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

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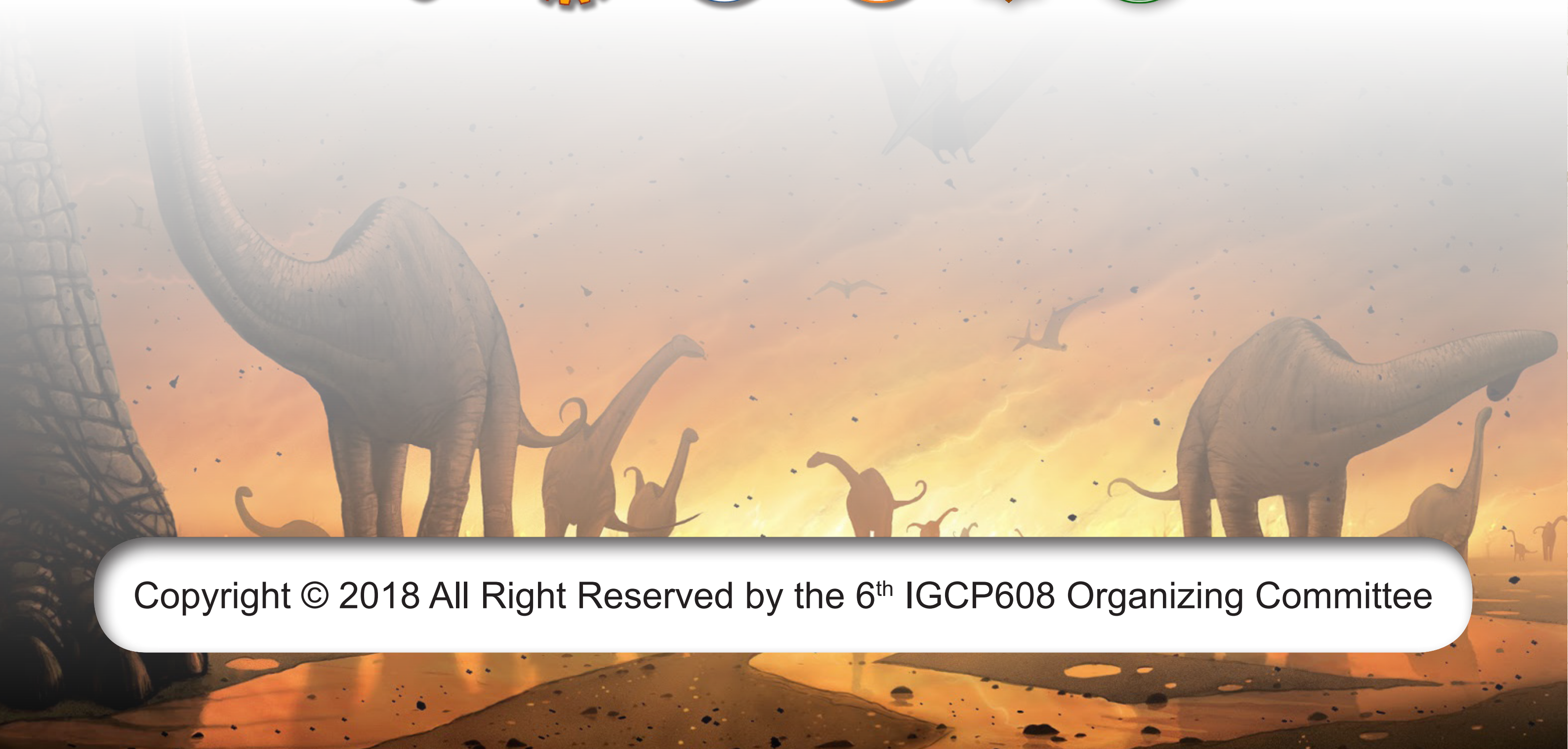

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PREFACE

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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- Miss Orn-Uma Summart, Director of Sirindhorn Museum
  (Symposium Secretary)


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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 - Welcome speech by: Address by the governor of Khon Kaen Province - Speech by: IGCP 608 leader - Opening address by: Director General of Department of Mineral Resources 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 Closing Ceremony Project summary of IGCP 608 Next Project proposal IGCP608 Business meeting 18.30-21.30 Farewell Party
Saturday November 17, 2018	Departure of participants

Thursday, November 15, 2018

Srichan 1 Room, Charoen Thani Hotel

TIME	PROGRAMME
8.30-9.00	Registration
9.00-9.45	**Welcome speech by:** Address by the governor of Khon Kaen Province **Speech by:** IGCP 608 leader **Opening address by:** Director General of Department of Mineral Resources **Group Photo**
9.45-10.00	Coffee break
10.00-10.30	**Keynote: Review and Revision of the so-called 'Khorat Group', NE, 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	**UNESCO Global Geoparks of Korea: Focusing on Mudeungsan UGGp** *By Min Huh*
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	**Facies and geochemical analysis for basin evolution of the Late Cretaceous Neungju Basin, SW Korea – a preliminary study** *By Hyojong Lee,Taejin Choi*
14.15-14.30	**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*
14.30.14.45	**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*
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	**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*
16.15-16.45	**Poster Session**
17.00-18.00	**Culter programme**
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	**Radiolarian assemblage of Barremian to Aptian interval in the Tethys and the influence of the oceanic anoxic event (OAE) 1a** *By Xin Li*
11.45-12.00	**Dinoflagellate cyst biostratigraphy of Eocene in Duina, Yadong, Tibet, China** *By Wenyuan Zhang, Youjia Yao, Yuewei Li, Tianyang Wang, Xinfa Li, Guobiao Li*
12.00-13.00	*Lunch*

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

Chairman: Dr. Adichat Surikum

13.00-13.30	**Keynote: Diversity of Mesozoic Crocodiles in the northeastern Thailand** *By Komsorn Lauprasert*
13.30-13.45	**Vertebrate remains from the Early Cretaceous fluvial deposits of Phu Wiang Valley, Khon Kaen Province, Northeastern Thailand** *By Kamonlak Wongko, Phornphen Chanthasit, Pitaksit Ditbanjong*

13.45-14.00	**Non-marine Cretaceous turtles of Japan and its significance for paleoenvironmental analysis** *By Ren Hirayama*
14.00-14.15	**Carettochelyid turtle from the Lower Cretaceous of Japan and the diversification of the pan-trionychian turtles** *By Teppei Sonoda*
14.15-14.30	**Turtles from the Lower Cretaceous Khok Kruat Formation of Northeastern Thailand: new data** *By Wilailak Naksri*
14.30-14.45	*Coffee Break*

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

Chairman: Dr. Romain Amiot

14.45-15.00	**All about Sirindhorna khoratensis (Ornithopoda; Hadrosauroidea)** *By Masateru Shibata*
15.00-15.15	**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*
15.15-15.30	**Late Cretaceous Vertebrate faunal similarities between India and Madagascar: palaeobiogeographic scenarios** *By Guntupalli V.R. Prasad*
15.30-15.45	**Holocene climate and environmental changes in Mongolia as recorded in the sediments of lakes: a review.** *By Oyunchimeg Tserentsegmid*
15.45-16.00	
16.00-16:45	***Closing Symposium Session*** *By the IGCP 608 leader* ***Project Summary of IGCP608*** *By Hisao Ando* ***Next new project proposal following IGCP608*** *By Gang Li*
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*
18.30-21.30	***Farewell Party***

Poster Presentation

1.	**Depositional environment of Lower Cretaceous lacustrine sedimentary rocks in Central Mongolia** *By Bat-Orshikh Erdenetsogt, Sung Kyung Hong, Jiyoung Choi, Boldbaatar Gantulga, Niiden Ichinnorov, Nyamsambuu Odgerel, Gombosuren Tsolmon, Norov Baigalmaa, Enkhbayar Bolormaa*
2.	**Depositional processes and transport mechanism of upper Ullyonsan Conglomerates in the Cretaceous Yeongyang Subbasin of Gyeongsang Sedimentary Basin, Korea** *By Ki-Hun Yu, Daekyo Cheong, Daewoo Kim*
3.	**The skull of Pelecanimimus polyodon (Theropoda, Lower Cretaceous, Spain): comparative approach to Asian Ornithomimosauria** *By Elena Cuesta, Francisco Ortega, José Luis Sanz*
4.	**Distribution of Charophytes in the lower Cretaceous of the lake basins in Mongolia and conditions of their growth** *By Gereltsetseg Lkhagvaa*
5.	**Provenance of the Cretaceous Neungju Basin, Korea** *By Min Gyu Kwon, Taejin Choi, Seung Won Shin*
6.	**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*
7.	**Depositional environments of the Early Jurassic Nam Phong Formation in Nong Bua Daeng District, Chaiyaphum, northeastern Thailand** *By Rattanaphorn Hanta*
8.	**The cranial endocranial of Phuwiangosaurus sirindhonae** *By Siripat Kaikaew*
9.	**Preliminary study on the growth of *Fukuiraptor kitadaniensis* (Dinosauria: Theropoda)** *By Soki Hattori, Yoichi Azuma, Soichiro Kawabe*
10.	**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*
11.	**Stratigraphy and Structureof Jurassic – Cretaceous Rocks in the Thong San Khan and Chat Trakan Areas, Northern Thailand** *By Pongsathon Kanna, Weerapan Srichan, Phisit Limtrakun, Boontarika Srithai, Pitaksit Ditbanjong, Rungroj Benjakul and Rattanaporn Fongngern*
12.	**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.

