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Stress Patterns Across South Africa: Something Amiss?

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To mitigate the uncertainties in assessing the geohazards and rock conditions that affect the nuclear, mining (including hydrocarbon extraction) and civil engineering activities in South Africa, the authors are working to improve the data coverage concerning the present day stress field. In principle, this implies constraining the principal compressive stresses ($\sigma 1 > \sigma 2 > \sigma 3$) or at least the maximum horizontal compressive stress (σH) because knowledge of these parameters may determine the reactivation potential of known faults, or the behaviour of large excavations and wells. By contrast, much of the subcontinent is under-represented in the World Stress Map database. For this reason we have taken a number of steps, firstly by installing a compact Trillium seismic sensor at Stofkloof (Namaqualand; adjacent to the Vaalputs low and intermediate level radioactive waste disposal facility) and 1-sec sensors at Aggeneys and Koffiemeul (Bushmanland). All stations are equipped with Reftek data loggers and powered by solar panels. The data from these stations will be integrated with data from the national network to obtain focal mechanism solutions for seismic events in the Northern Cape – southernmost Namibia region (also known as the Grootvloer cluster). These neotectonic stress tensors are then combined with σH parameters obtained from calliper logs of off-shore wells and from the geometry of joints, faults and sheared fractures in palaeosols (Bushmanland), soils and calcrete (NW Free State) and aeolianites (southern Cape). We also include underground rock engineering phenomenological observations and measurements, and data in the public domain. Our data consistently indicate a NNW-SSE oriented σH (Wegener Stress Anomaly or WSA) that prevails across most of central, southern and western South Africa, Namibia up to the Ruacana hydroelectric power plant at the Angola border. However, in the Congo basin, a few earthquake focal mechanisms suggest rotation of the regional σH to an E-W direction. Geological units affected by the WSA include the Cretaceous oceanic lithosphere (Walvis Ridge), the southern Angola-Kasai craton, the offshore Outeniqua and Orange Basins, the Cape Fold Belt, the Namaqualand metamorphic complex, and the Archaean Craton up to the Witwatersrand basin and the Witbank coal field. In contrast, σH azimuths in the NE-SW quadrants seem prevalent in E Mpumalanga, N Natal, and northern Limpopo. Whereas the origin of these latter stress azimuths are probably linked to the propagation of the E African Rift System, the strike-slip to transpressional character of much of the WSA remains unexplained. Similarly puzzling are a 3-fold increase in seismic events (proxy for strain rate) over the past 20 years in the Grootvloer cluster, and evidence that the WSA is the last of at least 7 successive tectonic regimes to leave their brittle imprints along the SE Atlantic seaboard since the break-up of W Gondwana.