



**J. G. PURVIS & ASSOCIATES PTY. LIMITED**

**CONSULTING AND CONTRACT GEOLOGISTS**

A.B.N. 80 009 545 591

715 West Tamar Highway  
Legana, Tasmania 7277

Telephone: (03) 6330 1434  
Facsimile: (03) 6330 1595  
Email: jgpurvis@tassie.net.au

## ***SAMPLING AND METALLURGICAL TESTING OF SURFICIAL ZINC CLAYS***

***GRIEVES***

***EL 47/2004, WESTERN TASMANIA***

***REPORT FOR ZINIFEX AUSTRALIA***



*Excavating Pit 170, Grieves zinc clay deposit*

***J.G. Purvis  
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## 1. SUMMARY

Zinifex has tested the feasibility of recovering zinc from surficial organic clays at Grieves Siding, 12km south of Zeehan in Western Tasmania. The clays contain an Inferred Mineral Resource of 283,000t @ 4.5% Zn. They directly overlie an estimated potential resource of 700,000t @ 8% Zn within the Gordon Limestone.

The aim was to determine if the zinc-rich clay could be fed into the flotation circuit at Zinifex's Rosebery Mine, 40 km by road NE of Grieves. The possibility of using gravity separation to produce a sphalerite concentrate for delivery direct to Zinifex's Risdon refinery in Hobart was also tested.

Five pits 2.5–4.8m deep were dug into the deposit and 150kg of clay taken from each. Grades of the five samples varied from 2.5% - 17.5% Zn. Flotation and gravity separation tests were conducted by Ammtec at Burnie and Zinifex's Century Mine in Queensland. This was complimented by geochemical and mineralogical studies including SEM and XRD. Detailed results are presented in Lai (2006).

Although the mineralogical work showed the zinc is present as fine-grained low-iron sphalerite, metallurgical results were poor. Ammtec concluded the clay would have difficulty meeting grades and recoveries required at Rosebery. Key results were:

Flotation tests on high-grade Pit 181 clay using a carbon pre-float produced a best result of 39% Zn recovery. Tests on the +38 micron fraction only (60% of the sample) and using excessive reagents, achieved a Zn recovery of 55%.

A 10:1 blend of Rosebery ore and Pit 181 clay obtained recoveries of 77% for Zn and 46% for Pb. (Normal Rosebery mill recoveries are 91-93% for Zn).

Reagent consumption was extremely high, to the extent reagent cost alone would be enough to make Grieves material uneconomic to treat at Rosebery.

Gravity separation tests of Pit 181 clay achieved recoveries of 9.5% for Zn on a shaking table and 9% in a Falcon concentrator. Most tests achieved no actual concentration, tailings and "concentrate" having much the same grade.

The flotation recovery figures mean that if Grieves clay was treated in the Rosebery mill the zinc lost would be more than double that contained in the clay brought in.

The problems are due to the <30 micron grainsize of most of the sphalerite and the fact it occurs within peaty organic material comprising 50-80% of all samples. Much of the sphalerite is colloform, apparently actively depositing from meteoric water onto the carbon. SEM imaging shows the organics are relatively young and some sort of organic replacement of decomposed limestone seems indicated. While the feasibility of economically recovering zinc from the clays can't be ruled out, the testing has demonstrated it is not possible using conventional flotation or gravity separation.

It is concluded that both the Grieves clays and the underlying partly-oxidized hard-rock mineralization, cannot be treated in any existing Zinifex infrastructure and therefore would have to be treated in a stand-alone facility. The small size, modest grade and acknowledged limited potential for increasing the identified resources, suggest this is unlikely to be an economic proposition on a scale of interest to Zinifex.

## 2. INTRODUCTION

The carbonate-hosted Grieves zinc deposit and overlying zinc clays occur on the 23 sq km Henty Road EL 47/2004 held by South Eastern Resources Limited, a subsidiary of Icon Resources Ltd. The deposits lie under swampy buttongrass plains adjacent to Henty Road, 12 km south of Zeehan in Western Tasmania. See Figure 1.

The first systematic exploration and drilling at Grieves was in the 1980's by EZ and Amoco, but it was extensive drilling by CRA Exploration 1992-97 that outlined the hard-rock and surficial clay deposits.

In 1998 Allegiance Mining conducted limited metallurgical tests on three aircore drill samples from the zinc-rich surficial clays. This work obtained zinc recoveries below 30%. The results were not regarded as conclusive because of the small sample size and the fact they were badly oxidized, being more than five years old.

In September 2005 Zinifex Australia Limited signed a 12 month option agreement with South Eastern Resources over EL 47/2004. Zinifex primarily sought to test the feasibility of recovering zinc from the surficial clays in the flotation circuit at their nearby Rosebery Zn-Pb mine. Failing that, the possibility of using on-site gravity separation to produce a sphalerite concentrate suitable for shipping directly to Zinifex's Risdon refinery was also to be investigated.

This report describes the programme of pit sampling, summarizes the results of the metallurgical and mineralogical testwork, and assesses the significance of the findings. The author was responsible for designing and carrying out the sampling and co-ordinating the testing.

The metallurgical programme was primarily undertaken by metallurgist Kim Lai of Ammtec in Burnie. Mineralogical and other studies were carried out by Stafford McKnight (University of Ballarat), Keith Scott and Neil Sherwood (CSIRO), and Gary McArthur (MODA). Zinifex staff involved included metallurgists Ken Sherry and Nicola Semler (Century Mine), and geologist Trevor Ellice (Rosebery). Zinifex technical assistant Craig Archer assisted with the pit sampling.

The work was undertaken at the request of Angela Lorrigan, Principal Geologist of Zinifex Australia.

***Figure 1: Location Plan***



### 3. TENURE & ACCESS

Henty Road EL 47/2004 was granted to South Eastern Resources Limited on 3<sup>rd</sup> February 2005 for a period of five years. The Licence covers 23 sq km on either side of Henty Road, the highway linking the towns of Zeehan and Strahan.

