Archeologia e Calcolatori
30, 2019, 309-328

GIS AND REMOTE SENSING FOR POST-DICTIVE ANALYSIS OF ARCHAEOLOGICAL FEATURES. A CASE STUDY FROM THE ETNEAN REGION (SICILY)

1. Introduction and objectives

In this paper[1], we present a project regarding the application of remote sensing techniques in the unique Etna landscape, specifically in its western slope. Scholars have usually obtained successful results through the use of satellite imagery (a reference list in Lambers, Traviglia 2016) in several landscapes (Parkak 2009; Menze, Ur 2011; Lasaponara, Masini 2014; Traviglia, Torsello 2017): from desert ones (Rajani, Rajawat 2011) to South-American forests (Blom *et al.* 2007; Trier, Larsen, Solberg 2009; Garrison 2010; Mantellini 2015).

For instance, although many Italian Universities, including those in Sicily, and research centers have a long tradition in programs of landscape archaeology and territorial studies (Lasaponara, Masini 2008; Ciminale *et al.* 2009; Gallo *et al.* 2009; Agapiou *et al.* 2016; Castrorao Barba *et al.* 2016; Opitz, Herrmann 2018), there have not been studies focusing directly on the Etnean area, where the detection of vegetation marks becomes very difficult, or in some cases, impossible. Relevant researches have been carried out in the volcanic Arenal Region of Costa Rica by professor P. Sheets (Sheets, McKee 1994). His studies focused on the relationship between human presence and the specific volcanic landscape. However, a great distance exists between Costa Rica and Sicily: vegetation, soil's geomorphological composition, human history and the same volcanic activity change completely.

This study aims to fill the gap existing in the scientific literature, evaluating the benefits of the use of multispectral imagery in the identification of archaeological features in a volcanic landscape. The paper is intended to provide sufficient data to allow other teams to accept and/or modify our procedure. However, there are significant challenges to the deployment of such method and some crucial considerations arise:

1) Firstly, what is the best archaeological photo-interpretation procedure in such peculiar natural context?
2) What kind of archaeological features can be identified?

[1] A. Gennaro gave his principal contribute writing paragraphs 1 and 2; G. Mussumeci, M. Mangiameli, A. Candiano and G. Fargione wrote paragraphs 3 and 4. All authors discussed the final manuscript and contributed writing abstract, results and conclusions.

3) Are Vegetation Indices useful instruments in order to discover archaeological structures buried in a volcanic landscape? Which are the most useful spectral bands for archaeological purpose?
4) In short, can we trust on archaeological instruments and remote sensing techniques at our disposal?

To answer all these questions, we adopted a post-dictive approach. In this specific case, the post-dictive approach consists in changing completely the usual and common workflow of the archaeological research, starting from reliable data, not from uncertain and unclear ones. Our project starts from a post-dictive point of view. In summary, we collect evidence coming from archaeological excavations and make a comparison between this kind of data and the one obtained from the application of remote sensing techniques. This comparison allows us to test instruments and tools, developing a specific methodological discussion on them.

Finally, it is worth mentioning that the entire research has been developed with the GIS technology support in an open-source and low-cost context, using QGIS, which is a professional free and open source GIS software.

2. The area of study and the post-dictive approach

The selected case study is of great archaeological interest and it lies on the western slope of the European highest active volcano, Etna. The mountain and its spectacular activity are rooted in the collective imagination and memory of modern and ancient inhabitants. Etna is the protagonist of numerous myths and legend since ancient times (Guidoboni *et al.* 2014). Deucalion and his wife surveyed the Deluge fleeing to Etna, probably because Etna was the highest mountain of the Greek world and the only part not covered by water. In addition, Etna was the well-known Typhon's jail, the monster born of Ge and Tartarus and thrown under the volcano by Zeus after an epic battle. In 252 AD, during an eruption, the inhabitants of Catania used the veil of the martyred St. Agata at the flow front as a shield, avoiding the destruction of the city. Later, the same object was used on several occasions.

The study of myth is an important part of several academic disciplines (on the emerging "geo-mythology" see Piccardi, Masse 2007), and a number of papers and manuscripts has been written on the relationship between myth and geographic elements. For example, the intense Etnean volcanic activity has been interpreted by Greeks as the consequences of Typhon's imprisonment (Caruso 2007).

Mount Etna has been inscribed in the World Heritage List in June 2013. The scientific committee describes «Mount Etna (as) one of the best-studied and monitored volcanoes in the world, and continues to influence volcanology, geophysics and other earth science disciplines. Mount Etna's notoriety, scientific importance, and cultural and educational value are of global significance» (http://whc.unesco.org/en/list/1427).

Despite this prestigious acknowledgment, archaeological interest has never been strong and the north-western flank is much less known than the southern and eastern ones due to the lack of systematic archaeological investigations. Even Paolo Orsi, the father of Sicilian archeology, worked here just for few days, bringing to light a thermal complex in 1905, located in Erranteria district (territory of Bronte) but unfortunately now lost. The discovered part (Orsi 1905, 1907), dated to Late-Roman period, consisted in three rooms with polychrome mosaics and can be referred to one of the *villae* scattered throughout the populated and cultivated area.

