A history of deformation within Pietre Cotte rhyolite flow (Vulcano)

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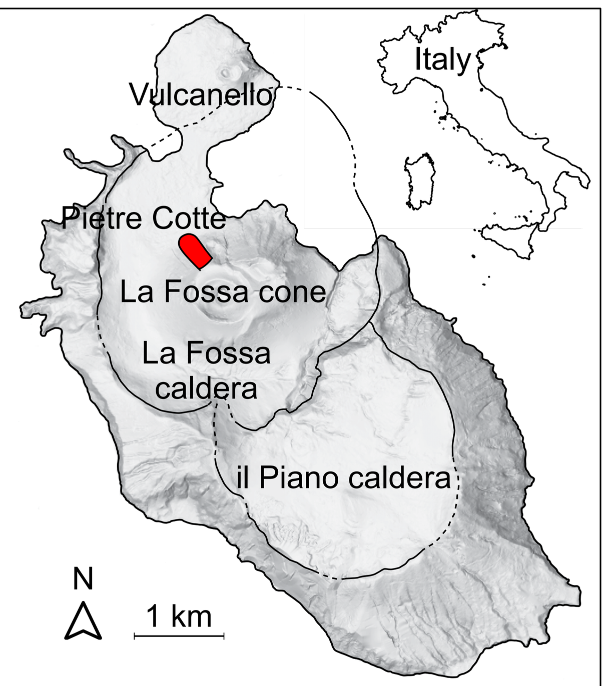
Geological setting

Pietre Cotte (literally "cooked stone") is a rhyolite flow located on the NW flank of the Fossa cone (Vulcano, Italy). It was emplaced around 1740.

The unit is ~380 m long, ~170 m wide, and up to ~15 m thick at the flow front. The lower half of the unit is well exposed through two lateral gullies, while the upper half has been buried under products of the 1888–1890 eruption.



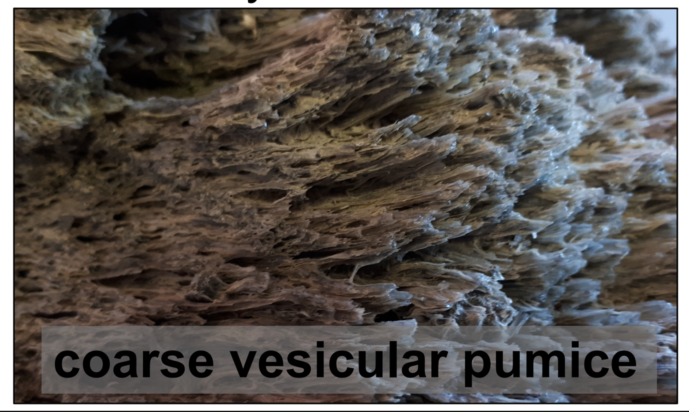
Rationale and methods

Rhyolite flows are rarer than basalt flows. The only case observed while active was Cordón Caulle rhyolite flow (Chile) in 2011–2012. To better understand the dynamics of these flows, we thus need to study past, frozen flows. Pietre Cotte is an ideal case study: the flow is young and offers outstanding exposure in 3D.

We carried out structural mapping and facies analysis during two field campaigns. Orientated samples were also used to determine variations in flow direction through the anisotropy of magnetic susceptibility (AMS). The superimposition of structures, along with textural features, allowed us to build a five-step model of **the rheological and structural evolution of the Pietre Cotte flow**.

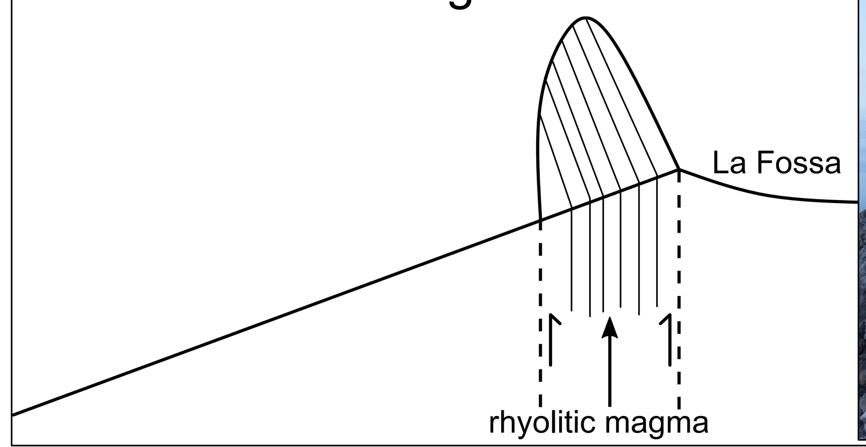
Flow facies

As in Fink's (1983) model, the Pietre Cotte flow shows three main facies based on their texture: **obsidian**, **lithoidal rhyolite**, and **pumice** (either finely or coarsely vesicular). Obsidian and rhyolite are often intertwined, defining flow bands.



