Project Proposal Form

1. Indicate the division into which the project falls

(1) 2 3 4

to which the project is also related

1 2 (3) (4)

2. Short title of the project

Paleoclimates of the Cretaceous in Asia

3. Full title of the project

Paleoclimates in Asia during the Cretaceous: their variations, causes, and biotic and environmental responses

4. Proposed by

Yong Il Lee, Xiaoqiao Wan, Takashi Sakai, and Krishnan Ayyasami

5. Mailing address, name, telephone, fax, e-mail

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6. Scale of the project

Continental (Asia), global implications

7. Brief outline of the project

The project aims to gather paleoclimatic information and important clues that can help to tell us what caused changes in paleoclimate in Asia during the Cretaceous and to understand the physical and biological systems responding to changes of climate on different time scales. The project will undertake a detailed survey in South and East Asia to gather paleoclimatic information from terrestrial and marine sediments through studies on many types of proxy data such as basin architectures, stratigraphic frameworks, lithologic and biotic indicators, and geochemical properties of paleosols and fossils both marine and terrestrial. Based on these data the spatial paleoclimatic variations and temporal paleoclimatic changes will be delineated. Then, paleoclimatic-forcing factors will be interpreted considering tectonic activity, relative sea-level changes and igneous activity. The project will include three active working groups; Stable carbon isotope stratigraphy, Biotic records, and Lithological proxy records.

8. Estimated duration of the project

Five years (2006-2010)

9. Tentative work schedule (items by year)

Year 1 (2006)

***** Create web site of the IGCP Project No. 507.

***** 1st International Symposium in Fukuoka, Japan in conjunction with the 17th International Association of Sedimentologists (IAS) Congress in Japan (August 27-Sept 1). One of the proponents, Prof. Yong Il Lee, requested a special session in the 17th International Association of Sedimentologists (IAS) Congress program to the Organizing Committee of the Congress and as a result a special session entitled "Paleoclimate of the Cretaceous in Asia (TS11-3)" has been already set up and allocated in the IAS Congress program. Thus, the first International Meeting of the project will be held at the IAS meeting. Also, the first business meeting will be made at the same time to determine the detailed projects to be undertaken over the next four years of research.

***** A four-day field workshop for Cretaceous sequences distributed in Kyushu, Japan will be held by the guidance of Dr. T. Sakai of Kyushu University.

***** Continued fieldwork on Cretaceous sequences in Thailand by collaborated scientists from Thailand, Korea, and India focusing on sequence architecture, paleosols, provenance, and palynological aspects; sponsored by the Korean Science and Engineering Foundation.

***** Continued research on $\delta^{13}C$ stratigraphy of the non-marine and partly marine Lower Cretaceous sequences in NE China to compare and correlate the data of the Early Cretaceous in NE China with those of European and mid-Pacific and Japanese sections; sponsored by the Japan Society for the Promotion of Science and National Science Foundation of China.

***** Field excursions to Cretaceous units in Pakistan/India; initiative research on basin analysis and paleoclimate information in a single basin by scientists from project-participating countries. Also, in the field excursion planned is a training workshop in the scientific method relating geological studies such as preparation techniques, dating techniques, and practical stratigraphy/sedimentology studies.

***** Discussion of presented papers at the First International Meeting in peer-reviewed, international scientific journals.

***** Establish working groups: Stable carbon isotope stratigraphy, Biotic records and Lithological proxy records working groups.

Year 2 (2007)

***** 2nd International Symposium and business meeting in Seoul, Korea in late August. In the second meeting of the project, the state-of-the-art knowledge of Cretaceous paleoclimates in each participating country will be presented in addition to regular research results. The results

of this information will be published as a proposed edited volume. Also, planned is a special symposium session dealing with preliminary research results done on a selected sedimentary basin in Pakistan/India in the first year.

* A field trip to Lower Cretaceous deposits in South to Southeast Korea to discuss the sedimentary environments, taphonomy, paleosols and paleoclimates by participating scientists.
* Continued research on $\delta^{13}C$ stratigraphy of the non-marine and partly marine Lower Cretaceous sequences in NE China to compare and correlate the data of the Early Cretaceous in NE China with those of European and mid-Pacific and Japanese sections; sponsored by the Japan Society for the Promotion of Science and National Science Foundation of China.
* Discussion of publication of papers presented at the Second International Meeting in a peer-reviewed, international scientific journal.
* Continued research on the sedimentary basin in Pakistan/India.
* Discussion of the selection of the second sedimentary basin and field excursions that can be studied by multinational scientists.

Year 3 (2008)

* 3rd International Symposium and business meeting in Islamabad, Pakistan in late December. At the meeting, in addition to the presentation of regular research results, the final results of researches on a Pakistan/Indian sedimentary basin done for the first two years will be presented.
* A four- to five-day field workshop is planned to be held in the sedimentary basin where the various aspects of research have been carried out for the first two years.
* Attend the International Geological Congress in Oslo, Norway and present papers.
* Prepare the database for Cretaceous biodiversity in Asia
* Prepare the database for proxies of paleoclimates in Asia such as distribution of red beds and coals, etc.
* Discussion of publication of papers presented at the Third International Meeting in a peer-reviewed, international scientific journal.

Year 4 (2009)

* 4th International Symposium and business meeting in Tiruchchirappalli, South India in late December. Regular research papers and preliminary research results of the second sedimentary basin chosen for detailed research will be presented.
* A field meeting of three to four days duration in Trichinopoly (Ariyalur) to study marine

Cretaceous near the southeastern coast (about 100 km from coast) of India.

* Attend the 8th International Symposium on the Cretaceous in Plymouth, England and present papers.
* Discuss the selection of the third sedimentary basin for an intensive study by multinational cooperating scientists.
* Discussion of publication of papers presented at the 8th International Symposium on the Cretaceous and the Fourth International Meeting in a peer-reviewed, international scientific journal.
* Prepare construction of paleogeographic maps containing major belts of coal accumulation and red beds distribution.

Year 5 (2010)

* 5th International Symposium and business meeting in Beijing, China in late August. This meeting will summarize results of IGCP Project.
* Publication of a synthesis of the outcome of the IGCP Project.
* Organize and attend the Spain meeting to compare paleoclimate information between Asian and European sections, which was proposed by a participating member, Prof. M.A. Lamolda of Spain.
* Final report for IGCP Project.

10. Results expected of the project

a) in theoretical sciences

Based on data of various paleoclimatic indicators and detailed stratigrpahic frameworks, the spatial paleoclimatic variations and temporal paleoclimatic changes during the Cretaceous Asia will be delineated. Then, we can understand paleoclimatic forcing factors and enhance our understanding of the greenhouse world. In the Himalaya there are Cretaceous deposits that have not been covered in the previous IGCP Project 434 and the preceding ones. The ophiolite rocks in the Indo-Myanmar border and in the Lesser Himalaya require special attention. This work will give an impetus in the study of the evolution of major mountain ranges and the time involved in the build-up of such huge mountain chains and associated volcanic/tectonic activity as well as its paleoclimatic responses.

b) in applied sciences and technology

We can increase our knowledge of the relationship between paleoclimatic and

paleoceanographic patterns and the distribution of various economic deposits including coal, petroleum source rocks, and evaporites, which are widely distributed in the project study area. Using this knowledge we can increase the resources of these economic deposits.

c) in respect of benefit to society

The results of this project will enhance our understanding about the future global warming and raise scientific interests in environmental concerns as well as public awareness alike. Our interest in Cretaceous climates stems from the current concern over modern global warming. Extreme warmth in the middle part of the Cretaceous represents one of the best examples of greenhouse climate conditions in the geologic record. Some of the most important questions of our time relate to understanding how human activities may be modifying current and future climates. Will Earth enter another warm climate state due to rising atmospheric greenhouse gas concentrations? Will a future warm Earth system exhibit climatic and biotic stability or abrupt change and extreme states? How do climate extremes and rapid climate fluctuations affect biotic stability? Cretaceous climate studies may be the best key we have to answering these questions. Cretaceous climate data can help to inform the public about the near- and long-term possible effects of anthropogenic climate change, whose perspective is simply not available in modern and historical records. Because land-sea configuration during the Cretaceous was very different from today, the Cretaceous cannot serve as a direct analog for a future greenhouse Earth. However, Cretaceous sediments may hold the best record with which to improve our understanding of climate variability and biotic responses to change on a warm Earth. In addition, the project will kindle the interest in the evolution of flowering plants that dominate the world today. The floral response to the climate of the period may also be interpreted.

