Geological and Volcanological characteristics of the Western Pontine Islands (WPI)

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SCUOLA ESTIVA DI GEOMORFOLOGIA, ECOLOGIA E BIOLOGIA IN AMBIENTE MARINO E INSULARE
TERZA EDIZIONE

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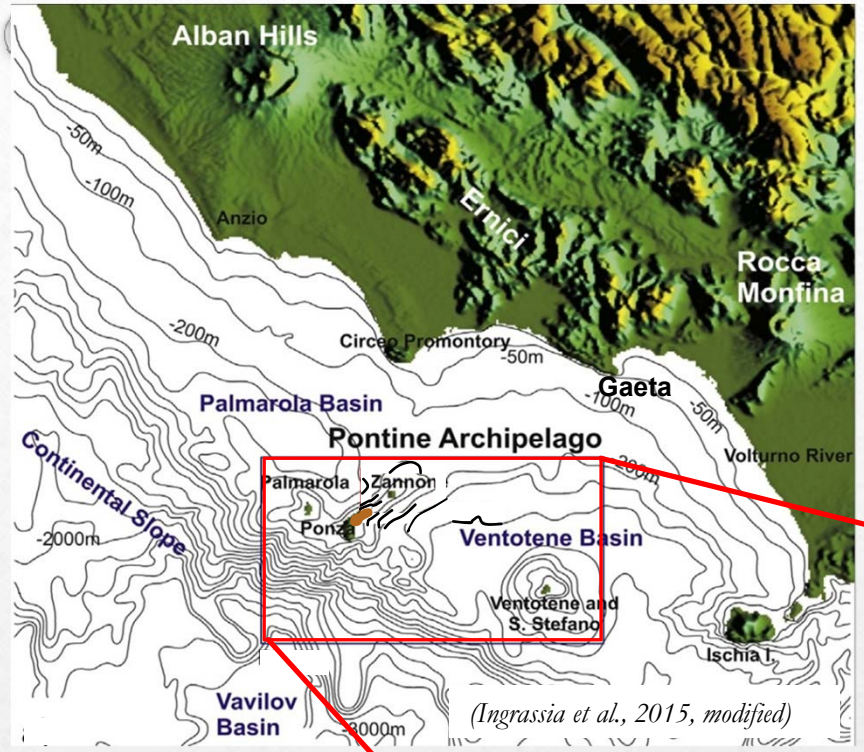
The Western Pontine Islands
Context



(Ingrassia et al., 2015, modified)

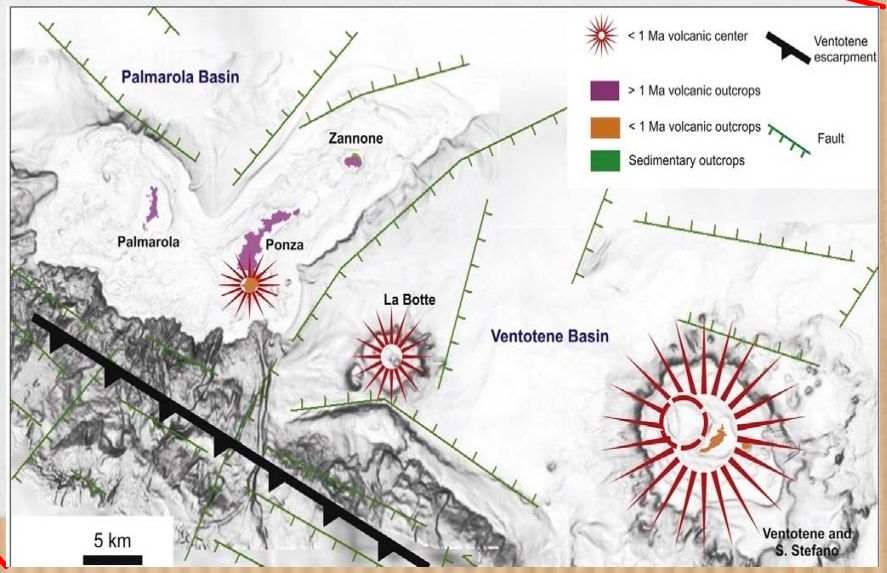
The Pontine Archipelago is formed by a 50-km-long chain of five islands (Ponza, Zannone and Palmarola - the western islands; Ventotene and Santo Stefano - the eastern islands), localized on the eastern Tyrrhenian continental margin, between the Circeo Promontory and the Gaeta Gulf.

In this sector the margin is characterized by a narrow continental shelf (delimited by the -200 m isobaths) of about 25 km, connected to the bathyal Vavilov plain through a steep escarpment NW-SE oriented.

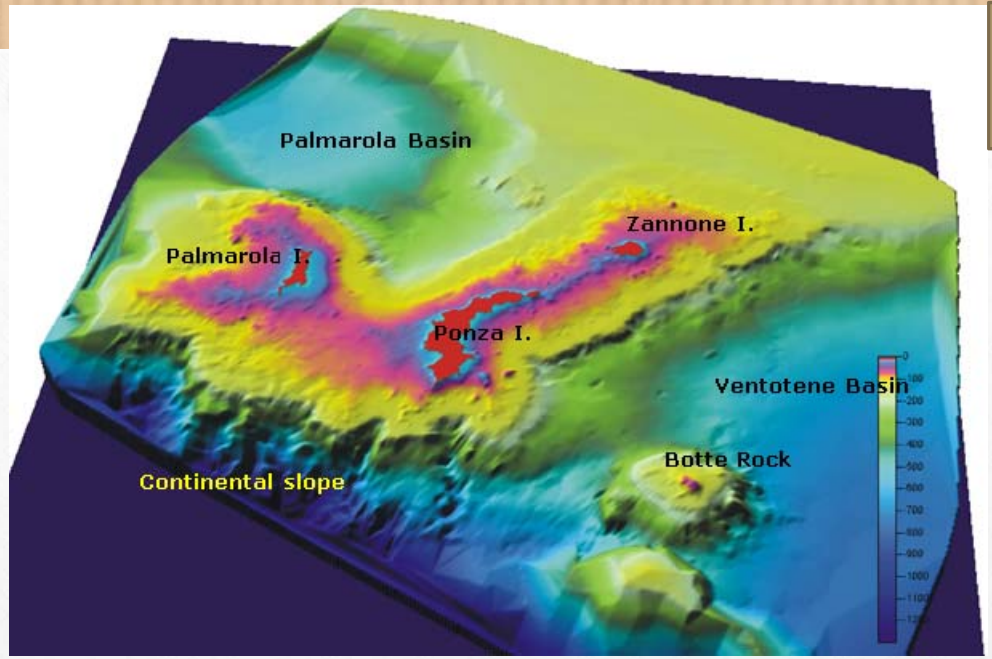
Maximum shelf extension is reached offshore Circeo Promontory (more than 40 km), where a NE–SW elongate structural high divides the two major areas of sedimentation: the intraslope basins of Palmarola (to the NW) and Ventotene (to the SE), both filled by Plio-Pleistocene siliciclastic sequences (Zitellini et al., 1984).

The general setting of the area is commonly ascribed to the Plio-Pleistocene extensional phase related to the opening of the Tyrrhenian Sea, which affected progressively the eastern Tyrrhenian margin.

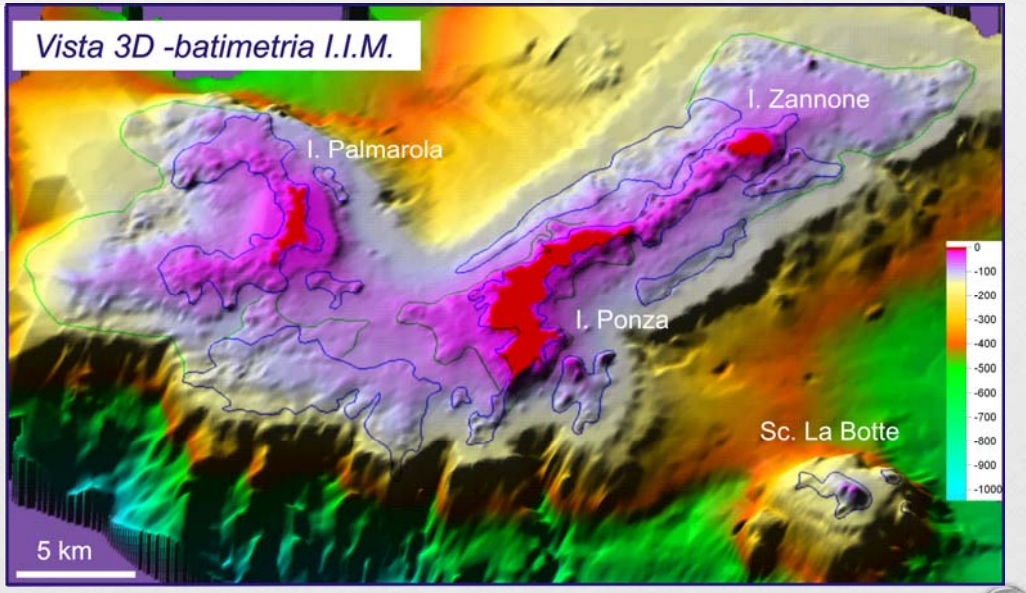
This extensional phase was responsible for the formation of the steep continental escarpment, for the intraslope basins formation and for the general “horst and graben” setting, characteristics of the continental shelf.



