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Identification of the high fluid pressure source driving the 2009 L'Aquila earthquake sequence

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The April 6, 2009 L'Aquila intraplate earthquake (Mw=6.3) in the Central Apennines occurred at the boundary separating regions of diffuse CO2 degassing and regions where degassing is not observed. The same tectonic and geologic environment hosted the 1997 Colfiorito sequence to the north, which was shown through modelling to be driven by degassing of a high-pressure fluid source at depth. Unlike the Colfiorito sequence, where the fluid pressure distribution at depth was unknown, here we show the 3D fluid pressure distribution in the focal area of the L'Aquila earthquake. We apply a new analysis technique termed Focal Mechanism Tomography using seismic data to identify three large-scale pockets of high fluid pressure at depths of 7-10 km. An independent dataset of well-located aftershocks shows a very strong correlation between the high pressure regions and aftershock hypocenters. The shape of over-pressured regions and the evolution of aftershock locations indicate that this sequence is also being driven by trapped reservoirs of high pressure fluid, presumably CO2. Some correlation is found with volumetric compression from the main-shock acting upon the over-pressured poro-elastic reservoir, and indications of fracturing and subsequent flow from trapped high pressure pockets. The mapped 3D fluid pressure field provides an important boundary condition for forward modelling of fluid flow and stress evolution for a mechanistic assessment of the continuing seismic hazard in the region. These results also form a baseline hypothesis against which other geophysical and geochemical measurements can be tested.

Keywords: Fluid pressure fields in the crust, Focal mechanism tomography,
Driving mechnaims of aftershock events, Focal mechanism data of seismic events, Stress inversion, Bayesian modelling and ABIC