The Volsci Volcanic Field (central Italy): Anatomy of a tectonically controlled, carbonate-seated, volcanic activity

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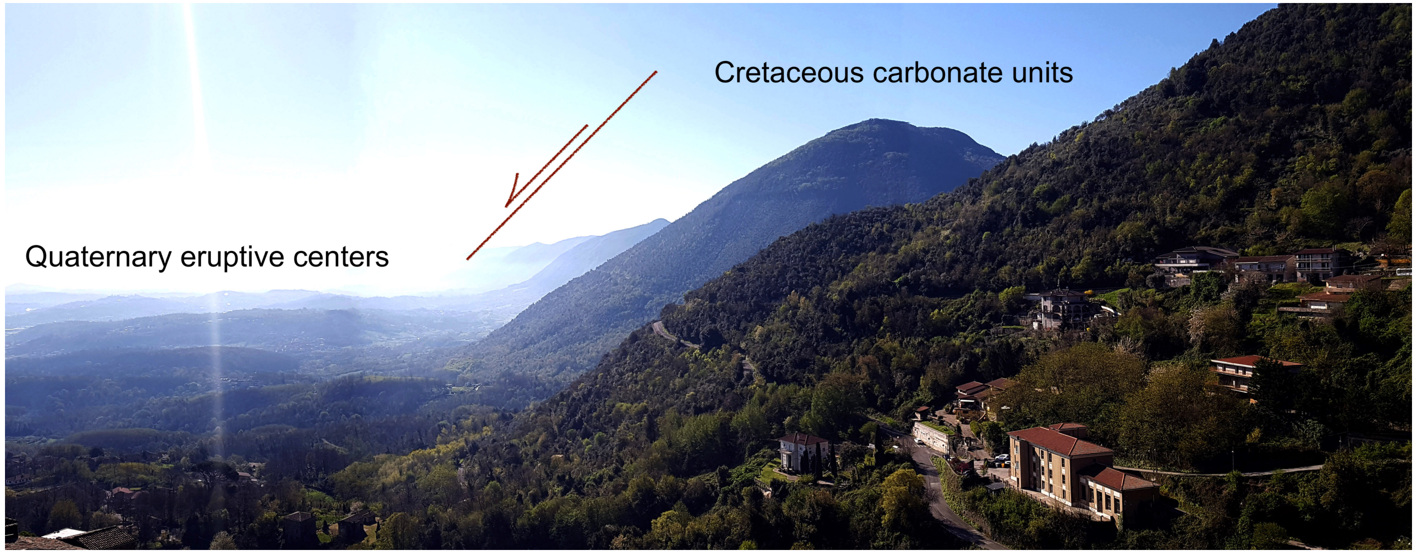

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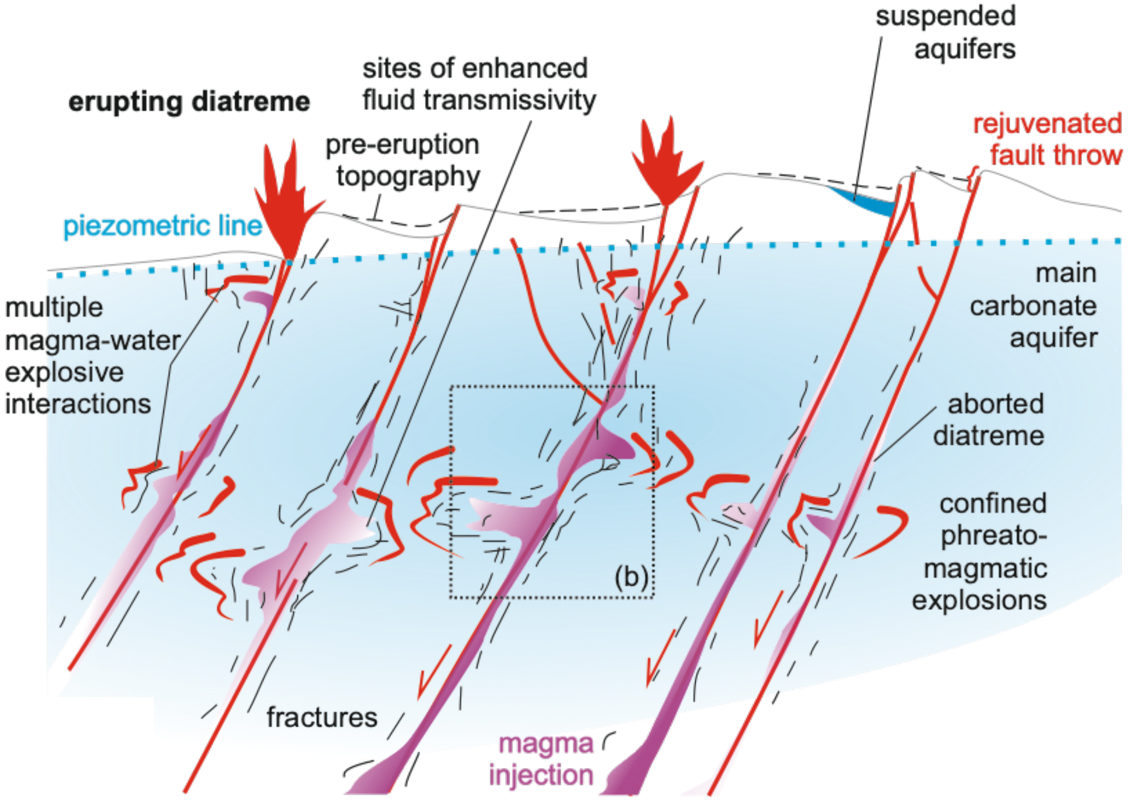
RESEARCH AIM

Through the last years some new papers dealt with the tectonic and volcanic evolution of southern Latium as it reveals recent activity worthy to be investigated.
In light of new $^{40}Ar/^{39}Ar$ geochronological data and compositional characterization of juvenile eruptive products, we:

- refine the **history of Volsci Volcanic Field (VVF) activity** and
- envisage the implications on the **pre-eruptive magma system** and the continental subduction processes from the source to the surface.