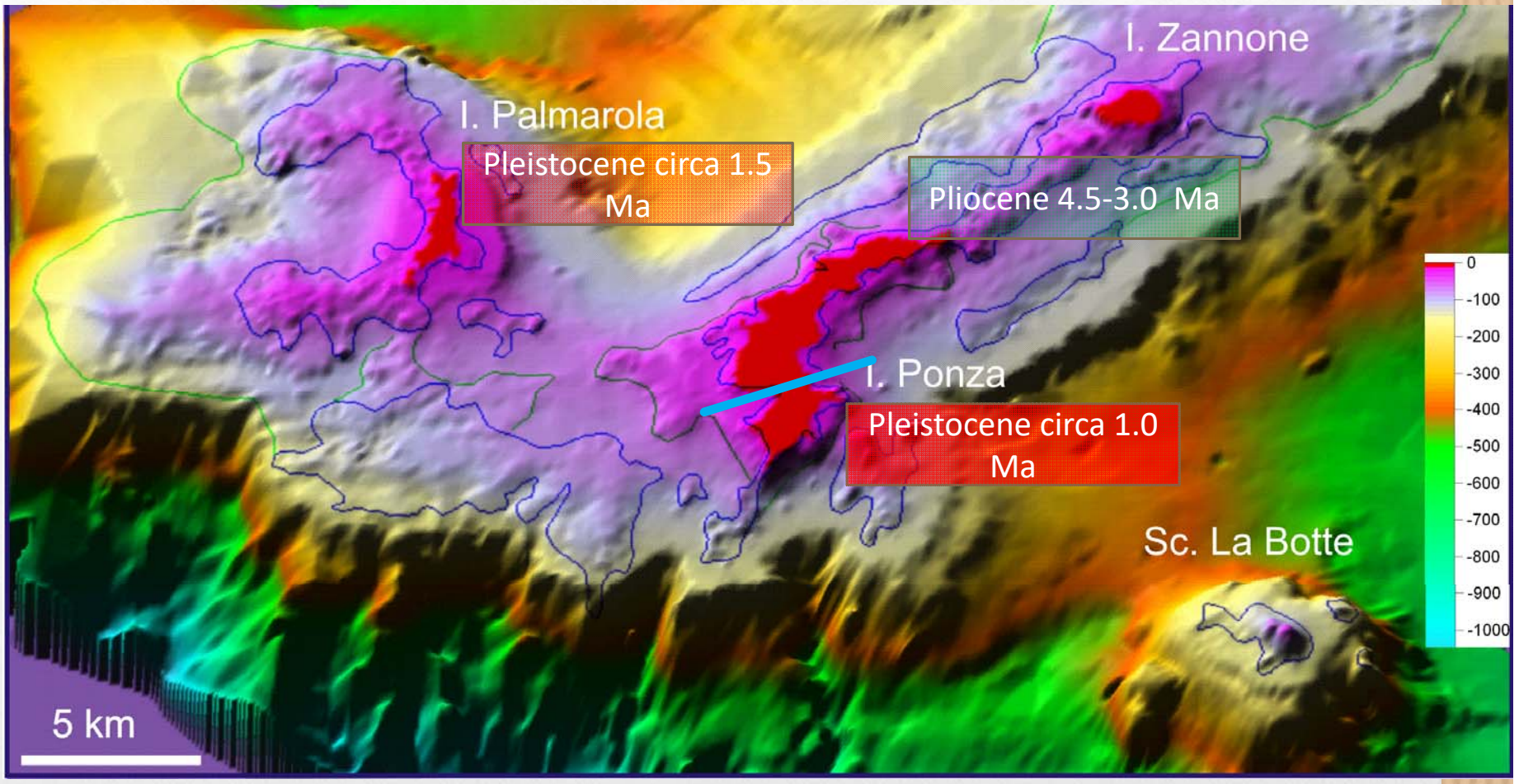
The Western Pontine Islands
Context



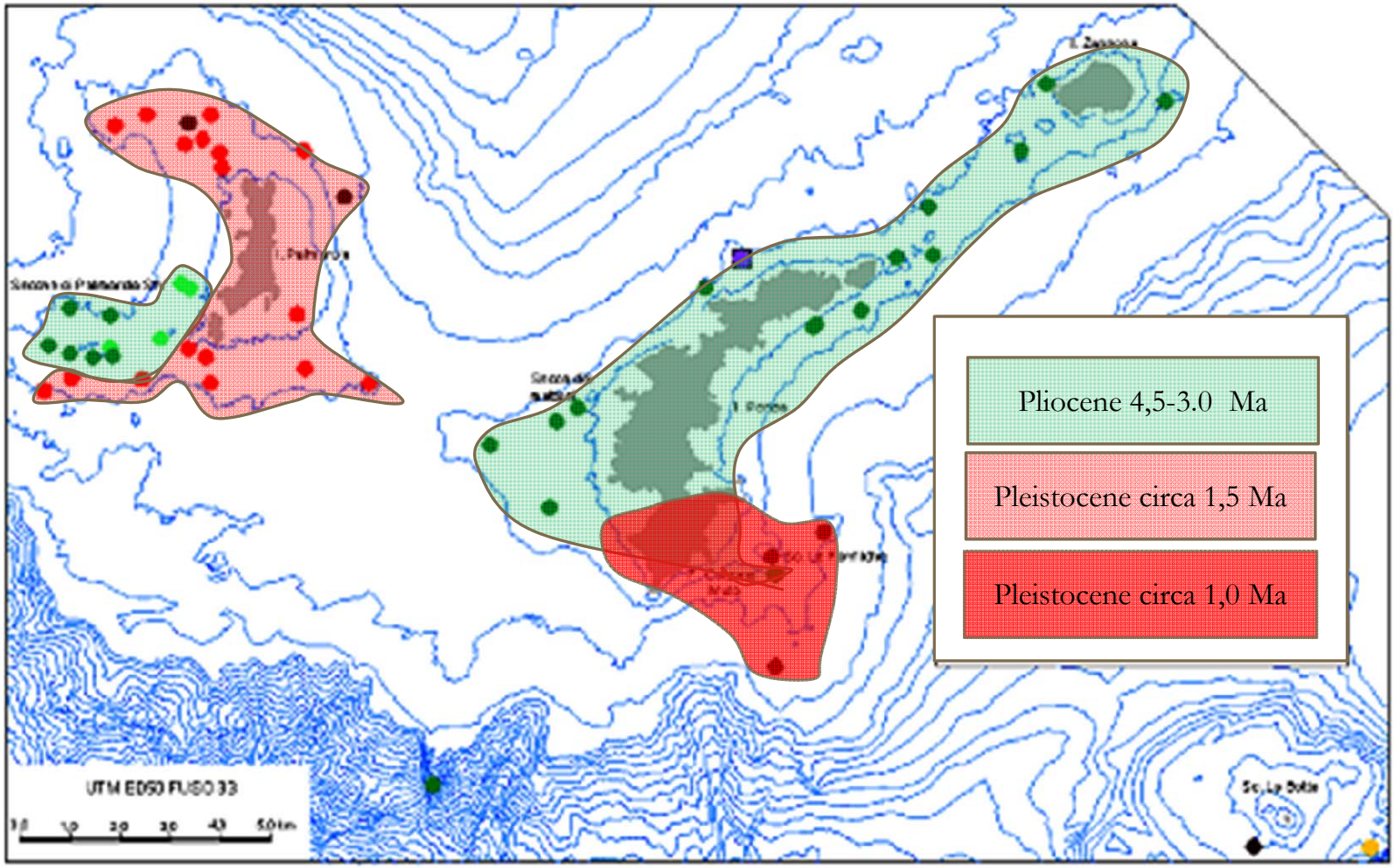
Shaded relief map of the Western Pontine Archipelago evidencing the structural high, bordered by the Palmarola and Ventotene basins and facing the steep continental slope.



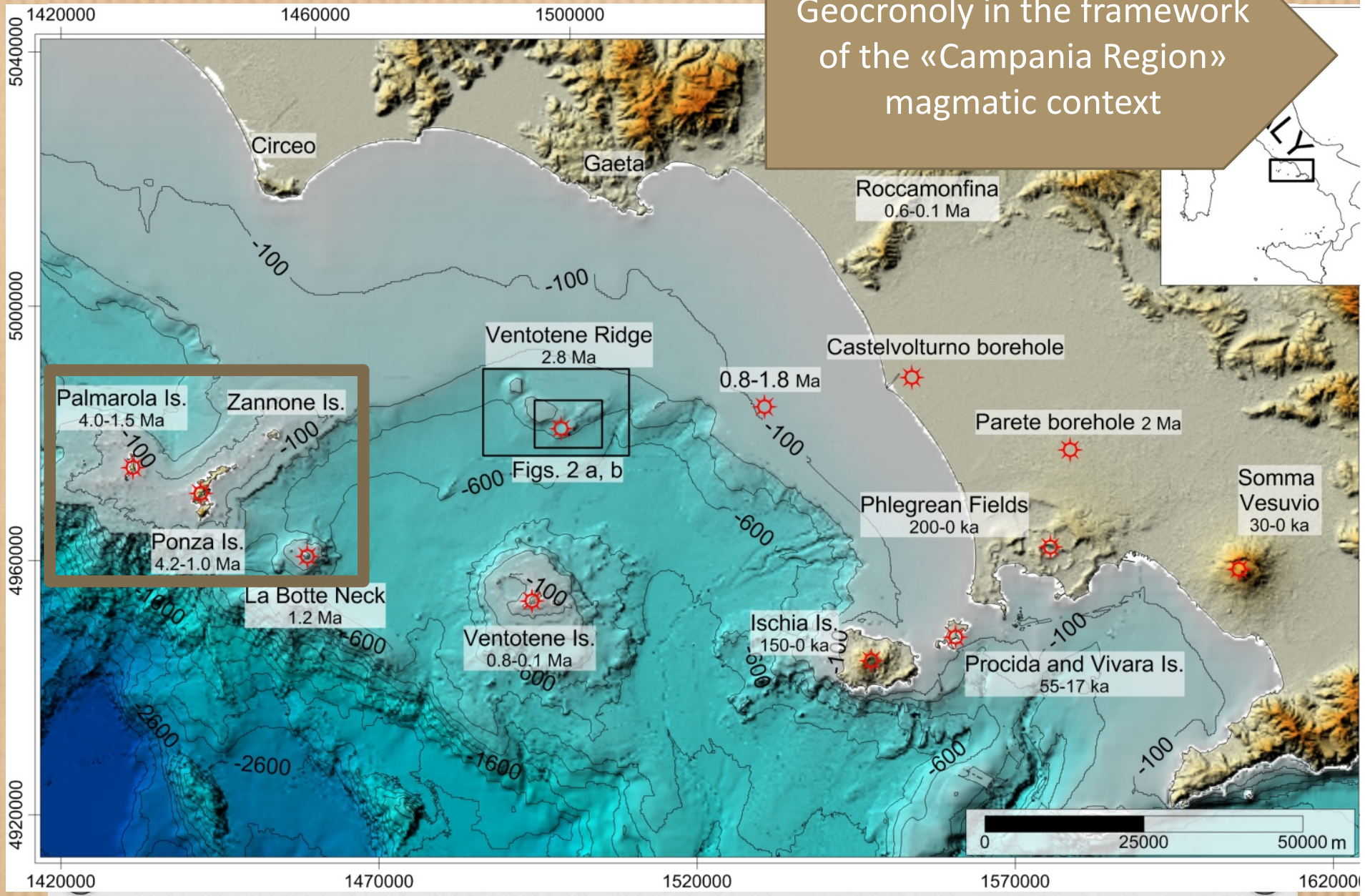
The Western Pontine Islands
Geocronology