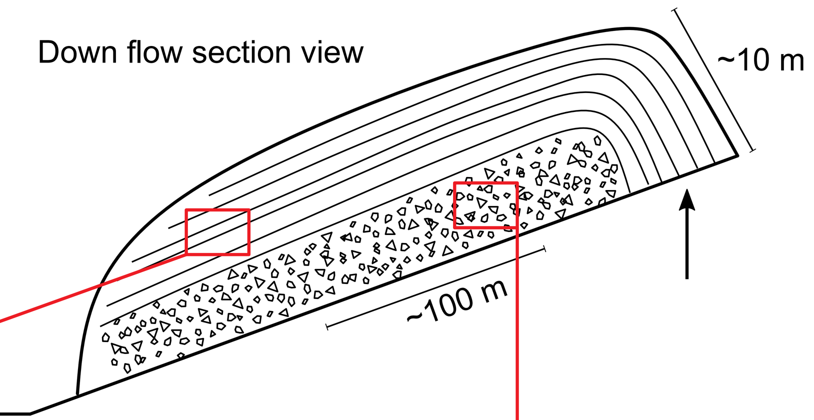
Step 1

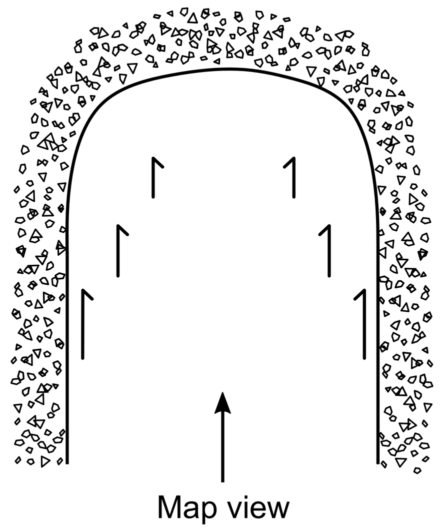
Rhyolitic magma is extruded from a point at 270 m a.s.l. on the cone's outer flank just below the crater rim, with a **sub-vertical foliation** inherited from shearing along the conduit walls during ascent.



Step 2

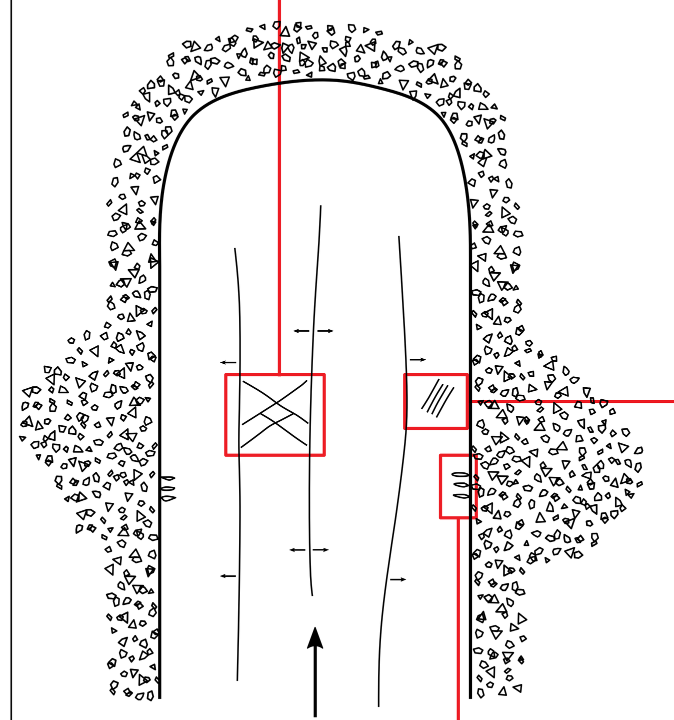
The lava starts flowing on the steep (~34°) upper slope. Brittle deformation occurs on the sides and at the base, where shearing is focused, generating a **basal breccia** and **lateral rubble levees**. Ductile deformation **stretches vesicles** parallel to the flow direction.

