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The Attenuation and Scattering Signature of Fluid Reservoirs and Tectonic Interactions in the Central-Southern Apennines (Italy)

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The intricate tectonics of Central-Southern Italy, characterized by its complex fault network and sparse seismicity distribution, have posed a significant challenge to understanding the region's seismic hazard, its three-dimensional structural assessment, and the role of fluids in the seismic release. Conventional geophysical techniques, often limited by low seismicity rates, have struggled to provide a comprehensive picture of the crustal structures, and a coherent geophysical model of the area is still absent. Leveraging the last decade's expanded detection capabilities of the Italian seismic network, we were able to make up for this lack and employed seismic attenuation and scattering tomography methods to produce complete 3D attenuation models of the crust.

By analyzing the energy loss of seismic waves as their propagation through the crust, the study revealed a pervasive pattern of high attenuation zones that extend along the entire Apenninic Chain, particularly concentrated in Southern Italy. The distribution of these anomalies aligns closely with the regional fault structures suggesting a strict relationship with the fracture level due to the tectonic processes. In contrast to the bigger anomalies, the study also identified prominent low attenuation and scattering volumes corresponding to the Fucino and Morrone-Porrara fault systems. These are likely regions of accumulated stress where the locked seismic energy release contributes to the high seismic hazard. Furthermore, the study identified a previously undetected high-attenuation region beneath the Matese extensional system, indicating a potential source of both deep and shallow circulation of fluid. Another anomaly was detected near the L'Aquila 2009 seismogenic area, suggesting a regional distribution of fluid-rich areas.

The findings of this study provide unprecedented insights into the tectonic interactions and fluid sources of Central-Southern Italy, with significant implications for seismic hazard assessment, fluid exploration, and the development of effective mitigation strategies for this geologically active region.