11. The following sequential results are expected (with indication of years)

* 2006: Discussion and summary of paleoclimatic information currently available and plans for further study. A program of work in all the participation countries where one Cretaceous basin will be identified for detailed work on paleoclimatology for one year or two. If this method is successful, it may be repeated in the following years.
* 2007-2010: Publication of four/five volumes of Proceedings of the Symposium and four/five volumes of Field Excursion Guidebooks that synthesize the geology and paleoclimatology of the field study areas.
* 2007-2008: Acquisition of nonmarine and marine proxy data of paleoclimate and establishment of detailed stratigraphic frameworks in Asian Cretaceous strata.
* 2009: Comparison of nonmarine and marine paleoclimatic information and interpretation of

land-ocean interactions.

* 2010: Synthesis of paleoclimates in the Asian Cretaceous and geohistory of tectonic and magmatic activities as well as results of all the paleontological studies that contribute to the biostratigraphy, taxonomy and paleoclimatology. Construction of two or three paleogeographic maps showing major belts of coal accumulation and red beds.

12. The present state of activities in this field (include the names of institutions and responsible persons)

Studies on the Cretaceous paleoenvironments have been carried out continuously through the IGCP Projects 245, 350 and 434. The IGCP Project 245 mainly concentrated on the stratal correlation of Cretaceous bioevents across the globe and in the following IGCP 350 depositional systems of Cretaceous sediments and their tectonic implications were the main subjects of the study. Through these two IGCP Projects much information about the distribution and tectonic configuration of Cretaceous sedimentary basins in South and East Asia has been gathered. In the following IGCP 434 it was aimed to gather Cretaceous geochemical data, especially carbon isotope curves, for understanding of carbon cycle through the land-ocean interactions. Although its aim has not been fully achieved by the IGCP Project 434 activity during the past five years, much information on the land-ocean interactions of carbon cycle has been gathered for database, presented at the annual international symposiums of the Project, and published in international peer-reviewed journals. Only the leading countries can afford to apply such techniques for studying carbon isotope stratigraphy. However, through the IGCP 434 activity many collaborated researches have been initiated between participating countries scientists and are now being studied (e.g., Korea-Thailand, China-Japan, Korea-Japan, India-Korea, Russia-Japan, etc). More meaningful results are expected to be produced from these ongoing joint researches, which will be used for paleoclimatological information in the proposed project. As mentioned above, the basic knowledge for the Cretaceous paleoclimates in the project study area is mature enough to initiate the proposed project. The only effort we have to pay attention is to focus research directions to paleoclimatic implications of existing and ongoing research results and integrate the available data for synthesis. Paleoenvironmental synthesis of the project study area has been published in several monographs. Some of them are as follows.

Chang, K.H. and Park, S.K. (Eds.), 1995, Environmental and tectonic history of East and South Asia. Kyungpook National University, Daegu, 434p.

Okada, H., Hirano, H., Matsukawa, M. and Kiminami, K. (Eds.), 1997, Cretaceous environmental change in East and South Asia (IGCP350)-Contributions from Japan.

Geological Society of Japan Memoir 48, Tokyo, 188p.
Okada, H. and Mateer, N.J. (Eds.), 2000, Cretaceous environments of Asia. Elsevier, 255p.
Jin, M.S., Lee, S.R., Choi, H.I., Park, K.H., Koh, S.M. and Cho, D.L. (Eds.), 2002, Mesozoic sedimentation, igneous activity and mineralization in South Korea. Korea Institute of Geoscience and Mineral Resources, Daejeon, 243p.
Mantajit, N. and Potisat, S. (Eds.), 2002, Geology of Thailand. Department of Mineral Resources, Bangkok, 342p.

Intensive studies of the research topics related to this project are being undertaken by the following research associates.

China: Prof. X. Wan (China University of Geosciences - paleontology/foraminifers); Prof. P.J. Chen (Nanjing Institute of Geology and Paleontology - paleontology/dinosaurs); Prof. J. Sha (Nanjing Institute of Geology and Paleontology - paleontology/molluscs); Prof. S. Huang (Chengdu University of Technology - sedimentology); Prof. X. Hu (Nanjing University - stratigraphy/paleontology), Dr. M. Wei (Natural Museum of Beijing - paleontology/invertebrates); Prof. X. Li (Chengdu University of Technology - sedimentology); Prof. D. Xuan (China University of Geosciences - sedimentology, tectonics); Dr. G. Li (Nanjing Institute of Geology and Paleontology - paleontology/molluscs); Dr. B. Jiang (Nanjing University - paleontology/molluscs)

India: Prof. S.K. Tandon (University of Delhi - paleosols, stable isotope geochemistry); Dr. R. Vijaya (Birdal Sahni Institute of Palaeobotany - paleontology/palynology); Dr. K. Ayyasami (Geological Survey of India - paleontology/invertebrates); Prof. B.P. Singh (University of Jammu - sedimentology); Dr. S. Bajpai (Indian Institute of Technology - paleontology/vertebrates)

Japan: Prof. H. Hirano (Waseda University - paleontology/ammonites, stable isotope geochemistry); Prof. Y. Saka (Waseda University - sedimentology, structural geology); Prof. Y. Kondo (Kochi University - paleontology/molluscs); Prof. H. Ando (Ibaraki University - sedimentology, paleontology); Dr. T. Hasegawa (Kanazawa University - stable isotope geochemistry); Dr. T. Sakai (Kyushu University - sedimentology); Dr. T. Ohta (Kyushu University - sedimentary petrology); Prof. K. Ishida (Tokushima University - paleontology/radiolarians); Prof. T. Kozai (Naruto University of Education - paleontology/molluscs); Prof. K.I. Hisada (University of Tsukuba - sedimentary petrology, structural geology); Dr. K. Kodama (Kochi University - paleomagnetism)

Russia: Prof. G.L. Kirillova (Institute of Tectonics and Geophysics - stratigraphy); Dr. Y.D. Zakharov (Russian Academy of Sciences - paleontology/foraminiferas)

Philippines: Prof. M. de Leon (University of Philippines - paleontology/foraminiferas); Prof. G.P. Yumul, Jr. (University of Philippines - geochemistry, ophiolites)

Switzerland: Dr. F. Hirsch (Naruto University of Education - stratigraphy, paleontology/invertebrates)

Korea: Prof. M. Huh (Chonnam National University - paleontology/invertebrates, dinosaurs); Prof. Y.I. Lee (Seoul National University - sedimentology, paleoclimatology); Prof. D.K. Cheong (Kangwon National University - sedimentology); Prof. I.S. Paik (Pukyong National University - sedimentology, taphonomy); Prof. S.J. Lee (Kyungpook National University - paleontology/calcareous algae); Dr. Y.N. Lee (Korea Institute of Geoscience and Mineral Resources - paleontology/vertebrates); Prof. H.S. Lim (Mokpo National University - geochronology, sedimentology); Prof. K.H. Park (Pukyong National University - geochemistry); Prof. S.J. Doh (Korea University - paleomagnetism); Prof. Y.J. Jwa (Gyeongsang National University - petrology); Prof. Hyo-Taek Chon (Seoul National University, geochemistry)

Thailand: Dr. A. Meesook (Bureau of Mineral Resources - paleontology/molluscs); Dr. J. Tulyatid (Bureau of Mineral Resources - geophysics); Mr. N. Teerarungsigul (Bureau of Mineral Resources – sedimentology, stratigraphy)

Pakistan: Mr. Munir-ul-Haq (Geological Survey of Pakistan - paleontology/vertebrates); Prof. Muhammad A. Farooqui (University of Balochistan - sedimentology); Mr. M. Sadiq Malkani (Geological Survey of Pakistan - paleontology/vertebrates)

Mongolia: Dr. Y. Khand (Mongolian Academy of Sciences - paleontology/invertebrates); Dr. R. Barsbold (Mongolian Academy of Sciences - paleontology/dinosaurs); Prof. L. Jargal (National University of Mongolia - sedimentary petrology, coal geology)

