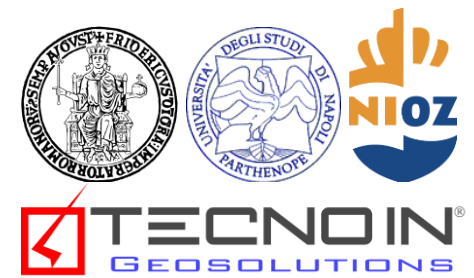


# WORKSHOP

20\_21\_22 settembre 2022  
Castello di SANTA SEVERA



**Le peschiere romane del Mediterraneo:**  
vincoli e interpretazioni per la definizione delle variazioni  
del livello del mare negli ultimi 2000 anni

## ***The importance of fish tanks in the reconstruction of the Roman Campi Flegrei Landscape***

*C. Caporizzo<sup>1</sup>, G. Mattei<sup>1</sup>, L. Amato<sup>2</sup>, A. Cinque<sup>3</sup>, G. Pappone<sup>1</sup>, A. Sorrentino<sup>1</sup>, P. Stocchi<sup>4</sup>, S. Troisi<sup>1</sup>, P.P.C. Aucelli<sup>1</sup>*

<sup>1</sup> *Science and Technology Department, Università degli Studi di Napoli Parthenope, Naples, Italy*

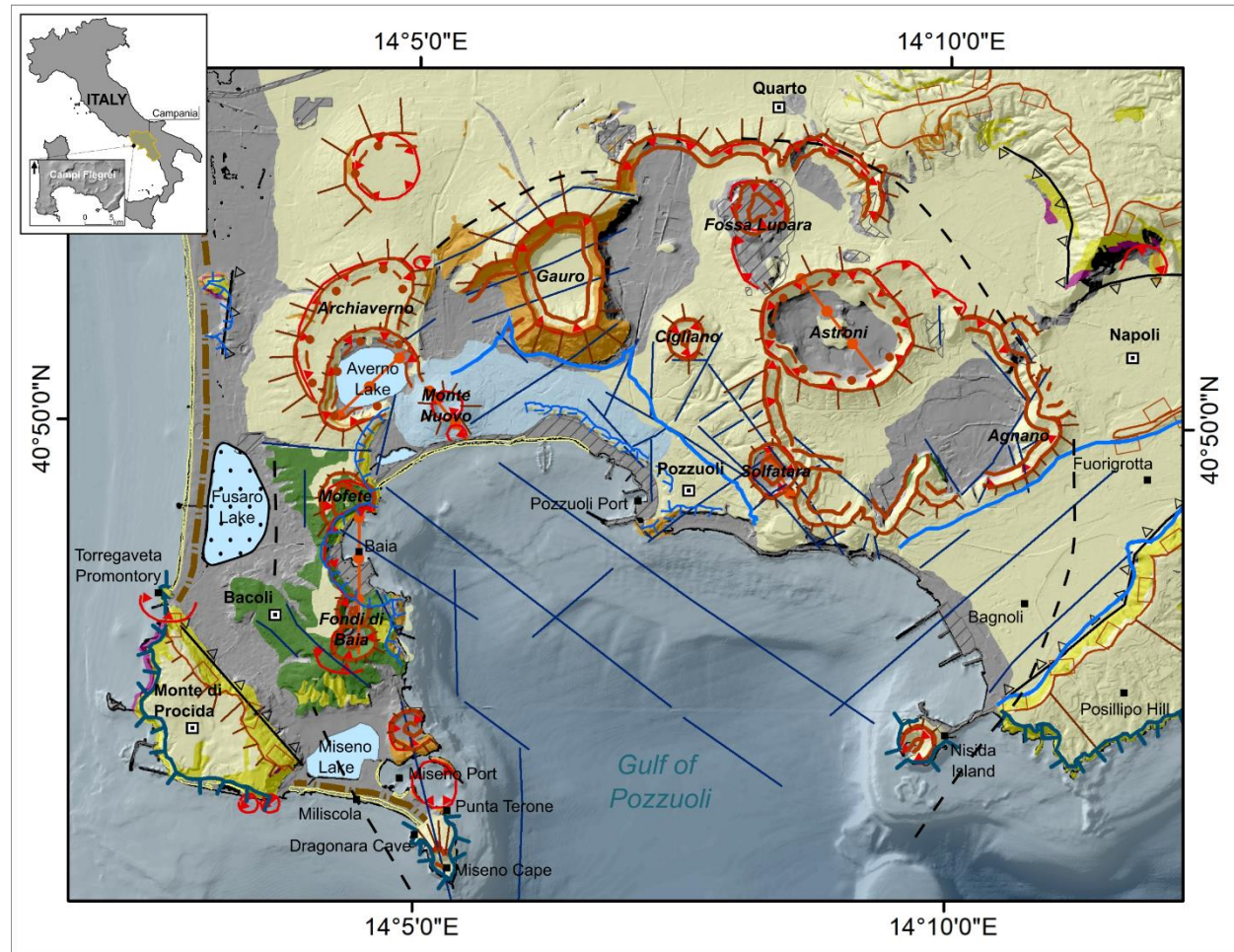
<sup>2</sup> *Tecno-In S.p.A. - Engineering Services, Naples, Italy*

<sup>3</sup> *Earth Science Department, Università degli Studi di Napoli Federico II, Naples, Italy*









<sup>4</sup> *Coastal Systems Department, Royal Netherlands Institute for Sea Research, Den Burg, The Netherlands*

## STUDY AREA














The Gulf of Naples (view from Posillipo Hill)

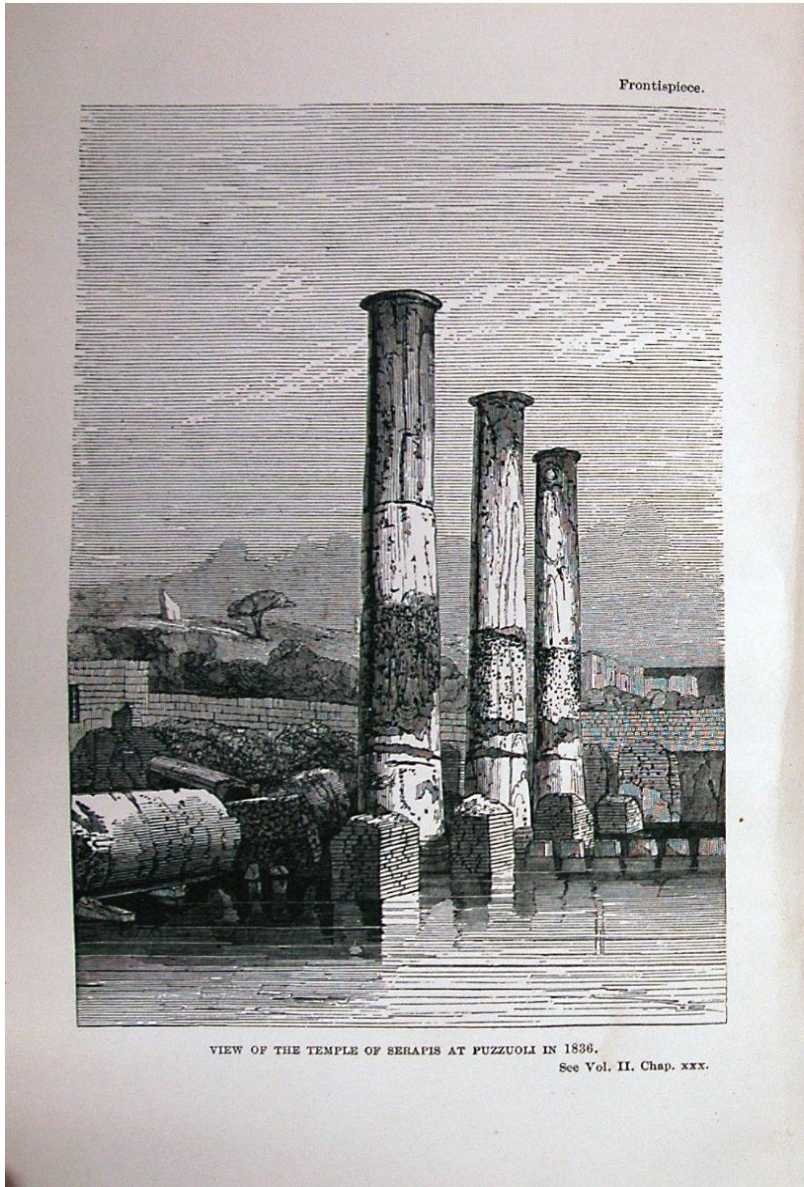


### COASTAL AND ANTHROPIC DEPOSITS AND LANDFORMS

-  beach ridge
-  Holocene maximum marine ingressions
-  Fusaro lagoon
-  structure-controlled paleo-sea cliff
-  Beach deposits
-  Anthropogenic infill
-  sea cliff
-  Recent deposits reworked by anthropic activities

### VOLCANIC DEPOSITS AND LANDFORMS

-  tuff cone
  -  tuff ring
  -  faults
  -  caldera ring faults
  -  crater rims
  -  eruptive fissures
  -  CI deposits (39.0 ka BP)
  -  NYT deposits (15.0 ka BP)
  -  NYT caldera (Di Vito et al., 1999)
  -  Pyroclastics of Monte Nuovo eruption (1538 AD)
- Post - Caldera Volcanic Phases (ka BP)**
-  3.5 - 5.5
  -  9.1 - 9.6
  -  10.6 - 15.0



## PRINCIPLES OF GEOLOGY

OR THE

MODERN CHANGES OF THE EARTH  
AND ITS INHABITANTS

CONSIDERED AS ILLUSTRATIVE OF GEOLOGY

By SIR CHARLES LYELL, BART., M.A., F.R.S.

'Verè scire est per causas scire'—BACON

'The stony rocks are not primeval, but the daughters of Time'—LINNÆUS, *Syst. Nat.* ed. 5, *Stockholm*, 1748, p. 219

'Amid all the revolutions of the globe the economy of Nature has been uniform, and her laws are the only things that have resisted the general movement. The rivers and the rocks, the seas and the continents, have been changed in all their parts; but the laws which direct those changes, and the rules to which they are subject, have remained invariably the same'—PLAYFAIR, *Illustrations of the Huttonian Theory*, § 374

ELEVENTH AND ENTIRELY REVISED EDITION

IN TWO VOLUMES—VOL. I.

