



Airborne Geophysical Surveys

Mark Dransfield



Fugro collects and interprets data related to the earth's surface and the soils and rocks beneath. On the basis of this the Company provides advice, generally for purposes related to the oil and gas, mining and the construction industries

2008 Outlook

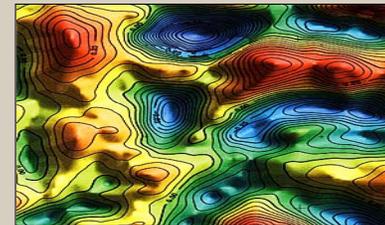
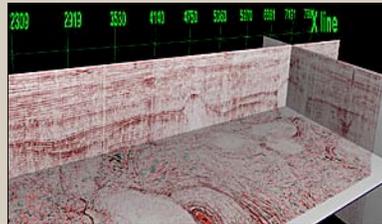
- > €2.1 billion revenue
- ~ €270 million profit
- ~ €400 million expansion investments





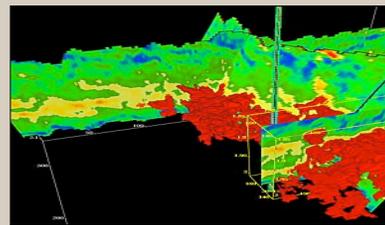
Fugro Geoscience Division

Fugro Multi Client Services



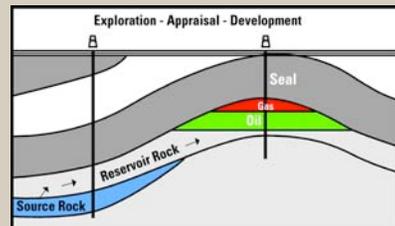
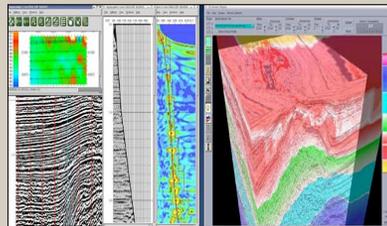
**Fugro Gravity & Magnetic Services
Fugro Airborne Surveys
Fugro Ground Geophysics**

Fugro-Geoteam



Fugro-Jason

Fugro Seismic Imaging



Fugro Robertson

Fugro's Geoscience Division is Unique
in its ability to acquire, process and interpret all five of the key G&G data sets:
Geology, Seismic, EM, Gravity & Magnetics





Everywhere





Resource exploration – importance in the global economy

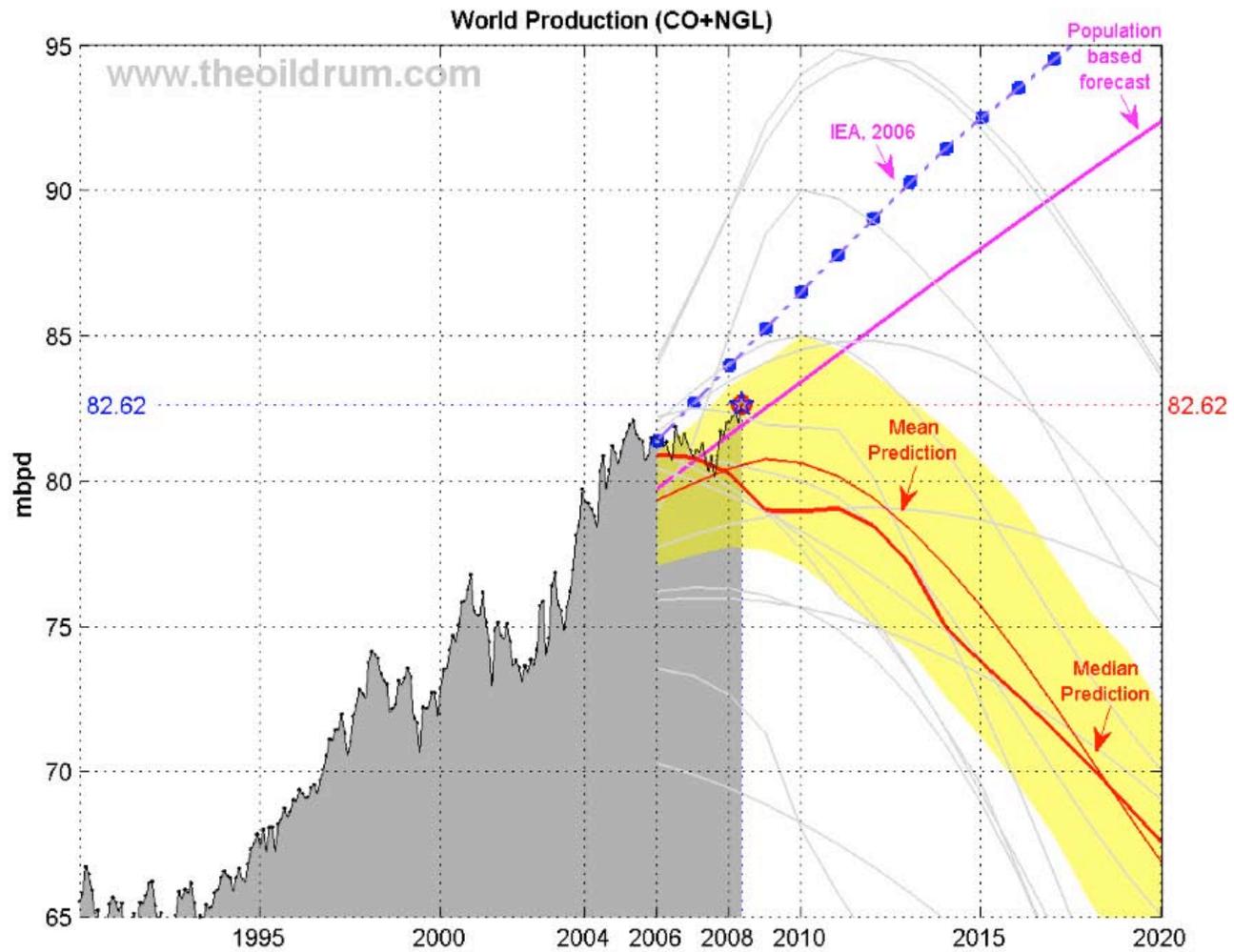
- > 8 billion people - increasing proportion wealthy
- Unsustainable
- → Avoid collapse while changing behaviour

