic events on the evolution of mid-Cretaceous radiolaria in the North Atlantic and western Tethys. Marine Micropaleontology 30: 139-158.

Erbacher J, Huber BT, Norris RD & Markey M 2001. Increased thermohaline stratification as a possible cause for an ocean anoxic event in the Cretaceous period. Nature 409: 325-327.

Erbacher J, Thurow J & Littke R 1996. Evolution patterns of radiolaria and organic matter variations: A new approach to identify sea level changes in mid-Cretaceous pelagic environments. Geology 24: 499−502.

Fürsich FT 1998. Environmental distribution of trace fossils in the Jurassic of Kachchh (western India). Facies 39(1): 243−272.

Fürsich FT, Uchman A, Alberti M & Pandey DK 2018. Trace fossils of an amalgamated storm-bed succession from the Jurassic of the Kachchh Basin, India: The significance of timeaveraging in ichnology. Journal of Palaeogeography 7(1): 14−31. doi: 10.1016/j.jop.2017.11.002

Fernández-Martínez J, Rodríguez-Tovar F, Piñuela L, Martínez-Ruiz F & García-Ramos JC 2021. Bottom- and pore-water oxygenation during the early Toarcian Oceanic Anoxic Event (T-OAE) in the Asturian Basin (N Spain): Ichnological information to improve facies analysis Sedimentary Geology 419: 105909. https://doi.org/10.1016/j.sedgeo.2021.105909.

Follmi KB, Bodin S, Godet A, Linder P & Van de Schootbrugge B 2007. Unlocking paleo-environmental information from Early Cretaceous shelf sediments in the Helvetic Alps: stratigraphy is the key! Swiss Journal of Geosciences 100: 349-369.

Forster A, Schouten S, Moriya K, Wilson PA & Sinninghe Damste JS 2007. Tropical warming and intermittent cooling during the Cenomanian/Turonian oceanic anoxic event 2: Sea surface temperature records from the equatorial Atlantic. Paleoceanography 22:, PA1219. doi:1210.1029/2006PA001349.

Frijia G, Parente M, Di Lucia M & Mutti M 2015. Carbon and strontium isotope stratigraphy of the Upper Cretaceous (Cenomanian-Campanian) shallow-water carbonates of southern Italy: chronostratigraphic calibration of larger foraminifera biostratigraphy. Cretaceous Research 53: 110-139.

Gaetani M & Garzanti E 1991. Multicyclic history of the northern India continental margin (north-western) Himalaya. American Association of Petroleum Geologists Bulletin 75: 1427−1446.

Galasso F, Schmid-Rohl A, Feist-Burkhardt S, Bernasconi SM & Hermann ES 2021. Changes in organic matter composition during the Toarcian Oceanic Anoxic Event (T-OAE) in the Posidonia Shale Formation from Dormettingen (SW-Germany). Palaeogeography, Palaeoclimatology, Palaeoecology 569: 110327. https://doi.org/10.1016/j.palaeo.2021.110327

Gale AS, Kennedy WJ, Burnett JA, Caron M & Kidd BE 1996. The late Albian to early Cenomanian succession near Rosans (Drome, SE France): an integrated study (ammonites, inoceramids, planktonic Foraminifera, nannofossils, oxygen and carbon isotopes). Cretaceous Research 17: 515-606.

Gale AS, Kennedy WJ & Walaszczyk I 2019. Upper Albian, Cenomanian and Lower Turonian stratigraphy, ammonite and inoceramid bivalve faunas from the Cauvery Basin, Tamil Nadu, South India. Acta Geologica Polonica 69(2): 161−338.

Galeotti S, Sprovieri M, Coccioni R, Bellanca A & Neri R 2003. Orbitally modulated black shale deposition in the upper Albian Amadeus Segment (central Italy): a multi-proxy reconstruction. Palaeogeography Palaeoclimatology Palaeoecology 190: 441-458.

Gambacorta G, Jenkyns HC, Russo F, Tsikos H, Wilson PA, Faucher G & Erba E 2015. Carbon- and oxygen-isotope records of mid-Cretaceous Tethyan pelagic sequences from the Umbria-Marcheand Belluno Basins (Italy). Newsletter on Stratigraphy 48: 299-323.

Garzanti E 1992. Stratigraphy of the Early Cretaceous Giumal Group (Zanskar Range, Northern India). Rivista Italiana di Paleontologia e Stratigrafia 97(3-4): 485−510.

Gavrilov YO, Shcherbinina EA & Aleksandrova GN 2019. Mesozoic and Early Cenozoic paleoecological events in the sedimentary record of the NE Peri-Tethys and adjacent areas: an overview. Lithology and Mineral Resources 54(6): 524-543.

Gerard A 1827. On the Valley of the Satluj River. Transactions of the Royal Asiatic Society of London 1: 1−343.

Giorgioni M, Weissert H, Bernasconi SM, Hochuli PA, Keller CE, Coccioni R, Petrizzo MR, Lukeneder PA & Garcia TI 2015. Paleoceanographic changes during the Albian-Cenomanian in the Tethys and North Atlantic and the onset of the Cretaceous chalk. Global and Planetary Change 126: 46-61.

Giraldo-G´omez VM, Petrizzo MR, Erba E & Bottini C 2022. Paleoceanographic inferences from benthic foraminifera across the early Aptian Ocean Anoxic Event 1a in the western Tethys Palaeogeography, Palaeoclimatology, Palaeoecology 588: 110803. doi.org/10.1016/j.palaeo.2021.110803

Giraud F, Pittet B, Grosheny D, Baudin F, Lécuyer C & Sakamoto T 2018. The palaeoceanographic crisis of the Early Aptian (OAE 1a) in the Vocontian Basin (SE France). Palaeogeography, Palaeoclimatology, Palaeoecology 511: 483–505. doi.org/10.1016/j.palaeo.2018.09.014.

Govindan A 2017. Late Cretaceous pelagic red shales in the Cauvery Basin, Southeast India, its biostratigraphy and paleoceanographic implications. In: Kathal, P.K., Nigam R. & Talib, A. (eds.): Advanced micropaleontology, India 107−118.