Vietnam: Dr. N.X. Khien (Research Institute of Geology and Mineral Resources - sedimentology); Dr. L.T. Nghinh (Institute of Geological Sciences - sedimentology, stratigraphy); Dr. Nguyen Linh Ngoc (Research Institute of Geology and Mineral Resources - sedimentology)

Myanmar: Dr. Z. Win (Yangon University - paleontology/foraminiferas)

Spain: Prof. M. A. Lamolda (Facultad de Ciencias-UPV - paleontology/foraminiferas)

13. Participation

a) What countries and institutions are in your opinion likely to participate in the project

East and South Asian countries and other countries concerned: China, Japan, Korea, Philippines, Vietnam, Far East Russia, Thailand, Mongolia, India, Pakistan, Myanmar, Cambodia, Laos,

Indonesia, Malaysia, Bangladesh, France, Kyrgyzstan, Sri Lanka, Switzerland, U.S.A., Australia, Germany, Spain, United Kingdom

b) What countries or institutions (or individuals) have already

• agreed to co-operate : China, Japan, Korea, India, Pakistan, Thailand, Far East Russia, Mongolia, Philippines, Vietnam, Spain, United Kingdom, U.S.A., Switzerland, Australia.
• shown interest in the project : Malaysia, Indonesia, Myanmar.

c) What countries and/or regions are in your opinion most important to the success of the study

China, Japan, Korea, India, Pakistan, Far East Russia, Thailand, Vietnam

14. Location of major field activities

From west to east, Pakistan, India, Thailand, Vietnam, China, Philippines, Mongolia, Korea, Far East Russia and Japan. Also, western Tethys region will be studied and compared with those of the major field study areas of the project.

15. Location of major laboratory research (expected or assured co-operation of laboratories)

China: Nanjing Institute of Geology and Paleontology; China University of Geosciences, Beijing; Chengdu University of Technology; Nanjing University; Jilin University

India: Geological Survey of India; Indian Institute of Technology, Roorkee, Mumbai and Kharagpur; University of Delhi, Delhi; University of Lucknow, Lucknow; University of Madras, Chennai; Birbal Sahni Institute of Palaeobotany, Lucknow; Nagpur University, Nagpur; Nagaland University, Kohima

Japan: Waseda University; Tsukuba University; Kyushu University; Kanazawa University; Tokushima University; Naruto University of Education; Geological Survey of Japan; Ibraki University; Kochi University

Korea: Seoul National University; Pukyong National University; Kangwon National University, Kyungpook National University; Chonnam National University; Korea Institute of Geoscience and Mineral Resources

Pakistan: Geological Survey of Pakistan; University of Balochistan, Quetta

Thailand: Geological Survey Division, Bureau of Mineral Resources

Russia: Institute of Tectonics and Geophysics; Far Eastern Geological Institute
Philippines: University of the Philippines
Vietnam: Research Institute of Geological and Mineral Resources; Institute of Geological Sciences
Mongolia: Mongolian Academy of Sciences; National University of Mongolia
And other participating institutions

16. Attach

a) Attachment 1: Full Description of the Proposed Project

Summary of Previous Work

The objectives of IGCP-434 "Land-ocean interactions of carbon cycle and bio-diversity change during the Cretaceous in Asia (1999~2003+O.E.T.)" were to 1) establish the stable carbon isotope stratigraphy, 2) analyze the environmental changes from biogeochemical point of view, 3) analyze factors which control the carbon cycle, and 4) correlate and analyze factors and bio-diversity. Through five international symposiums with field excursions a significant progress on understanding of Cretaceous carbon cycles in Asia has been achieved. Sequence stratigraphic concept has been applied to several Cretaceous nonmarine and marine successions to understand basin evolution. Detailed biostratigraphic data conducted during this project were instrumental for basin analysis. Also, several globally correlatable chemostratigraphic marker beds that represent significant events in carbon cycle were identified in the Asian Cretaceous by carbon isotopic study on fossils and sedimentary materials. Through researches conducted in various disciplines of geological sciences during the previous project Cretaceous paleoclimatic information of Asia has been slowly being accumulated, which calls for a successor project to deal with this subject more extensively. The scientific outcome of the previous project is rich including several internationally peer-reviewed symposium volumes that were published and are being published. In addition to the scientific achievements more important actual outcome of the previous projects is scientific collaborations among scientists of participated member countries. Also, the participation of young scientists and students in trainings at international symposiums and field excursions were of immense significance and added values. Several joint research projects were initiated during the project and are now being conducted. The spirit of these international collaborations will be continued and encouraged in the successor project, and through these collaborations scientific data will be shared and integrated regionally to improve our understanding of Cretaceous paleoclimates in Asia. Not only participating scientists but also

participating students will benefit such international collaborations in the successor project.

Full Title: Paleoclimates in Asia during the Cretaceous: their variations, causes, and biotic and environmental responses
(Short Title: Paleoclimates of the Cretaceous in Asia)

The Cretaceous is well known to be one of the greenhouse periods in Earth history and is the most recent example of the greenhouse world. The Cretaceous is very important for understanding potential anthropogenic changes in climate. Geological records are reasonably well preserved in Asia and thus important information about the Cretaceous paleoclimates can be obtained. The proposed project aims to gather more paleoclimatic information and important clues that can help tell us what caused changes in paleoclimate in Asia during the Cretaceous and to understand the physical and biological systems responding to changes of climate on different time scales.

The proposed project comprises several topics to be discussed in the proposed project duration for five years. They are 1) paleoclimates from terrestrial sediments, 2) paleoclimates from marine sediments, 3) ecosystem changes due to paleoclimate changes, and 4) tectonic influences on paleoclimates.

1. Paleoclimates from terrestrial sediments

The South and East Asia that will be studied in the proposed project covers wide geographic area ranging in latitude from 10^{o} S to 70^{o} N. During the Cretaceous, except Indian subcontinent the main SE and E Asia was located at similar geographic position as today. India was located at high latitude in the Southern Hemisphere and traveled northward across the equator during the Cretaceous. Although SE and E Asia remained in the same geographic position as today, the paleoclimate in Asia during the Cretaceous is thought to be quite different from that of today considering that the Cretaceous Period is one of the warmest periods in Earth's history.

Nonmarine Cretaceous strata in South and East Asia contain many biotic and lithologic indicators of paleoclimate. These proxy indicators were not paid much attention compared to studies on their respective paleontologic and sedimentologic aspects. In this project, more attention will be paid to gather many types of proxy data for spatial paleoclimatic variations and temporal paleoclimatic changes. Nonmarine strata also contain red beds, often with characteristic paleosols and calcareous nodules. Paleosols and calcareous nodules will provide important environmental conditions during their formation on land surfaces. Paleosol types may indicate climatic conditions and topographic situation. Carbon and oxygen isotopic compositions of pedogenic carbonate nodules will reveal vegetation types, probable surface

temperatures, as well as paleoatmospheric CO_2 concentrations. Once paleosol types and carbonate nodule-bearing strata are chronologically arranged, paleosol type distribution and stable isotopic compositions of carbonate nodules would provide temporal variations of local to regional paleoclimatic conditions. These data will be compared with zonal circulation models. If there exist some difference between them, forcing factors of paleoclimatic changes have to be identified. Similar preliminary studies have been applied in limited areas in the previous project. A regional paleoclimatic reconstruction cannot be made from a few data points and thus we are going to apply this technique to wide geographic areas and stratigraphically different sequences.

The Early Cretaceous is thought to have been a time of elevated partial pressure of atmospheric CO_2 (PCO_2), which was possibly related to increased rates of mid-ocean ridge spreading and associated volcanism (e.g., Jones and Jenkyns, 2001). However, the Early Cretaceous (Berriasian-Barremian) is thought to have been relatively cooler than the mid-Cretaceous greenhouse, which may have been initiated in the Late Barremian to Early Aptian (Larson, 1991a, b; Larson and Erba, 1999). Two contrasting paleoatmospheric PCO_2 levels (relatively low- Robinson et al., 2002; relatively high- Lee, 2003) were suggested by pedogenic carbon isotope data. More studies on Lower Cretaceous pedogenic carbonates are needed to check the possible presence of cooler paleoclimatic conditions as well as the close link between PCO_2 and temperature, which was suggested by Royer et al. (2004). The candidate countries for this study in the proposed project will be Thailand, China, Japan, Mongolia, India, Pakistan and Korea. Several joint researches between participating countries have been started and are being conducted. Similar researches will be extended to Middle to Upper Cretaceous paleosols to infer paleoatmospheric PCO_2 levels and corresponding paleoclimate changes during the Cretaceous.