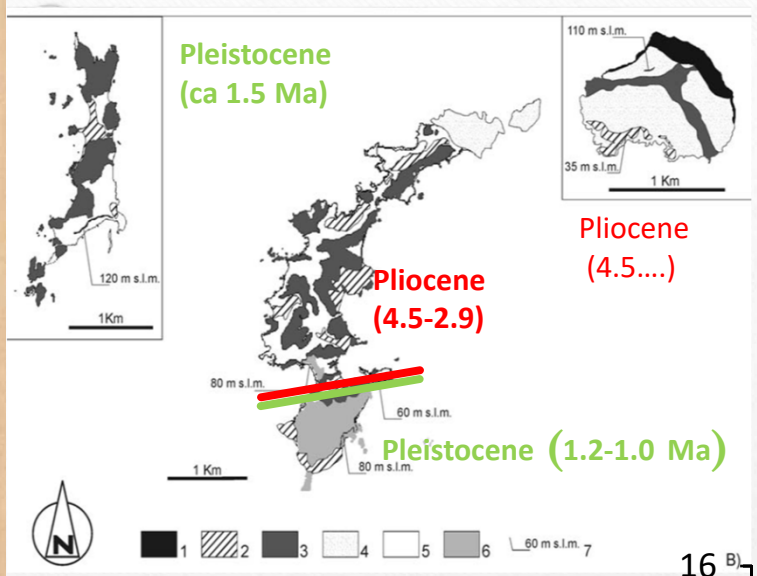


The Western Pontine Islands
Geocronology



The Western Pontine Islands
Geocronoly in the framework of the «Campania Region» magmatic context

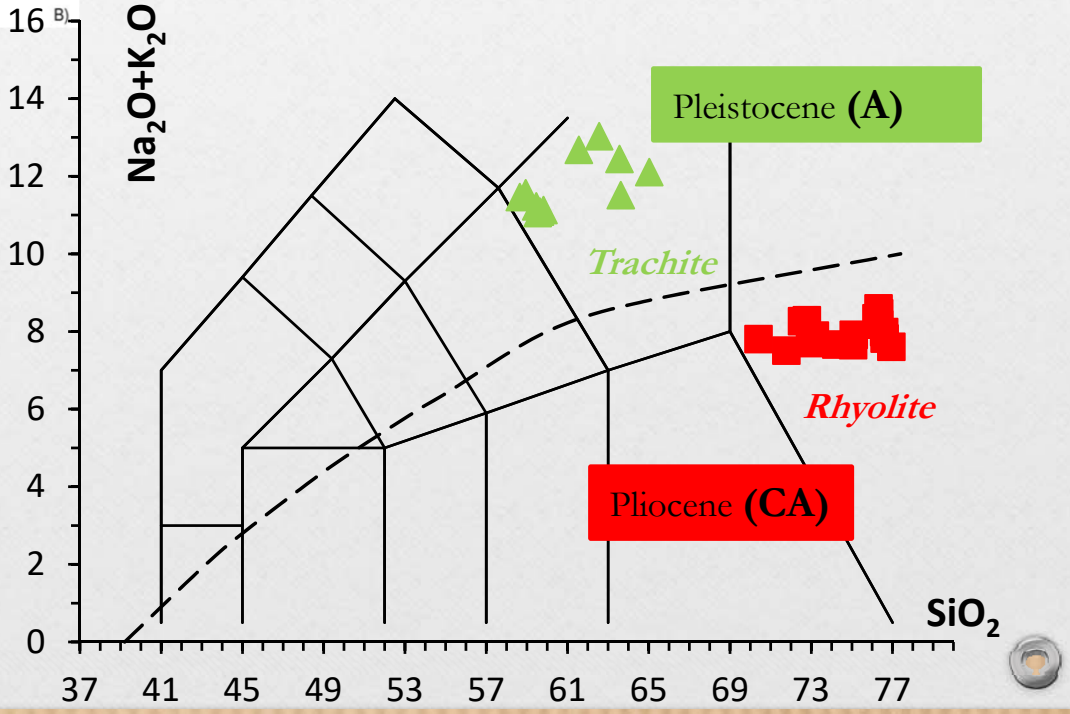




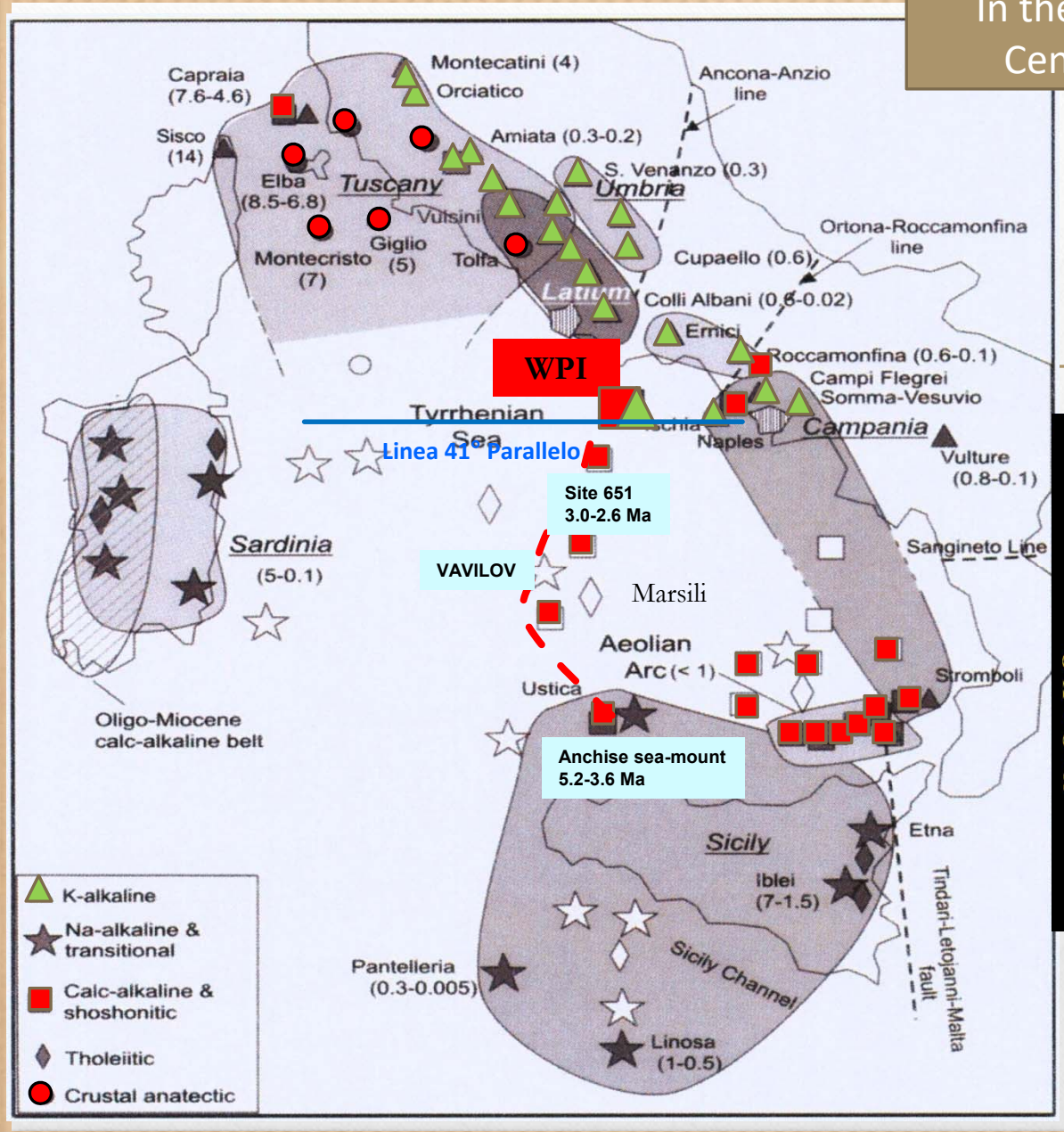
WPI were built during two main volcanic cycles:

1) The **Pliocene** (4.5-2.9 ma) volcanic clycle produced **silica-rich, calcalkaline (CA) RHYOLITE** volcanic units which constitute the dominant products in Ponza and Zannone Islands;

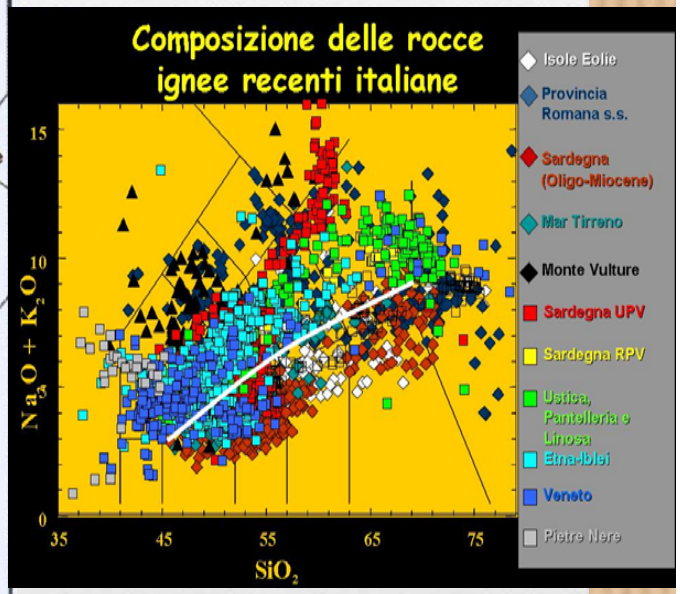
2) The **Pleistocene** (1.6-1.0 ma) cycle produced alkali-rich **"alkaline" (A) TRACHITE** outcropping in the south-eastern part of Ponza I. and Palmarola I.



