THE PINNACLES GOLD AND BASE METAL DEPOSITS, WESTERN TASMANIA

J.C. van Moort

School of Earth Sciences, University of Tasmania, GPO Box 252-79, Hobart TAS 7001

LOCATION

The Pinnacles deposits (Pinnacles Southern Trenches mine, and small workings at Thomas' Tunnel, Brown's Tunnel and Leo's Find) strike along 1400 m on the western flanks of Burns Peak (Figure 1). They are located some 10 km N of Rosebery at 41°40'S and 145° 32'E; Tasmania North West (SK55-01) 1:250 000 map sheet.

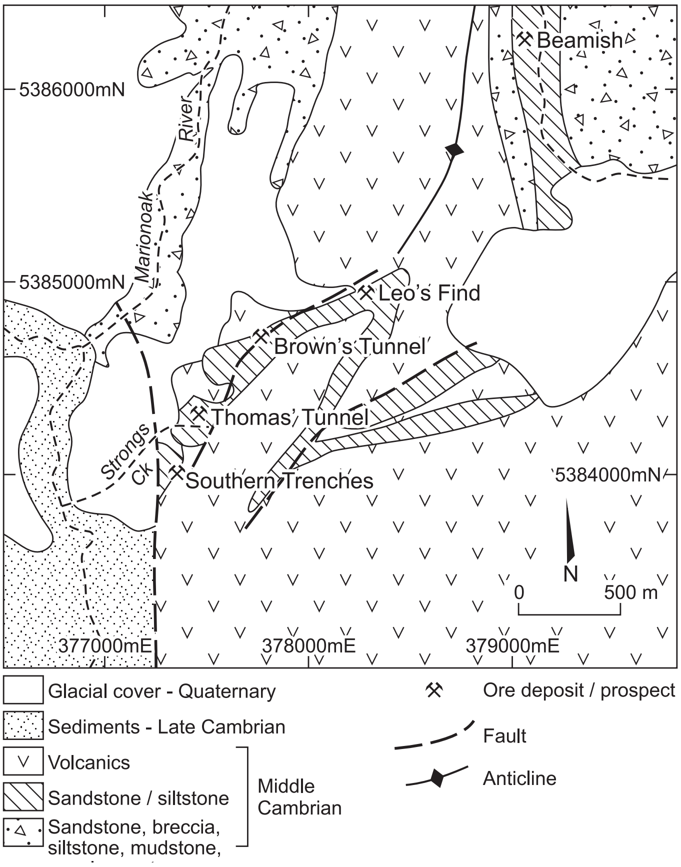

Figure 1. Pinnacles area: prospect locations and geology (after Corbett and McNeill 1986).

DISCOVERY HISTORY

Following the discovery of alluvial gold in the Marionoak River and its tributary, Strong's Creek, 'rich copper ore' in the Pinnacles area was reported in 1896. By 1918, less than 500 t of ore had been mined from several small Zn-Pb-Cu-Ag-Au occurrences. The Pinnacles, and the adjacent Burns Peak and Boco areas to the E, have been intensely explored by the Electrolytic Zinc Company of Australasia and its successor, Pasminco, for more than thirty years. This resulted in the development of the Pinnacles Southern Trenches Mine in 2000 but further exploration has failed to locate additional economically significant mineralization (McNeill, 2001).

PHYSICAL FEATURES AND ENVIRONMENT

Burns Peak and the Pinnacles are NNE-aligned hills of some 600 m height that overlook a plain at about 400 m. They are drained to the E by Boco Creek and to the W and S by the Marionoak River and its tributaries. The climate is cool temperate, with a mean rainfall of 2200 mm pa, distributed throughout the year, and mean January and July temperatures of 12°C and 5°C, respectively. Vegetation consists of medium density rainforest along Boco Creek and on the peaks, and dense rainforest on the slopes. Only low shrubs grow above mineralization.

