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Drainage and Drumlins

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The morphology of drumlin fields suggests that an instability mechanism is at play in their formation, amplifying certain wavelengths on initially nearly flat ice sheet bed and shaping them into a quasi-regular assembly of landforms with identifiable characteristic sizes and shapes. Here we investigate how the interplay between a distributed drainage system, stresses at the bed induced by the flow of ice over bed topography and the evolution of bed topography can lead to a positive feedback that allows bedforms to emerge. Specifically, normal stress variations induced by ice flow over bed topography affects effective pressure and hydraulic gradient at the bed so as to re-route water flow and change the sediment carrying capacity of the drainage system in a way that causes net erosion in drumlin troughs and deposition on drumlin crests (though over time, these too may experience a slow process of net erosion). We investigate the formation of two- and three-dimensional bedforms, their final shape and internal stratigraphy, and show that the feedback under consideration provides a viable mechanism for the formation not only of drumlins but also of Rogen moraines, capable of reproducing the general morphology and internal composition of many bedforms.