Application of Gravitational Curvature Analysis to Structural Domaining of Geology
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Introduction
This poster demonstrates theory and practical application of the use of multi-component Gravity Gradiometry data in visual interpretation.

Concepts
- Gravity Gradient data are delivered as a multi-channel data set with 5 independent components, Gxx, Gxy, Gzx, Gzy, Gzz (Figure 1).
- Only 2 components, Gzz and Gxx, are used to calculate Total Vertical Gradient (TVG) and Total Horizontal Gradient (THG).
- Many combinations and transformations are possible, but they should convey physical meaning to the interpreter.

Gradients and Invariance
- Makes sense to consider combining horizontal gradient effects
- Combining in certain ways preserves gradient variation – Invariance
- Two distinct types together explain horizontal gradient variation:
  - Total Horizontal Gradient (THG)
  - Total Horizontal Curve (THC)
- In a ratio with the vertical gradient, they explain shape deviation in 3D space (phase)
  - Tilt Angle (TA)
  - Curvature Angle (CA) also known as SHAPE INDEX
- Tensor is now grouped in only 3 ways!!! – Figure 2.
  - Symmetric Tensors can be decomposed using diagonalization to produce a form invariant of measurement reference frame – Figure 3.
  - Eigenvalues represent invariant gradient signal amplitudes of tensor, based only on variance
  - Three Signal Invariants functions arise from solution of characteristic equation for diagonalizing a tensor
    - $\lambda_1$ is the trace of the tensor (Laplace Equation = 0)
    - $|I|$ is sum of squares of eigenvalues of tensor
    - $\lambda_2$ is determinant of tensor = product of eigenvalues
    - EVASA is square root of $|I|$ and is equivalent to Analytical Signal Amplitude of eigenvalues.
    - CUBEDET is cube root of $\lambda_2$
- ALL INVARIANT GRADIENT AND SIGNAL COMPONENTS HAVE A PHYSICAL MEANING AND CAN BE USED IN INTERPRETATION!!

Figure 1. Gravity and Gradient Components
Figure 2. Invariant Groupings of Tensor Components
Figure 3. Tensor Diagonalization, Eigenvalues and Signal Invariants
Figure 4. Gravity and Gradient Contours
Gravity Gradiometry Imaging Examples

Halls Creek Orogen Falcon AGG Survey

- To evaluate the transformation images, an AGG/FTG dataset had to be chosen that was both publicly available and had well-mapped geology and a structural interpretation.
- Unfortunately, a basin example was not available that met all three criteria, however, the same principles apply and plenty of data now exist.
- Data chosen was from the Halls Creek Orogen between Kununurra, flown as Falcon AGG Survey by Fugro Airborne Surveys in 2009.
- Data is 500m line-spaced and approx. 50km x 140km in dimension. It was reprocessed and imaged by Gondwana Geoscience.

References
- Carlos, C., 2014. Automatic generation of 3D geophysical models using curvatures derived from airborne gravity gradient data. Geophysics. 79, no. 5; P. G49–G58, 9

Comments and Conclusions
- The RGB images perform an extraordinary job of domaining the geology, particularly as it was a completely independent mapping exercise performed by the Geological Survey of Western Australia (GSWA) a number of years ago.
- A similar remark pertains to the GSWA 100k structural interpretation.
- Much of the interpretation by the GSWA is based on both airphoto and aeromagnetics as much as ground mapping. Therefore it is clear that the interpretation can be only improved by using the gradiometry data.
- The RGB and Intensity images even appears to be differentiating different types of granite!
- It is clear that yellow and white colours correspond to high density and anticlinal features
- Cyan/green colours are low density or synclinal features
- Blue colours are steeper slopes and lower density rocks
- Red areas are moderately dense or saddle zones
- Black areas are flat geology and fractures of low density
- Differences in the CA and TA are due to variances in gross morphology from vertical to sub horizontal.