In the frame of our research, we also deal with the **sub-surface and eruptive processes** of the VVF maar-diatremes that drove magma injection and controlled the sites of magma-water explosive interaction. These eventually acted as paths to surface during phreatomagmatic eruptions.

PICO PRESENTATION OUTLINE AND HYPERLINKS

GEOLOGICAL SETTING

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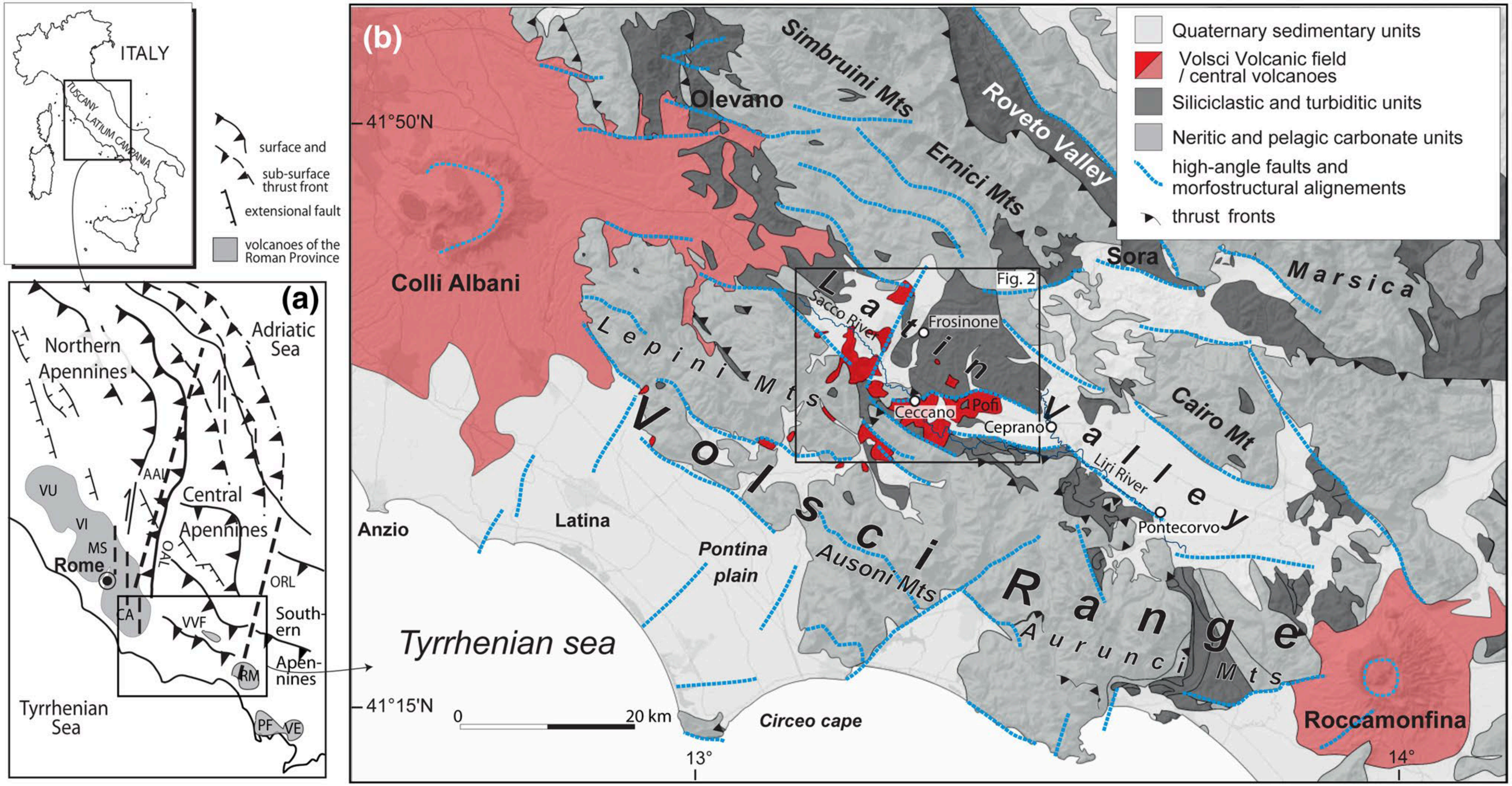