A review of dinosaurs in Thailand

Varavudh Suteethorn[1], Suravech Suteethorn[1,2], Phornphen Chanthasit[3] and Eric Buffetaut[1,4]

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Abstract

Since the first dinosaur bone of Thailand found in 1980s, there were at least 34 species of dinosaur including 27 taxa from osteological evidences and 7 ichnotaxa. Most of them came from the members of Khorat plateau. While, the others were deposited in the red bed from Phra Yao (northern), Trad (eastern) and Krabi (southern). The oldest dinosaur bone bed is started from the Triassic Nam Phong Formation in northeastern Thailand. This bone bed yielded one of the oldest sauropod dinosaurs, *Isanosaurus attavipachi*, and prosauropod. The younger formation was represented by the Late Jurassic Phu Kradung Formation. New discovery has unveiled the dinosaur sanctuary. More than five thousand bones of several dinosaurs taxa and individuals have been found, i.e., mamenchisaurid, sinraptorid, stegosaurid and ornithichian. Also, crocodiliformes, turtles, bony fishes, fresh water sharks and pterosaur were found from this locality. Recent studies have conclusively shown this assemblage containing is very reminiscent of that from some Chinese formation, notably the Upper Shaximiao Formation of Sichuan. Comparative studies from this locality may lead to a better understanding of the palaeobiogeographical events linked with faunal change during the Late Jurassic/Early Cretaceous in Southeast Asia. The dinosaur records of Southeast Asia is limiting at the Early Cretaceous period. Thus it seem that the evolutionary of dinosaurs in Thailand were started from the Late Triassic-Early Jurassic period then replaced by the endemic Asian dinosaur assemblages during the Late Jurassic-Earliest Cretaceous age and finally the Early Cretaceous dinosaurs were occupied over the Indochina peninsula as evident in Thai, Laos and Malaysia.

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.

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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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Abstract

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.

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Carettochelyid turtle from the Lower Cretaceous of Japan and the diversification of the pan-trionychian turtles

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Abstract

The Carettochelyidae (Trionychia, Testudines), a sister group of soft-shelled turtles (the Trionychidae), is known from the Lower Cretaceous of Laos and Thailand as the oldest record. The distribution has been restricted in Asia during the Cretaceous, although it has spread widely onto Europe, North America, and Asia during the Eocene (Joyce et al., 2004). In the present day, only one living species *Carettochelys insculpta* is distributed in the northern Australia and the southern New Guinea. Here we report the first occurrence of carettochelyid turtle from the Early Cretaceous of Japan. New materials of carettochelyids are three disarticulated shell elements including a peripheral and right and left hypoplastron. These are collected from the dinosaur quarry at Katsuyama city in Fukui Prefecture, central Japan, where fluvial deposits of the Kitadani Formation (Aptian) of the Tetori Group are exposed. The Surface of shells are covered by characteristic sculpture that consists of irregular fine pits, grooves, and tubercles. The hypoplastron with very narrow bridge is quite similar to anosteirine *Kyzylkumemys* and *Anosteira* in shape. The carapace length is estimated about 9 cm long.

All four families of pan-trionychia, Trionychidae, Carettochelyidae, Adocidae, and Nanhsiungchelyidae, are here recognized from the Kitadani Formation. In contrast, one or two groups of pan-trionychia have been occurred from the other sites of the Lower Cretaceous such as Kyrgyzstan, China, Korea, Laos and Thailand (e.g., Hirayama et al., 2000; Lapparent de Broin, 2004; Tong et al., 2009; Li et al., 2015). The Kuwajima (Hauterivian? -Barremian) and Akaiwa (Barremian? -Aptian) formations underlying the Kitadani Formation yields more basal pan-trionychian turtles that have no synapomorphy as any families (e.g., Hirayama et al., 2000, 2005, 2012). It suggests that the morphological evolution of pan-trionychian turtles might have been occurred around Aptian age, and four families of pan-trionychia might have appeared at the almost same period in the coastal region of Asia.

Keywords: turtle, Trionychia, Lower Cretaceous, Kitadani Formation, Tetori Group

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CLMTV cooperation and compilation of the Jurassic and Cretaceous Mapping

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Abstract

During 1990 to 2000, oceanic plate stratigraphy of East and Southeast Asia was the main issue for all geologists who involved in Gondwana study. It was because of it is a key to the implication on the Tectonic evolution of the region. The studies showed that there are many suture zones commenced differently both on times and settings. It was also led us to have more understanding on mineral deposits related to subduction zones. Many mines were opened, particularly along the borderline from Western Indonesia extended northward to Southern China. Furthermore, the information on Tectonic related mineral deposits were applied in many places where similarity is identified.

At that time, fault contacts were the noted along the borderline of two countries, either on rock type or age. The verification by field survey was impossible because of the accessibility was so limited, military or minority issues. Therefore the best way to delineate the fault contacts was sharing information through the seminars or workshops organized by international organization, such as IGCP GEOSEA CCOP. As of IGCP working system, both on information sharing and capacity building, groups of geologist were formed to tackle a specific subject. Many success case studies were made thereafter, such as Permian strata from Western Thailand to Northwest Myanmar, Carboniferous fossil along borderline between Malaysia and J/K boundaries transect between Vietnam Lao PDR Thailand and Myanmar.

Starting from 2002, Geological Survey of Japan initiated through CCOP to have a sharing mechanism on geoscience information, on Metadata project. Later on in 2006, Metadata Phase II and One Geology were started where both geoscience information including the Harmonized 2M scale geologic maps. Many CCOP countries also published their own 1M scale geologic map with the ISO for Geographic Information Metadata. At present, 1M scale geologic map of CCOP (ASEAN) Member Countries program is in progress, expected to be published by 2020. There are two (2) focused groups separated by major geological settings, Cambodia Lao PDR Myanmar Thailand and Vietnam (CLMTV) as one group and another group of PNG TML Indonesia Philippines Brunei Singapore and Malaysia.

Moreover, there are many cooperation programs on Transboundary area in CLMTV countries, based on the current interesting topics. Water and Groundwater interaction program is focused on Mekong region, both for water management and water pollution. Geo-hazard program, on Active fault and landslide, is focused on sharing information, capacity building and community-based mitigation. Many programs are also focused to support the establishment of Geopark, especially in the Countries are not yet a member of the UNESCO

Geopark. It has been proved also that working on mutual respect with mutual benefit basis is the best approach for these programs.

Recently, Jurassic to Cretaceous Transboundary Geoscience program was started in CLMTV countries. This program is also focused on promoting the young geologists through YES Network established during 2007 International Year of Planet Earth. Two workshops, firstly in 2017 and then again 2018, were organized in Bangkok, with cooperation from CCOP, Geological Society of Thailand and Thai Department of Mineral Resources. Most recent studies from CLMTVT countries, especially on the transboundary topics were presented in this annually workshop. Map of specific geoscience information, such as groundwater, index fossil, mineral resources and tectonic evolution of J/K, are shared and discussed among the participant where international standard is applied.

The first expected output of these cooperation programs is on the data and information sharing. However during the commencing, knowledge enhancement and capacity buildings are focused for all stakeholders too. Finally, we, CCOP, would like to have all of the geoscience information be ready-to-used via internet on CCOP and CLMTV WebGIS portal. Eventually, Outreach or Geoscience for the Public is our final output of these transboundary programs.

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 1,100 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.

