Dear Editor,

We are very grateful to you for kindly inviting us to revise and resubmit our manuscript.

The paper has been modified taking into account the reviewers' suggestions/comments and our own answers. The corrections and/or changes have been highlighted in yellow.

Yours truly,
Antonio Contino and co-authors.

RESPONSE TO THE FIRST REVIEWER (REPORT 2)

Authors' response: Dear Reviewer #1, we are very grateful to you for your very positive judgement.

RESPONSE TO THE SECOND REVIEWER (REPORT 1)

Comment from referee: The authors claim that their documentary data analysis to reconstruct the circumstances of landslide events occurring in historical times, is a significant methodological and scientific contribution of a pioneering nature. This is arguable, Geoarcheology is a well-established discipline. The geoarcheological approaches/techniques have been applied to the analysis of the occurrence of natural hazards on historical sites (e.g., Field & Banning, 1998 Geoarcheology, 13: 595-616; Bottari & Sepe, 2013: Quaternary Int. 309-309: 105-111). It is particularly well developed for the study of past earthquakes (e.g, Stiros, 2001-Jour. Structural Geology, 23: 545-562; Silva et al. 2005 Tectonophysics, 408: 129-146; Katz and Crouvi, 2007 Eng. Geology 95: 57-78; Rodriguez-Pascua et al. 2010 GSA Special Paper 471).

Author's response:

Dear Referee #2,

Our paper is based on the combined analysis of geological data and unpublished historical datasets (documentary data, ancient maps, ancient engravings, etc.), as well as of the existing relevant literature. This analysis has played a crucial role in this case study, concerning a landslide event that occurred in historical times. This is clearly inferred not only from the title of the paper, but also and above all from its para. 2.5 (Documentary Evidence).

We grant that geoarchaeology, which relates earth sciences to archaeology, has become a well-established discipline. However, the approach taken by and/or the techniques typically used by this disciplinary branch have no direct relevance to the content of our pioneering study (indeed, no reference is made to geoarchaeology in the abstract or body of our paper). It is only in the conclusions that we express the desirability of a future archaeological investigation in the study area (see 472-474).

Finally, in all the relevant literature that you mentioned, no single paper used historical sources in support of research.

Author’s changes in manuscript:

None.

Comment from referee:

In any case, the main criticism to the submitted manuscript is that the analysis of the failure mechanism, the sedimentological and/or textural description of the rockfall deposits and the geological characterization of the source (predisposing factors), which must be based on evidences and field observations, is missing. (...).

The mechanism is unclear. Despite the case is described as a rockfall, the authors conclude it was a rockslide (lines 391-397). This conclusion is based exclusively on the estimated volume of the deposits rather than on the analysis the kinematic features either observed at the deposits themselves or at the detachment area. Which is arguable.

The authors state (lines 361-362) that any attempt to obtain the possible trajectories related to the Sclafani landslide would be unreliable. Moreover (lines 372-375 and answers to the reviewers), they consider that the deposits might have been eroded. Taking this into account, how can the runout length, shadow, and travel distance angles and volume be determined?

Author’s response:

The paper emphasises the complexity of the event (see lines 346-351) and the lithological heterogeneity of the landslide deposits, as well as of the entire slope, from the top of the castle to the bottom of the lower cliff (see lines 371-373).

We classified the event as a rockslide not only on the basis of the areal extent and estimated volume of the landslide deposits, but also and above all through cross-checks of mutually-fitting geological and historical data, thus providing a consistent picture in spite of the lack of eyewitness reports of an event that took place 160 years ago.

In the current stage of research, no pre- and post-event maps are available to make appropriate comparisons, especially in terms of morphology of the lower talus slope, whose dominant outcrops consist of soft rocks. Based on documentary sources, the extreme rainstorm of 12-13 Sept. 1851 triggered major erosional and landsliding events, which deeply and irreversibly changed many slopes, especially those made up of soft rocks, deepening and widening ravines (e.g. see Supplementary Information, Table S2, source 14). This suggests that the morphology of the lower talus slope may have been extremely different from the current one, prior to the triggering of the Sclafani landslide. Hence, any attempt to reconstruct the trajectories of the 1851 event from the current morphology of the lower talus slope may reasonably be poorly reliable or unreliable.

Finally, there has been a misunderstanding: erosional processes in the subsequent 160 years did not affect the landslide deposits, but rather the soft rocks (radiolarites and siliceous shales) forming the lower talus slope.

Author’s changes in manuscript:

In page 11, lines 361-364, as follows:

This suggests that the morphology of the lower talus slope may have been extremely different from the current one, prior to the triggering of the Sclafani landslide. Hence, any attempt to reconstruct the trajectories of the 1851 event from the current morphology of the lower talus slope may reasonably be poorly reliable or unreliable.

