Preface

Marine and Non-marine Jurassic: Boundary Events and Correlation

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The Jurassic, spanning about 201 to 145 Ma[1—4] is an important period in geological history for the evolution of life and Earth. Numerous global events happened during this period:

(1) Tectonic activity was at a very high level, the breakup and drifting of Pangea, associated with extensive volcanism at the beginning of Jurassis in the Central Atlantic province occurred, as well as the violent Circum Pacific (Yanshan) orogeny and volcanic activity caused by the collisions between Palaeo-Pacific margins[5].

(2) The palaeogeography greatly changed, e.g. the rifting of the Pangean supercontinent led to the opening of the North Atlantic and to the northwestward drift of North America, resulting in a narrowing of the Pacific[6,7], sea level was undergoing eustatic oscillations superimposed upon an overall significant sea-level rise from the Hettangian to the Tithonian[7—9] in Europe and America, whilst great regressions, especially during the Middle-Late Jurassic, happened in middle and east Asia, and parts of North America.

(3) Huge continental flood basalt provinces were emplaced including the CAMP[10—12], and Karoo-Ferrar[13] that may have severe climate and biotic consequences. Atmospheric CO_2 concentration in the Jurassic was high[14,15] and the climate in this period was warmer[16], resulting in formation of large quantities of coal and oil, even in the high-latitude areas. In particular, during the Jurassic latitudinal temperature gradients were established and, since the Late Jurassic the latitudinal influences had become so pronounced that the animal world was segregated into the Tethyan, Boreal and other faunal realms[17], causing the difficulties in establishing global GSSPs for Upper Jurassic Stages and the base of Cretaceous[2,18—21]. In addition, there were great biotic changes during the Jurassic Period including the major biodiversity variation represented by the mass extinctions at the end of the Triassic and other minor extinctions in the Pliensbachian-Toarcian and end-Tithonian[22,23] as well as the subsequent recoveries of life in both the marine and terrestrial ecosystems.

A variety of experiences and approaches have been accumulated which resulted in the availability of highly precise correlation within the marine Jurassic, though correlation of marine Triassic/Jurassic[24], Jurassic/Cretaceous boundaries and particularly the non-marine international Jurassic correlation, have long been debated and not yet resolved on a global scale. Furthermore, our knowledge is still limited regarding the major geological events, as well as their record and potential correlation during the Jurassic. Non-marine formations should be correlated with ma-

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rine formations as the international chronostratigraphical scale is based on marine strata. Therefore, the non-marine strata must be integrated into the chroronostratigraphic scheme by correlating non-marine with marine strata, mainly by means of the fossil content and other geological data[21,25], for example sequence stratigraphy[8,9,20,26]. Recognition of depositional systems and subsystems and determination of their fluctuation in space and time lead to a high-resolution sequence stratigraphic analysis and internally consistent sequence stratigraphic scheme of marginal-marine and continental deposits. This template can be compared with fossiliferous marine sediments. Sedimentation in the shallow, epeiric basins is particularly sensitive to reflect changes in sea level. Correlative significance is of transgressive surfaces and it is enhanced when they are coupled with their non-marine correlative surfaces. Development of transgression and recognition of its coeval effects in continental deposits is of crucial significance in reliable sequence stratigraphic correlation between fossiliferous marine and non-marine deposits[21,26].

In order to promote studies on the marine and non-marine Jurassic, the IGCP project 506 was approved in 2005 by UNESCO and IUGS as an international project beginning in 2005. This project emphasizes multidisciplinary integration of the global correlation of marine and non-marine Jurassic and associated major geological events. Over 100 participants from about 40 countries are participating in this project (see the IGCP 506 website: http://www.nigpas.ac.cn/igcp506).. As an international project, IGCP 506 covers cross-disciplinary approaches, including palaeontology, lithostratigraphy, biostratigraphy, sequence stratigraphy, lithology (volcanic and sedimentary), sedimentology, geochemistry, isotopic dating, tectonics, and geophysics (palaeomagnetism) etc.

The aims of IGCP 506 project include:

(1) To highlight and emphasize the importance of marine and non-marine Jurassic for understanding the evolutionary trends of both life and Earth history.

(2) To provide a forum for enhancing international cooperation for geologists and palaeontologists interested in the Jurassic System.