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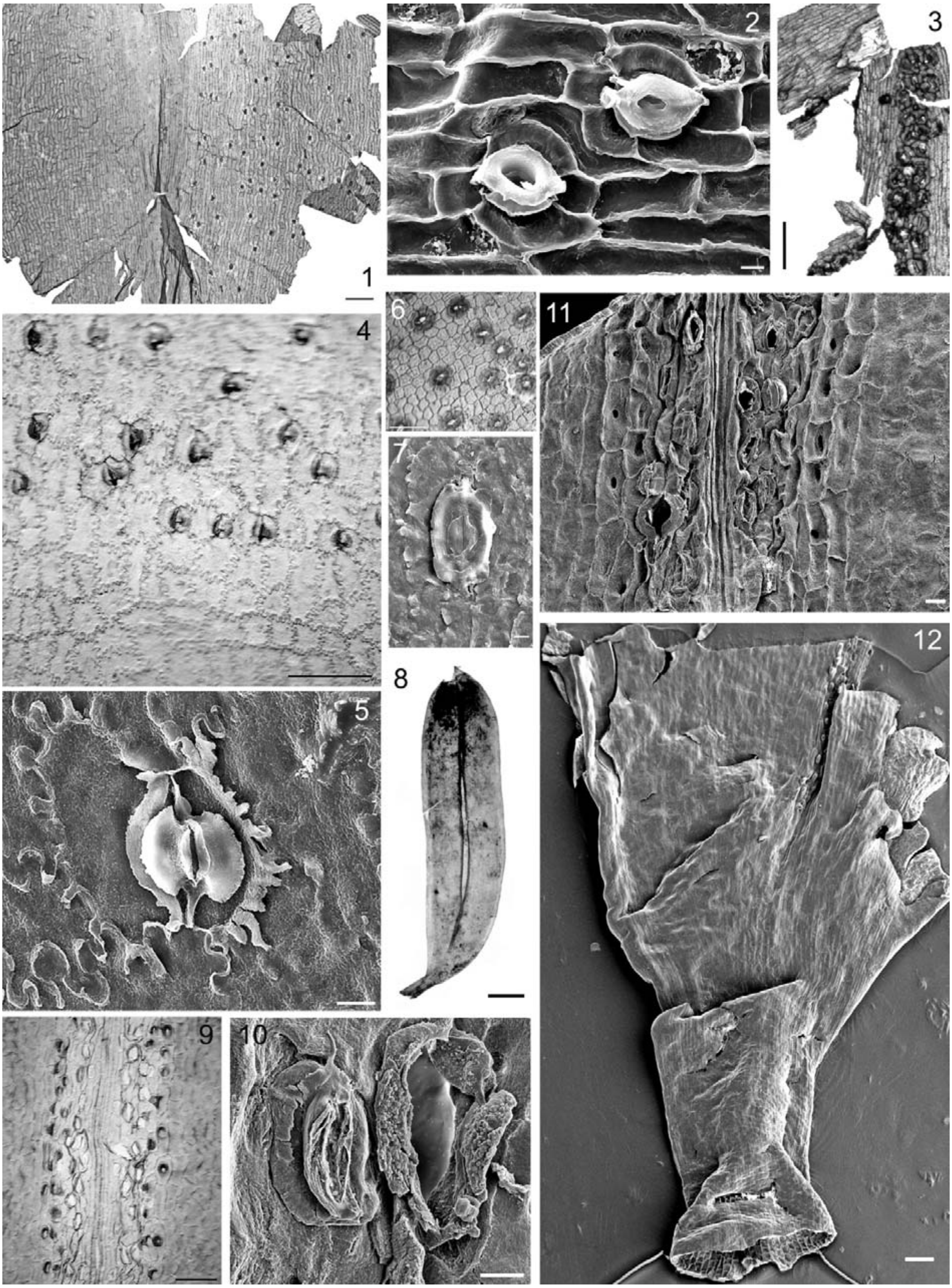
Table I. The coal-forming plants of the Early Cretaceous Kuti formation (South-eastern Transbaikalia, Russia)

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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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).

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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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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

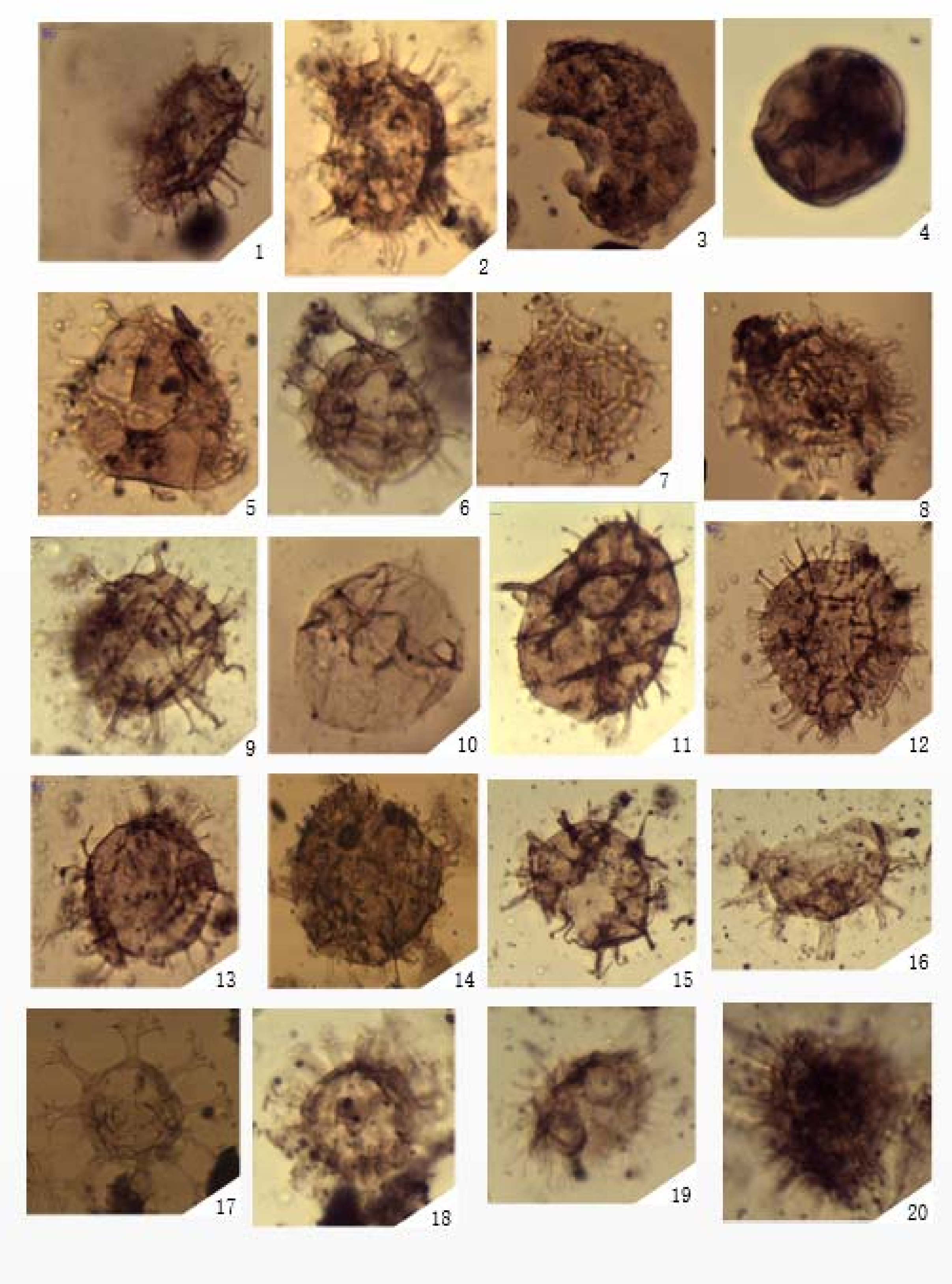

Fig.1 Represent elements of Eocence dinoflagellate assemblage in Duina, Tibet
(Scale: x 400)

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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.

