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Interactive
Comment

Interactive comment on "Hitting rock bottom: morphological responses of bedrock-confined streams to a catastrophic flood" *by* M. Baggs Sargood et al.

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We thank Jens Turowski for reviewing our paper and have have made most of the suggested changes to the manuscript which hopefully improves the clarity. It was always our intention to submit a relatively simple quantification of the effects of a rare event in a low sediment supply landscape with large hydrological variability. We hope the corrections, if accepted, in the revised version highlight that such landscapes behave very differently with regards to frequency of mobilisation and frequency of potential abrasion. We think this may have important implications for the documented long term rates of drainage incision as characterised on the Australian craton. We address each of the comments below:

The manuscript describes an interesting case study for the effect of large floods on bedrock channels. However, there are a number of points that need to be clarified and elaborated on.

Introduction: There is some important recent literature that could be included to set up the paper. For suggestions (not exhaustive) see the detailed comments.

RESPONSE: We have taken these comments on board and diversified the literature cited within the manuscript and included many of the suggestions.

Methods: The information on methods is sparse in places. I would welcome more information; for example on the lidar processing and the grain size measurements (see minor comments and below). The meteorological and geomorphic information is incomplete in places (see detailed comments).

RESPONSE: We have improved the detail within the methods and provided the reader with a better appreciation of the limitations of the technique.

Grain size distributions: the calculations of initiation of motion rely on various percentiles of the grain size distribution. I wonder how accurate the measurements are. It is well known that the sample size needs to adjusted to the largest clast on the bed (see e.g., Church et al., 1987, River bed gravels: sampling and analysis, in Sediment transport in gravel-bed rivers). With boulders of at least 1.7m in diameter (page 1104,line 26) or larger (4.8m, page 1105, line 1), I have doubts that point counts including a hundred pebbles give accurate estimates of the D90. The photographs in Figure 3 also suggest a very coarse bed. I also wonder how the authors dealt with fines and what the smallest grains were that they considered (with regard to establishing D16).

RESPONSE:We now provide a better description of the data itself (Table 2 expanded to include all grain size parameters) and acknowledge the potential limitations of the modified pebble-count technique. Due to the remote location of the study area it was

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not feasible to undertake a volumetric analysis but the poorly organised bars were assessed using a line intersect technique, avoiding large outliers which are seen in Figure 3. Measurements were taken down to 2 mm (granules). The authors are aware of the limitations as outlined by Church et al., (1987) and now at least place some caveats on the data.

Conceptual model: The treatment of the conceptual model depicted in Figure 7 is a bit thin at the moment. The model needs to be described in more detail in the text, explaining the different stages. In particular, it would be interesting to discuss when the bulk of the bedrock erosion is actually happening, during the extreme events or during subsequent small floods that are able to attack the exposed bedrock. Further, the model should be contrasted with other models in the literature, such as ones proposed in the papers by Yanites et al. and Turowski et al. (which are cited elsewhere in the current manuscript), the model results discussed by Lague, JGR, 2010, Reduction of long-term bedrock incision efficiency by short-term alluvial cover intermittency, or the conceptual framework by Hovius and Stark, 2006, Landslide-driven erosion and topographic evolution of active mountain belts, in: Landslides from Massive Rock Slope Failure, NATO Science Series (their fig. 5). The effects of small versus large events could also be better treated.

RESPONSE: In the discussion we have addressed the how the proposed conceptual model adds to the understanding of the evolution of mountain streams with particular reference to low-supply landscapes. We have added detail to this section and engage with the role of smaller floods which is an issue raised by Paul Carling.

Page.line

1096.21 Bedrock channels: : : I suggest to add 'typically' to this sentence, as not all small streams have highly variable flow regimes (e.g., in small glaciated catchments),or resistant boundary conditions (e.g., highly fragmented or weak bedrock). Corrected

1096.25 some work of Baker could be cited here (e.g., Baker and Kale, The role of

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extreme floods in shaping bedrock channels, in: Rivers over Rock, 1998). Included

1097.6 There is some important recent literature that could be informative here from a modelling point of view. See for instance Lague et al., JGR 2005, Discharge, discharge variability and the bedrock channel profile, Lague, JGR 2010, Reduction of long-term bedrock incision efficiency by short-term alluvial cover intermittency, Molnar et al. JGR 2006, Relationships among probability distributions of stream discharges in floods, climate, bed load transport, and river incision, Snyder et al., JGR 2003, Importance of a stochastic distribution of floods and erosion thresholds in the bedrock river incision problem.