Grasby SE, Crowley JL, Mohr MT, Percival JB, Ardakani OH, Galloway J, Bringué M, Smith IR & Yuan W 2024. Oceanic anoxic event 3 in Arctic Canada-Arc volcanism and ocean fertilization drove anoxia. Geological Society of America. https://doi.org/10.1130/B37632.1

Grocke D 2002. The carbon isotope composition of ancient CO_2 based on higher-plant organic matter. Philosophical Transactions of the Royal Society of London. Series A Mathematical, Physical and Engineering Sciences 360: 633-658.

Gröcke DR & Joeckel RM 2008. A stratigraphic test of the terrestrial carbon isotope record of the latest Albian OAE from the Dakota Formation, Nebraska. In: Joeckel RM, Ludvigson GA, Macfarlane PA (eds), FIELD TRIP 2: Fluvial-Estuarine Deposition in the Mid-Cretaceous Dakota Formation, Kansas and Nebraska. Kansas Geologic Survey, Lawrence, KS, pp. 24–30.

Gröcke DR, Ludvigson GA, Witzke BL, Robinson SA, Joeckel RM, Ufnar DF & Ravn RL 2006. Recognizing the Albian-Cenomanian (OAE1d) sequence boundary using plant carbon isotopes: Dakota Formation, Western Interior Basin, USA. Geology 34: 193-196.

Guler MV, Lazo DG, Pazos PJ, Borel CM, Ottone EG, Tyson RV, Cesaretti N & Aguirre-Urreta MB 2013. Palynofacies analysis and palynology of the Agua de la Mula Member (Agrio Formation) in a sequence stratigraphy framework, Lower Cretaceous, Neuquén basin, Argentina. Cretaceous Research 41: 65-81.

Gyawali BR, Nishi H, Takashima R, Herrle JO, Takayanagi H, Latil JL & Iryu Y 2017. Upper Albian–upper Turonian calcareous nannofossil biostratigraphy and chemostratigraphy in the Vocontian Basin, southeastern France. Newsletter on Stratigraphy 50(2): 111-139.

Haig DW & Lynch DA 1993. A late early Albian marine transgressive pulse over northeastern Australia, precursor to epeiric basin anoxia: Foraminiferal evidence. Marine Micropaleontology 22: 311−362.

Han Z, Hu X, Hu Z, Jenkyns HC & Su T 2022. Geochemical evidence from the Kioto Carbonate Platform (Tibet) reveals enhanced terrigenous input and deoxygenation during the early Toarcian. Global and Planetary Change 215: 103887.

Hart MB, Joshi A & Watkinson MP 2001. Mid-Late Cretaceous stratigraphy of the Cauvery Basin and the development of the eastern Indian Ocean. Journal of Geological Society of India 58: 217−229.

Hayden HH 1904. The geology of Spiti, with part of Burshar and Rupshu. Memoirs of the Geological Survey of India 36: 1−129.

Hayden HH 1908. A sketch of the geography and geology of the Himalaya Mountains and Tibet. The Geology of the Himalaya, Part 4, Government of India Press 1−236.

Heimhofer U, Hochuli PA, Burla S, Andersen N & Weissert H, 2003. Terrestrial carbon-isotope records from coastal deposits (Algarve, Portugal): a tool for chemostratigraphic correlation on an intrabasinal and global scale. Terra Nova 15(1): 8-13.

Hennhoefer D, Al Suwaidi A, Bottini C, Helja E & Steuber T 2018. The Albian to Turonian carbon isotope record from the Shilaif Basin (United Arab Emirates) and its regional and intercontinental correlation. Sedimentology 66: 536-555.

Herrle JO, Kossler P, Friedrich O, Erlenkeuser H & Hemleben C 2004. High-resolution carbon isotope records of the Aptian to Lower Albian from SE France and the Mazagan Plateau (DSDP Site 545): a stratigraphic tool for paleoceanographic and paleobiologic reconstruction. Earth and Planetary Science Letters 218: 149-161.

Herrle JO & Mutterlose J 2003. Calcareous nannofossils from the Aptian– early Albian of SE France: paleoceanographic and biostratigraphic implications. Cretaceous Research 24: 1- 22.

Herrle JO, Schroder-Adams CJ, Davis W, Pugh AT, Galloway JM & Fath J 2015. Mid-Cretaceous High Arctic stratigraphy, climate, and Oceanic Anoxic Events. Geology 43: 403-406.

Hesselbo SP, Gröcke DR, Jenkyns HC, Bjerrum CJ, Farrimond P, Bell HSM & Green OR 2000. Massive dissociation of gas hydrate during a Jurassic oceanic anoxic event. Nature 406(6794): 392-395.

Hesselbo SP, Jenkyns HC, Duarte LV & Oliveira LCV 2007. Carbon-isotope record of the Early Jurassic (Toarcian) Oceanic Anoxic Event from fossil wood and marine carbonate (Lusitanian Basin, Portugal). Earth and Planetary Science Letters 253: 455-470.

Huang Y, Jin X, Pancost RD, Kemp DB & Naafs BDA 2024. An intensified lacustrine methane cycle during the Toarcian OAE (Jenkyns Event) in the Ordos Basin, northern China. Earth and Planetary Science Letters 639: 118766. https://doi.org/10.1016/j.epsl.2024.118766.

Huber BT & Leckie RM 2011. Planktic foraminiferal species turnover across deep-sea Aptian/Albian boundary sections. Journal of Foraminiferal Research 41: 53-95.

Huber BT, Hodell DA & Hamilton CP 1995. Mid- to Late Cretaceous climate of the southern high latitudes: stable isotopic evidence for minimal equator-to-pole thermal gradients. Geological Society of America Bulletin 107(10):1164-1191.

Huber BT, MacLeod KG, Watkins DK & Coffin MF 2018. The rise and fall of the Cretaceous hot greenhouse climate. Global and Planetary Change 167: 1-23.

Huber BT, Norris RD & MacLeod KG 2002. Deep-sea paleotemperature record of extreme warmth during the Cretaceous. Geology 30, 123–126.

Jadoul F, Garzanti E & Fois E 1990. Upper Triassic-Lower Jurassic stratigraphy and palaeogeographic evolution of the Zanskar Tethys Himalaya (Zangla Unit). Rivista Italianadi Paleontologia e Stratigrafia 95(4): 357−396. doi.org/10.13130/2039-4942/10621.

Jarvis I, Gale A, Jenkyns HC & Pearce MA 2006. Secular variation in Late Cretaceous carbon isotopes: a new δ13C carbonate reference curve for the Cenomanian-Campanian (99.6–70.6 Ma). Geological Magzine 143(5): 561-608.