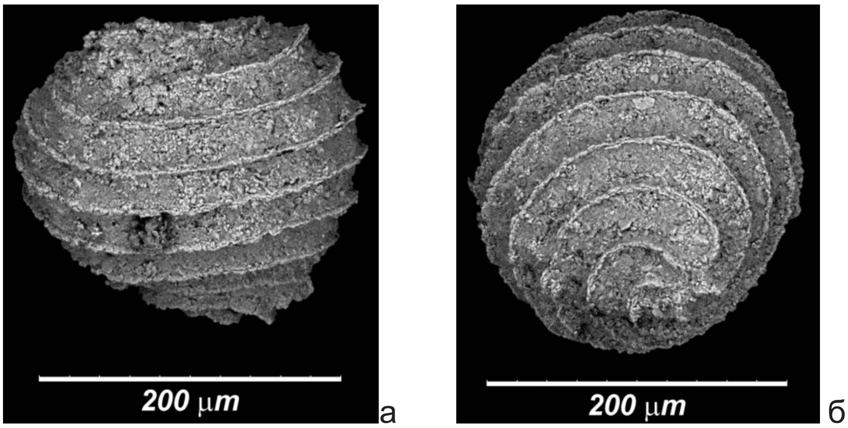

Fig. 1 Aclistochara caii а/ lateral view, б/ basal view

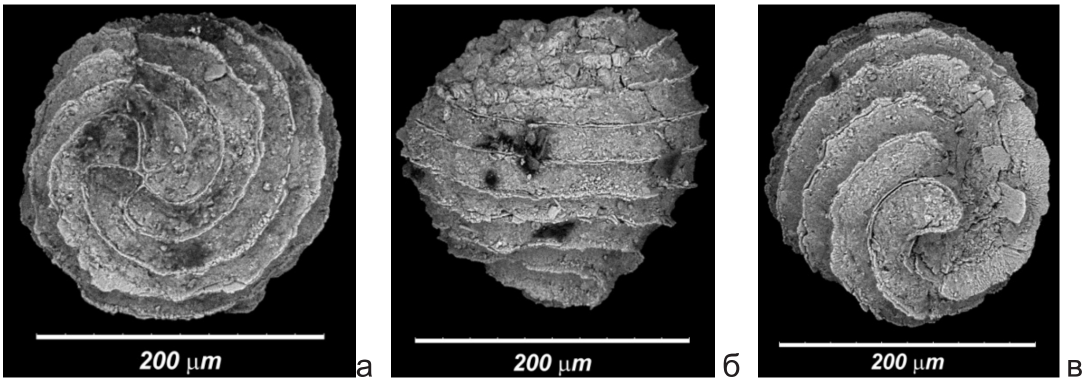

Fig. 2 Mesochara sp. төрөл а/ apical view б/ lateral view, в/ basal view

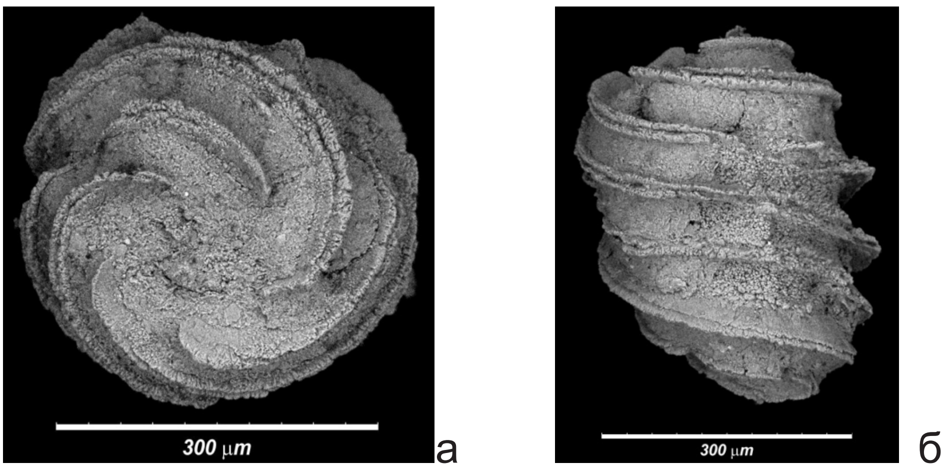

Fig. 3 Raskyella sp. төрөл а/ apical view, б/ lateral view

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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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Extended Abstract

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

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Abstract

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 11,230±60 yr BP and 9,690 yr BP. During a generally regressive phase, lake level in the Uvs Nuur has been dated between 7,310±90 yr BP and 3,250±70 yr BP (An et al., 2008). Lastly, lacustrine sedimentation occurred during the late Holocene between 3,010±50 yr BP and 4,030±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 9,000 to 7000 yr BP and colder dry climate about 7,000 to 5,000 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 $70^{0}10^{'}$-$82^{0}00^{'}$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 indicu*s (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.

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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

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

Acknowledgements

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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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Abstract

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.

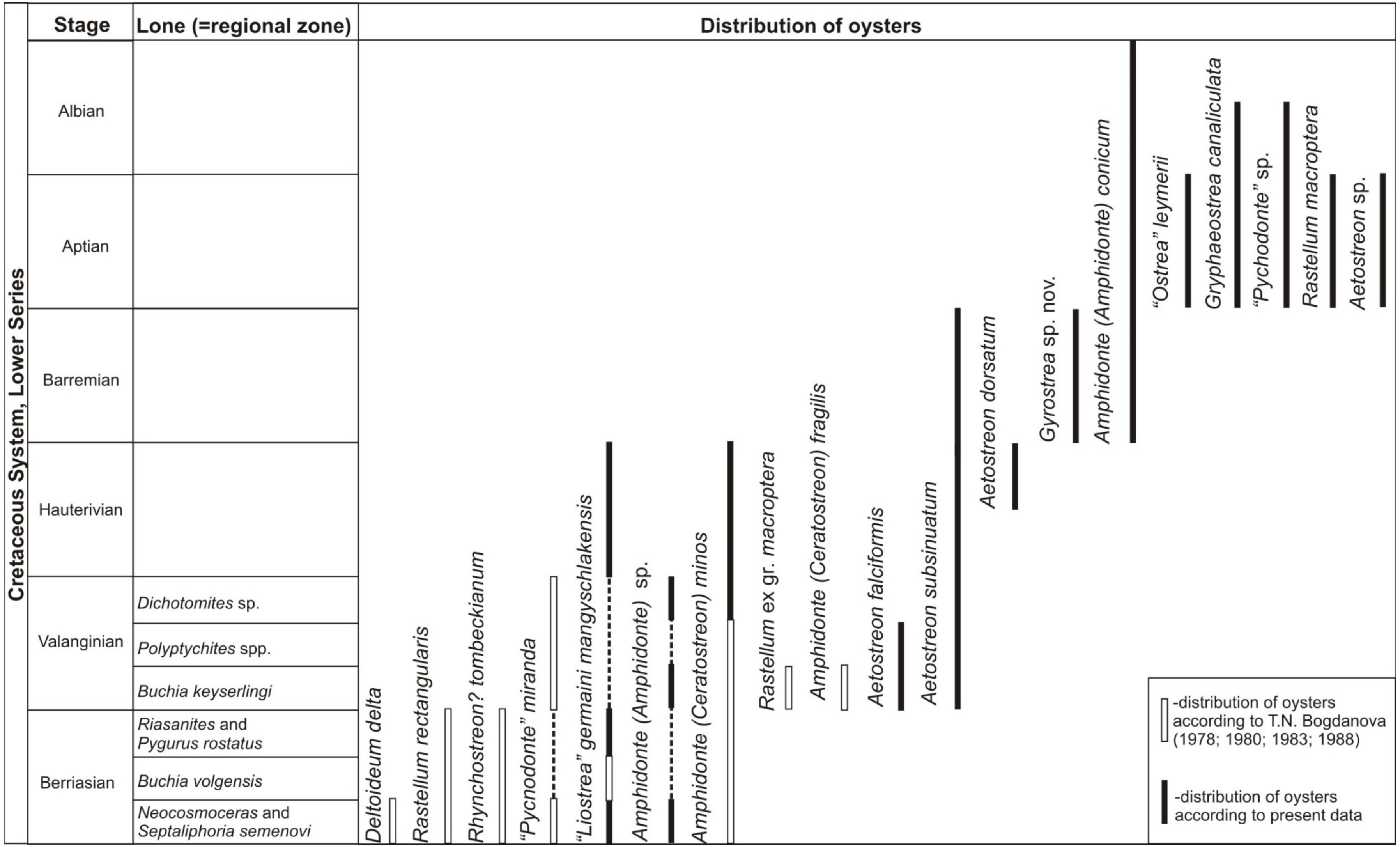

Fig. 1. Stratigraphic distribution of oysters in Lower Cretaceous of Mangyshlak peninsula.

