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THE DECADENCE OF THE SAMBUCINA ABBEY (CALABRIA, SOUTHERN ITALY): GEOLOGICAL AND HISTORICAL HINTS

ABSTRACT: PERONACE E., GALLI P. & SCARASCIA MUGNOZZA G., *The decadence of the Sambucina Abbey (Calabria, southern Italy): geological and historical hints*. (IT ISSN 0391-9838, 2009).

An integrated geological and historical approach has been adopted to understand the suite of natural events which led to the progressive disruption of the Cistercian Sambucina Abbey (Luzzi, Crati Valley, Calabria) since its early foundation in the 12th century. The Abbey relics lay on the eastern shoulder of the Crati Graben, on the crystalline-metamorphic domains of the Palaeozoic rocks of the Sila Massif. By means of both aerial photo interpretation and field survey, a multiple roto-translational slide affecting a large sector of the Sambucina slope has been recognized. In the same area, several shallow landslides concur in aggravating the instability of the Abbey area. Historical documents collected in libraries and archives suggest that the primitive core of the Abbey, destroyed by the 1184 earthquake, was soon rebuilt by the Cistercians following the monumental building rules of their order. Around 1220, the Abbey was again hit by a local earthquake and by a coseismic landslide, which caused the temporary abandonment of the site. Finally, in 1569, a catastrophic landslide completely destroyed the abbatial complex, which was thus abandoned for a long time. On the basis of the historical accounts of this disaster, of the archaeological evidence in the Abbey relics, and of the geomorphological evidence, the geological model of the landslide has been reconstructed.

KEY WORDS: Landslide, Weathering, Historical seismicity, Calabria, Italy.

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Nel presente lavoro è stato adottato un approccio integrato storico-geologico finalizzato alla ricostruzione degli eventi naturali che hanno causato la progressiva distruzione dell'Abbazia cistercense della Sambucina (Luzzi, Valle del Crati, Calabria) a partire dalla sua fondazione nel 12° secolo. Ciò che rimane dell'antico impianto dell'abbazia, sul bordo orientale del graben del Crati, è fondato sulle rocce cristallino-metamorfiche Paleozoiche del massiccio silano. A seguito dell'interpretazione di foto aeree e da rilevamenti di campagna, è stata individuata una frana di grandi dimensioni, assimilabile ad uno scorrimento rototraslazionale multiplo, che ha coinvolto un ampio settore del versante della Sambucina. Inoltre, alcune frane superficiali rilevate nell'area di studio hanno concorso ulteriormente ad aumentare l'instabilità del sito cistercense. Numerosi documenti storici consultati in archivi e biblioteche suggeriscono che il nucleo primitivo benedettino dell'abbazia, distrutto una prima volta dal terremoto del 1184, fu ricostruito dai Cistercensi seguendo lo schema progettuale del proprio ordine monastico. Intorno al 1220, l'abbazia fu interessata da una frana, presumibilmente innescata da un terremoto di origine locale, determinando nuovamente il temporaneo abbandono del sito. Infine, una catastrofica frana, assimilabile a quella riconosciuta su base geologica e geomorfologica, distrusse completamente il complesso abbaziale nel marzo del 1569, così da determinarne il completo abbandono per lunghi anni. Sulla base della descrizione storica del disastro, delle evidenze archeologiche sui resti dell'abbazia e degli elementi geomorfologici, è stato ricostruito il modello geologico della frana in questione.

TERMINI CHIAVE: Frana, Alterazione, Sismicità storica, Calabria.

INTRODUCTION

This paper focuses on the geomorphological evolution of the slope in the Crati Valley where, about one thousand years ago, a group of monks founded the first Cistercian abbey of Calabria, and on the historical vicissitudes that affected this site due to natural events.

The Abbey was initially built up by the Benedictine friars (first half of the 12th century), and became during the Middle Age one of the most powerful Cistercians settlements of southern Italy. However, starting from its foundation, it was repeatedly damaged by earthquakes and landslides, which deeply conditioned the history of this ancient settlement, giving the times for its disruption, re-

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construction and partial abandonment after a devastating landslide in 1569.

By combining local geological field survey with archive and architectural research on the Abbey, the series of main geomorphologic events that modified the landscape of this sector of the Crati Valley in the past thousand years was reconstructed.

The results also provided a compelling framework for the historical and architectural phases that led to the present condition of the Sambucina Abbey (fig. 1). Since the beginning of the 20th century, several questions remained uncertain amongst Art History's scholars as far as the anomalous plan of this Cistercian settlement is concerned. In fact, the present buildings and plan of the monastery do not account at all for the canonical design followed by this Monastic Order since the 12th century. In particular, by defining the geological model of the last disruptive landslide, light could be cast on the lost original volumes, and on the original surrounding landscape of this important Abbey.

SEISMOTECTONICS OF THE INVESTIGATED AREA

The seismicity of Calabria is one of the strongest of the Mediterranean belt, in terms of both maximum magnitude and earthquake frequency. More than 20 events with M>6 occurred since 91 BC between the Messina Straits and the Crati Basin (fig. 2). These earthquakes are mainly clustered between 1638 and 1908 AD, when most of the main seismogenic structures of Calabria ruptured roughly from north to south. This fact can be mainly explained as due to the real seismogenic characteristics of the Calabrian faults (Galli & Bosi, 2002; 2003; Galli & Scionti, 2006; Galli & *alii*, 2007), and, secondarily, by the loss of primary historical sources (i.e. at least in the first millennium AD - Scionti & Galli, 2005).

Since the end of the 1990's, paleoseismic studies carried out from Mt. Pollino (Northern Calabria) to the Gioia Tauro Plain (Southern Calabria) started to unravel the tangled skein of earthquake occurrence in the Calabrian Arc (cf. Galli & *alii*, 2007). Unfortunately these detailed studies were carried out only along few outcropping seismogenic faults, while for entire sectors of Calabria (such as the Crati Graben) definitive data are still needed.