*Illustrated with Maps, Plates, and Woodcuts*

LONDON

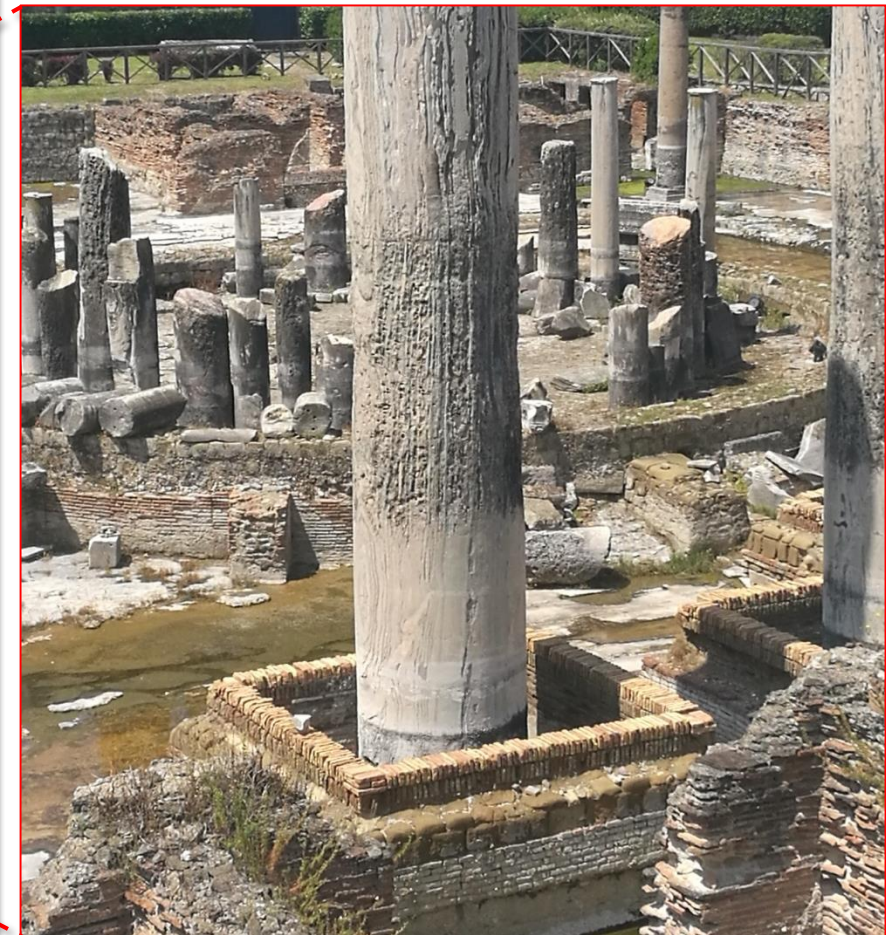
JOHN MURRAY, ALBEMARLE STREET

1872

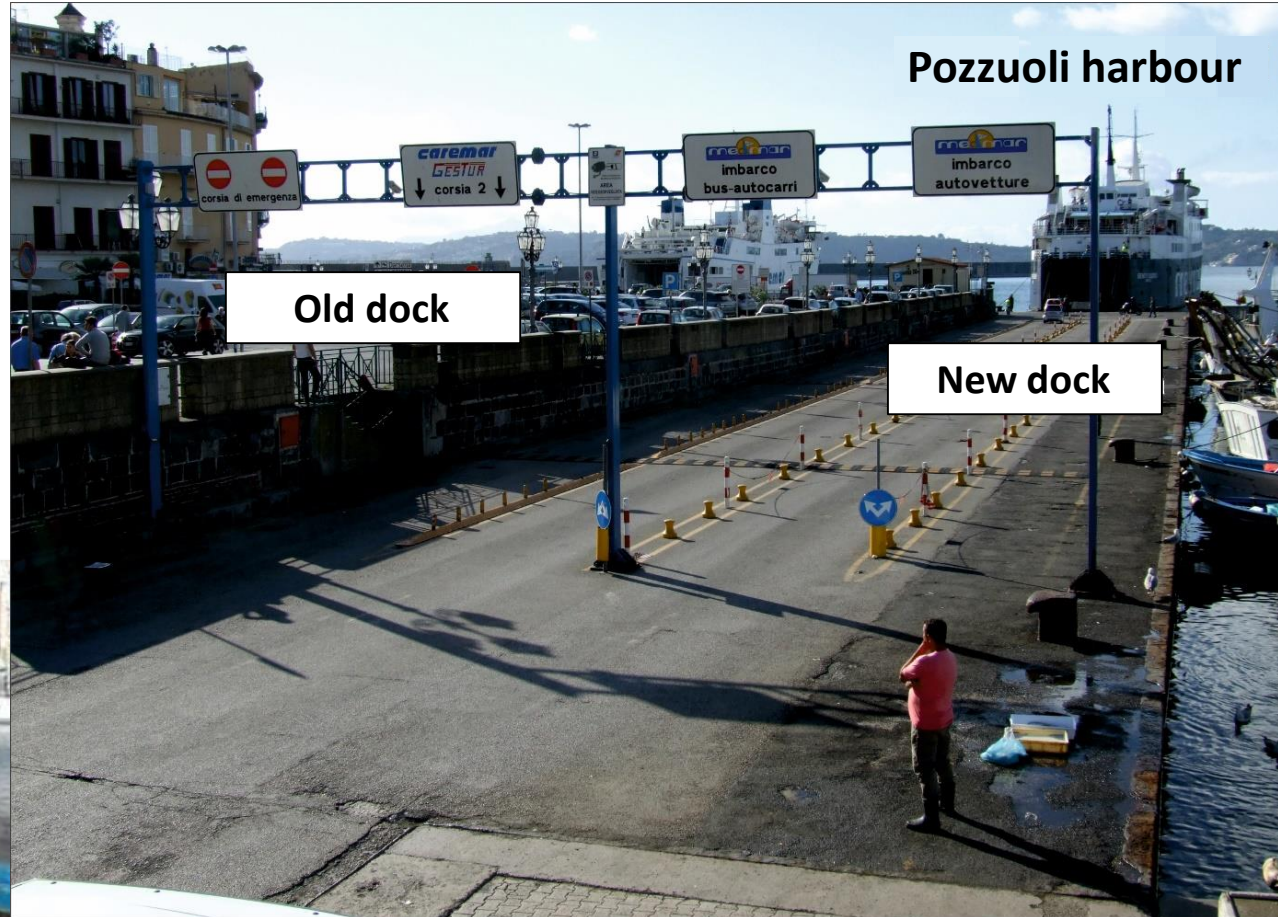
*The right of translation is reserved*

## MACELLUM

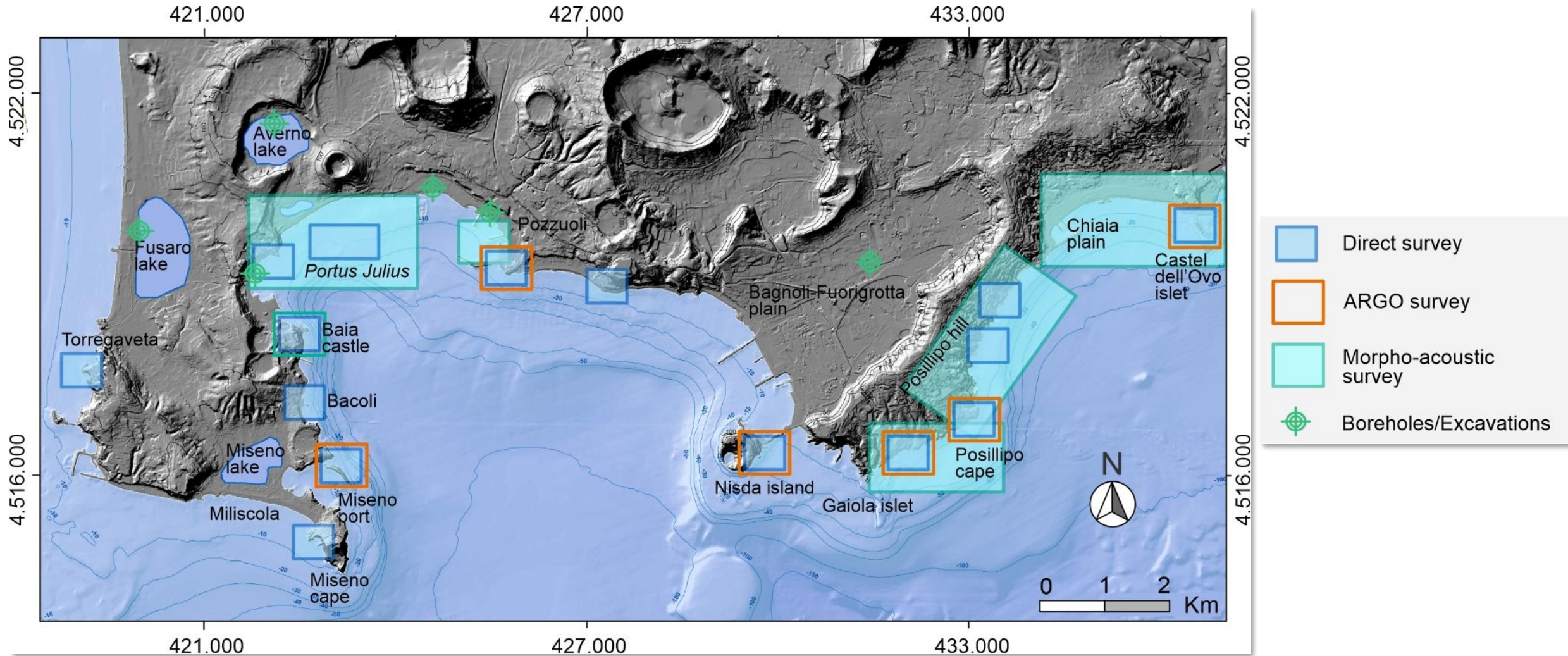
### The Roman Market at Pozzuoli



The effects of the last bradyseismic crisis recorded along the harbour area of Pozzuoli in 1983-1985 with a uplift of 2 m (3 mm/day)



## METHODS – Multi-survey approach

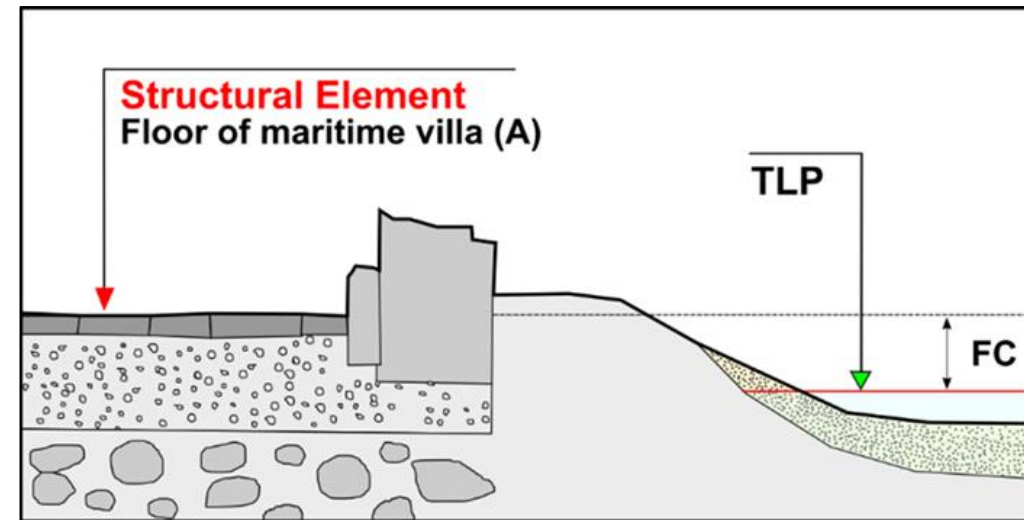
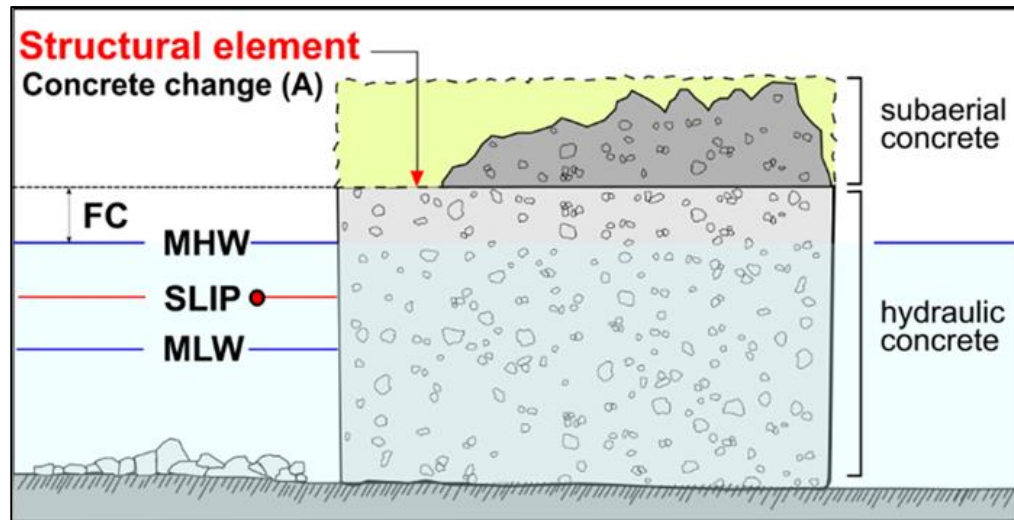


## METHODS – Direct Surveys and archaeological sea-level markers

1. Extensive geological and geomorphological on-field observations supported by archaeological interpretations;
2. Underwater geo-archaeological surveys Along the submerged sector and detection of submersion of SLMs;
3. Correction of the submersion measurements;
4. Determination of RSLs according to the more recent international standards.

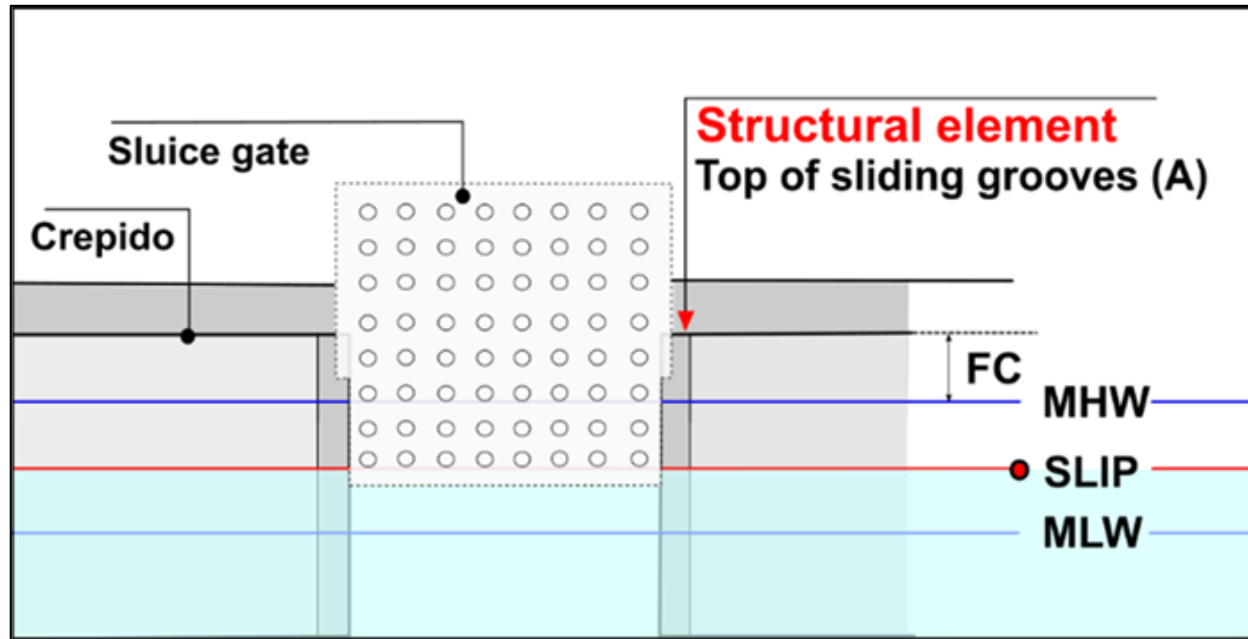
$$SLIP = A - FC - \frac{IR}{2}$$

**A:** elevation above MSL  
**FC:** functional clearance  
**IR:** Indicative range



## METHODS – Direct Surveys and archaeological sea-level markers

### FISH TANKS



$$SLIP = A - FC - \frac{IR}{2}$$

A: elevation above MSL  
FC: functional clearance  
IR: Indicative range



Fish tank (Portus Julius, Pozzuoli)

## METHODS – Indirect surveys



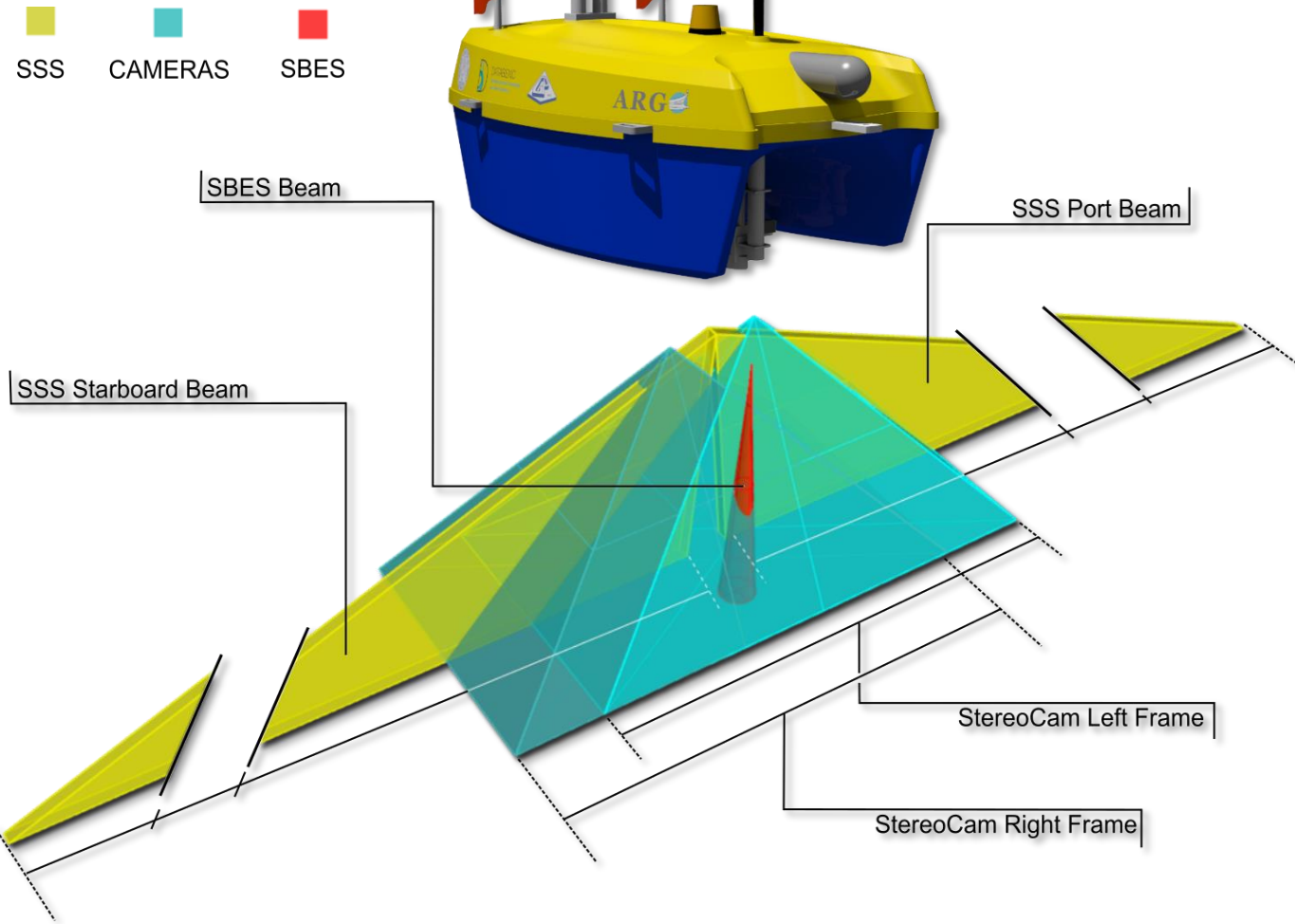
### 1. Traditional Morphoacoustic surveys

- MBES
- SSS

### 2. ARGO system

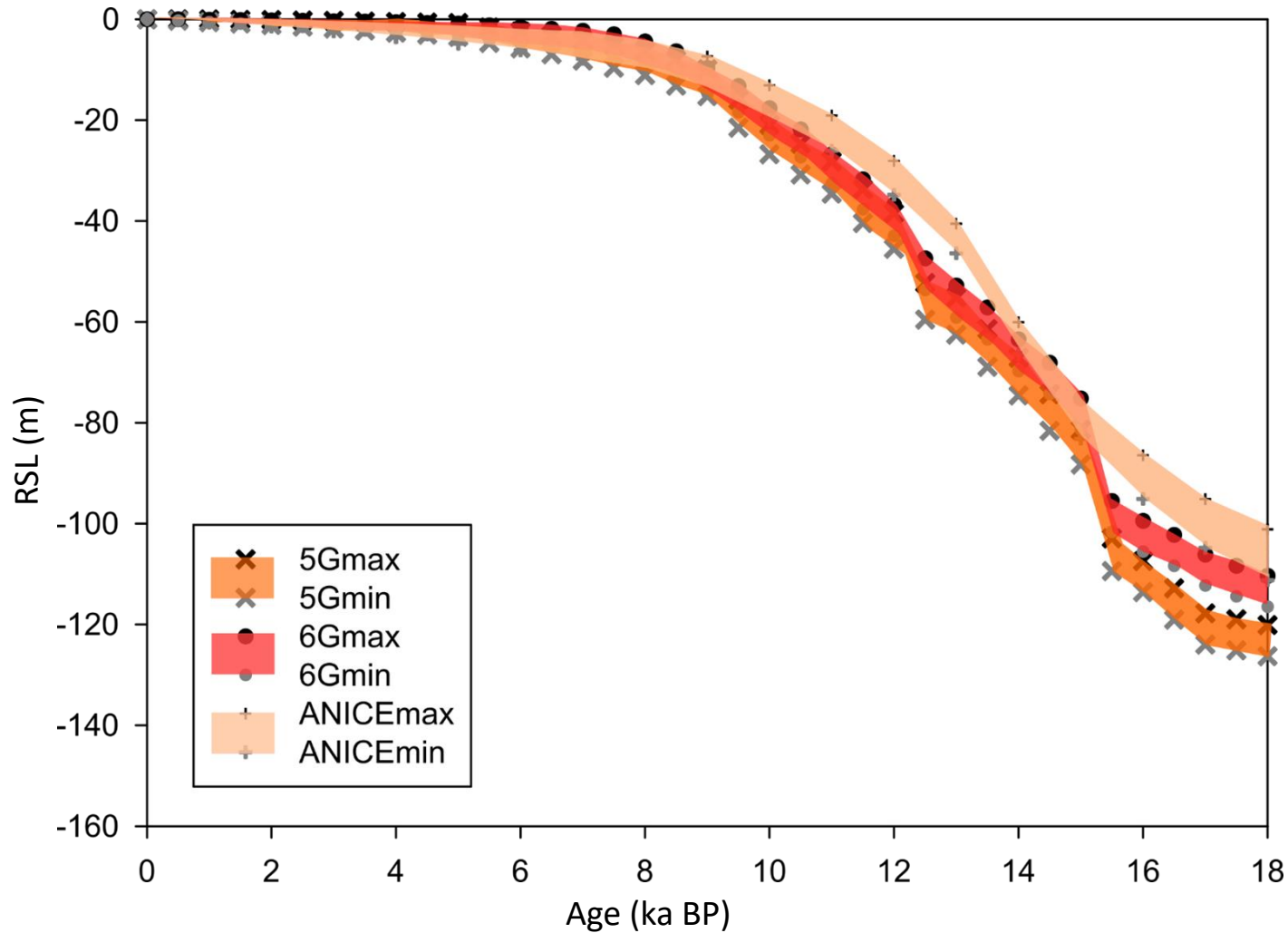
- SBES
- SSS
- Photogrammetry

} simultaneously





## METHODS – GIA Models



### ICE SHEET CRONOLGIES

ICE-5G (Peltier, 2004)

