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Glacial Geomorphology

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Erosional Processes and Landforms

Erosion in glacial environments shapes some of the most distinctive landforms, including striated rock surfaces, roches moutonnées, cirques and troughs, forming some of the most remarkable landscapes on Earth.

The presence of glacier ice in a drainage basin also significantly affects the development of erosional features beyond the ice boundary, such as proglacial meltwater channels. These erosional features vary greatly in scale, reflecting the influence of glacial processes over different time spans.

How Do Glaciers Originate and Move?

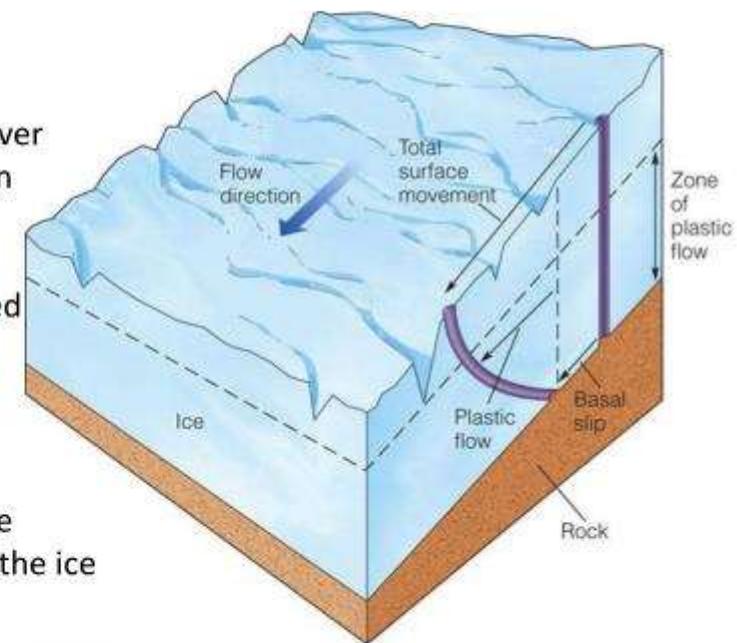
Glaciers move thru

- Basal Slip and
- Plastic Flow

If a slope is present glaciers may slide over their underlying surface, a phenomenon called basal slip

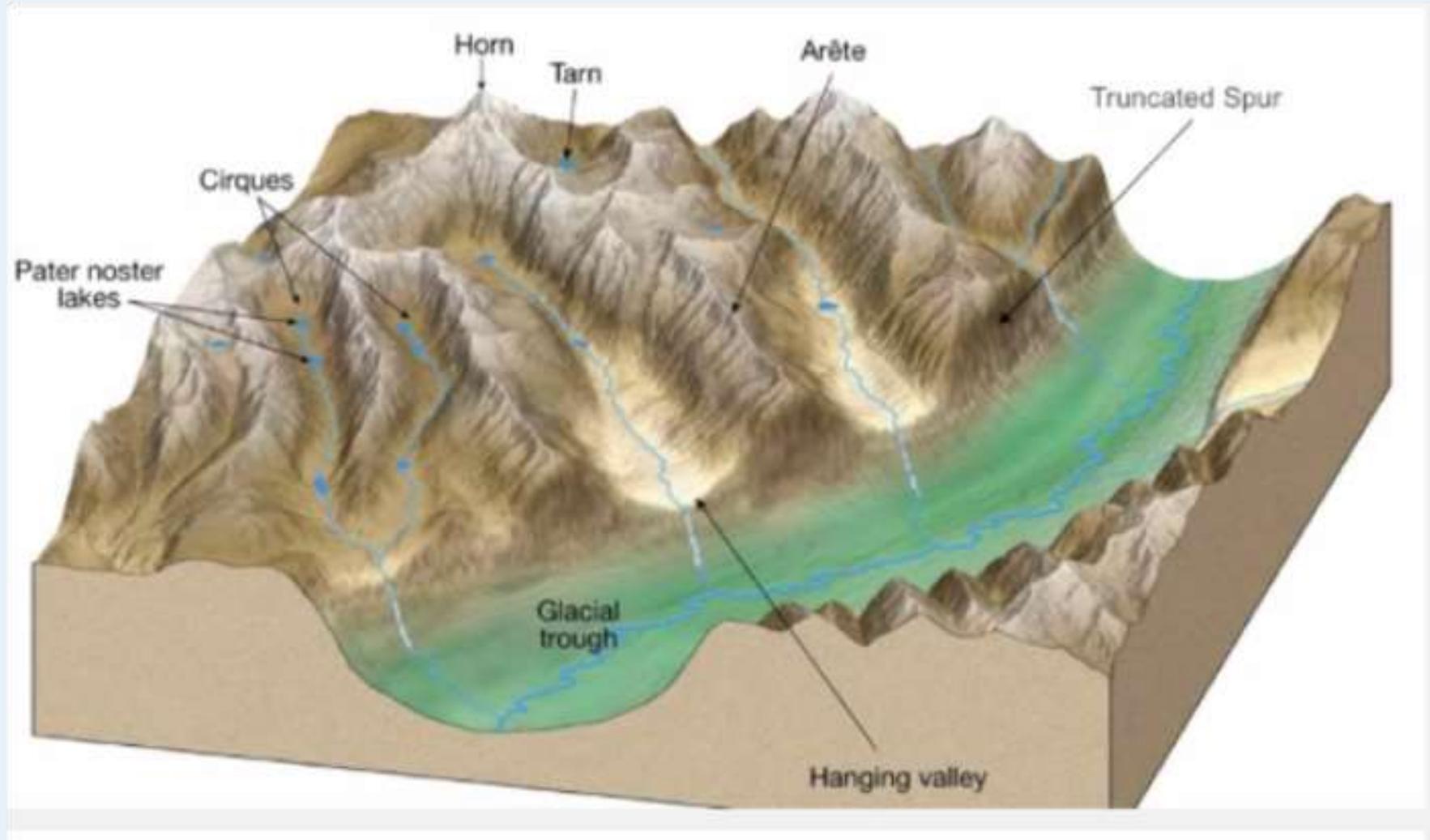
Most of their movement is accomplished by plastic flow, a type of deformation that takes place in response to stress.