In general, prehistoric cave occupation is the only topic that archaeologists have extensively investigated (Privitera 2007). To start our research, the first step was to identify an emblematic area of the Etna's landscape complexities (Fig. 1). The selected zone is located on the north-western slope, in the territory of Bronte, a town about 50 km far from Catania. The study-area lies between three districts: *Santa Venera*, *Edera* and *Balze Soprane*. A national roadway (S.S. 120) separates the first two from the latter. However, in this paper the focus is mainly on *Edera* and *Santa Venera*'s archaeological remains.

This territory is part of a large and characteristic lava plain of the Saracena's valley, a tributary of the Simeto river, located above 800-900 m a.s.l., in the territory of Bronte. Due to its great naturalistic interest from a geologic, floristic-vegetation and faunal point of view, the entire area, belonging to Etna Park, has been identified as a Site of Community Importance (SCI).

In some deposits, *Santa Venera* lavas appear as pseudo-craters, while in others the lava flow looks like a real lava bulwark (Caffo 2015, 37). In addition, because of the presence of near Lake Gurrida and rivers (especially Flascio and Saracena), the site periodically can turn into a swamp or wetland.

The lava plateau hosts several different herbaceous communities. In general, the vegetation has steppe characteristics and covers discontinuously the surface; this type of environment is dominated by *Ferula communis*, a tall flowering plant related to common fennel. While the oldest lava plains are subjected to pasturage, the new ones are covered by shrub vegetation and this type of flora can be considered as pioneer community. Between the lava blocks, perennial herbs are widespread and, when the soil is deeper, the vegetation increases: here it is possible to find woodlands, dominated by *Quercus* (Cirnigliaro, Federico 2015).

The data briefly presented highlight the uniqueness of the Etna region. However, from an archaeological point of view, all the elements mentioned above represent some of the main problems encountered in the landscape analysis. The archaeological photo-interpretation is a quite complex process,

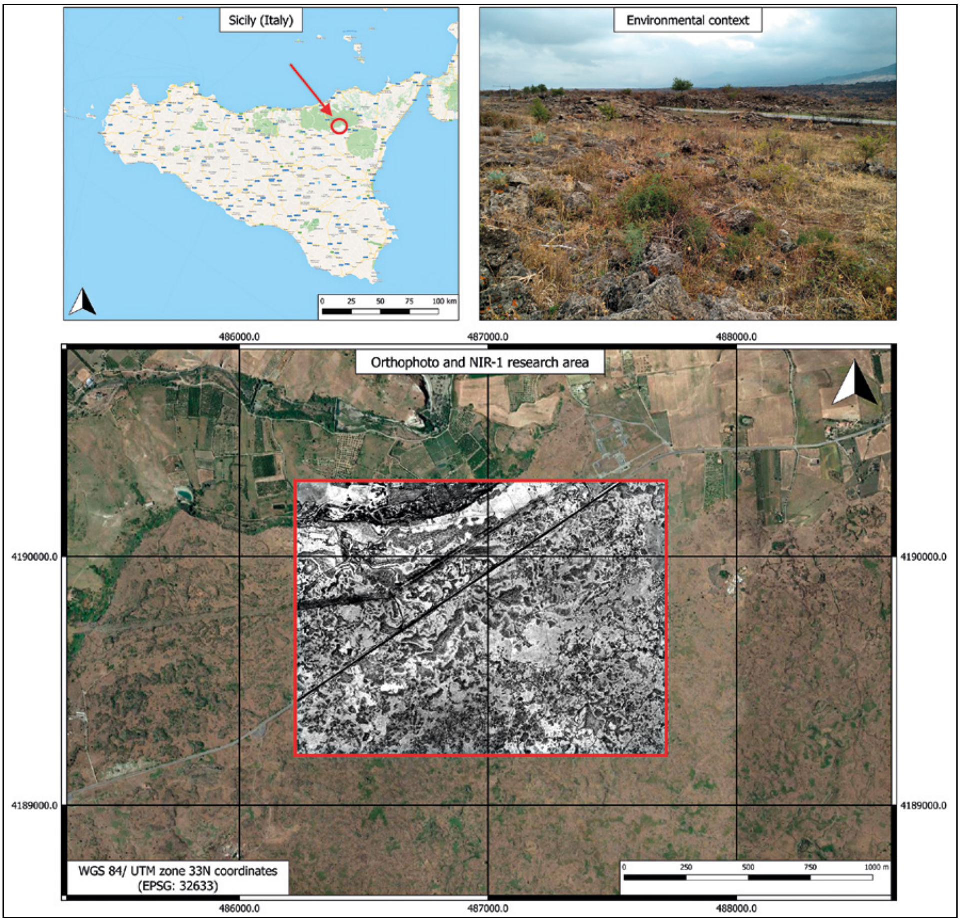

Fig. 1 – Location map of the study area: Sicily, Etna Western flank (photo by authors).

with many lures[2] because of the geological and morphological characteristics of the area. Moreover, in areas that have rough scrub vegetation and a highly irregular topography with cliffs and fissures, the existence of crop marks is seriously reduced. In addition, where the soil has no vegetation cover, soil marks cannot be easily detected due to the mineral composition of lava terrain. The problem becomes even more complex due to the presence of lava-stone walls. Such remains were built because *Edera* district was part of the Duchy of Bronte, a latifundium gifted to Nelson in 1799 by King Ferdinand IV of

[2] Lures are visible features that just evoke archaeological traces.

