



Natural Hazards, Human Factors, and “Ghost Towns”: a Multi-Level Approach

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Abstract

The abandonment of inhabited places is a phenomenon that concerns many countries worldwide and Italy particularly where a large number of deserted settlements are hosted. Many are the factors driving and conditioning the abandonment of a site, such as natural extreme events (e.g. earthquakes, landslides, and floods) and/or human (not) actions. Once the site is abandoned, the built-up area experiences a progressive physical decay so posing problems about the policies to be adopted to manage and maintain the buildings (or their ruins). That being stated, the article proposes an integrated methodological approach to analyse both the natural/human factors causing the abandonment of settlements and conservation state of deserted places over time. To test the methodology, we considered the old town of Craco (Basilicata, Southern Italy) as a case study. That “ghost town”, whose fascinating urban and natural landscapes have been the set of numerous international films, was gradually transferred to other two places since the 1960s due to the landslides that have affected the site over the centuries. Three were the explicit key aims of the research. The first was to scrutinise the activations/reactivations of the landslides jointly with their effects on the built environment so to critically go over the actions put into the field by the institutions to mitigate the hydrogeological risk. The second was to examine whether and how the landslide occurrences conditioned the urban growth of the Craco over time. The third was to investigate in relation to the vegetation growth in the Craco downtown over the last 15 years or so, to infer clues on future decay trends and conservation strategies of the built environment. The purposes were reached considering a geological-geomorphological, historical, and remote-sensing approach. In detail, the first goal was met (re)considering a cross-correlated analysis, in diachronic key, of edited/unedited archive sources with geological/geomorphological perspectives. The second was followed up performing the analysis of the Craco urban growth over the centuries and correlating it with the history of landslide occurrences. The third target was pursued by means of NDVI (Normalized Difference Vegetation Index) time series obtained from Landsat TM and Sentinel 2 data along with HSV (Hue, Saturation, Value) colour system techniques applied to multi-date Google Earth photos. From the perspective angle, the results of this research can contribute to setup proper resilience strategies for sites subject to hydrogeological hazard similar to that affects Craco, thus helping to identify conservation plans as well as enhancement policies of “ghost towns”.

Keywords Abandoned towns · Natural hazards · Cultural heritage · Resilience · NDVI technique · HSV colour system

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Ruins, likewise the art, are an invitation to sense the time
[Marc Augé]

Introduction

The abandonment of inhabited places is a phenomenon well-known in numerous countries over the world and it goes through the centuries since ancient times (e.g. the destruction and abandonment of Pompeii due to 79 A.D. Vesuvius eruption). In the Middle Ages, a profound demographic and economic reorganisation due to a series of events, such as the black plague of 1348, various wars, and constant famines, led to the disappearance of thousands of villages in Europe (Beresford and Hurst 1971; Demians D'Archimbaud 1974; Arthur 2010), with notable differences between regions, among which Basilicata stood out (Pedio 1990; Lasaponara and Masini 2009). In this region of Southern Italy, about 30% of rural settlements were abandoned for a number of factors among which the hydrogeological instability phenomena (Lasaponara et al. 2010).

The occurrence of site abandonment has taken on a relevance in Europe during the last decades of the twentieth century as a consequence of extensive social, economic, and cultural changes that have permeated the continent in that period. These transformations have led rapid urban expansion to the detriment of both smaller settlements and remote rural villages that have been deserted by inhabitants with the consequent birth of “ghost towns” (East 2017).

Many are the driving forces or conditioning factors that can lead to the abandonment of sites. We refer to both *natural causes* (e.g. earthquakes, landslides, floods, volcanic eruptions, environmental conditions, and disease) and *human (not) actions* such as wars, economic fluctuations, demographic aspects, population transfer towards urban areas, marginality and place isolation due to the lack of infrastructure, and technological or industrial disasters.

Looking at the international scenario, the extension and the causes of the phenomenon are quite diversified. In the Western United States, the appearance of “ghost towns” was driven mainly by economic reasons due to the abandonment of mining centres born since the 1848 California “gold rush” age (Candura 1993). The abandonment of mines and the consequent birth of “ghost towns” are the prominent feature also in the northern Canadian landscape, whilst in Africa, the phenomenon is mainly due to wars, diseases, and mine abandonment (Drewes and van Aswegen 2008; Pirlone 2016; Keeling and Sandlos 2017).

Moving the attention to the European scenario, the abandonment raises an important statistical significance especially in Italy, but also in France, Greece, Ireland, Spain, and Portugal. In these countries, which host many settlements abandoned

since the Middle Ages, the main causes of abandonment were wars, natural hazards, diseases, urbanisation, and work shortage. However, Italy holds the record of number of “ghost towns” in Europe. About 6,000 are the places abandoned (especially in central and southern portion of the peninsula), including proper villages/towns, *alpeggi* (mountain pastures) and *stazzi* (typical rural settlements). In addition, the trend for the next future seems to be towards an increase of the occurrence of the abandonment considering that about twenty-eight hundred are the villages at risk of disappearing in the next future (Pirlone 2016). Many are the causes listed as abandonment factors (Guidoboni and Ferrari 2000; Coletta 2014; Gizzi et al. 2015; Pirlone 2016; Porfido and Spiga 2016; East 2017; Masini et al. 2018) such as:

- 1) *Earthquakes* and/or *landslides* (e.g. Campomaggiore abandoned after a landslide occurred in 1886, Craco whose abandonment started after the 1963 landslide, in the Basilicata Region; Apice and Melito abandoned after the 1962 and 1980 Irpinia earthquakes, Romagnano al Monte abandoned after the 1980 earthquake, in the Campania Region; Gibellina, transferred after the 1968 Belice earthquake, in the Sicily Region),
- 2) *Wars* (e.g. San Pietro Infine, destroyed by the World War II bombing, in Campania; Cisterna, in Basilicata, that suffered a decline after its destruction by Norman in the late Middle Ages),
- 3) *Marginality* and *place isolation* (e.g. Presenzano, Pietravairano, and Borgo San Felice, in Campania),
- 4) *Epidemic* and *sacking* (e.g. Monterano, Lazio Region),
- 5) *Emigration* (e.g. Fantino, Calabria Region).

The abandonment of sites can lead to three main possible consequences: (a) the migration of population or their dispersion in other inhabited places with the disappearance of the abandoned towns from the geography of settled sites, (b) the total shifting (at a variable distance) of towns with the rebuilding from scratch of new settlements, and (c) the partial shifting of towns with rebuilding in areas contiguous or not to the old settlements (Guidoboni and Ferrari 2000; Galadini 2016; Gizzi et al. 2016). Noticeably, since their abandonment, the buildings (or their ruins) start a progressive physical decay, so posing problems in relation to the policies to be adopted to maintain and manage the deserted settlements.

Due to the circumstance that the abandonment of sites is being increasing over time, the implementation of proper policies is required to manage towns subject to the influence of human and/or natural factors. Therefore, it is crucial to investigate in depth the causes that led leaving sites in historical time to learn lessons from the past and understand the role of natural as well as human elements in driving or conditioning

the site decline, also focusing the attention on the resilience of past communities. At the same time, “ghost towns” can be an important touristic resource to be preserved and enhanced for both the cultural heritage they preserve and what they represent. For example, in order to increase the risk awareness, the places that preserve evidences of the occurrence of natural extreme events can be considered a useful geotourism resource for educational purpose (Migoñ and Migoñ-Pijet 2018).

That being stated, this study aims to setup a multidisciplinary and interdisciplinary methodological approach suitable to investigate both the natural/human factors that caused the abandonment of settlements and evolution of the conservation state of the deserted places over time. To test the methodology, we considered the old town of Craco as case study. It is located in Basilicata (Southern Italy), a region that for its natural as well as built features can be well-thought-out a real open-air laboratory (Gizzi et al. 2018).

Old Craco, prior to and after its abandonment, has been the set of many films for its fascinating urban and natural landscapes. Today, Craco can be considered an emblematic case of (ineffective) efforts made to guarantee the survival of the people place, affected by (re)activations of landslides over the past centuries. Many attempts were made by institutions to mitigate the hydrogeological risk, but the shifting of the town was inevitable. Therefore, the transfer was certainly caused by the landslide occurrence, but it was also conditioned, in terms of modality and times of fulfilment, by the actions put into the

field by both the national and local institutions. After the abandonment, the historical centre has experienced a progressive degradation of the built-up area whose prosecution could put at risk the survival of the site, also preventing its exploitation for touristic/cinematographic drives.

The proposed methodology was applied having three main purposes in mind (Fig. 1):

- 1) To analyse the activations/reactivations of the landslides jointly with their effects on the built environment and to critically review the actions put into the field by the institutions for mitigating the hydrogeological risk;
- 2) To investigate whether and how the landslide occurrences over time conditioned the Craco urban development;
- 3) To explore the trends in the conservation state of the Craco buildings, analysing the vegetation growth over time (from 2003 to 2018) to infer clues about future conservation strategies.

The first aim was reached (re)considering a cross-correlated analysis, in diachronic key, of (un)edited archive sources with geological/geomorphological considerations. The second purpose was reached performing the analysis of the urban growth over the centuries and correlating it with the landslide chronology study. The third goal was pursued using NDVI (Normalized Difference Vegetation Index) time series obtained from Landsat TM and Sentinel 2 data along with

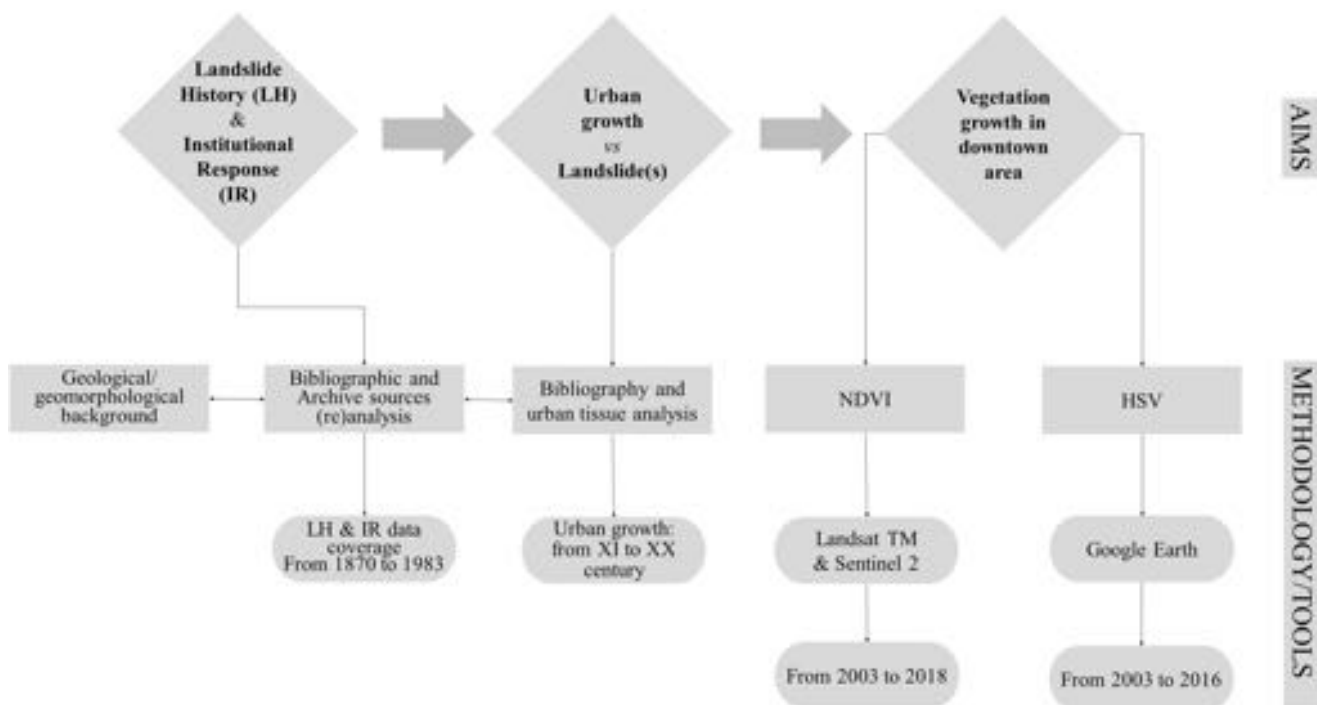


Fig. 1 Representation of the methodology adopted for the research

HSV (Hue, Saturation, Value) colour system techniques applied to multi-date Google Earth photos.

Taken overall, the results of this research will be useful to properly defining the possible actions to be undertaken to increase the resilience of small settlements and improve the management of future post-calamity phase in the hypothesis of abandonment and transfer of small settlement. Furthermore, the results of this work will be useful in the planning of conservation, safeguard, and enhancement strategies of “ghost towns”.

Geographical, Geological, and Geomorphological Settings of the Craco Area

The old Craco is a small (abandoned) town located in the southern-eastern portion of the Basilicata Region (Southern Italy, Figs. 2 and 3), largely occupied by a tertiary fold-and-thrust belt that recorded episodes of both positive and negative inversion tectonics (Tavernelli and Prosser 2003). From the geological point of view, the Craco ridge on which the town of medieval origin was built is located just to the west of the buried front of the Southern Apennine Chain (Fig. 4a). It is situated at about 390 m a.s.l. and extends in a north-west-south-east direction, bounded on the south-west by

the Bruscata stream, and on the north-east by the Pescara stream, a tributary of the Cavone river, which flows into the Ionian Sea, crossing the Metaponto Plain. In the area, remarkable outcrops of the allochthonous units tectonically cover the Plio-Pleistocene clastic deposits of the Bradanic foredeep and are, in turn, blanketed by younger conglomerates, sands and clays of Plio-Pleistocene age, deformed by the continuous advancement of the front of the chain towards the north-easterly quadrants (Bentivenga et al. 2005) (Fig. 4b).

The allochthonous units are overthrust, along the sub-horizontal surface, on the Plio-Pleistocene deposits of the foredeep, in turn resting on the Apulia foreland, lowered by steps from high-angle normal faults. The oil exploration that has interested the area has provided data that include the advancement of the allochthonous units, occurred until the middle Pleistocene, since a bed of the overthrust units was found onto deposits of lower Pleistocene age (Balduzzi et al. 1982). The Craco ridge is made up of allochthonous units put in place by a main back-thrust structure responsible for the deformation of the Apennine Chain front (Bentivenga et al. 2005) (Figs. 5 and 6(a)).

The allochthonous units are represented by the *Argille Varicolori* (Cretaceous-Oligocene), overlain by Pliocene sediments. The latter consist of deposits belonging to two distinct sedimentary cycles separated by an unconformity.



Fig. 2 Geographical sketch showing the location of the Craco old town

Fig. 3 The Craco old town taken from south-east (photo by Bentivenga M)



This is evident in some points on the north-eastern side of the Craco hill and in particular in the locality of Macinecchie, where along the ridge, we can see the discordance surface that separates the two depositional cycles and in particular the onlap support of the deposits of the second cycle on the same surface (Fig. 6(b)).

The first cycle consists of lenticular conglomerate bodies with sandy interlayers, bioclastic sands (“lower sands” in Fig. 5), marly clays with sandy horizons, and finally bioclastic sands (“upper sands” in Fig. 5), with an overall thickness estimated around 350 m. The second cycle consists of grey marly clays with intercalations of sand and tuff levels of metric thickness.

In the Craco area, the detected tectonic structures have a lateral discontinuity and this is easily found in the geological map (Fig. 5). The lateral variability in the geometry of the structures is partly linked to the presence of numerous faults with an anti-Apennine orientation that displace the contractional structures. The presence of these faults was verified by mapping in detail the main conglomerate horizons located at the base of the first cycle. Furthermore, important anti-Apennine faults are clearly visible between the localities of Macinecchie and Tempa S. Lorenzo.

