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Thermal characterization of the Italian crust from thermodynamics and joint-inversion of receiver functions and Rayleigh wave phase velocities.

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The inference of crustal temperature is limited by the scarcity of heat-flow measurements and their unreliability, especially in active regions where the assumption of pure heat conduction does not hold. We propose two alternative approaches for constraining the thermal structure at crustal depth, based on seismic observables and thermodynamics.

We invert receiver functions and ambient-noise dispersion curves at 50 locations across the Italian peninsula. Beside the retrieval of a subsurface model in terms of Vs and Vp/Vs, the trans-dimensional, Monte Carlo Markov chain algorithm used for inversions allows a quantitative estimation of the likelihood of occurrence of a seismic interface within the crust. Sharp and well constrained seismic interface where the Vp/Vs ratio increases above 1.8 are interpreted as indicative of the transition of quartz from its α to β form. Such seismic interfaces are then used for the inference of the local geothermal gradient. As a comparison, we employ an alternative method that relies on the translation of shear wave velocities at depth into absolute temperature through thermodynamics, assuming that the chemical composition is known (we use the global estimate from Rudnick and Gao [2003]). The similarity of the outcomes from the two approaches is remarkable and coherent with the known tectonic and geodynamic setting of the Italian peninsula. Based on this premise, we produce the first quantitative estimation of Moho temperatures for this area. These are comprised between 800 and 900°C, approaching 1000°C in the thickest portion of the western Alps and central Apennines. A shallow and anomalously hot Moho (>800°C at 15 km depth) is found in the Tyrrhenian basin, coherent with its extensional regime, high heat-flow and volcanism (i.e. Vavilov and Marsili active seamounts). In the Tuscan magmatic province, we find Moho temperatures >800°C at 20-25 km that are compatible with the significant hydrothermal activity and known geothermal potential of the area. Our findings also unravel a significant thermal anomaly at the transition between the Alpine and Apennine orogens in NW Italy. The robustness of this feature is supported by independent geological and geophysical evidence. More in-depth studies are required for clarifying its cause, role and possible implications in the evolution of the Alps-Apennine transition.

The proposed methods, relying on seismic observable and thermodynamics, can surpass heat-flow data for temperature inference in terms of coverage, resolution and data abundance, suggesting that these would be potentially employed in a variety of geological and tectonic complexes.