

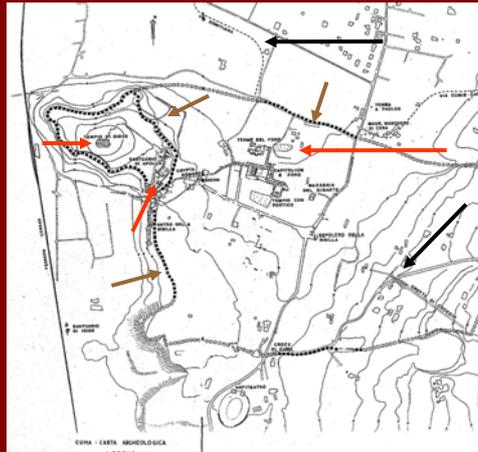
## CUMAE - HISTORY



Immediately out of the Campi Flegrei there's Cuma, the second settlement of Magna Grecia around Naples after that of Pythecusa. Cuma is located on the top of hill right on the sea, keeping a defensive position and played a vital role in the spreading of Hellenic culture and later at Roman Times.

Regarded by the ancient sources as the most ancient and northernmost of the colonies of Great Greece, the town of Cumae was founded by Euboic colonists in the second half of the 8th century BC. Few elements of the town of Cumae are preserved.

These include the acropolis with its **temples**, which were restructured in the Oscan-Campanian phase and in the Augustan period; the Roman **forum** with some earlier structures of the Oscan-Campanian square and, probably, of the still earlier Greek *agorá*; and the remains of a few roads dating from the Roman period



## The integration of different technologies to create a 3D model of CUMAE

In a framework of a larger program of investigations in the ancient town of Cumae in Campania (Italy), we carried out the mapping of the still visible stretches of the ramparts of the ancient town.

Due to the characteristics of the site, where there is no direct eye-contact between topographical stations and, hence, between visible remains, we chose to use a combination of a total station and a single-frequency centimetrical DGPS in differential mode.

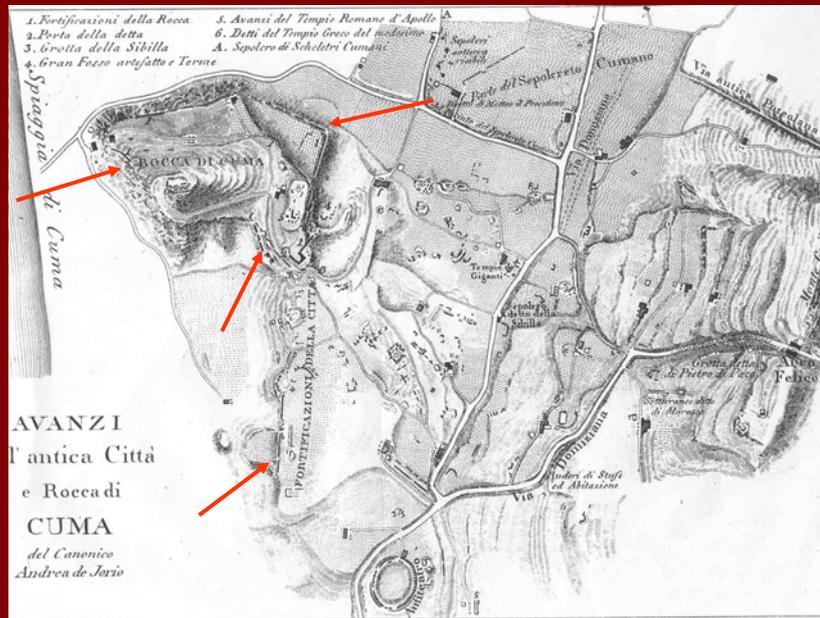
## The Methodology

Here we discuss some specific aspects of the methodology, notably the gathering of data in the field and the drawing up of a three-dimensional model of the area of Cumae which has yielded some interesting results.

A traditional two-dimensional approach would not have been able to produce the same scope of information within a short period of time.

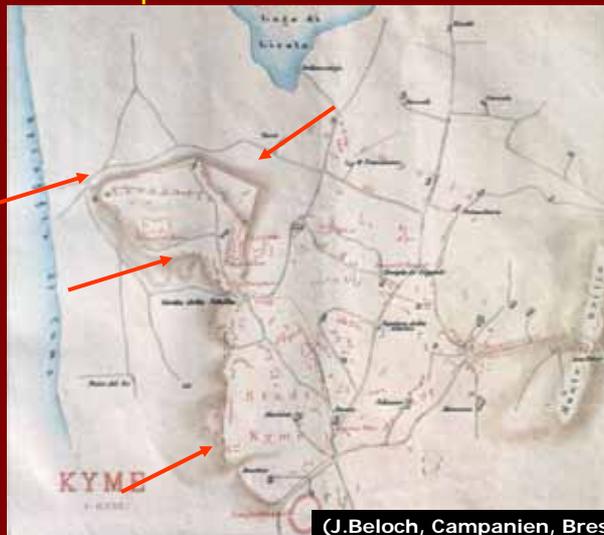
## Short - History

As some old maps attest, nineteenth-century scholars were familiar with most of the remains of the ramparts still visible on the acropolis, but only the west side of the ramparts of the low city was known to them



(A. De Iorio, Guida di Pozzuoli e contorni, Napoli 1822)

When one observes these old maps carefully one notices stretches of the ramparts at different altitudes on the slopes of the acropolis.



