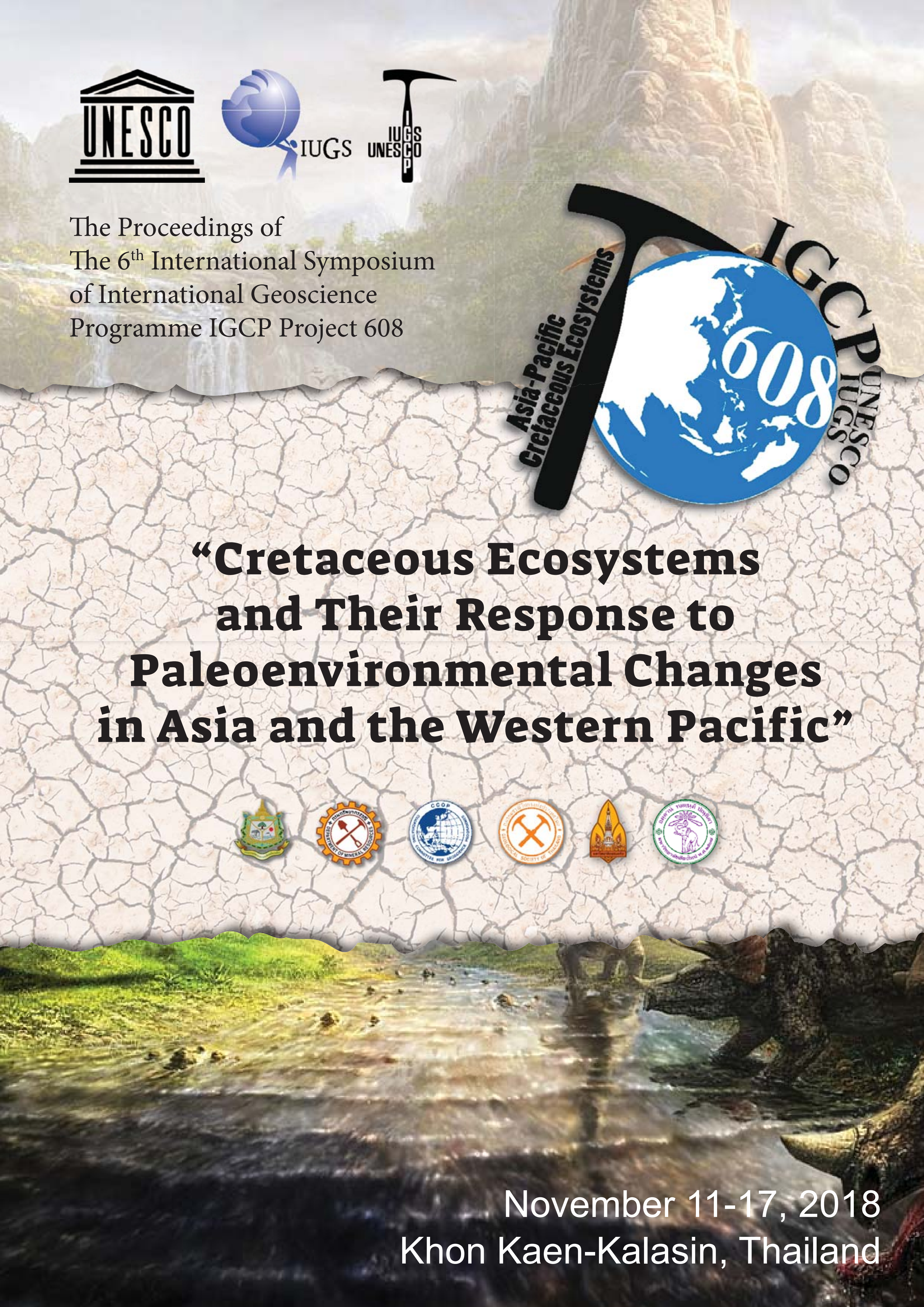

The Proceedings of
The 6th International Symposium
of International Geoscience
Programme IGCP Project 608

"Cretaceous Ecosystems and Their Response to Paleoenvironmental Changes in Asia and the Western Pacific"

November 11-17, 2018
Khon Kaen-Kalasin, Thailand

The 6th International Symposium
of International Geoscience
Programme IGCP Project 608

"Cretaceous Ecosystems and Their Response to Paleoenvironmental Changes in Asia and the Western Pacific"

We cordially invite you to participate in the 6th International Symposium of IGCP608, which will be held from November 11 to 17, 2018 in Khon Kaen - Kalasin Province, Thailand.

The mechanisms underlying the evolution of the Asia-Pacific Cretaceous ecosystems are far from being fully understood. The IGCP608 project is aimed to reconstruct the Cretaceous ecosystems and the history of their responses to paleoenvironmental changes in Asia and the Western Pacific. The Symposium will serve as a platform for participants to share their views on the paleoenvironmental changes impacts both on terrestrial and marine ecosystems. The scientific programme will cover a wide range of topics including paleoclimate, paleogeography, paleontology, stratigraphy, tectonics, and petroleum geology.

The symposium is dedicated to the 10th anniversary of the Sirindhorn Museum. The Sirindhorn Museum is an important tourist attraction of Thailand. It is a well-known dinosaur museum containing new dinosaur genera and species first found in Thailand. These new dinosaurs are important additions to our knowledge of dinosaur diversity during the Mesozoic Era. Moreover, the museum is a research institution, and its beauty attracts large numbers of both Thai and foreign tourists. Thus far, more than 3,000,000 people have visited the museum, and each passing year adds significantly to this total. The museum has a conservation approach to tourism activities and promotes cooperation with local communities, helping local people to supplement their income by producing and selling souvenirs.

The 6th International Symposium of the IGCP608 in Khon Kaen - Kalasin Province will provide an opportunity for discussion of the latest advances in studies of Asia-Pacific Cretaceous ecosystems. In addition to scientific sessions, the pre-symposium field excursion will be organized in the Khorat Plateau, Northeastern Thailand to observe the Jurassic-Cretaceous non-marine deposits (Khorat Group) with abundant dinosaurs and other geo-conservation sites.

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- Dr. Phornphen Chanthasit, Senior Geologist
- Mr. Kajornphat Suksriboonampai, Senior Geologist
- Miss Orn-Uma Summart, Director of Sirindhorn Museum
  (Symposium Secretary)

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By: Wenyuan Zhang, Youjia Yao, Yuewei LI, Tianyang Wang, Xinfa LI and Guobiao LI

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GENERAL INFORMATION

11-17 November 2018 Thailand

Sunday November 11, 2018	Arrival of Pre-Symposium field excursion participants at Khon Kaen Province
Monday-Wednesday November 12-14, 2018	Pre-symposium field excursion "The Cretaceous non-marine deposits (Khorat Group) with dinosaur and vertebrate fossil sites"
Wednesday November 14, 2018	Arrival of Symposium participants at Charoen Thani Hotel, Khon Kaen Province
Thursday November 15, 2018	8.30-9.00 Registration 9.00-9.45 Welcoming Address by the Director General of DMR Opening Symposium Session by the IGCP 608 leader 10.00-12.00 Keynotes and oral presentations on the Cretaceous terrestrial and marine environments in Asia and the Western Pacific 12.00-13.00 Lunch 13.00-16.45 Keynote and oral presentations on the Cretaceous terrestrial and marine environments in Asia and the Western Pacific 17.00-18.00 Poster sessions 18.30-21.30 Welcome dinner
Friday November 16, 2018	8.30-12.15 Keynote and oral presentations on the evolution of Cretaceous terrestrial and marine ecosystems in Asia and the Western Pacific 12.15-13.15 Lunch 13.15-16.00 Oral presentations on the evolution of Cretaceous terrestrial and marine ecosystems in Asia and the Western Pacific 16.00-18.00 IGCP608 Business meeting Cultural Programme 18.30-21.30 Farewell Party
Saturday November 17, 2018	Departure of participants

DETAIL OF SCIENTIFIC PROGRAMME

Thursday, November 15, 2018

Srichan 1 Room, Charoen Thani Hotel

TIME	PROGRAMME
8.30-9.00	Registration
9.00-9.45	**Welcoming Address** by the Director General of Department of Mineral Resources, Thailand **Opening Symposium Session** by the IGCP 608 leader **Group Photo**
9.45-10.00	Coffee break
10.00-10.30	**Keynote: Geology and stratigraphy of Jurassic–Cretaceous rocks, Northeastern Thailand** *By: Nares Sattayarak*
10.30.-11.00	**Keynote: A reviews of Dinosaurs in Thailand** *By: Varavudh Suteethorn*
11.00-11.30	**Keynote: Significance of Cretaceous strata in the Japanese Islands: Cretaceous continental arc–trench system** *By: Hisao Ando, Masaki Takahashi*
	Cretaceous Terrestrial and Marine Environments in Asia and the Western Pacific Chairman: Mr. Nares Sattayarak
11.30-11.45	**Depositional processes and transport mechanism of upper Ullyonsan Conglomerates in the Cretaceous Yeongyang Sub-basin of Gyeongsang Sedimentary Basin, Korea** *By Ki-Hun Yu, Daekyo Cheong*
11.45-12.00	**The facies analysis of sedimentology of the Phu Tok Noi architecture, Phu Tok Formation, Khorat Plateau, Northeast Thailand.** *By Kiattisak Sonpirom, Peangta Satarugsa, Natthawiroj Silaratana*
12.00-13.00	*Lunch*
	Cretaceous Terrestrial and Marine Environments in Asia and the Western Pacific Chairman: Prof. Hisao Ando
13.00-13.15	**CLMTV cooperation and compilation of the Jurassic and Cretaceous mapping** *By Adichat Surinkum, Director of CCOP*
13.15-13.30	**Searching for the non-marine Jurassic/Cretaceous boundary in northeastern China** *By Gang Li, Atsushi Matsuoka*
13.30-13.45	**Lithostratigraphy of the Berapit Formation along the Malaysia-Thailand border** *By Mat Niza bin Abdul Rahman, Mohamad Hussein bin Jamaluddin*
13.45-14.00	**Through the looking glass: Insights from radiolarian research in elucidating the geologic evolution of the Philippines** *By Edanjarlo J. Marquez, Karlo L. Queaño, Carla B. Dimalanta*
14.00-14.15	**Provenance of the Cretaceous Neungju Basin, Korea** *By Min Gyu Kwon, Taejin Choi, Seung Won Shin*
14.15-14.30	**Facies and geochemical analysis for basin evolution of the Late Cretaceous Neungju Basin, SW Korea – a preliminary study** *By Hyojong Lee, Taejin Choi*

14.30.14.45	**Detrital zircon U-Pb and radiolarian biostratigraphy in the Tethys Himalaya, southern Tibet: constraints on the timing of Initial Indian–Asia Collision** *By Tianyang Wang, Guobiao Li, Zhang Wenyuan, Xinfa Li, Xusong Ma*
14.45-15.00	*Coffee Break*

Cretaceous Terrestrial and Marine Environments in Asia and the Western Pacific

Chairman: Prof. Sunil Bajpai

15.00-15.15	**Integrated study of volcano-stratigraphy, magneto-stratigraphy, reptilian tetropods and palynology: tracking biotic and environmental changes across Cretaceous–Palaeogene during Deccan volcanism** *By Dhananjay M. Mohabey, Bandana Samant*
15.15.15.30	**Palaeoecology of a Maastrichtian lake during Deccan environmental transition: evidences from Malwa Plateau** *By Dhobale Anup, Dhananjay M. Mohabey, Deepesh Yadav and Bandana Samant*
15.30-15.45	**Palynoflora and microfauna from Late Cretaceous Lameta sediments and Intertrappean sediments of Nand–Dongargaon and Salbardi–Belkher inland basins of central India: age and paleoenvironment implications** *By Hemant Sonkusare, Bandana Samant and D.M. Mohabey*
15.45-16.00	**Cretaceous formations of part of East Coast of India** *By Jayaraju Nadimikeri*
16.00.16.15	**Refined chronostratigraphy of the late Mesozoic terrestrial strata in South China and its tectono-stratigraphic evolution** *By Xianghui Li, Chaokai Zhang, Yongxiang Li, Yin Wang, Ling Liu*
16.15-16.30	**Terrestrial climates in East Asia during the Cretaceous inferred from the stable oxygen and carbon isotope compositions of vertebrate apatites: further results** *By Romain Amiot*
16.30-16.45	**Biostratigraphic zonation of Late Cretaceous sediments in Southern Sierra Madpe, Philippines** *By Maybellyn Zepeda*
17.00-18.00	**Poster Session**
18.30-21.30	***Welcome Dinner***

Friday, November 16, 2018

Srichan 1 Room, Charoen Thani Hotel

Evolution of Cretaceous Terrestrial and Marine Ecosystems in Asia and the Western Pacific

Chairman: Dr. Dhananjay M. Mohabey

8.30-8.45	**Plant fossils from the Lower Cretaceous in Shandong Province, China** *By Sun Bainian, Jin Peihong, Hua Yifan, Huang Rehan*
8.45-9.00	**Flora of coal-bearing deposits of Central Transbaikalia (Russia)** *By Eugenia V. Bugdaeva, Valentina S. Markevich, Tatiana A. Kovaleva*
9.00-9.15	**The Early Cretaceous angiosperm pollen of Transbaikalia and Primorye region (Russia)** *By Eugenia V. Bugdaeva, Valentina S. Markevich*
9.15-9.30	**Palynology studies of the Talbulag coal deposit, Eastern Mongolia** *By Niiden Ichinnorov, Gombosuren Tsolmon, Adiya Eviikhuu, Gantulga Enerel, Nyamsambuu Odgerel*
9.30-9.45	**Late Cretaceous paleogeography of the Deccan Volcanic Province, peninsular India: palynological evidence** *By Vandana Prasad, Sunil Bajpai*

9.45-10.00	**Upper Cretaceous palynofloras from the Himenoura Group (Southwest Japan) and consequences for the Normapolles and Aquilapollenites palynological provinces in eastern Asia** *By Julien Legrand, Toshifumi Komatsu, Yuka Miyake, Takanobu Tsuihiji, Makoto Manabe*
10.00-10.15	*Coffee-break*

Evolution of Cretaceous Terrestrial and Marine Ecosystems in Asia and the Western Pacific

Chairman: Prof. Daekyo Cheong

10.15-10.30	**Belemnite diversity across the Jurassic–Cretaceous boundary in Russian northern Eurasia** *By Oksana S. Dzyuba*
10.30.-11.00	**Buchia associations and interregional correlation of the Jurassic–Cretaceous boundary interval in Russian Boreal basins: new data from the Russian platform, Siberia, and the Far East** *By Boris N. Shurygin, Olga S. Urman and Oksana S. Dzyuba*
11.00-11.30	**Lower Cretaceous oysters from Mangyshlak peninsula (northwestern Kazakhstan) and Crimea peninsula: taxonomical composition and stratigraphic distribution (preliminary data)** *By Igor N. Kosenko, Egor K. Metelkin*
11.30-11.45	**A Cenomanian–Turonian pelecypodal faunule from the Upper Pan Laung Formation, Kinda Area, Myittha Township, East Central Myanmar** *By Myo Myint, Thaw Tint*
11.45-12.00	**Radiolarian assemblage of Barremian to Aptian interval in the Tethys and the influence of the oceanic anoxic event (OAE) 1a** *By Xin Li*
12.00-12.15	**Dinoflagellate cyst biostratigraphy of Eocene in Duina, Yadong, Tibet, China** *By Wenyuan Zhang, Youjia Yao, Yuewei Li, Tianyang Wang, Xinfa Li, Guobiao Li*
12.15-13.15	*Lunch*

Evolution of Cretaceous Terrestrial and Marine Ecosystems in Asia and the Western Pacific

Chairman: Dr. Adichat Surikum

13.15-13.45	**Keynote: Diversity of Mesozoic Crocodiles in the northeastern Thailand** *By Komsorn Lauprasert*
13.45-14.00	**Vertebrate remains from the Early Cretaceous fluvial deposits of Phu Wiang Valley, Khon Kaen Province, Northeastern Thailand** *By Kamonlak Wongko, Phornphen Chanthasit, Pitaksit Ditbanjong*
14.00-14.15	**Non-marine Cretaceous turtles of Japan and its significance for paleoenvironmental analysis** *By Ren Hirayama*
14.15-14.30	**Carettochelyid turtle from the Lower Cretaceous of Japan and the diversification of the pan-trionychian turtles** *By Teppei Sonoda*
14.30-14.45	**Turtles from the Lower Cretaceous Khok Kruat Formation of Northeastern Thailand: new data** *By Wilailak Naksri*
14.45-15.00	*Coffee Break*

Evolution of Cretaceous Terrestrial and Marine Ecosystems in Asia and the Western Pacific

Chairman: Dr. Romain Amiot

15.00-15.15	**All about Sirindhorna khoratensis (Ornithopoda; Hadrosauroidea)** *By Masateru Shibata*

15.15-15.30	**The Early Cretaceous Birds from the Kitadani Formation, Katsuyama, Fukui, Japan: a unique window to the extinct avifauna in the Far East** *By Takuya Imai, Yoichi Azuma, Masateru Shibata, Soichiro Kawabe, Kazunori Miyata, Yuta Tsukiji*
15.30-15.45	**Late Cretaceous Vertebrate faunal similarities between India and Madagascar: palaeobiogeographic scenarios** *By Guntupalli V.R. Prasad*
15.45-16.00	**Holocene climate and environmental changes in Mongolia as recorded in the sediments of lakes: a review.** *By Oyunchimeg Tserentsegmid*
16.00-16:10	***Closing Symposium Session*** *by the IGCP 608 leader*
16.10-16.20	*Coffee Break*
16.20-18.00	***Business Meeting:*** *Kaen Nakhon Room, Charoen Thani Hotel* *Project Summary of IGCP608 (2013-2017+2018)* *Next new project proposal following IGCP608*
	Cultural Programme
18.30-21.30	***Farewell Party***

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1. **Depositional environment of Lower Cretaceous lacustrine sedimentary rocks in Central Mongolia**
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2. **The skull of Pelecanimimus polyodon (Theropoda, Lower Cretaceous, Spain): comparative approach to Asian Ornithomimosauria**
   By Elena Cuesta, Francisco Ortega, José Luis Sanz
3. **Distribution of Charophytes in the lower Cretaceous of the lake basins in Mongolia and conditions of their growth**
   By Gereltsetseg Lkhagvaa
4. **Sedimentology and stratigraphy of Phuwiang Dinosaur excavation sites, Khon Kaen Province, Northeastern Thailand**
   By Pitaksit Ditbanjong, Kritsada Moonpa, Nontawat Srisomporn, Nuttawat Obaom, Kamonlak Wongko, Phornphen Chanthasit
5. **Depositional environments of the Early Jurassic Nam Phong Formation in Nong Bua Daeng District, Chaiyaphum, northeastern Thailand**
   By Rattanaphorn Hanta
6. **The cranial endocranial of Phuwiangosaurus sirindhonae**
   By Siripat Kaikaew
7. **Preliminary study on the growth of Fukuiraptor kitadaniensis (Dinosauria: Theropoda)**
   By Soki Hattori, Yoichi Azuma, Soichiro Kawabe
8. **Preliminary study on the provenance of the Hayang Group sandstones in the Gyeongsang Basin, Korea using detrital zircon geochronology**
   By Taejin Choi, Min Gyu Kwon
9. **Late Jurassic – Early Cretaceous Belemnites in Gyangze, Southern Tibet, China**
   By Liping Hu, Yuewei Li, Qi Li, Weiyuan Zhang, Guobiao Li

ABSTRACT

The Sixth International Symposium of International Geoscience Programme IGCP Project 608

“Cretaceous Ecosystems and Their Response to Paleoenvironmental Changes in Asia and the Western Pacific”

November 11-17, 2018, Khon Kaen-Kalasin, Thailand

A Cenomanian-Turonian Pelecypodal Faunule From the Upper Pan Laung Formation, Kinda Area, Myittha Township, East Central Myanmar

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Abstract

The newly updated contribution herein highlights the Cenomanian-Turonian pelecypodal faunule representing the upper most part of the Pan Lung Formation, which was based on the part of master thesis submitted to Department of Geology, University of Yangon, Myanmar, in 1990. A hitherto unknown Cenomanian-Turonian pelecypodal faunule consisting of *Protocardium hillanim* Sowerby, *Inoceramus panlaungenesis n. sp. and Chlamys pauciradiatus n. sp.,* and associated with fragments of naculids, was discovered from interbedded mudstone and sandstone of the upper Pan Laung Formation exposed on the west bank of the Pan Laung River, half-a-mile southwest of Peinhnebin village, Kinda area, Myittha Township, which highlights the extension of the Cenomanian-Turonian marine transgression over this segment of the western margin of the Shan-Thai Terrane called Sibumasu Terrane (Figures 2, 3 and 4).

The Jurassic-Cretaceous Pan Laung Formation (Garson, et al.; 1976), carrying the Pelecypodal faunule is described lies just on the west of the Pan Laung Fault Zone along which the present Pan Laung River takes its course from the south to the north and which delimits the eastern boundary of the Jurassic - Cretaceous sequence on the west that made up the Tagondaing range (Myo Myint, 1990) (Figures 1). Moreover, The Pan Laung Formation is defined as Necomian by Chit Saing (2000) and mid Jurassic to mid Cretaceous by Myint Thein et al (2000). The faunule bearing unit as exposed half-a-mile southwest of Peinhnebin village (Grid 819758, Map 93 C-8) is mainly gray calcareous siltstones and mudstones which have been extensively sheared and tightly folded. Further southwest and up the hill and underlying the Cretaceous without any evidence of a stratigraphic lacuna is mudstone unit that bears *Thracia luducensis* Hayami (1972) and other bivalves indicating Toarcian (Myo Myint, 1990). The entire Jurassic-Cretaceous sequence on the west bank has entirely dips through the dip amounts and intensity of deformation considerably increase toward the main Pan Laung Fault Zone to the east. On the south and north of the Cenomanian-Turonian exposure that lies on the tip of the eastern spur of the Tagondaing range, run oblique cross faults (NE-SW) that had cut off the

northern and southern continuation of the Cretaceous exposure under discussion.

The regional structural pattern along the Pan Laung valley is such that Mesozoic units (Anisian? to Turonian) trapped west of the Shan-scarp Fault (Nwalabo-Ezwe Fault by Garson

et al, 1976) (Figure 2) and east of the post- Cretaceous granodiorite batholiths emplacement and its apophyses, have been cut up into N-S elongated conspicuous wedges by the main longitudinal

Pan Laung Fault and its complementary sets of faults and a series of cross faults resulting in isolated, disconnected blocks of different lithologic sequence and age, and also assuming varying elevations all along this structural complex belt.

All about *Sirindhorna khoratensis* (Ornithopoda; Hadrosauroidea)

Masateru Shibata[1,2]*, Pratueng Jintasakul[3] Yoichi Azuma[1,2],
Duangsuda Chokchaloemwong[3] and Soichiro Kawabe[1,2]

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Abstract

Sirindhorna khoratensis, a basal hadrosauroid from the Lower Cretaceous of Thailand, is the best-preserved ornithopod dinosaur in Southeast Asia. Shibata et al. (2015) described skull elements, including premaxillla, maxillae, braincases, quadrate, and mandibles. Additionally, we have excavated abundant iguanodontian postcranial bones from the site. Those iguanodontian postcranial bones are assumed to belong to one taxon because discovered five braincases show no features to imply the existence of multi-taxa. Here, we introduce all about this great dinosaur; its postcranial skeleton and brain.

Postcranial skeleton: Composite restorations are produced for the postcranial skeleton because a few articulated elements have been known from the excavation site. In axial skeleton, one small axis, one complete mid-cervical and several broken cervical vertebra have been found. Interestingly, only one set of the articulated posterior cervical to anterior dorsal vertebrae was unearthed. In dorsal vertebrae, an isolated and well-preserved one and several broken or unfused ones have been known. Completely fused sacrum, lacking the dorsal and anterior portion, consists of three and one broken sacral vertebrae. In caudal vertebrae, no completely preserved one has been known, although more than ten vertebrae have been discovered. Anterior caudal vertebra shows well-developed transverse processes. Posterior caudal vertebrae normally show an anteroposteriorly elongated and hexagonal-shaped centrum.

Appendicular skeleton is also reconstructable. The pectoral girdle and forelimb shows relatively a robust structure: the broad and expanded proximal portion of the scapula, relatively small main body of the sternal with expanded caudolateral process, and the large and distinct olecranon process of ulna. No manual elements have been identified. The pelvic girdle and hindlimb bones also have been known. Although almost all bones are broken and deformed, an assemblage of partially articulated pedal phalanges was found. Variable sizes of femora are included.

Brain: CT-scanning of one well-preserved braincase of *S. khoratensis* shows the endocranial anatomy of *S. khoratensis*. The reconstructed endocast shows typical dinosaurian brain morphology with rostrocaudally-elongated posture. The following general endocast features of this animal resemble those of basal iguanodonitans A large peak of the midbrain makes this brain a triangular shape in lateral aspect. The olfactory tract is projected rostrally at the rostral end of the cerebrum. The cerebral hemisphere is broad and

dorsoventrally compressed. Caudal to the cerebrum, there is a weak constriction. A large peak of the midbrain is possibly a pineal peak. The caudal region to this peak is constricted again, where the inner ear (endosseous labyrinth) is situated. The left endosseous labyrinth is also well-reconstructed although lacking the ventral portion. The rostrocaudal length of the endocast is 136 mm and the width is 52 mm at the cerebrum. Significantly, the ratio of the volume of the cerebrum to that of the endocast, which is approximately 30%, is much higher than any other non-hadrosaurid iguanodontians and close to those of hadrosaurids. Despite a large number of fossil records of iguanodontians, the endocranial anatomy information is still limited, particularly among non-hadorsaurid hadrosauroids. Therefore, *S. khoratensis* provides fundamental information of the endocranial anatomy of non-hadrosaurid hadrosauroid.

Belemnite diversity across the Jurassic–Cretaceous boundary in Russian northern Eurasia

O.S. Dzyuba

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Abstract

The taxonomic diversity of belemnites (Cylindroteuthididae) from the Volgian and Ryazanian of northern East Siberia (Nordvik and Boyarka sections), northwestern West Siberia (Lopsiya, Maurynya, and Yatriya sections) and Central Russia (Gorodischi, Kashpir, Nikitino, and Durnenki sections) are studied. In Siberia, two different trends occurred in the dynamics of belemnite species diversity across the Jurassic–Cretaceous boundary. In the NW margin of the West Siberian sea (Lyapin paleobay), the growth of belemnite diversity began at the end of the Middle Volgian and significantly increased in the Late Volgian. The peak of the belemnite taxonomic diversity occurred in the terminal Volgian–beginning of the Ryazanian, i.e. it falls on the beginning of the Cretaceous (Dzyuba, 2013; Dzyuba et al., 2018). The West Siberian 'peak' corresponds to a sharp decline on the species diversity curve of the belemnites in the north of Eastern Siberia (Khatanga paleostrait). In the second half of the Ryazanian, the number of species substantially decreased all over the Siberia. Belemnite assemblages in the Central Russian sea did not experience any peculiar diversity changes (either positive or negative) across the Jurassic–Cretaceous boundary.

Belemnite assemblages were undoubtedly influenced by different global and regional factors. The dynamics of belemnite diversity in the Lyapin paleobay correlates well with climatic events. A gradual increase of species number during the Volgian–beginning of the Ryazanian in Western Siberia as well as penetration of the Tethyan *Hibolithes* (Belemnopseidae) at the end of this time interval correspond to a global warming and temperature elevation in Boreal basin, and the subsequent reduction of species diversity in the second half of the Ryazanian is correlated with a gradual cooling (Dzyuba, 2013; Dzyuba et al., 2013, 2018). Ryazanian belemnites of the Central Russian sea show the best correlation between dynamics of belemnite diversity and transgressive–regressive events.

The correlation between belemnite diversity curves and eustatic or transgressive–regressive curves is often not recorded. This can probably be attributed to the complicated character of this relationship; a decrease (or increase) in belemnite diversity can be linked to by either shallowing or deepening of their habitat. For example, the Kimmeridgian eustatic and transgressive events obviously favored a rise in biodiversity in Siberian seas; however, the further deepening of the West Siberian sea in the Volgian led to the formation of pseudoabyssal depths (down to 500 m and below) in its central part and an almost complete absence of belemnites, excluding juveniles transported by currents (Marinov et al., 2006). In northern East Siberia with the increased transgression and deepening of the basin down to 200 m and over in the area of the modern Nordvik Peninsula, the number of

belemnites was reduced (Dzyuba, 2012; Zakharov et al., 2014). In the open sea deep-water facies of Jurassic–Cretaceous transitional time, belemnites are missing despite the occurrence of ammonites and numerous Buchias. A subsequent shallowing of deep areas invariably led to the inverse process when belemnites returned to faunal communities and their taxonomic diversity gradually increased (cf. Dzyuba, 2013). However, an extreme shallowing of the basins in turn negatively influenced the species diversity. In the terminal Volgian, the Central Russian sea became a shallow basin with highly abundant belemnites against the background of very low species and generic diversity (Yanin, 2001).

At the superspecific level changes in Siberian belemnites in the Volgian and Ryazanian are comparatively weak. Almost all genera occurring in the Upper Jurassic pass into the Lower Cretaceous. The most perceptible change took place at the beginning of the Middle Volgian when in the Lyapin Bay three cylindroteuthidid genera, *Acroteuthis* (Pachyteuthidinae), *Liobelus* (Simobelinae), and *Eulagonibelus* (Lagonibelinae) first occurred. During the Volgian and Ryazanian ages none of the taxa superspecific in rank disappeared from the Siberian belemnite assemblages, with the exception of southern migrants (Boreal-Atlantic genus *Eulagonibelus*, and Tethyan genus *Hibolithes*) that penetrated into the western West Siberian sea for a short time. By the terminal Middle Volgian in the Boreal-Atlantic seas Cylindroteuthidinae, Lagonibelinae, and the genus *Pachyteuthis* disappeared sequentially, and temporarily the genera *Boreioteuthis* and *Simobelus* (re-occurred in the Early Cretaceous). In the Arctic seas, these taxa continued to exist and generated a number of new species. In the Central Russian sea, as well as in shallow seas of NW Europe, only *Acroteuthis* and *Liobelus* with dorsoventrally depressed and flattened on the ventral side rostra occurred at the Jurassic–Cretaceous boundary as the most adapted to shallow environment.

References

Dzyuba, O.S., 2012. Belemnites and biostratigraphy of the Jurassic–Cretaceous boundary deposits of northern East Siberia: new data on the Nordvik Peninsula. Stratigr. Geol. Correl. 20(1), 53–72.

Dzyuba, O.S., 2013. Belemnites in the Jurassic–Cretaceous boundary interval of the Mauryn'ya and Yatriya River sections, Western Siberia: Biostratigraphic significance and dynamics of taxonomic diversity. Stratigr. Geol. Correl. 21(2), 189–214.

Dzyuba, O.S., Izokh, O.P., Shurygin, B.N., 2013. Carbon isotope excursions in Boreal Jurassic–Cretaceous boundary sections and their correlation potential. Palaeogeogr. Palaeoclimatol. Palaeoecol. 381–382, 33–46.

Dzyuba, O.S., Pestchevitskaya, E.B., Urman, O.S., Shurygin, B.N., Alifirov, A.S., Igolnikov, A.E., Kosenko, I.N., 2018. The Maurynya section, West Siberia: a key section of the Jurassic–Cretaceous boundary deposits of shallow marine genesis. Russ. Geol. Geophys. 59, 864–890.