In the studied area, the ~NNW-SSE Crati faults system (fig. 2) controlled the opening of the Crati Basin during Lower-Middle Pleistocene (Tortorici, 1982), and its hangingwall fits with the highest intensity datapoint distribution of the southward-migrating-sequence of 1767-1835-1854-1870 events. Nevertheless, as mentioned above, the area lacks of both recent faulted deposits and/or cumulated surface rupture evidence (Galli & Bosi, 2003). This fact implies that the slip-rates of these faults probably decreased in the Upper Pleistocene, as also suggested by the magnitude of the associated seismicity (Mw<6.2, i.e. not significant shallow deformation).

Beside the mentioned earthquakes, the Crati Valley was struck in 1184 by a frightful event, whose epicenter is still a matter of debate. All the available primary sources agree that the earthquake hit a vast area of Calabria, from the Crati to the Sinni Valley (at the boundary with the Basilicata region). Actually, a non-identified manuscript quoted by a local author (*Fragmenta monachorum Sambucinae,* by Pietro Scasilio, 13th cent.; in: Marchese, 1957) reports that the former Sambucina Abbey collapsed during this earthquake, as well as many others churches in the region.

FIG. 1 - View of the ruins of the Sambucina Abbey. Only part of the main nave and pieces of the original Romanesque portal remain of the monumental monastery destroyed by landslides and earthquakes.

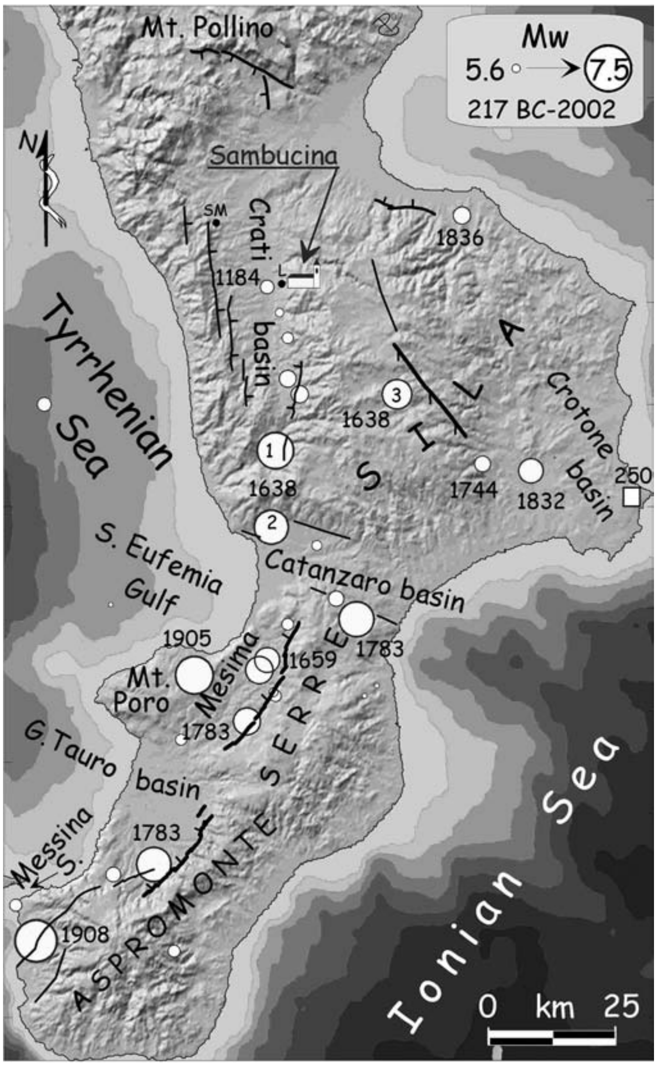


FIG. 2 - Earthquakes distribution in Calabria (mod. from Working Group CPTI, 2004. Mw>5.5) and primary seismogenetic faults (bold certain, i.e. investigated by paleoseismological analyses). Labels 1-3 inside 1638 epicentres define the shocks of March 27-28, and June 9. Square symbol is the archaeoseismic event dated around 250 AD by Galli & *alii* (2006); L. Luzzi; SM. San Marco Argentano (mod. from Galli & *alii*, 2007).

On the basis of all the available primary sources, a site catalogue was prepared for Luzzi (the nearest village to Sambucina; site intensity threshold: Is>6 MCS), in order to ascertain the level and recurrence of the seismic shaking of the area (tab. 1). According to this catalogue, the highest intensities were felt during the 1184 (9 MCS), 1638 (March 27; 9 MCS), and 1767 earthquakes (8-9 MCS), whereas unspecified damage (D in tab. 1) was reported by primary sources in 1220 (cf. Peronace, 2007), due to a poorly known seismic event which, probably, induced a landslide in the Sambucina area. It is worth noting that neither an earthquake record exists in 1569 (the date of the catastrophic landslide which destroyed the Sambucina Abbey) nor other information

TABLE 1 - Seismic catalogue of Luzzi (ordered by decreasing effects). On the left, epicentral parameters of the earthquake (Io=epicentral intensity; M=equivalent magnitude ~M_w); the two columns on the right are d, epicentral distance in km, and Is, site intensity (in bold, values reported by Boschi & *alii*, 2000; the other values were obtained according to the distribution of the neighbouring intensity points); D = damage

year	m	d	Epicentral Area	Lat	Long	Io MCS	M	d km	Is MCS
1184	5	24	Crati Valley	39.430	16.250	9	6.0	6	**9**
1638	3	27	Calabria	39.110	16.270	11	7.0	38	**9**
1767	7	14	Cosenza Area	39.380	16.280	8-9	5.7	8	**8-9**
1638	6	8	Crotone Area	39.220	16.570	9-10	6.7	33	8
1832	3	8	Crotone Area	39.070	16.900	9-10	6.4	65	7-8
1905	9	8	Calabria	38.670	16.070	11	7.0	89	**7-8**
1913	6	28	Roggiano	39.530	16.230	8	5.5	11	**7-8**
1783	3	28	Centr. Calabria	38.780	16.470	10	6.9	75	7
1835	10	12	Cosenza Area	39.330	16.300	9	5.9	13	7
1870	10	4	Cosenza Area	39.220	16.329	9-10	6.1	25	7
1854	2	12	Cosenza Area	39.250	16.300	9-10	6.1	22	**6-7**
~1220			Crati Valley	–	–	–	–	–	D

concern-ing seismically-induced landslides (except for the ~1220 event).