ICE-6G (Peltier et al., 2015)

ANICE (de Boer et al., 2013, 2014)

### LITHOSPHERE THICKNESS

60 km

90 km

120 km

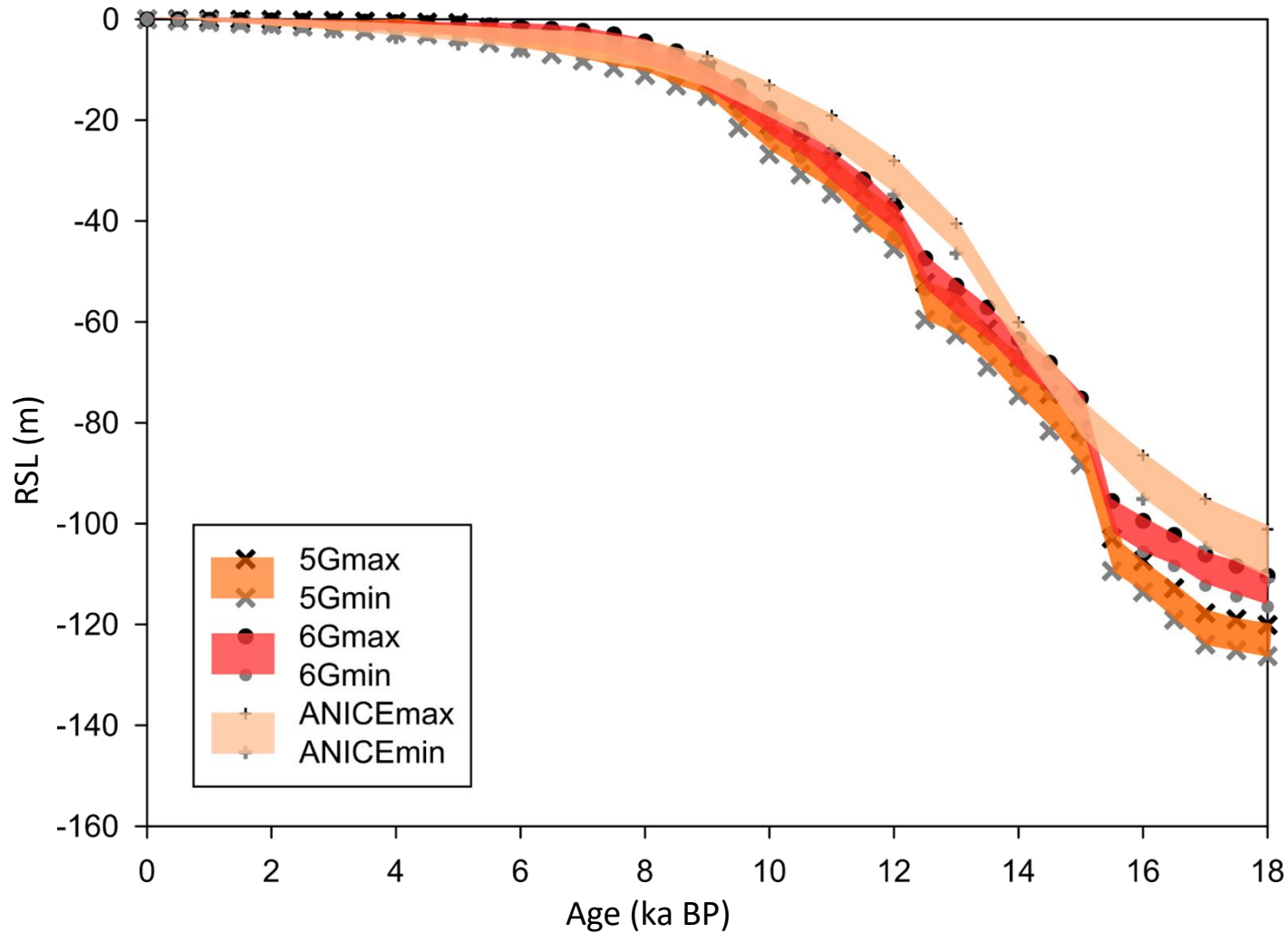
### MANTLE VISCOSITY

2 - 10 Pas

0.5 - 1 Pas

0.2 - 0.5 Pas

## METHODS – GIA Models and quantification of Vertical Ground Movements



# SPYDER

The Scientific Python Development Environment

$$VD_{SLIP_{rate}} = \frac{VD_{SLIP}}{T}$$

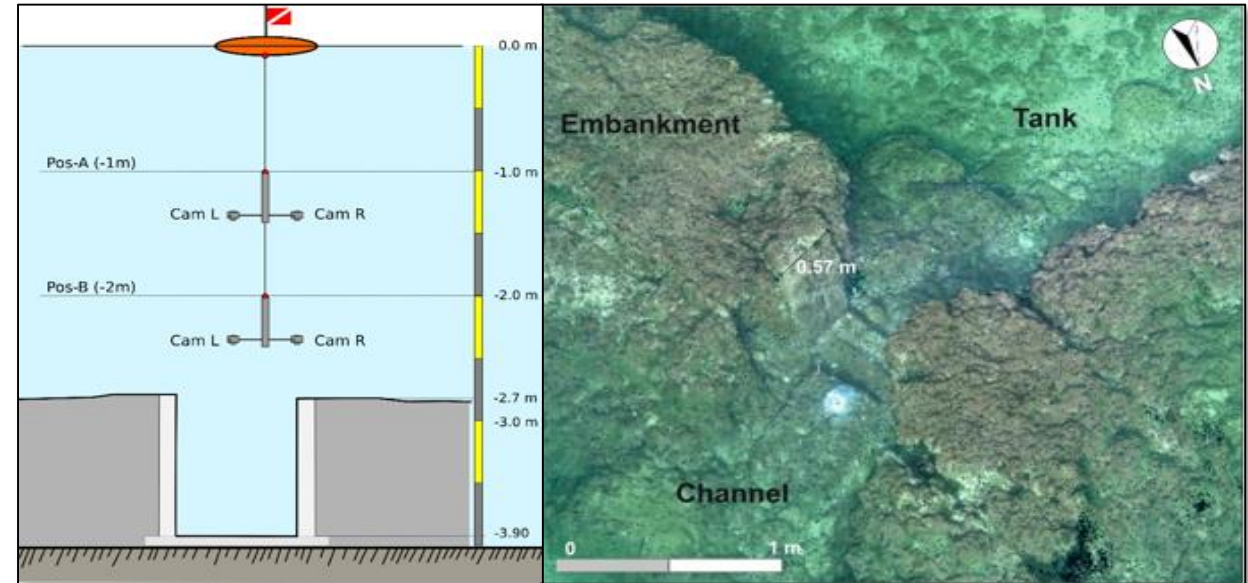
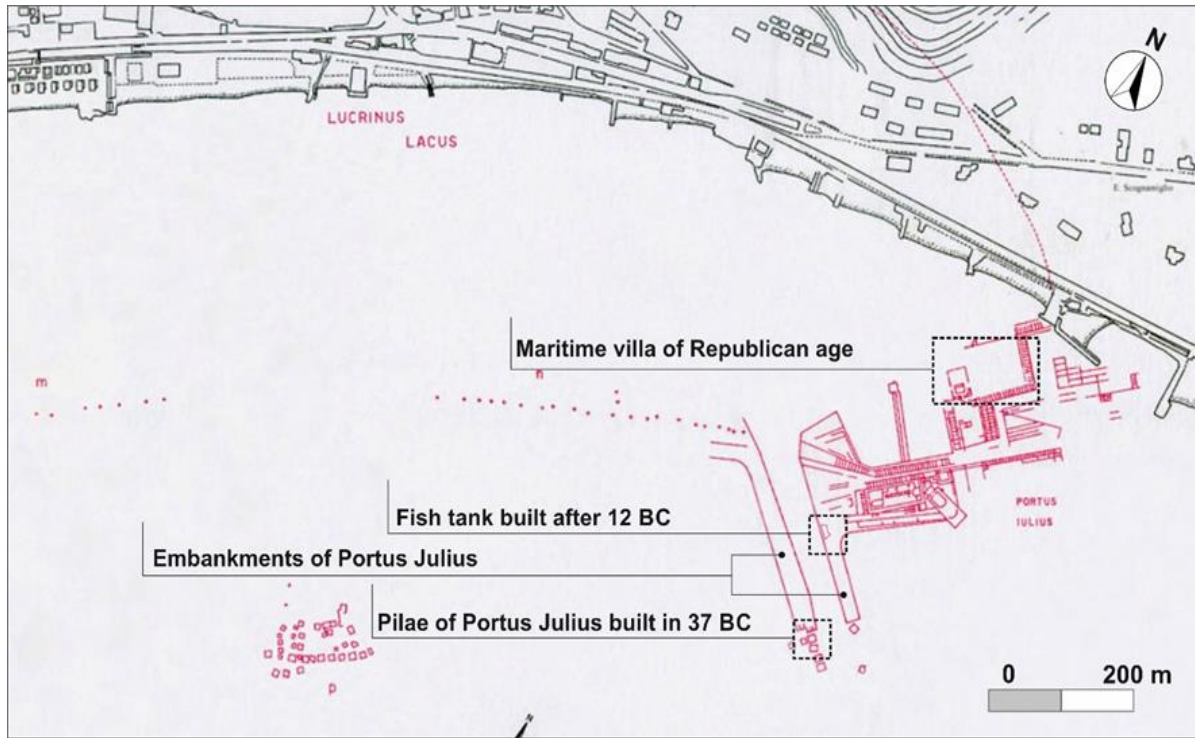
$$VD_{SLIP} = \frac{\sum_{n=1000} RSL_{On} - RSL_{Pn}}{n}$$