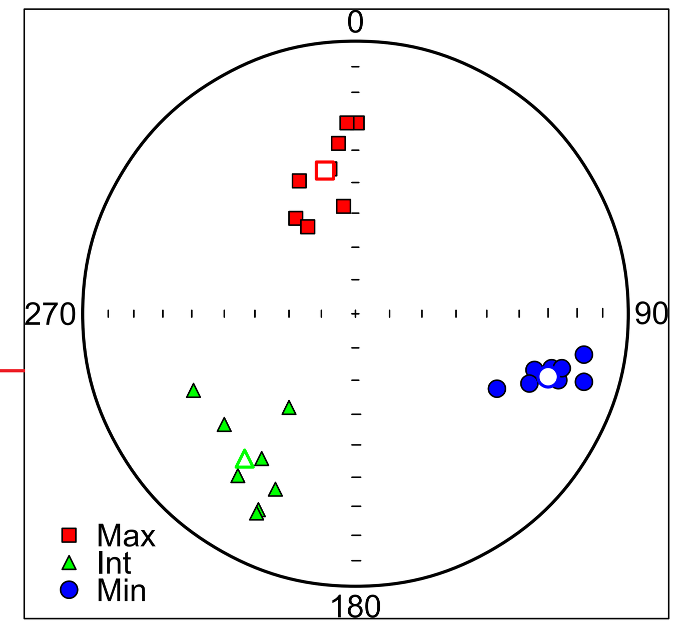




Step 3

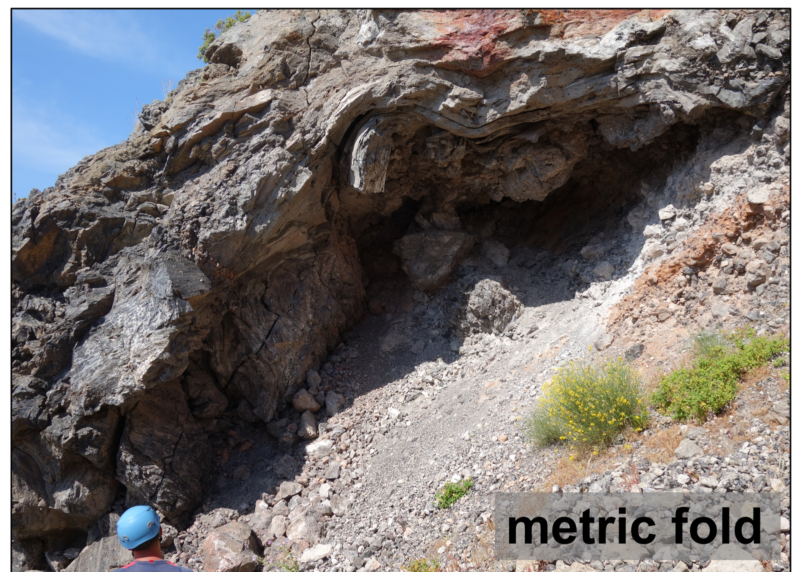
Lava emplacement on a steep slope triggers collapse of lateral levees (to generate block and ash flows whose deposits crop out locally in the basal breccia). By lowering the lateral stress, these events generate local **lateral spreading** of the flow, as shown by AMS data. Cracks develop parallel to the main flow direction, **extension cracks** open at the surface and **tension gashes** on the sides. These openings promote outgassing, creating **tuffisite veins**. Extension leads to decompression-triggered vesiculation, creating pumice pockets.

