(GS02) Mesozoic palynology and botany

Date: August 24, 25
Place: Room 5334 (oral), Room 6325 (poster)

Oral Presentation

Aug. 24 [PM2] Room: 5334

Chair: Shusheng Hu

15:10-15:30 **Middle Jurassic-Early Cretaceous palynomorphs from the Dinosaur members of the Tendaguru Formation, southern coastal Tanzania** GS02-O01 (355)

Emma Msaky

15:30-15:50 **Cretaceous forest composition and productivity inferred from a global fossil wood database** GS02-O02 (403)

Emiliano Peralta-Medina, Howard Falcon-Lang

Aug. 24 [PM3] Room: 5334

Chair: Hiroshi Kurita

16:20-16:40 **Cold polar winters in the Cretaceous greenhouse world** GS02-O03 (131)

Jane Francis, Vanessa Bowman, Jim Riding

16:40-17:00 **Dinoflagellate stratigraphy around the Cenomanian/Turonian boundary in New Zealand** GS02-O04 (455)

Poul Schioler, Takashi Hasagawa, James Crampton, Brad Field, Keisuke Fukushi

17:00-17:20 **An analysis of palynological data from petroliferous basins of India in developing high resolution biostratigraphy with recent significant finds from frontier areas as applied to petroleum industry** GS02-O05 (327)

Naresh Chandra Mehrotra

Aug. 25 [AM1] Room: 5334

Chair: Toshihiro Yamada

9:20-9:40 **Floristic reconstruction of two Lower Cretaceous sections from Peru during the period of early angiosperm diversification and their climatic implications** GS02-O06 (328)

Paula Mejia-Velasquez, Steven Manchester, Carlos Jaramillo

9:40-10:00 **New discoveries of Late Cretaceous floras from Northern Patagonia, Argentina** GS02-O07 (84)

N. Rubén Cúneo, Camila Martínez, María A. Gandolfo, Roberto Scasso, Ignacio Escapa

10:00-10:20 **A Turonian flower of the Ericaceae from the Raritan Formation of New Jersey, USA** GS02-O08 (202)

Shusheng Hu, David Winship Taylor, Leo J. Hickey

Poster Presentation

Aug. 25 [PM1] Room: 6325

13:30-14:30 **Palaeovegetation of Late Jurassic- Early Cretaceous coal-bearing sequence of Western India: Evidences from biomarker data** GS02-P01 (399)

Swagata Paul, Suryendu Dutta

GS02-O01 (355)

Middle Jurassic-Early Cretaceous palynomorphs from the Dinosaur members of the Tendaguru Formation, southern coastal Tanzania

Emma Msaky

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Middle Jurassic-Early Cretaceous dinoflagellate cysts were recorded from the Dinosaur members of the Tendaguru Formation, southern coastal Tanzania. The Lower Dinosaur Member yielded typical Bajocian-Callovian dinoflagellate cysts, such as, *Dissilodinium caddaense*, *Durotrigia filapicatum*, and *Nannoceratopsis gracilis*. Characteristic Oxfordian dinoflagellates: *Fistulacysta simplex*, *Egmontodinium elongatum*, and *Komewuia* sp. A are recovered from the *Nerinella* member. This Oxfordian age is supported by data concerning associated ammonites and ostracodes. The Middle Dinosaur Member yielded a miospore rich assemblage with a few statigraphically important dinoflagellate cysts of early Kimmeridgian age, which comprise Dingodinium *tuberosum* and *Barbaracysta creberbarbata*. The *Indotrigonia africana* Member contains a good and high diverse Kimmeridgian dinoflgellate assemblage with species including *Dingodinium swanense* and *Wanaea tendaguruensis*. The Kimmeridgian age is supported by data relating to associated ammonites and charophytes. Although the palynoflora assemblage documented from the Upper Dinosaur Member is poor, it has a few stratigraphically important dinoflagellate cyst species of the Tithonian-Early Cretaceous age, inter alia, *Circulodinium compta*. The age is in part consistent to data pertaining to ammonites.

