

Airborne Full Tensor Gravity Gradiometry Vs Ground Gravity Data in the search for mineral deposits

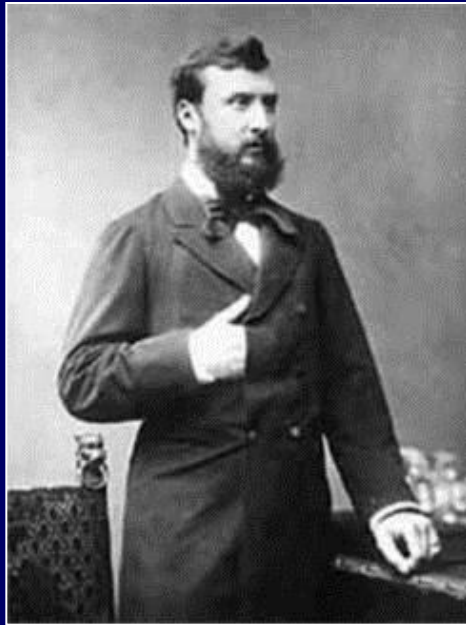
Tenyears Gumede
Knowledge Factory P/L

Outline

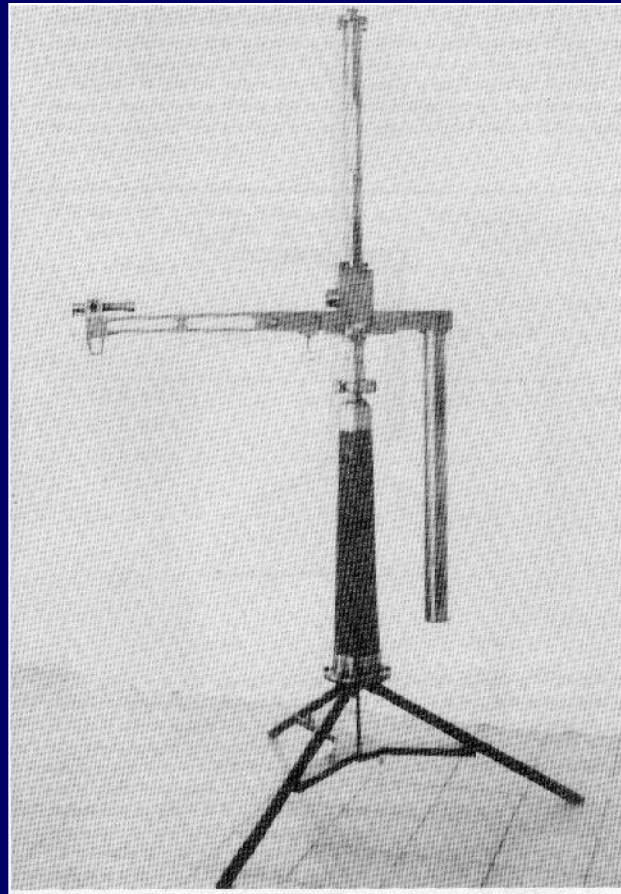
- History of gravity surveys
- Equivalence principle
- Gravity gradiometers in operation
- A comparison of data – ground and airborne
- Conclude

Airborne Gravity & Gradiometry

“A gravitational timeline....”



Baron Loran von Eotvos



Torsion Balance Gradiometer

Timeline

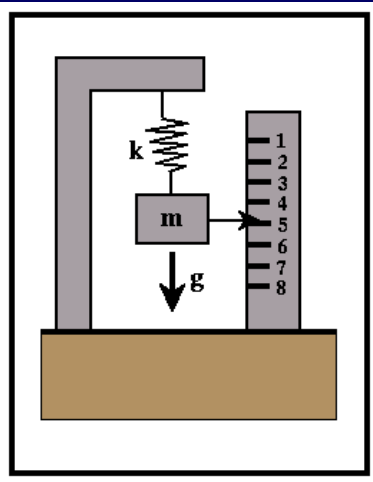
- Gravity gradiometry in resource exploration begins with the invention of the Eotvos torsion balance in 1896
- This invention's application to resource exploration was soon realized and by 1929, 170 torsion balances were used in North America
- Primary application – map salt domes for oil exploration

Cont

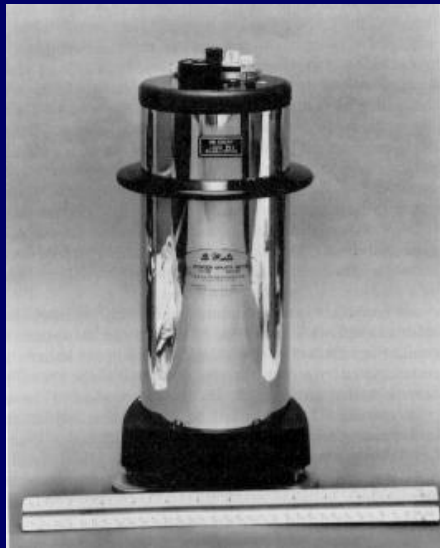
- Superseded by the faster gravimeter in the 1930s
- But continued to be of interest – investigation of equivalence principle

Cont

Gravity Instrumentation



$$x = \frac{m g}{k}$$



Worden Gravity Meter

Leveling
Screws

Level Bubbles

Eyepiece

Locking
Knob

Adjustment Dial

Reading



LaCoste & Romberg Gravity Meter

Ground Gravity Timeline



Units

Unit for acceleration is metre per second squared (m/s^2)

- $\mu\text{m/s}^2 = 10^{-6} \text{ m/s}^2$
- $1 \text{ mGal} = 10 \mu\text{m/s}^2$
- $1 \text{ gu} = 1 \mu\text{m/s}^2$

Units

Gravity gradient is a gradient acceleration :
acceleration units divided by distance units :
per second squared (s^{-2})

- $1 \text{ ns}^{-2} = 10^{-9} \text{ s}^{-2}$
- $1 \text{ Eo} = 1 \text{ ns}^{-2}$

Airborne Gravity & Gradiometry

“A gravitational timeline.....”