Marinov, V.A., Meledina, S.V., Dzyuba, O.S., Urman, O.S., Yazikova, O.V., Luchinina, V.A., Zamirailova, A.G., Fomin, A.N., 2006. Biofacies of Upper Jurassic and Lower Cretaceous sediments of central West Siberia. Stratigr. Geol. Correl. 14(4), 418–432.

Yanin, B.T., 2001. The Volgian biota of the Central Russian sea. Paper 1. Major evolutionary tendencies. Vestn. Mosk. Univ., Ser. Geol. 5, 10–15.

Zakharov, V.A., Rogov, M.A., Dzyuba, O.S., Žák, K., Košťák, M., Pruner, P., Skupien, P., Chadima, M., Mazuch, M., Nikitenko, B.L., 2014. Palaeoenvironments and palaeoceanography changes across the Jurassic/Cretaceous boundary in the Arctic realm: case study of the Nordvik section (north Siberia, Russia). Polar Res. 33, 19714.

Buchia associations and interregional correlation of the Jurassic–Cretaceous boundary interval in Russian Boreal basins: new data from the Russian platform, Siberia, and the Far East

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Bivalves attributed to the genus *Buchia* (Buchiidae) are widely used in the Upper Jurassic–Lower Cretaceous biostratigraphy of Boreal and adjacent areas. A eurybionticity of representatives of the Buchia determined the similarity of their association in various facial sections of the Jurassic–Cretaceous boundary interval for different biogeographic areas of Boreal paleobasins (Zakharov, 1981). It is evident that the precise position of the Jurassic–Cretaceous boundary, determined in the Tethyan section, will never be determined in Boreal sections (Shurygin and Dzyuba, 2015). The problem of identification of this level in Boreal sections can be solved only using a combination of data obtained by paleontological and nonpaleontological methods of stratigraphy. The magnetostratigraphic calibration of the *Buchia* succession was recently proposed for the Jurassic–Cretaceous boundary interval on the base of material from northern Siberia (Bragin et al., 2013) and Central Russia (Baraboshkin et al., 2016).

In Central Russia, abundant bivalves from the Middle Volgian–Ryazanian of the Kashpir section (Middle Volga Basin) as well as from the Ryazanian of the Nikitino, Durnenki and Chernaya Rechka sections (Oka River Basin) have been preliminary studied (Dzyuba et al., 2015; Urman et al., 2016). Bivalve assemblages are mainly represented by both typically Boreal and Subboreal forms. The following beds and zones based on *Buchia* are traced in Central Russia: *B. russiensis-mosquensis* Beds, *B. terebratuloides* Zone, *B. obliqua* Zone, *B. unschensis* Zone, *B. volgensis* Zone, *B. okensis* Zone, *B. jasikovi* Zone, and *B. tolmatschowi* Zone. In general, this buchiid succession repeats that of the Boreal standard (Zakharov et al., 1997; Nikitenko et al., 2013).

Buchiids are numerous in the Komsomolsk Group of the Northern Sikhote-Alin (Russian Far East), and we studied them in the key section at right bank of the Amur River opposite to Komsomolsk-on-Amur (Urman et al., 2014). The analysis of stratigraphic distribution of buchiids in the Upper Volgian–Lower Valanginian deposits allowed us to reveal the sequence of *Buchia*-bearing beds: this is well correlated with the *Buchia* zonal scales of many Boreal regions. Here, from the base upward, there have been recognized the following: *Buchia terebratuloides* Beds, *B. unschensis* & *B. terebratuloides* Beds, *B. volgensis* Beds, and *B. inflata* & *B. keyserlingi* Beds. The *B. unschensis* & *B. terebratuloides* Beds also yielded the Berriasian ammonite *Pseudosubplanites*? sp. of Tethyan affinity. Judging by finds of *Pseudosubplanites* cf. *grandis*, *P.* aff. *combesi* and *Berriasella* ex gr. *jacobi* in the Southern Primorye (Sey and Kalacheva, 1999), the penetration of Tethyan ammonites up to the

Northern Sikhote-Alin latitudes is more likely in the Jacobi–Grandis phases. Earlier, in the uppermost part of the Komsomolsk section, Kalacheva (Sey and Kalacheva, 1999) determined the Valanginian ammonite *Sarasinella* cf. *varians*, which was considered by Kalinin (2006) as representative of the genus *Kilianella*. The obtained paleontological data permit us to refine the age spans of the local stratigraphic units.

Our investigation allowed us to produce a more detailed *Buchia* scale for the regional stratigraphic schemes of the Russian Platform and the Russian Far East in the Jurassic–Cretaceous boundary interval, and to correlate these schemes with bio- and magnetostratigraphic zonations of Siberia.

References

Baraboshkin, E.Yu., Rogov, M.A., Guzhikov, A.Yu., Dzyuba, O.S., Urman, O.S., Shurygin, B.N., Pestchevitskaya, E.B., Manikin, A.G., 2016. Kashpir section (Volga River, Russia), the proposed auxiliary section for the J/K interval in Subboreal Realm, in: Michalík, J., Fekete, K. (Eds.), XIIth Jurassica Conference. Workshop of the ICS Berriasian Group and IGCP 632 (Smolenice, Slovakia): Field Trip Guide and Abstr. Book. Bratislava, pp. 109–112.

Bragin, V.Yu., Dzyuba, O.S., Kazansky, A.Yu., Shurygin, B.N., 2013. New data on the magnetostratigraphy of the Jurassic–Cretaceous boundary interval, Nordvik Peninsula (northern East Siberia). Russ. Geol. Geophys. 54, 329–342.

Dzyuba, O.S., Urman, O.S., Shurygin, B.N., 2015. Belemnites and bivalves from the Jurassic–Cretaceous boundary interval of the Kashpir section, Middle Volga Basin, Russia: Implications for biostratigraphy and Panboreal correlation, in: Baraboshkin, E.Yu., Bykov, D.E. (Resp. Eds.), The International Scientific Conference on the Jurassic/Cretaceous boundary, Samara: Proc. volume. Kassandra, Togliatti, pp. 36–41.

Kalinin, E.A., 2006. Beds with *Buchia* in the Jurassic–Lower Cretaceous sequence along the Amur River (Khabarovsk Krai) and their correlation with the Boreal zonal standard, in: Paleontology, Biostratigraphy, and Paleogeography of the Boreal Mesozoic. GEO, Novosibirsk, pp. 93–97 (in Russian).

Nikitenko, B.L., Shurygin, B.N., Knyazev, V.G., Meledina, S.V., Dzyuba, O.S., Lebedeva, N.K., Peshchevitskaya, E.B., Glinskikh, L.A., Goryacheva, A.A., Khafaeva, S.N., 2013. Jurassic and Cretaceous stratigraphy of the Anabar area (Arctic Siberia, Laptev Sea coast) and the Boreal zonal standard. Russ. Geol. Geophys. 54, 808–837.

Sey, I.I., Kalacheva, E.D., 1999. Early Cretaceous ammonites of the Sikhote Alin system and their biostratigraphic and biogeographical significance. Tikhookean. Geol. 18(6), 83–92 (in Russian).

Shurygin, B.N., Dzyuba, O.S., 2015. The Jurassic/Cretaceous boundary in northern Siberia and Boreal–Tethyan correlation of the boundary beds. Russ. Geol. Geophys. 56, 652–662.

Urman, O.S., Dzyuba, O.S., Kirillova, G.L., Shurygin, B.N., 2014. Buchia faunas and biostratigraphy of the Jurassic–Cretaceous boundary deposits in the Komsomolsk section (Russian Far East). Russ. J. Pac. Geol. 8(5), 346–359.

Urman, O.S., Shurygin, B.N., Dzyuba, O.S., 2016. New data on buchias and belemnites from the Ryazanian of the Oka River Basin (Central Russia), in: Baraboshkin, E.Yu. (Ed.), Cretaceous system of Russia and CIS countries: problems of stratigraphy and paleogeography: Proceedings. Chernomorpress Publishing House, Simferopol, pp. 279–281 (in Russian).

Zakharov, V.A., Bogomolov, Yu.I., Il'ina, V.I., Konstantinov, A.G., Kurushin, N.I., Lebedeva, N.K., Meledina, S.V., Nikitenko, B.L., Sobolev, E.S., Shurygin, B.N., 1997. Boreal zonal standard and biostratigraphy of the Siberian Mesozoic. Russ. Geol. Geophys. 38, 965–993.

Zakharov, V. A., 1981. Buchiids and Biostratigraphy of the Boreal Upper Jurassic and Neocomian. Nauka, Moscow (in Russian).

CLMTV cooperation and compilation of the Jurassic and Cretaceous Mapping

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Coal-forming Plants of The Early Cretaceous kuti formation (South-eastern Transbaikalia, Russia)

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Abstract

The Lower Cretaceous deposits of the south-eastern Transbaikalia are widely distributed, filling the riftogenic depressions of the Transbaikalian type. The Lower Cretaceous is divided into the Turga and Kuti formations. The former stratigraphic unit includes the volcanic-sedimentary rocks. The volcanites refer to an andesite-basalt series. The Kuti Formation overlies the Turga Formation in the marginal parts of the basins with unconformity, in the central parts – with gradual transitions. The Kuti Formation is represented by the coal-bearing alluvial-lacustrine and swamp sediments. These rocks are facially replaced by coarse detrital proluvial deposits to marginal areas of basins. Brown coals are distributed mainly in the upper part of the Kuti Formation; where up to 27 coal seams occur having thickness from 0.3 to 5.3 m, sometimes up to 22 m.

The Turga-Kharanor Basin is located in the southeastern part of Transbaikalia. Its sedimentary cover includes the volcanic-sedimentary Turga Formation, overlain by the coal-bearing Kuti Formation. The thickness of the first reaches 1100 m. The Kuti Formation is subdivided into two subformations; the lower one of which is characterized by a different interbeddings of sandstones, siltstones and mudstones with rare layers of gravel sandstones, conglomerates, and conglomerate breccias. An admixture of coal detritus is characteristic for sediments, rather often coaly mudstones and brown coals (2-6 m) occur. The thickness of the subformation is variable and reaches 500 m. The Upper Kuti subformation is composed of often alternating aleuritic sandstones and siltstones with interlayers and lenses of siderites, mudstones, gravelites. This part of the section contains numerous coal beds often having considerable thickness (from the first meters to 49 m). The thickness of the Upper Kuti subformation is 300-400 m.

The coal-bearing strata is a complex paragenetic series of lacustrine, swamp, alluvial and proluvial facies, often sharply variable and replacing each other both vertically and laterally. The clastic beds of the Kuti Formation are polymictic or oligomictic. The cement of rocks is represented by kaolinite, montmorillonite with an admixture of hydromica, silica, carbonates (siderite, calcite, dolomite, ankerite). The stratification in coarse-grained clastic rocks is wavy, lenticular, oblique, in fine-grained clastic rocks - horizontally laminated. The rocks are weakly cemented and diagenised.

For the Kuti Formation the Early Cretaceous palynological assemblage with angiosperm pollen *Asteropollis asteroides* Hedlund et Norris was obtained. It was revealed

diverse paleontological remains here: bivalves *Limnocyrena ovalis* (Rammelmeier), *L. hupehensis* (Grabau), *Unio obrutschewi* Martinson, insects, such as caddisflies *Folindusia* sp., *Terrindusia* sp. We found the fossil plants *Nilssoniopteris* aff. *prynadae* Samylina, *Ginkgo manchurica* (Yabe et Oishi) Meng et Chen, *Sphenobaiera* cf. *starukhiniae* Bugd., *Pseudotorellia kharanorica* Bugdaeva, *Tomharrisia* sp.A, *Pagiophyllum* sp., *Pityophyllum* sp., *Pityospermum* sp., *Pityostrobus* sp. (Bugdaeva, 1992, 1995).

We studied the coals sampled from the Kharanor Coal Mine and Urtuy Coal Mine located in the south-eastern Transbaikalia. The latter is situated in East Urulyunguy Basin, 10 km north of the city of Krasnokamensk. The Kuti Formation developed in this basin contains several coal seams, the thickest of which is the coal seam “Moshchny” having thickness 6-60 m. The Kharanor Coal Mine is located in Turga-Kharanor Basin, 260 km south-west of Chita city. The upper horizon of the coal layers of the Kuti Formation has up to 20 coal seams. The main coal seam is the "Novy I"; its thickness reaches 49 m, in the southeastern part of basin it is split into the strata "Novy 1-A" (thickness is about 13 m) and "Novy 1-B" (the coal bed mainly has a thickness of 17-22 m, and only in the southwestern part of mine reduced to 6-10 m). The coal seam "Novy II" (8.3 m) lies above. The thickness of the uppermost coal seam "Novy III" is unstable, and this coal bed has no industrial significance.

In 2018 the geologist of the Kharanor Coal Mine O.D. Gilfanova sent us the samples of coals from the "Novy" coal seam. After chemical maceration of the coals with the use of nitric acid and alkali, dispersed cuticles of the following plants were obtained. The coal bed "Novy 1-A" contains the remains of plants *Pseudotorellia* sp. A, *Elatides* sp. A, Czekanowskiales? sp. indet., Cheirolepidiaceae? sp. indet., coal bed "Novy III-A" - *Nilssoniopteris* aff. *prynadae* Samyl. (Table I, figs. 4-5), *Pseudotorellia kharanorica* (Table I, fig. 7), *Elatides* cf. *zhoui* Shi, Leslie, Herendeen, Ichinnorov, Takahashi, Knopf et Crane; coal bed "Novy III-B" – *N.* aff. *prynadae*, *P. kharanorica*, *Arctopitys* sp. A (Table I, Figures 8-12), *Pagiophyllum* sp. (Table I, fig. 6), *E.* cf. *zhoui*.

In 2018 the geologists of the Urtuy Coal Mine S.V. Chikov and N.V. Ovcharenko sent us the samples of coals from the "Moshchny" coal seam. We revealed that *Pseudotorellia* sp. A (Table I, fig. 1-2), *Elatides* sp. A (Table I, fig. 3) formed this coal.

Thus, the main coal-forming plants of the "Novy" coal seam of the Kharanor Coal Mine are representatives of the bennettites *Nilssoniopteris* aff. *prynadae*, ancient ginkgoalean *Pseudotorellia*, conifers *Elatides* sp. A, *E.* cf. *zhoui*, *Arctopitys* sp. A, *Pagiophyllum* sp. The plant communities of slopes consisted of ginkgoalean *Ginkgo manchurica*, *Tomharrisia* sp. A, and also plants having affinity with Pinaceae.

The main coal-forming plants of the "Moshchny" coal seam are *Pseudotorellia* and *Elatides*.

The significant role in the swamp vegetation played the ginkgoaleans and conifers, next in importance were bennettites. Also the share in buried phytomass of the ferns (based on palynological analysis) was very high.

Acknowledgments

The authors are grateful to geologist of the Kharanor Coal Mine O.D. Gilfanova and geologists S.V. Chikov and N.V. Ovcharenko of the Urtuy Coal Mine (Transbaikalian Region), to N.P. Domra (Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of Russian Academy of Sciences) for processing of the palynological samples. Our research was supported by Russian Foundation for Basic Research (grant 17-04-01582).

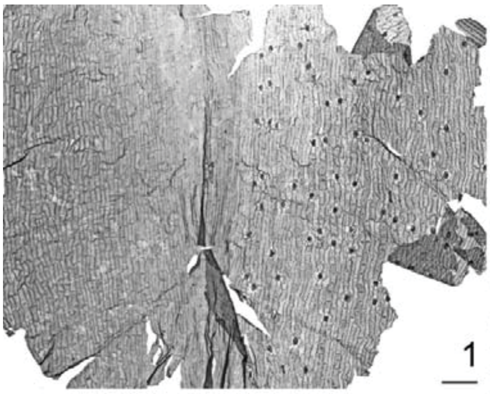
References

Bugdaeva E.V. The Early Cretaceous flora of Transbaikalia // In: Aspects of non-marine Cretaceous geology, (Eds.: N. Mateer, Chen P.-J.). Beijing: Ocean Press, China, 1992. P. 193-199.

Bugdaeva E.V. Pseudotorellia from the Lower Cretaceous coal-bearing deposits of Eastern Transbaikalia // Paleontological Journal. 1995. Vol. 29, N 1A. P. 182-184.

Table I. The coal-forming plants of the Early Cretaceous Kuti formation (South-eastern Transbaikalia, Russia)

Captions: figs. 1-2 – ginkgoalean Pseudotorellia sp. A., Urtuy Coal Mine, coal seam “M”, 1 – leaf, lower and upper cuticle, SEM, scale bar 200 μ; 2 – two stomata on the lower cuticle, scale bar 10 μ; fig. 3 – conifer Elatides sp.A, Urtuy Coal Mine, coal seam “M”, stomatal band, scale bar 200 μ; fig. 4-5 – bennettite Nilssoniopteris aff. prynadae Samyl., Kharanor Coal Mine, coal seam «Novy III-B», 4 – lower cuticle of leaf, costal and intercostals zones, scale bar 100 μ; 5 – stoma, SEM, scale bar 10 μ; fig. 6 – conifer Pagiophyllum sp., Kharanor Coal Mine, coal seam «Novy III-B», stomata, scale bar 100 μ; fig. 7 – ginkgoalean Pseudotorellia kharanorica Bugd., stoma, SEM, Kharanor Coal Mine, coal seam «Novy III-B», scale bar 10 μ; figs. 8-12 – conifer Arctopitys sp. A, Kharanor Coal Mine, coal seam «Novy III-B», 8 - leaf, scale bar 1 mm; 9 – groove with stomata bordered by papillae, scale bar 100 μ; 10 - two stomata, one of them is destroyed, SEM, scale bar 10 μ, 11 - groove with stomata bordered by papillae, SEM, scale bar 20 μ, 12 - lower part of leaf, in its upper part the groove with papillae, scale bar 100 μ.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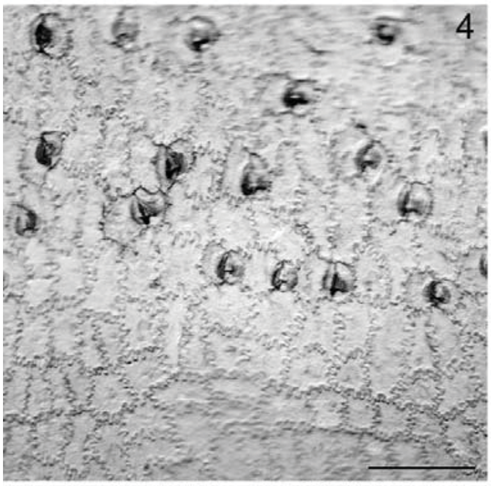
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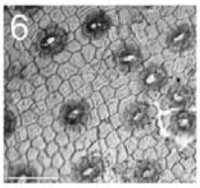
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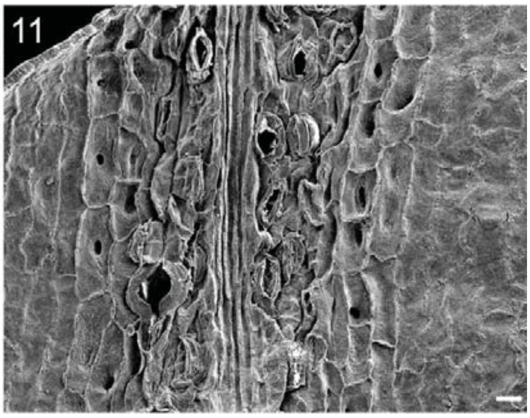
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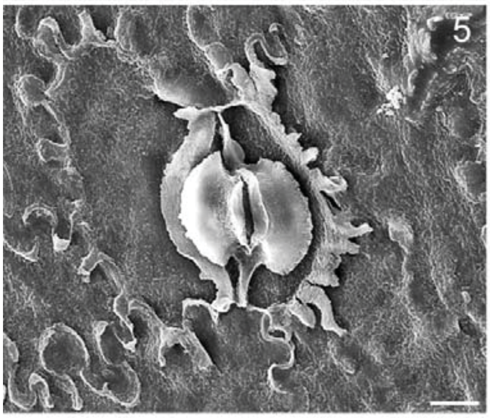
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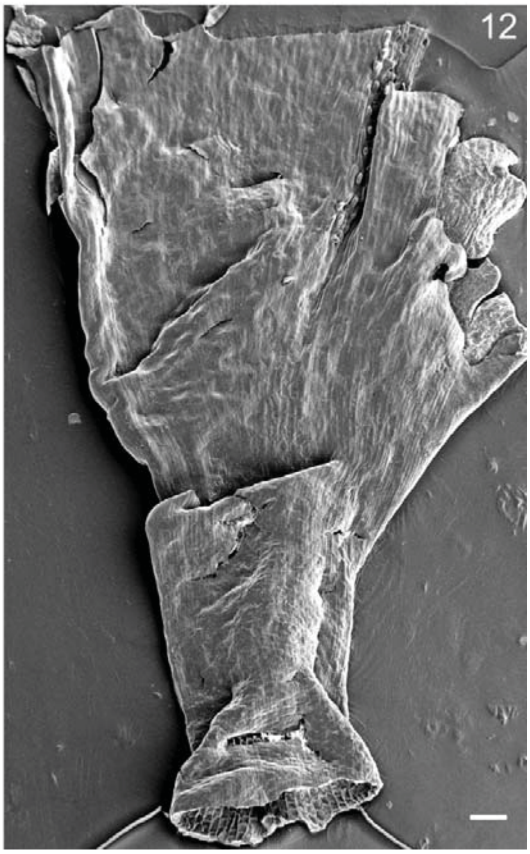
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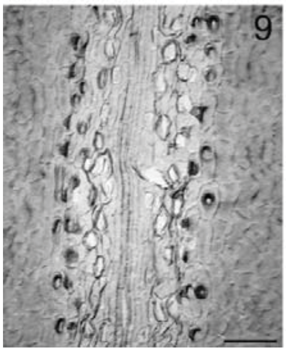
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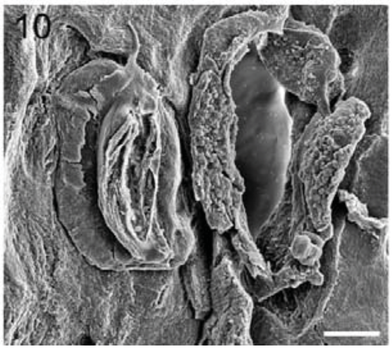
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Cretaceous Formation of part of East coast of India

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Abstract

The Cretaceous period was one of the most eventful time –spans in the Indian geological history. The study area occupied one of the important palaeogeographical locations in Indo-Pacific region during the Cretaceous period. The marine transgression and regression sedimentary sequences of the study area have acted as repositories for the accumulation of varying litho-units with rich faunal and floral assemblages and are more helpful in the inter-regional correlation of the Indo-Pacific region. Based on their distribution, tectonic setting and geographical position, the Indian Cretaceous basins have been grouped as follows: i) East Coast Basin, ii) Narmada Trough and Lameta Basin, iii) Kutch Shelf, iv) Jaiselmer Shelf, v) Bengal-Assam Basin, vi) Basins of the Himalayan belt and vii) Basins of the Indo Burma-Andaman . The East Coast basin consists of the Cauvery, Palar, Krishna-Godaveri and Mahanadi basins. The Cretaceous succession in Cauvery, Palar and KrishnaGodaveri together from South Indian Cretaceous. Of these geographic areas, the outcrop exposed in the vicinity of the Tiruchirapalli area is the largest one. The deep wells drilled for exploratory purpose by ONGC in the different parts of the basin indicate that the thickness of the sedimentary rocks is nearly 4 to 6 km thick which is ranging from Early Cretaceous to Recent age .The study also reveals the two third sedimentary sequences were deposited in the Cretaceous time. The paper attempts to deal with the economic importance of hydrocarbon deposits, mineral wealth etc., of the Cretaceous Basins of part of East Coast of India .

Depositional environment of Lower Cretaceous lacustrine sedimentary rocks in Central Mongolia

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Abstract

The depositional environment of Cretaceous sedimentary facies in Mongolia is poorly known and only few studies have been published so far (Traynor and Sladen, 1995; Sladen and Traynor, 2000; Yamamoto et al., 1998; Johnson et al., 2003; Hasegawa et al., 2018). Thus, 43 samples of Lower Cretaceous lacustrine oil shale were collected from 9 locations in Central Mongolia to improve understanding of their depositional environment as well as petroleum potential. Most of the samples are taken from outcrops of oil shale seams and intercalated carbonate layers, but also include 17 core samples from a borehole.

Total organic carbon (TOC) content and rock-Eval pyrolysis of the samples were performed using Rock-Eval 6 instrument equipped with TOC module. Organic carbon and total nitrogen isotopic compositions were analyzed using a stable isotope ratio mass spectrometer system with element analyzer (Vision-EA, IsoPrime, UK). Based on the results of bulk geochemical analysis (Rock-Eval), 7 oil shale samples were selected for biomarker analysis. The GCMS analyses were conducted with a Thermo Scientific Trace 1310 GC system coupled to a Thermo Scientific ISQ single quadrupole mass spectrometer.

Results indicate that Lower Cretaceous oil shale samples have highly oil prone type I kerogen, emphasized by high TOC (avg.10.1 %), S2 (68.7 mgHC/g rock) and HI (avg. 619 mgHC/g TOC). Organic matter (OM) in oil shales is accumulated in stratified lakes with anoxic bottom water, reflected by low Pr/Ph ratios (<0.28) and highly negative $\delta^{13}C_{org}$ (avg. -30.6‰) and highly positive $\delta^{15}N_t$ (avg. +10.5‰) values. The salinity of lakes was different, suggested by variable gammacerane index ranging from 0.03 to 0.44. In studied oil shale, aquatic plant was dominant OM source (0.42 to 0.7 of nC_{21-25}) with contribution from algae and land plant derived OM.

Early Cretaceous lakes in eastern Mongolia were developed in small discrete rift basins and there were minor differences among the basins, e.g., sedimentation rate etc. (Sladen and Traynor, 2000), and the lakes repeatedly expanded and contracted during rifting (Graham et al., 2001; Johnson et al., 2003). Because of its smaller size and instability, salinity, redox condition and OM input type in lake was changed easily and therefore variable among the lakes. The depositional environment of oil shale forming lakes in Central Mongolia was

similar to that of paleolakes in eastern and southeastern Mongolia as well as Erlain basin in China (Yamamoto et al., 1998; Johnson et al., 2003; Chen et al., 2014).

References

Chen, Z., Liu, G., Huang, Z., Lu, X., Luo, Q., Ding, X., 2014. Controls of oil family distribution and composition in nonmarine petroleum systems: a case study from Inner Mongolia Erlian Basin, Northern China. Journal of Asian Earth Sciences 92, 36-52

Graham et al., 2001. Graham, S.A., Hendrix, M.S., Johnson, C.L., Badamgarav,D., Badarch, G., Amory, J., Porter,M., Barsbold, R., Webb, L.E., Hacker, B.R., 2001. Sedimentary record and tectonic implications of Mesozoic rifting in Southeast Mongolia. Geological Society of America Bulletin 113, 1560–1579.

Johnson, C.L., Greene, T.J., Zinniker, D.A., Moldowan, J.M., Hendrix, M.S., Carroll, A.R., 2003. Geochemical characteristics and correlation of oil and nonmarine source rocks from Mongolia. AAPG Bulletin 87, 817–846.

Traynor, J.J., Sladen, C., 1995. Tectonic and stratigraphic evolution of the Mongolian People's Republic and its influence on hydrocarbon geology and potential. Marine and Petroleum Geology 12, 35–52.

Sladen, C., Traynor, J.J., 2000. Lakes during the evolution of Mongolia. In: Gierlowski-Kordesch, E.H. and Kelts, K.P. (Eds.), Lake basin through space and time: AAPG Studies in Geology 46, pp. 35-57.

Yamamoto, M., Bat-Erdene, D., Ulziihutag, P., Watanabe, Y., Imai, N., Kajiwara, Y., Takeda, N., Nakajima, T., 1998. Organic geochemistry and palynology of Lower cretaceous Zuunbayan oil shales, Mongolia. Geological Survey of Japan Bulletin 49, 257–274.

Hasegawa, H., Ando, H., Hasebe, N., Ichinnorov, N., Ohta, T., Hasegawa, T., Yamamoto, M., Li, G., Erdenetsogt, B., Heimhofer, U., Murata, T., Shinya, H., Enerel, G., Oyunjargal, G., Munkhtsetseg, O., Buyantegsh, B., Enkhbat, D., Suzuki, N., Irino, T., Yamamoto, K., Kouchi, Y., Orihashi, Y. (2018) Chronostratigraphy of the Jurassic–Cretaceous lacustrine deposits in southeast Mongolia. Island Arc 27, e12243. DOI: 10.1111/iar.12243

Depositional processes and transport mechanism of upper Ullyonsan Conglomerates in the Cretaceous Yeongyang Subbasin of Gyeongsang Sedimentary Basin, Korea

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Abstract

The sedimentary rocks of the Cretaceous sedimentary basins located in the southeastern part of the Korean Peninsula were analyzed by sedimentological study and the dynamic characteristics of sediment gravity flows. The clastic sedimentary rocks of the Ullyonsan Formation are mainly composed of conglomerate and sandstone. In particular, the upper sedimentary rocks are composed of reddish pebbly sandstone layers and conglomerate layers repeatedly and boulder-size clasts constituting the conglomerate have angular roundness and are larger than 1m in diameter. It is presumed that these conglomerates are formed while the sediments move and are accumulated in a short time at the source area adjacent to the fault scarp. Detailed sketches of the sedimentary rocks were drawn to understand the sedimentary structure, size, shape, composition, particle contact, geometry and size of the sedimentary rocks. The dynamic characteristics and the sedimentation process of gravity flow are interpreted based on the field data of conglomerate and sandstone layers. The conglomerate layer composed of cobble to boulder size clast was formed by high density fluids showing the dynamic characteristics of cohesionless debris flow carrying and depositing coarse sediments. The pebbly sandstone and conglomerate layer composed of pebble size clast was considered to be formed by transporting and depositing sediments by high density fluid showing dynamic characteristics of normal stream flows. Due to the characteristics of the proximal part of an alluvial fan, the continuous migration of the channels occurred. High-density fluids flowing in these channels are supposed to have the sediment content of a range of about 20-60% and continually experience changes in velocity, density, viscosity, and fluidity depending on time and space. Also it is believed that the dynamical characteristics similar to high-concentration turbidity current should change into the normal stream flow, and finally into the cohesionless debris flow as the flow velocity decreases.

Keywords : Proximal alluvial fan, normal stream flow, cohesionless debris flow, high density fluid, landslide

Detrital zircon U-Pb and radiolarian biostratigraphy in the Tethys Himalaya, southern Tibet: Constraints on the Timing of Initial Indian-Asia Collision

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Abstract

Upper Cretaceous to Eocene marine sedimentary sequences which consist of Asian-margin strata of the Gangdese arc and Indian-margin strata of the northern Tethys Himalaya provide constraints on the initial India-Asia collision and the closure time of the Neo-Tethys Ocean. We report sedimentological, petrographic, biostratigraphic and geochemical data on Cretaceous to Paleogene strata in the Beijia area, near Gyangze, located along the Yarlung-Zangbo Suture Zone in southern Tibet. Abundant radiolarian fossils were obtained from the Zongzhuo Formation andSeventy-three species of fifty genera were identified and assigned as follows: *Thanarla pulchra-Holocrytocanium barbui*, *Pseudoeucyrtis spinose*, *Dictyomitra formosa*, *D. koslovae* and *Amphipyndax pseudoconulus* the late Cretaceous Zones, and *Buryella tetradica* and *Bekoma campechensis* the late Paleocene zones. The late Paleocene Radiolarian zones from this succession can be compared with the radiolarian zones RP5 and RP6 in New Zealand, indicating a time interval of 61.5-55.5 Ma. The sandstones of Upper Cretaceous to Eocene Zongzhuo Formation and Beijia conglomerateare dominated by zircons younger than 200 Ma, showing a major peak at 76-134 Ma, comparable to those from the Gangdese arc. By contrast, the Lower Cretaceous Gyabula Formation is dominated by detrital zircons with Archean to Cambrian U-Pb ages, which we interpret to be derived from the Indian continent. The change in sedimentary provenance between the Gyabula and Zongzhuo formations from the southern Indian continent to the northern Gangdese arc and the radiolarian fauna in the Zongzhuo Formation denote the initiation of India-Asia collision occurred no later than 55.5 Ma.

