DOGWOOD PORPHYRY Cu-Mo PROSPECT, BENAMBRA TERRANE, VICTORIA

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LOCATION

The Dogwood Prospect is 12 km SW of Buchan, Victoria, at 37°34'25", 148°00'31"; Bairnsdale 1:250 000 map sheet SJ55-07.

DISCOVERY HISTORY

Australian Anglo American Prospecting Pty Ltd (AAAP) discovered low-grade porphyry Cu-Mo mineralization at Dogwood during 1978-83 while following up Cu anomalies in drainage sediment and soil samples (Orr, 1980). Supergene chalcocite overlying the mineralization was delineated by RC and diamond drilling by CRA Exploration Pty. Limited (CRAE) during 1988-94 (Maher, 1994). Recognition of supergene Cu mineralization in the Benambra Terrane, although in this instance uneconomic, highlights the potential of numerous other porphyry Cu ± Mo ± Au prospects in the region and the importance of immobile pathfinder elements, like Mo, that can provide a vector to undiscovered acid-weathered porphyry Cu deposits.

PHYSICAL FEATURES AND ENVIRONMENT

The prospect lies on the southern margin of the Eastern Highlands, N of the Gippsland coastal plains at between 240-440 m AHD. Relief is mostly less than 100 m, but resistant contact-metamorphosed Pinnak Sandstone, surrounding the Kaerwut Granodiorite, forms prominent ridges up to 180 m. The climate is humid with annual rainfall around 700 mm. Mean maximum and minimum monthly temperatures are 25°C and 12°C for January and 14°C and 3°C for July (Bureau of Meteorology, 2003).

GEOLOGICAL SETTING

The prospect lies within the Benambra Terrane of the Lachlan Fold Belt; close to the Cassilis, Ensay, and Haunted Stream faults. The prospect occurs within the multiphase Kaerwut Granodiorite (Klicker, 1984), one of a suite of granodiorite-tonalite stocks of probable Early Devonian age that include the Bete Bolong Suite. These flank the southern half of the Buchan Rift and, with Ordovician Pinnak Sandstone country rocks, host subeconomic porphyry Cu-Mo mineralization (Figure 1). VandenBerg *et al*. (2000) considered that this mafic, oxidized, high-level magmatism was linked to rifting and was similar to the Climax-type Mo intrusions that formed from lithospheric and lower crustal melts broadly coeval with strong rift-related extensional faulting. Extension and rifting are thought to have occurred in response to strike-slip faulting along the Ensay, Cassilis and Haunted Stream dextral faults.

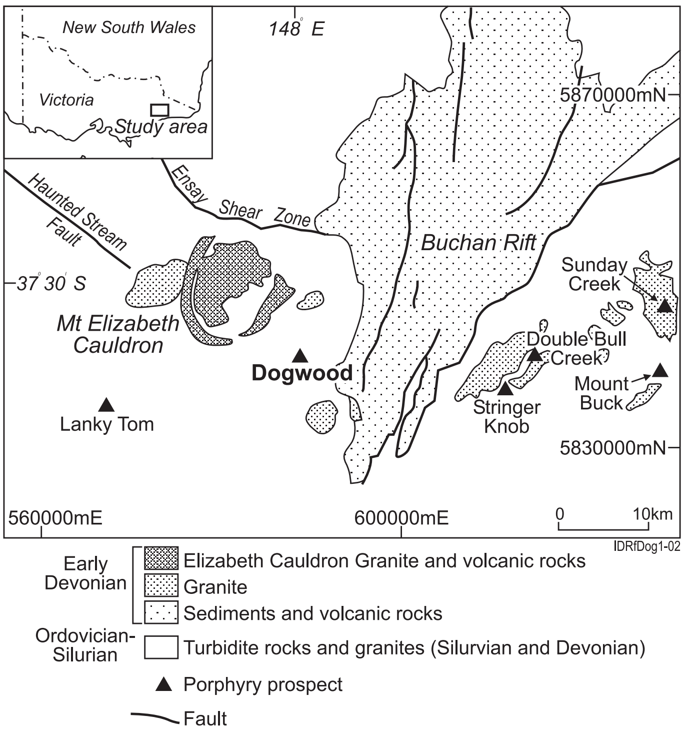

Figure 1. Simplified Early Devonian regional geology around the Buchan Rift with porphyry copper prospects (after Rajagopalan, 1999).