Pre-1980s & 90s

Long wavelength
accuracy 5 to 6km

1999-present

Intermediate wavelength
accuracy 2 to 4km

2000-present

Short wavelength
Accuracies 300m

The future

Short wavelength
Accuracies 100m

- Lacoste & Romberg meters
 - Carson & Fugro LCT
- AirGRAV and GT-1A
 - Sander Geophysics & Canadian Micro-Gravity
- Lockheed Martin instruments
 - Falcon, BHPB (Fugro Airborne Surveys), 5 instruments
 - Air-FTG®, Bell Geospace, 3 instruments
 - GGI, ArkeX, 3 instruments
- Instruments under development
 - EGG, ArkeX
 - AGG, Gedex,
 - Rio Tinto,
 - ‘String’ Gradiometer, Gravitec

Advantages

- When performed from space, speed of coverage is an advantage
- Ease of access and uniformity of coverage
- The above result in lower cost
- Airborne gravity is limited by equivalence principle (measurements on board an aircraft cannot distinguish accelerations due to gravity from those due to the motion of the aircraft)
- Gravity gradiometer can make the distinction

Applicability

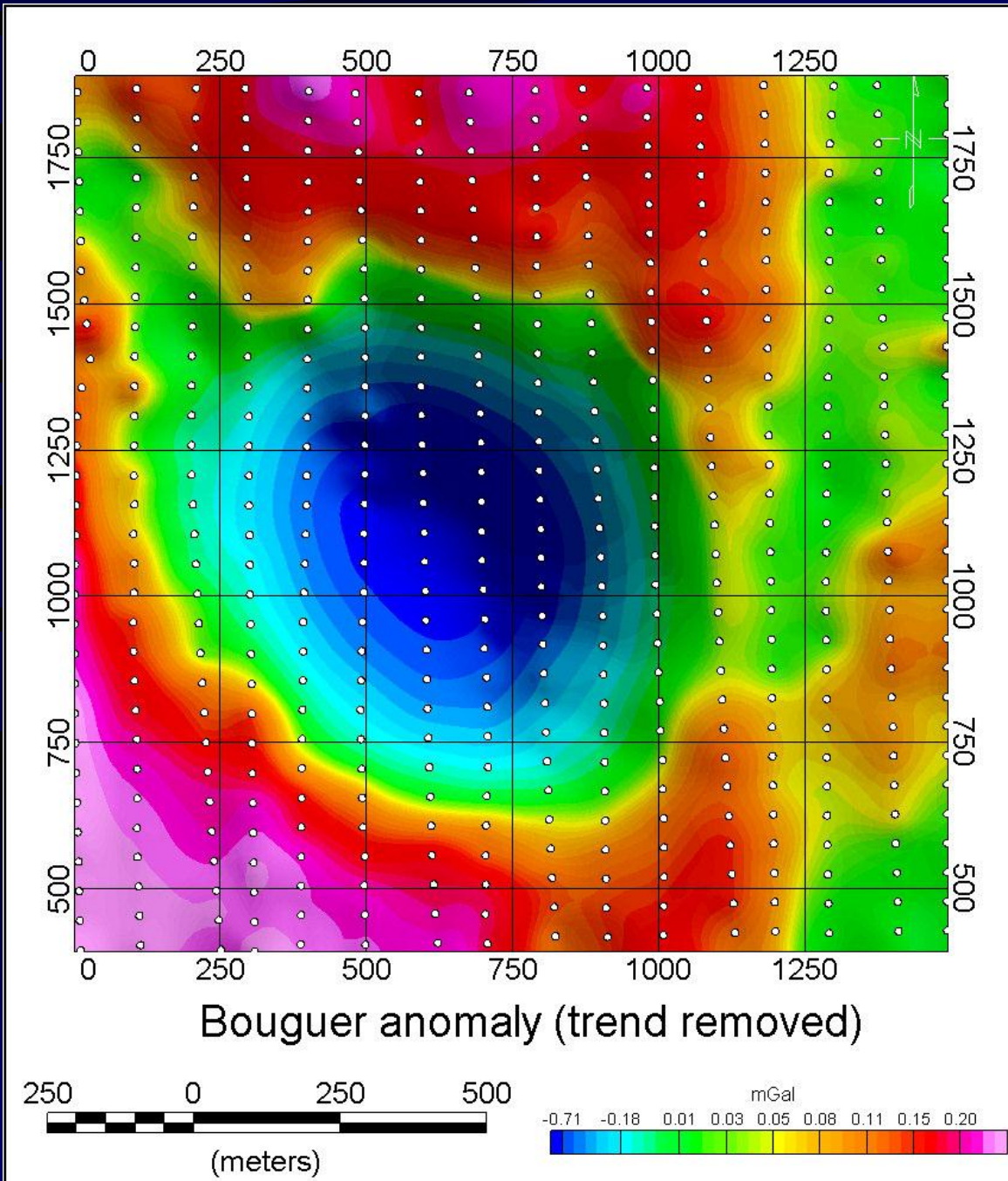
- *proved useful in the search for coal, base metals in iron-oxide copper-gold deposits, porphyries, Broken-Hill type deposits and volcanogenic massive sulphides, iron in massive haematite, nickel sulphides and gold. There have also been useful applications in the search for oil and gas.*
- *The Santo Domingo Sur copper deposit in*
- *Chile is one of project that is a gravity gradiometer discovery.*

Advantages Gravimeter

- Low capital cost
- Smaller size
- Low weight
- Comparisons need to consider accuracy across the entire wavenumber spectrum

