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Resolving the timing of brittle Paleogene Eurekan deformation of the High Arctic

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The enigmatic Eurekan deformation of the High Arctic encompasses a series of compressional and extensional tectonic episodes related to the evolution of circum-Greenland plate boundaries throughout the Paleogene. Although deformation has been separated into two phases (53–47 Ma; 47–34 Ma) on the basis of the seafloor spreading histories, the relationship between the tectonic evolution of circum-Arctic ocean basins and onshore deformation across the Canadian Arctic Archipelago, northern Greenland, and Svalbard is still ambiguous. This uncertainty is due to poor temporal constraints on the brittle geologic structures that dominate the deformation style. Presently, a paucity of Eurekan-related radiometric dates are restricted to syn-tectonic ash beds, few 40Ar/39Ar and K-Ar dates and limited apatite fission track analyses. Investigating crustal-scale structures across the Pearya Terrane of northern Ellesmere Island, Canada and its companion, the West Spitsbergen Fold-and-Thrust Belt of Svalbard we have successfully dated the onshore circum-Arctic deformation within a Eurekan framework. Eurekan deformation in the Pearya Terrane of northern Ellesmere Island is characterized by the superposition of laterally extensive, brittle strike-slip faults with variable kinematics on earlier Late Paleozoic Ellesmerian structures. The oldest reliable, foliation-defining white mica 40Ar/39Ar ages from the major fault zones are Ordovician-Silurian, with noticeable Devonian-Carboniferous dates along the Petersen Bay and Kulutingwak Fault zones, and some samples yielding ages as young as Late Triassic-Early Jurassic. Whereas the most recent displacement along these fault zones has previously been attributed to the second Eurekan phase, new zircon and apatite (U-Th)/He thermochronology yields dates with limited dispersion of c. 53 Ma, with average eU values of 200 to 2000 ppm. Consequently, with the exception of local fault blocks within the terrane-bounding Petersen Bay fault, major structures began to rapidly cool to <200°C during the first phase of Eurekan deformation. In comparison, numerical modelling of zircon (U-Th)/He data from Neoproterozoic metasedimentary units of Svalbard's Southwestern Basement Province elucidates a Cretaceous-Paleogene thermal history in which the crystalline basement was unroofed in the Late Cretaceous as a consequence of the opening of the Eurasian basin to the north. During the first phase of Eurekan deformation, Wedel Jarlsberg Land and Oscar II Land record early Eocene heating that is interpreted as tectonic burial during development of the West Spitsbergen Fold-and-Thrust Belt. Following the transition from compressional to dextral strike-slip tectonics along western Svalbard at c. 47 Ma, the models indicate rapid cooling throughout the mid to late Eocene, suggesting that exhumation of the fold-and-thrust belt was facilitated by transpressional tectonism. In Prins Karls Forland, >4 km of unroofing occurred during late Eurekan tectonism. Here, white mica 40Ar/39Ar dates from the Devonian-Carboniferous Bouréefjellet shear zone yield reproducible and chemically homogeneous population of ages between 55–44 Ma representing brittle reactivation of Ellesmerian structures throughout both phases of Eurekan deformation. Resolving the timing of Paleogene brittle tectonism across the High Arctic is required for reliable paleogeographic reconstructions and understanding the evolution of the Arctic ocean basin.