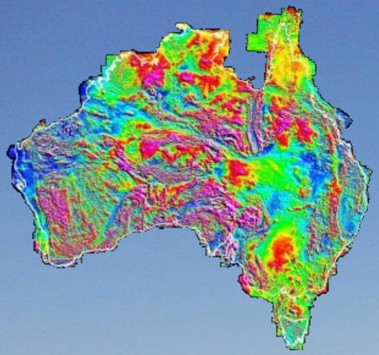
4D Metallogenesis: Uncover summit 2014



Theory of constraints applied to mineral systems

Where are the problems? What is the science?

Steve Beresford

FIRST QUANTUM MINERALS LTD.

“If I were given one hour to save the planet, I would spend 59 minutes defining the problem and one minute resolving it”

Albert Einstein

UNCOVER: Key science challenges

1. Increase knowledge of geodynamic evolution

   Extrapolation problem

2. **Multiple scales** – *the camp problem*

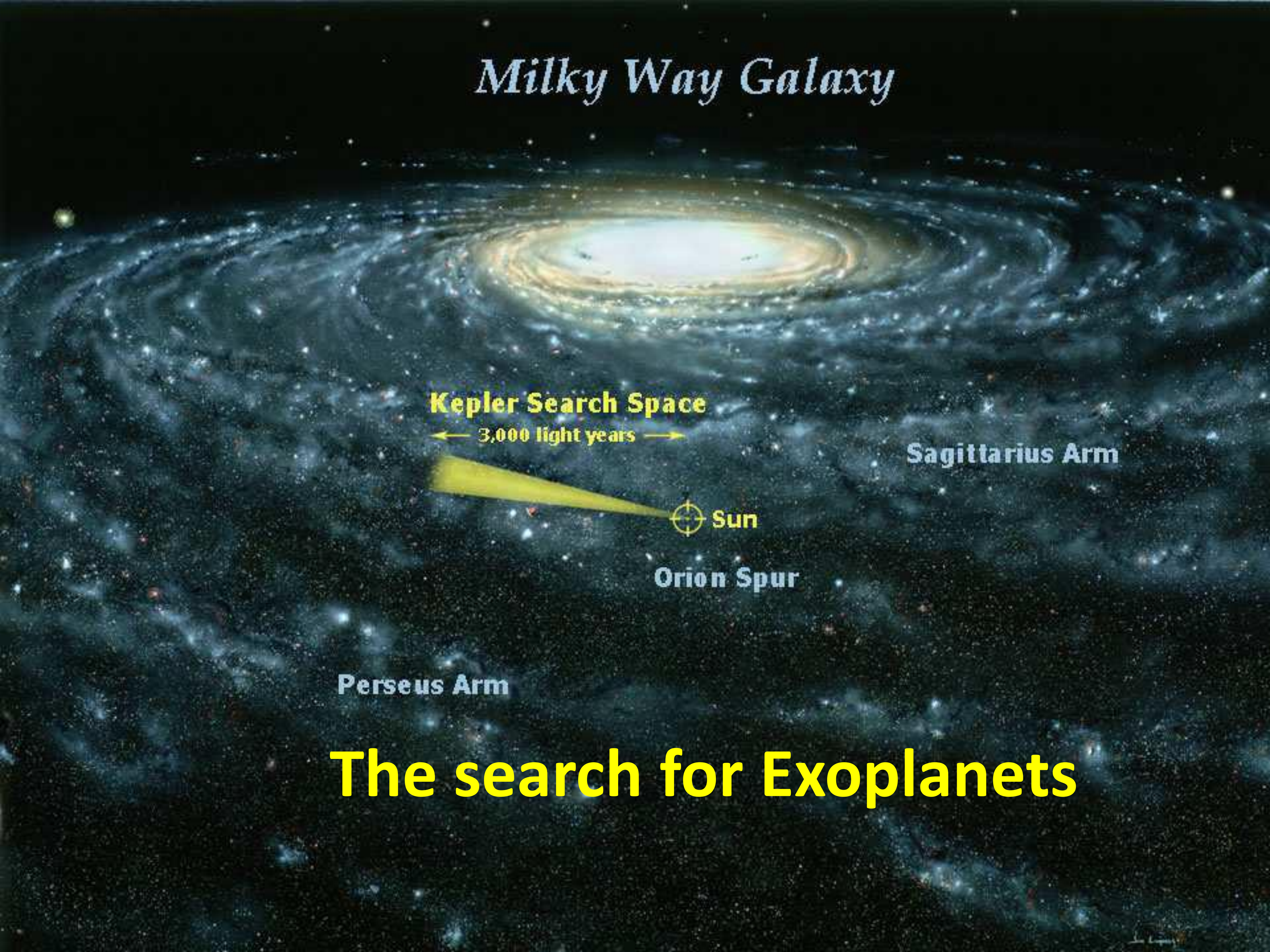
   Data representation problem

3. Harnessing computing power for prediction

   Accuracy problem

The problem fits squarely into area selection **not** detection.