(J. Beloch, Campanien, Breslau 1890)



The first phase of this work was dedicated to a survey of publications, archive sources, and graphic and photographic documents.

The information thus gathered was then verified by a surface investigation on the site. Some new elements emerged from a reexamination of some stretches of the walls previously known only from publications or archive documents. Even in recent studies, these stretches, up to now wrongly regarded as no longer visible, are not positioned exactly.

The information collected in this phase was stored in a relational database with a topographical index allowing immediate identification of the position of each stretch on the basis of the number of individual records.

Three categories of evidence were recorded: known and still visible stretches of the ramparts, known but no longer visible ones, and new stretches observed during our surface investigation or recognized by photo-interpretation.

Special care was devoted to the description of masonry in the attempt to clarify whether the use of different masonries actually reflects different building phases or was merely dictated, instead, by the orographic conformation of the site.

## A DBMS for the stretches of the ramparts

Nr_scheda	107	Condizione	Nota/Visibile
Riferimento			
Localizzazione	Fianco N dell'acropoli		
descrizione_topologica	Puntuale		
<b>Descrizione</b>	<p>Tratto di cinta muraria in opera quadrata isodoma mista di ortostati e assise piane, rinvenuto in prosecuzione del tratto nr. 106, da cui è separato, tuttavia, da un lungo tratto in blocchi di tufo legati con malta (nr. 111) di epoca successiva. Si conserva solo la cortina interna costruita con blocchi disposti in ortostati e</p>		
<b>Interpretazione</b>	<p>Tratto di cinta muraria di cui si conosceva solo un rilievo degli anni 30. Il Pagano, che l'ha pubblicato, ne aveva ricostruito l'ubicazione sul lato SW e lo aveva datato al IV-III sec. a.C. per la presenza di una feritoia con retrostante camera a volta, apprestata per un eventuale dispositivo balistico. In realtà la</p>		
Cronologia	III sec. a.C./II metà		
Fase			
Relazione stratigrafica del tipo	Anteriore		con la Struttura Nr. 112
<b>Oggetto</b>	Fortificazioni settentrionali dell'acropoli		
<b>Definizione</b>	<input checked="" type="checkbox"/> Cortina <input checked="" type="checkbox"/> Briglie <input type="checkbox"/> Emplekton		
<b>Dimensioni Struttura</b>	Conservate <input type="text"/> Visibili <input type="text"/> Stato_conservazione <input type="text"/> Cattivo Orientamento <input type="text"/> NNW-S/SE		
<b>Tecnica Costruttiva</b>			
<b>ELEVATO</b>	Tipo <input type="text"/> Opera quadrata isodoma/assise piane-ortostati		
<b>Anathyrosis</b>	<input type="text"/>	<b>Bugnato</b>	<input type="text"/>
<b>Dimensione Blocchi</b>	<input type="text"/> H. 37-43, sp. 87/H. 61-84, sp. 40.		
<b>FONDAZIONE</b>	Tipo <input type="text"/> Assise piane <input checked="" type="checkbox"/> Risega <input checked="" type="checkbox"/>		
<b>Dimensione Blocchi</b>	<input type="text"/>		
<b>Bibliografia</b> <input checked="" type="checkbox"/>	Richter 1885, pp. 185-192, tav. annessa, Pagano 1993, p. 867, fig. 14.		<b>Scavo</b> <input type="checkbox"/>
<b>Archivio</b> <input type="checkbox"/>	<input type="text"/>		
<b>Ricognizione</b> <input type="checkbox"/>	<input type="text"/>		
<b>Doc_grafica</b> <input checked="" type="checkbox"/>	SANACE RA/N1 nr. 6754		
<b>Doc_foto</b> <input type="checkbox"/>	<input type="text"/>		
Duplica record			

## Cartography – Data Integration

### Analogical information

- Historical maps (De Jorio, Beloch, etc.)
- Surveys obtained by map on 1 to 25.000
- Detailed surveys (1:50, 1:100, etc.)
- Geo-morphological and paleo-environmental reconstruction
- Geological and geo-physical prospecting
- Aerial photos

## Cartography – Data Integration

### Digital information

- Surveys obtained by EDM
- Topographical data by GPS
- Multispectral satellite data

## Cartography – Data Integration

### The integration of spatial, temporal and format data

#### Spatial technologies

- CAD/CAC - Design/Cartography
- GIS - System/Science
- GPS
- VR - QTVR
- Remote Sensing - Image Processing

## Cartography – Data Integration

### Aims

**combining** different-size scale maps

- *Cumulative Cartography*

**creating** a Multidimensional Maps

- *3D Model*

**implementing** a GIS-System

- *Management of thematic data*

## Cartography – Data Integration

### Problems

- Incorporating any spatial data source it is crucially important to consider the issues of *precision* and *accuracy*.