Keywords: Middle Jurassic-Early Cretaceous, Dinosaur members, Tendaguru Formation, Tanzania.

GS02-O02 (403)

Cretaceous forest composition and productivity inferred from a global fossil wood database

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Global patterns of Cretaceous forest composition and productivity are analyzed using a comprehensive fossil wood database (n = 2238). To ascertain forest composition, records were classified by botanical affinity, plotted on georeferenced paleomaps, and analyzed with ArcGIS tools. Results confirm previous conjecture that araucarioid and podocarpoid conifers were globally codominant in Early Cretaceous time, especially in humid tropical and paratropical biomes, but drastically reduced in numbers and range during the Late Cretaceous. Cupressoid conifers, which

were most common in seasonally dry mid-latitudes, and pinoid conifers, which were associated with temperate conditions at higher northern latitudes, also declined at the same time, though less markedly. Spatial analysis suggests that the loss of conifer forests (especially araucarioids) was linked to the rise of co-occurring angiosperms. Our data also show that while angiosperms explosively diversified in mid-Cretaceous time, they did not become forest dominants until the latest Cretaceous (25 m.y. later), by which time the modern relictual pattern of conifer distribution had been established. To ascertain forest productivity, mean tree-ring width data were obtained from direct measurements and literature reviews (n = 284) and plotted by paleolatitude. Comparison with modern data shows that Cretaceous forest productivity was significantly elevated (×2) in mid- and high paleolatitudes, implying a poleward displacement of the temperate zone by >15°. Our data provide quantitative verification of Cretaceous climate-vegetation models and improve the understanding of the long-term effects of future global warming.

Keywords: Conifers, angiosperm abundance, distribution patterns, biogeography, paleogeography.

GS02-O03 (131)
Cold polar winters in the Cretaceous greenhouse world

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The Late Cretaceous climate of Antarctica is considered to have been warm and ice-free, with levels of atmospheric CO_2 up to four times pre-industrial levels. Fossil plants and other climate proxies indicate warm oceans and sub-tropical conditions on land. In contrast, it has been proposed that large ice sheets must have existed on Antarctica to cause the +20m sea level changes recorded in Cretaceous sedimentary records in the Northern Hemisphere, but evidence of Cretaceous ice sheets on Antarctica has been hard to find. We now have new data from the marine palynological record which suggests that winters were cold enough for sea ice to form in the northern Antarctic Peninsula region during the latest Cretaceous ~70 million years ago. Blooms of small organic-walled cysts, comparable to modern sea ice cysts, have been recorded within the late Maastrichtian to earliest Paleocene López de Bertodano Formation on Seymour Island, Antarctic Peninsula. These blooms imply the presence of drifted seasonal sea ice reaching the tip of the Antarctic Peninsula during cold intervals, probably during periods of cold orbital forcing. Computer model simulations of sea ice and ice sheet evolution on Antarctica by DeConto et al. (2007) suggests that sea ice could have formed as far north as 65°S during late winter with 2 x CO_2. Their simulations also showed that seasonal sea ice could have been present with even higher CO_2 levels so long as ice caps were already present on the East Antarctic continent. Our evidence of sea ice along the Antarctic Peninsula therefore implies that significant ice caps were already present in East Antarctica during the latest Cretaceous.

Keywords: Cretaceous, Antarctica, dinoflagellates, glaciation, sea ice.