MORE INFORMATION ON REGIONAL VOLCANO-TECTONIC DYNAMICS IN MARRA ET AL. 2020

GEOLOGICAL MAP OF THE VOLSCI VOLCANIC FIELD

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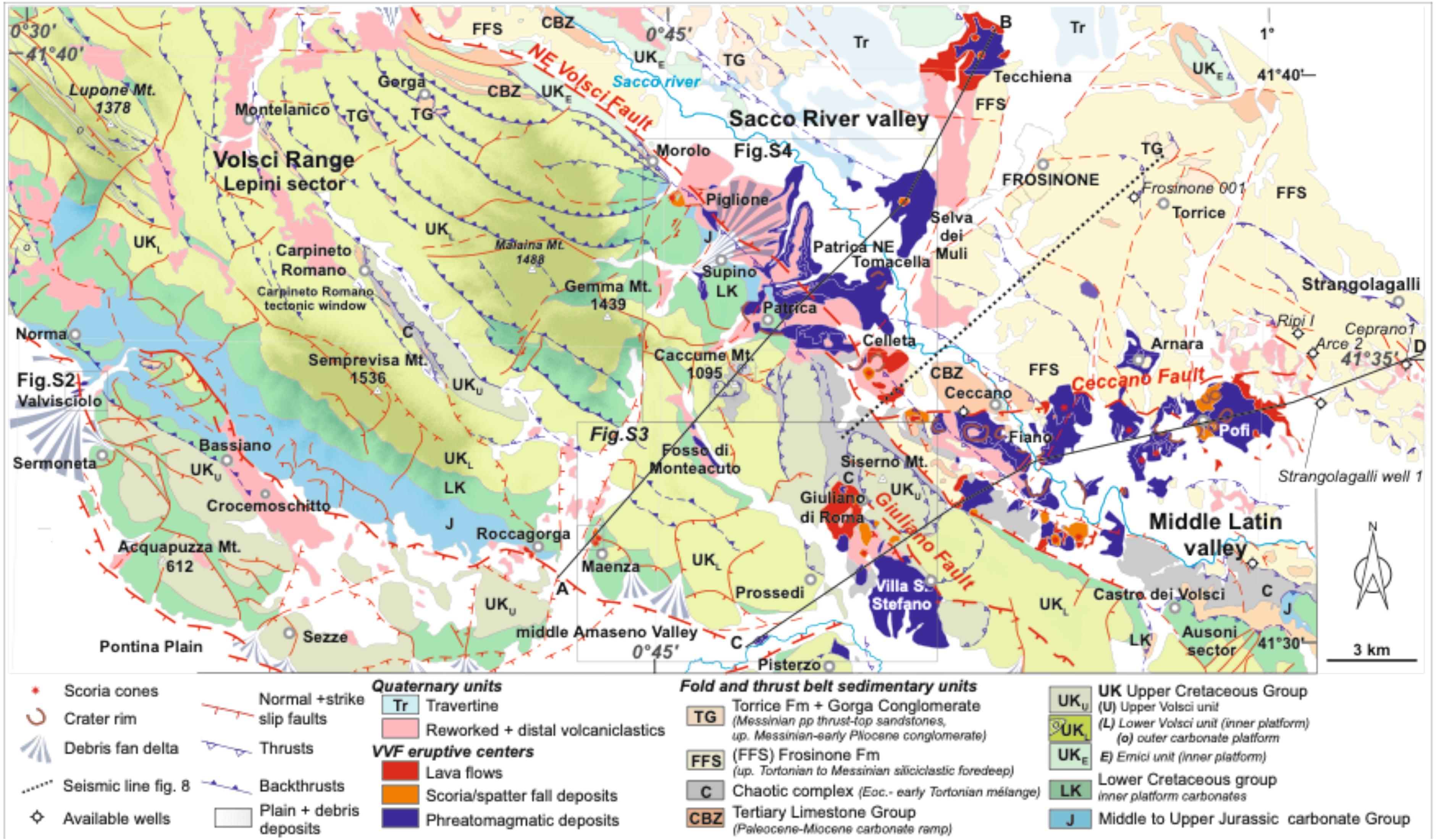
Geological sketch map of the northern Volsci Range and adjoining Middle Latin Valley, including locally sourced VVF eruptive centers. The traces of the seismic line (dotted) of and geological cross-sections (A-B and C-D) of the next slide are also shown.



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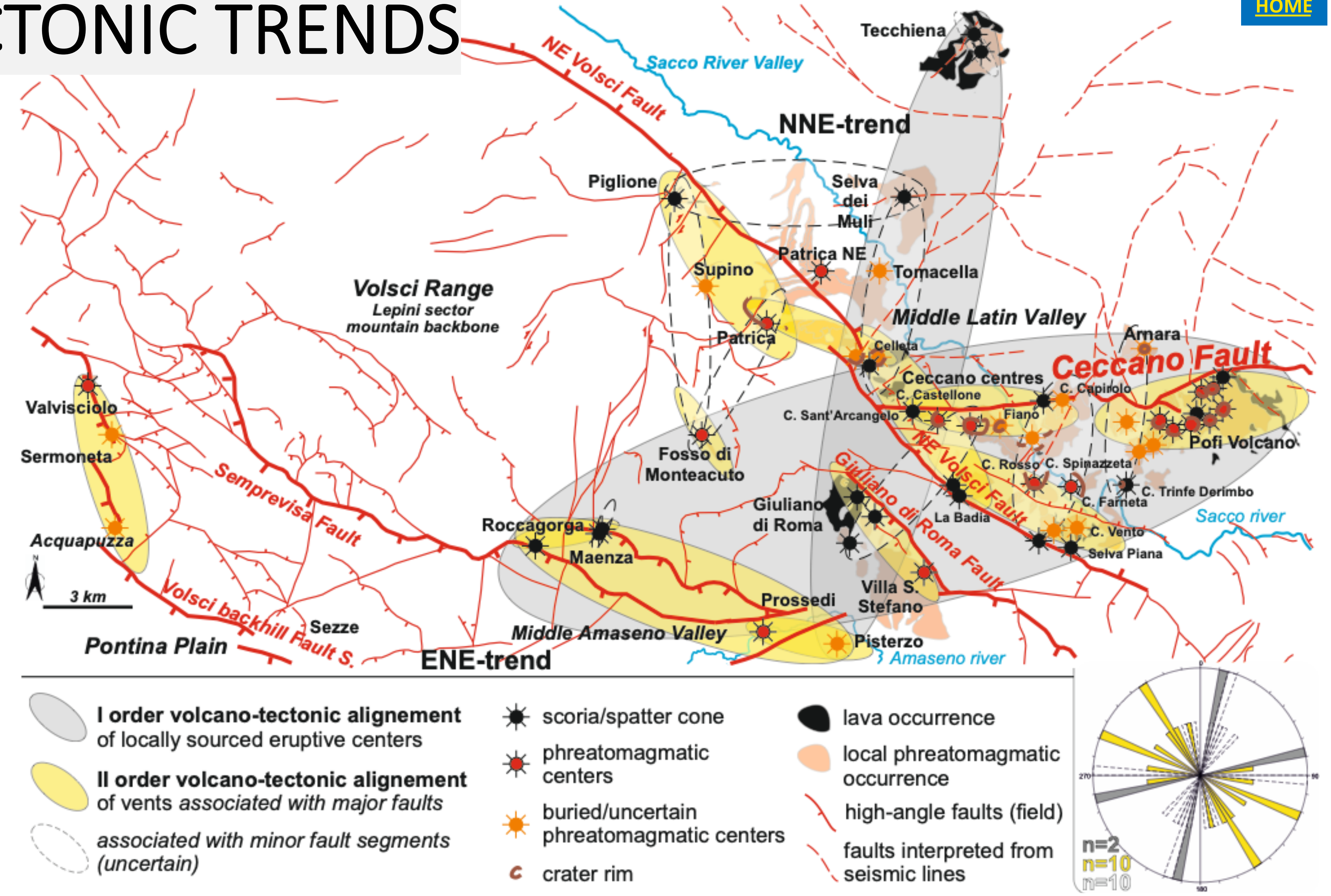
VOLCANO-TECTONIC TRENDS