Key words: India-Asia collision, Tethys Himalaya, Radiolarian, provenance analysis, detrital zircons

Acknowledgements

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References

Aitchison, J.C., Badengzhu, Davis, A.M., Liu, J.B., Luo, H., Malpas, J.G., McDermid, I.R.C., Wu, H.Y., Ziabrev, S.V., Zhou, M.F., 2000. Remnants of a Cretaceous intra-oceanic subduction system within the Yarlung-Zangbo suture (southern Tibet). Earth Planet. Sci.Lett. 183, 231–244.

Aitchison, J.C., Ali, J.R., Davis, A.M., 2007a. When and where did India and Asia collide? J.Geophys. Res. 112, B05423 doi: 10.1029/2006JB004706.

Ding, L., Kapp, P., Wan, X., 2005. Paleocene–Eocene record of ophilite obduction andinitial India–Asian collision, south central Tibet. Tectonics 24. doi:10.1029/2004TC001729 TC3001.

Li, G.B., Jiang, G.Q., Hu, X.M., Wan, X.Q., 2009a. New biostratigraphic data from the Cretaceous Bolinxiala Formation in Zanda, southwestern Tibet of China andtheir paleogeographic and paleoceanographic implications. Cretaceous Res.30, 1005–1018.

Li, G.B., Jiang, G.Q., Wan, X.Q., 2011. The age of the Chuangde Formation in Kangmar, southern Tibet of China: implications for the origin of Cretaceous oceanic red beds (CORBs) in the northern Tethyan Himalaya. Sed. Geol. 235, 111–121.

Li, G.B., Wan, X.Q., Liu, W.C., Bucher, H., Li, H.S., Goudemand, N., 2009b. A new Cretaceous age for the Saiqu “mélange”, southern Tibet, evidence from radiolaria.Cretaceous Res. 30, 35–40.

Li, G.B., Wan, X.X., Liu, W.C., Liang, D.Y., Hyesu, Y., 2005a. Discovery of Paleogene marine stratum along the southern side of Yarlung–Zangbo suture zone and its implications in tectonics. Sci. China, Ser. D. 48, 647–661.

Dinoflagellate cyst Biostratigraphy of Eocene in Duina, Yadong, Tibet, China

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Abstract

The Tibetan Plateau located in the southern part of the Asian continent and known as the "roof of the world" and the "third pole" was caused by the collision between the India plate and the Asian plate. The uplift of the Himalayas and the Qinghai-Tibet Plateau has had a profound impact on the changes in global geology, geochemistry and climate, so Chinese and foreign scholars have paid great attention to the collision between the Eurasian plate and the Indian plate. But there is still a lot of controversy about the starting time of the collision. The study of the closing time of the Tethys Ocean can provide the most direct constraint for the start time of the collision between the Eurasian plate and the Indian plate. The era of the highest marine strata in the region represents the time of the closure and the full collision of the Tethys.

In China, most of the Paleogene strata are continental sedimentary, and the marine paleoclimatic strata are only developed in Tibet, Xinjiang and parts of Taiwan. The southern part of the continent preserved a continuous marine paleocene to the Eocene strata, which are rich in fossils and can be used for stratigraphic division and contrast. A set of well-preserved Eocene marine strata developed in the East Asia Basin, which is rich in large amounts of sporopollen and dinoflagellate fossils. This paper focuses on the detailed study and identification of the fossils of the Eocene strata in the stacked reservoir, which 88 species of 63 dinoflagellate genus are identified and 4 assemblage zones are recognized as follows (Fig.1): *Apteodinium donghaiense - Apteodinium rohmbiforme, Chalesdowniea rhombiodalis - Hystrichokolpoma salacia*, *Membranilarnacia variata - Wetzeliella xinjian* and *Cleistosphaeridium shandongense - Luxadinium elongatum* assemblage zones. Based on the research and analysis of the fossils in the reservoir, it is concluded that the sedimentary period of the sandstone shale section of the study area can reach the late Eocene.

Key words: Eocene, Tethys, Dinoflagellate, Biostratigraphy, Yadong, Duina

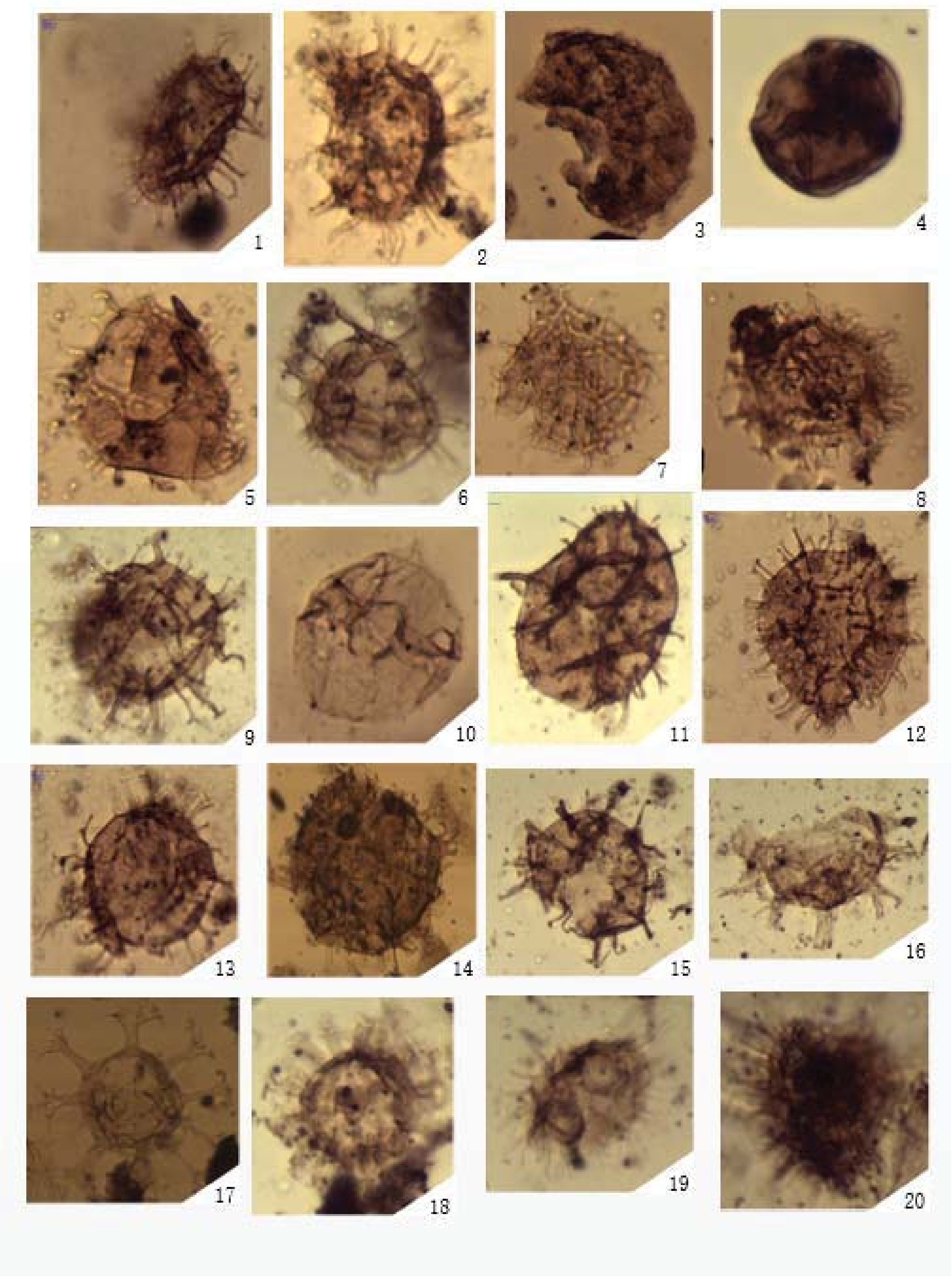

Fig.1 Represent elements of Eocence dinoflagellate assemblage in Duina, Tibet (Scale: x 400)

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References

Erica M. C., Pi Suhr Willumsen, Denise K. K.. 2014. A revised Paleocene (Teurian) dinoflagellate cyst zonation from eastern New Zealand. Review of Palaeobotany and Palynology, 202: 47–79.

Hamid Slimani, Koré Élysée Guédé, Graham L.Williams. 2016. Campanian to Eocene dino flagellate cyst biostratigraphy from the Tahar and Sekada sections at Arba Ayacha, western External Rif, Morocco. Review of Palaeobotany and Palynology, 228: 26–46.

Hiroshi Kurita. 2004. Paleogene dinoflagellate cyst biostratigraphy of northern Japan. Micropaleontology, 50 (suppl. no. 2): 2004.

Li, G.B., Wan, X.X., Liu, W.C., Liang, D.Y., Hyesu, Y., 2005a. Discovery of Paleogene marine stratum along the southern side of Yarlung–Zangbo suture zone and its implications in tectonics. Sci. China, Ser. D. 48, 647–661.

Distribution of Charophytes in the lower Cretaceous of the lake basins in Mongolia and conditions of their growth

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Abstract

Introduction: Currently factual and literature data on charophytes have been accumulated which allow to trace their development within the vast territory of Mongolia and neighboring areas of Middle and Central Asia since the Late Mesozoic till present days.

Results: During the Early Cretaceous for the territory of Mongolia characterized development of the extensive lake basins and humid climatic conditions.

Despite the extensive lacustrine basins of Lower Cretaceous in Mongolia, the Charophytes are found irregularly.

Lower Cretaceous

In the Neocomian (Hauterivian-Barremian) deposits of Charophytes were found in vicinity of Lake Ogii nuur and Bakhar (fig. 1.2.3) the Central Mongolia (**Shinekhudag Formation**). Among them are *Aclistochara caii Wang, Raskyella sp. Mesochara sp.. Aclistochara caii Wang* are known from the Lower Cretaceous sediments of China.

The Aptian-Albian (**Khokhteeg Formation**) assemblage of Charophytes is *Atopochara trivolvis Peck, Mesochara voluta (Peck) Shaikin, M. tuzsoni Rasky, M. tarica Kyansep-Rom., M. sainshandinica Kyansep-Rom., Mesochara sp., Aclistochara caii Wang, A. aff. lata Peck, Flabellochara aff. harrisi (Peck) Grambast, Flabellochara sp., Raskyella sp., Praechara sp., Porochara sp., Sphaerochara verticilata (Peck) Horn af Rantzien*. Charophytes were found in the Western and Central Mongolia, Southern Gobi and South - East Gobi.

Aclistochara lata, Flabellochara harrisi, Sphaerochara verticilata, Atopochara trivolvis are known from the Aptian sediments of North America (Peck, 1938a, 1938b, 1957) and Aptian-Albian sediments of Asia, Europe (N.P.Kyansep-Romashkina, 1967, 1969, 1974; Rasky, 1941, 1945, 1958; Prosnyakova, Shaikin, 1969). *Mesochara tarica* are known from the Aptian sediments of Fergana (Uzbekstan) (N.P.Kyansep-Romashkina, 1974). *Mesochara voluta* (Peck) Shaikin are known from the Aptian-Albian sediments of North America (Peck, 1938a, 1938b, 1957) and from the Upper Jurassic sediments of Donbassa and from the Lower Cretaceous sediments of Moldava and Krima. *Mesochara tuzsoni* are known from the Aptian sediments of Hungaria.

The Albian-Cenomanian (**Baruunbayan Formation**) assemblage of Charophytes: *Mesochara sainsandinica Kyansep-Rom., Mesochara tuzsoni Rasky, Atopochara trivolvis Peck*. Charophytes were found in the Southern Gobi and South - East Gobi.

Mesochara sainsandinica are known from the Aptian-Maastrichtian sediments of Southern Gobi and South - East Gobi.

The Lower Cretaceous deposits of the Mongolia are poor in fossils oogonia Charophytes. Lake basin was lightly salted waters, deep in the Lower Cretaceous, probably closed and more or less oligotrophic by its hydrology.

Keywords: Charophytes, Lower Cretaceous, Mongolia.

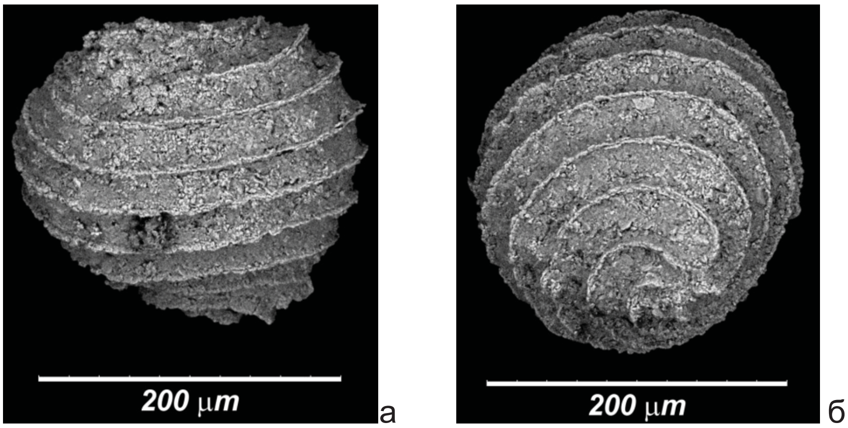

Fig. 1 Aclistochara caii а/ lateral view, б/ basal view

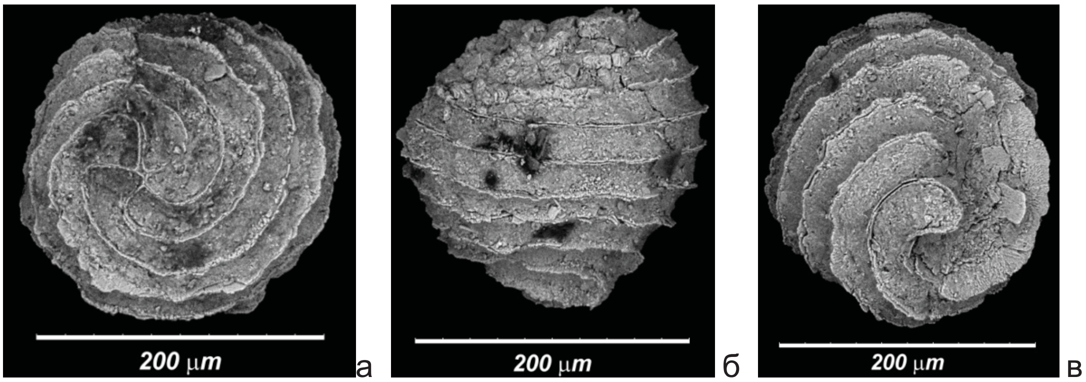

Fig. 2 Mesochara sp. төрөл а/ apical view б/ lateral view, в/ basal view

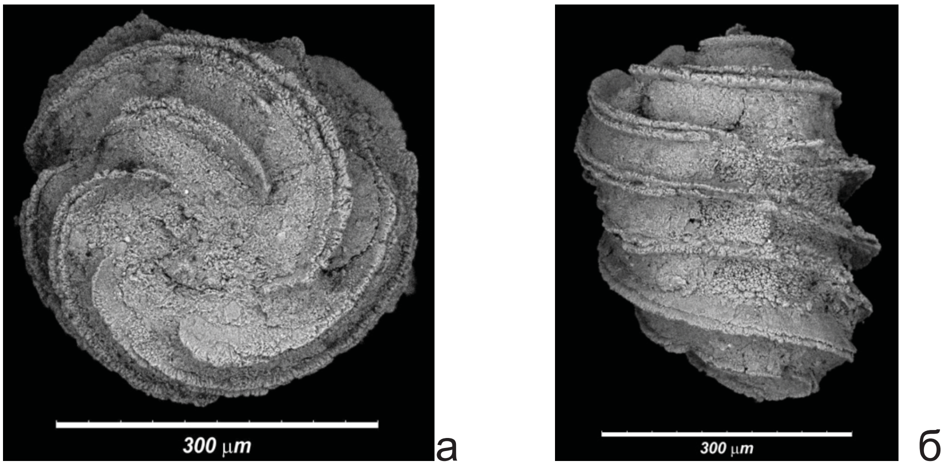

Fig. 3 Raskyella sp. төрөл а/ apical view, б/ lateral view

Reference

Barsbold R, Khand Yo. 2014. “Cretaceous of Mongolia” Second International Symposium of International Geoscience Programme (IGCP) Project 608. Abstract volume. P.127-130

Kyansep-Romashkina N.P. “Значение харовых водорслей для стратиграфий Мезозойских отложений Ферганы и палеолимнологических реконструкций“//The Problems of the study Ancient Lacustrine Basins in Eurasia. 1974. 21-37. In russian

Kyansep-Romashkina N.P. “Некоторые позднеюрские и меловые харофиты Монголии“//Joint Soviet-Mongolian Paleont. Exp.Transaction - 2. 1975, р. 181-204. In russian

Kyansep-Romashkina N.P. “Позднемеловые харовые водорсли из озерных отложений Монголии и Закавказья“//Limnobions of Ancient Lacustrine Basins in Eurasia, 1980. 71-90. In russian

Kyansep-Romashkina N.P. “Распространение харовых водорслей Мезозойских озерных бассейнах Монголии и условия их произрастания“// Mesozoic Lacustrine Basins in Mongolia. 1982. 158-180. In russian

Grambast L. Classification de l,embrachement des Charophytes. – Natur Monspeliensia, ser.bot., 1962, 14, 63-86

Grambast – Fessard N. Description de deux especes nouvelles d,Atopochara Peck (Clavatoraceae, Charophyta). – Geobios, 1980, N13, fasc. 1, Lyon, p.129-135

Horn af Rantzien H. Comparative studies of some modern, Cenozoic and Mesozoic charophyte fructifications. – Ibidem, 1959-1960, 5, 1, 1-17.

Peck R.E. A new family of Charophyta from the Lower Cretaceous of Texas. – J.Paleontol., 1938, 12, N1, p.173-176.

Peck R.E. North American mesozoic Charophyta. – U.S.Geol.Survey, Prof. Papers, 1957, N294-A, III, p.1-44.

Rasky K. Fossile Charophyten-Fruchtt aus Ungarn. – Ungar. Naturwiss. Mus., Naturwiss. Monogr., 1945, 2, S.1-74.

Wang Zhen. Cretaceous Charophytes from the Yangtze – Han River Basin with a note on the classification of Porocharaceae and Characeae. – Mem. Nanjing Inst.Geol.Paleont.Acad.Sinica, 1978, 9, 5, 61-88.

Facies and geochemical analysis for basin evolution of the late Cretaceous Neungju Basin, SW Korea – a preliminary study

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Abstract

During the Cretaceous, the East Asian continental margin including the Korean Peninsula was under a back-arc to intra-arc setting due to oblique subduction of the Izanagi Plate. Under an extensional/transtensional tectonic regime, more than 10 small basins were formed in the southwestern Korean Peninsula along the NE-SW-trending strike-slip fault systems. Although volcanic activities as well as climatic changes might strongly influence on the development of these basins, they have been less focused in previous studies. The Neungju Basin, the largest one of these basins, was deposited under alluvial to lacustrine environments, experiencing episodic volcanism. The basin-fill may provide a good opportunity to assess the roles of multiple controls including volcanic activities, climate change and tectonics for the development of the Cretaceous pull-apart basins in the Korean Peninsula. In this study, thus, facies and geochemical analyses were carried out to reconstruct basin development history and assess the controlling factors for the non-marine succession of the Neungju Basin.

As a preliminary result, we report facies transition and environmental changes for the sedimentary succession of the Neungju Basin. The entire basin-fill is subdivided into three stratigraphic intervals, representing temporal paleoenvironmental changes throughout the basin evolution. The lower interval is composed of distal alluvial fan facies. The alluvial fans were developed in hinterlands on the west, supplying sediments east- and southeast-ward. The middle interval is composed two regressive cycles, each showing an upward transition from marginal lake to sandflat facies. Volcaniclastic sediments occur at the bottoms of these regressive cycles, supplied from the south along the basin axis. The upper interval is composed of alluvial fan facies and shows a transition from distal to proximal alluvial fans. The deepening of the basin in the middle interval might be caused by increase in basin subsidence related to fault displacement, or climatic wetting and consequent increase of precipitation/evaporation ratio. The occurrence of volcaniclastic sediments before the deposition of marginal lake facies, however, suggests that crustal loading on the south induced by volcanic eruptions was more likely to cause flexural subsidence and the deepening. Further study will focus on petrographic and geochemical analyses of the non-marine sediments to constrain climatic changes and tectonic events during their deposition.

Flora of coal-bearing deposits of central Transbaikalia (Russia)

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Introduction

The Olon-Shibir Coal Mine is the main deposit in the Central Transbaikalia. This coal field is located in the north-eastern part of the Tugnuy Basin. From the north and the east, this basin is bordered by the Tsagan-Daban and Zagan ranges, in the south by the anticlinal fold of the Kapsal Mountain. The sedimentary sequence of Tugnuy Basin consists of volcanogenic Ichetuy Formation and coal-bearing Tugnuy Formation. The latter includes 22 coal seams; their total area is about 41 km^2. This stratigraphic unit is composed of normally-sedimentary, continental, alluvial-lacustrine-marshy sediments, mainly sandstones and siltstones, among which there are beds and lenses of coal. The thickness of the Tugnuy Formation in this coal field is about 150 m (Skoblo et al., 2001; Coal Base of Russia, 2001). The formation of peat bogs in the Early Tugnuy time was the result of the swamping of a vast lake occupied most of the basin. There were rivers that flowed into this lake from the southeastern side of the Tugnuy Basin. Basically peat accumulation took place in constantly swamping lakes of a wide river floodplain. The age of the Tugnuy Formation was proposed by V.M. Skoblo as the Middle Jurassic based on ostracods, conchostracans, and mollusks (Skoblo et al., 2001).

Material and method

The geologist of the Open Joint Stock Company “Tugnuy Coal Mine” G.D. Chimitov sampled for us the specimens of coals from the Olon-Shibir Coal Mine.

Palynological samples from the clastic and coal beds of the 8th, 15th, 17th, and 18th coal seams of the Olon-Shibir Coal Mine were processed using standard methods. Coals were treated with nitric acid and alkali, and then thoroughly washed out with distilled water to extract the phytoleims. Dispersed cuticles were prepared for study under an Axioscop 40 optical microscope equipped with an Axiocam HRc camera (Carl Zeiss).

The palynological spectra contain rather diverse and abundant palynomorphs. The dispersed cuticle *Pseudotorellia* sp. was obtained from coals.

The coal seam 8 has relatively simple structure. Its thickness varies from 1.2 to 2.5 m. In several separate disconnected lenses, the anomalous thickness can reach 6-8 m.

The palynological spectra from both clastic and coal layers of coal seam 8 are dominated by spores of cyatheaceous ferns. Sometimes these spores were found as unbroken sporangia, what evidences the vicinity that ferns habitat to the burial. Next in importance is bisaccate pollen having affinity with Pinaceae. Most often in the third position in palynological spectra from coals is the monosulcate pollen *Ginkgocycadophytus*, although in those from sandstones this role belongs to osmundaceous spores.

The coal seam 15 has thickness from 0.3 to 1 m. In the palynospectra of this seam, spores of Cyatheaceae dominate; the second in importance are bisaccate pollen and *Ginkgocycadophytus*. The diversity of palynomorphs increases. The percentage of spores of lower plants and pollen of Podozamitaceae becomes higher.

The coal seam 17 is mainly of simple, less moderately complex structure. The thickness is 1.5-2.5 m. The palynospectra of the coal and sill are dominated by Cyatheaceae, as in the palynospectrum of the roof of the coal the latter is replaced by Osmundaceae. On the second place in the spectra from the clastic beds is bisaccate pollen having affinity with Pinaceae, while in the coals - *Ginkgocycadophytus*. Also the amount of *Podozamites* pollen in the clastic increases, in coals its percentage drops.

The coal seam 18 is thick (1.60 to 8 m), sometimes very thick (up to 40-50 m). It is distributed over the whole area of coal field. The palynospectra are dominated by Cyatheaceae, next in importance is bisaccate pollen Pinaceae, in the third place - Osmundaceae or *Ginkgocycadophytus.*

For the purpose of palynological analysis, spores and pollen were united into the main groups: (1) Bryopsida and Lycopsida; (2) Dicksoniaceae and Cyatheaceae; (3) Schizaeaceae; (4) *Ginkgocycadophytus*; (5) bisaccate pollen having affinity with Pinaceae; (6) Araucariaceae; (7) Taxodiaceae; (8) others, including representatives of other groups of ferns, as well as Podozamitaceae, Cheirolepidiaceae, and angiosperms.

Results

The taxonomic composition of the palynospectra from the coal and clastic beds of the Olon-Shibir Coal Mine is approximately similar: they are dominated by Cyatheaceae, Pinaceae; the subdominants are Osmundaceae and *Ginkgocycadophytus*. The ferns and coniferous trees supplied the main phytomass for the formation of coal and, apparently, these plants formed coastal vegetation of the vast river valley. With the increased influx of terrigenous sand material into lowlands of basin, possibly as a result of floods, the amount of spores and pollen of plants of slope vegetation increased in the burials. For example, in the palynospectra of terrigenous layers, the role of Osmundaceae and Araucariaceae often increases.

The amount of pollen *Podozamites* is quite stable. It is not excluded that its producers or formed thickets between slope and lowland vegetation, or in a small amount were part of the latter. The absence of *Podozamites* cuticle in coals suggests the first assumption.

Pollen *Ginkgocycadophytus*, as is known, could be produced by different plants, such as representatives of Ginkgoales, Czekanowskiales, Bennettitales, Cycadales and some other groups. The findings of the dispersed cuticle *Pseudotorellia* in coals, the absence of finds of megafossils of bennettites and cycads suggest that it was produced by ginkgoaleans. It is not excluded and the role of the *Czekanowskia* as parent plant. This genus was found earlier by paleobotanists V.A. Vakhrameev and I.N. Srebrodolskaya from these deposits, but we did not find its remains in this locality. It should be noted that leaves of the czekanowskialeans possessed a fairly characteristic thick and resistant cuticle, which is well preserved in the burials; however, during the chemical maceration of coals such cuticle was not revealed. This pattern is characteristic of all Late Mesozoic coals in the south of Siberia and the Russian Far East.

It was much unexpected to found extremely rare pollen of angiosperms *Tricolpites* sp. and *Clavatipollenites incisus* Chlon. in almost all spectra from different sedimentological environments of the Olon-Shibir Coal Mine. It should be noted that usually the appearance of the first angiosperms is marked by the appearance of single pollen grains, the number of palynomorphs along the section regularly increases, and their species diversity is increasing, for example, in the Barremian-Albian sections of Portugal (Heimhofer et al., 2007). V.A. Vakhrameev and I.Z. Kotova (1977) have found angiosperm pollen *Asteropollis asteroides* Hedl. et Norr. in the Barremian-Aptian (pre-Albian) continental deposits of the Zaza (Baisa locality), Beklemishevo, Chita-Ingoda, East Urulunguy, Konda, and Arbagar basins of Transbaikalia. We collected paleobotanical material from Baisa locality of the Zaza Basin. According to our data, the composition of angiosperms in the palynospectra from this section is more diverse. In addition to their find, we also obtained *Clavatipollenites hughesii* Coup. and *Tricolpites* sp.

The Middle Jurassic age of the Tugnuy Formation was first substantiated by G.G. Martinsson (1961) and Ch.M. Kolesnikov (1964) on the basis of finds of fossil bivalves. A.N. Oleynikov (1975) and E.K. Trussova (Jurassic continental biocenoses ..., 1985) also considered the age of this stratigraphic unit as the Early-Middle Jurassic based on the study of conchostracans. V.M. Skoblo, based on ostracods, also supported the Middle Jurassic age (2001). According to VA. Vakhrameev, fossil plants (collections of V.M. Skoblo) have a wide stratigraphic distribution - the Jurassic and Early Cretaceous. They have some similarities with the Middle Jurassic floras of the Irkutsk Basin and Tuva (Siberia). Thus, Vakhrameev bent in favor ("although not with full guarantee") of the Middle Jurassic age of the Tugnuy Formation (Skoblo et al, 2001).

The discovery of angiosperms in the palynological assemblage of the Tugnuy Formation leads to a new look at its age and place in the stratigraphic chart of Transbaikalia, and also at the time of coal formation in this region. We consider the age of the palynospectra of the Tugnuy Formation from the Olon-Shibir Coal Mine as the Early Cretaceous (apparently Barremian-Aptian). In addition to angiosperms, spores of ferns having affinity with the Schizaeaceae (*Cicatricosisporites* sp., *Impardecisporites apiveruccatus* (Coup.) Venkat., Kar. et Raza, *Concavissimisporites asper* Poc., and *Pilosisporites setiferus* (Verb.) Verb.), Polypodiaceae (*Laevigatosporites ovatus* Wils. et Webst., *L. ovoideus* Takah.), pollen of plants having affinity with the Pinaceae (*Alisporites aequalis* (Bolch.) Chlon., *A. bilateralis* Rouse, *A. similis* (Balme) Dett.) were revealed. These taxa are usually characteristic of the Early Cretaceous palynofloras of the Siberia-Canadian floristic region.

Summarizing the above, we consider the age of the coal-bearing deposits of the Olon-Shibir Coal Mine, belonging to the Tugnuy Formation, as the Barremian-Aptian. Our main conclusion of our studies - the Mesozoic coal formation in Transbaikalia was manifested only in the mid-Cretaceous.

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References

Coal Base of Russia. Volume IV. Coal Basins and Deposits of Eastern Siberia (Tunguska and Taimyr basins, Deposits of Transbaikalia). Ed. by V.F. Cherepovskii. Moscow: ZAO “Geoinformmark”, 2001. 493 p. [in Russian].

Heimhoffer U., Hochuli P.A., Burla S., Weissert H. New records of Early Cretaceous angiosperm pollen from Portuguese coastal deposits: Implications for the timing of the early angiosperm radiation. Review of Palaeobotany and Palynology. 2007. Vol. 144. P. 39–76.

