Goldfields St Ives and Y4 Project Targeting Exercise

28-29 September 2007

predictive mineral discovery Cooperative Research Centre

Purpose

Science Meeting first and foremost

- Rigorous debate
- Gap analysis (will help sponsors)
- Realise a unique opportunity
  - last big get together with sponsors
  - SIG access to researchers 1-on-1
  - test of what data are most ‘valuable’
  - to understand the ‘orogenic’ gold mineral system
  - team work for Y4 and true test of our capability and utility for predictive mineral discovery
- Final report

Part II: Practical Targeting across the scales

SCALE 1: REGIONAL ANALYSIS–How to recognise a gold (metal) bearing province (1000 km x1000 km area selection)

KEY CRITERIA (inc. Ranking)
NECESSARY DATA
MINIMUM DATA DENSITY

Data Data Density

SCALE 2: DISTRICT ANALYSIS–How to identify the location of major mineral camps (60 km x 60 km area selection)

KEY CRITERIA (inc. Ranking)
NECESSARY DATA
MINIMUM DATA DENSITY
An undercover example and how to explore in this space

Data Data Density

SCALE 3: PROSPECT ANALYSIS–How to identify the location of a specific ore deposit (5 km x 5 km area selection)

KEY CRITERIA (inc. Ranking)
NECESSARY DATA
MINIMUM DATA DENSITY
An undercover example and how to explore in this space

Data Data Density

SCALE 4: ORE SYSTEM DEFINITION
KEY CRITERIA (inc. Ranking)
NECESSARY DATA
MINIMUM DATA DENSITY

Data Data Density

1000km x 1000km targeting

SCALE 1: REGIONAL ANALYSIS–How to recognise a gold (metal) bearing province (1000 km x1000 km area selection)

- *Why be in the Yilgarn cf. Pilbara*
- *Benefits for area selection globally and in Australia under cover*
- *more comparison synthesis needed (eg Superior, Slave, Birrimian, Soa Francisco, Pilbara, Barberton etc?*

KEY CRITERIA (inc. Ranking)
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1000km x 1000km targeting

Process: Mantle metasomatism or rejuvenation

- thinned lithosphere
- relatively juvenile crustal age T_{DM}
- mantle plumes
- ‘greenstone’ sequences incl. komatiites
- mantle magmas incl. sanukitoids

1000km x 1000km targeting

Process: Pathways to mantle

- alkalic intrusions incl. syenites, kimberlites, lamprophyres, carbonatites etc.
- sutures
- mantle edges
- crustal cracks
- big worms
- mafic dykes (even young ones)

1000km x 1000km targeting

Process: Large-scale heating/melting/fluid systems

- large volume crustal melts (Low-Ca or A-type granites)
- metamorphic aureoles
- electrically conductive crustal anomalies

1000km x 1000km targeting

Process: Rapid exhumation

- core complexes
- late-stage siliciclastic basins with granite (deep rock) detritus
- fluviatile systems
- compressed event history incl. relevant PT*t* paths (isothermal decompression)

1000km x 1000km targeting

Process: Active orogenesis

- elongate orogenic belts
- subduction-accretion
- tectonic mode switching
- changing subduction vector, slab dip or delamination

1000km x 1000km targeting

Process: Cratonisation and preservation

- erosion level with widespread greenschist grade metamorphic rocks preserved

1000km x 1000km targeting

Process: "Convergence" of favourable processes

- Presence of known giants

60km x 60km targeting

SCALE 2: DISTRICT ANALYSIS–How to identify the location of major mineral camps (60 km x 60 km area selection)

- *Where in the Yilgarn?*
- *Youanmi cf. Eastern Goldfields*
- *Kalgoorlie terrane cf. Burtville terrane*

KEY CRITERIA (inc. Ranking)
NECESSARY DATA
MINIMUM DATA DENSITY

60km x 60km targeting

Process: Connected fluid pathways

- Strain partitioning with large areas of low strain with preserved stratigraphy separated by narrow elongate high strain domains
- large scale alteration cells (W, As??, Phengite-Ms)
- large scale metamorphic ‘cells’ note gradients or boundaries in grade

60km x 60km targeting

Process: Fluid Focus - Structural complexity

- reactivation of old structures especially basin or domain bounding
- switching tectonic mode: strike-slip and dip slip kinematics
- cross structures with domain/stratigraphic boundaries or other structures that were active with mineralisation and
- high ‘D numbers’ (fractal dimensions?)
- worms

60km x 60km targeting

Process: Fluid Focus - structural architecture

- bends and deviations from mean strike on faults
- soft and hard accommodation or stress transfer zones
- domes at all depths
- domes linked to deep cracks and through-going breaching faults
- growth faults
- low-angle shear zones (seals?)
- 2nd and 3rd order structures linked to ‘major’ structures??