Jenkyns HC 1980.Cretaceous anoxic events: from continents to oceans. Journal of Geological Society of London 137(2): 171−188.

Jenkyns HC 1995. Carbon-isotope stratigraphy and paleoceanographic significance of the Lower Cretaceous shallow-water carbonates of Resolution Guyot, Mid-Pacific Mountains. In: Winterer EL, Sager WW, Firth JV, Sinton JM (eds), Proc. ODP, Scientific Results 143: 99-104.

Jenkyns HC 1999. Mesozoic anoxic events and palaeoclimate. Zentralblatt für Geologie und Palaeontologie 1997(7-9): 943−949.

Jenkyns HC 2003. Evidence for rapid climate change in the Mesozoic-Palaeogene greenhouse world. Philosophical Transaction of Royal Society London, Series A: Mathematical Physical and Engineering Sciences 361(1810): 1885−1916.

Jenkyns HC 2010. Geochemistry of oceanic anoxic events. Geochemistry Geophysics Geosystems 11(3): 1−30. doi.10.1029/2009GC002788.

Jenkyns HC, Gale AS & Corfield RM 1994. Carbon- and oxygen-isotope stratigraphy of the English Chalk and Italian Scaglia and its palaeoclimatic significance. Geological Magzine 131(1): 1-34.

Jin X, Shi Z, Baranyi V, Kemp DB, Han Z, Luo G, Hu J, He F, Chen L & Preto N 2020. The Jenkyns Event (early Toarcian OAE) in the Ordos Basin, North China. Global and Planetary Change 193: 103273. https://doi.org/10.1016/j.gloplacha.2020.103273.

Jones MM, Ibarra DE, Gao Y, Sageman BB, Selby D, Chamberlain C & Graham SA 2018. Evaluating Late Cretaceous OAEs and the influence of marine incursions on organic carbon burial in an expansive East Asian paleo-lake. Earth and Planetary Science Letters 484: 41-52.

Jones MM, Sageman B, Selby D, Jicha B, Singer B & Titus A 2021. Regional chronostratigraphic synthesis of the Cenomanian-Turonian Oceanic Anoxic Event 2 (OAE2) interval, Western Interior Basin (USA): new Re–Os chemostratigraphy and $^{40}Ar/^{39}Ar$ geochronology. Geological Society of America Bulletin 133: 1090-1104.

Junium CK, Meyers SR & Arthur MA 2018. Nitrogen cycle dynamics in the Late Cretaceous Greenhouse. Earth and Planetary Science Letters 481: 404-411.

Karakitsios V, Tzortzaki E, Giraud F & Pasadakis N 2018. First evidence for the early Aptian Oceanic Anoxic Event (OAE1a) from the Western margin of the Pindos Ocean (NW Greece). Geobios 51: 187-210.

Kemp DB, Baranyi V, Izumi K & Burgess RD 2019. Organic matter variations and links to climate across the early Toarcian oceanic anoxic event (T-OAE) in Toyora area, southwest Japan. Palaeogeography, Palaeoclimatology, Palaeoecology 530: 90-102.

Kemp DB, Suan G, Fantasia A, Jin S & Chen W 2022. Global organic carbon burial during the Toarcian oceanic anoxic event: patterns and controls. Earth Science Review 231: 104086. https://doi.org/10.1016/j.earscirev.2022.104086.

Kemp DB, Coe AL, Cohen AS & Schwark L 2005. Astronomical pacing of methane release in the Early Jurassic period. Nature 437: 396-399. doi:10.1038/nature04037.

Krishna J 2017. The Indian Mesozoic chronicle, Springer, Singapore 1-748.

Kuroda J, Ogawa NO, Tanimizu M, Coffin M, Tokuyama H, Kitazato H & Ohkouchi N 2007. Contemporaneous massive subaerial volcanism and late Cretaceous Oceanic Anoxic Event 2. Earth and Planetary Science Letters 256: 211-223.

Lamolda MA & Paul CRC 2007. Carbon and oxygen stable isotopes across the Coniacian/Santonian boundary at Olazagutia, northern Spain. Cretaceous Research 28: 37-45.

Langdon C, Takahashi T, Sweeney C, Chipman D, Goddard J, Marubini F, Aceves H, Barnett H & Atkinson M 2000. Effect of calcium carbonate saturation state on the calcification rate of an experimental coral reef. Global Geochemical Cycles 14: 639-654.

Larson RL 1991. Latest pulse of Earth: Evidence for a mid-Cretaceous superplume. Geology 19, 547-550.

Leckie RM, Bralower TJ & Cashman R 2002. Oceanic anoxic events and plankton evolution: Biotic response to tectonic forcing during the mid-Cretaceous. Paleoceanography 17(3): 623-642. doi.10.1029/2001PA000623

Li X, Jenkyns HC, Wang C, Hu X, Chen X, Wei Y, Huang Y & Cui J 2006. Upper Cretaceous carbon- and oxygen-isotope stratigraphy of hemipelagic carbonate facies from southern Tibet. China. Journal of the Geological Society of London 163(2): 375-382.

Li X, Wei Y, Li Y & Zhang C 2016. Carbon isotope records of the early Albian oceanic anoxic event (OAE) 1b from eastern Tethys (southern Tibet, China). Cretaceous Research 62: 109-121.

Lini A, Weissert H & Erba E 1992.The Valanginian carbon isotope event: a first episode of greenhouse climate conditions during the Cretaceous. Terra Nova 4(3): 374−384.

Locklair R, Sageman B & Lerman A 2011. Marine carbon burial flux and the carbon isotope record of Late Cretaceous (Coniacian–Santonian) Oceanic Anoxic Event III. Sedimentary Geology 235(1/2): 38-49.

Lowrie W, Alvarez W, Silva IP & Monechi S 1980. Lower Cretaceous magnetic stratigraphy in Umbrian pelagic carbonate rocks. Geophysical Journal International 60: 263-281. https://doi.org/10.1111/j.1365-246X.1980.tb04292.x.

Luciani V, Cobianchi M & Jenkyns HC 2004. Albian high-resolution biostratigraphy and isotope stratigraphy: The Coppa della Nuvola pelagic succession of the Gargano Promontory (Southern Italy). Eclogae geologie Helvetica 97: 77-92.

