

Controls 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 volcanoclastic 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 remobilisation 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 volcanoclastic 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

Deposit	Host rock	Deposit style	Alteration	Copper (%)	Gold (g/t)	Contained gold (t)	Size (Mt)
Cadia Hill ^a	Quartz monzonite porphyry	Sheeted veins	Propylitic, phyllic	0.16	0.63	221.3	352
Ridgeway ^a	Monzonite, quartz monzonite, volcanics	Quartz-sulfide stockwork		0.77	2.5	132.6	54
Cadia Quarry ^a	Quartz monzonite porphyry, volcanics	Quartz-sulfide stockwork	Potassic, phyllic	0.21	0.40	16.0	40
Cadia East ^a	Quartz monzonite porphyry	Wallrock-hosted vein system	Potassic, phyllic propylitic	0.37	0.43	94.6	220
Cadia Far East ^{a, b}	Quartz monzonite porphyry	Wallrock-hosted vein system	Potassic, phyllic propylitic	0.48	1.7	107.1	63
Big Cadia skarn ^a	Volcaniclastic sandstone	Stratabound replacement	Propylitic	0.50	0.40	12.0	30
Little Cadia skarn ^a	Volcaniclastic sandstone	Stratabound replacement	Propylitic	0.40	0.30	2.4	8

Resource data: ^aHolliday et al. (2002); ^bTedder et al. (2001)

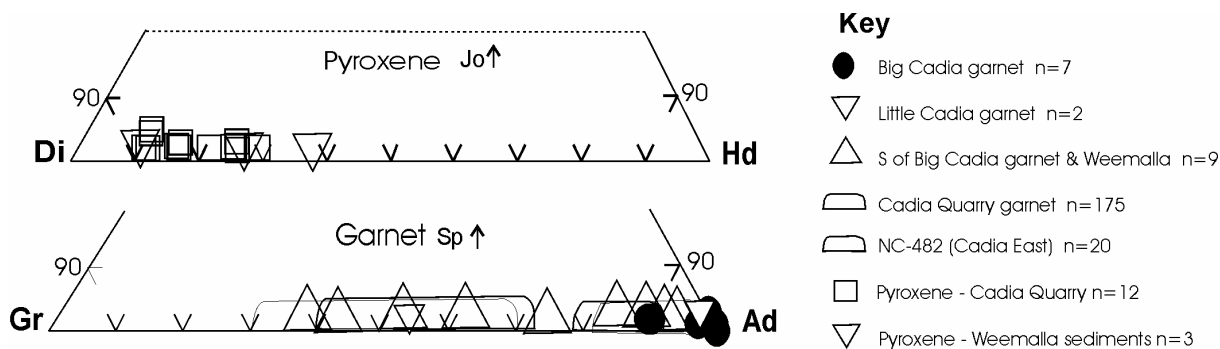


Figure 1.