60km x 60km targeting

Process: Fluid Focus - Rheological or lithological complexity

- abundant porphyries, esp enriched Mafic and Syenite-types
- complex stratigraphic architecture – volcanic domes/centres, sequence boundaries
- thick greenstone sequences?
- deep-marine late basins (seals?) – within 1 km of u/c???????
- early alteration systems (silicification etc)
- Fe-rich rock types
- carbonaceous rocks

60km x 60km targeting

Process: Fluid-chemical complexity

- gradients of oxidised and reduced fluid types in alteration mineralogy
- sharp metamorphic gradients and metamorphic overprints
- range of stable isotopes

60km x 60km targeting

Process: Cover and dispersion processes

- <<1 km to target depth
- depth of weathering
- age of weathering
- architecture of regolith (palaeochannels, conductors, ground water)
- landscape evolution – presence of salt lakes

5km x 5km targeting

SCALE 3: PROSPECT ANALYSIS–How to identify the location of a specific ore deposit (5 km x 5 km area selection)

- *Where in the Kalgoorlie Terrane (undercover) do I want to be in?*
- *When I chose my area and put down a hole, what should I expect?*
    - decision tree?
    - probably the most valuable scale to get 'right'
    - this is the domain of the stretched Junior who may be on good ground
    - danger of major walking away too early
    - change paradigms (St Ives) – dolerite not only favourable lithology, not just restraining bends (better process understanding will help decision making)

5km x 5km targeting

Process: Active hydrothermal system

- magnetic anomalies and broad haloes, demagnetised zones
- buried granites (in domes)
- widespread silification
- topography or palaeotopography

5km x 5km targeting

Process: Active hydrothermal system - Fluid-chemical complexity

- gradients of oxidised and reduced fluid types in alteration mineralogy
- range of stable isotopes
- Au and pathfinders (As ++++?) above background

5km x 5km targeting

Process: Fluid Focus - Structural complexity

- reactivation of old structures
- switching tectonic mode: strike-slip and dip slip kinematics
- cross structures active with mineralisation

5km x 5km targeting

Process: Fluid Focus - structural architecture

- bends and deviations from mean strike on faults
- soft and hard accommodation or stress transfer or damage zones, fault tips
- domes and near dome regions
- growth faults
- seals
- 2nd and 3rd order structures

5km x 5km targeting

Process: Fluid Focus - Rheological or lithological complexity

- small stocks, plutons, porphyries, dykes, boudins
- complex stratigraphic architecture – volcanic domes/centres, sequence boundaries
- early alteration systems (silicification etc)
- Fe-rich rock types
- carbonaceous rocks

5km x 5km targeting

Process: Fluid-chemical complexity

- detailed gradients of oxidised and reduced fluid types in alteration mineralogy
- complex metal associations

5km x 5km targeting

Process: Cover and dispersion processes

- <<1 km to target depth
- depth of weathering
- age of weathering
- architecture of regolith (palaeochannels, conductors, ground water)
- landscape evolution

1km x 1km targeting

- Quality depends on bounding 5x5 selection
- Develop a deposit model:
  - alteration
  - architectural features
  - structural complexity
  - competency contrasts
  - favourable hosts
- First ‘chase’ surficial gold anomalies in stream seds and supergene
- Three aspects to target model
  - structural
  - alteration geochemical
  - lithological

1km x 1km targeting: Structure

- structural mapping
  - worms
  - fwd models
  - test jogs and intersections
- which way to drill?
- define lithology will constrain structure
  - targeted geophysics
  - magnetic quiet zones
  - sub audio magnetics

1km x 1km targeting: Alteration/geochemistry

- define gradients
  - PIMA
    - white mica composition and peaks
  - whole-rock multi-element geochem
    - As/Sb ratios
    - W, Mo, B, Te, V
  - inversions of potential fields (see Chopping)
    - rock property changes (velocity, density, susceptibility)
  - Stable isotope variations
    - C, O, S, D
- Caveats
  - read map patterns
  - conscious of lithology
  - conscious of mineralisation style

1km x 1km targeting: lithology

- geological map variations in lithology
  - look at maps
  - multi-element geochemistry
- competency contrasts
- differentiated dolerites

So you want to drill?

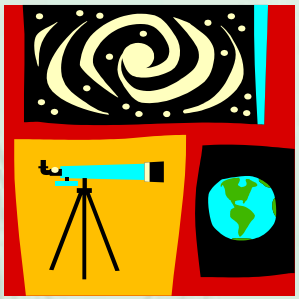
- direction – then orient the core
- sample for Au and log
- collect PIMA and ME geochem
- integrate alteration and lithology
- detailed structural analysis
- Does all this new data support or invalidate the model – be objective?
- Decide where next

Mine scale

- decide what model is NB and what scale to look at it
- process can be confusing and dynamic
- scrutinise data (eg density, ‘right’ direction, incomplete, poorly logged)
- many decision trees operating
- go back and forth to 5x5 - is it still supported
- don’t assume model correct
  - structure and kinematics, alteration, high-strain zones

Guiding Thoughts

- Integration: Space and Time
  - ALL of our process-criteria must be integrated in time and space



- We should be looking to better integrate features-criteria into process and justification of why the feature-criteria is NB