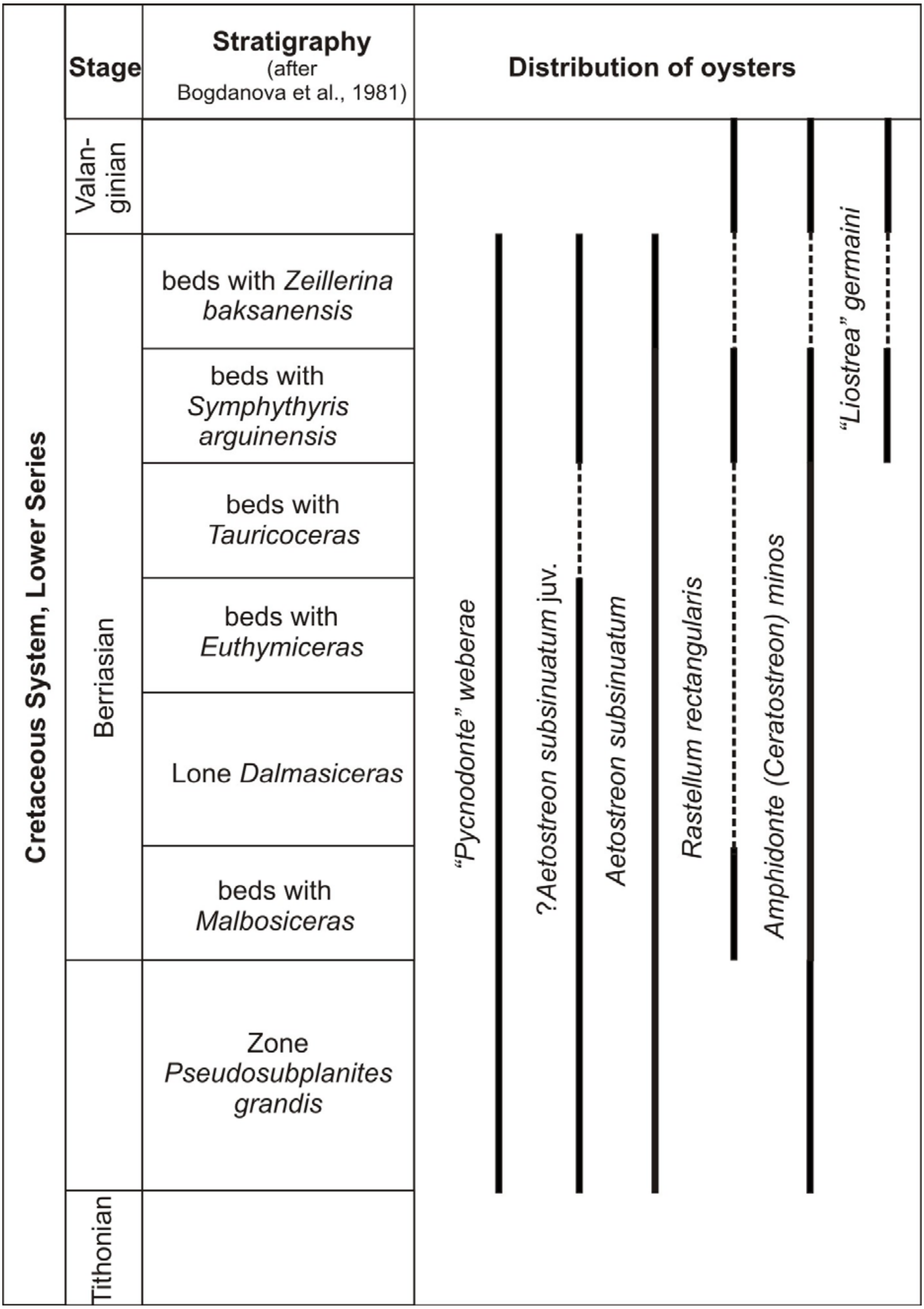

Fig. 2. Stratigraphic distribution of oysters in Berriasian - Valanginian of Crimea peninsula.

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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 coastal area.

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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.

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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.

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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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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.

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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 3,560 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(1,854 Ma). Jeokbyeok Tuff and Ongam Conglomerate, located in eastern of the basin contain only detrital zircons of Early Proterozoic(1,848~2,476 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

Abstract

Non-marine Mesozoic red beds in the northeastern part of Thailand was first mentioned in 1923 by Wallace Lee in his report on coal and petroleum exploration. Twenty years later, Brown *et al*. (1953) named the Khorat Series to represent these strata and Triassic limestone of northern Thailand. After measured 5 stratigraphic type sections, Ward and Bunnag coined the new name “Khorat Group” in 1964. They divided the Group into 7 formations in ascended order namely as follow the Nam Phong, Phu Kradung, Phra Wihan, Sao Khua, Phu Phan, Khok Kruat and Unnamed Formations. Iwai *et al*., (1966) proposed a new formation “Huai Hin Lat” as the lowest formation, rested conformably under the Nam Phong Formation and gave the Rhatian to Liassic ages from plant fossils found. On the other hand, Gardner *et al* (1967) proposed the name Maha Sarakham Formation to replace the Unnamed, the uppermost formation of the Group. The age of these rock salt strata were believed to be from Late Cretaceous to probably as late as Early Tertiary. In the following decades, many formations found locally in various areas were mapped and placed as the lowest formation of the Khorat Group, e.g., Nam Pha, Sap Mai Daeng, Lom Sak. However, Chonglakmani and Sattayarak (1978) combined all those formations laid down below the Nam Phong Formation into one formation, due to their equivalence in litho-stratigraphy. The name Huai Hin Lat Formation was selected according to the rule of priority.

On the upper portion of the Group, Hite and Japakasetr (1979) described the sequence of the Maha Sarakham Formation into 6 units from bottom to top, as follow the Basal Anhydrite, Lower Rock Salt, Lower Claystone (Lower Clastics), Middle Rock Salt, Middle Claystone (Middle Clastics), Upper Rock Salt and Upper Claystone (Upper Clastics). In the meantime, Sattayarak and Suteethorn (1979) mapped the mountainous area located in the northeastern part of the Khorat Plateau and presented the new rock strata called the Phu Tok Formation which was believed to be mainly eolian sediments as probably equivalent to the Upper Clastics of the Maha Sarakham Formation.

It had been almost 2 decades that Thai geologists accepted that the Mesozoic monotonous redbeds Khorat Group composed of 9 formations in ascended order namely the Huai Hin Lat , Nam Phong, Phu Kradung, Phra Wihan, Sao Khua, Phu Phan, Khok Kruat, Maha Sarakham, and Phu Tok. All formations were accumulated in the same basin “the Khorat Basin”.

In 1989 Sattayarak *et al*, proposed a new Triassic sedimentary sequences found in the west area of the Khorat Plateau. These sediments deposited mainly in half graben rift basin. These rocks took place in various kinds of depositional environment. e.g., alluvial fan, river, swamp and lake. This rock sequence was comparable to the Huai Hin Lat Formation. They further suggested that after rifting culminated and a mild deformation took place, the whole area was subsided due to thermal cooling and formed a huge sagging basin, the Khorat Basin. Hence this rock formation should be separated from the Khorat Group.

Unfortunately, Sattayarak *et al*. did not coin this formation name but called it Triassic half - garben sediments. Subsequently, geologists from foreign oil companies dubbed it as Khuchinarai Formation and/or Group.

Later on, Sattayarak and Polachan (1990) demonstrated an unconformity between the Khok Kruat and Maha Sarakham Formations and proposed to move the later and the Phu Tok Formation out of the Khorat Group.

Up to now, study on various topics relating to the Khorat Group via different tools, concepts, and methodologies have been carried. Such as geophysics, radioactive, paleomagnetism, palynology, paleontology, stratigraphy and structural geology. These studies resulted in many proposed revisions e.g., the proper nomenclature and subdivisions, the correct ages, paleogeography, as well as, basin configuration and evolution.

In conclusion, more studies and discussions on many topics related to the so-called Khorat Group should be carried and published for better understanding and more benefits of Thai geologists.