GS02-O04 (455)
Dinoflagellate stratigraphy around the Cenomanian/Turonian boundary in New Zealand

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The interval of the Cretaceous oceanic anoxic event 2 (OAE2) and the Cenomanian/Turonian (C/T) boundary is identified in New Zealand sections from a positive 2‰ carbon isotope excursion (CIE) and the highest occurrence of top Cenomanian markers such as *Lithosphaeridium siphoniphorum*, together with the lowest occurrence of *Heterosphaeridium difficile*, marker for the basal Turonian. The C/T CIE is not associated with organic-rich mudstones in the New Zealand sections but is instead associated with mudstones with low TOC contents and in some sections, with red beds, indicating oxic conditions at the sediment/water interface at the time of deposition. The C/T boundary as well as strata coeval with the OAE2 are located within the upper part of the New Zealand Arowhanan Stage in an interval enigmatically barren of macrofossils. However, dinoflagellates occur commonly and the Arowhanan stage can be subdivided into 6 zones based on dinoflagellates. Although Cretaceous black shales have not yet been identified in the New Zealand region, thermogenic oil and gas seeps are present at various places on the NZ East Coast where latest Cretaceous and younger source rocks are immature. It is thought that the oil and gas derived from older, mid-Cretaceous rocks. Understanding the mid-Cretaceous source rock play is important for on-going petroleum exploration of the East Coast Basin and the adjacent offshore Raukumara Basin.

Keywords: dinoflagellate biostratigraphy, carbon isotope excursion, OAE2, Cenomanian/Turonian boundary, Arowhanan Stage.

GS02-O05 (327)

An analysis of palynological data from petroliferous basins of India in developing high resolution biostratigraphy with recent significant finds from frontier areas as applied to petroleum industry

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An analysis of dinoflagellate cysts and spore-pollen data from the Mesozoic and Tertiary subsurface sediments of petroliferous basins of India has helped in establishing the high resolution biostratigraphic and biochronostratigraphic framework. A maximum resolution of 2 Ma (Cambay Basin); 1 Ma (Western Offshore); 3.3 Ma (Cauvery Basin); 0.17 Ma (Krishna-Godavari Basin) and 1 Ma (Assam-Arakan Basin) has been achieved based on dinoflagellate cysts and spore-pollen data. This work is mainly based on published information from study of hundreds of wells by Mehrotra and his associates at Oil & Natural Gas Corporation Ltd (ONGC), India's National Oil Company and later at Birbal Sahni Institute of Palaeobotany, Lucknow (BSIP), during the last 10 years. Recently, Mehrotra et al (2010) have updated their studies in Western Offshore and Krishna-Godavari, the most productive and prospective basins, respectively. Forty-three dinoflagellate biohorizons have been identified in the subsurface Tertiary sediments of Western Offshore. In Krishna-Godavari Basin eighty-two dinoflagellate biohorizons have been identified in subsurface of Mesozoic-Tertiary and tied up with spores-pollen and foraminiferal data. A very fine dinoflagellate cyst based resolution has been achieved at most levels. Statistical analysis of palynological data has resulted in delineating micropalaeoenvironments; these data sets have been successfully applied in developing sequence biostratigraphy in several blocks in both K-G Basin and Western Offshore. Palaeogeographic reconstructions at very close interval of 1 Ma in the main source rock i.e. Panna Formation in Western Offshore have been developed. The high impact palynological data has helped in refining the existing geological models in both Krishna-Godavari Basin and Mumbai Offshore for giving

lead to successful hydrocarbon exploration. On the hydrocarbon prospects in Frontier areas, Mehrotra et. al. (2008 & 2012) have reported significant initial finds. These include first record of Type-I matured, Liptinite organic matter facies from Late Neoproterozoic of Rajasthan and acritarchs and algae of Cryogenien to Ediacaran age from Ganga Basin. The studies have lead to increased interest in exploration in Rajasthan and Ganga Basin. The present paper also briefly deals with major petroleum systems and source rocks in Cambay, Western Offshore, K-G, Cauvery and Assam-Arakan basins.

Keywords: high impact palynology, hydrocarbon exploration, dinoflagellate biohorizons, sequence biostratigraphy, source rock.

