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# Reverse fault propagation in shales and associated decametric deformation gradients.

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The southern Pyrenean Zone shows a classical thin-skinned fold-and-thrust belt. Particularly interesting is the thrust sequence detached in the Upper Triassic low-strength level cropping out in the central-western sector of the chain (Leyre-Orba thrust system). Along its mapped trace, the Leyre thrust cleanly places the Cretaceous units on top of the Eocene (syn-tectonic) marls of the Jaca basin. However, in the footwall of this thrust there is a series of smaller-scale faults related to the main thrust and involving exclusively the marly units.

Understanding the deformation that marls (often lacking structural indicators) have acquired is a subject of interest to many geoscientists, given the role that these rocks play in geological storage systems. Knowing the state of the rock fabric may be essential to understand variations in its expected physical properties. In particular, Anisotropy of Magnetic Susceptibility (AMS) is a technique that can be successfully (although perhaps not easily) applied on these lithologies, provided that clay minerals present on marls are responsible of the magnetic signal of the fabric.

The marls of the Arro-Fiscal formation show fracturing and a pervasive cleavage along a width of hundreds of meters along strike the Leyre fault. The penetrativity of cleavage gradually increases with the proximity to the main fault, as demonstrated by Boiron et al. (2020). However, new data presented in Gracia-Puzo et al. (2021) and this communication show that the deformation gradient is not a single progression, but that there rather are variations in the intensity of deformation, as indicated by the magnetic fabric data of the marls, what can also be correlated with outcrop observations in the field.

A second look at the outcrops, after considering AMS data, has permitted to detect faults that a priori were not observed, since they involve the same monotonous lithology in both walls. Therefore, they are not presented in previous cartographies. In outcrop view, we can detect areas where the marls have undergone significant deformation, with a very penetrative, almost slaty cleavage. These deformation zones are metric in thickness, and the less intense pencil cleavage in the marls can extend several tens of meters in thickness across strike.

For realizing the presence of these faults, the study of the magnetic fabric has revealed as a useful tool, since it gives a very accurate picture of strain conditions (Parés, 1999; Gracia-Puzo, 2021). In

this presentation, microscopic data are also added. Together with the AMS dataset, they are aimed to characterize the fabric of the deformed marl, and thus to understand how deformation has developed in the context of the foreland of the Leyre thrust and the Arro-Fiscal Formation, at different scales. Gathering AMS data, thin sections and field observations, we conclude that a symmetrical deformation shadow is observed in these faults, involving both the foot-wall and hanging-wall.

Finally, in this work, we aim to characterize these strained beds, which differ in scale and geometry from other known deformed marls, thus extending our knowledge of shale cleavage formation.