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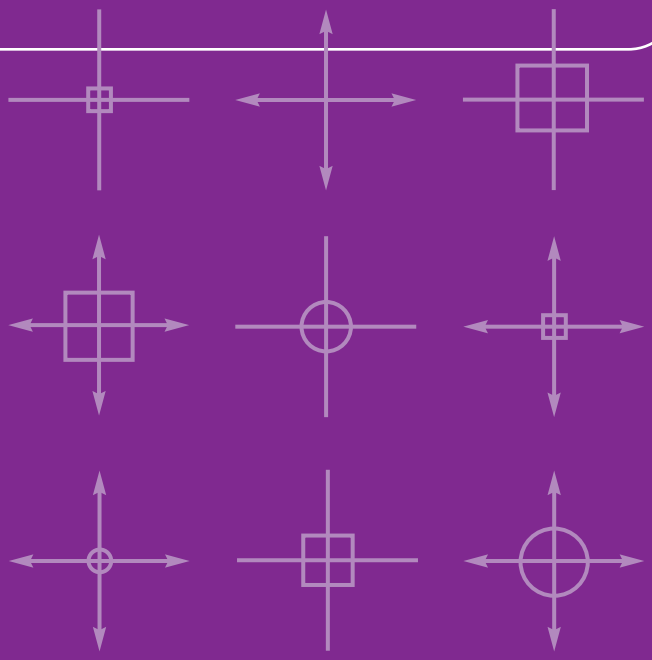

STADT ARCHÄOLOGIE WIEN

The fortified settlement of Bivignano.

Computer graphic tools in analysis and its representation

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Abstract: The fortified settlement of Bivignano (Arezzo, Italy) is a part of a large system of castles developed between the eleventh and twelfth centuries in a minor valley of the Cerfone river, an affluent of the Tiber river. Founded by the family of the Count of Bivignano, the castle is a part of the noble residence (a “casa-torre” typology with a plan dimension of 10.25 by 7.50 meters, of which 9.30 meters are still intact) and with the adjacent church of Santa Maria (rebuilt in the seventeenth century on the original early medieval chapel). The rest of the buildings consist of housing and service areas, which have been in use until the mid-seventies. Today the castle is in a deep state of abandonment also due to the continuous looting that deprives it of the architectural elements that are easily re-usable elsewhere, which accelerates the processes of decay. The research group DM_SHS at DiDA (Dipartimento di Architettura dell’Università degli Studi di Firenze) has recently initiated a digital survey campaign aimed to the production of 3D models, useful not only to provide documentary evidence of the entire castle and to support stratigraphic, metrologic, and structural/diagnostic analysis, but also to try out advanced texturing procedures, made available by the use of computer graphics (such as baking and UV parameterization), capable to correlate the results of such analysis to the models themselves; this allows a more appropriate reading of the information and facilitates the dissemination of the results also through the web. The paper will therefore be able to assess the progress of scientific research in the particular field that gathers together digital survey, 3D modeling and computer graphics for furthering the knowledge, enhancement and dissemination of the cultural heritage.

Keywords: Bivignano, digital survey, cultural heritage, computer graphics, 3D models

The castle of Bivignano

The structures of the medieval castle of Bivignano (the first evidence dates back to the eleventh century), even after centuries-old changes, are still visible (Fig. 1). On a small hill at an altitude of 700 meters above sea level, certainly constructed to make up an efficient defense, the first castle was built as a fortress for the Counts of Bivignano (who seem to have taken their name from the name of the place), then it became a settlement with a large population and is now completely abandoned (PIERI 1998: 41).
Emanuele Repetti, in his "Dizionario geografico fisico storico della Toscana" written in the first half of the nineteenth century, describes the settlement of Bivignano thus:

> *Bivignano in the Tiber Valley. It lies on the slope of the hills on the north side of the Marzana mountain, between the Padonchia and Cerfone torrents. Bivignano was since the 11th century, a small municipality which included a parish. It was later granted the status of countship, which gave the title to a noble family*

of Arezzo, who retained the patronage of the church of Bivignano until 1784, when this family donated it to serve as the Bishop's mess. Bivignano has a population of 350 inhabitants (REPETTI 1833: 330).