In a glacier the pressure comes from the weight of the ice piled above; it forces the ice crystals to slip past one another



<https://www.slideserve.com/ellery/glaciers>

Erosional Processes and Landforms



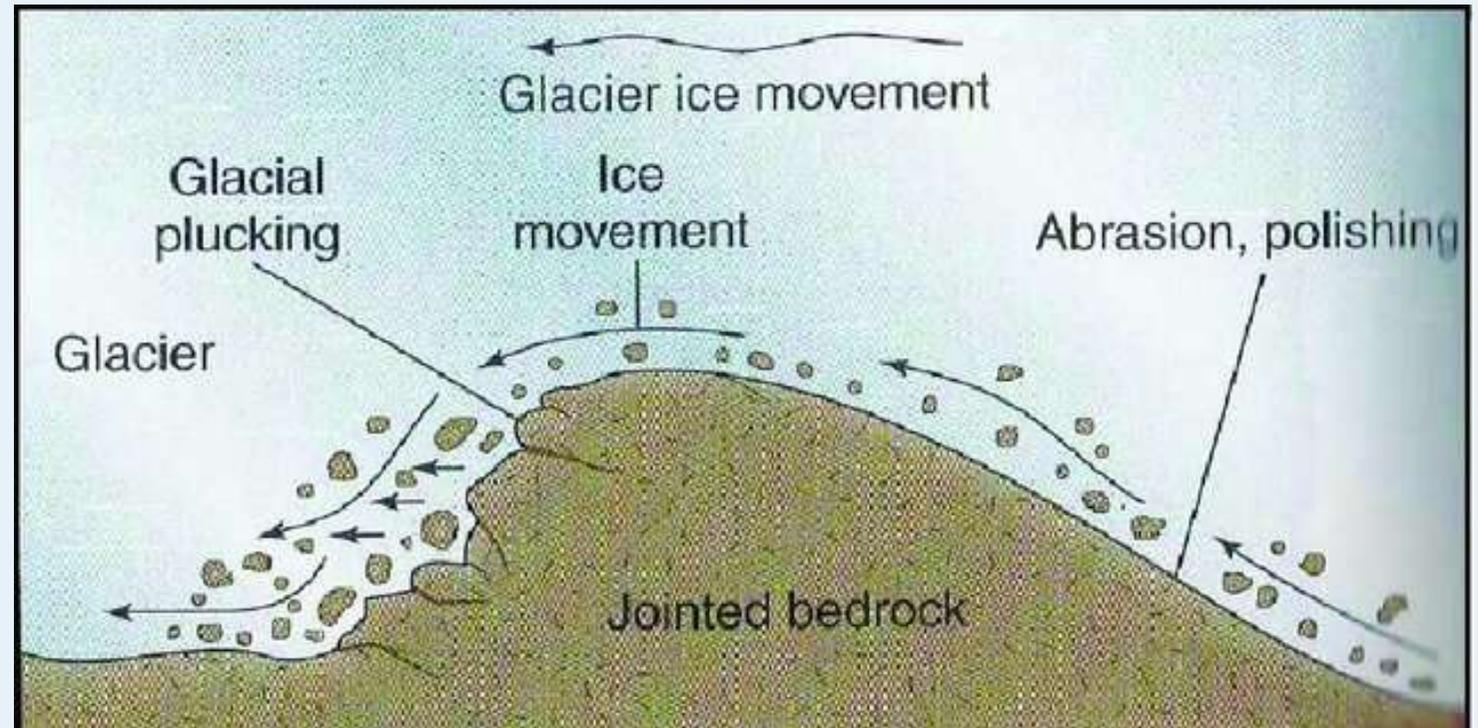
<https://geog-scitt.weebly.com/teaching-ideas/category/glacial-erosion>

Erosional Processes and Landforms

1. **Abrasion:** Abrasion is the process of wearing down rock surfaces through striation (scoring of bedrock) and polishing, where rough rock surfaces are smoothed by the removal of small protrusions.