GEOLOGICAL SETTING

The Middle Cambrian Central Volcanic Complex of the Mount Read Volcanic Sequence hosts most of the sulphide mineralization of Western Tasmania. In the Pinnacles area, the footwall consists dominantly of dacitic and rhyolitic volcaniclastics, with minor andesites and andesitic volcaniclastics. At Southern Trenches, both the footwall and the hangingwall rocks are ignimbritic. Dacitic lapilli tuffs and andesite form the hanging wall to a barite-rich lens and galena-rich veining at Thomas' Tunnel. This andesite, in part, forms the footwall to massive sulphide mineralization at Brown's Tunnel (Collins *et al.*, 1981). The host rock consists of variously silicified siltstone with minor sand- and ash-beds (Gregory 1986). Cleavage and fold axial planes turn from NW and N in the S to NE in the Pinnacles area. Stacking of massive sulphide lenses and/or feeder systems occurs at slightly different levels. Some hundred metres to the W, the Rosebery Fault, intersected by drill holes, separates the volcanic rocks from Late Cambrian shales, sandstones and tuffs (Figure 1).

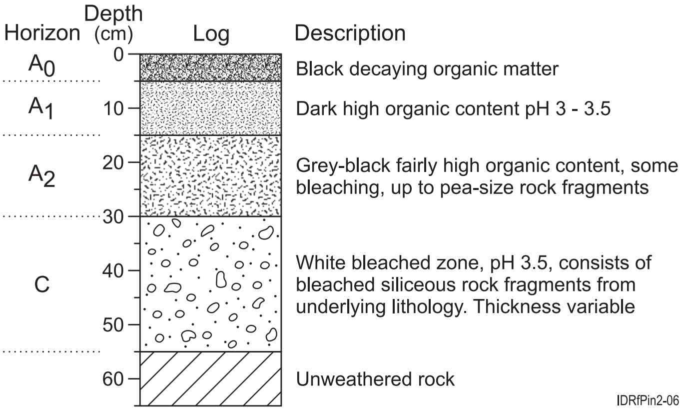

Figure 2. Soil profile near the Pinnacles Southern Trenches (after Farrell and Orr 1977).

REGOLITH

The area was glaciated during the Pleistocene and is mantled by shallow (<0.5 m) lithosols over relatively unweathered bedrock (Figure 2).

MINERALIZATION

Mineralization consists of small pods of massive, stratiform Zn-Pb-Cu-Ag-Au sulphides and sulphide breccia, rare stringer veins and widespread disseminated and veinlet mineralization. The sulphide pods rest on the near-vertical NW limb of an anticline. All mineralization occurs 100 m from the Pinnacles Shear. The massive sulphide contains clasts and intervals of chert and is surrounded by a siliceous envelope up to 8 m wide that extends along strike for 200 m. The massive sulphides comprise medium-grained bedded sphalerite, pyrite and chalcopyrite with accessory tetrahedrite and Au. The gangue is quartz, barite and minor siderite, kutnohorite ($\mathrm{Ca(Mn,Mg,Fe)(CO_3)_2}$) and ankerite (Gregory 1986). There are traces of fuchsite in the footwall at Brown's Tunnel.

Alteration related to mineralization consists of a proximal siliceous envelope with sericite, pyrite, chlorite and patchy, strong, pervasive ankerite alteration. At the surface, at the Southern Trenches, this envelope strikes 60 m and is up to 9 m wide. This is surrounded by a sericite-silica-pyrite±chlorite±ankerite assemblage, extending 25 m into the footwall and approximately 35 m into the hangingwall. Common cubic casts after pyrite occur up to 80 m E and at least 25 m W of the host horizon. Small-scale open-cut mining in the Southern Trenches area in 2000-2001 produced 14 100 t of ore at 11.9% Zn, 7.9% Pb, 1.3% Cu, 55 g/t Ag and 8.9 g/t Au (Mineral Resources Tasmania, 2001).