**RSL<sup>O</sup>**: Observed Relative Sea Level

**RSL<sup>P</sup>**: Predicted Relative Sea Level

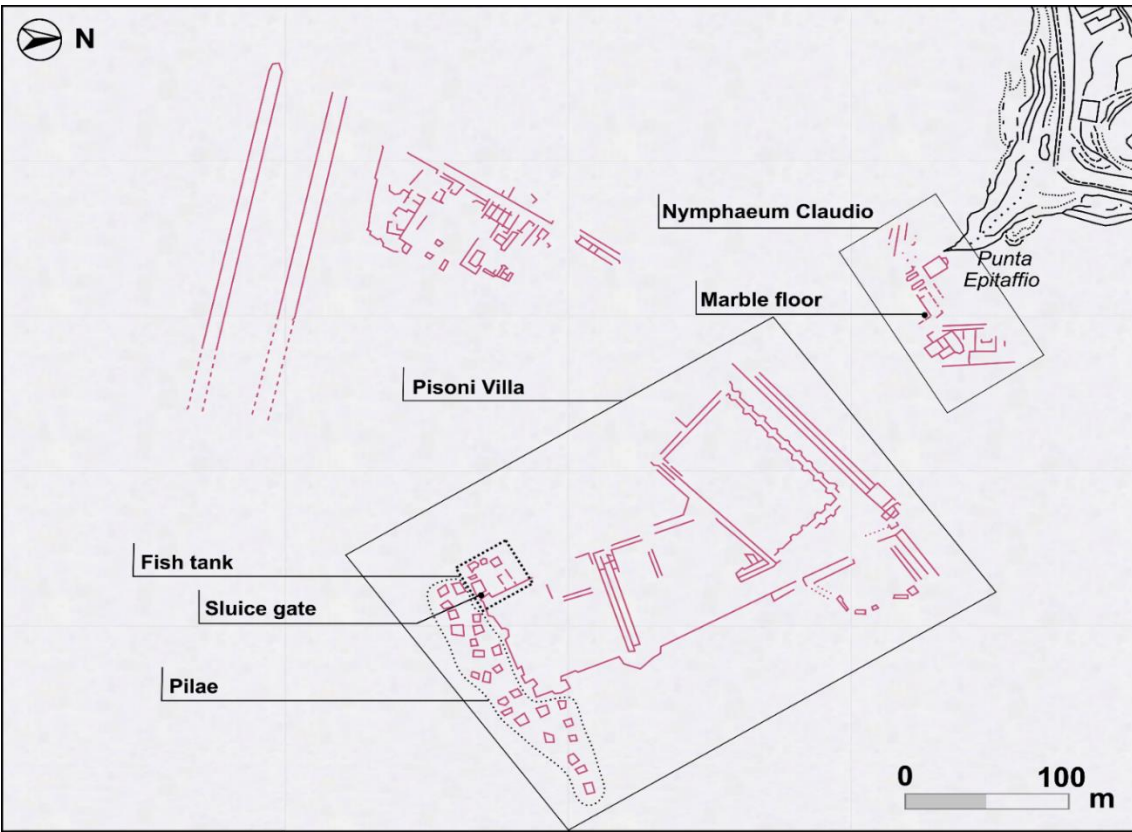
**T** : Time/Age

## RESULTS – PORTUS JULIUS



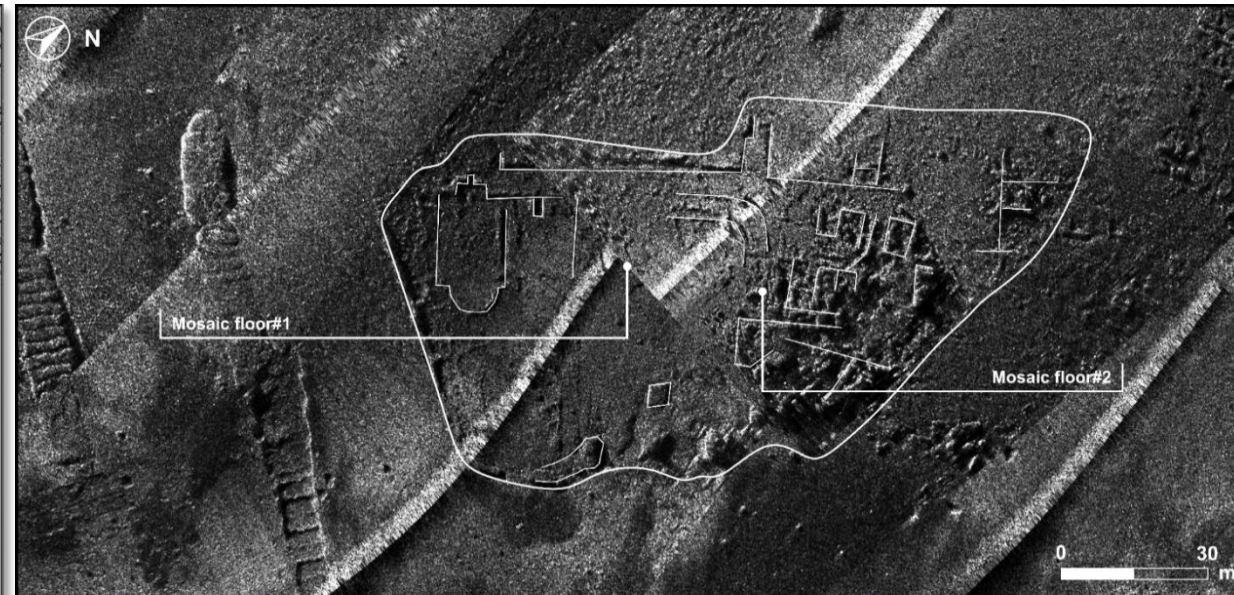
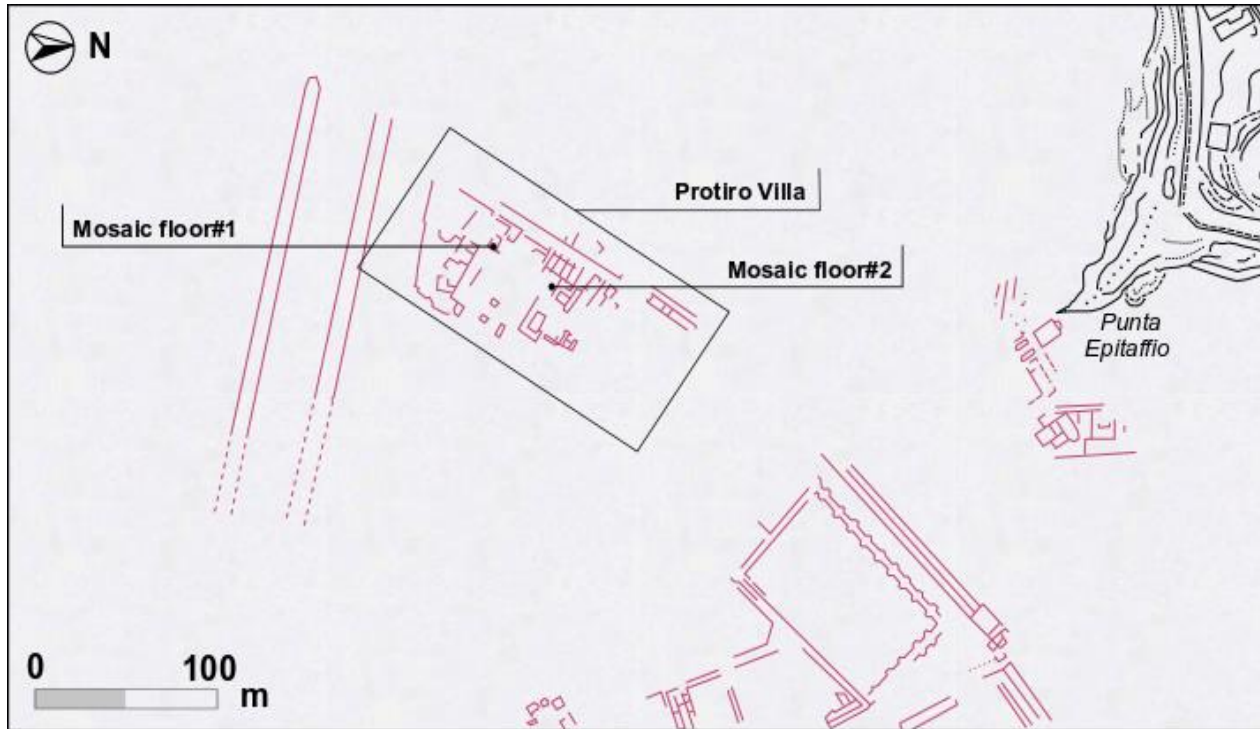
SLM	Type	Age	RSL (m MSL)
Sluice Gate	SLIP	12 BC	-3.10±0.29
<i>Pilae</i>	SLIP	37 BC	-3.10±0.29

## RESULTS – PISONI VILLA AND EMPEROR CLAUDIUS NYMPHAEUM



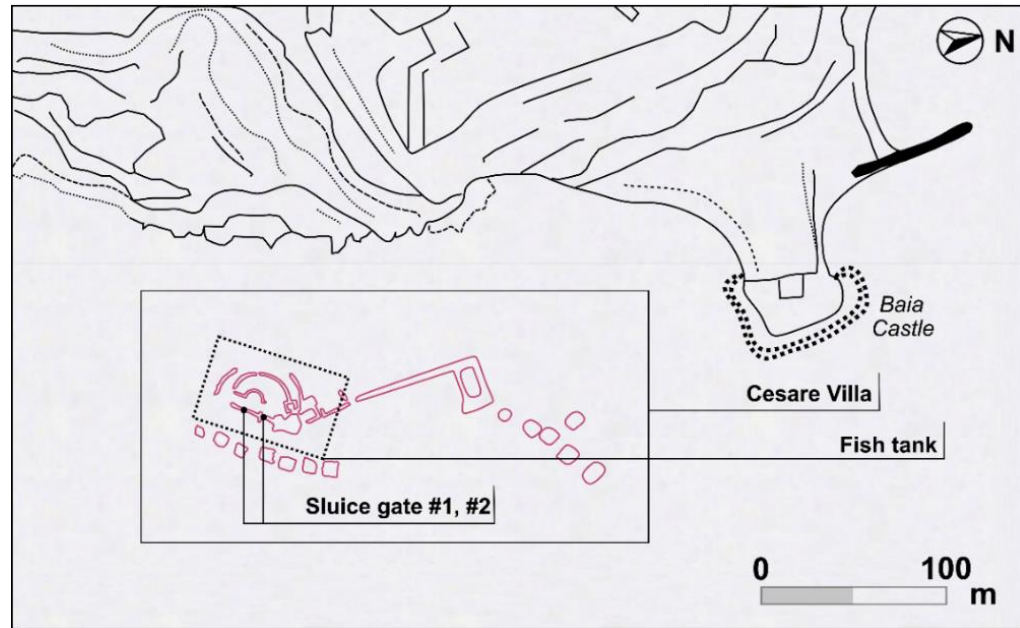
SLM	Type	Age	RSL (m MSL)
Sluice Gate	SLIP	70-100 AD	-6.9±0.29
Pavement	TLP	41-54 AD	<-5.3±0.07

## RESULTS – PROTIRO VILLA



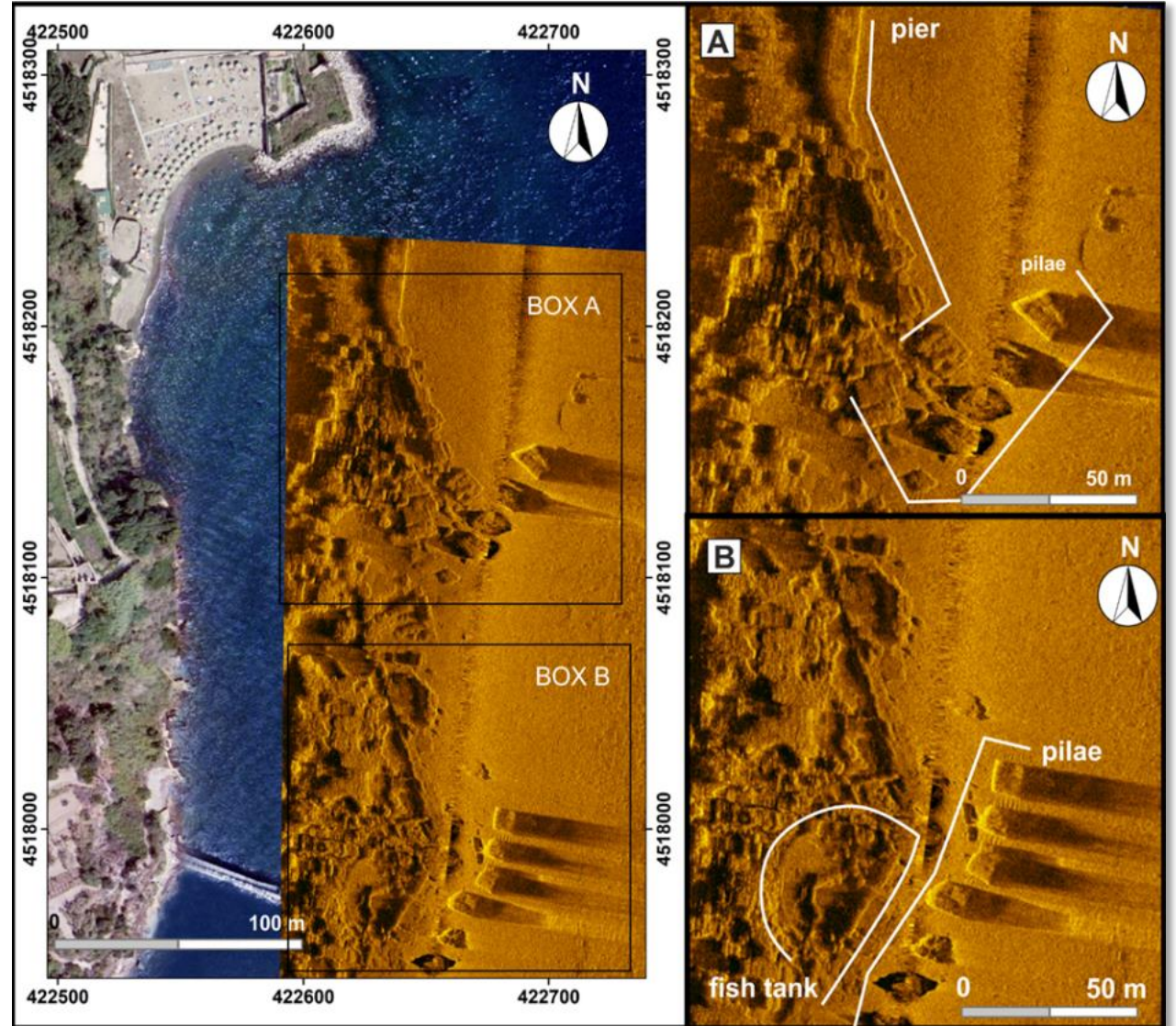
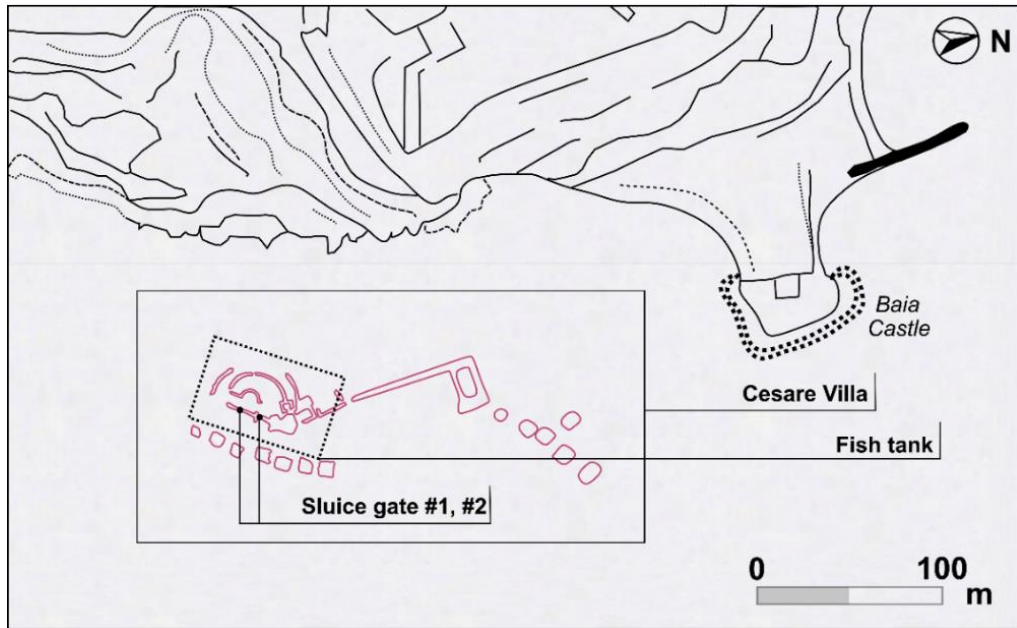
SLM	Type	Age	RSL (m MSL)
Pavement	TLP	100-120 AD	<-6.10±0.07
Pavement	TLP	100-120 AD	<-6.10±0.07

## RESULTS – CAESAR VILLA AT THE ARAGONESE CASTLE OF BAIA



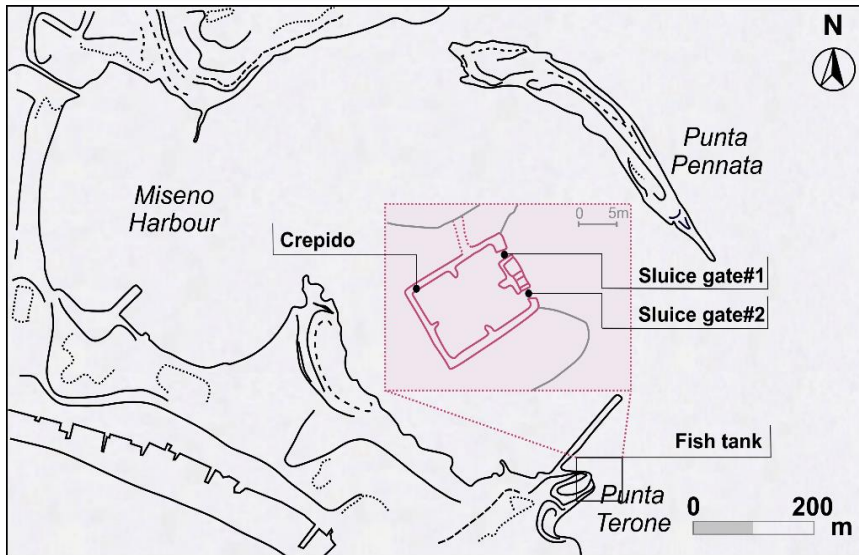
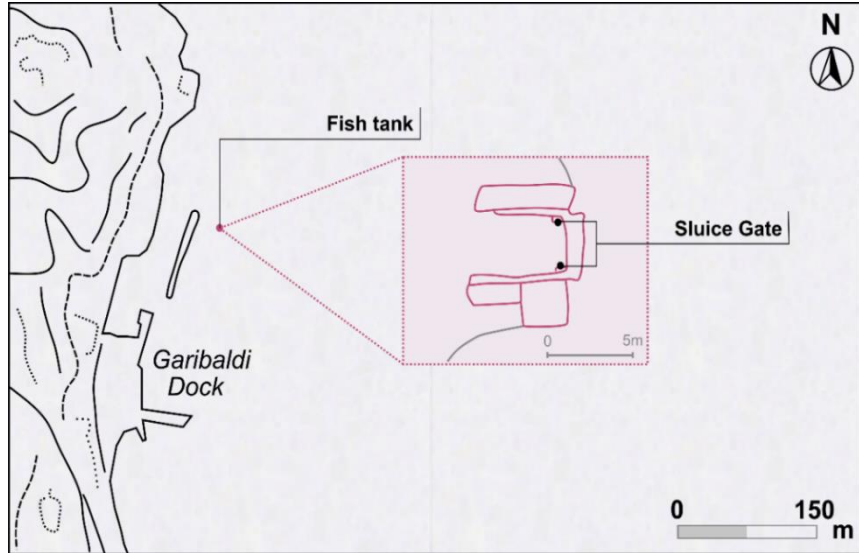
SLM	Type	Age	RSL (m MSL)
Sluice Gate	SLIP	60-44 BC	-4.20 ±0.29

## RESULTS – CAESAR VILLA AT THE ARAGONESE CASTLE OF BAIÀ



SLM	Type	Age	RSL (m MSL)
Sluice Gate	SLIP	60-44 BC	-4.20 ±0.29

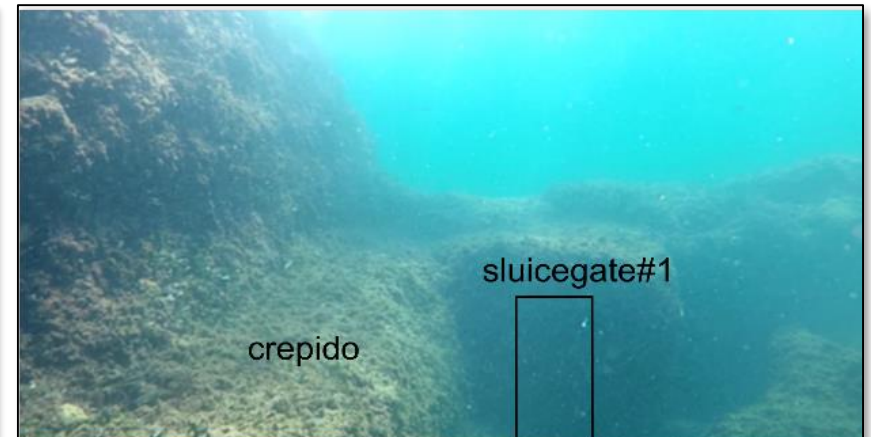
## RESULTS – HORTALUS VILLA AND PUNTA TERONE



SLM	Type	Age	RSL (m MSL)
Sluice Gate	SLIP	70-50 BC	-4.0 ±0.29
Sluice Gate	SLIP	50-12 BC	-4.20 ±0.29