- Diminishing resource base
- **One** requirement: find new resources



Resources difficult to find

OIL

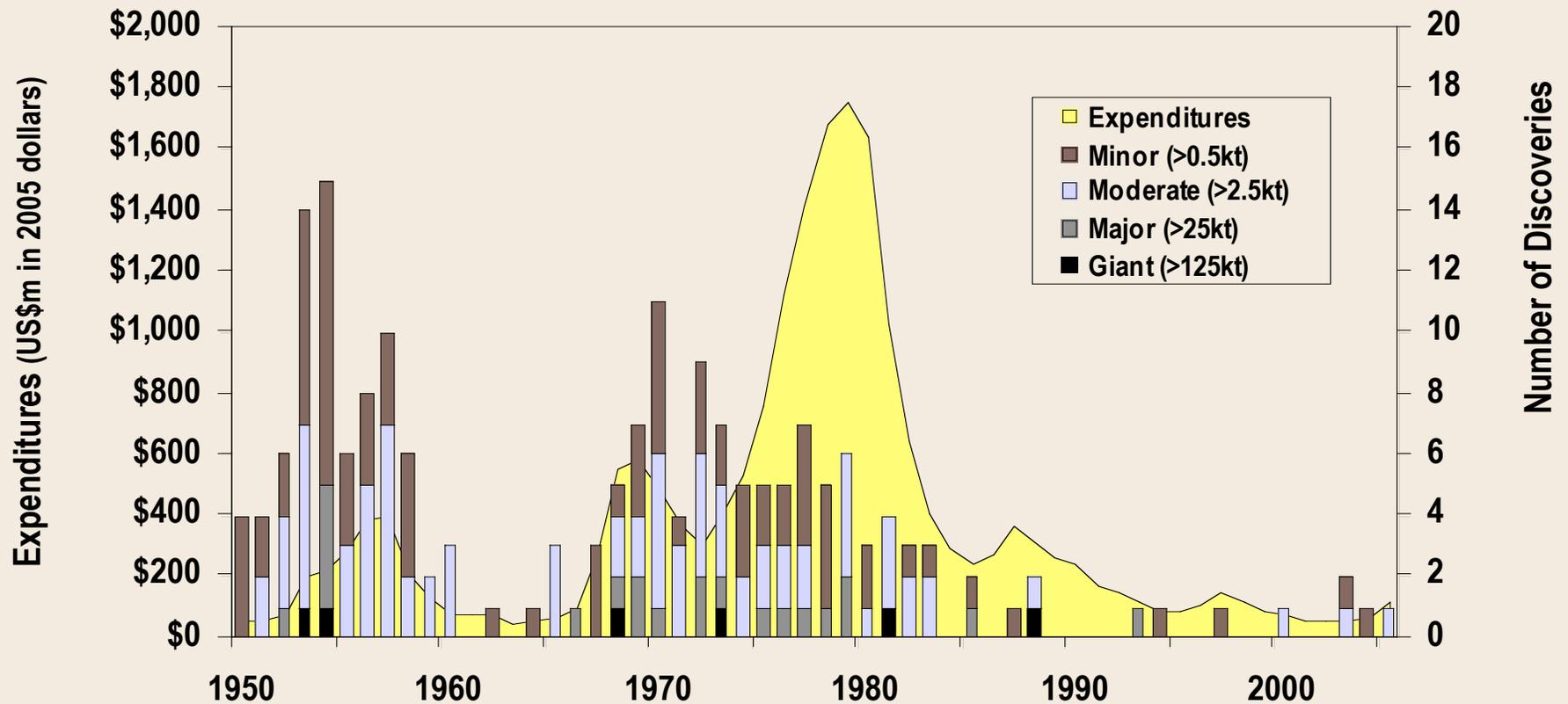




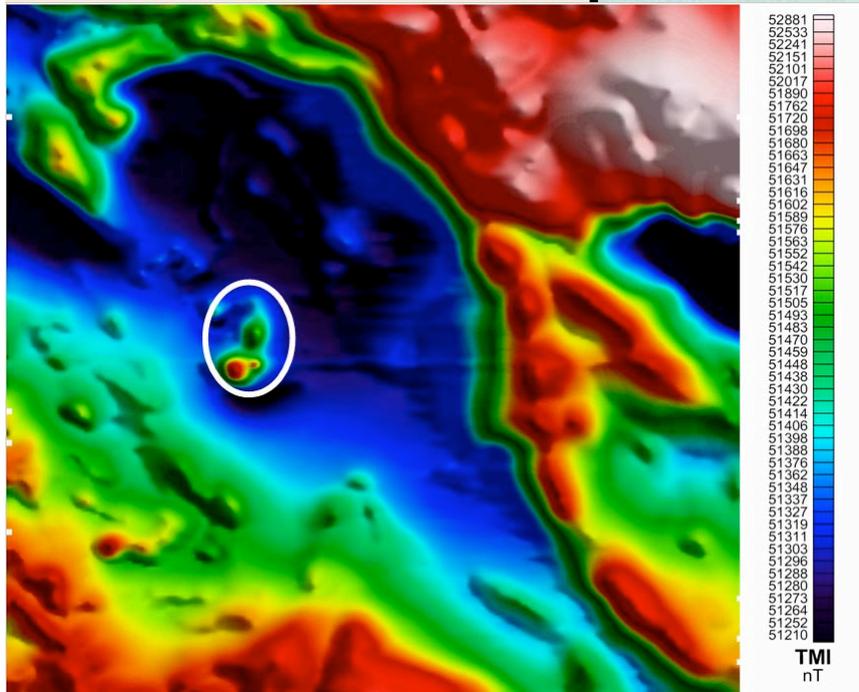
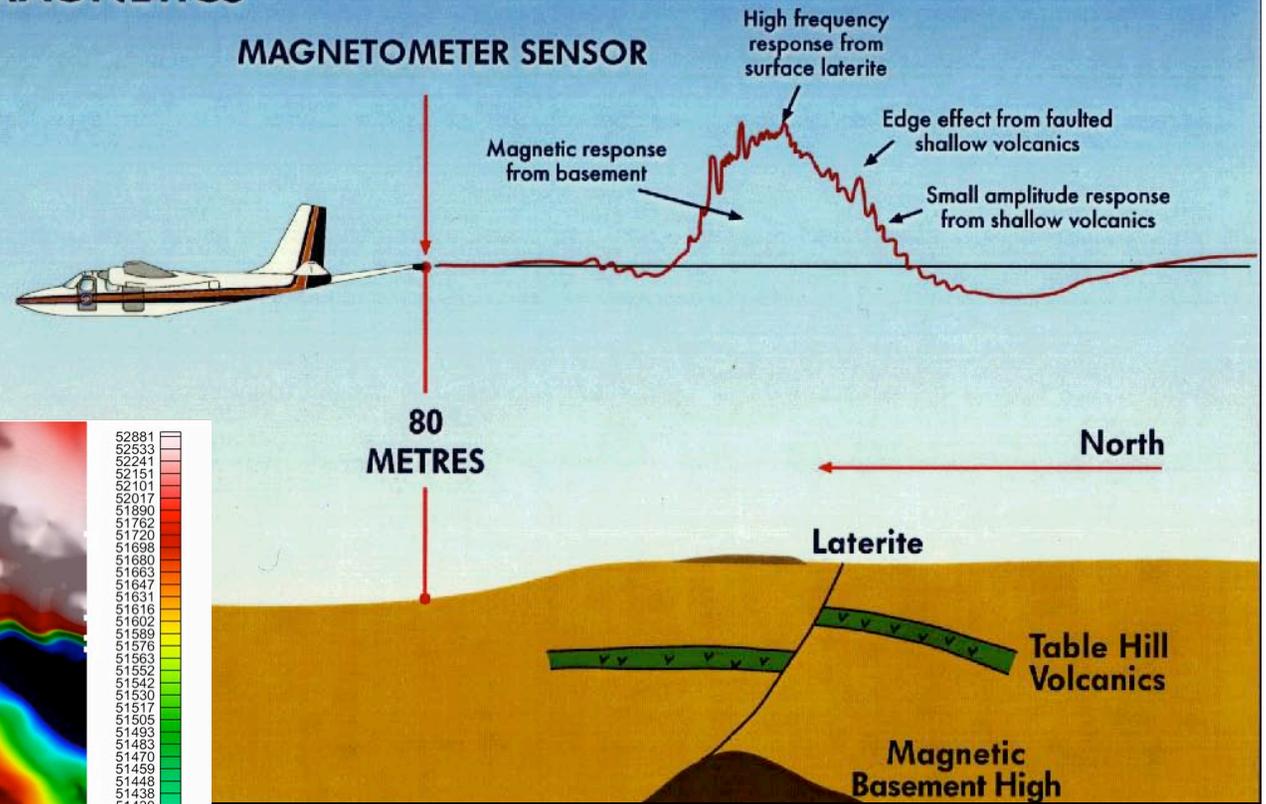
