LECTURE

The end-Permian mass extinction

Summary of a lecture presented to the Society on Saturday 8th February 2003 by Dr Paul Wignall of Leeds University.

Our knowledge and understanding of the end-Permian mass extinction has increased dramatically in the past 10 years as the pace of research on this, the largest mass extinction event of all time, has intensified. Much of the long-standing dogma has been swept away, particularly the notion that it was a protracted crisis, spread over millions of years, associated with a spectacular sea-level fall. It is now generally appreciated that the extinction was geologically fast (spread over tens of thousands of years). The event also appears to have occurred during a phase of rapid sea-level rise not fall! This change in perception has come from the study of widely scattered Permian-Triassic boundary sections and an improvement in the diversity of dating techniques for Late Permian strata. Thus, many sections previously thought to be lacking Uppermost Permian rocks have been shown to have a complete record of this interval.

With the new data have come new ideas as to the cause of the extinction. The marine extinctions are associated with the widespread development of oxygen-poor bottom waters; lethal conditions that seem to have spread into remarkably shallow water settings and thus to have severely restricted the available habitat area for marine life. On land there is abundant evidence for dramatic global warming across the Permian-Triassic transition and this climatic change is almost certainly responsible for the dramatic extinction of terrestrial plant life particularly in higher latitudes.

Undoubtedly the most significant development in the past decade has been the realisation, thanks to vastly improved radiometric dating techniques, that the eruption of the Siberian Traps flood basalt province coincided with the end-Permian mass extinction. These Traps are just one manifestation of the most voluminous form of volcanism known on Earth. Many other provinces have also been found to coincide with other mass extinctions in the past few years. The Siberian Traps were a particularly large province, with an original volume of extrusive volcanic material perhaps approaching 4 - 5 million cubic kilometres. The question has therefore arisen of how the observed phenomenon of extinction/ocean anoxia/warming can be related to the eruption of huge amounts of basalt. This question is also pertinent to other mass extinction horizons (for example the end-Triassic and early Jurassic extinctions) for which there is a similar coincidence of events.

The most obvious climatic impact of large, modern volcanic eruptions is the short-term cooling effect caused by the fine haze of volcanic dust and sulphate aerosols that can be injected into the stratosphere. However, these effects only last a year or so because the dust and aerosols are rained out of the atmosphere and they are only capable of affecting the hemisphere in which the volcanism occurs. It is a moot point whether such affects would have any long term damage. The quiet nature of flood basalt eruptions also makes it unlikely that the volcanic dust and gases would ever reach the stratosphere. Thus, many workers have tended to focus on the likely climatic impact of volcanic carbon dioxide emissions during flood basalt eruptions. After all, the geological record suggests that warming, not cooling, occurred during many mass extinctions including the end-Permian event. However, despite the size of the Siberian Traps, calculations, based on the known volume of gas emitted during modern basaltic eruptions, suggest that the rate of carbon dioxide emissions during Siberian volcanism are not likely to have greatly exceeded modern anthropogenic emissions.

This leaves the link between volcanism, climate change and extinction something of a puzzle and many workers now view the volcanism as a trigger in a chain of events. A favourite source of further greenhouse gases in many models is gas hydrates. This substance is essentially ice but it traps alkane gases, mostly methane, in its interstices and is found in huge volumes below the seafloor on many continental slopes. Just a few degrees warming of ocean water would be required to melt these hydrates and release their methane load into the atmosphere, whereupon it would greatly exacerbate any warming trend. Thus, the eruption of a giant volcanic province is envisaged to trigger a lethal positive feedback mechanism of rapid global warming, the effects of which seem to have been to slow down ocean circulation and cause an oxygen crisis for marine life. The parallels of such scenarios with modern environmental concerns are of course very apparent. The end-Permian mass extinction should perhaps be viewed as a warning from history.

Literature

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