Within this system, the main fault shows an apparent left lateral strike-slip kinematics that cut both thrust and back-

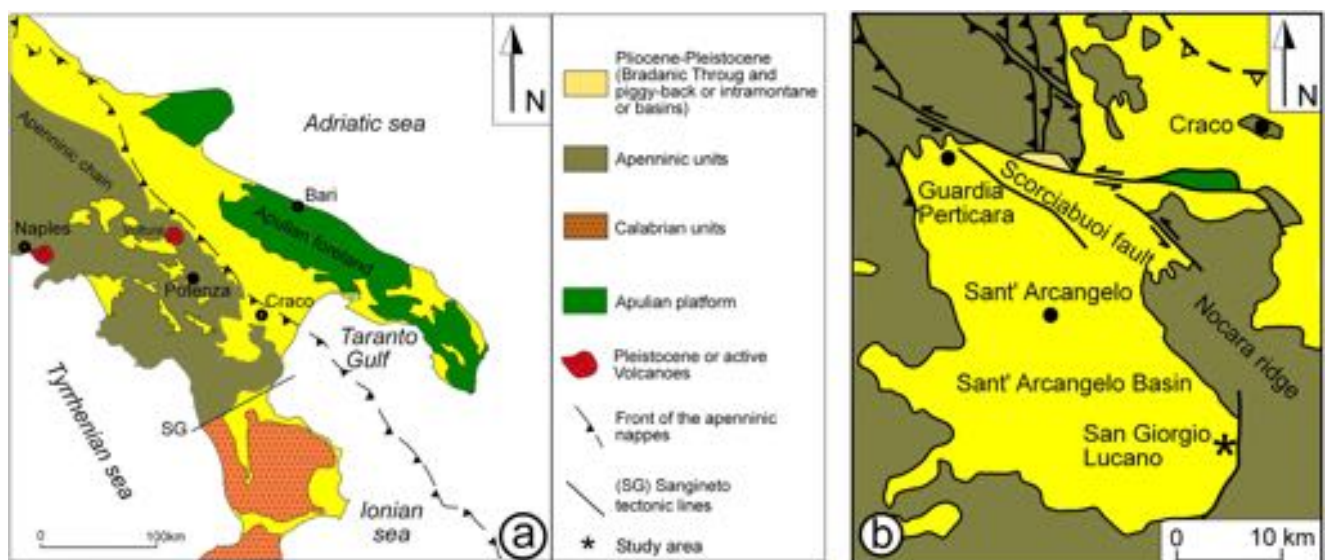


Fig. 4 Geological sketch map of Southern Apennines (a) (after Bentivenga et al. 2004) and eastern sector of the Southern Apennines including the Craco study area (b) (after Pieri et al. 1994, modified)

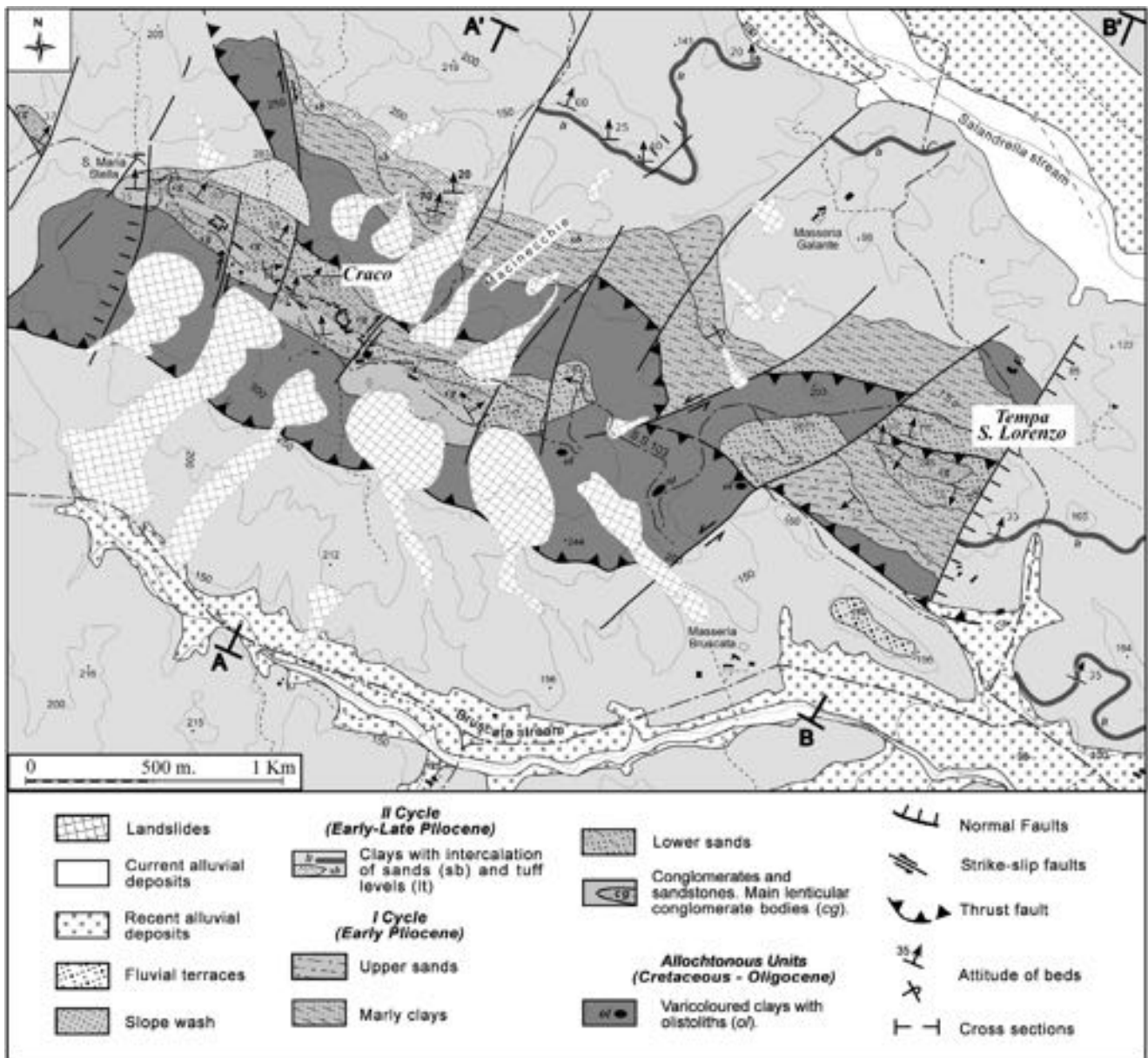


Fig. 5 Geological map of the Craco area (after Bentivenga et al. 2005)

thrust of about 1 km (Fig. 5). In the Craco area, the Pliocene deposits and the *Argille Varicolori* form a submerged monoclinal to the north-east (Figs. 5 and 6(a)), situated on the roof of a main back-thrust that carries the *Argille Varicolori* on the clays of the second cycle. The tectonic contact, inclined about 60° towards NE, is clearly visible from the Bruscata ditch, along the southern slope of the Craco hill.

Sometimes, the *Argille Varicolori* are covered by the basal conglomerate of the first cycle, which always plunges towards the northeast with inclinations of about 60°. As well as on the left side of the Bruscata ditch, the *Argille Varicolori* also emerge in correspondence to the north-eastern slope of the Craco hill, in the Macinecchie locality, where apparently, they are superimposed on the conglomerates and the lower sands.

This anomalous situation can be explained by a second back-thrust, which brings the *Argille Varicolori* over the lower sands or marly clays of the first cycle, as indicated in the geological profile of Fig. 6(a).

The geological study carried out in the Craco area (Bentivenga et al. 2005) made possible to highlight the processes that operated on the front of the chain, documenting how the progressive deformation of the allochthon units occurred at the same time as the sedimentation of the Pliocene deposits, as evidenced by the support in onlap of the deposits of the second cycle on those of the first cycle (Fig. 6(b)).

The tectonic evolution of the area took place with the formation process of mélangé (Roure et al. 1991), responsible for the considerable internal deformation that characterises the

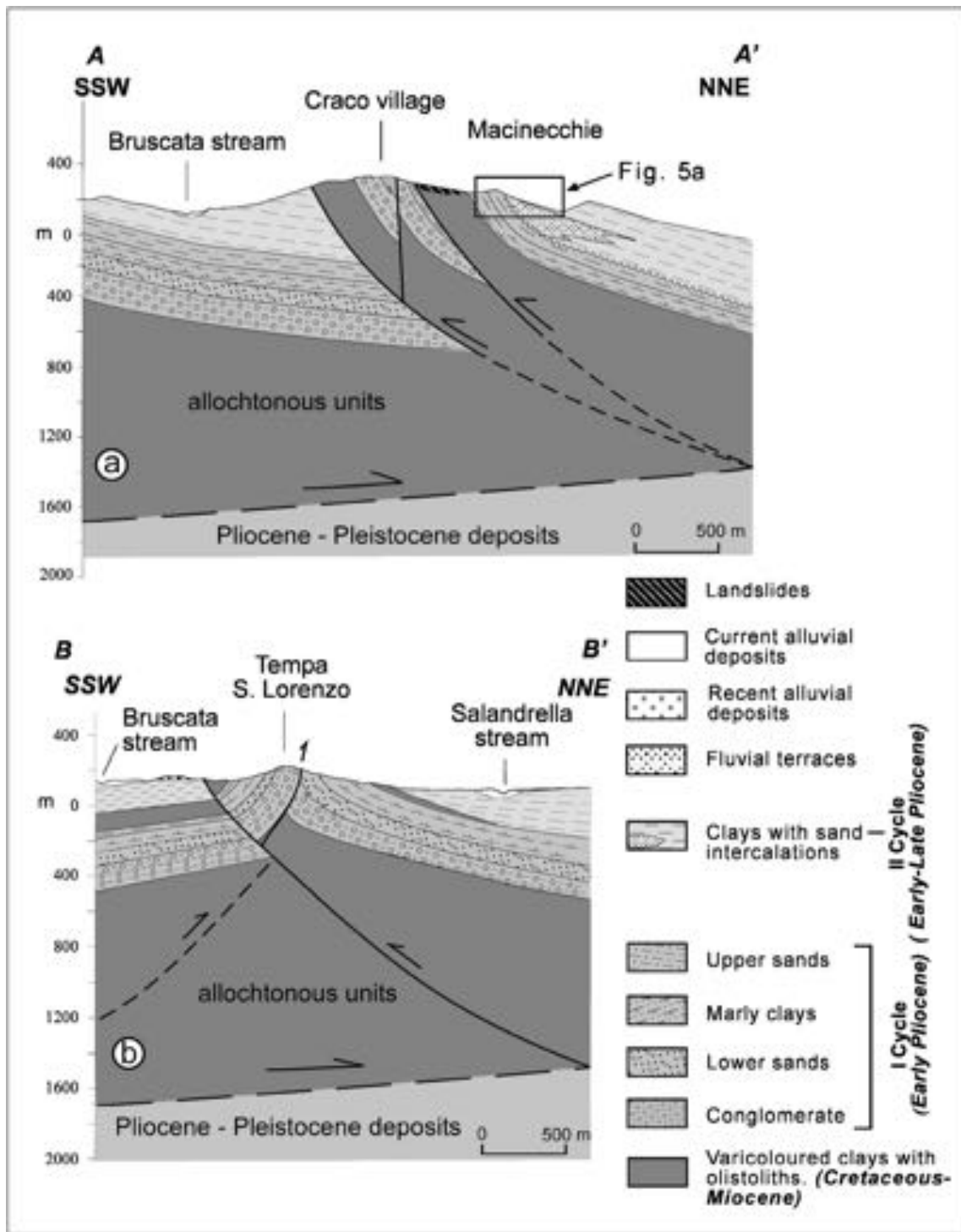


Fig. 6 Cross-sections showing the main tectonic and stratigraphic elements of the Craco area (Bentivenga et al. 2005). For the location of the sections, see Fig. 5

Argille Varicolori. This happened before the deposition of the Pliocene succession. In fact, the deposits of the first cycle rest directly on the already deformed *Argille Varicolori*, which constituted the front portion of the prism of accretion of the Southern Apennines. It followed then, an intense tectonic activity that characterised the end of the first cycle causes a northeast tilting of the whole succession. The deformation

continued during the Pliocene—lower Pleistocene giving rise to thrust and back-thrust that deformed the clays of the summit Pliocene. From the end of the lower Pleistocene, the beginning of the middle Pleistocene the area was affected by lifting phenomena that generated a series of marine terraces throughout the Gulf of Taranto (Bentivenga et al. 2004 cum *bib*). The Craco ridge has a NW-SE orientation according to the

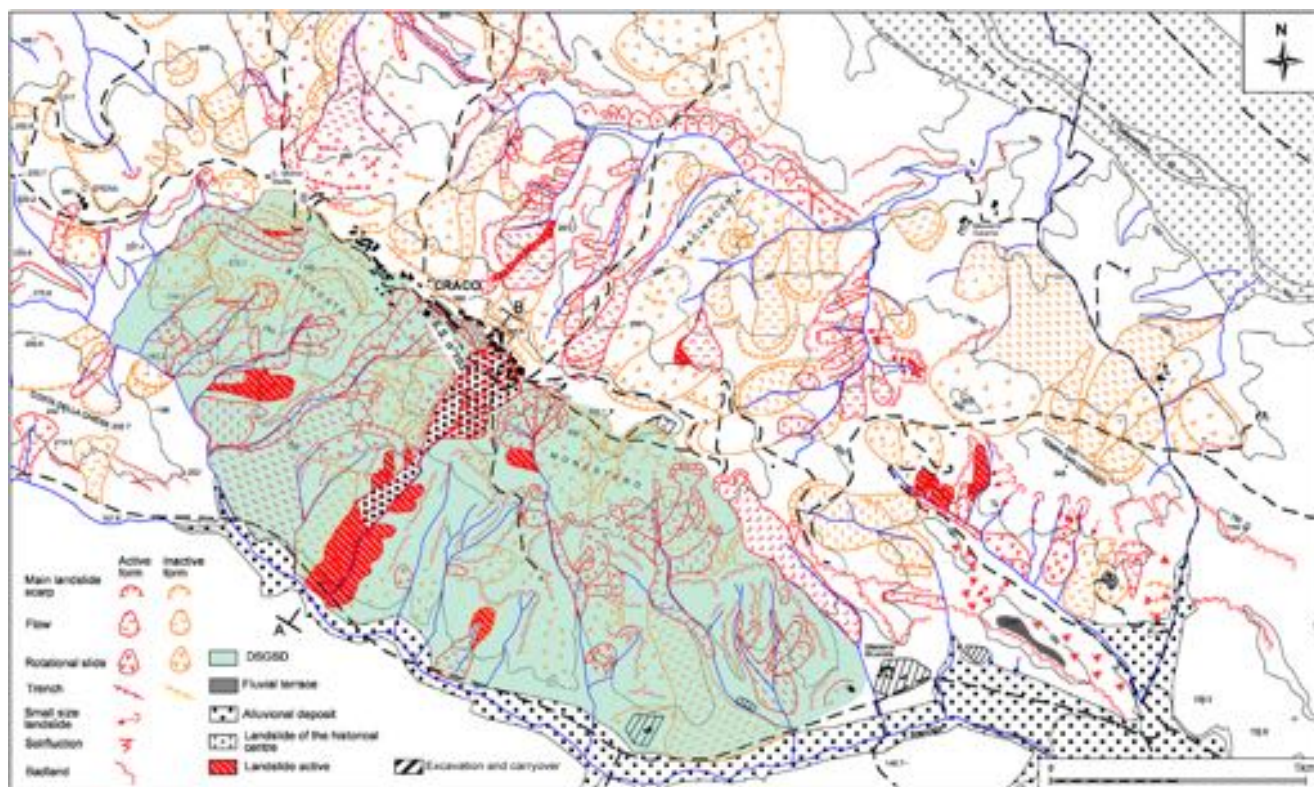


Fig. 7 Geomorphological map of the Craco area (after Bentivenga et al. 2004)

Apennine directions and it is bordered on the south-west by the Bruscata creek and on the northeast by the Salandrella stream (Fig. 7).

The north-eastern side of the ridge has an average slope of about 13° and it is affected by numerous landslides, some of which develop along the entire slope, until reaching the valley floor. The movements were classified as complex landslides, which show a rotational slide in the upper part of the slope; differently, lobes and undulations, which are typical of the flows, are present downstream (Varnes 1978; Del Del Prete and Petley 1982; Carrara et al. 1985; Bentivenga et al. 2014).

The trenches and counter-slopes generally present a limited linear development both because they are dissected by the valley incisions and because they are obliterated by processes of filling from debris.