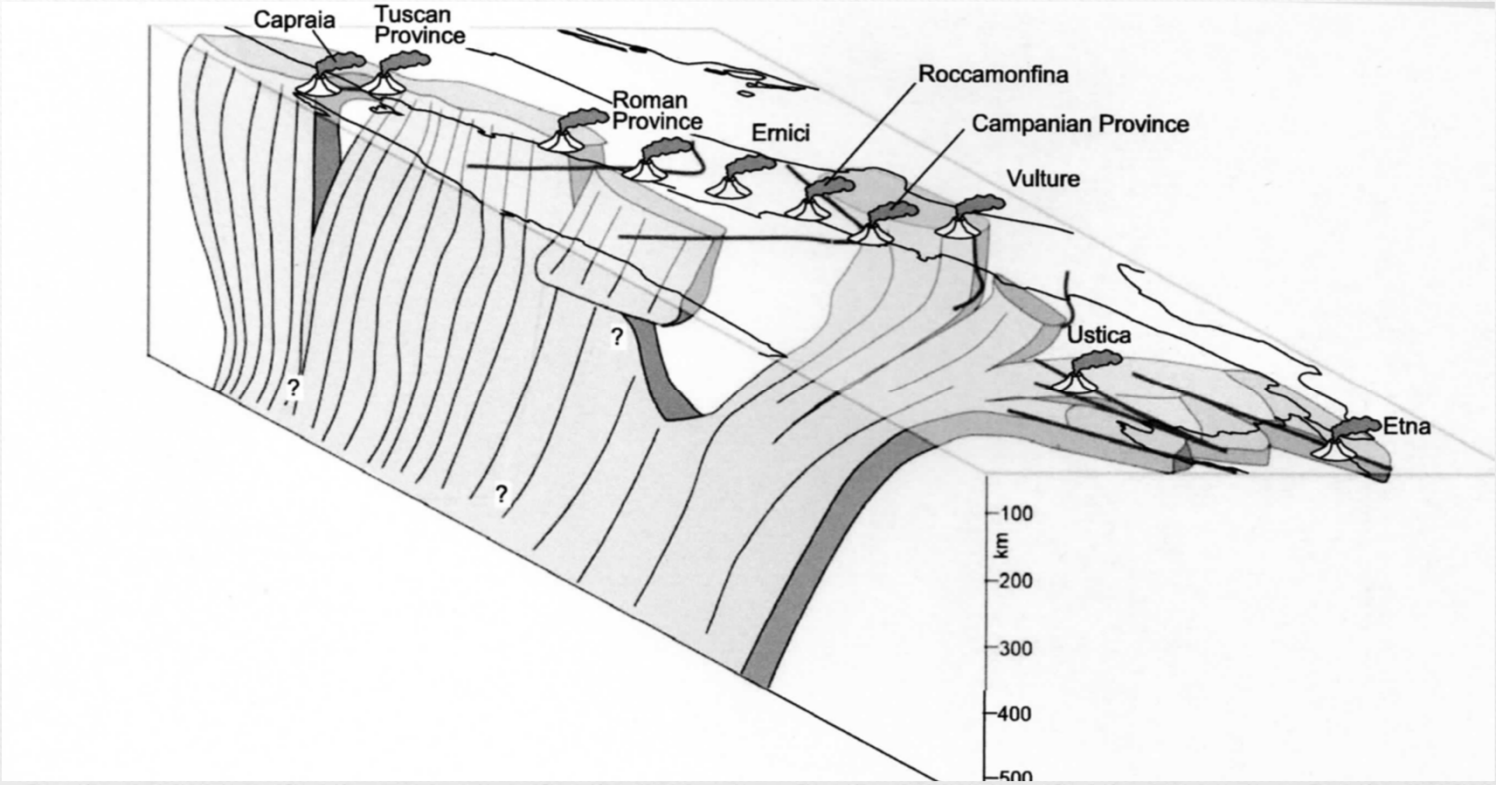
The Western Pontine Islands
In the framework of the Italian Cenozoic magmatic context



The magmatism of Western Pontine Islands marks the transition from calcalkaline **(CA)** to alkaline **(A)** magma series.

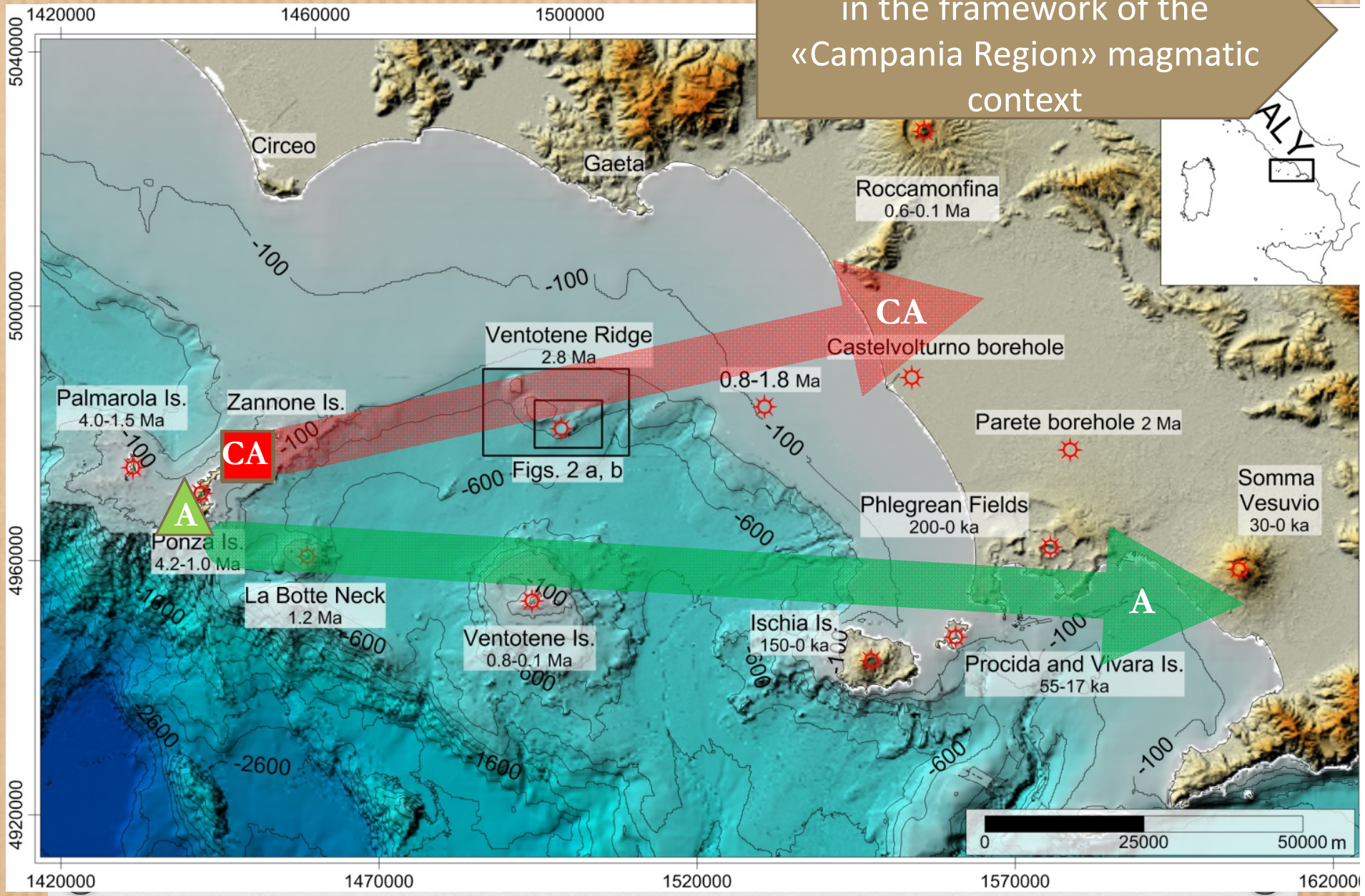


Kinematics of slab tear faults during subduction segmentation and implications for Italian magmatism



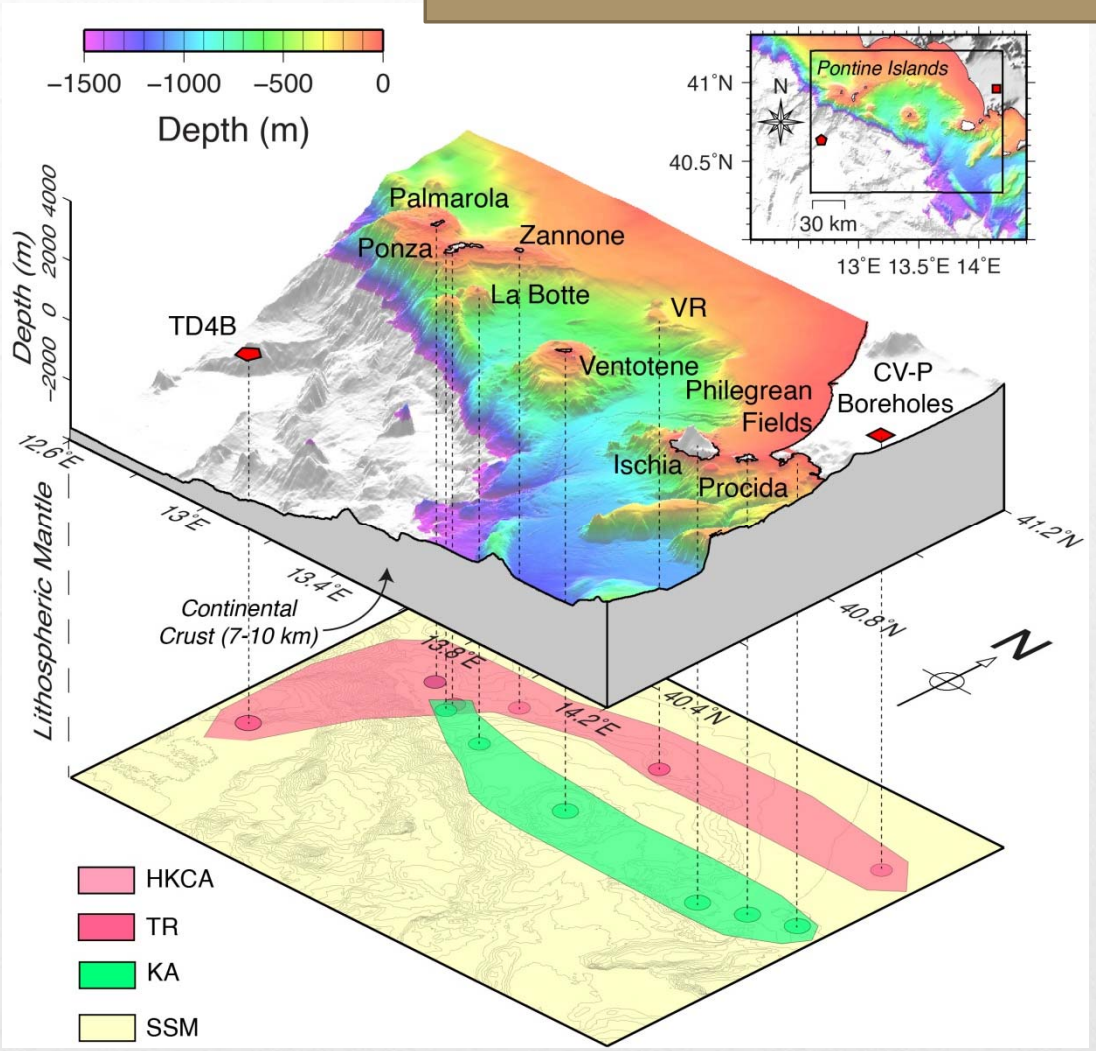
Rosenbaum et al., 2014

The Western Pontine Islands in the framework of the «Campania Region» magmatic context



The Western Pontine Islands
Petrogenetic model

Petrogenetic scheme relating mantle sources and generated magmas in the Central Tyrrhenian domain.