The fact of being distant from the principal economic and political centers of the region while being connected to these centers by a regional viability along the hillside, which, over the centuries, completely lost its function (today it communicates the few rural aggregates that still persist), explains why Bivignano remained inhabitted since the early middle-ages, allowing, as well as how its structures remained almost intact to this day.

(G. L.)

Fig. 1 – The castle of Bivignano is currently in a deep state of abandonment also due to the continuous looting that deprives it of the architectural elements, accelerating the processes of decay (M. Genuini)

Territorial overview

The Cerfone Valley is located between Tuscany and Umbria and its limits are modeled on the ancient *limes* that, in the sixteenth century, separated the Grand Duchy of Tuscany and the Papal States.

Its territory is part of the Upper Tiber Valley - the torrent from which it takes its name (Cerfone) flows into the homonymous river - which is the natural confluence between Romagna, Tuscany and the Marches (Fig. 2). The valley floor is characterized by the presence of an ancient Roman road that ran along the waterway linking Arezzo and Città di Castello. Its territory revolves around the city of Arezzo to which its centers remained always linked.

Fig. 2 – The castle of Bivignano is located on the terrace overlooking the valley of the Cerfone river (M. Genuini)

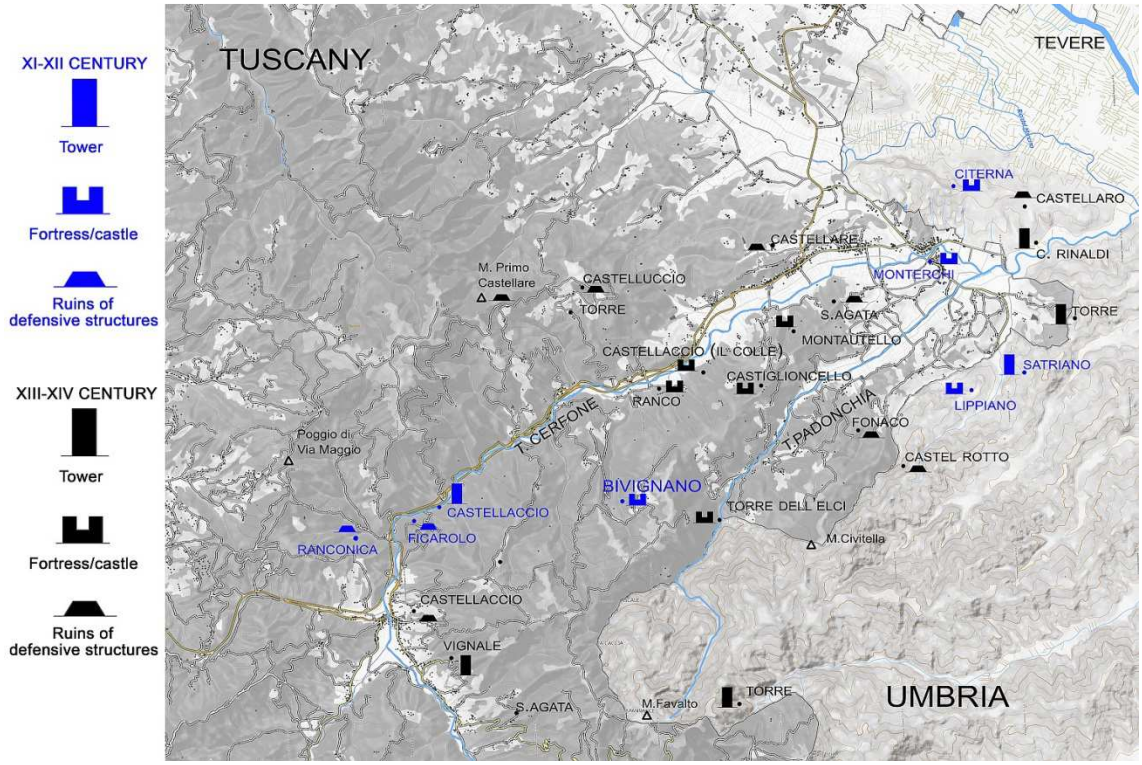

Fig. 3 – Documented fortifications in the Valley of the Cerfone river (S. De Fraja)

