Control on Skarn Mineralisation and Alteration at the Cadia Deposits, New South Wales, Australia.

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The Cadia skarns in eastern New South Wales, Australia, are associated with the Late Ordovician, shoshonitic Cadia Intrusive Complex (CIC). The Cadia porphyry gold-copper district is the largest mineralized, intrusive-related system in eastern Australia. Both the Big and Little Cadia skarns are Fe-rich and host Cu-Au mineralisation within a ~40m thick volcaniclastic sandstone and adjacent, predominantly calcareous units. These lithologies represent the most important control on skarn formation. The ore horizon has undergone post-ore displacement along steeply-dipping, predominantly reverse faults, without significant re-mobilisation of ore. Cu-Au mineralisation occurs as chalcopyrite and minor native gold formed in intimate association with epidote-chlorite-quartz-calcite and within interstices of bladed hematite and magnetite. Gold-copper ratios within the skarns are generally lower than for porphyry gold-copper deposits at Cadia, particularly the high tonnage, low-grade Cadia Hill deposit. Ore and calc-silicate gangue mineralogy, including garnet and pyroxene compositions and ratios, are consistent with oxidized, Au-Fe-bearing Cu skarns, commonly associated with porphyry deposits (Fig. 1).

At Big Cadia, mineralisation occurs several hundred meters north of the mineralizing CIC. Magmatic-dominated fluids from the CIC drove progressive consumption of carbonate, and produced classic skarn zonation over a 800m interval from Cadia Quarry to Big Cadia consisting of: i) proximal garnet>>pyroxene; ii) intermediate garnet>pyroxene+scapolite; and iii) distal Fe-oxide skarn with Cu-Au mineralisation (Figs. 2a to d). Alteration of non-calcareous units adjacent to the CIC includes, and magnetite-quartz-biotite hornfels and lesser hydrothermal biotite-K-feldspar-quartz. Sulphide and native gold mineralisation occur adjacent to garnet-bearing veins, peripheral to the main garnet-rich zone, and suggest that garnet-forming fluids carried ore metals in solution.

At Little Cadia and Cadia East, skarn zonation consisting of proximal calc-silicate skarn and distal mineralisation, is approximately similar to Big Cadia and occurs within the same volcaniclastic unit. The zonation is however developed symmetrically north and south about a mineralized quartz-monzonite porphyry (QMP) CIC-related intrusion at depth (Cadia Far East) (Figs. 3). Potassic (K-feldspar-biotite-magnetite) alteration is also developed within a narrow vertical zone above the intrusion. Where this zone intersects calcareous units, there is close association between potassic-alteration and veins and prograde garnet-bearing skarn. Hydrous retrogression (chlorite-calcite-epidote) has altered much of the prograde garnet-dominant mineralogy at Cadia, with overprinting strongest at Little Cadia.

The styles and distribution of alteration and mineralisation suggest that fluids migrating laterally within calcareous units, from strongly altered QMP phases of the CIC at Cadia Quarry, formed the Big Cadia skarn (Fig. 4a). Skarn formation at Little Cadia was probably related to CIC-derived fluids migrating vertically and laterally within permeable calcareous units (Fig. 4b). Structural controls may also have been significant in focusing fluids and the emplacement of late, mineralizing (QMP) phases of the CIC. Potential for additional skarn mineralisation exists in the region, including either reduced Au-skarn types, and/or Cu-Au skarns associated with porphyry deposits.
TABLE 1. Summary geological and resource data for the Cadia deposits

