Author comments on the review from Anonymous Referee #3

We thank the reviewer for the offered criticism. We will address all comments sequentially, with our responses to the comments in blue font.

Reviewer comment: First, it's important to present the input of the original study which presented the analysis of two sets of continuous exposure history using 36Cl profiles sampled on the ~10m high fault scarp on 2 fault segments at Anogia (64 samples) et Parori (65 samples) and their model allow for the identification of the 464 B.C.E. earthquake that destroyed Sparta at their Parori site together with four additional earthquakes that ruptured the Sparta fault in the last 13 ka with similar co-seismic slip of ~2 m and with time intervals ranging from 500 yr to 4500 yr (Benedetti et al., 2002). The 464 B.C.E. earthquake was not resolved from the modelling of the original 36Cl dataset of the Anogia site by Benedetti et al. (2002) and several parameters such as the inheritance and erosion were neglected in the original analysis, the geometry was simplified and the production rate of Cl36 in Calcium was actively debated at the time. Therefore, there are room for a reappraisal of older dataset to help to better assess the seismic history of normal fault using 36Cl data. Yet, at this stage, it is difficult to assess the reappraisal and improvement made on the 36Cl analysis at Anogia and I would therefore recommend major corrections to be done before considering any publication. It is unfortunate that the REY data has not help much as with other studies (i.e Manighetti et al., 2010), so I will focus my remarks and questions on the cosmogenic data analysis.

Authors' reply: We agree with the reviewer that there are advances in the cosmogenic science that justify a revisiting the pioneering Benedetti et al. (2002) study of site(s) on the Sparta Fault, and we will improve our justification for revisiting the Anogia site in the revised manuscript. In addition to the extensive work already presented, including sampling along two transects at Anogia, including one directly adjacent to their sampling profile, incorporating REY analyses, and the inclusion of an updated and comprehensive model (Schlagenhauf et al., 2010) to include additional important controls on ^{36}Cl concentrations (e.g., inheritance, erosion, and scarp geometry), we will take the opportunity of revision to update our analysis with more recently developed models, including a Bayesian analysis.

We highlight here, and will increasingly highlight in our revised manuscript, that it is important for the community to learn of our (negative, but revealing) REY results. They point to controls other than soil pH on REY distributions of a carbonate fault scarp. This is an important finding with implications for research methodology that extend well beyond the Sparta Fault scarp. It is a key point that two reviewers have missed, which indicates a need for us to better explain the implications of our REY results.

Reviewer comment: The revised 36Cl modelling is only apply to the one of original profile, it might help to revised both sites for the discussion using the same production rate & codes??

Authors' reply: This is a good idea, in theory. However, the Benedetti et al. (2002) data has excessive intersample noise, which, in our opinion, precludes detailed inferences on paleoseismicity (i.e., inferring individual earthquakes). The Parori profile from Benedetti et al. can give an average exhumation rate but given the development in our knowledge of faulting and ^{36}Cl dating since 2002, we do not consider it worthwhile trying to analyze both of their profiles in detail. Please note that our comment is not a criticism of Benedetti et al. – it was a pioneering study.

Reviewer comment: Scaling samples that have different geometry, thickness and therefore attenuation must be discussed and scaled properly.

Authors' reply: All slab samples were 3 cm thick and the drill core samples were 2.5 cm thick. The impact of these different thicknesses is minor and they are accounted for in our modelling. However, we will explicitly state that in our revised manuscript.

Reviewer comment: Combining samples from different profiles that have different fault geometry, erosion, inheritance and potential shielding must be discussed.

Authors' reply: The fault geometry is the same at both of our profile locations (separated by 50 m), within our measurement limits. We assume erosion to be the same at both profiles based on surface features of the scarp and because there is no way to independently assess post-exhumation erosion of the scarp surface. We experimented with different erosion rates in our 36Cl modelling. We will ensure that the points raised here by the reviewer are clear in our revised manuscript.

Reviewer comment: There is no clear comparison of the results of the different models, a figure would help clarify (height versus time, using the co-seismic slip of each earthquake estimated age).

Authors' reply: We will modify the figure that presents our ^{36}Cl modelling to better illustrate paleoseismic interpretations.