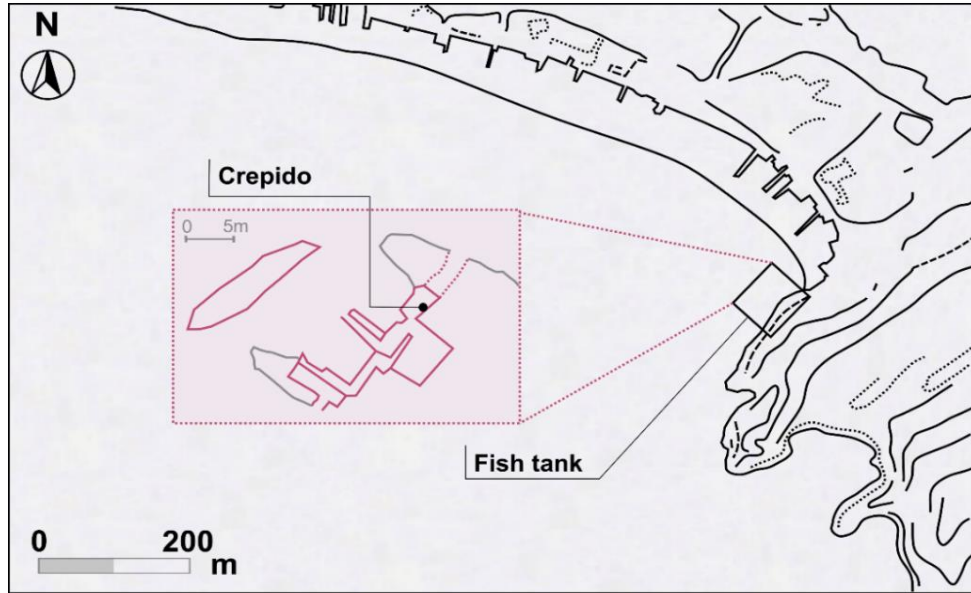
Fish tank at Bacoli



Fish tank at Punta Terone



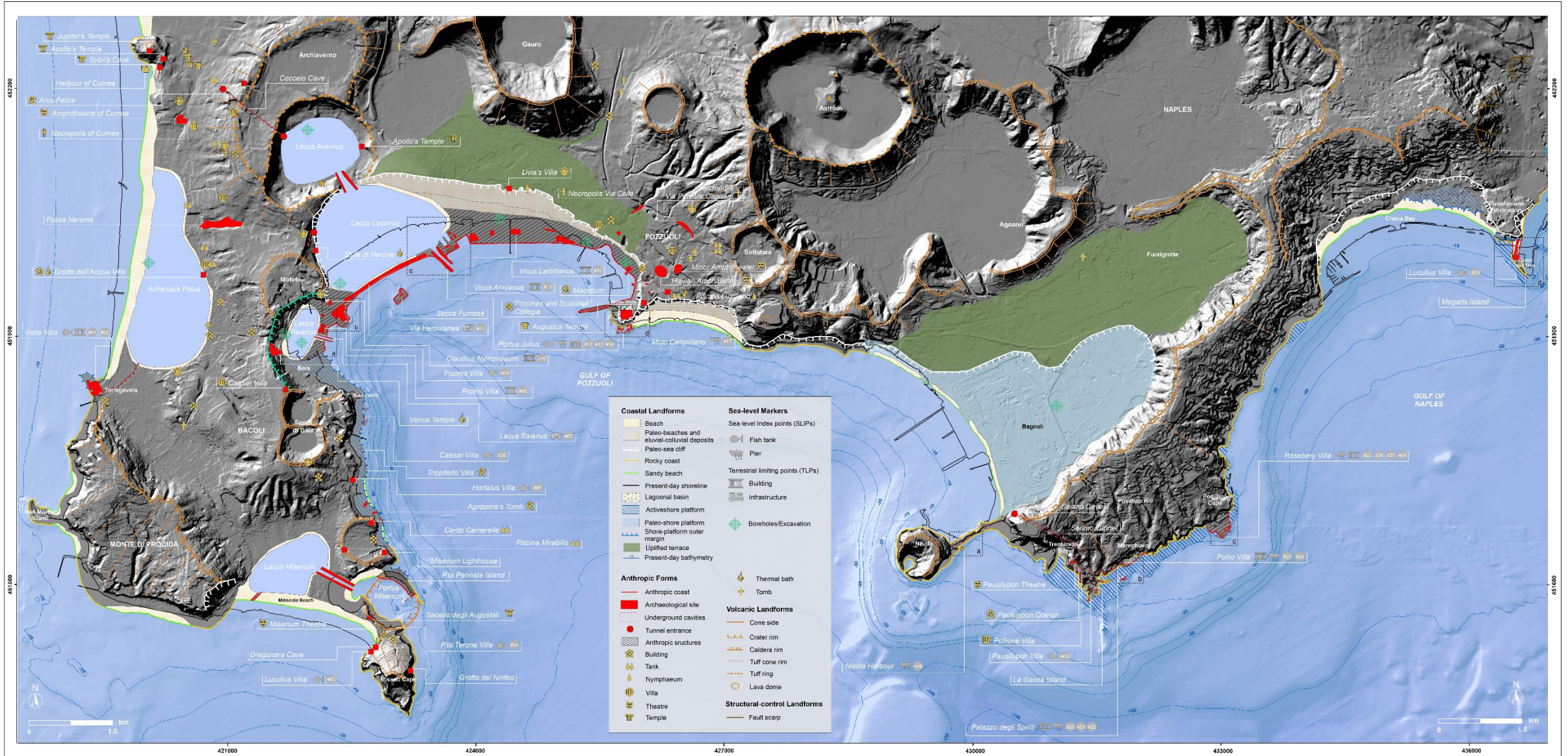
## RESULTS – LUCULLUS VILLA



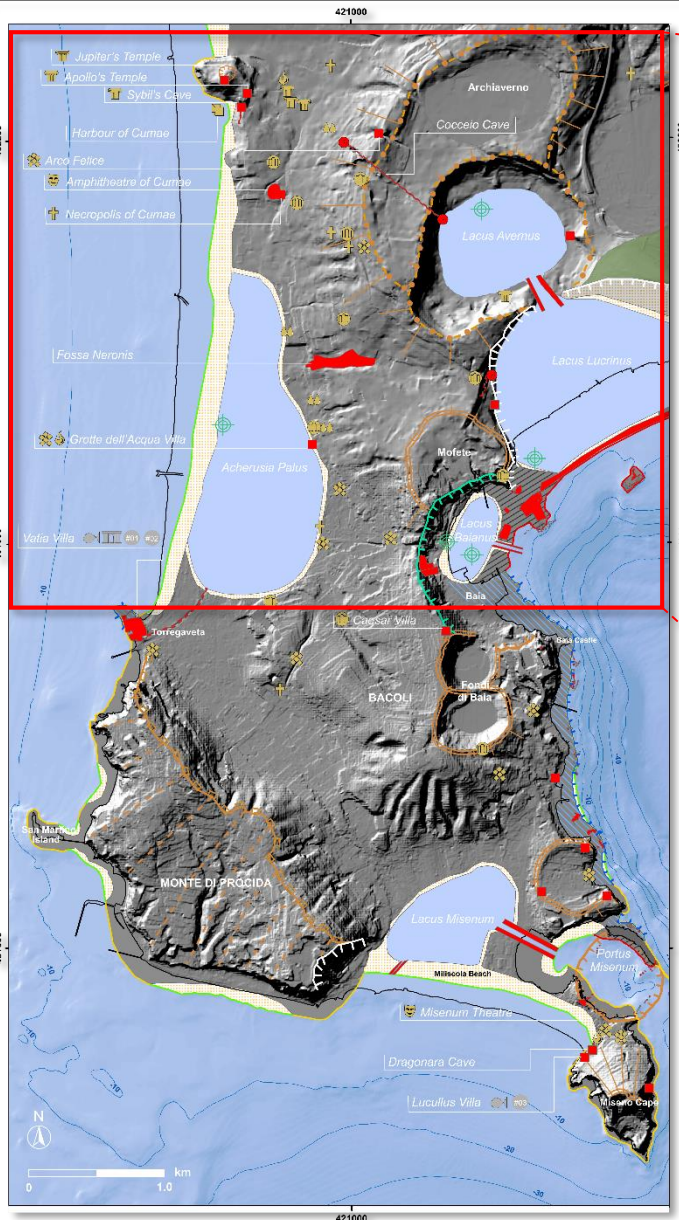
SLM	Type	Age	RSL (m MSL)
Crepido	SLIP	60 BC	-3.2 ±0.29