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Host rock</th>
<th>Deposit style</th>
<th>Alteration</th>
<th>Copper (%)</th>
<th>Gold (g/t)</th>
<th>Contained gold (t)</th>
<th>Size (Mt)</th>
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</thead>
<tbody>
<tr>
<td>Cadia Hill</td>
<td>Quartz monzonite porphyry</td>
<td>Sheeted veins</td>
<td>Propylitic, phyllic</td>
<td>0.18</td>
<td>0.60</td>
<td>221.3</td>
<td>352</td>
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<td>Ridgeway</td>
<td>Monzonite, quartz monzonite, volcanics</td>
<td>Quartz-sulfide stockwork</td>
<td>0.77</td>
<td>2.5</td>
<td>13.6</td>
<td>54</td>
<td></td>
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<tr>
<td>Cadia Quarry</td>
<td>Quartz monzonite porphyry, volcanics</td>
<td>Quartz-sulfide stockwork</td>
<td>Potassic, phyllic</td>
<td>0.21</td>
<td>0.40</td>
<td>16.0</td>
<td>40</td>
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<tr>
<td>Cadia East</td>
<td>Quartz monzonite porphyry</td>
<td>Wallrock-hosted vein system</td>
<td>Potassic, propylitic</td>
<td>0.37</td>
<td>0.43</td>
<td>94.6</td>
<td>220</td>
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<tr>
<td>Cadia Far East</td>
<td>Quartz monzonite porphyry</td>
<td>Wallrock-hosted vein system</td>
<td>Potassic, propylitic</td>
<td>0.48</td>
<td>1.7</td>
<td>107.1</td>
<td>63</td>
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<td>Big Cadia skarn</td>
<td>Volcaniclastic sandstone</td>
<td>Stratabound replacement</td>
<td>Propylitic</td>
<td>0.50</td>
<td>0.40</td>
<td>12.0</td>
<td>30</td>
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<tr>
<td>Little Cadia skarn</td>
<td>Volcaniclastic sandstone</td>
<td>Stratabound replacement</td>
<td>Propylitic</td>
<td>0.40</td>
<td>0.30</td>
<td>2.4</td>
<td>8</td>
</tr>
</tbody>
</table>

Resource data: *Holiday et al. (2002); †Tedder et al. (2001)

Key
- Big Cadia garnet n=7
- Little Cadia garnet n=2
- S of Big Cadia garnet & Weermala n=5
- Cadia Quarry garnet n=175
- NC-482 (Cadia East) n=20
- Pyroxene - Cadia Quarry n=12
- Pyroxene - Weermala sediments n=3

Figure 1

Lithology
- Silurian
  - Sandstone, siltstone
  - Limestone & conglomerate
- Ordovician
  - Pegmatitic monzonite breccia
  - Quartz monzonite
- Diorite & monzodiorite
- Levan & tuffs
- Calcareous sandstones & minor conglomerates
- Conglomerate & volcanic breccia
- Limestone

- Fine-grained phyllic volcanic rocks, & feldspar & pyroxene intrusions
- Dextral fault
- Diamond drill hole
- ASL. Meters above sea level
- Section 5W of Cadia Mine Lease (C.M.L.) North

Figure 2a
Figure 2b

Legend - Alteration
- Silurian cover - unaltered
- Ordovician
  - >0.2 ppm Au & 0.2% Cu
  - Quartz vein zone
  - Intense quartz vein zone
  - Volcanic rocks, propylitic

- Hematite-magnetite skarn
- Skarned limestone
- Epidote-dominant
- Epidote-chlorite after garnet
- Garnet - pyroxene
- Garnet zone
- Carbonate breccia zone
- Volcanics, magnetite-quartz+biotite
- Quartz monzonite, potassic
- Quartz monzonite, phyllic
- Quartz monzonite, mainly propylitic
- Diopside & monzodiorite, propylitic

Figure 2c

Lithology
- Silurian
  - Sandstone, siltstone, limestone & conglomerate
- Ordovician
  - Aplitic dyke

- Pegmatitic monzonite breccia
- Quartz monzonite
- Lava & tuffs
- Calcareous sandstones & minor conglomerates
- Conglomerate & volcanic breccia
- Limestone
- Fine-grained phyllic volcanic rocks, & feldspar & pyroxene phyllic intrusions
- Dextral fault
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Figure 2d

Interpretive cross section - Alteration Cadia East - Little Cadia 15600 +/- 100m

Figure 3
Figure 4 a and b.