HKCA: CA
TR: CA
KA: A
SSM: supra-subduction mantle source

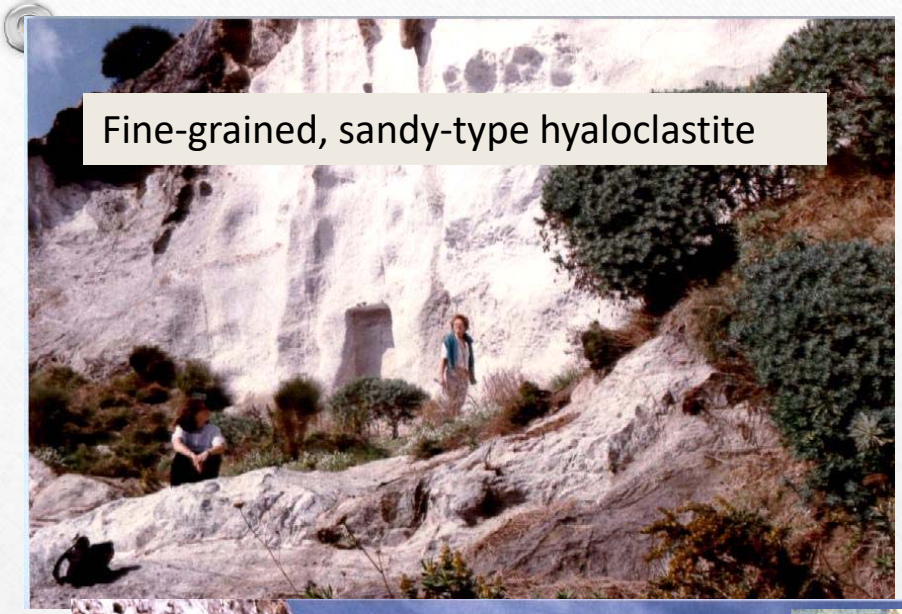
Conte et al. 2020

The Western Pontine Islands
Volcanology: Rhyolitic Hyaloclastite

……such rocks made Ponza famous in the scientific world **as the first example of acid hyaloclastite** and **still provide an excellent case study for the *acidic* submarine volcanism**.

The Western Pontine Islands

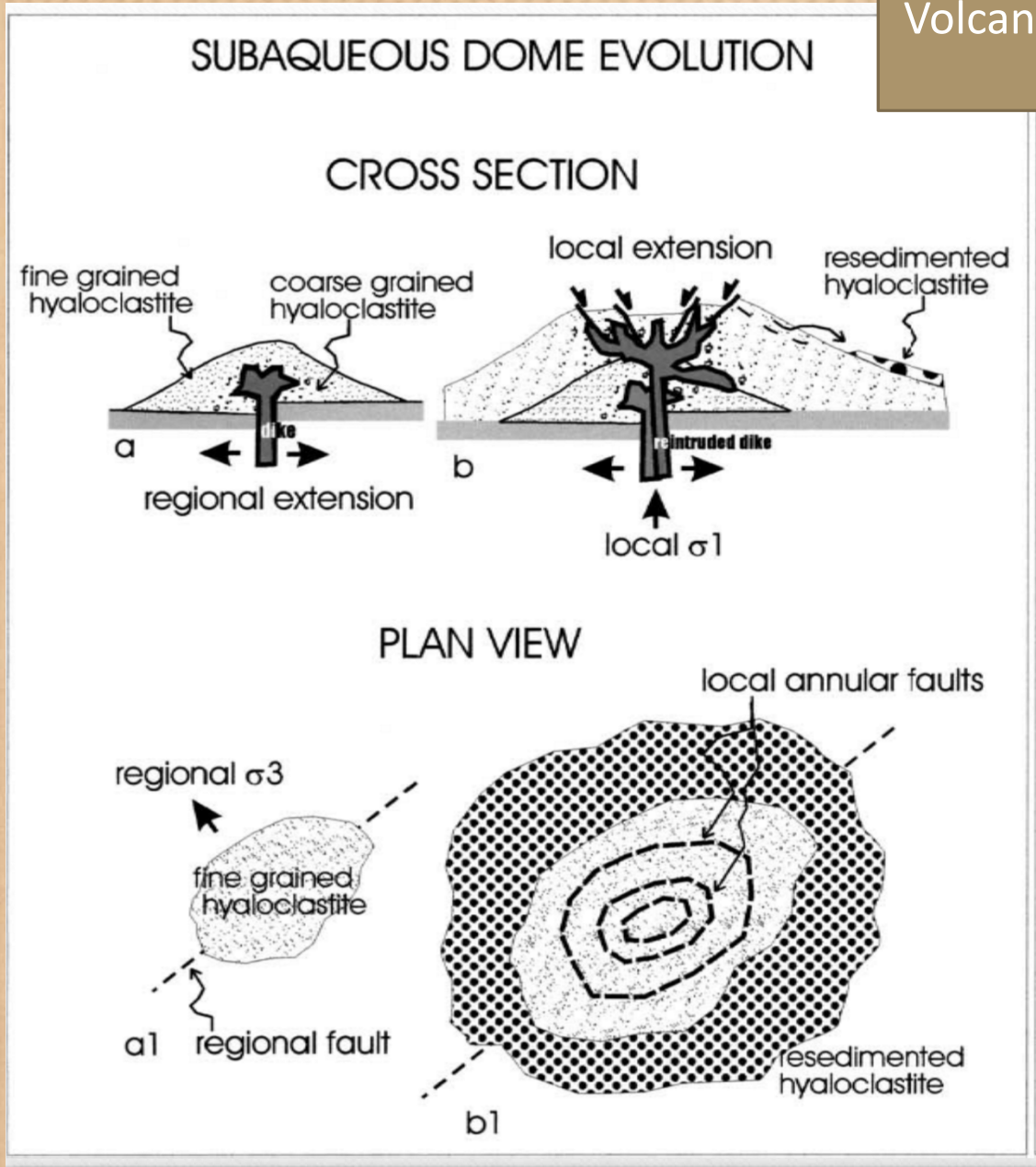
Volcanology: Various Hyaloclastic facies



Hyaloclastic unit in its coarsest facies showing large (pluri metric) obsidian blocks in a coarse sandy matrix.

The Western Pontine Islands
Volcanology

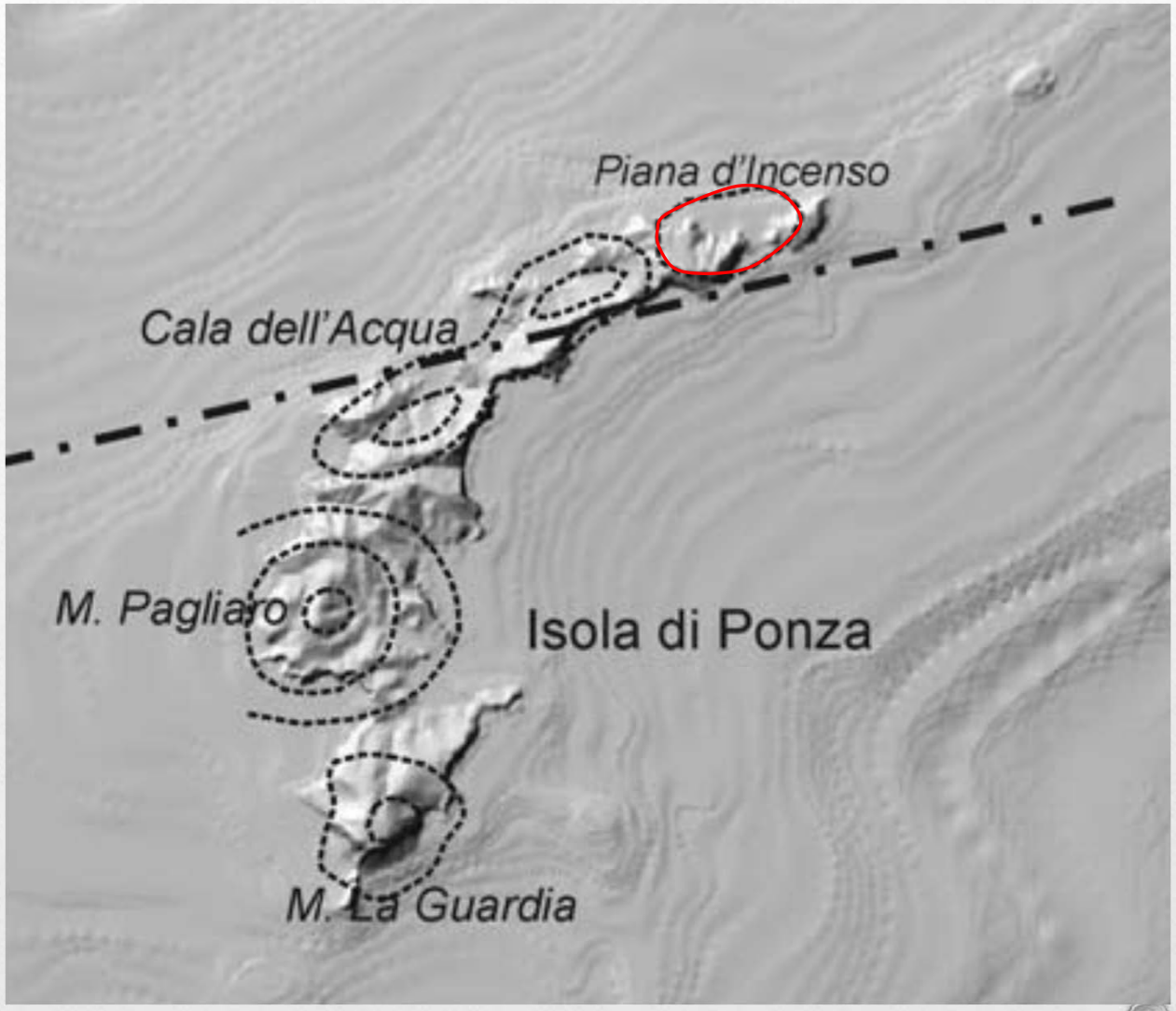
The Western Pontine Islands
Volcanology: *the hyaloclastite-dykes systems*