Example

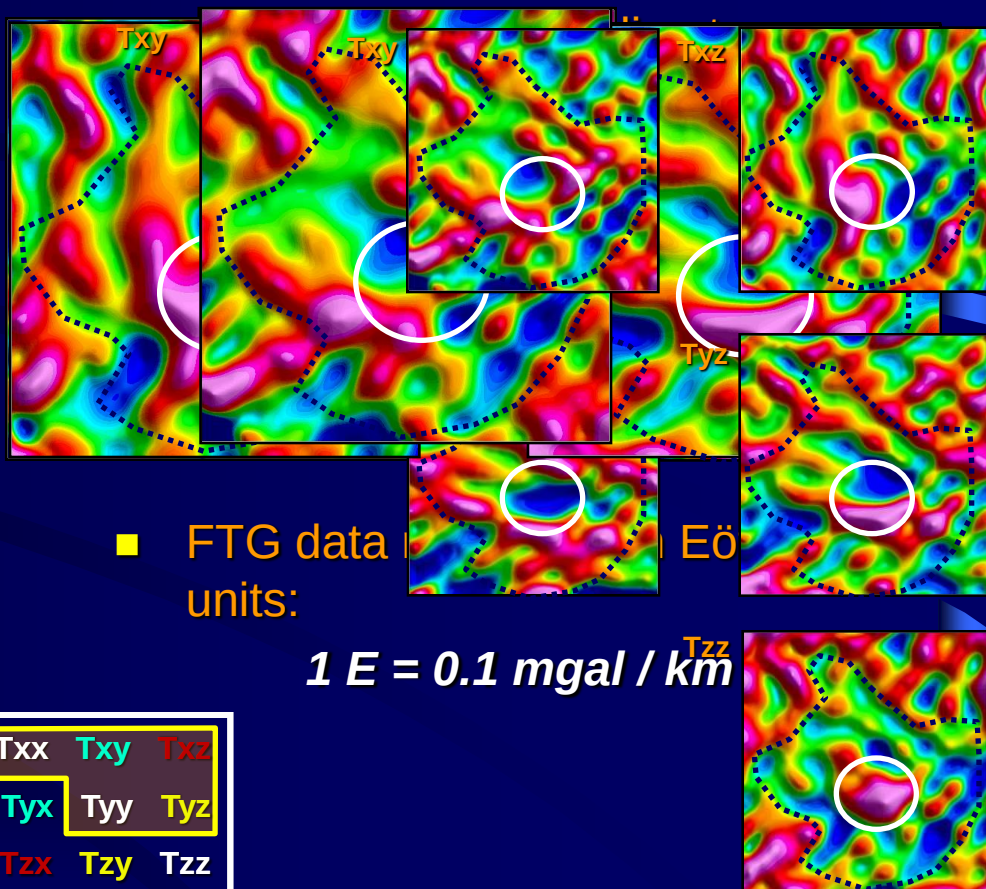
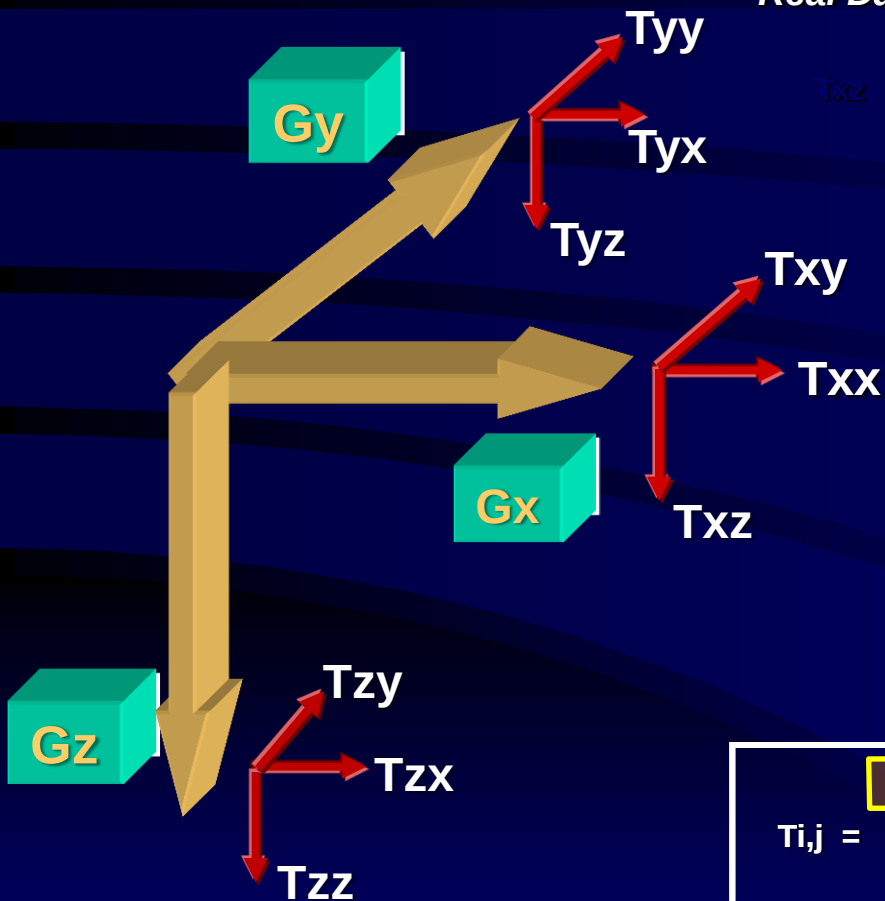
KIMBERLITE Gravity Anomaly



Full Tensor Gradient Technology:

Tensor components chart the changes in the gravity field as observed by geology

Real Data example from Vinton Dome salt body, Louisiana, USA



■ FTG data units:

$1 E = 0.1 \text{ mgal} / \text{km}$

$$T_{i,j} = \begin{bmatrix} T_{xx} & T_{xy} & T_{xz} \\ T_{yx} & T_{yy} & T_{yz} \\ T_{zx} & T_{zy} & T_{zz} \end{bmatrix}$$

.....Full Tensor Gradiometry for target detection and delineation

Airborne Gravity & Gradiometry

“..a key tool in the Exploration Toolbox....”

- Need to improve / enhance ground gravity coverage:
 - Land access;
 - Difficult / rugged terrain.
- A Geological mapping technology:
 - Regional and localised surveying capabilities;
 - Structural and lithological contact mapper;
 - Depth to bedrock / Overburden issues.
- A Target Prospector:
 - Direct: Kimberlite (Diamonds), Porphyry systems (Copper etc), Massive sulphides (Base Metals), Geothermal;
 - Indirect: Structural / Stratigraphic (hydrocarbons), Salt (hydrocarbons), Palaeochannels (alluvial diamonds / gold / uranium, sand & gravel, ground water).

