THURSDAYS GOSSAN PORPHYRY COPPER PROSPECT, WESTERN VICTORIA

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LOCATION

Thursdays Gossan is approximately 60 km SW of Ararat, Victoria, at 37°36'41"S, 142°36'27"E; Ballarat 1:250 000 map sheet (SJ54-08).

DISCOVERY HISTORY

Western Mining Corporation explored areas of Cambrian volcanics for Au and base metals in the late 1960s. They interpreted their regional –80 mesh stream sediment sampling and rock chip sampling as reflecting differing lithologies (Clappison, 1972). Pennzoil of Australia Ltd. (later Duval Mining (Australia) Ltd.) discovered stinger chalcopyrite mineralization at the Wickliffe prospect and malachite-stained gossanous float with 2.9% Cu at the Thursdays Gossan prospect in the mid 1970s. Auger soil sampling, RAB drilling and diamond drilling identified strongly pyritic, chalcocite-bearing fine-grained rhyolitic tuff with up to 0.8% Cu (Roberts, 1981). The fractured and sheared host rocks suggested that the mineralization was structurally controlled with little potential for economic massive sulphides and the ground was relinquished (Roberts, 1982).

Pennzoil's data was reviewed in 1991 by Geopeko (later North Exploration) who recognized the potential of the calc-alkaline Mount Stavely Volcanic Complex for hosting both porphyry Cu and volcanogenic massive sulphide mineralization (Horvath, 1993). Air core drilling at Thursdays Gossan identified extensive (3x1.2 km) quartz-sericite-pyrite alteration with associated chalcocite mineralization believed to be related to the intrusion of several quartz-feldspar porphyries. Deep diamond drilling for primary mineralization intersected weakly mineralized dacitic porphyries. It was thought that mineralization was related to late overprinting and further exploration focused on locating the source.

CRA Exploration Pty. Ltd. (later Rio Tinto Exploration Pty. Ltd.) joined with North Exploration to explore for porphyry Cu, volcanic associated Cu-Zn-Au and structurally controlled Au deposits (Parkinson, 1996). A data review highlighted the potential for supergene Cu mineralization along a 100-200 m wide annulus of fractured and altered sediments and volcanics. Deep diamond drilling intersected wide zones of low grade Cu mineralization within fractured, sericite-pyrite altered and veined sediments and tuff, intruded by dioritic feldspar porphyry dykes (Donnelly, 1997).

PHYSICAL FEATURES AND ENVIRONMENT

The Mount Stavely belt outcrops poorly as a series of low, isolated hills at the western end of the West Victorian Uplands (Ollier and Joyce, 1986). The climate is temperate with an average rainfall of 560 mm distributed evenly throughout the year. Historically, Mount Stavely had abundant open woodlands of *Acacia* ssp., flanked by grassy plains. Today, parts are cultivated, others under pasture (Camilleri, 1999).

GEOLOGICAL SETTING

The Mount Stavely Volcanic Complex is part of the Grampians-Stavely structural zone in western Victoria (VandenBerg *et al*., 2000). The zone contains largely buried Cambrian tholeitte-boninite rocks and poorly outcropping calc-alkaline volcanic rocks infaulted as belts within Cambrian Glenthompson Sandstone. The Mount Stavely Volcanic Complex is a fault-bound sequence of Cambrian andesitic to rhyolitic lavas and volcaniclastic rocks and plugs of tonalite, which are either interbedded with, or faulted against, the quartz rich turbidites of the Glenthompson Sandstone (Stuart-Smith and Black, 1999).

At Mount Stavely, a 2-3 km wide belt of calc-alkaline volcanic rocks trend NW for approximately 30 km. Cainozoic outwash plains of the Grampians Group cover the belt to the N, and Cainozoic basalts and sediments bound it to the S. Thursdays Gossan is towards the northern end of exposed Mount Stavely volcanic rocks and is partially covered by shallow outwash colluvium (Figure 1).