The lower part of the eastern slope has graded slopes on the clayey sediments, with support and exposure towards the southern quadrants. The escarpments are affected by badland forms that sometimes develop for several hundred metres as in the northern part of the district of Macinecchia. At the bottom of the same slope there is a flat area occupied by the large ordinary layer of the Salandrella ditch and its Holocene terraces. The south-western slope of the Craco ridge has an average slope of about 11° and it is affected by landslides with similar types to those described for the north-eastern slope, although generally presenting larger dimensions. There is a variety of earth flows that develop along the entire slope

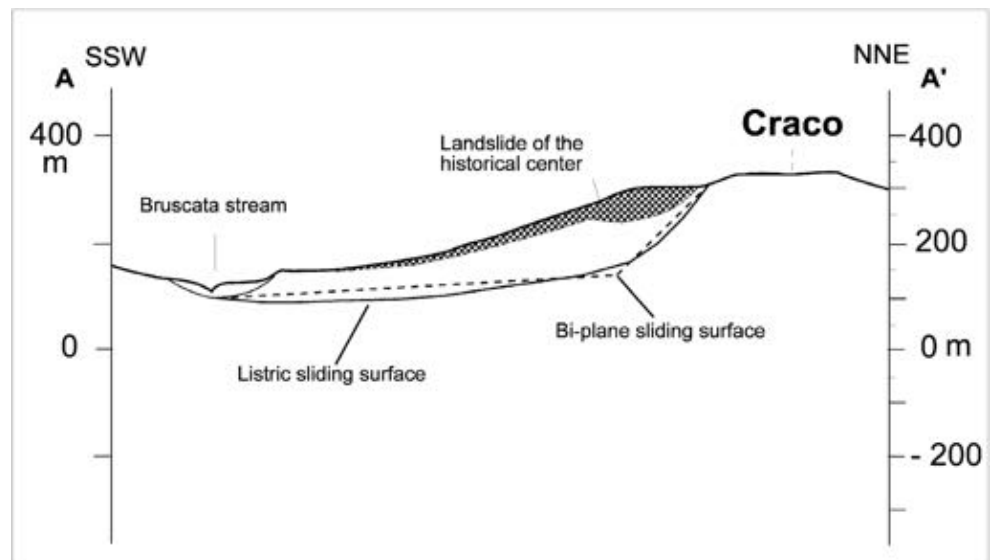
involving the conglomerates that outcrop at the summit of the relief; the *Argille Varicolori* placed halfway up and the Pliocene clays emerging in the lower part. The south-western slope of the Craco ridge is largely faced by a Deep-Seated Gravitational Slope Deformation highlighted by two trenches arched upstream and by the deviation of the Bruscata ditch downstream (Bentivenga et al. 2004) (Figs. 7 and 8).

The Landslide Chronology, Damage, and Complex Institutional Response

As we said ahead, the slopes of the ridge where the old Craco is settled have been historically affected by mass movements. Two of these are the most important due to the damage caused to the buildings and infrastructures over the past decades. We refer to the *Historical centre* landslide (Fig. 8), at the south-western side of the town, and the *Convent* landslide, at the eastern boundary of the settlement. In order to investigate the chronology of (re)activations of the two main landslides, their effects (on territory, buildings, and infrastructures), and consequent administrative and institutional response, we started from the analysis of the bibliographic sources.

Previous works analyse the landslides in the Craco within the general scheme of landslide typologies or hydrogeological instability picture of the Basilicata Region (Cotecchia 1959; Brugner and Valdinucci 1973; Pellegrino and Priore 1973;

Fig. 8 Geomorphological cross-section along the south-western slope showing the geometric features of the *Historical centre* landslide (after Bentivenga et al. 2004). For the location of the section, see Fig. 7



Cotecchia et al. 1979). Further studies focalize their interest on the Craco landslide features, historical reactivations, and damage caused to some structures built in the early 1970s to mitigate the hydrogeological risk (Pellegrino 1972; Del Prete 1990). The Craco landslides are also investigated in other articles that consider the geological and geotechnical aspects of the mass movements as well as the damage caused by the reactivations of them (Del Del Prete and Petley 1982; Gostelow et al. 1997; Bentivenga et al. 2004; Del Del Monaco et al. 2004). However, these papers do not supply inclusive information about the landslide chronology, damage, and actions put into the field by institutions.

Starting from this background, we performed a wide-ranging and cross-correlated (re)analysis of primary edited and unedited written and iconographic sources, preserved in the National Historical Archive of Civil Protection Department in Rome, National State Archive of Potenza, National State Archive of Matera, and Archive of Basilicata Region (see Appendix for the complete list of the sources examined). The documents go all the way through about one century of administrative and technical actions put into the field from the national as well as local institutions such as the National Geological Service, Civil Engineering Corps., Municipality of Craco, Prefecture of Matera, and the *Commissariato Civile* for Basilicata. This was an institution born in 1904 to build infrastructures and public works in Basilicata, including those to consolidate the towns affected by hydrogeological instability.

The new research allowed to increase the completeness of data related to the landslide reactivation history and the damage caused by the mass movements. Furthermore, by the searches and examinations of the new sources, the role played by institutions was investigated in depth (Table 1).

All the data gathered from historical sources concerning the landslide occurrence and damage as well as the public works carried out to restore the damage or mitigating the hydrogeological risk were pinpointed on maps or aerial photos arranged in a GIS environment. From the methodological point of view, the locating of those events was possible by the use of maps and aerial photos as close as possible to the landslide occurrences or public interventions. The use of GIS platform also allowed the overlapping between the different historical information layers with the recent/present urban layouts to infer the changes, over the decades, in the urban and neighbouring areas of the Craco.

The first notice regarding the *Historical centre* landslide goes back to 1870 (Angelucci et al. 2013) when a mass movement was recorded in the southeast portion of the town (Figs. 9 and 10). However, the landslide was already active well before the nineteenth century.

The quality and completeness of information about the landslides and their effects raise from 1886, year in which the trigger of the landslide in the southern portion of the town caused the collapse of 40–50 houses, without casualties. The movement was indirectly correlated by technicians to the unskillfulness in the planning and building, carried out in the previous years, of one of the trunks of the *Val d'Agri* state road (SS 103) that still today marks out the southern border of the Craco historical centre. In consequence of the 1886 movement, the local authorities ordered to the citizens to both close the water-supply tanks sited in the southern portion of the town and waterproof tanks located in the other quarters of the town. Furthermore, in order to sustain SS103 an arched wing wall was built in 1888. The wall had the thickness of 3.5 m and foundation resting at 18 m depth. The attempt to mitigate the risk failed due to faults in the planning of the wall

Table 1 Landslide(s) reactivations (Ls), consolidation works (Cs), and events related to the Craco transfer (Tr) from 1870 to 1983. Beside the short report of the events, the table refers back to map elaborations presented in Figs. 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19. For the sources consulted, see [Appendix](#)

Date	Event	Brief description of the event	Reference to
1870	Ls	First news on the <i>Historical centre</i> landslide	Fig. 10, Area 1
1886	Ls/Cs	For the building of the 13th section of the <i>Val d'Agri</i> national road (SS103), drainage works were carried out and a retaining wall was built to consolidate the <i>Historical centre</i> landslide. In the area where the wall was built, the same landslide had already caused (in an unspecified period) the collapse of numerous houses. The retaining wall was not founded in the bedrock and it was not designed of the appropriate thickness. Consequently, it was damaged causing the collapse of the houses adjacent to the national road. About 40–50 houses collapsed, but without victims. Following this circumstance, the Craco town council asked the Civil Engineers to build a new wall. To consolidate the landslide, the town council also ordered the closure of all the tanks in the lower inhabited area and the waterproofing of those in the remaining part of the town	Fig. 10, Area 1
1888	Ls/Cs	In the southern part of the built-up area, a 3.5-m-thick arched retaining wall was built, with foundations resting at a depth of 18 m. Historical sources report a 20 cm drop immediately after the wall building	==
October/December 1907	Ls	Reactivation of landslides (probably both <i>Historical Centre</i> and <i>Convent</i>) with damage to buildings of the southern and eastern part of the town	==
28 October 1915	Cs	Design of consolidation works relating to the building of retaining walls and drainage system as well as the arrangement of ditches in the areas bordering the town. These works were partly carried out in the 1910s and in the 1920s	Fig. 10, Area 2
1922	Cs	Consolidation works of the <i>Historical centre</i> landslide	==
1931	Ls/Cs	Accentuation of the landslide (<i>Historical centre</i>) that caused extensive cracks in the wall built in 1888. Reinforcement and defence works were carried out. The rains fell in January caused the collapse of a retaining wall. Consolidation works were scheduled on 10 March 1931. To prevent the landslide of a stretch of soil facing the Corso Umberto I, about 35 m long and 7 m high, the construction of an arched retaining wall was planned. Furthermore, the waterproofing of Via Risorgimento was planned, above the wall under construction	Fig. 10, Areas 3 and 4
15 July 1932	Cs	Following the floods of January 1931, a further appraisal of the work required to complete the consolidation of the town	Fig. 10, Area 6
1937	Ls/Cs	After the 1937 floods, some houses in Rione Granatella collapsed and heavy damage in buildings located close to those collapsed were recorded. The Office of Civil Engineers of Matera drafted an expert report to carry out some consolidation works. The rains of 1938 caused a crack widening in the affected buildings	==
July 1938	Cs	Consolidation works were carried out on the eastern slope of the inhabited centre: the construction of two retaining walls to safeguard some unsafe houses and the realisation of a ditch for conveying rainwater outside the quarter	==
9 June 1943	Cs	Consolidation works were planned at the Rione Risorgimento and Corso Umberto with the construction of a retaining wall and waterproofing works	Fig. 11, Area 7
February 1946	Ls/Cs	Collapses of some houses and serious damage to buildings. Works to channel the spring waters were planned	Fig. 11, Area 8
25 July 1947	Cs	Design of collection and disposal systems for well water in the landslide area	Fig. 11, area 13
21 March 1948	Cs	Design of rainwater drainage works in the landslide area	Fig. 11, Area 10
1948	Ls	Reactivations of both <i>Historical centre</i> and <i>Convent</i> landslides	==
1 July 1948	Cs	Planned of the following works: 1) waterproofing of roads in the landslide areas of the town and 2) construction of a retaining wall at Largo Alighieri for the consolidation of Via Umberto I. At this date, the works to consolidate the landslide downstream of the state road were in progress. The works concerned the disposal of spring waters and the construction of check dams	Fig. 11, areas 9 and 10
20 December 1948	Ls/Cs	Shoring up and consolidation of buildings due to the reactivation of the landslide movement	Fig. 11, Area 11
24 January 1949	Cs	Restoration works were planned on the sewerage that had suffered damage. Retaining walls were also designed	Fig. 11, Area 12
7 August 1950	Cs	Execution of works (planned on 25 July 1947) consisting of collection and disposal systems for well water in the landslide area	Fig. 11, Area 13
1952	Cs	Construction of a retaining wall, a continuation of that built in 1888, to consolidate the <i>Convent landslide</i>	==

Table 1 (continued)

Date	Event	Brief description of the event	Reference to
1954	Sports field	After an apparent period of inactivity of the landslide, a sports field was built on the landslide (<i>Historical centre</i>) body. The field was built downstream SS103 after levelling and artificial filling of the landslide terraces	Fig. 11, Area 14
May 1959	Cs	Consolidation works for the town were contracted for an amount of over two million lire	==
18 November 1959	Cs	The Civil Engineers Office of Matera designed works to consolidate the town with the construction of road paving, canalizations, check dams, and retaining walls.	Fig. 12
24–25 November 1959	Ls/Cs	Due to rainfall of over 400 mm over a 5-day period, there was the complete reactivation of the <i>Historical centre</i> landslide, which caused the destruction of the sports field, a dislocation of the road bridge and the first cracks of the houses upstream of the bridge. Demolition and shoring of the wall and the removal of rubble were planned.	==
March 1962	Cs	Consolidation works of the town were contracted	==
5 December 1963	Ls/Tr	<i>Convent landslide</i> , December 1963: the niche of detachment involved the streets of Marco Aurelio, Maroncelli, Pisacane, Cavour, and Melchiorre del Fico. In the area, cracks were observed in the buildings as well as in the wall built in 1952 to support SS103. The wall, 20 m high, lacked of proper drainage. The landslide phenomenon did not show particularly striking manifestations. <i>Historical centre landslide</i> . The cracks in the buildings were widespread above all in via San Giovanni and along an arch, which, starting from via Galliano passed through via Pagano and reached via Garibaldi. Even in via San Felice (north-west) incipient lesions were observed in the buildings. Fractures also occurred downstream of the retaining wall with an increase in its bulging. The ground downstream of the wall suffered a drop of 1 m, whilst from 1959 to the beginning of December 1963, the drop was 4–5 m. The landslide reactivated after a dry summer and a previous period without any particular rainfall events. This led to the conclusion that the causes of the landslide reactivation were losses from the water supply or sewerage system. Given the severity of the consequences caused by landslide phenomena, the total transfer of the town was proposed in the area (Sant'Angelo) immediately north-west of the town or in the more distant area (Peschiera)	Fig. 13
12 December 1963	Cs	In order to consolidate the <i>Historical centre</i> landslide, the Civil Engineers authorised the realisation of urgent works. The control of the efficiency status of the sewer and the aqueduct was requested	==
January 1964	Tr	The locality of Peschiera was chosen for the total transfer of the town, which hosted about 400 families	Fig. 18a
May 1964	Tr	Definition of the types of houses and the costs required for the total transfer of Craco	==
June 1964	Tr	The geological survey of the Peschiera area was carried out, chosen for the transfer of 70% of the town. It was hypothesised that the remaining parts of town not affected by the landslide could have had Sant'Angelo as area of expansion as not affected by landslides	==
17 January 1965	Cs/Ls	The bridge built in 1888 (area of the <i>Historical centre</i> landslide) underwent a translation of a meter with a simultaneous lowering of two meters which damaged it making unusable. Many houses upstream of the bridge were abandoned due to the strong landslide activity between 1963 and 1965 (over 60 houses in 1963 and about 150 in 1965). Because of the damage caused by the events of 1963 and 1965, the evacuation order of the built-up area was issued (1968). Furthermore, the demolition of the old retaining wall and construction of a new wall were planned. The new wall was designed with the following characteristics: reinforced concrete platform 4 m wide and 60 m long, founded on 800-mm-diameter reinforced piles and over 30 m depth	Fig. 14
23 April 1965	Tr	Issue of the Presidential Decree for the total transfer of the town in the Peschiera area (Presidential Decree April 23, 1965, No. 800 pursuant to Law No. 445 of July 9, 1908)	==
26 July 1965	Tr	Construction of a second group of 24 stable masonry shelters, in addition to 50 built in 1964	==
23–24 September 1965	Ls	Following the floods of 23 and 24 September 1965, shoring and demolition of buildings at risk in the Santa Maria and Pagano districts were ordered	==
31 January 1967	Tr	The Municipal Council of Craco opposes the transfer of the town solely to the Peschiera area, asking the transfer to be divided into two locations: Peschiera and Sant'Angelo	==
November 1967	Tr	Another technical inspection was carried out which highlighted the need for a partial transfer only. Both the area of Peschiera and Sant'Angelo, adjacent to the town, were suggested. At that date, the <i>Convent landslide</i> was judged inactive. The landslide of the <i>Historical centre</i> had a development of about 1000 m, with a width of 100 m and an average thickness of 4 m	Fig. 15
23 March 1968	Tr	Another technical inspection suggested the need to carry out paving and waterproofing of all the roads of the town with the demolition of the southern quarter. In addition, it was suggested the partial transfer of the town in the area of Sant'Angelo, thus excluding the Peschiera zone	==
1 April 1968	Tr	At this date, there were 85 families settled in the locality of Peschiera whilst 432 families still had to be transferred. The Civil Engineering Office of Matera accepted the proposal of the Municipality of Craco modifying the transfer from total to partial, in the two localities of Peschiera and S. Angelo	Figs. 17a and 18c
1969	Ls	Reactivations of the landslides	==

Table 1 (continued)

Date	Event	Brief description of the event	Reference to
08 January 1970	Ls	After the rains, the <i>Historical centre</i> landslide was reactivated. The activation also involved a part of SS103. Seven houses were evacuated	==
Autumn 1970	Ls	Some small landslides were recorded	==
April 1971	Ls	Total collapse of the uninhabited area with the opening of wide detachment edges that reached the top areas of the inhabited area (in 1971 approximately 150 dwellings were evacuated, in 1972 around 200). Two large cracks opened, one in Piazza Garibaldi and the other below the church. The new retaining wall suffered a drop of 2 m and its western part was broken. Altogether, the wall suffered a translation greater than 3 m, whilst a lowering of 15 m of the ground to downstream of the wall caused the denudation of the structure	Fig. 19, Area 14
18–19 January 1972	Ls	The territory of Craco was affected by landslides following the storms on 18–19 January 1972	==
1973	Ls	Landslide reactivation (probably that of the <i>Historical centre</i>)	==
1975	Ls	Landslide reactivation (probably that of the <i>Historical centre</i>)	==
21 May 1976	Tr	Design of some urbanisation works of Craco-Peschiera (road, sewerage, and water network)	==
1979	Ls	Reactivations of the landslides	==
12 January 1979	Tr	At that date, part of the urbanisation works in the locality of Peschiera (water supply, sewerage, public lighting, and road network) were still to be realised	==
1980	Ls	Reactivation (uncertain) of the landslide in the historical centre. Total abandonment of the town	==
16 March 1983	Cs	Consolidation work of Craco downtown area, consisting of waterproofing works, demolition of unsafe buildings, and construction of retaining walls. At that date, the town still hosted many families. In many interventions, over the years, many unsafe buildings in the historic centre were demolished	Fig., 19, Area 15

that suffered a sinking of about 20 cm immediately after being built. The inadequacy of the retaining wall to hinder the soil movements was also testified when the reactivation of the landslide in 1931 caused heavy cracks in the wall that was reinforced. After the 1931 event, consolidation works were planned in the urban settlements to prevent further soil instability phenomena. These works, planned in 1931 and 1932, were added to the previous extensive works carried out in 1915 and consisting in building of retaining wall and drainage

in the built-up area, and the hydraulic-forest arrangements of the ditches surrounding the town.