Ludvigson GA, Joeckel RM, Murphy LR, Stockli DF, Gonzalez LA, Suarez CA, Kirkland JI & Al-Suwaidi A 2015. The emerging terrestrial record of Aptian-Albian global change. Cretaceous Research 56: 1-24.

Luft de Souza F, Krahl G & Fauth G 2018. Late Cretaceous (Cenomanian-Maastrichtian) planktic foraminifera from Goban Spur (DSDP sites 549 and 550): Biostratigraphic inferences. Cretaceous Research 86: 238-250.

Lukeneder A, Suttner TJ & Bertle RJ 2013. New Ammonoid Taxa from the Lower Cretaceous Giumal Formation of the Tethyan Himalaya (Northern India). Palaeontology 56(5): 991−1028.

Machado MC, Chemale Jr, F, Kawashita K, Rey O & Moura CAV 2016. Isotope studies of carbonate rocks of La Luna Formation (Venezuela) to constrain the oceanic anoxic event 3 (OAE3). Journal of South American Earth Sciences 72: 38-48.

Macleod KG, White LT, Wainman CC, Martinez M, Jones MM, Batenburg SJ, Riquier L *et al*. 2020. Late Cretaceous stratigraphy and paleoceanographic evolution in the Great Australian Bight Basin based on results from IODP Site U1512. Gondwana Research 83: 80-95.

Madhavaraju J, Scott RW, Sial AN & Ramirez-Montoya E 2021.Chemo- and biostratigraphy of the Cretaceous Dalmiapuram Formation, Uttatur Group, Kallakudi II section, Cauvery Basin, South India Arabian Journal of Geosciences 14: 1868.

Madhavaraju J, Sial AN, Hussain SM, Nagarajan R & Ramasamy S 2015. Petrography and stable isotopic variations in Dalmiapuram Formation of Cauvery Basin, South India: implication on OAE1d. Chinese Journal of Geochemistry 34(3): 447−458.

Mansour A, Gentzis T, Carvajal-Ortiz H, Tahoun SS & Wagreich M 2020a. Geochemistry and palynology of the upper Albian at the Abu Gharadig Basin, southern Tethys: Constraints on the oceanic anoxic event 1d. Geological Journal 55:6338-6360. DOI: 10.1002/gj.3810.

Mansour A, Wagreich M, Gentzis T, Ocubalidet S, Tahoun SS & Elewa AMT 2020b. Depositional and organic carbon-controlled regimes during the Coniacian-Santonian event: first results from the southern Tethys (Egypt). Marine and Petroleum Geology 115: 104285.

Martinez M & Dera G 2015. Orbital pacing of carbon fluxes by a ~9-My eccentricity cycle during the Mesozoic. Proceeding of the National Academy of Science 112(41): 12604−12609. doi/10.1073/pnas.1419946112.

Matley CA 1921. On the stratigraphy, fossils and geological relationships of the Lameta beds of Jubbulpore. Records of the Geological Survey of India 53: 142−169.

Matsumoto H, Goto KT, Shimoda G, Watanabe Y, Shirai K, Tejada MLG, Ishikawa A, Ando A, Sano T, Kuroda J & Suzuki K 2024. Brief and intensive volcanic emissions from Ontong Java Nui heralded Oceanic Anoxic Event 1a. Communications Earth & Environment 5:155. https://doi.org/10.1038/s43247-024-01310-0

Matsumoto H, Kuroda J, Coccioni R, Frontalini F, Sakai S, Ogawa NO & Ohkouchi N 2020. Marine Os isotopic evidence for multiple volcanic episodes during Cretaceous Oceanic Anoxic Event 1b. Scientific Reports 10: 12601.

Matsumoto H, Shirai K, Huber BT, MacLeod KG & Kuroda J 2023. High-resolution marine osmium and carbon isotopic record across the Aptian–Albian boundary in the southern South Atlantic: evidence for enhanced continental weathering and ocean acidification. Palaeogeography Palaeoclimatology Palaeoecology 613: 111414.

Mattioli E, Pittet B, Petitpierre L & Mailliot S 2009. Dramatic decrease of pelagic carbonate production by nannoplankton across the Early Toarcian anoxic event (T-OAE). Global and Planetary Change 65: 134-145. doi:10.1016/j.gloplacha.2008.10.018.

McAnena A, Flogel S, Hofmann P, Herrle JO, Griesand A, Pross J, Talbot HM, Rethemeyer J, Wallmann K & Wagner T 2013. Atlantic cooling associated with a marine biotic crisis during the mid-Cretaceous period. Nature Geoscience 6: 558-561.

McElwain JC & Hesselbo SP 2005. Changes in carbon dioxide during an oceanic anoxic event linked to intrusion into Gondwana coals. Nature, 435(7041): 479-482. https://doi.org/10.1038/nature03618.

Medlicott HB 1872. Note on the Lameta or infratrappean formation of Central India. Journal of Palaeontological Society of India 5: 115–120.

Melinte-Dobrinescu MC, Relu-Dumitru R & Marius S 2015. Palaeoenvironmental changes across the Albian-Cenomanian boundary interval of the Eastern Carpathians. Cretaceous Research 54: 68-85.

Meyers PA, Bernasconi SM & Forster A 2006. Origins and accumulation of organic matter in expanded Albian to Santonian black shale sequences on the Demerara Rise, South American margin. Organic Geochemistry 37:, 1816-1830.

Midtkandal I, Svensen H, Planke S, Corfu F, Polteau S, Torsvik TH, Faleide JI, Grundvåg SA, Selnes H, Kürschner W & Olaussen S 2016. The Aptian (Early Cretaceous) oceanic anoxic event (OAE1a) in Svalbard, Barents Sea, and the absolute age of the Barremian-Aptian boundary. Palaeogeography, Palaeoclimatology, Palaeoecology 463: 126-135. https://doi.org/10.1016/j.palaeo.2016.09.023.

Millan MI, Weissert HJ & Lopez-Horgue MA 2014. Expression of the late Aptian cold snaps and the OAE1b in a highly subsiding carbonate platform (Aralar, northern Spain). Palaeogeography Palaeoclimatology Palaeoecology 411: 167-179.

Mitchell S, Paul C & Gale A 1996. Carbon isotopes and sequence stratigraphy. Geological Society, London, Special Publications 104: 11–24. doi:10.1144/GSL.SP.1996.104.01.02.