Gradiometers in Operation



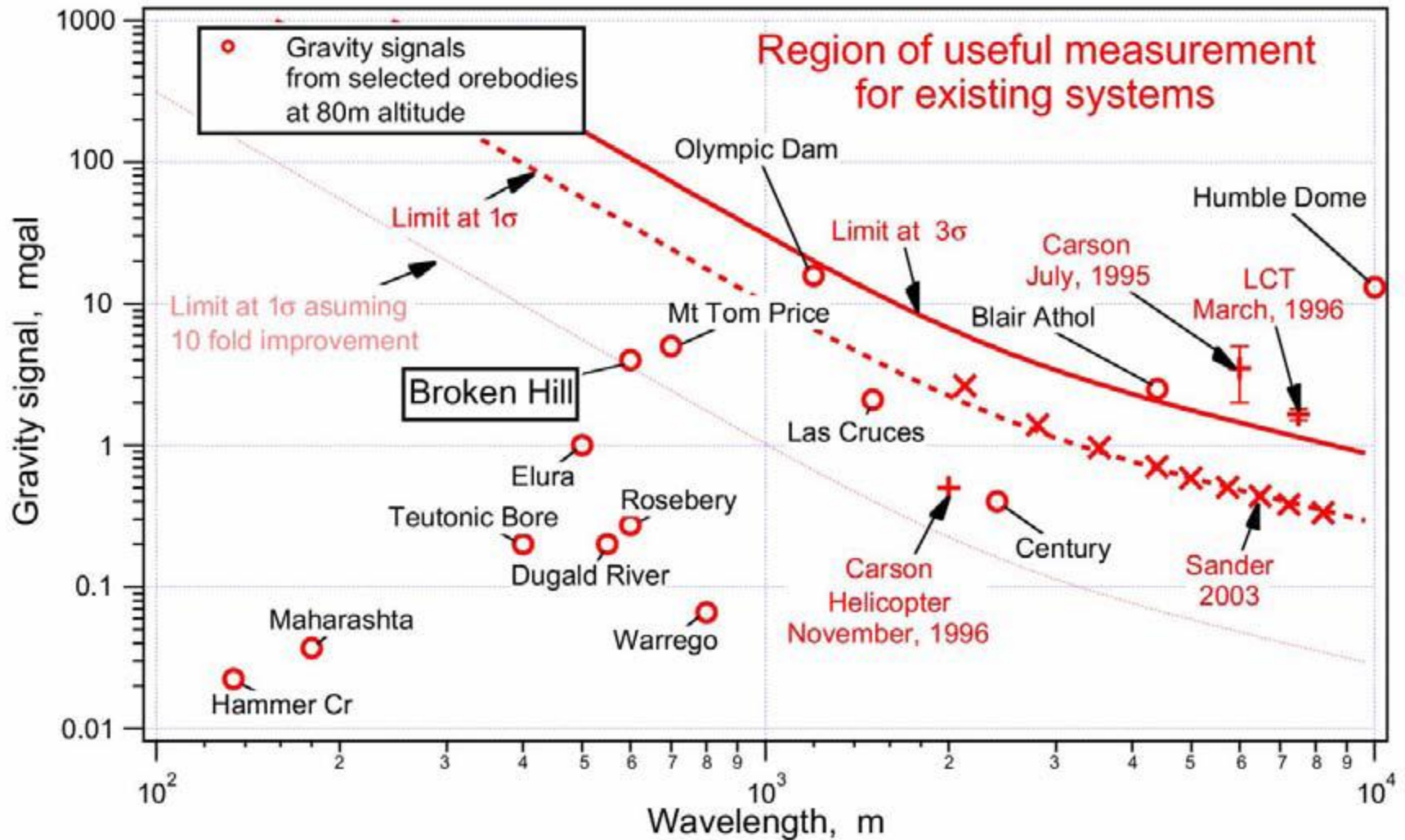
FALCON AGG

- Restricted in its use by the US State Department
- May only be used in countries approved in the applicable export license approvals
- Been used in Australia, Botswana, Canada, SA, ...Zambia
- Newton System services North and South America
- Einstein-Southern Africa, Galileo-Australia
- Strict limits on access to unprocessed data