Naples. Nowdays the ruins of colonial houses and the walls used as boundary markers are still visible in the entire area.

In order to find a useful solution, the strategy developed in our study is directed towards a post-dictive approach to archaeological data and remote sensing techniques. We decided to change completely the usual and common application of the procedure: starting from the "certain" (the archaeological evidences that are already known) and not from the "uncertain". The crucial point is that no archaeological structures are clearly visible in the multispectral images dated to April 2013. WorldView-2 multi-spectral dataset has been deliberately selected prior to the archaeological excavation carried out in 2015.

In general, the post-dictive approach can be considered as a sort of validity test of the entire archaeological methodology. The conceptual framework is built around one crucial idea: the validity of the final result is strictly related to the degree to which the outcome matches (or not) with a result already established in the past. In our case, the accuracy of our instruments lies in the differences existing between the results of photo interpretation process and the archaeological evidence already discovered. In other words, the post-dictive approach, as stated by scholars (Brogiolo *et al.* 2012: Arnoldus-Huyzendveld, Citter 2014; De Guio 2015), allows us to evaluate and test instruments and techniques at our disposal, emphasizing weaknesses and strengths.

In this context, *contrada Edera* represents the perfect case study. The Catania Superintendency undertook excavation in 1987, 1992, 2005 and 2015. In the Eighties and Nineties (Consoli 1988-1989) during the construction of the pipeline in the area, prehistoric layers, circular and rectangular structures were intercepted and discovered. The district has been one of the subjects of two field-walking surveys, carried out by University of Durham (Leone *et al.* 2007).

In 2015 systematic excavations carried out by the Superintendency of Catania completely brought to light a dozen of buildings: most of them, dated to Byzantine era (VIII-IX century), are located in the southern edge of the *Edera* district, not so far from the national road. In addition, archaeologists discovered a Greek complex, dated between VI-V century BC, near a modern farm. Unfortunately, archaeological works have not allowed to clarify date and function of a wall-structure that runs across the district for about 2 km.

To develop our research, two of the several Byzantine circular buildings discovered and the same wall-structure were selected.

3. Dataset

For this study, we used images from the WorldView-2 satellite sensor. The WorldView-2 telescope has a 110 cm aperture and flies at a higher altitude of 770 km.

The panchromatic sensor is susceptible to the visible and near-infrared (NIR) wavelengths and has a bandwidth of 450-800 nm. The multispectral sensor captures data in 8 spectral bands from coastal to NIR-2. Both panchromatic and multispectral sensors offer 11bits (2048 grey levels) radiometric resolution. The WorldView-2 data used for this study were acquired on April 19, 2013 (see Tab. 1).

Acquisition Date	2013-04-19
Acquisition Time	10:23:44
Cloud cover	0 %
Pan resolution	0,50 m
Multi resolution	2,00 m
Off-nadir	0 degree
Processing Level	Standard Lv. 2A
EPSG	32633

Table 1. Worldview-2 Image Metadata.

Regarding the post-dictive approach, it should be remembered that WV-2 multi-spectral images have been selected prior to the excavation operations carried out in 2015. In this way, the archaeological remains, which were brought to light later, are still hidden in the images. Moreover, we have chosen the optimal acquisition period (see e.g. Agapiou *et al.* 2013; Masini *et al.* 2018) to identify crop marks because they are more evident from spring to autumn, when the vegetation is growing.

4. Methodology

We adopted the procedure shown in Fig. 2 for the identification of anomalies or proxy indicators (Merola *et al.* 2006; Lasaponara *et al.* 2007; Lasaponara, Masini 2012; Cavalli *et al.* 2013; Masini, Lasaponara 2017). The WorldView-2 imagery products are available at different processing levels (basic, standard, orthorectified) serving the needs of different users. For our scope, geometrically and radiometrically correct images were used. We proceeded initially with data fusion technique in order to greatly improve geometrical resolution of multispectral images.

Subsequently, we applied enhancement techniques, suitable for the archaeological context, to facilitate the visual interpretation and the identification of proxy indicators. Often images, captured by satellite sensors, may not appear in the ideal conditions for visual interpretation.

At the end, the traces identified are validated and collected in a GIS environment as vector layers. Proxy indicators are shortly described, reporting the channels and indices where they are most evident. The main phases of the presented procedure are described in more detail in the followings paragraphs.