The flood event of 1937 and the heavy rain of 1938 caused the collapse of some buildings in the northeast portion of the town. Eleven years later, during the spring of 1948, after a period of about 20 years that saw the planning of public works (soil consolidation, drainage, and rain proofing) aimed at mitigating the hydrogeological risk in several quarters of the town, also the *Convent* slide reactivated. This event forced

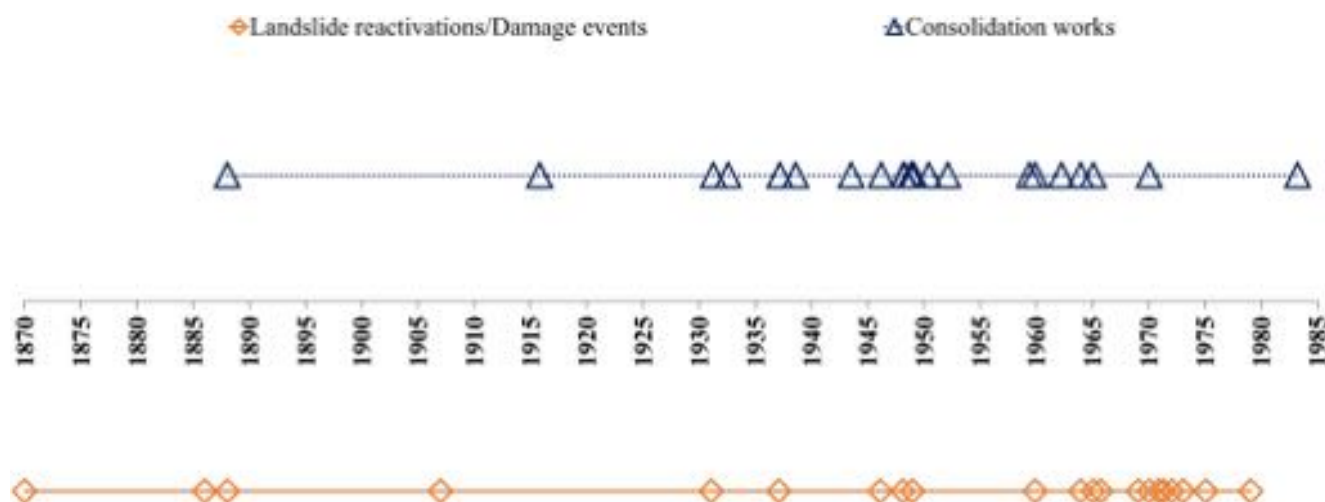
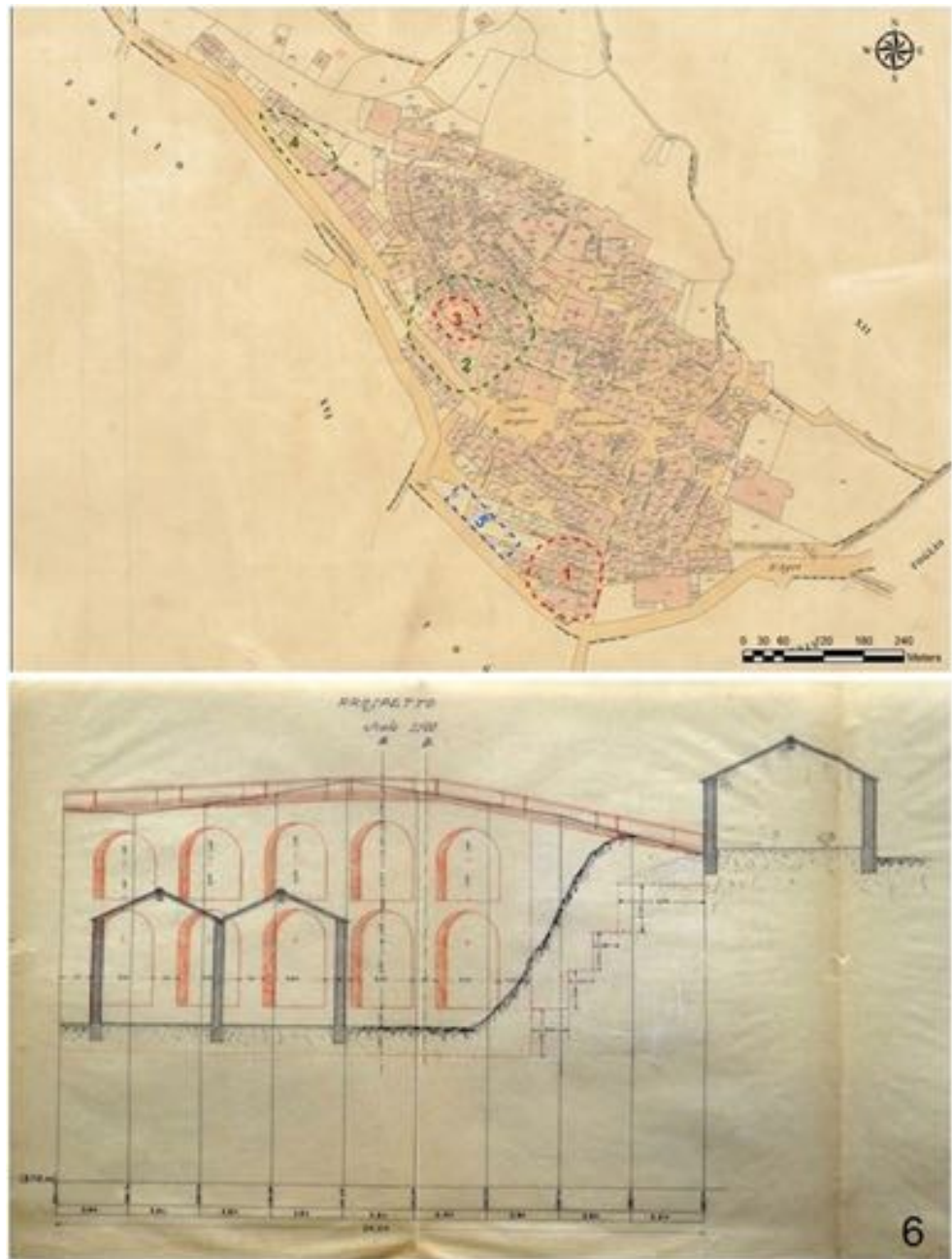


Fig. 9 Timeline showing the landslide (re)activations and the planning/realisation of the consolidation works. Beyond twenty were the (re)activations over a period of 115 years or so. In the same period, about the same number of consolidation works were performed, but frequently

they followed the mass movements. A limited number of works was performed in “peacetime” (before landslide movements) to manage the risk

Fig. 10 Areas affected by instability and consolidation works until the 1930s (drawn on the cadastral map dating back to the beginning of nineteenth century (map source: ASDPC, Div. 29 Matera C., Colobrano – Craco, B. 4. Planimetria catastale): (1) landslide reactivation (1870, 1886) and tank closing (1886); (2) Planning of consolidation works (28 October 1915); (3) backing wall collapse (1931); (4) backing wall design and paving (1931); (5) site where was located the war memorial built in the twenties. That monument can be noticed in Fig. 14(a, c) bordering the niche of the *Historical centre* landslide reactivated on 17 January 1965. (6) Arched backing wall design (map source: ASMT, FGC, I V., B. 344, F. 3739-3746. *Disegni delle opere d'arte...* Matera, 15 luglio 1932)

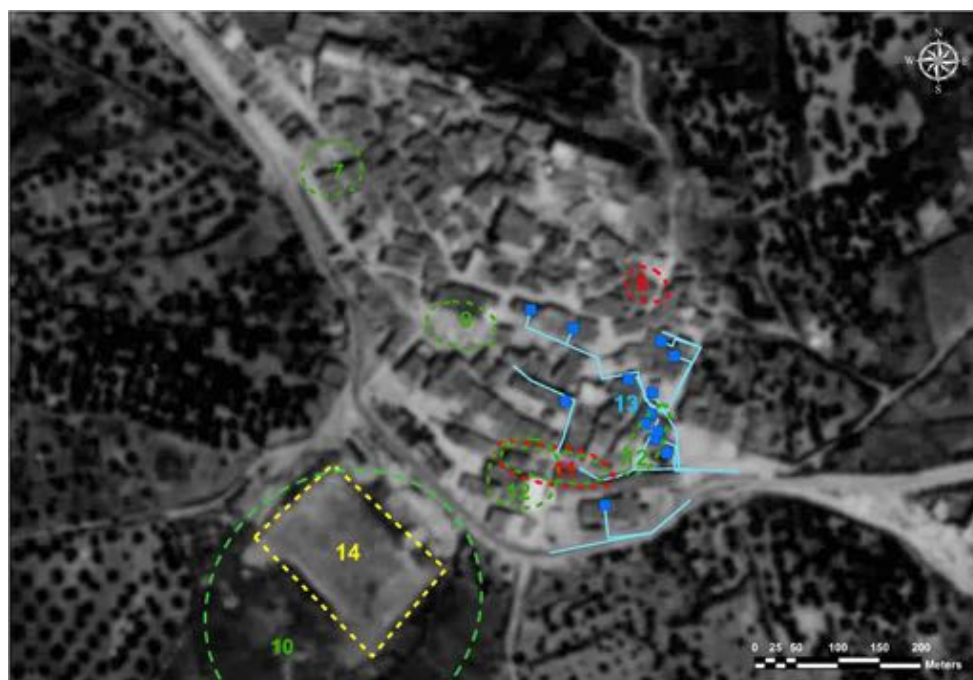


the institutions to build, in 1952, a containment wall to be identified as the physical extension of the arched structure built in 1888. Other consolidation works in several quarters of the towns were planned or farmed out since 1948. These efforts were thwarted when in 1954 a football field was built downstream SS103, on the landslide body that, in this way, was burdened by landfill. These works, jointly with 5 days of heavy rain, were reasonably responsible of the reactivation of the *Historical centre* landslide, on 24–25 November 1959. The movement caused the destruction of the football field, a portion of wall sustaining SS103, and damaged some buildings upstream SS103 (Fig. 11). At the end of 1950s, new

consolidation works of the town and its surrounding slopes were planned (Fig. 12).

Some years later, in December 1963, about a year and a half after the start of new consolidation works, both the landslides reactivated. These events led off to the transfer procedure of the built-up area that ended after the 23 November 1980 Irpinia-Basilicata earthquake ($M_w = 6.8$). The reactivation of the *Convent* landslide involved directly some portions of the built-up area and caused damage to the retaining wall built in 1952. However, the movement of the *Historical centre* landslide caused the heaviest effects (Fig. 13): sixty houses were made uninhabitable and

Fig. 11 Areas affected by instability and consolidation works from 1943 to 1954 (drawn on 1955 aerial photo); (7) backing wall design and paving (9 June 1943); (8) building collapse (February 1946); (9) wall construction (1 July 1948); (10) consolidation works downstream SS103, in the landslide area: the works consisted in the disposal of the spring waters and in the construction of bridles (7 January 1948); (11) shoring of buildings and their consolidation (20 December 1948); (12) restoration of drainage system and wall design (24 January 1949); (13) design of collection and disposal systems for well water in the landslide area (25 July 1947); (14) construction of the sports field (1954)



the retaining wall sustaining SS103 was bulged and cracked at both the ends. The reactivation took place after a dry summer and a period without special rainfall events. These circumstances led to think that the continuous leaks

from the sewage system, built in 1937, could be considered the determining cause of the movement whilst the nature of the soil and the underground water the predisposing factors.

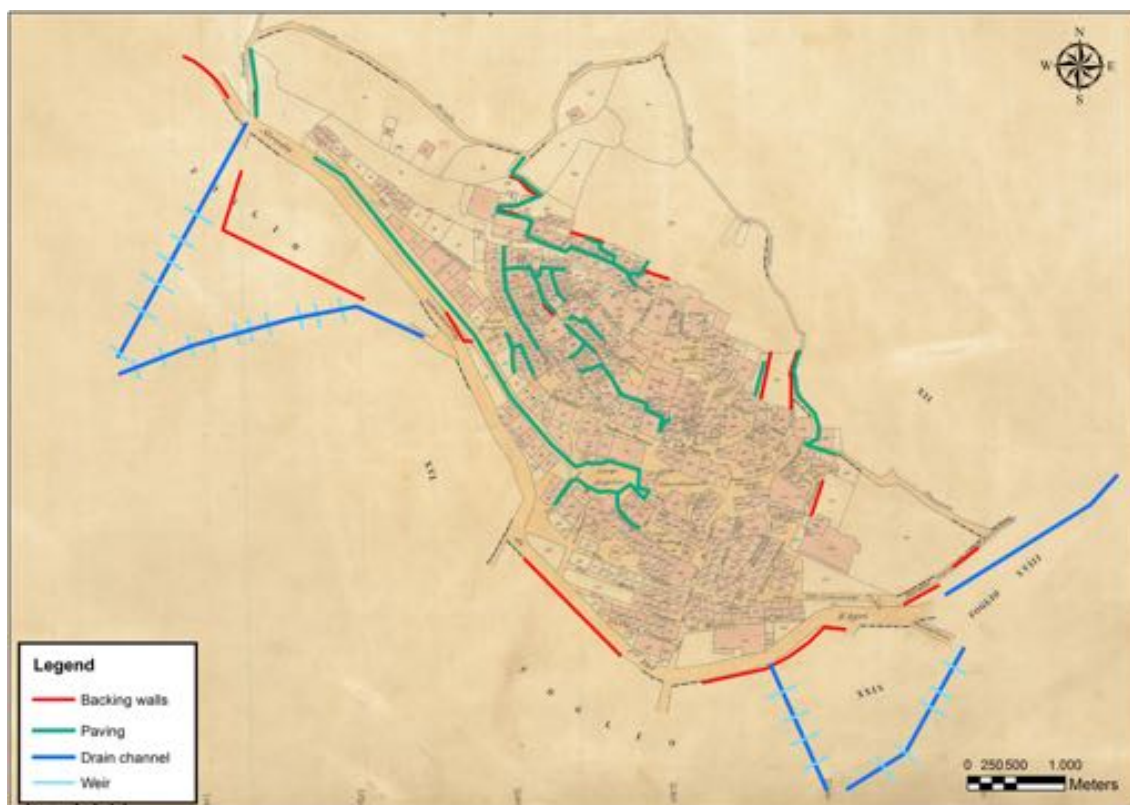


Fig. 12 Consolidation works planned at the end of the 1950s (18 November 1959) (re-drawn from the original map source: ASDPC, Div., C. Potenza, B. 138 AM. *Relazione dell'Ingegnere Dirigente...* Matera, 18 novembre 1959)