Möllera C, Bornemann A & Mutterlose J 2020. Climate and paleoceanography controlled size variations of calcareous nannofossils during the Valanginian Weissert Event (Early Cretaceous). Marine Micropaleontology 157: 101875. doi.org/10.1016/j.marmicro.2020.101875.

Müller T, Jurikova H, Gutjahr M, Tomaˇsových A, Schlogl, J, Liebetrau V, Duarte LV, Milovský R, Suan G, Mattioli E, Pittet B & Eisenhauer A 2020. Ocean acidification during the early Toarcian extinction event: evidence from boron isotopes in brachiopods. Geology 48: 1184-1188.

Mutterlose J & Ruffell A 1999. Milankovitch-scale palaeoclimate changes in pale-dark bedding rhythms from the Early Cretaceous (Hauterivian and Barremian) of eastern England and northern Germany. Palaeogeography Palaeoclimatology Palaeoecology 154: 133-160.

Mutterlose J, Bornemann A, Luppold FW, Owen HG, Ruffell A, Weiss W & Wray D 2003. The Vohrum section (northwest Germany) and the Aptian/Albian boundary. Cretaceous Research 24: 203-252.

Myrow PM, Hughes NC, Paulsen TS, Williams IS, Parcha SK, Thompson KR, Bowring SA, Peng SC & Ahluwalia AD 2003. Integrated tectonostratigraphic analysis of the Himalaya and implication for its tectonic reconstruction. Earth and Planetary Science Letters 212: 433−441.

Nagendra R & Reddy AN 2017. Major geologic events of the Cauvery Basin, India and their correlation with global signatures– A review. Journal of Palaeogeography 6(1): 69−83.

Navarro-Ramirez J-P, Bodin S, Heimhofer U & Immenhauser A 2015. Record of Albian to early Cenomanian environmental perturbation in the eastern sub-equatorial Pacific. Palaeogeography Palaeoclimatology Palaeoecology 423: 122-137.

Navidtalab A, Heimhofer U, Huck S, Omidvar M, Rahimpour-Bonab H, Aharipour R & Shakeri A 2019. Biochemostratigraphy of an upper Albian–Turonian succession from the southeastern Neo-Tethys margin, SW Iran. Palaeogeography Palaeoclimatology Palaeoecology 533: 109255.

Nederbragt AJ, Fiorentino A & Klosowska B 2001. Quantitative analysis of calcareous microfossils across the Albian–Cenomanian boundary oceanic anoxic event at DSDP Site 547 (North Atlantic). Palaeogeography Palaeoclimatology Palaeoecology 166(3–4): 401-421.

Nie Y, Fu X, Liang, Wei H, Chen Z, Lin F, Zeng S, Wu Y, Zou Y & Mansour A 2023. The Toarcian Oceanic Anoxic Event in a shelf environment (Eastern Tethys): Implications for weathering and redox conditions. Sedimentary Geology 455: 106476. https://doi.org/10.1016/j.sedgeo.2023.106476.

Nozaki T, Kato Y & Suzuki K 2013. Late Jurassic ocean anoxic event: evidence from voluminous sulphide deposition and preservation in the Panthalassa. Science Report 3: 1889. doi: 10.1038/srep01889.

O’Brien CL *et al.* 2017. Cretaceous sea-surface temperature evolution: Constraints from TEX86 and planktonic foraminiferal oxygen isotopes. Earth-Science Reviews 172: 224-247. doi.org/10.1016/j.earscirev.2017.07.012.

Oloriz F & Tintori A 1990. Upper Jurassic (Tithonian) ammonites from the Spiti shales in western Zanskar (NW Himalayas). Rivista Italiana di Paleontologia e Stratigrafia 96(4): 461−486.

Pandey B & Pathak DB 2015. Status of the Indian Early Cretaceous ammonoid record in light of recent observations in the Spiti Valley, Himachal Himalaya. Himalayan Geology 36(1): 1−8.

Pandey B & Pathak DB 2016. The possibility of the Oceanic Anoxic Events (OAEs) study in the Indian marine Jurassic-Cretaceous outcrops. Journal of the Geolological Society of India 87(3): 261−267.

Pathak DB 2007. Jurassic/Cretaceous boundary in the Spiti Himalaya, India. Journal of the Palaeontological Society of India 52(1): 51− 5.

Perez-Infante J, Farrimond P & Furrer M 1996. Global and local controls influencing the deposition of the La Luna Formation Cenomanian–Campanian., western Venezuela. Chemical Geology 130: 271-288.

Peti L & Thibault N 2017. Abundance and size changes in the calcareous nannofossil Schizosphaerella – Relation to sea-level, the carbonate factory and palaeoenvironmental change from the Sinemurian to earliest Toarcian of the Paris Basin. Palaeogeography, Palaeoclimatology, Palaeoecology 485: 271-282. https://doi.org/10.1016/j.palaeo.2017.06.019.

Petrizzo MR, Berrocoso AJ, Falzoni F, Huber BT & Macleod KG 2017. The Coniacian–Santonian sedimentary record in southern Tanzania (Ruvuma Basin, East Africa): Planktonic foraminiferal evolutionary, geochemical and palaeoceanographic patterns. Sedimentology 64: 252–285.

Petrizzo MR, Huber BT, Wilson PA & MacLeod KG 2008. Late Albian paleoceanography of the western subtropical North Atlantic. Paleoceanography 23(1): PA1213. https://doi.org/10.1029/2007PA001517.

Peybernes C, Giraud F, Jaillard E, Robert E, Masrour M, Aoutem M & Icame N 2013. Stratigraphic framework and calcareous nannofossil productivity of the Essaouira-Agadir

Basin (Morocco) during the Aptian-Early Albian: comparison with the north-Tethyan margin. Cretaceous Research 39: 149-169.

Phelps RM, Kerans C, Da-Gama ROBP, Jeremiah J, Hull D, Loucks RG 2015. Response and recovery of the Comanche carbonate platform surrounding multiple Cretaceous oceanic anoxic events, northern Gulf of Mexico. Cretaceous Research 54: 117-144.

Pratt LM & King JD 1986. Variable marine productivity and high eolian input recorded by rhythmic black shales in Mid-Cretaceous pelagic deposits from central Italy. Paleoceanography 1(4): 507−522.

Premoli Silva I, Erba E & Tornaghi ME 1989. Paleoenvironmental signals and changes in surface fertility in mid-Cretaceous Corg-rich pelagic facies of the fucoid marls (Central Italy). Geobios Memoirs Special publication 11: 225−236.