Early Cretaceous climatic provinces based on fossil land plants (Tetori-type, Ryoseki-type, and mixed type) have been well established and was summarized by Kimura (2000). However, in detail there exist some discrepancies in the floristic assemblages across the floristic province boundaries. For example, in the previous project the floristic assemblage difference between the Amur province of East Russia formerly thought of the Tetori type and typical Tetori-type flora have been noted, whereas the floristic assemblage of the Tetori Group in northern central Japan has much in common with that of the Middle Jurassic-Lower Cretaceous deposits in the Partizansk Basin, South Primorye, East Russia. Such discrepancies and similarities in floristic assemblages may indicate some temporal changes in paleoclimate. We need to study more about the spatial and temporal relationships of these biotic paleoclimatic indicators through more detailed biostratigraphic and/or geochronologic age controls.

2. Paleoclimates from marine sediments

Global sea level rose significantly from the Early to Late Cretaceous (Haq et al., 1988), thus nonmarine sedimentation is more expected during the Early Cretaceous providing terrestrial paleoclimates, whereas marine sedimentation is more expected during the Middle to Late Cretaceous providing paleoclimates in the ocean realm. New data and new proxies support the hypothesis of a mid-Cretaceous "hyperthermal" interval with tropical upper ocean temperatures that were several degrees higher than modern values in the tropical Atlantic (Norris et al., 2002; Wilson et al., 2002). Coincident with super warm tropical conditions, the Turonian southern high latitudes may have had temperatures more than 30^{o}C like that modern tropics (Huber et al., 1995; Bice et al., 2003). The idea of such a warm Cretaceous Earth has been suggested from well-studied deep-sea drilling project sediments collected from the Atlantic using stable oxygen isotopic compositions of planktonic as well as benthic foraminiferas. Compared to the Atlantic sediments, marine Cretaceous sediments in the India and Pacific have not been treated extensively. The marine Cretaceous sediments are now well preserved in South and Northeast Asia. Especially, marine Cretaceous sediments are well preserved in the Tibetan Plateau and Xinjiang areas, China. These sediments record high southern paleolatitudes to the low southern paleolatitudes during the Cretaceous due to the rifting of the Indian subcontinent from the Gondwana and its northward drift. Also, in Japan and Far East Russia, the Pacific-derived marine Cretaceous sediments were accreted to the continental margins. Due to their wide geographic dispersion, studies on these marine successions would provide latitudinal differences in Cretaceous ocean ecosystem variations. Through the previous IGCP project much information on paleontological aspects of these deposits have been gathered. In the successor project, paleoclimatic information will be gathered from these biotic climatic indicators to understand the Cretaceous paleooceanography. Through these studies Tethyan and Paleo-Pacific Ocean marine climatic data will be compared. Also, the Indian subcontinent contains marine sediments in its southern part, which enables us to get paleoclimatic information of the high to low latitudes of the Southern Hemisphere. This information can be compared with those obtained from low to high-latitude marine strata in the Northern Hemisphere. By doing this we can understand Cretaceous oceanic circulation and meridional heat transfer. As Indian subcontinent approached South Asia closely by the Late Cretaceous, a possible Cretaceous corridor existed from South India to South Asia through NE India. Considering the paleogeographic evolution in this area, sediments in such a transitional environment are expected to contain transitional paleoclimatic signatures as evidenced by the presence of marine faunal mixture of South Indian and South Asian affinities. These marine Cretaceous sediments can be studied in detail and we expect to get important data to test the idea of mid-Cretaceous "hyperthermal" events.

Through the researches during the previous project rises and falls of oceanic temperatures

during the Cretaceous at high-latitude oceans became established, mostly done by active Russian participating scientists (Zakharov et al., 2002). These scientists will become active members again in the successor project and will discuss about the active poleward heat transport in the Cretaceous.

Possible ice-sheet growths and decays have been reported during the Cretaceous. They are ephemeral ice sheets between middle Cenomanian and middle Turonian (Gale et al., 2002; Miller et al., 2003) and a moderate sized ice sheet during early Maastrichtian (Miller et al., 1999) based on oxygen isotope compositions of foraminifers. Although mid-Turonian glacioeustasy event of Miller et al. (2003) with highly depleted deep-sea benthic and southern high latitude $\delta^{18}O$ values that glacioeustasy at this time was unlikely (Huber et al., 2002). However, this needs to study stable isotope compositions of foraminifers and sequence stratigraphy of the Turonian sections in the proposed project study area in more detail

Several potential participating scientists submitted two full Integrated Ocean Drilling Project (IODP) proposals after positive reviews of preliminary proposals. Both proposals aim at drilling marine Cretaceous sequences in forearc basins of Northwest Pacific. Onshore geochemical data suggest that ocean temperatures during the Campanian NW Pacific were much warmer than previously thought (Moriya, 2003). Once these two proposals are accepted, the IODP program would provide more complete Cretaceous marine records in the NW Pacific. If successfully operated as planned, the results of this program will be one of the important subjects that will be discussed in the proposed project.

3. Ecosystem changes

In marine carbonate the positive carbon isotope excursion of 2~4‰ at the Cenomanian/Turonian (~93 Ma) reflects the increased burial rate of ^{13}C depleted organic carbon at the onset and during an ocean anoxic event (OAE). A concomitant drop in atmospheric PCO_2 of 20% to 40-80% was estimated previously. Simons et al. (2003) reported that a positive excursion of land-plant derived biomarkers (long chain n-alkanes) was observed at low latitudes but not observed at high latitudes, indicating the differential response of land-plant ecosystem to the OAE. Such positive carbon isotope composition excursions are also known to be associated with Albian to Aptian ocean anoxic events (OAEs). These ideas need to be checked to correlate between terrestrial ecosystem and marine ecosystem in the next project. Both Cretaceous nonmarine and marine sequences are widely exposed in the South and East Asia regions. Especially, Cretaceous climate from marine sediments can be studied in continuous sequences distributed in Northeast and South China, Qomdanma region of China, Far East Russia and Japan. These areas cover wide latitudinal regions and from studies on land plant-derived

materials latitudinal ecosystem variations through time in the nearby continental areas can be studied. Nonmarine records will be checked from paleosols distributed in the project area and the results will be compared with those of marine sequences. Especially, the expression of OAEs on the continents (e.g., lakes) needs to be closely checked in the following project.

4. Tectonic influences on paleoclimates

The Cretaceous paleogeography of SE and E Asia was already formed prior to the Cretaceous. The Indosinian Orogeny, which occurred during the Late Permian to Early Jurassic, represents the collisional event between the Indochina and South China blocks resulting in the closure of the Meso-Tethys (*sensu* Metcalfe, 1996). As a result of the Indosinian Orogeny high mountain ranges developed along the collision zone. Also, high mountain ranges existed along the collision belts between the South China and Sino-Korean (North China) blocks that lastly occurred in the Early Triassic, between the North China and Molgolia-Okhotsk blocks that occurred in late Paleozoic, and between microcontinents in SE Asia derived from Gondwanaland until the Early Cretaceous (Metcalfe, 1996). In addition to these collisional-related topographic highs already existed prior to the Cretaceous in SE and E Asia, high mountain chains called the Coastal Range as high as 3500 m to 4000 m were postulated to have existed along the eastern margin of East Asia (Okada, 2000). Okada (2000) ascribed the origin of the Coastal Range to active magmatism throughout the late Mesozoic, i.e., plume activity during the Late Jurassic to Early Cretaceous (Okada, 1999) and oceanic plate (Kula Plate) subduction-related Upper Cretaceous magmatism. Thick piles of Cretaceous coarse clastics in the Khorat Plateau of Thailand may also have been derived from the southern part of this Coastal Range. The continental regions to the west of the Coastal Range were probably affected by this topographic high as evidenced by the presence of arid and semi-desert conditions (Chen, 2000; Jerzykiewicz, 1998; Khand et al., 2000). All these paleogeographic and paleotopographic reconstructions suggest that SE and E Asia was largely compartmentalized by high mountain ranges of collisional and plume origins and thus paleoclimates as a whole seemed to have been much influenced by orographic effects. Such topographic highs might have supplied much clastic sediments into the nearby sedimentary basinal areas and influenced their deposition. By analyzing sedimentary characteristics, evaluation of such effects on paleoclimates during and after sediment deposition is one of the subjects that will be dealt in the proposed project.

