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Demonstration of a subglacial bedform continuum: Is a unifying formation theory required?

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Ice sheet flow organises sediment into undulating landforms called subglacial bedforms, making their genesis pertinent to understanding ice flow mechanics. Currently, there is a lack of consensus regarding their formation. An array of different theories exist which seek to explain specific types of bedform, e.g. flutes, drumlins, ribbed moraine, mega-scale glacial lineations (MSGL). In contrast, other theories appeal to the hypothesis that these landforms are actually the same phenomena that steadily vary on a scale and shape continuum and that possibly share the same mechanism of formation. Here we test the idea of a continuum by analysing the largest dataset of subglacial bedform morphometrics ever reported ($n \approx 100{,}000$). Scatter graphs of bedform size and shape metrics (length, width and elongation) reveal two separate clouds of data. The first is comprised of flutes, which form a separate distinct cluster to all other subglacial bedforms. The second, much larger, cloud of data comprises all remaining subglacial bedforms, which form a continuum of size and shape metrics. Hence, it is impossible to quantitatively differentiate previously assigned and commonly used landform labels based on their morphometry. Drumlins merge into MSGL forming subglacial lineations (aligned with flow direction), and these are adjoined to subglacial ribs (orthogonal to flow) by quasi-circular bedforms which occur within transition zones between ribbed moraine and drumlins. We interpret this as showing that a separate mechanism is required for flute generation and that the other landforms sit along a subglacial bedform continuum of ribs-circles-lineations, consistent with unifying theories for their formation.