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EDITORIAL

An introduction to Jurassic biodiversity and terrestrial environments

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This special issue of *Palaeobiodiversity and Palaeoenvironments* is devoted to studies of Jurassic terrestrial floras. The special issue *Jurassic biodiversity and terrestrial environments* includes nine contributions that investigate plant fossils and their spores and pollen from a range of localities across the globe that stratigraphically span the Jurassic (Fig. 1). These papers are a collective contribution to the IGCP project 632: *Continental crises of the Jurassic: Major extinction events and environmental changes within lacustrine ecosystems*.

The Jurassic (~ 201–145 million years ago) records the recovery and development of ecosystems in the aftermath the end-Triassic mass extinction (ETE), one of the so-called "big-five" mass extinction events of the Phanerozoic (e.g. McElwain et al. 2009; van de Schootbrugge et al. 2009). The supercontinent Pangea, which started to fragment during the Triassic, continued to separate through the Jurassic (e.g. McLoughlin 2001); however, the close arrangement of the continents meant that floras and faunas comprised many cosmopolitan elements. Elevated atmospheric CO_2 levels (e.g. McElwain et al. 2005; Steinthorsdottir and Vajda 2015), high-latitude vegetation, and a general lack of evidence for polar glaciation suggest that warm climates extended to high latitudes (e.g. Vakhrameev 1991). Several major evolutionary advances of the terrestrial biota took place during this period, including the appearance of the birds, the rise of the dinosaurs as the dominant land-based vertebrates (e.g. Upchurch and Barrett 2005) and the proliferation of bennettite-, advanced seed fern- and conifer-dominated floras (e.g. Anderson et al. 2007).

This article is a contribution to the special issue "Jurassic biodiversity and terrestrial environments"

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The contributions

This special issue integrates several new Jurassic palaeontological studies, with a particular focus on the Triassic–Jurassic (T–J) transition and palaeoenvironmental reconstructions based on plant macrofossils and spore–pollen data.

Peng et al. (2018) introduces the reader to the Triassic–Early Jurassic deposits of the Tarim Basin, China. Well-preserved spore–pollen assemblages are described and discussed with respect to biostratigraphy and palynofloral provinces. Additionally, a possible floral recovery succession following the end-Permian event is considered. Based on the spore–pollen assemblages, the authors propose that the boundary between the North and South China palynofloral provinces of the Late Triassic should be placed at the southern margin of the Tarim Basin (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0279-y).

The Triassic–Jurassic transition of the Sichuan Basin, south eastern China, is investigated by **Pole et al.** (2018), where palaeoenvironmental interpretations are provided based on sedimentological and charcoal evidence. The authors recovered charcoal throughout the studied interval, consistent with *Xenoxylon* (gymnosperm wood). Hummocky and swaley cross stratification in association with minor *Skolithos* and heterolithic