RESPONSE: We now have included a section within the introduction that engages with the modelling that has been undertaken on the effects of cover and the research that investigates flood frequency, sediment transport and river incision over longer time frames.

1100.12 What was the total rainfall of this second event?

RESPONSE:We have included details on the 2013 rainfall event within the text.

1102.5 For a recent review of flow velocity in mountain streams using a large field data compilation, see Rickenmann and Recking, WRR 2011, Evaluation of flow resistance in gravel-bed rivers through a large field data set. RESPONSE: We have revisited Rickenmann and Recking (2011) and checked against our estimates for Mannings n. Rickenmann and Recking (2011) make the valid point that the Manning-Strickler equation underperforms in the intermediate and large-scale roughness domains with small relative flow depths. Whilst the three field reaches are rough channels the ratio of estimated flow depth for the 2011 event relative to Dmax (6– 8 m:1.6 -1.0 m) is considered suitable for the techniques employed. Thankfully this is corroborated by basin-wide 2D modelling done for the 2011 event which we use as a calibration control for the downstream reach.

1103.10 Should be Eq. 6? Corrected

1103.13 What was the point density in the LiDAR measurements? What was the spatial resolution of the DEM? How was the gridding performed?

RESPONSE: We have now inserted much more detail of the DEM analysis into the Methods section.

1103.16 The method used to construct the error surface needs to be described in more detail. Corrected

1103.22 How did this normalization procedure affect error estimates? RESPONSE: We have now inserted a statement within the Methods (Section 3.3) about the potential uncertainty introduced by the normalisation technique. We cannot develop an approach that utilises a spatially variable error surface for the DEMs as we have insufficient metadata for the LiDAR to do this. As such we have assumed a uniform error surface across each DEM. Regardless of whether we use a minimum level of detection approach or a probabilistic approach the patterns of erosion both within a reach and between reaches stays the same, with the only change being the absolute values.

1104.12 It is unclear to me how much of the erosion is actual bedrock erosion and how much is the mobilization of sediment. A clear statement to clarify this would be helpful.

RESPONSE: We have inserted a statement to this effect at the end of this section.

1106.17 The term 'bedrock-confined' has been precisely defined by Meshkova et al., 2012, Nomenclature, complexity, semi-alluvial channels and sediment-flux-driven bedrock erosion, in: Gravel bed rivers – processes, tool, environments. I doubt that this precise use of the term has been taken up in the community, and it would benefit from a definition here. RESPONSE: We have actually chosen to use the term semi-alluvial to describe such settings following on from Meshkova et al., (2012)

1106.26 In my opinion this is too much interpretation for the results section. RESPONSE: We have modified this sentence to better reflect a results section.

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1107.13 abut? We have replaced this term to improve clarity. 1108.4 the word 'modern' seems misplaced here. Removed. 1108.13 'Alluvial overprint' refers to the behavior of a stream as an alluvial streams for instance by meandering, anastomosing, building step-pool units etc. in the sediment mantle overlying the bedrock. The presence of a sediment mantle itself is not the alluvial overprint. The alluvial overprint is not the cover, but occurs in it. See Meshkova et al., 2012, Nomenclature, complexity, semi-alluvial channels and sediment-flux-driven bedrock erosion, in: Gravel bed rivers – processes, tool, environments, and Turowski et al., ESPL 2013, Large floods, alluvial overprint, and bedrock erosion.

RESPONSE: We have modified our use of the term alluvial overprint to reflect these suggestions and are in keeping with suggestions from reviewer 1. In the manuscript we now highlight that the formation of coarse-grained bedforms (steps, cascades, bars etc) represent the alluvial overprint. In the discussion we have distinguished this from the cover effect.

