The Stress Field of southern Africa

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The main, more reliable sources of contemporary tectonic stress data for southern Africa include a) borehole breakouts in oil exploration wells from the offshore Orange River and Outeniqua basins, and b) focal mechanism/fault plane solutions from seismic events recorded by multiple stations. Somehow less reliable information is provided by c) stress measurements and stain release structures in operating mines and tunnels, as the newly induced stress in the rocks adjacent to the excavations will interfere with the natural field. A final, least-reliable source of information is provided by d) faults displacing Late Cenozoic sediments. The problem of these latest indicators is linked to the difficulty in finding dissected sediments of demonstrably contemporary, i.e. late Holocene age.

Our observations consistently indicate a NNW - N oriented azimuth of the maximum horizontal compressive stress (σH) that prevails across most of central, southern and western South Africa, and in Namibia up to the Angola border. However, in the Congo basin, a few earthquake focal mechanisms suggest rotation of the regional σ_H to an E-W direction. Geological units affected by this stress field belong to all ages, from Archaean cratons (Angola-Kasai, Kaapvaal) and Proterozoic Mobile belts (Namaqualand metamorphic complex) to the offshore Mesozoic to Cenozoic Outeniqua and Orange Basins and the Cretaceous oceanic lithosphere (Walvis Ridge). Azimuths of σ_H in the NE-SW quadrants seem prevalent in E Mpumalanga, N Natal, and northern Limpopo.

The southerly propagation of the E African Rift System is probably the main driver of stress both in the fractured crust of the northern and northeastern regions, and in the less fractured lithosphere that extends from the Kaapvaal craton to the Outeniqua basin. However, strike slip to transpressional character of the NNW-SSE oriented σH (Wegener Stress Anomaly or WSA) over much of western southern Africa remains unexplained.

The WSA is puzzling, especially because its intensity/strain rate has waxed and waned over time over time spans of decades (cf. the recent Augrabies seismic “swarm”) to tens of millions of years. At least 7 successive very different tectonic regimes have affected Namaqualand and W Namibia in the past 130 Ma; and in the Kaapvaal craton, thrust faults consistent with the same WSA displace likely late Cenozoic sediments at Bultfontein and near Douglas. At this latter locality, over-folding of Dwyka diamictite and reverse faults with a NE dip were also recognized, but their age/structural relations with the reverse faults dipping to the NW have not been resolved.

Key words: southern Africa, focal mechanism solutions, neotectonic stress, Wegener Stress Anomaly