REGOLITH

Weathering and tectonic history

The weathering of rocks of the Dogwood prospect is linked to the tectonic evolution of SE Australia. Weathering, initiated by the Middle Devonian Tabberabberan Orogeny, continued into the Late Mesozoic, by which time it had produced a deeply weathered land surface of low relief. Break up of Gondwanaland in the mid-Cretaceous resulted in major subsidence in the Gippsland Basin, combined with major uplift of a broad belt to the N of the coastal plain. Uplift began a continuing cycle of incision and lateral erosion. The Dogwood prospect lies between the subsided and uplifted landscapes; its mid-Palaeozoic to Late Mesozoic regolith is partially preserved in resistant rocks. Three main regolith units have been recognized and their distribution is shown in Figure 2A.

Miocene-Pliocene fluvial sand and gravel

Remnants of a Miocene-Pliocene fluvial sand and gravel sheet occur in the northern part of the prospect. The sheet has a flat top at around 200 m AHD. Clay, from decomposed lithic clasts, and localised ferruginous cement are products of Quaternary weathering.

Recessive Kaerwut Granodiorite

The largest granodiorite 'outcrop' (400 x 400 m) has been deeply incised and lies at 280-260 m AHD. Incision commenced in the mid-Cretaceous and stripped the mid-Palaeozoic to late Mesozoic regolith. Cainozoic weathering has left a shallow but well developed pedolith and saprolith. The granodiorite is covered by 4-10 m of colluvium shed from the surrounding high-relief contact-metamorphic aureole.

Resistant, leached Pinnak Sandstone

Pinnak Sandstone saprolith overlain by thin soil is widespread. The pedolith has been eroded. The saprolith is pallid, fractured sandstone, siltstone and shale with abundant goethite, from intense leaching by acidic groundwater. Reflectance spectrometry (Maher, 1994) identified a supergene argillic assemblage of kaolinite-halloysite±illite. Acidic weathering, due to weathering of abundant sulphide, began in the mid Palaeozoic and continued into the late Mesozoic. The distribution of acid-weathered rocks corresponds with abundant hypogene pyrite in the sericitic alteration zone (Figure 2A). The saprolith has been protected from erosion in resistant contact-metamorphosed Pinnak Sandstone that forms a shell with an elevation of up to 440 m AHD around the Kaerwut Granodiorite.

MINERALIZATION

The hypogene mineralization comprises chalcopyrite and molybdenite as disseminations and stockwork veins centred on the Kaerwut Granodiorite and its apophyses and extending into the surrounding Pinnak Sandstone. The highest Cu grades rarely exceed 0.4% (best 0.5 m @ 1.65% from 168.0 m in DG1) and are centred on the granodiorite and surround inferred NE sinistral faults. Highest Mo grades are centred on the granodiorite and rarely exceed 1200 ppm (best 1 m @ 2750 ppm from 209.0 m in DG6), but Mo concentrations are also high around the faults.

Propylitic alteration (chlorite-epidote-pyrite) envelops some veins close to the granodiorite and sericitic alteration (pyrite-sericite-quartz) surrounds the granodiorite (Figure 2). Weber (1999) described plagioclase cores consistent with restite mixing for one of the Bete Bolong Suite and speculated that chalcopyrite-molybdenite along joints, faults and in late dykes originated from a residual chlorine-rich fluid formed during solidification.