Premoli Silva I, Garzanti E & Gaetani M 1992. Stratigraphy of the Chikkim and Faru La Formation in the Zangla and Zumlung Units (Zanskar Range, India), with comparisons to the Thakkhola region (central Nepal): mid-Cretaceous evolution of the Indian passive margin. Rivista Italiana di Paleontologia e Stratigrafia 97(3-4): 511−564.

Price GD 2003. New constraints upon isotope variation during the early Cretaceous (Barremian-Cenomanian) from the Pacific Ocean. Geological Magzine 140: 513-522.

Pugh AT, Schroder-Adams CJ, Carter ES, Herrle JO, Galloway J, Haggart JW, Andrews JL & Hatsukano K 2014. Cenomanian to Santonian radiolarian Basin, Ellef Ringnes Island, Nunavut, Canada. Palaeogeography, Palaeoclimatology, Palaeoecology 413: 101-122.

Rangaraju MK, Agarwal A & Prabhakar KN 1993. Tectono-stratigraphy, structural styles, evolutionary model and hydrocarbon prospects of Cauvery and Palar Basins, India. In: Proceeding 2nd Seminar on Petroliferous Basins of India, Dehradun 1: 371−388.

Rasheed DA & Ravindran CN 1978. Foraminiferal biostratigraphic studies of the Ariyalur Group of Tiruchirapalli Cretaceous rocks of Tamil Nadu State. *In* Proceedings 7th Indian Colloquium on Micropalaeontology and Stratigraphy, Madras 321−336.

Reddy AN, Jaiprakash BC, Rao MV, Chidambaram L & Bhaktavatsala KV 2013. Sequence stratigraphy of late Cretaceous successions in the Ramnad sub-basin, Cauvery Basin, India. *In* Proceeding XXIII ICMS and International Symposium on Global Bioevents in Earth's History, Bangalore 78−97.

Reichelt K 2005. Late Aptian-Albian of the Vocontian Basin (SE-France) and Albian of NE-Texas: Biostratigraphic and Paleoceanographic Implications by Planktic Foraminifera Faunas. (Dissertation zur Erlangung des Grades eines Doktors der Naturwissenschaften, der Geowissenschaftlichen Fakultat der Eberhard-Karls- Universitat Tubingen, 125 pp).

Reolid M, Mattioli E, Duarte LV & Ruebsam W 2021. The early Toarcian Oceanic Anoxic Event: where do we stand? In: Reolid M, Mattioli E, Duarte LV, Ruebsam W (eds), Carbon cycle and ecosystem response to the Jenkyns Event in the Early Toarcian (Jurassic). GSL Special Publications 514: 101144/SP514-2021-74.

Rey O, Simo JA & Lorente MA 2004. A record of long- and short-term environmental and climatic change during OAE3: La Luna Formation, Late Cretaceous (Santonian early Campanian), Venezuela. Sedimentary Geology 170: 85.

Richey JD, Upchurch GR, Montanez IP, Lomax BH, Suarez MB, Crout NM, Joeckel RM, Ludvigson GA & Smith JJ 2018. Changes in CO_2 during Ocean Anoxic Event 1d indicate similarities to other carbon cycle perturbations. Earth and Planetary Science Letters 491: 172-182.

Riebesell U, Zondervan I, Rost B, Tortell PD, Zeebe RE & Morel FMM 2000. Reduced calcification of marine plankton in response to increased atmospheric CO_2. Nature 407: 364-367.

Robinson SA, Clarke LJ, Nederbragt A & Wood IG 2008. Mid-cretaceous oceanic anoxic events in the Pacific Ocean revealed by carbon-isotope stratigraphy of the Calera Limestone, California, USA. Geological Society of America Bulletin 120(11−12): 1416-1426.

Robinson SA, Dickson AJ, Pain A, Jenkyns HC, O'Brien CL, Farnsworth A & Lunt DJ 2019. Southern Hemisphere sea-surface temperatures during the Cenomanian–Turonian: Implications for the termination of Oceanic Anoxic Event 2. Geology 47: 131-134. doi.org/10.1130/G45842.1.

Rodriguez-Cuicas M & Montero-Serrano J 2020. Grony Garban Geochemical and mineralogical records of late Albian oceanic anoxic event 1d (OAE-1d) in the La Grita Member (southwestern Venezuela): Implications for weathering and provenance Journal of South American Earth Sciences 97: 102408. https://doi.org/10.1016/j.jsames.2019.102408.

Rodriguez-Cuicas M, Montero Serrano J & Garban G 2019. Palaeoenvironmental changes during the late Albian oceanic anoxic event 1d: an example from the Capacho Formation, southwestern Venezuela. Palaeogeography Palaeoclimatology Palaeoecology 521: 10-29.

Rodríguez-Tovar FJ & Uchman A 2017. The Faraoni event (latest Hauterivian) in ichnological record: The Río Argos section of southern Spain. Cretaceous Research 79: 109-121. doi.org/10.1016/j.cretres.2017.07.018.

Rogov MA, Shchepetova EV & Zakharov VA 2020. Late Jurassic-earliest Cretaceous prolonged shelf dysoxic-anoxic event and its possible causes. Geological Magazine 157(10): 1622-1642. doi.org/10.1017/S001675682000076X.

Sachse VF, Heim S, Jabour H, Kluth O, Schümann T, Aquit M & Littke R 2014. Organic geochemical characterization of Santonian to Early Campanian organic matter-rich marls (Sondage No. 1 cores) as related to OAE3 from the Tarfaya Basin, Morocco. Marine and Petroleum Geology 56: 290-304.

Sachse VF, Littke R, Jabour H, Schümann T & Kluth O 2012. Late Cretaceous (Late Turonian, Coniacian and Santonian) petroleum source rocks as part of an OAE, Tarfaya Basin, Morocco. Marine and Petroleum Geology 29: 35-49.

Satollia S, Lancic L, Muttonid G & Cencio AD 2018. The Lower Toarcian Serrone Marls (Northern Apennines, Italy): A 3.5 Myr record of marl deposition in the aftermath of the T-OAE. Palaeogeography, Palaeoclimatology, Palaeoecology 508: 35. https://doi.org/10.1016/j.palaeo.2018.07.011.

