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Stratigraphic ranges of dinoflagellate cysts from Cretaceous petroliferous basins of India and Brazil

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ABSTRACT

Mehrotra NC, Tewari R, Arai M, Garcia MJ & Bernardes-de-Oliveira MEC 2012. Stratigraphic ranges of dinoflagellate cysts from Cretaceous petroliferous basins of India and Brazil. The Palaeobotanist 61(1): 83-102.

Development of dinoflagellate cyst studies in India and Brazil is directly related with the exploration of hydrocarbons. During the last 3 decades these studies have intensified in various petroliferous basins of the two countries. These have proved to be of immense value in high impact palynological studies as applied in geological modelling for exploration. Stratigraphic ranges of significant dinoflagellate taxa from the two countries have been analysed in global context and presented through 6 Range Tables. This is the first step to build comparative database of these fossils from India and Brazil for obtaining a better understanding of their distribution and application in petroleum industry.

Key-words—Stratigraphic ranges, Dinoflagellate cysts, India, Brazil, Exploration of hydrocarbons.

भारत व ब्राज़ील की क्रिटेशियस पेट्रोलियमधारी द्रोणियों से प्राप्त घूर्णीकशाभ पुटियों के स्तरिक रेंज

नरेश सी मेहरोत्रा, रजनी तिवारी, मित्सुरु एरै, मारिया जुडीटे एवं मैरी ई सी बर्नान्डीज-डी-ऑलीवीरा

सारांश

भारत एवं ब्राज़ील में घूर्णीकशाभ पुटी अध्ययनों का विकास हाइड्रोकार्बनों के अन्वेषण से सीधे संबंधित है। पिछले तीन दशकों के दौरान ये अध्ययन इन दो देशों की विभिन्न पेट्रोलियमधारी द्रोणियों में बढ़े हैं। अन्वेषण हेतु भू-वैज्ञानिकीय प्रतिरुपण मे यथा अनुप्रयुक्त उच्च प्रभावी परागाणविक अध्ययनों में इनके असीम महत्व को सिद्ध कर दिया है। इन दो देशों से प्राप्त महत्वपूर्ण घूर्णीकशाभ टैक्सा के स्तरिक परिसर भू-मंडलीय परिप्रेक्ष्य में विश्लेषित किए गए हैं और 6 रेंज तालिकाओं के माध्यम से प्रदर्शित किए गए। पेट्रोलियम उद्योग में इनके वितरण एवं अनुप्रयोग को बेहतर समझने हेतु भारत व ब्राज़ील से प्राप्त इन जीवाश्मों के तुलनात्मक आंकड़ा आधार बनाने में यह पहला कदम है।

संकेत-शब्द—स्तरिक परिसर, घूर्णीकशाभ पुटियां, भारत, ब्राज़ील, हाइड्रोकार्बन का अन्वेषण।

Amplitudes estratigráficas de cistos de dinoflagelados das bacias petrolíferas Cretáceas da Índia e do Brasil

RESUMO

Desenvolvimento de estudos de cistos de dinoflagelados na Índia e no Brasil está diretamente relacionado com a exploração de hidrocarbonetos. Durante as três últimas décadas estes estudos tem se intensificado nas várias bacias petrolíferas de ambos os países. Isto provou ser de imenso valor em estudos palinológicos de alto impacto conforme aplicado nos modelos geológicos de exploração. Distribuições estratigráficas de importantes taxons de dinoflagelados dos

dois países foram analisadas num contexto global e apresentado em 6 tabelas estratigráficas. Este é um primeiro passo na construção de bases de dados comparativos destes fósseis da Índia e do Brasil para obter uma melhor compreensão de suas distribuição e aplicação na industria de petróleo.

Palavras-chave—Distribuições estratigráficas, Cistos de dinoflagelados, Índia, Brasil, Exploração de hidrocarbonetos.

INTRODUCTION

Development of dinoflagellate cyst studies in India and Brazil is directly connected with exploration of hydrocarbons by their National Oil Companies – ONGC and PETROBRAS, respectively. It picked up in India in early eighties with the increase in exploration activities in its petroliferous basins, particularly Western Offshore, Krishna-Godavari and Cauvery basins (Fig. 1). Almost at the same time the Brazilian scientists recorded hundreds of stratigraphically significant dinocyst spp. from country's sedimentary basins rich in hydrocarbons (Fig. 2). This is the first attempt to analyse the

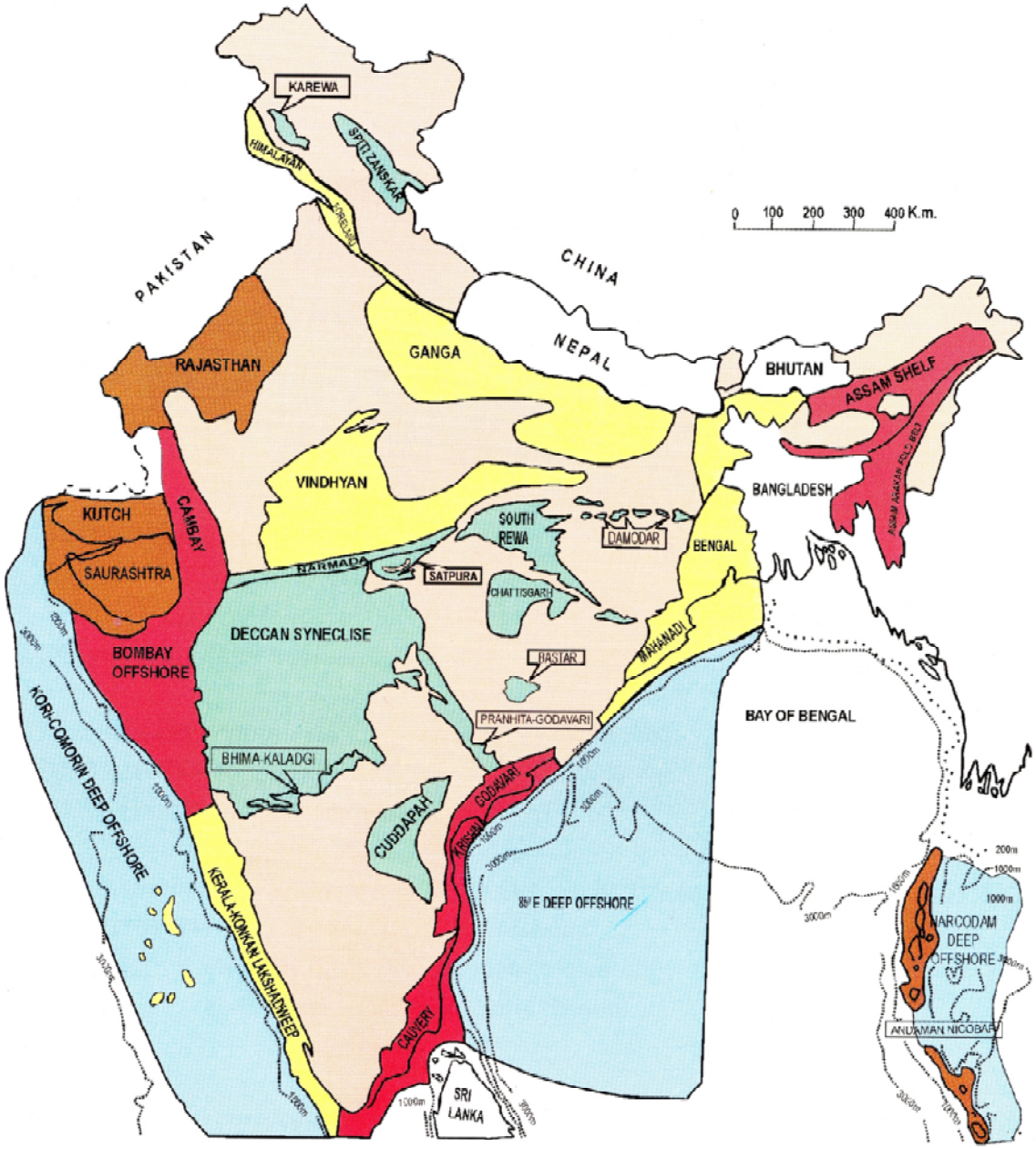


Fig. 1—Map of India showing sedimentary basins0 (after Mehrotra *et al.*, 2002).

dinocyst biostratigraphic records of the two countries with reference to their stratigraphic ranges, particularly their extinction levels (LAD's). This is aimed to have a better understanding of their distribution and stratigraphic significance in the region. The available data reveal at least 60 dinoflagellate taxa common between India and Brazil in the Cretaceous basins. Their stratigraphic ranges in the two regions along with their global occurrences have been presented through six stratigraphic range tables.

Stratigraphic ranges of dinoflagellate species from Indian basins are mentioned. For Brazilian basins these are mainly after Arai (2007) and Lana and Botelho (1989); in some case ranges are slightly modified based on our knowledge (not published) from subsurface data of India and Brazil. For global ranges of dinoflagellate cysts several publications have been consulted. Williams *et al.* (1993); Mehrotra and Aswal (2003); Mehrotra and Singh (2003) and Mehrotra *et al.* (2005, 2008), are the main records. The ranges of William *et al.*, 1993 (adjusted to Hardenbol *et al.*, 1998 time scale), Williams *et al.*