OVERVIEW ON THE SAMBUCINA ABBEY HISTORY

As mentioned above, the Sambucina Abbey was founded around the half of the 12th century, that is during the Normans rule in southern Italy (see tab. 2). Thanks to repeated deeds of gift (from both the Normans and the Roman Church), this first Cistercians settlement of Calabria became an important centre of culture and power, with several filiations spread in Calabria, Sicily, and Apulia (see Marchese, 1964; Russo, 1988; De Leo, 1993). The first complex, probably grown and enlarged over an older Benedictine monastery (i.e. S. Maria de Mensuo and S. Maria di Requisita; Marchese, 1964; Russo, 1974; 1988), was seriously damaged by the 1184 earthquake (Scasilio, 13th cent., in: Marchese, 1957), and then rebuilt by the monks of the Casamari Abbey, following the canonical Cistercian model

TABLE 2 - Summary table of the main events in the Sambucina history, and related sources

Time	event	Source/reference
12th cent.	foundation	Marchese, 1957;1964; De Leo, 1993
1184	**earthquake**	Scasilio, 13th cent. in Marchese, 1957
1220	**landslide earthquake?**	*Privilegium* of Pope Honorius the 3rd, October 29 1221, n. 64 A; and *Diploma* by Emperor Frederic the 2nd, February 22 1222, n.128; in Pratesi, 1958
1409	flourishing	Water-supply design for the Abbey in Marchese, 1957; and Zinzi, 1999
1569	**landslide**	Buffolati & Guerra, 1576 in Marchese, 1957
1625	Calepino's reconstruction	1625 inscription in the façade of the portal
18th cent.	restoration and rebuilding	building of the small cloister (fig. 4a) Zinzi, 1999
18th cent.	decline	Marchese, 1957;1964

(e.g. Marchese, 1957; De Leo, 1993; Zinzi, 1999). For the aim of this paper, it is worth to note that the typical Cistercian monasteries usually developed around a cloister, with the church located in the northern and, possibly, higher sector (Latin cross, with three naves, and rectangular apse). Around the cloister there were different rooms devoted to the life of the monks (see figs. 3 and 4).

Therefore, it can be presumed that this was the aspect of the Abbey when it was (again) hit by an earthquake, and involved in a landslide in 1220, as described by contemporary documents: «*…monasterium... situm sit in loco ruinoso et alias valde inepto*» (*Privilegium* of Pope Honorius the 3rd dated October 29, 1221, n. 64 A, in Pratesi, 1958); «*…monasterium Sambucin[e], tamquam in solo tremulo et labenti fundatum, casum minatur pariter et ruinam et ex terre natura labilis ut arena fondamenta sunt ipsius monasteri conquassata…*» (*Diploma* by Emperor Frederic the 2nd dated February 22, 1222, n. 128 in Pratesi, 1958); «*…Sane, cum monasterium Sambucin[e] in loco ruinoso et alias valde inepto positum et nonnunquam terremotibus conquassatum…*» (*Privilegium* of Pope Honorius the 3rd dated June 1222, n. 130, in Pratesi, 1958).

In 1222, the monks asked and obtained to move into their filiation of S. Maria della Matina (near the village of San Marco Argentano), at least during the cold seasons (see documents in Pratesi, 1958). In 1409, the Monastery was again rich and flourishing, as shown in figure 3 (related to a water-supply design for the Abbey; Marchese, 1957; Zinzi, 1999).

In 1569, a catastrophic landslide (described in the following chapters) destroyed large sectors of the Monastery, that had been restored by the prior Cesare Calepino at the beginning of the 16th century (as recorded by an inscription in the façade, dated 1625). The remains of the great portal, probably slid downhill, were recovered and reassembled on the stump of the survived nave (fig. 1), whereas the present overall aspect of the Abbey derives from further restorations and rebuilding (e.g. the new small cloister) during the 18th century (see Zinzi, 1999; fig. 4a).

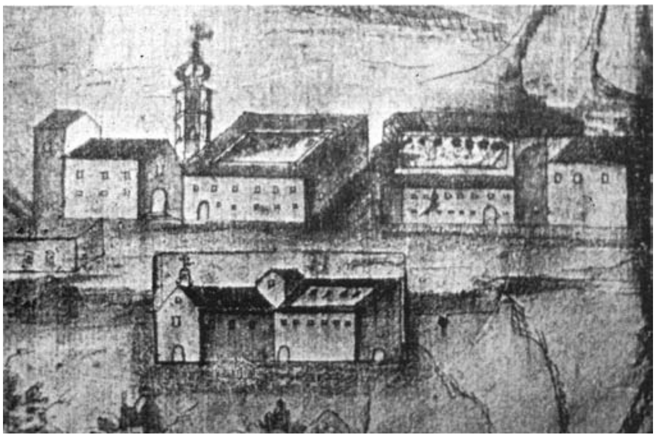


FIG. 3 - Detail of a drawing-project dated 1409 of the Monk's aqueduct, that illustrates the position of the Abbey and the surrounding buildings as they were before the disruptive landslide of 1569 (Marchese, 1957; Zinzi, 1999).