Jurassic continental biocenoses of Southern Siberia and adjacent territories. Ed. by A.P. Rasnitsyn. Moscow: Nauka, 1985. 199 p. [in Russian]

Kolesnikov Ch.M. Stratigraphy of the continental Mesozoic of Transbaikalia. In: G.G. Martinsson (ed.), Stratigraphy and paleontology of the Mesozoic and Cenozoic deposits of East Siberia and the Far East. Moscow-Leningrad: Nauka, 1964. P. 5-138 [in Russian]

Martinsson G.G. The Mesozoic and Cenozoic mollusks of the continental deposits of the Siberian platform, Transbaikalia and Mongolia. Moscow-Leningrad: AN SSSR, 1961. 322 pp. [in Russian]

Oleynikov A.N. Stratigraphy and phyllopods of the Jurassic and Cretaceous of Eastern Transbaikalia. Transactions of VSEGEI. Vol. 138. 1975. 172 p. [in Russian]

Skoblo V.M., Lyamina N.A., Rudnev A.F., Luzina I.V. The Continental Upper Mesozoic of the Pribaikalia and Transbaikalia (stratigraphy, depositional environments, correlation). Novosibirsk: Publishing House of the SB RAS. 2001. 332 p. [in Russian]

Vachrameev V.A. and Kotova I.Z. Drevnie pokrytosemennye I soputstvuyushchie im rasteniya iz nizhnemelovykh otlozheniy Zabaikalya (The early angiosperms and the associated plants from the Lower Cretaceous deposits of Transbaikalia). Paleontologicheskii zhurnal (Paleontological Journal). 1977. 4. P. 101-109. [in Russian]

Geodynamic and tectonic evolution of South Asia (Indo-Pak subcontinent)

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Abstract

The timing of isolation, migration and collision of Indo-Pak subcontinent are problems for biogeoscientists. Indo-Pak paleobiogeography, tectonics and geodynamics are interesting due to its Jurassic contact with Gondwana (Southern land), Cretaceous as journey and island, and Cenozoic with Asia (Northern land). Here, both the geological and biological evidences from Pakistan are explained for the understanding of this issue. During Late Triassic (220 Ma) the lands united as Pangea. The breakup of Pangaea started in Middle Jurassic (170 Ma) while, the breakup of Gondwana started in Late Jurassic (160 Ma).

First tectonic episode of Indo-Pakistan orogeny: Late Triassic to middle Jurassic marine starta were found in middle and lower Indus basin. First major tectonic episode of Indo-Pak occured at Jurassic-Cretaceous boundary which resulted in the deposition of terrestrial/lacustrine disconformble laterites or ironstones (Dilband Formation) in northern Kirthar and southern Sulaiman foldbelt and provide a clue for separation of Indo-Pak from Madagascar and start of northward journey at 135 Ma (Fig.1a). This episode is also responsible for the rising of Khairpur-Jacobabad-Dilband high which served as the basis of separation (Fig. 1a,b,c,d,e) of Sulaiman (middle Indus) and Kirthar (lower Indus) basins. While the upper Indus basin was already/previously separated from middle and lower Indus basin at pre Jurassic time. Marine strata was dominant in the Lower Cretcaeous while detritial sandstone coastal and detritial in the east and shallow marine in the west were dominant in the Upper Cretaceous. Wide range of erosion where Precambrian Salt Range Formation in Eastern Salt Range and Cambrian dolomite in Tatta Pani, Kotli are capped by Infra-Tertiary boundary Indus Formation (bauxite/ laterite) show long journey of more than 5000 km in a period of 67 Million years (135 Ma–68 Ma) with average speed of 8-10cm/year. This long journey in long time period created geographical changes like migration from southern landmasses to northern landmasses which affected subcontinent biota, its paleoclimates, its geological and geomaorphological changes (Fig.1a,b,c,d,e), etc. When Indo-Pak plate came close to Asian plate, the stress created subduction of Tethys plate at the line of Karakoram Suture (Mirkani-Drosh- Sor-Laspur-Yasin-Chatorkhand-Chalt-Hispar-Panmah-Shigar-Hushe-Machelu belt- further join the Shyok valleys) under Hindukush- Karakoram (Fig.1c). Further stress at later created subduction of Tethys sea plate at the line of Northern Indus Suture (Mohmand- Swat- Besham- Sapat- Chilas- Haramosh- Astore- Shontar Top, South Deosai, Kargil- Ladakh; Fig.1c) under Kohistan- Ladakh belt resulted in the form of Kohistan- Ladakh magmatic arc.

Second tectonic episode of Indo-Pak orogeny: The Indo-Pak collided first time with Asia at Latest Cretaceous about 68 Ma. The western Indus suture (UthalBela-Wadkhuzdar-Nal-west of Sorab-Kardgap/west of western Shirinab thrust-Sheikh Wasil-west of Quetta/ Samugli- Kuchlak- Gawal- Khanozai- Muslimbagh- Qila Saifullah- Zhob- Waziristan- Western Kurram- West of Mohmand) well developed by the obduction of ophiolites. Indo-Pak plate docked with Afghan-Kohistan-Ladakh Tethyan belt. Further northward movements created the Ornach-Nal-Chaman transform left lateral fault (Fig.1c,d,e). In Chaman region this fault line is diverged from western Indus Suture (Fig.1c,d,e) because the Pishin-Kakar-Khorasan zone (between Chaman fault and Western Indus Suture) is a part of Balochistan (forarc) basin. During Early Paleocene sea transgressed and during Late Paleocene sea regressed from the western Sulaiman, northern Balochistan, upper Indus basins due to further uplift. This show the uplift of area by glancing contact of Indo-Pakistan plate with Asia at 68Ma and moderate contact at 55Ma, because even global events attributed to collision appear to have lagged ≥ 20Ma after the widely accepted time for collision inception. This collision acts as a pivot point for counterclockwise rotation of Indo-Pak plate. As a result the northwestern margin of Indo-Pak plate became elevated creating a terrestrial environments for the deposition of Latest Cretaceous Vitakri Formation (overbank red muds and meandering sandstones, Ziarat-Sor Kach Zhob laterite) in the lower and middle Indus while the Indus Formation (bauxite and laterite) in the upper Indus basins (Fig.1b). This collision is also responsible for the birth of Paleo-Indus River Systems (Fig.1d,e) generally flows from north to south and northwest to southeast (Fig.1b,c) and ended the Paleo Vitakri river systems (generally flows from east to west, from Indo-Pak shield to Tethys; Fig.1b,c) in the middle and upper Indus basin.

The first collision with Asia during latest Cretaceous is also revealed by lithostratigraphic correlation of Indus basin (subcontinent block) with Balochistan basin (Tethyan block). The Paleocene Dungan and Lockhart limestone of Indus basin matches closely with Paleocene Nisai limestone. It can be observed clearly in Sharin Jogezai area of Qila Saifullah district of Balochistan and also adjoining Indus basin part area like Quetta-Ziarat-Sanjawi-Duki etc. The Eocene Shagala Group (Murgha Faqirzai, Mina and Shagala formations) matches closely Chamalang/Ghazij and Panoba groups. The Murgha Faqirzai green shales matches closely with Early Eocene Shaheed Ghat (mainly green shale with minor sandstone) of Middle and Lower Indus while with Panoba green shale of upper Indus. Following Mina formation (alternating sandstone with green shale) matches closely with Toi Formation of Indus Basin. Following terrestrial shagala Formation (alternating sandstone and red/maroon muds) of Balochistan basin matches closely with Kingri formation and Kuldana group of Indus Basin. Following Oligocene-Pliocene Vihowa group/Potwar group are also found in Indus basin and also northern Balochistan basin while in South Balochistan/Makran it is represented by Talar group. The Pleistocene-Holocene Bostan or Kech of Balochistan basin matches closely with Sakhi Sarwar Group / Soan Group of Indus basin. Consequently during Early Eocene the Northern Indus Suture and northern block of western Indus suture and surrounding areas were uplifted enough to originate the Paleo Indus River systems supplying first time detritials/clasts from northwest and north and generally flows from northwest to southeast in Sulaiman (middle Indus) and north to south in Khyber-Hazara-

Kashmir (uppermost Indus) and Kohat-Potwar (upper Indus) basins. The Paleo Indus river systems during Eocene provided the clastic or detritial materials of Shagala Group (Murgha Faqirzai=Siahan=Hoshab, Mina=Zurati=Pajgur, and Shagala=Shagalu formations) in Balochistan basin, Chamalang Group=Ghazij Group (Shaheed Ghat, Toi, Kingri, Drug and Baska formations)) in middle Indus and Panoba Group (Panoba, Shekhan, Bahadurkhel and Jatta formations), Nammal Group (Nammal and Sakesar formations) and Kuldana Group (Choregali and Kuldana formations) in upper Indus.

Third tectonic episode of Indo-Pak orogeny: Tethys further regressed and permanently closed (due to hard contact with Asia at 40-35 Ma; Fig.1d) from upper and middle Indus basins of Pakistan during Late Eocene while the Lower Indus basin was under Tethys. This hard contact on **third episode** created further uplift, folding and faulting (mainly south verging thrusts) and deposition of terrestrial Potwar/Vihowa (Siwalik) Group. From Lower Indus basin the Tethys closed during Early Miocene. Last major geoevent at Pliocene-Pleistocene boundary created further uplift, folding and faulting and the deposition of coarse clastics. Present morphology is product of many tectonic episodes while northward flight of plate is continued. It further regressed and permanently closed (due to hard contact with Asia at 40-35 Ma) from upper and middle Indus basins of Pakistan during Late Eocene while the Lower Indus basin was under Tethys. This hard contact created further uplift, folding and faulting (mainly south verging thrusts) and deposition of terrestrial Potwar/Vihowa (Siwalik) Group. From Lower Indus basin the Tethys closed during Early Miocene.

The **third orogeny** occurred at the Eocene-Oligocene (40-35 Ma; Fig.1e) boundary which is responsible for the rising of northern part of Pakistan (Himalaya) which was the clastic source of Potwar group (Siwalik group) in Kohat and Potwar basin, Vihowa group in Sulaiman and Kirthar basins. The third orogeny occurred after the 20 million years of second orogeny. In this way the second orogeny also needs 20 million years (75-55 Ma) for rising of Hinterland (Zhob-Afghan block) to supply the clastic materials. During early Eocene East and southeastern part of Sulaiman foldbelt remained under sea, where marine Shaheed Ghat (shale) and Drug formation (rubbly limestone, marl and shale) was deposited, which were followed by wide spread platform type evaporitic deposits (Baska gypsum), in turn followed by marine Kahan group (Habib Rahi, Domanda, Pir Koh and Drazinda formations). In the Oligocene the Tethys Sea was permanently regressed from the upper and middle Indus basins, however southward of Jacobabad high the sea remained in the Oligocene and regressed in the Miocene and later further southward.

Fourth tectonic episode of Indo-Pak orogeny: The **fourth main orogeny** occurred at the Pliocene-Pleistocene boundary resulted the further folding and faulting.

Fifth tectonic episode of Indo-Pak orogeny: The **fifth and so far last main orogeny** occurred at the boundary of Pleistocene and Holocene resulted the folding and faulting.

This shifting of source rocks of detrital materials show the uplift of area by glancing contact of Indo-Pak plate with Asia during 68Ma and hard contact at 40Ma, because even global events rightly or wrongly attributed to collision appear to have lagged >20 Ma after the widely accepted time for collision inception. Detrital sedimentary records along convergent plate margins are widely regarded as key repositories, for precisely containing the timing of both major and minor tectonic events. Last major geoevent at Pliocene-Pleistocene boundary created further uplift, folding and faulting and the deposition of coarse clastics of Soan/Sakhi Sarwar Group. Present morphology is product of many tectonic episodes while northward flight of plate is continued. Cretaceous fauna shows relative close relation with Gondwana (Southern land) but also include some endemic fossils which reveal isolation of Indo-Pak from nothern and southern lands during Cretaceous.

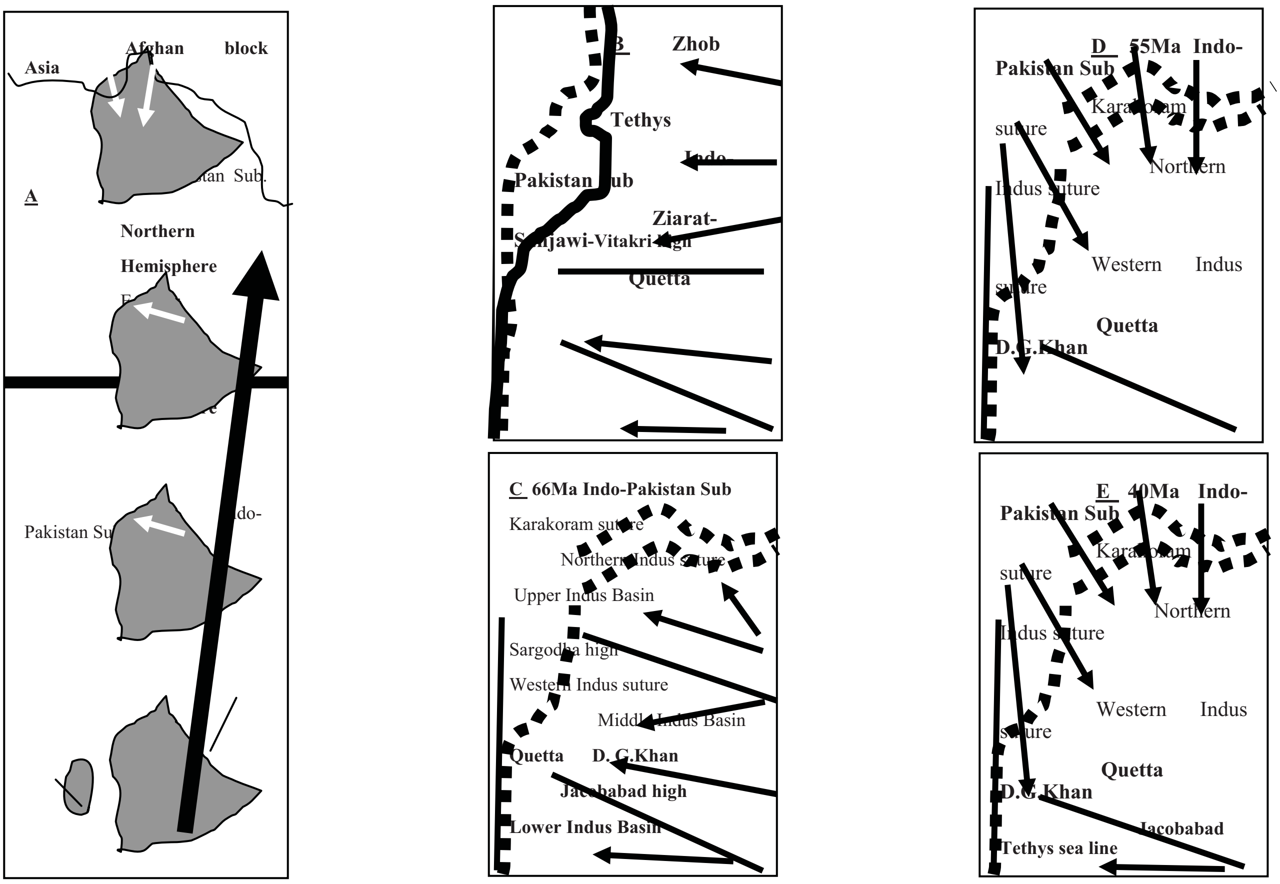

Figure 1. **A**, northward flight of Indo-Pakistan subcontinent (South Asia). **B**, at latest Cretaceous, tethys sea line (thick line), western Indus suture (dotted line), Paleo-Vitakri river systems (arrow shows movement directions) and Ziarat-Sanjawi-Vitakri high (east west central line) are shown. Pre-Eocene source of clasts of Indus basin were from east (Indo-Pakistan shield). Arrows show westward flow of Paleo-Vitakri river systems. **C**, Cretaceous-Paleogene boundary (66 Ma), thick dotted line show Indus Suture and Karakoram Suture. The western part of Indus Suture is called Western Indus Suture and northern part of Indus Suture called Northern Indus Suture. The northernmost thick dotted line shows Karakoram suture (Shyok suture). Pre-Eocene source of clasts of Sulaiman basin from east (Indo-Pakistan shield) via Paleo-Vitakri river systems. Line in the centre shows Sargodha high and line in the south show Jacobabad-Khairpur high and north-south line on western boarder shows Bela-Ornach-Nal-Chamman transform fault (left lateral fault). In northern part this transform fault diverge westward from Western Indus Suture, consequently North Balochistan (Kakar-Khorasan) basin is a part of Balochistan Basin. Arrows show westward flow of Paleo-Vitakri river systems. **D**, at 55 Ma post Paleocene source of upper Indus, middle Indus and northestern part of lower Indus basins clasts via Paleo-Indus river system flows from northwest and north to southeast and south. Paleo-Vitakri river systems occurred only on southeastern Kirthar (lower Indus) basin. E, at 40 Ma the hard contact created detritial deposits of of Indus basin.

Holocene Climate and Environmental Changes in Mongolia as Recorded in The Sediments of Lake: A Review

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Abtract

The Mongolian plateau is located at the dry land and semidry land region, and is affected by global-scale climate systems: the North Atlantic Oscillations (NAO), and the East Asian summer monsoon which is associated with the El Nino-Southern Oscillations (ENSO) and Intertropical Convergence Zone in the tropical Pacific (Tudhope et al., 2001). Mongolia has extreme continental climate with very cold winters and warm summers. The climate becomes increasingly moist from south to north due to decreases in temperature and increases in precipitation. Lake sediments is very good archive for past climatic conditions for a variety of reasons. In particular, lakes with a deep central basin are likely to contain continuous sedimentary geologic records. Lake levels are a sensitive index of regional effective moisture. Using mollusc profiles from lake sediments, Grunert et al., (2000) found that Uvs Nuur and adjacent Bayan Nuur reached their highest stands in the upper late glacial and early Holocene, between 11230±60 yr BP and 9690 yr BP. During a generally regressive phase, lake level in the Uvs Nuur has been dated between 7310±90 yr BP and 3250±70 yr BP (An et al., 2008). Lastly, lacustrine sedimentation occurred during the late Holocene between 3010±50 yr BP and 4030±50 yr BP (An et al., 2008). Lake Hovsgol of northern Mongolia has been studied (Altunbaev and Samarina, 1977: Dorofeyuk and Trasov, 1998; Fedotov et al., 2001, 2004; Prokopenko et al., 2003; 2005; 2008; 2009; Tserentsegmid et al., 2008). The climate biogenic indicators SiO2biog, Corg, diatoms and elements are indicated Holocene/Pleistocene-11.5 ky BP, a warm period Bolling-Allerod (BA, 15-13 ky BP) in the end of Pleistocene, a cold period Younger Dryas (YD, 13-11.5 ky BP) (Tserentsegmid et al., 2008). In Northern Mongolia at the Gun Nuur lake core corresponding to warm period from 9000 to 7000 yr BP and colder dry climate about 7000 to 5000 yr BP. This interpretation is consistent with dry period in sedimentary proxy from Lake Telmen-north-central Mongolia (Pecl et al., 2002; Fowel et al ., 2003).

Keywords: Climate change, lake sediments, lake levels, Bolling-Allerod, Younger Dryas

Integrated study of volcano-stratigraphy, magneto-stratigraphy, reptilian tetropods and palynology: tracking biotic and environmental changes across Cretaceous-Palaeogene during Deccan volcanism.

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Abstract

The voluminous eruption (ca. 1.3 x 10^{6} km^{3}) of Deccan contimental flood basalts (DCFB) is considered to have erupted at least in three phases over a period of at least 6-7 million years (69-63 My- Jay and Widdowson, 2008, 68-61 My Sheth et al. 2001). Mostly based on the study of lava flows of Western Ghats in the main Deccan volcanic province (DVP) it is hypothesised that these three discreet phases of volcanism were represented by the earliest one at ca. 67.5 Ma near C30r-C30n transition followed by second (also main) phase within C29r just before the K-Pg boundary and the third or last phase within Palaeogene spanning C29r-C29n (Chenet et al. 2007, 2009; Keller et al. 2008). Recently Schoene and others (2014) based on U-Pb zircon dating suggested that the main phase of eruptions was initiated at least 250,000 ky before the K-Pg boundary and the 1.1 Km^{3} of lava erupted in 750,000 ky. Also based on study in Western Ghat Renne et al. (2015) concluded that with the boloid impact at Chicxulub at K-Pg more than 70% of the Deccan lava with more massive and episodic was erupted suggesting a causal-link between the volcanism and boloid impact. However, it has been difficut to test any hypothesis for timing and durations of the phases for lack of accurate estimates of total volume of magma eruptions in geographically separated Deccan provinces and their chronostratigraphic constraints on the lava piles. Present aerial extent of Deccan volcanic province is over 500, 000 km^{2} between the latitudes 15^{0} $10^{'}$-24^{0}30' N and longitude $70^{'}10^{'}$-$82^{0}00^{'}$E (Geological Survey of India, 1993) that could originally be much large exceeding 1,5000,000 km^{2} (Hooper,1999). The Deccan provinces viz. Western Deccan volcanic province, Eastern Deccan volcanic province, Northern Deccan volcanic Province and undesignated sequences of Saurashtra and Kutch are spatio-temporarily separated having separate sites and source of eruptions and also the different timing and duration of eruptions (Mohabey, 2013, Samant and Mohabey, 2014, Schoebel et al. 2014). The stratigraphic correlation of lava flows based on chemo-stratigraphy is difficult as similar chemo-strato types are found in diffrent magnetochrons in different provinces. The volcanic sequences are associated with sediments (*infratrappean/Lameta* and deposited at 'Ground Zero' before covered with the first flows arriving locally and the sediments (*intertrappean*) deposited at multiple stratigrphic levels during the period of repose in the volcanism.

It is crucial to observe relatioship if any between the changing biota and Deccan volcanic eruptions, especially their nature and magnitude in three different phases of eruptions. We studied over 150 geographically separated sections in different DVP to

observe biotic and environmental changes during the eruptive history of different provinces. For tracking biotic or environmental changes the sedimentary layers at multiple stratigraphic levels were targeted in the volcanic sequences having chronostratigraphic constraints provided mainly by volcano-stratigraphy, magneto-stratigraphy and available radiomatric dating of lava flows. The infratrappean sediments at 'Ground Zero' are time-transgressive semi-arid alluvial-limnic deposits of C30n to C29r (Maastrichtian) in different provinces/basins, whereas the intertrappean are mainly the lake sediments of C30n to C28r Maastrichtian-Paleocene (Samant and Mohabey, 2014) deposited over the fresh lava surface.

Vertebrates recovered from the sediments mostly included tetrapods- frogs (*Indobatrachus pusilus*), turtles (Shweboemys /Bothremydid/Kumademydinae -*Sankuchemys* and *Kuramademys*), Lizards (*Agma*, *Litakis*, Pristiguana), Crocodylimorphs (Notosuchids, *Simosuchus*), snakes- (Althenophid madtsoiids - *Sanajeh indicus*, *Madtsoia pisdurensis* Wilson et al. 2010, Mohabey et al. 2011), titanosauriforme sauropods (*Isisaurus*, *Jainosaurus*), abelisaurid theropods- *Rajasaurus*, *Rahiolisarus*, *Indosuchus*, *Indosaurus* and noasaurids- *Laevisuchus indicus* (Huene and Matley, 1933, Wilson et al. 2003, Novas et al. 2010) and numerous mammal teeth. The taxanomic affinity of these Indian reptiles favours connection between Indian subcontinent and Madagascar that persisted till stage of late Cretaceous and consequent endemism after its separation from Madagascar. The studies strongly suggest that the Indian Late Cretaceous (Maastrichtian) reptiles were adversely impacted by the initiation of Deccan volcanism and arrival of first lava flows locally in different provinces. Relatively, more diversity and abundance of reptlilian fauna is observable at 'Ground Zero' conditions before the advent of volcanism. The titanosauriforme and abelisaurids make their first appearance coeval with angiosperms in the C30n Maastrichtian on the Indian subcontinent 500,000 ky before the K-Pg boundary but only one or two species of titanosaurs survived the initial onslaught by volcanic eruptions and totally disappear at least 350 ky before the K-Pg boundary. A distinct change from angiosperm-gymnosperm dominant flora to angiosperm-pteridophyte association with the advent of volcanic activity is recorded in the Indian Maastrichtian. Further, at higher stratigraphic level in the Deccan volcanic sequences a change over from Maastrichtian marker palynoflora to Paleocene marker palyflora is recorded (Samant and Mohabey 2014). It is observed that a change in the diversity of reptiles and extinction of dinosaurs commensurate much before the K-Pg boundary as response to advent of Deccan volcanism and arrival of first lava flows locally. The timing of such biotic changes is noticeably different from North Americal terrestrial K-Pg boundary sections that is linked to the boloid impact.

References

Chenet, A. L., X. Quidelleur, F. Fluteau, and V. Courtillot (2007), 40K-40Ar dating of the main Deccan large igneous province: Further evidence of KTB age and short duration, Earth Planet. Sci. Lett., 263, 1–15, doi:10.1016/j.epsl.2007.07.011.

Chenet, A.L., V. Courtillot, Fre´de´ric Fluteau, M. Ge´rard, Xavier Quidelleur, S. F. R. Khadri, K. V. Subbarao, and Thor Thordarson (2009). Determination of rapid Deccan eruptions across the Cretaceous-Tertiary boundary using paleomagnetic secular variation: Constraints from analysis of eight new sections and synthesis for a 3500-m-thick composite section. J. Geophys. Res., 114, B06103,doi:10.1029 /2008JB005644, 2009.

Geological Survy of India (1993). Geological Map of India, 1:5 million scale. Government of India, Publication, Kolkata.

Hooper, P. R. (1999). The timing of crustal extension and the eruption of continental flood basalts. Nature, 345(6272), 246- 249.

Jay, A. E., Widdowson, M. (2008). Stratigraphy, structure and volcanology of the SE Deccan continental flood basalt province: implications for eruptive extent and volumes. J. Geological Society, 165, 177-188.

Keller, G., T. Adatte, S. Gardin, A. Bartolini, and S. Bajpai (2008), Main Deccan Volcanism phase ends near the K-T boundary: Evidence from the Krishna Godavari Basin, SE India, Earth Planet. Sci. Lett., 268, 293–311, doi:10.1016/j.epsl.2008.01.015.

Mohabey D. M., Head J.J. (2011). A new species of the snake *Madtsoia* from the Upper Cretaceous of India and its palaeobiogeographic implications. J. Vert. Pal., v. 31(3), pp. 588-595.

Mohabey D.M and Samant Bandana (2013). Deccan Continental Flood Basalt Eruption Terminated Indian Dinosaurs before the Cretaceous-Paleogene Boundary. Geological Society of India, Special Publication No. 1, 2013, pp.260-267.

Novas, F.E., Chaterjee, S., Rudra, .K. and Dutta, P.M. (2010) *Rahiolisaurus gujaratensis*, n. gen. n. sp., a new abelisaurid theropod from the Late Cretaceous of India. In: S. Bhandopadhyay (eds) New Aspects of Mesozoic Biodiversity, Lecture notes in Earth Sciences, 132, DOI 10.1007/978-3-642-10311-7_3, @Springer-verlag berlin Heidelberg 2010.

Paul R. Renne, Courtney J. Sprain, Mark A. Richards, Stephen Self, Loÿc Vanderkluysen and Kanchan Pande. (2015). State shift in Deccanvolcanism at the Cretaceous-Paleogene boundary, possibly induced by impact. Science, 350 (6256), 76-78.

Samant B. and Mohabey D.M. (2014). Deccan volcanic eruptions and their impact on flora: Palynological evidence. The Geological Society of America Special Paper 505, 171–191, doi:10.1130/2014.2505(08).

Schoene, B., Samperton K.M,. Eddy, M. P., Keller, G., Adatte, T., Bowring S A., Khadri, S.F.R.. and Gertsch, B. (2014). U-Pb geochronology of Deccan traps and relation to end Cretaceous mass extinction. Science express, 10.1126/science.aaa0118, 1-5.

Sheth, H.C., Pande Kanchan and Bhutani, R. (2001) 40Ar-Ar39 age of a national monument: the Gilbert Hill basalt, Deccan Trap, Bombay, Curr. Sci., v. 80, pp. 1437-1440.

Von Huene F.B. and Matley, C.A. (1933) Cretaceous-Saurischia and Ornithischia of the Central Provinces of India, Geol. Surv.India, Mem. 1, Pal. India, No. 21, pp. 1-24.

Wilson J. A., Paul C. S., Srivastava S., Bhatt, D. K., Khosla, A. and Sahni, A. (2003). A new abelisaurid (Dinosauria, Theropoda) from the Lameta Fomation (Cretaceous, Maastrichtian) of India. Contrib. Mus. Pal., Uni. Michigan, 31(1), pp.1-42.

Wilson, J. A., Mohabey D. M., Peter S. E. and Head J. J. (2010). Predation upon hatchling dinosaurs by a new snake from the Late Cretaceous of India. PLoS Bio., v. 8(3), pp. 1-10.

Late Cretaceous paleogeography of the Deccan Volcanic Province, peninsular India: palynological evidence

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Abstract

The Late Cretaceous sedimentary sequences (Infra- and Intertrappean beds) of Deccan Volcanic Province (DVP) of Central India is extremely rich in fossil flora and fauna. Due to both terrestrial and marine nature of fossils present in these sequences, considerable efforts were made over the last decade to delineate the marine and terrestrial ecosystems within the volcanic province. Identification of marine facies in a few locations of the central-western part of the province have so far proved insufficient in providing a complete perspective on the paleoenvironment, including the nature and extent of marine sea ways during the Late Cretaceous in central India. In the present study sedimentary successions from a number of Infra- and Intertrappean sections, namely, bore hole sediments from Ashtona village, Yeotmal District (Infratrappean), Nand area (Infratrappean), Ninma river section (Intertrappean), Dhaiwal (Intertrappean) were studied for their palynological content. The presence of a large number of mangrove pollen *Spinizonocolpites* pollen (Nypa), in these sediments indicate a brackish marine depositional setting due to the development of large scale shallow marine seaways in central India during the Late Cretaceous. The presence of mangrove pollen and dinoflagellate cysts in the Yeotmal region, Wardha basin, during the Late Cretaceous adds to the previously described marine signatures from the Intertrappean sediments from Rajamundary, Krishna-Godavari basin on the Southeastern margin of peninsular India. Subsequent investigations in the Wardha-Godavari basin have also provided compelling evidence that suggest the presence of shallow seaways in central India, which initiated from the east coast through the Godavari rift zone during the late Cretaceous, while earlier reports of planktonic foraminifera from the intertrappean sediments at Jhilmili near Nagpur suggested marine incursion through Narmada rift zone from the West Coast. It is thus inferred that during the Late Cretaceous the central India was connected to both eastern and western marine seaways rather than from the western corridor only.

Late Cretaceous Vertebrate Faunal Similarities between India and Madagascar: Palaeobiogeographic Scenarios

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Abstract

India and Madagascar were integral parts of the southern supercontinent Gondwanaland until the end of Late Jurassic and continued to stay as contiguous landmasses even after successive break-ups from Africa, and Australia-Antarctica block. In the Late Cretaceous (~88 Ma ago), the Marion hot spot volcanism led to the separation of India and the Seychelles block from Madagascar. Following this break-up, India underwent rapid northward drift ultimately leading to its collision with mainland Asia whereas Madagascar remained in its southern position. The continental Upper Cretaceous deposits of India represented by the Lameta Formation (=infratrappean beds), the Deccan volcano-sedimentary sequences (=intertrappean beds) of central and western India and the Upper Cretaceous (Maastrichtian) Kallamedu Formation, Caurvery Basin (South India) have been extensively investigated in recent years for their vertebrate faunas. These studies revealed the presence of many new taxa of amphibians, lizards, turtles, snakes, crocodiles, extensive dinosaur nesting sites and some new dinosaur bone yielding horizons, and several mammalian taxa. The Madagascan continental Upper Cretaceous (Maastrichtian) deposits are known by the well studied Maevarano Formation of Mahajanga Basin, northwestern Madagascar. A diverse vertebrate fauna comprising of fishes, amphibians, lizards, snakes, turtles, crocodiles, dinosaurs and mammals has been described from the Maevarano Formation by the palaeontologists of Stony Brook University, New York, USA. A comparison of the Maastrichtian faunas from India and Madagascar reveals a close similarity between them though these faunas come from rocks deposited 20-22 Ma after the break-up of Madagascar from India-the Seychelles block. The faunal similarities, particularly between some fish taxa, bothremydid turtles, simosuchid crocodiles, nigerophiid and madtsoiid snakes, and abelisaurid dinosaurs, are observed. It is puzzling to find such close similarity between faunas of two landmasses separated ~20 Ma ago. To explain this biogeographic anomaly, one can offer two explanations: 1) vicariant evolution of once a single fauna into disjunct faunas, or 2) there were some faunal dispersals between India and Madagascar at the end of Cretaceous across the Mozambique Channel. The sister group relationships established between bothremydid turtles, nigerophiid snakes, and abelisaurid dinosaurs support the second biogeographic scenario. However, it is an enigma how these over sea dispersals took place between India and Madagascar when a wide body of marine waters separated India and Madagascar at the end of Cretaceous.