In addition, many extensive left-lateral strike-slip faults in E Asia such as Tanlu Fault in China, Amur Suture in Far East Russia, several NE-SW trending parallel faults in the Korean Peninsula, East Fault Zone in South China Sea, and tectonic zones in Japanese Islands had been active during the Cretaceous and exerted intense shearing on the continental margins of

Southeast and East Asia. Due to these tectonic activities, many extensional basins formed and were filled with nonmarine sediments, which may preserve signatures of continental paleoclimates during deposition. The cause of these tectonic activities is generally ascribed to an abnormal high-velocity and oblique-slip motion of the Proto-Pacific (Izanagi) Plate subduction beneath the Eurasian continent. Due to the extensional basin formation, volcanic activities were associated during initial stages of basin development and consequently basin fills are dominated by volcaniclastics. Such volcanic activities as well as resulting topographic highs in wide regions have not been cited as a plausible cause of paleoclimatic changes in Cretaceous Asia, but they are expected to have caused some changes in paleoclimates, which will form one of subjects dealt in the next project. As an example, post-mid-Albian volcanic belt formation, a total cooling and considerable biota rejuvenation were reported in East Russia (Kirillova et al., 2000). The paleoclimates before and after these volcanic activities will be compared and any influence of regional volcanic activities on paleoclimate will be evaluated. For this aspect, more detailed chronostratigraphic works are needed to establish tectonic evolution and regional correlation of paleoclimatic information in corresponding strata.

The sinistral strike-slip displacement also caused juxtaposition of terranes located in previously low-latitude regions with mid- to high-latitude continental blocks. Thus, such tectonic setting provides a good opportunity to compare and contrast latitudinal gradients of paleoclimates during the Cretaceous. By comparing paleoclimatic characteristics recorded in the northerly drifted terranes now located in the mid- to high latitudes with those of low latitude regions, we may be able to reconstruct the paleogeography of the eastern Asian margin prior to the tectonic displacement. In addition to these displaced terranes, there exist many accreted terranes along the Asian continental margins due to subduction of oceanic plates. From these accreted terranes we can also get Cretaceous paleoclimtic information, and by doing this we can understand the paleooceanographic conditions between the Tethys and Paleo-Pacific.

By reconstructing Cretaceous paleoclimates, the range of climatic variability on different time scales can be determined, and the accuracy of computer models that try to simulate Cretaceous climatic conditions can be tested. These studies help us learn how the climate system behaves, what controls it, and how it is likely to change in the future. We know it will change, but we lack a clear view of how and at what rate. The results of the project will enhance our understanding of these questions.

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b) Attachment 2: Work Plan

The proposed project plans to do the following subjects.

1. Both nonmarine and marine sedimentary strata will be studied using sequence stratigraphic technique to understand basinal architectures and relative roles of eustatic sea level change and tectonism in sedimentary basin development.
2. The spatial and temporal changes of the bio-diversity of Cretaceous marine and terrestrial organisms will be elucidated in detail by adopting more defined biostratigrpahy, biogeography and geochronological techniques. An updated database of the regional Cretaceous fossil record (e.g., the list of the taxa with their accurate stratigraphic and paleogeographic ranges) will form the basis of this research purpose. This subject is the main focus of the Biotic Records Working Group (will be led by Prof. X. Wan and Dr. K. Ayyasami)
3. Paleosols and related sedimentary rocks and lacustrine deposits in nonmarine successions will be studied extensively by applying geochemical methods for potential database for interpretation of terrestrial paleoclimates. This subject will be studied by the Lithological Proxy Records Working Group (will be led by Profs. Y.I. Lee and I.S. Paik).
4. High-resolution stratigraphic framework and correlation of marine successions will be established, and marine fossils and terrestrial plant-derived materials in marine strata will be studied by stable isotope geochemistry. This subject will be handled by the Stable Carbon Isotope Stratigraphy Working Group (will be led by Prof. H. Hirano).
5. Geohistory of tectonic and magmatic activities during the Cretaceous will be synthesized and their influences on sedimentary succession development and paleoclimates will be evaluated.
6. A program to conduct one-day workshop on the case histories on paleoclimates/mathematical models for interpretation of paleoclimate after the international symposiums proposed will be an advantage to the students and researchers alike. As mathematics is employed in the modeling of present day monsoon climate, this program is likely to provide a background to the use of statistics/statistics in the paleoclimatological studies.
7. Scientists and students from the developing countries will be provided a chance for training and use of technical facilities in the developed countries. Both Japan and Korea have an international cooperation program offered by JICA (Japan International Cooperation Agency) and KOICA (Korea International Cooperation Agency). Researchers from the participating countries apply for these programs and once approved by these agencies they have chances for training themselves. Actually, several programs were already offered to researchers from Southeast Asian countries through these programs. Also, the research-funding agencies like

KOSEF (Korea Science and Engineering Foundation), JSPS (Japan Society for the Promotion of Science) and NSFC (National Natural Science Foundation of China) provide many opportunites for scientists of the ASEAN and APEC countries to visit Korea, Japan or China to do post-doctoral research, collaborative research, analytical equipment use and technical training. The proposed project will encourage scientists from the participating member countries to make and/or extend connections with scientists in Japan, Korea and China to use these opportunities more often.

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Prof. Muhammad A. Farooqui, Centre of Excellence in Mineralogy, University of Balochistan, Quetta, Pakistan, E-mail: farooqima@yahoo.com (sedimentology)

Mr. M. Sadiq Malkani, Assistant Director, Palenology and Stratigraphy Branch, Geological Survey of Pakistan, P.O. Box 15, Sariab Road, Quetta, Pakistan, E-mail: malkanims@yahoo.com (paleontology-dinosaurs)

SPAIN

Prof. Marcos A. Lamolda, Depto. De Estratigrafica y Paleontologica, Facultad de Ciencias, Univ. De Granada, Adva. de Fuentenueva s/n, 18002 Granada, Spain, E-mail: mlamolda@ugr.es (paleontology-foraminiferas)

UNITED KINGDOM

Prof. Malcolm Hart, School of Earth, Ocean and Environmental Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, United Kingdom, E-Mail: M.Hart@plymouth,ac.uk (paleontology-foraminiferas, stratigraphy)

U.S.A.

Prof. Jeffrey A. Wilson, Museum of Paleontology and Department of Geological Sciences, University of Michigan, 1109 Geddes Road, Ann Arbor, MI 48109-1079, U.S.A., E-mail: wilsonja@umich.edu (paleontology)

AUSTRALIA

Prof. R.A. Henderson, School of Earth Sciences, James Cook University, Townsville Q1d 4811, Austalia, E-Mail: Bob.Henderson@jcu.edu.au (tectonics, paleontology)

d) Attachment 4: Curriculum Vitae of Proposers

Yong Il Lee
Professor
School of Earth and Environmental Sciences, Seoul National University,
Seoul 151-747, Korea
Tel: +82-2-880-6736, Fax: +82-2-871-3269, E-mail: lee2602@plaza.snu.ac.kr

[EDUCATION]
B.S. in Geology, Seoul National University, Seoul, February 1978.
M.S. in Geology, Seoul National University, Seoul, February 1980.
Ph.D. in Geology, University of Illinois at Urbana-Champaign, Illinois, October 1984

[EMPLOYMENT HISTORY AND SERVICE]

1985. 12.～present	Assistant Professor (85~90), Associate Professor (90~95), Professor (96~), Seoul National University
1991. 12.～1992. 12.	Visiting Professor, University of California, USA
1995. 8.～1997. 8.	Chairman, Department of Geological Sciences, Seoul National University
1997. 3.～ 2004. 3	Member/Vice Chairman, Science Committee of the Korean Committee for Ocean Drilling Program (KODP)
1998. 7.～ 2002. 8	Director, Institute of Geological and Environmental Sciences, Seoul National University

[PROFESSIONAL SOCIETY ACTIVITY]

1995. 2～2001. 3	Director/Vice President, Korean Society of Petroleum Geology
1996. 6.～1998. 6.	Director/Editorial Member/Chairman of the International Symposium Organizing Committee for 50th Anniversary, Geological Society of Korea
1998. 6.～2003. 12	Deputy Editor/Editor, *Journal of Geological Society of Korea*
2001. 3. ~ 2003. 3	President, Korean Society of Petroleum Geology
2004. 1.~ present	Associate Editor, Journal *The Island Arc*
2004. 6 ~ present	Associate Editor, *Journal of Geological Society of Thailand*

[AWARDS]
1995. 10. 27. Best Paper Award, Geological Society of Korea

2000. 5. 19. Excellent Paper Award, Korea Federation of Science and Technology Societies

2002. 8 Citation - *2000 Outstanding Scientists of the 21st Century*, International Biographical Centre, Cambridge, UK

2002/2003 Citation - *The Contemporary Who's Who* American Biographical Institute, Raleigh, North Carolina, U.S.A.