Comment from referee:

An event attaining 0.68 million cubic meters that occurred 160 year ago, should have left a visible scar at the source. In fact, many Holocene rockfalls scarps of similar size are still observable in the landscape. Unfortunately, no description of the rockfall source is provided in the text. The statements on the role of the discontinuities in the instability (lines 270-276, 442-445) are not based on observations. A proper geomechanical or structural characterization of the rock cliff was not carried out. The authors mention (lines 296-299) that no published data are available about the level of fracturing of the bedrock and that slope is inaccessible. However, pictures S1 and S2 suggest otherwise. Rock mass outcrops may be accessed from castle and at the base of the cliff.

Author’s response:

Unfortunately, historical sources fail to provide indications about the source area, even if they report that the source area was still active a few years after the 1851 event, as evidenced by further collapses of rock masses, including one (three years after the Sclafani landslide) that completely blocked the mule track connecting the built-up area with the thermal springs (see Supplementary Information, Table S2, source 7). This track rests entirely on the lower talus slope and is overhanged by the cliff of the castle, from which rocks continued to detach themselves. As mentioned in the paper, excavation works for building a road in 1930 radically changed the morphology of the area immediately overlying the source area, as use was made of explosives to cross the 1851 landslide rubble (now covered in part by vegetation).

To provide reliable data, a structural/geomechanical characterisation of the area should necessarily include in-depth surveys (particularly significant in the source area, where the detachment surface has an uneven pattern), possibly in 3D, of the entire rock body (Ellipsactinia breccias), i.e. of the source area of the 1851 event. In the future, this will be possible only by resorting to direct cliff-wall survey techniques of mountaineering/climbing type and/or to indirect survey techniques, including appropriate remote-sensing ones (e.g. terrestrial laser scanning). Moreover, at the site of the Sclafani castle, the top part of the rock outcrops is mostly masked by medieval fortifications.

Author’s changes in manuscript:

None.

Comment from referee:

I invite the authors to have a look published works describing the deposits, the geological and the geomechanical contexts of ancient sites affected by landslides/rockfalls. These are someexamples: Dykes, 2007 (Landslides,4: 279-290); Senatore et al. 2013 (Geoarcheology, 29:1-15); Fanti et al. 2013 (Landslides, 10: 409-420); Gigli et al. 2012 (NHESS, 12:1883-1903); Zarroca et al. 2014 (Landslides, 11: 655-671); Margottini et al. 2015 (Landslides, 12: 193-204); Gül et al. 2016 (Environ. Earth Sci. 75: 1310)

Author's response:

Dear Referee #2, we thank you for quoting these interesting papers about ancient landslide sites, although their geological and geomorphological settings have very few points of similarity with our case study. However, none of these studies uses historical data from documentary sources and/or historical maps in support of research.

Author's changes in manuscript:

None.

RESPONSE TO THE SECOND REVIEWER (REPORT 3)

Author's response:

Dear Reviewer #3,

We are very grateful to you for expressing appreciation for our paper and providing us with useful suggestions and insightful comments. Below, you will find our answers to your careful suggestions, as well as the changes made to our manuscript that you have recommended.

Comment from referee:

- It would have been great to include some kind of 3D information concerning the studied area. This could help the reader to get a better impression of the geological setting. It would also assist in a better geo-referencing of all exposed information in this research article. It might worth the effort to work in 3D and to produce a valid 3D model of the studied area. This would also enable a reconstruction of the event, by means of numerical modelling. The authors are correctly pointing out that geomorphological alterations in the area through time, make it difficult to model the rockfall event (i.e. rockfall trajectories), but my opinion is slightly different. A correct 3D model of the existing topography enriched with information concerning possible rockfall release positions and size of boulders (rockfall scenarios), could provide enough information for a preliminary dynamic analysis of the event by means of rockfall numerical modelling (in 2D or 3D). At least the 'Rockfall potential' of the given slope could be explored. This in turn, could yield information about the energy magnitude and the travel path of the historical event as well as for possible future events at the area. I have the feeling that the authors can greatly improve the manuscript by including such kind of information.(….)

Figure 1: Study area, satellite imagery relative to figure 2 in the manuscript. Satellite imagery or ortho-photographs can assist in transmitting crucial information to the reader. In example, the structural geology (faults and other structural elements) of the studied area could be better explained with the aid of a proper ortho-photograph or satellite imagery. Of course, the image above and following images in this review, arrive from standard internet resources (Google maps). It might be possible to obtain satellite images of better quality from other sources.

Figure 2: Satellite imagery relative to the geomorphological map in figure 5. Geological formations could be better visualized on an orthophoto or satellite imagery.

Figure 3: 3D overview of the area, assisting in a correct interpretation of geological structures. The cross section presented in figure 3 of the manuscript (Lower Cliff, Lower Talus Slope etc.) could be much better explained on the basis of a 3D model.

