

Interactive comment on “Evaluating post-glacial bedrock erosion and surface exposure duration by coupling in-situ OSL and ^{10}Be dating” by Benjamin Lehmann et al.

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 ($\dot{t} = 3.5 \times 10^{-3} \text{ mm a}^{-1}$ for 2300 years) and 17.2 mm for sample MBTP6 ($\dot{t} = 4.3 \text{ mm a}^{-1}$ for 4 years). The three

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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.

Specific suggested changes:

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' p2, line 15: 'of know age' should be 'of known age' p3, line 1: 'until being completely' should be 'until completely' p3, line 8: add 'a' after $\sim 10^6$ p3, line 13: 'historical' could be 'historic' p3, line 14: 'in the Canyonlands' should be 'in Canyonlands' p4, line 4: change 'roche moutonnée' to glacially polished bedrock p4, line 6: delete 'a' before transient 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. Fig 1c does not show roches moutonnée morphology as stated in the caption. It shows glacially abraded. Roches moutonnée have quite specific morphology. 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. 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 Sohbati et al. (2018) and your work. It would be good to show how 'exactly the same' your results are. 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. p.9, Fig. 4 caption: 'Sect. 2.1.2' should be 'Sect.

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2.1.1' p.10, Fig. 5 caption: 'Sect. 2.1.2' should be 'Sect. 2.1.1'. Please check all occurrences of cross-referencing carefully. 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? p.13, line 2-3: the erosion rates 10^{-2} mm a^{-1} and 1 mm a^{-1} do not appear in Sect. 2.1.2 as stated. p.14, line 8: 'Figs. 6a, b, c, d' should be 'Figs. 7a, b, c, d' p.14, line 17: delete 'but constant for an infinite' p.15, line 3: 'valid' should be 'validate' p.15, line 7: check Sect number 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' p.15, line 12: 'parameters' should be 'parameter' p.15, line 15: delete 'further the limit laying in' p.18, Fig 8c: show the precise location of sample MBTP6. This is important to explain the shielding value in Table 3. p.20, Table 2 caption, line 8: 'in between' should be 'between'. This happens twice in the line 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. p.20, line 18: 'Figure 8' should be 'Figure 9' p.20, line 30: 'reference profile is lying at 23.5 mm' should be 'reference profile is at 23.5 mm' p.21, line 9: 'lies in between' should be 'lies between' p.21, line 9: ' $e = 1$ mm a^{-1} ' should be ' $e = 10$ mm a^{-1} ' p.21, line 10: 'Sect. 3.2' should be 'Sect. 3.3' p.21, line 15: ' $e = 1$ mm a^{-1} ' should be ' $e = 10$ mm a^{-1} ' p.23, line 20: 'erosion rate about' should be 'erosion rate of about' p.23, line 22: '(Rades et al. 2018) have showed' should be '(Rades et al. 2018) showed' p.24, line 9: 'for too long duration' should be 'for long durations' p.24, line 12: 'time ts pair' should be 'time ts pairs' p.24, line 24: ' $\dot{D} = 4.3$ m a^{-1} during $t_s = 4$ years)' should be ' $\dot{D} = 4.3$ mm a^{-1} during $t_s = 4$ years)', i.e. millimetres, not metres p.24, line 27: 'limit our method' should be 'limits of our method' 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}Be concentration. These types of issues should be explored more. p.24, line 34: ‘The assumption that surface at 2094. . .almost 50ka latter than. . .’ should be ‘The assumption that a surface at 2094. . .almost 50ka longer than. . .’ p.25, line 1: ‘latter’ should be ‘later’ p.26, line 5: ‘the correction TCN dating of erosion’ should be ‘an erosion correction for TCN dating’ p.26, line 9: ‘gab’ should be ‘gap’ p.28, Fig. A2 caption: ‘These samples were in 2016 . . .profiles’ should be ‘These samples were. . .profiles in 2016’ p.28, Fig. A3 caption: ‘comparable to the average values obtained. . .’ What does comparable mean? What were the average values? Quantify “comparable”. p.29, Fig. A4 caption: ‘exposure age obtains using’ should be ‘exposure age calculated using’

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