How do you know you’re in a world class Nickel camp?

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114m @4% Ni

"From little things big things grow"
Voisey’s Bay

- Far Eastern Deeps
- Eastern Deeps
- Ovoid
- Discovery Hill
- Western Extension
- Reid Brook Zone
The individual intrusions within the cluster are connected in 3D!

Slide courtesy Dawn Evans-Lamswood
Outline

- Introduction
  - World class – do we know what it means?
  - Confidence
- Discovery History
  - Geology and predictive concepts
- Mineral systems and Target context
- Deposit summary
- Camps – what are they?
  - World class deposits are clustered
  - Intrusive connectivity and corridors
- Staging systems and camp footprints
  - Accommodation space and stress regime
What is a camp?
Confidence

- Through predictive concepts
- Mineral Systems approach (do more than use the word holistic)
- Learn the lessons from world class discoveries. Visiting deposits are only junkets if that is your attitude
Mineral systems approach - understand the target context

ORE DEPOSIT SETTING

DISTRICT -SCALE SETTING

PROVINCE/SUB-PROVINCE-SCALE TECTONIC SETTING

GLOBAL - SCALE GEODYNAMIC SETTING

Hronsky
World class deposits Ni-Cu-PGE are not simply larger ‘common garden’ deposits

Schodde and Hronsky 2006
World class Ni-Cu-PGE deposits

- excluding komatiites

Ni metal tonnes

- Sudbury Camp
- Duluth
- Pechenga
- Voisey's Bay
- Nebo-Babel
- Nkomati
- Selebi-Phikwe
- Kabanga

Red line denotes 1.3MNiT cut off of Schodde and Hronsky (2006), a rough approximation for world class

Source: Host websites
Understand there is a continuum of Ni-Cu-PGE styles and one predictive or detective technique will NOT work for all styles.
Understand and invest in target context

Getting out and hitting rocks is crucial but not enough
Independent test of a good structure

Lahtinen et al. 2007

It should be reused again and again eg Pechenga-Imandra-Varzuga
Beware of myths and intellectual blindness

Manage heuristics and challenge dogma
(it is the basis of exploration)
No feeders, no funnels: the feeder model is missing the point.

Myth: There are no world class examples of funnel shaped intrusion hosted Ni-Cu-PGE deposits.

Myth: Conduits/pipes are not necessarily feeders to large intrusions. The ovoid is not the mouth of a large intrusion!
1. Breccia pipes
   eg Aguablanca, Carr Boyd
2. Chonoliths or conduits
   eg Noril’sk, Nebo-Babel
Chonolith definition:

"a discordant igneous intrusion of irregular shape which has either been passively squeezed into a pre-existing cavity or has actively forced apart the country rock. It’s relationship with the invaded country rock is very complex and terms such as dyke, laccolith, etc., cannot be used" (Tomkeieff, 1983).
Deposit characteristics

- Igneous breccias (discriminate from tectonic breccias)

- Hydromagmatic phases, pegmatoids, varied or taxitic texture – the volatile link. 17% of the Siberian Traps is composed of pyroclastics

- Concentric crystallisation

- Well differentiated on scale of intrusive complex
Taxite or varied textured
Pipes are only part of the intrusive complex!

Seat et al 2006
Sulfide are pooling/concentrating after crystallisation!

World class deposit rarely accumulate by gravitational settling
This is syn-emplacement mobilisation.
not solid state remobilisation
This is a syn-magmatic breccia not remobilisation.

Magmatic breccia rimming the Ovoid, Voisey’s Bay.
This is remobilisation!
Clustering

Not all the elements of the cluster are mineralised. This will become important:
- Emplacement level
- Erosional level
- Stress regime
How are deposits linked?

We don’t deliberately target or drill barren domains

Slide courtesy Dawn Evans-Lamswood
Image the entire ore system as early as possible
Wilson 2002

1. FOSSIL MOHO zones: e.g. Ivrea Zone, Alps
2. FLOOD BASALT PROVINCES
   e.g. E. Greenland (Tertiary)
   Paraná, Brazil (135 Ma); Karoo, S. Africa (180 Ma)
3. SILL COMPLEXES
   e.g. Atlantic Margins (Tertiary)
4. REGIONAL DYKE SWARMS
   e.g. Proterozoic, S. Sweden; S. Greenland
5. Mid-crustal magma storage -
   indirect evidence from geochemical studies; 3-D seismic
6. LAYERED IGNEOUS COMPLEXES
   e.g. Atlantic Margins (Tertiary intrusions)
Lesson from modern systems

Magmatic Mush Column

Marsh 1998

Shervais et al 2006
Prior to uplift

Contaminated magma continues towards surface
Magma ponds in crust
Magma ascends from mantle

After uplift

Suggested relics of the feeder apparatus for the upper magma chamber, which has been removed by erosion
“World class Ni-Cu-PGE deposits are the surface manifestation of crustal scale intrusive complexes”
Imaging the ore system
Accommodation space and stress regime

90% of magmatism in modern rifts and transpressional basins is focussed in accommodation zones
Schematic Cross Section: Relationships Between Deposits, Structure, and Transfer of Silicate and Sulphide Magma

- Upper Chamber (Eastern Deeps)
- Sulphide Emplacement
- Sulphide Trap
- Ovoid and Mini-Ovoid Zones
- Lower Conduit
- Conduit Dyke
- Sulphide Entrainment
- Lower Chamber (Western Deeps)

- Troctolite
- Massive Sulphide
- Pre-intrusive faults/joints
- Syn-emplacement fault

Geological relationships from Lightfoot and Naldrett (1999); structural interpretation from Cruden et al., (2000)
Conclusions

• Invest in developing confidence in your targets

• Understand the target context. It’s not arm wavering, its the difference between chasing any common garden deposit and world class.

• Getting out and hitting rocks is crucial but a poor target is a poor target. Improve your probability of success

• World class systems are clustered (it’s what makes them world class). Invest early in mapping the whole system and corridor (use appropriate tools and spacing). If for nothing else it generate geological targets.

• Chonoliths are not feeders to intrusions. They are parts of networks or a corridor of intrusions which often include larger receptacles (layered intrusions) and passively emplaced dykes and sills.

• These ‘camps’ include a diversity of deposit styles reflecting the diversity of intrusive styles, assimilation histories, magma evolution, and evolving/fluctuating S solubility.

“World class Ni-Cu-PGE deposits are the surface manifestation of crustal scale intrusive complexes”
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