East of the road the licence falls within the Dundas Regional Reserve, where exploration and mining is permitted but work programmes are subject to scrutiny by the Tasmanian Government's Mineral Exploration Working Group. West of the road is within State Forest. The vegetation in the licence area is predominantly buttongrass and heath, with patches of medium-height eucalypt saplings.

In the area of the zinc deposits Henty Road traverses the Badger River valley. For several hundred metres either side of the road there are low-lying swampy buttongrass plains overlying weathered Gordon Limestone. The plains are flanked west and east by escarpments of Ordovician and Silurian sandstone 70-90m high, topped by the Professor Plateau – a Late Tertiary peneplain.

The 4WD Queensberry Track cuts across the northern end of the surficial zinc clay deposit which lies at the base of the escarpment east of Henty Road (see photograph below). The old Grieves Siding railway formation also extends close to the deposit along with several old shallow road-gravel quarries. The area receives over 2000mm of rain annually and access across the swampy buttongrass in the vicinity of the zinc clays requires wide-tracked vehicles and some care.

In September 2005 Zinifex Australia Limited signed a one-year option agreement with South Eastern Resources. The option commits Zinifex to expenditure of \$120,000 on the EL and expires on 30<sup>th</sup> September 2006. In January 2006 Icon Resources Ltd., in a related-party transaction, purchased two-thirds of South Eastern Resources and the remaining one-third after Icon listed on the ASX in June 2006.



*Grieves, view to SE. from Henty Road. South Block of zinc clay deposit (dashed) at base of Moina Sandstone escarpment with Tertiary peneplain on skyline. Gordon Limestone under buttongrass swamp in foreground.*

#### 4. GEOLOGY

Grieves is underlain by a sequence of Upper Cambrian to Devonian sediments dipping NW. In the broader area the sediments are folded around anticlinal and synclinal axes trending NW and cut by a series of NW-trending faults. On a local scale Grieves lies in the axial part of a broad syncline. See Figure 2.

The unit of interest at Grieves is Ordovician Gordon Limestone which is 600m thick and dips 35-60° NW. The dark grey limestone contains various facies including a basal bioclastic argillite and oolite, several micrites and occasional silty or argillaceous zones. Dolomite dominates the upper half of the unit at Grieves. The limestone is affected by strong Tertiary weathering to a depth of several hundred metres.

The Gordon Limestone is conformably underlain by hard siliceous Moina Sandstone (Lower Ordovician) and conformably overlain by Silurian Crotty Quartzite. Both units outcrop, forming 70-90m high escarpments either side of the low-lying limestone.

The limestone does not outcrop, much of the surficial 20m being highly decomposed and decarbonatized by weathering to firm black or brown clay. This "clay" is actually largely made up of organic matter. The clays are overlain by up to 8m (usually <2m) of hard Moina Sandstone gravel coming off the escarpment and a surface veneer of swampy peat. The surficial organic clays contain significant values of Zn, Pb and Fe, in a deposit directly overlying the sub-surface trace of the basal hard-rock main mineralized zone. The recent work has shown the metals occur within the clays as fine colloform sphalerite and galena, apparently actively depositing within the organic carbon and "growing" in-situ.

Hard-rock<sup>1</sup> Zn-Pb mineralization occurs in three poddy stratiform horizons within the limestone, principally the basal 50m adjacent to the contact with the underlying Moina Sandstone. This main mineralized zone is about 750m long at Grieves and accompanied by strong siderite alteration. It is part of a regionally-extensive zone of siderite alteration along the basal contact of the limestone (Figure 2). Zn-Pb mineralization also occurs in the middle section of the limestone, associated with dolomite breccia and silty/argillaceous beds. Weaker mineralization, accompanied by siderite alteration, occurs at the upper contact with Crotty Quartzite.

CRAE thought the original primary hard-rock mineralization at Grieves was probably mostly sphalerite and of Ordovician age. However, the altered and mineralized limestone has since been extensively oxidized by weathering, mostly during the Tertiary, in places to depths over 400m. In these oxidized zones much of the altered limestone has been converted to stratabound ferruginous or dark grey clays and the mineralization to a complex mixture of zinc sulphides, zinc silicates and zinc carbonates, including zincian siderite.

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<sup>1</sup> "Hard-rock" is a misnomer as much of the mineralization and adjacent altered host rocks are oxidized to vughy broken clays.



***Figure 2: Geology***

## 5. PREVIOUS EXPLORATION

Grieves has been the subject of an energetic exploration effort since the mid 1980's. About \$1.1 million was spent in the period 1992-98 by the CRA Exploration (Rio Tinto) – Allegiance Mining JV alone. When expenditure from the earlier Amoco-EZ JV is added the overall figure would be close to \$2 million.

Zinc mineralization was delineated at Grieves in the 1980's by the Amoco-EZ JV as part of a major search of the Gordon Limestone in the Zeehan area for Irish-style Pb-Zn deposits. The JV conducted geochemical and geophysical surveys, and drilled 40 diamond drillholes to a maximum depth of 737m. The drilling located discontinuous low-grade stratiform zinc mineralization at the base of the limestone (best intersection: 6% Zn over 5m). A second horizon further up in the limestone returned 8% Zn over 7m. Shallow bedrock sampling obtained values as high as 19.5% Zn & 2.4% Pb in weathered limestone. Costeans excavated at these anomalies encountered 20m @ 7% Zn and 8m @ 10% Zn in the surficial clays.

From 1992-97, CRA Exploration undertook a large systematic programme at Grieves. The surficial clays were tested 1992-94 by 400 aircore holes averaging 13m deep. Near the base of the underlying limestone 50 of these holes delineated a 750m long surficial zinc clay deposit with an average grade around 4% Zn. Although mineralogical studies suggested much of the zinc was in low-iron sphalerite CRAE did not carry out metallurgical testing of the clays.