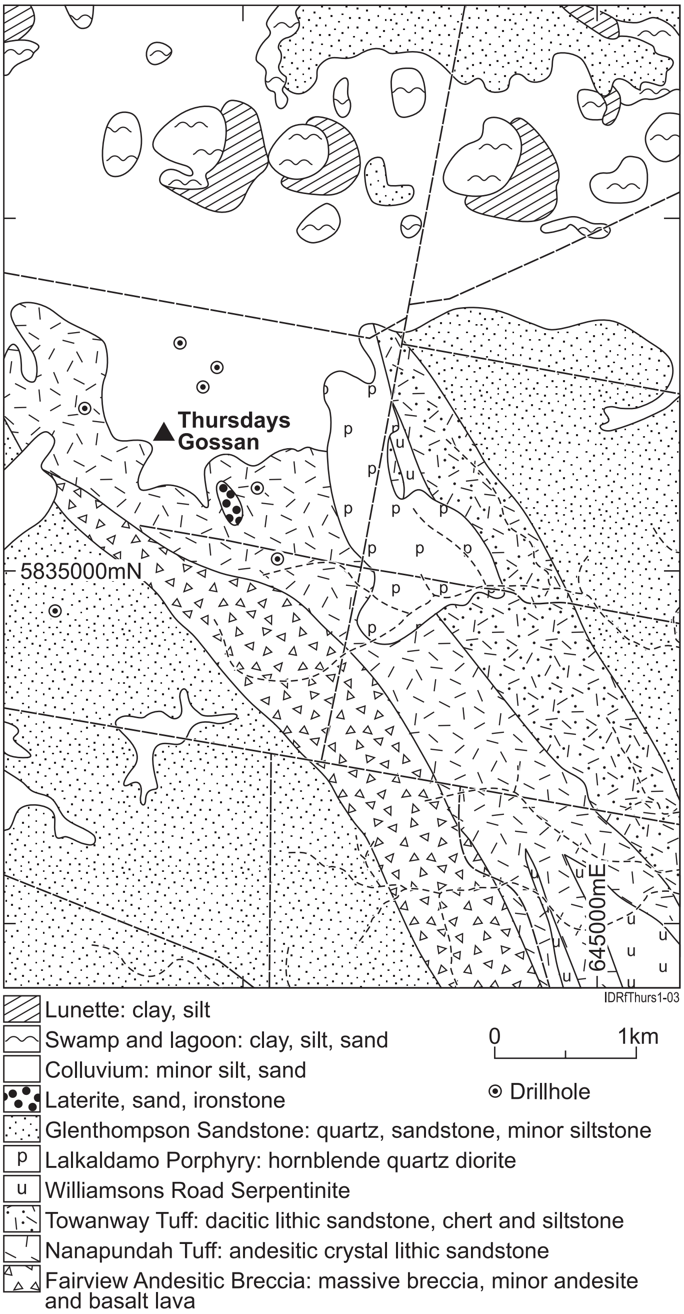

Figure 1. Geology of the northern Mount Stavely Belt (after Stuart-Smith and Buckland, 2000).

REGOLITH

Spencer-Jones (1965) described ferruginous sands, gravels, clays and concretionary ironstones forming a table-like surface on rocks E of the Grampians. This was later referred to as the Dundas Surface and described as a laterite capped piedmont downs, sloping away from the highlands and variably incised along the margins (Jenkin, 1976; King, 1985). The Dundas Surface is a deep weathering profile of ferruginous or silcrete duricrust over a pallid or mottled zone tens of metres deep (Cayley and Taylor, 1997). The surface is developed on lower Palaeozoic rocks and Cainozoic sediments and includes low hills of fresh Mount Stavely Volcanic Complex rocks around Mount Stavely. Its age is constrained by its development on Miocene strata and buried by the overlying late Pliocene-Pleistocene Newer Volcanics (Stuart-Smith and Black, 1999).

In the Thursdays Gossan area, two regolithunits, Muirhead and Stavely, have been delineated (Ollier and Joyce, 1986). The Muirhead unit extends from the southern end of the Grampians and includes Quaternary alluvium developed as swamps, plains and lunettes. Further S, the Stavely regolith unit is the erosional surface developed on Palaeozoic bedrock. More detailed work by Camilleri (1999), using the RTMAP classification, divided the regolith into three landform units: *in situ* weathered Glenthompson Sandstone (Glenelg), *in situ* weathered Cambrian volcanic and intrusive rocks (Stavely) and transported lacustrine quartz and clay (Cockajemmy). Immediately N of Thursdays Gossan, the Cockajemmy Lakes palaeochannel has a series of shallow saline lakes across alluvial quartz and clay-rich regolith. South of the palaeochannel, at the margin of outcropping Palaeozoic bedrock, there is higher relief. Further S, there are outcropping weathered volcanics. Adjacent to the volcanic belt, weakly weathered Glenthompson Sandstone has a high mica content.