2. **Plucking (quarrying):**

3. **Melt water:**

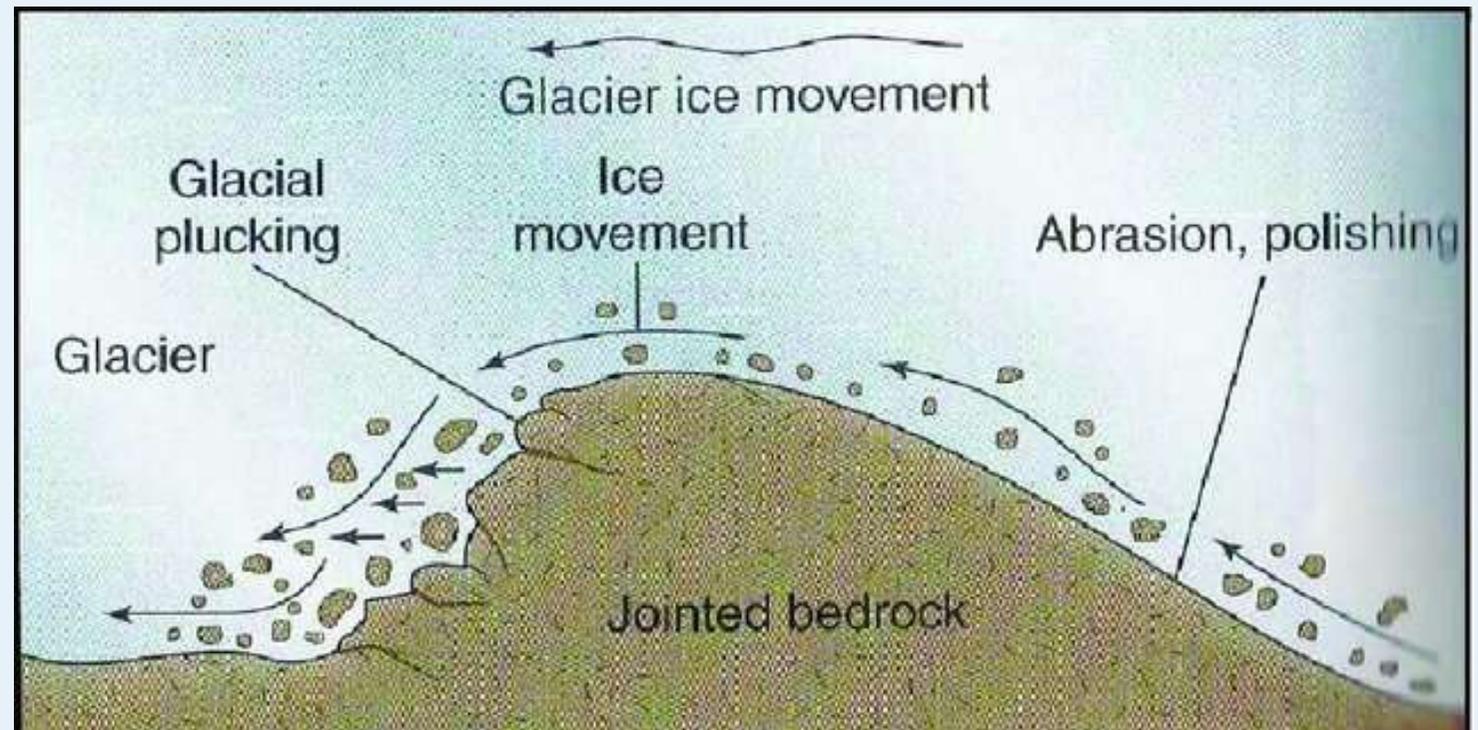


[https://www.researchgate.net/publication/361585706 Geological parameters and shear strength of dry tills from the southern half of Norway in relation to bedrock geology /figures?lo=1](https://www.researchgate.net/publication/361585706_Geological_parameters_and_shear_strength_of_dry_tills_from_the_southern_half_of_Norway_in_relation_to_bedrock_geology/figures?lo=1)

Erosional Processes and Landforms

1. Abrasion:

2. **Plucking (quarrying):** Temporary stress concentrations beneath clasts moving across the surface can widen cracks in the rock, eventually isolating fragments from the main rock mass. The arrangement of joints and other large cracks in the rock plays a major role in quarrying processes. Additionally, fractures on flat bedrock surfaces suggest that microcracks can rapidly expand under stress concentrations below clasts. Recent research on quarrying has focused on fracturing at the edge of rock steps, where large stress gradients can arise due to decreasing water pressure in cavities on the **lee** side.



[https://www.researchgate.net/publication/361585706 Geological parameters and shear strength of dry tills from the southern half of Norway in relation to bedrock geology/figures?lo=1](https://www.researchgate.net/publication/361585706_Geological_parameters_and_shear_strength_of_dry_tills_from_the_southern_half_of_Norway_in_relation_to_bedrock_geology/figures?lo=1)