REGOLITH EXPRESSION

Bedrock

The distributions of Zn, Pb, Cu, Fe, Au and Ag at Southern Trenches have been determined by surface rock chip sampling (Woolford, 2000). The Pb (Figure 3) and Zn (not shown) data are closely matched, with the highest abundances occurring around the main sulphide pods. Gold dispersion in the regolith is very restricted. Whole rock geochemistry by Stevens (1974), McKibben (1993) and Woolford (2000) shows the

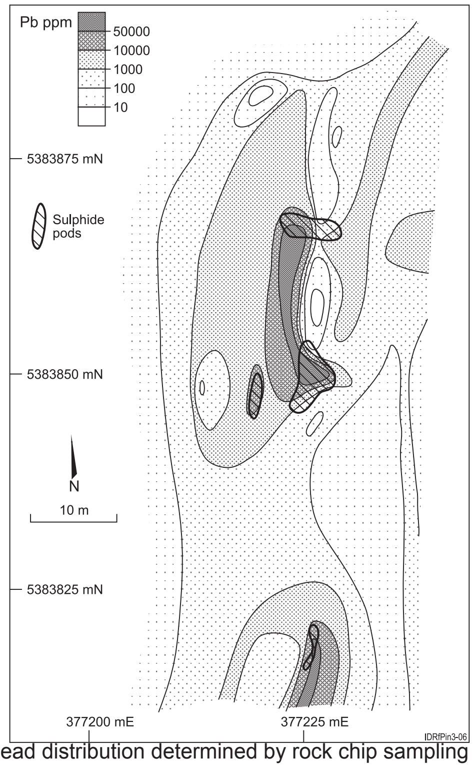

Figure 3. Lead distribution determined by rock chip sampling at Southern Trenches (after Woolford 2000).

TABLE 1
COMPOSITION OF DRY ASHED SOIL IN PIT SOUTH OF PINNACLES SOUTH TRENCH

Depth mm	Horizon	Cu ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm	Mn ppm	C** %
25-50	A0	13	77	156	6	1450	30	13.45
50-150	A1	8	66	59	6	1200	20	6.08*
150-250	A2	6	64	20	4	1200	20	5.37
250-350	A2/C	2	52	16	5	1100	20	4.34
350-450	C	2	34	12	5	900	15	1.68
450-550	C	2	30	10	5	800	15	0.67
550-650	saprolite	20	180	68	nd	nd	nd	nd

* Humus at this level contains 51.1% C, 4.2% N, 4.2% H and has a C/N ratio of 12
** Air-dry material prior to ashing

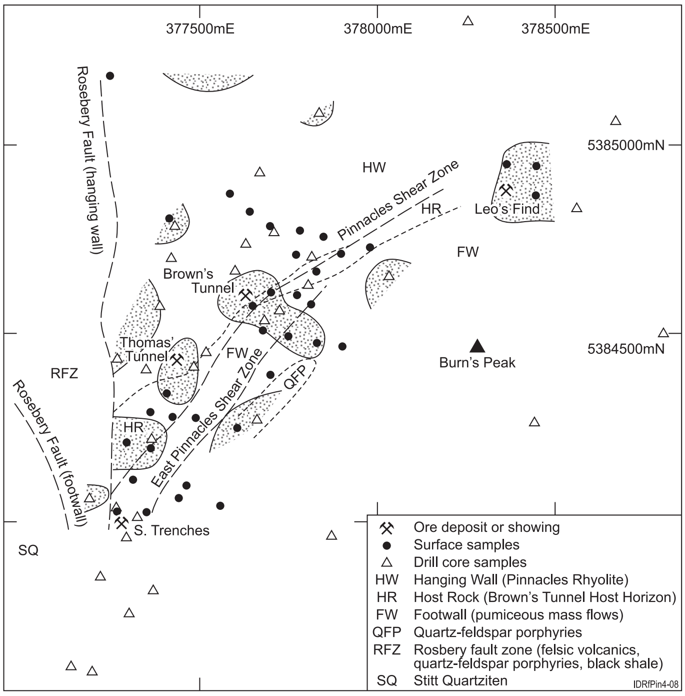

Figure 4. Location of rock samples in outcrop and shallow drillholes, indicating distribution of Ba (>500 ppm) in the acid insoluble residues (after Aung Pwa and van Moort, 1996). Geological information from Pasminco Exploration.