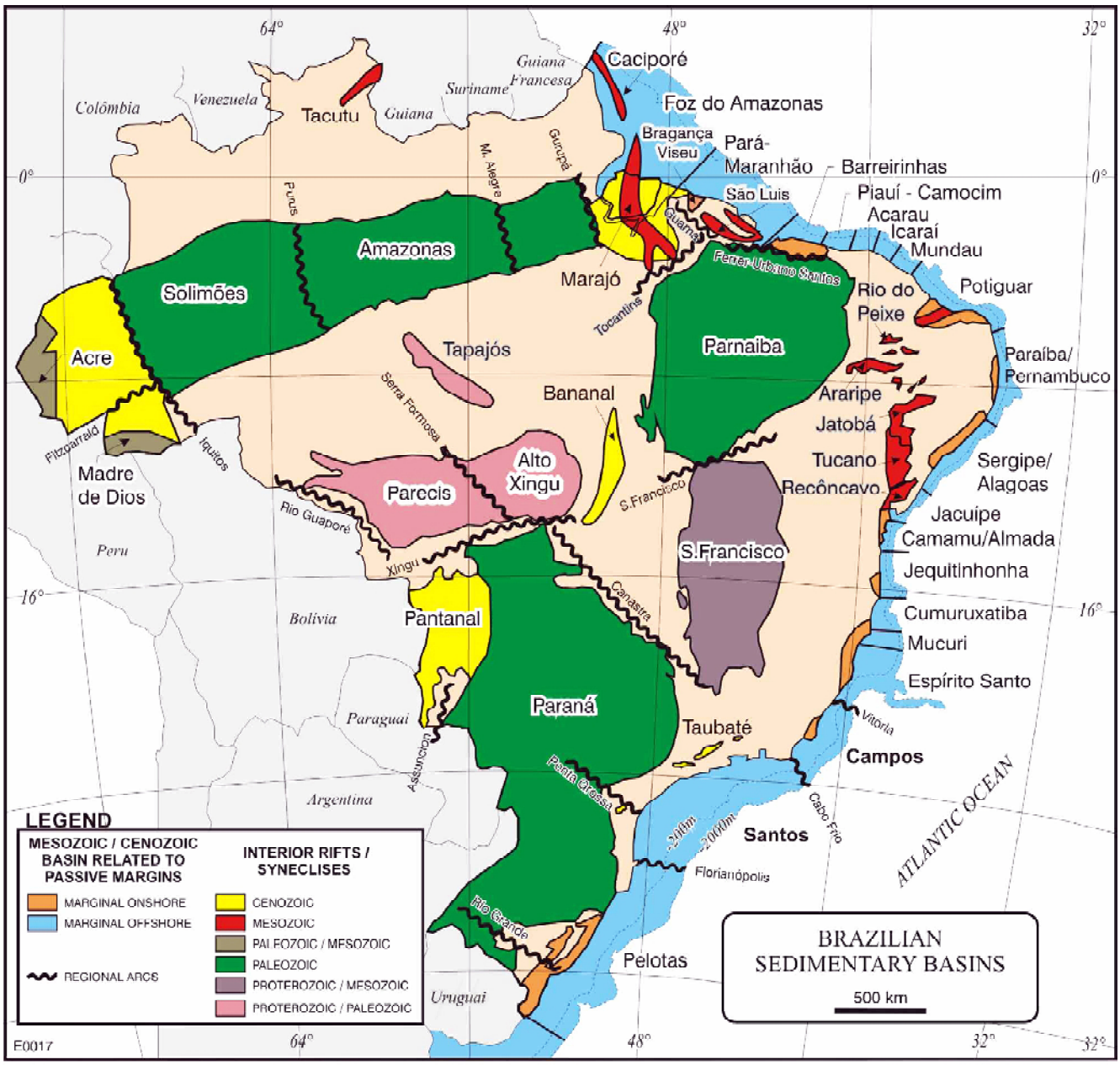


Fig. 2—Location map showing Brazilian sedimentary basins (after Zalan, 2004). The Cretaceous basins are represented mostly by Red (Mesozoic rifts), Orange (Marginal onshore) and Blue (Marginal offshore) colours.

(1998) (in Hardenbol *et al.*, 1998) are further refined to time scale of Gradstein *et al.* (2005-2009) (Time Scale Creator 5).

Distribution of dinoflagellate genera and species are in alphabetical order. Details of taxonomic references can be found in Khowaja-Ateequzzaman *et al.* (2006), Fensome *et al.* (1991, 1993, 1995, 1996) and above mentioned references.

GENUS—ACHOMOSPHAERA Evitt, 1963

Achomosphaera regiensis Corradini, 1973

Known stratigraphic range—Upper Cretaceous of Italy (Corradini, 1973).

Occurrence in Indian basins—Krishna-Godavari (K-G) Basin: Maastrichtian (Mehrotra & Sarjeant, 1987).

Occurrence in Brazilian basins—Ceara Basin: Campanian Superior to Maastrichtian (75-67 Ma) (Lana & Roesner, 2002).

GENUS—ANDALUSIELLA Riegel, 1974 emend. Reigel & Sarjeant, 1982 emend. Masure *et al.*, 1996

Andalusiella polymorpha (Malloy, 1972) Lentin & Williams, 1977b

Known stratigraphic range—Early Campanian to Danian top (79-60.2 Ma).

Occurrence in Indian basins—Meghalaya, Late Maastrichtian-Danian (Kumar *et al.*, 1996).

Occurrence in Brazilian basins—Ceara: Middle Campanian to Basal Maastrichtian (79-69 Ma) (Lana & Roesner, 2002).

GENUS—APTEODINIUM Eisenack, 1958a emend. Sarjeant, 1985 emend. Lucas-Clark, 1987

Apteodinium granulatum Eisenack, 1958 emend. Sarjeant, 1985 emend. Lucas-Clark, 1987

Known stratigraphic range—Early Valanginian to Senonian (138-95 Ma).

Occurrence in Indian basins—Cauvery, Albian (Venkatachala & Kumar, 1980); Kutch, Late Jurassic (Kumar, 1986a); K-G, Hauterivian-Barremian (Kumar, 1986a); Palar Basin: Hauterivian-Barremian (Khowaja Ateequzzaman & Jain, 1982).

Occurrence in Brazilian basins—Ceara: Aptian Superior to Mid Albian (118-105 Ma); Sergipe, Aptian Superior to Mid Albian (118-105 Ma); Campos Basin: Inferior Campanian to Vraconiano (112-100 Ma).

Apteodinium reticulatum Singh, 1971

Known stratigraphic range—Early Cretaceous (Late Albian).

Occurrence in Indian basins—Cauvery Basin: Albian (Venkatachala & Kumar, 1980).

Occurrence in Brazilian basins—Campos Basin: Coniacian to Middle Campanian (89-75 Ma).

GENUS—ASCODINIUM Cookson & Eisenack, 1960a emend. Helenes, 1983

Ascodinium acromorphum Cookson & Eisenack, 1960

Known stratigraphic range—Late Albian to Cenomanian.

Occurrence in Indian basins—K-G Basin: (Kumar, 1982) Valanginian – Hauterivian reassessed Hauterivian by Garg *et al.* (1988).

Occurrence in Brazilian basins—Campos Basin: Vraconian to Cenomanian Superior (102-93 Ma).

GENUS—CALLIALOSPHAERIDIUM Davey & Williams, 1960b emend. Duxbury, 1980 emend. Below, 1981

Callialosphaeridium asymmetricum (Deflandre & Courteville, 1939) Davey & Williams, 1966b emend. Clarke & Verdier, 1967

Known stratigraphic range—Hauterivian to Early Campanian (132-80 Ma).

Occurrence in Indian basins—Cauvery Basin: Early Albian (Jain, 1977b) to Early Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Santos Basin: Albian Superior to Turonian Inferior (105-91 Ma) (Masure & Arai, 2003).

GENUS—CERODINIUM Vozzhennikova, 1963 emend. Lentin & Williams, 1987

Cerodinium diebelii (Alberti, 1959b) Lentin & Williams, 1987

Known stratigraphic range—Santonian to Danian (86-61.20 Ma).

Occurrence in Indian basins—Assam Basin: Late Maastrichtian (Kumar *et al.*, 1996); K-G Basin: Early Campanian to Late Maastrichtian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Ceara Basin: Campanian Inferior to Maastrichtian Superior (79-65 Ma); Potiguar Basin: Maastrichtian – Paleocene (Lana & Botelho Neto, 1989); Pernambuco-Paraiba Basin: Upper Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002); Almada Basin: Upper Maastrichtian (67-65 Ma).

GENUS—CHATANGIELLA Vozzhennikova, 1967 emend. Lentin & Williams, 1987 emend. N.G. Marshal, 1988

Chatangiella ditissima (McIntyre, 1975) Lentin & Williams, 1976

Known stratigraphic range—Santonian / Coniacian Boundary to Early Campanian (85.8-78.8 Ma).

Occurrence in Indian basins—K-G Basin: Early Valanginian to Late Campanian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Campos Basin: Late Maastrichtian to Early Campanian (83-65 Ma) (*C.* spp.) Santos Basin: Early Turonian (94-91 Ma) (C cf. *ditissima*).

GENUS—CHLAMYDOPHORELLA Cookson & Eisenack, 1958 emend. Duxbury, 1983

Chlamydophorella nyei Cookson & Eisenack, 1958

Known stratigraphic range—Hauterivian to Caniacian / Turonian Boundary (134-89 Ma).

Occurrence in Indian basins—K-G Basin: Tithonian to Santonian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Santos Basin: Middle Albian (108-104 Ma).

GENUS—CIRCULODINIUM Alberti, 1961

Circulodinium distinctum (Deflandre & Cookson, 1955) Jansonius, 1986

Known stratigraphic range—Portlandian – Late Maastrichtian (141-65.8 Ma).

Occurrence in Indian basins—Palar Basin: Hauterivian – Barremian (Khowaja Ateequzzaman & Garg, 2002); Cauvery Basin: Neocomian to Aptian (Mehrotra *et al.*, 2002); K-G Basin: Tithonian to Late Maastrichtian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Ceara Basin: Early Cenomanian – Early Maastrichtian (100-69 Ma); Campos Basin: Early Albian – Late Cenomanian (112-93 Ma); Santos Basin: Early Cenomanian to Turonian top (100-89 Ma); Pelotas Basin: Early Aptian (91-85 Ma).

GENUS—CORDOSPHAERIDIUM Eisenack, 1963 emend. Morgenroth, 1968 emend. May, 1980 emend. Marheinecke, 1992

Cordosphaeridium fibrospinosum Davey & Williams, 1966b

Known stratigraphic range—Early Maastrichtian to Rupelian (69-31 Ma).

Occurrence in Indian basins—Cambay Basin: Eocene (Mehrotra *et al.*, 1996); Mumbai Offshore Basin: Thanetian – Rupelian (Mehrotra *et al.*, 2003); K-G Basin: Early Eocene to Oligocene (Mehrotra & Singh, 2003); Assam-Arakan Basin: Late Thanetian – Middle Eocene, Oligocene – Early Miocene (Saxena & Sarkar, 2000); Cauvery Basin: Latest Maastrichtian (Jain, 1978); Kutch Basin: Eocene (Jain & Tandon, 1981); Simla Hills, Subathu Formation, Palaeocene, Ypresian - Lutenian (Khanna *et al.*, 1981); Malla Johar area, Late Cretaceous – Middle Eocene (Mehrotra & Sinha, 1981).

