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Deep-time paleoclimate archive in High Arctic, Svalbard, Norway

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An appraisal of ancient Earth's climate dynamics is crucial for understanding the modern climate system and predicting how this might change in the future. Major climate-shift events in the Earth's past demonstrate the scale, duration and response of the climate system to various global and local climate stressors.

More than 650 million years of deep-time paleoclimate changes are archived in the sedimentary succession of Svalbard; an archipelago located in the Norwegian High Arctic. The excellently outcropping geological successions of Svalbard date back to the Proterozoic, and record both temporal and spatial changing climatic and environmental conditions strongly linked to the northward continental drift of the archipelago from southern hemisphere in Precambrian to its present-day Polar latitudes.

The oldest deposits that record major climatic events and associated environmental perturbations in Svalbard include tillites related to several Cryogenian glacial events and the overlying Ediacaran carbonates. The Lower Paleozoic succession documents episodes of marine biodiversification, including the Great Ordovician Biodiversification Event (GOBE), which is linked to cooling of previously warm tropical oceans. The arid to semi-arid climate of the Devonian promoted a terrestrial plant diversification. The Lower Carboniferous coal-bearing strata were deposited in humid and tropical climate settings prevailing in northern Pangea. The Upper Carboniferous-

Lower Permian succession consists of interbedded carbonates, evaporites and red siliciclastics, including remains of paleokarst. The continued northward drift into subtropical latitudes promoted a change back to arid to semi-arid climates, occurring during the overall global icehouse conditions. During the Late Permian, marine sponges were occupying most of the ecological niches, leading to the deposition of weathering-resistant spiculites. But these ecosystems were rapidly and dramatically impacted by the End Permian Mass Extinction (EPME), which lasted well into the Early Triassic.

By the Mesozoic, Svalbard was approaching mid-latitudes. The exposed in Svalbard deposits of Triassic mega-delta features evidence for a temperate or humid climate, indicated by thick coal beds that transitioned to an arid climatic environment at the end of the Triassic and Early Jurassic succession with caliche and calcareous soil profiles. The Lower Cretaceous strata (deposited at c. 66 °N) record several cold snaps despite the overall greenhouse climate characterizing the period and most notably the global crisis associated with the Aptian oceanic anoxic event 1a (OAE1a).

By the Paleogene, Svalbard had reached Arctic latitudes, and as characterised by overall moderate to warm temperate climate, punctuated by warming episodes, including the Palaeocene–Eocene Thermal maximum (PETM). The Neogene cooling is missing from onshore records, but high-resolution glacial climate evidence exists offshore and from geomorphology and unconsolidated strata of Late Quaternary-Holocene age.

In this contribution, we synthesize former and ongoing studies of deep-time paleoclimate in Svalbard and provide knowledge gaps to optimize the use of Svalbard as an archive for deep-time paleoclimate research. The exceptional exposures, accessibility, and completeness of the 650 million long sedimentary records makes Svalbard unique archive for deep-time paleoclimate research. In addition to Svalbard's excellent outcrops, fully cored research and coal exploration boreholes provide an excellent foundation for further research with minimal environmental consequences.