Authors' Response to Reviews of

"Old orogen - young topography: Lithological contrasts controlling erosion and relief formation in the Bohemian Massif"

Jörg Robl et al.
ESURF,

RC: ***Reviewers' Comment***, AR: Authors' Response

Dear reviewer,

Thank you for taking the time to evaluate our manuscript and for providing valuable suggestions for improvement. We are pleased that the review did not question the applied methods and results. However, after reading the review, we realized that we had overlooked several structural problems in the presentation. We think that this is also the reason why several aspects were understood differently from what we wanted to present. We are confident that we can solve the problems mentioned and are ready to improve the manuscript accordingly so that it is suitable for publication in ESURF.

Raised issue: The first major point of criticism is the 'inconsistency between the goal of this study and the presentation of the results'. After carefully reading the article again from this point of view, we can understand the criticism. This problem, as well as other major issues described in the review, arise from the introduction, where the research question is not stated clearly enough.

Planed task 1: We will rewrite the introduction and explain the research question in general terms before we characterize our study region: Our aim is to understand the effect of strong erodibility contrasts between the cover sediments and the crystalline basement on the evolution of topographic patterns and erosion rates during inversion (uplift) of a peripheral foreland basin. A situation with easy-to-erode sediments overlying hard-to-erode bedrock, where rivers remove the cover sediments and reach the bedrock with progressive uplift, can be observed on the periphery of many mountain ranges and leads to characteristic topographic patterns.

Planed task 2: We will take up the suggestion of reviewer 2 and draw a cartoon to accompany the new introduction on the evolution of the landscape in such a geological setting.

Raised issue: As a part of the first major point of criticism, the lack of separate morphometric analyses for different bedrock types and for different landscape geometries is criticized. Our focus on simple catchment-averaged topographic metrics is motivated by the fact that erosion rates based on the concentration of cosmogenic nuclides are also averaged and represent a mixed signal of different types of rocks and landscape geometries. In general, this signal can hardly be disentangled either. A splitting of the regions according to topographic features (e.g. manual mapping of low relief surfaces) or the splitting of the regions into different bedrock types makes little sense in this respect.

Planed task 1: Explanatory paragraphs at the end of the introduction and in the description of the correlations between erosion rate and catchment-wide metrics explaining why catchment-wide topographic metrics are useful in this study.

Planed task 2: A better integration of the figures and the extensive table in the supplement to demonstrate differences in topographic metrics between catchments dominated by the crystalline basement and those dominated by the sedimentary cover (Aschach catchment).

Planed task 3: A better integration of and referencing to the pilot study we conducted (Wetzlinger et al., 2023), where a detailed morphometric analysis is shown. However, showing the figures of the spatial distribution of the topographic metrics again in this paper seems not be be very useful to us.

Planed task 4: Accompanied by a new figure (cartoon), we will explain in the introduction, which topographic patterns we expect at the transition from sediment to crystalline bedrock and how these patterns change over time: the transition from sedimentary to crystalline bedrock leads to transient conditions in both the fluvial channels and the hillslopes. Consequently, the topographic metrics within crystalline bedrock-dominated regions show a high degree of variance, as we also show in our figures. The change from cover sediments to basement rocks will continue to have an effect for a long time as erosion progresses until the river geometry has adjusted to the new substrate properties. This can be seen very clearly in the Aschach catchment, where the knickpoint in the longitudinal river profile is located within the basement bedrocks and not further upstream at the transition from basement to cover rocks. The removal of the sedimentary covers down to the basement is significantly faster than establishing an equilibrium longitudinal river profile in the basement bedrock. The long response time for the landscape to adapt to the change in lithology is responsible for the marked variations in topographic metrics within the crystalline basement.