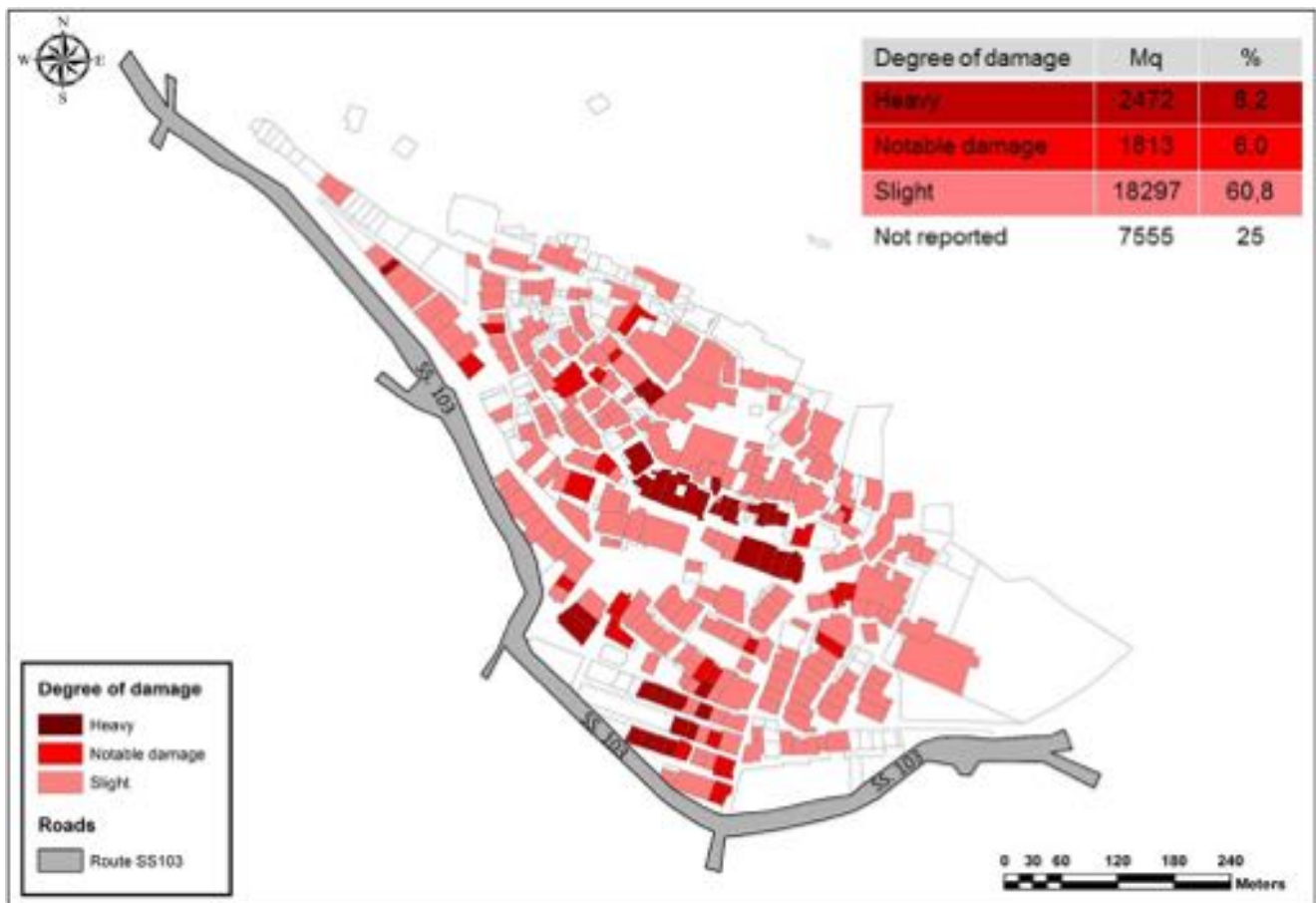


Fig. 13 Map of damage caused by (probably) 1963 landslide reactivation (re-drawn from the original -undated- map. Map source: ADRBa-SPIX, C. 305. *Mappa del danneggiamento...*)

Yet, the *Historical centre* landslide reactivated again in January 1965 when about 150 houses were abandoned with the partial collapse of the retaining wall, built to sustain SS103 (Fig. 14). In consequence of the 1963 and 1965 reactivations, the demolition of the SS103 wall and the building of a new wall made up of reinforced concrete were planned at the end of the 1960s. Due to the landslide effects, the backing of the main road SS103 at the foot of the village was planned (Fig. 19).

Due to the consequences caused by 1963 landslides, the Geological Service suggested the total transfer of the built-up area to a location about 6 km away, in east direction (*Peschiera* site) (Brugner 1964—*ASDPC, Trasferimento di Craco, SNB... Relazione Geologica del Dott. Walter Brugner... Roma, 2/gennaio 1964*). The total transfer of the 400 families that lived in the town was approved by the local government on 1964 and approved by the President of Republic on 1965 by a special decree (DPR 23 April 1965, n. 800). This act started the drafting of the project of the new settlement whose first houses were built within July 1965. However, the identification of the site where transferring the people changed in the following years. Actually, a further geological survey (Balboni 1964—*ASDPC, Trasferimento di Craco... Relazione Geologica del Dott. Ing. Amedeo Balboni... Roma, 26giugno1964*) was performed by

the Geological Service. This shed light that the total transfer of the site was not necessary, but “only” 70% of it required the evacuation and transfer. At the same time, the survey suggested that another area (*Santi’Angelo* site) located at the west of the historical centre could be considered suitable to host the new settlement due both its geographical position and hydrogeological stability. This new technical opinion was taken as a reference by the local government to modify, on 31 January 1967, the decision already made 3 years before, so defining that the transfer would have been realised in two areas: (i) at east of the settlement, quite away from it, (ii) at west, very close to the town. The decision of the municipal authorities matured considering also the discontent spread among the people due to the socio-economic drawbacks that would have accrued with the transfer of Craco only in the *Peschiera* site. A few days later, the new decision (4 February 1967), the local government published the transfer plan including the families to be transferred in the two selected sites. However, in the months following that decision, the Geological Service performed other two technical surveys of the Craco area (Beneo 1967—*ASDPC, Trasferimento di Craco... Relazione Geologica...*; Moretti 1968—*ASDPC, Trasferimento di Craco... Relazione Geologica...*). The survey performed by Beneo took also stock of the mass movements in



Fig. 14 Photos of damage caused by the 17 January 1965 landslide event. The green boxes show the view angle of the historical photos taken in the aftermath of the parossistic event. Image in (e) shows the landslide niche upstream the retaining wall so testifying the retrogressive features of the

mass movement. Photos (a), (b), (c), and (e) show the First World War memorial that is close to the landslide niche (source: ASCPC, Div. 29 Matera, C., Colobraro - Craco, B. 4... Craco, 17 gennaio 1965)

the areas surrounding the built-up area, identifying the state of activity of eleven landslides. The *Convento* landslide was considered inactive and the *Historical centre* mass movement was evaluated having the length of 1 km, the width of 100 m, and the thickness of 4 m (Fig. 15).

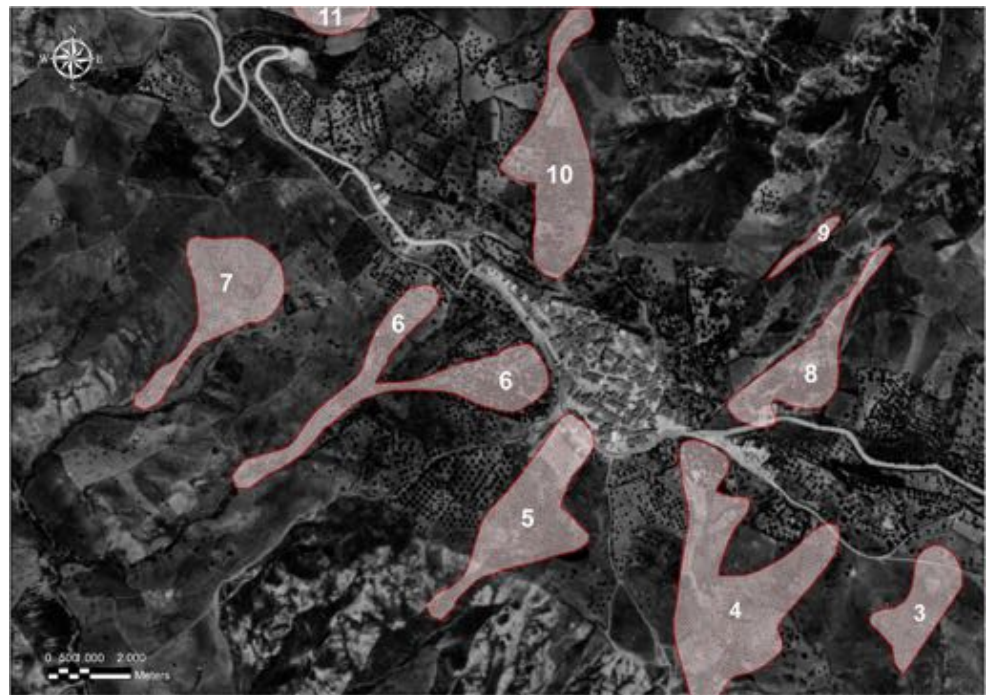
By the two surveys, partially different technical opinions emerged. On the one hand, the two technicians agreed on the necessity only of a partial transfer of the inhabited area instead of its total relocation; on the other hand, the new surveys disagreed about the sites where hosting the new settlements: one technician suggested the sites of *Sant'Angelo* and *Peschiera* (Beneo 1967—*ASDPC, Trasferimento di Craco... Relazione Geologica...*), the other left out from the choice the last site (Moretti 1968—*ASDPC, Trasferimento di Craco... Relazione Geologica...*). The final decision about the transfer saw to prevail the chosen of a partial transfer in the two localities above-mentioned (D.P.R., Decree of President of Republic, no. 1393 of 14 October 1968) (Figs. 16, 17, and 18).

However, the transfer went quite slowly. At 1 April 1968, the families settled to *Peschiera* were 85 whilst another 432 families still had to be transferred. The difficulties in transferring can be argued considering that some urbanisation works (e.g. roads, drainage systems, public lighting) still had to be carried out eleven years after the decree of transfer. Furthermore, the transfer project had several radical changes as we can see comparing the 1960s projects with the actual urban layouts of the areas chosen to transfer the historical centre.

During the transfer phase, other reactivations were recorded in 1969, 1970, 1971, and 1979. In particular, in 1970 and 1971, other buildings were damaged and the reinforced concrete retaining wall suffered a lowering of about 2 m and a horizontal translation of about 3 m. Furthermore, the western portion of the same wall was broken.

An additional factor that contributed to worsen the static condition of the buildings was the 23 November 1980 Irpinia-Basilicata earthquake ($M_w = 6.8$) that caused heavy damage in Basilicata and damage in numerous building of the Craco

Fig. 15 Landslides as surveyed by Beneo (Beneo 1967; redrawn from the original geomorphological map on 1955 aerial photo); (4) *Convent landslide* (evaluated as inactive at the survey data); (5) *Historical centre landslide* (active); (6) inactive landslide; (7) inactive landslide; (8) landslide triggered by leaks of water from the drain system; (9) landslide caused by presence of spring water; (10) stabilised landslide (source of the geomorphological map: ASDPC, *Trasferimento di Craco, SNB... Rilievo geologico di dettaglio redatto dal Dott. Ing. Enzo Beneo...* Matera, 1 aprile 1968)



historical centre (Gizzi et al. 2012) so that the public authorities ordered to evacuate it. However, many families continued to live in the downtown area in the years following the earthquake. In order to mitigate the hydrogeological risk, further consolidation works of the village (e.g. rain proofing, demolition of unsafe buildings, and building of retaining walls) were carried out also in the 1980s (Fig. 19).

Historical-Urbanistic Background of Craco

According to the archaeological data, the origin of Craco would be around the seventh century B.C. At that time, the area near Craco, called Montedoro, would have been populated by Greek settlers from the Ionian coast, and in particular from the city of Metaponto founded in the seventh century B.C. According to the historical sources, the first attestation of the existence of Craco, as a toponym and inhabited settlement, dates back to 1060 (Angelucci et al. 2013). In that year, an important episcopal synod took place at Tursi, during which the boundaries of the diocese of Tricarico were redefined including, among others, Craco. From the eleventh century onwards, a territorial reorganisation programme, known as encastellation, started in Basilicata as well as in other regions of Southern Italy. The term encastellation refers to the phenomenon which occurred during the Middle Ages which led to the building of castles, intended both as a feudal residence and fortified settlement, also functional to a process of centralization of the population that took place in particular between the tenth and twelfth centuries, in order to protect themselves from the new waves of barbarian invasions.

Therefore, it was based on the construction of a network of defensive structures, including castles and towers, that had the dual function of controlling the territory and allowing adequate security conditions for the settlements that were being built ex novo or renewing (Masini 2006), thus favouring a process of centralization of the population. Such encastellation involved also Craco whose strategic position allowed dominating a vast territory that included the Cavone and Agri rivers. The latter in the twelfth-thirteenth centuries, it was still navigable. The castle of Craco was a tower, still preserved (Fig. 20a), typical of Norman fortified architecture, spread during the Norman Conquest of Southern Italy (1060–1130) and in the following decades. At the foot of the tower, on the southern slope of the ridge, a first nucleus of houses (see orange-coloured area in Fig. 20b), of an annular shape, developed around it (Angelucci et al. 2013). The Arab geographer Idrisi could observe this landscape in 1154 as indeed he did during his journeys in Southern Italy.

The first news on the demographic consistency date back to 1277 when Craco has about 450 inhabitants that become 600 in 1320. At this time, the mother church of San Nicola dates back. The population continues to increase in the following centuries: 750 in 1440, 1800 in 1521, and about 2300 in 1595 (Angelucci et al. 2013). Between the sixteenth and seventeenth centuries (Manfredi 2003), the village continues its expansion to the south, the mother church is enlarged and new churches are built (see red-coloured area in Fig. 20b). The expansion followed up to the foot of the hill at the end of the nineteenth century (see light blue-coloured area in Figs. 20b and 21). In this century, in particular in 1870 and 1886, the first landslide events occurred, affecting the southeast zone of Craco (for additional details, the reader is

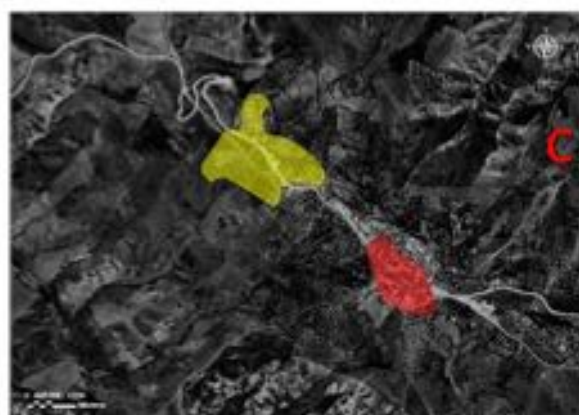


Fig. 16 Original general plan for the partial transfer of the historical centre to Peschiera and Sant’Angelo sites (a, b) (1 April 1968). The areas identified in red colour represent the portion of the town to be transferred. The yellow (*Sant’Angelo* site) and the green areas (*Peschiera* site) represent approximately the two zones in which the town will be transferred in the years following the transfer decree. **a**

Full-scale map of the areas; **b** Zoom of the area inside the rectangle indicated in **a**; **c** The same zone as in **b**, but viewed from an aerial photograph taken in 1955 (elaboration by the authors). Sources of the maps in **a** and **b**: ASDPC, *Trasferimento di Craco*, SNB. *Indicazione dell’area di trasferimento di Craco su Foglio IGM...* Matera, 1 aprile 1968)

referred to paragraph 3), thus suggesting a possible cause-effect link between the last urban expansion and the landslide re-activation(s). This would seem to be confirmed by the fact that most buildings affected by heavy and serious damage (see Fig. 13) are dated to the urban expansion occurred between the nineteenth and twentieth centuries (Fig. 20b).

The Vegetation Growth in the Abandoned Town: Insights for Analysing the Building Conservation State

The growth of vegetation in urban areas changes as respect the natural environment due to presence of buildings, roads, soil compaction phenomena for vehicle use, and so on. These activities cause vegetation removal due to soil disturbance (Webb and Wilshire 1980). Once the urban area is abandoned, the disturbed land and vegetation can recover.

Wells (1961) examining a “ghost town” in Nevada desert environment observed that after 33 years, the recovery of vegetation was slow. Himes (1966) found that the whole cover in a town that had been abandoned for 2 years was 14%, compared to 35% when the site was inhabited. Klatt and Hein (1978) examined vegetation differences among one active prairie dog town and three towns, which were abandoned for different years. They found that percent cover of total vegetation, grasses, and increaser and invader species declined with length of abandonment. Knapp (1991), analysing five semiarid Montana “ghost towns”, suggest that the processes of soil and vegetation recovery can exceed by far 45 to 77 years of abandonment. For the purposes of analysing the vegetation growth in Craco, we used NDVI (Normalized Difference Vegetation Index) time series obtained from Landsat TM and Sentinel 2 data along with HSV (Hue, Saturation, Value) colour system techniques applied to multi-date Google Earth photos.