Occurrence in Brazilian basins—Pernambuco-Paraiba Basin: Upper Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002). The LAD of *C. fibrospinosum* in Brazil must be in Middle Eocene (unpublished data).

Cordosphaeridium gracile (Eisenack, 1954b) Davey & Williams, 1966b emend. Davey & Williams, 1966b

Known stratigraphic range—Early Campanian (Late Cretaceous) – Late Oligocene (79-30 Ma).

Occurrence in Indian basins—Cauvery Basin: Latest Maastrichtian (Jain, 1978); Kutch Basin: Middle Late Eocene to Miocene; Assam-Arakan Basin: Late Thanetian - Early Miocene; Himalayan Basin: Early Eocene, Late Ypresian-Lutetian; K-G Basin: Lutetian-Bartonian; Cambay-Gulf: Ypresian-Lutenian-Priabanian-Rupelian-Burdigalian.

Occurrence in Brazilian basins—Pernambuco-Paraiba Basin: Late Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002).

GENUS—CORONIFERA Cookson & Eisenack, 1958 emend. Davey, 1974 emend. May, 1980 emend. Mao Shaozhi & Norris, 1988

Coronifera oceanica Cookson & Eisenack, 1958 emend. May, 1980

Known stratigraphic range—Hauterivian – Early Maastrichtian/Late Campanian Boundary (129.5-71.3 Ma).

Occurrence in Indian basins—K-G Basin: Barremian – Late Maastrichtian (Mehrotra & Aswal, 2003); Cauvery Basin: Valanginian-Hauterivian (Kumar, 1986a, Garg *et al.*, 1988), Middle – Late Turonian (Khowaja-Ateequzzaman & Garg, 2002); Palar Basin: Hauterivian-Barremian (Khowaja Ateequzzaman & Jain, 1992).

Occurrence in Brazilian basins—Santos Basin: Mid Albian to Early Turonian (109-91 Ma); Barreirinhas, Mid Albian (105 Ma).

GENUS—CRIBROPERIDINIUM Neale & Sarjeant, 1962 emend. Davey, 1969a emend. Sarjeant, 1982b emend. Helenes, 1984

Cribroperidinium edwardsii (Cookson & Eisenack, 1958) Davey, 1969a

Known stratigraphic range—Early Valanginian – Turonian/Cenomanian Boundary (139-93.5 Ma).

Occurrence in Indian basins—K-G Basin: Berriasian – Turonian (Mehrotra & Aswal, 2003); Palar Basin: Hauterivian – Barremian (Khowaja Ateequzzaman & Jain, 1992); Cauvery Basin: Early Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Sergipe Basin: Late Aptian (118-112 Ma); Campos Basin: Early Albian – Late Cenomanian (112-93 Ma); Santos Basin: Vraconian – Early Cenomanian (102-97 Ma); Pelotas Basin: Cenomanian (100-93.5 Ma).

Cribroperidinium fetchamense (Sarjeant, 1966b) Helenes, 1984

Known stratigraphic range—Early Valanginian – Turonian/Cenomanian Boundary (126-92 Ma).

Occurrence in Indian basins—Cauvery Basin: Albian (Venkatachala & Kumar, 1986) (referred as C. cf. *fetchamense*).

Occurrence in Brazilian basins—Campos Basin: Vraconian (uppermost Albian) (Arai & Masure, 1997).

GENUS—CYCLONEPHELIUM Deflandre & Cookson, 1955 emend. Cookson & Eisenack, 1962b emend. Williams & Downie, 1966c emend. Ioannides *et al.*, 1977 emend. Sarjeant & Stover, 1978 emend. Stover & Evitt, 1978 emend. Dortofer & Danies, 1980

Cyclonephelium chabaca Below, 1981

Known stratigraphic range—Aptian - Cenomanian.

Occurrence in Indian basins—Cauvery Basin: Early Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Ceara Basin: Early Cenomanian – Early Campanian (100-79 Ma); Potiguar Basin: Mid Cenomanian – Early Turonian (97-91 Ma); Sergipe Basin: Early Campanian (83-79 Ma); Santos Basin: Vraconian – Late Turonian (102-89 Ma).

Cyclonephelium compactum Deflandre & Cookson, 1955

Known stratigraphic range—Albian - Santonian.

Occurrence in Indian basins—Himalaya, Late Palaeocene – Eocene; Cauvery Basin: Early – Late Turonian.

Occurrence in Brazilian basins—Barreirinhas Basin: Mid – Late Albian (109-102 Ma); Potiguar Basin: Late Cenomanian (95-93 Ma); Campos Basin: Late Albian – Vraconian (105-100 Ma).

Cyclonephelium paucimarginatum Cookson & Eisenack, 1962b

Known stratigraphic range—? Upper Albian - Cenomanian.

Occurrence in Indian basins—Cauvery Basin: Late Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Campos Basin: Vraconian (uppermost Albian) (Arai & Masure, 1997).

Cyclonephelium vannophorum Davey, 1969a

Known stratigraphic range—Cenomanian.

Occurrence in Indian basins—Cauvery Basin: Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Ceara Basin: Late Albian – Coniacian (105-86 Ma); Potiguar Basin: Mid Cenomanian to – Early Turonian (97-91 Ma); Santos Basin: Vraconian – Early Cenomanian (102-97 Ma).

GENUS—DINOGYMNIUM Deflandre Evitt *et al.*, 1967 emend. Vozzhennikova, 1990

Dinogymnium acuminatum Evitt *et al.*, 1967

Known stratigraphic range—Turonian-Late Maastrichtian (90-65 Ma).

Occurrence in Indian basins—Cauvery Basin: Maastrichtian (Mehrotra *et al.*, 2002); K-G Basin: Maastrichtian (Mehrotra & Aswal, 2003); Assam-Arakan Basin: Maastrichtian (Jain *et al.*, 1975) Kumar *et al.*, 1996.

Occurrence in Brazilian basins—Foz Do Amazonas Basin: Early Campanian – Late Maastrichtian (83-65 Ma); Para-Maranhao, Coniacian – Late Maastrichtian (89-65 Ma); Ceara Basin: Early Cenomanian – Late Maastrichtian (83-65 Ma) Pernambuco-Paraiba, Late Maastrichtian (67-65 Ma); Sergipe Basin: Coniacian-Late Maastrichtian (89-65 Ma); Espirito Santo, Late Santonian – Late Maastrichtian (84-65 Ma); Campos, Early Santonian – Late Maastrichtian (86-65 Ma).

Dinogymnium nelsonense (Cookson, 1956) Evitt *et al.*, 1967

Known stratigraphic range—Senonian.

Occurrence in Indian basins—Cauvery Basin: Cretaceous (Venkatachala & Sharma, 1974); Assam-Arakan, Maastrichtian (Jain *et al.*, 1975).

Occurrence in Brazilian basins—Sergipe Basin: Late Maastrichtian (67-65 Ma).

GENUS—DISPHAEROGENA O. Wetzel, 1933 emend. Sarjeant, 1985b

Disphaerogena carposphaeropsis Wetzel, 1933b emend. Sarjeant, 1985b

Known stratigraphic range—Late Cretaceous.

Occurrence in Indian basins—Latest Maastrichtian (Kumar *et al.*, 1996).

Occurrence in Brazilian basins—Ceara Basin: Early – Late Maastrichtian (69-65 Ma); Campos Basin: Late Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002).

GENUS—EXOCHOSPHAERIDUM Davey *et al.*, 1966

Exochosphaeridium bifidum (Clarke & Verdier, 1967) Clarke *et al.*, 1968 emend. Davey, 1969b

Known stratigraphic range—Comanian – Campanian.

Occurrence in Indian basins—Palar Basin: Hauterivian – Barremian.

Occurrence in Brazilian basins—Potuguar, Middle Cenomanian – Early Turonian (95-93 Ma); Pernambuco-Paraiba, Late Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002).

GENUS—FLORENTINA Davey & Verdier, 1973 emend. Duxbury, 1980

Florentina buspina (Davey & Verdier, 1976) Duxbury, 1980

Known stratigraphic range—Senonian.

Occurrence in Indian basins—Cauvery Basin: Mid Turonian (Khowaja- Ateequzzaman, 2002).

Occurrence in Brazilian basins—Santos Basin: Early Turonian (93-91 Ma).

Florentina ferox (Deflandre, 1937b) Duxbury, 1980

Known stratigraphic range—Senonian.

Occurrence in Indian basins—K-G Basin: Kimmeridgian – Late Maastrichtian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Campos Basin: Vraconian (102-100 Ma).

Florentina mantelii (Davey & Wilson, 1966b) Davey & Verdier, 1973

Known stratigraphic range—Late Hauterivian – Turonian (130-91 Ma).

Occurrence in Indian basins—K-G Basin: Kimmeridgian – Santonian (Mehrotra & Aswal, 2003); Cauvery Basin: Early Albian – Middle Turonian (Khowaja Ateequzzaman *et al.*, 2008).

Occurrence in Brazilian basins—Potiguar Basin: Mid Cenomanian – Early Turonian (97-91 Ma); Sergipe Basin: Late Aptian-Middle Albian (118-91 Ma), Campos Basin: Early Albian – Early Cenomanian (112-97 Ma); Pelotas, Early Aptian (125-118 Ma).

GENUS—HAPSOCYSTA Davey, 1979b

Hapsocysta pteridictya (Eisenack & Cookson, 1960) Davey, 1979b

Known stratigraphic range—? Late Albian – Cenomanian.

Occurrence in Indian basins—Cauvery Basin: Albian – Cenomanian (Mehrotra *et al.*, 2002); Early Turonian (Khowaja-Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Campos Basin: Vraconian (102-100 Ma).

GENUS—HETEROSPHAERIDIUM Cookson & Eisenack, 1968 emend. Yun, 1981

Heterosphaeridium difficile (Manum & Cookson, 1964) Ioannides, 1986

Known stratigraphic range—Turonian-Santonian (91-85 Ma).

Occurrence in Indian basins—Cauvery Basin: Early Turonian (Khowaja- Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Santo Basin: Late Turonian to Early Santonian (91-85 Ma); Campos Basin: Late Turonian – Middle Santonian (91-84 Ma); Pelotas Basin: Late Turonian – Middle Santonian (91-94 Ma).

