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PREFACE

Special Issue Mass Extinctions–Preface

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This thematic volume arose from a desire to acknowledge the pioneering contributions to mass extinction studies made by Professor Tony Hallam over the past 50 years and includes papers from several theme sessions held at the annual meeting of the Geological Society of America held in Denver in October 2013 along with other solicited contributions. They provide both a breadth of temporal coverage and also reflect the broad spectrum of earth scientists currently involved in studying these ancient crises, ranging from palaeontologists to volcanologists to earth system modellers.

Our initial contribution (**Wignall & van de Schootbrugge**) provides a summary of Tony's many papers on mass extinctions, places them in the context of current research and shows just how innovative many of his ideas were. Thus, the notion of sea-level rise, anoxia and marine extinction can be traced back to his work in the early 1960s whilst he, in effect, 'discovered' the end-Triassic mass extinction 35 years ago, at a time when the main turnover and diversity losses were thought to occur much earlier in Late Triassic time.

Tony was also one of the first to highlight the curious nature of the Early Triassic world in the aftermath of the end-Permian mass extinction: a time of global low diversity and very slow recovery rates. **Song *et al.*** examine this Early Triassic recovery for foraminifers, one of the few groups with a good fossil record at this time, and show in detail the diversity trends within this group. Part of the problem for denizens of Early Triassic oceans seems to have been the prevalence of anoxia, and **Wignall *et al.*** look at the detailed record of redox changes in the shelf seas of Spitsbergen. They show the extraordinarily nearshore development of oxygen-restricted conditions in a hyperpycnite-dominated succession and a remarkable series of fluctuations that are better linked with temperature rather than palaeobathymetric fluctuations.

The link between extinctions, environmental deterioration and volcanism (especially with the emplacement of large igneous provinces (LIPs)) is a common theme in mass extinction studies, and **Saunders** provides an up-to-date review of two of the best-known connections, that of the Siberian Traps and the end-Permian mass extinction, and the Central Atlantic Magmatic Province and the end-Triassic mass extinction. Erupted gas volumes are a key factor in understanding LIPs, and climate change and box modelling of the carbon cycle, undertaken here by **Bachan & Payne**, is an important approach to evaluating these relationships. They show that rapid release of large amounts of volcanic carbon dioxide, recorded by carbon isotope changes, can lead to harmful consequences such as ocean acidification. **Van de Schootbrugge & Wignall** provide a state-of-the-art review of scenarios for the end-Permian and end-Triassic mass-extinctions, comparing proximate triggers, such as ocean acidification, ocean anoxia and climate change. A number of important triggers are very similar for both extinction events, suggesting that the ultimate causes were also comparable. Both extinction events can be confidently linked to the emplacement of the Siberian Traps and the Central Atlantic Magmatic Province, across the Permian/Triassic and Triassic/Jurassic boundaries, respectively.

Precisely equating the timing of LIP eruptions to extinctions is generally difficult because the volcanic and fossil records are rarely found in the same place. Recently, mercury levels (normalized to organic carbon) in the sedimentary record have been developed as a proxy for volcanic effusion. The great value of this approach is seen in the study of **Grasby *et al.*** on the Permian–Triassic marine strata of Spitsbergen. They show three Hg/TOC spikes, which remarkably coincide with known extinctions in the Middle Permian, at the end of the Permian and at the Smithian/Spathian Stage boundary. This is as neat a link between a volcanism proxy and extinction as could be wished for. Improved dating and correlation of sections is essential to constrain the timing of events leading to extinction. **Lindström** discusses the use of palynomorphs for cross-continent land–sea correlation. Indeed, palynology is the only micropalaeontological domain that gives simultaneous insight into environmental changes on land and in the oceans. For the end-Triassic extinction, plant extinctions reconstructed from pollen and spore abundances were more dramatic in the northern hemisphere, which is an important conclusion

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that links plant extinctions to the supraregional effects of flood basalt volcanism. A similar hemispheric dichotomy is observed for a mid-Triassic climate perturbation. **Ruffell, Simms and Wignall** review the evidence for environmental changes associated with the Carnian Humid Episode that is associated with biotic turnover and geochemical anomalies. Similar to what is observed for the end-Triassic extinction, the evidence for environmental change is strongest in the northern hemisphere. The authors conclude that the eruption of the Wrangellia LIP is the most likely cause of the observed changes.