CHARACTERISTICS OF PORPHYRY Au-Cu SYSTEMS IN THE ORDOVICIAN MACQUARIE ARC OF NSW

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Abstract
The early Ordovician to early Silurian Macquarie arc of the Lachlan Orogen in NSW is Australia’s only economic porphyry Cu-Au province. The province is currently host to six active mines with a further two deposits in feasibility stages. An additional seventeen significant porphyry systems exist within the Macquarie arc making a total of twenty five porphyry systems (Smith et al., 2003). In addition a further ten significant Cu and/or Au systems that may be porphyry-related in the broader sense exist (Table 1; Figure 1). Numerous other minor occurrences with porphyry or porphyry-related characteristics occur throughout the arc.

The deposits are not uniformly distributed throughout the volcanic belts and extreme clustering is evident at all scales. The location of the known systems is heavily skewed toward four productive districts. These districts occupy approximately 11% of the explored volcanic belts but contain 92% of the known systems. Two of the districts contain all of the known economic and feasibility stage systems. These districts can be distinguished to a certain extent from much of the remaining Macquarie arc, but no single or combination of features can definitively distinguish them.

The productive Porphyry Districts share many features (in addition to their mineral endowment) that distinguish them from much of the Macquarie arc. Importantly however these features do not uniquely define the productive districts because other areas have been identified that share some of the features but are not yet known to be productive.

One of the most critical and striking aspects of the districts is the abundance of intrusive rocks compared to the Macquarie arc outside the productive districts. The Cadia-Forest Reefs District as we define it has an area of 430 km² and within this mapped intrusive rocks occupy 51 km². Therefore approximately 12% of the total area of the Cadia Forest Reefs District is represented by intrusive rocks compared to 3.5% in the Molong Volcanic Belt as a whole.

The Ordovician volcanic belts display compositions ranging from ultramafic to felsic; however the dominant compositions are within the basalt to andesite range (Wyborn, 1992; Wyborn, 1997). Within the Porphyry Districts, compositions are relatively more felsic with a greater representation of andesitic and trachytic rocks.

The association between potassic magmas and mineralization in the Macquarie arc has been discussed by numerous workers (eg Muller et al., 1994; Holliday et al., 2002; Blevin, 2002). Blevin (2002) has highlighted that intrusives of the Goonumbla and Cadia Districts are more K-enriched than the intrusives of the Copper Hill area and supported an association between K-enrichment and mineralisation potential.

The variable K-enrichment is reflected in modal quartz contents with the less K-enriched rocks containing quartz at much lower SiO2 values than the more K-enriched magma suites (Blevin, 2002). Both of the isolated porphyry systems (Cargo and Copper Hill) are characterized by quartz-rich suites (Torrey & White, 1998, Blevin, 2002).

Insufficient published data exists to evaluate the K-enrichment of the other districts and the Macquarie arc as a whole; however it is likely that the intrusive chemistry and degree of enrichment could prove to be one of the most reliable discriminators of productive districts. Another feature of the intrusive rocks that helps distinguish the Porphyry Districts is their distinct
pink to brick red color due to fine hematite dusting. Although rocks of this color occur outside the productive districts, pink to red rocks are overrepresented in the districts.

The JNVB and MVB are highly magnetic and are easily identified on regional aeromagnetic data. However the character of the belts is not uniform and a number of complexes within the belts display anomalous character. All of the Porphyry Districts have the anomalous character; however several anomalous complexes exist that, to date, have not proven to be productive.

The anomalous complexes are characterized by highly complex magnetic signatures ranging from intense highs to deep lows and distinctly curvilinear to blocky patterns. We interpret these signatures to reflect a higher abundance of variably magnetic intrusive rocks and a greater degree of magnetite destructive and magnetite constructive alteration. In those parts of the arc outside the complexes the patterns are dominated by stratigraphic variations in magnetic character.

Gravity data helps to distinguish the Goonumbla and Lake Cowal Districts. Both occur within the major regional gravity high that underlies the JNVB but correspond in part with ovoid gravity lows apparent in published gravity data (Heithersay & Walshe, 1995). Modeling of the Goonumbla gravity data has been interpreted to indicate the presence of a zoned felsic intrusive complex at depth that was the source of the mineralizing porphyries (Clarke & Schmidt, 2001).

Large scale NW-trending cross-structures have been inferred to play a part in localizing K-enriched magmas and mineralization in the Lachlan Orogen (Glen & Walshe, 1999; Glen & Wyborn, 1997; Glen et al., 1998). The most commonly cited one (the Lachlan Transverse Zone) contains the Goonumbla and Cadia-Forest Reefs Districts. Definition of these structural zones is severely hampered by the effects of major post-Ordovician structural events and their applicability to exploration is limited.