GS02-O06 (328)

Floristic reconstruction of two Lower Cretaceous sections from Peru during the period of early angiosperm diversification and their climatic implications

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We present the floristic and climatic reconstruction of two tropical sections of Lower Cretaceous age through quantitative palynological analyses. The palynoflora of the Merced Section (Oriente Group) is dominated by spores (79.4% abundance and 74% richness in average per sample), non-gnetalean gymnosperms (20.5% abundance; 22% richness) and scarce angiosperm pollen (< 1% abundance and 1.8% richness). The Merced Section contains several of the characteristic components of the pre Aptian *Dicheiropollis etruscus/ Afropollis* palynofloral Province (e.g. common *Araucariacidites*, occurrence of *Eucommiidites*), although it lacks several of the province's key components, including the xerophytic genera *Classopollis* and *Ephedripites/Gnetaceaepollenites*. The second site, the Aguas Frias Section (La Raya and Agua Caliente Formations) contains floristic elements characteristic of Aptian – Albian age, being predominantly composed by spores (43.8% abundance; 34% richness), followed by non-gnetalean gymnosperms (33% abundance and 20.7% richness), angiosperms (15.1% abundance and 29.1% richness) and gnetales (7.9% abundance and 15.4% richness). This floristic composition corresponds mainly to the Albian – Cenomanian Elaterates Province due to the diversity of ephedroid pollen grains and the presence of elater bearing taxa, which have been associated with dry climatic conditions. Similar floristic assemblages have been found in tropical Brazil to West Africa. In both of our Peruvian sections there are abundant and diverse spores and low abundance of the xerophytic indicator *Classopollis* (< 2% of the palynomorphs), which may be indicative of more humid conditions in western South America compared to the remaining Northwest Gondwana during the Lower Cretaceous.

Keywords: quantitative palynology, evolutionary patterns, South America flora, global warming, tropical floras.

GS02-O07 (84)

New discoveries of Late Cretaceous floras from Northern Patagonia, Argentina

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Southern Hemisphere Late Cretaceous floras are, in general, scarcely recorded and they are barely described for South America. However, in the last few years, new discoveries from Northern Patagonia, Argentina, have proved that Late Cretaceous floras are more abundant and diverse than previously expected. In particular, paleobotanical studies on two paleofloras, the La Colonia (Campanian–Maastrichtian) and Lefipán (Maastrichtian) have begun to transform our knowledge of an otherwise unknown fossil record for Patagonia. In this contribution we concentrate on the Lefipán Formation paleobotanical record that clearly reflects the presence of an extremely diverse macro and microflora. Geologically, the Lefipán Formation is represented by an upper part, which is a thick coastal deposit that shows marine influence and a lower part where terrestrial facies prevail. At the Cañadón del Loro locality (lower Lefipán Fm.), two plant assemblages were identified: one represented by aquatic angiosperms of the Nelumbonaceae, which occur in pure assemblages composed of leaves and possible seeds, and that represent the second record of this primitive eudicot family in the Southern Hemisphere. The remaining plant assemblage corresponds to conifers and terrestrial angiosperms, including cutinized branches and leafy twigs, seed cones and ovuliferous complexes, which preserve diagnostic characters that allow a preliminary interpretation for the presence of two araucarian lineages (or sections). Angiosperm remains are more diverse than expected, and several leaf morphotypes can be distinguished by their leaf architecture. Interestingly, one of these morphotypes has well–preserved cuticular characters and leaf architecture, indicative of lauracean affinities. In addition, this morphotype also shows insect damage. The presence of low-density venation values for the leaf morphotypes suggests possible rainforest conditions, a feature that is compatible with previous information obtained from other plant localities in the upper part of the Lefipán Fm. Finally, it must be emphasized that the lauracean and some other morphotypes have been also recorded in the younger early Danian Salamanca flora from the same region, suggesting that many angiosperm lineages survived the dramatic events at the K-T boundary.