[OTHER INTERNATIONAL ACTIVITY]

1999 ~ present Regional Coordinator, IGCP Project 434 – participated in all IGCP 434 international symposiums and field excursions

1998 ~ 2002 Chaiman of IGCP 411 Korean Working Group – participated in all IGCP 411 international symposiums and field excursions

1997. 3 ~ 10.30. Chaiman, the International Symposium Organizing Committee for the 50th Anniversary of the Geological Society of Korea

2000. 8.～2000. 9 Chairman, Organizing Committee for the 2nd International Symposium, IGCP Project No. 411

[LIST OF KEY PUBLICATIONS (related to IGCP project-Cretaceous geology since 1999)]

Lee, Y. I., 1999, Stable isotopic composition of calcic paleosols of the Early Cretaceous Hasandong Formation, southeastern Korea. *Palaeogeography Palaeoclimatology Palaeoecology* v. 150, p. 123-133.

Lee, Y. I. and Hisada, K., 1999, Stable isotopic composition of pedogenic carbonates of the Early Cretaceous Shimonoseki Subgroup, W. Honshu, Japan. *Palaeogeography Palaeoclimatology Palaeoecology* v. 153, p. 127-138.

Lee, J. I. and Lee, Y. I., 2000, Provenance of the Early Cretaceous Hayang Group, Gyeongsang Basin, southeastern Korea: Implications for the Early Cretaceous continental arc volcanics. *Journal of Sedimentary Research* v. 70, p. 151-158

Paik, I. S., Kim, H. J. and Lee, Y. I., 2001, Dinosaur track-bearing deposits in the Cretaceous Jindong Formation, Korea: occurrences, palaeoenvironments and preservation. *Cretaceous Research* v. 22, p. 79-92.

Lee, J.I. and Lee, Y. I., 2001, Kübler illite crystallinity index of the Cretaceous Gyeongsang Basin, Korea: implications for basin evolution. *Clays and Clay Minerals* v. 49, p. 36-43.

Paik, I. S., Kim, H. J., Park, K.-H., Song, Y. S., Lee, Y. I., Hwang, J. Y. and Huh, M., 2001, Palaeoenvironments and taphonomic preservation of dinosaur bone-bearing deposits in the Lower Cretaceous Hasandong Formation, Korea. *Cretaceous Research* v. 22, p. 627-642.

Sur, K. H., Lee, Y. I. and Hisada, K. I., 2002, Diagenesis of the Lower Cretaceous Kanmon

Group sandstones, SW Japan. *Journal of Asian Earth Sciences* v. 20. p. 921-935

Lim, H. S., Lee, Y. I. and Min, K. D., 2003, Thermal history of the Cretaceous Sindong Group, Gyeongsang Basin, Korea based on fission track analysis. *Basin Research* v. 15, p. 139-152.

Kim, Y. and Lee, Y. I., 2003, Radiaxial fibrous calcites as low-magnesium calcite cement precipitated in a marine-meteoric mixing zone. *Sedimentology* v. 50, p. 731-742.

Lee, J. I. and Lee, Y. I., 2003, Geochemistry and provenance of Lower Cretaceous Sindong and Hayang mudrocks, Gyeongsang Basin, southeastern Korea. *Geosciences Journal* v. 7, p. 107-122.

Lee, Y. W., Lee, Y. I. and Hisada, K.-i., 2003, Palaeosols in the Cretaceous Goshoura and Mifune groups, SW Japan and their palaeoclimatic implications. *Palaeogeography Palaeoclimatology Palaeoecology* v. 199, p. 265-282.

Armstrong-Altrin, J. S., Lee, Y. I., Verma, S. P. and Ramasamy, S., 2004, Geochemistry of sandstones from the Upper Miocene Kudankulam Formation, southern India: Implications for provenance, weathering, and tectonic setting. *Journal of Sedimentary Research* v. 74, p. 285-297.

Lee, Y. I., Lim, H. S. and Yoon, H. I., 2004, Geochemistry of soils of King George Island, South Shetland Islands, West Antarctica: implications for pedogenesis in cold polar regions. *Geochimica Cosmochimica Acta* v. 68, p. 4319-4333.

Lee, Y. I., Sur, K. H. and Hisada, K. -i., 2005, Asymmetric diagenetic changes in a half-graben basin, the Kanmon Group (Early Cretaceous), SW Japan. *Cretaceous Research* v. 26, p. 73-84.

Lim, H. S. and Lee, Y. I., 2005, Cooling history of the Upper Cretaceous Palgongsan Granite, Gyeongsang Basin, SE Korea and its tectonic implications for uplift in the active continental margin. *Tectonophysics* v. 403, p. 151-165.

Lee, Y. I. and Kim, J. Y., 2005, Provenance of the Hayang Group (Lower Cretaceous) in the Yeongyang Subbasin, SE Korea and its bearing on the Cretaceous paleogeography of SW Japan. *Palaeogeography Palaeoclimatology Palaeoecoology* doi:10.1016/j.palaeo.2005.06.017.

Lee, Y. I. and Lim, D. H., 2005, Sandstone diagenesis of the Lower Cretaceous Sindong Group, Gyeongsang Basin, southeastern Korea: implications for compositional and paleoenivonmental controls. *The Island Arc* (in press).

Xiaoqiao Wan

Professor

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[EDUCATION]

B.S. in Paleontology, Wuhan College of Geology, Wuhan, 1979.

M.S. in Paleontology, China University of Geosciences, Beijing, 1980.

Ph.D. in Micropaleontology, China University of Geosciences, Beijing, 1985.

[EMPLOYMENT HISTORY AND SERVICE]

Post-doctoral Research Fellow, University College of Wales, U.K. (1987-1988)

Professor in Geology and Paleontology, China University of Geosciences, Beijing

Director, the Geological Survey Institute, China University of Geosciences, Beijing

[PROFESSIONAL SOCIETY ACTIVITY]

Member, the Standing Committee of China Society of Paleontology

Vice Chairman, China Society of Micropaleontology

Member, the Standing Committee of China Society on Tibetan Plateau

Member, China Society of Geology

[RESEARCH AND FIELD WORK]

Most research on Mesozoic and Cenozoic strata and paleontology, especially on marine Cretaceous in Tibet and lacustrine Cretaceous in the Songliao Basin of China. In this research field, he has established a marine biostratigraphic sequence from the Jurassic to Eocene; obtained evidence of the mid-Cretaceous oceanic anoxic event in southern Tibet. Recent work is dealing with the study of stratigraphy and sedimentology on both sides of the Yarlung Zangbo suture and focusing on the collision time between Indian and Eurasian Plates and basin evolution.