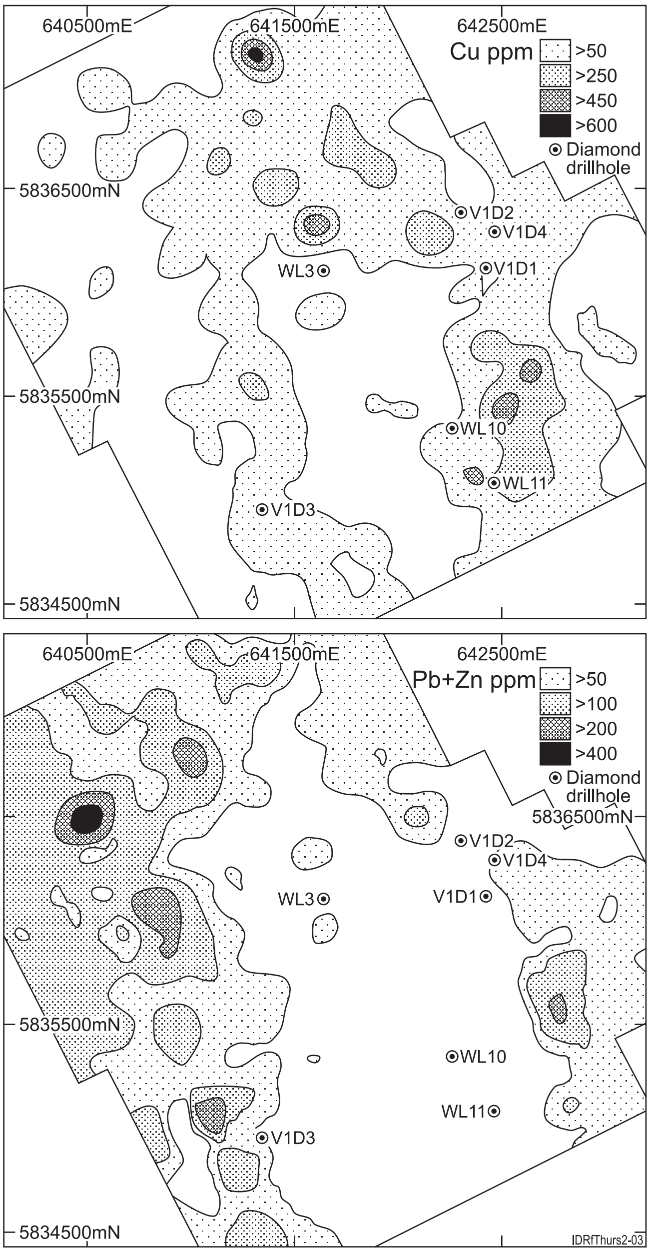

Figure 2. Pennzoil auger soil geochemistry; A: Cu distribution; B: Pb+Zn distribution.

MINERALIZATION

Mineralization at Thursdays Gossan is hosted by undeformed, weak to strongly silica-sericite-pyrite altered, low-K, dacitic sub-volcanic porphyries and enveloping sediments (Horvath, 1994). It forms a shell within silica-sericite-pyrite altered volcanic rocks surrounding a relatively barren feldspar porphyry core (Parkinson, 1996). Supergene Cu mineralization (chalcocite, bornite) is concentrated in stockwork quartz veins, fractures and shears at the weathering front. Lower grade primary disseminated and vein-style mineralization (chalcopyrite, pyrite and rare molybdenite) occurs throughout the porphyry and adjacent sedimentary and volcanic rocks beneath. The youngest intrusives (tonalite and monzodiorite) are barren (Spencer, 1996). Large (3x1.2 km), concentric alteration haloes (advanced argillic surrounded by intermediate argillic, silicic, sericitic and propylitic) surround the mineralized porphyries (Horvath, 1994).

The best intersection in the supergene mineralization was 36 m at 1.1% Cu (including 12 m at 2.02% Cu). Follow-up deeper diamond drilling intersected 229 m at 0.22% Cu (supergene and protore) with mineralization dependent on fracture density and coinciding with intermediate argillic alteration. Fluid inclusions indicated hydrothermal fluids with intermediate trapping temperatures and high salinities consistent with magmatic-meteoric fluid mixing and distal porphyry mineralization (Horvath, 1995).

Drilling for a deeper higher grade porphyry core below the weathering front in the centre of the alteration system gave 10 m at 0.24% Cu from 164 m in sericite-altered feldspar porphyry with disseminated and vein chalcopyrite (Parkinson, 1996). Drilling along strike intersected wide intervals of low-grade Cu (186 m at 0.145% Cu, including a supergene cap of 6 m at 0.38% Cu; Donnelly, 1997).

REGOLITH EXPRESSION

At Thursdays Gossan, the Dundas Surface residual profile has been eroded. Only small isolated outcrops of lateritic residuum remain on high points (260-270 m RL). Down slope, ferruginous rubble and float (some gossanous) form part of the colluvium-alluvium surface. Rock chip sampling of malachite-stained gossanous float gave up to 2.9% Cu, 54 g/t Ag and 3.7 g/t Au.