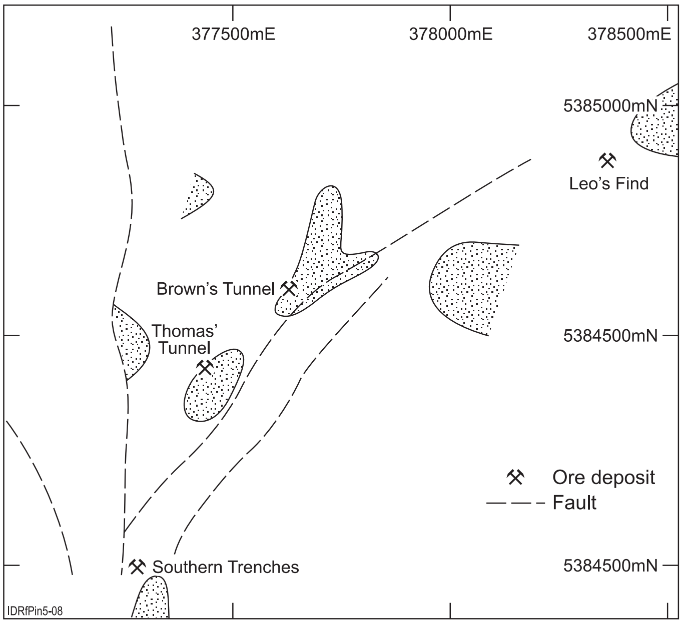

Figure 5. Location of rock samples and areas with concentrations of Ba x Mn (x 10-4) >10 and Zn x Pb>50 (ppm) in the acid insoluble residue of surface rocks and shallow drill holes (after Aung Pwa and van Moort, 1996). Geological sketch after Pasminco Exploration.

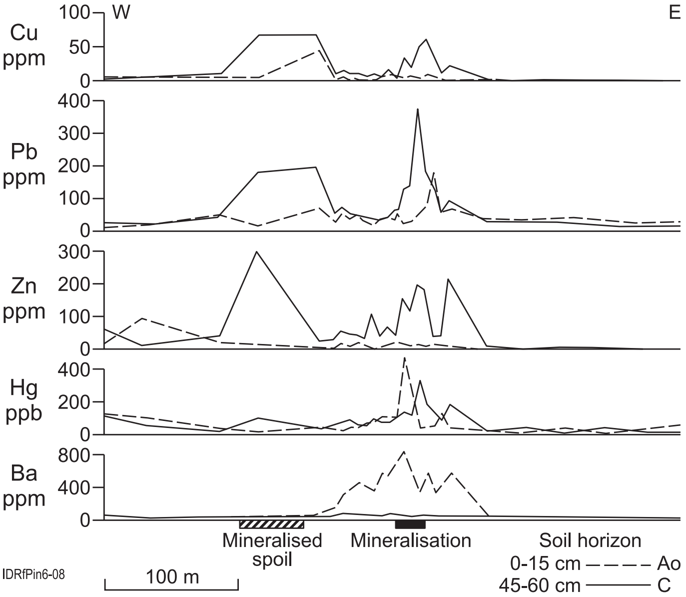

Figure 6. Soil traverse, Pinnacles, comparing responses in the A0 and C horizons. Data on minus 175 μm fraction (after Farrell and Orr, 1980).

rocks at the Southern Trenches are similar to the pumiceous footwall of the Rosebery Mine sequence. There are no regional alteration patterns related to sericitization (*i.e.,* enrichment of K and Rb) or plagioclase destruction (*i.e.,* depletion of Na, Ca and Sr).