We define three orders of volcano-tectonic trends, based on the length scale, relationships with fault segments and other morphotectonic indicators.
Two principal (first order) structural trends, striking NNE and ENE, respectively are considered the surface expression of high-angle lithospheric faults that cross the Latin Valley foredeep and the VR fold-and-thrust belt domains.



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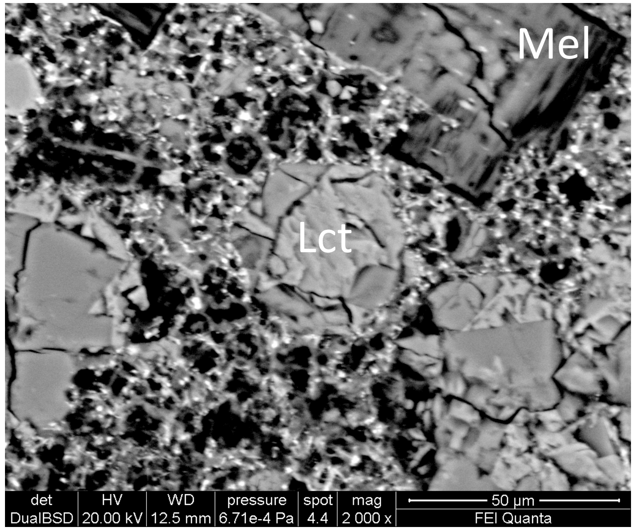
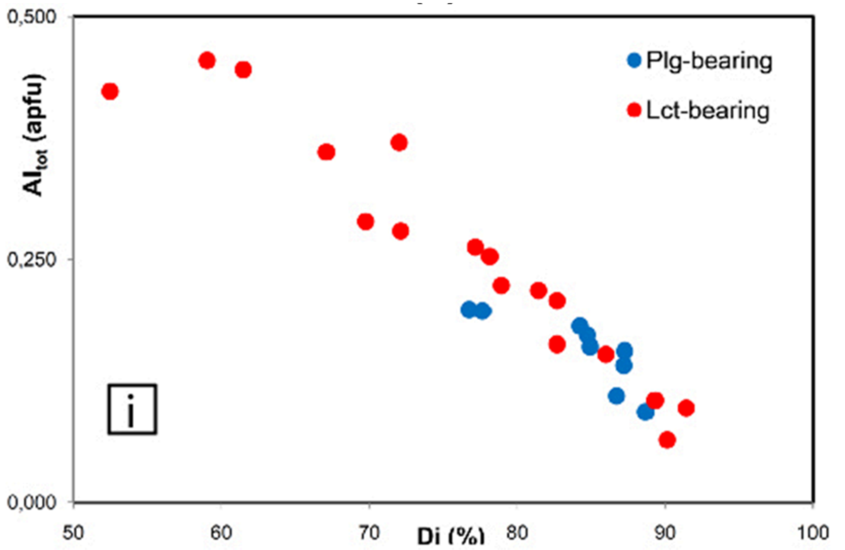
BIMODAL PRIMITIVE MAGMAS: Lct- vs Plg-bearing

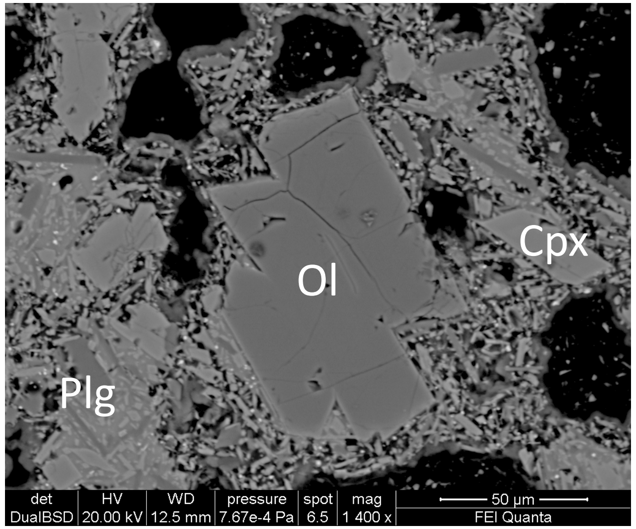
We distinguish Leucite-bearing *versus* Plagioclase-bearing rock types.