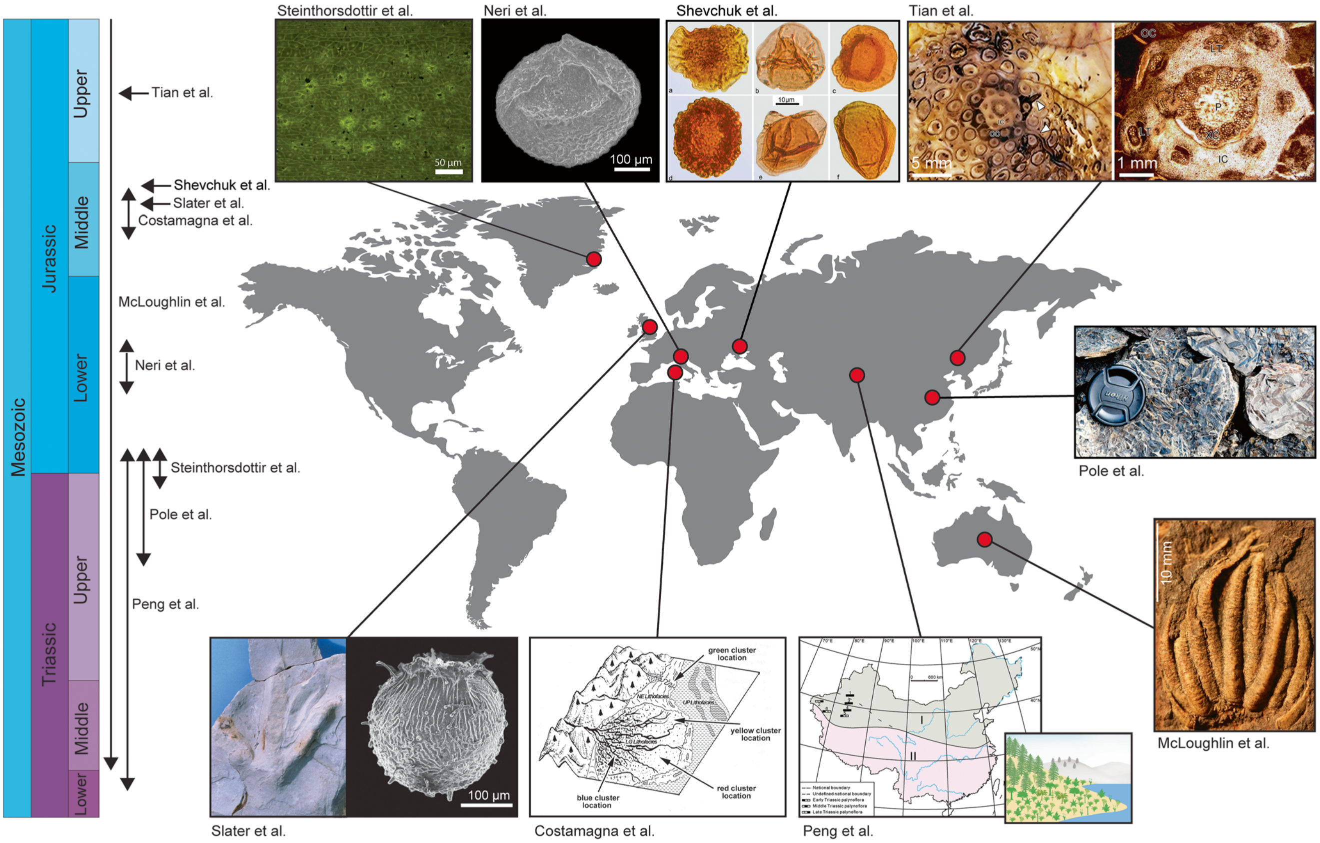

Fig. 1 Stratigraphic chart and map showing the temporal and spatial distribution of fossil material studied in this special issue

bedding provide evidence for shallow marine conditions and suggested a wave-dominated coast palaeoenvironment. The authors suggest that intense storms and frequent fires indicate high ecological disturbance through this mass extinction episode within the Sichuan Basin (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0315-y).

The reader continues to explore the Triassic–Jurassic interval in the contribution by **Steinthorsdottir et al**. (2018). The authors investigate plant cuticles from a T–J section from Astartekløft, East Greenland. A range of morphological changes of cuticles are presented from hundreds of Ginkgoales and Bennettitales specimens. Based on morphological structures of distorted cuticles that are consistent with modern SO_2-caused cuticle damage, Steinthorsdottir et al. (2018) infer that SO_2 played a major role in the ecosystem response observed across the T–J interval. The authors state that cuticle surface morphology has the potential to provide a proxy for SO_2 (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0297-9).

Building on previous surveys of the relatively little-studied Australian Jurassic floras (Turner et al. 2009; McLoughlin et al. 2015), **McLoughlin et al**. (2018) systematically describe the range of bennettitopsid reproductive structures from Mesozoic strata of that continent. They formally define five new species of *Williamsonia*, one new species of *Cycadolepis*, and propose the new combination *Fredlindia moretonensis*. Among these, they identify the oldest bennettitalean reproductive organ known globally. The authors note that the Australian bennettitalean floras share few species with lower palaeolatitude regions of Pangea and are notably impoverished in fossils of reproductive organs vis-à-vis foliar remains. The authors investigate the ecological strategies of bennettites that may have led to this scarcity of reproductive organs (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0286-z).

The contribution by **Neri et al**. (2018) sheds light on one of the most famous Lower Jurassic fossiliferous areas of Europe, the Rotzo Formation of the Monte Lessini area. For the first time, megaspores are described from this succession, testifying to the presence of selaginellalean lycophytes, a group that is otherwise not recorded from the generally extensive and diverse macroflora of this area. These megaspores are found in association with charcoal and amber drops, permitting a reconstruction of a paralic swamp environment with a warm and humid (monsoonal) climate. Moreover, this underlines how brackish environments of this kind were well-suited for the preservation of fossil plant remains (including amber) (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0314-z).