GS02-O08 (202)

A Turonian flower of the Ericaceae from the Raritan Formation of New Jersey, USA

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A single charcoalified mesofossil flower with in situ ovules and adherent pollen has been recovered from carbonaceous clay of the South Amboy Fire Clay Member of the Raritan Formation from the Linden Clay Pit, Middlesex County, New Jersey. The flower is pentamerous and minute, measuring 2.0 mm long by 1.2 mm wide. The preserved basal remnants of the perianth form a single ring resulting from the fusion of an inner and an outer whorl of sympetalous and synsepalous elements. An annular disc is located inside of the stamens. The ovary is superior, syncarpous, and 5-carpellate, 1.1mm long, and 0.9 mm wide. The remnant of the style is t 0.5 mm long and hollow. The stumps of 10 filament bases are present arranged in two whorls, one opposite the septae of the carpels, the other opposite the locules. Pollen grains, which are found adhering to the filament bases and also

lying between the petals and the ovary wall, are oblate, 14 by 21µm, tricolporoidate, with short colpi, and scabrate to regulate sculpturing. The ovules are rectangular, averaging 105 by 66 µm in length and width, arranged horizontally, and axile, with more than 50 ovules per locule. The floral and pollen characteristics of this flower, such as the connate corolla, the annular disc, the syncarpous and 5-locular ovary, hollow style, horizontal ovules, axile placentation, and tricolporoidate, oblate pollen; strongly suggest that its closest affinity lies with the Ericaceae. This initial hypothesis was further evaluated using a morphological data set by Kron et al., 2002, enhanced with 6 pollen characters from data in the literature. This analysis placed the fossil within the Family Ericaceae, near the base of the tree. If the tree was rooted with *Enkianthus*, the fossil was placed close to Monotropoideae and Arbutoideae but not within either clade. Thus our investigation supports the placement of the Linden flower within Ericaceae as an early member of family as it began its diversification into the existing subfamilies.

Keywords: charcoalified mesofossil, flower, Turonian, Ericaceae, Raritan Formation.

GS02-P01 (399)

Palaeovegetation of Late Jurassic- Early Cretaceous coal-bearing sequence of Western India: Evidences from biomarker data

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Palaeogeogragraphic model depicts that India started moving towards northern hemisphere during the Late Jurassic after its separation from Gondwanaland until the India-Asia collision at *ca.* 55 Ma. We investigated biomarkers from Late Jurassic to Early Cretaceous coal-bearing sequences of Western India to understand the paleofloral community of the island continent during the Mesozoic era. Biological markers or molecular fossils that are stable under geological conditions mostly originate from biological lipids. These biomarkers encode information about ancient biodiversity, trophic associations, and environmental conditions. The samples have been collected from Guneri, Trambau area (Bhuj Formation) and Chawad river section (Jhuran Formation) of Kutch Basin, Western India. This study includes Rock Eval pyrolysis, in order to reveal the thermal maturity as well as characterization of kerogen and identification of biomarkers by gas chromatography-mass spectrometry (GC-MS) technique for tracing redox condition of depositional environment and palaeovegetation. The Rock-Eval pyrolysis data shows that samples are thermally immature (Rock-Eval T_{max} ranges from 416^{o}C to 425^{o}C) and the source is the mixture of Type-II and Type III organic matter. Saturated hydrocarbons are dominated by C_{14} to C_{35} *n*-alkanes. Pristane/Phytane ratio (ranges from 0.8 to 2.8) indicates suboxic depositional environment. The major diterpenoids identified in the coal samples are phylocladane, *ent*-beyerene, isopimarane, norisopimarane, labdane, simonellite, cadalene and diaromatic totarane. We also have identified few aromatic triterpenoids such as chrysene, 4b,5,6,12-tetrahydrochrysene, 2,9 dimethyl picene and 3,4,7-trimethyl-1,2,3,4 tetrahydrochrysene. Abundant occurrence of diterpenoids suggests that conifers dominated forest served as a major source of organic matter for the formation of these coals. However, presence of aromatic triterpenoids indicates that angiosperms evolved during the Late Jurassic to Early Cretaceous time in India.

Keywords: Late Jurassic to Early Cretaceous coal, palaeovegetation, diterpenoids, aromatic triterpenoids.