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Structural evolution of a crustal-scale seismogenic fault in a magmatic arc: The Bolfin Fault Zone (Atacama Fault System)

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The nucleation and evolution of major crustal-scale seismogenic faults in the crystalline basement as well as the process of strain localization represent a long-standing, but poorly understood, issue in structural geology and fault mechanics. Here, we addressed the spatio-temporal evolution of the Bolfin Fault Zone (BFZ), a >40-km-long exhumed seismogenic splay fault of the 1000-km-long strike-slip Atacama Fault System. The BFZ has a sinuous fault trace across the Mesozoic magmatic arc of the Coastal Cordillera (Northern Chile). Seismic faulting occurred at 5-7 km depth and ≤ 270 °C in a fluid-rich environment as recorded by extensive propylitic alteration and epidote-chlorite veining. The ancient (125-118 Ma) seismicity is attested by the widespread occurrence of pseudotachylytes both in the fault core and in the damage zone. Field geological surveys indicate nucleation of the BFZ on precursory geometrical anisotropies represented by magmatic foliation of plutons (northern and central segments) and andesitic dyke swarms (southern segment) within the heterogeneous crystalline basement. Faulting exploited the segments of precursory anisotropies that were favorably oriented with respect to the long-term stress field associated with the oblique ancient subduction. The large-scale sinuous geometry of the BFZ may result from linkage of these anisotropy-pinned segments during fault growth. This evolution may provide a model to explain the complex fault pattern of the crustal-scale Atacama Fault System.