Geochronology Discuss.,
https://doi.org/10.5194/gchron-2019-2-AC2, 2019

Interactive comment on "Chlorine-36/beryllium-10 burial dating of alluvial fan sediments associated with the Mission Creek strand of the San Andreas Fault system, California, USA" *by* Greg Balco et al.

Greg Balco et al.

balcs@bgc.org

Received and published: 20 June 2019

Both reviews of this paper were very positive and recommended publication with minor revisions, but highlighted a number of sections of the text that were unclear or lacked needed details. We appreciate the careful attention to the paper by both reviewers, and here we respond to the comments in the second review by Jennifer Lamp.

This review included (i) one general remark about the paper overall; (ii) several comments on specific sections of the paper; and (iii) minor typographical errors or technical corrections. We respond to (i) and (ii) here. We have corrected the minor errors in the revised text and do not discuss them specifically here.

Printer-friendly version

Discussion paper

Review comments are highlighted below in italics and our responses follow.

My only general critique is that I'd like to see a more detailed discussion of the uncertainties associated with using this technique, and the impacts on the final 36Cl/10Be ratio. Should "external" errors be used (i.e., those including uncertainties in the productions rates in addition to measurement uncertainties) because you're comparing two different isotopes in two different minerals with varying production pathways? While I'm not an expert on 36Cl cosmogenic dating, I would expect that the multiple production paths for 36Cl and the 36Cl production rate dependence on the chemical makeup of the K-feldspars and bulk rock (plus the uncertainty in water content, etc.) could make the error on the 36Cl concentration (and hence the final ratio) quite large depending on what uncertainties are propagated through the calculations. It's possible that this information could be gleaned from the MATLAB scripts, but it would be nice to see a few sentences of discussion in the manuscript about this.

We certainly agree with the gist of this comment – that in certain situations, production rate uncertainties for some Cl-36 production pathways can be very large, which would result in terrible precision for burial dating with nuclide pairs including Cl-36. We can try to clarify some additional aspects of the comment here.

In most cosmogenic-nuclide literature, this paper included, "internal" uncertainties in a burial age refer to uncertainties stemming only from measurement uncertainties in nuclide concentrations, and "external" uncertainties are larger and take into account uncertainties in the independently determined parameters needed to compute the burial age, specifically the production ratio and the decay constants. This is true for burial dating with any nuclide pair, and is not specific to Cl-36.

Cl-36 production has some complications that are not present for Be-10 and Al-26, and these affect both of these uncertainties. First, the need to correct for supported nucleogenic Cl-36 adds uncertainty to measurements of the cosmogenic Cl-36 concentration, and therefore to both the internal and external uncertainties in a burial age.

However, as is very well highlighted in this study, this is only really important when cosmogenic Cl-36 concentrations are very low. Second, although estimates of spallogenic production rates for Cl-36 likely have similar precision as those for Be-10 and Al-26, estimates of thermal neutron production rates are extremely imprecise, so a sample with significant neutron capture production might have a very uncertain production ratio and therefore a very large external uncertainty. And then, finally, these two issues are linked in a complicated way, because high Cl concentrations in a target mineral lead to both high nucleogenic Cl-36 concentrations and high thermal neutron production; the former is only important when cosmogenic Cl-36 concentrations are low, but the latter is important always.

However, our main point in this paper is that both nucleogenic Cl-36 and thermal neutron capture production are serious problems – we discussed this at some length in pages 3-4 of the submitted paper – so we used feldspar separates with very low Cl concentrations and therefore very low neutron capture production, which minimize both problems. Having done this, we felt that it was off topic to provide a detailed review of exactly why they are serious problems (for example, the Alfimov and Ivy-Ochs paper gives an excellent review of the uncertainty in neutron capture production). Regardless, we appreciate the reviewer's calling our attention to this, and have added some material to this discussion in an attempt to clarify this issue.

I wonder if the title could be reframed to focus more on the technique than the specific Mission Creek application, as I think the study most con- vincingly explores the background and limitations of the 36Cl/10Be pair as a general burial dating technique. Something like: 36Cl/10Be burial dating of granitoid clasts: a case study in the San Andreas Fault system (etc.). Or, something that would highlight the technique/method over the application in this case.

Regrettably, we disagree. We think that the technical aspects of the burial-dating method and the slip rate of the San Andreas Fault system are both important. We tried several titles and we think this one is the clearest and most compact.

Page 2 Lines 10-15: See general comment above; does the better precision for the 36Cl/10Be pair hold out if production rate/chemical composition uncertainties are taken into account?

Yes, as long as Cl-36 production is nearly all by Ca and K spallation. That's the assumption in Figure 2. We clarified this.