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

Sedimentology and stratigraphy of Phuwiang Dinosaur excavation sites, Khon Kaen Province, northeastern Thailand

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Abstract

Phuwiang Mountain Range, where first dinosaur bone of Thailand was discovered, is located in the northeastern part of Thailand. Since 1977, Thai-French collaboration team had researched continuously in the Early Cretaceous Phuwiang fossil sites and found 4 new dinosaur species including *Siamosaurus suteethorni*, *Phuwiangosaurus sirindhornae*, *Siamtyrannus isanensis* and *Kinnareemimus khonkaenensis*. However, few studies in sedimentology and stratigraphy were reported. This work aims to study sedimentology and stratigraphy of 9 excavation sites in Phuwiang Moutain where bones and foot print were found. According to field observation and facies analysis method, sedimentary successions are composed of reddish to maroon siltstone and sandstone, conglomerate, calcrete layer and limestone. Twelve lithofacies have been established and can be grouped into 4 facies association interpreted as 1) channel fill deposit 2) crevasse splay deposit 3) lake and flood plain deposit and 4) overbank deposit. Sedimentary logs from 9 excavation sites are correlated and can group into 3 units. The lowermost, unit A is white sandstone with cross bedding where dinosaur foot prints are present at site No.8. Unit B, overlying on Unit A, is composed of medium to thick bedded sandstone interbedded with siltstone. Conglomerate can be locally found with some bone fragments. The uppermost, unit C consists of reddish siltstone, sandstone, limestone, conglomerate and calcrete layer. Bivalve and dinosaur bones are common in this unit. After the previous works, unit A can correlated to upper Phra Wihan Formation and unit B and C correlated to Sao Khua Formation of Khorat Group. The results of this study suggest that unit C have the most potential for future fossil exploration and research.

Key Word: Stratigraphy, Phuwiang, Dinosaur sites, Early Cretaceous, northeastern Thailand

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.

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Stratigraphy and Structure of Jurassic – Cretaceous Rocks in the Thong San Khan and Chat Trakan Areas, Northern Thailand.

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Abstract

Jurassic – Cretaceous rocks in the Thong San Khan and Chat Trakan areas can be classified to 8 rock units from detail mapping. Unit A is composed of tuff interbedded with tuffaceous sandstone, pyroclastic breccia and agglomerate. Unit B is white sandstone interbedded with thin bedded siltstone. Unit C is dominated by cross-bedded medium-grained white sandstone. Unit D is mainly white and greenish grey sandstone. Unit E is consisted of red fine-grained sandstone, red siltstone interbedded with medium-grained sandstone. Unit F is composed of reddish purple fine-grained sandstone and reddish purple siltstone. Fragments of fossil turtle shells and fossil fish scales were found in the middle part of unit F. Unit G is composed of grey sandstone and reddish purple siltstone. Unit H is mainly white sandstone and conglomerate. Sedimentary strata (unit B to G) are mainly continental deposit with corresponding to Khorat Group. Previously, unit A was interpreted to be Jpk, unit B to D were grouped as JKpw whereas units E to H were grouped as Ksk with recently found terrestrial fauna. In these areas, the geologic structures of Jurassic – Cretaceous rocks are dominantly fold and thrust structures with closely N-S trending. NE-SW trending left lateral strike slip faulting cross-cut the middle part of the area and is possibly associated to the fold-thrust structure developing in the Cenozoic tectonic of SE Asia.

Key words: Stratigraphy, structure, Jurassic – Cretaceous, northern Thailand

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.

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The depositional environments of the Late Jurassic-Early Cretaceous Phu Noi dinosaur site, Phu Kradung Formation, Kalasin, northeastern Thailand

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Abstract

Phu Noi is a small rounded and marginal erosional remnant hill of the NW-SE aligned Phu Phan Range. Phu Noi has gently southwestward dipping beds of the lower part of the Phu Kradung Formation. The area is covered by sparse trees and shrub of the dry dipterocarp forest. The discovery of the Phu Noi fossil site was from the fish scales and bone fragment finding by the villagers. A further excavation and research activities have been proceeded by the collaboration between Department of Mineral Resources, Mahasarakham University and French paleontologists. A great number of dinosaur remains comprising of mamenchisaurid sauropods, sinraptorid theropods, small theropod and ornithopod found associated with pterosaurs, hybodont sharks, bony fishes, turtles, temnospondyls, teleosaurid crocodilians, bivalve and plants were collected in situ. The fossil assemblage suggests the Late Jurassic and likely a latest Jurassic to earliest Cretaceous in age to the site. This study aims to provide information on the sedimentary depositional environment and to elucidate the accumulation of these fauna by using field data, petrography and geochemical analysis. The studied section was approximately 10 meters thick. It comprises mainly of the lower greenish gray clastic facies and the upper grayish red purple finer grained deposits. The lower greenish gray facies was composed primarily of the lowermost conglomerate with vertebrate fragments and the overlying moderately to well sorted very fine to fine grained calcareous sandstone. According to petrography and geochemical analysis, sandstone is composed of quartz, feldspar and other minerals such as biotite, muscovite and chlorite. These sandstone beds show planar cross lamination and ribbon structure which evidenced the crevasse channel deposit. This lower facies forms gradational contact to the overlying grayish red purple fine grained sandstone to mudstone deposits. This upper fine grained facies comprises of the well-developed ripple lamination, pedogenic slickensides, mica-rich mottling mudstone to very fine grained sandstone in which the majority of fossil and dinosaurs were found. The fossil bearing bed is successively overlaid by the strongly mottling mudstone and the horizontal thin beds of fissile mudstone to very fine grained sandstone representing crevasse splay deposit with a lowering current energy to stagnant shallow water. In summary, the Phu Noi dinosaurs was accumulated in the crevasse splay deposits of the meandering river system.

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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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.

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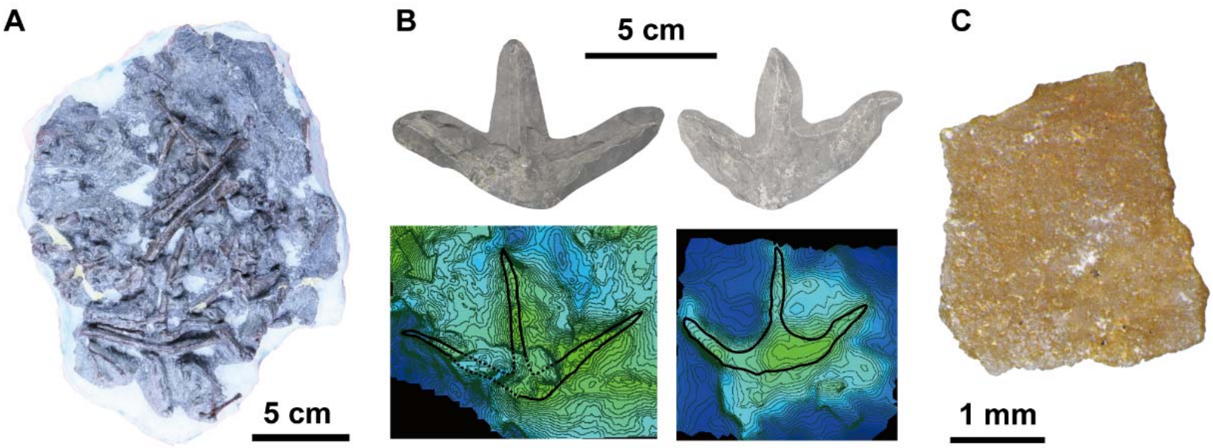

Figure 1. Avian fossils from the Kitadani Formation. (A) Partial skeleton of a pygostylian bird, FPDM-V-9769; (B) Tracks, FPDM-F-74 (top left) and FPDM-F-75 (top right) with corresponding topographic images (bottom) for each specimen; and (C) eggshell, FPDM-V-9175.

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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Extended Abstract

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.

Discussion

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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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.

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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

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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.

Vertebrate remains from the Early Cretaceous fluvial deposits of Phu Wiang Valley, Khon Kaen Province, Northeastern Thailand

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Abstract

Remains of dinosaurs and other vertebrates including sharks, bony fish, turtle, crocodilians and footprints were reported from the Sao Khua Formation and Phra Wihan Formation of Phu Wiang Valley, Khon Kaen Province in northeastern Thailand. These two formations of the Khorat Group are Early Cretaceous continental deposit. Most of dinosaur bones and teeth are found in reddish siltstone and sandstone from crevasse splay and flood plain deposits of a low-energy meandering river system. The most prominent dinosaur fossils discovered at Phu Wiang valley is a new species of a sauropod dinosaur later named as *Phuwiangosaurus sirindhornae* after the name of Her Royal Highness Princess Maha Chakri Sirindhorn who pay a great attention in the dinosaur research. Moreover, Thai and French paleontologists erected other three new dinosaur species comprising of a large theropod *Siamotyrannus isanensis* together with a spinosaurid, *Siamosaurus suteethorni* and an ostrich-mimic dinosaur, *Kinnareemimus khonkaenensis*. Due to low-energy current, the preservation of dinosaur bones and teeth, notably the partial skeleton of a *Phuwiangosaurus* is particularly good. The other vertebrate fossils transported under high energy condition and deposited in the low- energy current are fragmentary. The presence of caliche pebble conglomerate indicates arid – semiaridity in subtropic climate.