**Precision** implies that the degree of measurement of an attribute is refined

**Accuracy** that the measurement taken is correct within the degree of precision indicated

## Methodology – WHY DGPS?

- the preserved stretches are hard to access because of the thick vegetation hiding them and the erosion and crumbling of the slopes of the hill of the acropolis and Mount Grillo.

Furthermore, the remains of the walls are disseminated over a very vast area and are sometimes very far from one another.

## Methodology – WHY DGPS?

To the purpose of exploiting in full the potential of our instruments, use of the DGPS was restricted to the solution of specifically topographic problems such as **anchoring** points and georeferencing elements, while the total station was used to **survey visible structures**.

The combined use of both instruments also helped us to overcome some practical limitations. The DGPS requires good visibility and is hence useless in vegetation, whereas the total station cannot work smoothly if there are obstacles between it and its target.

## Methodology – WHY DGPS?

The points fixed were anchored in their turn to two nodes of the Military Geographical Institute WGS 84 topographical network lying at less than 20 km from the site of Cumae.

This made it possible to calibrate the GPS and narrow down its error margin to **plus/minus 2 cm**. The carrying out of the survey required four people working full-time for two weeks.

## Methodology – WHY DGPS?

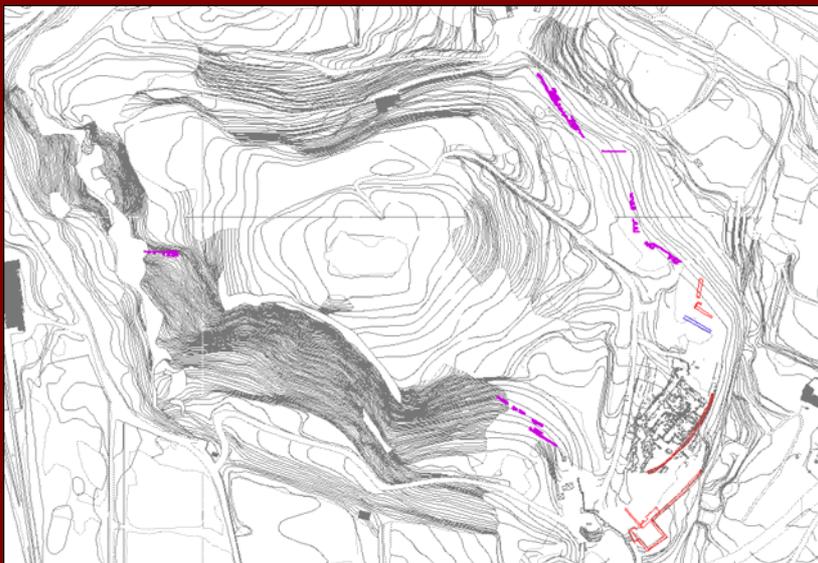
It was possible to draw up a detailed map of the ramparts within a short time. Each georeferenced stretch was inserted in a general map to provide a cartographic base for GIS processing.

The vectorial drawing was superimposed precisely on a digital map on a 1:500 scale, and the archaeological structures were connected two-dimensionally to the morphology of the area.

### Acropoli stretches: NE side - External Courtain



### Acropolis: the positioning of still visible stretches of the ramparts superimposed on a photogrammetric map



## The Project: An archaeological Park



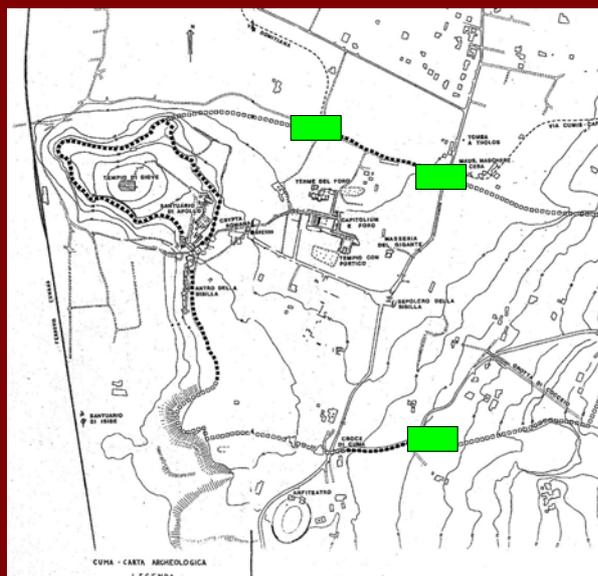
## Hypothesis of new archaeological area



From the mid-Nineties onward, the University of Naples l'Orientale has resumed investigation of the site, concentrating on the northern stretch of the ramparts of the low city.

The excavation has shed light on the layout of the walls along that side and revealed at least **five building phases** along the same perimeter over a time range going from the sixth to the first century BC.