Heterosphaeridium heteracanthum (Deflandre & Cookson, 1955) Eisenack & Kjellstrom, 1972

Known stratigraphic range—Upper Cretaceous (Senonian); Paleocene – Lower Eocene.

Occurrence in Indian basins—Cauvery Basin: Oligocene; Assam & Tripura, Eocene-Miocene; Kutch Basin: Early Eocene (Khowaja-Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Sergipe Basin: Late Albian - Middle Campanian (105-75 Ma); Espirito Santo Basin: Vraconian – Late Maastrichtian (102-65 Ma); Campos Basin: Vraconian – Earliest Maastrichtian (102-69 Ma); Pelotas Basin: Vraconian – Earliest Maastrichtian (102-69 Ma).

GENUS—HYSTRICHODINIUM Deflandre, 1935 emend. Sarjeant, 1966b emend. Clarke & Verdier, 1967

Hystrichodinium pulchrum Deflandre, 1935

Known stratigraphic range—Portlandian – Late Campanian / Early Maastrichtian Boundary (132-71.3 Ma).

Occurrence in Indian basins—Mumbai Offshore Basin: Thanetian – Bartonian (55-41 Ma); Cauvery Basin: Thanetian (Mehrotra *et al.*, 2002), Early Albian (Jain, 1977), Barronian-Aptian (Mehrotra & Sarjeant, 1986); K-G Basin: Ypresian – Bartonian (Mehrotra & Singh, 2003); Hauterivian – Barremian (Kumar, 1986a reassessed by Garg *et al.*, 2008); Palar Basin: Hauterivian – Barremian (Khowaja-Ateequzzaman & Jain, 1992); Assam-Arakan Basin: Thanetian (Mehrotra *et al.*, 2002).

Occurrence in Brazilian basins—Barreirinhas Basin: Early – Late Cenomanian (100-93 Ma); Ceara Basin: Middle

Campanian – Early Maastrichtian (79-67 Ma); Sergipe Basin: Early Albian – Early Campanian (112-79 Ma); Espirito Santo Basin: Early Albian – Late Santonian (112-83 Ma); Campos Basin: Vraconian– Earliest Maastrichtian (102-69 Ma); Santos Basin: Late Albian – Early Turonian (105-91 Ma).

GENUS—HYSTRICHOSPHAERIDIUM Deflandre, 1937b emend. Davey & Williams 1966b

Hystrichosphaeridium tubiferum (Ehrenburg, 1838) Deflandre, 1937b emend. Davey & Williams, 1966b

Known stratigraphic range—Early Aptian – Ypresian (118-49 Ma).

Occurrence in Indian basins—Mumbai Offshore Basin: Selandian – Ypresian (58-49 Ma) Mehrotra *et al.*, 2003; K-G Basin: Selandian – Rupelian (Mehrotra & Singh, 2003), Valanginian – Hauterivian, Campanian – Maastrichtian; Cauvery Basin: Albian, Late Turonian; Assam Basin: Middle Eocene; Kutch, Middle- Late Eocene; Himalaya, Late Palaeocene – Late Eocene (Khowaja-Ateequzzaman *et al.*, 2008).

Occurrence in Brazilian basins—Pernambuco-Pariaba Basin: Late Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002).

GENUS—IMPAGIDINIUM Stover & Evitt, 1978

Impagidinium patulum (Wall, 1967) Stover & Evitt, 1978

Known stratigraphic range—Early Langhian – Recent (16.28-0 Ma).

Occurrence in Indian basins—K-G Basin: Late Oligocene – Pleistocene and younger (Mehrotra & Singh, 2003).

Occurrence in Brazilian basins—All offshore basins of the Brazilian continental margin: Neogene (unpublished data).

GENUS—ISABELIDINIUM Lentin & Williams, 1977a emend. Marshall, 1988

Isabelidinium acuminatum (Cookson & Eisenack, 1958) Stover & Evitt, 1978

Known stratigraphic range—Turonian – Early Maastrichtian (90-69 Ma).

Occurrence in Indian basins—Cauvery Basin: Early Turonian (Khowaja- Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Campos Basin: Early Campanian - Late Maastrichtian (83-65 Ma).

GENUS—KLEITHRIASPHAERIDIUM Davey, 1974

Kleithriasphaeridium loffrense Davey & Verdier, 1976

Known stratigraphic range—Early Albian / Late Aptian Boundary – Early Campanian (112.2-78.8 Ma).

Occurrence in Indian basins—K-G Basin: Aptian – Late Campanian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Ceara Basin: Middle Campanian – Early Maastrichtian (79-69 Ma).

GENUS—LEBERIDOCYSTA Stover & Evitt, 1978

Leberidocysta chlamydata (Cookson & Eisenack, 1962b) Stover & Evitt, 1978 emend. Fechner, 1985 emend. Marheinecke, 1992

Known stratigraphic range—Early Albian / Late Aptian Boundary – Late Campanian (112.2-75 Ma).

Occurrence in Indian basins—K-G Basin: Valanginian – Hauterinian (Kumar, 1986a); Cauvery Basin: Early Albian (Jain, 1977b).

Occurrence in Brazilian basins—Campos Basin: Vraconian – Late Campanian (102-71 Ma).

Leberidocysta deflocata (Davey & Verdier, 1973) Stover & Evitt, 1978

Known stratigraphic range—Late Albian–Early Cenomanian.

Occurrence in Indian basins—K-G Basin: Hauterivian – Barremian (Kumar, 1986a, age reassessed by Garg *et al.,* 1988).

Occurrence in Brazilian basins—Campos Basin: Late Albian – Vraconian (105-100 Ma).

GENUS—LITOSPHAERIDIUM Davey & Williams, 1966b emend. Davey & Verdier, 1973

Litosphaeridium siphoniphorum (Cookson & Eisenack, 1958) Davey & Williams, 1966b emend. Lucas-Clark, 1984

Known stratigraphic range—Late Albian/Mid Albian Boundary – Turonian / Cenomanian Boundary (103-93.5 Ma).

Occurrence in Indian basins—K-G Basin: Cenomanian – Turonian (Mehrotra & Aswal, 2003); Cauvery Basin: Early Turonian (Khowaja-Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Campos Basin: Vraconian – Early Turonian (102-91 Ma); Pelotas Basin: Vraconian - Late Cenomanian (102-93 Ma); Sergipe Basin: Cenomanian (98.5 - 93.5 Ma).

Litosphaeridium arundum (Eisenack & Cookson, 1960) Davey, 1979b emend. Lucas-Clark, 1984

Known stratigraphic range—Early Albian – Cenomanian / Late Albian Boundary (111-98.9 Ma).

Occurrence in Indian basins—K-G Basin: Kimmeridgian – Cenomanian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Campos Basin: Early Albian – Early Cenomanian (112-97 Ma); Santos Basin: Mid Albian – Late Albian (109-102 Ma).

GENUS—NELSONIELLA Cookson & Eisenack, 1960a

Nelsoniella aceras Cookson & Eisenack, 1960a

Known stratigraphic range—Santonian–Campanian.

Occurrence in Indian basins—K-G Basin: Turonian – Late Campanian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Pelotas Basin: Late Santonian – Early Campanian (84-79 Ma); Santos Basin: Late Santonian – Early Campanian (84-79 Ma); Campos Basin: Late Santonian – Early Campanian (84-79 Ma).

GENUS—ODONTOCHITINA Deflandre, 1935 emend. Davey, 1970

Odontochitina operculata (Wetzel, 1933a) Deflandre & Cookson, 1955

Known stratigraphic range—Hauterivian – Early Maastrichtian (130-70 Ma).

Occurrence in Indian basins—K-G Basin: Tithonian – Maastrichtian (Mehrotra & Aswal, 2003); Cauvery Basin: Early Albian – Late Turonian.

Occurrence in Brazilian basins—Barreirinhas Basin: Middle Albian (109-105 Ma); Potiguar Basin: Late Albian (105-102 Ma); Sergipe Basin: Early Albian – Late Santonian (112-83 Ma); Espiroto Santos Basin: Early Albian – Early Campanian (112-79 Ma); Campos Basin: Early Albian – Late Campanian (112-71 Ma); Santos Basin: Early Albian – Vraconian (112-100 Ma).

Odontochitina costata Alberti, 1961 emend. Clarke & Verdier, 1967

Known stratigraphic range—Cenomanian/Late Albian Boundary – Late Campanian (98.90-70.43 Ma).

Occurrence in Indian basins—K-G Basin: Maastrichtian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Ceara Basin: Early Cenomanian – Late Campanian (100-71 Ma); Potiguar Basin: Middle – Late Cenomanian (97-93 Ma); Sergipe Basin: Late Albian – Early Campanian (106-79 Ma); Campos Basin: Vraconian – Late Campanian (102-71 Ma); Pelotas Basin: Early Cenomanian – Early Turonian (100-91 Ma).

Odontochitina porifera Cookson, 1956

Known stratigraphic range—Coniacian – Santonian (89-85 Ma).

Occurrence in Indian basins—K-G Basin: Barremian – Campanian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Sergipe Basin: Early Campanian (83-79 Ma); Campos Basin: Early Santonian – Early Campanian (86-79 Ma); Pelotas Basin: Early Turonian (93-91 Ma).

Odontochitina cribropoda Deflandre & Cookson, 1955

Known stratigraphic range—Upper Cretaceous.

Occurrence in Indian basins—Cauvery Basin: Early Albian (Jain, 1977b); Himalaya, Late Cretaceous – Middle Eocene.

Occurrence in Brazilian basins—Campos Basin: Vraconian (102-100 Ma).

GENUS—OLIGOSPHAERIDIUM Davey & Williams, 1966b emend. Davey, 1982b

Oligosphaeridium complex (White) Davey & Williams, 1966b

Known stratigraphic range—Early Valanginian – Basal Lutenian (131-48 Ma).

Occurrence in Indian basins—Cauvery Basin: Aptian (Mehrotra *et al.*, 2002) – Late Turonian; K-G Basin: Valanginian – Hauterivian; Neocomian, Priabonian, Ypresian, Bartonian (Mehrotra & Singh, 2003); Assam-Arakan Basin: Lower-Middle Eocene (Mehrotra *et al.*, 2002); Kutch Basin: Middle-Late Eocene; Palar Basin: Hauterivian-Barremian; Himalaya, Late Cretaceous – Middle Eocene (Spiti-Sangchamalla Formation), Palaeocene – Late Eocene (Subathu Formation).