Research work is listed as follows:

1980 - 85.	Research of Mesozoic and Cenozoic strata and paleontology
1986 - 89	Research of Cretaceous black shales in southern Tibet
1987 - 89	Research of Mesozoic foraminifera from Tibet

1990 - 94	Research of Tertiary biostratigrahy and paleoceanography in the South China Sea
1992 - 95	Research of Cretaceous forearc basin in Tibet (collaborate with U.K.)
1995 - 96	Research of sedimentary rocks of the Xigaze flysch in Tibet
1993 - 95	Research of Cretaceous oceanic anoxic event in Tibet (collaborate with Spain)
1995 - 2003	Tectonostratigraphical approach to the exploration of mineral resources in South China and Tibet (collaborate with Italy and Canada)
1998 - 2003	Dating the continental collision between Indian and Asian plates
1998 -	Correlation of nonmarine Cretaceous stages of China
2005 -	Middle Cretaceous biotic and isotopic signatures in the Songliao Basin, NE China
2005 -	Terrestrial sedimentary response to the Cretaceous major geological events and climate change

Since 1980, investigation and geological field work in Tibet for 16 times

[LIST OF PUBLICATIONS (since 2000)]

Wan, X., Li, G., Hallam, A. and Wignal, P., 2000, Cretaceous and Tertiary boundary in the Tingri region of southern Tibet. *Earth Science Frontiers* v. 7, suppl: p. 14-17.

Wan, X., 2000, Biostratigraphy and sedimentary development of the Jurassic of southern Tibet. *Proceedings of the 5th International Symposium on the Jurassic System*, Trans Tech Publications Ltd., Switzerland.

Zhao, W. and Wan, X., 2001, Recovery of foraminifera from the Late Cretaceous Cenomanian-Turonian mass extinction in Gamba, southern Tibet. *Acta Palaeontologica Sinica* v. 40, p. 189-194.

Wan, X., Din, L., Li, J. and Cai, H., 2001, Latest Cretaceous to Early Eocene marine strata in the Zhongba region, Tibet. *Journal of Stratigraphy* v. 25, p. 21-26.

Wan, X., Liang, D. and Li, G., 2002, Palaeocene strata in Gamba, Tibet and influence of tectonism. *Acta Geologica Sinica* v. 76, p. 154-162.

Wan, X. and Ding, L., 2002, Discovery of the latest Cretaceous planktonic foraminifera from Gyirong of southern Tibet and its chronostratigraphic significance. *Acta Palaeontologica Sinica* v. 41, p. 89-95.

Zhao, W. and Wan, X., 2002, Mid-Cretaceous anomaly and their responses to sea-level changes in Tingri of Tibet. *Advance in Earth Sciences* v. 17, p. 331-338.

Zhao, W. and Wan, X., 2003, The bio-palaeocanographic events during the late stage of the Tibet-Tethyan Sea evolution. *Beijing Geological Publishing House*, p. 1-166.

Wan, X., Wu, Y. and Li, G., 2003, Distribution of mid-Cretaceous obitolinids in Xizang (Tibet)

and its paleobiogeographic implications. *Acta Geologica Sinica* v. 77, p. 1-8.

Wan, X., Liu, W. and Li, G., 2003, Cretaceous black shale and dissolved oxygen content – A case study in southern Tibet. *Geology in China* v. 30, p. 36-47.

Wan, X., Wei, M. and Li, G., 2003, $\delta^{13}C$ values from the Cenomanian-Turonian passage beds of southern Tibet. *Journal of Asian Earth Sciences* v. 31, p. 861-866.

Wan, X., Wignall, P. B. and Zhao, W., 2003, The Cenomanian-Turonian extinction and oceanic anoxic event: evidence from South Tibet. *Palaeogeography Palaeoclimatology Palaeoecology* v. 199, p. 283-298.

Wan, X. and Si, J., 2004, Variation of foraminiferal composition in Cretaceous oceanic anoxic to oxic circumstances, southern Tibet, China. *Journal of China University of Geosciences* v. 15, p. 46-54.

Ding, L., Kapp, P. and Wan, X., 2005, Paleocene-Eocene record of ophiolite obduction and initial India-Asia collision, south central Tibet. *Tectonics* v. 24.

Li, G., Wan, X., Liu, W., Liang, D. and Yun, H., 2005, The discovery of Paleogene marine stratum along the southern side of Yarlung-Zangbo suture zone and its implications in tectonics. *Science in China, Series D* v. 48, p. 647-661.

Wan, X., Lamolda, M. A., Si, J. and Li, G., 2005, Foraminiferal stratigraphy of Late Cretaceous red beds in southern Tibet. *Cretaceous Research* v. 26, p. 43-48.

Wan, X. and Sarti, M. (Eds.), 2005, Cretaceous Oceanic Red Beds and Land-Ocean Interaction. *Cretaceous Research* v. 26 (1).

Takashi Sakai

Associate Professor

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[EDUCATION]

B.S. in Geology, Kagoshima University, Kagoshima, 1974.

M.S. in Geology, Kyushu University, Fukuoka, 1976.

Ph.D. in Geology, Kyushu University, Fukuoka, 1996.

[EMPLOYMENT HISTORY AND SERVICE]

Faculty of Science, Department of Geology, Kyushu University since the completion of the doctoral course at Kyushu University.

Regional Coordinator for the IGCP Project 434

[RESEARCH AND FIELD WORK]

Tectonic evolution of continental margins of Southeast and East Asia during the Cretaceous. Research area: many sedimentary basins in SE Asia (India, Myanmar, Malaysia, Thailand, Vietnam and Philippine) and East Asia (China, Korea and Far East Russia) through the activities of IGCP Projects 350 and 434. During these two projects, I had contributed to the co-working programs between Japan and other countries (China, Myanmar, Russia, Thailand and Vietnam).

[LIST OF PUBLICATIONS (since 1995)]

Okamoto K. and Sakai, T., 1995, Sedimentary facies and fossil mollusks of the Oligocene Ashiya Group in the Hikoshima Takenokojima and Nishiyama Area, Shimonoseki City, Southwest Japan. *Bulletin Mizunami Fossil Museum*, no. 22, p. 19-50.

Tsuchida, D., Shimoyama S., Sakai, T. and Okada, H., 1995, Parachute gravels on the gravel beach of the Ysuyazaki coast, North Kyushu. *Journal of Sedimentological Society of Japan*, v. 41, p. 57-63. (in Japanese with English abstract).

Sakai, T. and Okada, H., 1996, Sedimentation and tectonics of the Cretaceous sedimentary basins of the Axial and Kurosegawa Tectonic Zones in Kyushu, SW Japan. *Memoir of Geological Society of Japan*, No. 48, p. 7-28.

Okada, H., Hamada, Y., Moriyama, M., Hamada, S. and Sakai, T., 1996, Staurolite petroprovince in the East China Sea. *Memoir of Faculty of Science, Kyushu. University, Series D, Earth & Planetary Sciences,*v. 29, p. 1-16.

Okada, H. and Sakai, T., 2000, The Cretaceous System of the Japanese Islands and its physical environments. *In*: Okada, H. and Mateer, N. J. (Eds.), *Cretaceous Environments of Asia*, p. 113-144, Developments in Palaeontology and Stratigraphy, No. 17, Elsevier.

Sakai, T., 2001, Sequence stratigraphy of the Cretaceous Yezo Supergroup. *In*: Hirano, H., Sakai, T. and others (Eds.), *Environments of the Cretaceous Yezo Forearc Basin – Carbon cycle and bio-diversity change-, Excursion Guidebook*, International Conference of Paleocenography VII, *Bulletin of Nakagawa Museum of Natural History,* v. 4, p. 1-52.

Ohta, T. and Sakai, T., 2003, Revised stratigraphy of the Paleozoic and Mesozoic successions and proposal of the Jurassic Ashikita Group in the Uminoura area of the Kurosegaawa Tectonic Belt, western Kyushu, SW Japan. *Bulletin of Geological Society of Japan*, v. 109, p. 671-688 (in Japanese with English abstract).

Ohta, T. and Sakai, T., 2004, Deep-marine sedimentation and seqence evolution of the Toyora Group in the Nagato Basin, Inner Zone of SW Japan. *Journal of Geological Society of Thailand, Special Issue*, No. 1, p. 45-60.

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Director

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[EDUCATION]

B.S. in Geology, Presidency College, Chennai-5, October 1971.

M.S. in Geology, Presidency College, Chennai-5, November 1973.