CRAE tested the zinc mineralization in the underlying limestone with 36 diamond holes. The main zone (up to 50m wide and 750m long) at the base of the limestone was directly beneath the surficial zinc clay deposit. The mineralization was a partially-oxidized mixture of zinc sulphides, silicates and carbonates (including sphalerite, smithsonite and zincian siderite). CRAE (Rio Tinto) ceased work in 1997 after concluding Grieves was unlikely to meet their development criteria of at least 16 Mt @ 8% Zn for a viable sulphide deposit, or 1 Mtpa @ 4% Zn for a viable mine in the clays.

The challenge was then taken up by Rio Tinto's hitherto silent JV partner, Allegiance Mining. Using the existing data Allegiance estimated the potential mineral resources at 0.3 Mt @ 5% Zn for the surficial clay and 0.7 Mt @ 8% Zn for the hard-rock (Newnham, 1998a&b). They concluded that the size potential of the hard rock mineralization was "relatively small" with limited scope for increasing it to 2 Mt.

They made a preliminary study of the practicality and financial viability of a small mining operation in the clays, which suggested such a venture could be viable. However, in late 1998 their flotation testing of three 4–16kg clay samples from CRAE aircore holes ZG115, 149 & 180, obtained zinc recoveries of only 26.3%, 13.8% and 29.5% respectively. The poor result was considered to be possibly due to oxidization of the samples which were over five years old at the time of testing.

No further work was carried out at Grieves before the property was applied for by South Eastern Resources in 2004.

## **6. SURFICIAL ZINC CLAY RESOURCE**

### **6.1 Definition**

The surficial zinc clay deposit trends NE for about 750m along the base of the Moina Sandstone escarpment. See Figure 3. It is defined by 50 of the 400 CRAE aircore holes. The 50m-spaced sections drawn by Newnham (1998b) show it varies greatly in width, depth and grade. Overall, it is 15-60m wide (averaging around 30-40m) and 4-20m in depth (at varying distances below surface).

The deposit is broken up by NW-trending faults into three blocks: North, Central and South. The latter two blocks are separated from North Block by the major Grieves Fault, which was encountered by drilling in the limestone beneath where it offsets the mineralization 130m sinistrally. The clay deposit naturally mirrors the offset.

CRAE's vertical aircore holes were spaced at 10m intervals along the drill sections so the sectional information is generally satisfactory, although Newnham (1998b) identified several where the holes either didn't extend fully across the deposit or didn't go deep enough to bottom it. A greater problem is the excessive spacing of the drill sections which are up to 140m apart, although mostly 50-80m apart. This leaves significant untested gaps within the deposit particularly at the northern ends of the South and Central blocks. The NE and SW extremities of the deposit are also ill-defined with potential extensions in both directions, especially the latter.

Newnham considered another 90 holes (1800m) would be required to define a pre-mining resource, with the final drill pattern roughly 25-35m x 10-15m. Given the problem outlined below it is possible even this pattern would be insufficient.

### **6.2 Grade Variability**

The 2m samples in the CRAE aircore holes showed the grade of the clays within the deposit varies from 1% Zn to 28% Zn. Grade distribution is extremely variable and Newnham's sections display a fairly low level of grade correlation between holes only 10m apart. Some typical sections are shown in Figure 4. The best grades tend to be towards the SW end of South Block.

As reported in Section 7, this mirrors the experience during pitting – the grades were variable, there was poor correlation with the corresponding aircore holes and the best Zn grades were in the south-western-most two pits in South Block.

***Figure 3: Surficial Zinc Clays – Plan***

***Figure 4: Surficial Zinc Clays - Sections***



### 6.3 Resource Calculations

In December 2005, Tracie Burrows for South Eastern Resources calculated a JORC-compliant Inferred Resource for the zinc clays of 409,000t @ 3.9% Zn (Burrows, 2005). This was made up as follows:

**Table 1: Zinc Clays Inferred Mineral Resource (Burrows 2005)  
(Dry Tonnes)**

Block	Tonnes	Zn (%)	Pb (%)	Ag (g/t)	Fe (%)	S (%)	Cu (ppm)	As (ppm)	Mn (%)	Mg (%)
North	164,000	3.2	0.1	0.5	4.7	3.0	67	17	0.1	0.5
Central	65,000	1.1	0.2	2	11.5	9.3	46	-	0.1	-
South	180,000	5.6	0.6	3	6.1	6.5	50	84	0.2	0.4
<b>TOTAL</b>	<b>409,000</b>	<b>3.9</b>	<b>0.3</b>	<b>1.8</b>	<b>6.4</b>	<b>5.5</b>	<b>56</b>	<b>44</b>	<b>0.1</b>	<b>0.4</b>

In the absence of any density measurements Burrows calculated the figure on a dry tonnes basis using a bulk density of 1.7, being the figure for dry pulverized clay. Newnham (1998b) had also used this 1.7 figure in his Potential Resource calculation of 294,000t @ 5.3% Zn.

Since Burrows did her calculation bulk density measurements have been made by Ammtec on clays from the five pits. The measurements of the damp material as it occurs in-situ averaged 1.45, with a range from 1.29 to 1.56.

A revised Inferred Resource has been calculated using Burrows' volume figures and a bulk density of 1.4. This calculation is on a wet tonnes basis. The Central Block has been taken out, as realistically 1.1% Zn does not constitute a resource. However, Newnham (1998b) put a figure of 34,000t @ 3.6% Zn on this block so there is some resource here, albeit at a lesser tonnage and better grade than that calculated by Burrows.