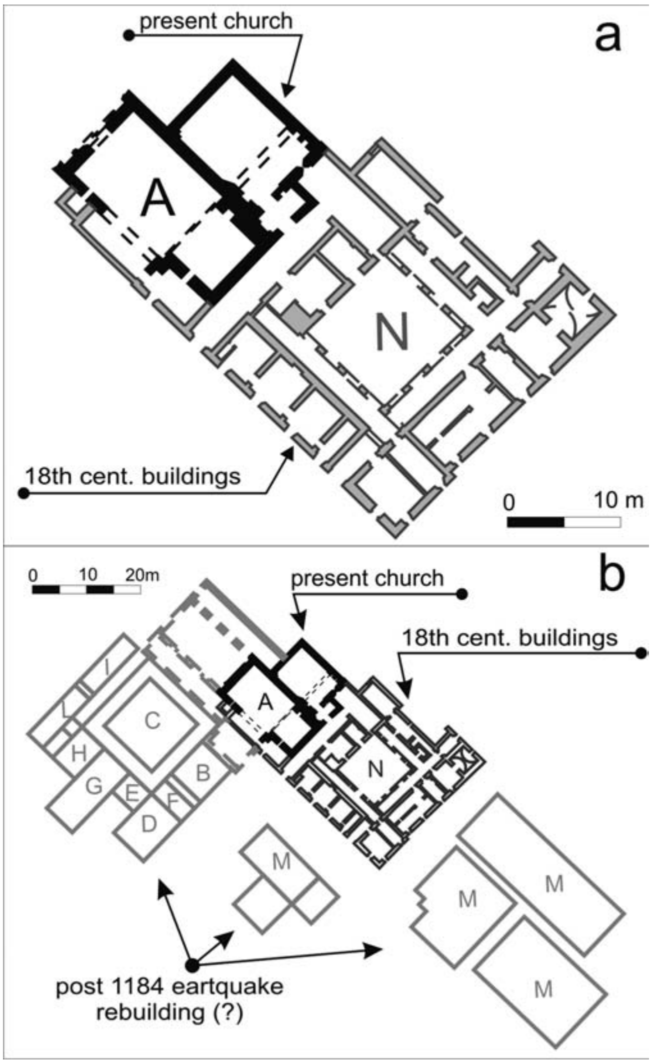


FIG. 4 - a, plan of the present church with the 18th century cloister. b, probable plan of the ancient Abbey, reconstructed on the basis of Martelli's (1957) and Zinzi's (1999) works, the 1409 drawing, and a typical Cistercian-abbey's plan.

In figure 4b, the data obtained from excavations and studies carried out at the abbey site in the past century are summarized (Martelli, 1957; Zinzi, 1999). Together with the image of the 15th Century Abbey given in figure 3, and on the basis of the typical Cistercians monastery-design, this figure tentatively provides the post-1184 earthquake aspect of the Sambucina Monastery (i.e. that hit by the 1222 and 1569 events).

GEOLOGICAL AND GEOMORPHOLOGICAL FRAMEWORK OF THE AREA

The study area is located in the Luzzi area, on the western side of the Sila Massif, along the slopes facing the N-S oriented Crati Valley. The Sila Massif is mainly composed by overthrusted nappes of Paleozoic metamorphic and igneous rocks, which were emplaced during Oligocene - Lower Miocene time (Amodio Morelli & *alii*, 1976; Tortorici, 1982). From a structural and geomorphological point of view, the Massif is a horst bounded by N-S-trending Quaternary normal faults, whereas the Crati Basin may be considered as a fault-bounded block basin (Turco & *alii*, 1990). Due to the intense erosional processes along the slopes of the Sila Massif and of the western Coastal Range (Dramis & *alii*, 1990; Critelli, 1999), the Crati Basin is filled by a sedimentary succession spanning from Miocene to Middle-Upper Pleistocene (Colella, 1994), overlying the Paleozoic rocks of the Calabride Complex (fig. 5).

The Paleozoic crystalline units that outcrop in the study area are constituted, from the bottom to the top, by:

- Polia-Copanello unit (Amodio Morelli & *alii*, 1976), composed by biotitic heterogeneous gneiss, and kinzigitic gneiss (Lanzafame & Zuffa, 1976). These rocks show migmatitic features; they are strongly biotitic with garnet and sillimanite and contain small bodies of amphibolites and leucosomes. The biotitic heterogeneous gneiss, locally intruded by pegmatitic dykes, generally appear tectonized and weathered mainly along the sub-horizontal contacts with the kinzigitic gneiss (Lanzafame & Zuffa, 1976; Borrelli & *alii*, 2007).
- Mt. Gariglione Unit (Amodio Morelli & *alii*, 1976), composed by quartzdioritic-granite trondhjemite (Lanzafame & Zuffa, 1976). Usually they are completely weathered and show the typical feature of red-brownish coarse sand (Lanzafame & Zuffa, 1976; Borrelli & *alii*, 2007).

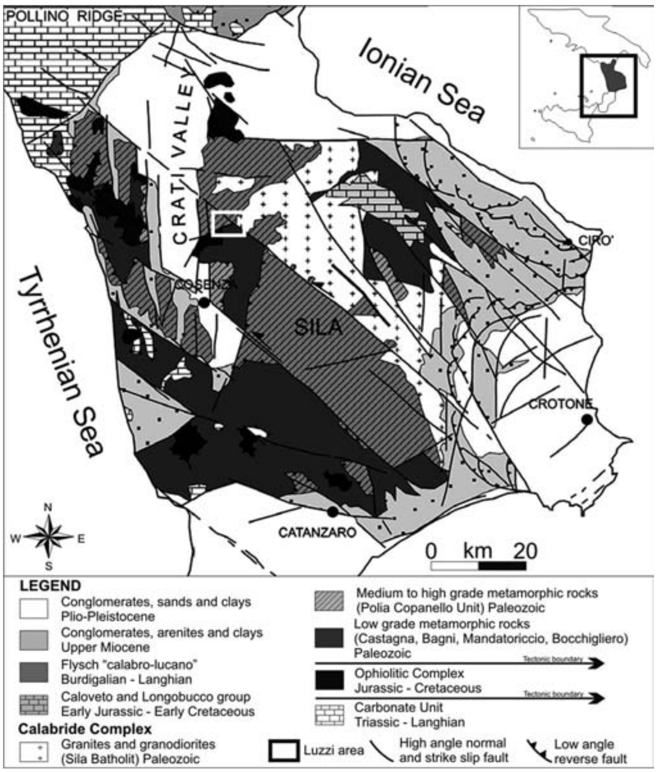


FIG. 5 - Geological sketch map of central-northern Calabria, modified from Spina & *alii*, 2007.

