



## **Mud volcanoes as key-systems to investigate continental degassing and the role of seismicity on mass transfer**

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The flow of fluids into the Earth's crust can produce large-scale heat and mass transport. The mechanisms and driving forces for this fluid-transport range from molecular diffusion, to grain boundary diffusion and to advective flow. Recent studies [Torgersen, 2010 and references therein] suggest that large-scale vertical transport of fluids in the continental crust is likely advective and episodic. So it is crucial to understand if the variability of the measured degassing flux is a reflection of this episodic and advective transport.

Here we try to answer these questions by using the noble gases. In particular He that is recognized as a powerful tracer in various fields, such as hydrology, hydrocarbon exploration, mantle processes [Burnard, 2013]. Degassing of He produced in the crust mainly consists of two stages that act on different scales: (1) the release of volatiles from the mineral/rocks and (2) their transport toward the surface [Burnard, 2013]. Tectonic deformation of rocks can rupture mineral grains, cause pervasive fracturing, increase effective porosity, open new fault zones. These processes lead to a release of accumulated geogenic gases (e.g. He) trapped in immobile porosity and/or mineral grains to adjacent fracture networks, which allow transport through the system.

We have developed our study in the central Apennines, which is a seismically active region. We investigate the outgassing of He from two mud volcano systems (Nirano and Regnano) since the geographical distance from active volcanic systems and the typical radiogenic He isotope signature indicate the crustal origin of the outgassing volatiles. Furthermore in this area an aseismic sequence (Mw 6.1) occurred on 2012 May at shallow depths (about 7–9 km).

We have compared both in situ  $4\text{He}$  production and  $4\text{He}$  from an external crustal flux, with the helium contained in the Nirano-Regnano natural hydrocarbon reservoirs. Our model uses a high precision basin volume reconstruction based on the geological-map data and calibrated by using data from deep wells. Our results indicate a higher amount of helium in the reservoir than one could expect. So this study supports that He that is released by rock fracturing contributes to the amount of He emitted from these mud volcanoes.

This approach furnishes new tools for the use of natural degassing as a tool to monitor and investigate the state of stress and strain in Earth materials and the effect of deformation on material transport properties.

### References

- Burnard P., 2013, Noble gases as geochemical tracers, Pete Burnard Editor, Springer.  
Torgersen T., 2010, Continental degassing flux of  $4\text{He}$  and its variability. *Geochemistry, Geophysics Geosystems* 11:1–15. doi: 10.1029/2009GC002930