The revised Inferred Resource is as follows:

**Table 2: Revised Zinc Clays Inferred Mineral Resource  
(Wet tonnes)**

Block	Tonnes	Zn (%)	Pb (%)	Ag (g/t)	Fe (%)	S (%)	Cu (ppm)	As (ppm)	Mn (%)	Mg (%)
North	135,000	3.2	0.1	0.5	4.7	3.0	67	17	0.1	0.5
South	148,000	5.6	0.6	3	6.1	6.5	50	84	0.2	0.4
<b>TOTAL</b>	<b>283,000</b>	<b>4.5</b>	<b>0.4</b>	<b>1.8</b>	<b>5.4</b>	<b>4.8</b>	<b>58</b>	<b>52</b>	<b>0.2</b>	<b>0.4</b>

## **7. PIT SAMPLING**

On 3<sup>rd</sup> - 4<sup>th</sup> January 2006, five pits were excavated into the zinc clays to a maximum depth of 4.8m. From each pit a bulk sample comprising six 20-litre plastic pails of material (about 150kg) was taken from the selected depth interval, immediately sealed and dispatched for metallurgical testing. In addition, a 3-5kg representative assay sample was taken from each pit. Two-litre liquor samples were taken from three pits.

### **7.1 Pit Siting**

Pit locations are shown in Figure 3. The pitting aimed to test North and South blocks. Pit sites were chosen to coincide with CRAE aircore holes where values in excess of 2.5% Zn had been obtained within 4m of surface (considered the practical limit for the excavator in the damp ground). Only six out of the 50 aircore holes into the clay deposit met this criteria:

North Block: Holes ZG115 & 264

South Block: Holes ZG170, 178, 181 & 368

Although pits were dug at all these sites, Pit 178 had to be aborted when it struck hard quartz sandstone (a huge detached block of Moina Sandstone?) just below the buttongrass at the designated location. This highlights a problem that became evident during pitting. The aircore holes were drilled in 1992-94 and since then the pegs marking the hole collars have suffered from weather and human interference. Except for Pit 368 where the original drill peg was still in place, all sites had to be located by GPS as the pegs were either missing or had clearly been disturbed.

AMG co-ordinates used for the GPS (unit accuracy  $\pm 2$ m) were obtained from last-edition CRAE drill logs, which agreed with hole positions as shown on prospect plans. However, on the ground it is clear from the locations of in-situ grid pegs, local features and the substantial mismatch of some pit versus aircore geology and likewise assay values, that the log co-ordinates don't quite match actual ground position. The errors are not consistent and are estimated to be in the order of 10-12m maximum.

This is more or less confirmed by the location of aircore hole ZG368, the only peg in its original position, with log co-ordinates 5349175N, 364459E. The GPS put the peg position 11m further south and 3m further east at 5349164N, 364462E. While these co-ordinate errors don't sound much, they are significant in the context of a deposit as little as 15-20m wide in places and with zinc grades showing marked variations between 10m-spaced drill holes.

### **7.2 Pit Details & Summary Results**

Partly because of the co-ordinate discrepancies there was considerable variation in grade between the pits and aircore holes supposedly on the same sites, as shown in Table 3:

**Table 3: Grade Correlation between Pits and Aircore Holes**

Sample Site	Pit Zn %	Hole Zn %	Pit Pb %	Hole Pb %
Pit 115, 2.6- 4m / Hole ZG115, 2.8- 4m	2.84	9.32	0.06	0.23
Pit 170, 2-4m / Hole ZG170, 2-4m	2.53	3.09	0.10	1.88
Pit 181, 2-4m / Hole ZG181, 1.5–4m	17.5	7.81	1.45	2.2
Pit 264, 1.5-2.25m / Hole ZG264, 3-6m	2.69	3.58	0.09	0.07
Pit 368, 2-4m / Hole ZG368, 2-4m	4.98	2.67	1.63	0.46

**Pit 368:** The SW-most pit in South Block.  
 AMG co-ords (GPS): 5349164mN / 364462mE  
 Depth: 4m  
 Sample interval: 2 - 4m  
 Ammttec pit assay: 4.98% Zn, 1.63% Pb (CRAE Aircore: 2.67% Zn, 0.46% Pb)  
 Organics: 73.7%  
 Bulk density: 1.51  
 Pit liquor: pH 4.82; Zn 0.02 mg/l  
 Log: 0 – 2m: Semi-consolidated white quartz sandstone gravel  
 2 – 2.6m: Black to dark brown firm clay  
 2.6 – 4.0m: Firm brown (minor grey patches), weathered clayey rock with fine pale banding (not seen in-situ). Veinlets after carbonate.



*Pit 368. Fine banding in zinc-rich organic clays (field of view = 20cm).*

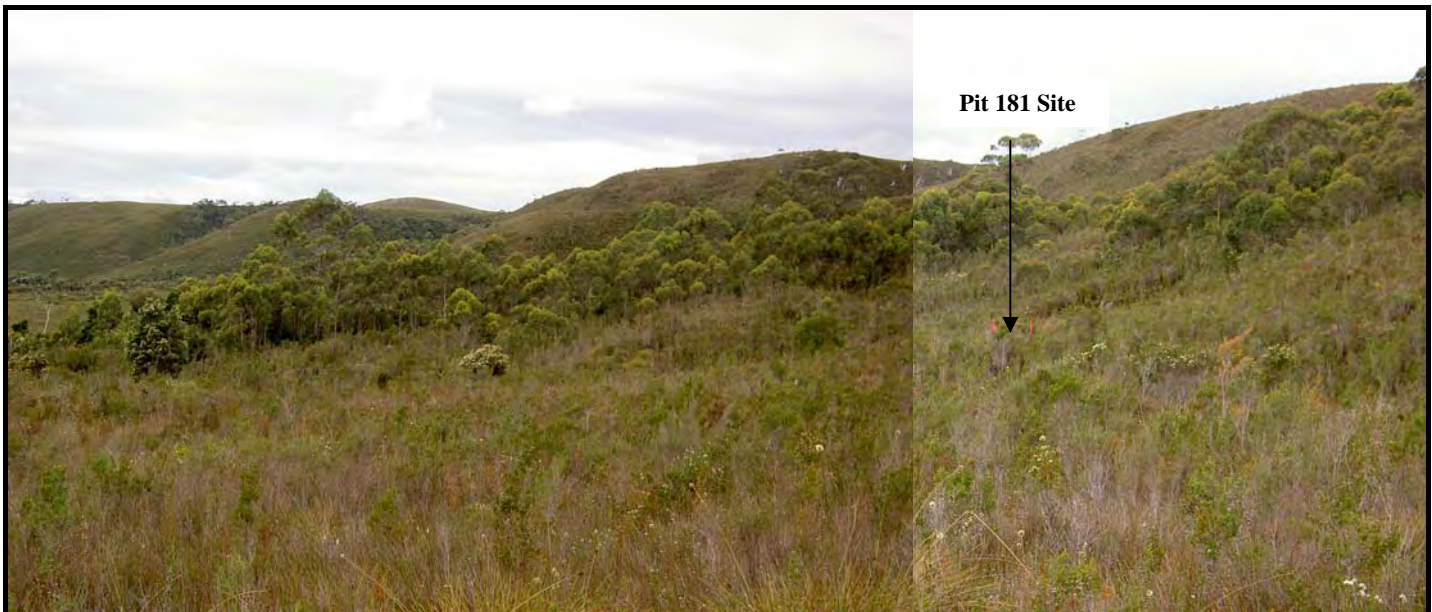
*Pit 368. Brown organic zinc clays grading 5% Zn and 1.6% Pb, beneath quartz sandstone gravel*