Occurrence in Brazilian basins—Para-Maranhao Basin: Early Albian – Late Cenomanian (112-93 Ma); Sao Luis Basin: Early Albian – Late Cenomanian (112-93 Ma); Barreirinhas Basin: Middle – Late Albian (109-102 Ma); Ceara Basin: Late Aptian – Middle Campanian (118-75 Ma); Pernambuco-Paraiba, Late Maastrichtian (67-65 Ma); Sergipe Basin: Late Aptian – Vraconian (118-100 Ma); Espiroto Santo Basin: Early Albian – Vraconian (112-100 Ma).

Oligosphaeridium complex subsp. *brevispinum* Jain, 1977b

Known stratigraphic range—Vraconian–Late Santonian.

Occurrence in Indian basins—Cauvery Basin: Early Albian (Jain, 1977b), Late Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Campos Basin: Vraconian – Late Santonian (102-83.5 Ma).

Oligosphaeridium albertense (Pocock, 1962) Davey & Williams, 1969

Known stratigraphic range—Early Cretaceous.

Occurrence in Indian basins—Cauvery Basin: ? Aptian - Early Albian; Palar Basin: Hauterivian – Barremian; Rajasthan Basin: Cretaceous.

Occurrence in Brazilian basins—Sergipe Basin: Late Aptian – Middle Albian (118-105 Ma).

Oligosphaeridium poculum Jain, 1977b

Known stratigraphic range—Early Albian.

Occurrence in Indian basins—Cauvery Basin: Early Albian.

Occurrence in Brazilian basins—Sergipe Basin: Late Aptian (118-112 Ma); Santos Basin: Middle Albian (109-105 Ma).

Oligosphaeridium porosum Lentin & Williams, 1981

Known stratigraphic range—Early Albian.

Occurrence in Indian basins—Himalaya Basin: Early Eocene (Sarkar, 1991); Cauvery Basin: Early Albian (Jain, 1977b).

Occurrence in Brazilian basins—Santos Basin: Middle Albian – Middle Cenomanian (109-95 Ma).

Oligosphaeridium pulcherrimum (Deflandre & Cookson, 1955) Davey & Williams, 1966

Known stratigraphic range—Early Cretaceous.

Occurrence in Indian basins—Cauvery Basin: Early Albian, Early Turonian; Himalaya Basin: Late Jurassic, Late Cretaceous – Middle Eocene; K-G Basin: Hauterivian – Barremian; Kutch Basin: Early Kimmeridgian – Tithonian; Palar Basin: Hauterivian – Barremian.

Occurrence in Brazilian basins—SA LUIS Basin: Early – Late Cenomanian (100-93 Ma); Barreirinhas Basin: Middle Albian (109-105 Ma); Ceara Basin: Early Albian – Middle Santonian (112-84 Ma); Potiguar Basin: Early Turonian (93-91 Ma); Sergipe Basin: Late Aptian – Late Santonian (118-83 Ma); Espirito Santo Basin: Early Albian – Vraconian (112-100 Ma); Santos Basin: Late Albian – Early Turonian (105-91 Ma).

GENUS—PALAEOCYSTODINIUM Alberti, 1961

Palaeocystodinium australinum (Cookson, 1965b) Lentin & Williams, 1976 emend. Meloy, 1972

Known stratigraphic range—Late Maastrichtian – Palaeocene.

Occurrence in Indian basins—Andaman, Early Eocene (Mandal *et al.*, 2003).

Occurrence in Brazilian basins—Pernambuco-Paraiba Basin: Late Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002).

Palaeocystodinium golzowense Alberti, 1961

Known stratigraphic range—Priabonian-Tortonian (37-8 Ma).

Occurrence in Indian basins—Assam-Arakan Basin: Late Maastrichtian (Kumar *et al.*, 1996).

Occurrence in Brazilian basins—Pernambuco-Paraiba Basin: Late Maastrichtian – Danian (67-61 Ma) (Sarkis *et al.*, 2002); Sergipe Basin: Late Maastrichtian.

GENUS—PALAEOHYSTRICHOPHORA Deflandre, 1935 emend. Deflandre & Cookson, 1955

Palaeohystrichophora infusorioides Deflandre, 1932

Known stratigraphic range—Cenomanian – Early Maastrichtian (98-71 Ma).

Occurrence in Indian basins—Cauvery Basin: Early Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Ceara Basin: Late Albian – Early Maastrichtian (105-67 Ma); Potiguar Basin: Mid Cenomanian – Early Turonian (97-91 Ma); Campos Basin: Vraconian – Late Campanian (102-75 Ma); Santos Basin: Vraconian – Early Turonian (102-89 Ma); Pelotas Basin: Vraconian – Early Turonian (102-91 Ma).

GENUS—PALAEOPERIDINIUM Deflandre, 1934 emend. Lentin & Williams, 1976

Palaeoperidinium cretaceum Pocock, 1962 emends. Lentin & Williams, 1976, Harding, 1990, Evitt *et al.* 1998

Known stratigraphic range—Aptian – Albian.

Occurrence in Indian basins—K-G Basin: Hauterivian – Maastrichtian (Mehrotra & Aswal, 2003); Palar Basin: Hauterivian – Barremian (Khowaja Ateequzzaman & Jain, 1992); Cauvery Basin: Middle – Late Turonian (Khowaja Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Sergipe Basin: Late Aptian (119-112 Ma); Campos Basin: Early Albian – Mid Cenomanian (112-95 Ma); Santos Basin: Middle Albian – Middle Cenomanian (109-95 Ma); Pelotas Basin: Early Aptian – Early Albian (125-109 Ma).

GENUS—PROLIXOSPHAERIDIUM Davey *et al.*, 1966 emend. Davey, 1969a

Prolixosphaeridium conulum Davey, 1969a

Known stratigraphic range—Cenomanian.

Occurrence in Indian basins—K-G Basin: Hauterivian – Barrenian (Kumar, 1986a; Garg *et al.*, 1981); Assam Basin: Palaeocene (Singh & Tripathi, 1989).

Occurrence in Brazilian basins—Santos Basin: Late Albian – Early Turonian (105-91 Ma); Campos Basin: Early Albian – Vraconian (112-100 Ma).

GENUS—PSEUDOCERATIUM Gocht, 1957 emend. Dörhiöfer & Davies, 1980 emend. Bint, 1986 emend. Helby, 1987

Pseudoceratium anaphrissum (Sarjeant, 1966c) Bint, 1986 emend. Harding, 1990

Known stratigraphic range—Lower Barremian.

Occurrence in Indian basins—Palar Basin: Hauterivian – Barremian (Khowaja Ateequzzaman & Jain, 1992); Cauvery Basin: Early Albian (Jain, 1977b); K-G Basin: Tithonian – Early Albian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Ceara Basin: Late Aptian – Middle Albian (118-105 Ma); Campos Basin: Early – Middle Albian (112-108 Ma); Pelotas Basin: Early Aptian – Early Albian (125-109 Ma).

GENUS—PTERODINIUM Eisenack, 1958a emend. Yun, 1981 emend. Sarjeant, 1985a

Pterodinium cingulatum* subsp. *cingulatum (Wetzel, 1933b) below, 1981a

Known stratigraphic range—Cenomanian – Pleistocene.

Occurrence in Indian basins—Cauvery Basin: Early Albian (Jain, 1977).

Occurrence in Brazilian basins—Sergipe Basin: Late Albian; Espirito-Santo Basin: Early Albian – Early Campanian (112-79 Ma); Campos Basin: Early Albian – Late Maastrichtian (112-65 Ma); Santos Basin: Middle Albian (109-105 Ma); Pelotas Basin: Late Albian (105-102 Ma).

GENUS—SPINIFERITES Mantell, 1850 emend. Sarjeant, 1980

Spiniferites ramosus* subsp. *multibrevis (Davey & Williams, 1966a) Lantin & Williams, 1973

Known stratigraphic range—Early Cretaceous, Late Cretaceous, Early Eocene.

Occurrence in Indian basins—Assam Basin: Early – Middle Eocene; Cauvery Basin: Late Palaeocene.

Occurrence in Brazilian basins—Santos Basin: Middle Albian – Late Turonian (108-89 Ma); Aparipe Basin: Late Aptian (112 Ma) (Arai & Coimbra, 1990).

GENUS—SURCULOSPHAERIDIUM Davey *et al.*, 1966 emend. Davey, 1982

Surculosphaeridium longifurcatum Davey *et al.*, in Davey *et al.*, 1966

Known stratigraphic range—Early Albian – Early Campanian (111-78.8 Ma).

Occurrence in Indian basins—K-G Basin: Barreiasian – Campanian (Mehrotra & Aswal, 2003); Cauvery Basin: Early Albian (Jain, 1977b).

Occurrence in Brazilian basins—Santos Basin: Turonian (Masure & Arai, 2003).

GENUS—TANYOSPHAERIDIUM Davey & Williams, 1966b

Tanyosphaeridium variecalamum Davey & Williams, 1966b

Known stratigraphic range—Late Valanginian – Early Maastrichtian (137-69 Ma).

Occurrence in Indian basins—Cambay Basin (Gulf), Ypresian - Burdigalian (Mehrotra *et al.*, 1996); K-G Basin: Early Oligocene (Mehrotra & Singh, 2003); Cauvery Basin: Albian (Venkatachala & Kumar, 1980); Palar Basin: Hauterivian – Barremian (Khowaja Ateequzzaman & Jain, 1992).

Occurrence in Brazilian basins—Sergipe Basin: Early Campanian (83-79 Ma); Campos Basin: Vraconian (uppermost Albiana) (Arai & Masure, 1997).

GENUS—TRICHODINIUM Eisenack & Cookson, 1960 emend. Clarke & Verdier, 1967

Trichodinium castanea (Deflandre, 1935) Clarke & Verdier, 1967

Known stratigraphic range—Berriasian – Early Maastrichtian (142-69 Ma), Foucher & Monteil, 1998 in Hardenbol *et al.*, 1998.

Occurrence in Indian basins—K-G Basin: Cenomanian – Campanian (Mehrotra & Aswal, 2003) Cauvery Basin: Early Albian (Jain, 1977b), Early Turonian (Khowaja- Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Pelotas Basin: Early Aptian (125-118 Ma); Campos Basin: Early Albian – Middle Campanian (112-75 Ma); Santos Basin: Middle Albian – Vraconian (109-100 Ma); Espirito Santo Basin: Early Albian – Early Campanian (112-75 Ma); Sergipe Basin: Late Aptian – Middle Campanian (118-75 Ma); Potiguar Basin: Middle Cenomanian – Early Turonian (95-91 Ma); Barreirinhas Basin: Middle Albian (109-105 Ma).