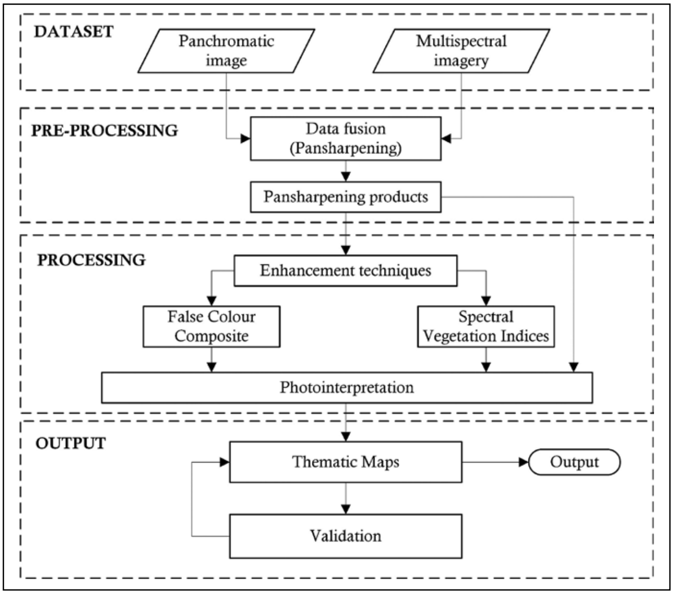

Fig. 2 – Flowchart of the procedure adopted for the identification of superficial anomalies.

4.1 *Data fusion*

Data fusion (or pansharpening) is a technique that allows to combine the high spatial resolution of the acquired image in the panchromatic band with the spectral information of multispectral bands (with lower spatial resolution). The result is a great geometrical resolution improvement of the multispectral images (Lasaponara *et al.* 2006; Vivone *et al.* 2015).

In this study, the pansharpening was performed using Orfeo Toolbox available in the QGIS software. Starting from the 8-band multispectral image with spatial resolution equal to 2 m, we obtained a multispectral image having spatial resolution equal to 0.50 m.

The performance of the various spectral bands for the identification of archaeological features suggests that the best bands are Red Edge (705-745 nm) and *NIR-1* (770-895 nm). This result is in agreement with several studies (Agapiou *et al.* 2013, 2014, 2016), which identify the optimal spectral region for detection of crop marks between 700 nm and 800 nm.

4.2 *Enhancement techniques*

Emphasis or enhancement techniques play a fundamental role in order to facilitate the visual interpretation and the identification of features and archaeological marks (Bennett *et al.* 2012). For this aim, we selected, in QGIS software, the FCC technique (False Color Composite) and the calculation of the Spectral Vegetation Indices.

The first technique consists in the assignment of RGB colors to three generic bands of the electromagnetic spectrum, to emphasize a particular informative content of the images. We looked for the best possible combination in order to maximize the contrast existing between archaeological marks and surrounding environment (Alexakis *et al.* 2009; Lasaponara, Masini 2012). After several tests, we realized that the most useful combination is the NIR 1-Red-Green, taking into account the territorial context, characterized by a high contrast between rock and vegetation. The second technique is an algebraic combination of the reflectance values of spectral bands (Bannari *et al.* 1995) to determine the Spectral Vegetation Indices.

In archaeological research, these indices could be used to identify changes in vegetation growth, which may indicate the existence of buried structures (Lasaponara *et al.* 2007). In addition, Vegetation Indices could be useful for the identification of archaeological marks not perceivable through True Color Composite (TCC) or FCC. These changes can be mainly noticed from Near Infrared (NIR) to Infrared bands (Agapiou *et al.* 2012).

For our purpose, several different indices typically used for analysis of archaeological features have been calculated (Jordan 1969; Rouse *et al.* 1974; Chen 1996; Huete 1998; Lasaponara, Masini 2006). Below we present only the most suitable spectral indices with WV-2 sensor in a volcanic context.

4.2.1 NDVI (Normalized Difference Vegetation Index)

This index consists in the normalized difference of the radiance (or reflectance) of the near infrared and of the red, which is:

$$NDVI = \frac{NIR - R}{NIR + R}$$

where NIR is the reflectance in the near infrared band and R is the reflectance in the red band. This index allows to emphasize the differential growth of vegetation, both positive and negative.

4.2.2 SAVI (Soil Adjusted Vegetation Index)

The index is a compromise between the ratio indices, such as the NDVI, and the orthogonal indices, such as the PVI (Richardson, Wiegand 1977):

$$SAVI = \frac{NIR - R}{NIR + R + L}(1 + L)$$

The SAVI is an alteration of the NDVI with a correction factor L. The originality of this index consists in the reduction of the disturbing effect of the soil.

4.2.3 SRI (Simple Ratio Index)

This index is simply calculated as the ratio between the reflectance in the NIR and in the Red, that is:

$$SRI = \frac{NIR}{R}$$

This index allows emphasizing the contrast between soil/rock and vegetation.