The strong weathering makes it difficult to identify the contacts between the granitic and the gneissic units. However, during field surveys, in few outcrops a whitish band along the contact between gneiss and granites was identified, interpreted as the result of a thermo-metamorphic contact. This band allows tracing the boundary between the two units also where it is masked by vegetation or colluvium (fig. 6). According to Barrese & *alii* (2006) and Pellegrino & Prestininzi (2007), the presence of sulphide along the contact between the gneiss and the granites produced a series of geochemical processes that involved also the silicates of the surrounding intrusive complex. These processes yielded the progressive weathering of the involved rock mass, contributing to the inset of the slopes instability.

In the investigated area, two main types of slope movements were mapped: a *deep multiple roto-translational slip* (D2c in Hutchinson, 1988), involving large part of the abbey slope, from the hilltop down to the Ilice River; and several shallow landslides, affecting the deposits produced by the weathering of Palaeozoic rocks (e.g. in Borrelli & *alii*, 2007).

The mentioned *roto-translational slip* is mainly visible on aerial photos, similarly to others in the same geolithological context (Gullà & Niceforo, 2003; Barrese & *alii*, 2006; Pellegrino & Prestininzi, 2007).

The geomorphological survey pointed out the following elements: a large scarp at the top of the slope, with an associated sagging; several scarps and trenches along the spurs of the slopes; bulging, counterslopes, and deviations of streams in the accumulation zone. According to geomorphological and surface geological data (unfortunately, no deep borehole data exist in the area), the uppermost portion of the basal surface of rupture of the slide developed along the contact aureole between gneiss and granite. On the other hand, the two flanks are controlled by structural discontinuities (i.e. faults) inside the gneissic unit, involving a mass thickness of some hundred meters (fig. 7).

As mentioned above, the whole area is featured by widespread slope instabilities, affecting the saprolitic and residual colluvial materials, with thickness in the order of tens of meters. Several morphological evidences of slope deformation were recognized along the entire Sambucina slope - such as scarps, counterslope terraces, inclined trees and large cracks in the man-made structures (e.g. roads, walls, and buildings). In the study area, slope instabilities are commonly triggered by both rainfalls and snowfalls, as several eye-witnesses claim. In some cases, damage to the road network was reported, mainly to the 559 National Road (Mercuri & Merenda, 1981; CNR-GNDCI, 1995; Calcaterra & *alii*, 2004; A.S.I.Cal., 2008). The widespread extension of this kind of phenomena was quantified by Mercuri & Merenda (1981), who calculated that 42,4% of the Ilice basin was affected by landslides following an intense rainfall event occurred in January 1981.