Resources difficult to find

URANIUM

Primary uranium deposits only : Western World : 1950-2005



MAGNETICS

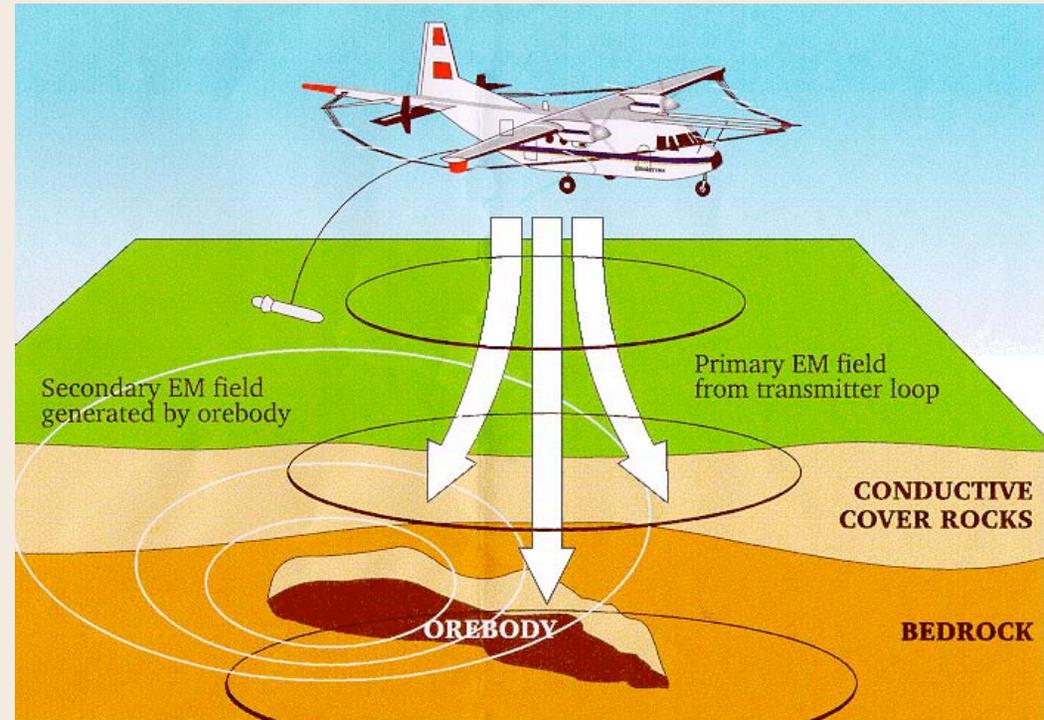
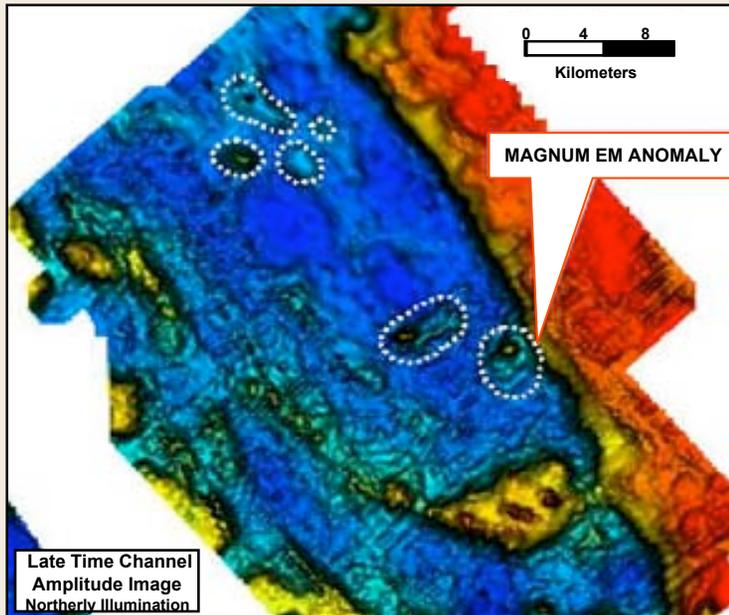