**Pit 181:** South Block, ~50m NE of Pit 368  
AMG co-ords (GPS): 5349206mN / 364495mE  
Depth: 4.5m  
Sample interval: 2 - 4m  
Ammtec pit assay: 17.5% Zn, 1.45% Pb  
(CRAE Aircore: 7.81% Zn, 2.2% Pb)  
Organics: 80%  
Bulk density: 1.55  
Pit liquor: pH 4.43; Zn 0.01 mg/l  
Log:  
0 – 1m: Black sticky peat  
1 – 2m: Semi-consolidated quartz sandstone gravel  
2 – 4.5m: Light orange-brown to dark brown,  
  
firm, lightweight, totally oxidized clayey rock with black partings. Occasional green partings (chlorite?) below 4m.

*Pit 181. Brown organic zinc clays grading 17.5% Zn and 1.45% Pb.*



*Looking NW along South Block of zinc clay deposit from vicinity of Pit 181.*

**Pit 170:** South Block, ~45m NE of Pit 181  
AMG co-ords (GPS): 5349238mN / 364532mE  
Depth: 4.8m  
Sample interval: 2 - 4m  
Ammtec pit assay: 2.53% Zn, 0.1% Pb (CRAE Aircore: 3.09% Zn, 1.88% Pb)  
Organics: 49.9%  
Bulk density: 1.56  
Pit liquor: pH 6.25; Zn 0.07 mg/l  
Log:  
0 – 0.3m: Black peat.  
0.3 – 0.9m: Quartz sandstone gravel  
0.9 – 2.0m: Grey and brown, weathered clayey blocky rock with some fine banding (not seen in-situ)  
2.0 – 4.0m: Black to dark brown, soft clayey crumbly rock. Material is heavier than in Pits 368 & 181  
4.0 – 4.5m: Fawn to pale grey, firm oxidized limestone  
4.5 – 4.8m: Pale grey/fawn, harder weakly oxidized limestone.  
All rock below 0.9m dips NW at 45°.



*Pit 170. Brown to black organic zinc clays grading 2.5% Zn in contact with pale oxidized limestone (to the right). Note 45° dip of clays and limestone towards camera.*





Site of Pit 115, North Block. View to SW across Grieves Fault 100m from camera, which offsets clay deposit 130m to left of picture.



<b>Pit 115:</b>	North Block, middle section
AMG co-ords (GPS):	5349634mN / 364729mE
Depth:	4.3m
Sample interval:	2.6 – 4m
Ammtec pit assay:	2.84% Zn, 0.06% Pb (CRAE Aircore: 9.32% Zn, 0.23% Pb)
Organics:	63.5%
Bulk density:	1.29
Log:	
0 – 0.2m:	Black peat
0.2 – 2.6m:	Coarse bouldery (to 45cm) quartz sandstone gravel
2.6 – 4.3m:	Dark brown to black, totally oxidized clayey rock – some relict bedding (not seen in-situ) & pale (after carbonate) veining. Quite soft and lightweight. Abundant black partings.

Pit 115. Dark brown to black organic zinc clays grading 2.8% Zn overlain by 2.6m of coarse gravel.

**Pit 264:** North Block – in old DMR quarry  
AMG co-ords (GPS): 5349705mN / 364826mE  
Depth: 2.5m  
Sample interval: 1.5 – 2.25m  
Ammtec pit assay: 2.69% Zn, 0.09% Pb  
(CRAE Aircore: 3.58% Zn, 0.07% Pb)  
Organics: 85.8%  
Sulphur: 6.37%  
Bulk density: 1.32  
Log:  
0 – 1.5m: Quartz sandstone gravel with stained brown to black matrix  
1.5 – 2.25m: Dark brown, firm clayey oxidized rock with 2-3cm thick near-vertical seams of soft black lustrous material with sub-concoidal fracture. Relict near-vertical carbonate veinlets  
2.25-2.5m: Pale fawny-brown, moderately hard (from totally rotten and soft to quite hard), oxidized shaley and sandy impure limestone.



*3cm seam of black amorphous organic material in zinc clay, Pit 264.*





*Coal-like organic zinc clays from Pit 264. This pit had the highest total carbon content at 28%.*

### **7.3 Discussion of Pit Geology**

In all pits the clay, despite its lignitic nature, appeared to be after rotten in-situ limestone. Pits 170 & 264 bottomed in limestone. Relict bedding and carbonate veining was occasionally visible in the clay but only measurable in Pit 170 where bedding dipped 45° NW, as did the underlying limestone. Where encountered in pits 170 & 264 the clay base was irregular and generally gradational, merging into harder less-oxidized limestone. The limestone was notably paler in colour than the clay.

