

**Interactive comment on “Evaluating post-glacial bedrock erosion and surface exposure duration by coupling in-situ OSL and <sup>10</sup>Be dating” by Benjamin Lehmann et al.**

Answers to Anonymous Referee #2

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This paper presents the first coupling of TCN and OSL surface exposure dating to quantify post glacial erosion in paraglacial environments. The authors present sensitivity tests of a bleaching model and combine this model with a cosmogenic nuclide accumulation model to determine the erosion rates and durations that fit the measured data. The modelling is explained using synthetic data and is subsequently applied to two natural samples collected from a vertical profile along the Trélaporte ridge of the Mer de Glace glacier. The OSL technique deployed in this paper is very sensitive to erosion over short timescales. In the samples used here the thickness of rock removed ranges from 8.05 mm for sample MBTP1 ( $\dot{\epsilon} = 3.5 \times 10^{-3} \text{ mm a}^{-1}$  for 2300 years) and 17.2 mm for sample MBTP6 ( $\dot{\epsilon} = 4.3 \text{ mm a}^{-1}$  for 4 years). The three orders of magnitude variation in erosion rates cannot be reconciled with the geomorphology of the sample sites, and is not explored further in this paper. Overall the paper presents an exciting new approach for determining bedrock surface exposure ages and erosion rates using OSL. The theoretical coupling of OSL and TCN data is elegant but application to geological samples demonstrates that the results require very careful interpretation.

The OSL technique deployed in this paper is very sensitive to erosion and scaling the results to longer term evolution of valley sides or even mountain ranges is likely to be difficult, as is clearly demonstrated by the geological samples used in this study. Nonetheless, the approach is very promising.

**We are grateful for this very constructive review provided by Anonymous Referee #2. Please find in the following the answer and comment on the reviewer feedbacks. Comments of the reviewer are underling and our answers are in bolt.**

p1, line 29: ‘Glacially-polished bedrock, or so-called “roche moutonnées” offers’, not all glacially polished rock is a roche moutonnée, for example Fig 1c, please change to ‘Glacially polished bedrock offers’

**Changed as suggested.**

p2, line 15: ‘of know age’ should be ‘of known age’

**Changed as suggested.**

p3, line 1: ‘until being completely’ should be ‘until completely’

**Changed as suggested.**

p3, line 8: add ‘a’ after  $10^6$

**Changed as suggested.**

p3, line 13: ‘historical’ could be ‘historic’

**Changed as suggested.**

p3, line 14: ‘in the Canyonlands’ should be ‘in Canyonlands’

**Changed as suggested.**

p4, line 4: change ‘roche moutonnée’ to glacially polished bedrock

**Changed as suggested.**

p4, line 6: delete ‘a’ before transient

**Changed as suggested.**

p4, line 11-14, Fig 1 caption: where is the craig and tail referred to in the caption? Roches moutonnée are not short-lived features, neither are crag and tails.

**In the sake of clarity, we removed “roches moutonnées, craig and tails” from the caption.**

Fig 1c does not show roches moutonnée morphology as stated in the caption. It shows glacially abraded. Roches moutonnée have quite specific morphology.

**We changed “roches moutonnée” to “glacially abraded surfaces”.**

p6, line 20-29: these two paragraphs explaining the 3rd and 4th terms of eq. 1 should be placed before the para starting with ‘Ou et al. (2018)...’ on p5, line 34.

**Changed as suggested.**

p6, line 29: you state that you ‘obtain exactly the same results using our numerical solution (Fig. A3).’ Where is this demonstrated. Fig. A3 does not show a comparison between Sohbaty et al. (2018) and your work. It would be good to show how ‘exactly the same’ your results are.