Variations in static magnetic field of earth due to magnetic minerals.

Measure frequency change via Zeeman effect in He or alkali metals.



Airborne Electromagnetics

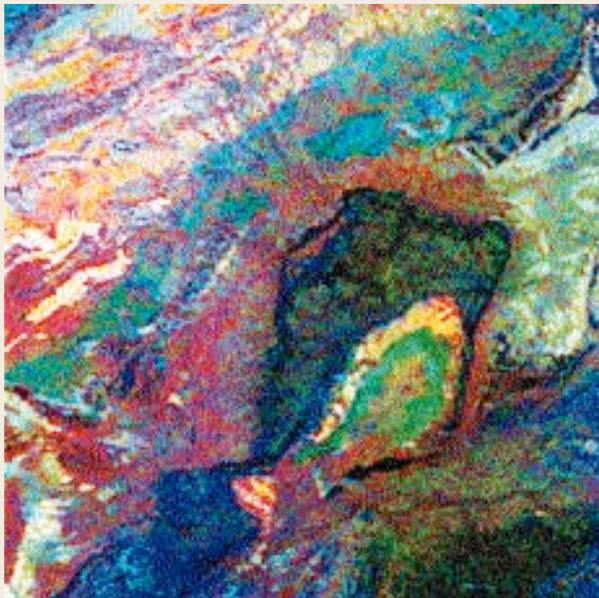


“High-grade gold-copper mineralisation is associated with the massive pyrrhotite-chalcopyrite veining”

Variations in conductivity (ionic fluids, sulphide minerals).
Transmit varying EM field, inductively sense response.



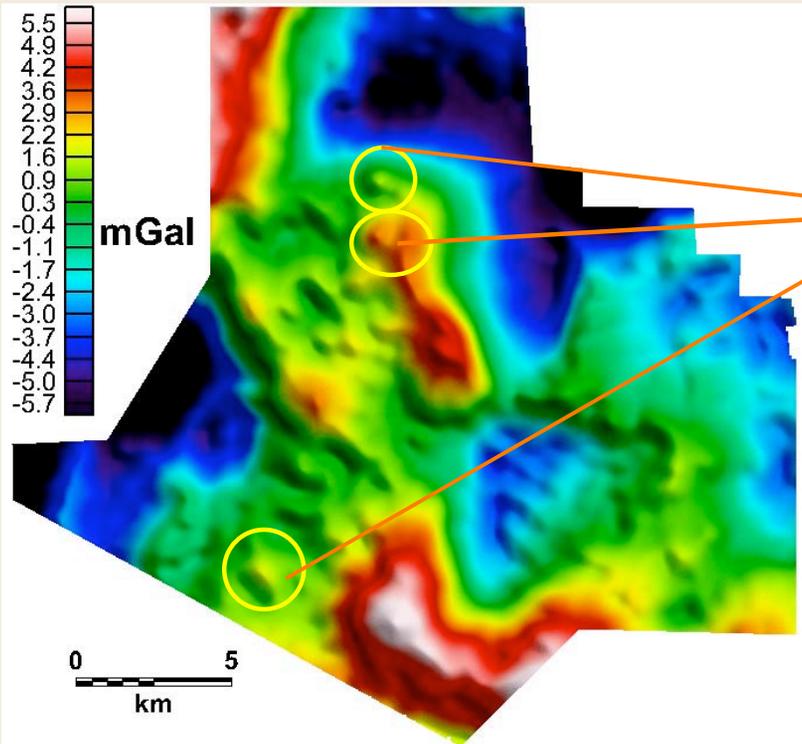
- NaI scintillation spectrometers
- Map distribution of K^{40} , Th^{232} and $U^{235, 238}$



