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The Permian-Triassic boundary across the Barents Shelf: an intricate record of climate change, mass extinction, recovery, and basin reorganisation

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About 252 million years ago, near the end of the Permian, the Earth experienced its most dramatic mass extinction, caused by magmatic intrusions and volcanic eruptions associated with the Siberian Traps Large Igneous Province. This led to catastrophic global climatic changes, impacts of which lasted well into the Early Triassic.

Here, we summarise the results gathered from the study of sedimentary successions spread across the Barents Shelf that recorded the End Permian Mass Extinction (EPME) and its aftermaths across the Permian-Triassic boundary. Data and samples were collected from the Festningen section in western Spitsbergen; the DD-1 core and the associated river section in Deltadalen, central Spitsbergen; a core (7933/4-U-3) drilled by the Norwegian Petroleum Directorate offshore Kvitøya in northern Svalbard; and a core (7130/4-1; production licence 586) recovered from the Finnmark Platform in the Barents Sea. A series of state-of-the-art analyses were conducted on the collected material, including detailed facies analysis, organic and C-isotope geochemistry, mercury content, geochronology, high resolution XRF core scanning, petrography, ichnology, and palaeontology. Analyses were, where relevant, tied to the outcrops using digital outcrop models.

Traditionally, the Permian-Triassic boundary in Svalbard (and across the High Arctic regions) was placed at the marked and rapid facies change at the top of the siliceous mudstones and spiculites of the Kapp Starostin Formation, which are overlain by soft, non-siliceous mudstones and siltstones of the Vardebukta and Vikinghøgda formations. This abrupt facies change, which also marks the collapse of sponges, occurs across a few centimetres. Given that the non-siliceous mudstones were definitely of Early Triassic age, based on ammonoid biostratigraphy, this

lithostratigraphic boundary was believed to represent a lacuna or a hiatus of several million years, with the uppermost Permian strata absent from the sedimentary record.

The base of the Triassic, however, is not defined by ammonoid biostratigraphy but by the conodont *Hindeodus parvus*, which was recently reported to occur a few meters above the lithostratigraphic boundary in the Deltadalen section. This means that the lithostratigraphic boundary is of Permian age. Additionally, our new data show that sedimentation was continuous across this lithostratigraphic boundary, corresponding to major environmental changes, potentially associated with a reorganisation of the basin(s) physiography.

Furthermore, the 6-8 ‰ $\delta^{13}C_{org}$ negative excursion associated with the EPME falls between the lithostratigraphic and the Permian-Triassic boundary at all measured sections. These negative carbon isotope excursions occur in intervals with numerous tephra layers, the lowest of which has been dated at 252.13 ± 0.62 Ma, potentially connecting the recorded changes to the Siberian Traps. The EPME is also corroborated by the very abrupt decline of trace fossil abundance and diversity, as anoxia extended from proximal and shallow water to deeper settings. Geochemical and ichnological data support the existence of multiple anoxic pulses, separated by very brief periods of enhanced oxygen levels. It took ca. 150 Kyr for life to recover after the EPME, based on sedimentation rate calculations. Data also suggest that the hinterland of the basin experienced a shift towards more arid climatic conditions and increased eutrophication.