Schlanger SO & Jenkyns HC 1976. Cretaceous oceanic anoxic events: Causes and consequences. Geologie en Mijnbouw 55: 179−184.

Scott RW, Formolo M, Rush N, Owens JD & Oboh-Ikuenobe F 2013. Upper Albian OAE 1d event in the Chihuahua Trough, New Mexico, U.S.A. Cretaceous Research 46: 136-150.

Scott RW, Rush N, Hojnacki R, Campbell W, Wang Y & Lai X 2020. Albian (Lower Cretaceous) carbon isotope chemozones, Texas Comanche Shelf and Mexican Chihuahua Trough: Implications for OAEs. Cretaceous Research 112: 104453. https://doi.org/10.1016/j.cretres.2020.104453.

Sinninghe Damsté JS, Van Bentum EC, Reichart G-J, Pross J & Schouten S 2010. A CO_2 decrease-driven cooling and increased latitudinal temperature gradient during the mid-retaceous Oceanic Anoxic Event 2. Earth and Planetary Science Letters 293: 97-103. doi.org/10 .1016/j.epsl.2010.02.027.

Sliter WV 1989. Aptian anoxia in the Pacific Basin. Geology 17: 909-912. https://doi.org/10.1130/0091-7613.

Sooraj CP, Gupta S & Punekar J 2024. Spatio-temporal variability in microfossil and geochemical records of Cenomanian-Turonian oceanic anoxic event-2: a review. Journal of Palaeogeography (Article in press): 1-29.

Sprovieri M, Sabatino N, Pelosi N, Batenburg SJ, Coccioni R, Iavarone M & Mazzola S 2013. Late Cretaceous orbitally-paced carbon isotope stratigraphy from the Bottaccione Gorge (Italy). Palaeogeography Palaeoclimatology Palaeoecology 379: 81-94.

Srikantia SV & Bhargava ON 1998. Geology of Himachal Pradesh. Geological Society of India, Text Book Series 9: 1-406.

Srikantia SV 1981. The lithostratigraphy, sedimentation and structure of Proterozoic-Phanerozoic formations of Spiti basin in the higher Himalaya of Himachal Pradesh, India. In: Sinha AK, Singh B & Pal M (eds), Contemporary geoscientific researches in Himalaya, Dehradun 31-48.

Stein R, Rullkötter J & Welte DH 1989. Changes in paleoenvironments in the Atlantic Ocean during Cretaceous times: results from black shales studies. Geologische Rundschau 78: 883-901.

Stoll HM & Schrag DP 2000. High-resolution stable isotope records from the Upper Cretaceous rocks of Italy and Spain: Glacial episodes in a greenhouse planet? Geological Society of America Bulletin 112: 308-319.

Stoll HM & Schrag DP 2001. High-resolution stable isotope records from the Upper Cretaceous rocks of Italy and Spain: Glacial episodes in a greenhouse planet? Bulletin of the Geological Society of America 112(2): 308−319.

Strasser A, Caron M & Gjermeni M 2001. The Aptian, Albian and Cenomanian of Roter Sattel, Romandes Prealps, Switzerland: a high-resolution record of oceanographic changes. Cretaceous Research 22(2): 173-199.

Suan G, Nikitenko BL, Rogov MA, Baudin F, Spangenberg JE, Knyazev VG, Glinskikh LA, Goryacheva AA, Adatte T, Riding JB, Follmi KB, Pittet B, Mattioli E & L´ecuyer C 2011. Polar record of Early Jurassic massive carbon injection. Earth and Planetary Science Letters 312: 102-113. https://doi.org/10.1016/j.epsl.2011.09.050.

Suarez MB, Milder T, Peng N, Suarez CA, You H, Li D & Dodson P 2018. Chemostratigraphy of the Lower Cretaceous dinosaur-bearing Xiagou and Zhonggou formations, Yujingzi Basin, northwest China. Journal of Vertebrate Paleontology 38: 12-21.

Sundaram R, Henderson RA, Ayyasami K & Stilwell JD 2001. A lithostratigraphic revision and palaeoenvironmental assessment of the Cretaceous system exposed in the onshore Cauvery Basin, southern India. Cretaceous Research 22: 743−762.

Svensen H, Planke S, Chevallier L, Malthe-Sorenssena A, Corfu F & Jamtveit B 2007. Hydrothermal venting of greenhouse gases triggering Early Jurassic global warming. Earth and Planetary Science Letters 256: 554-566.

Takashima R, Kawabe F, Nishi H, Moriya K, Wani R & Ando H 2004. Geology and stratigraphy of forearc basin sediments in Hokkaido, Japan: Cretaceous environmental events on the north-west Pacific margin. Cretaceous Research 25(3): 365-390.

Takashima R, Nishi H, Huber BT & Leckie RM 2006. Greenhouse world and the Mesozoic ocean. Oceanography 19(4): 82−92.

Takashima R, Nishi H, Yamanaka T, Hayashi K, Waseda A, Obuse A, Tomosugi T, Deguchi N & Mochizuki S 2010. High-resolution terrestrial carbon isotope and planktic foraminiferal records of the Upper Cenomanian to the Lower Campanian in the Northwest Pacific: Earth and Planetary Science Letters 289: 570-582.

Talbi R, Amri A, Boujemaa A, Gabtni H, Spiller R & Levey R 2021. First evidence of the early cretaceous oceanic anoxic events (MBE and OAE1a) in the southern Tethyan margin (NE-Tunisia): biostratigraphy and shale resource system Journal of Petroleum Exploration and Production Technology 11:1559-1575.

Tedeschi LR, Jenkyns HC, Robinson SA, Lana CC, Menezes Santos MRF & Tognoli FM 2020. Aptian carbon-isotope record from the Sergipe-Alagoas Basin: New insights into oceanic anoxic event 1a and the timing of seawater entry into the South Atlantic. Newsletters on Stratigraphy 53: 333-364. https://doi.org/10.1127/nos/2019/0529.

Tessin A, Schroder-Adams C, Elderbak K, Sheldon ND & Hendy I 2019. Local versus seaway-wide trends in deoxygenation in the Late Cretaceous Western Interior Seaway. GSA Bull. 131 (5-6), 1017–1030.

Tewari A, Hart MB & Watkinson MP 1996. Foraminiferal recovery after the mid-Cretaceous oceanic anoxic events (OAEs) in the Cauvery Basin, southeast India. Geological Society of London, Special Publication 102(1): 237−244.