(3) To promote and produce information on the Jurassic System using integrated multidisciplinary approaches.

(4) To help improve public education for a better understanding of the whole Jurassic world, and hence Earth history in general.

The main research areas of IGCP 506 project include marine and non-marine Jurassic stratigraphy and correlation, marine and non-marine Jurassic boundary definitions, and major Jurassic events, stratigraphical records, patterns and causes.

The main scientific goals of this project include the following topics:

(1) To recognize the spatial and temporal distribution pattern of the major events through the Jurassic and the Triassic/Jurassic and Jurassic/Cretaceous boundary intervals.

(2) To study the fossil and stratigraphical records of these geo- and bio-events.

(3) To examine the biodiversity changes of major biota through the major events, including their extinction, recovery, radiation and evolutionary trends.

(4) To make further correlation of such events in different regions and backgrounds, particularly with regard to relations between marine and non-marine events.

(5) To reveal the potential causes and patterns of these events.

In accordance with the project plan, the first international symposium was held in 2005 in Nanjing, China focusing on the topic of the Jurassic Boundary Events. About 100 participants from 14 countries attended this meeting, including USA, UK, France, Russia, Sweden, Romania, Poland, Australia, Japan, Thailand, India, Vietnam and China. About 72 abstracts were received and the Abstract Volume was printed for the symposium. Ten oral sessions were organized and a one-day field excursion was arranged to examine the geology and Jurassic stratigraphy in the vicinity of Nanjing City. In addition, the International Working Group of IGCP 506 held its first business meeting during this symposium to discuss the project targets, research directions, yearly programme plan and schedule, and to identify the regional representative members or country coordinators for this IGCP project.

This special issue publishes the results of selected works discussed at the International Symposium on the Jurassic Boundary Events—The first annual meeting of the IGCP 506 held in Nanjing, China on November 1—4, 2005. The symposium covered a wide range of topics related to the Marine and Non-marine Jurassic studies including palaeobiology, biostratigraophy, chronostratigraphy, cyclostratigraphy, magnetotraigraphy, sedimentology, palaeogeography, palaeoclimatology, geochemistry, tectonics, remote sensing, palaeo-oceanogeography, sea level changes, and the carbon cycle.

This volume including this preface and 29 papers spans a wide spectrum of the Marine and Non-marine Jurassic interns of the boundary events and correlation. Among the papers included herein, seven papers address different aspects of the Triassic/Jurassic and Jurassic/Cretaceous boundary events. Morton[26] addresses the chronostratigraphic units in the Jurassic and their boundaries, with the emphasis on their definition, recognition and correlation, as well as causal mechanisms. This contribution is very important for further studies on correlation between the marine and non-marine Jurassic. Hirsch et al.[27] give new insights into the Triassic-Jurassic boundary in the Asher Volcanism in Middle Eastern Levant and discuss the magmatic event. They conclude that the volume of Asher volcanics may reflect a role for volcanism in the T/J mass-extinction. The carbon isotope negative excursion across the Triassic-Jurassic boundary in the sections at Germig in Tibetan Himalayas is discussed[28]. The Pronounced negative excursions between the Triassic and Jurassic boundary correspond to the end-Triassic extinction. Vajda and Wigforss-Lange[29] describe new results on the stratigraphy of the Jurassic-Cretaceous boundary in Southern Sweden based on palynological and sedimentological interpretations. A well preserved palynological assemblage of pollen and spores from land plants is revealed. The vegetation on land consisted of a canopy of coniferous forest with an under storey vegetation of ferns in a warm, temperate climate. Palynofloral composition shows resemblance with assemblages described from the Northern Chinese Floral Province and comparisons with the palynofloras of the Jehol Group are made. The sedimentological succession of the Vitabäck Clay shows that the basal sequence represents an anomalous deposit, interpreted to represent tsunami deposits and comparison with similar co-eaval tsunami-related deposits from France is discussed. A recent advance in the studies of the Jurassic-Cretaceous boundary in northeastern China is reported by Sha et al.[19]. *Buchia* and dinoflagellate cyst assemblages from two areas in eastern Heilongjiang indicate the presence of the Jurassic-Cretaceous boundary interval. New data on the isotopic composition of Jurassic-Early Cretaceous cephalopods are reported by Zakharov et al.[30], based on the some shells derived from the Russian Platform, Poland, Germany and England. The Jurassic-Early Cretaceous climatic conditions are discussed in details. Kemkin and Sha[31] discuss the main Jurassic geological events along the eastern Palaeo-Asian continental margin.

