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Constraints on the glacial erosion rule

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It is thought that glaciers erode their underlying bedrock mainly through abrasion and quarrying. Theories predict erosion to be proportional to ice-sliding velocity raised to some power:

$$\dot{e} = K_g u_s^l \tag{1}$$

where $\dot{e}$ is the erosion rate, and K_g a proportionality constant and l an exponent. By implementing such a rule in numerical models, it has been possible to reproduce typical glacial landscape features, such as U-shape valleys, hanging valleys, glacial cirques or fjords. Although there have been great advances in the level of sophistication of these models, for example through the inclusion of high-order ice dynamics and subglacial hydrology, the proportionality constant, and the exponent have remained poorly constrained parameters. Recently, two independent studies in the Antarctic Peninsula and Patagonian Andes (Koppes et al., 2015) and the Franz Josef Glacier, New Zealand (Herman et al., 2015) simultaneously collected erosion rate and ice velocity data to find that erosion depends non-linearly on sliding velocity, and that the exponent on velocity is about 2. Such a nonlinear rule is appealing because it may, in part, explain the observed variations in erosion rates globally. Furthermore, an exponent about 2 closely matches theoretical predictions for abrasion. Although it is tempting to argue that abrasion is the dominant process for fast flowing glaciers like the Franz Josef Glacier, there is a clear need for more data and better quantification for the role of quarrying. Both studies also led to very similar values for the proportionality constant K_g. These new results therefore imply that glacial erosion processes might be better constrained than previously thought. Given that glacial velocity can nowadays be measured and modeled at an unprecedented resolution, it may potentially become possible to use glacial erosion models in a predictive manner.

Herman, F. et al. "Erosion by an Alpine glacier." *Science* 350.6257 (2015): 193-195.

Koppes, M. et al. "Observed latitudinal variations in erosion as a function of glacier dynamics." *Nature* 526.7571 (2015): 100-103.