More than 30 fortifications are documented in the Valley, but only Ranco and Bivignano retain imposing ruins (Fig. 3). Three main parishes administered the territory of the Cerfone valley in the twelfth century: Sant'Antimo in Monterchi, Ranco in mid-valley and San Donnino in Palazzo del Pero. Many churches, abbeys and monasteries that still preserve their structures were attached to these parishes (BIANCHINI 2011). For a secondary valley with a limited extension, such as the Cerfone Valley, the presence of such a large number of castles may seem strange; on the contrary, this situation is very common in the lower valley of the Tiber. The cause of this density can be, in the first analysis, due to the fact that the settlements in the valley, although they reached a certain degree of autonomy, never formed into rural communities, but rather always remained feudal estates belonging to the major comital families of Arezzo (or of the neighboring power centers), such as the Lambardi, Tarlati, the Marquis of Monte Santa Maria Tiberina, the Aldobrandini, etcetera. The small villages, which therefore never achieved full autonomy, taken together constituted an effective control network which undoubtedly contributed to the fortune of their lordships. The oldest document relating to the Counts of Bivignano dates from 1145: a bull from Pope Eugene III records that the Pope himself intervened in a dispute over the ownership of the castle of Sasseto between the Bishop of Arezzo Jerome et nobilem virum Henricum de Bivignano (DE FRAJA 2011: 74). The area has been inhabited since Etruscan times, as is evident from the presence of numerous finds in the proximity of the cemetery (CHIERICI 2011: 39-42).

(M. G.)