Late Jurassic – Early Cretaceous Belemnites in Gyangze, Southern Tibet, China

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Abstract

Abstract The southern Tibet is rich in Belemnites， The output of the Belemnite is mainly concentrated in the Late Jurassic to Early Cretaceous strata. The research of Belemnites in southern Tibet originated in the early 20th century. In the 1980s, the Chinese Academy of Sciences organized several large-scale comprehensive scientific investigations in the southern Tibet region, collected and studied a large number of Belemnites, and since then, there have been few studies on Belemnites in southern Tibet.

As a kind of important fossil in the marine Jurassic and Cretaceous strata, the belemnites is of great significance to determine the age of the strata and to analyze the sedimentary environment. The belemnites fossils described in this thesis were mainly collected from the Jiabula Formation in the Cretaceous in Rilang, Gyangzi, and a small part of them were collected from the Zhela Formation in Wangdan, Bailang. The Cretaceous Jiabula Formation is mainly composed of black shale. The Belemnites of the Jiabula Formation are abundant and of positive significance for us to determining the age and explore the environment of the Jiabula Formation. Based on the analysis of the fossils, it is concluded that the collected belemnites should belong to two genera, one is the Late Jurassic *Belemnopsis*, preserved in dark gray shale, which suggested an anoxic depositional environment with deep water; the other is the early Cretaceous *Hibolites*, which also suggests a similar depositional environment.

Key words: Southern Tibet; Belemnites, Jiabula Formation, Zhela Formation

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References (Omitted)

Lithostratigraphy of the Berapit formation along the Malaysia-Thailand border

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ABSTRACT

The term Berapit formation had been introduced by the Malaysian Working Group of the Malaysia-Thailand Border Joint Geological Survey for a sequence of continental deposits exposed near Bukit Berapit checkpoint in Pengkalan Hulu area of northern Perak. The Berapit formation comprises a sequence of well cemented conglomerate unit that unconformably overlies the Silurian-Devonian Kroh formation. Previously it was considered as the lowermost part of the Nenering beds that later was renamed as Nenering formation.

Lithologically, the Berapit formation consists of reddish brown, massive, poorly sorted, matrix supported conglomerate. The clasts are subangular to rounded, ranging from 1 cm-10 cm in diameter, made up of sandstone, shale and minor limestone; cemented by reddish sandy matrix. It shows a fining upwards sequence and the clasts show an imbrication of about N-S direction with plunging towards north. Based on poorly sorted, subangular to subrounded clasts which were well cemented by reddish argillaceous and arenaceous materials, the conglomerate unit may be deposited in a channel of a continental environment not far from the source.

Previous study revealed that the age of the Berapit formation is of late Early Cretaceous based on the presence of few *Caronatisporatelata* and *Spheripollertesscabratus* (pollen) that characterize the Aptian-Albian age.

Keywords: Berapit formation, well-cemented conglomerate, Early Cretaceous

Lower Cretaceous oysters from Mangyshlak peninsula (northwestern Kazakhstan) and Crimea peninsula: taxonomical composition and stratigraphic distribution (preliminary data)

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Rich collections of Lower Cretaceous (Berriasian-Albian) oysters from Mangyshlak peninsula (northeastern of Caspian Sea) collected by geologists from All Russia Research Geological Institute (VSEGEI; Russia, St. Petersburg) as well as collection of Berriasian-Valanginian oysters from Crimea (north of Black Sea) collected by T.N. Bogdanova (VSEGEI) have been studied.

Taxonomical composition of Berriasian oysters from Mangyshlak is similar to those from Crimea (Figs. 1 and 2). Common taxa are represented by *Rastellum rectangularis* (Roemer), *Amphidonte (Ceratostreon) minos* (Coquand) and *“Liostrea” germaini* (Coquand). Taxa from the subfamily Pycnodonteinae Stenzel, 1959 have been identified from both regions: *“Pycnodonte” weberae* (Yanin in Tsceltsova) in Crimea and *“Pycnodonte” miranda* (Bogdanova) in Mangyshlak. Both species show typical character of Pycnodonteinae - appearance of chomata. However, their taxonomic position within the Pycnodonteinae should be clarified. Species *Deltoideum delta* (Smith) typical for Upper Jurassic of Europe has been previously identified in Berriasian of Mangyshlak by Bogdanova (1988). This proves that this species crossed the Jurassic/Cretaceous boundary. *Aetostreon subsinuatum* (Leymerie) appeared in Berriasian in Crimea and only in Valanginian in Mangyshlak.

Valanginian oysters associations from Mangyshlak are more diverse than in Crimea. Common taxa are *A. (C.) minos*, *“L.” germaini* and *Rastellum*. In addition *“P.” miranda*, *Aetostreon subsinuatum* and *A. falciformis* (Leymerie) have been identified in Mangyshlak.

Hauterivian oysters associations inherited taxonomic composition from Valanginian. In Mangyshlak they are represented by *“L.” germaini*, *A. (C.) minos*, *Aetostreon subsinuatum* and *A. dorsatum* (Leymerie).

In Barremian *Amphidonte (Amphidonte) conicum* (Sowerby) and *Gyrostrea* sp. nov. appeared. The finding of *Gyrostrea* in Barremian of Mangyshlak is the oldest known. Previously this genus was considered as typical for Upper cretaceous (Stenzel, 1971; Mirkamalov, 1986).

Aptian is characterized by appearance of new species: *“Ostrea” leymerii* (Deshayes in Leymerie) and *Gryphaeostrea canaliculata* (Sowerby), *Rastellum macroptera* (Sowerby) and *“Pycnodonte”* sp. Only *A. (A.) conicum*, *G. canaliculata* and *“Pycnodonte”* sp. have been identified in Albian of Mangyshlak.

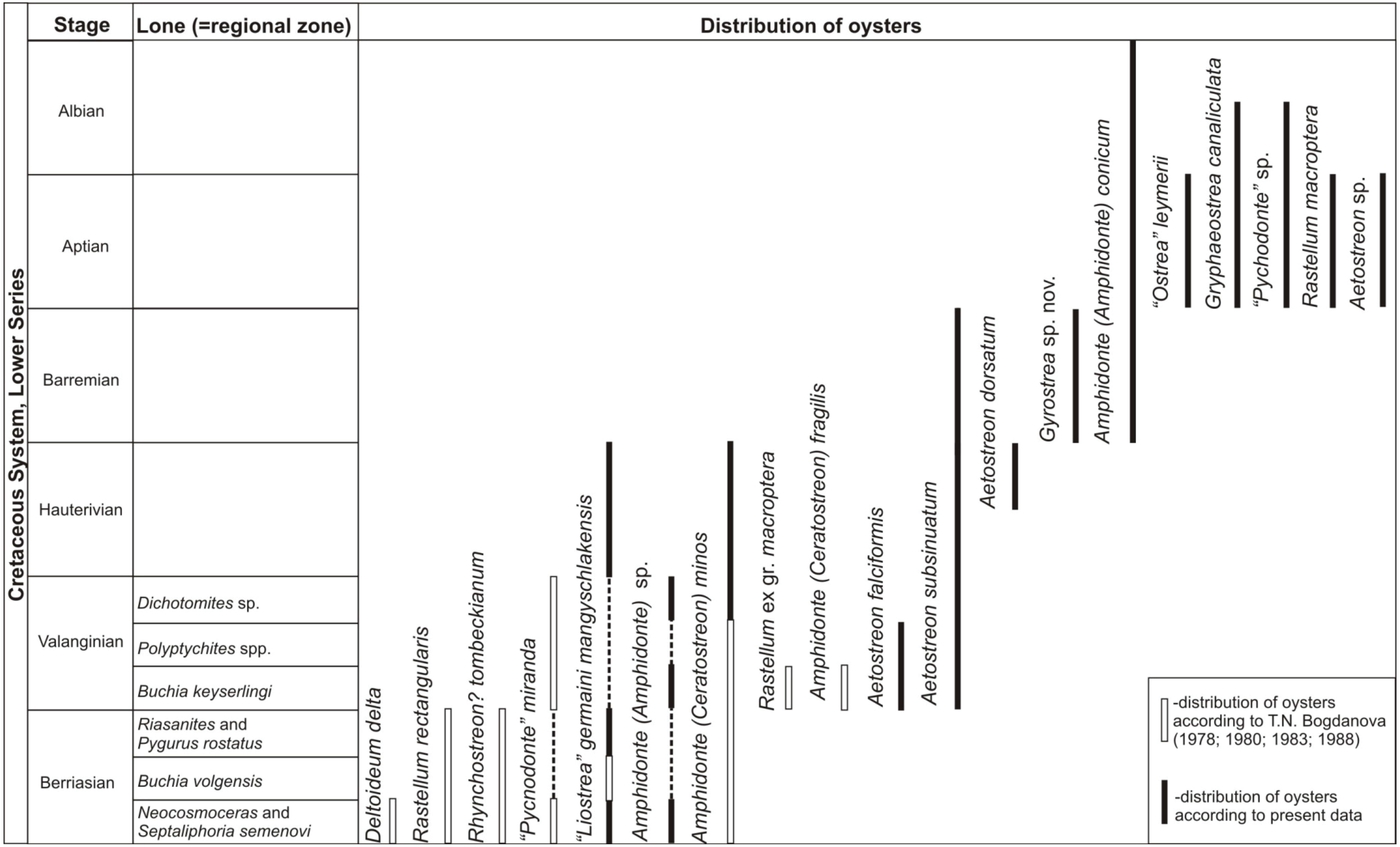

Fig. 1. Stratigraphic distribution of oysters in Lower Cretaceous of Mangyshlak peninsula.

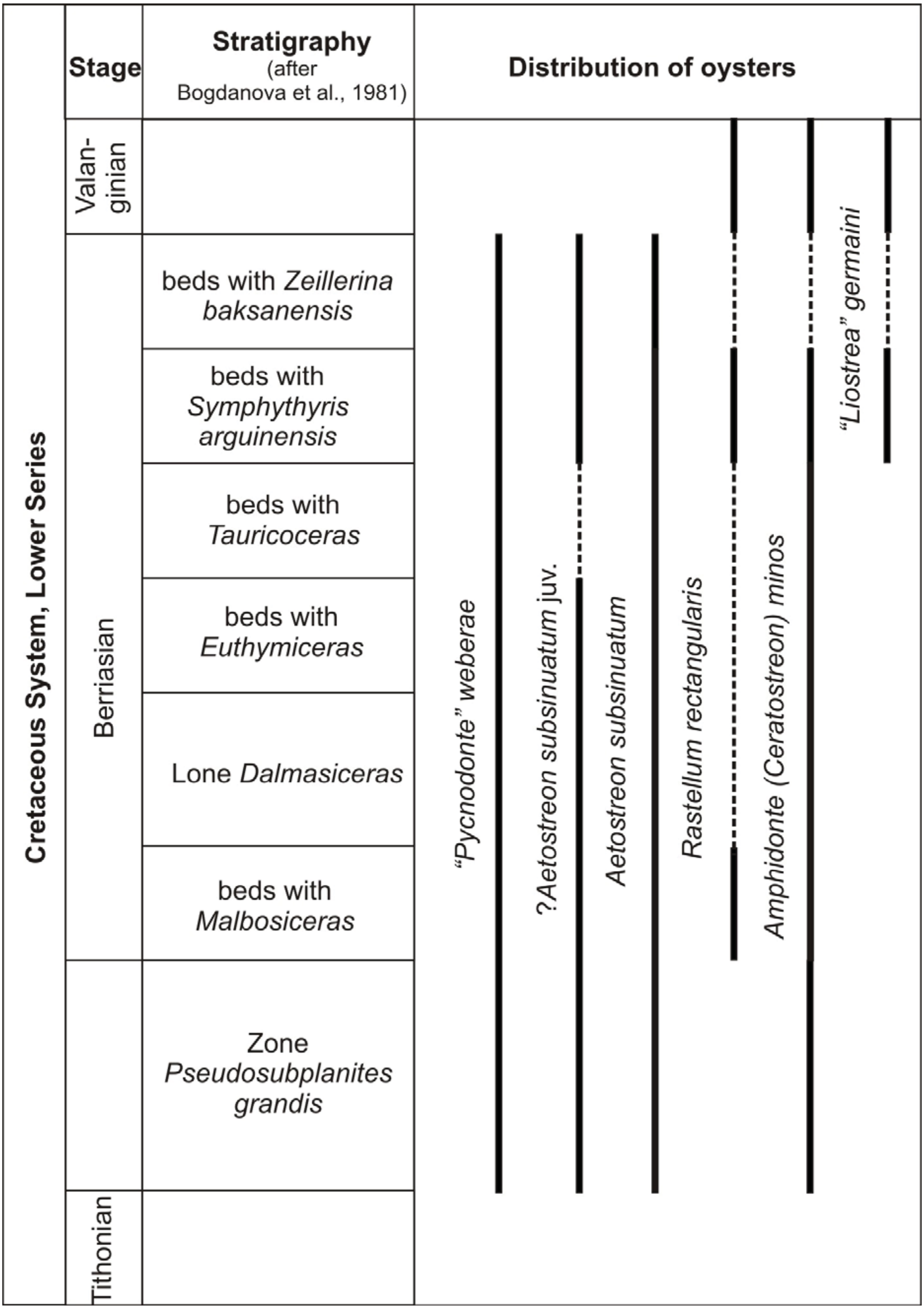

Fig. 2. Stratigraphic distribution of oysters in Berriasian - Valanginian of Crimea peninsula.

References

Bogdanova, T.N., 1978. Berriasian and valanginian oysters from Mangyshlak. In: Second All Union Symposium on morphology, system, phylogeny and ecogenesis of the Bivalvia. Abstracts. 8-10. Tiraspol Pedagogic State Institute, Tiraspol (in Russian).

Bogdanova, T.N., 1980. New early Cretaceous oysters from Mangyshlak. In: New species of fossil plants and invertebrates of USSR. Vol. 5, 26-28. Nauka, Moscow (in Russian).

Bogdanova, T.N., Lobacheva, S.V., Prozorovsky, V.A., and Favorskaya, T.A., 1981. Concerning the division of the Berriasian of the Crimean mountains. Bulletin of Leningrad State University, Geology/Geography 6 (1), 5-14 (in Russian).

Bogdanova, T.N., 1983. Type Mollusca. Class Bivalvia. In: Valanginian of Mangyshlak. 72-87. Nauka, Moscow (in Russian).

Bogdanova, T.N., 1988. Type Mollusca. Class Bivalvia. In: Berriasian of Mangyshlak. 134-156. Nauka, Leningrad (in Russian).

Mirkamalov, Kh.Kh., 1986. Stratigraphy and fauna of Cretaceous deposits of southwestern Gissar Ridge. 104 p. “FAN”, Tashkent (in Russian).

Stenzel, H.B., 1971. Oysters. In: R.C. Moore (ed.), Treatise of Invertabrate Palaeontology (N), Mollusca 6, Bivalvia 3, N953-N1224. University of Kansas, Lawrence.

Non-marine Cretaceous turtles of Japan and its significance for paleoenvironmental analysis

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Abstract

Non-marine Cretaceous turtles are known from some dozen localities of Japan (Hirayama, 2006; Sonoda et al;, 2015). Although most of materials are disarticulated and fragmentary turtle shells, they are still useful for systematics based some features such as sculptures and scute morphology remained on the shell surface (Hirayama et al., 2012). Fossil turtles are especially abundant in two geological units, the Early Cretaceous Tetori Group of Central Japan, and the Late Cretaceous Kuji Group of Iwate Prefecture of Northeastern Japan (Hirayama 2010, 2017a, b; Hirayama et al., 2010).

In the Tetori Group distributed in Gifu, Ishikawa, and Fukui Prefectures around the Mt. Hakusan, at least 13 different turtle taxa of 7 families are known (Hirayama, 2017b). Most of turtles are classified as the group of Trionychia, such as the genus *Adocus* (Adocidae), Nanhsiungchelyidae, and Trionychidae in the uppermost Kitadani Formation (presumed as the late Aptian), whereas more basal Trionychia is found from the older Okurodani and Kuwajima Formations (presumed as the Hauterivian to Barremian; Hirayama, 2002; Sano, 2018). *Kappachelys okurai*, an intermediate form between basal Trionychia and true Trionychidae, was reported from the Akaiwa Formation (presumed as the early Aptian; Hirayama et al., 2012; Sano, 2018). Thus, turtles seem rather important as index fossils for correlating non-marine sediments of the Tetori Group.

Non-marine turtles from the Tamagawa Formation (dated as the Turonian) of Iwate Prefecture are more developed as much bigger and diversified (Hirayama, 2017b). They are identified as 5 different taxa, such as *Adocus*, Trionychidae, Carettochelyidae, and Lindholmemydidae. Both *Adocus* and trionychids are more than twice the size of turtles from the Tetori Group.

Non-marine Cretaceous turtles from China and Mongolia are classified as only few taxa or families from one locality such as Sinemydidae or Trionychidae in the Early Cretaceous, and Nanhsiungchelyidae, Trionychidae or Lindholmemydidae in the Late Cretaceous (Hirayama, 2017a). Thus, taxonomic diversifications of the Cretaceous non-marine turtles in Japan seem significantly larger than those of the inland area of Asian continent, reflecting more humid and stable paleoclimate in the costal area.

References

Hirayama, R. 2002. Preliminary report of the fossil turtles from the Kitadani Formation (Early Cretaceous) of the Tetori Group of Katsuyama, Fukui Prefecture, Central Japan. Memoir of the Fukui Prefectural Dinosaur Museum, 1: 29-40, 6 figs. (in Japanese with English abstract).

Hirayama, R. 2006. Review of fossil turtles of Japan. Fossils (Palaeont. Soc. Japan) 80:47-59, 11 figs., 1 tab. (in Japanese with English abstract)

Hirayama, R. 2010. Non-marine turtles from the Early Cretaceous Tetori Group of Kasekikabe of Hakusan City, Ishikawa Prefecture, Central Japan. In, [Scientific report on fossils from the Kuwajima Formation, Tetori Group, of Kuwajima "Kaseki-kabe", Hakusan City, Ishikawa, Japan], pp.19-24, 2 figs. Hakusan City Board of Education, Ishikawa Prefecture, Japan. (in Japanese)

Hirayama, R. 2017a. Fossil turtles from the Tetori Group: their systematics and biostratigraphic significance. Program and Abstracts of the 35th Annual Meeting of the Fossil Research, 9. (in Japanese)

Hirayama, R. 2017b. Fossil vertebrate assemblages from the Late Cretaceous Tamagawa Formation of Kuji City, Iwate Prefecture, eastern Japan.Proceedings and Field guidebook for the 5th International Symposium of International Geoscience Program IGCP Project 608, p. 77-78.

Hirayama, R., Brinkman, D.B. and Danilov, I.G. 2000. Distribution and biogeography of non-marine Cretaceous turtles. Russian Journal of Herpetology, 7:181-198.

Hirayama, R., Isaji, S. and Hibino, T. 2012. *Kappachelys okurai* gen. et sp. nov., a new stem soft-shelled turtle from the Early Cretaceous of Japan. In: Brinkman, D.B., P. A. Holroyd, and J. D. Gardner (eds.), “Morphology and Evolution of Turtles: Origin and Early Diversification.”, pp. 179-185. Springer, Dordrecht.

Hirayama, R., Kobayashi, Y., Sonoda, T., and Sasaki, K. 2010. Preliminary report of terrestrial vertebrates from the Late Cretaceous Tamagawa Formation of the Kuji Group of Kuji, Iwate Prefecture, eastern Japan. Journal of Fossil Research 42: 74-82, 10 figs. (in Japanese with English abstract)

Nakajima, Y., Danilov, I. G., Hirayama, R., Sonoda, T. and Scheyer, T. M. 2017. Origin of softshell turtles, and their dispersal during the mid-Cretaceous supergreenhouse. Journal of Vertebrate Paleontology 37 (2).

Sano, S. 2018. Recent advances in the stratigraphy of the Upper Mesozoic Tetori Group in northern Central Japan : beyond the paradigm of Maeda （1961） . Journal of Fossil Research 51: 5-14. (in Japanese with English abstract)

Sonoda, T., Hirayama, R., Okazaki, Y. and Ando, H. 2015. A new species of the genus Adocus (Order Testudines; Family Adocidae) from the Lower Cretaceous of Southwest Japan. Paleontologocal Research 19:26-32.

On Non-Marine and Marine Correlation of Cretaceous Strata

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Abstract

The international chronostratigraphic framework chart and the time scale of the Cretaceous System established by the International Commission on Stratigraphy is based on marine rocks and radiometric ages. However, abundant non-marine Cretaceous deposits globally exist, particularly in Central, East and Southeast Asia including China, Mongolia, Korea, Japan, Viet Nam, Lao, and Thailand, where the non-marine Cretaceous deposits, containing various fossils and more or less volcanic materials, are widely distributed. There is almost no consensus on ages of these strata, their subdivision and correlation, and the place of the Jurassic/Cretaceous boundary. Consequently, the non-marine must be correlated with marine strata, mainly on the basis of the biostratigraphy and radiometric dating obtained from the strata concerned. Through correct taxonomic identification of both marine and non-marine fossils in alternating marine and non-marine strata, it should be possible to correlate both marine and non-marine strata with the international chronostratigraphic chart (http:/www.stratigraphy.org) and, therefore, to determine or constrain the age of the non-marine strata/fossils (chronostratigraphy). The intervening tuffs, tuffaceous rocks and lavas can also be radiometrically dated (geochronology), hence providing a basis for accurate age determinations of the associated sedimentary rocks and the fossils they contain. The recognition of orbitally-force cyclic strata in non-marine strata, especially in lacustrine rocks, also provides an astrochronology and aid in non-marine Cretaceous chronology (cyclostratigraphy/ astrostratigraphy). Some of the non-marine fossils constrained by marine fossils and radiometric and /or astronomical dating could be widely used in non-marine stratigraphic subdivision, correlation and age as indicators.

Keywords: Non-marine; marine; correlation; Cretaceous

Palaeoecology of a Maastrichtian lake during Deccan environmental transition: evidences from Malwa Plateau

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Abstract

Biotic and environmental impact of Deccan volcanism across the Cretaceous-Paleogene boundary (K-Pg B) has been a matter of debate. The Deccan volcanic sequences of Malwa Plateau north of Narmada represent the northern most lava piles of Deccan eruptions mainly in the state of Madhya Pradesh, India . The lava sequences are classifield as Malwa Group of Deccan traps (Geological Survey of India, 1993). Presently occupying over 50,000 km^2 the lava fields represent at least 46 basaltic lava flows having a cumulative thickness of over 730m. The flows are associated with multiple intertrappean sedimentary beds and red/green boles (weathered basalt profiles/palaeosols) at different strargraphic levels. The sediments designated as 'intertrappean' are lake deposits formed over the lava surface during the pause in the vocanic activity and record the history of contemporary biota and environments.

In Malwa Group the lake sediments are present at 8 stratigraphic levels associated with lava flows of lower series of flows of Mandleshawar and Kalisindh formations. The upper series of lava flows are not associated with any intertrappean sediments. Our investigation showed that the lava piles of lower series were erupted during the magnetochron C30n (Schoebel et al, 2014, Mohabey et al, 2018). The lake sediments at Bagvanya locality in the Bagh Valley in Dhar District are deposits between the two basal lava flows. Outcrops of the sediments are spread over 4 km^2 that may be the minimum size of the Bagwanya lake that developed over the fresh lava surface. The lake sediments were studied in eight geographically separated sections having thickness 120 cm to 240 cm. The sediments are mainly yellow to cream finely laminated clayey siltstone to siltstone representing a fine suspension deposits derived from the basin when the lake water level was high. The limonitic bands in the siltstones indicate intermittent aerial exposure of the sediments and their oxidation. The intercalated carbonate band showing carst-weathering features and detachments represents the deposits during the dry spell developing alkalinity with evaporative conditions. In the upper parts the sediments mainly comprise cream to yellow argillaceous bioturbated limestone with thin gray hard clay and black to gray chert bands. Towards the top the intercalated argillaceous carbonate bands possibly represent their deposition during the low water level strand along the margins of the lake. The lake sediments show that they are smectite-quartz dominated in the lower parts whereas in the upper parts it is vermiculite dominated suggesting that they are derived products after the weathering of basalt flows. The quartz may be detritus derived from the basinal margins. The capping 30-40 cm thick micritic limestone with thin chert stringers are full of float or

debris-wash freshwater gastropods.Stable isotope analysis of few gastropods showed value as $\delta^{13}C$ -6.1 and $\delta^{18}O$ -13.3.

Plants as represented by pollen-spores are dominantly aquatic to semiquatic mainly *Gabonosporis, Sparganiaceaepollenites* and *Azolla cretacae* (Salvineaceae family)- the later suggesting prevalence of temperature within 20^{0}-30°C and neutral to alkaline pH in the lake at the time of deposition. These plants possibly colonised the lake floor with good light and oxygenated conditions and may be some shrubs and herbs growing along the lake margins. Sizeable presence of charophyte gyrogonites suggests their growth in shallow water (1-3m) may be having a slight alkalinity. Commonly present diatom frustules- pinnate and centric (*Aulocoseira*) also suggest alkaline lake conditions during low-water level strand during dry phase of lake. Vertebrates are mainly represented by isolated teeth and dermal armour fragments of Notosuchid crocodylimorphs, indeterminate lizards (Eolacertiia *Litakis*?), diversified fishes dominated by *Lepisosteus* and *Lepidotes* with scarce presence of Pycnodontidae, Clupeids and batoids.

Thus, based on the studies it is interpreted that the lake was developed on the fresh lava surface of the earliest flow of C30n Maastrichtian. It was a small to medium sized ($4km^{2}$), shallow water lake wherein the sediments under oxygenated conditions were deposited during the wet and dry phase of the lake under semi-arid to arid conditions. Exclusive aquatic to semi-aquatic plants colonised different parts of the lake inhabitated by aquatic reptiles- crocodylimorphs, lizards (semiaquatic?), frogs and fishes.

References

Geological Survey of India. (1993). Published Quadrangle Geological Map. Map Printing Division, Geological Survey of India, Government of India Publications, Hyderebad.

Mohabey, D.M., Samant, B. , Deepesh Kumar, Dhobale A., Rudra, A. and Datta, S. (2018). Record of charcoal from early Maastrichtian intertrapean lake sediments of Bagh valley of Madhya Pradesh: palaeofire proxy. Curr. Sci. , 114 (7), 1540-1544.

Stefan Schöbel Helga de Wall Morgan Ganerød Manoj K. Pandit Christian Rolf (2014). Magnetostratigraphy and 40Ar–39Ar geochronology of the Malwa Plateau region (Northern Deccan Traps), central western India: Significance and correlation with the main Deccan Large Igneous Province sequences. J. Asian Ear. Sci., 89, 28-45.

Palynoflora and microfauna from Late Cretaceous Lameta sediments and Intertrappean sediments of Nand-Dongargaon and Salbardi-Belkher inland basins of central India: age and paleoenvironment implications

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Abstract

Late Cretaceous-Early Paleocene Deccan Volcanic Flood Basalt occupying an area of about 500,000 km^2 in peninsular India. The Lameta sediments of Late Cretaceous covered the six inland basins viz. Nand-Dongargaon (N-D); Jabalpur; Sagar; Ambikapur-Amarkantak; Balasinor-Jhabua and Salbardi-Belkher in the states of Maharashtra, Madhya Pradesh and Gujarat of Central India. The detail palynology and clay mineralogy is carried out of sediments of Nand-Dongargaon and Salbardi-Belkher inland basins during present study. Lithologically, Lameta sediments comprises of limestone, red and green clay, marlite and calcareous sandstone. The palynoflora from the Lameta sediments and sauropod dinosaur coprolites is represented by gymnosperms (*Araucariacites* sp., *Cycadopites* sp., *Podocarpidites* sp., *Classopollis sp.*, etc), angiosperms (*Palmaepollenites* sp., *Longapertites* sp., *Graminidites* sp., *Compositoipollenites, Multiareolites,* Tetracolporate and Polycolporate pollen, etc.) and pteridophytes (*Azolla* massulae, *Cyathidites*, trilete spores, etc.). Presence of good preservation of three genera of thecamoebians viz. *Centropyxis*, *Difflugia* and *Pontigulasia,* grass phytoliths of Poaceae, starch cells, peltate hairs, fungi and other plant remains like leaf cuticles, starch cells and tracheal material. Other biota like fungal spore (*Monocellate*, *Dicellate* and *Multicellate*), algal (*Botryococcus, Oedogonium*) and bacterial remains associated with diatom frustules (*Aulacoseira*), invertebrates like gastropods and bivalves have also been recovered.

However, many intertrappean beds have been studied from the study area and lithologically they comprises mostly of cherty limestone with nodular structure, highly fossiliferous dark green/ black grey chert, shales, shaly chert, tuffaceous breccias, green clay and white clay, sandy shales and occasional calcareous sandstone. The biotic assemblage of intertrappean beds consists of freshwater Maastrichtian age marker palynoflora *viz. Jiangsupollis, Farabeipollis, Aquilapollenites bengalensis, Gabonisporis vigaurouxii, Gabonisporites, Azolla*. Microfauna such as Foraminiferal linings, *peridinium* dinoflagellate and other organic structures, Gastropods (*Physa, Lymnia, Turittela* and *Viviforms*) and Ostracods (*Mongolianella*, *Cypridopsis, Frambocythere and Paracypretta, etc*) have also been recovered. Apart from Palynoflora, megafloral remains represented by palm roots, fossil woods of both dicots and monocots, well preserved fruits of angiosperm plants are also present in intertrappean beds of the study area. Palynology from coprolites of N-D basin suggests sauropod dinosaurs preferred to ate soft tissues of angiosperms and gymnosperms. The presence of phytoliths of Poaceae indicates diversity of grasses during the Maastrichtian period. Sauropod dinosaurs ingested thecamoebians, burnt grasses, sponge spicules, diatoms, fungal spores, mycorrhizal fungi and other plant tissues during intake of water.

Lithology, Palynoflora and Clay mineralogy from the study area suggests prevalence of Arid to Semiarid climate with marked seasonality, lacustrine environments and prevailing sub-humid condition at the time of deposition of the intertrappean beds. The study helped in understanding the deposition and recording Palynoflora and microfauna, environmental condition from the Lameta and Intertrappean sediments, floral changes with the volcanic activity in the Nand-Dongargaon and Salbardi-Belkher inland basin as well as climate during Late Cretaceous-Early Paleocene.