GENUS—XENASCUS Cookson & Eisenack, 1969 emend. Yun Hyesu, 1981 emend. Stover & Helby, 1987a

Xenascus ceratoides (Deflandre, 1937b) Lentin & Williams, 1973

Known stratigraphic range—Early Maastrichtian – Barremian (126.5-69 Ma).

Occurrence in Indian basins—Cauvery Basin: Early – Late Turonian (93.5 – 89 Ma) Khowaja-Ateequzzaman & Garg, 2002.

Occurrence in Brazilian basins—Campos Basin: Middle Albian – Early Maastrichtian (109-67 Ma); Potiguar Basin: Late Cenomanian – Early Turonian (95-91 Ma); Ceara Basin: Middle Campanian – Early Maastrichtian (79-67 Ma).

GENUS—XIPHOPHORIDIUM Sarjeant, 1966b

Xiphophoridium alatum (Cookson & Eisenack, 1962b) Sarjeant, 1966b

Known stratigraphic range—Santonian – Late Albian (98-86 Ma).

Occurrence in Indian basins—Cauvery Basin: Late Turonian (Khowaja- Ateequzzaman & Garg, 2002).

Occurrence in Brazilian basins—Pelotas Basin: Late Albian (105-102 Ma); Santos Basin: Middle Cenomanian (97-95 Ma); Campos Basin: Late Albian – Early Santonian (105-85 Ma); Espirito Santo Basin: Early Albian – Late Santonian (112-83 Ma); Sergipe Basin: Late Albian – Early Campanian (105-79 Ma); Potiguar Basin: Middle Cenomanian – Early Turonian (97-91 Ma).

GENUS—WREVITTIA Helenes & Lucas-Clark, 1997

Wrevittia cassidata (Eisenack & Cookson, 1960) Helenes & Lucas-Clark, 1997

Known stratigraphic range—Late Oxfordian / Middle Oxfordian Boundary – Cenomanian.

Occurrence in Indian basins—Cauvery Basin: Barremian – Turonian (Mehrotra *et al.*, 2005); Palar Basin: Hauterivian – Barremian (Khowaja-Ateequzzaman & Jain, 1992); K-G Basin: Hauterivian – Barremian, Cenomanian - Turonian (Mehrotra & Aswal, 2003).

Occurrence in Brazilian basins—Pelotas Basin: Early Aptian (125-118 Ma) (Arai *et al.*, 2006).

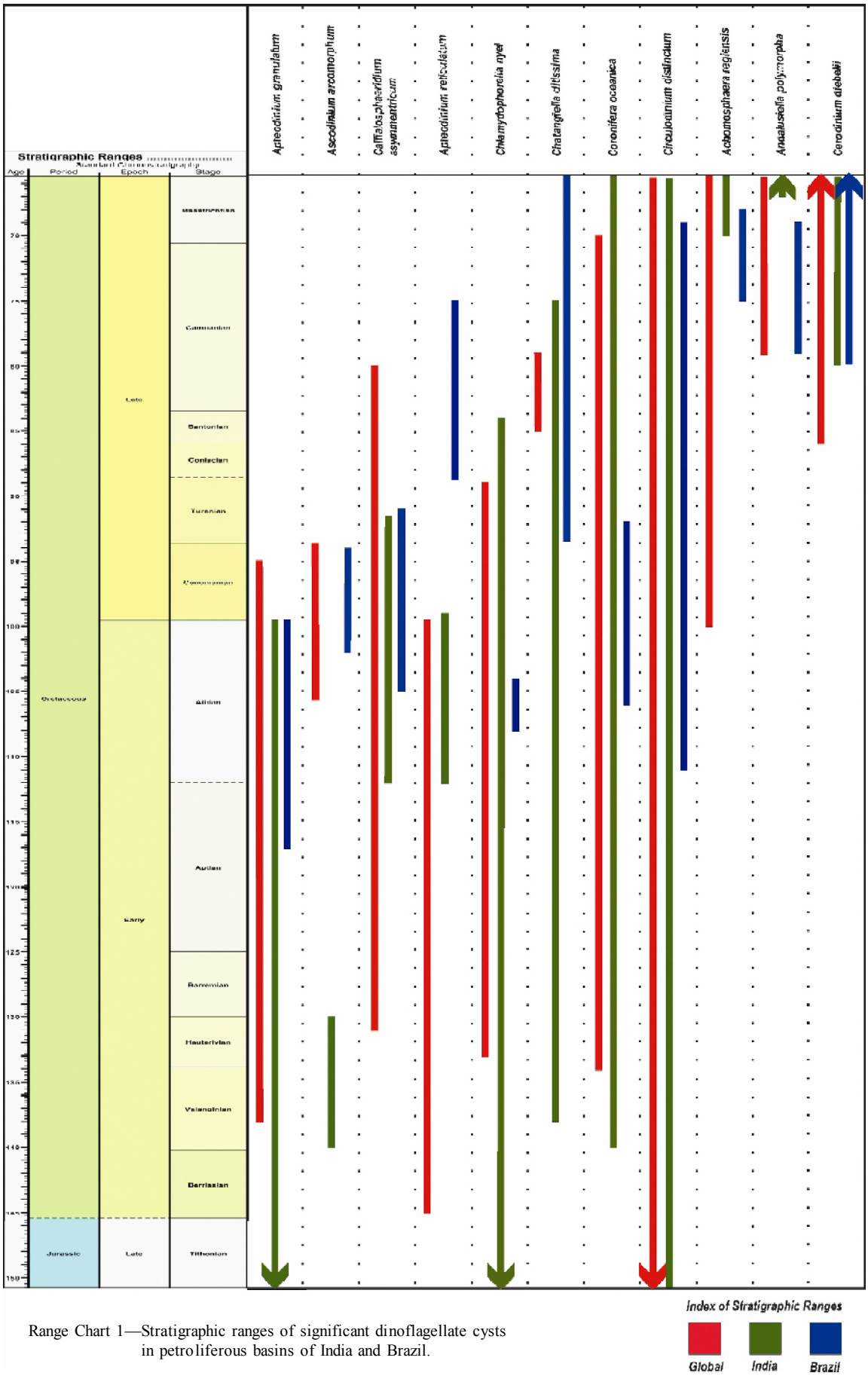
DISCUSSION

An analysis of the dinoflagellate cyst data from India and Brazil (Range Charts 1 to 6) suggests close comparison of 27 stratigraphically significant species in term of their ranges from Albian, Turonian, Campanion and Maastrichtian. There are some stratigraphically significant taxa of Cretaceous which are recorded from India but absent in Brazil. Similarly, a few dinoflagellate species recorded from Brazil are absent in Indian basins.

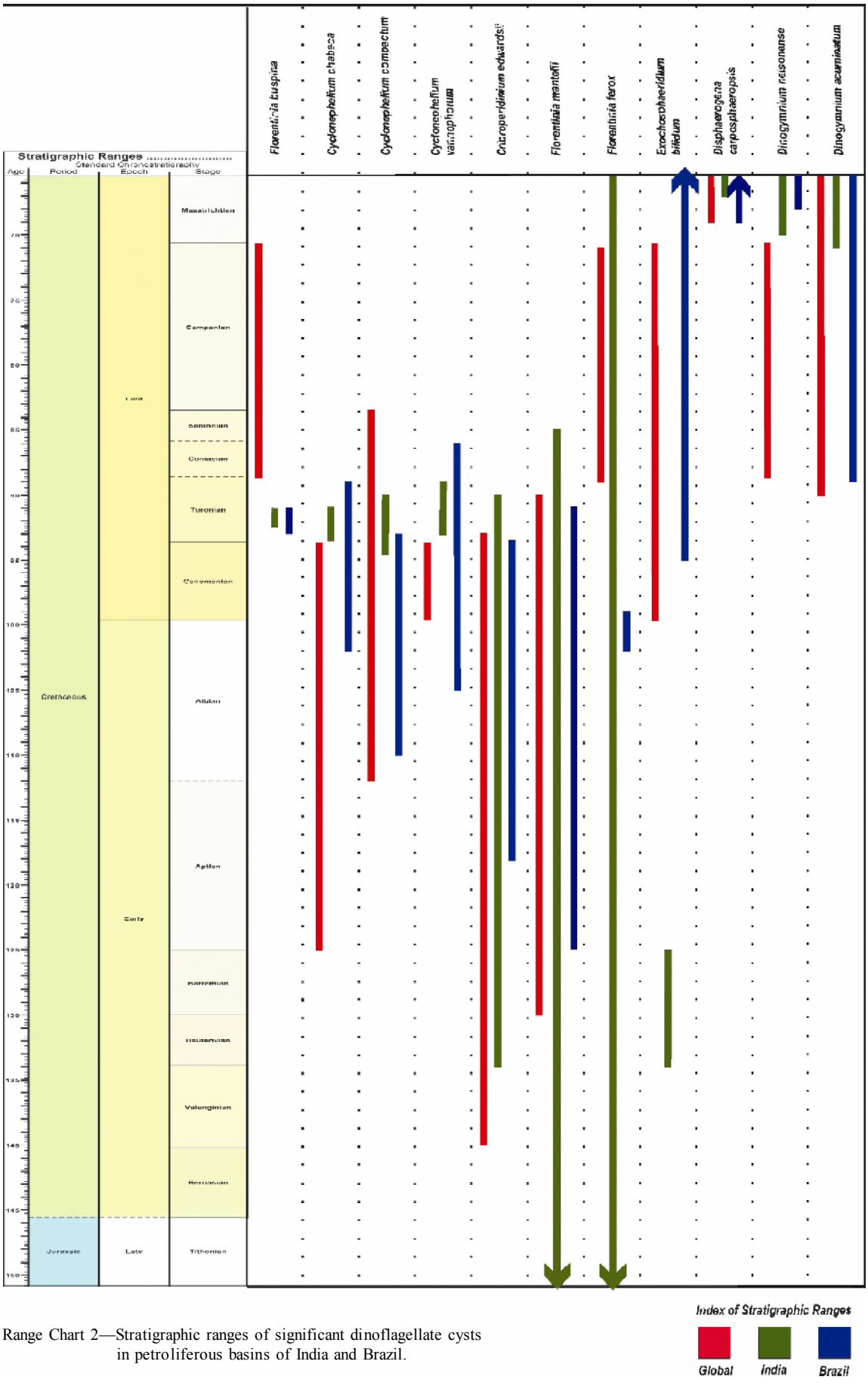
Last Appearance Datum (LAD's) of above dinoflagellate species is given here in tabular form. It is clearly understood as we generate more data and publish, our understanding of the distribution of dinoflagellate species from India and Brazil will considerably enhance.