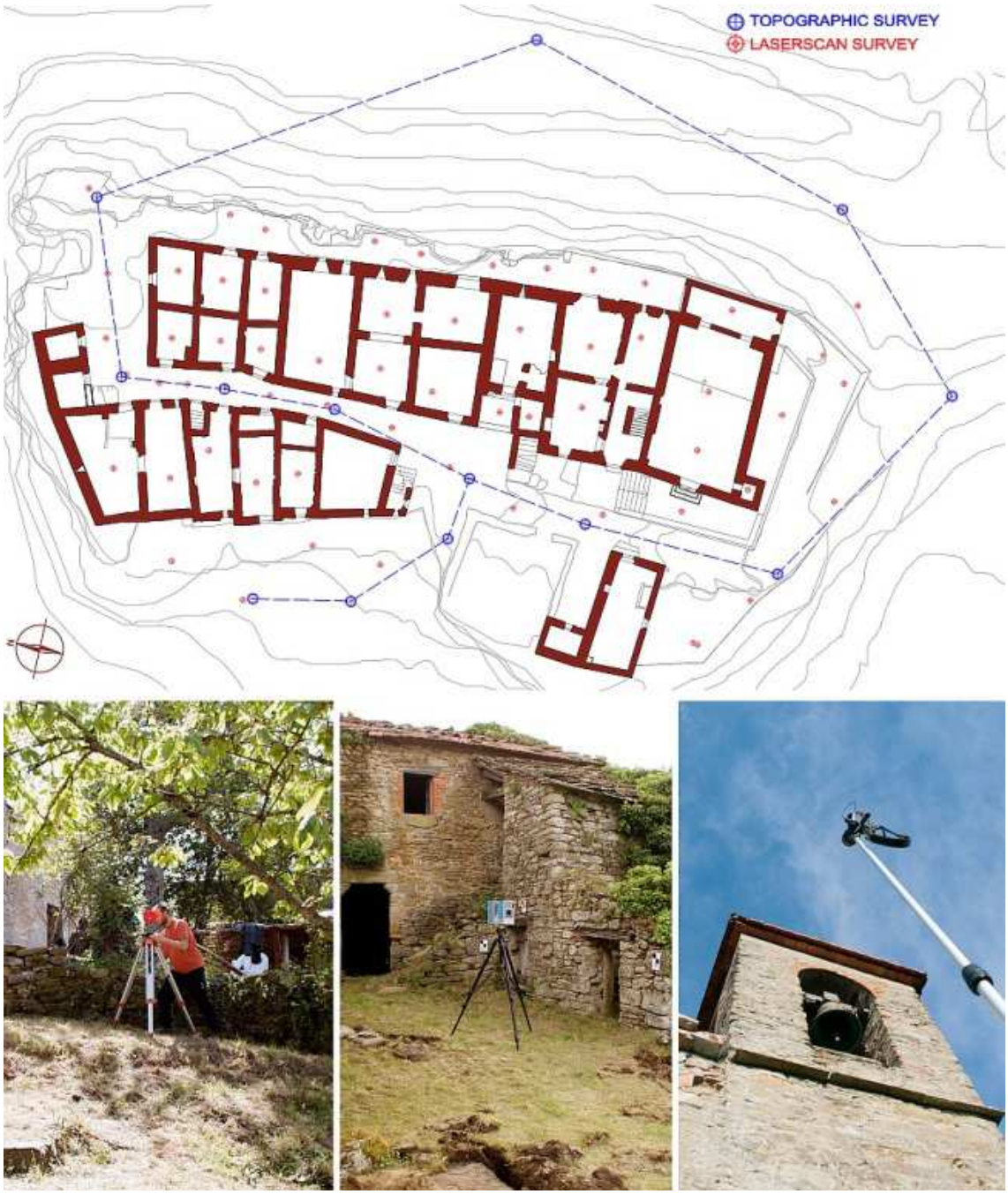

Fig. 4 – Integrated survey campaign

Documentation procedures

The Research Unit DM_SHS (acronym for Documentation and Managements of Small Historical Settlements) aims to analyze the minor historical centers in order to propose to the local administrations conservation and valorization projects able to counteract the decay and depopulation processes to which the settlements are subject. To do this, the team of researchers composed of scholars and professors belonging to several Italian universities and with different disciplinary competencies, covering the main areas of study necessary to understand the identity of such places, engages, from time to time, in an archeologically analysis, the geological analysis of the sites, the morphological and structural analysis of the architectures,

the study of published and unpublished documents that may allow the reconstruction of the phases of formation and transformation of the village, etcetera.

(A. M.)

Fig. 5 – Plan and fronts of the fortified settlement of Bivignano (M. Genuini)

Integrated survey

The survey of the physical structure of the settlement and its surroundings characterizes the first phase of the investigation. It is now clear and accepted by the scientific community that a high-quality digital survey establishes an indispensable document, particularly in relation to the geometrical-dimension aspect of the construction, on which later analyses will stand (BIANCHINI 2014:15-24).
In the specific case of the settlement of Bivignano, the survey campaign, which lasted five days, saw a group of researchers use different documentation techniques mainly based on the use of active sensors (laser scanners) and passive sensors (digital photogrammetry), in addition to the traditional procedures of direct survey (Fig. 4). The data collected amounted to 73 dense point clouds that, when registered, provided a dense model of points equal to 6.619.904.853 billion of points (the weight of the archive .imp is 140 Gbytes). The topographical support has allowed taking a large number of control points, needed to align the clouds between them in addition to providing the overall size of each body of the building. The digital photogrammetry, made with a calibrated reflex camera, has allowed to deduce (from 2500 frames) a dense point cloud (congruent with that obtained by the laser scanner) and, especially, some high quality texture (in terms of pixels). The processing of the different integrated data made it possible to prepare the plants and the sections of the entire settlement, in addition to the photo-plans (Fig. 5).

(A. M.)