4.2.4 MSR (Modified Simple Ratio)

$$MSR = \frac{R}{\left(\frac{NIR}{R} + 1\right)^{0.5}}$$

In literature there are other versions of the Simple Ratio compared to the original one proposed by Jordan in 1969. In particular, the Modified Simple Ratio gives good results in the archaeological field and for the WV-2.

4.3 *Validation phase*

Once the data processing phase is completed, the proxy indicators detected are validated through surface surveys, GPS surveys and aerial shots. Finally, the Semi-Automatic Classification Plugin (SCP) in QGIS was used to process multispectral images and to perform their supervised classification (Mangiameli *et al.* 2018).

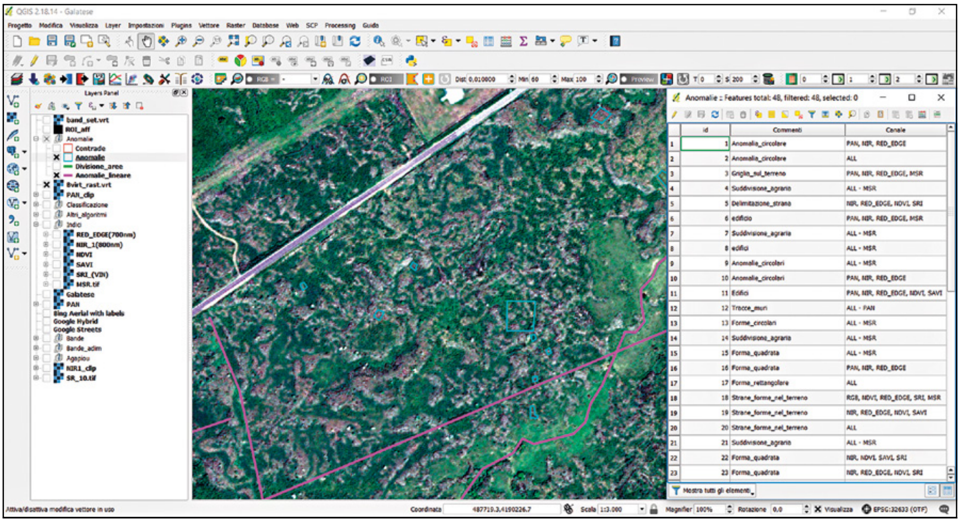

Fig. 3 – Identified area, linear anomalies and respective attribute table.

The archaeological features identified are validated and managed in a GIS environment as vector layers with an associated spatial database (Mangiameli *et al.* 2013, 2015; Masini, Lasaponara 2017). The proxy indicators are shortly described, reporting channels and indices where they are most evident (Fig. 3).

5. Results

In this paper we present the work focused only on *Edera* and *Santa Venera* districts, but the research also involved other neighbouring areas, such as the areas of *contrada Balze Soprane*. Following the procedure above discussed, a very significant sample of proxy indicators was collected, of which only a minimal part imputable to archaeological elements. False traces are numerous and very common in such complex environments.

Regarding the post-dictive analysis, the area chosen is the richest of archaeological evidence (validity tests from a post-dictive point of view). As stated before, the archaeological remains are hidden by vegetation in our WV-2 multi-spectral images, because imagery has been deliberately selected before the start of the 2015 archaeological excavation (Fig. 4). Here, we present two case studies, which, in our opinion, can summarize the application of the procedure presented.

5.1 *Buildings 5 and 6*

Buildings 5 and 6 are located about 260 m SE of the national roadway. The area has been subject to some brief investigations in 1987 and 1992 by the Superintendency of Syracuse before and then Catania; further excavations have been undertaken in 2015 (Tab. 2).

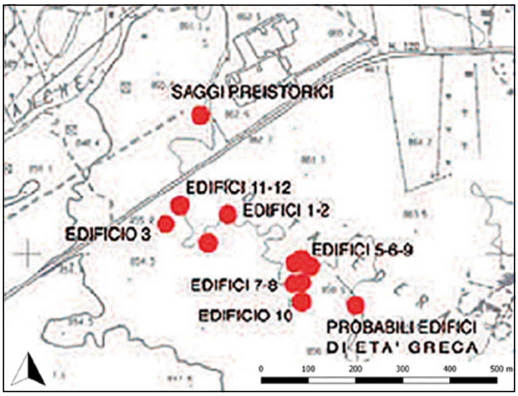

Fig. 4 – Areas of intervention and findings of 2015, *contrada Balze Soprane* and *Edera* (from Puglisi, Turco 2015, 69).

	Latitude	*Longitude*
Building 5	37°51'26.24677"	14°51'30.74743"
Building 6	37°51'25.60662"	14°51'31.52725"

Tab. 2 Geographical coordinates WGS 84 of the Buildings 5 and 6.

Both buildings are two circular-shaped structures with an internal diameter of 5.50 m and 4.16 m respectively, characterized by a perimeter wall made up of large polygonal blocks of lava stone (Fig 5).