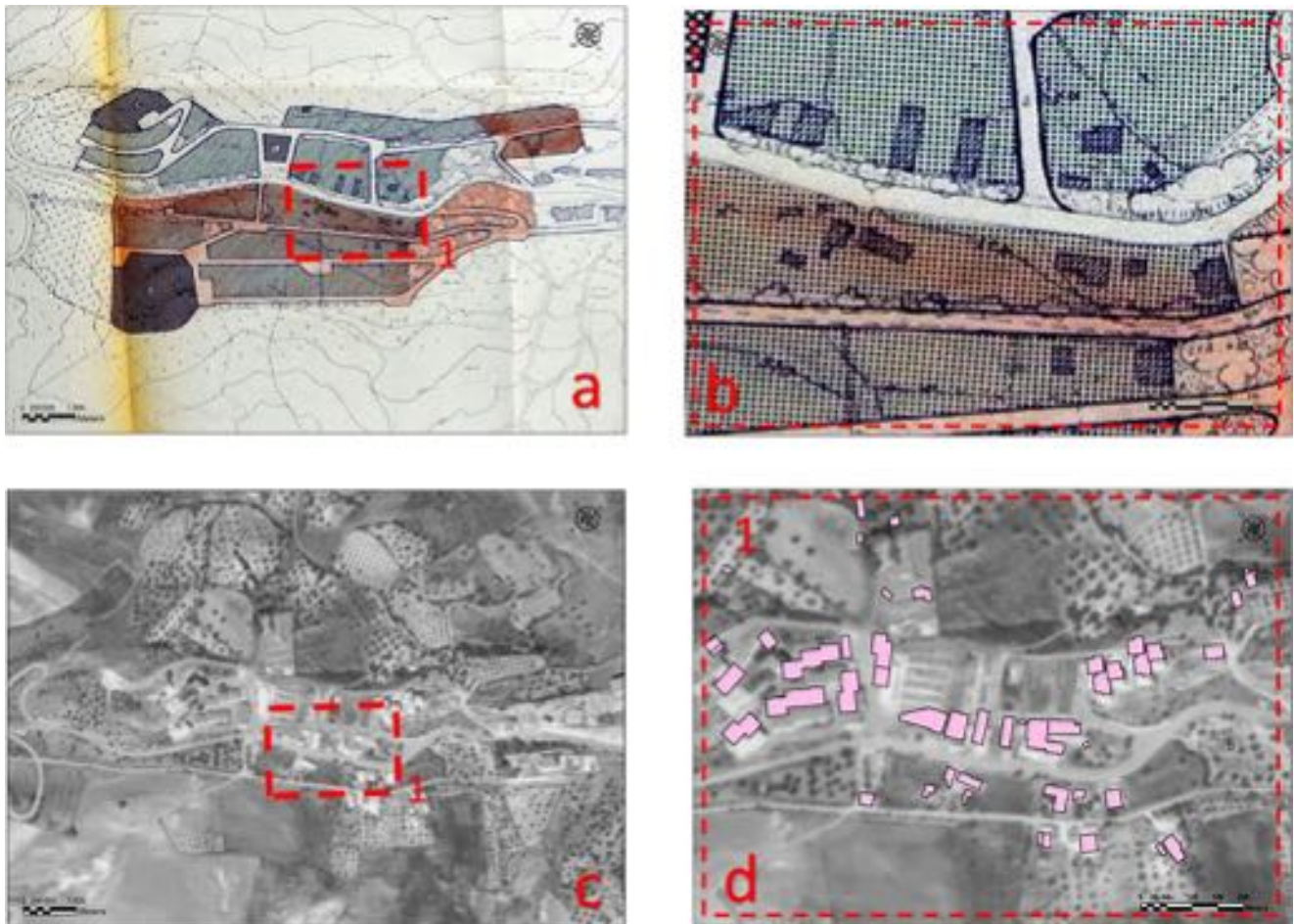


Fig. 17 Transfer to *Sant'Angelo* area. In **a**, the original plan (1 April 1968) (map source: ASDPC, *Trasferimento di Craco, SNB... Planimetrie delle zone di insediamento Peschiera e S. Angelo...*

Matera, 1 aprile 1968); **b** Magnification of area (1) in **a**; **c** and **d** The situations in 2003: only a partial correspondence with the original project can be noticed

Normalized Difference of Vegetation Index Analysis

The presence and the amount of vegetation impact both surface processes and urban/built heritage conservation, and for these reasons in this study, we performed a multi-temporal analysis, based on satellite data, for the identification and the characterisation of multi-temporal variations of the vegetation conditions for the Craco area.

Remote sensing of vegetation has been traditionally based on optical data and carried out using vegetation indices that are a spectral combination of diverse bands, devised to emphasise the spectral changes caused by the presence, amount, and condition of vegetation in the short and long terms (Cuomo et al. 2001). Therefore, spectral combinations are *ad hoc* defined using different bands in order to emphasis the spectral changes linked to the diverse vegetation types, chlorophyll, moisture content, etc. The simplest form of vegetation index is a ratio between two digital values from red (RED) and near-infrared (NIR) spectral bands, but the most widely used index is the

well-known Normalized Difference Vegetation Index (NDVI), computed using Eq. (1):

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED}) \quad (1)$$

The vegetation indices operate by contrasting intense chlorophyll pigment absorption in the red (RED in Eq. (1)) against the high reflectance in the near-infrared (NIR) of leaf mesophyll. Moreover, in the most commonly used spectral indices, the normalisation (in the NDVI expressed as the ratio in formula 1) reduces the effects of atmospheric contamination. The NDVI is indicative of presence, amount, and status of vegetation being that it is related to the photosynthetic activity, green leaf area index, and moisture content, and therefore, NDVI changes are indicative of variations in vegetation composition and dynamics. In other words, vegetated areas show higher NDVI compared to bare soil, and within vegetated areas, dense and healthy vegetation shows higher NDVI values compared with unhealthy or sparsely vegetated areas.

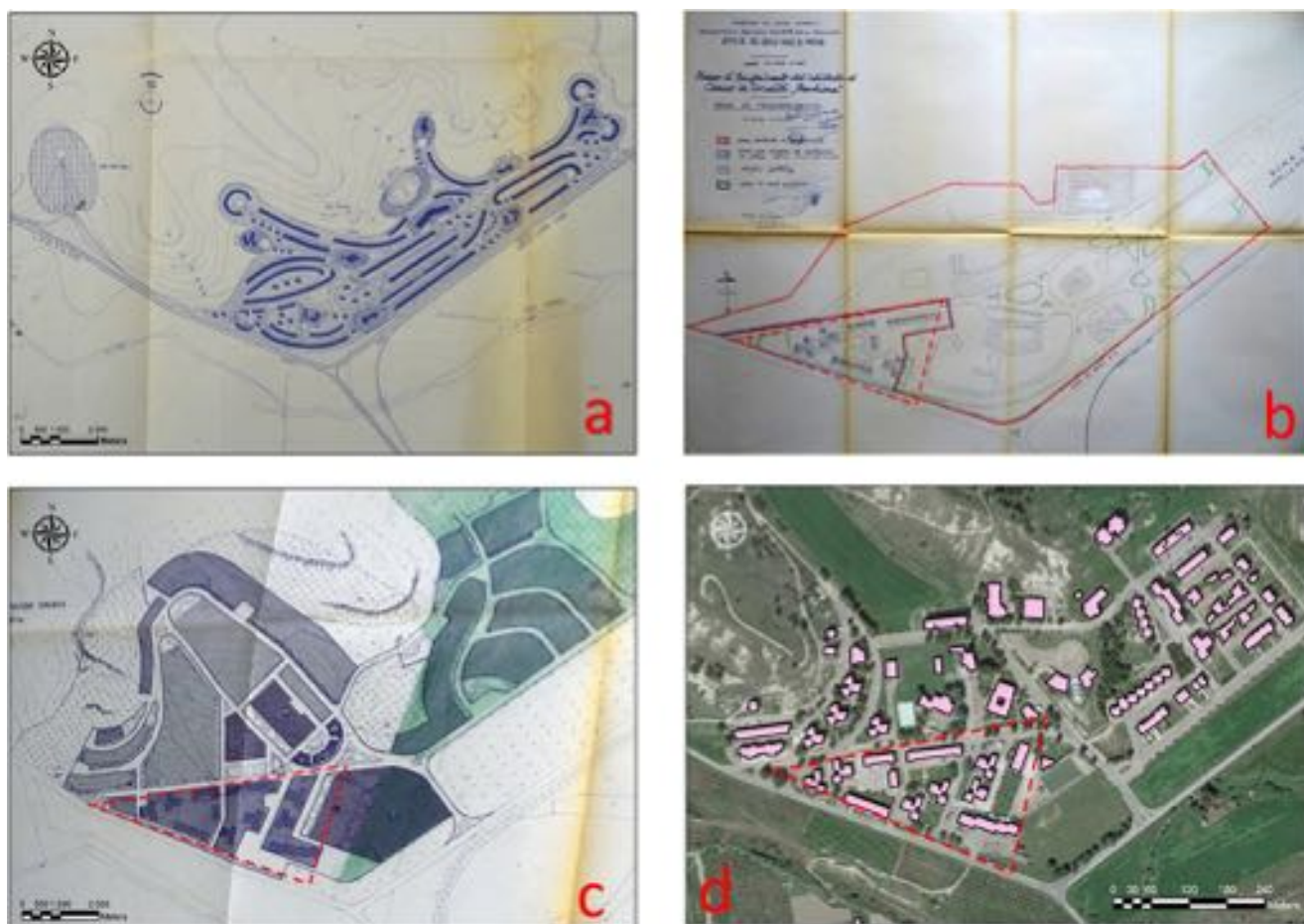


Fig. 18 **a** The first transfer plan to *Peschiera* in 1964 (20 January 1964). The plan refers to the hypothesis of transfer of the historical centre only to one site (map source: *ADRBA – SPIX, C. 305. Disegni eseguiti dal Provveditorato alle Opere Pubbliche...* Matera, 20 gennaio 1964). **b** Update of the transfer project on 26 January 1965 (map source: *ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Piano di*

trasferimento dell'abitato... s.l., 26/ gennaio 1965). **c** 1 April 1968 transfer plan. The 1968 plan provided for the transfer to the two areas of *Peschiera* and *Sant'Angelo* (map source: *ASDPC, Trasferimento di Craco, SNB...* *Planimetrie delle zone...* Matera, 1 aprile 1968). **d** Current situation, where only partial correspondence between urban plans in **a**, **b**, or **c** can be detected (photo by Google Earth 2016)

NDVI is undoubtedly recognised as one of the most effective and widely (see, for example [Evans and Geerken 2006](#); [Lasaponara and Masini 2012](#)) used proxy indicators of both (i) presence and (ii) status of vegetation. Multi-temporal analysis of NDVI tends to emphasise the vegetation changes observed in diverse timescale, inter-annual and intra-annual seasonal (phenology) and/or meteorological conditions. For these reasons, NDVI is generally used for both (i) the identification of the presence of vegetation and (ii) the characterisation of vegetation types and status.

For the purpose of our analysis, firstly, we performed an overview on the state-of-the-art on the vegetation conditions observed in the area under investigation. Outputs from independent studies clearly enhanced an increasing trend in the presence of spontaneous vegetation, as found in [Cuomo et al. \(2001\)](#) and [Mancino et al. \(2014\)](#). In more details, [Cuomo et al. \(2001\)](#) investigated the variations of NDVI-AVHRR from 1985 to 1999 time series and found a continuously and systematically increasing trend of NDVI for the Craco area, as shown in the map of [Fig. 22](#).

[Mancino et al. \(2014\)](#) performed investigations using Landsat TM data and highlighted a general increasing trend in many areas of the Basilicata Region including the Craco zone.

The second step of our analysis was based on NDVI-based investigations performed *ad hoc* for the Craco area using a time series of satellite Landsat TM and Sentinel 2 data, acquired from 2003 to 2016 and 2017–2018 for free from the USGS and ESA websites, respectively. Both of these satellite data provide information in different spectral bands including the most relevant for our analysis that are the red and near-infrared channels. Moreover, being geo-referred, satellite-based information can be easily integrated with all the available information (in the digital and non-digital format) within a GIS environment thus facilitating the elaboration and interpretation of heterogeneous data sources.

For the purposes of our analysis, we split and separately analysed the NDVI for Craco urban cover and the surrounding areas being that we expect that vegetation adversely affects the

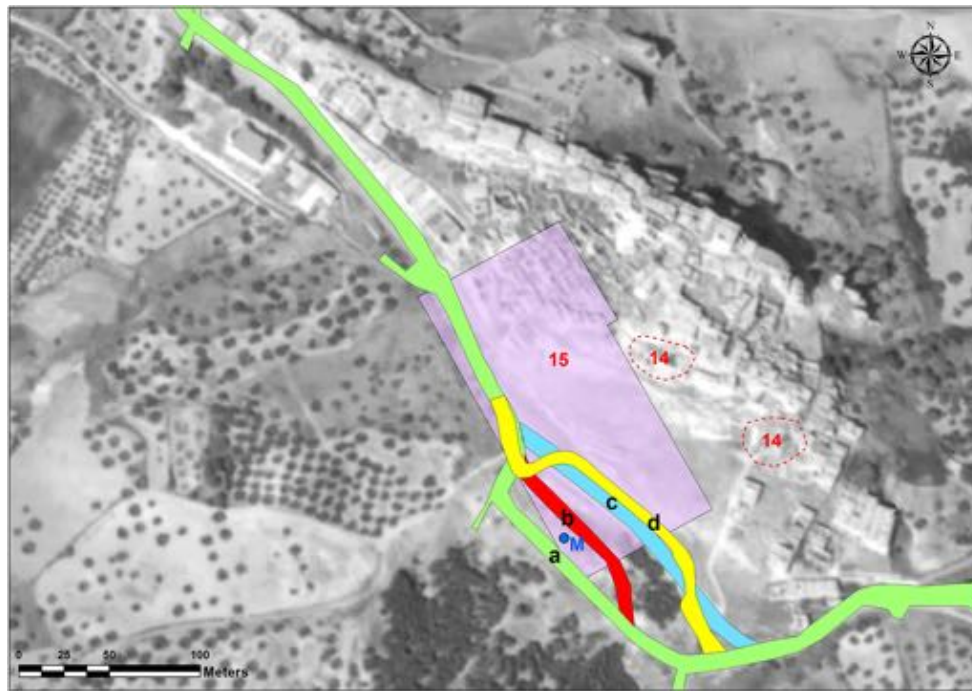


Fig. 19 Changes in the SS103 route over the decades and areas affected by instability in the 1970s and 1980s (aerial photo year 2003): (14) Damage due to the *Historical centre* landslide reactivation. (15) Consolidation works with waterproofing surfaces and rainwater disposal. The map also shows the changes of the SS103 route over the decades so testifying the retrogressive feature of the landslide. In detail, (a) SS103 route up to the beginning of the 1960s ; (b) SS103 route post the 1965

landslide reactivation; (c) current route; (d) provisional route probably built after the 23 November 1980 Irpinia earthquake ($M_w = 6.8$); M = First World War memorial whose location constraints the position of the SS103 at the time of the 1965 January landslide reactivation (see also Figs. 10 and 14). The whole retreat of the road (from “a to c”) can be estimated in 40 m or so

built heritage whereas the impact on the surrounding areas have to be assessed according to the local specific conditions and landslide issues. Outputs from our analysis are depicted in Fig. 22 which shows (i) an orthophoto that clearly highlights the presence of vegetation on the top and inside of the partially collapsed buildings of the Craco; (ii) on the bottom, the increasing trends in NDVI time series from 2003 to 2018 as obtained from the satellite time series made up of Landsat TM and Sentinel 2 data set; (iii) on the right, the map of the variations of NDVI-AVHRR from 1985 to 1999 time series that clearly exhibits the continuously and systematically increasing trends of NDVI for the Craco area over the years.

As a whole, we can highlight that both literature findings and outputs from the analysis that we *ad hoc* carried out for the Craco area (using Landsat TM and Sentinel 2 time series) clearly show the continuously and systematically increasing trends of NDVI, and in turn in vegetation dynamic, from 2003 to 2018.

HSV Analysis

Usually, colours, in the image acquisition, are recorded in keeping with the RGB (red, green, and blue) system.

However, some authors (e.g. Rangayyan et al. 2011; Guarnieri et al. 2014) argued that for the image classification aim, RGB is not the best representation system because strong correlation from these three bands exists. For this reason, another type of image representation can be used, the HIS or HSV system. In them, the mathematical description of each colour is closer to the human visual system. In the HSV system, Hue (H) represents (in degree) the dominant wavelength in the colour, Saturation (S) expresses the percentage of the colour purity and intensity, Value (V) measures the spectral definition of each colour in percentage, expressing in this way its brightness.