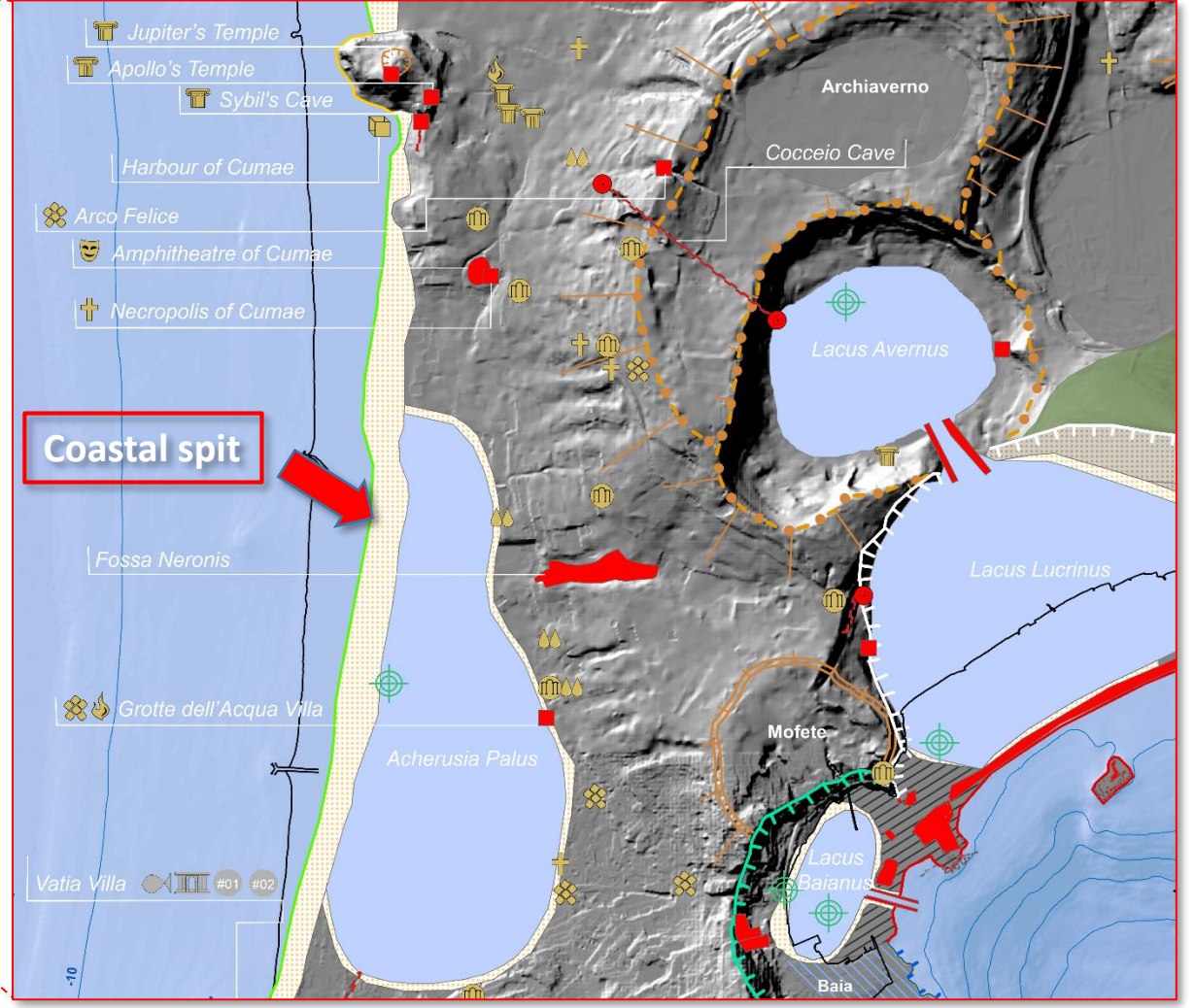
## RESULTS – RECONSTRUCTION OF CAMPI FLEGREI ROMAN COASTAL LANDSCAPE



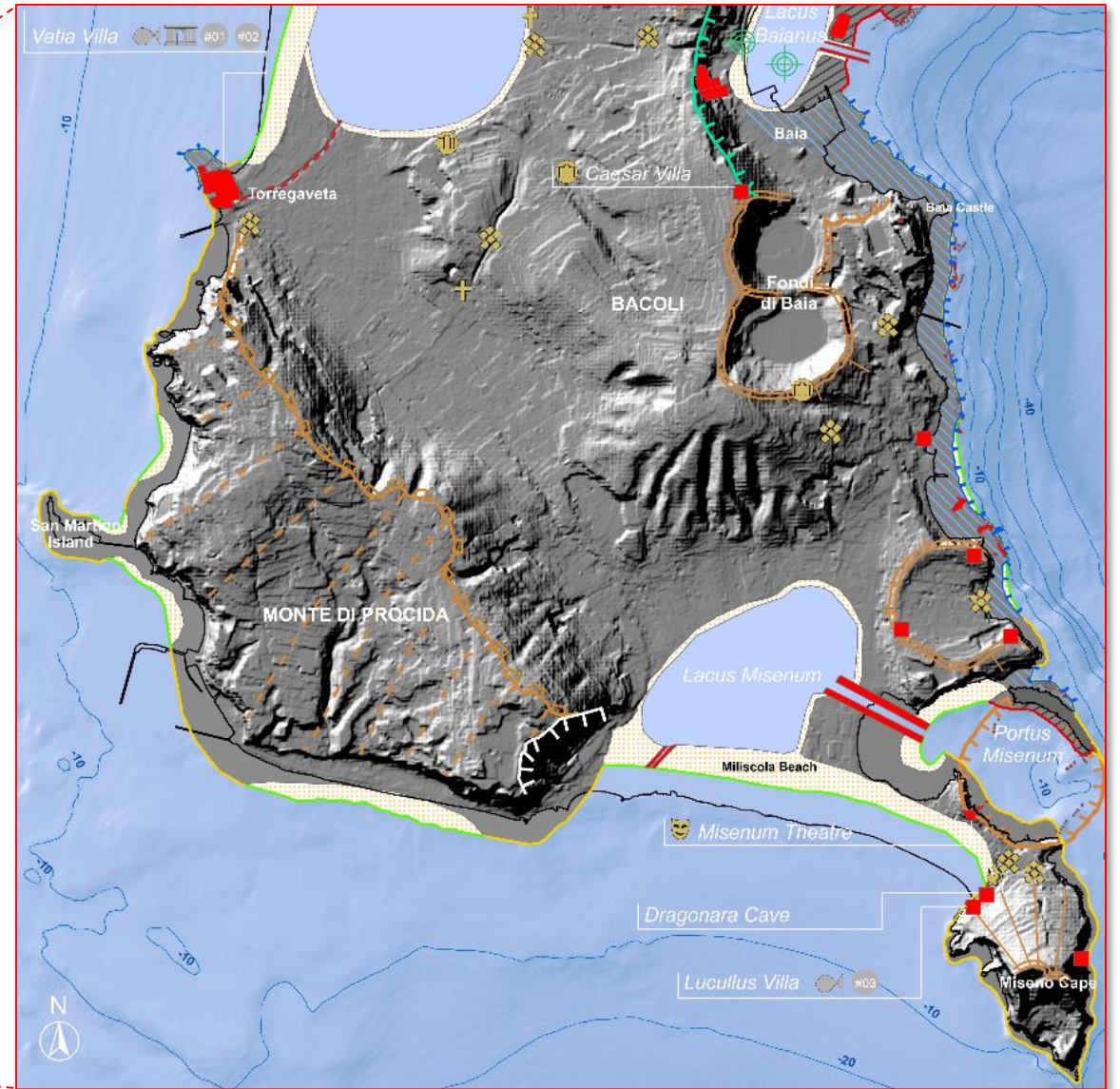
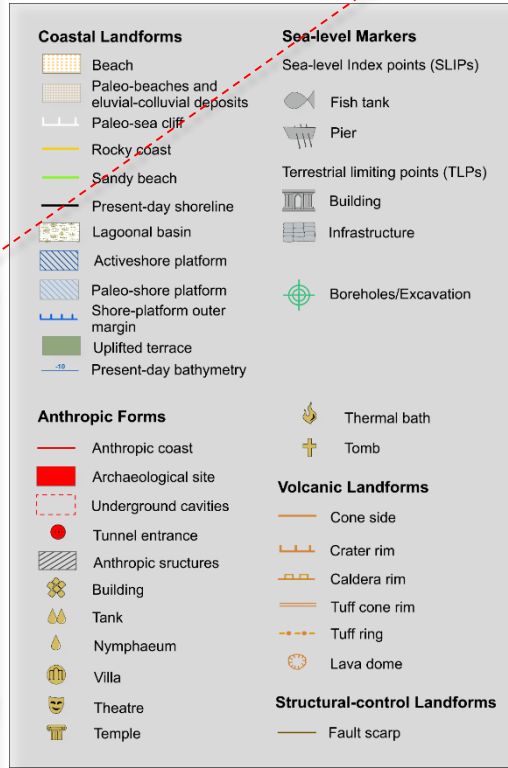
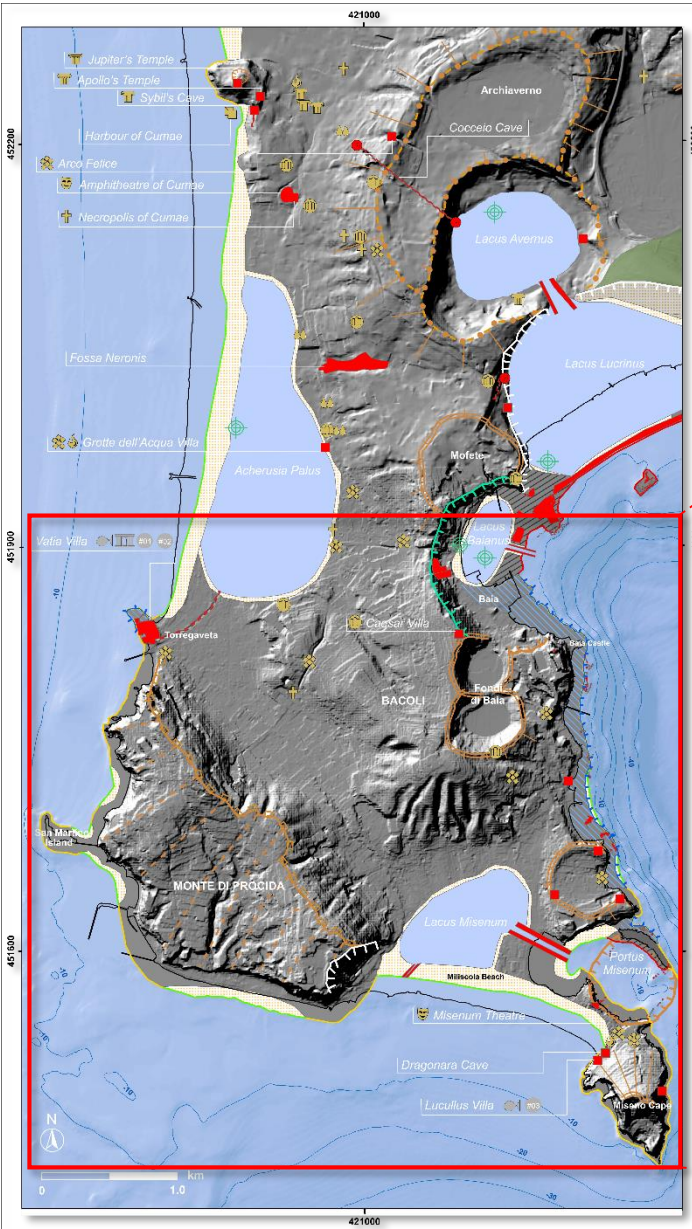
### Sector 1: Reconstruction of the Roman coastal Landscape

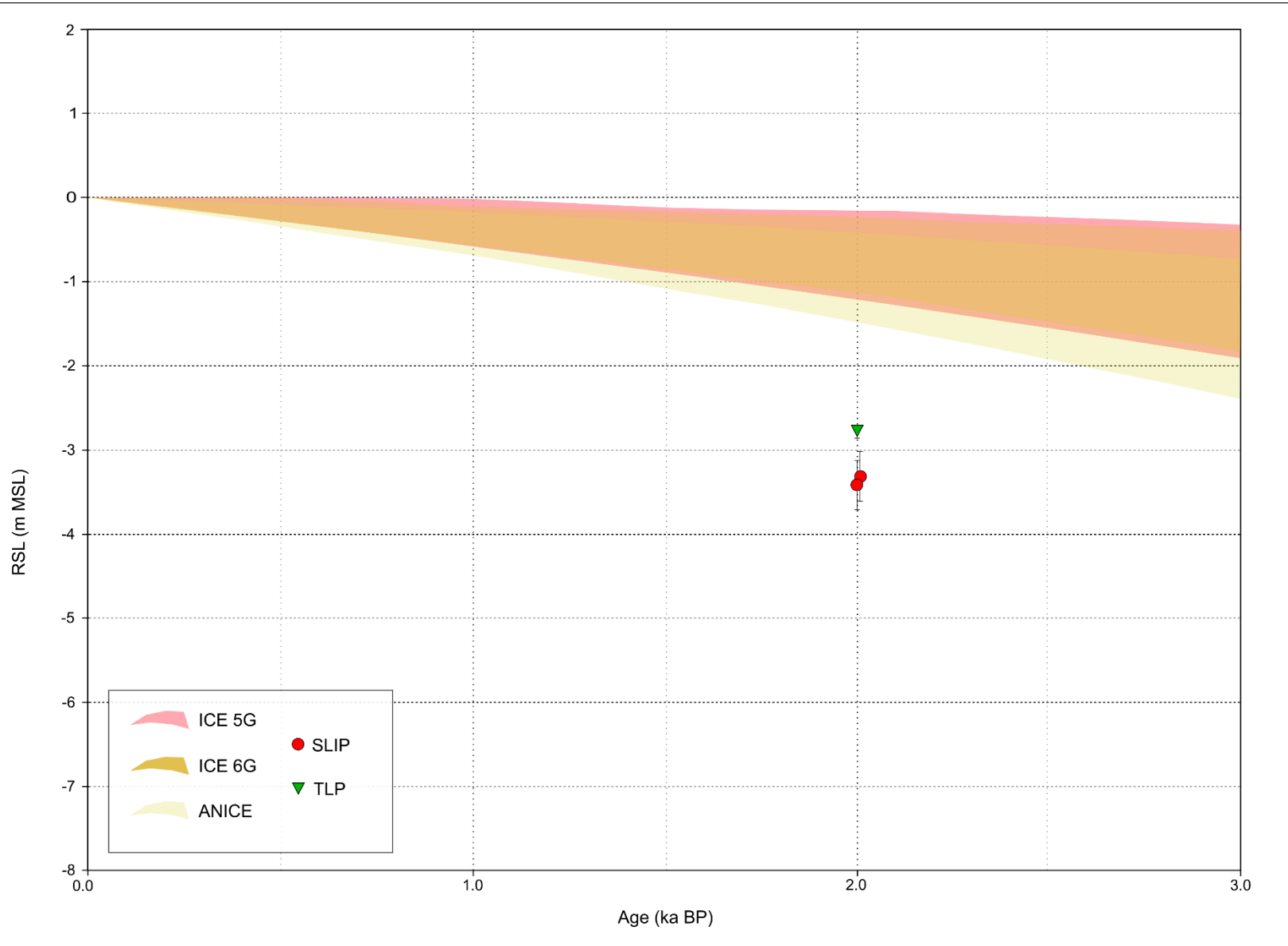


Coastal Landforms		Sea-level Markers	
	Beach		Sea-level Index points (SLIPs)
	Paleo-beaches and eluvial-colluvial deposits		Fish tank
	Paleo-sea cliff		Pier
	Rocky coast		Terrestrial limiting points (TLPs)
	Sandy beach		Building
	Present-day shoreline		Infrastructure
	Lagoonal basin		Boreholes/Excavation
	Activeshore platform		
	Paleo-shore platform		
	Shore-platform outer margin		
	Uplifted terrace		
	Present-day bathymetry		
Anthropic Forms			Thermal bath
	Anthropic coast		Tomb
	Archaeological site		
	Underground cavities		
	Tunnel entrance		
	Anthropic structures		
	Building		
	Tank		
	Nymphaeum		
	Villa		
	Theatre		
	Temple		
Volcanic Landforms			Cone side
			Crater rim
			Caldera rim
			Tuff cone rim
			Tuff ring
			Lava dome
Structural-control Landforms			Fault scarp



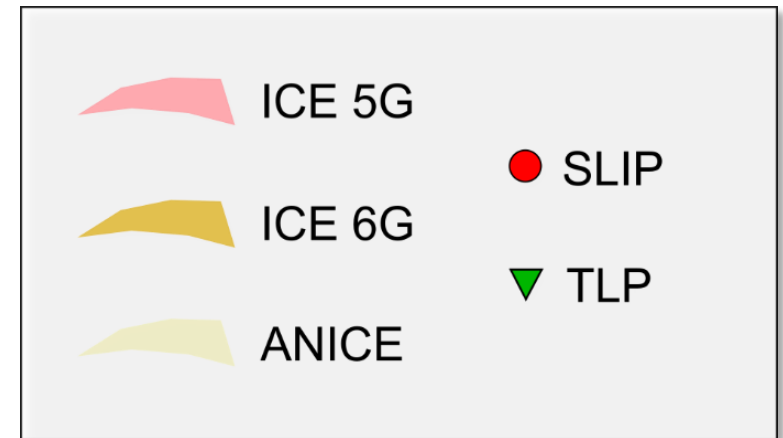
### Sector 1: Reconstruction of the Roman coastal Landscape