The search for Exoplanets



The Exoplanet detection problem

- **The aim:** Find NEW *habitable* exoplanets
- **The hypothesis:** The galaxy is teeming with exoplanets. How do we find them when the footprint is not directly detectable (yet)
- **The detection problem:** Planets are millions of times dimmer than stars and distant
- **Multiple planet system model** – how many ways can we form multiple planets?

Step change in exoplanet system science – bridging the gap to detection

- 20 years ago we couldn't detect a single exoplanet. Now we have 1700

What's changed:

- **Manageable** search space for detection technology
- Greater predictive controls – exoplanet systems models
- Technology advances: Spectrometer advances, optics, **computing power**
- Predicting habitable planet footprint despite no direct detection.
- *Confidence without direct detection.*

Source: NASA

The future:

- Infrared detects planet heat – most effective at locating gas giants i.e. this is not the target. Visible light – Simple observation. The Earth looks blue.

FIRST QUANTUM MINERALS LTD.

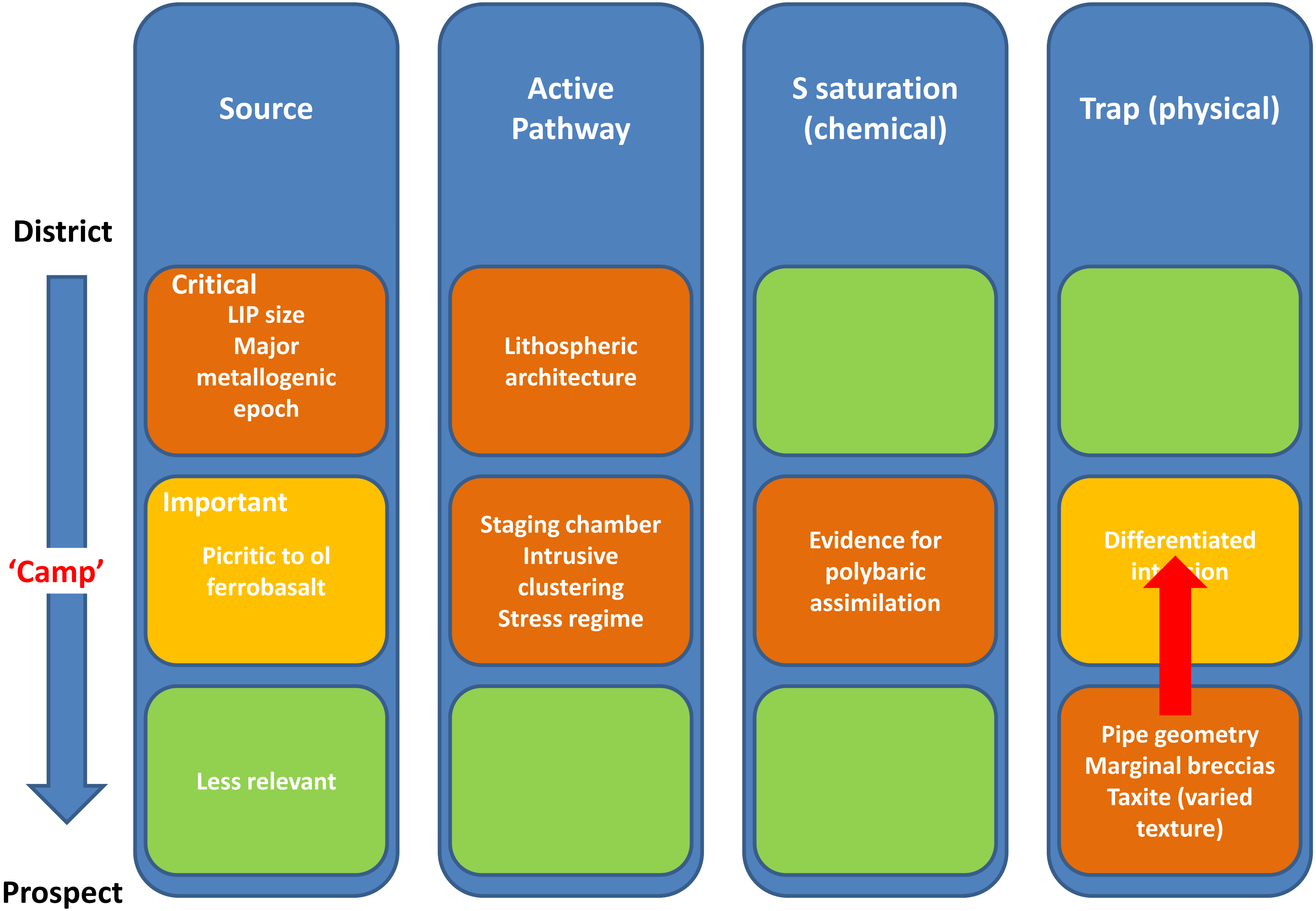
Mineral Systems models

Meyers Law

Its simple to make things complex

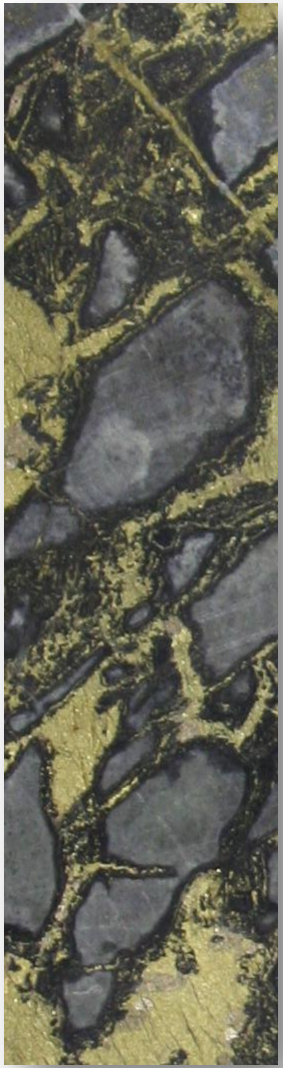
Its complex to make things simple

Mafic (ultramafic) Nickel Copper



CONCEPT: The theory of constraints

Focus on the connectors or weak points



- The presence of a resilient craton margin and the confirmed presence of a chonolith are big technical advances in Nickel exploration geoscience because they represent HUGE jumps in $P_{\text{world class discovery}}$ and $P_{\text{economic threshold.}}$