Keyword: Vertebrate remains; Cretaceous; Phu Wiang Valley; Khon Kaen Province; Thailand

Diversity of Mesozoic crocodiles in the northeastern Thailand

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Abstract

Three formations of the Khorat Plateau, northeastern Thailand, were investigated and excavated the vertebrate fossils, including the Phu Kradung Formation which is dated as Late Jurassic-Early Cretaceous; whereas the Sao Khua and Khok Kruat Formations are dated as Early Cretaceous (Racey *et al.,* 1996; Carter & Bristow, 2003). All material were described and compared with well-known specimens from the European and Russian Museums to assess their taxonomic identification at the lowest possible level. The result shows that the Phu Kradung Formation consists of three families: Pholidosauridae, *"Chalawan thailandicus* (Buffetaut and Ingavat 1980), Atoposauridae (based on the typical teeth morphology) and Teleosauridae (based on a complete skull with mandibles). The Sao Khua Formation also consists of two Families. The first one is Goniopholididae which consist of two genera, i.e., *"Goniopholis" phuwiengensis* Buffetaut and Ingavat 1983 and *Siamosuchus phuphokensis* Lauprasert et al., 2007. The second family is Atoposauridae, *Theriosuchus gradinaris* Lauprasert, et al., 2010. The youngest formation of the Khorat Group, the Khok Kruat Formation comprises three families: Goniopholididae (KPS 1, from the Khorat Fossil Museum, Nakhon Ratchasima Province) and Atoposauridae (based on teeth morphology) from Ubon Ratchathani Province. Furthermore, this formation also presents a primitive neosuchian crocodile, *Khoratosuchus jintasakulii* Lauprasert et al., 2009 from Nakhon Ratchasima Province, which is considered as Family *incertae sedis*.

The crocodilian diversity of the Khorat Plateau is much more increasing from the previous study from one family and two genera (before 2006) to five families and at least six genera. The crocodile faunas from the Khorat Plateau are rather different from North America, Europe and China which indicates that Thai crocodiles are mostly endemic animals.

Keywords: Diversity, Mesozoic, Crocodilian, northeastern Thailand

Academic Values of Mudeungsan UNESCO Global Geopark

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Abstract

The Mudeungsan UNESCO Global Geopark is located in the southern part of the Korean peninsula near the large regional city of Gwangju. Administration is shared between Gwangju City and two counties of Jeollanam Province. The Mudeungsan UGG gets its name from Mount Mudeung which rises about 1,178 m above the lowlands. The core area of 75 km^2 is within Mudeungsan National Park. In and around the area there are many villages and cultural features closely connected to Mt Mudeung. Twenty geosites have been identified in the 1,051 km^2 mountainous UGG area. Seven geological periods are represented. The geological sites range from five large colonnades of polygonally jointed tuff columns recording at least three phases of Cretaceous volcanic activity, extensive periglacially-produced block streams and cryoplanation surfaces, unusual microclimatic environments within talus accumulations, very unique dinosaur footprints and trackways, and a variety of other geological and geomorphological features such as lengthy scenic cliff-lines and waterfalls. Among them, outstanding universal value sites are colunnades of Mudeung Mt., Unjusa stratified tuff, Hwasun Dolmen site, Seoyuri dinosaur fossil site and Climatic change in Quaternary

Moreover, one of the greatest features of the Mudeungsan Global Geopark is its unique culture stemming from geological features. Unjusa temple (Unjusa stratified tuff), the UNESCO World heritage list, is well-developed tuff stratifications by the volcanic activities of the Cretaceous era. The Buddha statues and pagodas in this temple were subdivided into their own cultures by stratified tuff. The Hwasun Dolmen Site is supposed that they used the giant rocks separated in layers and naturally weather-flowed along the soil and built the dolmens in place. Chunghyodong clay mineral site is the place where the porcelain which was called 'Buncheongsagi'. This porcelain is highly related to the characteristics of the Mt. Mudeung's soil. The soil for making ceramic material occur from the weathered soil in the adjacent area by applying the kaolin in the Mt. Mudeung.

Among the various projects promoted in the Mudeungsan Glabal Geopark, the geoeducation program is the most outstanding and interesting. The program is developed to combine indoor and outdoor classes in conjunction with geosites.

Dinosaurs, Birds and Pterosaurs of Korea: A Paradise of Mesozoic Vertebrates

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Abstract

Korea is one of the best known regions in the world for the Cretaceous vertebrate ichnology. Abundance of diverse vertebrate tracks with very good quality of preservation and high density of occurrence of tracks and track-bearing stratigraphic beds in the Cretaceous of Korea represent the Mesozoic paradise of vertebrates and the UNESCO World Heritage candidate and Global Geopark.

Bird tracks named in Korea are much more diverse than those of any other countries in the world. The smallest theropod tracks (Minisauripus), raptor tracks with only two digits impressions (Dromaeosauripus), new ornithopod tracks with three clover leaf-shape (Ornithpodichnus), a new ichnospecies of Brontopodus (B. pentadactylus), new quadrupedal ornithopod tracks (Caririchnium kyoungsookimi and C. yeongdongensis), the largest pterosaur tracks (Haenamichnus gainensis), the second named bird tracks (Koreanaornis), the oldest web-footed bird tracks (Ignotornis yangi), and diverse dinosaur eggshells including Macroelongatoolithus goseongensis, as well as new dinosaur bones (Koreanosaurus and Koreaceratops) first named in the Cretaceous of Korea have very significant scientific values for understanding the history of the Mesozoic vertebrates.

Several new dinosaur tracks recently named in Korea are as follows: Hamanosauripus ungulates (Kim, 1986), Koreanosauripus cheongi (Kim, 1986), Brontopodus ichnosp. (Lockley et al. 2006), Dromaeosauripus hamanensis (Kim et al. 2008), Minisauripus zhenshounani (Lockley et al. 2008), Ornithopodichnus masanensis (Kim et al. 2009), Brontopodus birdi (Kim et al. 2012), Ornithopodichnus (Lockley et al. 2012), Caririchnium kyoungsookimi (Lim et al. 2012), Brontopodus pentadactylus (Kim and Lockley, 2012), Dromaeosauripus jinjuensis (Kim et al. 2012), Caririchnium yeongdongensis (Kim et al. 2016). Several new dinosaur tracks recently named in Korea are also important for

understanding gait, stance, and behavior of dinosaurs. They are Brontopodus pentadactylus (Kim and Lockley, 2012), Caririchnium kyoungsookimi (Lim et al. 2012), C. yeongdongensis (Kim et al. 2016), Dromaeosauripus hamanensis (Kim et al. 2008), D. jinjuensis (Kim et al. 2012), Minisauripus (Kim et al. 2012), and Ornithopodichnus masanensis (Kim et al. 2009).

How vertebrate tracks are abundant in Korea can be estimated on the basis of comparison of counting data of tracks and trackways, and tracksites. The world largest tracksite in terms of exposed surface was the Upper Cretaceous dinosaur tracksite at Cal Orckó of Bolivia. The tracksite was the most spectacular in the world exposing more than 5,000 tracks. However, unfortunately the track-bearing surface was collapsed in 2010. Eleven tracksites of Spain and Portugal for nomination of the World Heritage inscription contain about 13,640 tracks. Recent study showed that about 1,370 trackways and 14,280 tracks of dinosaurs have been reported from the Cretaceous at ~90 tracksites in Korea. It was known that Spain has about 150 tracksites and High plains of eastern Colorado and New Mexico have about 70 dinosaur tracksites. Therefore, Korea is a region with one of the most abundant and highly dense occurrence of dinosaur tracks and trackways.

Compared with dinosaur tracks and eggshells, dinosaur bones have been rarely reported from the Cretaceous of Korea. In this regard, a new basal ornithopod dinosaur described as Koreanosaurus boseongnesis (Huh et al. 2010), the first ceratopsian dinosaur described as Koreacertops hwaseongensis (Lee et al. 2011) and Pukyongosaurus millenniumi (Dong et al. 2001) are paleontologically important.