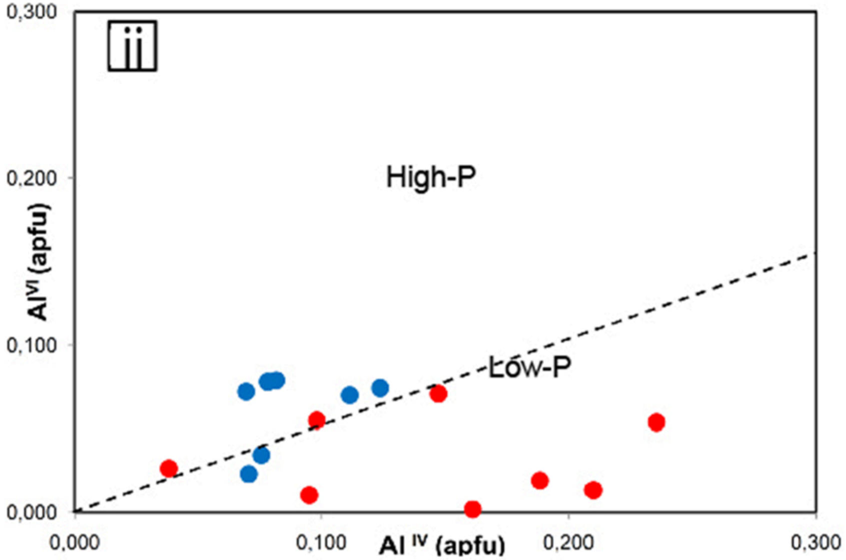
Lct-bearing scoria clasts contain clinopyroxene (Cpx), phlogopite (Phl), melilite (Mel) phenocrysts and leucite (Lct) ± olivine (Ol) microphenocrysts.





Plg-bearing scoria clasts are characterized by Cpx + Plg ± Ol ± Mgt and relatively abundant fresh glass.

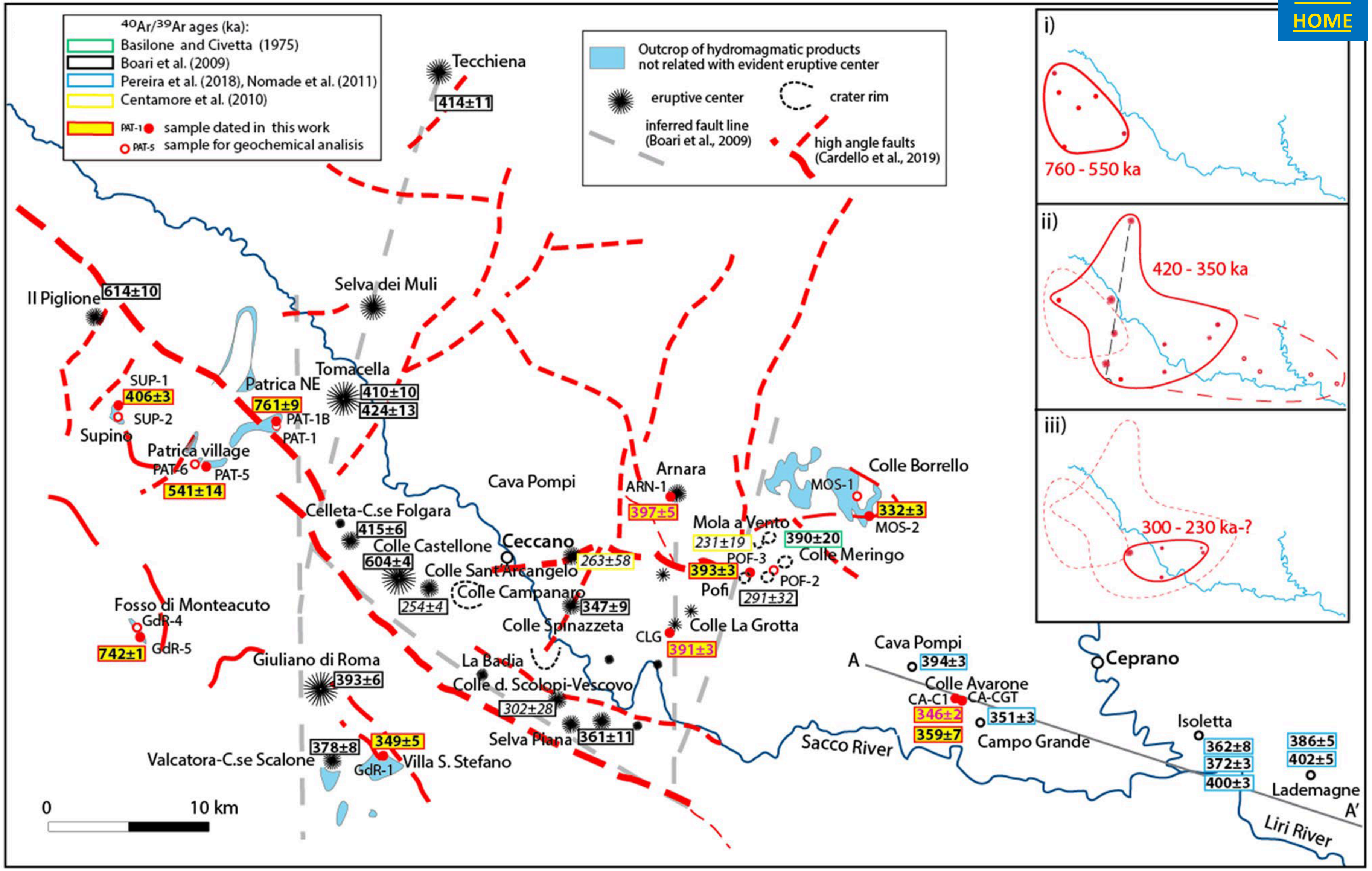




DATA IN: MARRA ET AL. 2021

NEW $^{40}Ar/^{39}Ar$ AGES

Leucite-bearing, high-K (HKS) magmas (for which we report for the first time the phlogopite phenocryst compositions) mostly fed the **early phase of activity** (~ 761–539 ka), then primitive, plagioclase-bearing (KS) magmas appeared during the **climactic phase** (~ 424–349 ka), partially overlapping with HKS ones, and then prevailed during the **late phase of activity** (~ 300–231 ka).