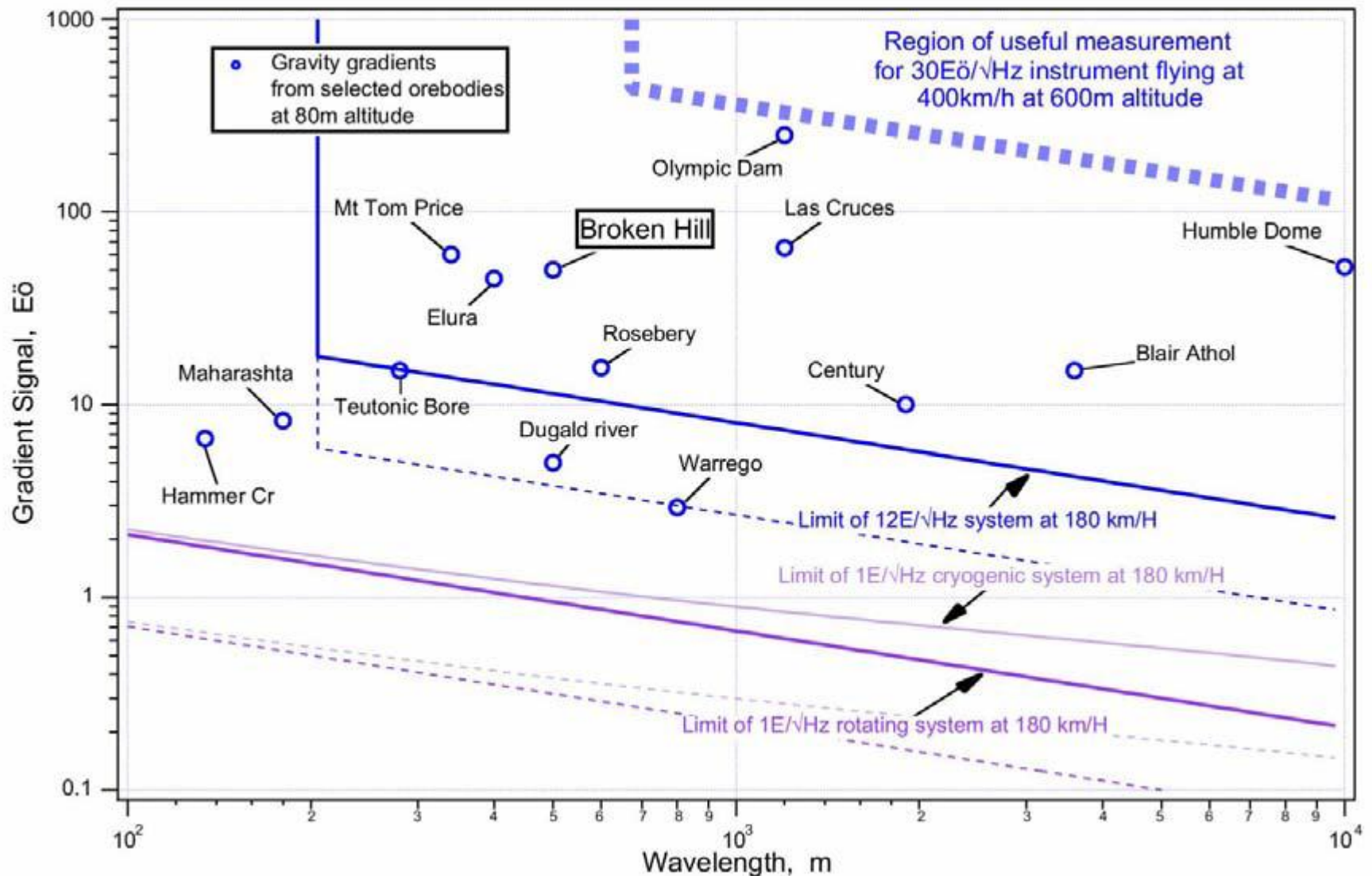
Bell Geospace

- 1998 – Bell Geospace took delivery of an FTG built by Lockheed Martin for ship borne gravity – 3D-Full Tensor Gravity
- Later modified for airborne use (Air- FTG)

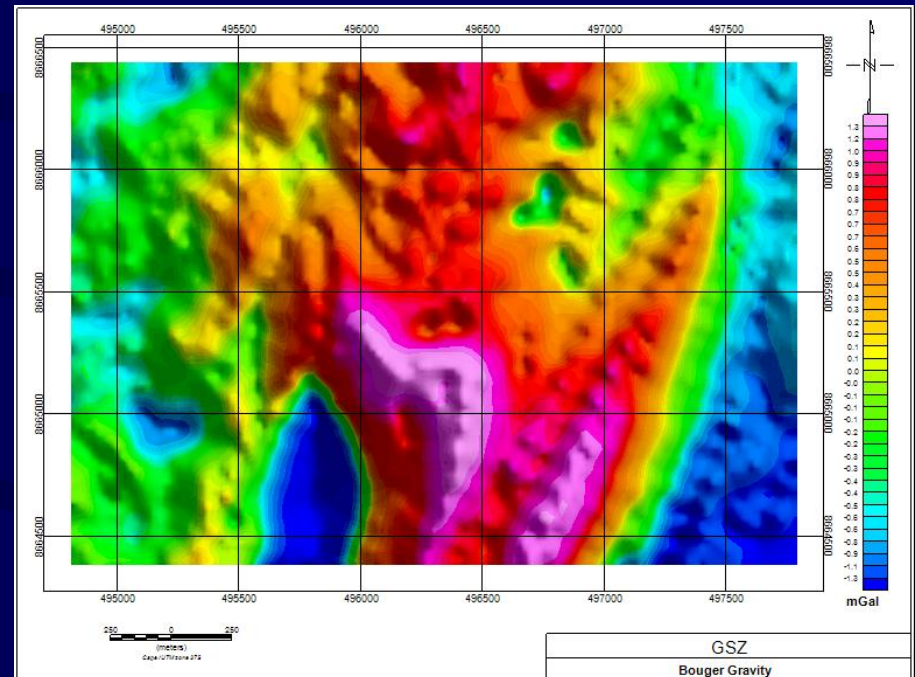
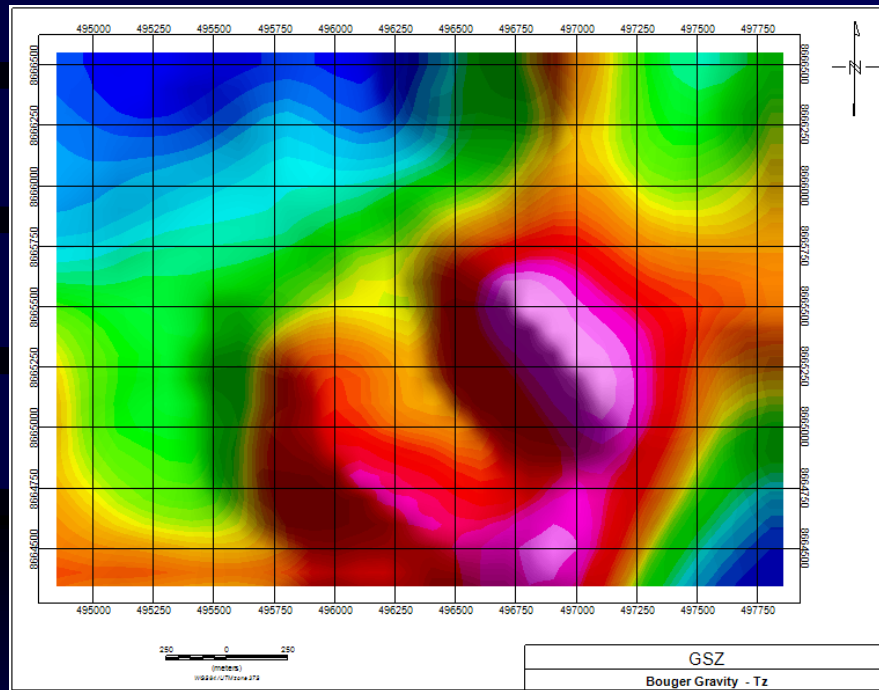
Region of useful measurements



