Summary:

Exploration characteristics of IOCG systems in the Gawler Craton

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IOCG Workshop
Adelaide, 24 February 2006
Outline

Part 1
• ‘Essential ingredients’ as they relate to exploration for mineralised IOCG systems
• A model for the Olympic Dam region

Part 2
• Map of IOCG Potential

Questions
Part 1

‘Essential ingredients’
(i.e., key geological characteristics and processes required to form major IOCG systems, focussing on mappable features)

and IOCG model
Tectonic / thermal ingredients

1. ‘Plumbing’ - major Mesoproter IOCG systems in re-activated Palaeoproter orogenic belts at margins of Archaean ‘core’; not anorogenic, but geodynamic settings still unclear.

2. Timing - Iron oxide Cu-Au (±U) in eastern Gawler, and Au in central Gawler, all at ~1575-1595 Ma: broadly coeval and spatially associated with some Hiltaba-GRV magmatism.

3. Heat - IOCG districts developed where very high heat flow at 1575-1595 Ma (represented by A-type high-T magmas, mafics, and Fe-oxide alteration).
Tectonic / thermal ingredients

1. **PLUMBING+SOURCE** - Palaeoprot orogenic belt(s) at margin of Archaean, + metased basins, + NW/NE faults

2. **TIMING** – broadly coeval with Hiltaba-GRV

3. **HEAT** – manifest in 1575-1595 Ma mafic & high-temp granitoid complexes & volcs

Major IOCGs in overlaps
4. Fluid/metal/sulfur ‘sources’ - Palaeoprot meta-sedimentary basins (with ex-evaporites?), Fe-rich but not too reduced (e.g., Wallaroo Gp; Willyama SG equivalents?)

5. Metal/sulfur ‘sources’ - IOCG districts have 1575-1595 Ma mafic intrusions, ± felsic/ mafic volcanic centres

6. Favourable ‘trap’ rocks - not critical except for U-rich IOCGs (A-type granitic host may be essential)
Lithological / stratigraphic ingredients

- Prominent Hill
- Olympic Dam
- Acropolis
- Wirrda Well
- Emmie Bluff
- Carrapateena
- Wallaroo

- Hiltaba Suite granitoid (1595-1570 Ma)
- Mafic intrusions
- Gawler Range Volcanics
- Mafic Gawler Range Volcanics
- Wallaroo Gp - metasedimentary & metavolcanic rocks
- Intrusive rocks, mainly felsic; mafic
- Hutchison Gp & equivalents; BIF
- Undifferentiated Archaean to Palaeoproterozoic rocks
- IOCG(U) deposit or prospect

(from Skirrow, Bastrakov, Raymond et al., 2002)
7. **Crust-scale fluid pathways** - e.g. terrane boundaries, upper-crustal major fault complexes active at 1575-1595 Ma (extension and/or compression?)

8. **District-scale fluid pathways** - NW-trending regional and district transpressive (?) fault/shear zones, AND district-to-deposit-scale NE-trending ?conjugate faults/shears (OD region at least)

9. **Local fluid pathways** - localised extension(?) (e.g. dilatent jogs) during IOCG mineralisation; *breccias* are a product of the structural-magmatic-hydrothermal settings
Crust- to deposit-scale fault/shear zones

Edges or ‘worms’

Conjugate NW & NE worm=fault? network

Regional- to deposit-scale structure

Olympic Dam Breccia Complex & diatremes

WNW dextral shear

Edge azimuth histogram

NNE fault
10. **Regional alteration** - magnetite - calsilicate (amphibole, cpx) - Kfeldspar/ albite and/ or magnetite - biotite alteration ± minor Cu-Au-LREE (high-T hypersaline fluids did this!)

11. **District to local alteration** - high-level Cu-Au (-U) has hematite-sericite-chlorite-carbonate; deeper Cloncurry style IOCGs may resemble regional alt’n

12. **Geochemistry** - Cu, Au, Ag, U, LREE, Ba, F, P, Co; high epsilon-Nd and low delta-34-S values are good

13. **Zoning** - laterally or vertically from LREE to Au to Cu-Au within hematitic breccias; if magnetite present, tends to be deeper and with chalcopyrite-pyrite; phengite a vector(?)
Regional-, district- and deposit-scale alteration mapped undercover using inversion of potential field data

Basement geology

Anomalous magnetite (> ~2% vol.)

Anomalous hematite (> ~2%)

search contacts & edges of ‘hematite’ zones

Archaean metaseds

gabbro (~1760 Ma)

granite (~1590 Ma)

Olympic Dam

dacite

basalt

granite (~1850 Ma)

metaseds

mgt

hm

Olympic Dam

20 km

IOCG Workshop, Feb06

Geoscience Australia
A model for the Olympic Dam region

1575-1595 Ma: granite, unroofing, volcanics, Cu-U-Au where coincidence of ingredients

Modified from Skirrow et al. (submitted)
Post-1575-1595 Ma (pre-Adelaidean): erosion, Pandurra Fm

14. Near-surface Olympic Dam style IOCGs require **little or no exhumation** to preserve this environment
   - Compression / extension ‘switched off’ at ~1575 Ma
   - Deeper Ernest Henry style requires exhumation to be detectable by ‘shallow’ exploration methods
Part 2

Map of IOCG Potential of the Gawler Craton
(preliminary edition)
Greyscale background: “1.5vd” magnetics (TMI + 1st vertical derivative)

Key metased units

Hiltaba-GRV classification (Budd, 2006)