Wall-rock alteration in a 500 x 1800 m area straddling the Leo's Find, Browns Tunnel, Thomas' Tunnel and Southern Trenches was studied using the acid-insoluble residues of 64 pulped surface and near-surface rock samples. The pulps were leached with hot HNO_3 to remove oxides, hydroxides, carbonates, sulphates, sulphides and chlorites. The residue of primary and secondary quartz/chalcedony, feldspar and sericite was analysed by PIXE-PIGME for 20 elements. Background abundances are very low, because the material is dominantly silica. The Ba abundance is >500 ppm in minor mineralized areas but not at Southern Trenches (Figure 4). However, the Ba x Mn index reaches >10 in all mineralized areas. In combination with the Zn x Pb mineralization index, these define the location of the workings quite well (Figure 5), but have a smaller areal extent at the Pinnacles than at Rosebery and Hercules (van Moort and Aung Pwa, 2005; Briggs and McNeill, 2005). Moreover, the Rb/Al and Rb/K ratios do not have the magnitude and extent of the sericitic alteration zones at the Rosebery and Hercules deposits.

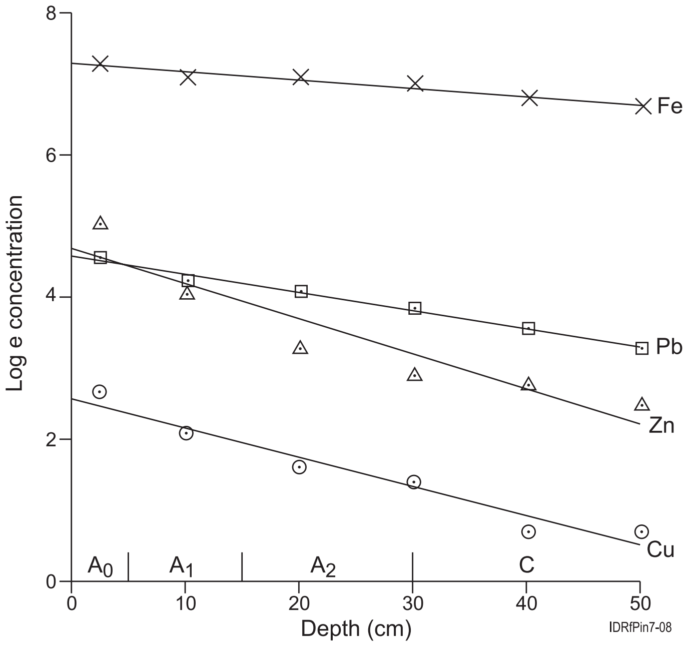

Figure 7. Element concentrations as a function of depth in shallow lithosol south of Pinnacles Southern Trenches (after Beamish 1978). The lines are the least squares fit.

Soil

Farrell and Orr (1980) presented data for a 470 m EW orientation traverse in the Southern Trenches area. They analyzed the minus 175 µm fraction of the A_0 and C horizons for Cu, Pb and Zn ($HNO_3/HClO_4$ digestion), Ba ($HNO_3/HClO_4/H_3PO_4$ digestion) and Hg (acid digestion, hydride reduction and flameless AAS). Copper, Pb and Zn were found to be concentrated in the A_0 horizon (Figure 6), presumably as organo-metallic complexes and thereby resisting solution and downward leaching. In comparison, Ba is concentrated in the C horizon, whereas Hg is variable. Subsequently, a similar fraction of the A_0 horizon was sampled over an 1100 x 1400 m area on a 20 x100 m grid (Hall, 1978; Farrell and Orr, 1980). This survey showed discontinuous base metal anomalies that were shown by subsequent costeaning and drilling to reflect, in part, mineralization. As part of the same program, two soil profiles over mineralization were investigated in pits at Southern Trenches by Beamish (1978). Samples from below 25 mm depth were crushed to <180 µm and analysed for Cu, Pb, Zn, Mn, Ni and Ba. The soil profile is given in Figure 2. The two pits are almost identical, with the highest abundances of Cu, Pb and Zn in the ash of black decaying material of the A_0 horizon. Concentrations sharply decrease in A_1, A_2 and C horizons (Table 1 and Figure 4), possibly increasing in the saprolite. The decrease may be explained if the profile is likened to an exchange column, fed by material from decaying organic material from fallen leaves. Water percolating through the A_0 horizon, is enriched in carbonic and humic acids. Although weak, these acids are in continual supply from the decomposing humus. and leach the horizons below. Soil sampling in western Tasmania is generally confined to the C horizon (saprolite/saprock; in practice as deep as the auger can penetrate). Because the B horizon is generally absent, sampling at constant depth (0.1-0.2 m) results in meaningless data. Further discussion of element mobility and dispersion in these lithosols is given by Russell and van Moort (1981).