Keywords: Sauropod dinosaurs, coprolites, Palynoflora, Microfauna, Maastrichtian, Intertrappeans, Inland basins, Deccan Volcanic Flood Basalt, Central India.

Palynology studies of the Talbulag coal deposit, Eastern Mongolia

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Abstract

Palynology studies of the Early Cretaceous of the eastern part of Mongolia, Talbulag coal deposit studied for the first time to improve geological dating and correlation of spore-pollen assemblages. The assemblage described from open-pit Talbulag coal deposit, Aptian-Albian age for the Tevshiingovi formation (Khukhteeg Formation) in this area. The quantitative composition of the palynofloras is characterized by the dominance or abundance of pollen produced by the non-saccate gymnosperm pollen such as Cycadopites, Ginkgocycadopites and bisaccite coniferus Pinuspollenites, Podocarpidites, Quadraculina, Ginkgocycadopites, Inaperturapollenites, Cycadopites, Piceapollenites. Spores are not numerous, but presented different species of Concavisporites, Cyathidites, Osmundacidites, Cycatricosisporites, Laevigatosporites, Cyathidites, Lycopodiumsporites, Baculatisporites, Biretisporites.

This palynocomplex is different from the previous lower Cretaceous palynocomplex (Ichinnorov, 2005, 2009, Ichinnorov, et all, 2016, 2017). In the previous assemblages were occurred many species of spores such as Pilosisporites trichopapillosus, Pilosisporites notensis, Pilosisporites verus, Cooksonites variabilis, Trilobosporites microverrucatus, in this assemblage not found these spores. Spores are represented by abundant species of Cyathidites, Osmundacides.

According to occurrences of spores and pollen the stratigraphic distribution of palynoassemblage is Aptian-Albian (correlated to the Khukhteeg) Formation.

The palynological evidence is consistent with a humid and warm paleoclimate.

References

Ichinnorov, N. 2005. Palynostratigraphic results of Shinekhudag and Khukhteeg Formations, Eastern Mongolia. Mongolian Geoscientist. No. 27, p.12-14.

Ichinnorov,N. 2009. Palynocomplex of Mongolia. Paleontology of Mongolia, Fanerozoic Flora. 133-155.

Ichinnorov Niiden, Christa-Ch. Hofmann, Hasegawa Hitoshi, Uranbileg Luvsantseden. 2016. Lower Cretaceous formations and palynology of the Matad area (Tamsag Basin), southeastern Mongolia. The Fourth International Symposium of International Geoscience Programme IGCP Project 608, Short Papers, Novosibirsk,p. 86-89.

Ichinnorov N., Eviikhuu A. , Gankhuyag Ch., Tsolmon G., Enkhtugs U. "Lower Cretaceous spore-pollen from brown coal deposit, Erdenetsogt Govi, Southeast Mongolia". Abstract, P.92-93.

Plant Fossils from the Lower Cretaceous in Shandong Province, China

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Abstract

The Cretaceous is an important "greenhouse climate" period, and a series of geological tectonic and climatic activities happened in the time, which led to tremendous changes in the global environment. The study on the Cretaceous plant fossils has a constructive contribution for understanding palaeoclimate during this stage. The Laiyang area is located in the central region of the Shandong Peninsula, China. A set of lacustrine-dominated strata are developed in this area.

Plant fossils in this paper were collected from the Lower Cretaceous Laiyang Formation of Shandong Province, eastern China, which provides an important fossil evidence for analyzing paleoclimate, paleoecology and palaeogeography. Based on the morphological features and microstructures of vegetative and reproductive organs, 21 species of 10 genus from 5 families are identified, and *Equisetites*, *Pararaucaria*, *Elatides, Brachyphyllum*, *Pagiophyllum*, *Cupressinocladus*, and *Ephedra* are discussed deeply. The dominate elements of the Laiyang flora are the Coniferopsida, Cycadopsida, Bennettiopsida, Filicinae and Pteridospermae. Otherwise, Ginkgopsida and Ephedraceae are rare. In additional, the paleoatmospheric CO_2 concentrations of the Early Cretaceous are reconstructed by using the stomatal parameters of Coniferopsida plant fossils from Laiyang Formation, which has important guiding significance for predicting the trend of global climate change in future.

The paleoatmospheric CO_2 concentration of the Early Cretaceous is reconstructed using the stomatal ratio based on three species of *Brachyphyllum*, *Pagiophyllum* and *Cupressinocladus*, with good indication of CO_2 concentration. Furthermore, the lower paleo–atmospheric CO_2 concentration suggests a cooling trend of the palaeoclimate during the Early Cretaceous (Hauterivian–Barremian) of the Shandong.

Keywords: Early Cretaceous, plant fossil, paleoclimate, Shandong Province

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References:

Aucour A.M., Gomez B., Sheppard S.M.F., et al., 2008. $\delta^{13}C$ and stomatal number variability in the Cretaceous conifer *Frenelopsis* [J]. Palaeogeography Palaeoclimatology Palaeoecology, 257: 462–473.

Axsmith B.J., 2006. The vegetative structure of a Lower Cretaceous conifer from Arkansas: further implications for morphospecies concepts in the Cheirolepidiaceae [J]. Cretaceous Research, 27: 309–317.

Berner R.A., 2006. GEOCARBSULF: a combined model for Phanerozoic atmospheric O_2 and CO_2 [J]. Geochimica et Cosmochimica Acta, 70: 5653–5664.

Channing A., Zamuner A., Edwards D., et al., 2011. *Equisetum thermale* sp. nov. (Equisetales) from the Jurassic San Agustín hot spring deposit, Patagonia: anatomy, paleoecology, and inferred paleoecophysiology [J]. American Journal of Botany, 98: 680–697.

Friis E.M., Pedersen K.R., Crane P.R., 2009. Early Cretaceous mesofossils from Portugal and eastern North America related to the Bennettitales–Erdtmanithecales–Gnetales group [J]. American Journal of Botany, 96: 252–283.

Haworth M., Heath J., McElwain J.C., 2010. Differences in the response sensitivity of stomatal index to atmospheric CO_2 among four genera of Cupressaceae conifers [J]. Annals of Botany, 105: 411–418.

Tomlinson P.B., Takaso T., 2002. Seed cone structure in conifers in relation to development and pollination: a biological approach [J]. Canadian Journal of Botany, 80: 1250–1273.

Preliminary study on the growth of *Fukuiraptor kitadaniensis* (Dinosauria: Theropoda)

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Abstract

Fukuiraptor kitadaniensis is an allosauroid theropod known from the Lower Cretaceous Kitadani Formation, Tetori Group cropping out in the Kitadani Dinosaur Quarry, Fukui, Japan. A number of isolated bones of this taxon have been collected from the quarry including the growth series of femora, most of which are much smaller than those of the holotype specimen (FPDM V97122; Currie & Azuma, 2006). Although such concentration of juvenile specimens may indicate nesting or breeding (Currie & Azuma, 2006), a substantially-low growth rate could be an alternative reason for such bias. To address this question, we examine the age composition and reconstruct the growth curve of *F. kitadaniensis* based on the femoral growth series.

Currie & Azuma (2006) reports 18 femora of *F. kitadaniensis* in addition to the holotype specimen. Because this taxon is the only allosauroid species recognized in this quarry, its identification was based on six characters synapomorphic to allosauroids. First, we re-examined these femora and other theropod femora from the quarry based on eight characters, six from Currie & Azuma (2006) and additional two as follows; the mid-shaft is mediolaterally narrow and dorsoventrally elongated in the cross section, and the trochanteric shelf does not reach the plantar margin of the shaft. Second, we analyzed thin sections of four femora of *Fukuiraptor* including the holotype specimen to locate the best section to count LAGs (lines of arrested growth), which are growth rings with an annual periodicity occurring in the bones of tetrapods. There is a nutrient foramen on the dorsal aspect of the proximal shaft (Azuma & Currie, 2000) which probably suggests the position of the center of growth, where the cortical bone possibly records the largest number of LAGs. The computed tomographic images of the specimens revealed that the foramen penetrates the cortical bone nearly perpendicular to the long axis of the shaft. This suggests that the center of growth of the femur is possibly in this region of the shaft, just proximal to the fourth trochanter and distal to the lesser trochanter. Because of these reasons, we made thin sections of this region, in addition to the one at the mid-diaphysis region, which is a standard procedure in previous histological studies on theropods. In this presentation, we report the result and discuss the implication of our thin section analysis.

REFERENCES:

Azuma, Y., and P. J. Currie. 2000. A new carnosaur (Dinosauria: Theropoda) from the Lower Cretaceous of Japan. Canadian Journal of Earth Sciences 37:1735–1753.

Currie, P. J., and Y. Azuma. 2006. New specimens, including a growth series, of *Fukuiraptor* (Dinosauria, Theropoda) from the Lower Cretaceous Kitadani Quarry of Japan. Journal of Paleontological Society of Korea 22:173–193.

Preliminary study on the provenance of the Hayang Group sandstones in the Gyeongsang Basin, Korea using detrital zircon geochronology

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Abstract

Gyeongsang Basin is the largest Cretaceous nonmarine sedimentary basin in the Korean Peninsula, formed by extension in an active continental margin setting. The basinfill of the Gyeongsang Basin is subdivided into the Sindong, Hayang and Yucheon groups with decreasing age. The Hayang Group is divided into three subbasins: Yeongyang, Euiseong, and Milyang subbasins southward. Each subbasin has stratigraphically different basinfill each other, which means their different evolution history. To characterize the sedimentary provenance and basin drainage systems of the succession, 12 Hayang Group sandstones in the Yeongyang subbasin were collected for U-Pb detrital zircon age dating using a laser-ablation-inductively-coupled-plasma mass spectrometry technique from each formation in four different parts of the subbasin.

Detrital zircons show a wide range of ages ranging from 3560 Ma to 99 Ma with spatial and temporal variation of age population. The zircon grains from western part of the basin are dominated by Jurassic and Paleoproterozoic ages, while those from the northern part are dominated by Paleoproterozoic ages with minor Mesozoic ages. Based on the statistical test, provenance of the Hayang Group sandstones in the Yeongyang subbasin can be grouped into three groups according to their differences in the ratio between the Mesozoic and Paleoproterozoic zircon age populations. These three groups may represent the shared detrital drainage systems and their evolution during the deposition of the Yeongyang subbasin sediments.

Provenance of the Cretaceous Neungju Basin, Korea

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Abstract

The Neungju Basin is a Cretaceous nonmarine basin located in the southwestern Korean Peninsula. Basinfill of the Neungju Basin consists mainly of conglomerate, sandstone, siltstone, and tuff. The Neungju Basin is filled by the Neungju Group, which consists mainly of siliciclastic and pyroclastic rocks with volcanic rocks. The strata of the Neungju Group consist of Oyeri Fm., Manwolsan Tuff, Jangdong Fm., Yeonhwali Fm., Yeonsan Fm., Jeokbyeok Tuff, Ongam Conglomerate. The Jangdong Tuff, one of the strata comprising the Neungju Group, bears dinosaur track. Depositional environment of the Jangdong Tuff is interpreted to be a lake margin. However, sedimentological characteristics of the whole Neungju Basin have not been studied yet. Thus, we carried out petrography and detrital zircon geochronology analysis on the Neungju Basin sedimentary rocks to constrain their provenance.

Petrographic analysis on the Neungju Basin sediments reveals that the sandstones and matrices of the conglomerate are comprised mainly by angular grains of quartz, feldspar, and metasedimentary and volcanic rock fragments. The conglomerate are generally matrix-supported and contain angular clasts such as quartzite, schist, granite, and tuff. The amount of rock fragments increase up sequence.

Zircon grains in tuffs in the Neungju Basin show ages of 96~88 Ma and indicate depositional period of the basin. Conglomerates and sandstones mainly contain detrital zircons of Jurassic(187 Ma) and Early Proterozoic age(1853 Ma), but no Cretaceous zircons. Oyeri and Yeonsan Fm., located in northern part of the basin contain Jurassic(187 Ma) and Early Proterozoic zircon grains(1854 Ma). Jeokbyeok Tuff and Ongam Conglomerate, located in eastern of the basin contain only detrital zircons of Early Proterozoic(1848~2476 Ma). Jandong Fm., located in southwestern of the basin mainly contains Jurassic zircons(187 Ma).

Deposition of the Neungju Basin was begun at about 96~94 Ma, earlier than the eruption time of the Mudeungsan Tuff (86~84 Ma). Sediments comprising clastic rocks of the Neungju Basin were mainly supplied from nearby Jurassic granite, Paleozoic metasediments, and Early Proterozoic gneiss. Considering that the clastic sedimentary rocks do not contain Cretaceous zircons, the pyroclastic material was supplied intermittently from the southwest of the basin during the deposition of the Basin.

Refined chronostratigraphy of the late Mesozoic terrestrial strata in South China and its tectono-stratigraphic evolution

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Abstract

The late Mesozoic terrestrial strata in numerous small basins in South China provide important sedimentary archives to understand the tectonic evolution of South China and East Asia. However, establishing regional stratigraphic framework within a basin and precisely correlating strata among basins / regions remain challenging due to limited chronological constraints. In this study, we report zircon U-Pb ages of 21 samples and a compilation of 132 reliable age data from 15 type sections of the volcanic-sedimentary basins in South China. The synthesized geochronology allows us to establish a refined chronostratigraphy for the late Mesozoic terrestrial strata. New calibrated results indicate most of lithostratigraphic units are diachronic, laterally stacking, and / or interfingering in the Gan-Hang tectonic zone (back-arc or rifting basins), South China. Particularly, the Cretaceous type sections, such as the Zhoucun-Yanxia type section at Shouchang of Jiande and the Laozhu section of Lishui in western Zhejiang, were interpreted as two duplicates of the same stratigraphic sequences. Six stacking styles are classified for the relationship of lithostratigraphic units. Analysis of the refined chronostratigraphy and the stratal stacking styles together with lithological composition reveals three episodes of tectono-stratigraphic evolution. Episode Ⅰ (~145-125 Ma) is featured by intense volcanism, as evidenced by widespread volcanic strata and (137-120 Ma) A-type granites, and was probably related to the rollback of the subducting Paleo-Pacific plate; The strata deposited during Episode Ⅱ (~125-100 Ma) is composed of variegated sediments associated with/without volcanic intercalations in sedimentary faulted-depression basins, indicating the waning of volcanism and tectonism attributed to the ending of the Izanagi / Kula plate subduction; In Episode Ⅲ (<~100 Ma), red strata occurred along the NE-SW strike-slipping sinistral faulting or failed rifting in small basins, which probably resulted from the drastic directional change of the subduction of the Paleo-Pacific plate from NW to SN.

Keywords: chronostratigraphy; stratigraphic stacking; tectono-stratigraphy; late Mesozoic; South China

Review and Revision of the socalled "Khorat GRoup", NE, Thailand

Nares Sattayarak

Searching for the non-marine Jurassic/Cretaceous boundary in northeastern China

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Abstract

In northeastern China the well developed Jurassic and Cretaceous strata are mainly of non-marine origin. The definition of a non-marine Jurassic/Cretaceous (J/K) boundary in northeastern China is mainly based on the age assignment of the well known non-marine Jehol Biota of eastern Asia. Although the *Eosestheria-Ephemeropsis-Lycoptera* bearing strata in China, Mongolia and Transbaikalia of Russia were originally assigned to Early Cretaceous in 1920s, the whole Jehol Group of western Liaoning of northeastern China, which contains the Jehol Biota in the lower and the Fuxin Biota in the upper, was revised to Middle-Late Jurassic since early 1960s. This age revision was further supported by the recoveries of an alleged Bathonian (Middle Jurassic) *Arctocephalites* ammonite fauna and a Late Jurassic *Buchia* fauna from eastern Heilongjiang Province in middle 1980s. Since early 1990s, through the revisions of the above mentioned Jurassic marine faunas of eastern Heilongjiang to Early Cretaceous ones, the Jehol Biota was re-assigned back to the Early Cretaceous by some authors. At the same time the recoveries of feathered dinosaurs, early birds, mammals and angiosperms from the Yixian and Jiufotang formations stimulated the interests to carry out precise radiometric dating for the Jehol Group and its underlying strata in western Liaoning and northern Hebei. The new radiometric dating indicates that the non-marine J/K boundary in northern China would be delineated within the contemporaneous Houcheng (in northern Hebei) and Tuchengzi (in western Liaoning) formations, which are stratigraphically much lower than the Jehol Group of western Liaoning.

Keywords: Non-marine, Jurassic/Cretaceous boundary, northeastern China

Significance of Cretaceous strata in the Japanese Islands: Cretaceous continental arc-trench system

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Abstract

The Japanese Islands are situated in an active convergent margin along the eastern margin of Asian continent. Their geologic structure is therefore very complicated. The distribution of Cretaceous strata reflects the tectonic settings of four arc-trench systems: Kuril, Northeast (NE) Japan, Southwest (SW) Japan and Ryukyu (Takahashi and Ando, 2016). The tectonic configurations of the two main systems (NE Japan and SW Japan) during the Cretaceous have not yet been well resolved partly because of the heavy post-Cretaceous tectonic influence. This is because the Cretaceous strata had been affected by post-Paleogene tectonic movements such as the Japan Sea opening, the subduction of Philippines Sea Plate, the collision of the Izu-Ogasawara arc since the early Miocene. To establish the paleogeographic and paleoenvironmental reconstruction of the Cretaceous, we must thus pay attention carefully to the post-Cretaceous geologic settings.

We compiled spatiotemporal distributions of the Cretaceous rocks (plutonic and volcanic rocks, sedimentary rocks, and accretionary complexes) in the SW Japan and NE Japan arcs is based on the published geological maps as well as many current geological researches. Their distributions were drawn on the straight paleogeographical map of the SW Japan and NE Japan arcs prior to the opening of Japan Sea (25 Ma). Although the Cretaceous rock distributions apparently differ between the SW Japan and NE Japan arcs, their four parallel zonal arrangements can be broadly recognized throughout both arcs: 1) mostly non-marine sedimentary rocks in intra-arc basins, 2) granitic and volcanic rocks in the magmatic arc, 3) mainly marine and subordinately fluvial sedimentary rocks in forearc basins, and 4) sedimentary rocks of turbidite and mélange facies in accretionary complexes.

We correlated a total of 48 Cretaceous successions in intra-arc and forearc basins, from Kyushu to north Honshu islands on a stratigraphic chart and compiled them as to major sedimentary facies. This result shows the general similarity of major sedimentary facies and trends between the NE Japan and SW Japan arcs, suggesting that the forearc basins had been continued throughout the two arcs during the Cretaceous. Although surface exposures of Cretaceous strata are very scarce in NE Japan, the offshore forearc beneath the Pacific is estimated to contain very potent subsurface Cretaceous forearc basin sediments, spread more than a several tens of kilometers wide area. The conspicuous zonal distribution of Cretaceous forearc sediments along the southern half of SW Japan was possibly formed as the result of post-early Miocene tectonics, such as the Japan Sea opening and related

adjacent plate movements. Therefore, the conspicuous differences in geologic structure between SW Japan and NE Japan arcs, resulted from their differentiated Neogene tectonic histories.

Japanese Cretaceous strata record a wide variety of sedimentary facies and biofacies changes from offshore to shallow-marine to continental, reflecting paleoenvironments and basin tectonic settings such as backarc/intra arc, forearc and trench slope-trench basins along the single continental arc-trench system between the Eurasian Plate and the subducting Paleo-Pacific oceanic plate.

References

Ando, H. and Takahashi, M., 2017. Reconstruction of the Cretaceous Paleo-Japan continental arc-trench system reconsidered from Cretaceous geologic records in the Japanese Islands. Fossil (Kaseki), **102**, 43–62.

Takahashi, M. and Ando, H., 2016. Reconstruction of the Cretaceous continental arc of Japan on a viewpoint of arc-trench system. Fossil (Kaseki), 100, 45–59.

Terrestrial climates in East Asia during the Cretaceous inferred from the stable oxygen and carbon isotope compositions of vertebrate apatites; Further results

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Abstract

Past terrestrial climatic conditions in terms of local air temperatures and precipitation amounts can be inferred from the oxygen and carbon isotope compositions of vertebrate apatites preserved as fossilized skeletal remains (teeth, bones, scales). Using existing phosphate-water oxygen isotope fractionation equations established for extant crocodilians, turtles, mammals, dinosaurs and fish (Amiot et al., 2017, 2007, 2004; Barrick et al., 1999; Lécuyer et al., 2013), the $\delta^{18}O_w$ value of Cretaceous local surface waters can been estimated from vertebrate phosphate and, when possible, Mean Air Temperature (MAT) are calculated based on the known relationship existing between local meteoric water $\delta^{18}O_{mw}$ value and MAT (Dansgaard, 1964). The mean amount of annual precipitation (MAP) can be estimated from the $\delta^{13}C_{plant}$ value of C_3 plants (Diefendorf et al., 2010; Kohn, 2010). In turn, the average value of local Cretaceous C_3 plants $\delta^{13}C_{plant}$ value can be estimated either from the carbon isotope composition of preserved organic matter in sediments, or the $\delta^{13}C_c$ value of apatite carbonate of plant-eating vertebrates such as sauropodomorph and ornithischian dinosaurs (Fricke et al., 2008; Fricke and Pearson, 2008; Tütken, 2011). Using published and newly acquired oxygen isotope composition of vertebrate apatite phosphate, as well as carbon isotope compositions of sediment organic matter and dinosaur apatite carbonate, MAT and MAP have been estimated for Early and Late Cretaceous localities of East Asia (China, Japan, Thailand, Mongolia, Russia). The validity of these reconstructed climatic variables will be discussed in the light of their paleolatitudinal, paleogeographic and paleontologic contexts, and compared to other climate records.

References:

Amiot, R., Angst, D., Legendre, S., Buffetaut, E., Fourel, F., Adolfssen, J., André, A., Bojar, A.V., Canoville, A., Barral, A., Goedert, J., Halas, S., Kusuhashi, N., Pestchevitskaya, E., Rey, K., Royer, A., Saraiva, A.Á.F., Savary-Sismondini, B., Siméon, J.-L., Touzeau, A., Zhou, Z., Lécuyer, C., 2017. Oxygen isotope fractionation between bird bone phosphate and drinking water. Sci. Nat. 104, 47. https://doi.org/10.1007/s00114-017-1468-2

Amiot, R., Lécuyer, C., Buffetaut, E., Fluteau, F., Legendre, S., Martineau, F., 2004. Latitudinal temperature gradient during the Cretaceous Upper Campanian-Middle Maastrichtian: $\delta^{18}O$ record of continental vertebrates. Earth Planet. Sci. Lett. 226, 255–272. https://doi.org/10.1016/j.epsl.2004.07.015

Amiot, R., Lécuyer, C., Escarguel, G., Billon-Bruyat, J.-P., Buffetaut, E., Langlois, C., Martin, S., Martineau, F., Mazin, J.-M., 2007. Oxygen isotope fractionation between crocodilian phosphate and water. Palaeogeogr. Palaeoclimatol. Palaeoecol. 243, 412–420. https://doi.org/10.1016/j.palaeo.2006.08.013

Barrick, R.E., Fischer, A.G., Showers, W.J., 1999. Oxygen isotopes from turtle bone: applications for terrestrial paleoclimates? Palaios 14, 186–191. https://doi.org/10.2307/3515374

Dansgaard, W., 1964. Stable isotopes in precipitation. Tellus 16, 436–468. https://doi.org/10.1111/j.2153-3490.1964.tb00181.x

Diefendorf, A.F., Mueller, K.E., Wing, S.L., Koch, P.L., Freeman, K.H., 2010. Global patterns in leaf ^{13}C discrimination and implications for studies of past and future climate. Proc. Natl. Acad. Sci. 107, 5738.

Fricke, H.C., Pearson, D.A., 2008. Stable isotope evidence for changes in dietary niche partitioning among hadrosaurian and ceratopsian dinosaurs of the Hell Creek Formation, North Dakota. Paleobiology 34, 534–552.

Fricke, H.C., Rogers, R.R., Backlund, R., Dwyer, C.N., Echt, S., 2008. Preservation of primary stable isotope signals in dinosaur remains, and environmental gradients of the Late Cretaceous of Montana and Alberta. Palaeogeogr. Palaeoclimatol. Palaeoecol. 266, 13–27.

Kohn, M.J., 2010. Carbon isotope compositions of terrestrial C_3 plants as indicators of (paleo) ecology and (paleo) climate. Proc. Natl. Acad. Sci. 107, 19691–19695.

Lécuyer, C., Amiot, R., Touzeau, A., Trotter, J., 2013. Calibration of the phosphate δ^{18}O thermometer with carbonate–water oxygen isotope fractionation equations. Chem. Geol. 347, 217–226. https://doi.org/10.1016/j.chemgeo.2013.03.008

Tütken, T., 2011. The diet of sauropod dinosaurs: implications from carbon isotope analysis of teeth, bones, and plants, in: Klein, N., Remes, K., Sander, M. (Eds.), Biology of the Sauropod Dinosaurs: Understanding the Life of Giants. Indiana University Press, Bloomington, pp. 57–79.

The Early Cretaceous angiosperm pollen of Transbaikalia and Primorye region (Russia)

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Abstract

We revealed in recent years the angiosperm pollen in the Lower Cretaceous deposits of the Transbaikalia and Primorye region.

In the Porechye quarry of the Ilyichevka coal field of the Razdolnaya River Basin (Southern Primorye region), which outcrops the Lipovtsy Formation of the Aptian age, pollen of the *Clavatipollenites hughesii* Coup., *Tricolpites micromunus* Burger, *T. vulgaris* Pierce, *T. variabilis* Burger, *Tricolpites* spp., *Quercites sparsus* (Mark.) Samoil., *Retitricolpites georgensis* Brenn. was found. The percentage of this pollen in the palynospectra is extremely low. In the sequence of this formation, the aforementioned palynomorphs appear above the acidic tuffs, widely distributed in the upper part of the thick rhabdopissite-humic coal seam. In this territory, after the termination of coal accumulation, the extensive river valleys developed. Such environments are favorable for angiosperm colonization.

In the palynospectra of coeval sediments, outcropping in the Aleksei-Nikolsky quarry in this basin, *Tricolpites* spp. (0.9%) and *Clavatipollenites hughesii* (0.3%) were obtained. The acidic tuff bed in the thick rhabdopissite-humic coal seam is almost not expressed, alluvial deposits are not found. Perhaps the existence of marsh conditions was unfavorable for flowering plants, so they are extremely rare here.

In 2015, we visited Dongning coal mine in the north-western margin of the Razdolnaya River Basin in China, where the coeval coal-bearing deposits are developed. Here in palynospectra of the Dongning Formation we identified the following species of angiosperms: *Tricolpites* sp., *Quercites sparsus*, *Retitricolpites vulgaris*, *R. georgensis*, *Clavatipollenites hughesii*, *Fraxiniopollenites variabilis* Stanl. The percentage of this pollen is very low - most often a fraction of a percent, sometimes 1-2%, maximum 2.9%.

The early angiosperms of Transbaikalia were first discovered by paleoentomologists of the Paleontological Institute (Moscow) in the Baisa locality in Central Transbaikalia, where the Zaza Formation of the Barremian-Aptian age is distributed. V.A. Vakhrameev and Z.I. Kotova (1977) described *Dicotylophyllum pussilum* Vachr. and pollen *Asteropollis asteroides* Hedl. et Norr. In the same article Kotova pointed to the findings of pollen, in addition to the above, as well as *Clavatipollenites hughesii* in the Lower Cretaceous deposits of the Transbaikalian basins, such as Konda, Beklemishevo, Chita-Ingoda, Arbagar, and East Urulungui.

We studied more abundant palynospectra from Baisa locality. They include *Asteropollis asteroides, Clavatipollenites hughesii, C. incisus* Chlon., and *Tricolpites* sp. The

lacustrine deposits of this locality were formed in semi-arid environments, which are indicated by the presence of marl and black "paper shale" layers.

Recently, in the palynospectra of the coal-bearing beds of the Tarbagatay coal mine of the Khilok River Basin and the Olon-Shibir coal mine of the Tugnuy Basin of Transbaikalia, we found single tricolpate pollen and monosulcate *Clavatipollenites incisus*. These findings are confined to the marsh facies. Besides angiosperms, the costate spores having affinity with Schizaeaceae (*Cicatricosisporites* sp., *Impardecispora apiveruccata*, *Concavissimisporites asperus, Pilosisporites setiferus*), characteristic of the Early Cretaceous, were found in these spectra. Based on these data, we believe that the age of these coal-bearing deposits is the Barremian-Aptian.

Thus, the first angiosperms of the Barremian-Aptian age of the Transbaikalia and Primorye region included plants that produced tricolpate and monosulcate pollen.

The pollen *Clavatipollenites* constitutes early elements in angiosperm pollen records from the western North Atlantic (Hochuli and Kelts, 1980) as well as in deposits from the North American Potomac Group (Brenner, 1963; Doyle and Robbins, 1977) and Portugal (Heimhofer et al., 2007). The oldest finding of this pollen type, according to Brenner (1996), was in sediments from Israel, dated as old as the late Hauterivian.

We have an interesting fact that the early angiosperms of the Transbaikalia and Primorye region certainly include very rare tricolpate pollen, while in pre-Albian palynofloras of Portugal and North America it is absent. It should be taken into account that the formation of these coeval floras took place in different paleoenvironments. The palynofloras we described existed in the inland continental basins of the Asian continent, whereas the floras of the Lusitanian Basin (the Cresmina section) and the Algarve Basin (the Luz section), and the Potomac Group of the Atlantic coasts - in the coastal lowlands. The European and North American sites from palaeolatitudes between ~10°S and ~60°N were mostly situated along the margins of the Tethys Ocean (Heimhofer et al., 2007, see references in this paper).

Two forms of *Clavatipollenites* are found in the Barremian sediments of the Cresmina section, in the lower Aptian - several forms of *Retimonocolpites, Asteropollis* and *Pennipollis*. The same palynomorphs are found throughout the entire section. After a break in sedimentation, more diverse pollen was found in the sediments of the lower Albian, including also *Dichastopollenites, Stellatopollis* and *Racemonocolpites*. Here, the first tricolpate pollen of the groups *Tricolpites, Artiopollis* and *Striatopollis* appears. Further along the section in the sediments of the middle and upper Albian, the number and diversity of angiosperms increases (Heimhofer et al., 2007).

In the Barremian and lower Aptian of the Cresmina section, the pollen of angiosperms in the assemblage is extremely small - less than 2%, the diversity varies from 2 forms in the Barremian to 4 in the lower Aptian. Above the unconformity in the lower Albian, the percentage of angiosperm pollen increases (5-8%), while the diversity increases to 17 taxa per sample (Heimhofer et al., 2007).

The pollen *Clavatipollenites, Retimonocolpites, Asteropollis*, as well as *Pennipollis* and *Stellatopollis* are found in the lower part of the lower Aptian of the Luz section. These palynomorphs are relatively common and distributed throughout the sequence (the upper part of the lower Aptian *Asteropollis* is not found). The early Albian assemblage is characterized by the appearance of new forms of monosulcate pollen (including *Dichastopollenites*) and tricolpate (*Tricolpites, Artiopollis, Virgo* spp., *Rousea* spp., *Phimopollenites* spp.).

The amount of angiosperm pollen in the early Aptian assemblage is less than 2% (total 5 taxa), in the late Aptian - less than 5% (5-10 taxa). From the end of the Aptian angiosperm pollen becomes an important element (5% and 10%). Diversity ranges from 10 to 15 (maximum 17) taxa in the early Albian.

