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Slip on 'weak' faults by the rotation of regional stress in the fracture damage zone

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The concept of stress rotation within fault zones is important in order to understand the strength of fault zones that are unfavourably oriented with respect to the remotely-applied driving stress. The San Andreas 'stress-heat flow paradox' and slip on low-angle normal faults imply that fault zone weakening must occur. Possible explanations for this weakening include weak fault materials, dynamic slip weakening and elevated pore fluid pressures. Stress rotation within the fault zone must accompany high pore fluid pressures, or effective σ_3 will be pushed well into the tensile field, resulting in hydrofracture, pore fluid pressure loss and fault strengthening. Here we show from field observations of a major tectonic fault, laboratory experiments and numerical modelling, that stress rotation is significant within the fractured damage zone surrounding a fault. We characterize the microfracture damage surrounding a major strike-slip fault within the Atacama fault system in northern Chile, which shows an exponential decrease with distance from the fault core. We then relate the microfracture damage to changes in elastic properties as measured in laboratory experiments. The field and laboratory data are then used in a two-dimensional plane strain model to show how the remotely applied stress field is affected as the fault core is approached. We show that greatest principal stress orientations of 80º with respect to the fault plane can be rotated to approximately 40º within the damage zone. The damage-induced change in elastic properties provide the necessary stress rotation to allow high pore pressure faulting, without resulting in hydrofracture.