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INVITED LECTURE: Evolving stress patterns across southern Africa since the end of Gondwana: puzzling clues to the intraplate seismicity of South Africa

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Once again, after the M5.5 event of 05 08 2014 near Orkney (North West Province) many South Africans wondered whether it was of tectonic origin or mining induced, given the exceptional amount of seismic energy cumulatively released in that area over 50 years. The concept that mining stress includes a natural, tectonic component calls for mining and civil engineers to consider the intensity and orientation of the natural principal compressive stresses (σ1>σ2>σ3), or at least the maximum horizontal compressive stress (σH) in their operational planning. Unfortunately, much of the African subcontinent is under-represented in the World Stress Map database.

Our consortium is addressing the problem of the scarcity of stress data by steadily unravelling previously unknown Post-Jurassic tectonic episodes in South Africa. We think that this holistic approach offers robust constraints when numerical models are used to duplicate the observed contemporary stress data.

*Palaeostress analysis. Published data for the Vaalputs site in Namaqualand demonstrate that strength and azimuth of σ1>σ2>σ3 waxed and waned during the Cretaceous-Palaeocene leading to least 6 successive, different tectonic regimes. The most robust of these episodes, at ˜84 Ma, was compressive, with σ1 oriented NNW-SSE, and probably affected the Waterberg plateau and Karas Mountains of Namibia. We are now studying Cenozoic tectonic events in the Cape Fold belt west of Cape Agulhas, and in the Kaapvaal craton at Bultfontein (NW Free State) and near Douglas (SE Northern Cape). In this area the Dwyka diamictite and the palaeo-Orange gravels are locally tightly co-folded and cut by thrusts with vertical throws of up to ˜7m.*Present day stress. To monitor and interpret the Grootvloer seismic cluster in the Northern Cape we replaced an obsolete TELS seismic instrument at the Vaalputs site with a compact, broad-band Trillium seismic sensor, and added two 1-sec sensors of the same make at Aggeneys and Koffiemeul (Bushmanland). The data from these stations will be integrated with those from the national network to obtain the focal mechanisms of the events. These stress tensors are then combined with σH parameters obtained from calliper logs of off-shore wells, in situ σ1>σ2>σ3 measurements, and geodetic data.

Our body of data consistently indicates a NNW-SSE oriented σH (nicknamed the Wegener Stress Anomaly or WSA) that prevails across most of central, southern and western South Africa and Namibia up to the Angola border. In the Congo basin, however, focal mechanisms of a few earthquakes suggest rotation of σH to an E-W direction, whereas σH oriented NE-SW prevails in E Mpumalanga, N Natal, and northern Limpopo. These NE-SW orientated σH vectors may define the southerly extension of the E African Rift System, whereas the strike-slip to transpressional character of the WSA and the thrust regimes of Mesozoic and Cenozoic age elude an explanation based on existing numerical models.

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