Last Appearance Datum (LAD's) of some stratigraphically significant dinoflagellates taxa common to India and Brazil

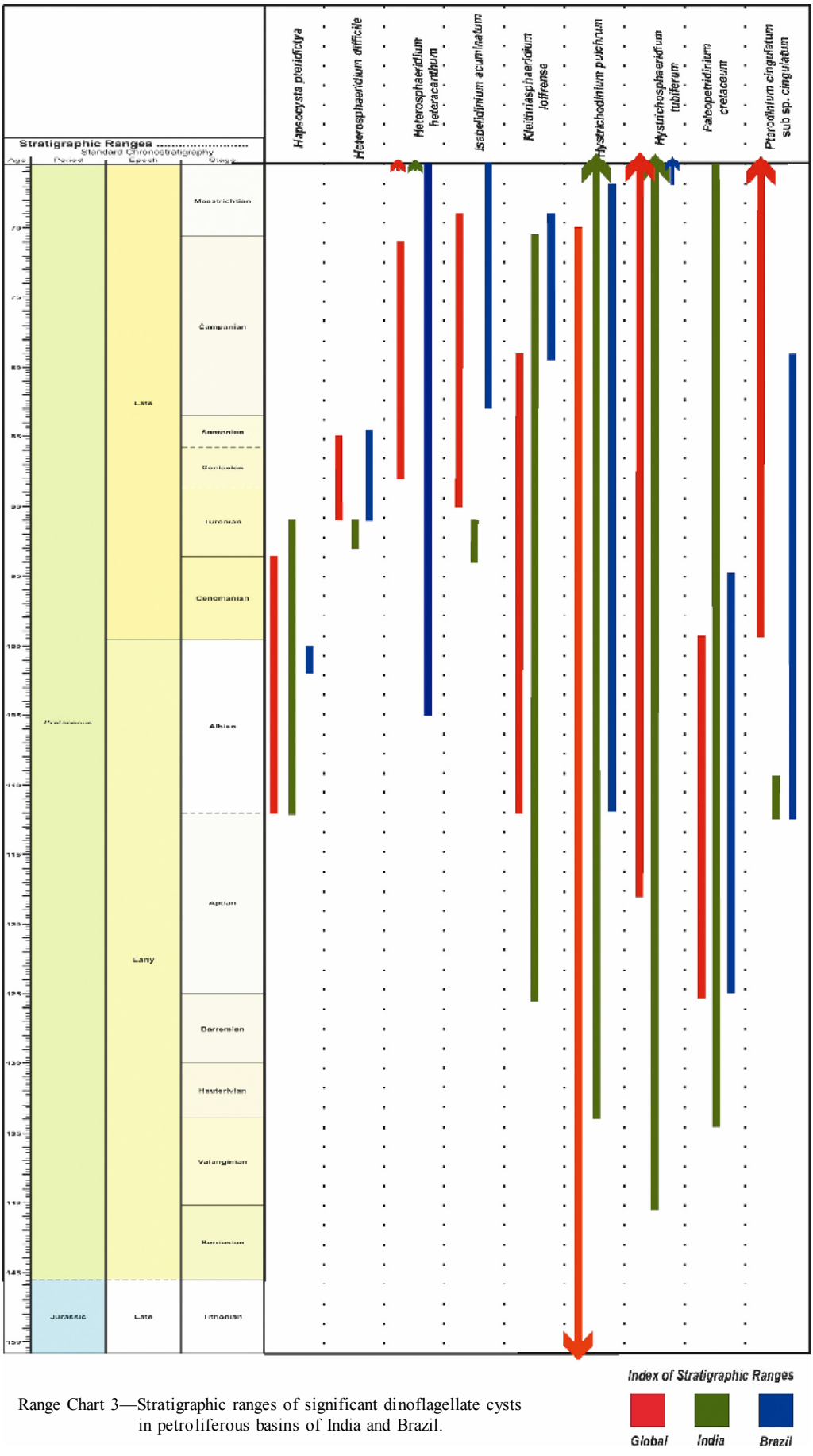
	India	***Brazil***
Achomophaera regiensis	Maastrichtian top	Maastrichtian (67 Ma)
Andalusiella polymorpha	Maastrichtian top	Basal Maastrichtian (69 Ma)
Circulodinium distinctum	Late Maastrichtian	Early Maastrichtian
Dinogymnium acuminatum	Late Maastrichtian	Late Maastrichtian
Dinogymnium nelsonense	Late Maastrichtian	Late Maastrichtian
Diasphaerogena carposphaeropsis	Late Maastrichtian	Danian
Cerodinium diebelii	Late Maastrichtian	Danian
Paleocystodinium golzowense	Late Maastrichtian	Danian
Kleithriasphaeridium loffrense	Late Campanian	Early Maastrichtian
Nelsoniella aceras	Late Campanian	Early Campanian
Odontochitina operculata	Maastrichtian	Late Campanian
Odontochitina porifera	Late Campanian	Early Campanian
Odontochitina costata	Maastrichtian	Late Campanian
Palaeoperidinium cretaceum	Late Maastrichtian	Mid Cenomanian
Trichodinium castanea	Late Campanian	Mid Campanian
Surculosphaeridium longifurcatum	Early Campanion	Turonian
Cyclonephelium vannophorum	Turonian	Coniacian
Cyclonephelium compactum	Early Turonian	Late Turonian
Cyclonephelium chabaca	Early Turonian	Late Turonian



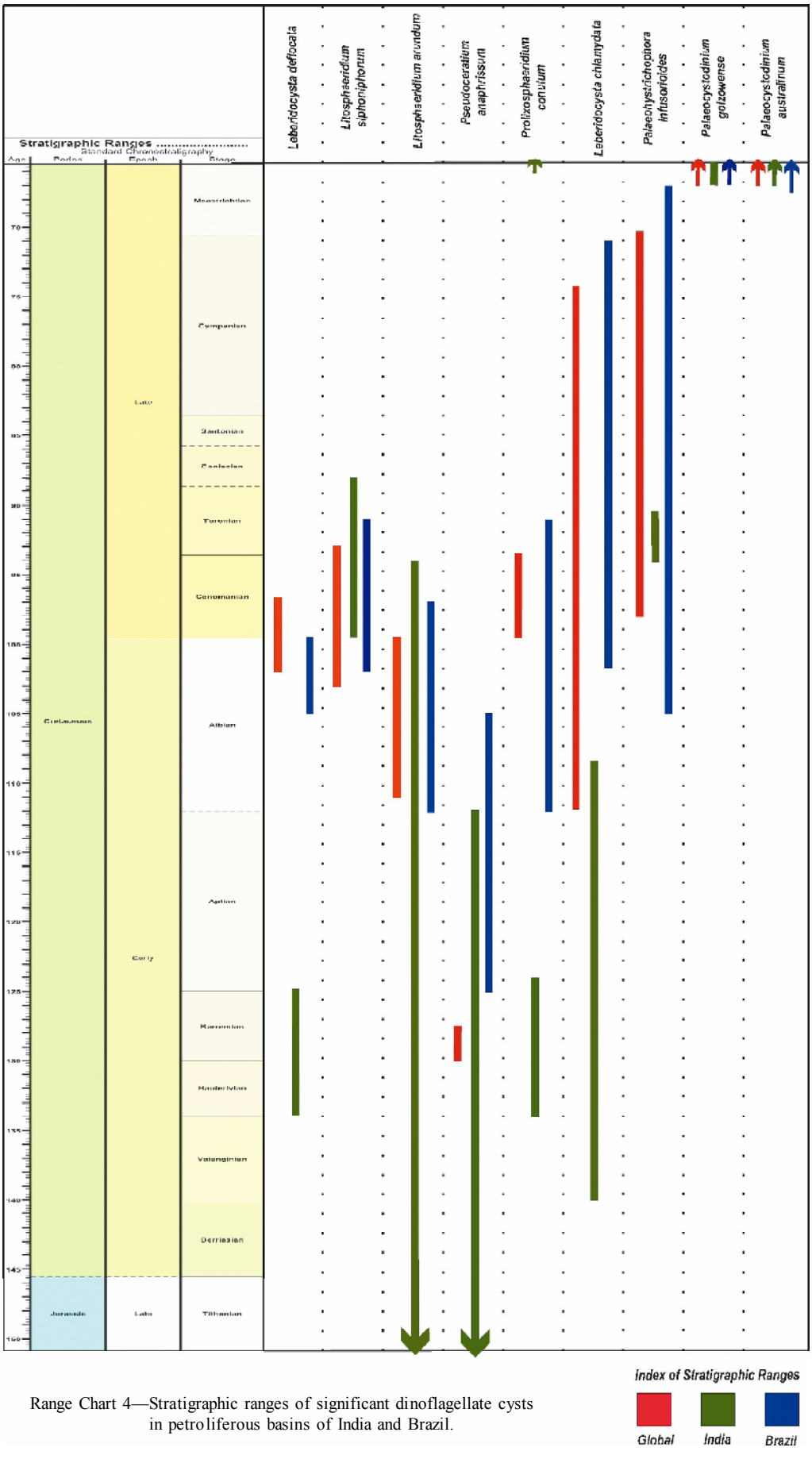
Range Chart 1—Stratigraphic ranges of significant dinoflagellate cysts in petroliferous basins of India and Brazil.



