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Extensional detachments in the external Rif: a mode of upper-crustal extension during oblique collision (Temsamane units, eastern Rif, Morocco)

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Oblique continental subduction of the north Maghrebian passive margin beneath the Alboran crustal domain during the middle to late Miocene resulted in ductile deformation and metamorphism of the Temsamane units. These units represent the structurally lowermost section of the external Rif that presently form the metamorphic basement of the late Miocene (Messinian) Kert and Boudinar basins. New structural mapping of the Temsamane massif has evidenced the importance of ductile strain localization in the stacking and later exhumation of these units. Three mylonitic shear zones have been identified in this crustal stack. The two lowermost ones are found at the base of large recumbent folds that involve both the Mesozoic cover and Paleozoic basement of the north Maghrebian margin. These show an ENE-WSW stretching lineation and produce the rotation of the previous NW-SE fold hinges towards this orientation. The uppermost mylonitic shear zone is approximately 100 m thick and shows a low-angle ramp geometry that cuts down into the fold and thrust stack. This shear zone shows top to the southwest transport sense and separates epizone metamorphic rocks of the Temsamane units below from anchizone rocks of the Ketama-Aknoul units above. Towards the east deformation becomes brittle, branching into a listric-fan normal-fault system that cuts trough late Miocene volcanics in the Tres Forcas cape. Towards the west and southwest, the ductile shear zone is cut by out of sequence high-angle normal faults that bound the northern margin of the Kert basin and separate anchizone to diagenetic rocks from the Aknoul unit from epizone Temsamane units. We interpret this shear zone as a brittle-ductile extensional detachment system that has contributed to the exhumation of the Temsamane units and the development of the elongated Temsamane metamorphic dome. This extension occurred in the hinterland of the Rif oblique collisional system that continued shortening further south producing the pre-Rif mountain fronts during the late Miocene, until present. This evolution is parallel to the one observed in the Betics, the northern branch of this orogenic system, during the same time period.