Reviewer comment: The modelling of the 36Cl data does not appear to include the contribution of all the pathways despite being integrated in the codes of Schlagenhauf et al. (2010). 36Cl is produced by spallation of K, Ca, Ti and Fe; slow negative muon captures by K and Ca; and low-energy (thermal and epithermal) neutron capture by 35Cl and also not integrated in the modelling, composition data are available for the original dataset (see appendix of Benedetti et al. 2002) and the new 36Cl. That will affect the model ages of the different earthquakes and there is no need to average over the profile if the data exist for each sample.

Authors' reply: We have included all pathways for ^{36}Cl production, according to the model of Schlagenhauf et al. (2010). However, we will explicitly state that we have accounted for these different production pathways in our revised manuscript. Concentrations of K, Ti, and Fe are, though, very low in our samples, so ^{36}Cl production from these elements is a minor contribution to the ^{36}Cl inventories.

We state in the Methods section that we use the chemical composition for each sample for one of our ^{36}Cl transects. Unfortunately, we did not assess this for both of our ^{36}Cl transects; hence, the need for a mean composition on that second transect and on the Benedetti et al. (2002) profile, from which the relevant sample specific chemical data are also missing (including in their published appendix).

Reviewer comment: The production rates of Cl36 in Ca, K, Fe and Ti used in the study need a proper discussion and be better justified. Several aspects are typically discussed, the production rates of the different targets, the scaling factors used, the atmospheric model, and the geomagnetic database used to correct for the temporal variation of the production rates. The paper should be clearer on the topic, the scaling of solar modulation and long-term uncertainties defined by Lifton et al. (2005) is not a production rate paper. The production rates of the main targets producing Cl36 have also been scaled for the different scaling scheme in the CRONUS-Earth effort (see Marrero et al., 2015, even if the abstract only present the LSDn solutions). It seems strange to work on a reappraisal of a dataset without using the up-to-date production rates or at the very least present a comparison of the modelling results using different production rates.

Authors' reply: The citation that we give (Lifton et al., 2005) is incomplete. The production rate we use is written in the Schlagenhauf et al. (2010) model code as Lifton et al. (2005) but we should cite Schlagenhauf et al. (2010) modified from Lifton et al. (2005).

Regarding the choice of production rate; it is standard practice to choose an accepted production rate and work with that, as long as all data are available for anyone to recalculate using a different accepted production rate. Also, from Schlagenhauf et al. (2010): "…all models but that of Dunai (2001), produce similar [36Cl] profiles, and so we conclude that the time variability of the geomagnetic field has a limited impact on the ^{36}Cl production rate." In other words, the choice of production rate and associated geomagnetic field model does not have much impact on age calculations from ^{36}Cl, as long as Dunai (2001) is avoided.

Specific comments: Thank you for your comments, and we will work to address these in our revised manuscript.

References used in the response:

Benedetti, L., Finkel, R., Papanastassiou, D., King, G., Armijo, R., Ryerson, F., Farber, D., and Flerit, F.: Post-glacial slip history of the Sparta fault (Greece) determined by ^{36}Cl cosmogenic dating: Evidence for non-periodic earthquakes. Geophysical Research Letters, 29, 1246, doi: 10.1029/2001GL014510, 2002.

Dunai, T.J.: Influence of secular variation of the geomagnetic field on production rates of in situ produced cosmogenic nuclides. Earth and Planetary Science Letters, 193, 197-212, 2001.

Lifton, N.A., Bieber, J.W., Clem, J.M., Duldig, M.L., Evenson, P., Humble, J.E., and Pyle, R.: Addressing solar modulation and long-term uncertainties in scaling secondary cosmic rays for in situ cosmogenic nuclide applications. Earth and Planetary Science Letters, 239, 140–161, 2005.

Manighetti, I., Boucher, E., Chauvel, C., Schlagenhauf, A., Benedetti, L.: Rare earth elements record past earthquakes on exhumed limestone fault planes. Terra Nova, 22, 477–482, doi: 10.1111/j.1365-3121.2010.00969.x, 2010.

Schlagenhauf, A., Gaudemer, Y., Benedetti, L., Manighetti, I., Palumbo, L., Schimmelpfennig, I., Finkel, R., and Pou, K.: Using in situ Chlorine-36 cosmonuclide to recover past earthquake histories on limestone normal fault scarps: a reappraisal of methodology and interpretations. Geophysical Journal International, 182, 36–72, doi: 10.1111/j.1365-246X.2010.04622.x, 2010.