- We have our step change BUT *Q: How do they connect?*
- They don't   yet!

What science is needed to establish that connection?

1. Define the tangible manifestation of the mineral system and a hard boundary at camp scale. When, where
2. Productive horizon
3. Clustering of intrusions – erosional level?
4. **Map chonoliths earlier**
5. **Can we map the critical moment?**

FIRST QUANTUM MINERALS LTD.

Imagery of the camp footprint – can we define a tangible boundary to a camp?

This isnt just the camp footprint, its a hard boundary

FIRST QUANTUM MINERALS LTD.

Can I map the target intrusions?

Q: What are the problems with mapping?

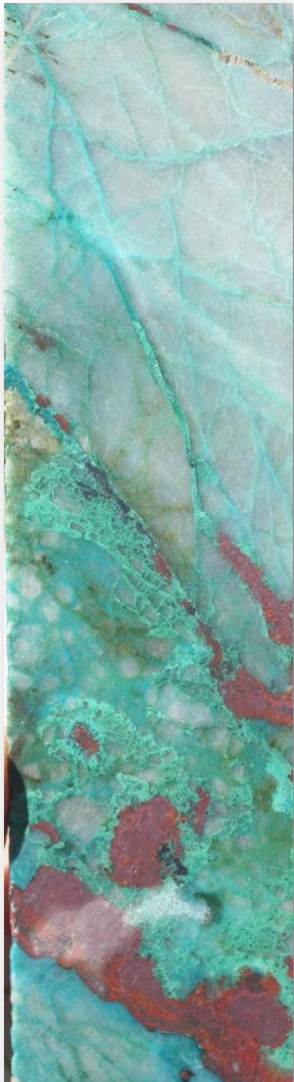
1. Data density
2. Petrophysical constraints eg magnetic contrast?
3. Magnetic remanence

What is the typical behavioural response?

Explore larger intrusions that easier found in pre competitive datasets. This is like hunting for a 10km diamond bearing pipe. Wishful thinking and missing the whole point.

The Mukluk lesson

and the risk of incomplete mineral systems in undercover targeting

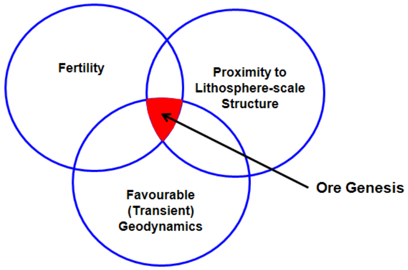


- $1.5B to assemble the tenure, $100M to build the drill platform, $150M to drill the well. 1.5 billion bbl estimated – dry!
- Seen by some as the single moment for the rise of ‘petroleum systems’
- Weakest point in the system model was timing (‘thief zones’ of petroleum migration)

Model sensitivity

Timing – transient geodynamics

- Can we image the 'critical moment'?