The development of angiosperms at an early stage in the Asian continent has similar features to that of the coast of the Tethys Ocean - a trend of a gradual increase in the amount and taxonomic diversity from the Barremian to the Albian, the presence of such palynomorphs as *Clavatipollenites, Asteropollis,* and *Tricolpites*. But there are also the differences - in the North American and West European palynofloras *Pennipollis, Dichastopollenites, Stellatopollis, Racemonocolpites, Artiopollis* and *Striatopollis* occured, and this pollen absent in the East Asian palynofloras. One of the most significant is the appearance of the tricolpate pollen in the early Albian, while in Asia it took place in the Barremian-Aptian palynofloras. Heimhofer et al. (2007) believe that the time of appearance of the eudicotyledons producing tricolpate pollen is the early Albian. But, note that from the Aptian deposits of the Potomac Group of the USA, the eudicot *Potomacapnos apeleutheron* (Jud, Hickey, 2013), similar to the representatives of modern Fumarioideae (Papaveraceae), was described. These authors, discussing the absence of co-occurring tricolpate pollen in locality, suggested that the tricolpate pollen may not have been preserved in these plant-bearing beds due to its entomophilous nature; it is also possible that low preservation probability indicates that some leaf features of extant eudicots appeared before the origin of tricolpate pollen.

According to E.-M. Friis et al. (2017), the eudicotyledons, producing tricolpate pollen, appeared at the Barremian-Aptian boundary and constituted an insignificant part of those plant communities. In the Albian these plants become more diverse and the common components of vegetation. These authors also assumed that the rarity of pre-Albian finds of eudicotyledons can be explained by their predominantly herbaceous or shrubby life forms.

The formation of the Early Cretaceous palynofloras of North America, Western Europe and East Asia underwent in different paleoenvironments. We can assume that the existence of a more humid climate on the Asian continent, confirmed by the extensive development of coal-bearing facies, was more favorable for the growth of plants producing tricolpate pollen. Perhaps the Albian humidization of climate in Portugal caused appearance of plants produced this pollen. The plants produced such palynomorphs as *Pennipollis, Dichastopollenites, Stellatopollis, Racemonocolpites, Artiopollis* and *Striatopollis*, absent in Asian palynofloras, probably existed under arid and semi-arid conditions.

With a difference in the taxonomic composition, the trend of quantitative participation of angiosperm pollen in the palynofloras of the Northern Hemisphere is very similar - from the share of one percent in the Barremian, 1-4% in the Aptian (at the end of the Aptian even 5-10%), more than 8% in the Albian. The taxonomical diversity of angiosperm pollen in the palynofloras also increases from 1-2 taxa in Barremian, 1-7 in the Aptian and more than 7 in the Albian.

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References

Brenner G.J. The Spores and Pollen of the Potomac Group of Maryland // Department of Geology, Mines and Water Resources Bulletin. 1963. Vol. 27. Department of Geology, Mines and Water Resources, Baltimore. P. 1-215.

Brenner G.J. Evidence for the earliest stage of angiosperm pollen evolution: a paleoequatorial section from Israel // Taylor D.W., Hickey L.J. (Eds.). Flowering Plant Origin, Evolution and Phylogeny. London: Chapman & Hall, 1996. P. 91–115.

Doyle J.A., Robbins E.I. Angiosperm pollen zonation of the continental Cretaceous of the Atlantic coastal plain and its application to deep wells in the Salisbury Embayment // Palynology. 1977. Vol. 1. P. 43–78.

Friis E.M., Pedersen K.R., Crane P.R. *Kenilanthus*, a new eudicot flower with tricolpate pollen from the Early Cretaceous (early-middle Albian) of eastern North America // Grana. 2017. Vol. 56, No. 3. P. 161–173.

Heimhofer U., Hochuli P.A., Burla S., Weissert H. New records of Early Cretaceous angiosperm pollen from Portuguese coastal deposits: Implications for the timing of the early angiosperm radiation // Review of Palaeobotany and Palynology. 2007. Vol. 144. P. 39–76.

Hochuli P., Kelts K. Palynology of Middle Cretaceous black clay facies from Deep Sea Drilling Project sites 417 and 418 of the western North Atlantic // Initial Reports of the Deep Sea Drilling Project. V. 51, 52, 53. Washington: U.S. Government Printing Office. 1980. P. 897–935.

Jud N.A., Hickey L.J. *Potomacapnos apeleutheron* gen. et sp. nov., a new Early Cretaceous angiosperm from the Potomac Group and its implications for the evolution of eudicot leaf architecture // American Journal of Botany. 2013. Vol. 100. № 12. P. 2437–2449.

Vakhrameev V.A., Kotova I.Z. Early Angiosperms and Associated Plants from the Lower
Cretaceous of Transbaikalia // Paleontol. Zhurn., 1977. No. 4. P. 101–109.

The Early Cretaceous Birds from the Kitadani Formation, Katsuyama, Fukui, Japan: a Unique Window to the Extinct Avifauna in the Far East

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Abstract

Abundant skeletal and trace fossils of the Early Cretaceous birds have been collected from northeastern China and the Korean Peninsula, facilitating our understanding of diversity, ecology, and evolution of birds during the time. In contrast, the Early Cretaceous avian fossils had been very poorly known from Japan. Here, we present avian fossils from the Lower Cretaceous Kitadani Formation, the Tetori Group. They comprise a single partial skeleton, seven separate tracks (Azuma, 1993), and a single eggshell fragment (Imai & Azuma, 2015), all collected from the Kitadani Dinosaur Quarry, Katsuyama, Fukui, Japan. The avian-fossil record of the Kitadani Formation is notable in that both skeletal and trace fossils occur, and that it can be compared to the avian-fossil record in other parts of East Asia.

The Kitadani Formation (Aptian) is the uppermost part of the Tetori Group cropping out in the central Japan and represents a temperate inland meandering fluvial system situated in the eastern continental margin of Asia (Sano & Yabe, 2016, and references therein). The formation is well-exposed in the Kitadani Dinosaur Quarry which yields various vertebrates including dinosaurs.

The partial skeleton (FPDM-V-9769) of a bird (Fig. 1A) comes from greenish siltstone, which is interpreted as an overbank deposit. High-resolution X-ray micro-computed-tomography at SPring-8 (RIKEN/JASRI, Hyogo, Japan) reveals that the skeleton is disarticulated and composed of fragmentary skull, several vertebrae with a pygostyle, furcula, coracoids, several ribs, partial ilium, and most of forelimbs and hindlimbs lacking pes. FPDM-V-9769 exhibits several primitive features including pygostyle with reminiscent individual caudal vertebrae, boomerang-shaped robust furcula, triangular-shaped and unfused ilium, unfused metacarpals and manual digits with manual craws, and unfused metatarsals, possibly suggesting its basal position in the clade Pygostilia. Histological and phylogenetic analyses are being conducted to assess its ontogenetic stage and phylogenetic position within class Aves.

The avian tracks occur in an alternating sequence of mudstone and fine sandstone. Among the seven avian tracks initially described by Azuma (1993), with aid of portable 3D imaging devices (Artec Spider and Artec Eva, Artec 3D), we present detailed description and taxonomic assessment of two specimens, FPDM-F-74 and FPDM-F-75 (Fig. 1B). FPDM-F-74 is large with slender digits with pointy ends and lacks hallux and webbing traces. FPDM-F-75 is smaller than FPDM-F-74, and exhibits webbing traces between digits II and III, and III and IV.

FPDM-F-75 is larger than most semi-palmate avian ichnotaxa. These avian tracks indicate the presence of at least two different avian taxa in the Kitadani Formation, one of them possibly being a shorebird with webbed pes.

Avian eggshell from the Kitadani Formation is represented by a single specimen, FPDM-V-9175 (Fig. 1C), coming from pale structureless siltstone rich in reworked calcareous nodules and small gastropods, interpreted as an overbank deposit. The specimen is assigned to its own oogenus and oospecies *Plagioolithus fukuiensis* (Imai & Azuma, 2015). The specimen exhibits a combination of characters that is comparable to extinct and extant avian eggshells including thin shell (0.44 mm), smooth external surface, non-branching and narrow pore canals with relatively constant width, and three structural layers. Imai & Azuma (2015) argues that FPDM-V-9175 most likely belongs to a bird, while additional specimens with associated skeletons are required to test this interpretation. It is noteworthy that, in contrast to other avian-fossil-bearing Lower Cretaceous deposits, the Kitadani Formation yields both skeletal fossils and hard-shelled eggshells. This is probably because the lacustrine and shallow marine deposits favor fossilization of delicate avian skeletons (e.g., the Jehol Group, northeastern China, and the Calizas de La Huérgina Formation, Las Hoyas, Spain), but not eggshells, while fluvial overbank deposits observed in the Kitadani Formation can adequately preserve both skeletons and eggshells.

In northeastern China and South Korea, the regions that are rich in avian fossils, occurrence avian skeletons, tracks, and eggshell from a single locality had not been reported. In this regard, the Kitadani Formation is notable where avian skeletons, tracks, and eggshells are all preserved, providing a variety of avian fossils. The Kitadani Formation and other avian-fossil-bearing horizons in Japan provide unique windows to the avifauna in the Far East during the Early Cretaceous.

References

Azuma, Y. 1993. The Early Cretaceous dinosaur ichnofauna and its paleoenvironmental development in the Tetori Group, Japan. Ph. D. dissertation, University of Tokyo, Tokyo, 155 pp.

Imai, T., and Azuma, Y. 2015. The oldest known avian eggshell, *Plagioolithus fukuiensis*, from the Lower Cretaceous (upper Barremian) Kitadani Formation, Fukui, Japan. Historical Biology 27: 1090–1097.

Sano, S., and Yabe, A. 2016. Fauna and flora of Early Cretaceous Tetori Group in Central Japan: The clues to revealing the evolution of Cretaceous terrestrial ecosystem in East Asia. Palaeoworld 26 (2): 253–267.

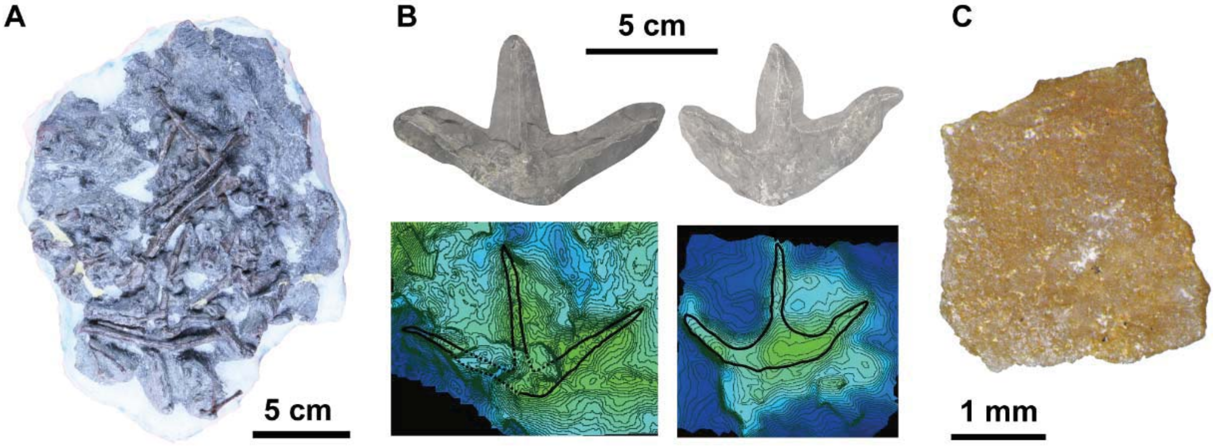

Figure 1. Avian fossils from the Kitadani Formation. (A) Partial skeleton of a pygostylian bird, FPDM-V-9769; (B) Tracks, FPDM-F-74 (top left) and FPDM-F-75 (top right) with corresponding topographic images (bottom) for each specimen; and (C) eggshell, FPDM-V-9175.

The Facies Analysis of Sedimentology of the Phu Tok Noi architecture, Phu Tok Formation, Khorat Plateau, Northeast Thailand.

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Abstract

This study aimed to detail the vertical succession of Phu Tok Noi, Phu Tok Formation exposed in the Khorat Plateua, Northeast Thailand with a facies analysis. From the bottom-to-top succession of the Phu Tok Formation at the PhuTok Noi area can be grouped into three facies that included ephemeral channel facies, eolian dune facies, and marginal lacustrine facies. The ephemeral channel faciesat the base is characterized by planar bedding and cross planar bedding of clast-supported intra formational conglomerate, and by grading up to massive sandstone, planar horizontal bedded sandstone and trough cross laminated sandstoneat the top. This facies indicates fluvial deposits. The eolian dune facies consists of thick to massive beds of large tangential cross bedding sandstone. In general, bedding of the eolian dune facies is truncated at the top surface with large cross bedding of high dip at the top with the dip angle decreasing to horizontal at the bottom of the succession. In addition, at the top of sequence, this eolian dune facies is interbedded with the marginal lacustrine facies. The marginal lacustrine facies consists of planar horizontal stratified sandstone at the base and fining upward to wavy ripple sandstone at the top with thickness up to 5 m.The wavy ripple sandstone is interstratified with lenses of coarse-grainded sandstone. The planar horizontally stratified sandstone is well sorted lying on an erosional surface of the underlying eolian dune remnant. The erosional surface indicates sheet flood flew rapidly over the sand dune into a lake basin. The wavy ripple sandstone with lenses of coarse grain sands is represented to wave-ripple deposit at shallow lake margin. These bed sets are up to 5 meters thick indicate a continued flow of subsurface water into a lake basin after sheet flood ceased.

Key words: PhuTokNoi, PhuTok Formation, eolian deposits

The Skull of *Pelecanimimus Polyyodon* (Theropoda, Lower Cretaceous, Spain): Comparative Approach to Asian Ornithomimosauria.

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Introduction

Pelecanimimus polyodon Pérez-Moreno et al. (1994) was discovered in the Spanish fossil site of Las Hoyas (Barremian, Lower Cretaceous). The holotype of *Pelecanimimus* is composed by the anterior half of an articulated skeleton that preserves evidence of soft-tissues as a soft occipital crest and a gular structure. Pelecanimimus was defined as a basal ornithomimosaurian (Pérez-Moreno et al., 1999), being the first ornithomimosaurian described in Europe.

Ornithomimosauria is widely distributed throughout the world. However, the Asian record contains a huge number of taxa that represents almost its lineage. There are primitive representatives such as Shenzhousaurus from China or Harpymimus from Mongolia. The more derived representatives are Beishalong and Sinornithomimus from China; and Garudimimus, Deinocheirus, Anserimimus and Gallimimus from Mongolia.

One of the most striking features of Ornithomimosauria is its dentition and the relation with its biomechanical and diet behaviour. A partial or complete edentulism and a development of keratinous beaks are specializations related to a most herbivorous dietary behaviour (e.g. Barret, 2005; Cuff and Rayfield, 2015). Most of the members of Ornithomimosauria are edentulous, especially the derived taxa as *Gallimimus, Garudimimus, Sinornithomimus* or *Deinocheirus*. However, *Pelecanimimus polyodon* has over 200 premaxillary, maxillary and dentary teeth. Pérez-Moreno et al. (1994) explained this condition as an alternative functional counterpart of the cutting edge of a beak. This function would become an exaptation with a slicing effect, eventually leading to the cutting edge observed in most derived ornithomimosaurs.

A detailed osteological description of the skull of *Pelecanimimus* is required previous to a functional study comparing the its biomechanics with those of the Asian edentulous derived ornithomimosaurian. Here, we perform an osteological description of the *Pelecanimimus* skull, whose features have been compared with those of other Asian ornithomimosaurian. A CT scan and 3D reconstruction have allowed to decipher some features not previously available.

Material and methods

The holotype of *Pelecanimimus polyodon* (MCCM-LH 7777) is the anterior half of an articulated skeleton. Both side of the skull was subjected to a delicate transfer preparation in order to eliminate the matrix around the fossil and allowing to observe both lateral views of the skull. This process was performed before its first publication in Pérez-Moreno et al., 1994. In the left side of the skull, the facial bones are almost perfectly preserved but the occipital part of the skull is crushed and disarticulated. The right side is also almost completely visible, only the snout is hidden. As the left part, the occipital area is disarticulated but more complete than that of the left one.

Pelecanimimus skull was CT scanned. The slices obtained were imported to a segmentation software for visualization, segmentation, identification and isolation of each single bone of the skull. This have allowed to decipher some osteological features, which are not visible in the fossil to the naked eye. For instance, identifying bones at medial side as splenial and prearticular or the right snout, which is obscured by sediments.

The osteological features of the skull of *Pelecanimimus* was compared with other members of Ornithomimosauria, whose information was gathered from the literature.

Results

Both premaxillary process in both premaxilla are in contact with the nasal and do not reach the antorbital fossa. *Pelecanimimus* presents 14 premaxillary teeth and a subnarial foramen on the lateral surface, over the teeth row. In the maxilla, there are two fenestra additional to the antorbital fenestra in the antorbital fossa, and the maxillary body is large, triangular, acute and posterodorsal inclined as in the basal ornithomimosaurian *Nqwebasaurus* (Choiniere et al., 2012). The maxillary teeth row only extends to the anterior end of the antorbital fossa. Posterior to the teeth row, the buccal edge is a sharp ridge as in derived ornithomimosaurian such as *Gallimimus* (Osmólska, 1972) or *Garudimimus* (Kobayashi and Barsbold, 2005a). The palatal process has a jugal ramus well developed. The lacrimal presents a well-projected posterior and anterior processes, a ventral process perpendicular to the anterior one and a medial recess separated by a vertical lamina. The prefrontal is hypertrophied, occupying almost half width of the orbital edge, and developing along the ventral process of the lacrimal. A peculiar feature in the jugal is the presence of a pneumatic recess between the lacrimal and maxillary processes, a primitive feature not observed in other ornithomimosaurian. The frontal is triangular in dorsal view and it have a dome on its posterodorsal surface. It is well-developed, occupying more than the half width of orbital edge. The dentaries have more than 100 teeth between both side and their anterior end is not anteroventrally deflected. The surangular has two posterior foramina and an anteroposteriorly oriented lateral ridge. The mandibular fenestra is reduced.

Discusion

Pelecanimimus shares with other ornithomimosaurs an elongated premaxilla, the separation between the maxilla and external naris, the domed surface of frontal, a sharp posterior margin of the maxilla, a well-developed jugal ramus of palatal, and a hypertrophied prefrontal. However, *Pelecanimimus* also retains several primitive features such as a premaxillary process not reaching the antorbital fossa or a pneumatic recess in the anterior ramus of jugal. Undoubtedly, the most striking feature of *Pelecanimimus* is the presence of approximately 200 premaxillary, maxillary and dentary teeth. Another autapomorphy associated to the dentition is the absence of a symphysis deflection of the dentary, which is present in all members of the group with known dentary, including those with dentary teeth as *Harpymimus* (Kobayashi and Barsbold, 2005b) and *Shenzousaurus* (Ji et al., 2003).

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References

Barrett, P. M., 2005. The diet of ostrich dinosaurs (Theropoda: Ornithomimosauria). Palaeontology 48(2), 347-358.

Choiniere, J. N., Forster, C. A., de Klerk, W. J., 2012. New information on *Nqwebasaurus thwazi*, a coelurosaurian theropod from the Early Cretaceous Kirkwood Formation in South Africa. Journal of African Earth Sciences 71, 1-17.

Cuff, A. R., Rayfield, E. J., 2015. Retrodeformation and muscular reconstruction of ornithomimosaurian dinosaur crania. PeerJ 3, e1093.

Ji, Q., Norell, M. A., Makovicky, P. J., Gao, K. Q., Ji, S. A., Yuan, C., 2003. An early ostrich dinosaur and implications for ornithomimosaur phylogeny. American Museum Novitates, 1-19.

Kobayashi, Y., Barsbold, R., 2005a. Reexamination of a primitive ornithomimosaur, *Garudimimus brevipes* Barsbold, 1981 (Dinosauria: Theropoda), from the Late Cretaceous of Mongolia. Canadian Journal of Earth Sciences 42(9), 1501-1521.

Kobayashi, Y., Barsbold, R., 2005b. Anatomy of *Harpymimus okladnikovi* Barsbold and Perle 1984 (Dinosauria; Theropoda) of Mongolia. In: The Carnivorous Dinosaurs. Indiana University Press, Bloomington 97-126.

Osmólska, H., Roniewicz, E., Barsbold, R., 1972. A new dinosaur, *Gallimimus bullatus* n. gen., n. sp. (Ornithomimidae) from the Upper Cretaceous of Mongolia. Palaeontologica Polonica 27, 103-143.

Pérez-Moreno, B. P., Sanz, J. L., Buscalioni, A. D., Moratalla, J. J., Ortega, F., Rasskin-Gutman, D., 1994. A unique multitoothed ornithomimosaur dinosaur from the Lower Cretaceous of Spain. Nature 370, 363.

Through The Looking Glass: Insights From Radiolarian Research in Elucidating The Geologic Evolution of The Philippines

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Abstract

The Philippines is one of the areas in the world where ophiolite and ophiolitic complexes have been studied. Available paleontologic and isotopic data have indicated that these sequences are pre-Cenozoic. In the last 30 years or so, radiolarian research has contributed in deciphering and understanding the geologic evolution of the Philippines. Most of these investigations are concentrated in Luzon with very few studies done in Visayas and in Mindanao. Figure 1 shows the location of areas discussed in this work.

Southern Sierra Madre, Rizal: The Kinabuan Formation, the sedimentary cover of the Montalban Ophiolite Complex, is composed of clastic and calcareous rocks. Reported ages varies from Turonian (Arcilla, 1991) and Campanian (Tumanda, 1994). Ringenbach (1992) opined that the depositional environment of the limestones as bathyal based on the presence of radiolarians.

Northern Sierra Madre, Rizal: Cherts associated with the Casiguran Ophiolite exposed along the eastern coast of the Northern Sierra Madre were investigated. The cherts and the limestone interbeds conformably overlie the ophiolite. The radiolarian assemblages from the cherts constrain the stratigraphic range of the cherts to the Lower Cretaceous (upper Barremian–lower Aptian to Albian)(Queaño et al., 2013). This new biostratigraphic result is in contrast with the Upper Cretaceous stratigraphic range previously reported in the region.

Zambales: The Zambales Ophiolite Complex (ZOC) is one of the most studied ophiolites in the region. Several massifs comprise the ZOC, one of which is the Coto Block overlain by clastic sedimentary units previously dated as Eocene. This resulted to tectonic models grounded on the assumption that the entire ZOC is Eocene. However, a recent study (Ishida et al., 2011, Queaño et al., 2011, Queaño et al., 2017a) showed the presence of chert blocks within the Early to Middle Miocene clastic formation overlying the Acoje Block in the northern part of the ophiolite complex. Radiolarians extracted from the cherts yielded a stratigraphic range that suggests a Late Jurassic to Early Cretaceous age. As such, a re-examination of ZOC is warranted.

Northwest Ilocos Norte: Radiolarian biostratigraphic investigation of the cherts that were incorporated withinthe tectonic mélange from the northwestern Ilocos Norte indicate an Upper Jurassic to Lower Cretaceous stratigraphic range (Queaño et al, 2017b). These chert units are incorporated within the Dos Hermanos Mélange which also includes metamorphic

and serpentinized peridotite fragments that are set in a highly sheared, sandy matrix. The radiolarianbiostratigraphic data provide evidence for the existence of a Mesozoic basinal source fromwhich the cherts and associated rocks were derived.

These research works have provided either new age information or refinement in the calibration of ages. It has also given additional evidence for the existence of a Mesozoic oceanic substratum as well as confirmation of the localities block affinity.

References:

Arcilla, C.A., 1991. Lithologic, age, and structural study of the Angat Ophiolite, Luzon, Philippines. M.Sc. Thesis, University of Illinois, Chicago, 107 pp.

Ishida, K., Suzuki, S., Dimalanta, C.B., Yumul, G.P. Jr., 2011. Radiolarian dating of ophiolites and the overlying tur- bidites in the Philippine Mobile Belt, Northern Luzon Island. Geocon 2011”Geology working for a resilient society”, Dec. 8-9, 2011, Quezon City, 20-21.

Queaño, K.L., Marquez, E.J., Dimalanta, C.B., Salapare, R.C., Guotana, J.M., Casulla, M., Paringit, M.A., Tumulak, M.L., Sanchez, M.P., Yumul, G.P. Jr., 2011. Mesozoic piece of oceanic lithosphere in Western Luzon: From the rocks of Northwestern Ilocos Norte to the Zambales Ohio- lite Complex. Geocon 2011”Geology working for a resilient society”, Dec. 8-9, 2011, Quezon City, 75.

Queaño, K.L., Marquez, E.J., Aitchison, J.C. and Ali, J.R., 2013. Radiolarian biostratigraphic data from the Casiguran Ophiolite, Northern Sierra Madre, Luzon, Philippines: Stratigraphic and tectonic implications. Journal of Asian Earth Sciences, v. 65, 131-142.

Queaño, K.L., Dimalanta, C.B., Yumul, G.P. Jr., Marquez, E.J., Faustino-Eslava, D.V., Suzuki, S. and Ishida, K. 2017a. Stratigraphic units overlying the Zambales Ophiolite Complex (ZOC) in Luzon, (Philippines): Tectonostratigraphic significance and regional implications. Journal of Asian Earth Sciences, Volume 142, 20-31.

Queaño, K.L., Marquez, E.J., Dimalanta, C.B., Aitchison, J.C., Ali, J.R. and Yumul, G.P. Jr., 2017. Mesozoic radiolarian faunas from the northwest Ilocos Region, Luzon, Philippines and their tectonic significance. Island Arc, e12195. doi:10.1111/iar.12195.

Ringenbach, J.C., 1992. La faille Philippine et les chaines en decrochement associees (centre-nord Luzon) evolution cenozoique et cinematique des deformations quaternaries. These de doctoral de lUniversite de Nice-Sophia Antipolis. Documents et Travaux, 16, 316 pp.

Titanosaurian pedal structures revealed from Mesozoic ichnological and skeletal records of South Asia (Indo-Pak peninsula)

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Abstract

A pes footprint from Late Cretaceous of Gujarat, India: A footprint (22.5cm x 16.5cm) of sauropod from the Late Cretaceous of India reported by Mohabey in 1986 shows three large oval toes on digit II, III and IV, and was referred to a titanosaur reported by Malkani in 2018.

Tracks and trackways from middle Jurassic (about 166Ma) of Malakhel Broach site of Mianwali Punjab, Pakistan: Trackways of the basal titanosaur *Malakhelisaurus mianwali* were reported by Malkani in 2007&2008 from the Middle Jurassic Samanasuk limestone of the upper Indus region. The trackway pattern shows three parallel trackways (Fig.1) indicating a herd. The trackways have a relatively wide gauge (internal trackway width of 0.4 m), asymmetric D shaped manus (about 50 cm x 70 cm) without unguals, a large circular symmetric pes with five digits (about 1.3 m x 1.3 m), with large oval anteriorly directed toes (all along the front edge) on digits II, III, IV and reduced outer digits I and V, and feeble W-shaped heel. Distinctive toe impressions clearly indicate three portions with a central oval-shaped ungual which is enveloped by a sole cushion of about 5 cm width or thickness, anteriorly encased by a broad reversed U-shaped hoof (Fig.1). The heteropody ratio is 1:4.5. Based on the locomotion gauge, the hip height is estimated at 4-5 m. This herd of basal titanosaurs attacked by a solitary large theropod. Trackways of a couple of small theropod show movement as herd or atleast couple. The ichnological records of *Malakhelisaurus* titanosaur matches closely with skeletal records of Pakisaurids (slender & large bodied) *Pakisaurus*.

Tracks and trackways from Latest Cretaceous of Zhob Sor Muzghai site of Balochistan, middle Indus basin of Pakistan: Tracks of most advanced titanosaur *Pashtosaurus zhobi* (Fig.1) reported by Malkani (2014) from the Latest Cretaceous Vitakri sandstone bed of the middle Indus. First trackway shows left and right pes and manus, and second trackway shows left and right manus (both slipped/glided) and right pes (Fig.1). The ichnite indicates a herd movement, a relatively narrower gauge (0.20-0.25 cm internal trackway width), D-shaped manus (50-55 cm x 70-75 cm) without claws, and a giant circular symmetric pes with five digits (1.27 m long and 1.28 m wide), with distinctive large oval anteriorly directed toes (all along the front edge) on digits II, III and IV, and reduced outer digits I and V. Central oval ungual is enveloped by a fleshy sole cushion which is anteriorly encased by a U-shaped hoof. Central digit III is inserted in a forward position which creates a W-shaped heel like in extant camels. One manual imprint shows marks of D-shaped

metacarpals I, II, III, IV and V. One manus is found 0.5m forward from pes while another manus is found forward 2m from same pes. The expected pace is more than 2m measured from anterior of pes to anterior of manus, and pes stride expected is about 4.5m and manus stride expected is about 4m. The pace and stride of about the same for manus and pes tracks, the stride is about 3.5 times the length of pes print (Farlow 1992) while in Pakistani ichnites this prediction seems to be correct as in middle Jurassic and Latest Cretaceous trackways reported by Malkani in 2018. Heteropody ratio is about 1:4.5. Applying formulae the average hip height is 5.8. Considering the stocky nature of pes and relatively less wide gauge movement, the acetabulum height of the trackmaker *Pashtosaurus zhobi* is estimated to be in the range of 3-5m. Ichnological records of trackmaker *Pashtosaurus zhobi* most advanced titanosaurian matches closely with skeletal records of balochisaurids (stocky and relatively small bodied) *Marisaurus jeffi* or *Balochisaurus malkani*. Middle Jurassic and Latest Cretaceous ichnites reveal the evolution of basal titanosaurs to most advanced titanosaurs. Skin impression on a natural cast of a footprint of the Latest Cretaceous titanosaur *Pashtosaurus zhobi* was reported which revealed tubercles, pits, principal line, wrinkles, whorl, loop, alternating grooves, fold and plunge type contoured textures. Some *Breviparopus* show claw marks directed outward as in *Brontopodus* but in other pes prints from the same trackway the claw marks seem to be anteriorly directed (Farlow 1992). *Brontopodus* is wide gauge and *Parabrontopodus* is narrow gauge. Middle Jurassic ichnite from Pakistan and Skye (UK) and latest Cretaceous ichnite from Pakistan and India provide symmetric pes with anteriorly directed on front edge tritoed. All these ichnites matches to *Breviparopus* on anteriorly directing toes and *Brontopodus* on wide gauge.

