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The re-birth of an inherited rift fault as a partly seismic discontinuity. Ambient noise tomography of the Ventaniella fault, NW Spain.

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The Ventaniella fault is an inherited structure that cuts across the Cantabrian Mountains and margin from the NW to the SE in the northern part of the Iberian Peninsula (NW Spain). This structure runs for more than 300 km inland, obliquely with respect to the orientation of the mountain belt, and it extends offshore, into the Bay of Biscay, for another 150 km. A significant part of its current length developed as an extensional fault active in the Late Permian and during the Triassic extensional processes, when the fault acted as a rift bounding fault and led to the formation of a thick Mesozoic sequence in the eastern block. In the Cenozoic, the alpine shortening reactivated it as a dextral strike slip fault with an associated reverse component. With the final docking of Iberia in Europe and the migration of the plate boundary to the South, the area began its current passive stage. The fault, however, shows low-magnitude seismicity at both ends in the current ca. 40 year old catalogue.

Crustal blocks on either side of the Ventaniella fault show a different tectonic history during the alpine shortening, being deformation substantially higher in the NE block, so much so that the orogenic root is mostly restricted to this part of the crust. Only the crust seems to have thickened to the east of the trace of the Ventaniella fault.

This study presents the first detailed analysis of ambient noise tomography in the crust supporting the central part of the Cantabrian Mountains, including crust from either side of the Ventaniella fault. Ambient noise data from a local short-period network and a regional broadband network (non-simultaneous) have been analyzed. The phase cross-correlation processing technique was used to obtain more than 34000 daily cross-correlations from 123 station pairs. They were then stacked by applying the time-frequency, phase-weighted methodology. The empirical Green's functions obtained provided the emergence of Rayleigh waves. After measuring group velocities, tomographic maps were computed at different periods and S-wave velocity slices were obtained reaching the first 12 km of the crust.

The results show shallow velocity patterns that can be related to surface geology in the first 5 km (either bedding and/or lithology and fracturing associated to faults) while below they rather depict the general intersection patterns of larger structures such as the Ventaniella fault system (including the Tarna fault, slightly oblique) with other alpine age or alpine-reactivated structures. One of the seismically active segments of the fault is located in an area where S-waves velocities are anomalously reduced, suggesting that the intersection of several faults generate damage zones favoring fluid circulation.

The current crustal architecture in northern Iberia is largely controlled by inherited temperature signature of the crust after various extensional events during the late Paleozoic and Mesozoic. Our results show how differences in tempreature structure created within the crust more than 240 Ma ago, and reinforced 100 Ma ago, influenced subsequent geological events and current intraplate seismicity distribution.