Main buildings

Among all the buildings of the settlement, the tower-palace and the church of Santa Maria are more interesting than the others. The turreted building, or palatial structure of the castle, dating from the 12th century, probably had a predominantly residential function (DE FRAJA 2011: 75). Of the primitive building, two dividing walls are still recognizable: the North wall and the East elevation. In the diagram the building measures 10,25 by 8,25 meters. On the northern elevation, which once overlooked the esplanade inside the fortified settlement, it was possible to find two entrances at high altitude; they were probably the ancient entrance to the tower, and the access to a walkway next to the tower. The eastern elevation retains a slit and two arched windows.

Over time, the tower has been modified and incorporated into the present rectory; a series of collapses and its later abandonment left half the tower roofless and was used until the Fifties as a sheep pen (Fig. 6).
The presence of a chapel or a church of small dimensions *infra moenia* is attested from the earliest documents, and over the centuries the religious building must have carried out continuously its function as a gathering-place for the inhabitants of a territory progressively more distant of the economic and political interests of the ruling powers of the moment. In the catalog of the parishes of 1804 Bivignano is called a *very extensive and steep curia*, situated at the far limits of the city of Arezzo, of the Province, and of Tuscany (PIERI 1998: 191). In 1900 it was considered one of the poorest parishes, often seen as a place of punishment for priests to be sent. Modified Amended several times during the eighteenth century, it took on its current appearance first through the adding of the rear volume (built by the company of the *SS. Sacramento*) and then of the bell tower (Fig. 7).

(A. A.)

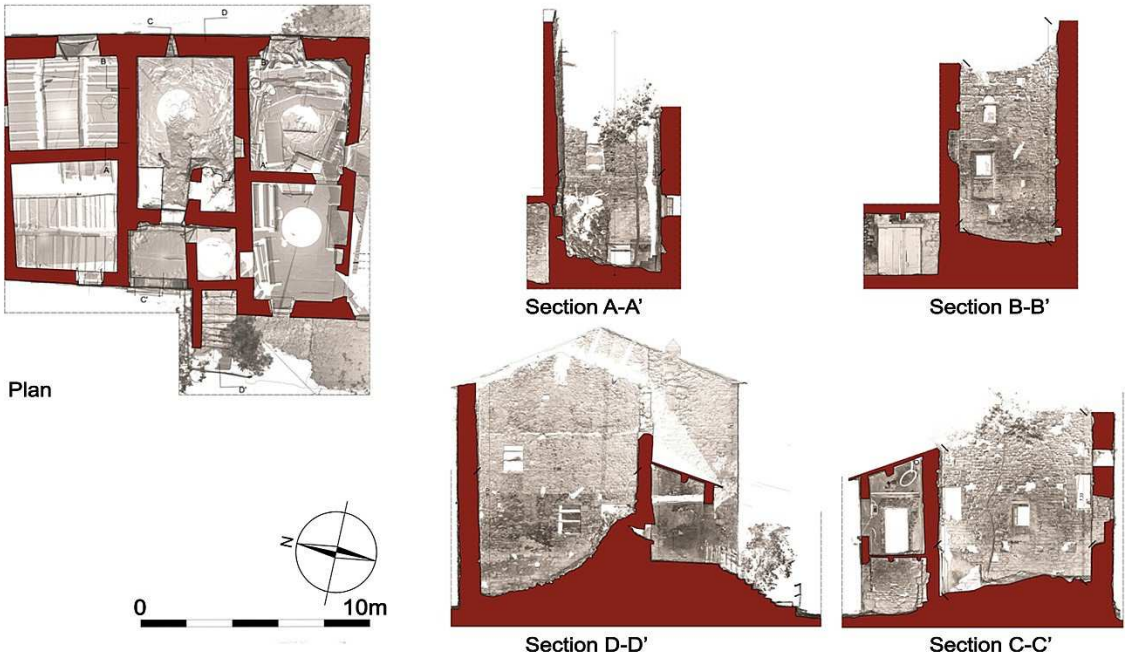

Fig. 6 – The turreted building, dating from the 12th century, probably had a predominantly residential function (M. Genuini)