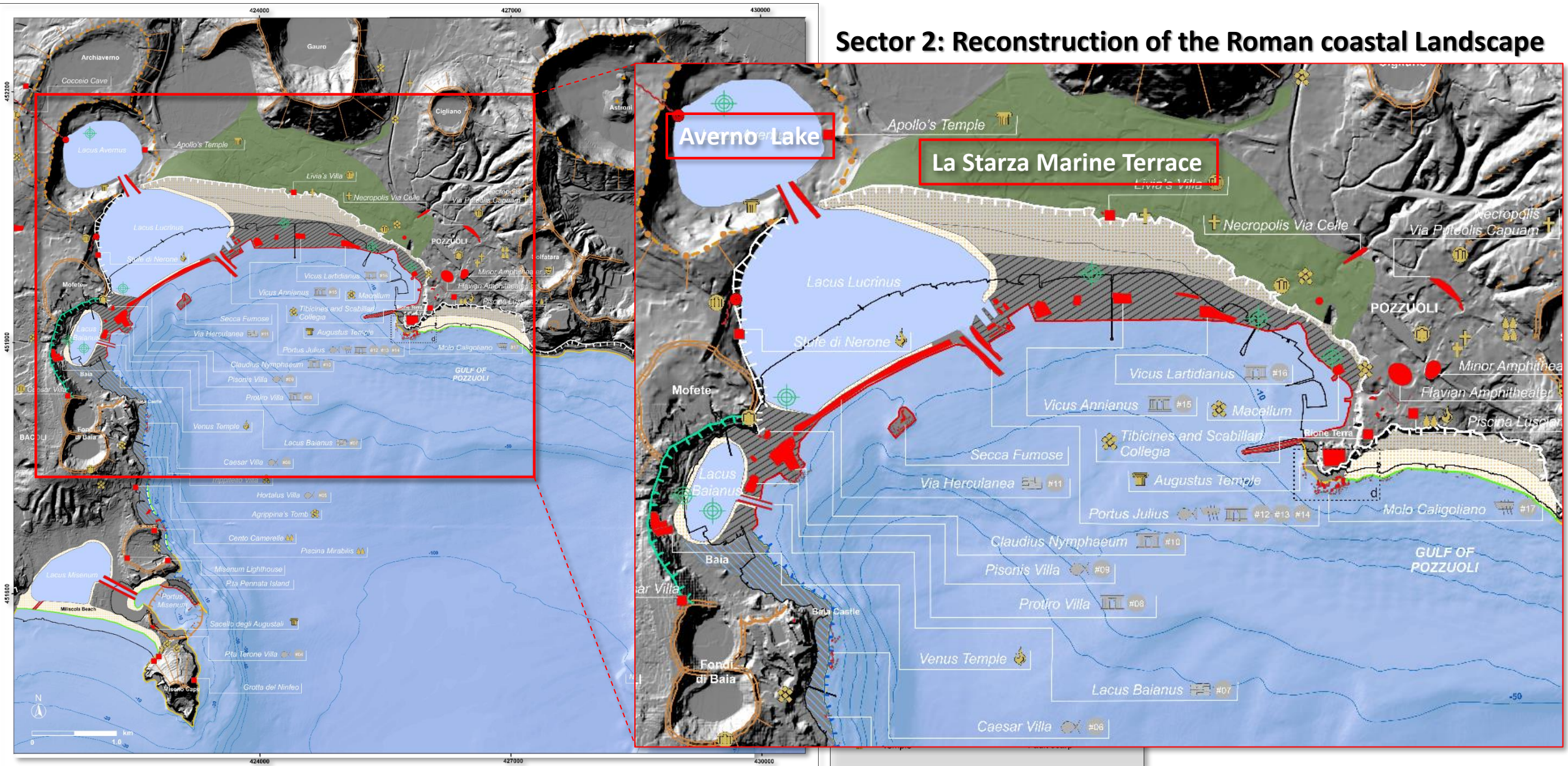


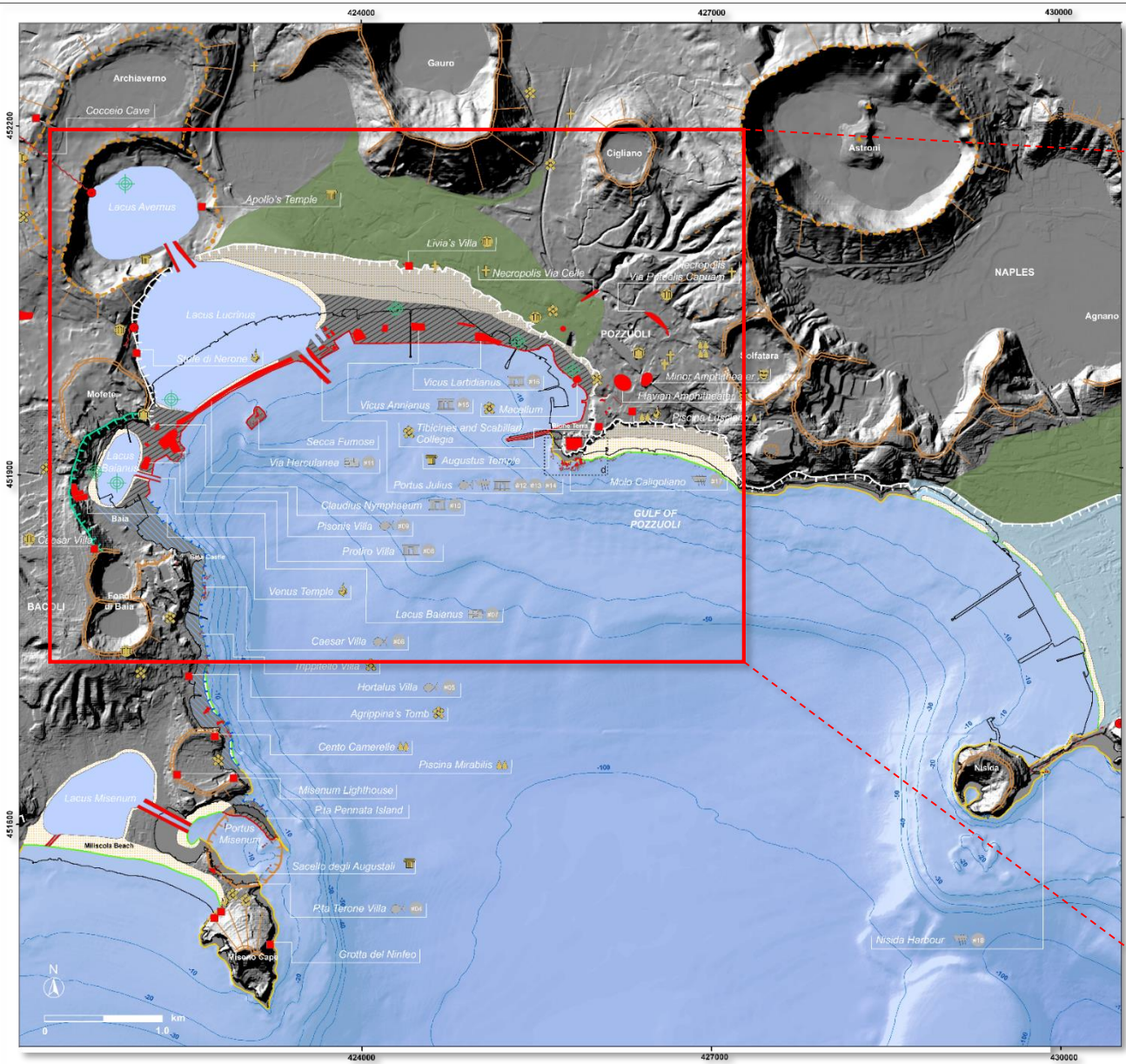
## SECTOR 1

### Comparison between GIA models and RSLs

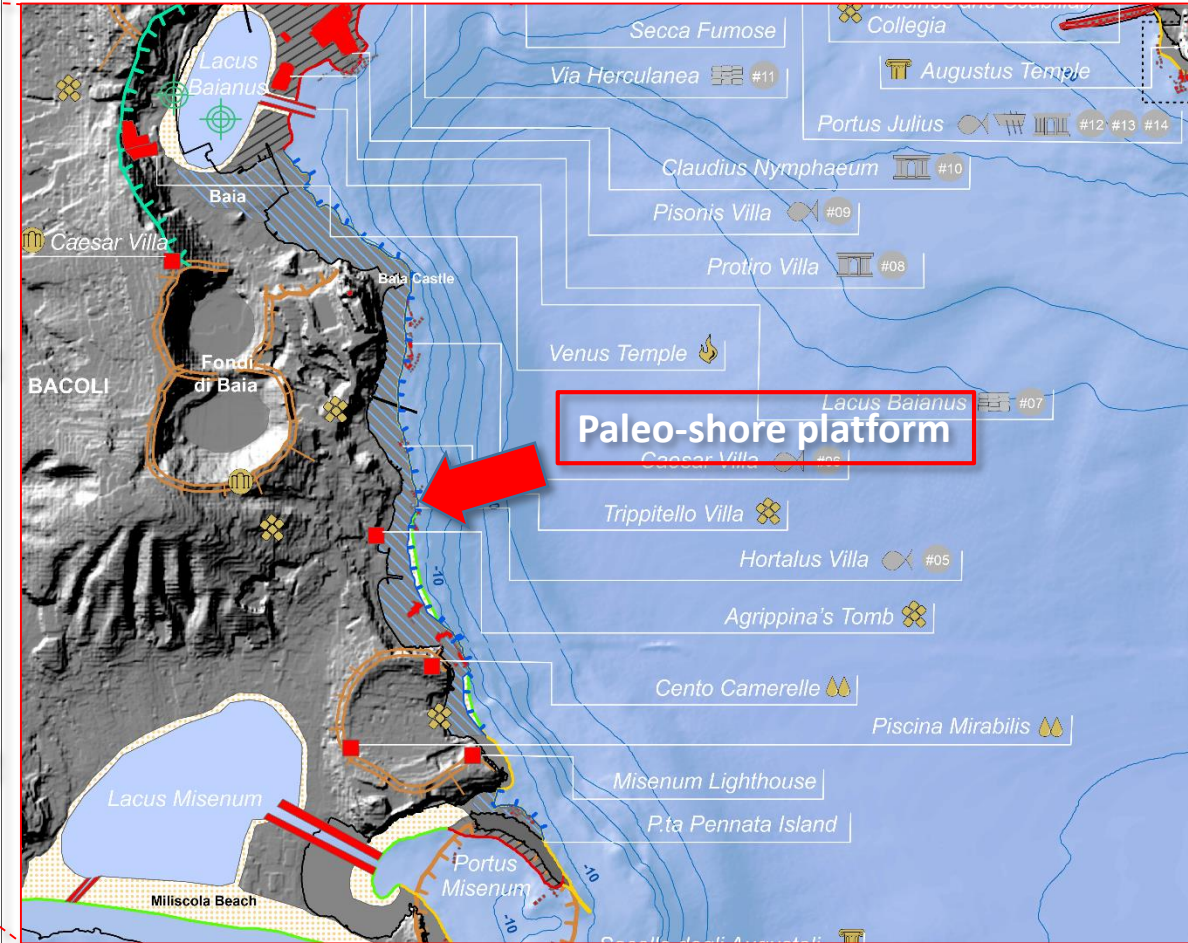


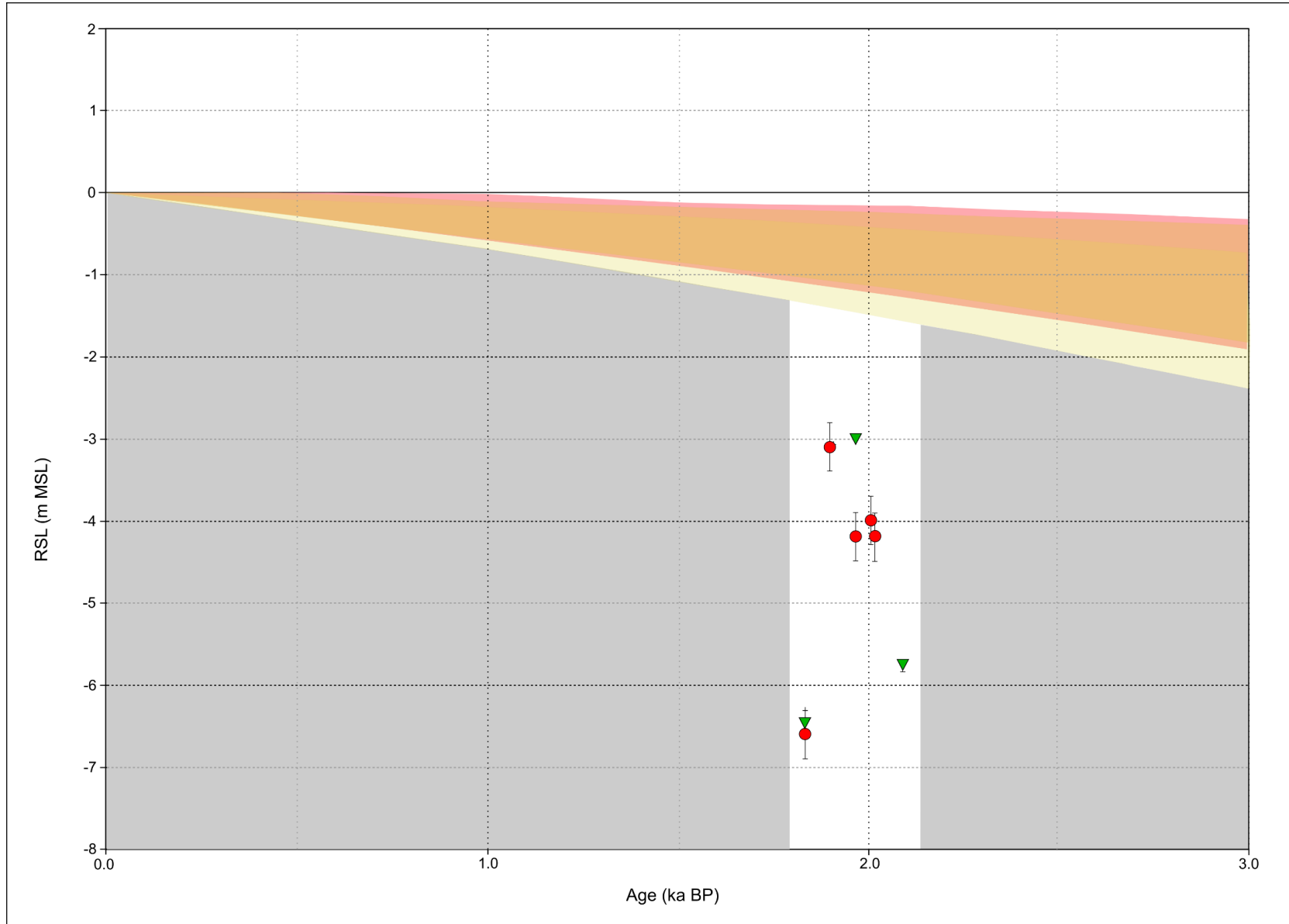
### Sector 2: Reconstruction of the Roman coastal Landscape





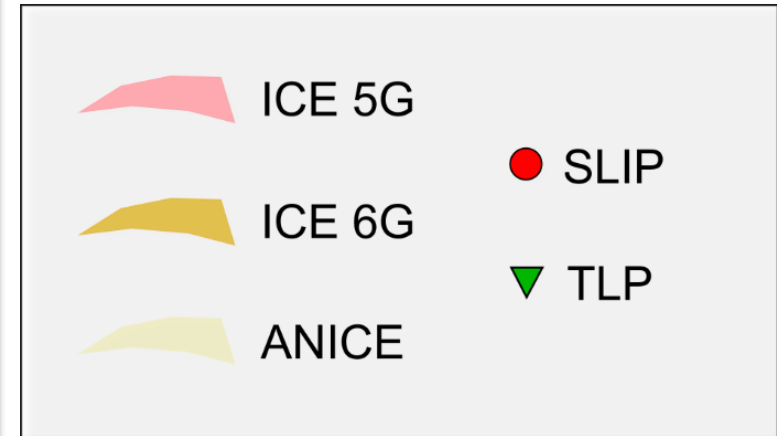
### Sector 2: Reconstruction of the Roman coastal Landscape





## SECTOR 2

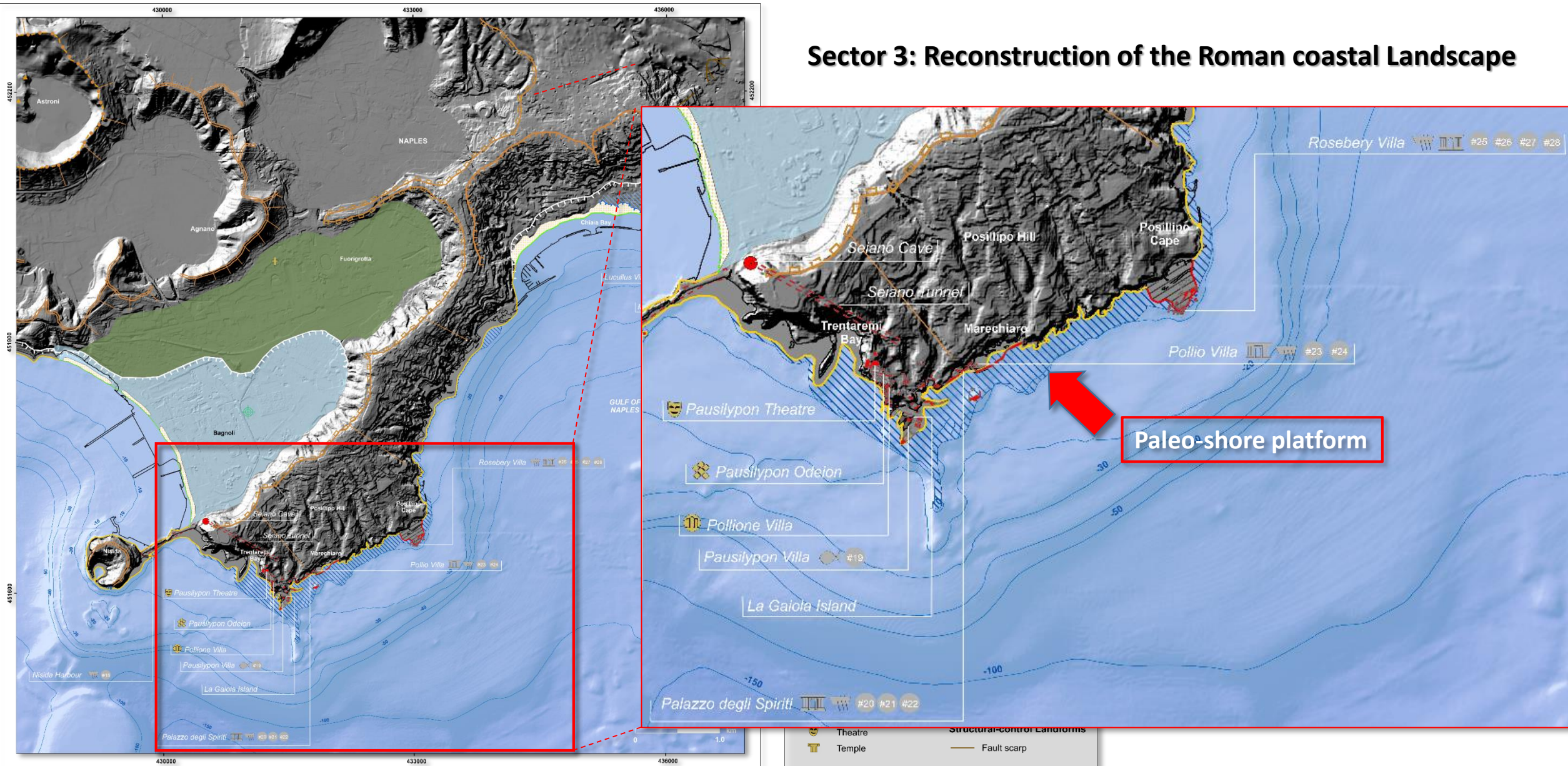
### Comparison between GIA models and RSLs

