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Non-volcanic CO_2 and CH_4 degassing in an actively extending orogen, southern Apennines, Italy

Ascione, A.[1], Bigi, S.[2], Ciotoli, G. [3,4], Mazzoli, S.[1] and Ruggiero[2], L.

[1]Department of Earth Sciences, Environment and Georesources (DiSTAR), University of Naples Federico II, Largo S. Marcellino 10, 80138, Naples, Italy, alessandra.ascione@unina.it
[2]Department of Earth Sciences, University of Rome Sapienza, Rome, Italy
[3]Institute of Environmental Geology and Geoengineering, National Research Council of Italy, Rome, Italy
[4]Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy

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The southern Apennines fold and thrust belt has been undergoing post-orogenic extension since ca. 700 kyr. Crustal extension controls active tectonics and seismogenesis in the mountain chain [1], with seismicity being characterized by low to moderate magnitude events punctuated by strong earthquakes [2]. Effective decoupling between deep and shallow structural levels is related to the strong rheological contrast produced by a fluid-saturated, clay-rich mélange zone interposed between buried autochthonous carbonates – continuous with those exposed in the Apulian foreland – and the allochthonous units. This mélange zone also acts as a seal preventing the migration of deep-seated aqueous fluids – as well as oil in the Basilicata region, which hosts the largest Europe's onshore oil fields – towards the surface.

On the other hand, the mountain belt is characterized by substantial gas flow, recorded as both distributed soil gas emissions and vigorous gas vents, associated with active faults at the surface. We measured a CO_2 flux up to 34000 g/m-2 per day at a gas vent, as well as large amounts of He (up to 52 ppm), Rn (up to 228 kBq/m3) and CH_4 (up to 5000 ppm).

Overpressured CO_2, which has been proposed as triggering normal fault earthquakes in the Apennines, has been interpreted as mostly of mantle origin. However, our new results from isotope analyses carried out on the carbon contained in both CO_2 and CH_4 indicate a dominant thermogenic origin for these gases, probably associated with the emplacement of magmatic sills within the lower section of the thick carbonate platform succession occurring at the base of the sedimentary cover in the southern Apennines. Our results bear major implication concerning the postulated occurrence of crustal faults allowing fluids to migrate directly from mantle depths to the surface.

References:

[1] Macchiavelli et al. (2012) Tectonophysics 580: 124–149

[2] Locati M et al. (2011) http://emidius.mi.ingv.it/DBMI11