Genesis and evolution of the volcanic units on Ponza giving a detailed description of the different hyaloclastic facies and relating the dykes emplacement due to the extensive regional tectonics

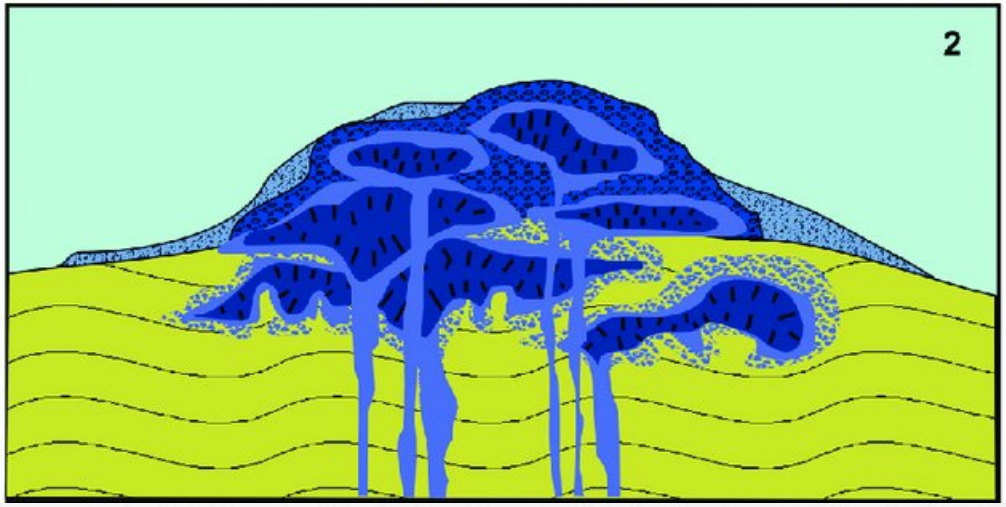
Caemassi et al., 1983

Three main coalescing domes of about 1km radius, centred at Cala dell'Acqua, Cala Fontana and M.te Pagliaro and aligned along a NE trending regional fracture, have been identified at Ponza on a morphological basis



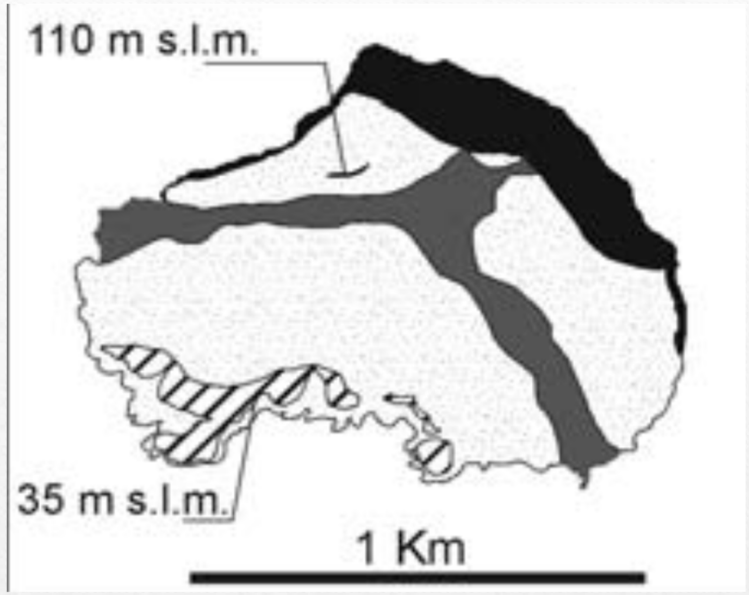
Geology: Piana dell'Incenso criptodoma

Evoluzione di un criptodoma riolitico endogeno (modified after Németh et al., 2008).



A Piana d'Incenso il doma è diverso dagli altri in quanto non si trova la ialoclastite fine bianca, ma una lava fortemente brecciata in cui spesso si riconoscono strutture di flusso. Ciò fa ritenere che la crescita del domo in questo caso è avvenuta essenzialmente in ambiente subaereo. In questo caso:

- il doma si forma per la lenta risalita di un flusso di lava molto viscosa. La lava si raffredda nelle zone più esterne e, se l'alimentazione non si interrompe, la spinta del materiale caldo rompe la crosta solida.
- La continua frantumazione delle parti solidificate forma un accumulo di brecce che presentano un passaggio sfumato con il corpo di lava massiva.
- Le brecce (talus) sono composte da blocchi spigolosi che rotolano dal fianchi del duomo e si depositano intorno alla base. Il deposito di brecce è quasi sempre privo di strutture, anche se talvolta può presentare stratificazioni con livelli di elementi più grossolani alternati ad altri più fini o a livelli di ceneri derivanti da occasionali esplosioni.

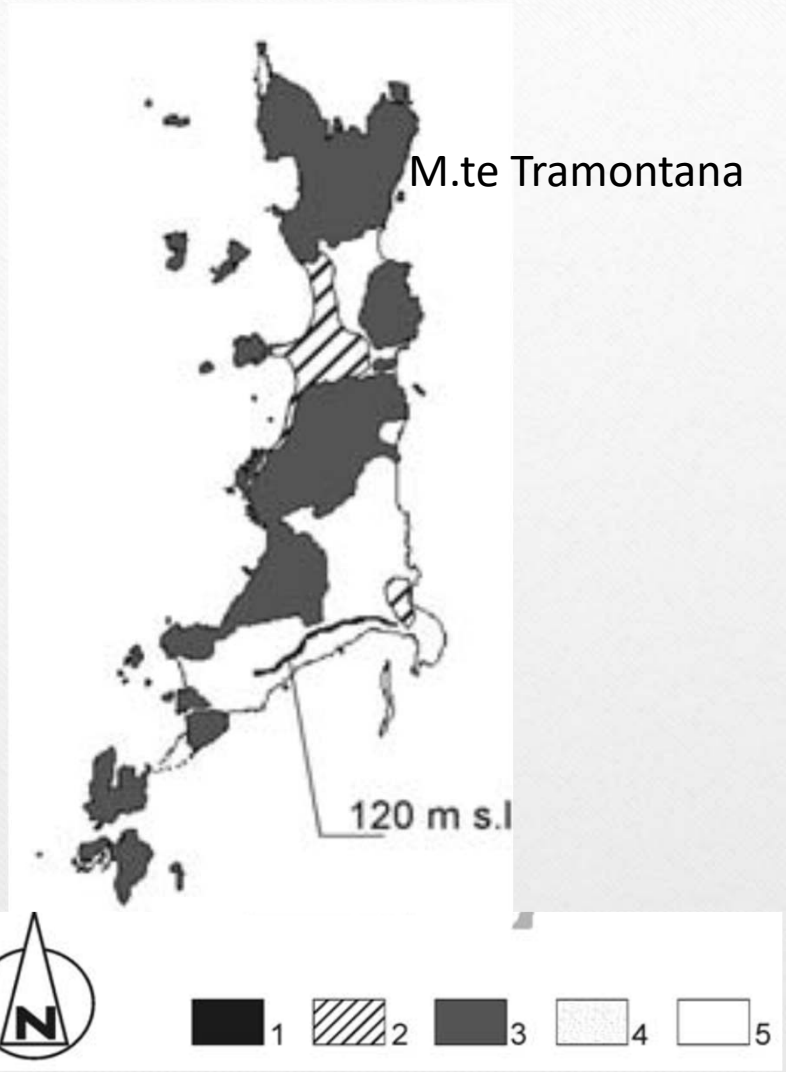


The volcanism in this island occurred in a subaqueous/subaerial environment as a consequence of local eustatic movements connected with the inflation and deflation of the volcanic edifice, following episodic pulses of magma.

The result are cooling units made up by clastic structure resulting by viscous lava flows/sea water interactions and dykes made up by compact lava, similar to that previously described for the doma of Cala d'Incenso.

1) Unità sedimentarie meso-cenozoiche. 2) Unità sedimentarie plio-quaternarie. 3) Lave riolitiche in dicchi. 4) Facies clastica di inerazione acqua/magma. *De Rita et al., 2004*)

Geology of Palmarola I.