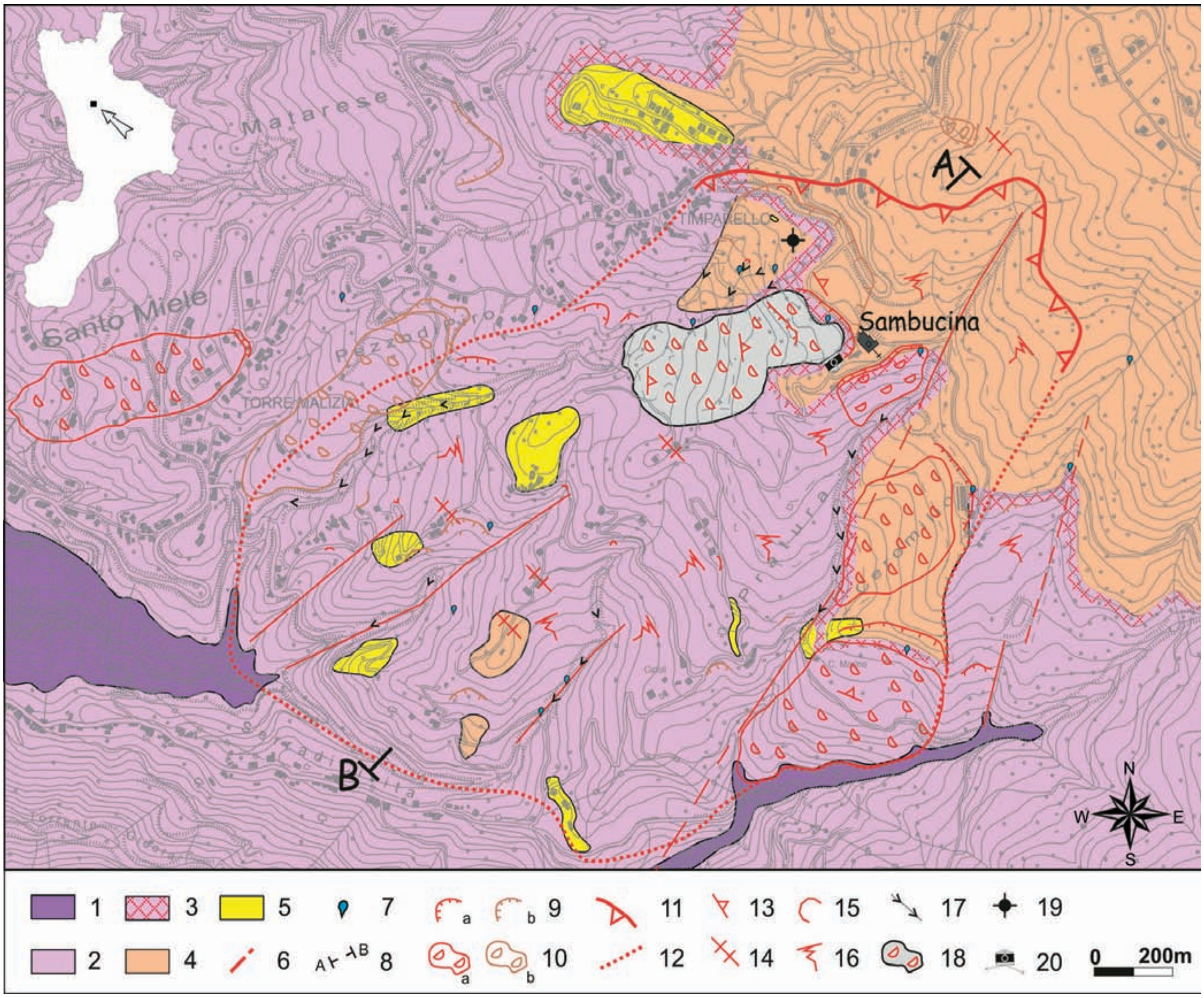


FIG. 6 - Geomorphological map of the study area (Luzzi, Cosenza), see rectangle in fig. 5: 1, kinzigitic gneiss; 2, biotitic heterogeneous gneiss; 3, contact aureole; 4, granites (weathered close to the contact aureole); 5, pegmatitic dyke; 6, fault; 7, spring; 8, trace of cross-section; 9, landslide scarp (a, recent; b, old); 10, landslide body (a, recent; b, old); 11, crown of multiple roto-translational slip; 12, boundary of multiple roto-translational slip; 13, counterslope; 14, morphologic trench; 15, unmappable landslide; 16, soil creep (B1a in Hutchinson, 1988); 17, downcutting water course; 18, Sambucina landslide; 19, borehole 20, point of view of figure 9.

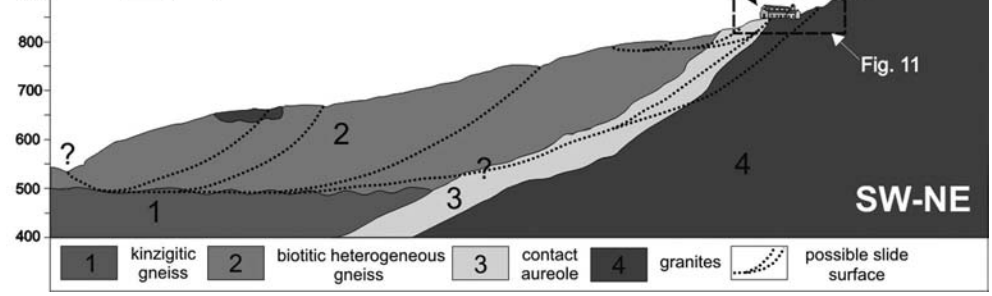


FIG. 7 - Geological section of the investigated slope. Note the hypothesized multiple roto-translational slip-surfaces. The hatched rectangle refers to figure 11.

THE 1569 LANDSLIDE

Historical hints

As mentioned before, the history of the Sambucina Abbey ended when a large landslide occurred in March 1569. A fit between historical data concerning this event with geological-geomorphological evidence surveyed at the site was attempted, by comparing the results with the presumed plan and volumes of the pre-existing monastery. Archival researches were carried out in Calabria, at Naples and Rome, searching for original documents concerning the landslide and/or the state of the monastery at that time. Unfortunately, most of the original documents concerning the Abbey went lost; sometime their traces lead to private archives, which no longer exist nowadays, or that merged into others - as in the case of the Archivio di Stato di Napoli, where some files of interest were destroyed during the Second World War.

Figure 8 shows the family tree of studies and sources quoting the 1569 landslide. The «key feature» concerning this issue is a local author (Marchese, 1957; 1964), who partly reported a coeval account of the landslide. The original text of this account is currently unavailable; anyway, according to Marchese (1964), who read the transcription of this document in manuscripts of other local authors (Calepino, 1625; Firrao, 1690 in Marchese, 1957), the document was addressed to a certain Cardinal Souchier. The original «piece» was written by Giusto Buffolati and Matteo Guerra, who actually lived at that time (Buffolati & Guerra, 1576, in: Marchese, 1957). Giusto Buffolati was the prior of the Casamari Abbey, who in that period surely visited other Cistercian monasteries of Calabria (Adorisio, 2000). This fact is also demonstrated by a manuscript found in Rome by the authors (BNCR, 16th cent.), which reports the results of his visits. Matteo Guerra was the Bishop of San Marco Argentano, at that time ruling also the Luzzi area; therefore, it is reasonable that he attended Buffolati in his trip. Finally, cardinal Souchier was the abbot of Clairvaux and Citeaux (1553-1571), and he actually ordered inspections to the monasteries in the Naples and Sicily Kingdom, such as the one accomplished by Nicholas Boucherat at the beginning of 1569 (ASV, 1569a; Marton, 1972). In this visit, Boucherat (ASV, 1569b) described the monastery of *S. Maria de Sabuchina* (=Sambucina) as totally collapsed: «*…omnia aedificia penitus destructa sunt praeter locum, ubi sunt duo aut tria cubicula. In eo nulli sunt monachi…*» (*…all the buildings are almost destroyed, except for a place where there are two or three rooms. No monk lives here…*).

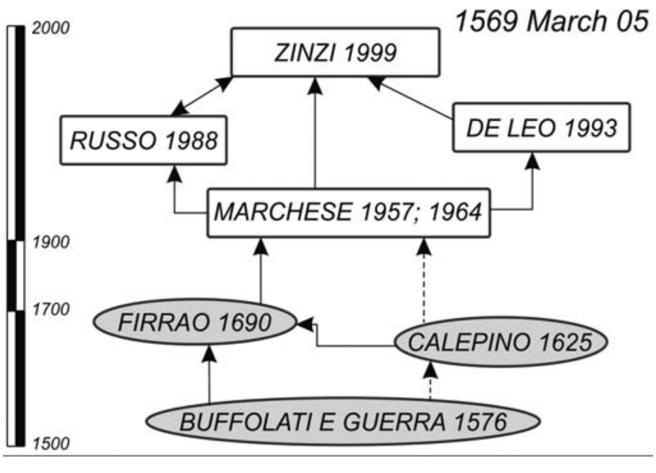


FIG. 8 - «Family tree» of the 1569 landslide sources. The ellipses envelop the sources reported by modern authors, which are currently unavailable. Dashed lines are uncertain philological filiations.

