# predictive mineral discovery
## COOPERATIVE RESEARCH CENTRE

# Structural architecture, hydrothermal alteration and fluid characteristics in the Kalgoorlie-Kambalda area, Western Australia

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## OVERVIEW

**In the Eastern Goldfields Province of Western Australia the tectonostratigraphic framework is well constrained (Archibald et al., 1977; Gee, 1979; Gresham and Loftus-Hills, 1981; Campbell and Hill, 1988; Swager, 1997; Weinberg et al., 2003), however, the characteristic hydrothermal and metamorphic alteration assemblages and related fluids are less well understood. It is critically important to gain a far better understanding of the structural-hydrothermal alteration-fluid relationships in order to develop new exploration models which will allow exploration under cover.**

**The Kalgoorlie-Kambalda region of the Eastern Goldfields Province is an ideal location to undertake this research on the characteristic hydrothermal alteration and metamorphic mineral assemblages associated with regional tectonic events and the nature and origin of hydrothermal fluids. The area has been actively mined for more than a century, and there is a wealth of information both historic and recent on mining centres in the area. Outcropping areas are easily accessible and drill core is readily available.**

## AIMS

i. **Evaluate and identify hydrothermal alteration assemblages and fluid characteristics during deformation, metamorphism, magmatism and gold mineralisation associated with De to D4 deformation events.**

ii. **Identify and characterize end-member hydrothermal fluids and alteration assemblages in space and time.**

iii. **Compare and contrast Au-endowed and barren alteration systems.**

iv. **Develop structural, alteration and genetic models through time.**

v. **Translate into an exploration model.**

## FOCUSES

i. **Kalgoorlie Terrane between Kalgoorlie and Kambalda.**

ii. **Detailed petrography of alteration and metamorphic minerals within and adjacent to the major fault systems and granitoid bodies in the study area to identify characteristic hydrothermal and metamorphic mineral assemblages associated with different tectonic, igneous and mineralising events, and to identify and characterise syn-depositional, pre-deformation seafloor alteration.**

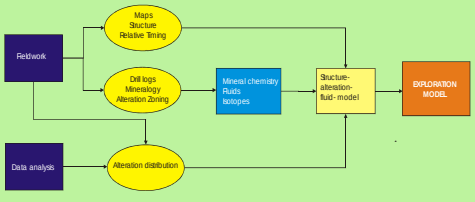
iii. **Mineral and fluid chemistry of hydrothermal alteration zones.**

iv. **P-T-X-t conditions of the hydrothermal fluids.**

## KEY MINERALS

| MINERAL | SETTING | AREA | LOCATION |
|---|---|---|---|
| Hematite | Seafloor | 1 | Golden Mile |
| | Oxidised Au-bearing fluid | 2 | Hannan South |
| | | 4 | Kambalda |
| Magnetite | Primary igneous | 1 | Golden Mile |
| | Hydrothermal – magmatic, | 2 | Hannan South |
| | metamorphic, etc. | 3 | New Celebration |
| | | 4 | Kambalda |
| | | 5 | |
| Epidote | Seafloor | 1 | Golden Mile |
| | Magmatic | 2 | Hannan South |
| | | 4 | Kambalda |
| Carbonate | Seafloor | 1 | Golden Mile |
| | Hydrothermal | 2 | Hannan South |
| | Magmatic | 3 | New Celebration |
| | Metamorphic | 4 | Kambalda |
| | Mantle | 5 | Foster Thrust |
| Amphibole? | Hydrothermal | 3 | Hampton- |
| | Metamorphic | | Boulder/Jubilee |
| Chlorite | Hydrothermal | 1 | Golden Mile |
| | Seafloor | 4 | Kambalda |
| | Metamorphic | 5 | Foster Thrust |
| Albite | Hydrothermal | 4 | Golden Mile |
| | Seafloor | 5 | Kambalda |
| | | 1 | Foster Thrust? |
| Biotite | Hydrothermal | 3 | New Celebration |
| | Seafloor | 4 | Kambalda |

## STRATEGY




## GOLDEN MILE(1)

CRITICAL QUESTIONS:

- What is the nature of the carbonate alteration?
- Can seafloor alteration be identified?
- How does this relate to De? D1?

## HANNAN SOUTH (2)

CRITICAL QUESTIONS:

- What are the characteristics of the D2 granitoid-related alteration assemblages? Are they skarns?
- What is the paragenetic sequence and how does the hydrothermal alteration relate to magmatism and gold mineralization?
- How does the magnetite-epidote alteration compare to similar alteration observed at Kambalda?
- What is the nature of the hydrothermal fluid?

## NEW CELEBRATION (3)

CRITICAL QUESTIONS:

- What are the geochemical characteristics of hydrothermal alteration minerals (quartz, albite, carbonate, pyrite, sericite, biotite, magnetite, hematite) associated with different hydrothermal alteration zones and mineralizing events?
- How do the mineral populations compare within the New Celebration area and with hydrothermal alteration assemblages in other study areas?
- What is the nature of the hydrothermal fluid (or fluids) associated with the mineralizing events and how do they relate to the D2-D3 Boulder-Lefroy Fault Zone?

