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Deciphering the structural style of the deformation front in the western Central Andes: insight from the Sierra de Moreno in northern Chile

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ABSTRACT

For many years, the deformation front of the western Central Andes has been interpreted as a single west-directed reverse fault, whose position coincides with the mountain front bounding the westernmost part of the Domeyko Cordillera. However, recent interpretations of industrial 2D seismic data have revealed a series of thick-skinned structures located several kilometers west of this sector, thereby opening a new debate regarding the position, geometry, and nature of the deformation front. To contribute to this discussion, we conducted a structural analysis along two key sectors of the Sierra de Moreno in northern Chile supported by field data and balanced cross-sections. Based on structural and stratigraphic relationships identified in the field, we explored different solutions to explain the regional-scale architecture of this region and to understand the tectonic mechanisms that have configured this part of the Andean forearc. Our results suggest that the Andean structure in this region corresponds to a doubly verging, hybrid thrust system composed of both thick- and thin-skinned, fold-related faults. This system is characterized by the interaction between west-directed, moderate- to steeply dipping, thick-skinned reverse faults and east-directed, thin-skinned, shallow thrusts, defining a structural framework comparable to a tectonic wedge. Furthermore, the exposure of folded and faulted marine Jurassic *syn*-rift strata in the hanging wall of one of the most significant structures (La Barrera Fault), together with their absence in adjacent fault blocks, can be explained by the reverse reactivation of an ancient Jurassic half-graben structure. This interpretation is consistent with previous seismic data analyses, which suggest that the deformation front of the western Central Andes is controlled by the inversion of inherited pre-orogenic normal faults, related to the pre-Andean extensional system established in northern Chile during the Mesozoic. Based on the restoration of the fold-related faults interpreted in our balanced cross-sections, we estimated a minimum crustal shortening of between 7 and 10 km, which was mainly accommodated by the tectonic inversion of Jurassic precursor normal faults and the propagation of newly formed thrust and reverse faults. In conclusion, the western deformation front of the Domeyko Cordillera is interpreted to have been controlled by the initial distribution of pre-existing normal faults.

1. Introduction

Tectonic transects across the Central Andes have played a fundamental role in understanding how plate convergence is partitioned between the subduction of oceanic lithosphere and the deformation of the continental margin of South America (e.g., Oncken et al., 2006; Horton, 2018; Giambiagi et al., 2022; Martínez et al., 2023; Martínez and Rojas-Vera, 2025). Inherited basement-involved extensional structures are a primary control on the localization, style, and magnitude of contractional deformation in many orogenic systems worldwide (e.g., Alps, Apennines, Pyrenees; Butler et al., 2006, 2018). Their reverse reactivation often drives thick-skinned deformation and along-strike variations in structural style; therefore, constraining their kinematic and geometric evolution during mountain building is critical. Resolving this issue is

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