Follow-up auger soil sampling (probably 'B' horizon clay) returned mixed results but was most effective where colluvium is thin, typically on slight rises. Here, Cu, Pb and Zn signatures indicated porphyry-style mineralization and metal zonation. Across the argillic altered system centre, these elements are all depleted. On the margins of the system, approximately coincident with silica-sericite-pyrite alteration, soil sampling outlined several arcuate >250 ppm Cu (90th percentile) anomalies (maximum 3600 ppm; Figure 2A). These are flanked by an outer halo of elevated Pb and Zn (Figure 2B). Drilling demonstrated a Cu-Mo association with elevated Mo in both the weathered and supergene zones. Molybdenum was not determined for the Pennzoil soil data but would provide a useful pathfinder for further exploration.

At depth, the regolith profile is complex. Combined weathering and hydrothermal alteration have produced an irregular weathering front (Figure 3). PIMA analyses on diamond core identified two early alteration zones: an upper argillic zone (hydrothermal kaolinite and

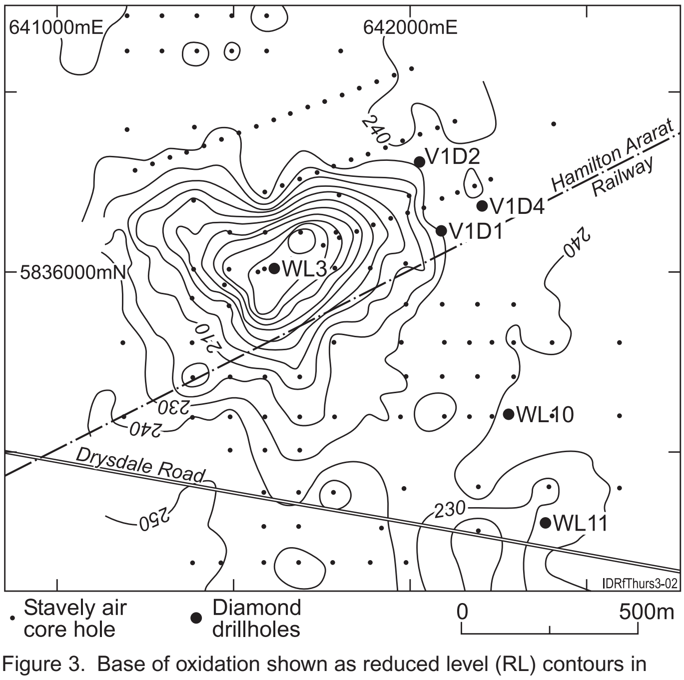

Figure 3. Base of oxidation shown as reduced level (RL) contours in metres (Rajagopolan, 1999).

SAMPLE MEDIA – SUMMARY TABLE

Sample Medium	Indicator Elements	Analytical methods	Detection limit (ppm)	Background (ppm)	Threshold (ppm)	Max anomaly (ppm)
Soil	Cu	AAS	5	20	450	3600
	Pb	AAS	5	10	60	4400
	Zn	AAS	5	10	145	930
Saprolite (argillic alteration)	Cu	ICP	2	20	80	91
	Mo	ICP	3	3	17	20
	Au	FA/AAS	0.01	0.01	0.1	0.19
Saprolite (sericitic alteration)	Cu	ICP	2	60	380	400
	Mo	ICP	3	4	20	24
	Au	FA/AAS	0.001	-	-	0.06
Supergene (argillic alteration)	Cu	ICP-OES	1	2000	4200	42500
	Mo	ICP-OES	1	20	200	260
Fresh rock (sericitic alteration / protore)	Cu	ICP	2	960	3000	5700
	Mo	ICP	3	6	32	52

dickite) and a lower sericitic (sericite-illite) zone. The effects of weathering are superimposed, resulting in disordering of the crystal structure of hydrothermal kaolinite (Spencer, 1996).

The base of oxidation is lower over most altered rocks due to acid leaching after oxidation of primary sulphides (Horvath, 1993). At its thickest, the oxidized zone is 150 m deep and coincides with argillic alteration (Figure 3). Weathering of the argillic zone has reduced Cu (20-90 ppm) and slightly elevated Mo (maximum 20 ppm) and Au abundances (maximum 0.19 ppm). In the sericitic zone, where weathering has penetrated 20-40 m, Cu abundances are lessened (60-400 ppm) but Mo is elevated slightly (mean 24 ppm) and Au (mean 0.06 ppm).

At the weathering front, Cu is enriched into a 5-40 m thick, irregular zone of supergene mineralization. The best supergene Cu intersection was 36 m at 1.1% Cu and 73 ppm Mo from 33 m in the argillic zone. In the sericitic zone, where primary Cu abundance is lower, supergene enrichment produces 0.2-0.4% Cu. Below the supergene zone, Cu declines to broad zones of 0.1-0.3% Cu. Minor elevated Mo is due to small, localized molybdenite veins.

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