The Macquarie arc porphyry Au-Cu systems represent a substantial exploration challenge in an area of increasing exploration maturity. Detailed exploration models that integrate the range of features of the significant systems will increase the probability of success.
Figure 1. Location of Macquarie arc porphyry and porphyry-related systems.
### Table 1. Macquarie arc porphyry and porphyry-related systems

<table>
<thead>
<tr>
<th>System</th>
<th>District</th>
<th>Style</th>
<th>Position of Magnetite</th>
<th>Status</th>
<th>Resources (Total Measured, Indicated and Inferred Reserves and Reserves) or Intersections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mt</td>
</tr>
<tr>
<td>E26</td>
<td>Northparkes</td>
<td>Porphyry Cu-Au</td>
<td>Peripheral magnetite-bearing zone, overprinted</td>
<td>Mine</td>
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<tr>
<td>E22</td>
<td>Northparkes</td>
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<td>Peripheral magnetite-bearing zone, overprinted</td>
<td>Mine</td>
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<td>Peripheral magnetite-bearing zone, overprinted</td>
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<td>Peripheral magnetite-bearing zone, overprinted</td>
<td>Mine</td>
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<td>Unknown</td>
<td>Inactive Prospect</td>
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<td>Inactive Prospect</td>
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<td>Inactive Prospect</td>
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<td>Magnetite Skarn</td>
<td>Unknown</td>
<td>Inactive Prospect</td>
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<td>Cadia Hill</td>
<td>Cadia-Forest Reefs</td>
<td>Porphyry Cu-Au</td>
<td>Widespread and unrelated to ore forming stage</td>
<td>Mine</td>
<td></td>
</tr>
<tr>
<td>Cadia Ridgeway</td>
<td>Cadia-Forest Reefs</td>
<td>Porphyry Cu-Au</td>
<td>Central and widespread peripheral</td>
<td>Mine</td>
<td></td>
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<tr>
<td>Cadia East</td>
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<td>Porphyry Cu-Au</td>
<td>Inactive Prospect</td>
<td></td>
<td></td>
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<td>Cadia Far East</td>
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<td>Porphyry Cu-Au</td>
<td>Related to early weakly mineralised veins</td>
<td>Feasibility</td>
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<td>Cadia Quarry</td>
<td>Cadia-Forest Reefs</td>
<td>Porphyry Cu-Au</td>
<td>Widespread and unrelated to ore forming stage</td>
<td>Active Prospect</td>
<td></td>
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<tr>
<td>Gooleys</td>
<td>Cadia-Forest Reefs</td>
<td>Porphyry Cu-Au</td>
<td>Widespread and unrelated to ore forming stage</td>
<td>Active Prospect</td>
<td></td>
</tr>
</tbody>
</table>
Big Cadia | Cadia-Forest Reefs | Magnetite Skarn | Central | Former mine
---|---|---|---|---
Little Cadia | Cadia-Forest Reefs | Magnetite Skarn | Central | Inactive Prospect
Junction Reefs | Cadia-Forest Reefs | Pyrrhotite Skarn | Former Mine | 247,500 ounces produced

| E43 | Lake Cowal | Porphyry Cu-Au | Central and peripheral magnetite-bearing zone | Inactive Prospect | 490 m @ 0.19% Cu
| Marsden | Lake Cowal | Porphyry Cu-Au | Inactive Prospect | 123 m @ 0.63 g/t Au, 0.7% Cu
| E42 | Lake Cowal | Carbonate -BM Au | 69.9 | 1.5
| E41 | Lake Cowal | Carbonate -BM Au |  |  |
| E46 | Lake Cowal | Carbonate -BM Au |  |  |

Mandama | Rain Hill | Porphyry Cu-Au | Central magnetite-bearing zone | Inactive Prospect | 206 m @ 0.51 g/t Au, 0.37% Cu
Cullingarai | Rain Hill | Porphyry Cu-Au | Central magnetite-bearing zone | Inactive Prospect | 50 m @ 0.76 g/t Au, 0.53% Cu
The Dam | Rain Hill | Porphyry Cu-Au | Completely overprinted | Inactive Prospect | 167 m @ 1.0 g/t Au, 0.7% Cu
Gidginbung | Rain Hill | High-S epithermal | Former Mine | 8.7 | 2.4
Copper Hill | Porphyry Cu-Au | Active Prospect | 6.6 | 0.8 | 0.8
Cargo | Cargo | Porphyry Cu-Au | Peripheral magnetite-bearing zone | Active Prospect | 108 m @ 0.22 g/t Au, 0.52% Cu
Cargo Area Au Systems (eg Spur Dalcoath) | Cargo | Quartz sulphide Au | Inactive Prospect | 3.7 | 1.24
Peak Hill | High-S epithermal | Former Mine |  |  |

References


Kolkert, R., 1998, Carbonate-base metal veins peripheral to the Northparkes Cu-Au deposits - vectors to mineralised centres?: Unpublished BSc Honours thesis, Hobart, Tasmania, University of Tasmania, 144 p