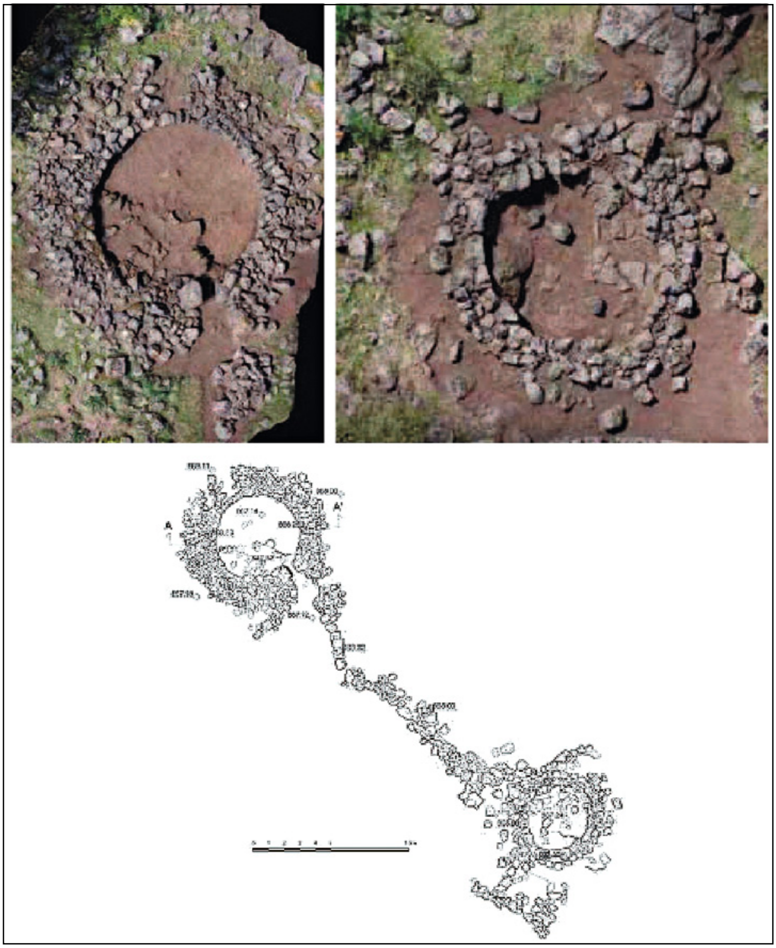

Fig. 5 – Orthophotos and plan of Buildings 5 and 6 (from CONTI, LIBETTI 2015, 127).

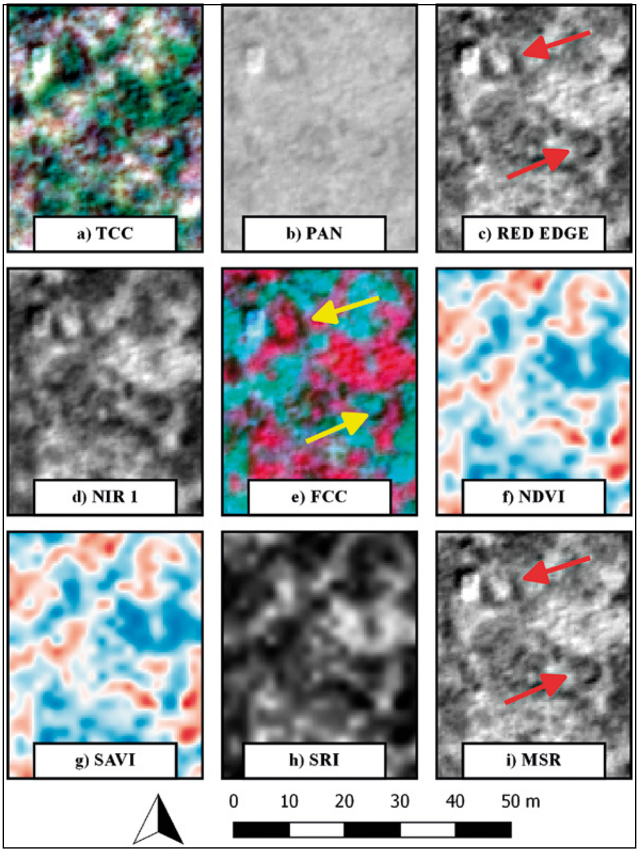

Fig. 6 – Buildings 5-6, *contrada Edera*, seen from the channels of the WV-2 and through the calculated indices: a) TCC; b) PAN; c) Red Edge; d) NIR 1; e) FCC; f) NDVI; g) SAVI; h) SRI; i) MSR.

Building 5, as well as other structures identified in *contrada Edera*, is located immediately S of a small rocky hill. The access to the structure consists of two jambs stone with large blocks arranged transversely to the wall and occupying the entire width.