**Figure A3 shows the output of the model using the same parameter of Sohbaty et al. (2018) study. The comparison between the two approaches is made by visual inspection of the shape of the bleaching front and the depth  $x_{50\%}$  defined as  $NLS(x_{50\%})=0.5$  value for every model outputs ( $NLS = \text{Normalized luminescence signal}$ ). We changed the sentence with “we obtain results which are similar to their results calculated using their an analytical solution (Fig. A3).”**

p.8, line 18: please explain the ‘15 and 25 mm values for our end-member simulations (Fig. 4).’ The values do not appear to match the curves in the figure.

**We thank the reviewer to point this lack of clarity, we changed for “22 and 31 mm (measured at the inflection point)”.**

p.9, Fig. 4 caption: ‘Sect. 2.1.2’ should be ‘Sect. 2.1.1’

**We kept Sect. 2.1.2. because in this section it is mentioned the “We use  $\overline{\sigma\phi_0} = 129 \text{ a}^{-1}$  and  $\mu = 0.596 \text{ mm}^{-1}$  that were determined from two calibration rock surfaces of similar granitic lithology from the Mont Blanc massif, with no erosion and known exposure age (Fig. A2). The values  $\dot{D} = 8 \text{ Gy ka}^{-1}$  and  $D_0 = 500 \text{ Gy}$  were selected as they are comparable to the average values obtained for samples used in this study.”**

p.10, Fig. 5 caption: ‘Sect. 2.1.2’ should be ‘Sect. 2.1.1’. Please check all occurrences of cross-referencing carefully.

**We kept Sect. 2.1.2. because in this section it is mentioned the “We use  $\overline{\sigma\phi_0} = 129 \text{ a}^{-1}$  and  $\mu = 0.596 \text{ mm}^{-1}$  that were determined from two calibration rock surfaces of similar granitic lithology from the Mont Blanc massif, with no erosion and known exposure age (Fig. A2). The values  $\dot{D} = 8 \text{ Gy ka}^{-1}$  and  $D_0 = 500 \text{ Gy}$  were selected as they are comparable to the average values obtained for samples used in this study.”**

p.12, line 6: ‘samples used in the following of this study (Table 3).’ Delete ‘the following’. Also, Table 3 does not show the averages for D-dot or D-zero. Which table are you referring to?

**Changed to “The value  $\dot{D} = 8 \times 10^{-3} \text{ Gy a}^{-1}$  was selected as average value obtained for samples used in this study ( $\dot{D} = 7.4$  and  $8.4 \times 10^{-3} \text{ Gy a}^{-1}$  in Table 2).”**

p.13, line 2-3: the erosion rates  $10^{-2} \text{ mm a}^{-1}$  and  $1 \text{ mm a}^{-1}$  do not appear in Sect. 2.1.2 as stated.

**We thank the reviewer for pointing this mistake, the erosion rates were mentioned in Section 2.1.2.3. This has been corrected.**

p.14, line 8: ‘Figs. 6a, b, c, d’ should be ‘Figs. 7a, b, c, d’

**We thank the reviewer for pointing this mistake, we changed as suggested.**

p.14, line 17: delete ‘but constant for an infinite’

**Changed as suggested.**

p.15, line 3: 'valid' should be 'validate'  
**Changed as suggested.**

p.15, line 7: check Sect number  
**Changed to Sect. 2.1.2.3.**

p.15, line 7-8: 'this range being arbitrarily decided even so the upper boundary is set to be approximately' should be 'this range being arbitrarily decided with the upper boundary set to approximately'  
**Changed as suggested.**

p.15, line 12: 'parameters' should be 'parameter'  
**Changed as suggested.**

p.15, line 15: delete 'further the limit laying in'  
**Changed as suggested.**

p.18, Fig 8c: show the precise location of sample MBTP6. This is important to explain the shielding value in Table 3.  
**The picture was changed and a white arrow have been placed to give a better view of the location of sample MBTP6.**

p.20, Table 2 caption, line 8: 'in between' should be 'between'. This happens twice in the line  
**Changed as suggested.**