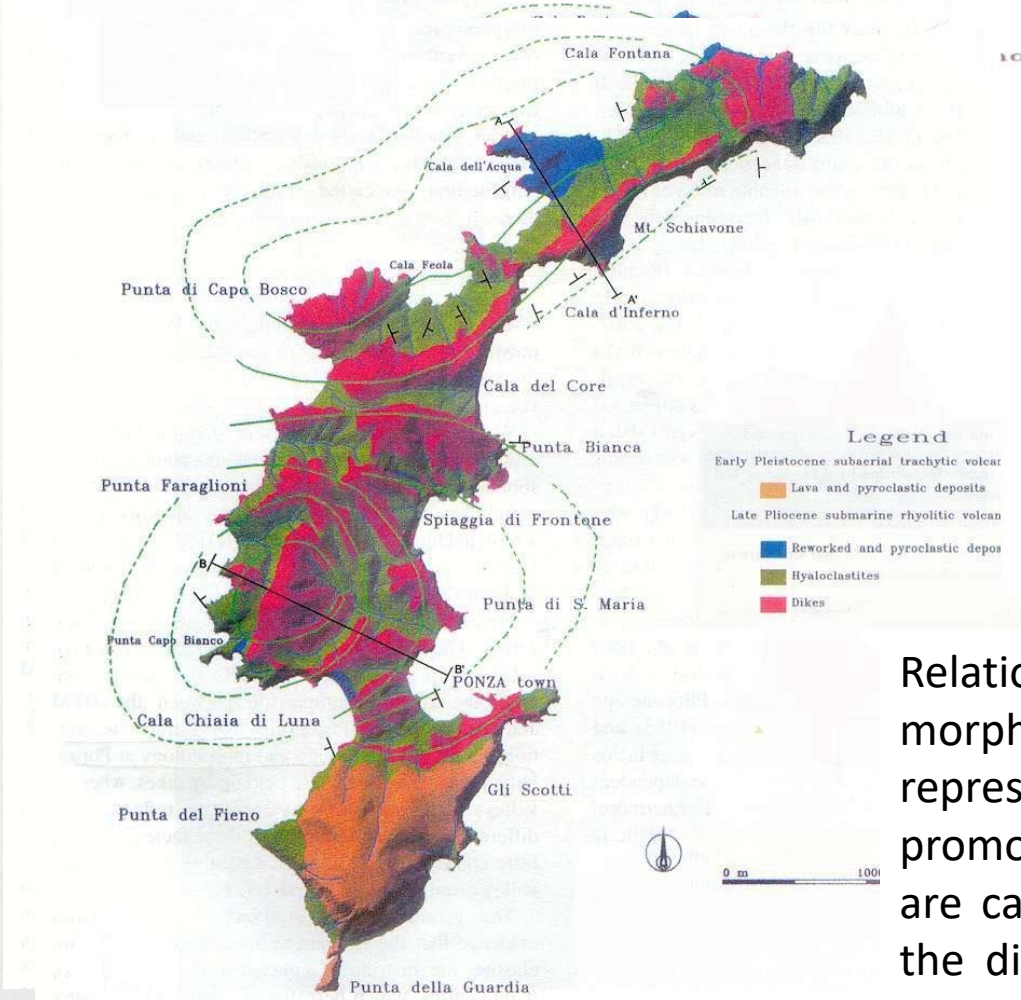


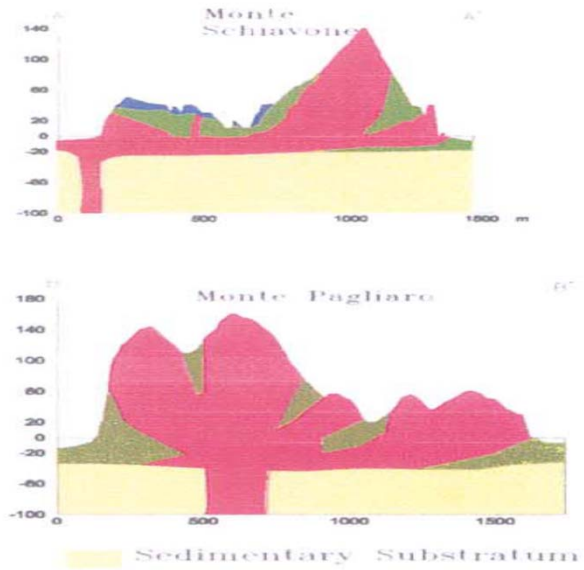
Large hyolitic domes are present in the centre and in the northern part of the island. Among these, of particular interest is the large obsidian dome of M.te Tramontana which constitute the northern end of the island.

Hyaloclastic unit made up of rhyolitic blocks, obsidians and welded pumices are present in the South.

1) Unità sedimentarie meso-cenozoiche. 2) Unità sedimentarie plio-quaternarie. 3) Lave riolitiche in dicchi. 4) Facies ialoclastica clasto sostenuta. 5) Facies ialoclastica matrice sostenuta.(*De Rita et al., 2004*)

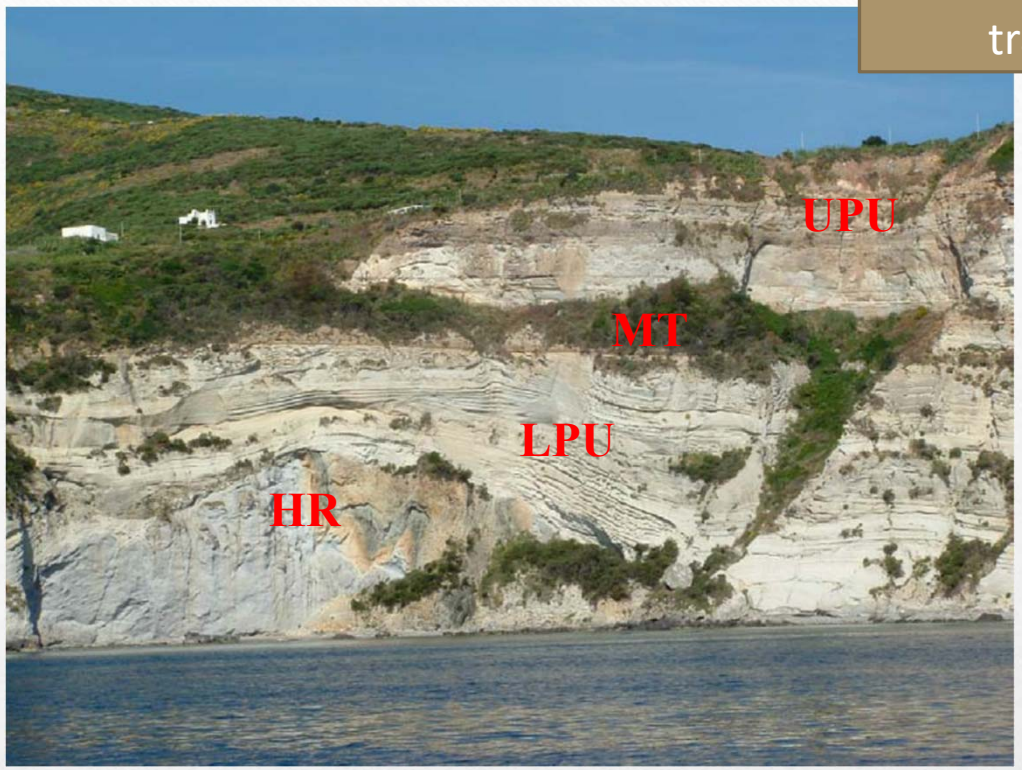
3D Geological map of Ponza (de Rita et al. 2001, modif.).





Relationship between the lithology and morphology in Ponza. Massive lava, represented by dykes, forms the relief, promontories and islets whereas valleys are carved in the hyaloclastite reflecting the different resistance to the erosional processes.

Geology of Ponza I. The Southeastern sector - Pleistocene trachytic pyroclastic units



Pyroclastic sequence outcropping in Ponza (Gli Scotti).
MT, marine terrace
UPU, Upper Pyroclastic Unit
LPU, Lower Pyroclastic Unit
HR, Hyaloclastic rhyolite

The Pleistocene volcanism, developed in the southern part of Ponza, marks the transition to the subaerial environment giving rise to trachytic pyroclasts.

Two eruptive units, separated by an erosional, depositional phase ("marine terrace") were recognized: a lower pyroclastic unit (LPU) and an upper pyroclastic unit. Products of the lowest sequence are well exposed at Chiaia di Luna, Bagno Vecchio, Gli Scotti and Punta del Fieno

Geology of Ponza I. The Southeastern sector - Pleistocene trachytic lava dome

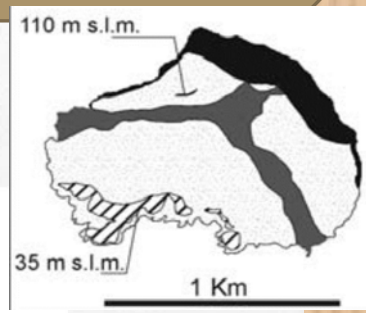
Trachytic lava overlaying the hyaloclastitc unit at Mt. Guardia. The contact is highlighted by a reddish scoria layer due to iron oxidation.

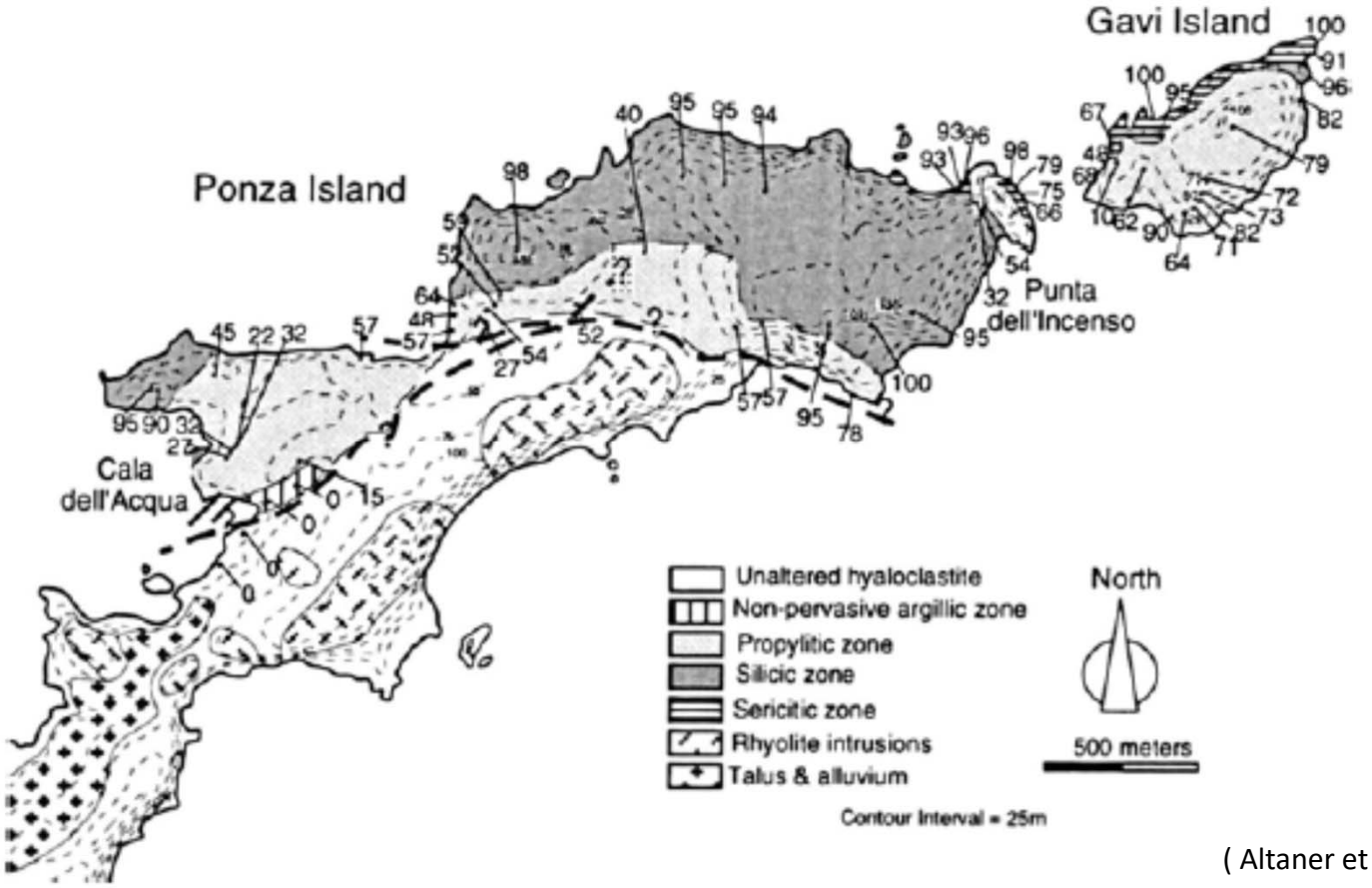
Cooling structures (vertical and curved columnar jointings) in the trachytic lava at Punta La Guardia.