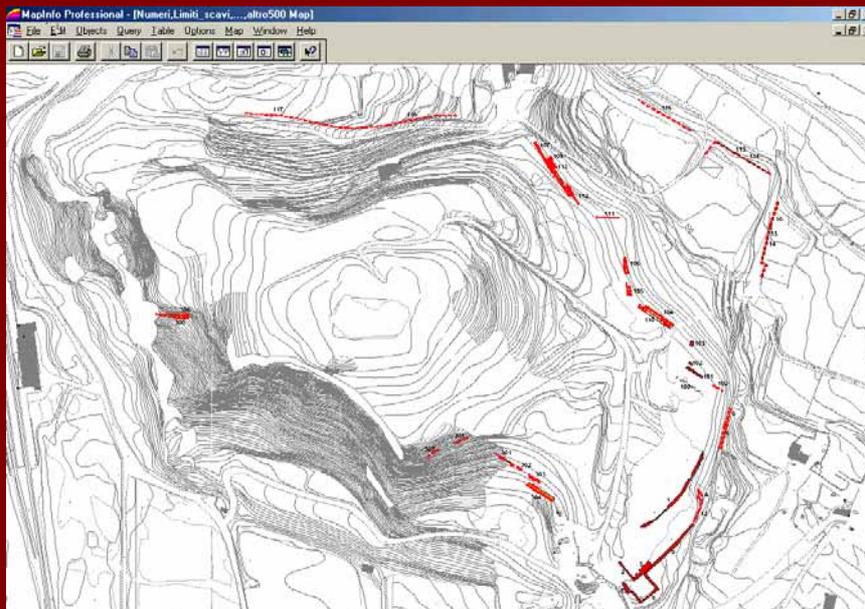
### Southern and Northern Fortifications Excavation: 1994/2004



## A general view



## A GIS-Based System for the ramparts





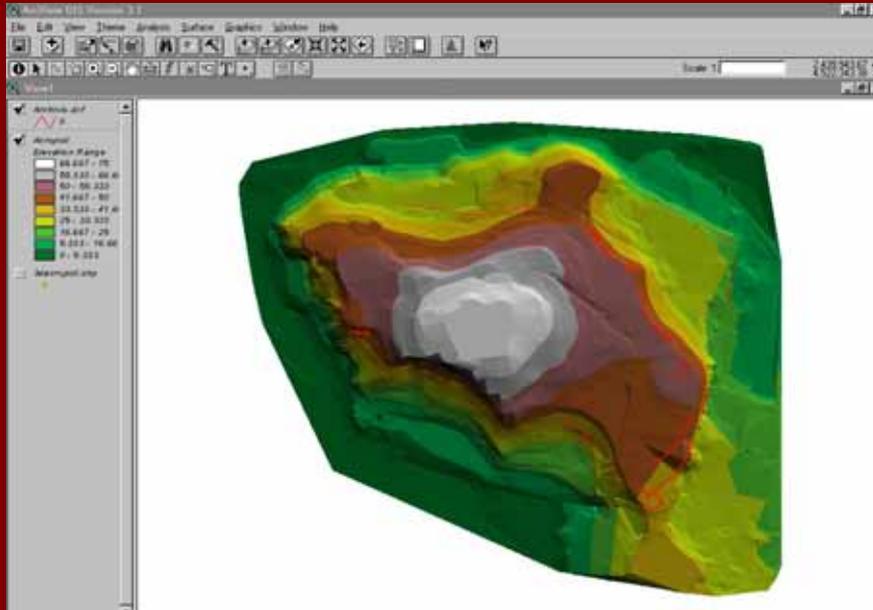
## 3D MODEL

- The DTM of the territory of Cumae derives from the digital orography extrapolated from the 1:500 photogrammetric survey. We drew up a point matrix (x, y, z,) describing the numeric model of contour lines placed at 50 cm from one another. To generate the 3D model, instead, the TIN method of numerical interpolation was applied to the point matrix.
- This method yielded extremely accurate results, as over 60,000 points were used to draw up a model for an area of 0.24 sq. Km.

## 3D MODEL

- The DTM was employed as a basis for further processing, such as calculating the gradient of the hilly slopes and the altitude of the ramparts at different historical times.
- In this way it was thus possible to highlight some phenomena which seem to have influenced building. At the same time, we were able to show that the choice of one or the other type of masonry was actually dictated by the orographic characteristics of the terrain.
- Above all, the creation of this three-dimensional model has made it possible to visualize the existence of several walled enclosures at different altitudes, some of which probably had the double function of terracing walls and ramparts.