Faults active at 1575-1595 Ma

Anomalous Cu (>200ppm) from drillholes & surface

IOCG alteration assemblages from drill hole logging

IOCG alteration zones from geophysical interp/modelling

Geochronology & Sm-Nd
• Areas ranked by potential, based on presence of ‘essential ingredients’

• Specific IOCG deposit targets not identified – use district-to-deposit-scale targeting criteria

1 – high potential
2
3
4 - moderate
Thanks to:

Geoscience Australia: Evgeniy Bastrakov, Anthony Budd, Nick Direen, Barry Drummond, Geoff Fraser, Bruce Goleby, Lindsay Hight, Dean Hoatson, Oliver Holm, Russell Korsch, Leonie Jones, Patrick Lyons, Peter Milligan, Malcolm Nicoll, Matti Peljo, Ollie Raymond, Peter Southgate, Matilda Thomas, Nick Williams, Lisa Worrall

Primary Industries & Resources South Australia, GSB: Colin Conor, Sue Daly, Marc Davies, Martin Fairclough, Garry Ferris, Caroline Grant, Paul Heithersay, John Keeling, Brian Logan, Alan Mauger, Mark McGeough, Wolfgang Preiss, Andrew Shearer, Michael Schwarz, Wen-long Zang

The University of Adelaide: Karin Barovich, Nick Direen, Graham Heinson, Martin Hand

University of Tasmania, CODES: Garry Davidson

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<thead>
<tr>
<th>ESSENTIAL INGREDIENT</th>
<th>MAPPING TOOLS/METHODS</th>
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<tbody>
<tr>
<td>*High palaeogeothermal gradients at time of IOCGs</td>
<td>Metamorphic petrology &amp; geochron; granite geochem as a guide to PT; broadband seismic &amp; MT as a guide to lithospheric structure?</td>
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<tr>
<td>*High-temperature K-rich A-type to I-type granites; 2.50-2.60 Ga, 1.5-1.6 Ga, 0.1 Ga may be favourable periods</td>
<td>Field mapping / hole logging; granite geochem; geochron; radiometrics to map high K-contents of A-types</td>
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<tr>
<td>*Mafic/ultramafic intrusive rocks (K-rich?), coeval with granitoids</td>
<td>Field mapping / hole logging; geochem; geochron; seismic reflection and refraction data</td>
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<tr>
<td>Pre-IOCG orogenic belts at margins of older cratons; *crustal domain boundaries</td>
<td>Synthesis of geophysical (incl. seismic, MT), geological, geochemical/isotopic (incl. Sm-Nd), geochron data; Moho depth; Skippy datasets</td>
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<tr>
<td>Networks of crustal-scale faults/shears</td>
<td>Field mapping; conventional interp and worming and inversion of potential field data; seismic reflection data</td>
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<tr>
<td>Metasedimentary-metavolcanic basin sequences older than syn-IOCG magmatism; not too reduced, with meta-evaporites?</td>
<td>Field mapping / hole logging; sequence strat; aeromags may detect redox gradients</td>
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<td>*Regional-scale (1-10km) Na (± Ca ± Fe) alteration (albite, actinolite, ± magnetite)</td>
<td>Field mapping; geochem; geochron; magnetics &amp; gravity (e.g. inversions); radiometrics (e.g., low K/Th ratios); hyperspectral mapping?</td>
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<td>*Regional- to local-scale K-Fe ± carbonate alteration and Cu-Au mineralisation (biotite, K-feldspar, ± magnetite, Cu-Fe sulfides)</td>
<td>Field mapping / hole logging; geochem; geochron; magnetics &amp; gravity (e.g. inversions); radiometrics (e.g., high K/Th); hyperspectral mapping?</td>
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<td>*Local-scale hematitic alteration &amp; Cu-Au±U mineralisation (hematite, sericite, chlorite, carbonate)</td>
<td>Field mapping / hole logging; geochem; geochron; magnetics &amp; gravity (e.g. inversions); radiometrics (e.g., high U; high K/Th); hyperspectral mapping?</td>
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<td>Hypersaline high-temp brines (associated with magnetite alteration) + lower salinity lower temp brines ± CO₂</td>
<td>Fluid inclusion studies incl. microanalysis to detect Cu-bearing fluids</td>
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<tr>
<td>Fe, Cu, Au, U, LREE, Ag, Ba, F, CO₃, P, Co, Mo</td>
<td>Geochemistry (e.g., compilations of exploration drillhole data), basic mineralogy</td>
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<td>Brittle-ductile shear zones with jogs (EH style) with syn-IOCG timing</td>
<td>Field mapping; interp &amp; worming of potential-field data; geochron of minerals in shear fabrics</td>
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<td>Brittle deformation structures (OD style) with syn-IOCG timing</td>
<td>Field mapping; interp &amp; worming of potential-field data; geochron of minerals in structures</td>
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<td>Volcanic maar/diatreme settings (OD style)</td>
<td>Field mapping / hole logging; interp &amp; worming of potential-field data</td>
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<td>*Preservation of near-palaeosurface setting (OD style)</td>
<td>Field mapping/ hole logging to detect presence of volcanics, epizonal alteration mineralogy, palaeo-weathering zones, etc</td>
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<td>Exhumation of mesothermal environment (EH style)</td>
<td>Field mapping/ hole logging to identify metamorphic assemblages &amp; PT conditions; Ar-Ar dating for thermal history &amp; exhumation</td>
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