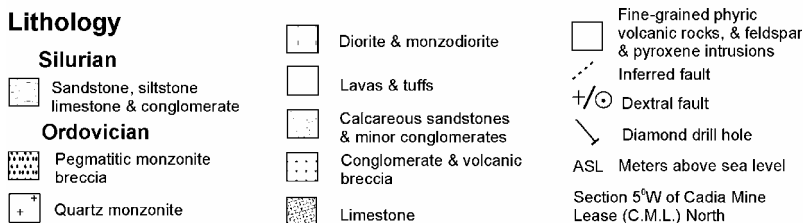
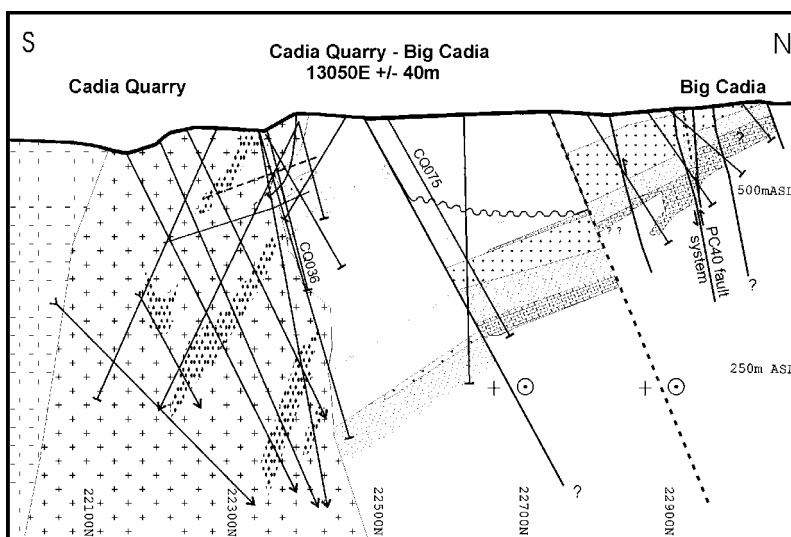
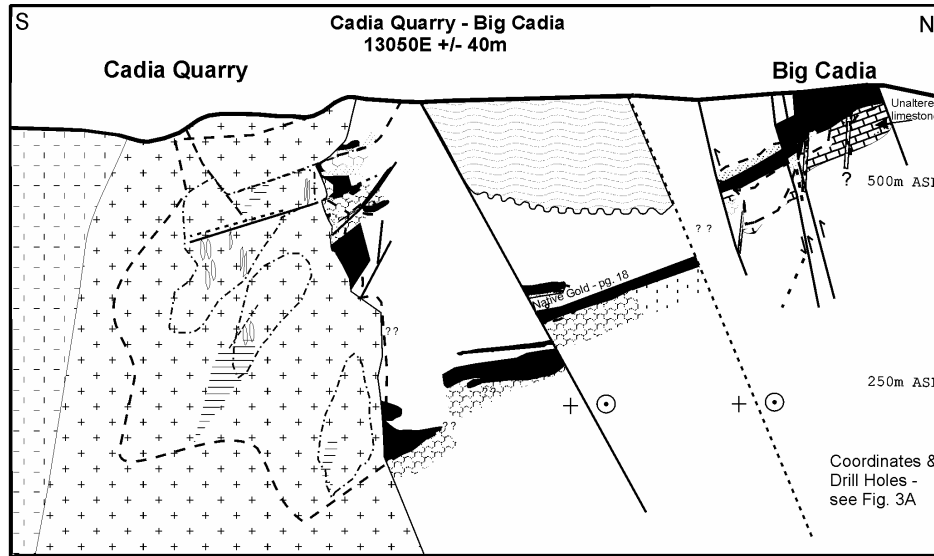


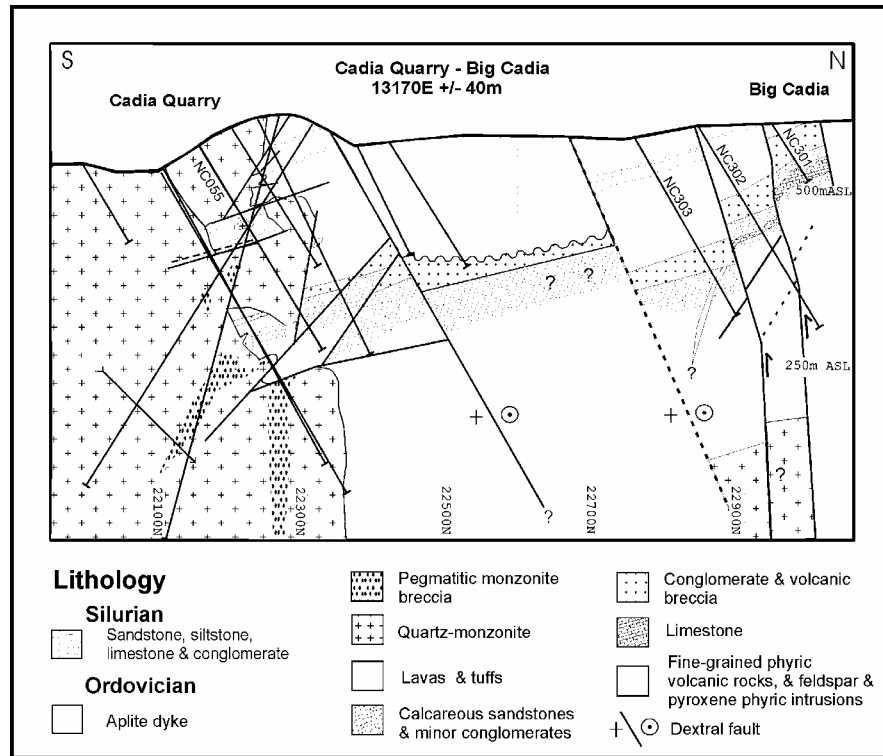
Figure 2a



Legend - Alteration

- | | | |
|-------------------------------------|-------------------------------|---|
| Silurian cover - unaltered | Hematite-magnetite skarn | Carbonate breccia zone |
| Ordovician
>0.2 ppm Au & 0.2% Cu | Skarned limestone | Volcanics, magnetite-quartz +/- biotite |
| Quartz vein zone | Epidote-dominant | Quartz monzonite, potassic |
| Intense quartz vein zone | Epidote-chlorite after garnet | Quartz monzonite, phyllic |
| Volcanic rocks, propylitic | Garnet - pyroxene | Quartz monzonite, mainly propylitic |
| | Garnet zone | Diorite & monzodiorite, propylitic |