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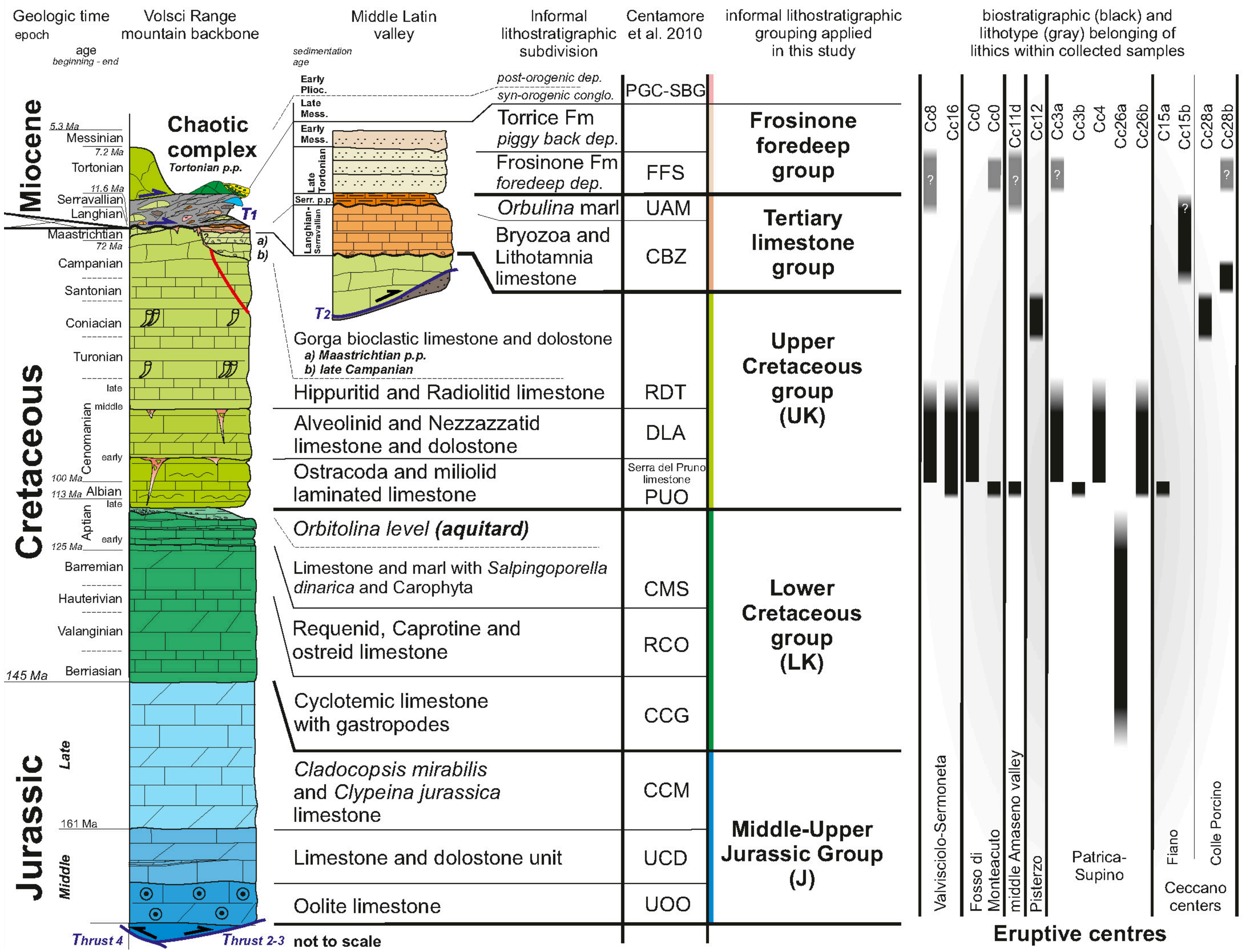
THE SITES OF MAGMA-WATER INTERACTION

MAGMA-CARBONATE WALL ROCK INTERACTION

Composite stratigraphic logs of the northern Volsci Range mountain backbone and Middle Latin Valley, correlated to the Geological Map of Italy.

On the right side, the biostratigraphic ranges of the fossil-bearing carbonate lithics collected from the VVF phreatomagmatic deposits (see : **CARDELLO ET AL. 2020**).
More regional stratigraphic information is provided in CARDELLO ET AL. 2021