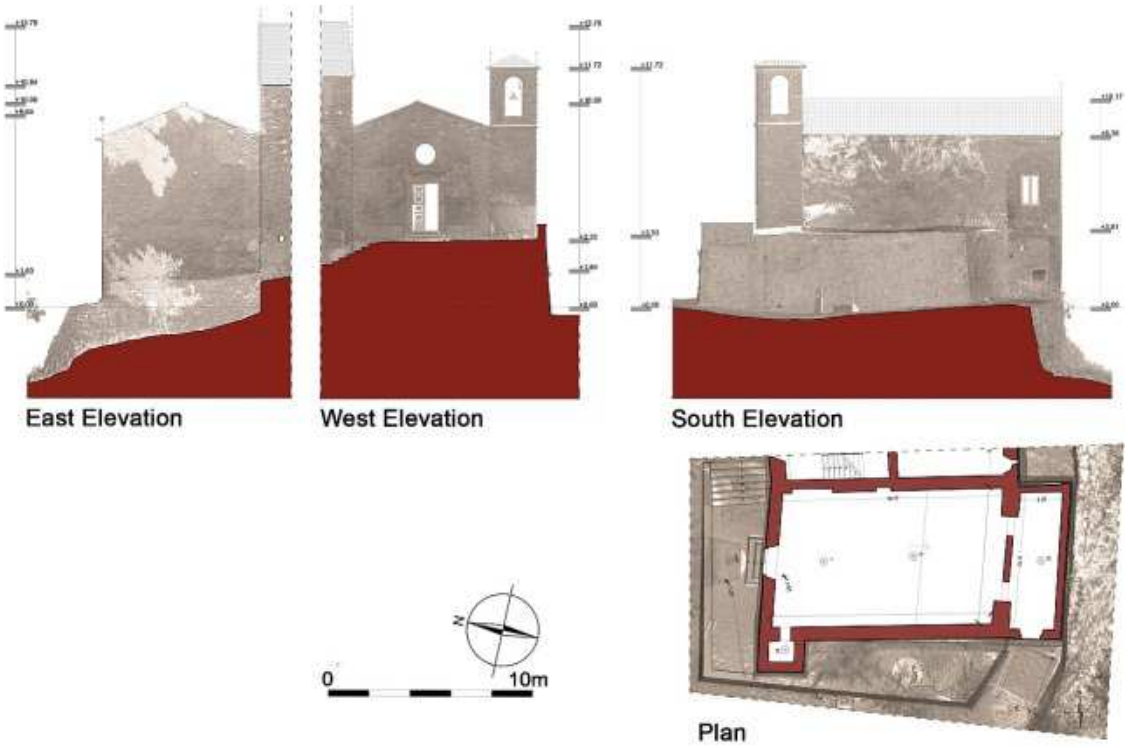

Fig. 7 – The church of Santa Maria. The presence of a chapel or a church of small dimensions *infra moenia* is attested from the earliest documents (M. Genuini)

Stratigraphic evidence

The on-site analysis conducted by archaeologists, historians and geologists finally allowed to assume the main phases of formation of the castle. It should be emphasized that in this initial phase of the research the relative chronology (inside the objects of study) has not been analyzed, but only the indicators in order to establish an absolute chronology between the existing bodies of the buildings. The analysis of the masonry techniques of each part of the buildings (Fig. 8), the comparison with other already dated in nearby areas, and the archeometric analysis for the dating of the mortar, have been relegated to a later stage.

(A. A.)

Fig. 8 – Stratigraphic and metrologic analysis (C. Nerucci, F. Diara)

Geological evidence

The on-site geological analysis allowed verifying that the material with which the whole settlement was built comes from the same geological area, so it seemed logical to look for a possible quarry in the vicinity of the castle. A probable quarry was identified in the western side of the survey to the East of the settlement. A

more careful reading of the geomorphological structure of the sandstone block that characterizes the promontory also allowed to establish a relationship between the size of the blocks and the height of the layers: they are equal in dimension to the layers themselves. It is possible, finally, that part of the building material comes from other excavation works that had become necessary to prepare the soil that hosts the buildings, in order to make it as level as possible, as well as from the soil taken from the front of the promontory to make it steeper for defensive reasons (Fig. 9).

