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Neotectonic stress mapping in Southern Africa solves the puzzling M5.5 Orkney Earthquake of 5 August 2014, North West Province, South Africa

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The 5th August 2014 earthquake with its epicentre near Orkney was the strongest in the mining regions of South Africa, and it received much attention from the media and the seismological community. The analysis of its seismic data, including those of the aftershocks, revealed some intriguing facts. Focal mechanism solution is suggesting a NW-oriented, sub-horizontal σ_1 and a left-lateral, predominantly strike slip movement along a cryptic fault plane striking NNW to N. Adding to the puzzle, the aftershock data indicated that most of the seismogenic displacement happened below the gold-bearing reef [1]. These results prompted an international effort to study *in situ* the slippage zone with an inclined borehole drilled from one of the adjacent mines [2]. In our companion study we capture stress data for southern Africa for the past 130 Ma and model their effects on the Witwatersrand basin. Our most reliable data are computed from borehole breakout measurements (mainly offshore exploration wells [3]) and fault plane solutions from seismic events recorded by multiple stations. Less reliable are stress and strain release structures in mines and tunnels as they may reflect, in varying degrees, anthropogenic influences. Further stress data were obtained from the analysis of faults displacing Cretaceous to Cenozoic sediments, even though the difficulty to date the movements severely constrains the application of this technique.

Available observations consistently indicate a NNW - N orientation of the maximum horizontal compressive stress (σ_H), named the Wegener Stress Anomaly [4] that prevails across most of South Africa and Namibia. The data were adopted to produce kinematic models of contemporary stress and strain rate across southern Africa [5, 6]. In particular, Bird's [6] best fit model (AF-SO-013) generates a belt of strike slip stress, with a strain rate ~$10^{-17.5}$ that extends in a NW direction across the North West Province from the Orkney area towards southern Botswana. Notwithstanding the rather coarse character of the AF-SO-013 model, we find that it predicts, within error, the ~350° strike and left-lateral sense of movement obtained from the aftershocks epicentres and focal plane solutions of the M5.5 earthquake.

Neotectonic activity in the Witwatersrand basin is consistent with finds within 100km SSW of Orkney, namely the undated thrust faults cutting calcrete at Bultfontein, and the proposed Late Pleistocene seismites in hot spring deposits at Florisbad [4]. The dearth of data precludes a quantitative assessment of the seismic hazard in the Orkney area, however greater insights might be obtained from more geological mapping in the northwestern Free State province and a forensic scrutiny of tremor swarms in

the Witwatersrand basins [4], starting from those, if any, with M > 2 x the Standard Deviation of the area average.

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