About eight papers in this volume introduce the new advances on the regional stratigraphical correlation of marine and non-marine Jurassic as well as their depositional environment. Shi et al.[32] highlight the main characteristics of and recent advances in the study of the Jurassic System in China. They emphasize that China is a critical area for marine and non-marine Jurassic correlation. Through various investigations, both marine and non-marine Jurassic assemblages and biozonations are established and as a consequence the marine and non-marine Jurassic stratigraphic system and correlation in China are clarified. Recent progress in studies of the Jurassic System in SW Japan is reviewed by Ishida et al.[33]. Meesook et al.[34] report the lithostratigraphy and faunal aspects of the marine Jurassic in Thailand based on fourteen lithostratigraphic units; additionally, they summarize the widespread non-marine Jurassic rocks in the northeastern part (Khorat Plateau), and partly in the northern, eastern, and southern parts of Thailand[35]. Depositional environments of Bathonian sediments from the Jaisalmer basin, and the depositional history of the early part of the Jurassic succession on the Rajasthan Shelf, western India are discussed respectively by Pandey et al.[36,37]. Khuc et al.[38] summarize the stratigraphy and palaeontology of the marine Jurassic strata in Vietnam with an emphasis on characteristic marine Jurassic ammonites. Finally, Li et al.[39] report radiometric dates of sediments derived from the Jurassic and Early Cretaceous metamorphic rocks of the Dabie Orogenic Belt in China.

Rich and diverse fossil organisms have been recorded in both marine and non-marine Jurassic sequences. There are numerous examples of calibration of sequences of continental floras and faunas against marine deposits would provide valuable insights into the geological and biological evolution of the Earth during the Jurassic Period. Understanding changes in the biodiversity of such important groups of fossil organisms is crucial for global correlation between marine and non-marine Jurassic deposits. In this special issue, about 14 papers are related with this important topic; and half of them focus on the terrestrial floral aspects that are recorded in non-marine Jurassic deposits. Popa et al.[40] report on the Early to Middle Jurassic succession in Romania and in particular emphasize the diverse and well preserved floras of the Carpathian Mountains and Dobrogea, Eastern Romania. The ages of these floras range from Hettangian to Sinemurian, with representatives of bryophytes, pteridophytes and gymnosperms. Wang et al.[41] describe a new cycadalean pollen cone, *Jurastrobus chenii* gen. et sp. nov., connected with vegetative parts from Inner Mongolia, China. This is the first record of a cycadalean pollen cone with *in situ* pollen grains and organically connected with its vegetative parts, and therefore sheding a new light on the morphological evolution of cycad plants. The biodiversity and climate of the Middle Jurassic floras from the Tiaojishan Formation in western Liaoning, China are reported by Wang et al[42]. The plant fossils include leaf impressions, compressions, permineralized rhizomes, fossil wood and dispersed spores and pollen grains. The floristic signature of the Tiaojishan Formation indicates that subtropical to temperate warm and humid climates prevailed during the late Middle Jurassic in the Beipiao area. Growth ring pattern analysis of the fossil conifer wood demonstrates a consistent and distinct seasonal climate during this interval. Yang et al.[43] describe a cheirolepidiaceous conifer *Brachyphyllum* (*Hirmeriella*?) sp. from the Early Jurassic Sangonghe Formation of the Junggar Basin, northern Xinjiang. Occurrence of cheirolepidiaceous foliage and *Classopollis* pollen in the Sangonghe Formation indicates that a warm and dry climate prevailed in the Junggar Basin during the Early Jurassic (Early Toarcian), supporting the hypothesis of a warming event at that time. A new structurally preserved cycad-like stem, *Lioxylon liaoningense* gen. et. sp. nov., from the Middle Jurassic of western Liaoning, China[44] is also decribed. Anatomical evidence indicates a close systematic affinity of *Lioxylon* with fossil and living Cycadales. This is the first systematic description of an anatomically preserved fossil cycad-like stem from China. In addition, Sun et al.[45] address the geochemical characteristics of plant cuticles of *Solenites murrayana* (Ginkgoales) from the Jurassic in Lanzhou, northwestern China. The distribution of soluble organic matter in cuticles shows that fossil plant cuticles have a definite action in forming terrestrial high-wax oil, which testifies the contribution of high plants to waxiness. This study proves that ginkgophytes, abundant in the Jurassic, are plants with a high potential for the formation of oil from coal. Moreover, the cuticular characters of fossil *Ginkgo* from northwestern China are discussed in terms of their implications for determinations of Jurassic atmospheric CO_2[46]. A combination of carbon isotope composition and stomatal characters of fossil leaves provides information about palaeo-atmospheric CO_2 levels and the physiology of fossil plants. The results show that Jurassic *Ginkgo* in China lived in an atmosphere with a CO_2 concentration 3—5 times higher than that of today.

