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Spatial and temporal interplay of local stress field and fluid migration along an Andean fold-and-thrust belt front

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The estimation of contemporary stress field and upper crustal deformation during the evolution of a foreland thrust belt is crucial to understand fluid migration and storage at the thrust front. Stress and paleostress analysis allow characterizing the evolution of the Miocene to Present stress field in the frontal part of the Malargüe fold-and-thrust belt (34.5-36.5ºS), Argentina, and the relationship between the stress field evolution and fluid migration. Based on analysis of stress-induced borehole breakouts and tensile fractures interpreted from televiewer images, mini-frac tests, seismological information, the calculation of the overburden from integration of density logs, dyke and sill analysis, and surface fault slip data, we discuss the relationship between the stress field and fluid migration. The analysis and interpretation of these data show that the stress field gradually changes from compressional in the northern domain (34.5º-35ºS, Sosneado and Río Atuel areas), to compressional/strike-slip in the central domain (35-36ºS; Puerto Rojas and Cerro Mollar areas), to pure strike-slip in the southern domain (36-36.5ºS, Palauco and Cajón de los Caballos areas), and this variation has an important impact over magma and oil migration.

Our results evidence a gradual change in the current tectonic regime from compressional to strike-slip regime with homogeneous maximum horizontal stress SHmax orientations, from the northern to southern domains, respectively. Quaternary strike-slip faults co-exist with reverse structures in the central domain, consistent with one mini-frac test indicating that the magnitude of the minimal horizontal stress Shmin is extremely close to the vertical stress Sv, and hence the existence of a compressive/strike-slip regime. Under this regime, intrusion of both dykes and sills are expected to occur. We suggest that under this specific stress regime (Shmin$\sim$Sv) a change from compression (Sv=σ3) to strike-slip (Sv=σ2) regime with a σ3/σ2 permutation occurs during the seismic cycle of the subduction-megathrust. The subduction system provides a first-order stress field with $\sim$E-W horizontal compression (SHmax). Second-order spatial and temporal variations in σ2 and σ3 relative magnitudes are interpreted here as relaxation of the horizontal principal stresses (both SHmax and Shmin) following a megathrust earthquake at the subduction zone. Analysis of distribution and conductivity of fracture systems in the central domain indicates that both low angle, reverse, N-S striking faults, and high-angle, NW and SW strike-slip faults are the most important hydraulic conduits at the thrust front. This is in agreement with the assumption that those fractures oriented such that they experienced a high ratio of shear to normal stress are critically stressed and most likely to have high conductivity.

The main outcome of this study is that variations along the thrust front can be explained by a regional first-order stress field influenced by second-order stress fluctuations as a result of the seismic cycle of the megathrust subduction system.