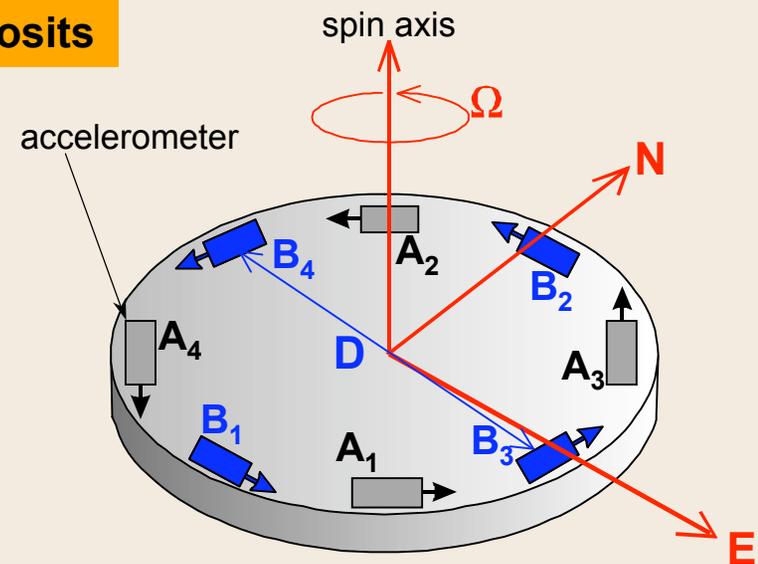


Airborne Gravity

110 Mt @ 0.7% cu, 1.0% Zn, 0.7% Au, 19 g/t Ag



Deposits



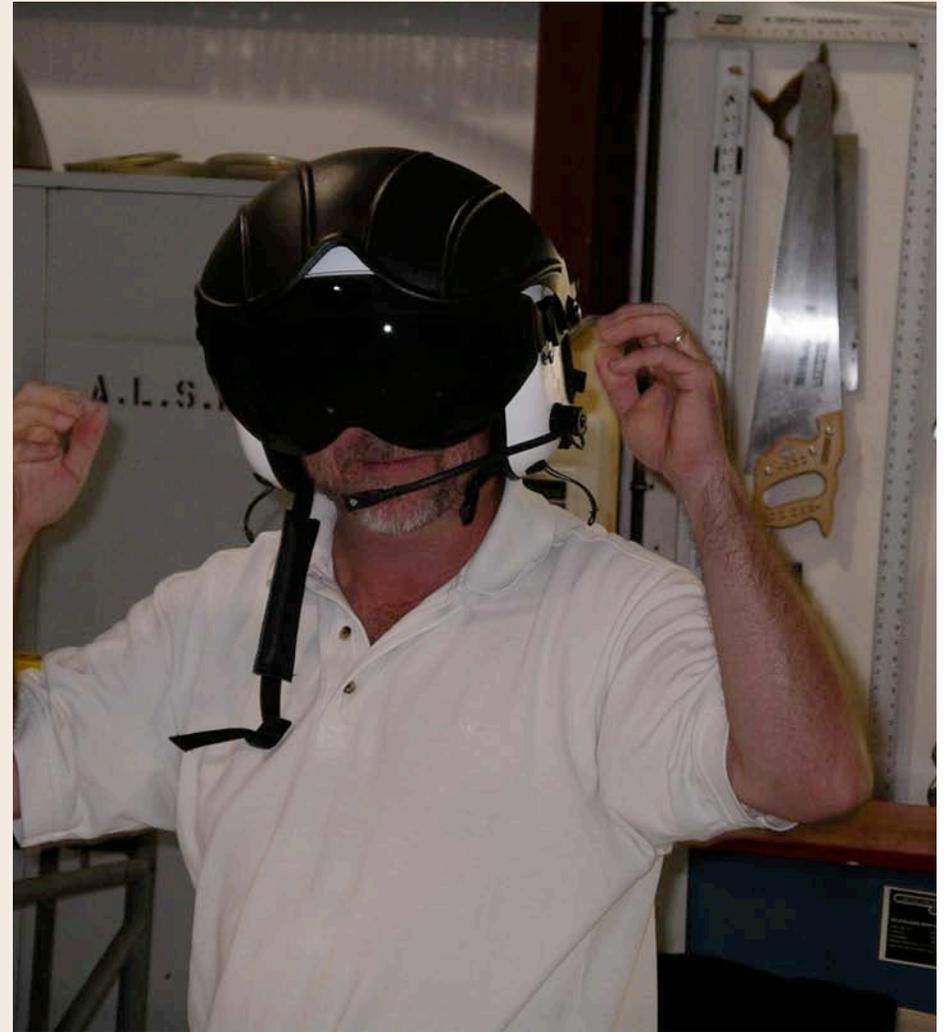
Variations in density of earth.

Gravimetry: accelerometer with GPS and filter.

Gradiometry: acceleration differentiator.