Figure 2b



Lithology

- | | | |
|--|---|---|
| Silurian
Sandstone, siltstone, limestone & conglomerate | Pegmatitic monzonite breccia | Conglomerate & volcanic breccia |
| Ordovician
Aplite dyke | Quartz-monzonite | Limestone |
| | Lavas & tuffs | Fine-grained phytic volcanic rocks, & feldspar & pyroxene phytic intrusions |
| | Calcareous sandstones & minor conglomerates | Dextral fault |

Figure 2c

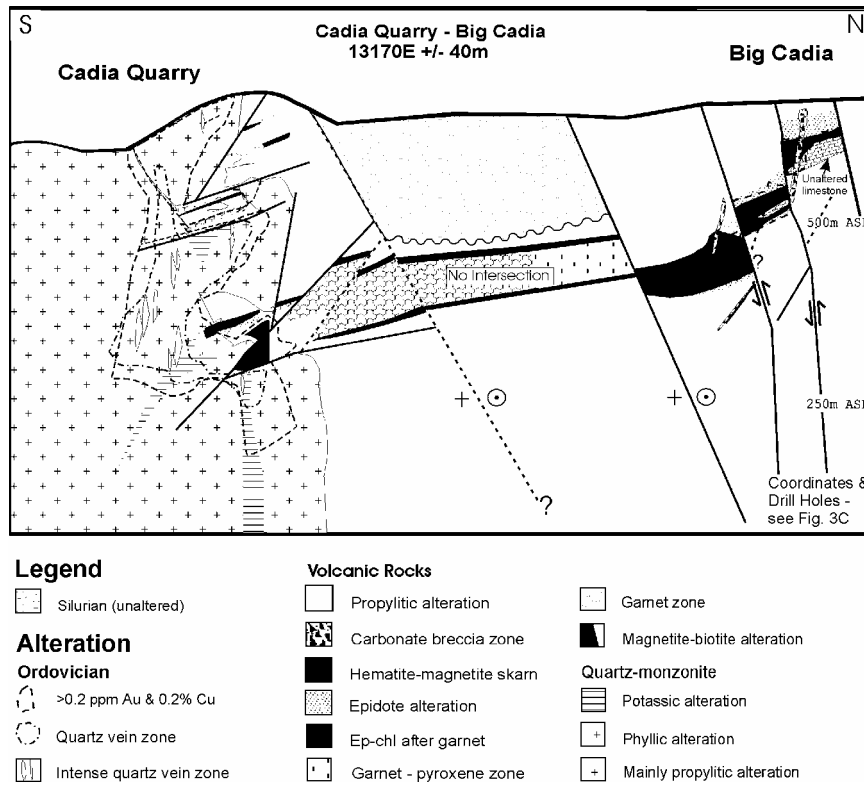


Figure 2d

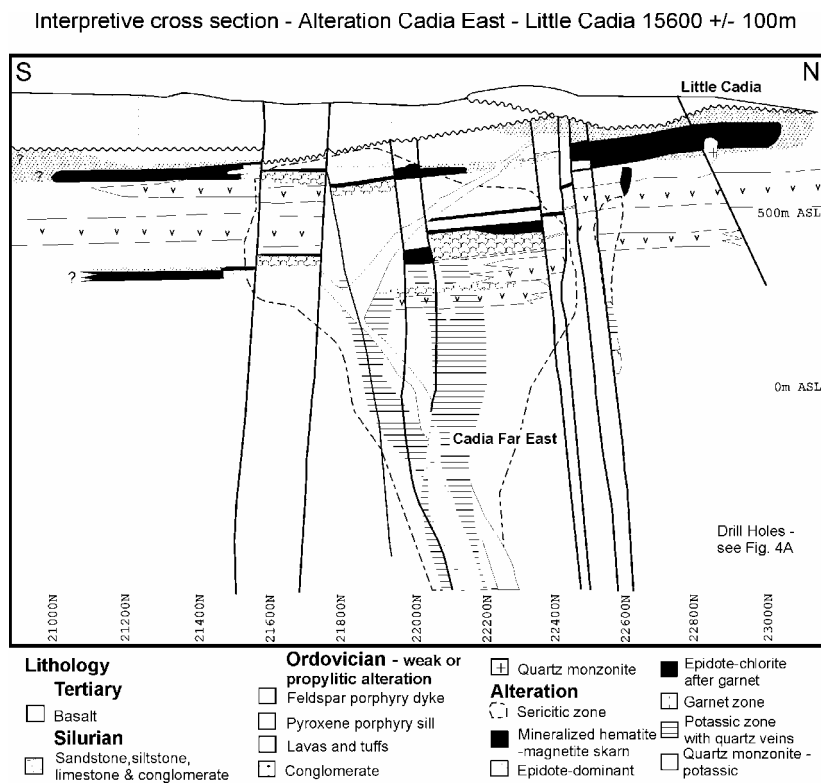


Figure 3

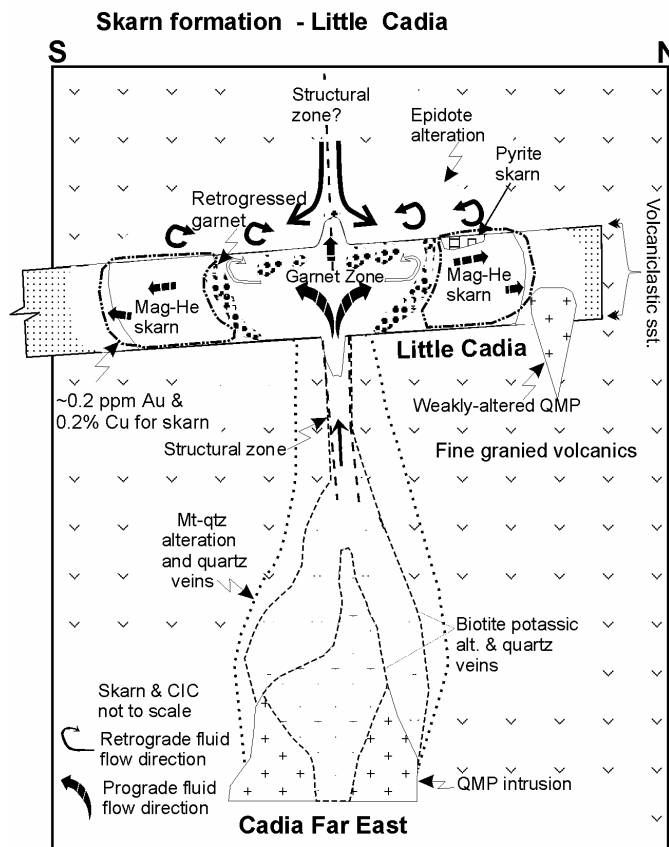
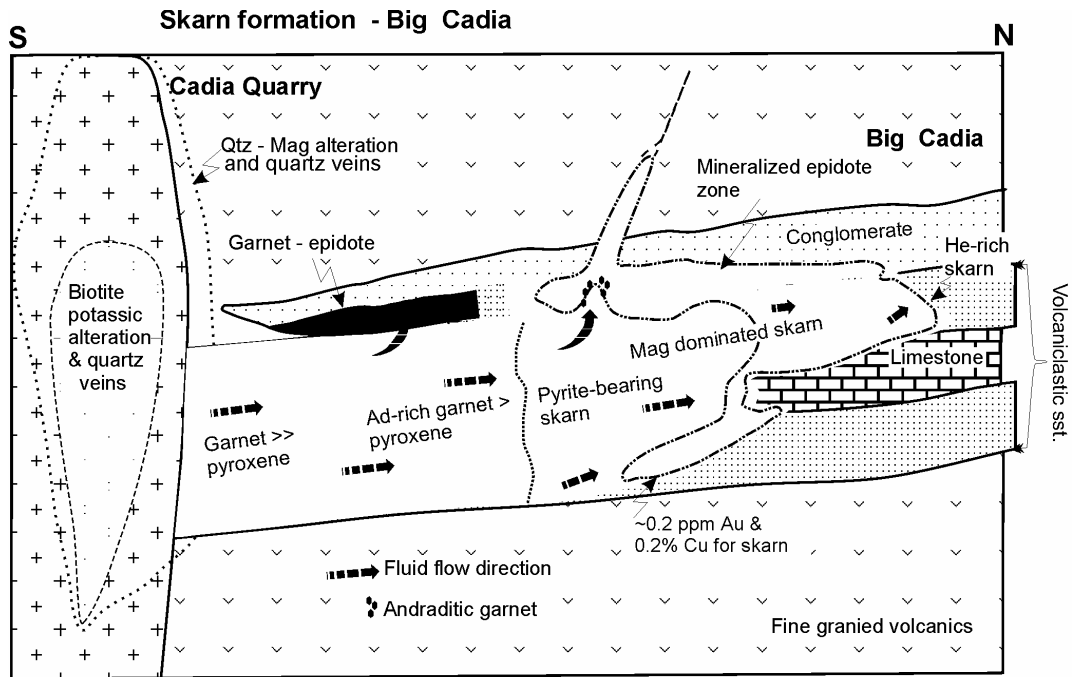


Figure 4 a and b.