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Cretaceous subduction in the Pyrenees: Iberian plate-kinematics in a mantle reference frame

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During the Cretaceous, Iberia was a microplate separated from Laurasia and Gondwana by ridges and transforms, and by a convergent margin to its northeast along which the Pyrenean fold-thrust belt developed. As a microplate, Iberia underwent a well-defined but ill-understood Albian-Aptian $\sim 35^{\circ}$ counterclockwise rotation relative to Eurasia. Three competing kinematic scenarios for Iberian motion in the late Mesozoic are all compatible with the Pyrenean geological record and comprise (1) transtensional eastward motion of Iberia versus Eurasia, (2) strike-slip motion followed by orthogonal extension and (3) scissor-style opening of the Bay of Biscay coupled with subduction in the Pyrenean realm. The last scenario is the only one consistent with paleomagnetic and ocean floor anomaly constraints showing Iberia's rotation, but is criticized because the upper mantle below the Pyrenees contains no evidence for a subducted slab. Here we show that when taking absolute plate motions into account, Aptian oceanic subduction in the Pyrenees followed by Albian slab break-off should leave a slab remnant in the present-day mid-mantle below NW Africa instead of below the Pyrenees. Mantle tomography shows a positive seismic velocity anomaly that matches the predicted position and dimension of such a slab remnant between 1900 and 1500 km depth below Reggane in Southern Algeria. Seismic tomographic imaging of the mantle structure therefore does not falsify the Pyrenean subduction hypothesis, and provides no basis to discard marine magnetic and paleomagnetic constraints on Iberia's kinematic history. Slab break-off explains the well-dated Albian-Cenomanian high-temperature metamorphism in the Pyrenees that hitherto has been interpreted as an expression of continental break-up and hyperextension. We suspect that subduction in the Pyrenees may have played a key role in driving the rapid Aptian rotation of the Iberian microplate.