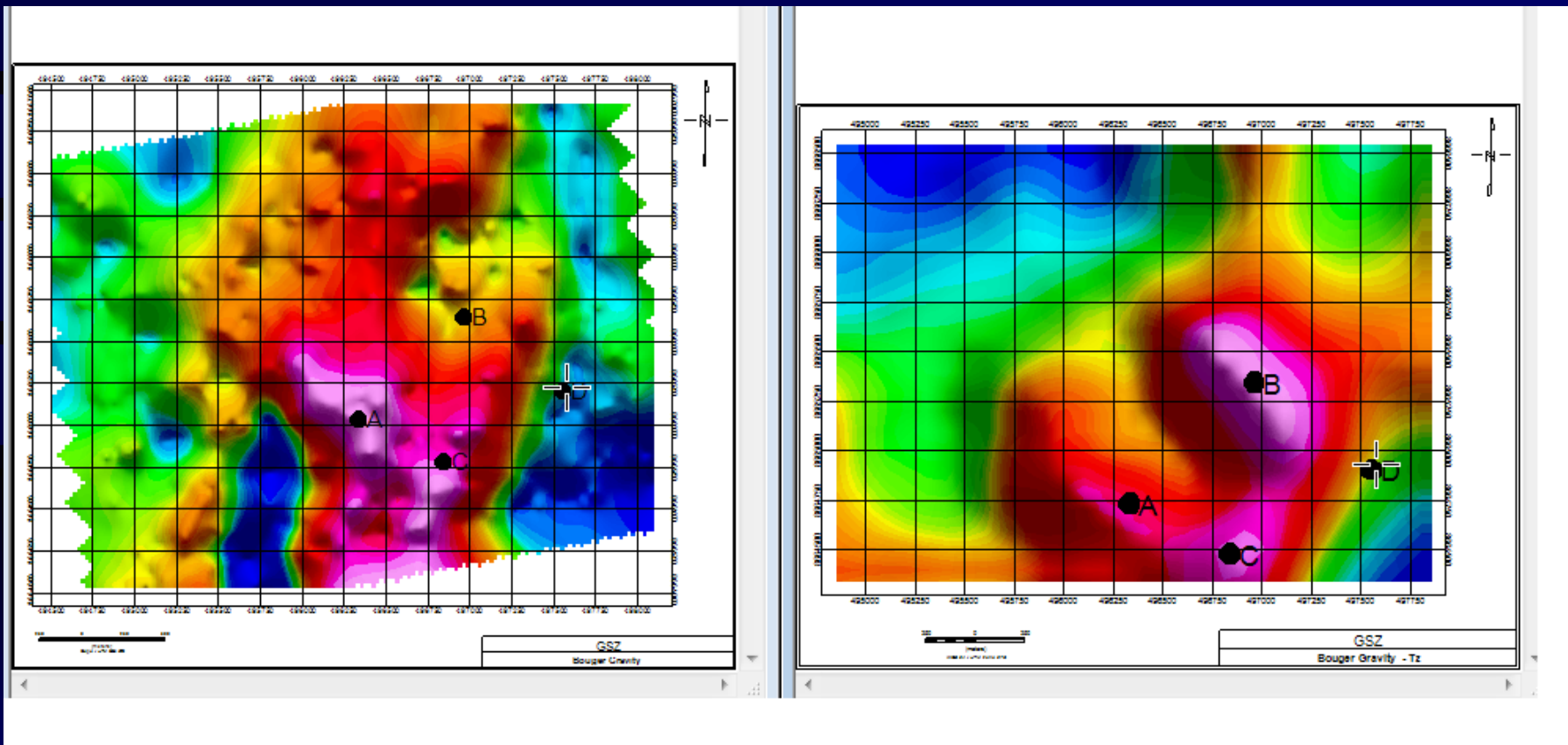
Region of useful measurement



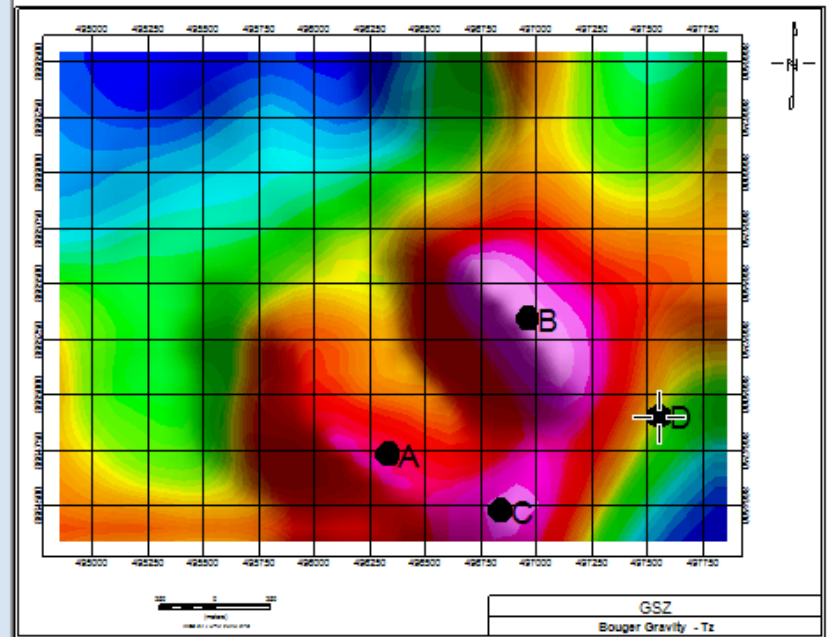
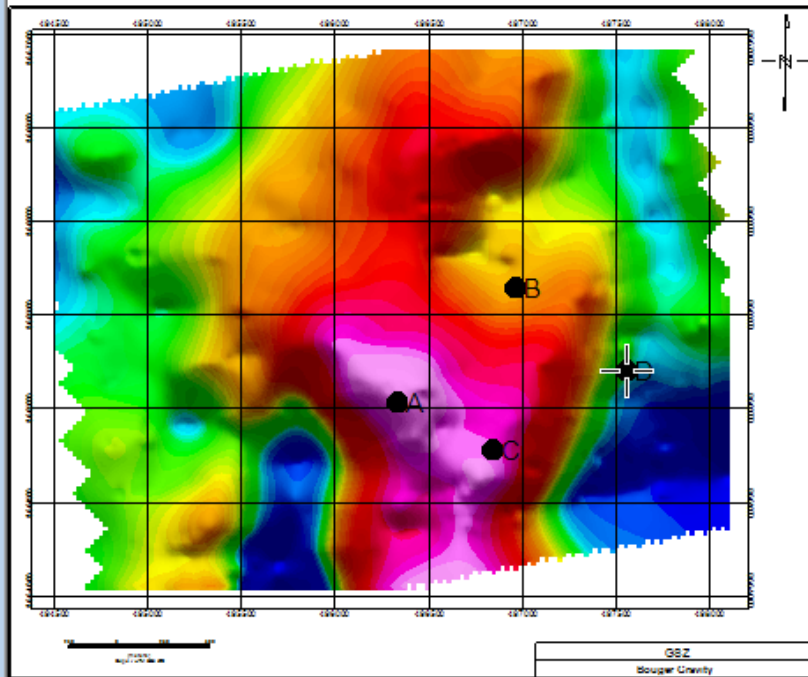
Airborne Vs Ground data