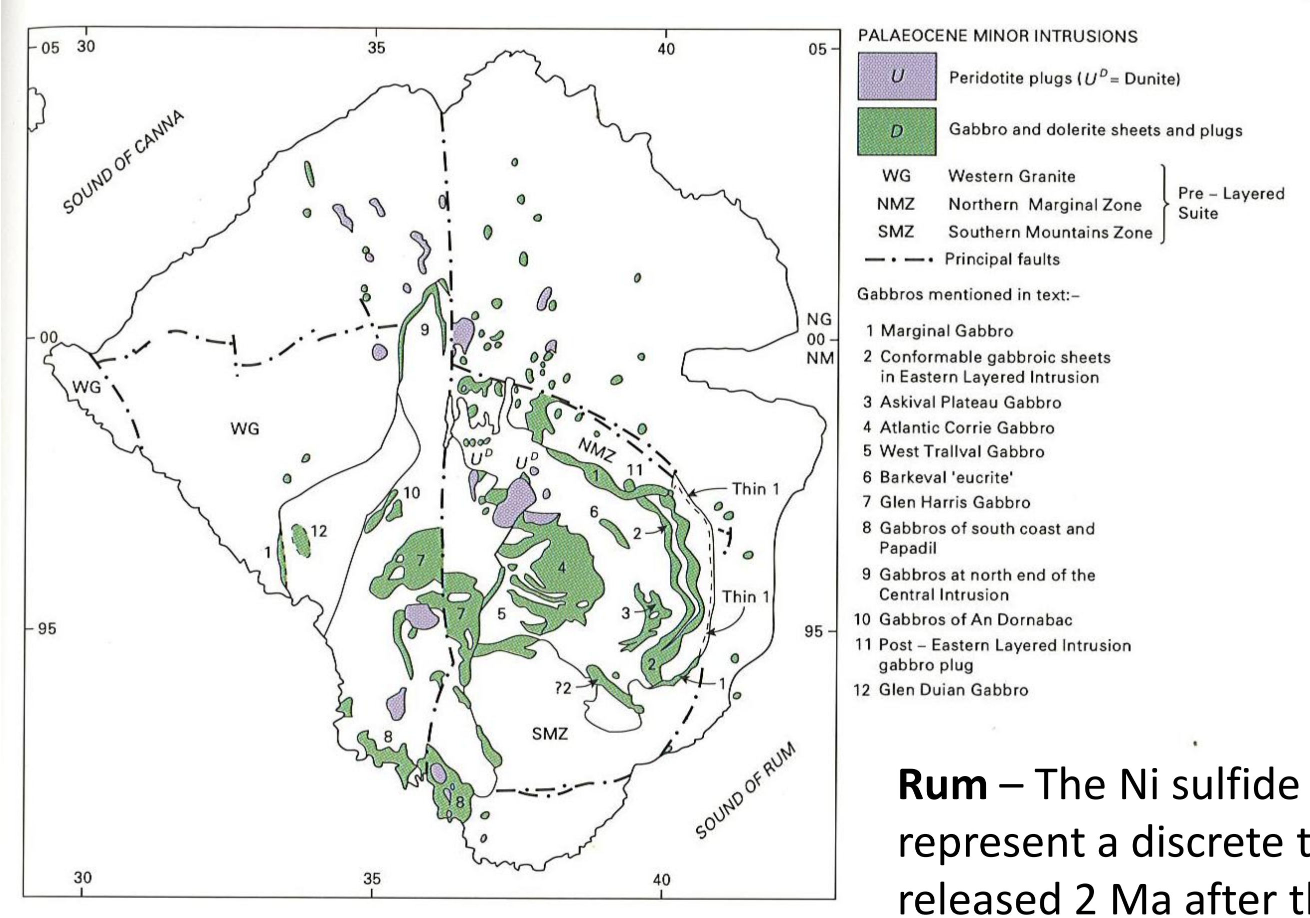


Figure 35 Distribution of gabbro sheets and plugs, and peridotite plugs in the Rum Central Complex and the surrounding rocks.

Rum – The Ni sulfide bearing intrusive suite represent a discrete temporal event – released 2 Ma after the peak of magmatic volume

FIRST QUANTUM MINERALS LTD.