### 3D model of acropoli

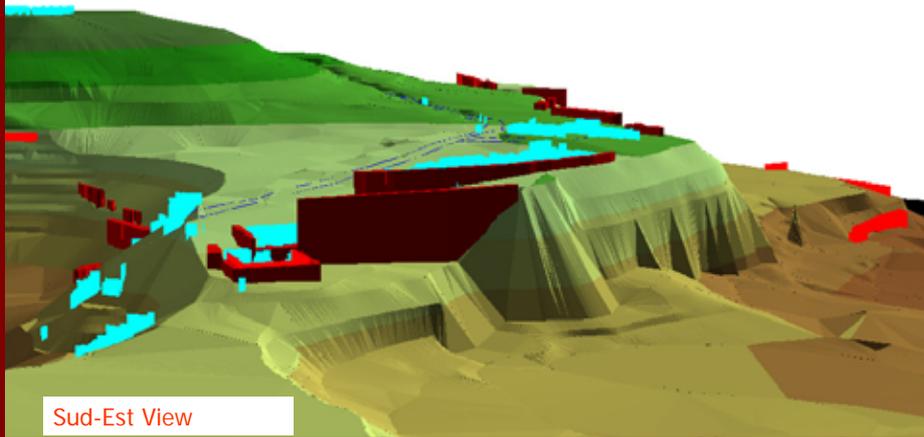


### Acropoli – Hypothesis of Reconstruction



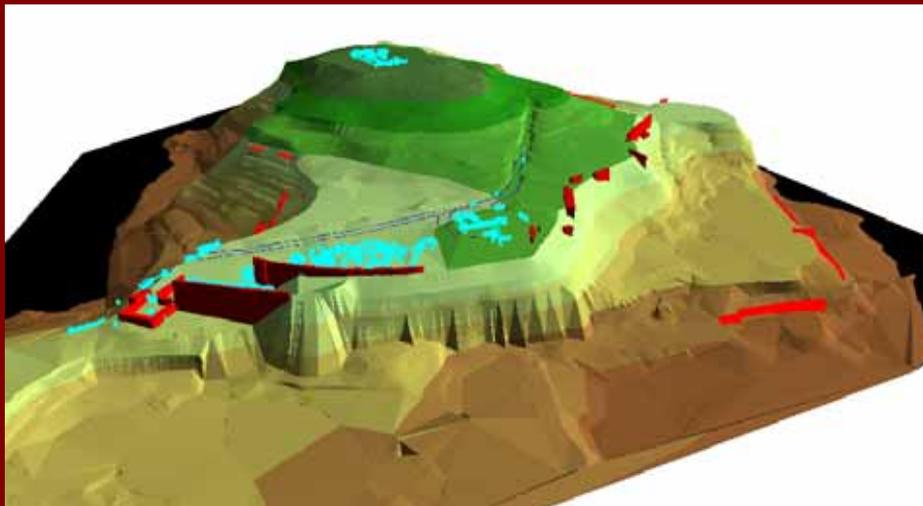
Sud-Est View

## Acropolis – Hypothesis of Reconstruction



Sud-Est View

## Acropolis – Hypothesis of Reconstruction



Nord-Est View

## Kyme Project I-II-III 1994 - 2004

- Aims: defining urban organization

### How ?

- Carrying out specific excavations in area previously investigated or not.
- Surveying ex novo remains belonging to urban organization by means of an unique topographical system.
- Yielding a digital cartography as base for further researches.

- Aims: defining urban organization

### How ?

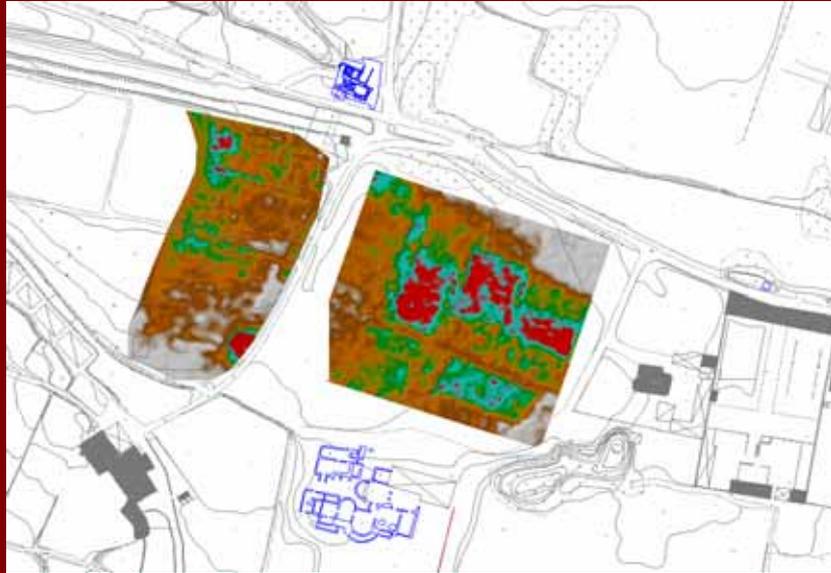
- Carrying out specific not-invasive investigations by means of geological prospectings (geo-electrical method)

## Urban Investigations in CUMA

- Excavations
- Surveys
- Geophysical Prospecting
- Historical Cadaster Map
- GIS-based System – Data Integration
- Simulation/Reconstruction