(M. G.)

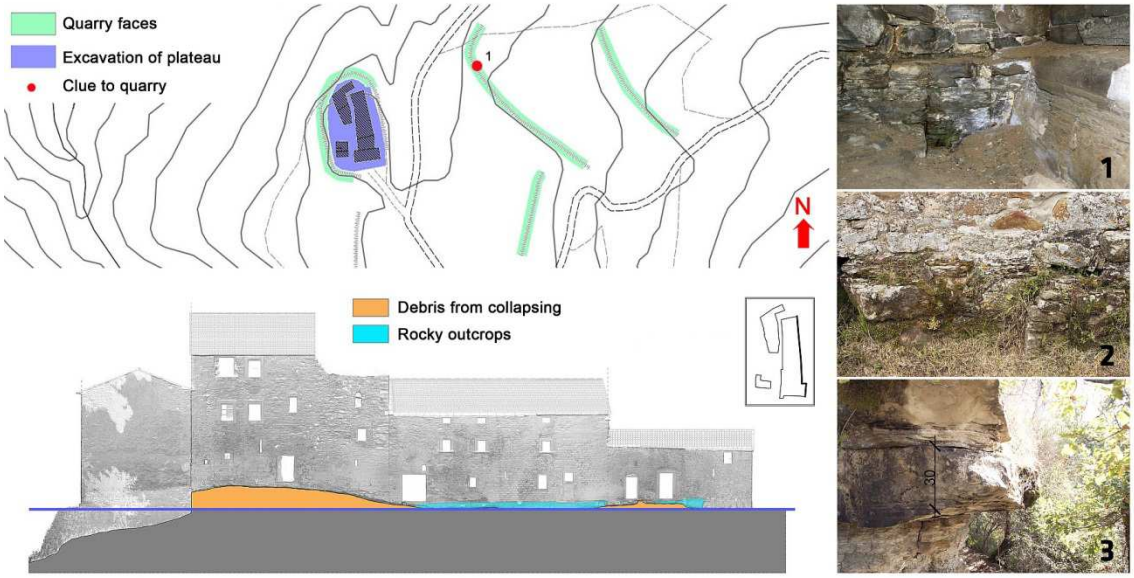

Fig. 9 – The geological analysis allowed to verify that the material with which the whole town was built comes from the same geological area, so it seemed logical to look for a possible quarry in the vicinity of the castle: 1. Internal masonry on rocky outcrop, 2. Outcrops on East side of the settlement, 3. Metric verification of the origin of the stones (S. Di Grazia)

Hypothesis: developmental phases

The set of studies conducted in the area of Bivignano have allowed us to hypothesize the following developmental stages (Fig. 10):

- the first phase dates back to the period of battlements of the entire area of the Valley of Cerfone (10th-11th centuries) which can be traced back to the construction of the tower-building, frequented by a local lord and its chapel. It is not certain that the walls are contemporary to such buildings or whether they belong to a later stage of expansion of the settlement together with the construction of the first residences;
- a second phase in which Bivignano is configured as a walled settlement characterized by a series of missing buildings which were functional to life in the castle;
- a third phase ascribable to the transformation of Bivignano, once the need for defense was no longer a priority, into a hamlet of sharecroppers. The division into small cadastral plots and the closing of the spaces between the various parts of the buildings is a sign of a maximum usage of space in a period of greater population;

- a fourth phase is the consolidation of the settlement and the reuse of the older structures as quarry material.

(A. M.)

Conclusions

The documentation and study undertaken by academic research centers on the numerous minor historical centers in the region of Tuscany, in a period of economic and financial crisis in which the funds available for the conservation and preservation of the cultural heritage are more and more reduced, assumes today a particular relevance.