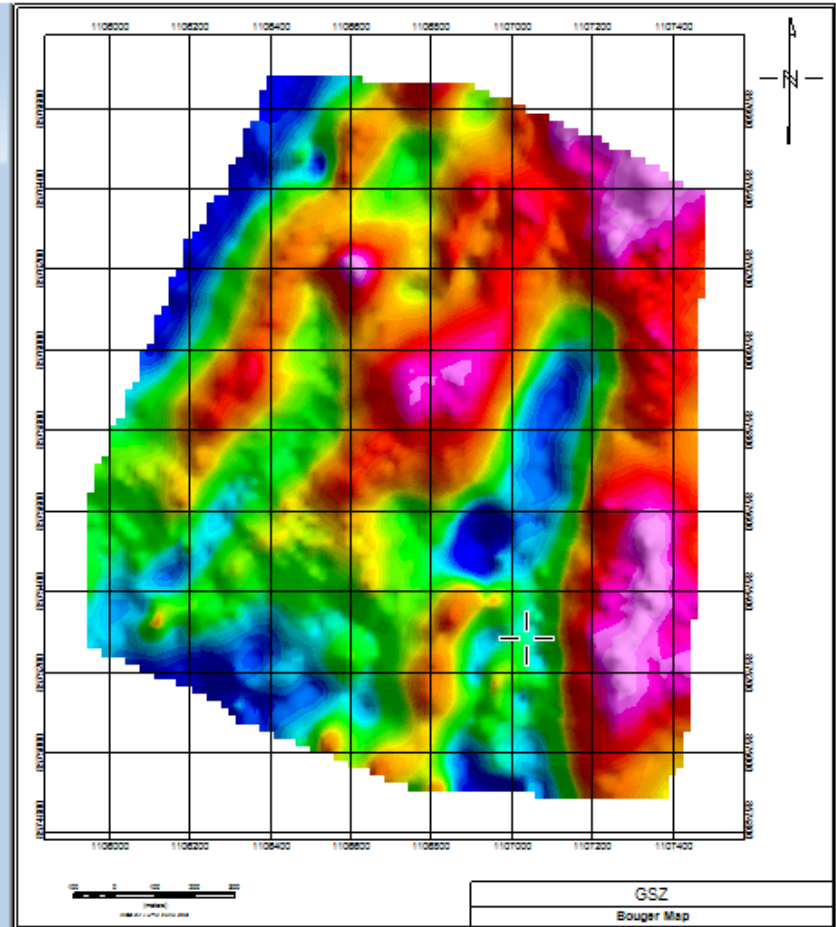
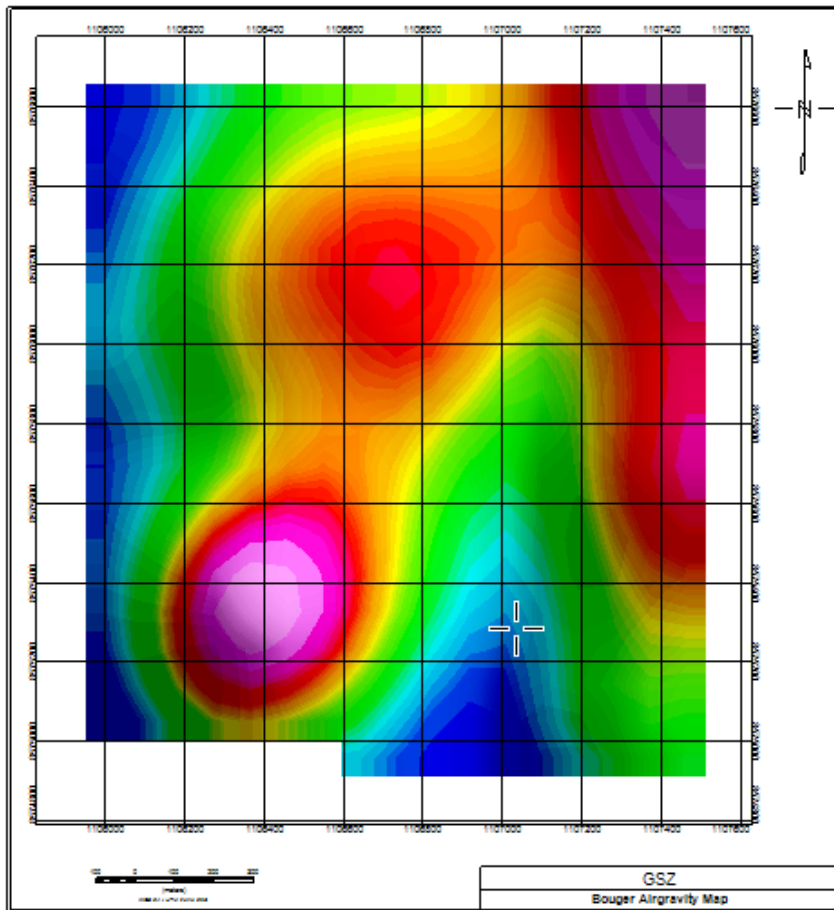
Desampled Ground Vs Airborne