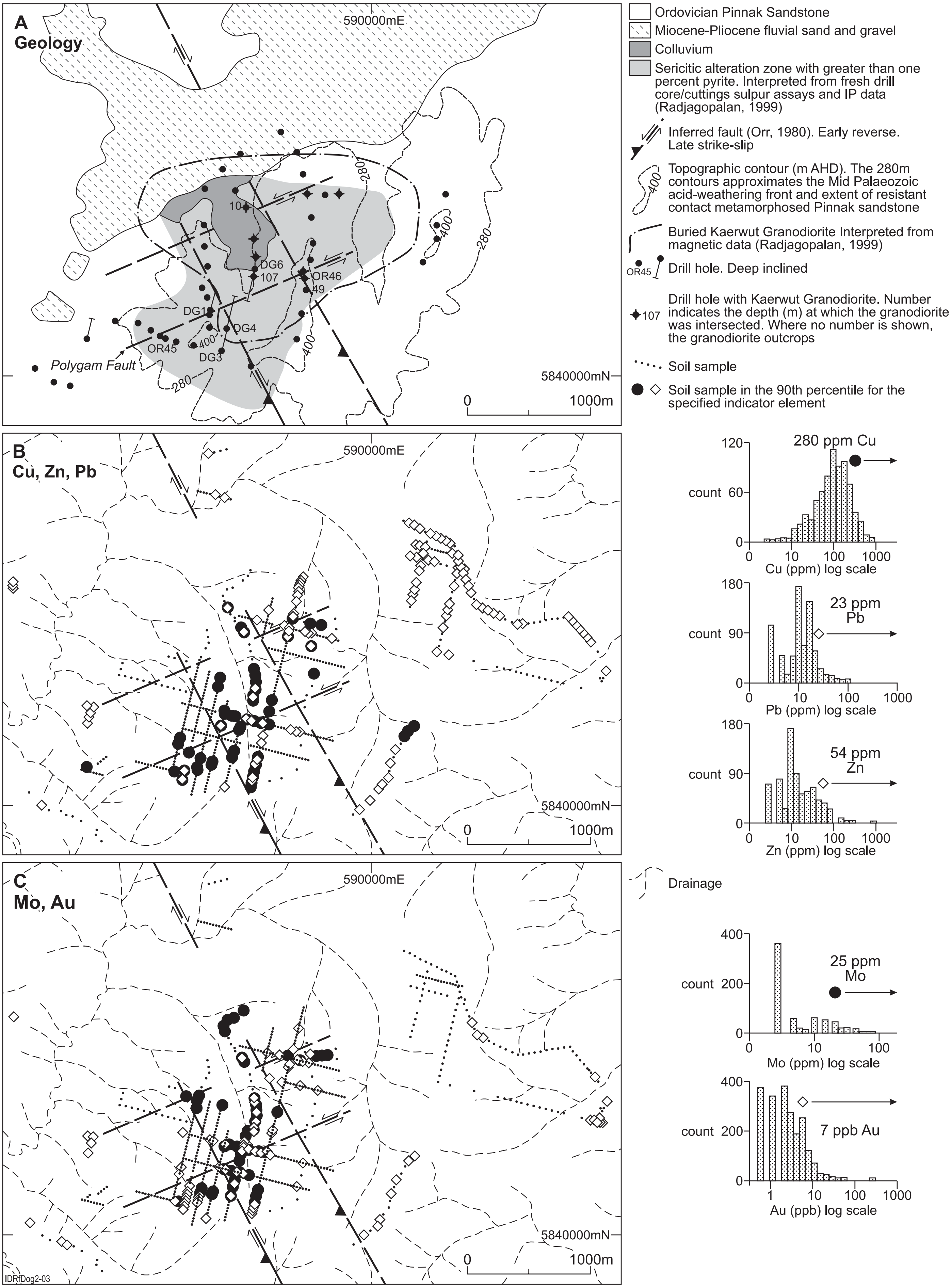

Figure 2. Geology (A); Cu, Pb and Zn soil geochemistry (B); Mo and Au soil geochemistry (C). Plans highlight samples containing >90th percentile of elements. In B, Pb and Zn have similar distributions. Data illustrate concentric Mo, Cu-Au, Pb-Zn-Mn and Au zonations, centred on the granodiorite (Maher, 1994).

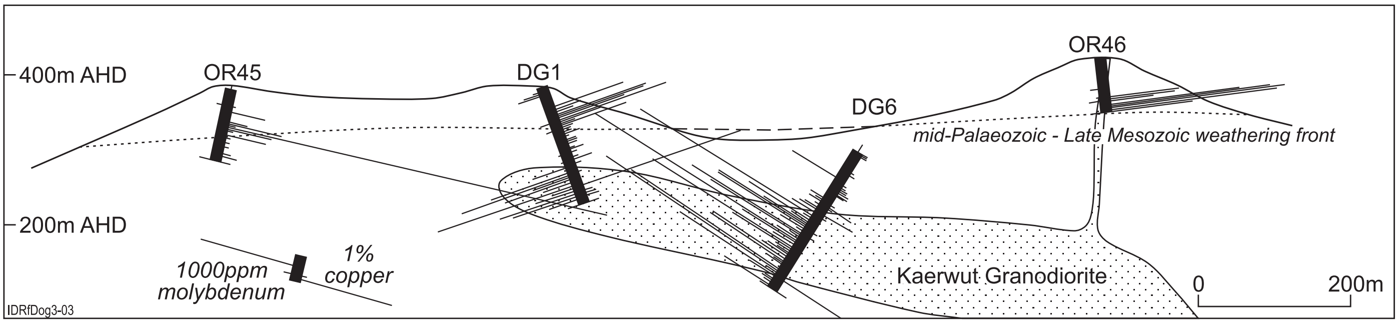

Figure 3. Section along the Polygam Fault showing down-hole Cu and Mo. Supergene Cu enrichment, as a chalcocite blanket, occurs above the mid-Palaeozoic – Late Mesozoic acid-weathering front. The granodiorite is inferred from drilling, Rajagopalan's (1999) magnetic interpretation and the distribution of contact metamorphosed Pinnak Sandstone.