Building 6, situated SE of Building 5, is currently in a poor state of preservation with parts of the perimeter wall, particularly access (on the W side), in a state of collapse. The two buildings are connected through a wall-structure, which can be interpreted as a sort of "passage" that linked the structures or as the remains of another building, probably rectangular. The interior floor was, probably, at the same level as the perimeter wall or, in any case, immediately above the lava stone bench.

Fig. 7 – Building 5 (in the foreground) and Building 6 (left, in the background) during the survey of 02-Oct-2017 (photo by the authors).

Materials identified during the excavations and the numerous similarities with structures already dated by archaeologists leave to assume that Buildings 5 and 6 could be identified as rural houses dating back to the end of the 8th century AD (Conti, Libetti 2015). As shown in Fig. 6, despite its limited extension, the analysed structures appear in true colour combination, in Red Edge, panchromatic, and a little less in NIR 1. As regards the indices, in this specific case they are not effective in the identification of the structures due to their homogeneity with the surrounding environment. However, it is worth mentioning that the archaeological remains emerged from the ground and they are in good condition, probably protected from rocky hill (Fig. 7).

Carefully analysing the multispectral image and using the most suitable instrument, we infer that the complex would be identified despite some obvious difficulties. Furthermore, the good preservation of the perimeter walls and the circular shape greatly help in the archaeological photo-interpretation process.

5.2 *Wall structure in* Santa Venera *district*

A large dry-built structure with lava stone blocks (Fig. 8) runs between km 174.4 and km 175 of the national roadway. This segment was discovered at the end of the '80s in *Edera* district, but further investigations have allowed the identification of the structure N of the SS 120, in *Balze Soprane* district, both E and W.

The wall structure shows a path that, although rather tortuous and characterized by curves that seem to follow the orography, has a trend substantially NE/SW (or semicircular).

Fig. 8 – Wall structure (survey of 31-Aug-2017) visible after a terrible fire (photo by the authors).

The overall length is over 2 km, of which about 1.5 km is located inside *Santa Venera* district, while the remaining part continues beyond the S.S. 120 in *Balze Soprane* district. In addition, modern tampering has partially modified the wall and the absence of dating pottery contributes to the complexity of a general framework. Due to such complications, the wall-structure is not easily framed chronologically and even its function is controversial: some scholars identify the wall as a medieval fortification, while others refuse to consider it ancient, believing that the wall structure is just a modern structure erected by shepherds (Puglisi, Turco 2015).

However, the construction technique is rather accurate, made up of mostly large, heavy, partially worked and juxtaposed lava stone blocks, whose interconnections are precise, with gaps filled with small splinters. The blocks, which have external face partially smoothed, are arranged on two parallel rows placed at about 2.80 m from each other; this distance tends to tighten at the curves that are along the path up to a minimum width of 1.50 m. The space between the two rows is filled with small lava stones and sand; there are also large blocks placed transversely with the function of joining the two faces of the structure.

As shown in Fig. 9, the wall-structure appears in all the images, but mainly in the NIR 1, Red edge and panchromatic bands; regarding the indices, NDVI seems to be the most effective one. In addition, the semicircular line of the wall catches the eye, but it disappears in areas with higher vegetation index values (in the image the areas with lighter colours). Examining these data, it is very difficult to infer if we would be able to detect it and recognize its archaeological

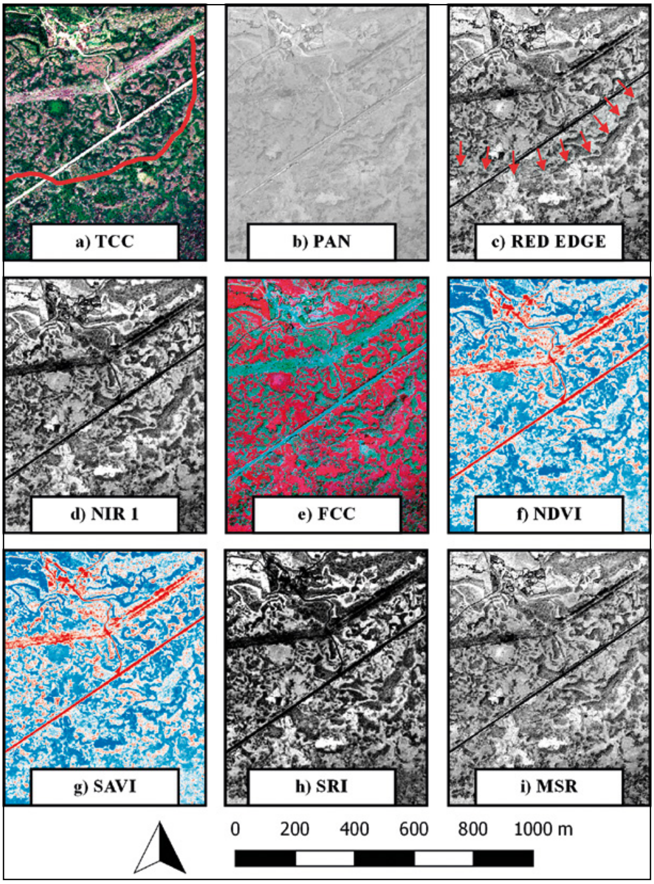

Fig. 9 – Wall-structure, in *Santa Venera* district, seen from the channels of the WV-2 and through the calculated indices: a) TCC; b) PAN; c) Red Edge; d) NIR 1; e) FCC; f) NDVI; g) SAVI; h) SRI; i) MSR.

value. On one side, the wall structure runs 2 km across districts, but on the other side, as stated before, just a few parts of it are clearly visible in our images.