Planed task 5: Explain, why we think that the area fraction of topographic metrics below / above thresholds in relief and channel slope are better suited for correlation analysis than expert-based mapping: the low relief surfaces mentioned are not a plateau but areas with a long wavelength–low amplitude topography. Expert-based mapping is possible in principle, but it is much less reproducible than determining the area fraction of catchments with topographic metrics (e.g. relief, steepness index) that exceed or fall below defined thresholds. We determined the topographic metrics for the different elevation levels as the signal of landscape adjustment to new conditions migrates upstream (i.e. steepening the channel and increasing local relief). These metrics are also included in the table in the supplement. We also think that the area fraction of topographic metrics below / above thresholds in relief and channel slope shows very well the respective proportions of the two landscape types in each catchment.

Planed task 6: Include a geophysical relief map to the supplement to show the spatial distribution of the two landscape types (incised / low relief) on a map. We agree that it would be easier for the reader to follow the story if the physiographic transition separating the incised from the low relief surfaces is shown. We will plot the physiographic transition as a line on the topographic map in current figure 1 and in the supplemental geophysical relief map.

Raised issue: It was difficult to understand why the Aschau catchment is of particular importance for understanding the landscape evolution of the region.

Planed task: The new introduction including the cartoon figure will solve this problem. The Achach catchment is the only catchment in the study region with a significant amount of cover sediments. However, the other catchments were also (at least partly) covered by these sediments at an earlier evolutionary stage. Due to the greater sediment thickness in the Aschach catchment (closer to the Alps than the other catchments), the evolution of a catchment controlled by sedimentary bedrock to a catchment controlled by crystalline basement rocks is delayed. The Aschach is therefore a key catchment for understanding the landscape evolution of peripheral foreland basins during basin inversion. This is the reason why we took a closer look at this catchment in the discussion section. However, we agree that the term ‘representative catchment’ is not appropriate.

Raised issue: The second problem mentioned in the review concerns the organization of the manuscript. In particular, the section on the Aschach catchment and the description of the numerical model were identified as misplaced. We understand that the organization of the manuscript is not well received by all readers. In principle, ESURF allows for both the classic structure with introduction, method, results and discussion or a more narrative structure where the method, results and discussion are treated together.

Planed task 1: In the revision, we would like to follow the less restrictive version and further relax the classic manuscript structure towards a more narrative style. We will break up the results and discussion sections and write new headings and transitions between sections.

Planed task 2: We plan to present the Aschach catchment much earlier in the manuscript (prior to the correlation analysis) as a key catchment for landscape evolution. This also gives us the opportunity to explain how mixed erosion and topographic signals are composed when viewed in the catchment average.

Planed task 3: The numerical model was designed to describe the key features of relief formation in an uplifting foreland basin. It is not about reproducing the exact timing and rates of landscape change, as about showing the evolutionary stages of a landscape in a region characterised by uniform uplift and strong spatial and temporal differences in bedrock properties. The exact determination of the bedrock erodibility is of secondary importance as long as the values lie within a reasonable range. We will give references for that and we will discuss the impact of different erodibility values (K) and erodibility ratios even more clearly than before.

Raised issue: Apparently confusing statements about spatially and temporally constant uplift rates were mentioned a the third point. We think that this is just a minor misunderstanding.

Planed task: It is clear that the inversion of the foreland basin leads to a change in the uplift rate, as a result of which the topography undergoes a transient state. If we speak of the formation of terrain steps despite uniform uplift, we mean uniform uplift with onset of basin inversion. The stepped landscape emerges as a result of the varying properties of the bedrock in a rising landscape. We will clarify this by revising the introduction.

Raised issue: In the last major issue, a lack of proper contextualization was addressed.

Planed task: We will explain the broader context in the introduction and discuss it at the end of the manuscript. There are numerous studies dealing with the influence of bedrock properties on erosion rates and landscape characteristics. However, as far as we know, there are no studies that address the topographic evolution of peripheral foreland basins after the mountain building phase. Peripheral foreland basins accompany all major mountain ranges on Earth and the findings of this study can be applied to other comparable regions.

Line-by-line comments

We will be happy to address the line-by-line comments in the course of a revision – thanks again for that!

On behalf of the co-authors

Jörg Robl