The most significant Cu grades are from a supergene chalcocite blanket developed over the sericitic alteration zone and preserved in contact-metamorphosed Pinnak Sandstone. Highest grades were along the conjugate Polygam Fault (Figure 2). The best intersection was 24.4 m @ 0.8% Cu as chalcocite from 65.6 m in OR46 (open at depth, including 13.3 m @ 1.1% Cu) from a pervasively sericite-quartz altered granodiorite apophysis along the fault. Grade and thickness of the supergene mineralization, and grade of primary mineralization, decrease sharply away from the fault (Maher, 1994).

REGOLITH EXPRESSION

Pinnak Sandstone, containing only 800 ppm Cu, overlies the 24.4 m @ 0.8% Polygam Fault intersection. Acidic groundwater has transported mobile metals and destroyed hypogene alteration. The sample media summary table shows depletion of Cu and Zn in acid-weathered rock compared to fresh rock. Molybdenum and Pb are relatively immobile here and are little depleted. Molybdenum can be used to map hypogene mineralization in the regolith. Figures 2B and C show broad, granodiorite-centred, hypogene metal zonation in soil. Nearly all soil and drilled samples lie within the Dogwood hydrothermal system. As a consequence, backgrounds and thresholds are not able to be determined. The geometric mean is given as a measure of central tendency for pathfinder elements. Although the 90th percentile is arbitrary, it accurately maps the metal zonation at Dogwood (see sample media summary table and Figures 2B and 2C). The chalcocite blanket is now perched at 250-390 m AHD. Incision of the blanket around the altered Kaerwut Granodiorite has created one of the highest ranked Cu drainage sediment anomalies in E Victoria.

The chalcocite blanket was developed above the mid-Palaeozoic to late Mesozoic weathering front, now between 250 and 390 m AHD. Chalcocite commonly coats hypogene pyrite, where present. It has been preserved in resistant contact-metamorphosed Pinnak Sandstone and has been eroded around the Kaerwut Granodiorite during uplift and rejuvenation of drainage initiated in the mid-Cretaceous. Consequently, supergene mineralization on the Polygam Fault lacks the strike extent to be economic (Figure 3).

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SAMPLE MEDIA—SUMMARY TABLE

Sample medium	Indicator elements	Analytic methods	Detection limits (ppm)	Geometric mean (ppm)	90th percentile (ppm)	Max anomaly (ppm)	Dispersion
Fresh rock*	Cu	ICPAES	5'	378	1296	16500	
	Mo	ICPAES	5 & 1'	12	213	2750	
	Pb	ICPAES	5	7	20	1030	
	Zn	ICPAES	5	27	72	254	
	Au	PM209	0.01	0.03	0.06	0.26	
Acid-weathered [leached] rock^	Cu	ICPAES	5'	240	584	860	high
	Mo	ICPAES	5 & 1'	9	26	275	low
	Pb	ICPAES	5	7	12	64	low
	Zn	ICPAES	5	9	22	87	high
	Au	PM209	0.01	0.02	0.05	0.10	low
Residual soil#	Cu	ICPAES	5	98	280	922	high
	Mo	ICPAES	5	6	25	100	low
	Pb	ICPAES	5	10	23	404	low
	Zn	ICPAES	5	14	54	1100	high
	Au	PM205	0.001	0.002	0.007	0.313	low
Drainage sediment+	Cu	AAS	5	22	160	1900	high
	Pb	AAS	5	9	20	70	high
	Zn	AAS	5	24	50	255	high

ICPAES—mixed acid digest including HF; Inductively coupled plasma atomic Emission Spectrometry.
PM205—50 g sample: aqua regia digest—AAS/GFA.
PM209—50 g sample: fire assay—AAS.
* Includes fresh rock from CRAE and AAAP drill holes except DG3, 4 & 6. Large numbers of Kaerwut Granodiorite samples from these holes were excluded so that the comparison between fresh rock and soil or acid-weathered rock, that have few Kaerwut Granodiorite samples, was not biased.
' Samples from DG1 were analysed by AAS after perchloric acid digestion.
^ Only weathered samples without sulphide from CRAE and AAAP drill holes with substantial supergene copper mineralization (>0.5% copper; OR9, 25, 40, 45, 46, DG1) were included in the dataset.
# CRAE unsieved samples. Samples of transported colluvium and Miocene–Pliocene fluvial sand and gravel were excluded.
+ AAAP -80# sieved samples. Insufficient samples were analysed for Mo for these results to be included in the analysis. No samples were analyzed for Au.