

## The end-Permian mass extinction and its aftermath

PAUL B. WIGNALL

School of Earth and Environment, University of Leeds, UK  
(p.wignall@see.leeds.ac.uk)

Our understanding of the timing of the end-Permian mass extinction and subsequent recovery has improved dramatically in the past few years. For long thought to be a protracted affair spread over several million years of the Late Permian, by the 1990s it was re-evaluated as a geologically abrupt crisis. Latest work shows the marine (and probably the terrestrial) extinction to be a two-phased event that straddles the Permian-Triassic boundary whilst the record from higher northern (Boreal) latitudes suggests the extinction phase was somewhat earlier. The ~200 kyr interval between the extinction pulses saw a transient recovery of the benthic fauna. The significance of this improved resolution of extinction timings can be compared with recent advances in both our understanding of ocean redox and sea-surface temperatures at this time. The first pulse of extinction saw the onset of open ocean anoxia but only a transient pulse of low- oxygen conditions whilst the second extinction pulse, in the earliest Triassic, coincides with the long-term establishment of global marine anoxia. The contemporaneous oxygen isotope record of conodont phosphate reveals a rapid temperature rise that persisted long in to the Early Triassic.

The Early Triassic fossil and geochemical record is one of the most extraordinary of the Phanerozoic. Carbon isotope stratigraphy is highly unstable with a series of both positive and negative excursions whilst the oxygen isotope record shows similar instability reflecting major temperature oscillations within an overall exceptionally hot interval. This culminated in the latest Smithian Stage with very light  $\delta^{13}\text{C}$  values (~2‰) and  $\delta^{18}\text{O}$  values suggestive of equatorial sea-surface temperatures >40°C. The marine invertebrate record is remarkably impoverished for 2 myrs with little in the way of recovery of the benthos whilst nektonic organisms radiated with their usual exuberance. Only after the Late Smithian Thermal Maximum can it be claimed that widespread diversification is underway although not until the Middle Triassic are conditions truly normal in marine and terrestrial habitats.

## Experimental study of majorite stability in chromium rich garnets

CH WIJBRANS<sup>1\*</sup>, S KLEMM<sup>1</sup> AND A ROHRBACH<sup>1</sup>

<sup>1</sup>Institut für Mineralogie, Universität Münster, Germany,  
(\*ineke.wijbrans@uni-muenster.de)

Garnet is an important constituent of upper mantle rocks, and is stable over a wide range of pressures. At high pressures (>5GPa), silica is incorporated into the octahedral site in the garnet structure partially replacing aluminium, which results in the so-called majorite component. In mantle rocks, this will cause the pyroxenes to gradually dissolve into garnet with increasing pressure [1]. Majoritic garnets are sometimes found as inclusions in deep diamonds and in mantle peridotites. The silicon content of these garnets is often used to estimate the depth of origin of these samples [2].

In addition to pressure [1], majorite stability is also expected to depend on temperature, composition of the garnet and presence of other Al-bearing phases or melt. For instance, the presence of chromium or ferric iron may decrease majorite stability with increasing pressure. If true, this has implications for the interpretation of the formation depth of diamond inclusions as the Cr/(Cr+Al) ratio is much higher in depleted lithospheric mantle compared to fertile mantle.

To investigate this further, we performed high pressure high temperature experiments in a Walker-type multi anvil press (Bristol design) at pressures between 6 and 14 GPa, and temperatures between 1400 and 1700 °C. Starting materials consist of silicate glasses or oxide mixes in the system  $\text{Cr}_2\text{O}_3\text{-CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ , with varying  $\text{Cr}_2\text{O}_3/(\text{Al}_2\text{O}_3+\text{Cr}_2\text{O}_3)$  ratio. Major and minor element concentrations of the phases present were determined by electron microprobe.

All experiments yielded garnet, most contained opx, olivine and (minor) cpx as stable phases. At high temperatures only one pyroxene phase is stable. Preliminary results indicate that for constant pressures and temperatures, the majorite component in garnet decreases with increasing Cr/(Cr+Al) of the bulk composition. However, this effect is most notable at high pressures (>11GPa), at lower pressures this effect is smaller.

[1] Akaogi and Akimoto (1977) *Physics of the Earth and Planetary Interiors* 15, 90-106. [2] Griffin (2008), *Geology* 36, 95-96.