In view of the role played by the mentioned persons at that time, the landslide account reported by Marchese (1957; 1964) could be considered reliable, also in the light of the terrific report provided by Boucherat (ASV, 1569b) on the conditions of the monastery just after the event occurred.

The core of the account by Buffolati & Guerra is: «*In March 5, 1569, after a violent snow and ice storm, followed by 6 days of uninterrupted rainstorm, in the main center of the Sambucina Abbey a several-arms-downfall* [i.e. some meters] *of the soil occurred, caused by a frightful landslide… The friars… observed that the wings of the Abbey and the middle of the church were enormously damaged, and were sliding toward the plain located below! …Twenty days after the inauspicious event, only the upper parts of the wings of the church and one part of the monastery close to them were safe. All the other parts of the church and of other buildings were swallowed by the abyss, with everything herein contained, whereas only few opened walls still stand up*» (translated from Marchese, 1957).

According to this text, the landslide was induced by the abundant snowfall and rain; the sliding of the buildings, following the first parossistic motion (with displacement of several meters), lasted several days.

Moreover, the text reports that only the apse sectors of the nave and of the aisles were preserved; in fact, these parts of the church are the only ones still visible today, following the restoration made in 1625 by the friar Calepino (date reported on the façade).

Landslide geology

As mentioned before, the geological investigations performed in the Sambucina area pointed out the presence of deeply weathered and jointed rock units belonging to a contact aureole. Two 20-m-deep boreholes (19, in fig. 6), located two hundred meters N from Sambucina inside the intrusive unit (4, in fig. 6), show that the granites are intensively jointed and altered, displaying a dominant sandy lithology (Olivieri, 1998). Similarly to other nearby case histories (Barrese & *alii*, 2006; Pellegrino & Prestininzi, 2007), slope movements of the same type are widespread in the area, involving saprolite and residual materials some tens of meters thick (Calcaterra & *alii*, 2004). Aerial photos interpretation and historical information supported site investigations in determining the mechanisms and the relative age of landslide activations in the area, with special reference to the one which destroyed the Sambucina Abbey (fig. 9). The 1569 landslide can be classified as a *roto-translational slide* (Varnes, 1978; Cruden & Varnes, 1996), involving both the saprolite and residual material derived from the weathering of the Paleozoic rock units, and the thermo-metamorphic contact aureole material, with an estimated maximum thickness of about 10-15 m, and a length in the order of 500 m (fig. 6).

As no geotechnical test could be carried out in the site area, the lithotechnical parameters of this landslide were tentatively inferred from few available data collected in adjacent areas (Olivieri, 1998; Calcaterra & *alii*, 2004; see tab. 3), such as the log interpretation of the mentioned boreholes, the SPT values distribution vs. depth along the same boreholes, and the results of two seismic refraction profiles, which suggest a superficial layer consisting of 10 m-thick loose debris.

With the aim of validating the inferred landslide geometry, seismic noise recording was performed within the landslide area by means of a digital tromograph Tromino (www.tromino.it). The results show a dominant first mode of vibration at 4.4 Hz; taking into account the relationships among frequency value, Vs (shear velocity: 220 m/s, see tab. 3) and thickness (H) of a given layer (i.e. n(Hz)=Vs/4H), the depth of the landslide mass (assumed to coincide with H) was estimated in the order of 12 m, which is well in agreement with the values hypothesized by previous investigations (Calcaterra & *alii*, 2004).

It is worth to note that a rainfall-induced roto-translational landslide was reactivated in 1996 not far from Sambucina (Santo Miele site, Luzzi; see fig. 6), involving the same weathered crystalline rocks, and causing severe damage to buildings and roads. Also in this case, according to Calcaterra & *alii* (2004), this 400 m long landslide would be the shallow part of a likely deeper movement.

Besides morphological and geotechnical aspects, the geological model of the 1569 landslide was developed by taking into account both the information contained in the report by Buffolati and Guerra (1576), and some architectural evidence. In figure 10, by comparing the plan of the present-day abbey (i.e. as drawn in the studies by Martelli, 1957, and by Zinzi, 1999; fig. 4a) with the image of the monastery in 1409 (fig. 3; see also fig. 4b), a tentative reconstruction of the original 12th century abbey complex and its relationships with the geomorphological features individuated in the area are shown.

This reconstruction points out that some sectors of the monastery are missing nowadays, and gives a reliable explanation for the non-orthodox plan of the current church. Figures 10 and 11 show that the 1569 landslide affected the core of the complex, cutting half of the church (A in fig. 10), the entire cloister area (B, C, D, E, F, G, H, I, L), while other buildings (M) disappeared due to another landslide affecting the southern side of the monastery. In particular, figure 11 tentatively evidences the sector of the slope where the Abbey was founded after the 1184 earthquake - possibly a sub-planar area once located westward of the present church, which slid downhill in 1569.

TABLE 3 - Geotechnical data obtained in landslide-areas adjacent to the Sambucina Abbey - after 1) Calcaterra & *alii* (2004), and 2) Olivieri (1998)

Lithological Units	**State**	γ (kN/m^3)	C'_P (kPa)	ϕ'_P (°)	ϕ'_R (°)	V_P (m/s)	V_S (m/s)
Saprolite	Loose	20.0[1]	0[1]	29[1]	23[1]	445[2]	220[2]
Fractured rocks	Dense/ fractured	21.0[1]	30[1]	32[1]	24[1]	2100[2]	1160[2]

It is worth noting that, before the disastrous 1569 event, the landslide also moved on other occasions. Although no reports explicitly refer to a landslide movement, it is possible that the 1184 earthquake triggered some slope movements near the former Benedictine abbey (which was then reconstructed). On the other hand, as aforementioned, in 1220 a landslide, probably associated with a local earthquake, seriously damaged the Abbey, in such a way that the monks were compelled to move to another monastery located close to the Sambucina.

