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The brittle evolution of the Critical Zone across South Africa: Implications for sustainable transformation

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South Africa has undergone significant economic and social transformation since becoming a democracy in 1994. Much of this transformation stems from rapid expansion and diversification within the mining and mineral sectors, together with a real shift in economic policy targeting nationwide societal reform. But recently, the economic growth of South Africa has slumped and the country has experienced growing inequality, fuelling social instability. South Africa aims to remedy this by ameliorating *inter alia* mineral and energy developments, and advancing equitable sharing of common resources within the Critical Zone. The Critical Zone is the dynamic interface from the lithosphere to exosphere, within which complex interactions between life-sustaining systems merge. This is a sensitive zone of transformation in which any human-induced negative interactions and chemical imbalances may have widespread implications on life and sustainable living.

A lack of knowledge, especially in South Africa, of how the Critical Zone is interconnected as part of the brittle upper crust is evident when considering the side effects associated with deep resource exploration that include; pollution within the hydrosphere and atmosphere; accelerated land degradation and soil loss and general instabilities within the brittle crust. In South Africa, these are atypical negative side-effects related to the mining and energy industries that bear enormous socio-economic externality costs. Our aim is to better characterise the history of brittle deformation across South Africa, and use this information to map the intricate fracture connectivity within the Critical Zone. This will be done by 3-D mapping of brittle features, notably dormant and active fractures, to establish their propagation parameters, and to determine their 'vascular' dynamics (connectivities). We present initial results from several localities around South Africa and highlight their control on fracture growth and bearing on future exploitation of resources including groundwater, minerals, soil and energy.

Understanding fracture evolution and how subsurface pathways are created over time may facilitate safe and efficient ways of manipulating brittle features in the Critical Zone. Information about the brittle responses of the Critical Zone in South Africa will compliment future exploration targets and technologies that focus and rely on deep fracture engineering. These include technologies such as; fluid sequestration, shale gas and geothermal energy extraction, windfarm and groundwater management.