The clay was not saturated, puggy or sloppy as had been anticipated, but firm and blocky, damp, lightweight and brown to black colour. All pits had free-standing vertical walls. There was a small amount of soft black pug in some samples, notably Pit 170.

Vein-like seams and partings of coaly, soft black lustrous amorphous organic material with sub-concoidal fracture, were common in some pits and spectacular in Pit 264 (see photographs). A sample of this material in Pit 264 was analysed – see Section 11.1.1. The organic component of the clay from pits 181 & 264 was studied by Neil Sherwood of CSIRO Petroleum – see Section 11.3.

## 8. METALLURGICAL TEST PROCEDURES

The pit samples were sealed in the field and delivered within 30 hours to Ammtec's Burnie Research Laboratory where they were immediately frozen to prevent oxidation.

The full range of tests carried out and the results, are detailed in Lai (2006). In sequence, the tests involved:

- Analysis of the 3-5kg assay samples from each pit for Zn, Pb, Ag, Cu, As, Fe, Ba, Au, Mn, Cd, Na, Mg, Al, SiO<sub>2</sub>, total C, non-carbonate C, elemental C, total S and sulphide S. Duplicates were done for Pit 115 (*with good agreement*).
- Size analysis, bulk density and solids SG measurements on all assay samples.
- EDTA extraction to determine degree of oxidation of zinc and lead minerals.
- XRD and SEM mineralogical analysis of the assay samples plus additional black vein sample from Pit 264, by Stafford McKnight, University of Ballarat.
- XRD and SEM mineralogical analysis of the assay samples from Pits 181 & 368 by Keith Scott of CSIRO, NSW.
- Mineralogy and mineral liberation assessment by Gary McArthur, MODA, Burnie.
- Acid and soda ash consumption tests on each assay sample.
- Flotation testing at Burnie of bulk sample from Pit 181.
- Flotation testing at Century Mine of bulk sample from Pit 181.
- Flotation test at Burnie of 9:1 blend of Rosebery ore and Pit 181 bulk sample.
- Gravity separation by shaking table on sized fractions of Pit 181 bulk sample.
- Gravity separation by Falcon Concentrator on Pit 181 bulk sample.
- Organic petrological analyses of grab samples from Pits 181 & 264 by Neil Sherwood of CSIRO Petroleum, NSW. (*Not reported by Lai - appears as Appendix 1 in this report*).

## 9. FLOTATION RESULTS

The following is a selective summary of Ammtec's metallurgical testwork. Section 9 covers the flotation tests and associated work including geochemical analyses and sizing. Gravity separation trial results appear in Section 10 and mineralogical studies in Section 11. For full results see Lai (2006).

### 9.1 Head Assays

See Table 4.

**Table 4: Head Assays of Pit Samples**

Pit No.	Zn %	Pb %	Ag g/t	Cu ppm	As ppm	Fe %	Ba ppm	Au g/t	Mn ppm
115	2.84	0.058	2	40	<50	0.79	40	<0.1	20
170	2.53	0.103	2	20	<50	4.01	30	<0.1	300
181	17.5	1.45	3	50	250	2.10	<10	<0.1	10
264	2.69	0.088	3	20	<50	4.33	<10	<0.1	140
368	4.98	1.63	12	290	100	1.10	10	<0.1	<10

Pit No.	Cd ppm	Na ppm	Mg ppm	Al %	SiO <sub>2</sub> %	S total %	S total Repeat%	Sulphide S %	Calc SO <sub>4</sub>
115	10	1010	1040	1.16	32.8	2.63	2.38	1.77	2.58
170	20	890	12400	0.77	35.0	4.94	4.60	3.72	3.66
181	330	250	320	2.27	9.16	11.5	10.7	10.3	3.60
264	20	590	5710	0.87	3.02	6.89	6.37	4.04	8.55
368	130	6800	1110	1.21	22.9	3.74	3.63	2.93	2.43

Pit No.	Total Carbon %	Non-carbonate Carbon %	Calc CO <sub>3</sub> %	Elemental Carbon %	Calc Organic Carbon %	Dry Solid SG	Bulk Density Wetcake	Moisture Content %
115	16.7	16.6	<0.15	2.32	14.3	2.23	1.29	
170	7.79	6.28	7.55	1.89	4.39	2.62	1.56	
181	16.8	16.5	0.15	1.55	15.0	2.31	1.55	42.9
264	27.8	26.3	7.50	16.3	10.0	1.80	1.32	
368	21.5	20.6	4.50	10.6	10.0	2.10	1.51	

Source: Lai, 2006

All samples have high carbon contents, of which between 36% and 89% is organic carbon. Most sulphur present is in sulphides and sulphur mass balance calculations (Table 5) suggest that no significant amounts of non-sulphide zinc minerals are present (confirmed by EDTA and acid solubility tests in Sections 9.3 and 9.4).



**Table 5: Sulphur Mass Balance Calculation**

	Pit 181	Pit 368
S required to balance Zn in sphalerite	8.58	2.44
S required to balance Pb in galena	0.22	0.25
S required to balance Fe in pyrite	2.41	1.26
TOTAL	11.21	3.95
S as assayed by Ammtec (average of 2 assays)	11.1	3.69

Source: After Scott, March 2006

## 9.2 Sizing

Sizing analysis was carried out on the dried unground pit assay samples. A selective summary of the results for Zn is shown in Table 6:

**Table 6: Zinc Size Distribution**

Size microns	Pit 115 Zn Distribution %	Pit 170 Zn Distribution %	Pit 181 Zn Distribution %	Pit 264 Zn Distribution %	Pit 368 Zn Distribution %
>300	16.2	18.3	25.0	10.4	18.4
+106-300	11.4	9.7	13.4	38.1	19.5
+38-106	25.9	15.9	21.3	23.5	27.4
+5-38	12.7	13.1	18.5	9.1	19.2
-5	33.8	43.0	21.8	18.9	15.5

Source: After Lai, 2006

The fine grained nature of the sphalerite is notable. In all pits (except 264 which had 40%) the majority of the Zn reported to the <75 micron fraction, ranging up to 67% in Pit 170.