Figure 4: Georeferencing of data with the help of a 3D model?

Figure 5: Possible Rockfall scenarios? Identification of the position of the historical Sclafani Spa?

Author's response:

We feel indebted to you for your valuable suggestions, especially because they provide a significant contribution to enhancing the clarity and thus quality of our paper. We have accepted your suggestion to add a 3D view of the surrounding area to the Supplementary Information, specifying the location of the site of the ancient spa and of the thermal springs, as well as the vantage point from which the photo in fig. 10 was taken.

Author's changes in manuscript:

See figure S5 in the Supplementary Information.

Comment from referee:

My personal view is that there is not enough information in the manuscript that could enable a "dynamic-kinematic" reconstruction of the analysed event. The description of the deposit and of the landform created as a consequence of the 1851 event could had been more detailed. The addition in the geomorphological map in figure 5, of the exact position of some silent witnesses (boulders transported by gravitational movements) concerning rockfall events at the same slope, could assist in quantifying the "slope dynamics" relative to rockfall events. A better description of size and sorting (there is only information about some very large boulders (in line 339: the largest ones are approximately equidimensional, 4 m in size?)

Author's response:

The mapping of some silent witnesses could be very useful, but it would require additional in-depth field surveys.

The materials making up the landslide deposits are of variable size: very small for fragments of siliceous shales and/or radiolarites (cm/dm), progressively larger from calcilutites (mostly dm, occasionally up to 1 m) to dolomites and limestones (from dm to some m). In the field, naturally-exposed landslide deposits are often obliterated by a thick vegetal cover. Small partial exposures, resulting from earthworks, show carbonate blocks (limestones and dolomites), generally of metre scale, embedded into a chaotic mass of fragments of radiolarites, siliceous shales and slab-shaped calcilutites.

Author's changes in manuscript:

In pages 11-12, lines 373-378, as follows:

The materials making up the landslide deposits are of variable size: very small for fragments of siliceous shales and/or radiolarites (cm/dm), progressively larger from calcilutites (mostly dm, occasionally up to 1 m) to dolomites and limestones (from dm to some m). In the field, naturally-exposed landslide deposits are often obliterated by a thick vegetal cover. Small partial exposures, resulting from earthworks, show carbonate blocks (limestones and dolomites), generally of metre scale, embedded into a chaotic mass of fragments of radiolarites, siliceous shales and slab-shaped calcilutites.

Comment from referee:

On the hydrological record concerning the studied area, is there enough data to allow the calculation of the recurrence interval (return period) of such powerful events as the described storm and the associated rainfall? This information could be useful for risk calculations.

Author's response:

Unfortunately, the relevant data are insufficient. So far, the statistical analyses of the hydrological records for central-western Sicily (the time series of the Palermo astronomical observatory, cfr. Micela, G. et al., *Due secoli di pioggia a Palermo*, Osservatorio Astronomico di Palermo G. S. Vaiana, Università di Palermo, Palermo 2001, 292 pp.) have not yielded meaningful results (e.g. cfr. Iuliano, V. and Nastasi, P., 1985, *Prime considerazioni sulla distribuzione statistica dei totali annui di Pioggia per Palermo (Osservatorio Astronomico)*, Rivista di Meteorologia Aeronautica, vol. 45, 2-3, pp. 91-99). A detailed investigation would certainly be helpful, i.e. by reviewing the hourly diagrams and the records of the Palermo astronomical observatory; indeed, in spite of their deficiencies, these data are only source available that covers a sufficiently long period of time (since 1801).

As to the Madonie mountains, hydrological records are very poor (cfr. Aureli, A., Contino, A. and Cusimano, G., *Aspetti idrogeologici e vulnerabilità all'inquinamento degli acquiferi delle Madonie (Sicilia centro settentrionale)*, Regione Siciliana Azienda Regionale Foreste Demaniali, Università degli Studi di Palermo, Dipartimento di Geologia e Geodesia, Consiglio Nazionale delle Ricerche, Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche, Pubbl. n. 2312, Collana Sicilia Foreste, 39, 168 pp., Sarcuto, Agrigento, 2008). Temperature and rain gauge stations in the area are decentralised with respect to the main mountain peaks and lie at much lower elevations. The few existing hydrometric stations have worked for too short periods and with numerous interruptions.

Author's changes in manuscript:

None.

Comment from referee:

I would have liked to see a properly scaled geological cross section similar to the one presented in figure 3, based on the geomorphological map in figure 5. A cross section indicating the event's travel path (i.e. from release position to the location of the ruined historical spa, according to the understanding of the authors) would in my opinion also improve the article.

Author's response:

We feel indebted to you for your valuable suggestions, especially because they provide a significant contribution to enhancing the clarity and thus quality of our paper.

Author's changes manuscript:

See figure S6 in the Supplementary Information.