Which option has the best $P_{\text{success (economic threshold)}}$?

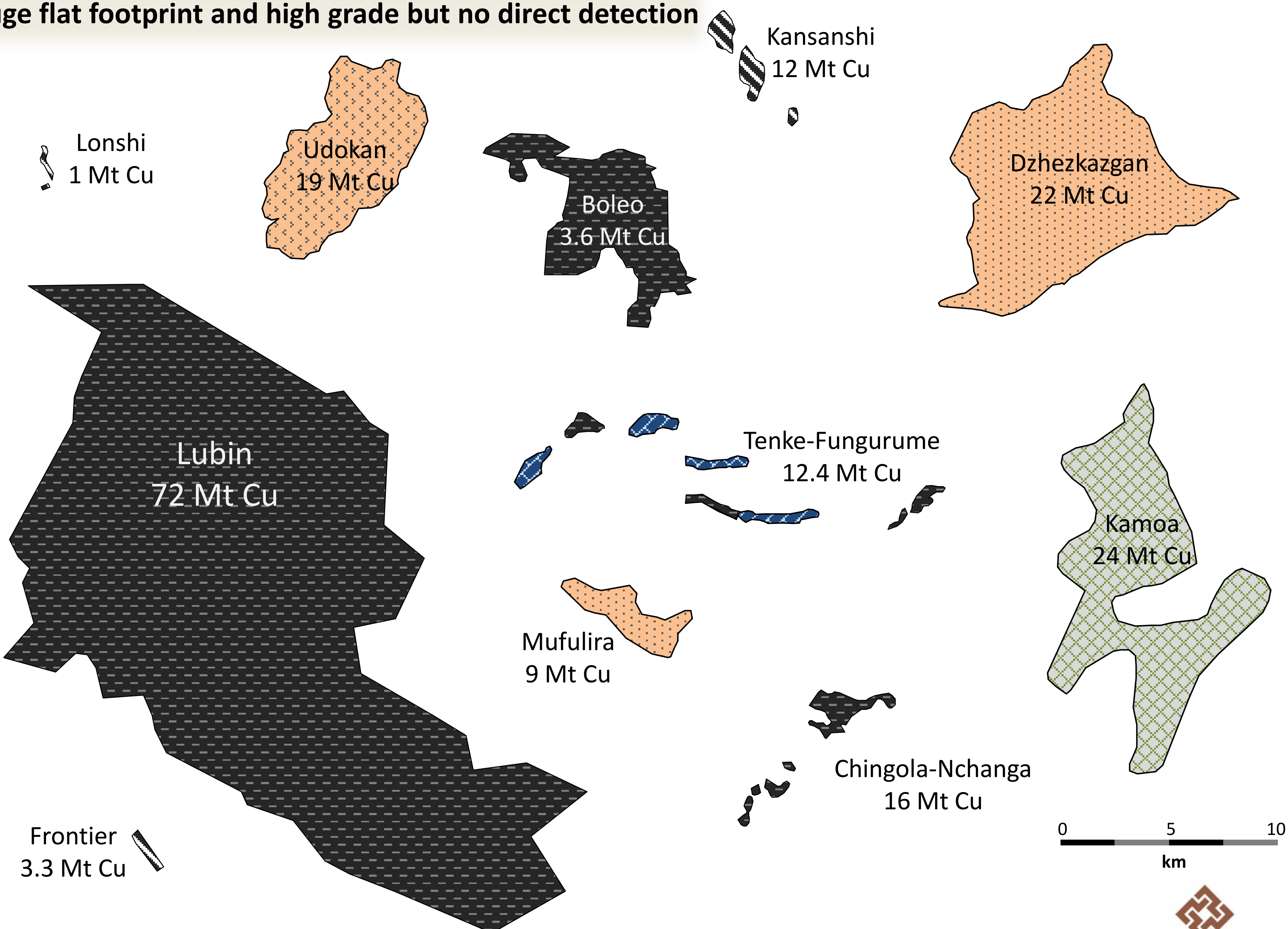
A project with outcropping massive sulfides in a large intrusion

or

A chonolith imaged in magnetics?

Majority will choose A, but historical P_{success} suggests it's B by three orders of magnitude. Behavioural issue not just technical

Huge flat footprint and high grade but no direct detection



Conclusions

- **Most mineral systems are weak at camp scale (transition)**
- **The translation from area selection to ground selection is only as good as the weakest point not the strongest**
- **This is the area of maximum research impact**
- **Define the key problems first NOT the key concepts or data. These problems will REQUIRE industry involvement (process as much as science).**

- **We can't work around area selection. Great detection in the wrong place still fails**