Author comments on the review from Anonymous Referee #1

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: Interestingly, the Authors clearly show that REY analyses are of little use for the Sparta Fault bedrock scarp, due to the presence of quartz and other silicate components in the breccia matrix included in the fault damage zone. This is a major contribution from the presented investigations.

Authors' reply: Thank you for picking up this key point. We agree that the REY analyses are important new data. However, it has become clear from the reviews that we need to more clearly state in our revision the general importance of our REY analyses to the reconstruction of paleo-earthquakes. We present data that clearly couples REY enrichment to the presence of quartz and clay in the microcrystalline cement of the fault scarp breccia, which dominates REY exchange with the soil. We were surprised to find this at the Sparta Fault (there is no mention of this in the literature) and would be similarly surprised if the Sparta Fault is the only one that contains fault breccia and therefore potentially also these impurities exposed on limestone normal faults. Indeed, there is a lack of detailed petrological examinations (including optical light microscopy and SEM on thin sections) in the literature dealing with limestone fault scarp dating using ^{36}Cl/REY, so important information might be missed (even with analyses of bulk and trace element scarp chemistry and even where concentrations of impurities is seemingly lower than what we found on the Sparta Fault). In addition, our analyses point to REY distributions in soil related to the mineral composition of the soil, in addition to its pH. The literature on applying REY analyses to the reconstruction of paleoseismicity on limestone fault scarps has focused on the role of pH (Carcaillet et al., 2008; Manighetti et al., 2010; Moraetis et al., 2015, 2023). Important controls on REY distributions exerted by mineralogical variations in hanging wall soils, and therefore fault scarps following postulated soil-scarp REY exchange, both remain little explored and have the potential to complicate interpretations of paleo-earthquakes from REY distributions on fault scarps.

Reviewer comment: My main comment concerns the general use of exposure dating for understanding the paleoearthquake history on a limestone bedrock fault scarp. In fact, the literature shows that defining individual earthquake ruptures using 36Cl on bedrock fault planes might be quite difficult. For instance, during the 2016 earthquake sequence in Central Italy, the main limestone scarp along the Vettore Fault ruptured following both the August 24 and the October 30 mainshocks, with a maximum slip of 20 cm and 210 cm, respectively. Clearly, exposure dating will not be able to discriminate among these two events, as already discussed by Bubeck et al. 2015 (Bubeck, A., Wilkinson, M., Roberts, G. P., Cowie, P. A., McCaffrey, K. J. W., Phillips, R., & Sammonds, P. (2015). The tectonic geomorphology of bedrock scarps on active normal faults in the Italian Apennines mapped using combined ground penetrating radar and terrestrial laser scanning. Geomorphology, 237, 38-51) and Cowie et al. 2017, for instance. This point should be clearly discussed in the Introduction, and taken into account in the Conclusions. The series of 4 strong, M7 paleoevents interpreted by the Authors is therefore affected by intrinsic problems of resolution; the 4 identified strong events might include several smaller , M6 to 6.3 (for instance, the Mw 6.3 L'Aquila eq in 2009 generated max displacement of ca. 10 cm), seismic events. M6 to 6.3 is a very severe earthquake for an ancient town like Sparta in 464 B.C., but also for the modern town of Sparta today. Therefore, conclusions in terms of seismic hazard based on the results collected by the Authors of this manuscript must be treated with care.

Authors' reply: This is a considered comment, and it is a very important one, with which we also agree. In analyzing our ^{36}Cl data, we felt most confidence in being able to calculate mean displacement rates for the Sparta scarp, while discerning the contributions of individual earthquakes to scarp exhumation is more uncertain. It is indeed possible that several earthquakes, clustered closely together in time, might have occurred but remain undetectable given the resolution of the ^{36}Cl dating technique. We will make this point more succinctly in our revision. For example, we could add text indicating that our earthquake magnitudes are maximum estimates, assuming that the modeled number of earthquakes is correct (based on statistical returns on the modeled number of earthquakes).

Specific comments in manuscript: We note these and will address those in the revised version. The reviewer raises a good point regarding the accuracy of historical records for earthquakes in Greece. Unfortunately, we do not find evidence in the literature of significant inputs of volcanic material to the terra rosa soils of the Mediterranean, as suggested by the reviewer. There is, however, evidence of significant inputs of North African dust (as we state in the manuscript).

References used in the response:

Carcaillet, J., Manighetti, I., Chauvel, C., Schlagenhauf, A., and Nicole, J.-M.: Identifying past earthquakes on an active normal fault (Magnola, Italy) from the chemical analysis of its exhumed carbonate fault plane. Earth and Planetary Science Letters, 271, 145–158, doi: 10.1016/j.epsl.2008.03.059, 2008.

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.

Moraetis, D., Mouslopoulou, V., and Pratikakis, A.: Sorption of the Rare Earth Elements and Yttrium (REE-Y) in calcite: the mechanism of a new effective tool in identifying paleoearthquakes on carbonate faults. Geophysical Research Abstracts, 17, EGU2015-3437, 2015.

Moraetis, D, Mouslopoulou, V., Pratikakis, A., Begg, J., Pracejus, B.: The mechanism of REE-Y impregnation on active carbonate normal fault scarps. Applied Geochemistry 155, 105703, 2023.