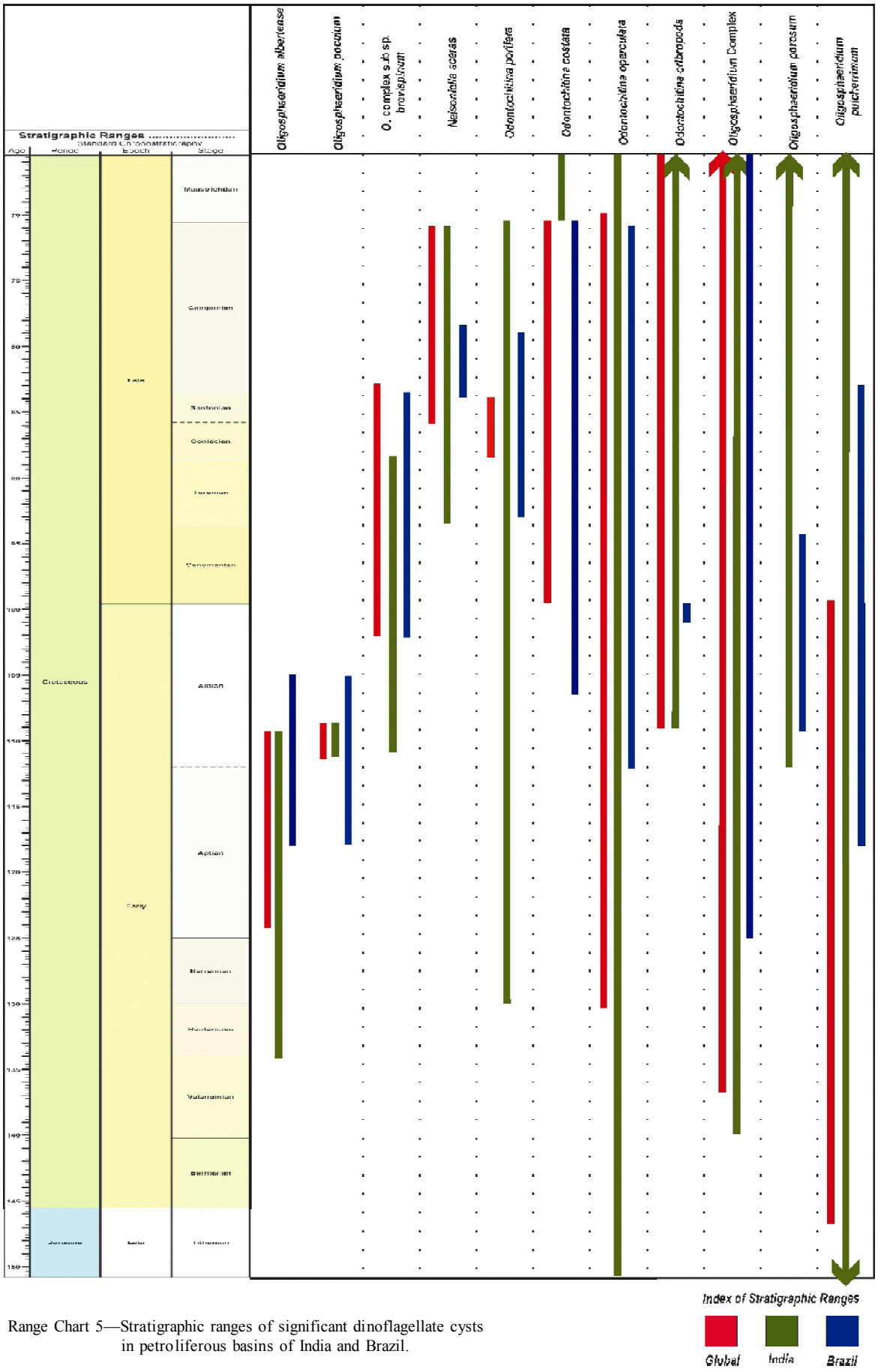
Range Chart 2—Stratigraphic ranges of significant dinoflagellate cysts in petroliferous basins of India and Brazil.



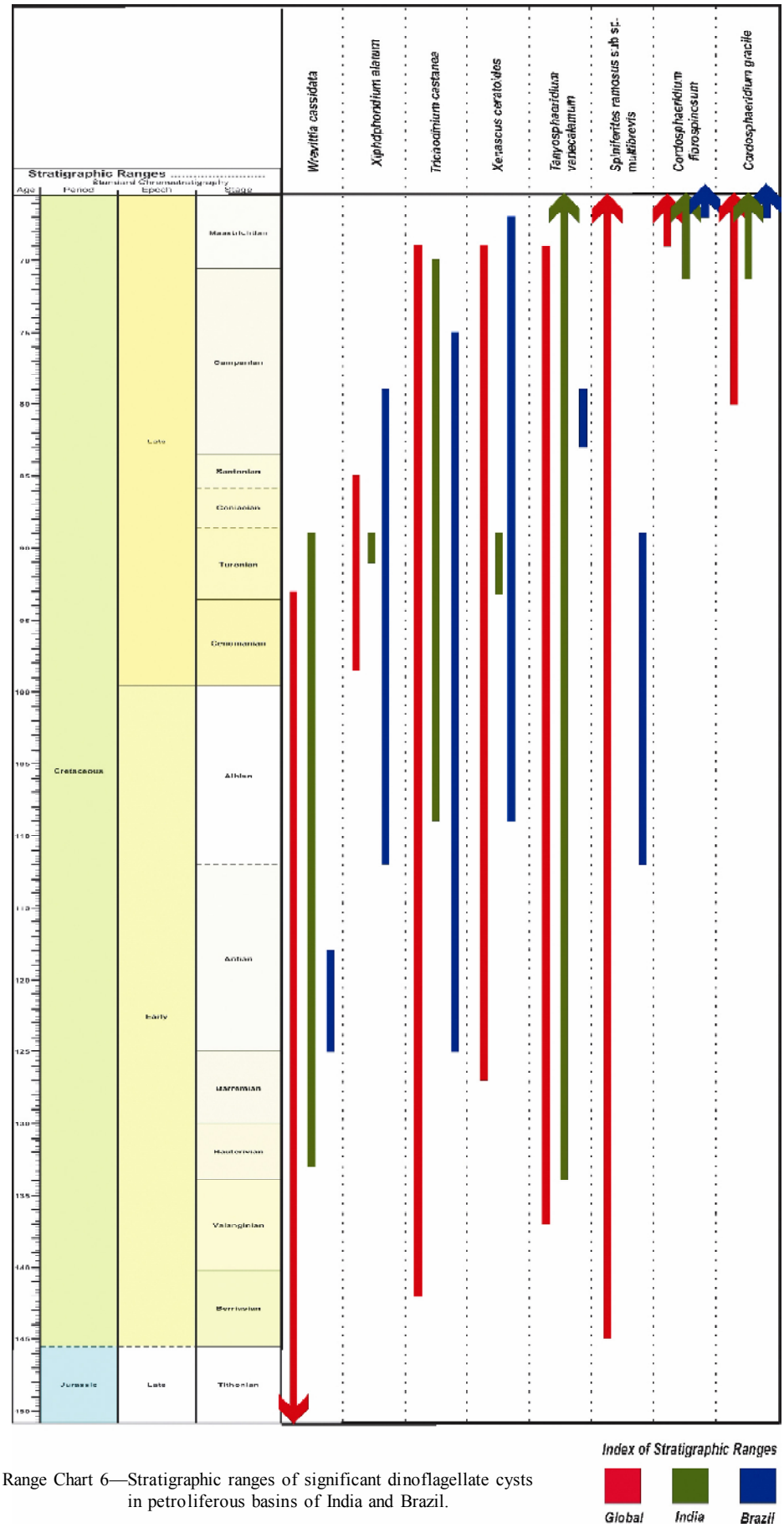
Range Chart 3—Stratigraphic ranges of significant dinoflagellate cysts in petroliferous basins of India and Brazil.



Range Chart 4—Stratigraphic ranges of significant dinoflagellate cysts in petroliferous basins of India and Brazil.



Range Chart 5—Stratigraphic ranges of significant dinoflagellate cysts in petroliferous basins of India and Brazil.



Range Chart 6—Stratigraphic ranges of significant dinoflagellate cysts in petroliferous basins of India and Brazil.

Heterosphaeridium difficile	Early Turonian	Early Santonian
Florentinia buspina	Mid Turonian	Early Turonian
Callialosphaeridium asymmetricum	Early Turonian	Early Turonian
Apteodinium granulatum	Albian top	Mid Campanion
Apteodinium reticulatum	Albian	Mid Campanion
Oligosphaeridium albertense	Early Albian	Mid Albian
Oligosphaeridium poculum	Early Albian	Mid Albian
Pseudoceratum anaphrissum	Early Albian	Mid Albian

LAD's of stratigraphically significant dinoflagellate cysts recorded from India but absent in Brazil

Trichodinium utinensis	Late Maastrichtian	65.50 Ma
Cannosphaeropsis utinensis	Late Maastrichtian	68.08 Ma
Psaligonyaulax deflandre	Basal Campanion	83.50 Ma
Stiphorosphaeridium anthophorum	Turonian top	89.00 Ma
Epiledosphaeridia spinosa	Late Cenomanian	94.83 Ma
Prolixosphaeridium parvispinosum	Late Cenomanian	94.50 Ma
Kiokansium williamsii	Late Cenomanian	95.00 Ma
Pseudoceratium polymorphum	Late Albian	100.30 Ma
Muderongia tetracantha	Late Aptian	114.00 Ma
Cerbia tabulata	Late Aptian	115.11 Ma
Pseudoceratium pelliferum	Late Aptian	116.00 Ma
Phoberosysta neocomica	Early Aptian	117.00 Ma
Ctenidodinium elegantulum	Early Aptian	118.44 Ma
Nelchinopsis kostromiensis	Hauterivian top	127.00 Ma
Muderongia simplex	Late Hauterivian	129.50 Ma
Scriniodinium attadelense	Barremian top	137.00 Ma
Kalyptea wisemaniae	Berriasian top	

LAD's of stratigraphically significant taxa from Brazil absent in India

Alisogymnium euclaense	Early Maastrichtian	67 Ma
Isabelidinium cooksoniae	Basal Maastrichtian	69 Ma
Atopodinium iuvene	Early Turonian	91 Ma
Gordicysta coronata	Late Albian	102 Ma

CONCLUDING REMARKS

While recognizing provincialism in dinoflagellate cysts distribution it is necessary to have integrated multimicrofossil data involving dinocycts, spores-pollen, microforaminifera and nannoplanktons from both Indian and Brazilian well sections. This is considered necessary for obtaining a precise comparison of their stratigraphic ranges. Such studies will not only significantlyhelp in geological modelling for hydrocarbon exploration but also provide a better understanding of palaeogeographic distribution of these dinocysts.

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