The first step to pass from the RGB to the HSV system is to express the R, G, and B bands from 0 to 1 (R' , G' , B'). Then the H, S, and V bands are calculated according to the following formulas:

$$V = M = \max (R', G', B')$$

$$m = \min (R', G', B')$$

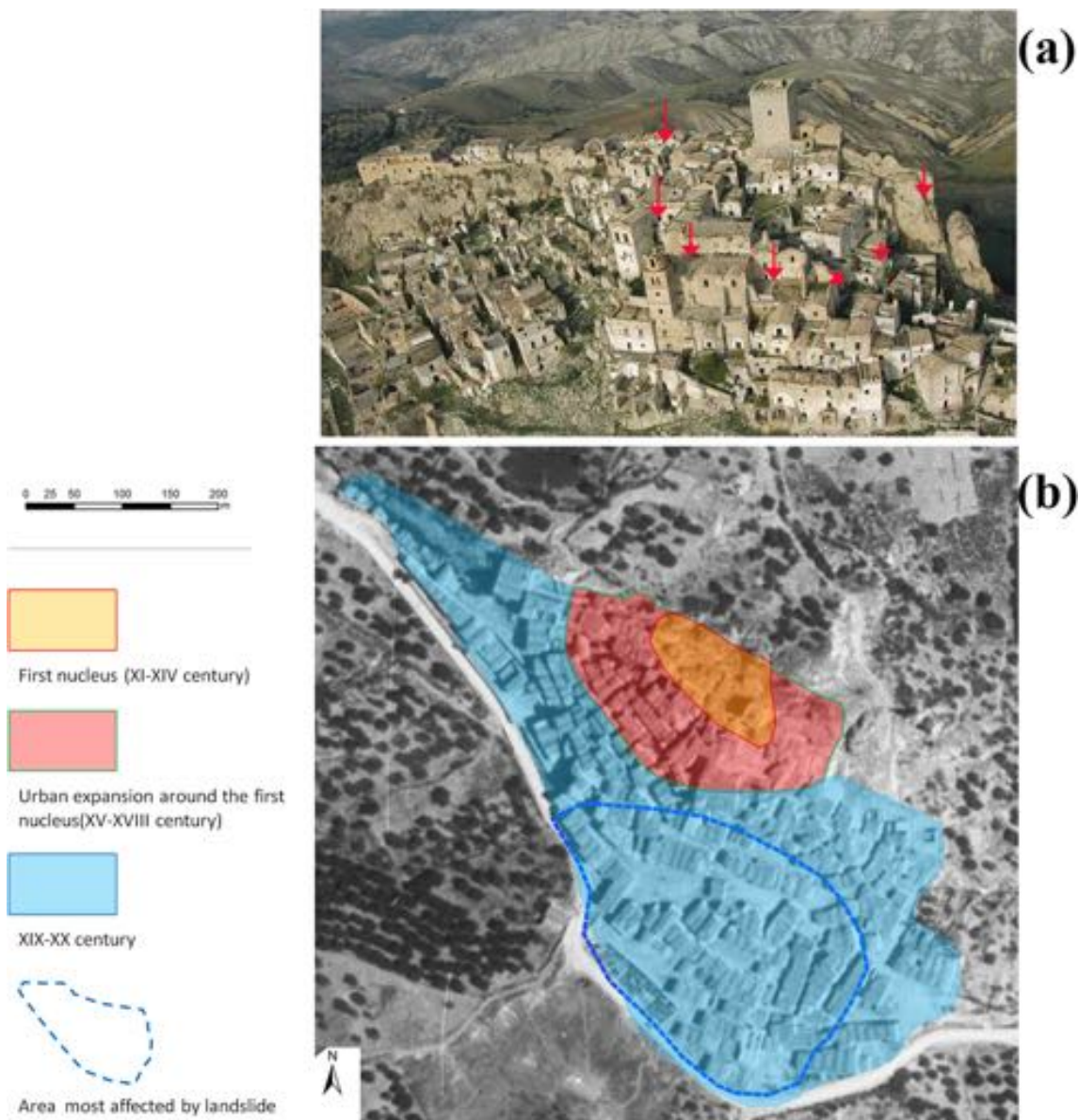


Fig. 20 **a** Detail of the old Craco with the tower. **b** Orthophoto with historical evolution of Craco characterised by three main historical building phases. Dashed blue line denotes the area most affected by the

effects of landslides over time (see “[Historical-Urbanistic Background of Craco](#)” for details on landslide occurrences and their effects)

$$C = M - m$$

$$H = \begin{cases} 0^\circ, & \text{if } C = 0 \\ 60^\circ \times \frac{G' - B'}{C} & \text{if } M = R' \\ 60^\circ \times \left(\frac{B' - R'}{C} + 2 \right) & \text{if } M = G' \\ 60^\circ \times \left(\frac{R' - G'}{C} + 4 \right) & \text{if } M = B' \end{cases}$$

$$S = \begin{cases} 0 & M = 0 \\ \frac{C}{M} & M \neq 0 \end{cases}$$

The advantage of this analysis is to perform image classification only considering visible channels. That becomes possible using images obtained by free source, such as the Google Earth platform. In detail, for the Craco case study, four images, dated 2003, 2006, 2015, and 2016, were considered and transformed from the RGB to the HSV system.

In particular, the results were obtained with the analysis of the Hue channel (Fig. 23), by which it is possible to see how the distribution of vegetation surface varies over the time span taken as a reference here. This was done by considering the Hue values from 90 to 180° (green). Images show, through 13 years, a significant growth of green areas, especially in the

Fig. 21 Cadastral map of 1807 portraying a detail of the urban landscape of Craco at the beginning of the nineteenth century (Archivio di Stato di Potenza, Uffici finanziari preunitari, vol. 40)

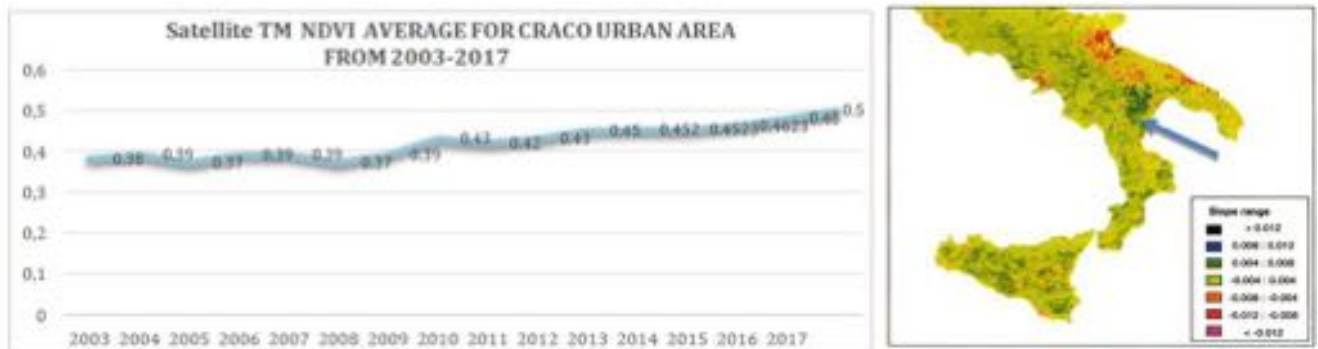


Fig. 22 Orthophoto of 2006 from *Geoportale Nazionale* —<http://www.pcn.minambiente.it/mattm/>— clearly shows the presence of vegetation on the top and inside the collapsed buildings. Bottom (on the left) NDVI time series from 2003 to 2018 as obtained from the Landsat TM and Sentinel 2

data satellite time series; on the right the map of the variations of NDVI-AVHRR from 1985 to 1999 time series that clearly shows the continuously and systematic increasing trends of NDVI for the Craco area (after Cuomo et al. 2001)

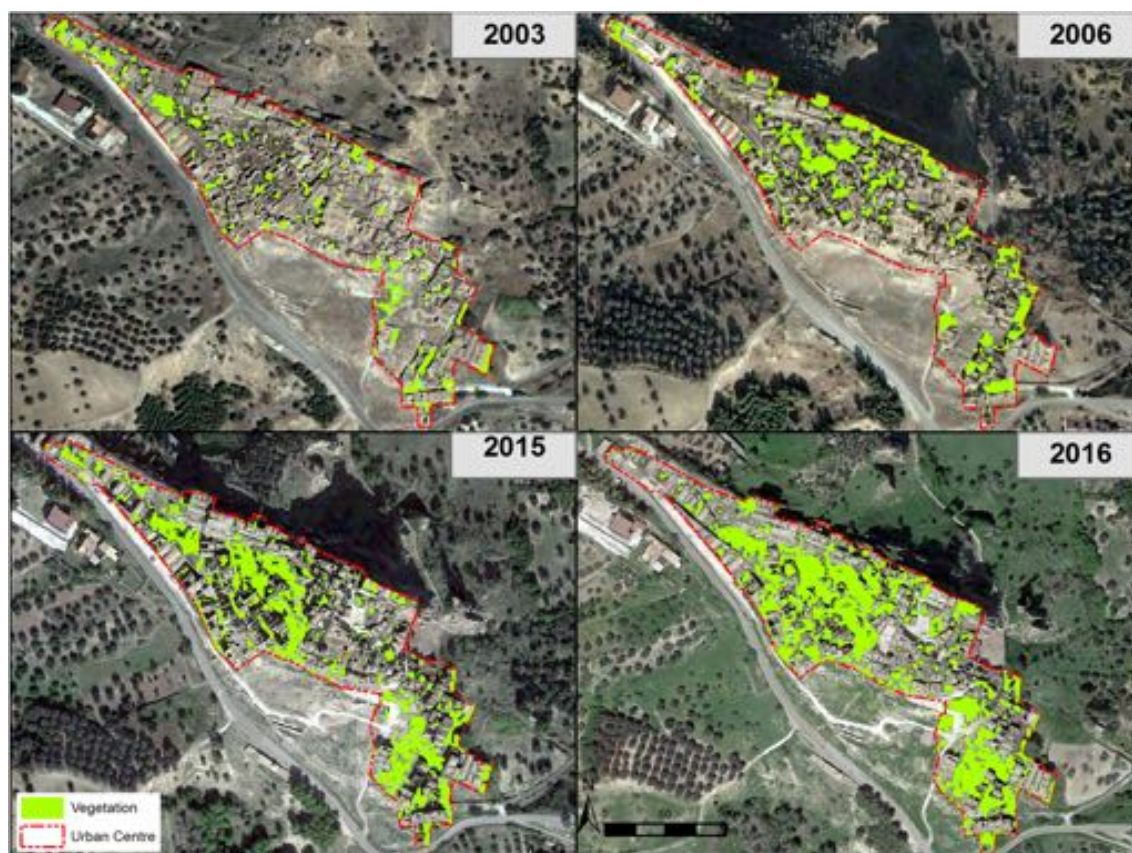


Fig. 23 Photos by Google Earth (2003, green areas in the Hue channel equal to 3382 m², 10% of the total; 2006, green areas in the Hue channel equal to 4882 m², 15% of the total; 2015, green areas in the Hue channel

equal to 7160 m², 22% of the total; 2016, green areas in the Hue channel equal to 10,160 m², 31% of the total)

central and southern parts of the urban centre. The vegetation coverage increased from 10% in 2003 to 31% in 2016 as respect to the built-up area (area identified by the red broken lines in Fig. 23). Consequently, built surfaces were covered partially or totally by the vegetation. So this quick and low-cost method allows to quantify the abandonment phenomenon and this is key for prevention, because its simplicity and cheapness stimulate the possibilities to carry out monitoring, through which to establish times and intervention management or planning.

Discussion

The abandonment of inhabited places is a phenomenon that has its roots in the past centuries. However, the deep changes that have permeated the social, economic, and cultural aspects in Europe during the last decades look like to have played a sort of “educational” role in people that are more prone to leave small settlements and remote rural villages to transfer in other sites. Consequently, “ghost towns” are not rare to be

observed in the landscape and a probable further increase of its territorial density will be observed in the next future.

To manage the phenomenon requires investigating in depth the causes that led to leave sites in historical time so as to learn lessons from past experiences, understanding the role of natural as well as human factors in driving or conditioning the decline of settlements, and focusing the attention also on the resilience of past communities (Curtis 1985). At the same time, “ghost towns” can be an important resource to be preserved for what they symbolise in terms of “tangible” memory of past events.

From the research discussed here, it emerges that over about one century, nearly twenty were the activations/reactivations of the two main landslides in Craco, with the consequent direct or indirect loss of about 30% of the original built-up area, beyond the heavy impact on infrastructures. Despite the recurrence of the movements, two aspects deserve to be mentioned. The first is that the repeated mass movements were not considered by inhabitants and institutions as a “warning”, but the areas heavily affected by landslide occurrences were, in some cases, rebuilt. Furthermore, the urban expansion of Craco towards the southern areas of the relief continued in the nineteenth-twentieth century

even if the retrogressive feature of the *Historical centre* landslide should have advised against that choice. The second refers to the circumstance that in many cases, the public works were planned/carried out after the landslide occurrence so highlighting a lack of a resolute institutional action aimed at arranging an organic plan to try mitigating the hydrogeological risk in “peace time” (before the paroxysmal events).

Furthermore, some works were carried out with unskillfulness or superficiality by technicians and/or workers, such as the building of retaining wall in the late nineteenth century or the building of the sports field just on the *Historical centre* landslide body. This circumstance certainly contributed to the reactivation of the movement at the end of the 1950s. It was also lacking a close convergence of actions between national and local authorities (e.g. Geological Service, Corps of Civil Engineering, and town council) to try to reduce the hydrogeological risk. Some of such actions met also with the resistance of inhabitants, unwilling to follow the order so partially making fruitless the efforts of risk mitigation. All these have to be added to a lack of knowledge about the features of the mass movements (the *Historical centre* landslide particularly) such as the depth of the sliding plane. These considerations can lead us to speculate that the settlement did not acquire resilience over time, but progressively lost it, thus determining the inevitable transfer.

As concerns the transfer, the initial phase (second half of 1960s) saw a divergence between the geological needs, shown by the national Geological Service and supported by the local government, and the socio-economic ones, claimed by inhabitants. Therefore, the initial area selected for the transfer (*Peschiera*) was considered by a segment of the citizens as inadequate. At a later time, the local government became a spokesman for the population’s needs so sustaining the transfer of the old site in two different places, the first far from the old town (*Peschiera*), the second (*Sant’Angelo*) close to the abandoned built-up area. These two choices, certainly steered by political opportunity issues, were also guided by a dualism between two different socio-economic visions. The first staked on a change of the economic perspective of the Craco inhabitants, by selecting a place closer to a developing industrial area (Pisticci and Val Basento zones); the second looked at the rural vocation of a portion of inhabitants that requested a new settlement close to their agricultural lands. Obviously, these changes in managing the situation had repercussions on the transfer timing and planning. Indeed, the transfer project suffered deep changes over the years following the official decision of the town shifting.

Nowadays, the presence of a settlement next to the abandoned town (*Sant’Angelo*) concurs to maintain a tie-up between inhabitants of the “new village” and the old town. In fact, the new village is felt by the local population as the “umbilical cord” with their historical roots that helps to enhance the sense of identity in the population that is conscious of what the old centre represents and contributes to its safeguard. Furthermore, until a few years

ago, the old town was still frequented for different reasons by inhabitants so that the site could be more properly described as “empty” rather than “abandoned” (Coletta 2014). Later on, the increase in building hazard collapse forced the local government to forbid the entry in the old town.

As regards the conservation state of the built-up area, both NDVI and HSV analyses have unanimously shown that a progressive and continuous vegetation growth has marked out the years from 2003 to 2018, with special regard to the 2008–2010 and 2015–2018 time spans, reaching a cover of about 30% of the residual built-up area. As an indirect consequence of that growth, the conservation state of old centre was reasonably made worse, with an increase of the building physical decay.

Conclusion

The article has considered a methodological approach to analyse both the natural/human factors accountable for the abandonment of settlements and conservation state of deserted places over time. The procedure, made up of a cross-correlated use of geological, geomorphological, historical, and remote-sensing investigations, was tested for the old town of Craco (Basilicata, Southern Italy).

From the research perspective angle, three are the main considerations that can be made. They concern (1) the management of towns both in prevention and in post-event phase; (2) the conservation planning of “ghost towns”, and (3) the enhancement of abandoned sites.

Firstly, the outcomes of this study stress the value of in-depth historical investigations to identify the detailed pictures of landslide occurrences, their effects on the built environment, and the actions put into the field by institution, so to show weaknesses in the risk management chain. This back analysis can be worthwhile to properly adjusting the possible actions to be undertaken for increasing the resilience of small settlements as well as to improve the decisions to be made regarding policy choices on the “destiny” of towns hit by heavy consequence of natural hazards. For example, for the risk management, our study has highlighted the need of a close synergy between central and local institutions as well as the necessity to involve the population by making them aware of the territorial risks, thus adapting their behaviour. As regards the post-event management and the possible transfer of built-up areas subject to risks, our study strengthens the need for in-depth socio-economic analysis of territories as well as the requirement to consider old centres as places where the identity of local communities is rooted.

Secondly, the research also highlighted the effectiveness of free-of-charge remote-sensing images to analyse the vegetation growth within abandoned towns. The availability of these uncharged tools can be of significant usefulness to periodically perform surveys so as to investigate site conditions and plan

accurate and timely conservation actions of the built environment. From this point of view, the Authors will perform further study to better evaluating the potentiality of both NDVI and HSV remote-sensing techniques in other abandoned urban contexts.