The activity ends with the emplacement of the effusive trachytic products, including: the 100 m thick lobate dome of M.te Guardia, which locally lies on the hyaloclastic basement and several trachytic islets forming relicts of necks and dykes, i.e. Punta della Guardia, the Calzone Muto Stacks and Le Formiche Rocks.

Geology of Ponza I.; Hydrothermal alteration

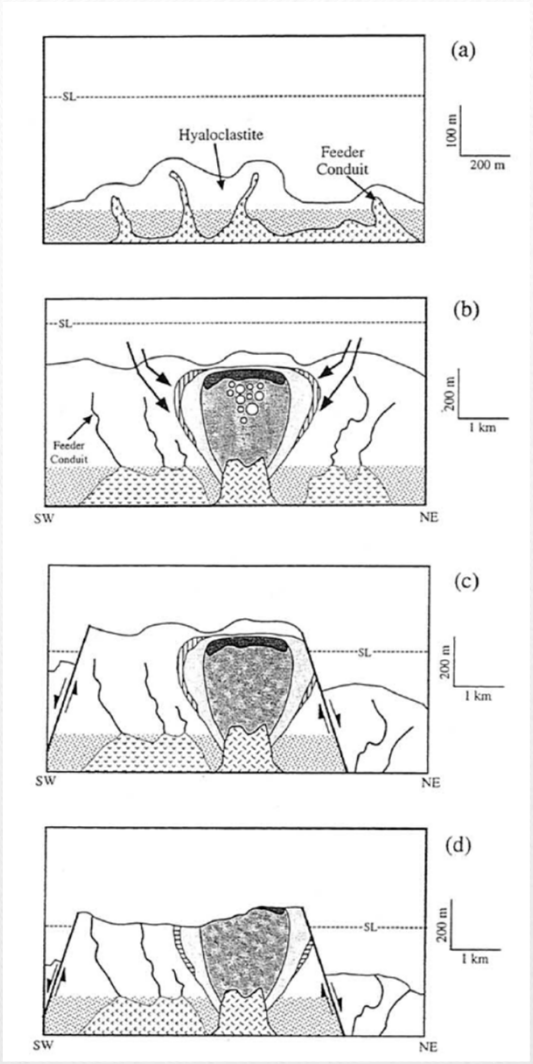
- In the northern part of Ponza, including the Islet of Gavi, and Zannone Island the hyaloclastic formation has been hydrotermally altered and characterized by a yellow color.





(Altaner et al. 2003, modif.).

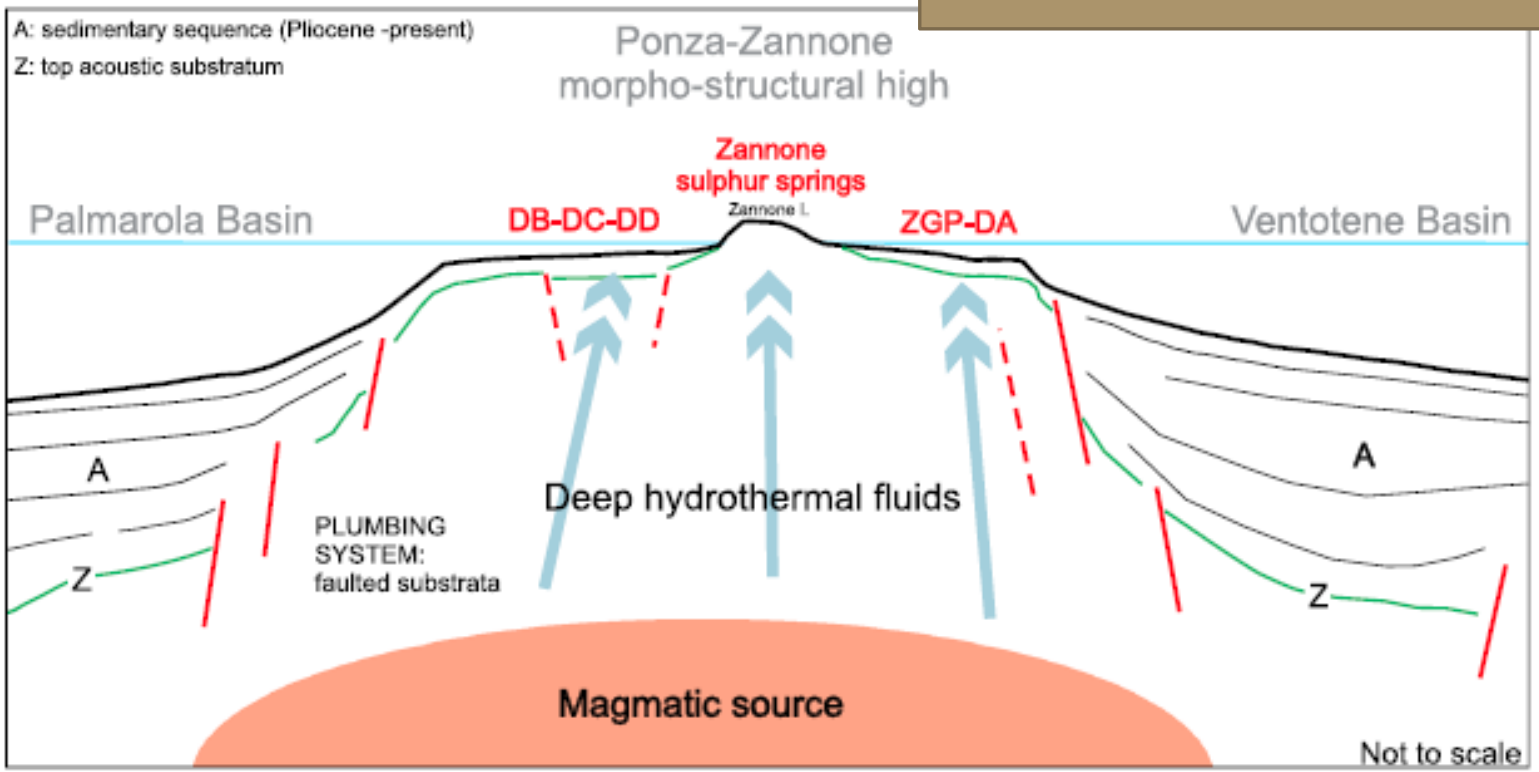
Geology of Ponza I.; Hydrothermal alteration



Schematic cross section showing the geologic evolution of northern Ponza and Gavi Island.
a) Hyaloclastite empacement
By feeder conduits;
b) hydrothermal alteration resulting from a magmatic intrusion and circulating seawater;
c) Normal faulting and subaerial exposure;
d) erosion.

(Altaner et al. 2003, modif.).

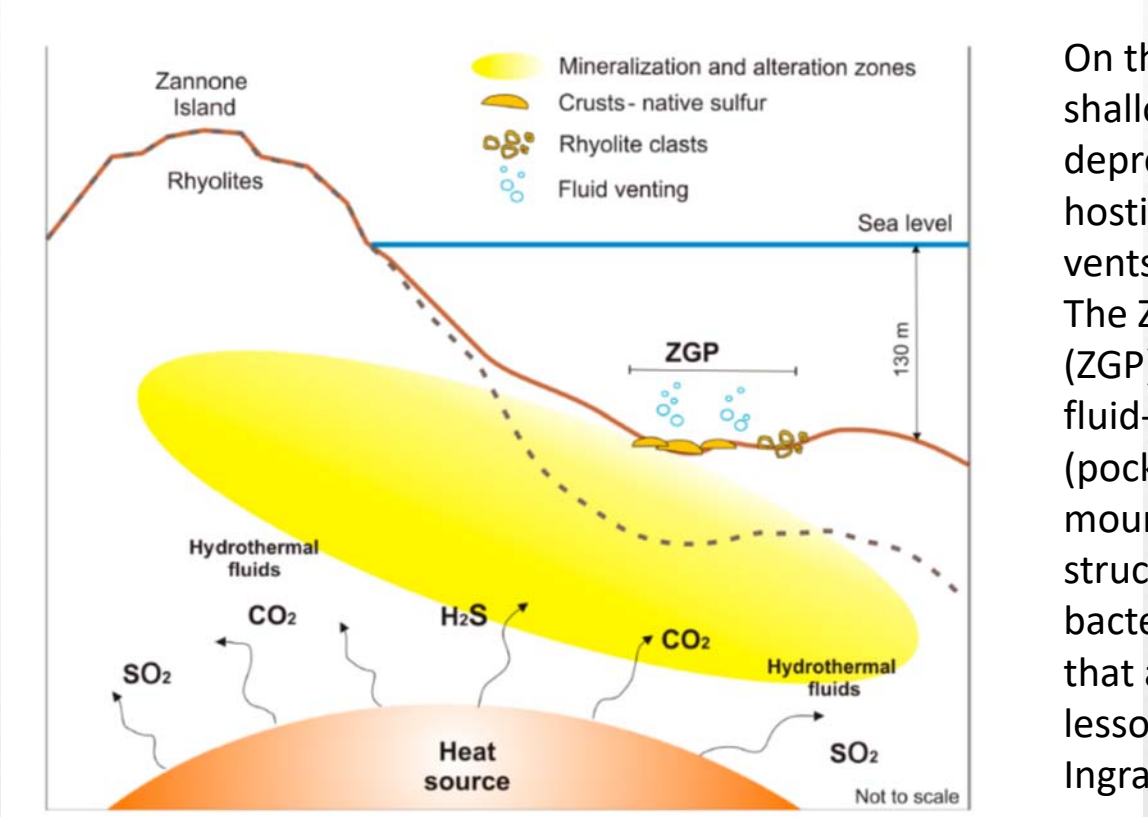
Model of Ponza-Zannone Hydrothermal field



Sketch of the structural setting of the Ponza and Zannone morphostructural high with indication of the hydrothermal field and main faults.
The deep geothermal system is fed by fluids relased by a magmatic source similar to Pleistocene trachytes.

Ingrassia et al., 2016

Hydrothermal field at the Zannone Giant Pockmark (ZGP)



Conte et al., 2020

On the shelf off Zannone Island a shallow-water (<150 m) giant depression (pockmark) is located hosting active hydrothermal vents.
The Zannone Giant Pockmark (ZGP) seabed displays different fluid-venting morphologies (pockmarks, lithified pavements, mounds, and cone-shaped structures) and widespread bacterial communities……
that are the subject of the next lessons by E. Martorelli and M. Ingrassia.

Grazie