Further slope movements occurred during the long life of the Abbey, up to recent times. In fact, according to some villagers, the road running below the church was offset by 1 m during the 1981 rainstorm, and other soil-slumps affected the slopes around the church. The retrogressive distribution of activity of the landslide is also evidenced by the cracks affecting the interior of the apse.

CONCLUSIONS

Through a multidisciplinary approach of study, the historical and geomorphological events which characterized the Sambucina Abbey site were analysed. The contribution given by the historical documents, as a mean of understanding the geometries, mechanisms and dating of ancient landslide phenomena was emphasized. In fact,

FIG. 9 - North-facing view of the 1569 landslide crown area (note the Sambucina remains to the right).

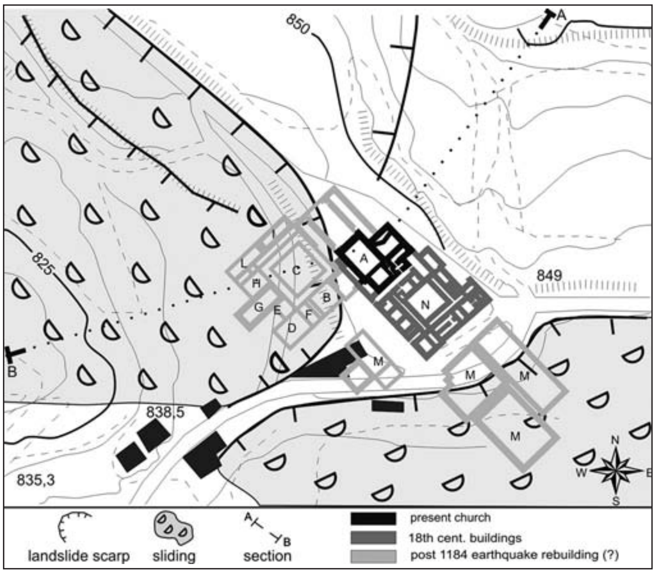


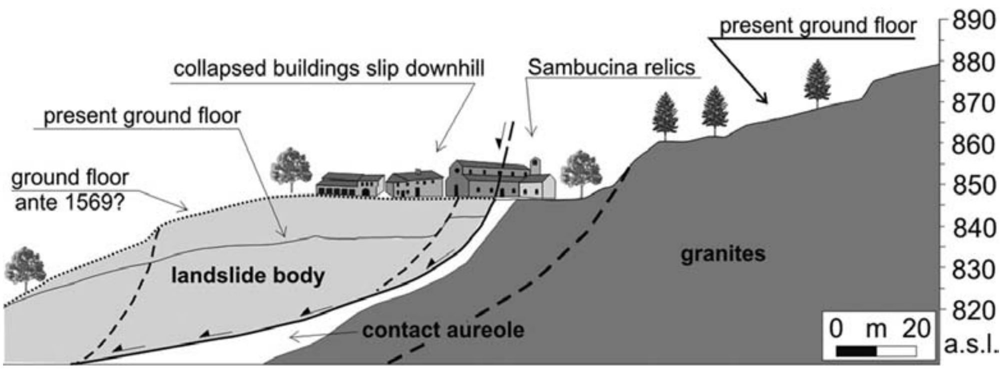
FIG. 10 - Reconstruction of the ancient monastery prior to the 1569 landslide. A, church; B, chapter-house; C, cloister; D, monks rooms; E, calefactorium; F, auditorium; G, monks refectory; H, kitchen; I, dispensarium; L, lay brothers refectory; M, monastic factory; N, 18th cent. cloister.

existed at the time of the Sambucina foundation but, due to repeated landslide activations in the past centuries, they slid down, and are missing nowadays.

Similarly to other case histories described in nearby geo-lithological and morphological environments, the shear surfaces of the main landslide are controlled by structural discontinuities, and by the presence of a contact-aureole developed during the intrusion of granites into the gneissic units. However, whereas the weathered and deeply jointed rocks of the contact aureole played a primary role for the onset of the multiple roto-translational slide affecting the entire Sambucina slope (the age of which is still under investigation), the more shallow slope instabilities, such as the 1569 one, occurred within the thick saprolitic and residual colluvial deposits derived from the Paleozoic rock units. As observed in the past, these roto-translational landslides can be induced, indifferently, by moderate seismic shaking (e.g. 1220 event) or by rain and snow storms (e.g. 1569 event).

On the basis of all the aforementioned issues, and remembering the cited earthquakes, landslides and storms, it can be stated that, in this case, Cistercians failed dramatically in choosing the place to build their monastery.

FIG. 11 - Schematic geologic section of the Sambucina slope. Note the hypothesized ground surface preceding the 1569 landslide, the existence of which is necessary for explaining the original abbey plan.



archive and library researches performed on the Sambucina Abbey provided the necessary information for restoring the chronology of the main natural events which affected this site in the past millennium. Since its foundation in the 12th century, the Abbey was firstly damaged by an earthquake in 1184, and then in 1220 by a landslide, which was presumably triggered by a local earthquake. In 1569, a catastrophic landslide completely destroyed the monastic complex, and the monks abandoned the monastery.

On the basis of geological investigations and interpretation of geomorphological evidence in the abbey area, the geological model of the 1569 landslide could be defined. Once compared and integrated with the data provided by the original 1569 landslide account, the geological model was used to cast light on some unsolved problems, raised in times, concerning the difference between the present church plan and the original design of the Cistercians complex (i.e. that pictured in 1409). Large areas, once located westward and southward of the present church,

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