$^{40}Ar/^{39}Ar$ AND ZIRCON U–Pb ANALYSES DATE THE HIAWATHA IMPACT STRUCTURE, NORTHWEST GREENLAND, TO THE LATE PALEOCENE

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Introduction: The ~31-km-wide Hiawatha structure, located beneath Hiawatha Glacier in northwestern Greenland, has been proposed as an impact structure that may have formed after the Pleistocene inception of the Greenland Ice Sheet [1]. However, available age constraints for the Hiawatha structure have only been tentative. The bedrock under the structure is likely a continuation of the highly metamorphosed 1.95–1.75 Ga [2] bedrock exposed immediately adjacent to Hiawatha Glacier, providing a maximum constraint on the structure's age [1]. Further age estimates have been based on indirect constraints, such as estimates of erosion rates and the structure's relationship to the Greenland Ice Sheet [1]. Here we dated the structure using detrital materials sampled immediately downstream thereof. We report $^{40}Ar/^{39}Ar$ analyses of impact-related glaciofluvial sand collected in 2016 and U–Pb analyses of shocked zircon from pebble-sized glaciofluvial clasts of impact melt rock collected in 2019.

Results: Of the 50 grains that underwent $^{40}Ar/^{39}Ar$ step-heating analysis, 29 developed 'U'- or 'saddle'-shaped age spectra, with 23 giving minimum apparent ages in the Paleocene. Two mini-plateaus gave Late Paleocene ages of 58.5 ± 0.3 Ma and 60.2 ± 0.5 Ma, respectively. The 62 U–Pb analysis performed on 43 zircon grains using secondary ion mass spectrometry (SIMS) defined a discordant array in concordia space, spreading between an upper intercept of ~1915 Ma and a Late Paleocene lower intercept. The ~1915 Ma age for the majority of unshocked zircon grains from the impact melt rocks agrees with known geological events and zircon ages from the bedrock adjacent to Hiawatha Glacier [2], supporting a local origin for the samples. Of the 45 analyses performed on shocked zircon grains, the youngest nine data points are statistically indistinguishable, giving a robust concordia age and a weighted mean $^{206}Pb/^{238}U$ age of 57.99 ± 0.54 Ma (MSWD = 1.18; probability = 0.30; n = 9). We consider this to be the most robust estimate for the age of the impact structure [3].

Discussion: Impact melt rocks collected less than 10 km downstream from the edge of the Hiawatha structure contain unshocked zircon with ages matching that of the bedrock adjacent to Hiawatha Glacier. Shocked zircon in these samples gives a ~58 Ma U–Pb age, which agrees with the younger of two $^{40}Ar/^{39}Ar$ mini-plateau ages from the sand sample. The samples were thus derived from a Late Paleocene impact structure somewhere upstream but sufficiently proximal that the target geology is indistinguishable geochronologically from that exposed where the samples were recovered. Given existing geomorphic evidence for an eroded complex impact structure beneath Hiawatha Glacier, we suggest this is the source of the samples and thus that the Hiawatha structure is a relatively large impact structure that formed in the Late Paleocene. The new age indicates that the Hiawatha impact structure significantly predates Pleistocene glaciation and is unrelated to either the Paleocene–Eocene Thermal Maximum or flood basalt volcanism in east Greenland. The impact was contemporaneous with the Paleocene Carbon Isotope Maximum, although the impact's exact paleoenvironmental and climatic significance await further investigation.

References: [1] Kjær K. H. et al. (2018) *Science Advances* 4:eaar8173. [2] Nutman A. P. et al. (2008) *Precambrian Research* 161:419–451. [3] Kenny G. G. et al. (2022) *Science Advances* 8:eabm2434.