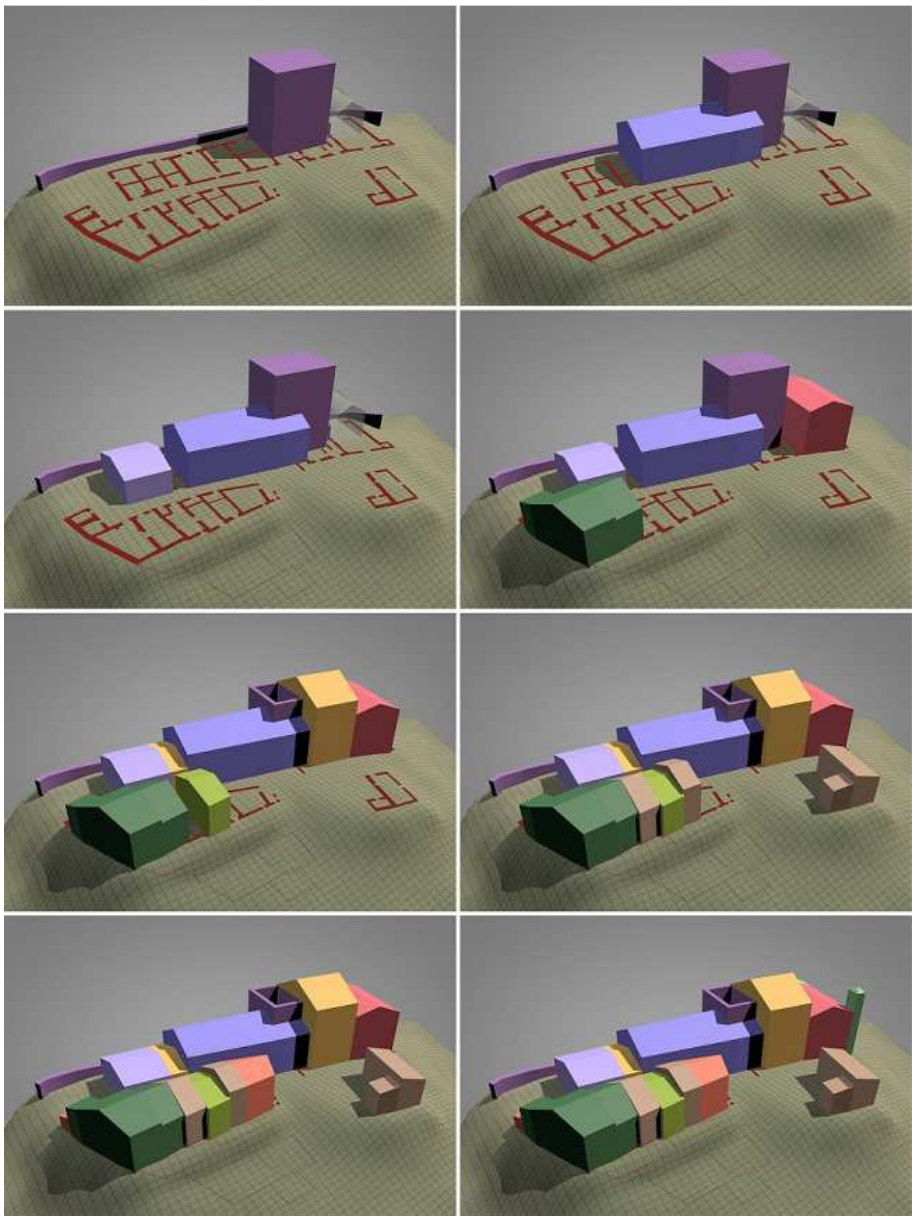

Fig. 10 – Hypothesis of development (A. Aliperta, M. Genuini)

It is our belief that only through a well-structured process of in-depth knowledge of these realities may innovative projects arise for their development, which can in turn give way to necessary and urgent conservation processes (MERLO and BUTINI 2014: 13-24). We hope that the use of today's major digital tools such as those for the 3D display of the information for scientific or informative purposes may also help to make easier the comprehension of the analysis of ruined architectural structures, both for specialists and enthusiasts alike.

(A. M.)

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