Earth Surf. Dynam. Discuss., 3, C350–C353, 2015
www.earth-surf-dynam-discuss.net/3/C350/2015/

Earth Surface Dynamics Discussions
Open Access

Interactive comment on "Efficacy of bedrock erosion by subglacial water flow" *by* F. Beaud et al.

JD Jansen (Referee)

john.jansen@uni-potsdam.de

Received and published: 11 October 2015

1. General comments

This is, in my view, a good piece of work. I enjoyed the reading and learned quite a bit along the way. The authors have implemented a thoroughly readable set of mathematical experiments that also serve those interested in bedrock erosion beyond the modelling community. As they note, subglacial meltwater erosion has been described for decades but not yet examined via a mechanistic model. This is the first comprehensive attempt and involves a well established fluvial abrasion model (initially two) modified for the subglacial environmentâĂŤgranting a high level of novelty and a potentially significant contribution to ESurf. The work builds upon a previous study involving the two senior authors (Beaud et al. 2014, Geomorph.), which focuses upon abrasion and

quarrying associated with sliding ice and not meltwater erosion dealt with here.

The research questions are set out clearly at the close of the Intro, then revisited and answered in the Discussion, and the step-by-step building of model complexity is especially good. Given the model's basis the findings are not a surprise: channelised rather than distributed drainage is most effective at carving bedrock, with relative sediment supply being the principal control on rates followed by hydraulic potential gradient (a function of ice geometry). The presentation of results is clear and concise, figures are good, and the efficient use of the Supp. keeps the clutter down. The referenced literature is adequate with an emphasis on more recent work.

I have few criticisms of this well constructed MS, but should make it clear that my expertise is with recognising and measuring the effects of fluvial/subglacial bedrock erosion, not with modelling such processes mathematically. I gained most out of this MS by considering the implications for field observations and I leave it to others to scrutinise the fine-grained details of the model implementation.

2. Specific comments [page:line]

[852:25] For the benefit of those outside the bedrock channel community, it might be useful to outline the 'tool and cover effect' more fully here; i.e. the modulation of bedrock erosion rate stemming from the balance between the supply of grains acting as erosional tools and the fraction of the bed exposed to impacts. Some explanation appears later (859:11-14), but something earlier and more explicit is preferable.

[853:5] Given that previous work (Beaud et al. 2014) shows that abrasion and quarrying processes reflect quite different governing roles for sliding versus hydraulic potential gradient, are some important dynamics being missed here by excluding quarrying from this analysis of meltwater erosion? It might be useful to discuss the ramifications of this omission.

[853:10-15] The enhanced erosional potential towards the ice margin is consistent with

ESurfD

3, C350–C353, 2015

the scenario described by Jansen et al. (2014) for inner gorges in N Sweden where incision is also attributed to meltwater during rapid deglaciation. The Swedish gorges stood within 100 km of the ice margin for ∼100–170 y, and thus their dimensions (20–35 m deep, and ∼100 m wide) lend some plausibility to the maximum incision rates (50-200 mm/y) predicted by the incision model (okay, that's enough self-promotion!).

[854:21] Greater subtlety concerning the question of inner gorge formation would be well placed here. Preservation of gorges through multiple glaciations, as advocated by Montgomery and Korup (2011), applies well to some localities but not others. For instance, postglacial inner gorge incision is demonstrated by McEwan et al. (2002, Arct. Antarct. Alp. Res.), and Schlunegger and Hinderer (2003, Terra N.), as well as the cited example of Valla et al. (2010).

[855:4-6] Genetic relations between these species of bedrock channel might be largely a proximal-distal issue: inner gorges reflecting the topographic confinement found in mountain areas whereas tunnel valleys seem restricted to open distal lowlands.

[857:1-2] Is this a fair assumption? Accommodating the growth of channel dimensions over time would seem to be an important part of a dynamic model.

[876:20-23] Egholm's iSOSIA might be ideal for this purpose.

[878:8-13] This is an interesting speculation. Could this approach be usefully inverted to explore the origins of certain of over-deepenings?

[879:6-15] One point possibly worth considering is that, unless erased by fast sliding ice, inner gorges are typically deepened progressively over successive glaciations. The erosion rates cited here might produce metre-scale channels, but a bedrock slot deepened over several glaciations would presumably exert some important preconditioning on subglacial meltwater conveyance. Perhaps the effect of inherited bedrock slots could be incorporated into future modelling efforts.

3. Technical points

ESurfD

3, C350–C353, 2015

[852:9] Perhaps stipulate what is meant by ‘equilibrium’ here.

[853:4] Lamb and Fonstad (2010) documents a rather small canyon. For something big perhaps Baynes et al. (2015, PNAS) would be more appropriate?

[855:13-14] This clear terminology is most welcome.

[859:10] This is incorrect; quarrying/plucking is by far the most widespread and efficient mechanism of fluvial bedrock erosion (because densely-jointed bedrock is predominant in most landscapes). Whipple et al. (2000, p. 493) states this, along with numerous others.

[862:4] ‘Linear’ with/to what? Neglecting downstream-fining is a major simplification. Is it possible to infer some effects based on the experiments in which grain size is changed?

[876:23-26] An ugly sentence, better rephrased.

[876:26] Change to ‘subglacial’.

John Jansen, Potsdam.

Interactive comment on Earth Surf. Dynam. Discuss., 3, 849, 2015.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper