Imaging the magma plumbing system of Ciomadul volcano and the Perşani Volcanic Field and constraining postcollisional magma dynamics

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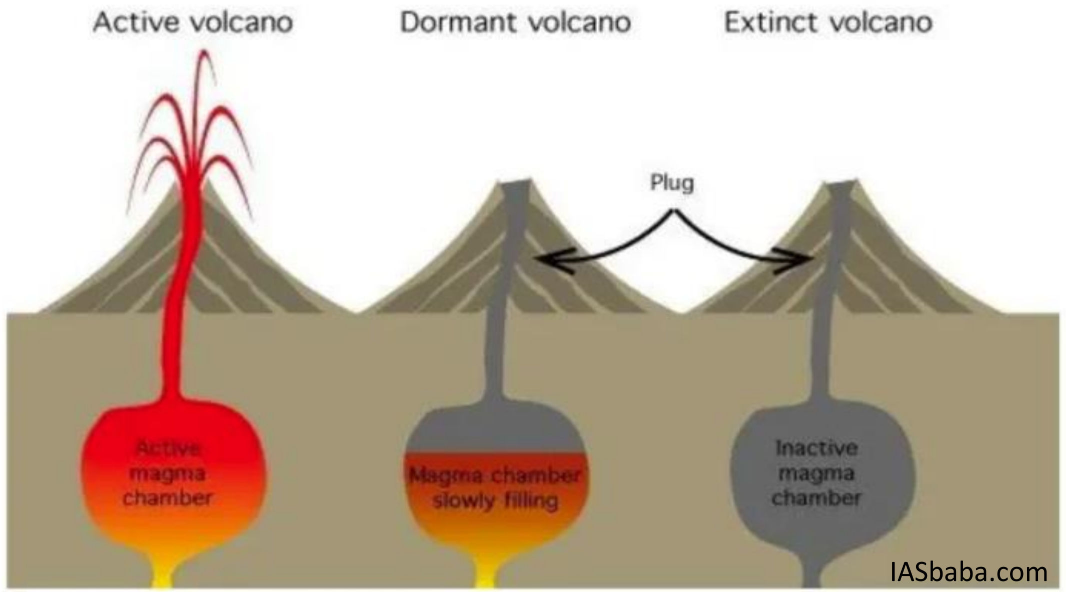
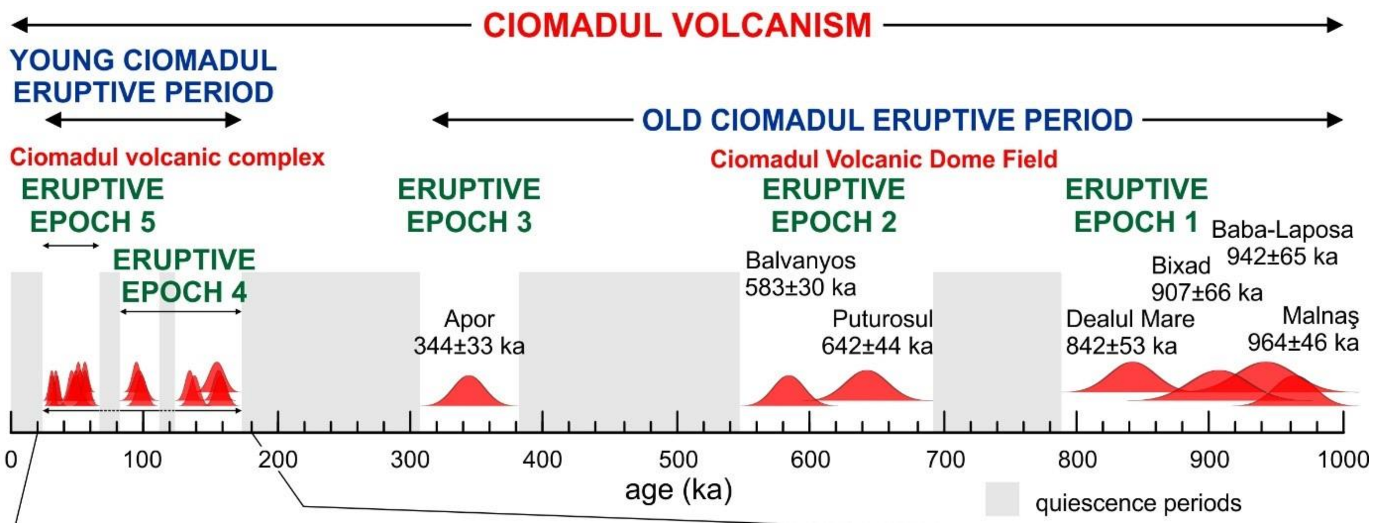
VOLCANOES WITH POTENTIALLY ACTIVE MAGMA STORAGE

- How do decide if a volcano is "inactive"?
- Length of time since last eruption? 10 ka ?
- Volcanic activity could be renewed, in the right conditions.
- To gain insights, one must examine the eruptive history and the current structure of the magma storage system.
- What is the depth and geometry of the magma storage system and what is the amount of magma or crystal mush present?



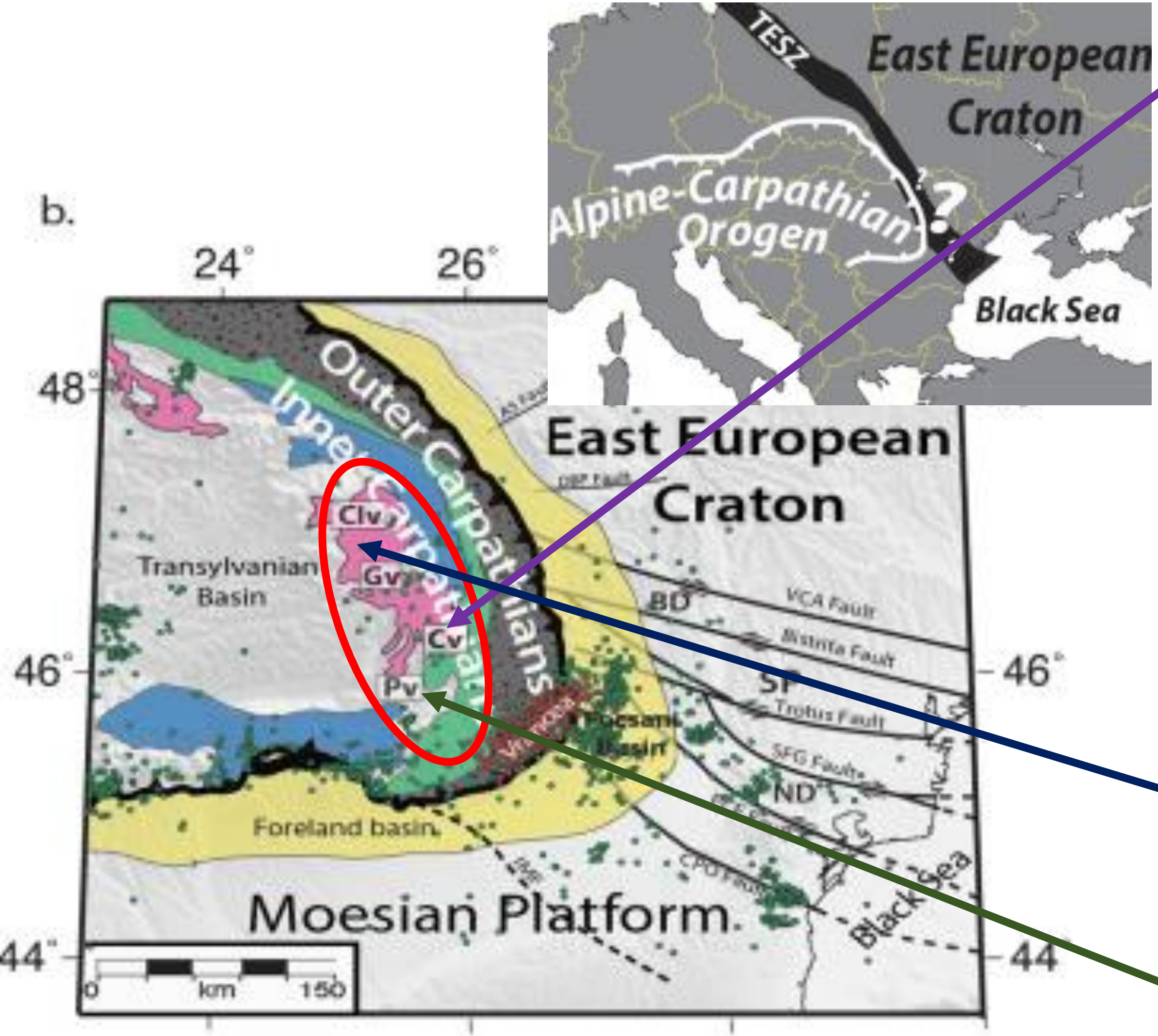
CIOMADUL (ROMANIA) – ERUPTIVE HISTORY



Harangi et al., 2010; Harangi et al., 2015, 2020; Molnár et al. 2018; 2019

- Ciomadul Volcano: Potentially Active Magmatic Storage
- Detailed eruption history
  (revealed by (U-Th)/He and U-Th zircon dating)
  -long repose time between phases:
  10,000-100,000 years
- Volcanism rejuvenated after long quiescence.
- Last eruption at occurred at 30,000 years ago
- Long lifetime of the magma storage - near-solidus "cold" crystal-mush state over 10,000s years.
- Remobilization due to injection of hot mafic magma
- Very fast reactivation possible - within weeks/months!
- Ciomadul: Potential for future reactivation and volcanic eruption even long lull in volcanic activity…
- An underrated risk → need more attention

CIOMADUL (ROMANIA)



Borleanu et al, 2021

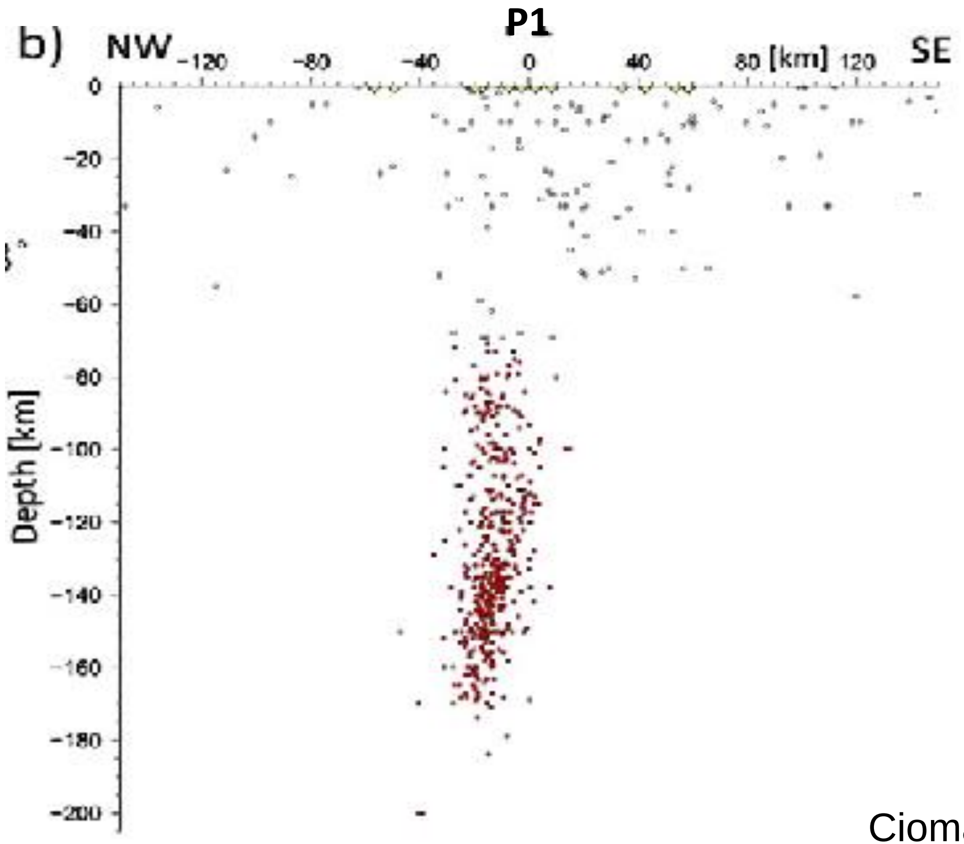
- Ciomadul is located at the south-eastern terminus of the Carpathian volcanic arc (Romania).
- It is the youngest volcano in eastern-central Europe

- To the north and north-west lies a chain of older volcanic complexes, the Călimani–Gurghiu-Harghita volcanic complex.

- To the west lies an enigmatic basaltic volcanic region, the Perşani volcanic field, with monogenetic cones.

VRANCEA ZONE

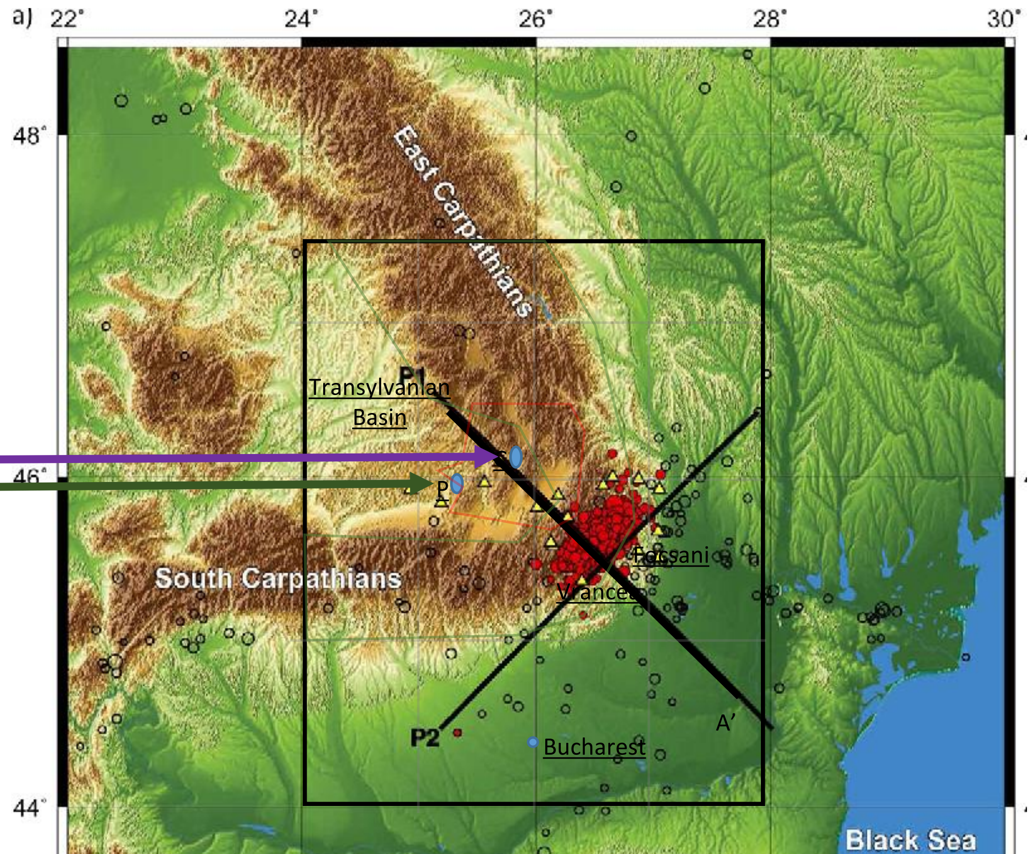
- Vrancea region (southeastern Carpathians) is one of the most active seismic zones in Europe.
- Many strong intermediate depth (70-180 km) earthquakes.



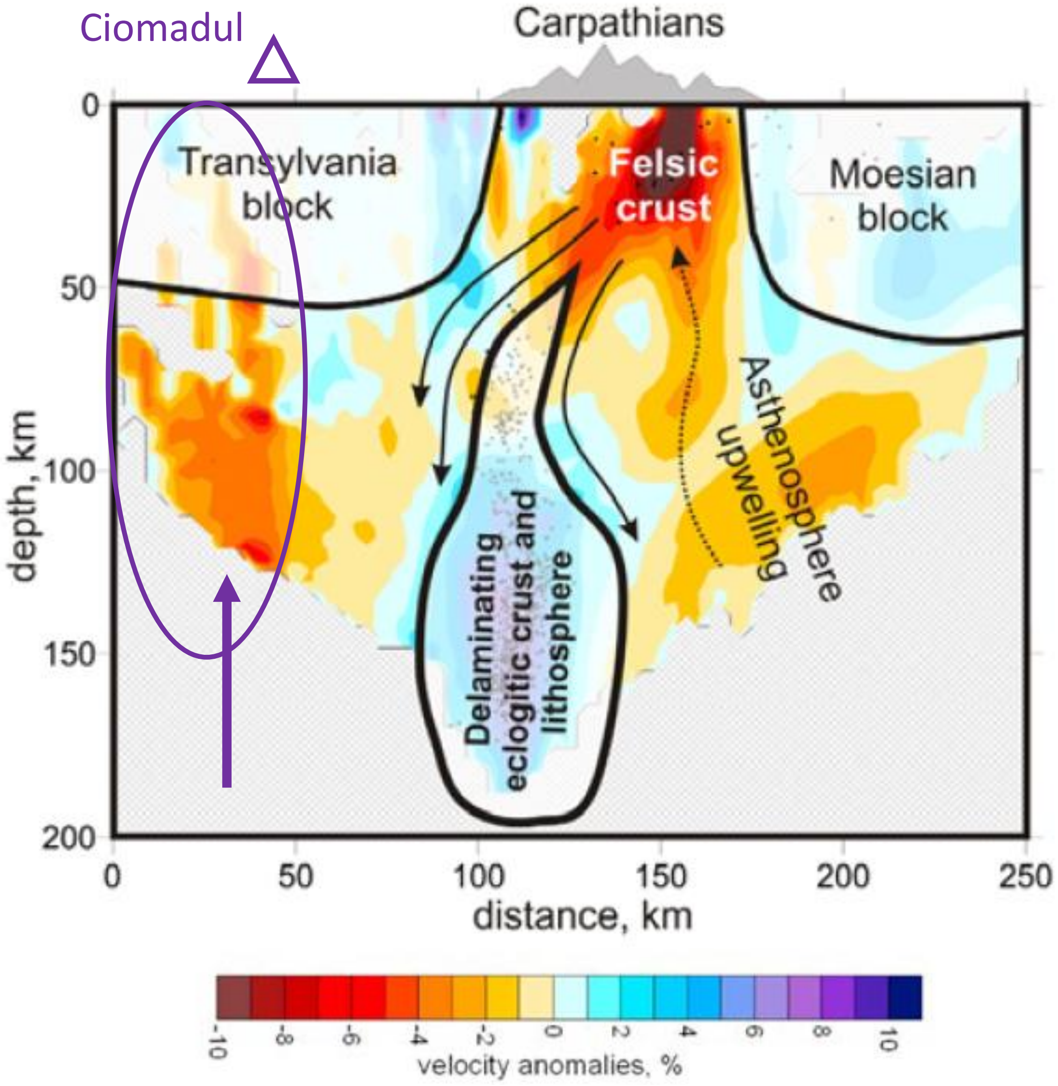
Bokelmann et al, 2014

Ciomadul

Persani

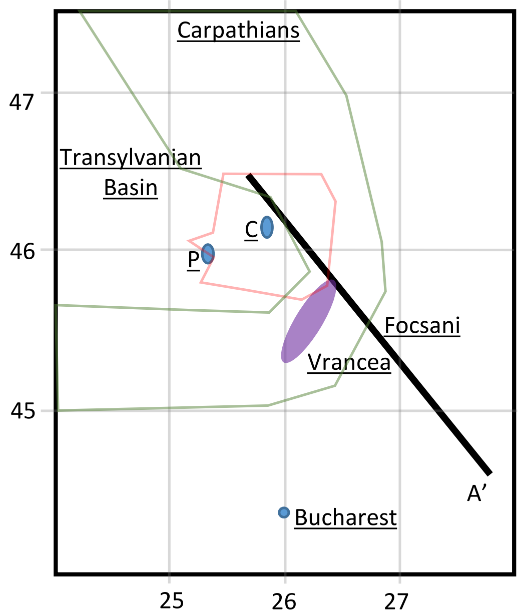


VRANCEA ZONE - VELOCITY MODEL (Vp)



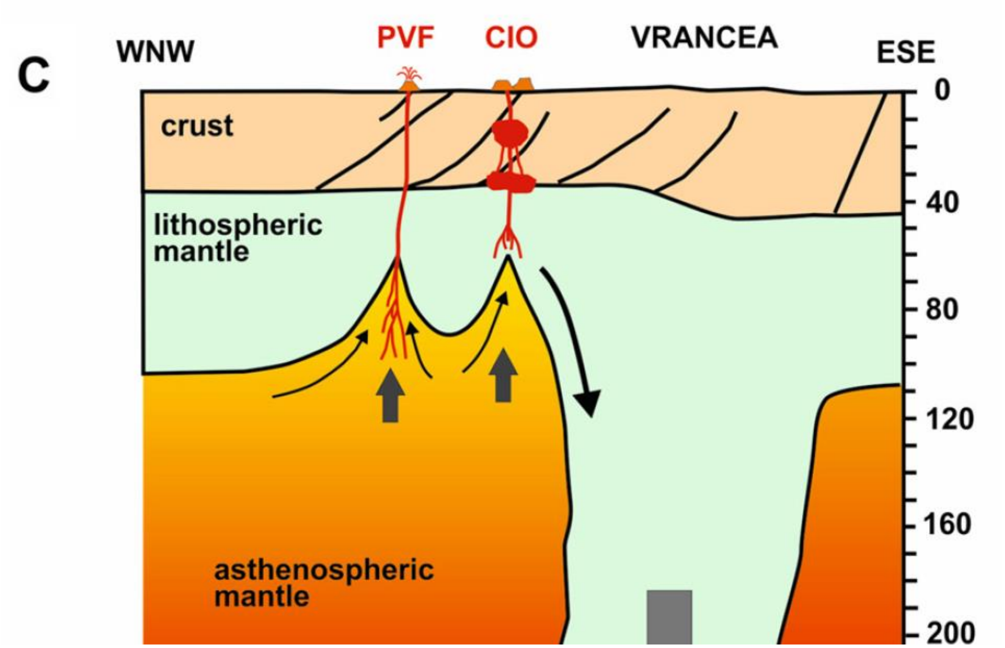
Koulakov et al, 2010

- Vrancea region (southeastern Carpathians) is one of the most active seismic zones in Europe.
- Many strong intermediate depth (70-180 km) earthquakes.
- High-velocity material beneath Vrancea at 60-200 km depth coincides with distribution of seismicity.
- Might represent delamination and descent of dense eclogitized lower crust, which underwent a transformation due to thickening from continent-continent collision.
- Return flow leads to upwelling of (asthenospheric) mantle

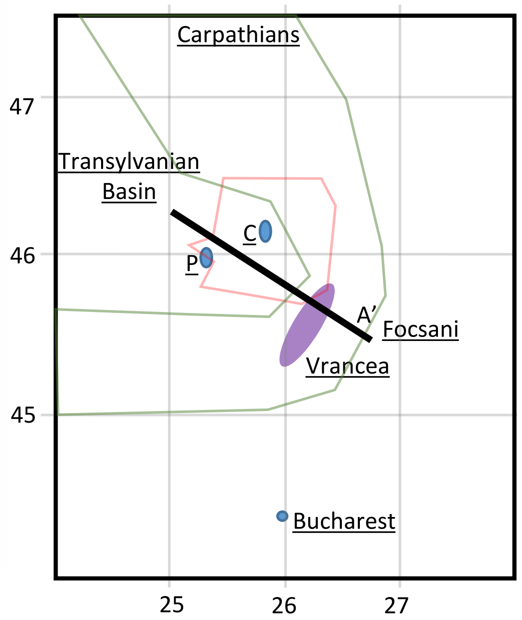


CIOMADUL & PERSANI

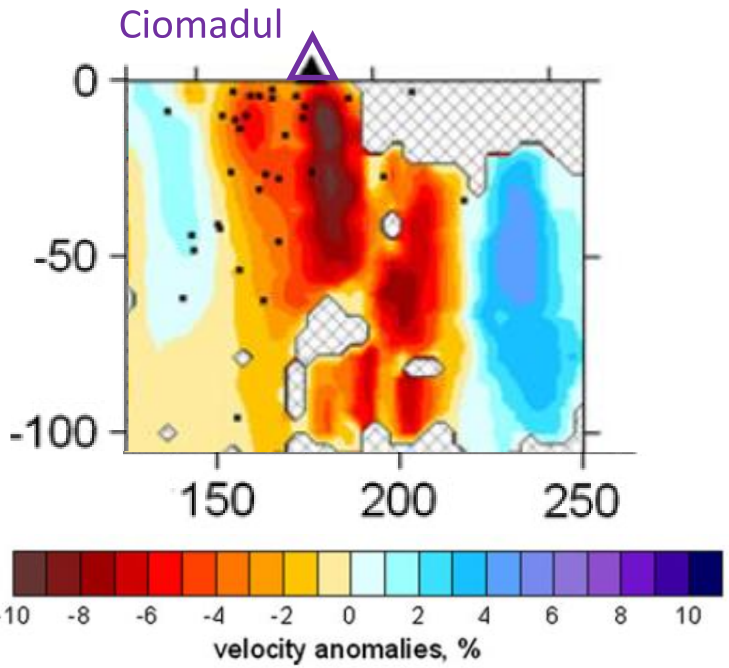
- Ciomadul, in this view, is part of a larger and more complex system.
- How does different style volcanism at Persani fit in?



Laumonier et al, 2019

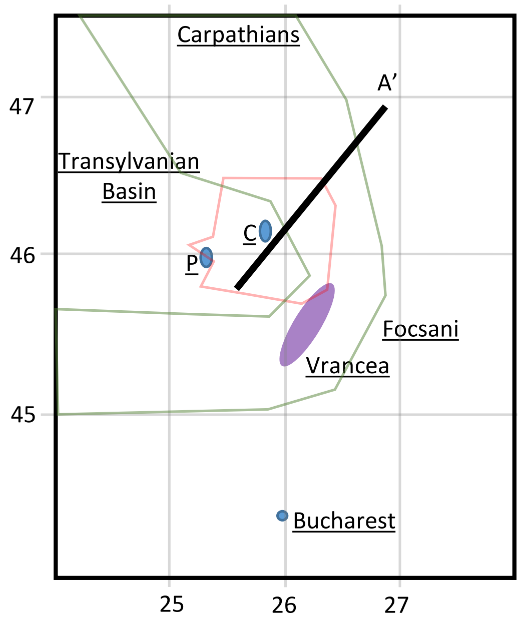


CIOMADUL - VELOCITY MODEL (Vp)



Popa et al, 2011

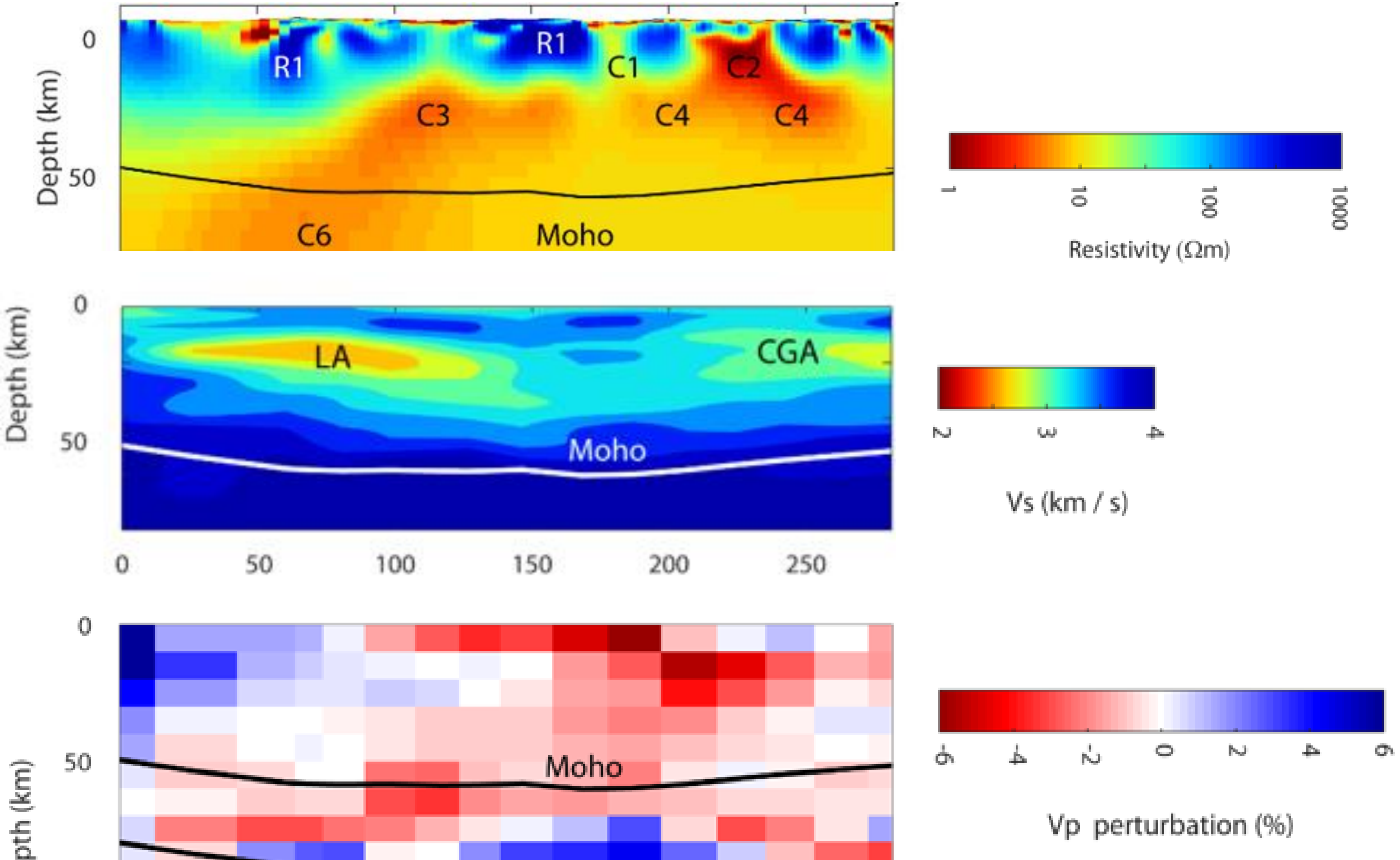
- Low-velocity lithosphere column beneath Ciomadul
- Possibly related to a thermal anomaly generated by migrating fluids or magma ascent and magma reservoir



DIFFERENCES BETWEEN SEISMIC AND ELECTRICAL MEASUREMENTS

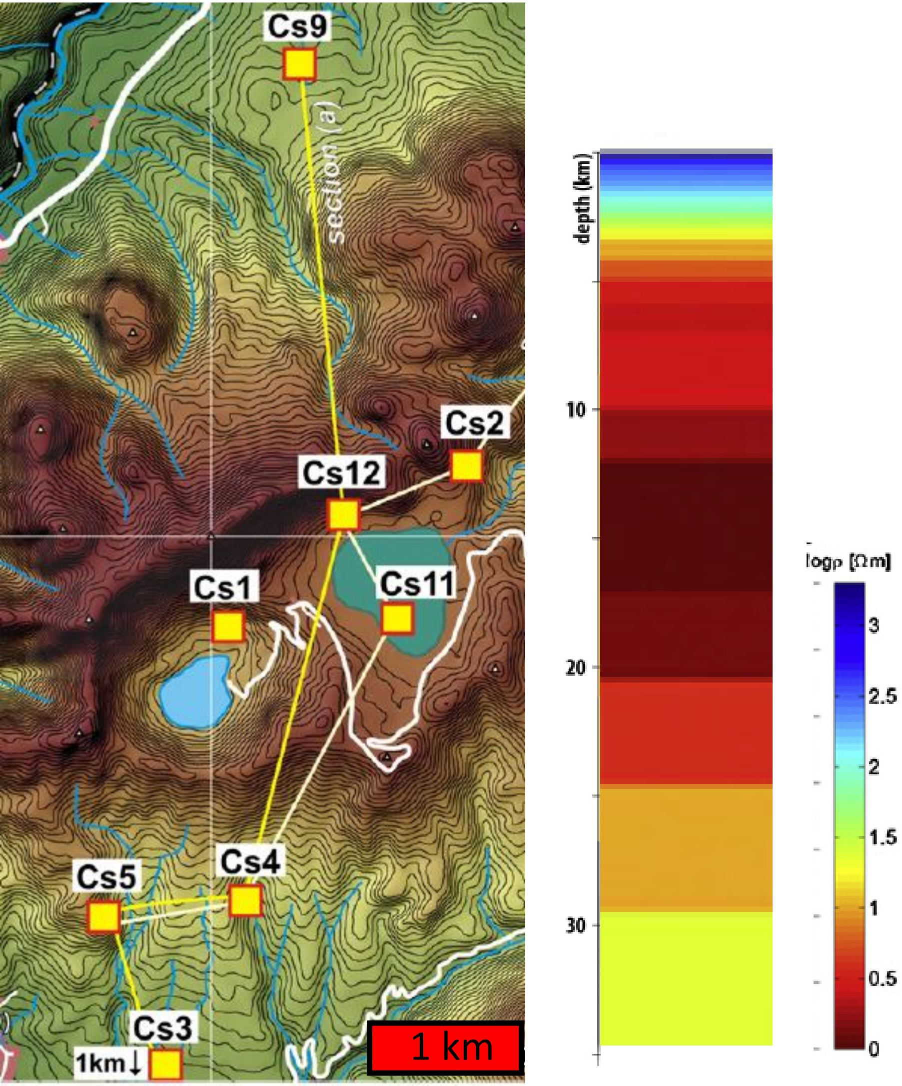
- Seismic tomography models
  and electrical resitivity models
  across a volcanic zone on the Puna plateau, Andes,
  illustrates typical differences between methods.

Unsworth, Comeau, et al, 2023



PREVIOUS ELECTRICAL RESISTIVITY MODEL

Harangi et al, 2015



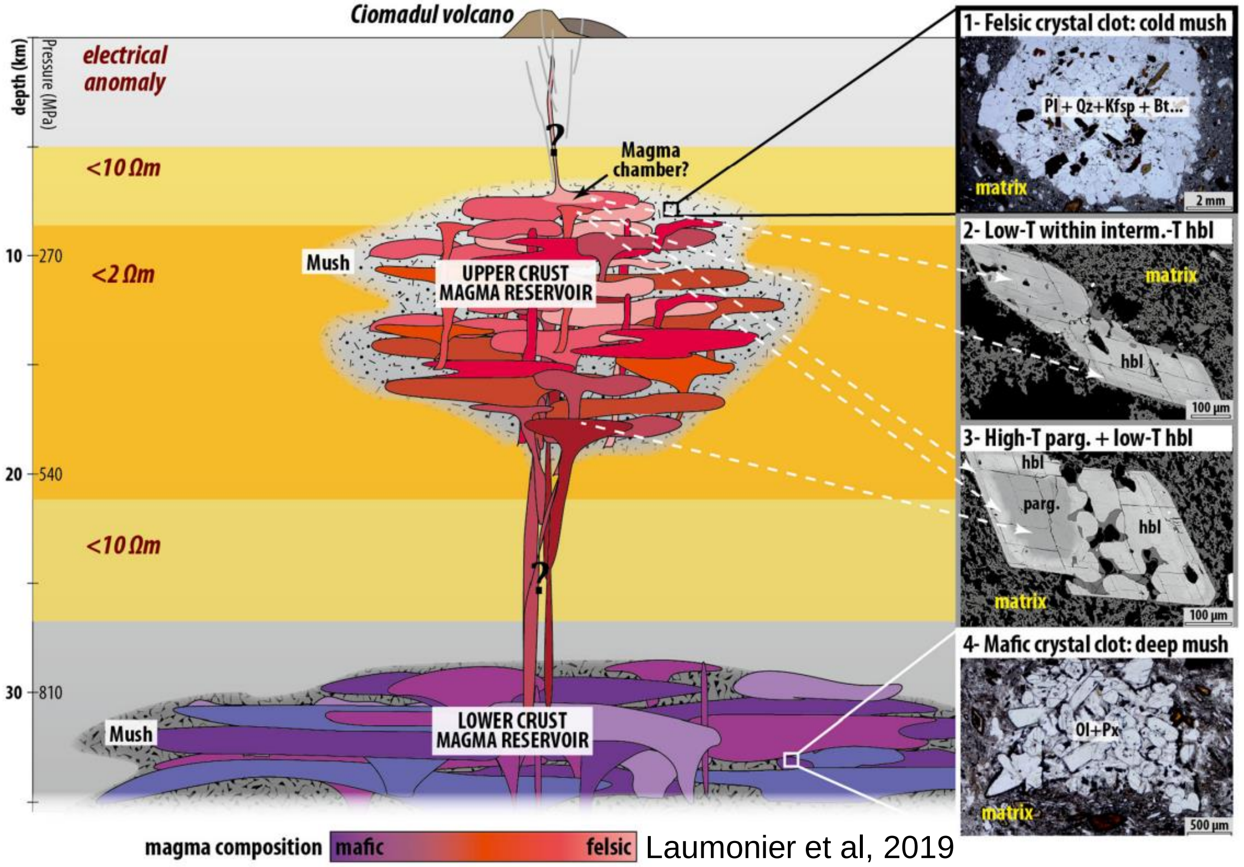
- In 2010, measurements in 12 locations across cone.
- 1-D resistivity model
- Low electric resistivity values at depth of 5–30 km beneath volcanic center.
- Interpreted as implying a partial melt zone: a melt-bearing silicic crystal mush body approximately 5-25 km below surface.

ELECTRICAL RESISTIVITY MODEL & PETROLOGICAL MODEL

- The geometry and size of the magma storage region and quantity of melt is unknown.
- Magma reservoir in the crust likely has complex geometry

- Understanding the structure of the volcanic plumbing system is crucial to understanding the evolution and assessing the hazard potential.

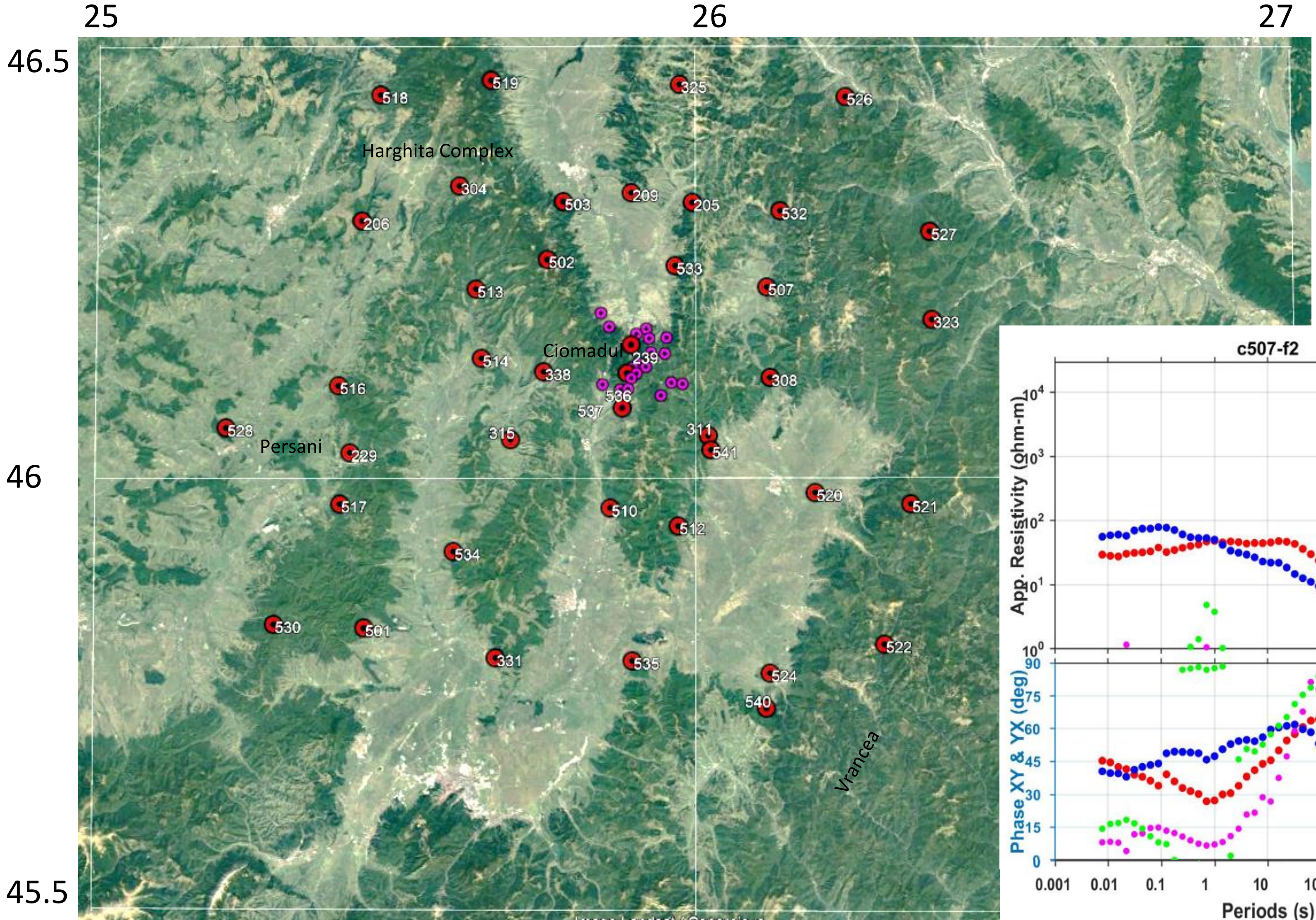
- Can we refine the structure in 3-D?

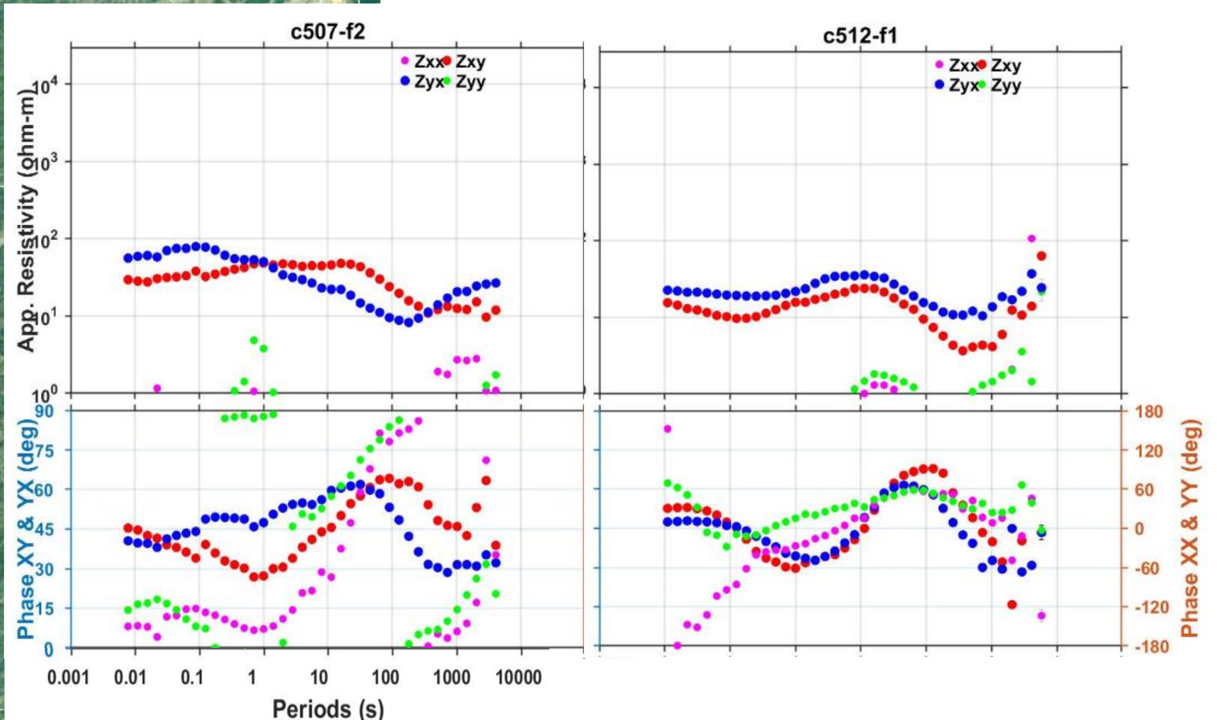


Laumonier et al, 2019

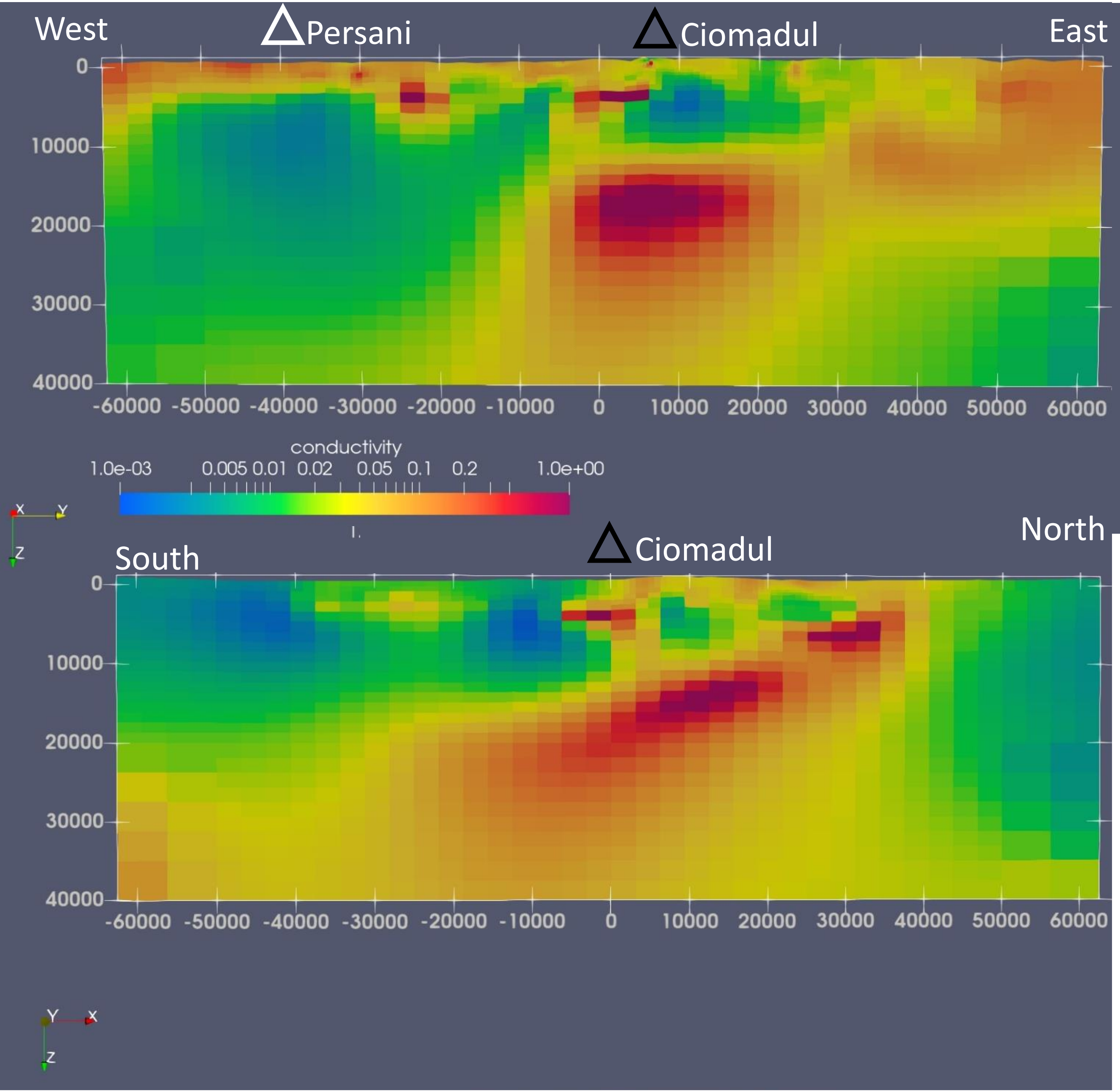
NEW MAGNETOTELLURIC MEASUREMENTS

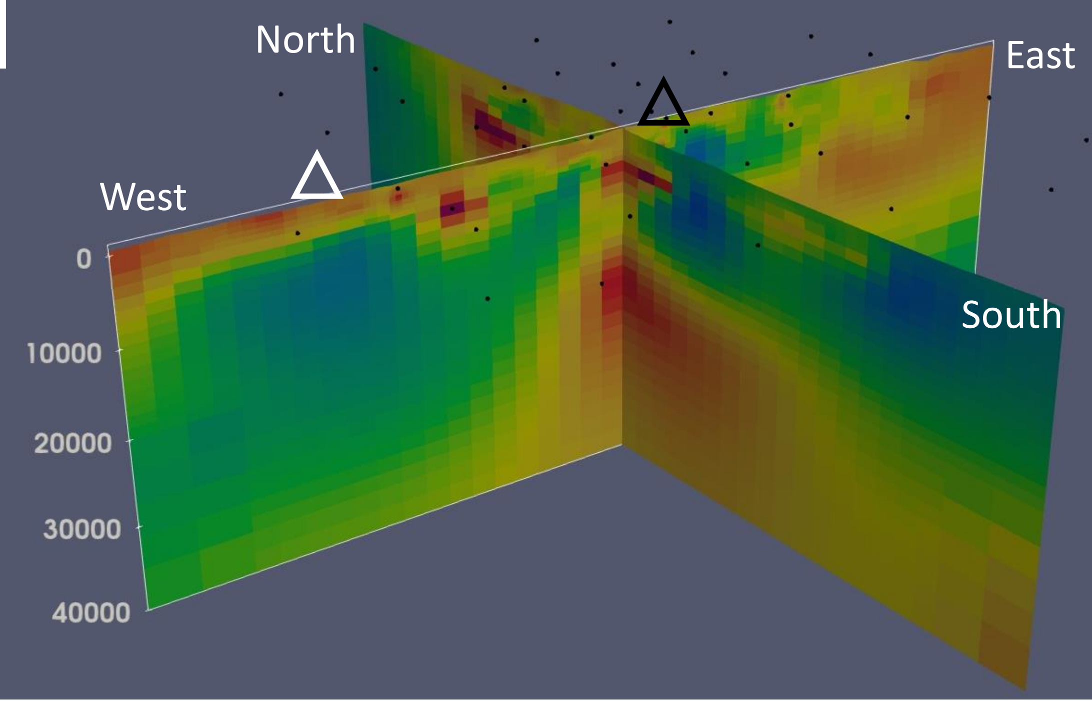
- In 2022, 41 new MT measurements were acquired.
- The region covered reaches from the Persani volcanic field to Ciomadul, and to the edge of the Vrancea.
- Approximately 75 x 75 km.
- Good quality data achieved, despite some noisy locations





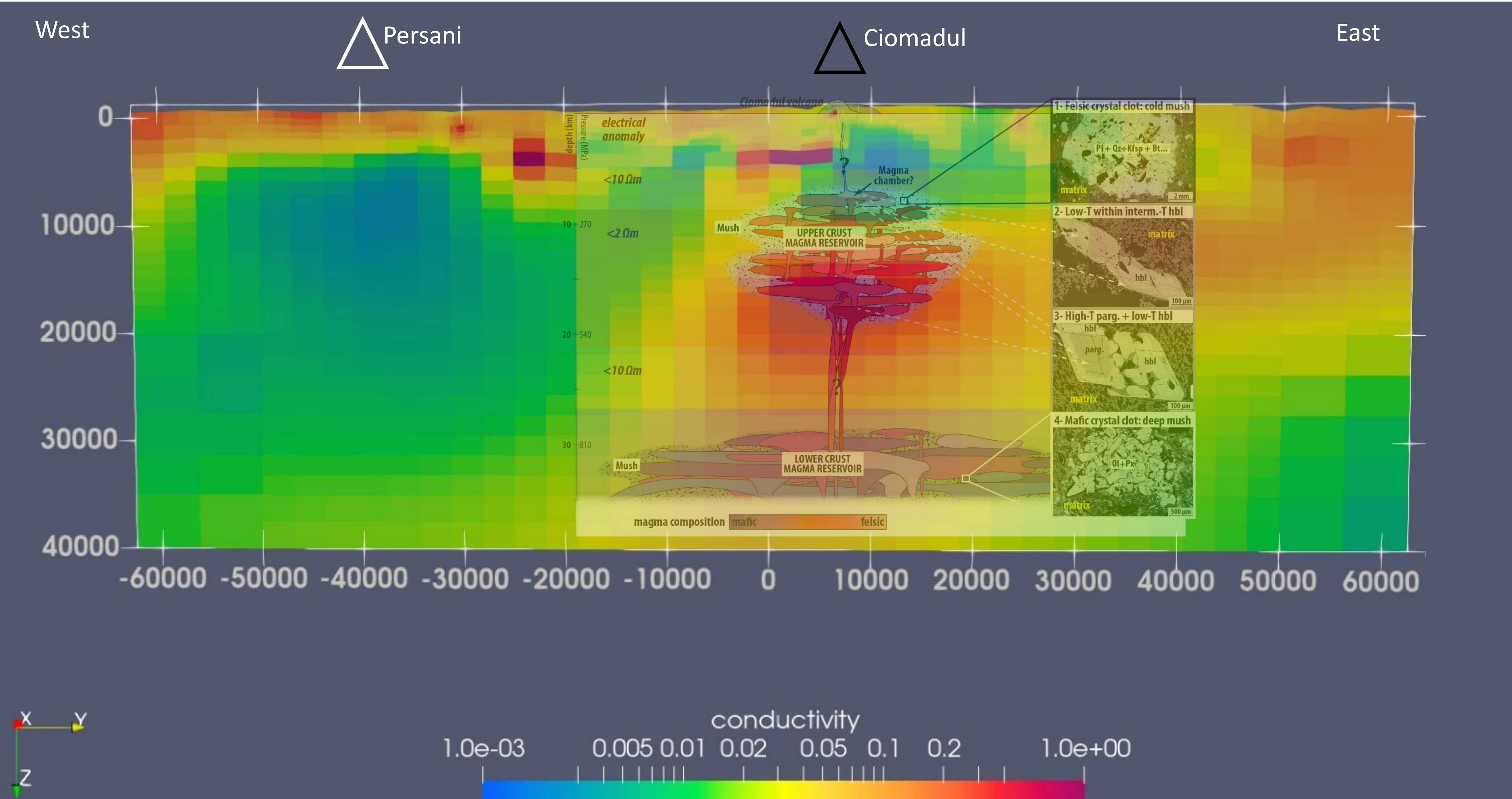
RESULTS

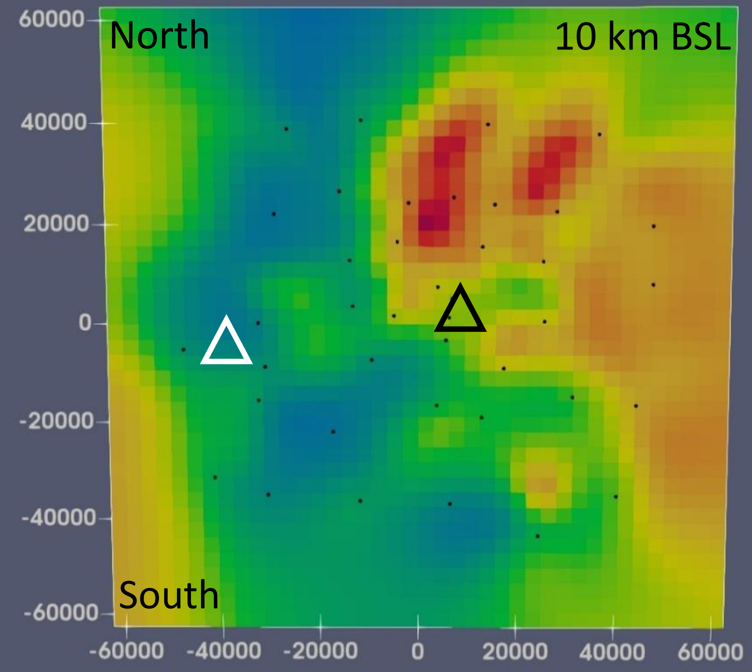


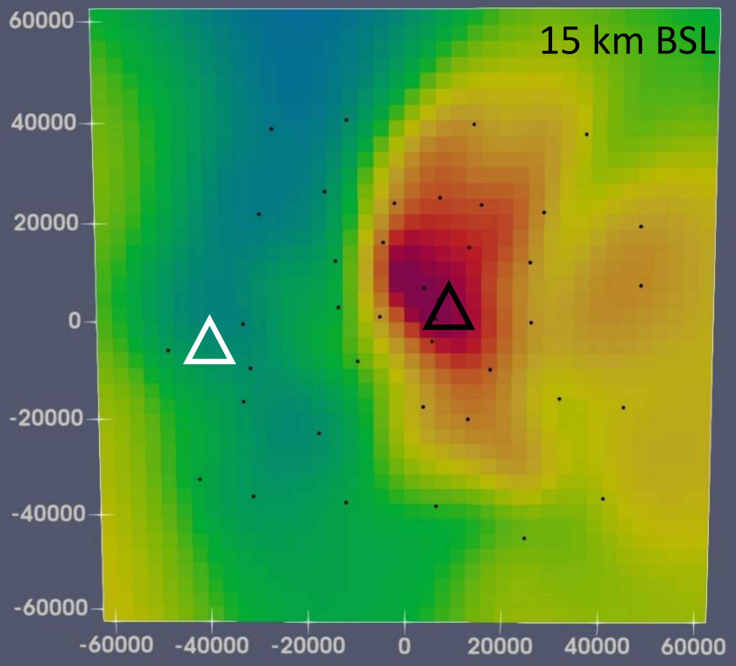


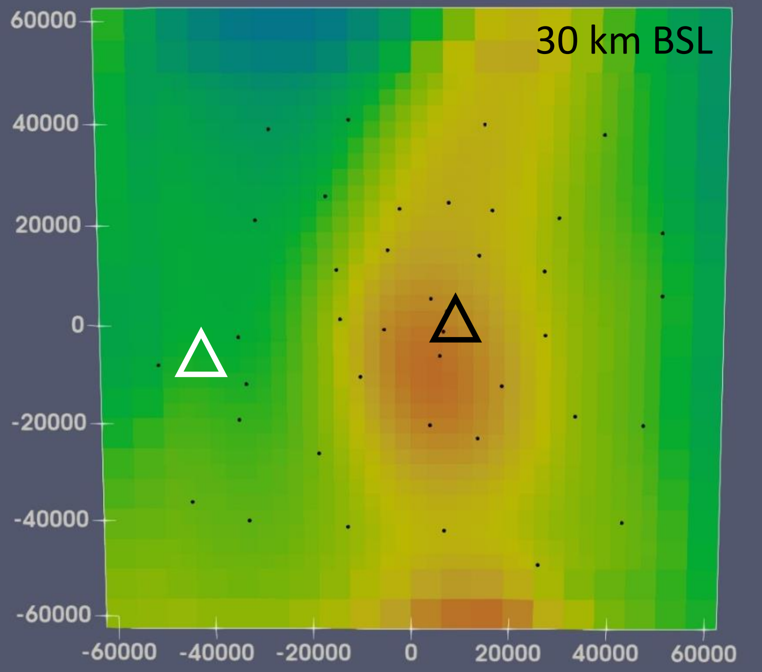
- Conductive anomalies approximately beneath the surface vent of Ciomadul.
- Shallow anomaly may be related to hydrothermal activity and alteration.
- Deeper anomaly consistent with the quantitative petrological models placing the upper melt bearing silicic crystal mush reservoir at a depth of 10-25 km.
- In contrast, no strong conductive anomaly is observed in the crust below Perşani, which fits the magma evolution model, i.e. small batches of mantle-derived magmas ascend rapidly through the crustal column.

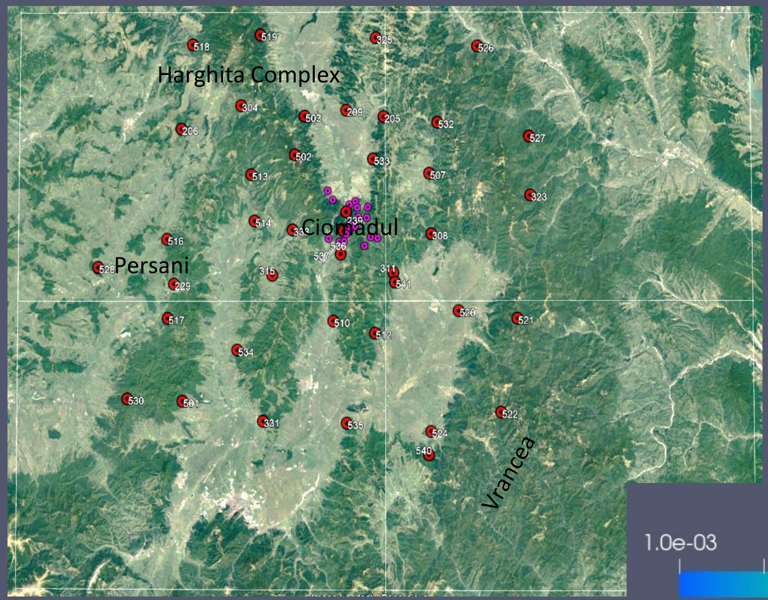
Images are compatible magma storage model based on petrology (e.g., Laumonier et al, 2019)











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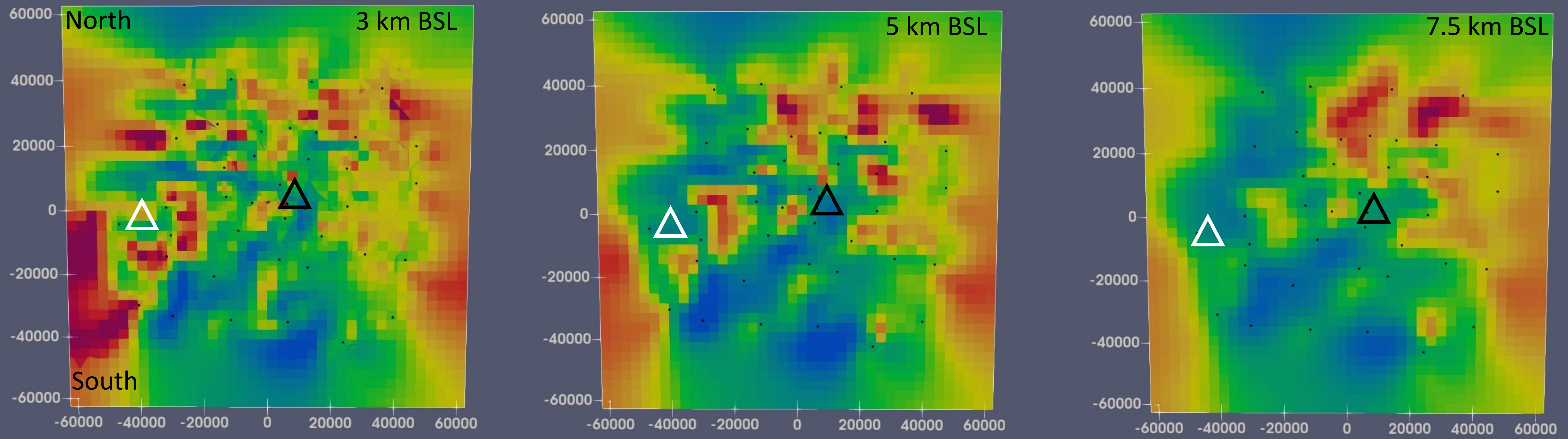

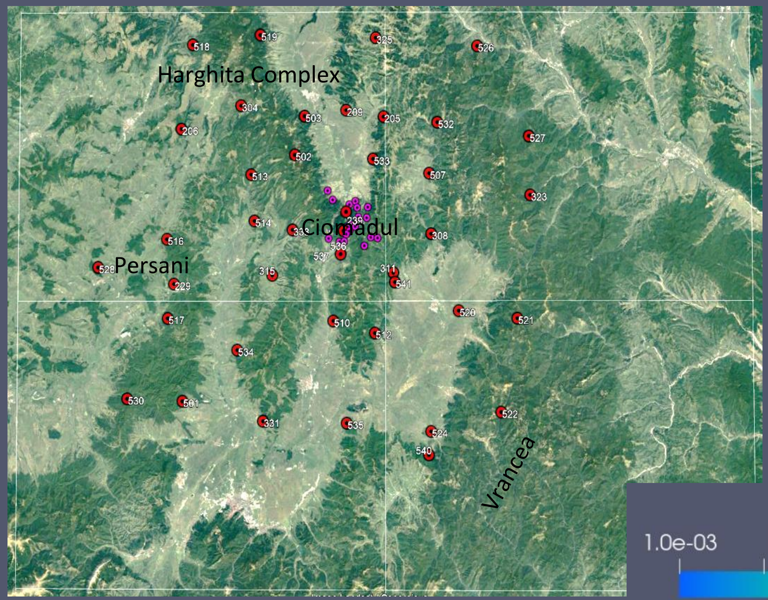

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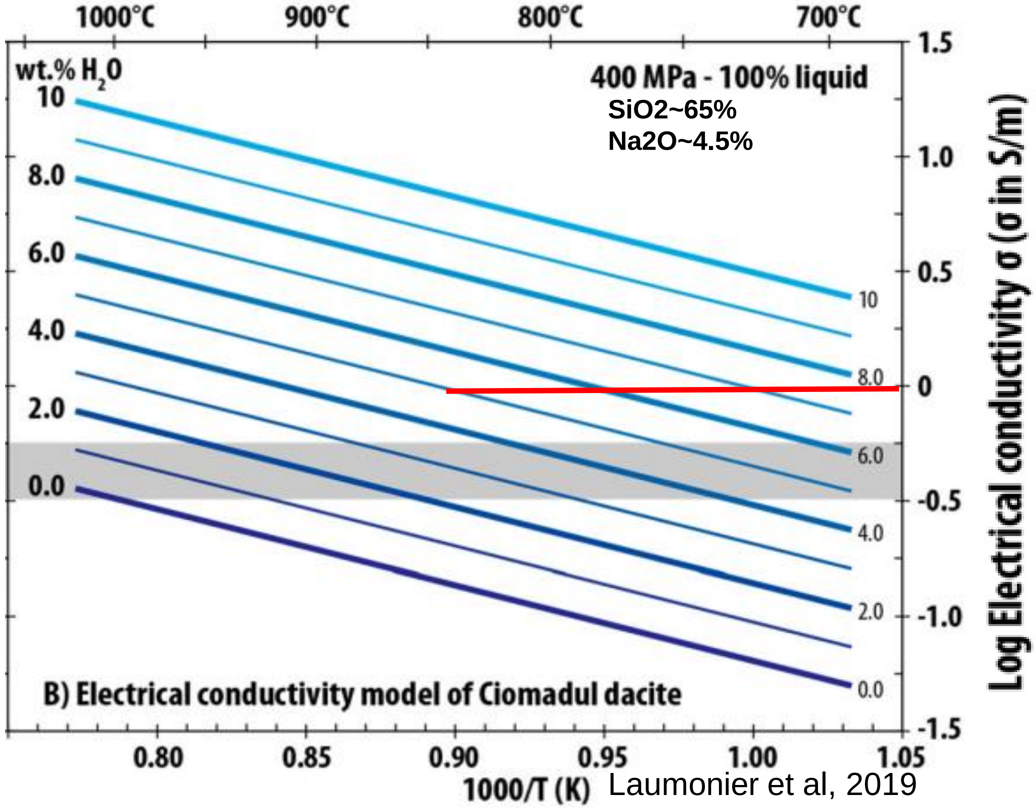
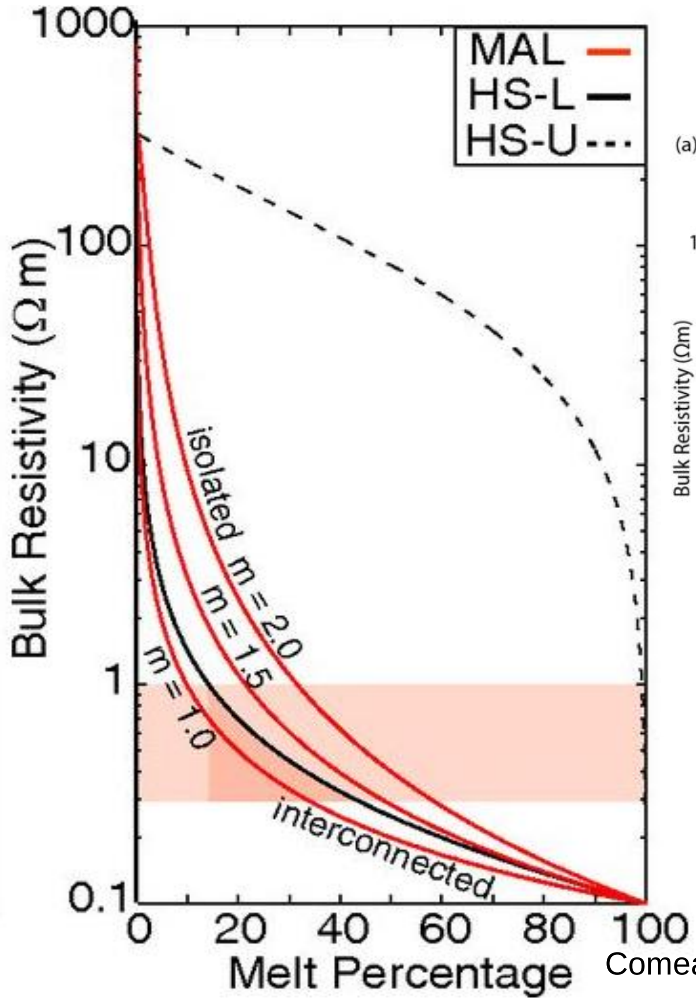
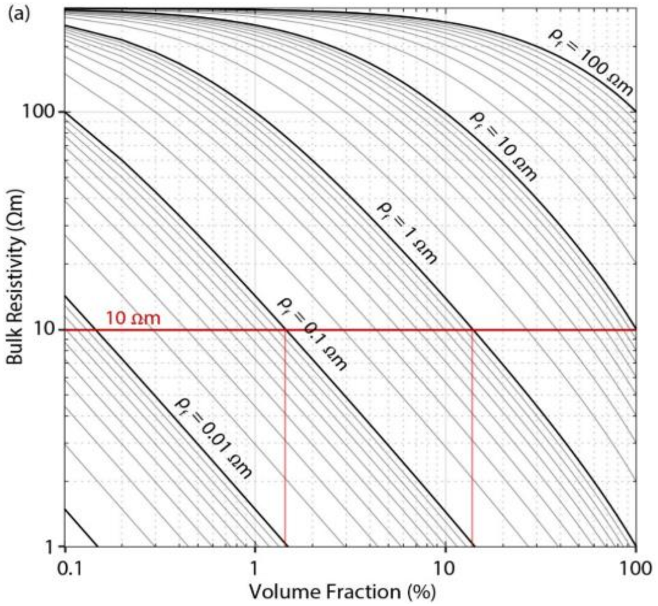
OUTLOOK

- Future tasks include:
  -detailed melt fraction calculations based on electrical resistivity and laboratory measurements of the rocks from Ciomadul

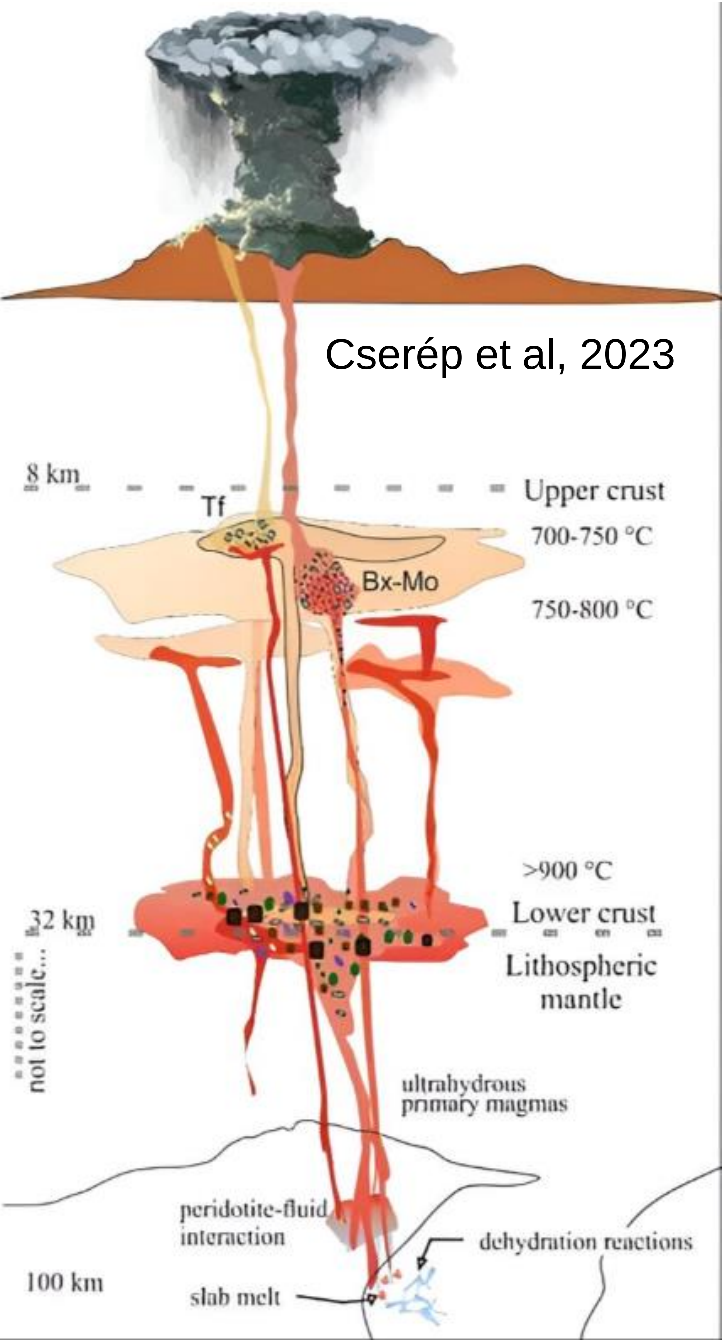


Laumonier et al, 2019





Comeau et al, 2016, 2023



Cserép et al, 2023

CONCLUSIONS

- Our results suggest that Ciomadul, a seemingly inactive volcano, is still underlain by a melt-bearing magma body and can be regarded as having potential for reactivation and further eruptions.