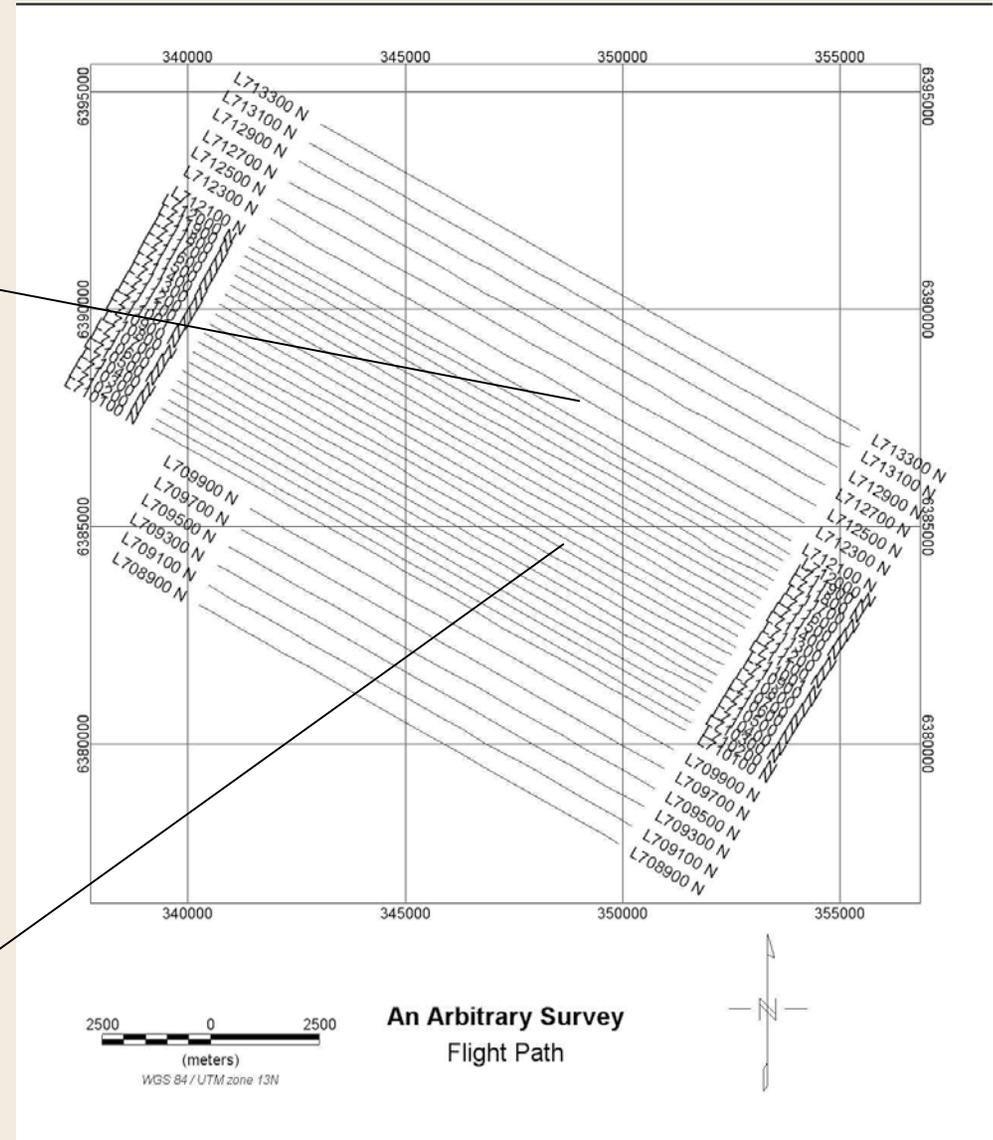
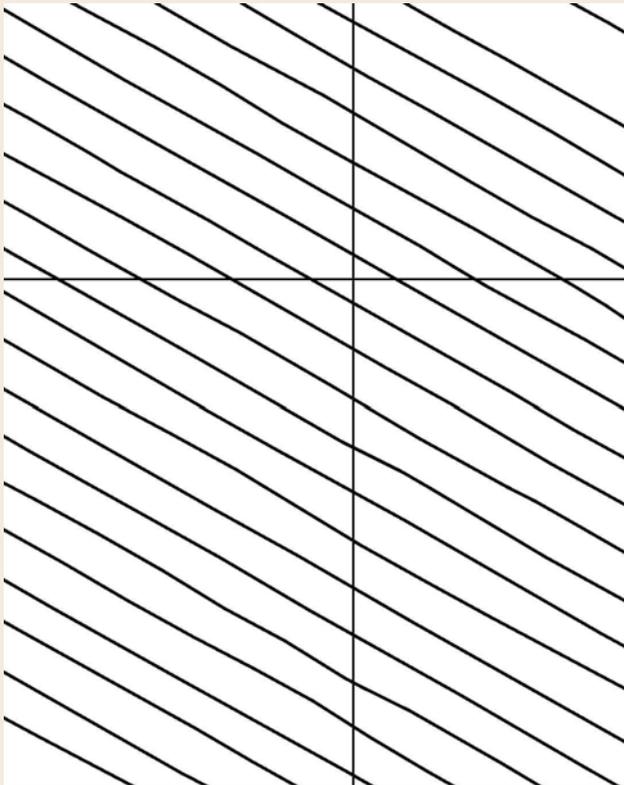
Position, navigation and time





The GPS revolution – eg flight path accuracy

- Revolution in 1980s.
 - Photos → GPS
- Real-time GPS tracking for pilot.