The most diverse and abundant bird tracks from the Cretaceous of Korea are remarkable compared with those of any other countries. To date, there are 26 Cretaceous avian ichnospecies assigned to 20 ichnogenera, if Archaeornithipus meijida and Magnoavipes lowei are interpreted as dinosaurian-like, and Moguiornis robusta, Dongyangornis sinensis, Ignotornis gajinensis, Gyeongsangornis lockleyi and Paxavipes babcockensis are included. Thus, six ichnogenera among the 20 ichnogenera of Cretaceous avian tracks were formally named in Korea. They are Koreanaornis (Kim, 1969), Jindongornipes (Lockley et al. 1992), Hwangsanipes (Yang et al. 1995), Uhangrichnus (Yang et al. 1995), Goseongornipes (Lockley et al. 2006) and Gyeongsangornipes (Kim et al. 2013). Eight avian ichnospecies among 26 ichnospecies of Cretaceous were also named in Korea, among which Ignotornis gajinenisis (Kim et al. 2012) are included. Therefore, about one third of Cretaceous avian ichnogenera and ichnospecies has been formally named in

Korea, which means the most diverse record in the world and much more diversity than those of any other countries. In this regard, the Gajin tracksite is notable. At the Gagin tracksite, more than 2500 well-preserved bird tracks associated with theropod and sauropod tracks were recorded from the Early Cretaceous Haman Formation of the Gajin area, Jinju, Korea. Bird tracks were described as Koreanaornis hamanensis, Goseongornipes markjonesi, ? Aquatilavipes, and Ignotornis gajinensis which is a semi-palmate bird track associated with arcuate to semi-circular, double-grooved impressions resulting from spoonbill-like feeding behavior. The Gajin tracksite represents a record of the world's richest and most diverse Cretaceous bird assemblage, which was dubbed "A paradise of Mesozoic birds".

The record of pterosaur ichnotaxa named in eight countries in the world. Although ichnotaxonomy of pterosaur tracks has been debated, three ichnogenera including Haenamichnus, Pteraichnus, and Pubeckopus and nine ichnospecies are regarded to be valid. Several Spanish ichnogenera and ichnospecies of pterosaurs as well as Pteraichnus koreanensis (Lee et al. 2008) are regarded as invalid ichnotaxa. If we follow these, Haenamichnus, one of three ichnogenera of pterosaurs, and Haenamichnus uhangriensis (Hwang et al. 2002) and H. gainensis (Kim et al. 2012), two of nine ichnospecies of pterosaurs, have been named from the Cretaceous of Korea. To date, nine valid ichnospecies belonging to three ichnogenera of pterosaur tracks have been known in the world. They are Pteraichnus saltwashensis (Stokes, 1957), P. stokesi (Lockley et al. 1995), P. longipodus (Fuentes Vidarte et al. 2004). P. parvus (Meijide Calvo et al. 2001), P. nipponensis (Lee et al. 2010), P. palacieisaenzi (Pascual Arribas et al. 2015), Purbeckopus pentadactylus (Wright et al. 1997), Haenamichnus uhangriensis (Hwang et al. 2002), and H. gainensis (Kim et al. 2012). Therefore, two of nine pterosaur ichnospecies and one of three ichnogenera of pterosaur tracks were formally named in Korea. Especially, Haenamichnus gainensis shows the longest trackway and it is the largest pterosaur tracks. In addition, Haenamichnus gainensis is the only one pterosaur tracks attributable to bipedal, fully erect, and digitgrade stance and gait. The other six ichnospecies have generally accepted as having been made by quadrupedal, semi-erect, and plantigrade pterosaurs. Therefore, Haenamichnus gainensis support Bennett (1990), who documented that at least some large pterodactyloids could have been primarily plantigrade bipeds.

Korean dinosaur eggs were named as Spheroolithus sp. (Huh and Zelenitsky, 2002), Faveoloolithus sp. (Huh and Zelenitsky, 2002), Dictyoolithus neixiangensis (Kim et al. 2011), Macroelongatoolithus goseongensis (Kim et al. 2011) and Macroelongatoolithus xixiaensis (Huh et al. 2014). Dinosaur teeth also recognized as named Chiayüsaurus asianensis (Lee et al. 1997) and Chiayüsaurus sp. (Park et al. 2000), and turtle tracks (Chelonipus ichnosp. Kim and Lockley, 2016) and mammaliform tracks (Koreasaltipes jinuensis Kim et al. 2017) included. Especially, lizard skeleton (Asprosaurus bibongriensis Park et al. 2015) has very important scientific valve related to dinosaur fossils in Korea and Asia.

Among the various projects promoted in the Mudeungsan Glabal Geopark, the geoeducation program is the most outstanding and interesting. The program is developed to combine indoor and outdoor classes in conjunction with geosites.

Sedimentary Environments of the Lower Formations of the Cretaceous Yeongyang Subbasin of the Gyeongsang Sedimentary Basin in Bonghwa-gun, Gyeongsangbuk-do, Korea

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Abstract

The Yeongyang Subbasin is separated from the Uiseong subbasin by the Cheongsong Ridge, which is connected to the Andong Fault in the west, and is bounded by a thrust in the north. The Myogog Formation is the lowest sedimentary sequence in the Yeongyang Subbasin, which has been known as a post-Daedong Group and pre-Gyeongsang Supergroup. This is an important stratigraphic unit connecting the Jurassic Daedong Group to the Cretaceous Gyeongsang Supergroup The Myogog Formation is distributed in a small wedge at the northwestern part of the Yeongyang Subbasin. The entire outcrops were measured as detailed columnar sections and were described from the lower Myogog Formation to the Ullyeonsan Formation and Donghwachi Formation. The sedimentary formations consists of five conglomerate facies, four sandstone facies, two siltstone and a mudstone facies(Ccs : clast-supported, stratified conglomerate. Ccd : clast-supported, disorganized conglomerate. Cms : matrix-supported, stratified conglomerate. Cmd : matrix-supported, disorganized conglomerate. tCmd : matrix-supported, disorganized tuffaceous conglomerate. Sgc : cross-stratified gravelly sandstone. Sm : massive sandstone. St : trough cross-stratified sandstone. tSm : massive tuffaceous sandstone. Ss : crudely stratified siltstone. Ml : laminated mudstone). The sedimentary sequences can be grouped into six facies associations on the basis of constituent sedimentary facies: swamp or lacustrine deposits(FA I: St-Ml / Sm-Ml), alluvial fan deposits along a fault scarp(FA II: Cmd-Ccd), pyoclastic-rich debris flow deposits(FA III: tCmd, Cmd), gravelly braided-stream deposits (FA IV: Cms-Ss /Cmd-Ss), sandy braided-stream deposits(FA V: Sgc-Ss), pyoclastic-rich mud flow deposits (FA VI: tSm). The sedimentary environment of the Mogog Formation was a swamp or lacustrine setting, and those of the Ullyeonsan Formation and Donghwachi Formation evolved from an alluvial fan to a braided stream nearby a very active volcano.

Keywords : Yeongyang Subbasin, Myogog Formation, Ullyeonsan Formation, Donghwachi Formation, facies, facies associations, swamp or lacustrine, alluvial fan, pyoclastic, debris flow, mud flow

Radiolarian assemblage of Barremian to Aptian interval in the Tethys and the influence of the oceanic anoxic event (OAE) 1a

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Abstract

Comparison of radiolarian assemblages from marls in the Gorgo a Cerbara section in the Umbria–Marche Basin in central Italy and from a siliceous sequence (section BB1) near Babazhadong in southern Tibet indicates similar faunas comparable to those in the *Aurisaturnalis carinatus* Zone and the *Turbocapsula costata* Zone. Comparison with the Gorgo a Cerbara section provides an accurate age constraint for the siliceous succession in southern Tibet, which contains no fossils other than radiolarians. The siliceous succession in section BB1 encompasses the Early Aptian Oceanic Anoxic Event 1a (OAE 1a). The Early Aptian OAE 1a is located in the upper part of the *Aurisaturnalis carinatus perforatus* subzone. The first occurrence biohorizon of the genus *Turbocapsula* and the evolutionary first appearance biohorizon of *T. costata* (Wu) *multicostata* Li & Matsuoka are useful criteria for constraining the OAE 1a. Common species of these two zones in both sections are: *Stichomitra communis* Squinabol, *Hiscocapsa grutterinki* (Tan Sin Hok), *Squinabollum asseni* (Tan Sin Hok), *Pseudoeucyrtis hanni* (Tan Sin Hok), *Mictyoditra columbarium* (Renz), *Acastea* sp., *Suna* sp., *Archaeospongoprunum patricki* Jud, and *Halesium* sp. Important and typical Early Cretaceous taxa, like *Archaeodictyomitra lacrimula* (Foreman), *A. excellens* (Tan Sin Hok), *Dictyomitra communis* (Squinabol), *Pantanellium* sp., and *A. carinatus perforates* Dumitrica and Dumitrica–Jud occurring in older strata show their last occurrence after the OAE 1a.


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