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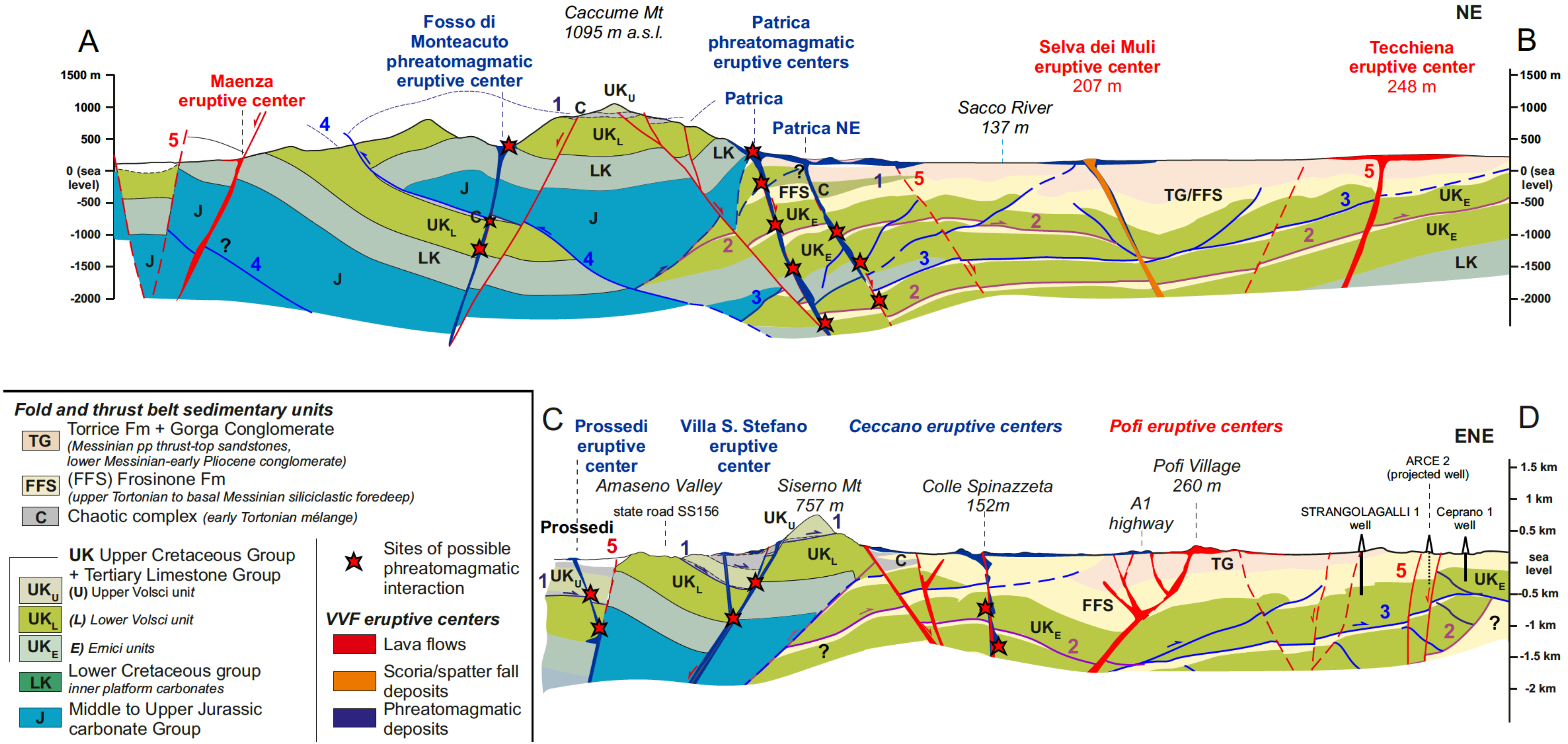
THE SITES OF MAGMA-WATER INTERACTION



MORE DETAILED STRUCTURAL STUDIES ARE IN CARDELLO ET AL. 2021

THE PEPERINO OVEN

MAGMA-CARBONATE WALL ROCK INTERACTION

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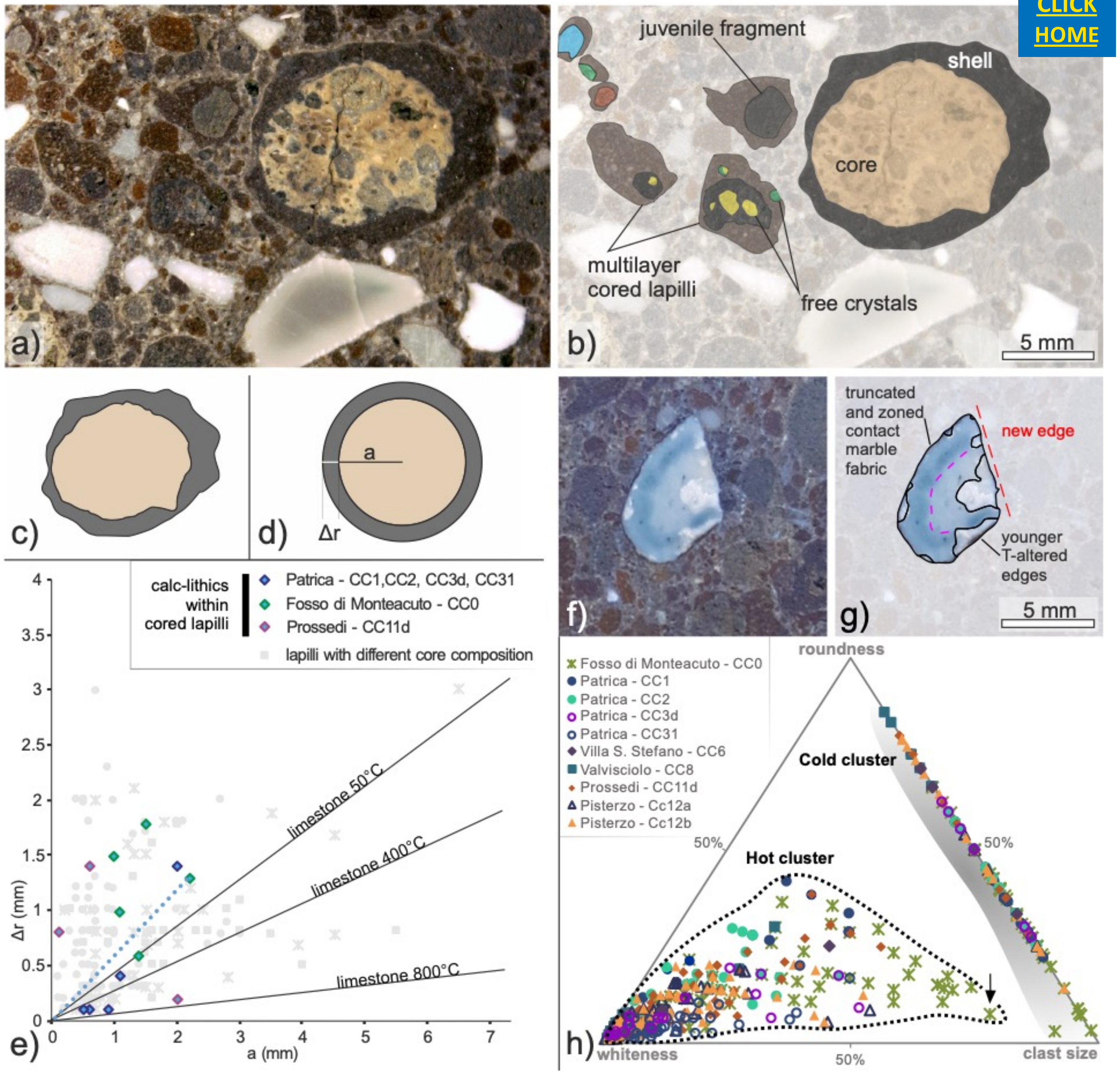
a) Peperino texture in VVF phreatomagmatic deposits;
b) Hand draw of image a), outlining the juvenile shells in a cored scoria lapilli;
c) example of core and shell from image b after thresholding and binarization;
d) shell thickness and core equivalent radius
e) plots of core radius (a) vs. crown thickness (Δr) for cored-lapilli from selected phreatomagmatic deposits
f-g) image and hand draw of a **zoned, rounded carbonate lithic** showing evidence of successive breakage and thermal alteration along the new-formed edges
h) **textural characterization of carbonate lithics from VVF eruptive centers**. The ternary diagram shows lithic clast sizes (measured along the mean axis, representative of phreatomagmatic fragmentation plus attrition during diatreme transport), the degree of whiteness (representative of thermal interaction), and roundness (representative of attrition due to recycling during diatreme transport). All values are normalized to 100 %.