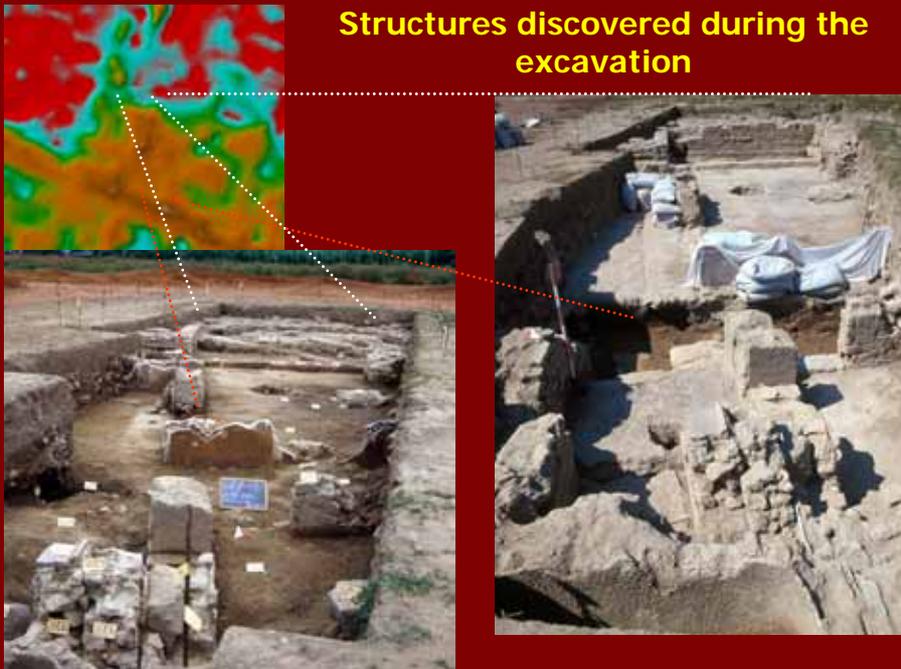


**Aerial view of zone investigated by means of geological prospecting**



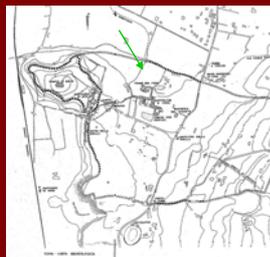
Resistivity Map after geo-referencing

### Structures discovered during the excavation

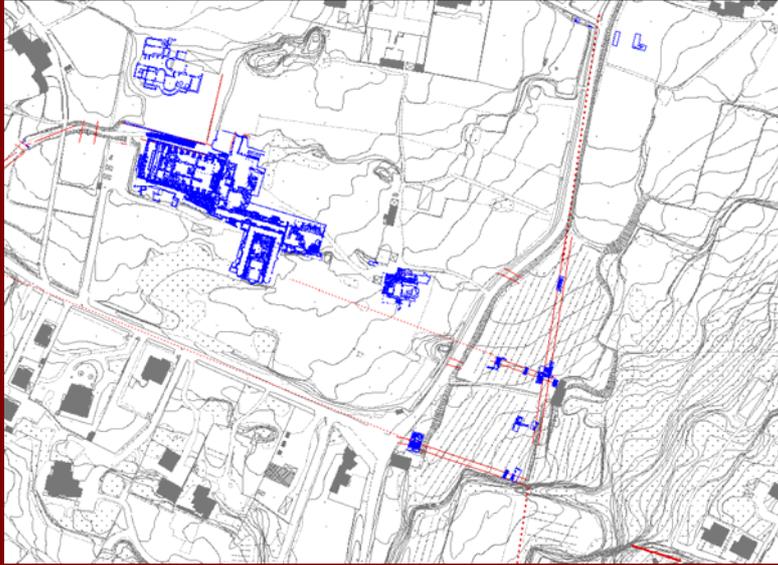




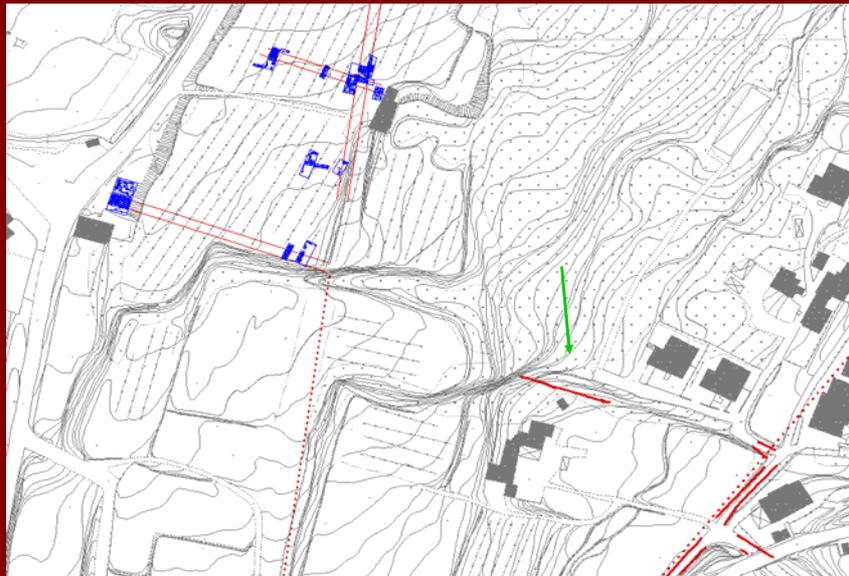
Resistivity map superimposed on historical map published by J. Beloch.