Over past decades, analysis of tens of thousands of soil and auger samples in the Pinnacles area have discovered no new targets, other than those originally found. The soil anomalies above the two pyritiferous shale zones in the headwaters of Boco Creek had saprock abundances of >220 ppm Pb and >130 ppm Zn. The corresponding A_0 horizon anomalies are displaced down-slope.

Vegetation

Element distributions shown by analysis of leaves of *Nothofagus cunninghamii* in the Boco area are in general agreement with A_o horizon soil sampling.

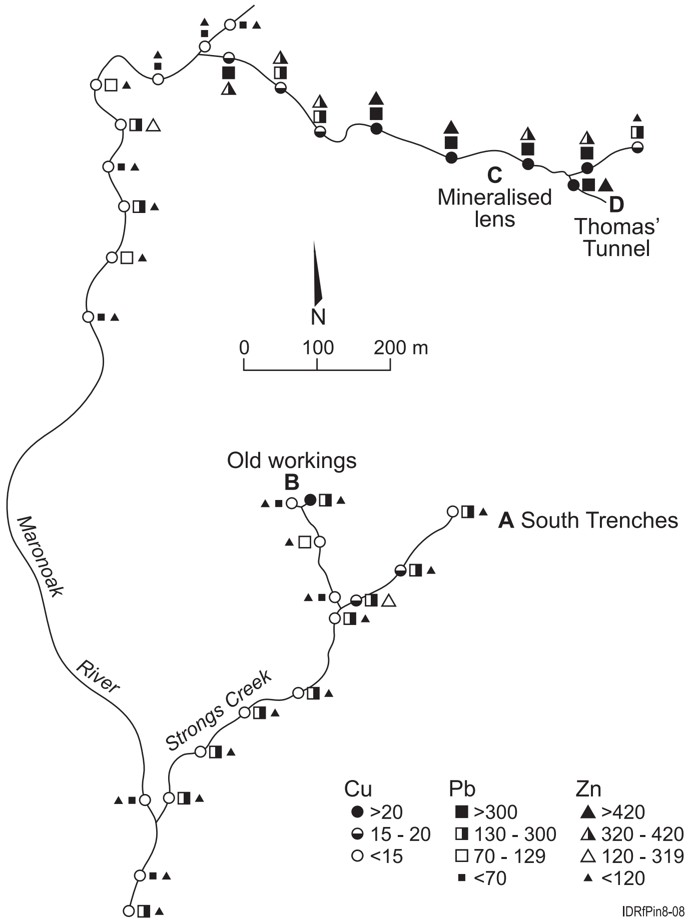

Figure 8. Concentrations of Cu, Pb and Zn in the <180 µm fraction of active stream sediments in the Southern Pinnacles area (after Beamish 1978).

Stream sediments

Beamish (1978) collected stream sediment samples (200 g) at approximately 100 m intervals from active streams draining Thomas' Tunnel and Southern Trenches (Figure 5). Samples were taken immediately upstream and downstream of creek junctions. Three fractions (850-450 µm, 450-180 µm and <180 µm) were analysed for Cu, Pb, Zn, Mn, Fe, Ni and Ba. The <180 µm fraction returns more abruptly to background and provides the best compromise between sample availability and contrast. R-mode factor analysis of each fraction produced element associations in Factor 1 consistent with the primary mineralization; for the <180 µm fraction, it is Ba-Cu-Pb-Zn. Plotting of Pb/Fe and Zn/(Mn+Fe) ratios magnifies the footprint of the

