The stress state in South African mines and its relationship to geological features

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The insitu stress state has been measured in a number of South African Mines by the CSIR Division of Mining Technology. The depths have ranged from 60m to 3352m. The measurements have been done using CSIR and CSIRO strain cells. There is general agreement between the measured vertical stresses and the calculated overburden stress, but the horizontal stresses vary in magnitude and direction considerably.

Recent studies (Sellers et al, 2002) have indicated that the variability reflects geological history of the various mining regions. The major principal stresses in the Bushveld Complex tend to follow the circular arc of the reef outcrop. The horizontal stresses are generally higher than the vertical stress. In the gold mining regions, the average horizontal stress is generally lower than the vertical stress. There is considerable stress anisotropy of the horizontal stress state. The trends of the major horizontal stresses are consistent with the tectonic evolution of the Witwatersrand basin and with observed geological structures. Stress anisotropy affects the damage patterns in stopes and tunnels because the stress induced fracturing follows the major principal stress trajectories and due to dynamic interaction between the seismic waves from rock bursts and seismic events and the openings (e.g. Durrheim et al, 1997).

The major principal stresses tend to be rotated from vertical near faults. Examples are shown of measurements near normal and thrust faults as well as on a dyke contact. The work highlights the stress state in the different mining regions that will be encountered during the deep drilling project. Experience with the measurements suggests that strain cell devices are suitable in most areas at depths of up to 2.5 Km. At greater depths the core tends to disc due to the high stress anisotropy and strain cell measurements are often unsuccessful (Coetzer et al, 2002). Time dependent borehole breakout and slip on the bedding planes, intersecting the holes, is observed within a few days that requires repeated re-drilling of the holes. At a depth of 3352m, temperatures of 50°C were measured in the borehole. The rock was even hotter causing creep of glues and overheating of instruments placed in the hole.
The stress state is an important input into mine design, but is not uniform throughout the region as is often assumed. The variability is determined by the geological history of the region and can vary considerably over short distances. Numerical modeling of the geological environment indicates how the stress can vary and is in agreement with observations. Any additional input regarding the changes in magnitude and direction of the stress state near geological features will be of great importance to developing safer mine designs and the understanding of the response of the rock mass to mine excavations.

References:
