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Surface exposure dating of Little Ice Age ice cap advances on Disko Island, West Greenland

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Little Ice Age (LIA: 1200-1920 AD) glacier advances in Greenland often form the most extensive positions of Greenland Ice Sheet (GrIS) ice cap and margins since the Early Holocene. Across Greenland these advances are commonly represented by un-vegetated moraines, usually within 1-5 km of the present ice margin. However, chronological constraints on glacier advances during this period are sparse, meaning that GrIS and ice cap behavior and advance/retreat chronology remains poorly understood during this period. At present the majority of ages are based on historical accounts, ice core data, and radiocarbon ages from proglacial threshold lakes. However, developments in the accuracy and precision of surface exposure methods allow dating of LIA moraine boulders, permitting an opportunity to better understand of ice dynamics during this period.

Geomorphological mapping and surface exposure dating (36Cl) were used to interpret moraine deposits from the Lyngmarksbræen on Disko Island, West Greenland. A Positive Degree Day (PDD) model was used to estimate Equilibrium Line Altitude (ELA) and mass balance changes for two distinct paleo-glacial extents. Three moraines (M1, M2, and M3) were mapped in the field, and sampled for 36Cl surface exposure dating. The outermost moraine (M1) was of clearly different morphology to the inner moraines, and present only in small fragments. M2 and M3 were distinct arcuate termino-lateral moraines within 50 m of one another, 1.5 km from the present ice margin. The weighted average of four 36Cl ages from M1 returned an early Holocene age of 8.4 $\pm$ 0.6 ka. M2 (four samples) returned an age of 0.57 $\pm$ 0.04 ka (1441 AD) and M3 (four samples) returned an age of 0.28 $\pm$ 0.02 ka (1732 AD).

These surface exposure ages represent the first robustly dated Greenlandic ice cap moraine sequence from the LIA. The two periods of ice cap advance and marginal stabilisation are similar to recorded periods of LIA GrIS advance in west Greenland, constrained through radiocarbon dating. Comparison with local and regional proxy and radiative forcing records, suggests that these advances were driven by decreases in summer insolation. Further studies from ice cap margins and the GrIS margin are essential in order to create a full, well-developed understanding of the timing of glacier behavior during the LIA.