Thirdly, an aspect worthy of mention concerns the enhancement of “ghost towns”. Studies on these places allow increasing their knowledge, a basic and preliminary phase for their enhancement. For places like Craco, the enhancement should be understood for both tourism and educational/training goals. Actually, Craco can be considered a real open-air laboratory through which to raise awareness among people, especially young generations, on the issue of natural and geological risks. From this point of view, it would be suitable to establish a “Park of the Memory” in Craco having educational aims. To do this, the park could benefit of the results arising from this research to accurately documenting through signage, thematic routes, mobile APPs, digital totems, etc., what happened in Craco during about a century of interaction between the hydrogeological hazard and human-built environment. The institution of such a park would also have the role of warning for both the population and institutions on the possible destiny that might encounter the small villages of the Italian Apennines, with special regard to Basilicata, a region characterised by a high hydrogeological and seismic hazard. In this outlook, the authors will accomplish studies alike to that proposed here considering other Italian and European inhabited sites made “ghost” by the pivotal influence of natural hazards.

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Author Contributions **Gizzi F.T.** conceived and directed the research, coordinated the drafting of the paper; wrote along with Masini N. and Lasaponara R. the “Introduction”. **Gizzi F.T.** also wrote “The Landslide Chronology, Damage, and Complex Institutional Response”, “Discussion”, and “Conclusion”, and revised the whole paper along with Masini N. **Bentivenga M.** wrote “Geographical, Geological, and Geomorphological Settings of the Craco Area” and supported the landslide historical data analysis by field surveys. **Lasaponara R.** was responsible of the NDVI analysis and wrote “Normalized Difference of Vegetation Index Analysis”. **Danese M.** performed the HSV investigations and wrote “HSV Analysis”. **Potenza M.R.** contributed to the landslide and institutional response investigations and elaborated the outputs in Figs. 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19. **Sileo M.** contributed to delineate the state-of-the-art about previous study on the Craco area and supported the historical landslide research. **Masini N.** co-directed the investigations and wrote “Historical-Urbanistic Background of Craco”.

Appendix. Archive Sources Analysed

Archive of Basilicata Region

Word shortening: ADRBa – SPIX (Archivio Decentrato Regione Basilicata—Basilicata Region Decentralized

Archive—c/o Spix); S. (Scatola—Box); B. (Busta—Portfolio); s.l. (Senza indicazione del luogo—Without indication of place); s.d. (Senza indicazione della data—Without date indication)

ADRBa – SPIX, S. 305. Disegni eseguiti dal Provveditorato alle Opere Pubbliche per la Basilicata – Ufficio del Genio Civile di Matera – riguardanti il Progetto dei lavori di costruzione in località “Peschiera” di ricoveri per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso di Craco. Ricoveri n. 12 per complessivi 64 vani legali. Importo complessivo £. 62.623.750. Matera, 20 gennaio 1964.

ADRBa – SPIX, S. 305. Relazione del Provveditorato alle Opere Pubbliche per la Basilicata – Ufficio del Genio Civile di Matera – riguardanti il Progetto dei lavori di costruzione in località “Peschiera” di ricoveri per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso di Craco. Ricoveri n. 12 per complessivi 64 vani legali. Importo complessivo £. 62.623.750. Matera, 20 gennaio 1964.

ADRBa – SPIX, S. 305. Relazione aggiuntiva del Provveditorato alle Opere Pubbliche per la Basilicata – Ufficio del Genio Civile di Matera – riguardante il Progetto dei lavori di costruzione in località “Peschiera” di ricoveri per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso di Craco. Ricoveri n. 18 per complessivi 102 vani legali. Importo complessivo £. 85.000.000. Matera, 18 marzo 1964.

ADRBa – SPIX, S. 305. Relazione del Provveditorato alle Opere Pubbliche per la Basilicata – Ufficio del Genio Civile di Matera – riguardante il Progetto dei lavori di costruzione in località “Peschiera” di ricoveri per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso di Craco. Ricoveri n. 12 per complessivi 64 vani legali. Importo complessivo £. 62.623.750. Matera, 20 maggio 1964.

ADRBa – SPIX, S. 305. Lettera dell’Impresa Fraccalvieri Nicola all’Ufficio del Genio Civile di Matera riguardante Lavori di costruzione di n. 12 ricoveri per complessivi 64 vani legali per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso, in località “Peschiera” del Comune di Craco. Offerta prezzi per allacciamento all’acquedotto. Matera, 25 giugno 1965.

ADRBa – SPIX, S. 305. Lettera dell’Ingegnere Capo del Genio Civile di Matera all’Impresa Fraccalvieri Nicola riguardante Legge 12-4-1948 no. 1010 Lavori di costruzione di n. 12 ricoveri per complessivi 64 vani legali per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso, in località “Peschiera” del Comune di Craco. Allacciamento all’acquedotto. Matera, 12 luglio 1965.

ADRBa – SPIX, S. 305. Lettera del Provveditorato alle Opere Pubbliche per la Basilicata di Potenza al dott. Ing. Nicola Aleni (Napoli) e p.c. all’Ufficio del Genio Civile di Matera con oggetto Incarico di collaudo- Contabilità finale dei lavori di costruzione di n. 12 ricoveri per complessivi 64

vani legali per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso in località “Peschiera” del Comune di Craco (Matera). Potenza, 17 giugno 1966.

ADRBa – SPIX, S. 305. Relazione-Verbale di visita-Certificato di collaudo del Provveditorato alle Opere Pubbliche per la Basilicata – Ufficio del Genio Civile di Matera riguardante Lavori di costruzione di n. 12 ricoveri per complessivi 64 vani legali per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso, in località “Peschiera” del Comune di Craco. Potenza, 23 luglio 1966.

ADRBa – SPIX, S. 305. Decreto di approvazione degli atti di contabilità finale da parte del Provveditorato alle Opere Pubbliche per la Basilicata e relativa liquidazione riguardante i lavori di costruzione in località “Peschiera” del Comune di Craco di n. 18 ricoveri per famiglie non abbienti rimaste senza tetto in dipendenza del movimento franoso. Potenza, 23 novembre 1966.

ADRBa – SPIX, S. 305. Lettera del Provveditorato alle Opere Pubbliche per la Basilicata all’Ufficio del Genio Civile di Matera e p.c. all’Ufficio Contratti con oggetto Craco: costruzione di n. 18 ricoveri per famiglie rimaste senza tetto, in località Peschiera. Impresa Santomassimo Antonio – Contabilità finale – Restituzione Atti. Potenza, 29 dicembre 1966.

ADRBa – SPIX, S. 305. Mappa del danneggiamento. s.l., s.d.

ADRBa – SPIX, S. 306, B. 121235. Relazione dell’Ingegnere Capo del Genio Civile di Matera riguardante il Progetto di urbanizzazione per il trasferimento dell’abitato del Comune di Craco in località Peschiera – Importo £. 360.000.000. Matera, 20 aprile 1976.

ADRBa – SPIX, S. 306, B. 121,235. Relazione Geologico-Tecnica sui terreni del Piano di Zona (Edilizia economica e popolare Legge 18/04/1962 no. 167). Redazione a cura dello Studio Idrogeologico dei dott. Geol. Calia e Baldassarre. Matera, 15 maggio 1976.

ADRBa – SPIX, S. 306, B. 121,235. Parere favorevole del Comitato Tecnico Amministrativo del Provveditorato alle Opere Pubbliche riguardante il Progetto di urbanizzazione per il trasferimento dell’abitato del Comune di Craco in località Peschiera dell’importo £. 360.000.000. Potenza, 21 maggio 1976.

ADRBa – SPIX, S. 306, B. 121235. Piano Regolatore Generale: Norme di Piano – Progettazione a cura degli Ingg. Buggiani, Filippi, Modigliano e Preger. s.l., 8 novembre 1977.

ADRBa – SPIX, S. 306, B. 121235. Piano Regolatore Generale: Relazione – Progettazione a cura degli Ingg. Buggiani, Filippi, Modigliano e Preger. s.l., 8 novembre 1977.

ADRBa – SPIX, S. 306, B. 121235. Relazione del Responsabile dell’Ufficio del Genio Civile di Matera riguardante la Perizia dei lavori di urbanizzazione per il

trasferimento dell’abitato di Craco in località Peschiera. Matera, 12 gennaio 1979.

ADRBa – SPIX, S. 306, B. 121235. Relazione del Responsabile dell’Ufficio del Genio Civile di Matera riguardante la Perizia dei lavori occorrenti per il consolidamento dell’abitato di Craco mediante impermeabilizzazione di superfici e di smaltimento delle acque piovane – Importo £. 160.000.000, con annessa planimetria con ubicazione delle zone di intervento. Matera, 16 marzo 1983.

National Historical Archive of Civil Protection Department in Rome

Word shortening: ASDPC (Archivio Storico Dipartimento della Protezione Civile—Historical Archive of the Civil Protection Department); Div. (Divisione—Division); SDiv. (Senza Divisione—Without division); C. (Consolidamenti—Consolidation works); B. (Busta—Portfolio); SNB (Senza Numero Busta—Without portfolio number); s.l. (Senza indicazione del luogo—Without indication of place); s.d. (Senza indicazione della data—Without date indication)

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Lettera della Real Prefettura di Matera al Ministero LL.PP. Direzione generale Edilizia e Opere Igieniche con oggetto Craco – Consolidamento abitato. Matera, 5 luglio 1938 Anno XVI.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Relazione dell’Ingegnere Dirigente del Corpo Reale del Genio Civile – Ufficio di Matera – riguardante perizia di somma urgenza per opere di pronto soccorso nell’abitato di Craco. Matera, 25 luglio 1938 Anno XVI.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Lettera del Provveditorato Regionale alle Opere Pubbliche per la Basilicata al Ministero dell’Industria e Commercio Direzione Generale delle Miniere – servizio geologico – con oggetto Craco (Matera) – Movimenti franosi. Potenza, 10 dicembre 1963.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Lettera del Provveditorato Regionale alle Opere Pubbliche per la Basilicata al Ministero LL.PP. Direzione Generale dei Servizi Speciali Div. 26 con oggetto Craco – Movimenti franosi. Potenza, 13 dicembre 1963.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Telegramma del Capo di Gabinetto del Ministero dell’Interno al Ministero LL.PP. riguardante la richiesta di notizie sul grave pericolo determinatosi a Craco a causa di un vasto movimento franoso. Roma, 23 dicembre 1963.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Telegramma del Provveditorato alle Opere Pubbliche al Ministero LL.PP. riguardante l’informativa circa la situazione determinatosi nell’abitato di Craco a causa di un vasto movimento franoso. s.l., 30 dicembre 1963.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Telegramma del Prefetto al Ministero LL.PP. riguardante la richiesta di assegnazione baracche e costruzione di 50 nuovi alloggi per le famiglie di Craco sgomberate a causa di un vasto movimento franoso. s.l., 2 gennaio 1964.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Telegramma del Ministero LL.PP. al Provveditorato alle Opere Pubbliche ed. al Prefetto di Matera riguardante la necessaria assegnazione di baracche per provvisorio ricovero dei sinistrati di Craco a causa di un vasto movimento franoso. Roma, 8 gennaio 1964.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Relazione del Provveditorato Regionale alle Opere Pubbliche per la Basilicata – Ufficio del Genio Civile di Matera – riguardante la proposta di trasferimento totale dell'abitato di Craco. Matera, 6 maggio 1964.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Telegramma del Provveditorato alle Opere Pubbliche al Ministero LL.PP. riguardante la richiesta di pronto soccorso nell'abitato di Craco a causa della rottura della rete fognaria con conseguente inquinamento dell'acqua potabile. s.l., 1 luglio 1964.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Relazione d'istruttoria del Provveditorato Regionale alle Opere Pubbliche per la Basilicata riguardante la proposta di trasferimento dell'abitato di Craco a cura e spese dello Stato Progetto di £. 800.000.000. s.l., 10 ottobre 1964.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Craco – Zona movimento franoso. Foto sciolte. Craco, 17 gennaio 1965.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Foglio IGM con indicazione dell'area di trasferimento di Craco in località Peschiera. s.l., 26 gennaio 1965.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Piano di trasferimento dell'abitato di Craco in località Peschiera: zona dell'abitato di Craco da trasferire. s.l., 26 gennaio 1965.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Piano di trasferimento dell'abitato di Craco in località Peschiera: zona di trasferimento. s.l., 26 gennaio 1965.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Parere favorevole del Consiglio Superiore dei Lavori Pubblici riguardante la proposta di inclusione dell'abitato di Craco (Matera) tra quelli da trasferire cura e spese dello Stato. s.l., 26 gennaio 1965.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Parere favorevole del Consiglio Superiore dei Lavori Pubblici riguardante la proposta di variante al totale trasferimento dell'abitato. s.l., 9 aprile 1968.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Lettera del Provveditorato Regionale alle Opere Pubbliche per la Basilicata all'Ufficio del Genio Civile di Matera ed. al Ministero LL.PP. Direzione Generale Servizi Speciali con

oggetto Programma esercizio 1969 – Craco: Lavori di consolidamento D.P. no. 12486 del 1.12.1969 registrato alla C.C. il 15.1.1970 reg. 1 Fol. 18. Potenza, 1 dicembre 1969.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Lettera del Provveditorato Regionale alle Opere Pubbliche per la Basilicata al Ministero LL.PP. Gabinetto – Ufficio interrogazioni – con oggetto Craco (Matera) – Movimento franoso. Interrogazione a risposta scritta no. 4-10098 presentata dall'On. Cataldo. Potenza, 2 febbraio 1970.

ASDPC, Div. 29 Matera C., Colobraro – Craco, B. 4. Planimetria catastale. s.l., s.d.

ASDPC, Trasferimento di Craco, SNB. Relazione Geologica del Dott. Walter Brugner del Servizio Geologico d'Italia riguardante le condizioni di stabilità dell'abitato di Craco (Provincia di Matera). Roma, 2 gennaio 1964.

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National State Archive of Matera

Word shortening: ASMT (Archivio di Stato di Matera—State Archive of Matera); FP (Fondo Prefettura—Prefecture Documents); FGC (Fondo Genio Civile—Civil Engineering Documents); SA (Servizio Amministrativo—Administrative Service); AdC (Affari dei Comuni—Affairs of municipalities); V. (Versamento—Deposit); B. (Busta—Envelope); F. (Fascicolo—File); s.l. (Senza indicazione del luogo—without indication of place); s.d. (Senza indicazione della data—without date indication)

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ASMT, FGC, I V., B. 351, F. 3814-3816. Disegni dell'Ufficio del Genio Civile di Matera riguardante i lavori per lo smaltimento delle acque di pozzi nella zona in frana nell'abitato di Craco. Matera, 25 agosto 1947.

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ASMT, FGC, I V., B. 928, F. 10302-10303. Relazione/Perizia del Provveditorato alle OO.PP. di Potenza – Ufficio del Genio Civile di Matera riguardante i lavori di fognatura e sistemazione di strada interne nell'abitato di Craco. Matera, 24 gennaio 1949.

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National State Archive of Potenza

Word shortening: ASPZ (Archivio di Stato di Potenza—State Archive of Potenza); CC (Commissariato Civile—Civil Commission); FP (Fondo Prefettura—Prefecture Documents); S2 (Serie 2); Cat. (Categoria—Category) F. (Fascicolo—File); B. (Busta—Envelope); Q. 1888-92 (Quinquennio—Quinquennium 1888-92); Q. 1903-1905 (Quinquennio—Quinquennium 1903-1905); s.l. (Senza indicazione del luogo—Without indication of place); s.d. (Senza indicazione della data—Without date indication)

ASPZ, CC, B. 1. Lettera del Sindaco di Craco al Prefetto Commissario Civile di Potenza con oggetto Denuncia di frane dell'abitato. Craco, 5 maggio 1903.

ASPZ, CC, B. 1. Lettera del Sindaco di Craco al Commissario Civile di Potenza con oggetto Provvedimenti per le frane di questo Comune. Craco, 28 gennaio 1908.

ASPZ, CC, B. 1. Lettera del Commissariato Civile di Potenza all'Ingegnere Capo del Genio Civile – Servizio Idraulico di Potenza con oggetto Consolidamento delle frane minaccianti l'abitato di Craco. Potenza, 1 febbraio 1908.

ASPZ, CC, B. 1. Lettera dell'Ingegnere Capo del Genio Civile – Ufficio Speciale per le Opere Idrauliche e di Bonifica in Basilicata di Potenza al Prefetto Commissario Civile di Potenza con oggetto Consolidamento dell'abitato di Craco – Progetto. Potenza, 28 ottobre 1905.

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ASPZ, FP, S2, Cat. 89, F. 38F, Q. 1888-92, Craco Frana. Lettera del Ministero LL.PP. – Direzione Generale di Ponti e Strade di Roma al Prefetto di Potenza con oggetto Legge 27/06/1869 Nazionale di Val d’Agri – Provvedimenti diretti ad evitare le frane che minacciano l’abitato di Craco. Roma, 23 luglio 1886.

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