3. Melt water:

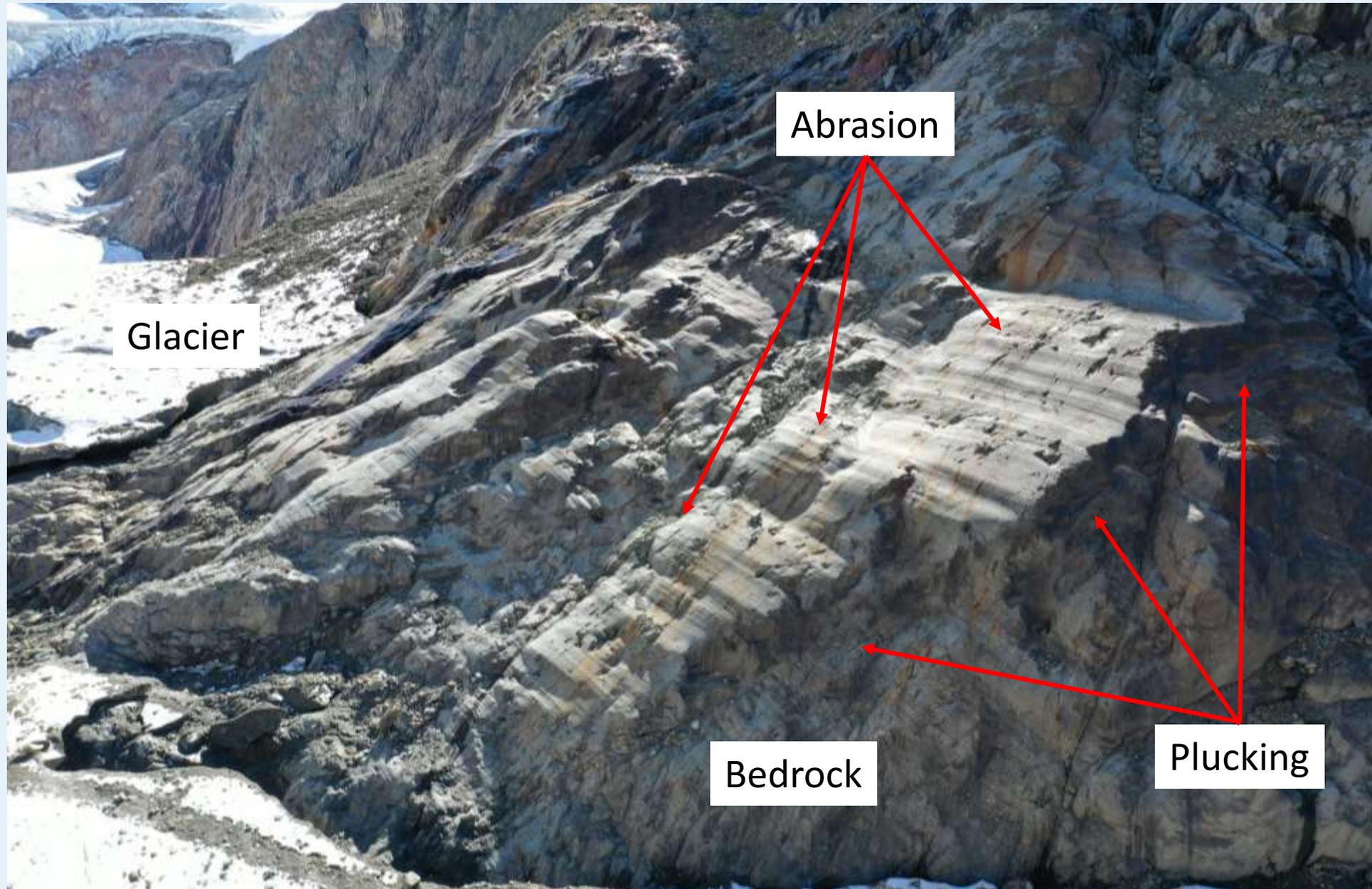
Erosional Processes and Landforms

Chattermarks / crescentic gouges (Small-scale forms)

Fracture marks or cracks in bedrock show evidence of rock flakes being removed by subglacial quarrying. These fractures are often called chattermarks, crescentic gouges, crescentic fractures, conchoidal fractures or lunate fractures. Chattermarks are crescent-shaped cracks, usually a few centimeters wide, with the open or concave side facing down-ice. They often appear as a series of closely spaced fractures nested together, formed by repeated fracture events beneath a single passing rock fragment, possibly linked to 'stick-slip' movements of the overriding ice.