Pedal skeletal records of titanosaurs from Indo-Pak subcontinent: From Indo-Pak many metacarpals, metatarsals and unguals have been reported (Fig.1). Unguals are large oval in titanosaurs instead of half oval and posteriorly blunted in large ornithischian like stegosaurs, hadrosaurs, etc. Titanosaurs pes unguals are broad, flattened and well rounded on both anterior and posterior tips while stegosaurs, hadrosaurs and other ornithopod and ornithischian have broad, flattened and well rounded only anterior tip. Characters matching of unguals of titanosaurs and *Stegosaurs* favour ungual assignment. Full oval plates are assigned as unguals of titanosaurs due to its coarsely rugose nature and transverse median cut on dorsal view like Stegosaurs, Hadrosaurs and other ornithopod and ornithischian unguals. Large area of base of ungual provides best contact with the ground during locomotion and balancing the heavy giant body especially on moist, sandy and softer grounds. Broad U shaped hoof prevent from backward slipping, while almost parallel headward and lateral slipping is observed in both forlimbs of Zhob ichnite from Pakistan. From Pakistan large oval unguals are assigned to titanosaurs (*Balochisaurus* and *Pakisaurus*). Similar oval unguals (previously considered as osteoderms) were reported from Malawi by Gomani in 2005, Argentina by Powell in 2003, and India by Huene and Matley in 1933 and Demic and Wilson in 2009. Oval shape of ungual helps for flexibility and rotation. Like titanosaurs, the *Apatosaurus* have oval unguals. Astragalus and calcaneum of sauropod are typically very rugose reported by Bonnan in 2005 and large oval unguals of titanosaurs are generally very rugose and typically with median cut reported by Malkani in 2018. All eusauropods unguals are recurved and some what sickle shaped reported by Wilson and

Sereno in 1998 and curved laterally reported by Langston in 1974 while the ungual in titanosaurs is large oval shaped plate directed anteriorly (all along the front edge) reported by Malkani in 2018. The marks of manus metacarpals are not clear in many manus prints showing manus sole cushion (Farlow 1992) while Latest Cretaceous site from Pakistan represents a manus footprints with separated marks of five metacarpals. Ungual are not found in titanosaursian manus so it forms compositely D-shaped manus while ornithischian have unguals in the manus. Possible phalangeal formula is 1-2-2-2-0, with toe formula of 0-1-1-1-0.

Differentiated pedal structures of titanosaurs (sauropod saurischian) and stegosaurs hadrosaurs, thyreophoran and other ornithopods (ornithischians): Titanosaurs show widegauge and ornithischian show narrow gauge movements. Titanosaurs have giant pes tracks more than 1m long and broad, while stegosaurs/ hadrosaurs have moderate pes tracks less than 1m long and broad. The larger pes of ornithopods are reported on 70cm long while titanosaurs go more than 1.2m. Titanosaurs have a five digits giant pes with toes on central digits II, III, IV and reduced outer digits I and V without toes, while stegosaurs/ hadrosaurs have a symmetric pes with only three digits. Pes in titanosaur is generally rounded or circular, while stegosaurs, hadrosaurs and other ornithopod and ornithischian have triangular shape. Pes digits in titanosaur are generally covered by flesh (except the hoof area) and compositely formed a composite sole while the hadrosaurs/stegosaurs have separated each digit. Unguals are oval in titanosaurs, and half oval and posteriorly blunted in stegosaurs/ hadrosaurs. Titanosaurs have a five digits manus without claws while stegosaurs/ hadrosaurs have a five digits manus with two or variable unguals. Titanosaurs are common in Late Cretaceous of Indo-Pak and no any fossils of stegosaurs, hadrosaurs and other ornithopod and ornithischian were found in Indo-Pak. Titanosaurs were common during late Cretaceous. Latest Cretaceous tracks are rare. In China Upper Cretaceous tracksites are rare, comprising only 6 of the 106 reported by Lockley and others in 2014. Majority of track-rich deposits from Korea are Early Cretaceous, the dating of Late Cretaceous tracks being problematic reported by Houck and others in 2006. In Europe there are also few Late Cretaceous tracksites reported by Lockley and Meyer in 2000 and in North America the Late Cretaceous sites are 5 which are considerably less than Early and “mid” Cretaceous sites 15 reported by Lockley and Lucas in 2014.

References

Malkani, M. S., 2018. Titanosaurian osteoderms and manus and pes shape revealed from ichnological and skeletal records of South Asia (Indo-Pak peninsula). Proceeding of 13th Symposium on “Mesozoic Terrestrial Ecosystems (MTE 13), July 21-23, 2018, University of Bonn, Germany, 2p .

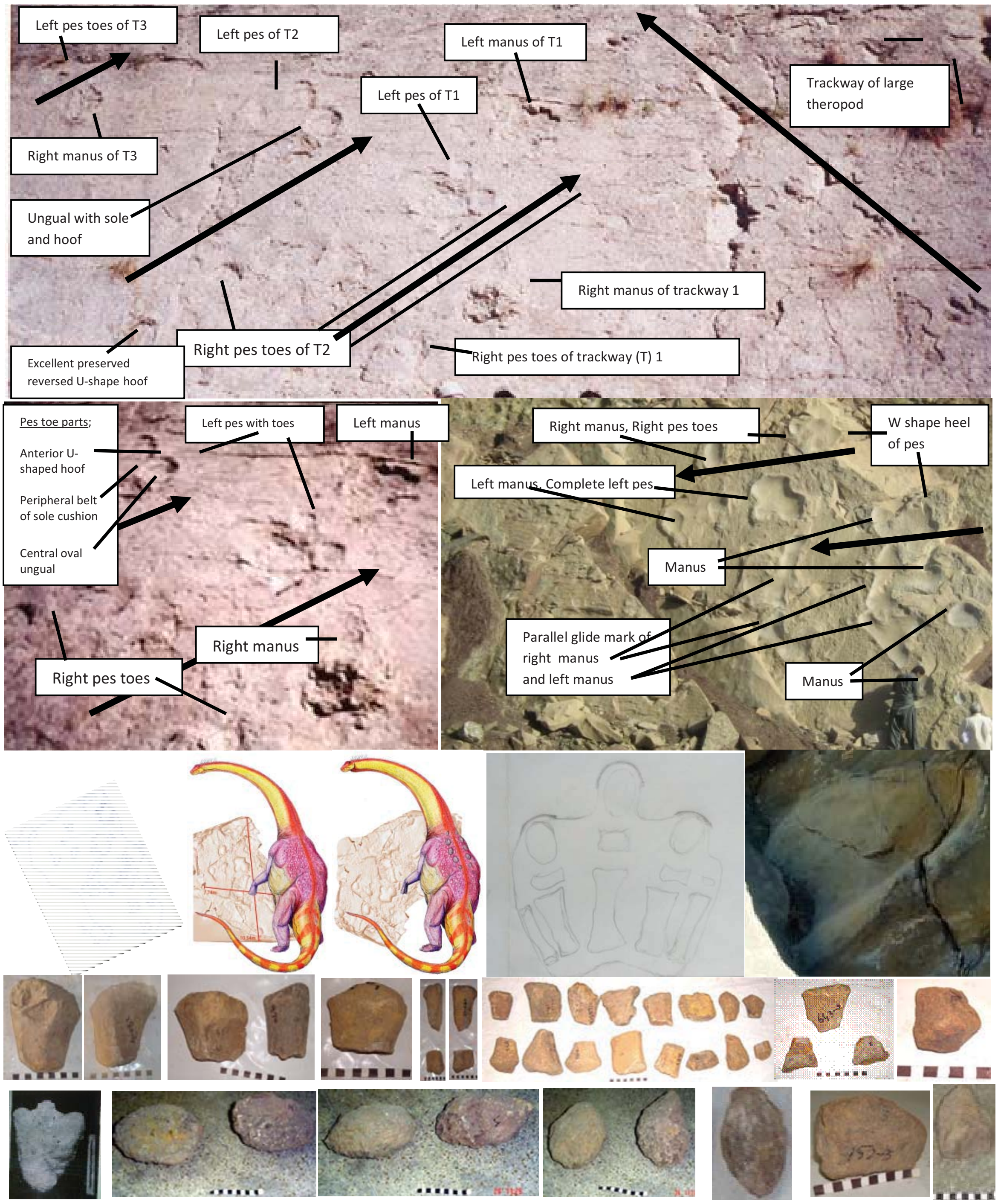

Figure 1. Row 1, plate 1 and Row 2, plate 1, footprints and trackways of a herd of wide gauge basal titanosaurs (*Malakhelisaurus mianwali*) obliquely confronted by a narrow gauge running large theropod (*Samanadrinda surghari*) found on Middle Jurassic Samanasuk Limestone of upper Indus; **Row 2, plate 2,** footprints and trackways of a herd of most advanced titanosaurs *Pashtosaurus zhobi* found on hard sandstone bed of Latest Cretaceous / late Maastrichtian Vitakri Formation; **Row 3, plate 1**, map of *Pashtosaurus zhobi* ichnotype; **plate 2**, 3-D model of Zhob track site and trackmaker model of *Pashtosaurus zhobi* (Dr. Nicholas Allen-a british journalist managed preparation of model of Zhob ichnite from Factum Arte London, and model of trackmaker *Pashtosaurus zhobi* from Dr. Dmitry Bogdanov – a Cardiologist in Chelyabinsk Russia and also a paleoartist https://dibgd.deviant art.com); **plate 3, tentative** sketch of pes with three toes and w shape heel; **plate 4,** manus prints with 5 metacarpals marks impressions; **Row 4, plate 1-9**, metacarpals and metatarsals of titanosaurs from Pakistan. **Row 5, plate 1**, pes footprint from Late Cretaceous of Gujrat, India reported in 1986 by Mohabey. **plate 2-4 pes** unguals of titanosaurs; **plate 5-6** possible ungual of another type of titanosaurs or vestigial metatarsal 5 or armor of titanosaurs; Scale each black and white digit is 1cm. Arrow shows direction of movements.

Titanosaurs, theropods, mesoeucrocodiles and pterosaurs from Pakistan; their paleobiogeographic implications

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Abstract

Mesozoic vertebrates found from the Jurassic and Cretaceous periods of Pakistan so far. The Middle Jurassic yielded the tracks of a herd of basal titanosaurian sauropods Malakhelisaurus mianwali (Malkani 2007;2008;2018b,c) confronted by a trackway of running large theropod Samanadrinda surghari (Malkani 2007), and trackways of a couple of small theropod Himalayadrinda potwari (Malkani 2015d). The Late Jurassic Sembar Formation yielded bone fossils of a basal titanosaur Brohisaurus kirthari based on postcrania (Malkani 2003a). The Latest Cretaceous (Latest Maastrichtian 68-66Ma) Vitakri Formation yielded most advanced titanosaurs, theropods, mesoeucrocodiles and pterosaurs (Malkani 2017a,2018a). Diverse osteoderms of titanosaurs and coprolite remains of titanosaur/theropod dinosaurs are found (Fig.1) from Pakistan (Malkani 2017a).

Pakisaurids Titanosaur from Pakistan: Pakisaurids are large and slender-bodied titanosaurs characterized by ratio about 1 of upper and lower mid-transverse width of mid-caudal centra and include Pakisaurus balochistani, Sulaimanisaurus gingerichi and Khetranisaurus barkhani (Malkani 2006; 2004). Pakisaurus balochistani is distinguished by tall and slender caudals and extremely slender tibia (Fig.1) and is based on the type series presacral and tall caudal vertebrae, sternal, scapulae, humerai, radius, ulnae, ilia, femora, slender tibia, fibula, foot and osteoderms found from SouthKinwa and exemplars from WestBor, NorthAlam, TopKinwa, Shalghara and Zubrapeak (Malkani 2017a,b). Sulaimanisaurus gingerichi is based on squarish mid-caudals found from SouthKinwa and exemplars from Sangiali, Shalghara and Mari Bohri (Malkani 2017a; 2006; 2004). Khetranisaurus barkhani is characterized by ratio slightly 1 of upper and lower mid-transverse width of mid-caudal centra and is based on caudal vertebrae from MidKinwa and exemplars from Bor, Mari Bohri and Grut (Malkani 2017a; 2006; 2004).

Marisaurs Titanosaur from Pakistan: Marisaurs are medium and stocky-bodied titanosaurs characterized by mid-caudal ratio about 1.5 and include Marisaurus jeffi, Maojandino alami and Gspsaurus pakistani (Malkani 2017a,c; 2015a). Marisaurus jeffi is based on the type series caudal vertebrae (including first biconvex), scapula, pubis, distal ischium/pubis and femur from MariBohri and exemplars from SouthBor and eastern TopKinwa (Malkani 2017a,c; 2006; 2004). Maojandino alami is based on axial and limb elements from Alam (Malkani 2017a; 2015a,b). Gspsaurus pakistani is based on adult skulls (Fig.1) from Alam. (Malkani 2017a; 2014a; 2015a).

Balochisaurs Titanosaur from Pakistan: Balochisaurs are small and stocky-bodied titanosaurs characterized by mid-caudal ratio about 2 and include Balochisaurus malkani, Nicksaurus razashahi and Saraikimasoom vitakri (Malkani 2017a,c; 2015a). Balochisaurus malkani is distinguished by stocky tibia, first caudal biconvex, and mid-caudal ratio about 2 and is based on type series presacral and broad caudal vertebrae (including first biconvex caudal), sternal, humerus, manus, ilia, femur, stocky tibia, fibula, ribs and neural spines found from MariBohri and exemplars from Kinwa, Zubra, and Grut (Malkani 2017a,c; 2006; 2004). Nicksaurus razashahi is based on cranial, very broad vertebrae and stocky limb bones from northKinwa(Malkani 2017a; 2015a,b). Saraikimasoom vitakri is based on very small complete skull (Fig.1) from SouthKinwa (Malkani 2017a,c; 2014a; 2015a).

Theropod dinosaurs from Pakistan Vitakridrinda sulaimani is a large bodied theropod based on the type series femora, centra, braincase, more than 9 teeth (D-oval shape with distinct great hollow and thin peripheral bone) and cranial remains from Alam, and referred vertebrae and limb bones from Sangiali, Shalghara, Mari Bohri, South and TopKinwa (Malkani 2017a,d; 2006; 2004). Vitakrisaurus saraiki is another large bodied theropod based on the type series hand/manus, vertebrae and leg bones from SouthBor (Malkani 2017a,d; 2010).

Mesoeucrocodiles from Pakistan: Pabwehshi pakistanensis is a mesoeucrocodile based on rostrum from Top Kinwa (Wilson et al. 2001). Induszalim bala is a mesoeucrocodile based on the type series rostrum, vertebrae and humerus/femur from Alam and referred vertebra (Fig.1) from Mari Bohri (Malkani 2017a,d; 2014b; 2015a). Sulaimanisuchus kinwai is a mesoeucrocodile based on the type series dentaries and tibia from SouthKinwa (Malkani 2017a,d; 2010). Khuzdarcroco zahri is a mesoeucrocodile based on rib/phalanges from Khuzdar (Malkani 2017a; 2015a,c).

Pterosaur-flying reptiles from Pakistan: Saraikisaurus minhui is a pterosaur (flying reptile) based on dentary from TopKinwa and referred dentary from SouthKinwa.

Tracks of titanosaurs and theropods from Pakistan: Mesozoic Tracks have been recorded for the basal titanosaur Malakhelisaurus mianwali (Malkani 2018b,c; 2008; 2007), the large theropod Samanadrinda surghari (Malkani 2007), and the small theropod Himalayadrinda potwari (Malkani 2015d) as well as for the most advanced titanosaur Pashtosaurus zhobi (Malkani 2018b,c; 2014a), the pterosaur flying reptile Anmolpakhi alleni (Malkani 2018b,c), and small vertebrates possibly birds, frogs, lizards, snakes and others (Malkani 2018b,c). Titanosaur footprints revealed D-shaped manus without ungual, and giant pes with large oval anteriorly directing tritoes. Distinctive oval ungual is surrounded by sole cushion which is anteriorly encased by hoof (Malkani 2018a,b,c). Ungual is rugose like Stegosaurs, but oval in titanosaurs (Fig.1) instead of half oval and blunted in Stegosaurs and Hadrosaurs (Malkani 2018b,c). Manus print shows 5 metacarpals marks compositely forming asymmetric D-shape.

Paleobiogeography of Indo-Pak: The majority of these fossils like biconvex first caudal of Marisaurus and Balochisaurus with saltasaurids of Argentina (South America), large oval ungual (without median cut) of Balochisaurus with indet Titanosaur of Argentina (South America), large oval ungual with median cut of Pakisaurus with Malawisaurus of Malawi (Africa) and many other fossils show a close relationship to Gondwana, but some endemic faunal elements like very small skull of the titanosaur Saraikimasoom vitakri, rostrum of the mesoeucrocodile Induszalim bala and dentary with teeth of the pterosaur Saraikisaurus minhui may show hypothesis of fragmentation of Gondwana leads into endemic forms of Indo-Pak fauna.

References

Malkani, M. S., 2018a. Mesozoic vertebrates from Pakistan and their paleobiogeographic affinities. Proceeding of 13th Symposium on "Mesozoic Terrestrial Ecosystems (MTE 13), July 21-23, 2018, University of Bonn, Germany, 2p.

Malkani, M. S., 2018b. Titanosaurian osteoderms and manus and pes shape revealed from ichnological and skeletal records of South Asia (Indo-Pak peninsula). Proceeding of 13th Symposium on "Mesozoic Terrestrial Ecosystems (MTE 13), July 21-23, 2018, University of Bonn, Germany, 2p .

Malkani, M. S., 2018c. Rapid discoveries of giant pes and associated manus footprints and tracks of titanosaurian sauropods from Pakistan: a review of Mesozoic ichnites from Indo-Pak subcontinent. Researchgate.net, Research 1-71p. DOI. 10.13140/RG.2.2.28481.45923.

Malkani, M. S., 2017a. Dinosaurs, mesoeucrocodiles and recent discovered biotas from Pakistan. Saify Siddiqui Publisher and Printing Press, College Road, Taunsa Sharif (District Dera Ghazi Khan), Pakistan, 82 pp.

Malkani, M. S., 2017b. A review of Pakisaurus titanosaur: Associated skeletons of sauropod and theropod dinosaurs and mesoeucrocodiles from Pakistan: Discussion on titanosaurs of Indo-Pak subcontinent. Proceedings of Fifth symposium of IGCP 608 October 22-28, Jeju, Korea, 116-119.

Malkani, M. S., 2017c. Balochisaurus malkani and Marisaurus jeffi balochisaurid titanosaurs of Pakistan: A review. Proceedings of Fifth Symposium of IGCP Project 608, October 22-28, 2017, Jeju Island, Korea, 40-43.

Malkani, M. S., 2017d. Theropod dinosaurs and mesoeucrocodiles from Pakistan: A review. Proceedings of Fifth International Symposium of IGCP Project 608, October 22-28, 2017, Jeju Island, Korea, 63-66.

Malkani, M. S., 2017e. Titanosaurian sauropod and abelisaurian theropod dinosaurs and Mesoeucrocodiles from Pakistan: A Review. Abstract of 5th Symp. of IGCP 632, September 30 to October 1, 2017, Arizona, USA, p 12.

Malkani, M. S., 2015a. Dinosaurs, mesoeucrocodiles, pterosaurs, new fauna and flora from Pakistan. Geological Survey of Pakistan, Information Release No. 823: i-iii,1-32.

Malkani, M. S., 2015b. Titanosaurian sauropod dinosaurs from Pakistan. Proceeding of 12th Symposium on "Mesozoic Terrestrial Ecosystems (MTE 12), August 15-20, 2015, Shenyang, China, 93-98.

Malkani, M. S., 2015c. Terrestrial mesoeucrocodiles from the Cretaceous of Pakistan. Proceedings of 12th Symposium on "Mesozoic Terrestrial Ecosystems (MTE 12), August 15-20, 2015, Shenyang, China, 242-246.

Malkani, M. S., 2015d. Footprints and trackways of dinosaurs from Indo-Pakistan Subcont.-Recent Advances in discoveries from Pakistan. Proceedings of MTE 12 Symposium, August 15-20, 2015, Shenyang, China, 186-191.

Malkani, M. S., 2014a. Titanosaurian sauropod dinosaurs from the Latest Cretaceous of Pakistan. Proceedings of 2nd symposium of International Geoscience Program (IGCP 608), Sept 04-06, Tokyo, Japan, 108-111.

Malkani, M. S., 2014b. Theropod dinosaurs and mesoeucrocodiles from the Terminal Cretaceous of Pakistan. Proceedings of 2nd Symposium of International Geoscience Program 608, Sept 04-06, Tokyo, Japan, 169-172.

Malkani, M. S., 2013. New Pterosaur from the Latest Cretaceous Terrestrial Strata of Pakistan. In; Abstract Book of 9th International Symposium on the Cretaceous System, September 1-5, Metu Congress Center, Middle East Technical University, Ankara, Turkey, 62.

Malkani, M. S., 2010. Stratigraphy and Mineral potential of Sulaiman basin, Pakistan. Sindh Univ. Research Journal (Science Series) 42 (2):39-66.

Malkani, M. S., 2008. *Marisaurus* (Titanosauria) remains from latest Cretaceous of Pakistan. Sindh Univ. Res. Journ. (Sci. Series) 40 (2):55-78.

Malkani, M. S., 2007. Trackways evidence of sauropod dinosaurs confronted by a theropod found from Mid Jur. Samana Suk Limestone of Pakistan. Sindh University Research Journal (Science Series) 39 (1):1-14.

Malkani, M. S., 2006. Biodiversity of saurischian dinosaurs from the latest Cretaceous Park of Pakistan. Journ. Appl. & Emerging Scien, 1(3):108-140.

Malkani, M. S., 2004. Saurischian dinosaurs from Late Cretaceous of Pakistan. In Hussain SS, and Akbar HD, eds. Fifth Pakistan Geological Congress, National Geological Society of Pakistan, Pakistan Museum of Natural History (Pakistan Science Foundation), April 14-15, Islamabad, 71-73.

Malkani, M. S., 2003a. First Jurassic dinosaur fossils found from Kirthar range, Balochistan, Pakistan. Geol. Bull. Univ.Peshawar 36:73-83.

Malkani M.S. 2003b. Pakistani Titanosauria; are armoured dinosaurs?. Geological Bulletin University of Peshawar 36:85-91.

Wilson, J. A., Malkani, M. S., Gingerich, P. D., 2001. New Crocodyliform (Reptilia, Mesoeucrocodylia) form the Upper Cretaceous of Pakistan. Contrib. Museum of Paleontology, University of Michigan, 30 (12): 321-336.

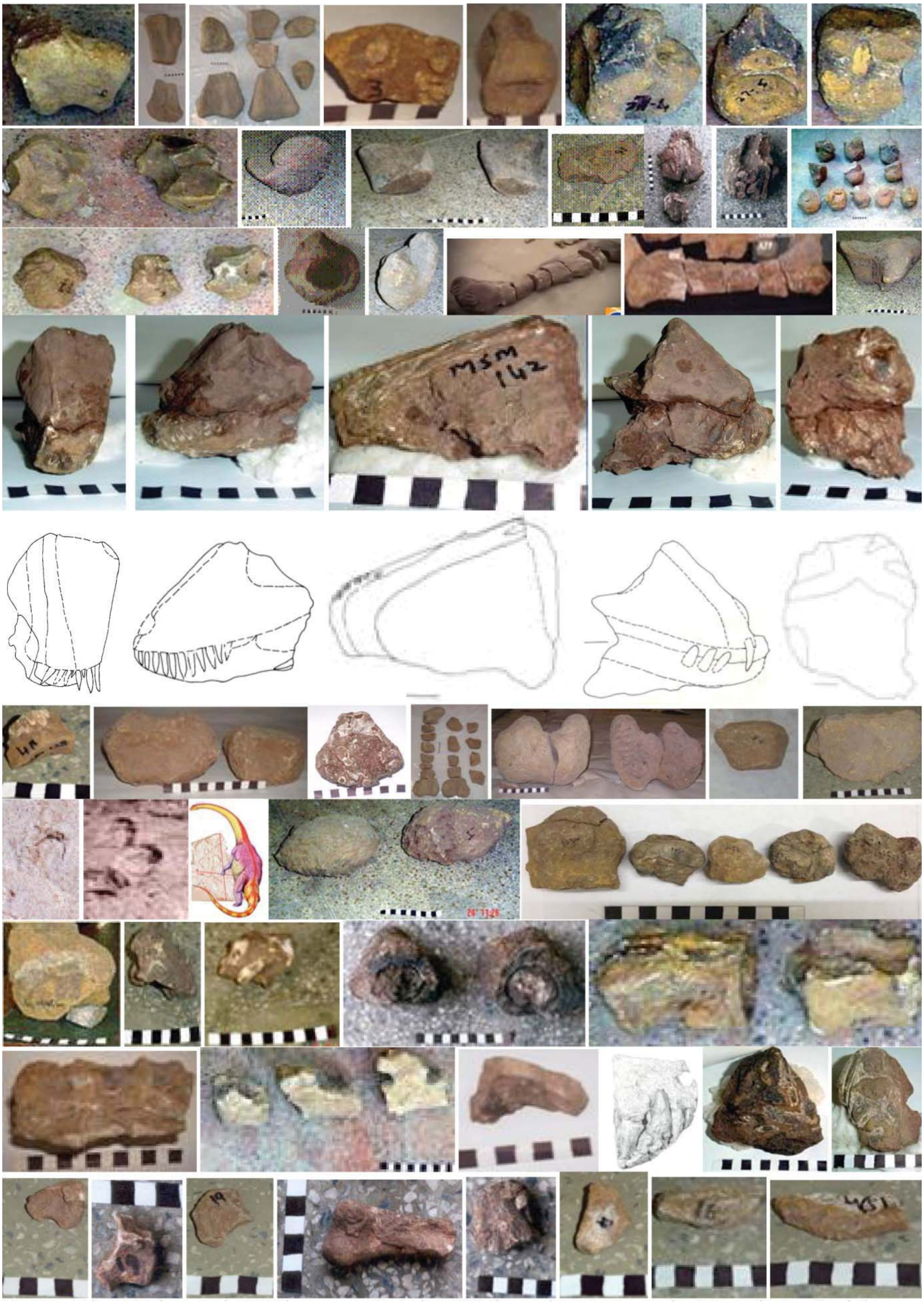

Fig. 1 Row 1, photo 1-5 *Pakisaurus*; photo 6-8 *Khetranisaurus.* Row 2, photo 1-4 Marisaurus; photo5-6 *Gspsaurus*; photo 7 *Maojandino*. Row 3, *Balochisaurus*. Row 4-5 *Saraikimasoom*. Row 6, *Nicksaurus.*Row 7, photo 1 hoof print; photo 2 three parts of large oval toe; photo 3 Model of *Malakhelisaurus=Pakisaurus*; photo 4 large oval ungual unguals; photo 5vesicular coprolite pieces of titanosaurs or theropods . Row 8, *Vitakridrinda*; Row 9, photo 1-3 *Vitakrisaurus*; photo 4 *Pabwehshi*; photo 5-6 *Induszalim*. Row 10, photo 1-4 Induszalim continued from previous row; photo 5-6 *Sulaimanisuchus*; photo 7-8 *Saraikisaurus minhui*. Scale each black unit is 1cm.

Turtles from the Lower Cretaceous Khok Kruat Formation of Nakhon Ratchasima, Northeastern Thailand: New data

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Abstract

Two pan-trionychian turtles have been reported from the Khok Kruat Formation in Nakhon Ratchasima, Northeastern Thailand including a carrettochelyid, *Kizylkumemys khoratensis* and an adocid, *Shachemys* sp., based on shell materials (Tong *et al.*, 2005; 2009). Since 2007, new turtle materials have been discovered by the Thailand-Japan Dinosaur Excavation Project at Suranaree and Khok Kruat subdistricts, Nakhon Ratchasima Province. The material consists mainly of shells of both *Shachemys* and *Kizylkumemys*, but also a nearly complete skull which probably belongs to *K. khoratensis* (Sonoda *et al*., 2015). The different shell characters in carrettochelyid may suggest sexual dimorphism or different taxon. In 2017, a skull and shell fragments have been discovered in a new locality, Ban Krok Duean Ha, Suranaree subdistrict. The taxonomic composition of the turtle fauna from the new locality is similar to that from Ban Saphan Hin. The comparisons of the skull of *K. khoratensis* with that of other carettochelyids will provide information on the cranial morphology and early evolution of the Carettochelyidae.

Keywords: turtle, Khok Kruat Formation, Nakhon Ratchasima, Thailand

References

Sonoda, T., Naksri, W., Shibata, M., Songtham, W., Jintasakul, P., and Azuma Y. 2015. New Materials of Pan-Trionychian Turtles from the Lower Cretaceous Khok Kruat Formation in Northeastern Thailand. Program and abstracts of the 2nd International Symposium on Asian Dinosaurs in Thailand 2015. Bangkok, Thailand. 19th-20th November 2015. p.49-50. (Oral presentation)

Tong, H., Claude, J., Suteethorn, V., Naksri, W., and Buffetaut, E. 2009. Turtle assemblages of the Khorat Group (Late Jurassic-Early Cretaceous) of NE Thailand and their palaeobiogeographical significance. In: Buffetaut, E., Cuny, G., Loeuff, J., & Suteethorn, V. (eds.) Late Palaeozoic and Mesozoic Ecosystems in SE Asia. London, Geological Society, Special Publication, 315, 141-152.

Tong, H., Suteethorn, V., Claude, J., Buffetaut, E., and Jintasakul, P. 2005. The turtle fauna from the Khok Kruat Formation (Early Cretaceous) of Thailand. In: Wanakao, L., Youngme, W., Srisuk, K., and Lertsirivorakul, R.(eds) Proceedings of the International Conference on Geology, Geotechnology and Mineral Resources of Indochina (GEOINDO 2005). Khon Kaen University, Khon Kaen, 610–614.

Upper Cretaceous palynofloras from the Himenoura Group (South West Japan) and consequences for the Normapolles and *Aquilapollenites* palynological provinces in eastern Asia

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Abstract

The Himenoura Group consisting of non-marine to marine siliciclastics is widely distributed in the western part of Kyushu Island, where it outcrops sporadically on Koshikishima Islands (Kamikoshikishima, Nakakoshikishima and Shimokoshikishima islands from North to South) and the Amakusa Archipelago (Kamishima and Shimoshima islands from North to South). The group, divided into Hinoshima and Amura formations on eastern Kamishima Island was assigned to the Santonian to middle Campanian, and strata of western Shimoshima Island to the Campanian to Maastrichtian on the basis of rich bivalve and ammonoid records. In the past few years, many vertebrate fossils, including dinosaurs, were newly discovered from the lower to middle Campanian strata of Shimokoshikishima Island and Maastrichtian strata of Kamikoshikishima Island. However, there exists no report about plant fossils from these strata and the paleovegetation still remains unclear. Recently, well-preserved palynomorphs were recovered from the Mitsuse Formation in Nagasaki area, which is stratigraphically equivalent to the Himenoura Group of Shimoshima Island.

We report here for the first time palyno-assemblages of the Himenoura Group, obtained from the Koshikishima Islands and the Amakusa Archipelago, and propose paleovegetation and paleoenvironment reconstructions for these areas. We could identify spores with affinities to the Bryophyta (Marchantiaceae), Lycophyta (Selaginellaceae, Lycopodiaceae) and Monilophyta (dominated by Cyatheaceae, Osmundaceae, Anemiaceae). Concerning Gymnosperm pollen, grains with affinities to the Coniferales (Cheirolepidiaceae, Podocarpaceae, Pinaceae) were most diversified. Some Angiosperm pollen of genera *Liliacidites* (Liliales) and *Aquilapollenites* were observed from Koshikishima Islands, and *Scollardia* was also obtained from the Amakusa Archipelago, among others. It represents the first report of index genera *Scollardia* and *Aquilapollenites* in South Japan. *Scollardia trapaformis* obtained from the Amura Formation has been previously reported only from the Maastrichtian of Canada, Sakhalin and China, and the present report from middle Campanian strata thus becomes the first occurrence of the species. Composition of the assemblage indicates a vegetation including a mangrove, with similar environmental conditions as the Mitsuse Formation. Moreover, Normapolles pollen was previously obtained from the later, and the presence of *Aquilapollenites* in the Koshikishima Islands permits to discuss about the geographical distribution and limit of these two provinces.