## 9.3 EDTA Extraction

EDTA dissolves non-sulphide Pb, Zn and Fe. The amount of metal extractable by EDTA gives an indication of the degree of oxidation. Results were as follows:

**Table 7: EDTA Extractable Metal (%)**

Metal	Pit 115	Pit 170	Pit 181	Pit 264	Pit 368
Zn	3.6	10.0	1.0	8.7	1.4
Pb	42.5	29.7	39.8	26.5	36.3
Fe	14.3	15.5	6.2	25.9	5.9

Source: After Lai, 2006

The results indicate a significant amount of the lead is present as oxide, hydroxide or carbonate. The zinc is present overwhelmingly as sulphide, a fact confirmed by tests for solubility in sulphuric acid (see 9.4 below) which showed only a minor fraction of the zinc is acid soluble (ie: not sphalerite).

#### 9.4 Reagent Consumption Tests

As a precursor to flotation trials tests were made on the pit assay samples for consumption of soda ash and sulphuric acid. See Table 8.

In the case of soda ash the target pH was 9 (the pH of the flotation feed at Rosebery). It was found that to achieve a pH of 8-9 soda ash consumption was extremely high with levels between 88 kg/t and 205 kg/t (cf: <0.5 kg/t at Rosebery).

*The cost of this level of soda ash is of the same order as the likely value of recoverable zinc in the Grievess clays.*

**Table 8: Soda Ash & Sulphuric Acid Consumption**

Reagent	Unit	Metal	Pit 115	Pit 170	Pit 181	Pit 264	Pit 368
Na <sub>2</sub> CO <sub>3</sub>	Kg/t		124.9	87.8	179.6	144.1	205.4
H <sub>2</sub> SO <sub>4</sub>	% acid soluble	Zn	9.7	17.4	3.2	15.0	3.3
		Cu	3.4	11.8	30.5	24.0	1.4
		Fe	0.02	0.02	0.01	0.03	0.01
		Al	38.8	28.6	80.8	73.2	59.1

*Source: After Lai, 2006*

It is worth noting that essentially all the 17.5% Zn in Pit 181 is in sphalerite.

#### 9.5 Flotation Testing

It was decided to initially carry out flotation testing on the Pit 181 bulk sample because it had the highest zinc grade. After it became clear the clay responded badly to flotation the remaining samples were not tested.

A series of flotation tests were carried out at Burnie including on a 9:1 blend of Rosebery ore and Pit 181 material. Further flotation tests, involving a carbon prefloat stage, were carried out by Zinifex metallurgists at Century Mine in Queensland.

##### 9.5.1 Flotation of Pit 181 Sample – Burnie

Two flotation tests on straight Pit 181 material produced dreadful results. In the first it was found impossible to get the pH to the required 9 without using huge amounts of soda ash and usage was limited to 30 kg/t, producing a pH of 7. At normal flotation reagent levels the froths were entirely barren. When excessive reagent levels were employed a miniscule amount of zinc was recovered but no lead.

In the second test the Pit 181 material was wet screened and the <38 micron fraction discarded (it was considered to be the material that was soaking up the reagents). The remaining sample was lightly ground to pass 106 microns. Again, soda ash consumption was high and 20 kg/t was used to get the pH to 8. This produced a zinc concentrate grading 27.6% Zn at 54.7% recovery and a lead concentrate grading 2.5% Pb at 2.8% recovery. These figures involve only modest upgrading of the 17.5% Zn & 1.45% Pb Pit 181 head grade. As the flotation feed was only part of the original material overall recovery would have been much lower.

Another major problem with the clay appeared during these tests. The flotation products were extremely slow to settle and filter, due to the fineness of the material and the organic carbon content.

### **9.5.2 Flotation of Pit 181 Sample - Century Mine**

As Zinifex's Century Zn-Pb mine in Queensland employs a prefloat to deal with carbon in their ore, 25 kg of Pit 181 clay was sent to Century for testing by this process.

Results were again poor. The zinc concentrate graded 24% Zn for a recovery of 39%. Only 23.7% of the lead was recovered in a "concentrate" grading just 2.2% Pb.

### **9.5.3 Flotation of Rosebery Ore : Pit 181 Blend**

About 40 kg of crushed Rosebery ore was obtained from the mill feed conveyor and tested by Ammtec using the normal Rosebery mill process. This was done to provide a reference benchmark against the two tests of a 9:1 blend of Rosebery ore and Pit 181 clay. The first of the blend tests used the same procedure as that for the Rosebery ore. The second involved the addition of sodium silicate to disperse fine gangue material (*improvements were marginal*).

These crucial tests showed that the Grieves clay badly affected the flotation performance of Rosebery ore. The main problems noted with the blend were:

#### **1. High reagent consumption.**

Soda ash consumption was 11-12 kg/t – 9x that used by Ammtec on the unblended Rosebery ore and almost 30x the normal 0.4 kg/t used in the Rosebery mill. Lime consumption was up 3-4x to 2 kg/t.

#### **2. Depressed zinc recovery.**

Zn recovery was depressed to 77%, down from 83% for Ammtec's test on Rosebery ore and poor by comparison with the normal 91-93% zinc recovery in the Rosebery mill.

#### **3. Contamination of the zinc concentrate.**

The zinc concentrate was heavily contaminated with 6% Pb. This was 9x the lead level Ammtec achieved with Rosebery ore zinc concentrate (0.66% Pb).

**4. Zinc losses to tailings.**

19% of the zinc was lost in the zinc rougher tail, compared to only 0.76% loss achieved by Ammtec with Rosebery ore.

**5. Lead circuit upset.**

Lead recovery was halved to 46%, versus 91% for Ammtec's Rosebery ore test. The lead circuit flotation kinetics also dramatically slowed when the clay was introduced.

**6. Slow filtration.**

Filtration of the blend flotation products was extremely slow.