Thibault N, Jarvis I, Voigt S, Gale AS, Attree K & Jenkyns HC 2016. Astronomical calibration and global correlation of the Santonian (Cretaceous) based on the marine carbon isotope record. Paleoceanography 31: https://doi.org/10.1002/ 2016PA002941.

Thiede J *et al.* 1981. Site 463: Western Mid-Pacific Mountains. Initial Reports of the Deep Sea Drilling Project 62: 33-156. https://doi.org/10.2973/dsdp.proc.62.102.1981.

Tur N & Wagreich M 2005. Bio- and isotope stratigraphy of Late Cretaceous oceanic red beds in the NE Caucasus. In: Godet A, Mort H, Linder P, Bodin S (eds), 7th International Workshop on Cretaceous, September 5-9, pp. 214–215.

Tyson RV, Esherwood P & Pattison KA 2005. Organic facies variations in the Valanginiane-mid-Hauterivian interval of the Agrio Formation (Chos Malal area, Neuquén, Argentina): local significance and global context. In: Veiga GD, Spalletti LA, Howell JA, Schwarz E (eds), The Neuquén basin, Argentina: A case study in sequence stratigraphy and basin dynamics. Geological Society of London Special Publication 252: 251-266.

Vahrenkamp VC 2013. Carbon isotope signatures of Albian to Cenomanian (Cretaceous) shelf carbonates of the Natih Formation, Sultanate of Oman. GeoArabia 18: 65-82.

van Breugel Y, Schouten S, Tsikos H, Erba E, Price GD & Sinninghe Damste JS 2007. Synchronous negative carbon isotope shifts in marine and terrestrial biomarkers at the onset of the early Aptian oceanic anoxic event 1a: evidence for the release of 13C-depleted carbon into the atmosphere. Paleoceanography 22: 1-13.

Wagner T, Herrle JO, Sinninghe Damste JS, Schouten S, Stüsser I & Hofmann P 2008. Rapid warming and salinity changes of Cretacous surface waters in the subtropical North Atlantic. Geology 36: 203-206.

Wagner T, Sinninghe Damsté, JS, Hofmann P & Beckmann B 2004. Euxinia and primary production in Late Cretaceous eastern equatorial Atlantic surface waters fostered orbitally driven formation of marine black shales. Paleoceanography 19(3): PA3009. doi.10.1029/2003PA000898.

Wagreich M & Krenmayr H-G 2005. Upper Cretaceous oceanic red beds (CORB) in the Northern Calcareous Alps (Nierental Formation, Austria): slope topography and clastic input as primary controlling factors. Cretaceous Research 26: 57-64.

Wang PJ, Chen CY & Liu HB 2016a. Aptian giant explosive volcanic eruptions in the Songliao Basin and Northeast Asia: a possible cause for global climate change and OAE-1a. Cretaceous Research 62: 98-108. Doi:10.1016/j.cretres.2015.09.021

Wang T, Ramezani J, Wang C, Wu H, He H & Bowring SA 2016b. High-precision U–Pb geochronologic constraints on the Late Cretaceous terrestrial cyclostratigraphy and geomagnetic polarity from the Songliao Basin, Northeast China. Earth and Planetary Science Letters 446: 37-44.

Watkins D, Cooper M & Wilson P 2005. Calcareous Nannoplankton response to late Albian oceanic anoxic event 1d in the Western North Atlantic. Paleoceanography 20: 1-14.

Weissert H & Lini A 1991. Ice age interludes during the time of Cretaceous greenhouse climate. In: Mueller, D.W., McKenzie, J.A. & Weissert, H. (eds.): Symposium controversies in modern geology London Academic Press 173−191.

Weissert H, Lini A, Föllmi KB & Kuhn O 1998. Correlation of Early Cretaceous carbon isotope stratigraphy and platform drowning events: A possible link. Palaeogeography Palaeoclimatology Palaeoecology 137(3-4): 189–203.

Wendler I, Willems H, Grafe K-U, Ding L & Luo H 2011. Upper Cretaceous interhemispheric correlation between the Southern Tethys and the Boreal: chemoand biostratigraphy and paleoclimatic reconstructions from a new section in the Tethys Himalaya. S-Tibet. Newsletters on Stratigraphy 44(2): 137-171.

Whatley BR & Bajpai S 2000. Further nonmarine ostracoda from the Late Cretaceous intertrappean deposits of the Anjar region, Kachchh, Gujarat, India. Revue de Micropaleontologie 43: 173–178.

Whatley R, Bajpai S & Srinivasan S 2002. Upper Cretaceous intertrappean non-marine Ostracoda from Mohagaonkala (Mohgaon-Kalan), Chhindwara District, Madhya Pradesh State, Central India. Journal of Micropalaeontology 21: 105–114.

Wilson P & Norris R 2001. Warm tropical ocean surface and global anoxia during mid-Cretaceous period. Nature 412: 425-428.

Wohlwend S, Hart MB & Weissert H 2016. Chemostratigraphy of the Upper Albian to mid-Turonian Natih Formation (Oman) – or: how authigenic carbonate changes a global pattern. The Depositional Record 2: 97-117.

Wójcik-Tabol P & Ślączka 2015. Are Early Cretaceous environmental changes recorded in deposits of the Western part of the Silesian Nappe? A geochemical approach. Palaeogeography Palaeoclimatology Palaeoecology 417: 293-308. doi.org/10.1016/j.palaeo.2014.10.040.

Yao H, Chen X, Melinte-Dobrinescu M, Wu H, Liang H & Weissert H 2018. Biostratigraphy, carbon isotopes and cyclostratigraphy of the Albian-Cenomanian transition and Oceanic Anoxic Event 1d in southern Tibet. Palaeogeography, Palaeoclimatology, Palaeoecology 499: 45-55.

Zhang GJ, Chen DZ, Huang KJ, Liu M, Huang TY, Yeasmin R & Fu Y 2021. Dramatic attenuation of continental weathering during the Ediacaran-Cambrian transition: Implications for the climatic-oceanic-biological co-evolution. Global and Planetary Change 203: 103518. https://doi.org/10.1016/j.gloplacha.2021.103518.

Zhang X, Chen K, Hu D & Sha J 2016. Mid-Cretaceous carbon cycle perturbations and Oceanic Anoxic events recorded in southern Tibet. Scientific Reports 6: 39643. https://doi.org/10.1038/srep39643.