Estimating the style and duration of former glaciation in the mountains of Britain and Ireland

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Project aim:

- To understand rates and timing of mountain landscape evolution over multiple glacial cycles

Methods:

- We investigate all glacial cirques in Britain and Ireland (Fig. 1), and model the style and duration of glacier-occupation within each during the Quaternary (i.e., the past 2.6 Ma).

- To model glaciers, we use a simple mass balance model driven by published temperature depression data from the Greenland Ice Core Project (for the past 120 ka), and from a benthic $\delta^{18}O$ stack (for the Quaternary as a whole).

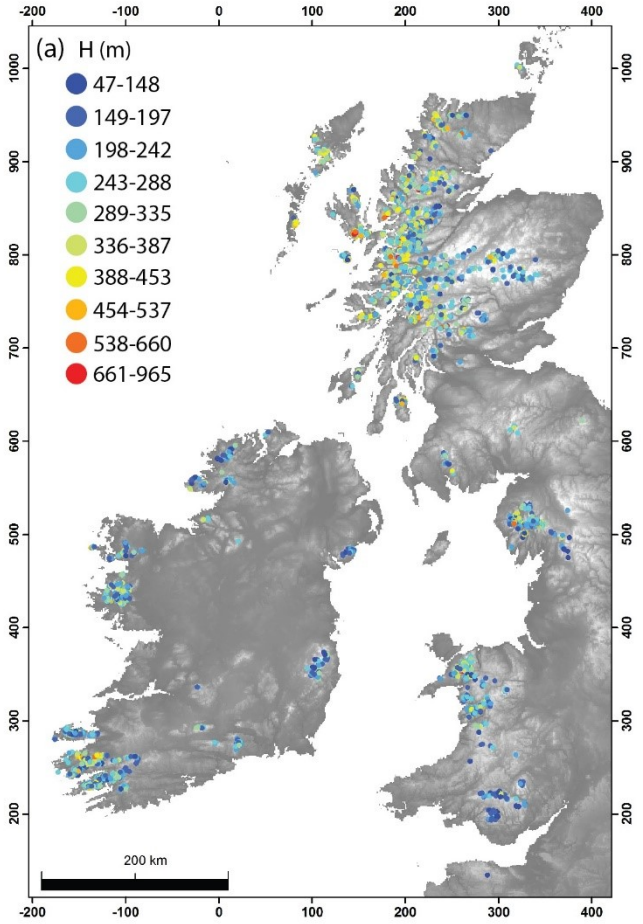

Fig. 1. All glacial cirques in Britain and Ireland, coloured according to their depth (altitudinal range)

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Results:

- During the Quaternary as a whole, on average, cirques of Britain and Ireland were:
  - Glacier-free for **1.1 ± 0.5 Ma**;
  - Occupied by small (cirque-confined) glaciers for **0.3 ± 0.2 Ma**
  - Occupied by large glaciers (including ice sheets) for **1.1 ± 0.4 Ma**.

- During the most recent glacial cycle specifically (i.e., the last 120 ka) (Fig. 2):
  - Glacier-free for **52.0 ± 21.2 ka**;
  - Occupied by small (cirque-confined) glaciers for **16.2 ± 9.9 ka**;
  - Occupied by large glaciers (including ice sheets) for **51.8 ± 18.6 ka**.

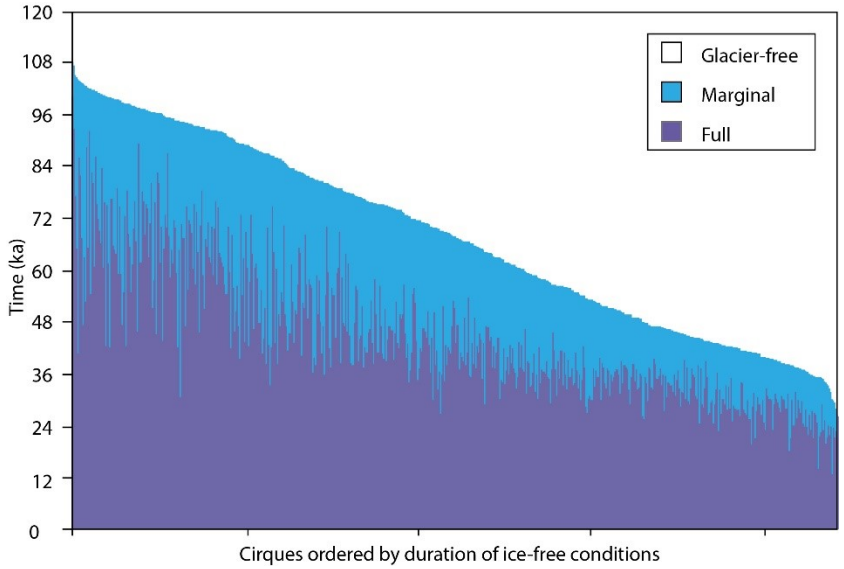

Fig. 2. Cirques classified according to the duration of the last glacial cycle (past 120 ka), that our modelling suggests they were glacier-free (white) occupied by small, largely cirque-confined, glaciers (light blue); and occupied by large glaciers (extending beyond cirque confines) (dark blue)