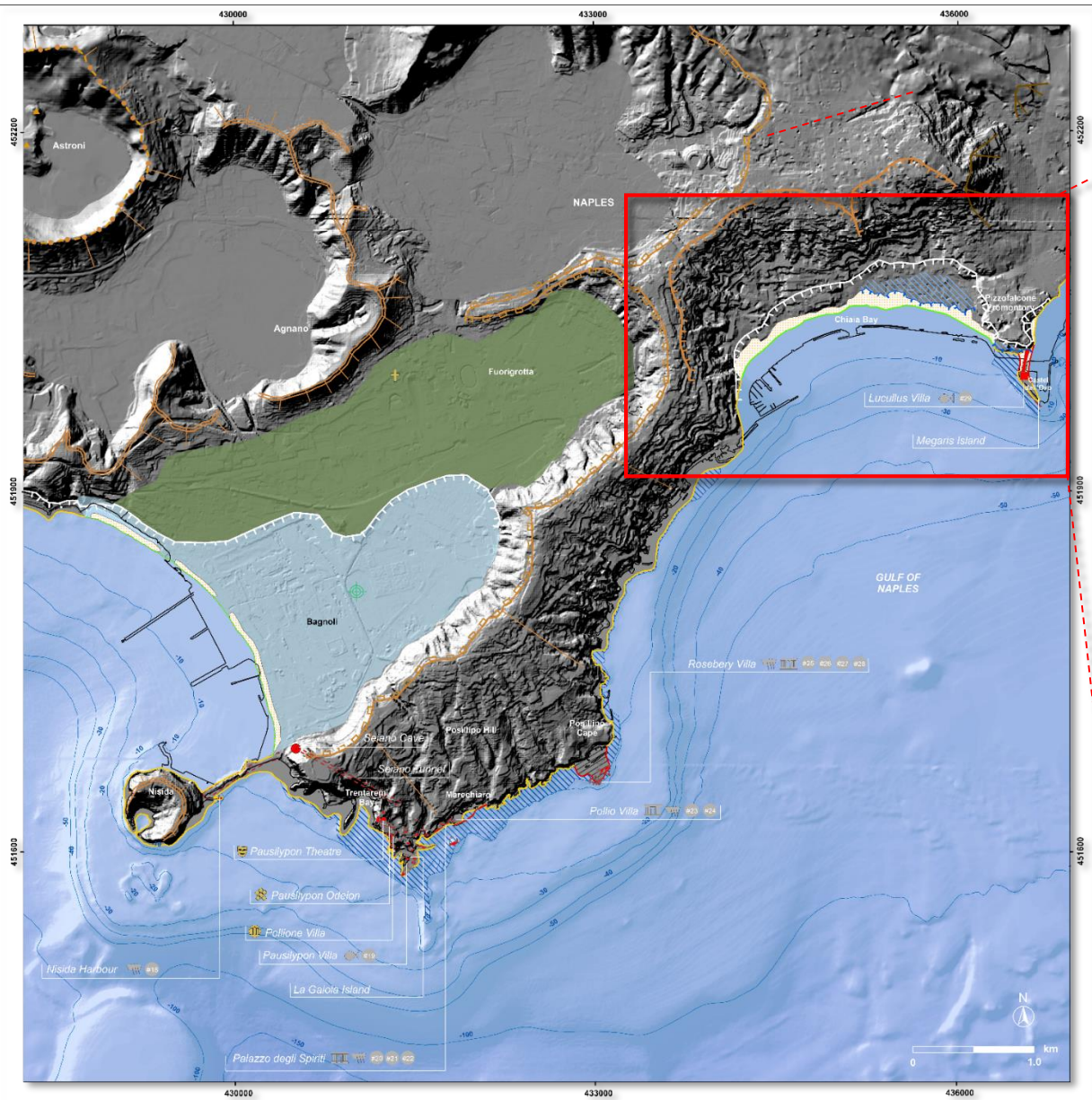


Grey shaded area: Data not included in the considered time span

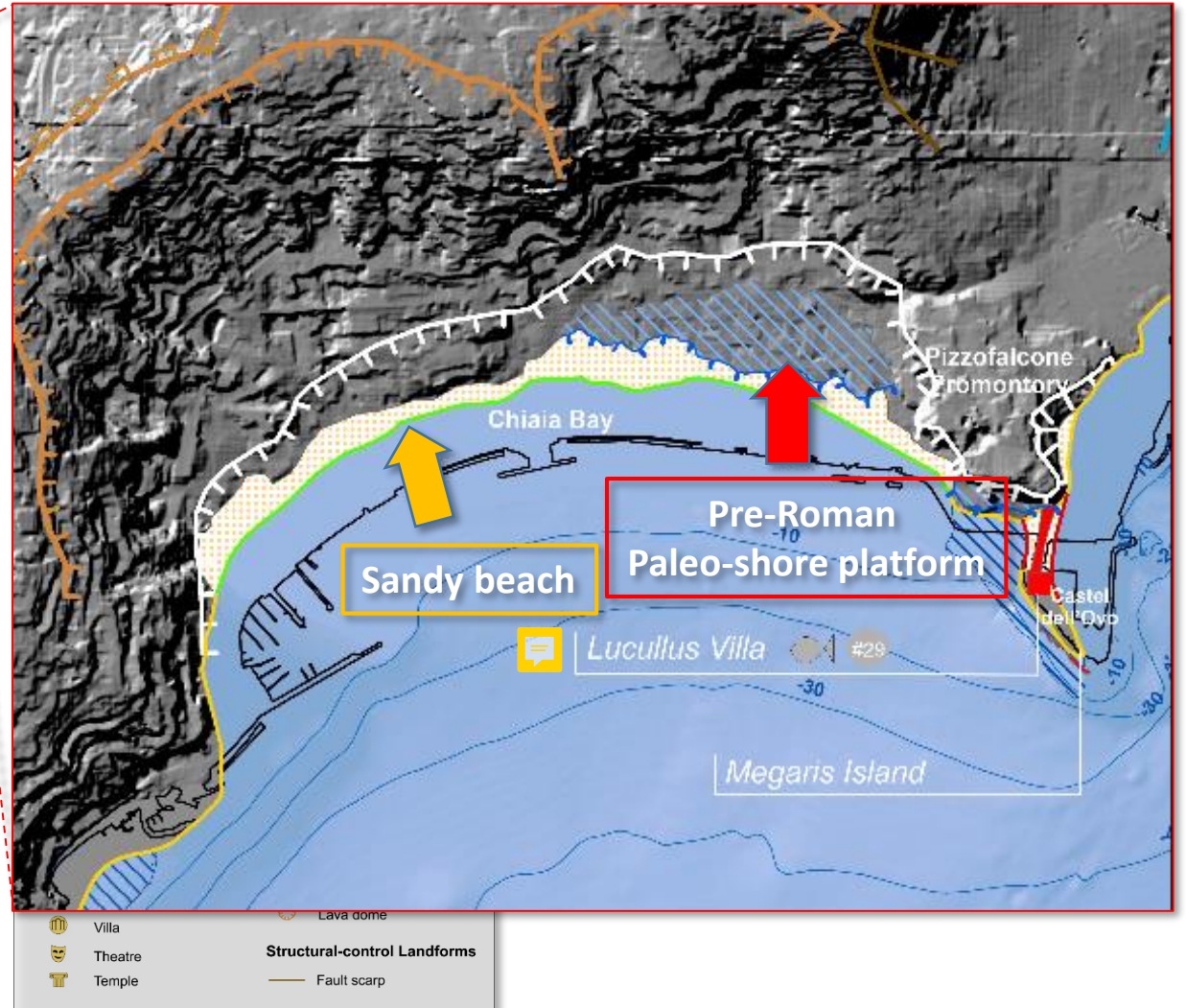


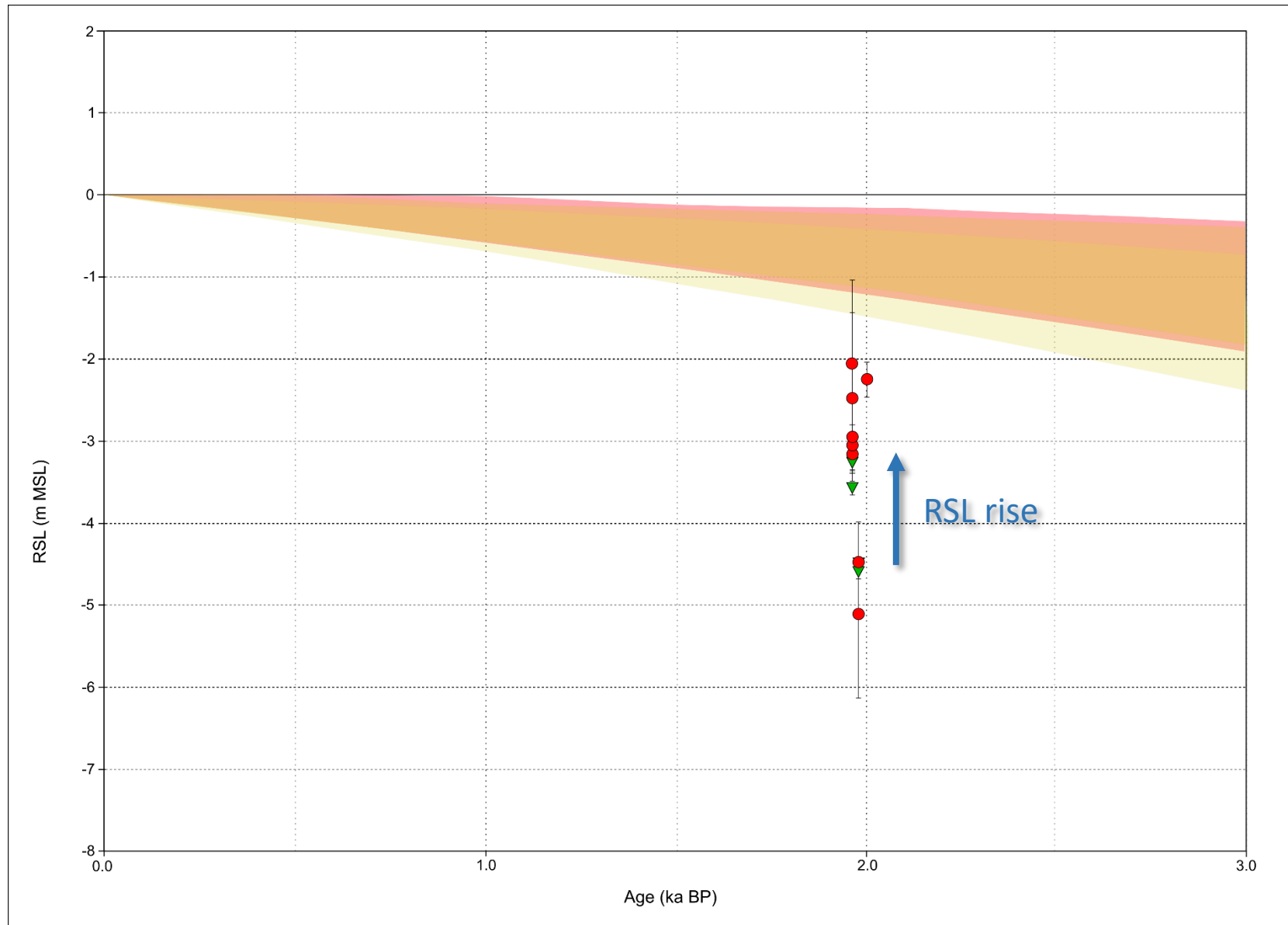
## Sector 3: Reconstruction of the Roman coastal Landscape





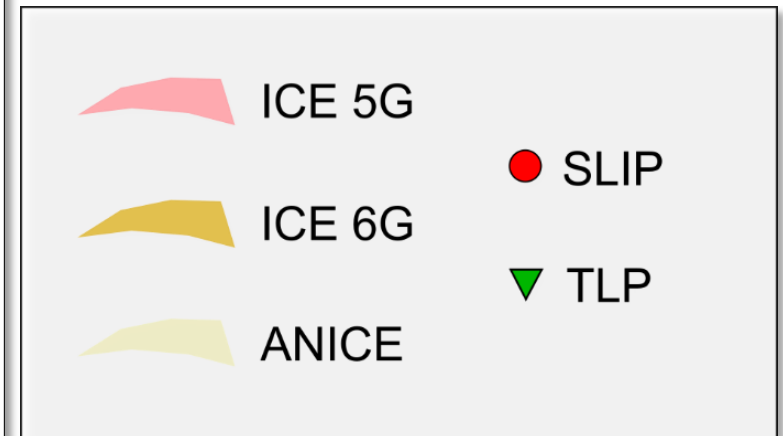
## Sector 3: Reconstruction of the Roman coastal Landscape



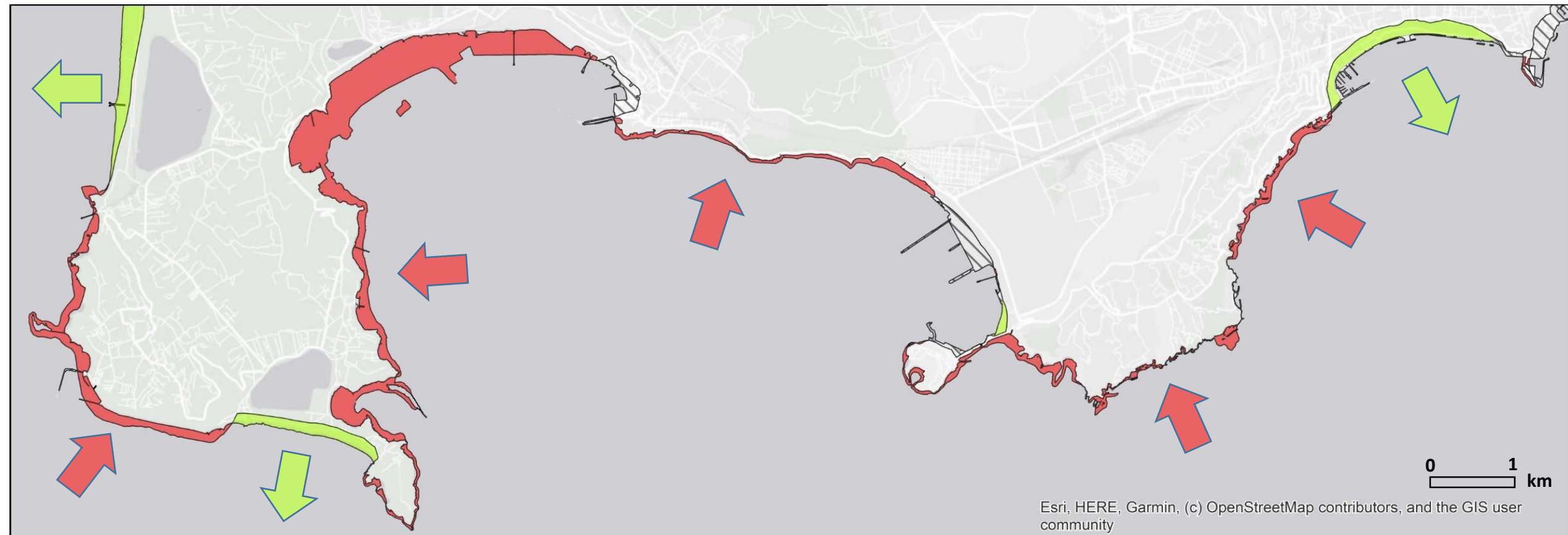


## SECTOR 3

### Comparison between GIA models and RSLs



## CONCLUSIONS – Determination of the overall local coastal trends

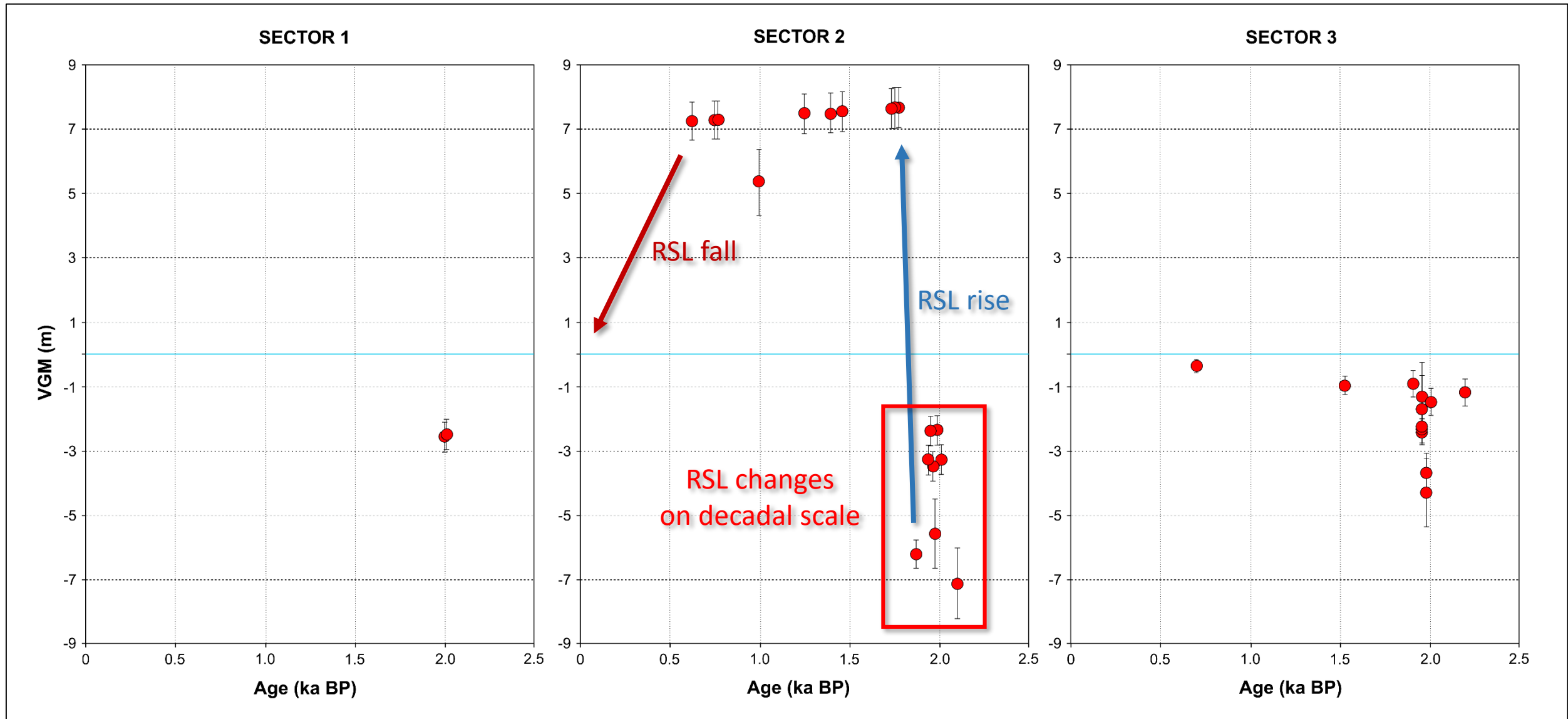


### Coastal trend

█ Retreat    █ Progradation

Anthropic infilling and structures

## CONCLUSIONS – Determination of the local Vertical Ground Movements



# WORKSHOP

20\_21\_22 settembre 2022  
Castello di SANTA SEVERA

**Le peschiere romane del Mediterraneo:**  
vincoli e interpretazioni per la definizione delle variazioni  
del livello del mare negli ultimi 2000 anni

**THANK YOU FOR YOUR ATTENTION!**

caporizzo.claudia@collaboratore.uniparthenope.it