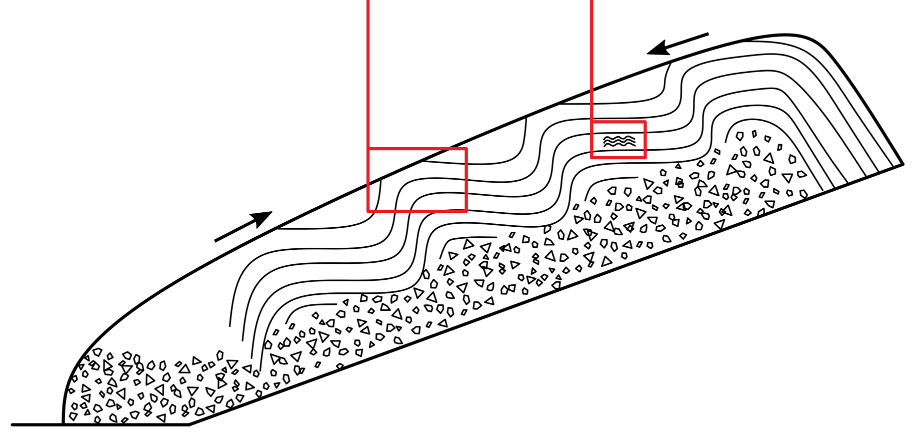




Step 4

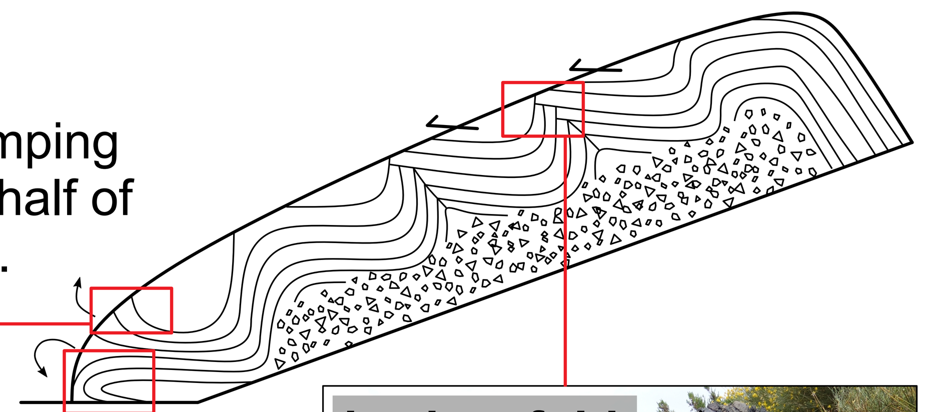
The flow front slows down as the lava reaches flat ground and stagnates, while lava behind the flow front on steeper slopes applies stress. This compressive stress generates **pluri-metric, "stairway-like" folds**, with a right angle between a horizontal limb and a vertical limb, as well as **microfolds**. These overprint the step 3 structures all the way back to the vent.

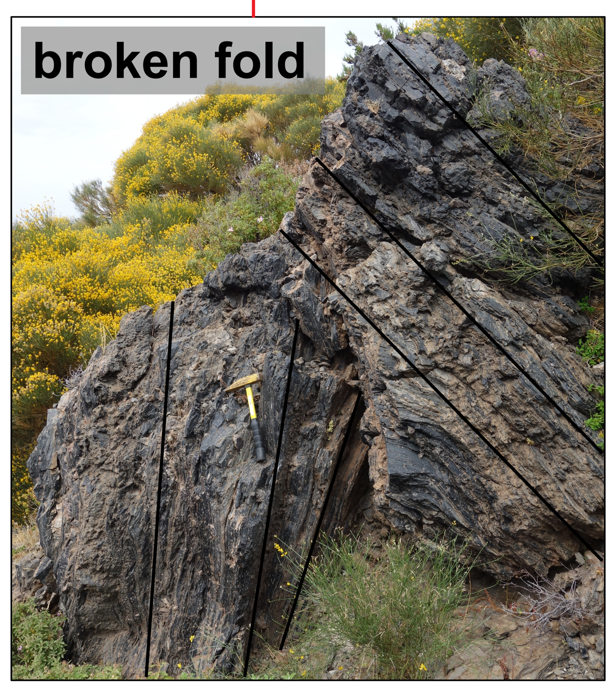




Step 5

The now **brittle folds break**, with the horizontal limb ramping up on top of the vertical one. At the flow front, the lower half of the flow **rolls over** itself, while the upper part **ramps up**.





Conclusion

The Pietre Cotte flow presents a succession of structures revealing a complex emplacement history in a very high viscosity environment, with **ductile and brittle deformation sometimes happening at the same time depending on local variation in stress conditions**. Deformation events drive textural changes (e.g. shearing creating flow bands, extension promoting vesiculation), leading to the different facies observed today in the field. We will now complete this study with quantitative data from textural and geochemical analysis in order to properly define the emplacement model.

Acknowledgements

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