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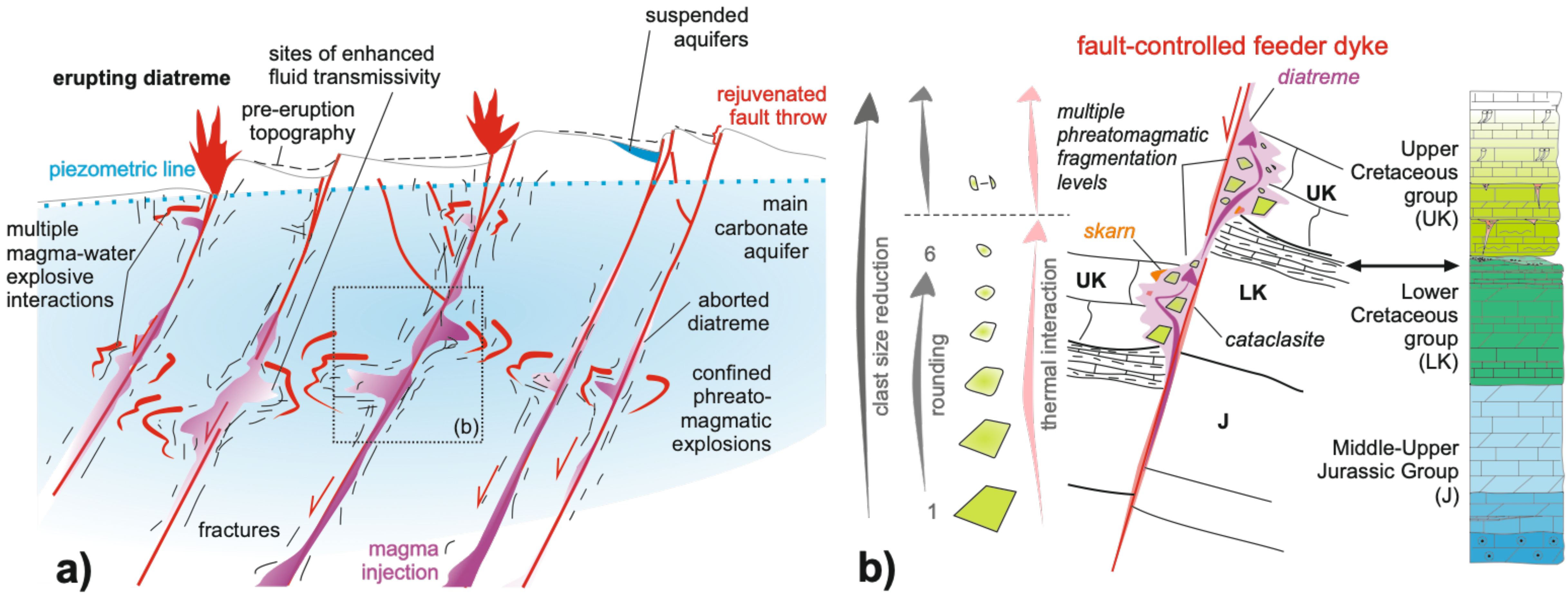
THE PEPERINO OVEN

a) Sketch model for the sub-surface and eruptive processes of the VVF maar-diatremes. Major high-angle normal faults (red lines) drove magma injection and controlled the sites of magma-water explosive interaction, eventually acting as paths to surface during phreatomagmatic eruptions.

b) Cartoon highlighting the stratigraphic and structural control of carbonate wall rocks over diatreme processes.



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CONCLUSIONS

1. **The clustering of eruptive centers is controlled by tectonic features**. Specifically, a first order control is related to crustal laceration and deep magma injection along a ENE-trending Quaternary lateral tear in the slab and to Mesozoic rift-related normal faults. Those structures primarily controlled the fast ascent of small-volume, nearly primary, magma batches from the mantle source (sort of "**bullet eruptions**"), as typical of "tectonically controlled volcanic fields".

2. **Lct-bearing (HKS) and Plg-bearing (KS) primitive magmas coexisted**. In particular, HKS magmas fed the early phase of activity, then KS magmas appeared during the climactic phase, partially overlapping in space and time with HKS ones, and then prevailed during the late phase of activity.

3. **The superposition of a second-order orogenic structures** (mainly normal faults) beyond controlling the local 3-D distribution pattern, **determined the activity styles of volcanic centers**.

4. **Magma-water explosive interaction occurred at multiple levels** (< 2.3 km depth), depending on the structural setting of the Albian-Cenomanian aquifer-bearing carbonates, which are intersected by high-angle faults. The progressive comminution, rounding and whitening of entrained carbonate lithics allow us to trace multistage diatreme processes.

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