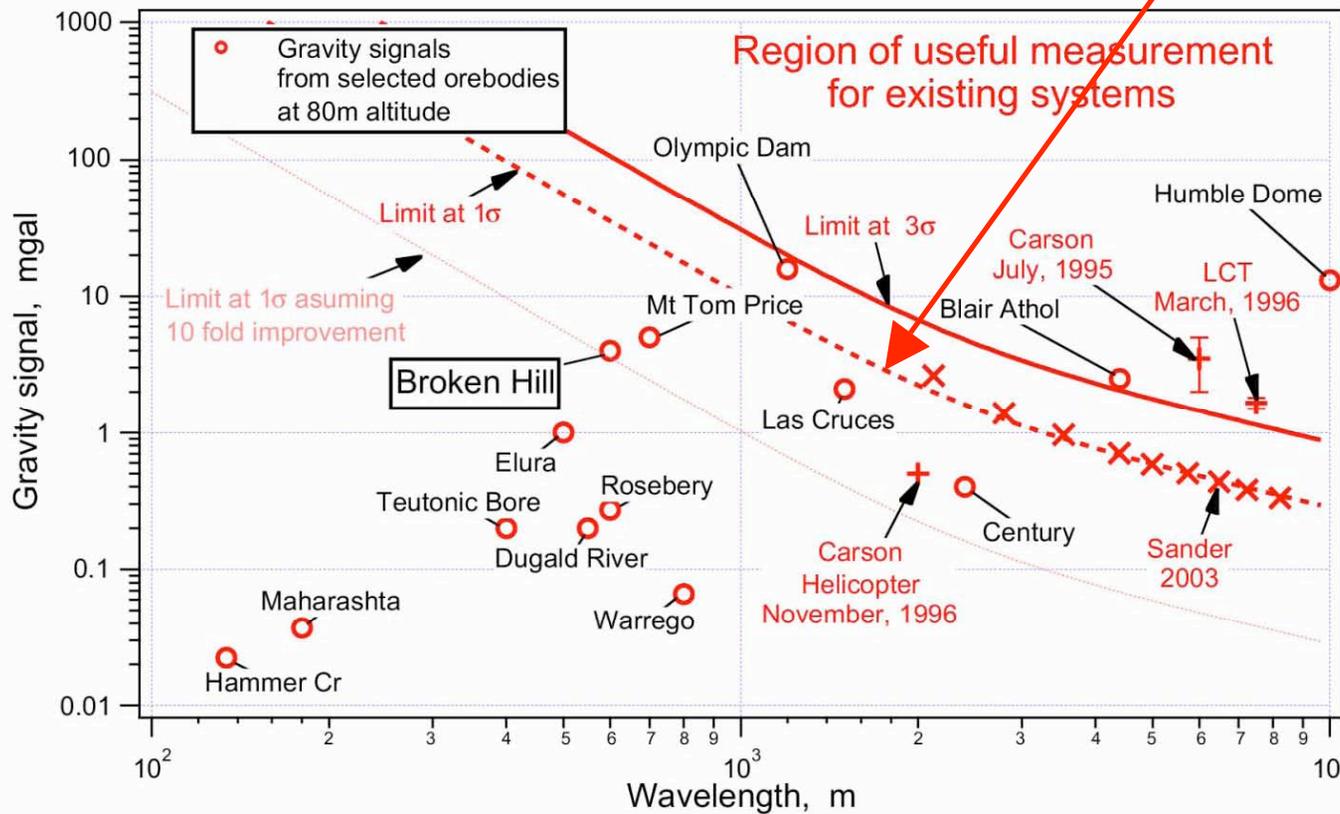


Airborne gravimetry & Equivalence

- Airborne gravimetry error limited by GPS accuracy (for given aircraft speed).

- Van Kann, 2004.

$$a_{rms} = (2\pi)^2 \sqrt{S_{o2}} \left(\frac{v^5}{5\lambda^5} + \frac{f_c^n v^{5-n}}{(5-n)\lambda^{5-n}} \right)^{1/2}$$



$n=3$
 $v=50 \text{ m/s}$
 $f_c=0.015 \text{ Hz}$
 $S_{o2}=0.01 \text{ m}$

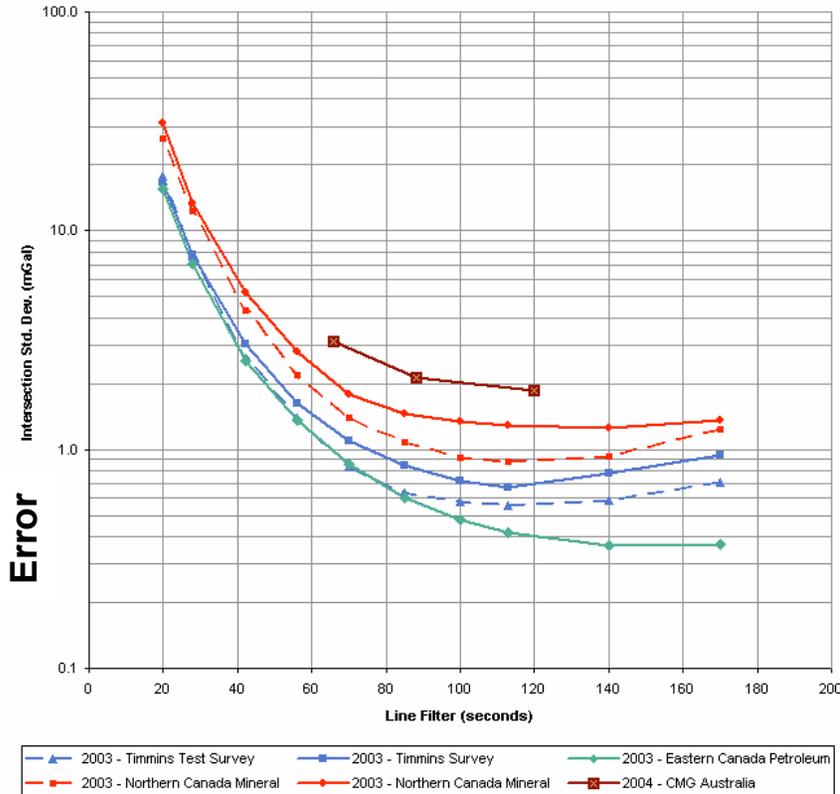




Navigation Errors → Airborne Gravimetry Errors

- “The northern Canada surveys were flown above the Arctic Circle, where the GPS signal is degraded by heavy ionospheric activity and poor satellite geometry.”

Luise Sander, Stefan Elieff, Quality Control Metrics for Airborne Gravity Data, KEGS Airborne Geophysics Symposium, Toronto, March 2008 & www.sgl.com*