Ph.D. in Geology, Indian Institute of Technology (IIT), Powai, Mumbai, July 1988

[TRAINING PROFILE]

Intensive Course in Surveying	College of Engineering, Guindy, Chennai (May, 1972)
Digital Computer Programming	IIT, Powai, Mumbai (Jan. - Apr., 1982)
Remote Sensing	IIT, Powai, Mumbai (Jan. - Apr., 1982)
First Orientational Course in GSI	Geological Survey of India (Nov. 1976 - Aug. 1977)
Unix-Impact In-service Training	Geological Survey of India (Feb. 1989)
Scanning Electron Microscopy	University of Western Australia, Nedlands, WA (Nov. 1996)
Workshop on Digital Tech. & GIS	Geological Survey of India (Oct. 2004)

[EMPLOYMENT HISTORY AND SERVICE]

1973. 11.～ 1973. 12	Geologist (temporary), Groundwater Department, Government of Tamil Nadu, India
1974. 12.～ 1975. 11.	Technical Assistant Grade-1, Oil and Gas Corporation, Assam, India
1975. 11.～ present	Geologist (Junior), Geologist (Senior) and Director, Geological Survey of India (Hyderabad, Kolkata, Chennai, Hyderbad)

[IMPORTANT DISCOVERIES]

1. Identification of faunal breaks in the Cretaceous succession of southern India based on invertebrate fossils.
2. Discovery of the remains of a stegosaurian dinosaur in the Trichinopoly Group (Turonian-Coniacian) of Tamil Nadu and a carnosaurian dinosaur from the famous Kallamedu (Cullmoad of Blanford) in the Cretaceous rocks of Ariyalur area.
3. Report on two turtle fossils including one exceptionally preserved as internal mould, form the Uttattur Group of the Cretaceous rocks of Tamil Nadu.

4. Reported a unique belemnoid from the Cretaceous rocks.
5. Discovery of a large inoceramid bivalve belonging to the genus *Sphenoceramus*, measuring more than 45 cm in length.
6. Find of a number of new species of heteromorphy ammonoids from the Cretaceous rocks.
7. Find of Santonian fossils in the lower part of the Ariyalur Group of rocks in Thanjavur district outcrop area.

[FELLOWSHIP/MEMBERSHIP]

Life member, Geological Society of India, Bangalore

Corresponding Member, the Subcommission on Cretaceous Stratigraphy, IUGS

Member, National Working Group (India) of IGCP Project 308 – Status of Paleocene/Eocene Boundary

Member, National Working Group (India) of IGCP Project 350 – Environmental changes during the Cretaceous of South and East Asia

Convener, National Working Group (India) of IGCP Project 434 – Land-ocean interactions of biodiversity and carbon cycle during Cretaceous in Asia (1998-2004)

[LIST OF PUBLICATIONS (since 2000)]

Ayyasami, K. and Anantharaman, S., 2000, Biostratigraphic definition of the Cretaceous – Tertiary boundary based on invertebrate fauna. *Rec. Geological Survey of India* v. 133, pt.5, p. 263.

Ayyasami, K., 2000, A texanitid ammonite from southern India. Proceedings of the XVI Indian Colloquium on Micropalaeontology and Stratigraphy, Goa, *Bulletin of the Oil and Natural Gas Corporation Limited* v. 37, p. 241-245.

Anantharaman, S. and Ayyasami, K., 2001, A revised age for the Cretaceous rocks of Pondicherry. *Indian Minerals* v. 55, p 85-90.

Sundaram, R., Henderson, R. A., Ayyasami, K. and Stilwell, J. D., 2001, Lithostratigraphic revision and paleoenvironmental assessment of the Cretaceous System exposed in the onshore Cauvery Basin, southern India. *Cretaceous Research* v. 22, p. 743-762

Ayyasami, K., 2001, Book review of Cretaceous stratigraphy: An update: Franz Kossmat volume published by the Journal of the Geological Society of India, Bangalore. *Cretaceous Research* v.22, p. 857.

Sirnivasan, R., Souminarayanan, Ayyasami, K. and Suryanarayanan, L. S., 2003, Occurrence and origin of the Quaternary glass sand resources in the dune complex of the Tamil Nadu coast. *Proceedings of the IV South Asia Geological Congress, New Delhi*, November 13-15, 2002, p. 347-353.

Ayyasami, K.**,** 2004. Sixth symposium on collection-building and natural history studies in Asia and the Pacific Rim – notes. *Journal of the Geological Society of India* v. 63, p. 569-570.

Ayyasami, K. and Kase, T., 2004, Collection, Identification, Cataloguing and preservation of invertebrate fossils in the Geological Survey of India. Proceedings of the 5th and 6th Symposium on Collection Building and Natural History studies in Asia and Pacific Rim (Ed.: Akiyama, S. et al.) *National Science Museum Monographs, Tokyo* v. 24, p. 1-4.

Ryoji Wani and Ayyasami, K.**,** 2004, A review of the Cretaceous biostratigraphy in the Ariyalur area, southern India. *Bulletin of the Mikasa City Museum*, No. 8, p. 1-15 (*In Japanese*).

Ayyasami, K.**,** 2004, Cretaceous genus *Menuites* Spath from the Miria Formation, Western Australia. *Bulletin of the Mikasa City Museum*, v. 8, p. 53-57.

e) Attachment 5: Summary of the Project

The Cretaceous is well known to be one of the greenhouse periods in Earth history and is the most recent example of the greenhouse world. The Cretaceous is very important for understanding potential anthropogenic changes in climate. Geological records are reasonably well preserved in Asia and thus important information about the Cretaceous paleoclimates can be obtained. This project is a successor project of IGCP Project No. 434 “Land-Ocean Interactions of Carbon Cycle and Bio-Diversity Change during the Cretaceous in Asia”, which was completed in 2003 with O.E.T. in 2004. The previous project mainly concerned about the chemostratigraphy using stable carbon isotopes and bio-diversity for improving correlation of Asian Cretaceous strata through studies of biostratigraphy. Based on accumulated scientific results in the previous project the project aims to gather more paleoclimatic information and important clues that can help tell us what caused changes in paleoclimate in Asia during the Cretaceous and to understand the physical and biological systems responding to changes of climate on different time scales.

The project will undertake a detailed survey in South and East Asia to gather paleoclimatic information from terrestrial and marine sediments through studies on many types of proxy data such as basin architectures, stratigraphic frameworks, lithologic and biotic indicators, and geochemical properties of paleosols and fossils both marine and terrestrial. Based on these data the spatial paleoclimatic variations and temporal paleoclimatic changes will be delineated. Then, paleoclimatic forcing factors will be interpreted considering tectonic activity, relative sea-level changes and igneous activity.

The societal benefits of the project include, among others, improving understanding of the relationship between paleoclimatic and paleoceanographic patterns and the distribution of various economic deposits including coal, petroleum source rocks, and evaporites, which are widely distributed in the study area. Also, the results of this project will enhance our understanding about the future global warming and raise scientific interests in environmental concerns as well as public awareness alike. In addition, the project will kindle the interest in the evolution of flowering plants that dominate the world today.

17. Other considerations

The proposed project is a successor project of IGCP Project No. 434 “Land-Ocean Interactions of Carbon Cycle and Bio-Diversity Change during the Cretaceous in Asia”. All co-leaders participated in the IGCP 434 Project as regional coordinators from the beginning of the IGCP 434 project. The co-leaders attended all international symposiums and field excursions during the project duration including attending the O.E.T. meeting in Vietnam, November, 2004. Through activities of the IGCP 434 Project the co-leaders became to know well all regional coordinators and most members of participating countries. One thing that needs to be mentioned is that at the 5th meeting in Thailand, December 2003 and 6th meeting in Vietnam, December 2004 we met many new young scientists and students from the participating developed and developing countries and saw the bright future of the successor project if it is granted. They were eager to get involved in international activities and we felt that they need an opportunity for promoting scientific growth and enhancing chances of discussion and collaboration with established scientists. Also, at the meeting several students showed their interests in studying for advanced degrees in the participating developed countries. The co-leaders think this is one of functions that the IGCP project provides to participating member countries.

It is understood that the project co-leaders will be responsible for the submission of annual progress reports as well as bibliographic data of all publications dealing with the results or activities of the project, all announcements of international public activities which may be connected with the project, such as conferences, field trips, and courses, and a condensed final report when the project has been finished.

It is further understood that the results of the Project will be published. One of each publication or circulated document will be supplied to the IGCP Secretariat. It is further understood that each publication resulting from the project has to carry, at a prominent place, a statement that it has been worked out as a contribution to the International Geological Correlation Programme. In books resulting from the project, the title page and, when technically possible, the cover should also carry the official symbol of the IGCP.

Date and Signature:

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On behalf of co-leaders