Discussion and conclusions:

- Comparing glacier occupation times to cirque depths reveals that **continuous cirque growth during glacier occupation is unlikely** (requiring average erosion rates of ~0.14 mm a^{-1}).

- We propose that **cirques attain much of their size during the first occupation of a non-glacially sculpted landscape** (perhaps during a single glacial cycle) (i.e., erosion rate = 1.0–25.4mm a^{-1}).

- **During subsequent glacier occupations, cirque growth may slow considerably** (erosion rate = 0.05–1.2 mm a^{-1}) because a least resistance shape develops, and subglacial sediment partly protects the bedrock.

- To show that cirques can form quickly, we highlight Tuya Butte (Fig. 3), where cirques of comparable size to those in Britain and Ireland developed in less than 140 ka.

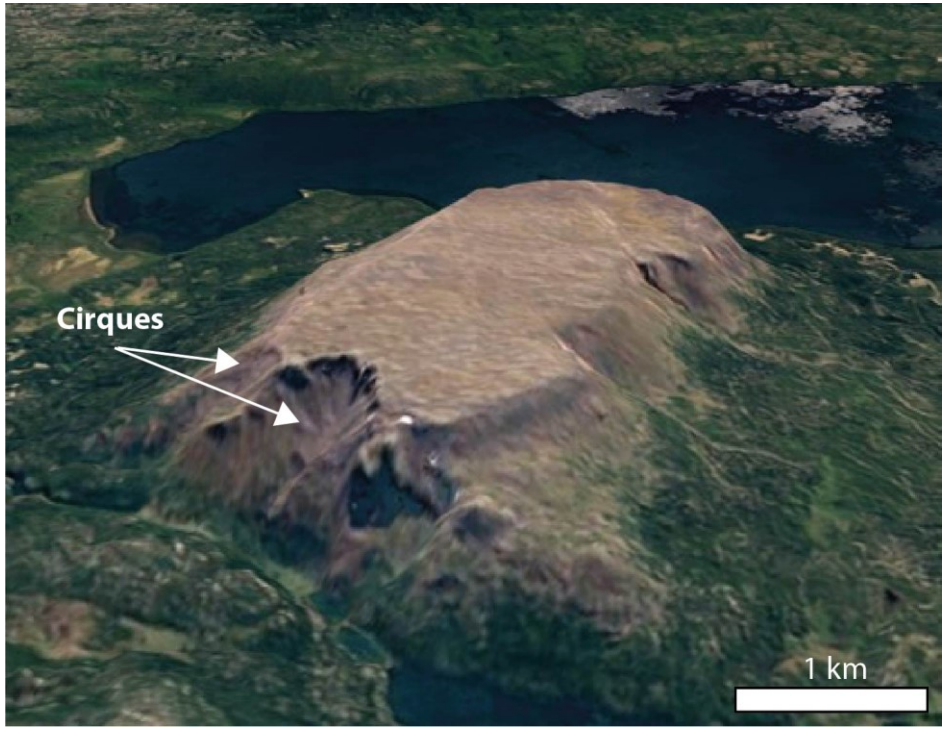

Fig. 3. Tuya Butte, northern British Columbia, where cirques of comparable dimensions to those in Britain and Ireland formed in <140 ka.

References:

- Barr, ID., Ely, JC., Spagnolo, M., Evans, IS., Tomkins, MD., 2019. The dynamics of mountain erosion: Cirque growth slows as landscapes age. *Earth Surface Processes and Landforms* **44**(13): 2628-2637. https://doi.org/10.1002/esp.4688
- DansgaardW, Johnsen SJ, Clausen HB, Dahl-Jensen D, Gundestrup NS, Hammer CU, Hvidberg CS, Steffensen JP, Sveinbjörnsdottir AE, Jouzel J, Bond G. 1993. Evidence for general instability of past climate from a 250-kyr ice-core record. *Nature* **364**(6434): 218–220. https://doi.org/10.1038/364218a0.
- Lisiecki LE, Raymo ME. 2005. A Pliocene–Pleistocene stack of 57 globally distributed benthic δ18O records. *Paleoceanography* **20**: PA1003. https://doi.org/10.1029/2004PA001071.