The Future of Exploration: A Vision for 2050

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Where have we come from?

What did Exploration look like in 1970?
Predicting the Future is about Two Very Different Things

- **EXTRAPOLATION**
  - Known trends
  - Relatively confident (short-mid term) predictions

- **DISCONTINUITIES**
  - Will definitely occur
  - Impossible to predict precisely
  - May invalidate Extrapolations
  - Need to consider possible scenarios
A Likely Extrapolation

3D Inversion of each dataset

Data Fusion to generate Solid Earth Model

SolidEarth proprietary software

BHP Billiton Presentation (Hronsky, 2007)
A Possible Discontinuity?

Cosmic Rays

High energy protons impinge on the upper atmosphere producing pions which decay to muons:

\[ \pi^+ \rightarrow \mu^+ \nu \]

Muons are heavy electrons

\[ m_{\mu} = 207 m_e, \tau_{\mu} = 2.1 \mu s \]

High energy muons (\( \mu \)) penetrate through large amounts of material.

Cosmic Ray Tomography works!

“Super-K” Muon Tomography


Underground Muon Exploration and Tomography

Due to the additional high density object, there is a deflection of cosmic ray muons at certain directions.

Inversion Technique: Complete Density Imaging

First try using the inversion software from the UBC Earth and Ocean Sciences Geological Inversion Facility.
Most gold and base-metal exploration focused on discovering large, relatively high-grade deposits at depth, driven by major improvements in both deep exploration drilling technology and in underground robotic mining.

Seafloor exploration and mining developed but remains a niche business; however, transfer of new technologies and concepts developed for the seafloor has a significant impact on land exploration, in particular in the area of remote-controlled technology operation (both deep mining and drilling).
• Predictive exploration targeting based on scale-integrated mineral system models with a strong focus on the physical processes of mass concentration. Many key underlying generic physical controls on ore-forming process have been elucidated. The footprint of ore-systems at regional scales has been characterised.

• The key role of lithospheric mantle architecture and compositional variability in controlling metallogeny is well understood and robust technologies (both geophysical and geochemical) are routinely applied to map this.

• Exploration targeting occurs in a context of well understood global secular evolution (mantle convection patterns, supercontinent cycles, evolution of hydrosphere and biosphere etc).

• Key interfaces between economic geology research and practical mineral exploration are well developed, leading to greater investment in R&D and more rapid take-up in the industry.
• Routine rapid airborne acquisition of multiple geophysical data sets (gravity, magnetics, conductivity, chargeability) produces 3D pseudo-geological models of the target rock-volume, based on data fusion and advanced petrophysical understanding. Much of this integrated data fusion is accomplished in real time.

• Sophisticated approaches (eg cosmogenic Be, AFT, accessory mineral provenance studies, geophysical techniques) are routinely applied to the mapping and interpretation of post-ore transported sedimentary sequences. A revolution in understanding has occurred similar to the regolith revolution in the late 20th Century.

• This understanding is linked to effective reconnaissance style exploration drilling techniques that are much cheaper than in 2010 and therefore buried unconformities have been rendered as transparent to detection technology as the surface of the earth presently is.
2050 Vision: What about the Discontinuities?

• Discontinuities in the period 1970-2010
  – Plate Tectonics
  – Digital Revolution
  – Satellites: communication, navigation and earth observation
  – Fall of Berlin Wall and Globalisation
  – CIP gold processing
  – Massive change in iron ore market (customer specs.)

• Some possibilities for 2010-2050
  – High resolution, remote, compositional mapping of the rock mass
    (based on new physical properties – eg muons?)
  – Breakthrough in the field of Complexity Science (currently like
    mechanics before Newton, thermodynamics before Carnot and modern
    physics before Einstein)
  – Breakthrough in our understanding of Geobiology (aka Geophysiology)
    of similar significance to the Plate Tectonic revolution
  – Breakthrough in biological leach technologies, changing the focus of
    exploration targets
  – Market-related discontinuities ; eg. the development of low-cost,
    ultrasafe, mini-nuclear reactors?
Geobiology:
The next Plate Tectonics?

Cady & Noffke (2009)
The Best Way to Predict the Future is to Create It!