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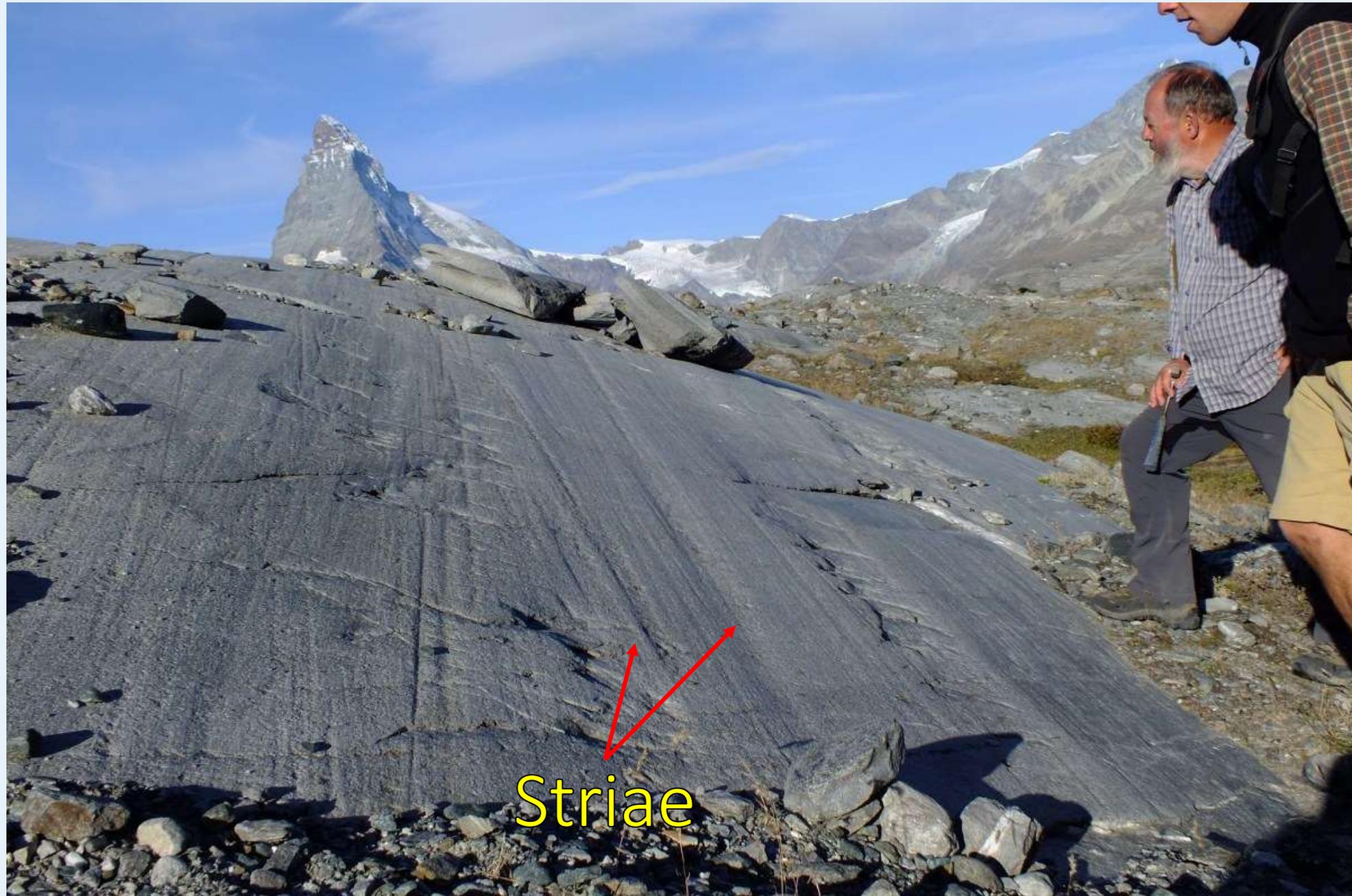
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Erosional Processes and Landforms

Striae and polished surfaces (Small-scale forms)

Striae (singular: striation) are scratches carved into the surfaces of bedrock or clasts, widely recognized as evidence of scoring by particles embedded in glacier ice. They are a direct result of subglacial abrasion. Striated rock surfaces often show polished areas that, when examined under a microscope, reveal a surface covered with densely spaced micro-striae.



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Striae and polished surfaces (Small-scale forms)



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Striae and polished surfaces (Small-scale forms)



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Striae and polished surfaces (Small-scale forms)





The orientations of striae can vary significantly across a single rock outcrop. On ***flat upper surfaces***, striae are usually parallel to one another, with only slight deviations from the average ice flow direction. In contrast, striae on ***irregular surfaces*** tend to show much greater variation, influenced by inconsistencies in the glacier's basal flow.



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Striae and polished surfaces (Small-scale forms)



















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Roches Moutonnées

Roches moutonnées are asymmetrical bedrock hills with smooth, abraded faces on the up-ice (stoss) side and fractured, quarried faces on the down-ice (lee) side. Their size varies from less than 1 meter to several hundred meters across.

Striae are common on the stoss sides, except on steep surfaces facing the glacier, while both striae and friction cracks appear on gently sloping stoss surfaces.

Polished areas are found along the sides and gentle slopes of the lee side, whereas plucked surfaces are located on steep, downglacier-facing parts.



