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Stress rotation, scale invariance and locked in stress

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In mining, anomalous or unexpected stress patterns leading to potentially hazardous rock conditions are often loosely ascribed to the phenomenon of "locked in stress". In this contribution I suggest that many anomalous stress patterns may be explained by rock strength anomalies, stress channelling and stress rotation without invoking the concept of stress that was somehow captured and retained by the rock for millions of years.

Stress rotation is commonly observed in deep South African gold mines, as reflected by curving extension fractures. A study of the geometric relations between brittle shear zones and extension fractures in the surrounds of advancing mining faces led to a new interpretation of the evolution of fractures in this environment [1]. The simple recognition that extension fractures map the δ1δ2 plane at the moment the fracture develops, allowed the reconstruction of events leading to the typical configuration of fractures around the active mining faces. The angle between the extension fracture and the shear zone wall depends on the normal load on the shear zone, allowing the distinction between transpressional shear and transtensional shear in the brittle domain. Such stress rotation has also been observed in platinum mines of the Bushveld Complex and in a copper mine in South America.

Power law frequency magnitude distributions hold over several orders of magnitude for earthquakes, faults and other natural phenomena. This suggests that the stress rotation within shear zones should also manifest over orders of magnitude, rendering the phenomenon scale invariant. Windsor et al. [2] describe an example of a large scale anomaly in stress orientation in the Andes where the major principle stress within the El Teniente Shear Zone (ETSZ) is oriented sub-perpendicular to the shear zone rather than perpendicular to the Andes mountain range, as is the case outside of the shear zone. The authors were not specific about the age of the stress within the shear zone, referring to the ETSZ as a transfer fault with paleo stress partitioning. It is suggested here that the stress within the shear zone and that outside of the shear zone are both the result of neo-tectonic load – within the shear zone the stress trajectories are simply rotated as in the case of a much smaller scale shear zone form a South African gold mine - explained in the Figure 1.

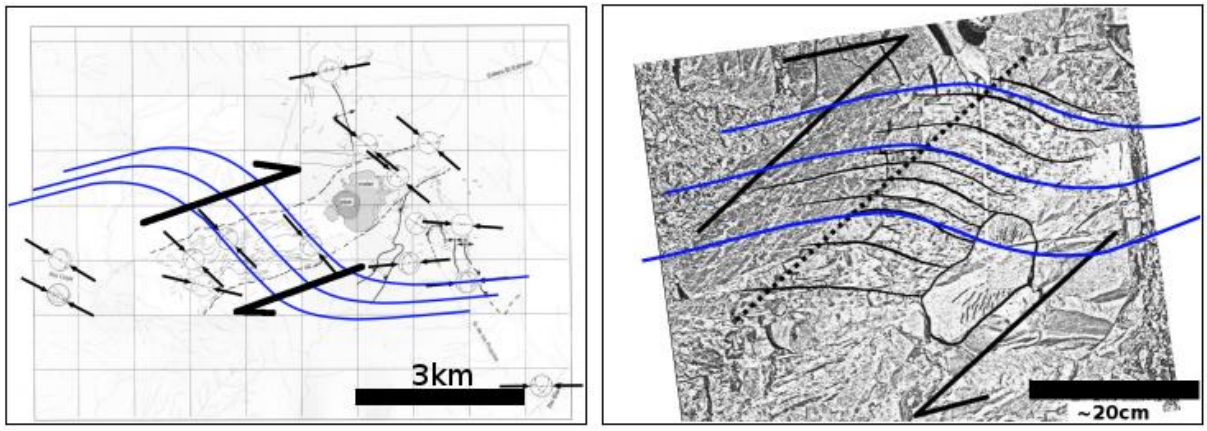

Figure 1: On the left is an interpretation of how stress trajectories are rotated through a large scale shear zone. On the right is a similar pattern of stress rotation through a shear zone in a S.A. gold mine - 4 orders of magnitude smaller.

References:

[1] van Aswegen G and Stander M (2012) Jour. S. Afr. Inst. Min. Metall., 112, 729-735.

[2]Windsor CR et al. (2006) Int. Symposium on In Situ Rock Stress, Trondheim, Norway, 533-540.