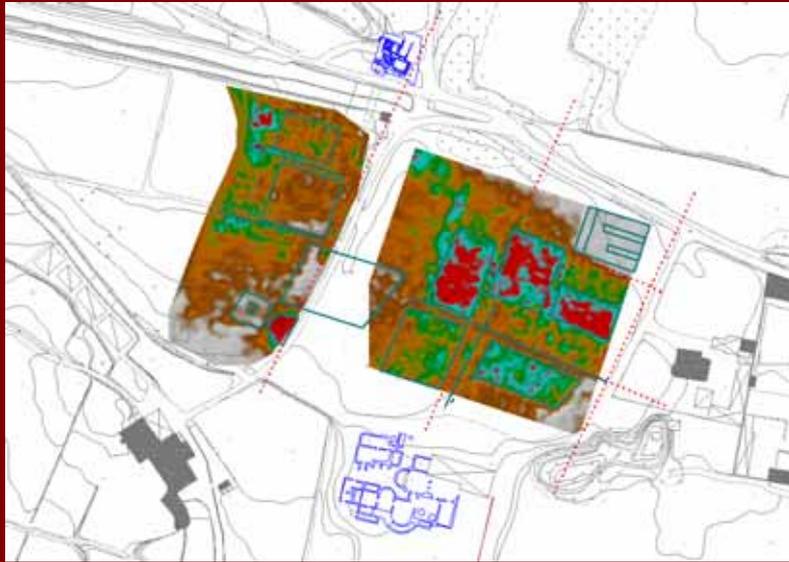
Schema of the recognized shapes superimposed on modern and historical maps



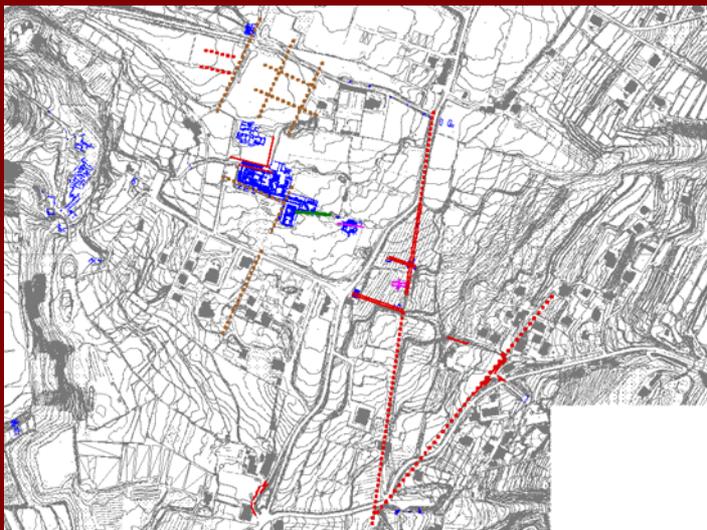
**Road outline with respect to Roman Forum.**



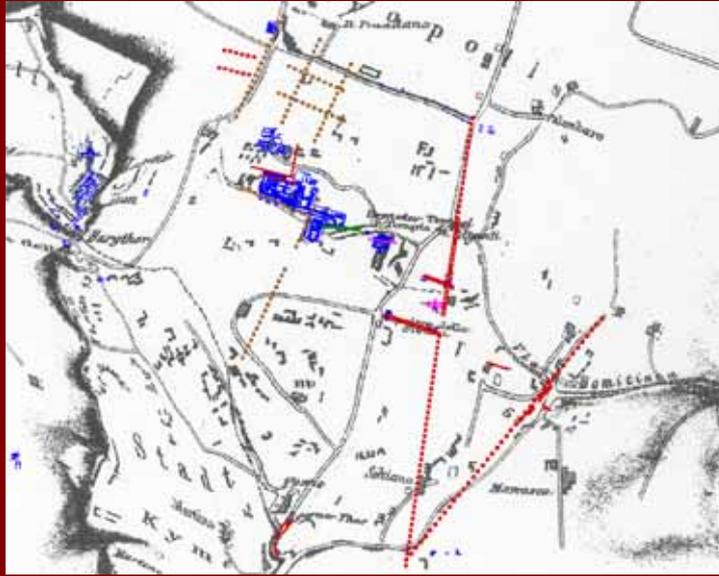
**Road outline with respect to other stretches of the "via Domiziana.**