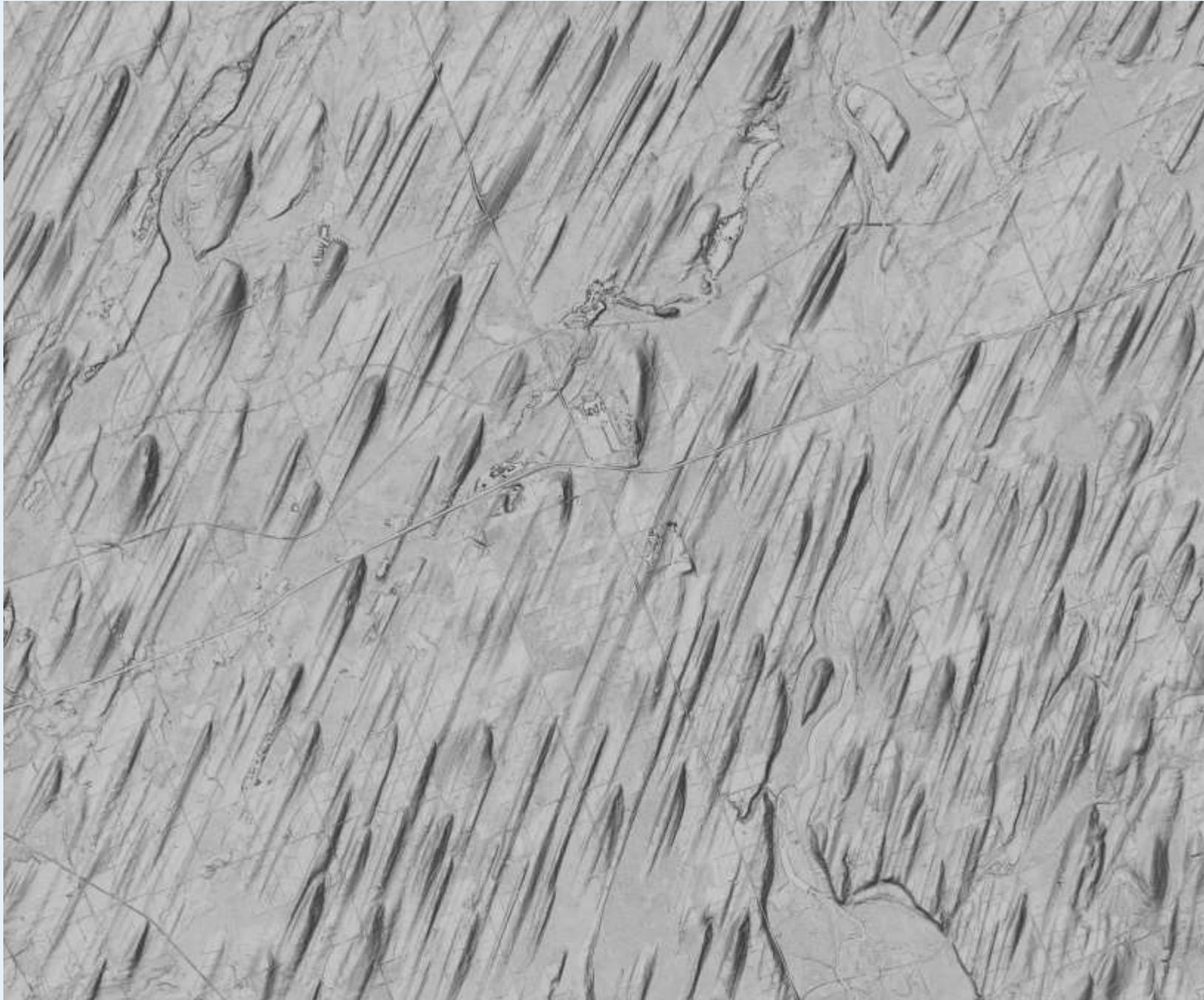
Whalebacks and Rock Drumlins

Whalebacks and rock drumlins are elongated, smooth bedrock formations that, unlike roches moutonnées, lack quarried faces on their down-ice (lee) sides.

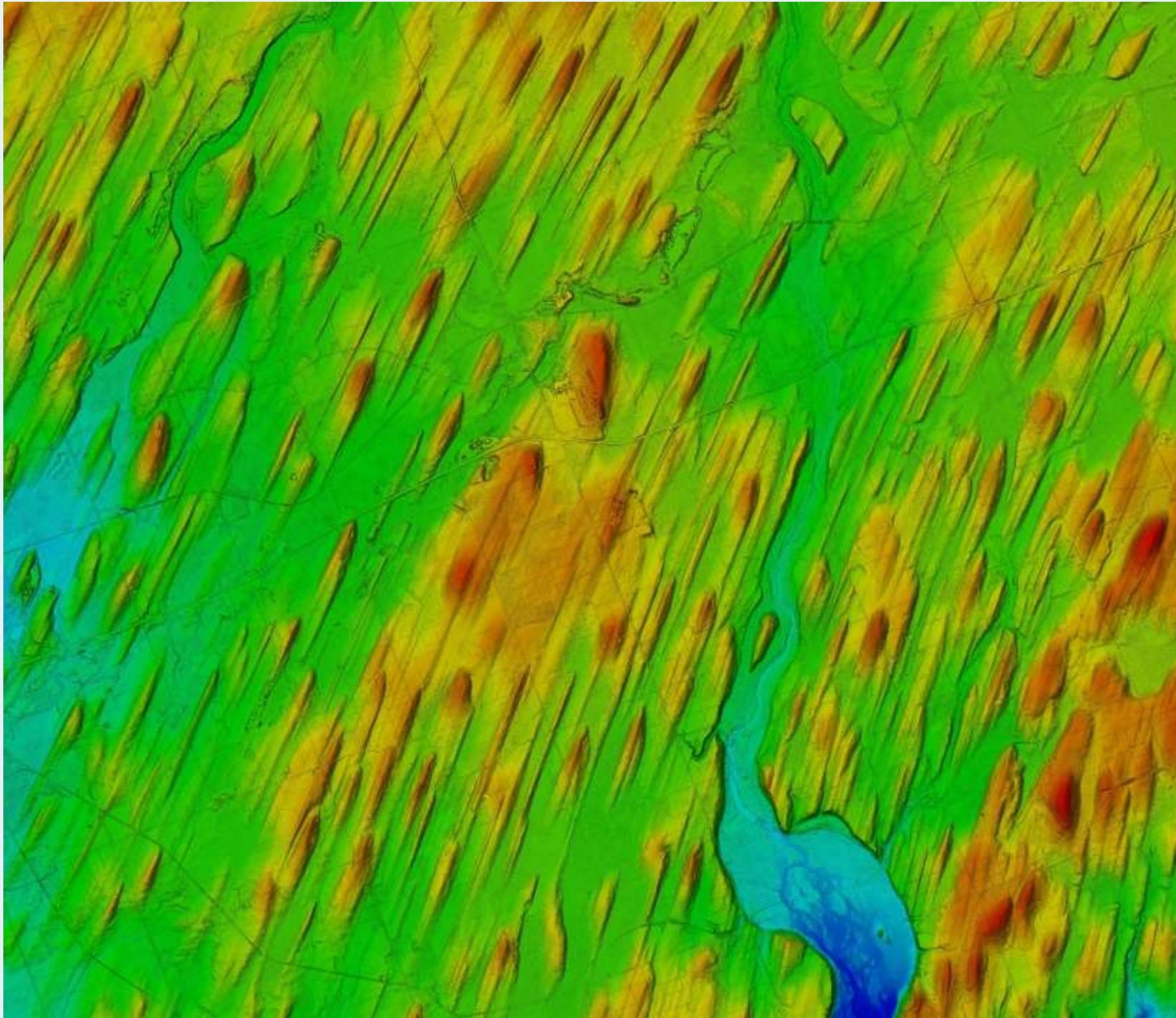
Whalebacks are roughly symmetrical and resemble whale backs breaking the ocean surface, while rock drumlins are asymmetrical, with steeper stoss (up-ice) sides and gently sloping lee sides. Both types often feature numerous striae and friction cracks.