Moreover, once anomaly or proxy indicator has been detected, the main issue concerns the overall interpretation of the feature. In fact, the landscape under investigation is a real stratified palimpsest, where it is often hard to distinguish between irrelevant and meaningful alignments, and those that are generically anthropogenic (boundary walls for example) from archaeological ones. It should be remembered that before the 1950 partition of these lands, Nelson's family properties extended far beyond districts of *Santa Venera* and *Edera* (where there are, nowdays, modern farms); the lands were parcelized, put up for sale and bought by peasants and Sicilian government. Following the change of ownership, boundary walls were erected and they are clearly still visible in this area.

6. Discussion and future research

This study provides the first post-dictive analysis of multispectral remote-sensing data for archaeological purpose in a volcanic environment. We started asking whether remote sensing techniques could have been useful in order to identify archaeological features in the Etna plains. The first issue that affects our interpretation process is the low-visibility level of crop marks. The volcanic spontaneous vegetation, when it exists, is less likely to exhibit stress or variation associated with underlying or emerging archaeological features. Although this study cannot be considered exhaustive, it provides some conclusions. The best results have been achieved with the NDVI and the SRI indices, initially developed for completely different landscapes. However, it must be emphasized that there is no "unique" NDVI calculation, as it is a formula that can be applied to a number of band combinations in multispectral data. For this reason, despite it is considered the most widely used, some scholars defined NDVI as «one of the worst performing indices for archaeological feature detection» in a grass-dominated environment (Bennett *et al.* 2012, 215). Regarding indices, future work is expected to be carried out by our team in two directions: first, we will try to improve or create new vegetation indices for specific volcanic environments, facilitating, in this way, the archaeological interpretation; secondly, since the performance of the indices varies by season and phenological stage, a multi-temporal analysis will be performed.

The second crucial issue deals with the presence of false traces. First, the difficulty in distinguishing a modern boundary wall from an archaeological one exists also because they both consist of lava-stone blocks. Secondary, a specific volcanic problem occurs. The lava solidification creates shapes that, at first glance, can be confused with anthropic structures, especially with circular buildings. The dimension of the buried archaeological features plays a crucial role: obviously, the bigger is the structure, the easier is to detect it, as indicated by the wall-structure.

The results of the post-dictive approach denote that NIR_1 and RED_EDGE are undoubtedly the most useful bands. Although the results may change in a different archaeological environment, these conclusions are in line with the outcomes obtained by other scholars (Verhoeven, Doneus 2011; Agapiou *et al.* 2012).

Archaeologically speaking, in relation to the evidence so far collected, we feel confident about the presence of other remains beyond the national roadway (S.S. 120). In this district, called *Balze Soprane*, we have identified many structures (huts?) and the continuation of the wall-structure (Gennaro *et al.* forth.). The application of remote sensing techniques lead us to enhance its entire path, but it cannot help us to date it correctly. Unfortunately, even the archaeological assemblage recovered from excavations in 2015 was not sufficient to suggest a chronological range and to propose any interpretation. To achieve this scope, general understanding of pattern of settlement in this area is needed. For example, assuming that the wall-structure and the circular huts already excavated are contemporary, the latter would be outside the enclosed area.

A second key aspect of the area under investigation is the problematic relationship between this settlement and the one, with strong continuity of settlement occupation from the Greek period until at least Medieval times, discovered by the English team from the University of Durham. In spite of the proximity of the two areas, the World-View 2 imagery could not be useful due to the presence of fruit trees. Studies of the geomorphology will be crucial for understanding of the nature (urban status?) of archaeological deposits and might provide evidence for the existence of buried structures.

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Acknowledgments

The project was carried out jointly by a team from the Department of Humanities (DISUM) and the Department of Civil Engineering and Architecture (DICAR) of the University of Catania. The authors would like to thank the *Soprintendenza per i Beni Culturali e Ambientali di Catania* for its support.

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ABSTRACT

This article illustrates the potential of multispectral satellite data for archaeological scope in the volcanic area of Mount Etna (Sicily, Italy). In particular, by adopting a post-dictive approach, GIS and FOSS technology was used to analyse different indices derived from World-View-2 multispectral data. The selected examples – two circular buildings and a wall-structure – illustrate successes and challenges of our method. The results indicate that NIR_1 and RED_EDGE are undoubtedly the most useful, while NDVI and SRI are the best performing indices.