1108.13 Please distinguish precisely between the cover effect, the alluvial overprint, and the overprint effect. Seidl and Dietrich were not concerned with the cover effect, and the citation is inappropriate here. For other work on the cover effect see for example Turowski et al., JGR 2007, Cover effect in bedrock abrasion: A new derivation and its implications for the modeling of bedrock channel morphology.

RESPONSE: We have removed the citation to Seidl and Dietrich and included reference to the Turowski (2007) paper.

1108.24 The year of the reference should be 2013. Corrected 1108.24 The interesting question here is for me: was bedrock exposed, allowing bedrock erosion, DURING the flood? The mantle of alluvium in 85% of the reach could be due to deposition in the waning part of the hydrograph. Using the threshold-based model by Turowski et al. 2013 referred to earlier in the paragraph, such behavior would be expected. RESPONSE: We agree with the reviewer but cannot accurately constrain whether the alluvial cover was indeed deposited in the waning stages of the 2011 flood. We presume based on the poorly organised loose character of the material that indeed the cover was emplaced during the falling stages of the 2011 flood. We think the frequency of such events is extremely low based on the pre-flood channel geometries and the mature vegetation multi decades in age growing on the sediment cover. When this is coupled with low background sediment supply rates, stable hillslopes we would expect that events like the 2011 flood is a rare opportunity for the bedrock to undergo physical abrasion.

1109.19 Large boulders are often mobilized due to scouring at their downstream side, rather than due to hydraulic lift and drag. The equation for the threshold of motion do not account for this process.

RESPONSE: We agree and have included a comment to this effect in the discussion.

C5301111.7 The conceptual model needs to be better explained in the text. The implications of the model for our thinking about bedrock channels need to be discussed. 1111.10 The 3 phases should be explained. The argument needs to be elaborated.

RESPONSE: We have expanded this section to better explain the implications for low sediment supply settings, such as the one presented here.

1111.16 See also Turowski et al., ESPL 2008, Distribution of erosion across bedrock channels. The literature on the debate over incised meanders could also be informative (e.g., Shepherd, Science 1972, Incised River Meanders: Evolution in Simulated Bedrock). 1112.8 anecdotal Corrected Table 2: In addition to D50, the authors used D16, D84 (both eq. 6) and D90 (eq. 1) for their calculations, but not D94. Dmax is frequently referred to in the text (also table 3), but is not given either. I suggest to include the values actually used in the paper into the table. Corrected – Table 2 now includes all relevant grain-size data

Fig. 6b: I find the figure way too small to read both on the screen and in the printout.

I suggest to separate this plot from the erosion map and treat it as a separate figure. Please also include error bars in the figure.

RESPONSE: We have re-done the analysis using multiple minLoD thresholds and re-present the normalised erosion data as a separate figure as requested complete with error bars(see a draft example in the attached figure).

Interactive comment on Earth Surf. Dynam. Discuss., 2, 1093, 2014.

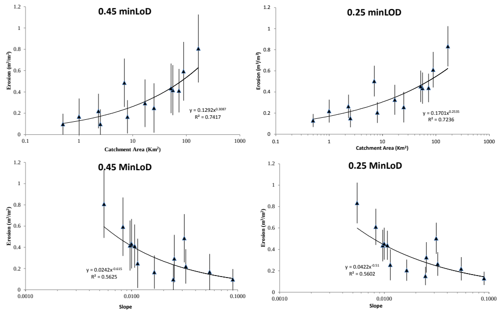
0.45 minLoD
Erosion (m³/m²)
y = 0.1292x^0.3087
R² = 0.7417
Catchment Area (Km²)
0.25 minLOD
Erosion (m³/m²)
y = 0.1701x^0.2535
R² = 0.7236
Catchment Area (Km²)
0.45 MinLoD
Erosion (m³/m²)
y = 0.0242x^-0.615
R² = 0.5625
Slope
0.25 MinLoD
Erosion (m³/m²)
y = 0.0422x^-0.51
R² = 0.5602
Slope

Fig. 1.