Page 6, Lines 8-10: Do you have pictures of these samples? Perhaps include them in the supplement if not in the main text?

Unfortunately, we do not have suitable photos of all the samples. We agree that this would have improved the paper.

Page 8, Lines 2-3: How does the amount/uncertainty of Cl in the HF affect the resulting burial age uncertainty?

It's just lumped into the uncertainty in the overall measurement of the Cl concentration, because we measured it and corrected for it. We clarified this in the text. It is important to note that in a situation like this one where total Cl concentrations are very low, failing to correct for this would eventually lead to large errors in the nucleogenic Cl-36 estimates.

Page 11, Lines 6-7: It would be interesting to provide a plot of either the 36Cl/10Be production ratio or just the 36Cl production rate vs. K-concentration for each sample as part of Fig. 5 or 6. (The reader could glean this from info in the Tables, but it would be nice visual).

Because nearly all production in these samples is from K spallation, the relationship is basically just a straight line. The plot is attached to this response as Fig 1, but we didn't think it justified an additional figure in the paper.

age 14: Line 31: ". . .do not show evidence of significant burial" is a little confusing because you also assert that the 36Cl/10Be ratios are due to post-burial nuclide production. Perhaps rephrase slightly?

We agree this is unclear. We have tried to clarify it in the revised text.

Page 16, Lines 9-14: Are there any visual differences (weathering features, grain size, etc.) between sample MC-P7-8 and the others?

Unfortunately, no. If there were any identifiable differences, we might have had a better success rate. This remains a serious obstacle to using burial dating in this geologic environment.

Page 16, Lines 14-15: Are these surfaces the same lithology as MC-P7-8?

Unclear, because the Binnie erosion rate estimates are for whole catchments. This is intended only to show that the order of magnitude of the erosion rates is within that observed in previous studies generally.

igure 2: Including a map here that is in between the scale of the inset regional map and the sample map would be helpful; it's a bit difficult to understand the position of the study site.

This is true. We have improved the map.

Interactive comment on Geochronology Discuss., https://doi.org/10.5194/gchron-2019-2, 2019.

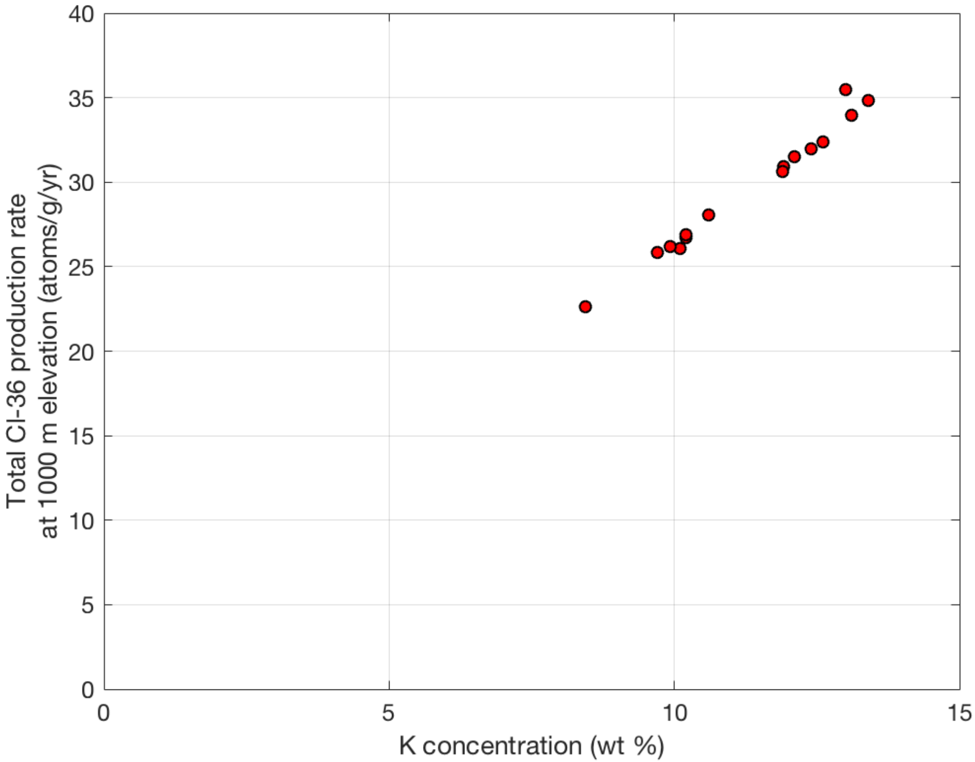

Fig. 1.

Printer-friendly version

Discussion paper