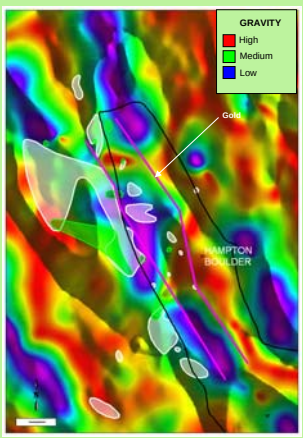
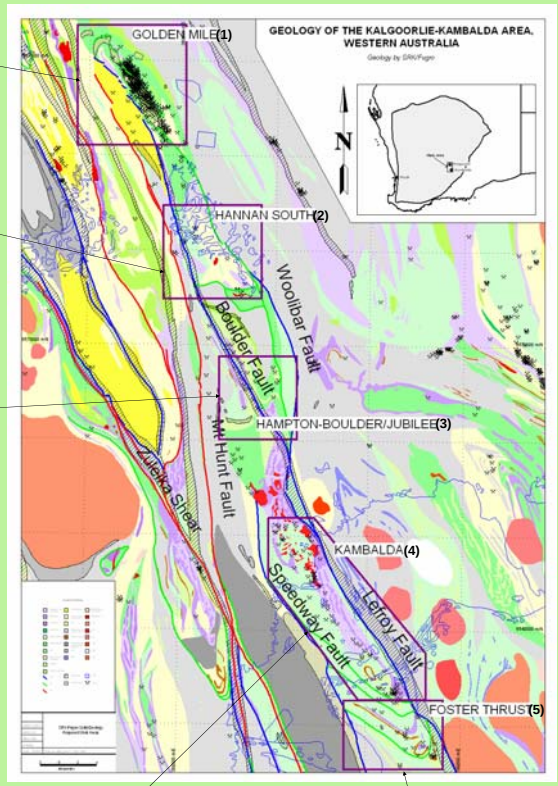



**Figure 1: Magnetite and epidote distribution at the Hampton-Boulder deposit. Down hole values for gold, magnetite and epidote have been projected to the hole collar therefore the shapes are offset slightly to the west. Some overlap between the two zones is observed, suggesting true magnetite-epidote alteration, as seen elsewhere in the Eastern Goldfields Province (e.g., Hannan South, Kambalda). However, most magnetite is spatially distinct from epidote, suggesting at least two alteration events have occurred. Taking into account the westerly offset, magnetite distribution shows a good spatial correlation with gravity lows, which may be felsic magmatic intrusions. This possibly indicates a magmatic origin for the hydrothermal fluids. (Neumayr et al., 2003).**




## KAMBALDA (4)

CRITICAL QUESTIONS:

- Is there any evidence for seafloor alteration?
- What are the spatial, mineralogical and textural characteristics of epidote-magnetite and magnetite assemblages?
- What is the nature of the carbonate?
- How do the hydrothermal alteration assemblages relate to porphyry stocks and dikes?
- How do the hydrothermal alteration assemblages relate to the Boulder-Lefroy Fault (D2-D3)? Other faults (D?)?

## FOSTER THRUST (5)

CRITICAL QUESTIONS:

- What is the nature of hydrothermal alteration associated with D1 thrusting
- What are the temporal and spatial relationships between seafloor alteration and alteration associated with D1 thrusting?
- Is seafloor alteration (if present) contemporaneous with deformation-associated alteration, or is it syn-depositonal, predating D1 (De)?
- What are the characteristics and spatial distribution of the hydrothermal alteration and fluids?
- What is the spatial distribution of the hydrothermal alteration?

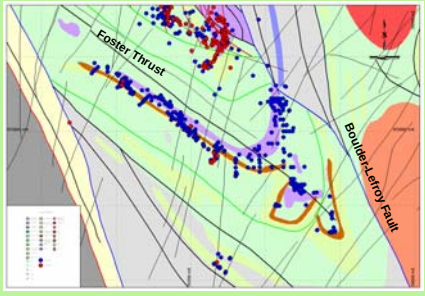



**Figure 2: Magnetite (red) and pyrrhotite (blue) distribution in diamond drill core at the Foster Thrust, Kambalda. Po-py assemblages are fairly ubiquitous at the Foster Thrust and suggest that reduced fluids were widespread. Magnetite assemblages (mt±py) distribution is more tightly focused, and appears to show some spatial correlation with minor NNE-SSW trending faults. Distribution of magnetite may be controlled by the movement of oxidized fluids (potentially sourced from underlying felsic magmatic intrusions (Neumayr et al., 2003)) along these faults.**

## SUMMARY

**•Preliminary investigations have resulted in the identification of five key areas in which to characterize alteration assemblages associated with De to D4 tectonic events.**

**•Testable alteration assemblages range from syn-depositional or early D1 seafloor alteration (Golden Mile, Foster Thrust) to possible magmatic (ep-mt-hem) assemblages (Hannan South) to trans-crustal fault-associated Au (New Celebration) to lower-order fault-network-hosted gold (Kambalda).**

**•Early results at New Celebration suggest a spatial correlation between magnetite distribution and gravity lows and indicate that most magnetite at the Hampton-Boulder pit occurs distally to the main gold lodes.**

**•Magnetite also appears to be spatially decoupled from epidote at New Celebration suggesting at least two alteration events have occurred.**

**•The distribution of pyrrhotite and magnetite assemblages at Foster Thrust suggest that reduced fluids were widespread but oxidized fluids were more tightly focused.**

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