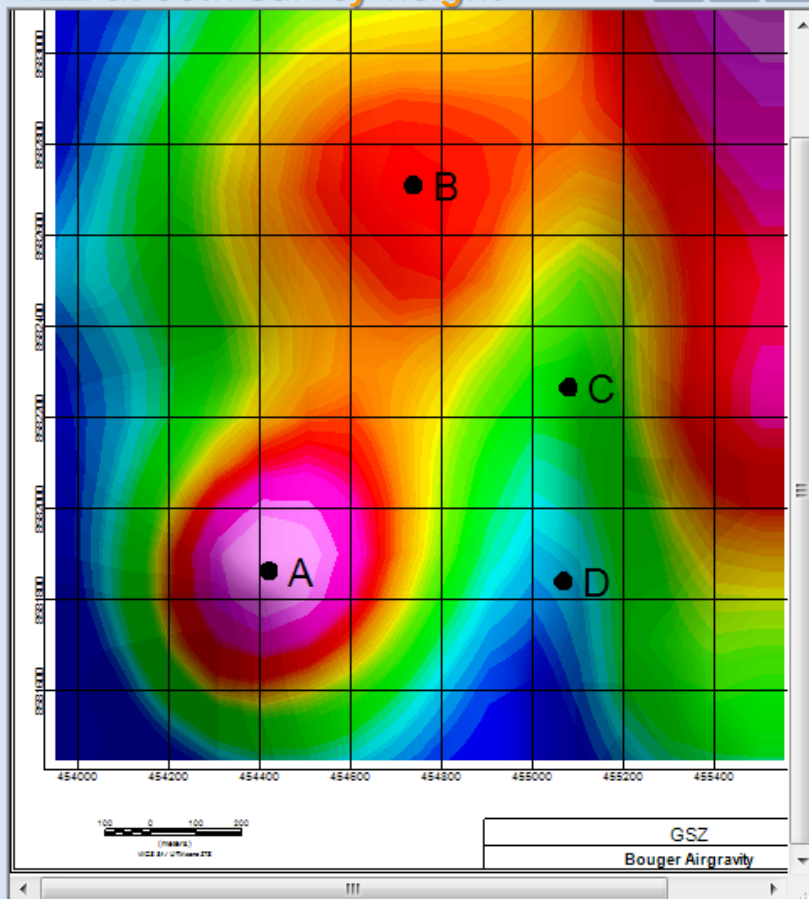
Upward continued versus Airborne Tzz



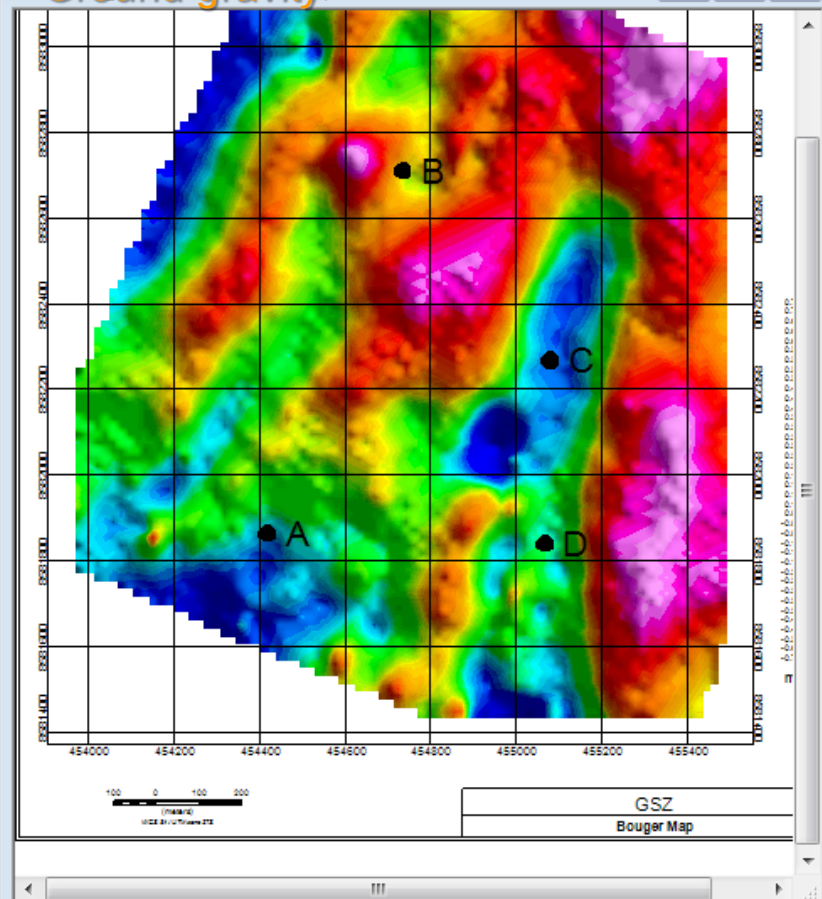
Airborne Vs Ground



TZZ at 80m survey height



Ground gravity



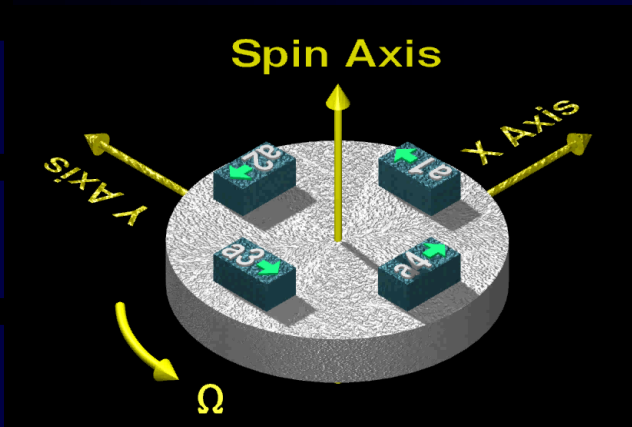
Conclusion

- Airborne gravity data has contributed in the discovery of large deposits.
- For smaller type deposits, it is recommended to follow-up airborne work with ground gravity
- Variation in anomaly mapping may be a results of poor elevation data



• Thank You

Gravity Gradient Instrument: Rotating accelerometers and GGIs



Gradients measured as the difference across opposing pairs of accelerometers;

Accelerometers rotate about spin axis to avoid bias in measurements along direction of primary components

GGIs configured as shown in cartoon within unit, i.e. 120° apart and 35° above the horizontal;

System also rotates to avoid bias in measurements