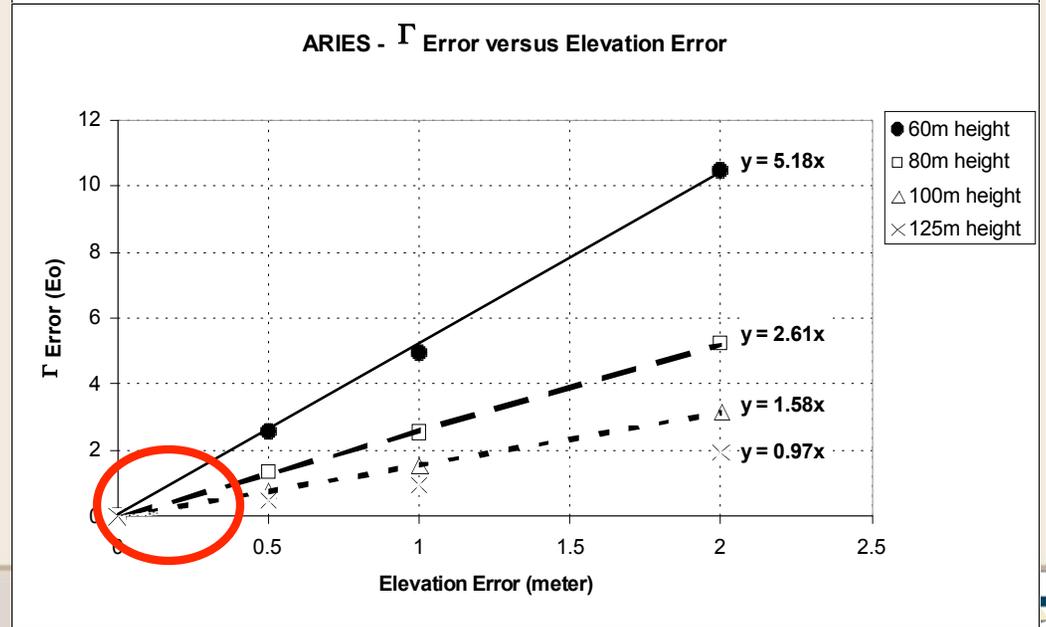
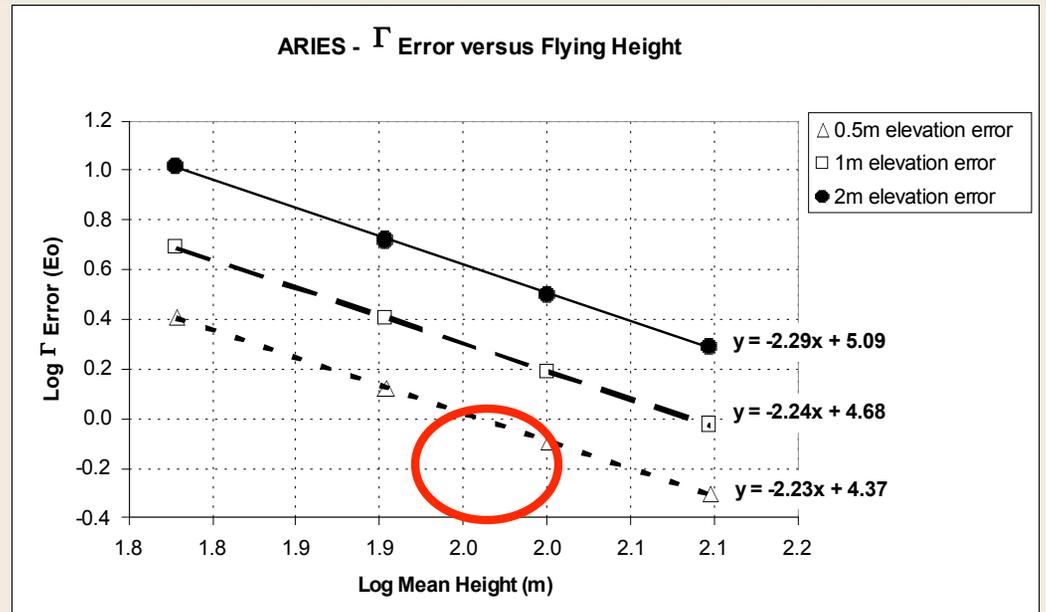
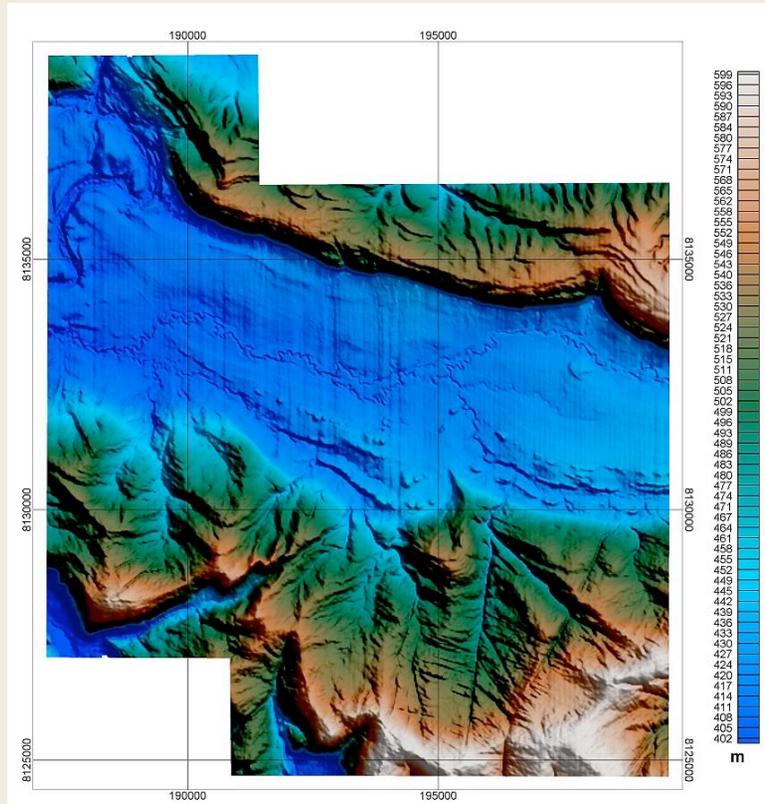
Red – northern Canada
Blue, Green – lower latitude

Filter Time



Gravity Gradiometer Terrain Corrections

$$\frac{\Delta\Gamma}{\Delta h} = G\rho r^{\alpha-1}h^{-\alpha}$$





Conclusion

- Improvements in exploration technology are required to find new resources
- Improvements in position, navigation & time → improvements in airborne geophysics





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