The Late Silurian Lau Event: isotopic evidence for causes of extinction

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The Silurian sequences of Gotland (Sweden), the Broken River region of NE Australia, were located on different palaeocontinents, the first on Baltica, the other on the N Gondwana margin. Though faunal differences are evident, conodonts are of prime importance for correlating the stratigraphies and identifying the Lau Event in the two regions. The Lau Event affected, *inter alia*,. acritarchs, corals, polychaetes, brachiopods, chitinozoans, ostracods, trilobites, tentaculites, graptolites, conodonts and fish. Imprecise knowledge of range-ends hampers quantitative evaluation of extinctions but a loss of at least 30 to 50 % of the species seems probable. Among higher taxa, the event caused extinction of a suborder of tabulate corals. Among conodonts, no platform-equipped taxon survived but 24 of the 34 species known to have persisted until the beginning of the event survived.

The sequence of lithologies is remarkably similar on Gotland (Sweden) and from the coral gardens section (COG) of the Jack Formation, North Queensland: A. argillaceous strata before the event; B. more weathering-resistant limestones during the early part of the event; C. oncoids and crinoids (oncolitic crinoid limestone or oncolite with crinoids) during the middle part of the event: D. argillaceous oncolite during the late part of the event, and then E. terrigenous clastics followed by F. oolite before G. return in each area to normal sediments.

Isotopic changes are very similar in both regions indicating globality of changes in ocean chemistry. The $\delta^{13}C_{carb}$ record includes a slow rise during A, a slightly more rapid rise during B, an abrupt (a few hundred years or less) shift upwards of >1‰ during 3 000-4 000 years before the lithologic change at B/C, a rapid rise initially during C, stable high values during D, an abrupt shift downwards at the start of E, followed by a rapid rise. In the detailed section through the coral gardens section (COG), C (carbonate, organic C), Sr and O isotope records indicate changes in ocean chemistry leading up to the event and in its aftermath. The relative timing of isotopic, lithological and faunal change give insight into the mechanisms driving the global change.

Silicic melt generation by basalt crystallization in the deep crust

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The thermal evolution of the crust when repeatedly invaded by basaltic sills was simulated numerically. A thermal anomaly progressively builds up as sills solidify and transfer their heat to the surrounding rocks. Eventually the solidus temperature is exceeded and melt starts to accumulate. The duration of the incubation period before the outset of melt accumulation depends on the magma intrusion rate and on the initial temperature of the crust. For example, with a 20°C km^{-1} geothermal gradient, an intrusion depth of 20 km and a magma intrusion rate of 50 m per 10,000 years, the incubation period is of $3x10^5$ years. Melt is generated simultaneously by incomplete crystallization of the fresh basalt, by remelting of formerly intruded basalt and by partial melting of the pre-existing old crust. The proportion of different melt sources depends on the configuration of the sills, on the fertility of the crust and on the water content and temperature of the injected basalt. For typical arc-type basalt injected at 1100°C and containing 2.5% water, most melt is generated by crystallization of the basalt itself. The intrusion of one 50 m sill every 10,000 years at 30 km depth during 3.2 millions years results in a partially molten layer 16 km thick. The melting degree ranges from 20 to 25% corresponding to an equivalent pure melt thickness of 3600 m. Comparison with experimental data indicates that the melt is dacitic to rhyolitic in composition. Part of the water originally present in the basalt is trapped in residual or cummulate amphiboles. The remaining water concentrates in the melt. Assuming 30% amphiboles trapping a total 0.6% of the water, the water concentration in the melt exceeds 8.5%. Because of this high water content, the melt viscosity is only 10^3-10^4 Pa s. Another effect of high water concentration is to decrease the melt density substantially. The low density and viscosity of these water-rich silicic melts promotes segregation of melt by compaction and Rayleigh-Taylor instabilities in the zone of partial melting. Subsequent ascent of this melt will be very rapid. These melts degas and crystallize when they ascend into the upper crust.