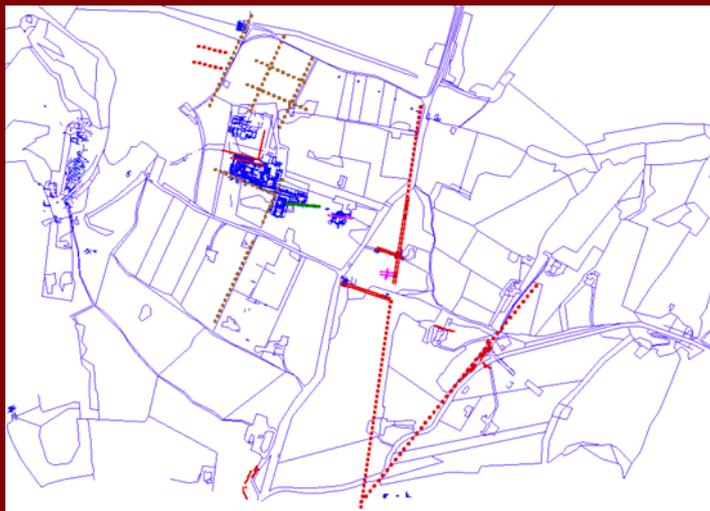
**Alignments discovered by means of geophysical prospectings**



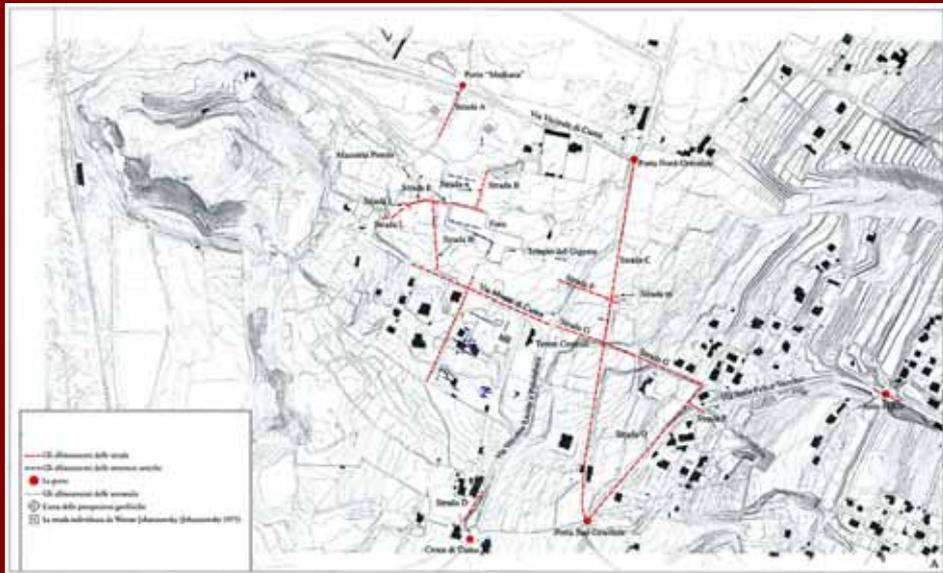
**Schematization of all the orientation-systems individuated**



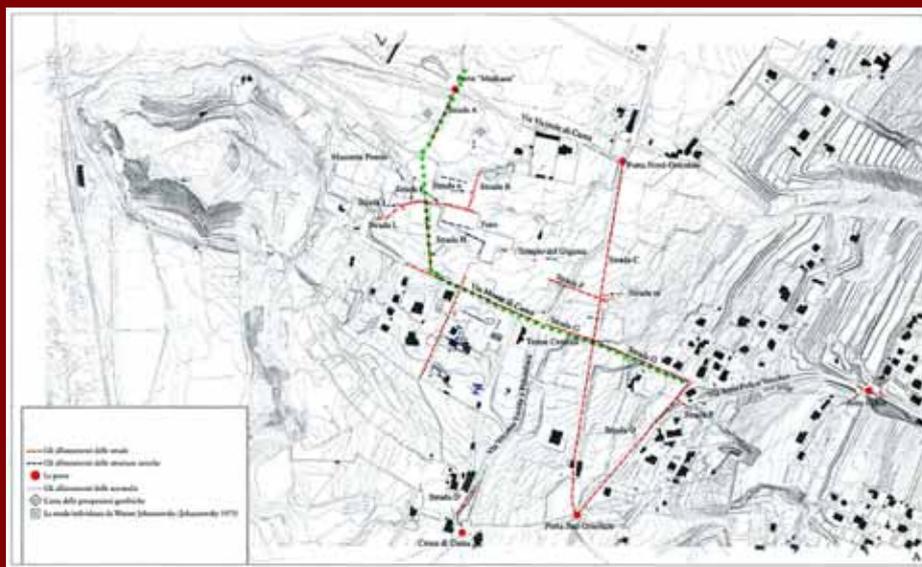
**Schematization of all the orientation-systems individuated**



**Schematization of all the orientation-systems individuated with respect of cadastral map**



**Schema of all the individuated orientation-systems**



**Reconstruction of urban plan of the "Via Domitiana"**