TABLE 2
SAMPLE MEDIA – SUMMARY TABLE

Primary mineralization	Zn, Pb, Cu, Ag, Au and Ba and Mn in gangue.
Wallrock alteration	VHMS deposits expressed in acid insoluble residue: barite and remnants of Mn bearing carbonates and further sericitisation and feldspar destruction. Criteria* for VHMS deposits are Ba>500 ppm and Mn>100 ppm, an index of ZnxPb >50 (in ppm)
Panning and sluicing	Fine flakes and rounded particles of gold, galena, pyrite, chalcopyrite
Active stream sediments	<180µm fraction Ba, Cu, Fe, Mn, Ni, Pb and Zn. The dispersion trail is 500 m long
Soil	Preferably C-horizon: Cu, Pb, Zn, Ni, Ag, As, Au, Ba, Fe, Mn (after dry-ashing) ** C on separate samples by Leco gas analyser
Vegetation	Dry-ashed material): detection limits **
Channel sampling	Cu, Pb, Zn, Fe, Ag, Au Au. Mn, Ba. Detection limits* Cu 4 ppm, Pb 5 ppm, Zn 5 ppm, Ag 2 ppm, Ba 30 ppm and Mn 50 ppm. Au by fire assay 5 ppb.

* Detection limits for XRF are Ba 30 ppm, Mn 50ppm, Zn 5 ppm, Pb 5 ppm, K 3 ppm, Rb 5 ppm and Al 100 ppm. Detection limits for PIXE/PIGME on bulk samples are Ba 50 ppm, Mn 7 ppm, Zn 2 ppm, Pb 4 ppm K 35 ppm, Rb 3 ppm and Al 400 ppm

** Detection limits in ppm for AAS are: Cu 1, Pb 5, Zn 2, Ni 5, Ba 10, Fe 5, Mn 2 mineralization at the Pinnacles by removing the effects of scavenging by Fe and Mn oxides.

Subsequent stream sediment sampling in the headwaters of Boco Creek traced a Cu-Pb-Zn anomaly upstream. Soil sampling and trenching located two pyritiferous, weathered, grit-like shale horizons, with 600 and 735 ppm Pb, 300 and 150 ppm Zn, 30 and 70 ppm Cu, and 500 and 700 ppm respectively. However, Ba is <500 ppm (Beamish prospect, Figure 1).

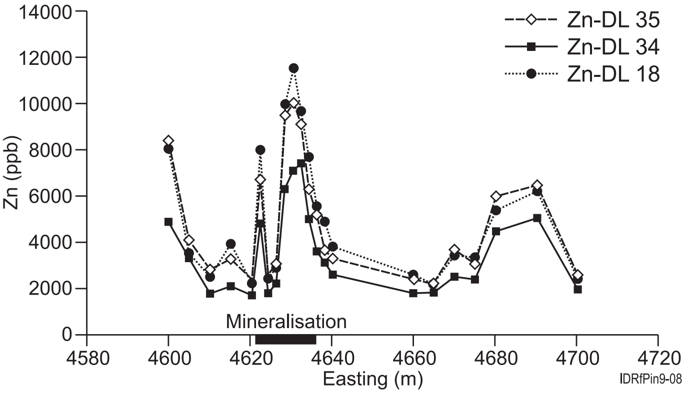

Figure 9. Abundances of Zn extracted by individual MMI "Deepleach" extractions Line 4400N, Southern Trenches (Dronseika, 1998).

Selective analysis

Soil samples along line 4400mN across the Southern Trenches mineralization were collected within the variably organic sandy loam layer, below the root mat zone, at 50-250 mm below surface (soil pH <5). Samples were sieved to <5 mm, dried and were leached with a very weak ion-exchange agent, a strong ion-exchange agent and a non-specific chelating/complexing agent for Ba and base metals. The abundances of Zn extracted by these three MMI leaches are similar and show a pronounced peak above the mineralization (Figure 9). Follow up by Bettenay (1998) showed that Zn and Cd best define the Southern Trenches mineralization, presumably due to their mobility or preference for the soil bonding sites accessed by the leaching solutions.

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