Palaeobotanical, palynological, and lithofacies studies of the Bajocian–Bathonian (Middle Jurassic) sequences of Sardinia are the focus of the contribution of **Costamagna et al**. (2018). The Genna Selole Formation was deposited in a complex landscape strongly influenced by tectonics, located close to the edge of the European continental shelf. Several distinct ecosystems are discerned that developed under the influence of a generally warm and humid climate, including alluvial fans with braided streams, paralic swamps and coasts, as well as lagoons and shallow marine environments. The discrepancies between the composition of the palynological and palaeobotanical associations prove once more the importance of multidisciplinary studies for palaeoenvironmental and palaeoclimatic interpretations (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0306-z).

The Middle Jurassic terrestrial deposits of the Yorkshire coast, UK, are discussed in this issue by **Slater et al**. (2018). These sequences are well-known for their exceptional plant macrofossil (e.g. Harris 1961; van Konijnenburg-van Cittert and Morgans 1999) and spore–pollen assemblages (e.g. Couper 1958; Slater et al. 2015; Slater and Wellman 2015, 2016). Slater et al. (2018) examine palynological assemblages and dinosaur footprint fossils to improve vegetation reconstructions and assess possible dinosaur–plant interactions. The authors hypothesize that the diverse vegetation of the Yorkshire Jurassic represented an attractive food source for herbivorous dinosaurs that gathered on the flood plains for freshwater and also used the non-vegetated plains and coastline as pathways (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0309-9).

In a study of the Bathonian Kamyanska flora of Ukraine, **Shevchuk et al**. (2018) describe palynofloras and compare these with coeval assemblages from other parts of Europe. The Kamyanska flora is chiefly preserved in continental sandstones, siltstones, and claystones and is located within a major hydrocarbon-producing region, the Dnieper-Donets Basin. The palynological analysis revealed a flora comprised of ferns, including Osmundaceae, Gleicheniaceae, and Cyatheaceae, with a canopy represented by Cupressaceae. These assemblages are broadly similar to other European Middle Jurassic palynofloras, revealing relatively limited floral provincialism at this time (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: https://doi.org/10.1007/s12549-017-0310-3).

The contribution of Tian et al. (2018) investigates several ferns that preserve anatomical details from Upper Jurassic strata of Inner Mongolia, China. The paper provides new data on the anatomical diversity and evolution of Mesozoic ferns and contributes to the understanding of Late Jurassic vegetation of Northeast China. Specifically, **Tian et al**. (2018) report several fern rhizomes and rachides, and importantly, the authors state that the finding of *Gleicheniorachis sinensis* sp. nov. represents the first unequivocal Jurassic record of Gleicheniaceae in northern China and the first record of a Jurassic permineralized gleicheniaceous fern from the Northern Hemisphere (*Palaeobiodiversity and Palaeoenvironments* 98(1) Doi: /https://doi.org/10.1007/s12549-017-0313-0).

Recent developments and future research

Fossil plants and their spores and pollen are widely used in biostratigraphy and provide important data to determine the extent and magnitude of deep-time climatic events. In recent years, the application of several novel techniques and exceptional fossil finds has advanced the fields of palaeobotany and palynology. The application of methods such as Raman and Fourier-transform infrared spectroscopy (FTIR) have provided new information regarding organic molecules in Mesozoic plants (Vajda et al. 2017) and older deposits (Qu et al. 2015). Furthermore, FTIR of spores and pollen has been used to develop a proxy for ultraviolet irradiance (Jardine et al. 2016; Jardine et al. 2017). The combination of high-resolution microscopy and computational image analyses has proved useful in determining the botanical affinity of enigmatic taxa (Mander et al. 2013); such approaches can be applied to many groups, thus improving vegetation reconstructions based on dispersed spores and pollen. Studies of stomatal indices have provided information on CO_2 levels in ancient atmospheres (e.g. McElwain et al. 2005; Steinthorsdottir and Vajda 2015). Other innovative approaches include holistic investigations of entire ecosystems to determine interactions between flora, fauna, and fungi (e.g. McLoughlin and Strullu-Derrien 2016). Three-dimensional tomographic reconstructions have revealed details of internal structures of individual plant organs (Steart et al. 2014) and rare examples of exceptional preservation that preserve sub-cellular details include silicified and calcified plants recovered from volcanic deposits (Bomfleur et al. 2014). Although much has been achieved in reconstructing Jurassic terrestrial ecosystems, integrated collaborative studies covering plant macrofossil and palynological data from the same successions are relatively uncommon and represent an avenue for future focus. Progress is required regarding taxonomic consistency among different regions to develop more robust stratigraphic correlations and investigate spatial variations in floras. In particular, further collaboration between plant macrofossil researchers and palynologists will accelerate progress to resolve temporal and spatial distributions of plant groups and resolve biogeographic patterns across the globe during the Jurassic.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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