For marine fossils, a recent record of calcareous nannofossils in Jurassic black shales is reported from two series, representing shelf to basin settings, in the Qiangtang Basin and northern Tibetan Plateau[47]. The black shale facies with high organic carbon content can be attributed to coccolithophorid high productivity and blooms, indicating that the Qiangtang black shales have a good to excellent oil-generation potential. Meanwhile, the Middle-Late Jurassic marine dinoflagellate cysts from the eastern Qiangtang Basin in the Qinghai-Tibet Plateau, China are reviewed[48]. Six assemblage zones are recognized covering the Callovian-Kimmeridgian interval, and the Jurassic-Cretaceous Boundary in the Wenquan section is reinvestigated. The phylogenetic relationships of large Branchiopoda have been one of the most controversial issues in the studies of Crustacea. Sun et al.[49] discuss the Jurassic radiation of large Branchiopoda (Arthropoda: Crustacea) by using secondary structure-based phylogeny and relaxed molecular clocks. Relaxed molecular clock analysis indicates that three conchostracan genera (*Imnadia*, *Caenestheriella*, *Caenestheria*) emerged during the Jurassic; and that most anostracan groups experienced an adaptive radiation during the Jurassic, probably related to the fragmentation of the Pangea supercontinent.

In addition, other investigations on the taxonomy of the Jurassic faunas have been included in this special issue. Thus, the diagnosis and the relationship of the genus *Abrestheria* (Crustacea: Conchostraca) from the Jurassic Dabeigou Formation of northern Hebei, China are revised[50]. Re-examination of the type specimens of the conchostracan genus *Abrestheria* using a scanning electron microscope (SEM) reveals details of carapace features of important taxonomic value, which has not been described before. The Lower and Middle Jurassic insects are rather poorly known from northwest China. Lin and Huang[51] make a revision of "*Parahagla lamina*" Lin and introduce two new species of the fossil insects *Aboilus* (Orthoptera: Prophalangopsidae) from the Early-Middle Jurassic of NW China. Furthermore, Tan and Ren[52] summarize the Jurassic and Cretaceous Cupedomorpha (Insecta: Coleoptera) faunas of China, and seven cupedid and ommatid assemblages are recognized from the Jurassic-Cretaceous rocks, covering the age from Middle Jurassic to Early Cretaceous. In recent years, many investigations have focused on the discussion of the age of the Daohugou fauna from Ningcheng County of Inner Mongolia. Huang et al. [53] briefly introduce their recent invertebrate findings from the Daohugou fauna: mainly insects, conchostracans, anostracans, and spiders. The age of the Daohugou fauna is considered to be Middle Jurassic on the basis of an analysis of various invertebrates especially insects and conchostracans, which show strong similarities to the Yanliao fauna of North China and the Karatau fauna of Kazakhstan.

According to the project plan, however, additional special issues with results of IGCP 506 will be published. The IGCP 506 will have a "Topical Symposium" during the 2nd International Palaeontological Congress (IPC 2006) to be held from June 17—21, 2006 in Beijing, China. In addition, a speciall session is scheduled to be held in the 7th International Congress on the Jurassic System (the 7th ICJS) in Krakow, Poland on September 11—14, 2006. Updated results and progress will be published in other special issues.

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