The absence of quarried lee faces in whalebacks and rock drumlins suggests that low-pressure cavities didn't form under the glacier during their creation. Cavity formation is prevented under thick ice with high overburden pressure, allowing abrasion to occur evenly across the bed and creating smooth, symmetrical whalebacks. Whalebacks are formed best under ice that is 1–2 km thick but can develop under ice a few hundred meters thick. In contrast, asymmetrical rock drumlins likely form when abrasion is concentrated on the stoss side, with abrasion and plucking limited on the lee side.

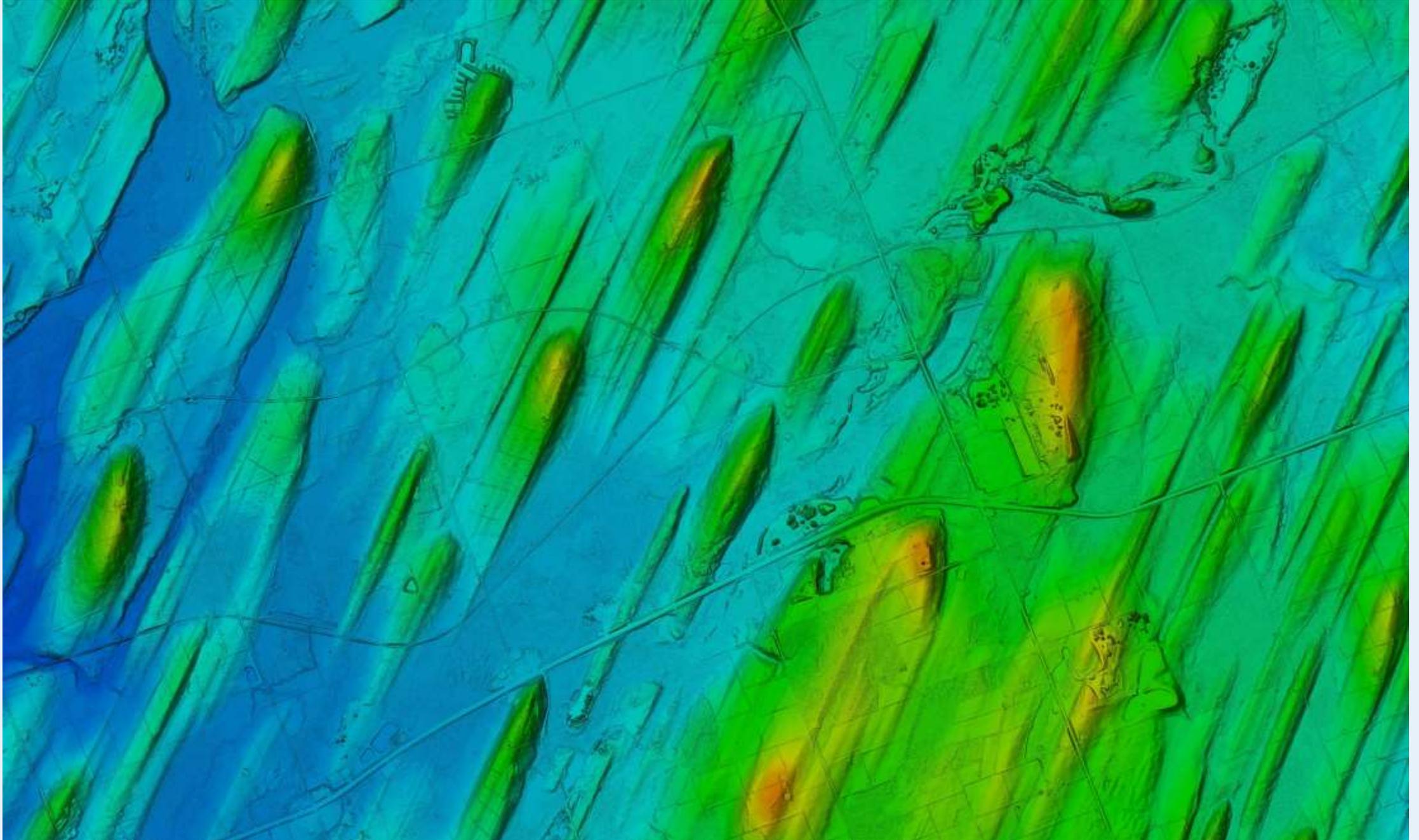
Whalebacks and Rock Drumlins



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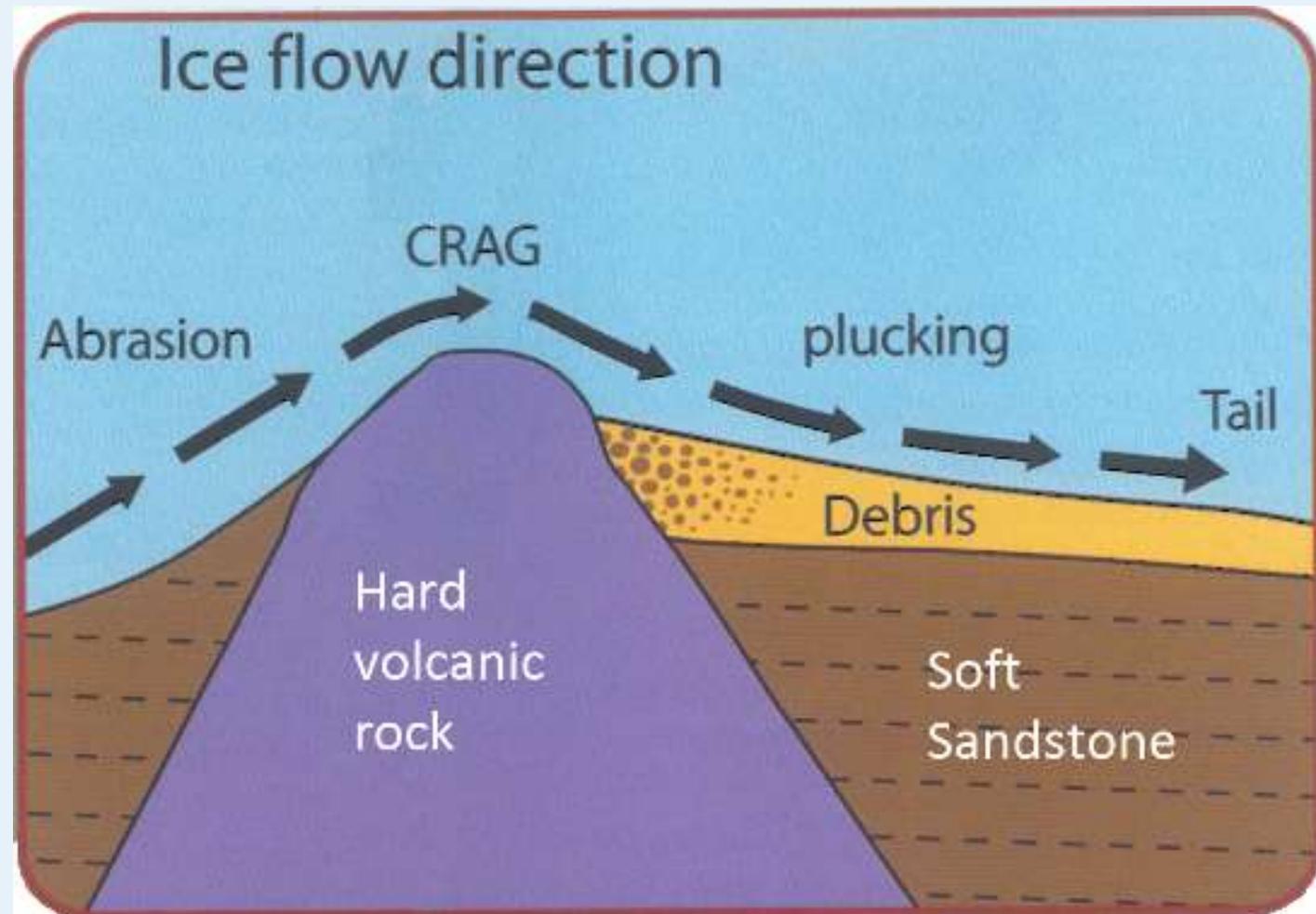


Whalebacks and Rock Drumlins



Crag and Tail

Erosional crag and tails are elongated, streamlined hills with a resistant bedrock crag at the up-ice end and a tapering tail of softer rock extending down-ice. These features form as ice flows around the obstacle, shielding the 'tail' from erosion. A classic example of a crag and tail is Edinburgh Castle and the Royal Mile.



<https://www.dundeelaw.info/timeline>