p.20, line 13-16: how is it possible that the calculated  $t_0$  exposure age uncertainties are smaller than the measured cosmogenic nuclide concentration uncertainties.  
**We thank the reviewer to point out this mistake, the uncertainties mentioned were representing the 1-sigma associated uncertainty, we replaced those uncertainties with 1-sigma uncertainty associated to the production rate.**

p.20, line 18: 'Figure 8' should be 'Figure 9'  
**Changed as suggested.**

p.20, line 30: 'reference profile is lying at 23.5 mm' should be 'reference profile is at 23.5 mm'  
**Changed as suggested.**

p.21, line 9: 'lies in between' should be 'lies between'  
**Changed as suggested.**

p.21, line 9: ' $\dot{\epsilon} = 1 \text{ mm a}^{-1}$ ' should be ' $\dot{\epsilon} = 10 \text{ mm a}^{-1}$ '  
**We thank the reviewer for pointing this mistake, we corrected this.**

p.21, line 10: 'Sect. 3.2' should be 'Sect. 3.3'  
**Changed as suggested.**

p.21, line 15: ' $\dot{\epsilon} = 1 \text{ mm a}^{-1}$ ' should be ' $\dot{\epsilon} = 10 \text{ mm a}^{-1}$ '  
**We thank the reviewer for pointing this mistake, this was corrected.**

p.23, line 20: 'erosion rate about' should be 'erosion rate of about'  
**Changed as suggested.**

p.23, line 22: '(Rades et al. 2018) have showed' should be '(Rades et al. 2018) showed'  
**Changed as suggested.**

p.24, line 9: ‘for too long duration’ should be ‘for long durations’  
**Changed as suggested.**

p.24, line 12: ‘time  $t_s$  pair’ should be ‘time  $t_s$  pairs’  
**Changed as suggested.**

p.24, line 24: ‘( $\dot{\epsilon} = 4.3 \text{ m a}^{-1}$  during  $t_s = 4$  years)’ should be ‘( $\dot{\epsilon} = 4.3 \text{ mm a}^{-1}$  during  $t_s = 4$  years)’, i.e. millimetres, not metres  
**Corrected.**

p.24, line 27: ‘limit our method’ should be ‘limits of our method’  
**Changed as suggested.**

p.24, line 29: ‘Such high difference of erosion between two locations of the same vertical profile is unlikely’. I think this statement is not supported by your data. Considering the difference in sample shielding it appears that MBTP6 was collected from a steeper slope than MBTP1. Fig. 3 suggests that the rock face may have lost mass by spallation, which could explain the order of magnitude lower  $^{10}\text{Be}$  concentration. These types of issues should be explored more.

**We thank the reviewer to point this, the sentence was changed to:**

**“Such high difference of erosion between two locations of the same vertical profile could be explain by the local topographic and environmental conditions such as slope surface and snow cover and controlling the efficiency of frost-cracking.”**

p.24, line 34: ‘The assumption that surface at 2094....almost 50 ka latter than...’ should be ‘The assumption that a surface at 2094....almost 50ka longer than...’  
**Changed as suggested.**

p.25, line 1: ‘latter’ should be ‘later’  
**Changed as suggested.**

p.26, line 5: ‘the correction TCN dating of erosion’ should be ‘an erosion correction for TCN dating’  
**Changed as suggested.**

p.26, line 9: ‘gab’ should be ‘gap’  
**Corrected.**

p.28, Fig. A2 caption: ‘These samples were in 2016 ...profiles’ should be ‘These samples were...profiles in 2016’  
**Changed as suggested.**

p.28, Fig. A3 caption: ‘comparable to the average values obtained...’ What does comparable mean? What were the average values? Quantify “comparable”.  
**We replaced the sentence in the caption by “using [...] similar values than Sohbaty et al. 2018” to avoid confusion.**

p.29, Fig. A4 caption: ‘exposure age obtains using’ should be ‘exposure age calculated using’  
**Changed as suggested.**