*It is abundantly clear that these problems make the Grieves clay totally unsuitable for introduction into the Rosebery mill circuit.*

## **10. GRAVITY SEPARATION TESTS**

Following the disappointing flotation trials the option of creating a sphalerite concentrate from the clay by gravity methods was investigated. This involved testing material from the high grade Pit 181 on a shaking table and in a Falcon concentrator.

### **10.1 Tabling**

The sample was screened and three size fractions: >212 micron, <212 >38 micron, and <38 >20 micron, tested on the table. The middlings from the first tabling of the <212 >38 micron fraction were tabled again in an attempt to obtain more concentrate.

Results were extremely poor. For the >212 micron and <38 >20 micron fractions the zinc grade of the tailings was actually higher than for the "concentrate", whose grade was lower than the head grade of the material – the sample had been degraded rather than upgraded. Although there was about 50% upgrading in the concentrate of the <212 >38 micron fraction, the re-tabling of the middlings produced a second concentrate with grade only marginally higher than its tailings. In all three cases the first-pass concentrate represented a zinc recovery of less than 10% and only reached 16% with the two passes in the <212 >38 micron fraction.

Results for lead were equally poor – no upgrading at all in the concentrate for the >212 micron fraction, a minimal 10% upgrade after the two passes for the <212 >38 micron fraction, and 16% upgrade for the <38 >20 micron fraction. In all cases lead recovery was less than 13%.

The tabling test results for zinc are summarized in Table 9.

**Table 9: Gravity Tabling Results for Zinc – Pit 181**

Size Fraction	>212 Micron Fraction		
Product	% Weight	% Zinc	% Recovery
Calc feed grade		20.5	
Concentrate	8.2	20.2	8.0
Middlings	11.8	14.6	8.4
Tailings	80.0	21.4	83.5
Size Fraction	<212 >38 Micron Fraction (2 passes)		
Calc feed grade		18.0	
Concentrate	11.8	24.9	16.3
Middlings	16.1	24.4	21.8
Tailings	72.1	15.5	61.8
Size Fraction	<38 >20 Micron Fraction		
Calc feed grade		22.0	
Concentrate	8.6	17.9	7.0
Tailings	91.4	22.4	93.0

Source: After Lai, 2006

## 10.2 Falcon Concentrator

The Falcon concentrator generates a high gravitational force by centrifugal action. Denser particles adhere to the chamber wall and are collected. A slurry of sample 181, with a low slurry density of 8%, was tested in the concentrator for 7 minutes.

Results were extremely poor. There was minimal upgrading of the zinc in the concentrate to 21% from the assay head grade of 17.5% Zn, with the concentrate representing a zinc recovery of just 9%. The tailings grade was 16.7% Zn. Results for lead were no better - the concentrate graded 2% Pb compared to the 1.45% head grade, with the concentrate representing 14% recovery. Tailings grade was 1% Pb.

## 11. MINERALOGY RESULTS

### 11.1 XRD and SEM Analysis

Small amounts of pulverized assay sample from each pit and a hand specimen of the black vein material from Pit 264, were sent by Ammtec to Stafford McKnight at the University of Ballarat for identification of the mineral species. Grab samples of material from the two highest zinc-assaying pits 181 & 368 were also sent by Zinifex to Keith Scott at CSIRO, NSW, for detailed mineralogical assessment.

Both reports are in Appendix E of Lai (2006). There are discrepancies in duplicated determinations between Ammtec, McKnight and Scott, which can be put down to the small amount of sample given to McKnight and the less than fully representative nature of the grab samples given to Scott. The % values quoted by McKnight and Scott should be taken as indicative only.



### 11.1.1 Results - S. McKnight

McKnight identified the major component of all samples as a dark amorphous organic-rich substance with the appearance of desiccated gel. This material was host to most of the sulphides present, especially the sphalerite. XRD determined the following components:

**Table 10: Quantitative XRD Results**

	Pit 115	Pit 170	Pit 181	Pit 264	Pit 368	Black seam Pit 264
<b>Amorphous organic content</b>	<b>63.5</b>	<b>49.9</b>	<b>80.0</b>	<b>85.8</b>	<b>73.7</b>	<b>89.2</b>
<b>Quartz</b>	<b>21.1</b>	<b>16.6</b>	<b>2.0</b>	<b>1.7</b>	<b>14.3</b>	<b>1.6</b>
<b>Muscovite</b>	<b>11.6</b>	<b>16.0</b>	<b>2.1</b>	<b>1.6</b>	<b>4.5</b>	<b>1.4</b>
<b>Chlorite</b>	<b>0.2</b>	<b>0.4</b>	<b>0.1</b>	<b>0.2</b>	<b>0.9</b>	<b>0.2</b>
<b>Pyrite</b>	<b>1.0</b>	<b>5.9</b>	<b>2.4</b>	<b>6.9</b>	<b>1.4</b>	<b>5.3</b>
<b>Sphalerite</b>	<b>2.1</b>	<b>2.2</b>	<b>12.0*</b>	<b>1.9</b>	<b>3.3*</b>	<b>1.9</b>
<b>Galena</b>	<b>0</b>	<b>0.3</b>	<b>0.7</b>	<b>0.3</b>	<b>1.2</b>	<b>0.2</b>
<b>Dolomite</b>	<b>0.1</b>	<b>6.8</b>	<b>0.1</b>	<b>0.7</b>	<b>0</b>	<b>0</b>
<b>Anhydrite</b>	<b>0</b>	<b>0</b>	<b>0.4</b>	<b>0.5</b>	<b>0</b>	<b>0</b>
<b>Kaolin</b>	<b>0.4</b>	<b>1.9</b>	<b>0.1</b>	<b>0.2</b>	<b>0.7</b>	<b>0</b>
<b>Goethite</b>	<b>0</b>	<b>0.1</b>	<b>0</b>	<b>0.2</b>	<b>0</b>	<b>0.2</b>

Source: From S. McKnight, May 2006

\* An obvious understatement as Ammtec's head assays of both samples contained more zinc than this.

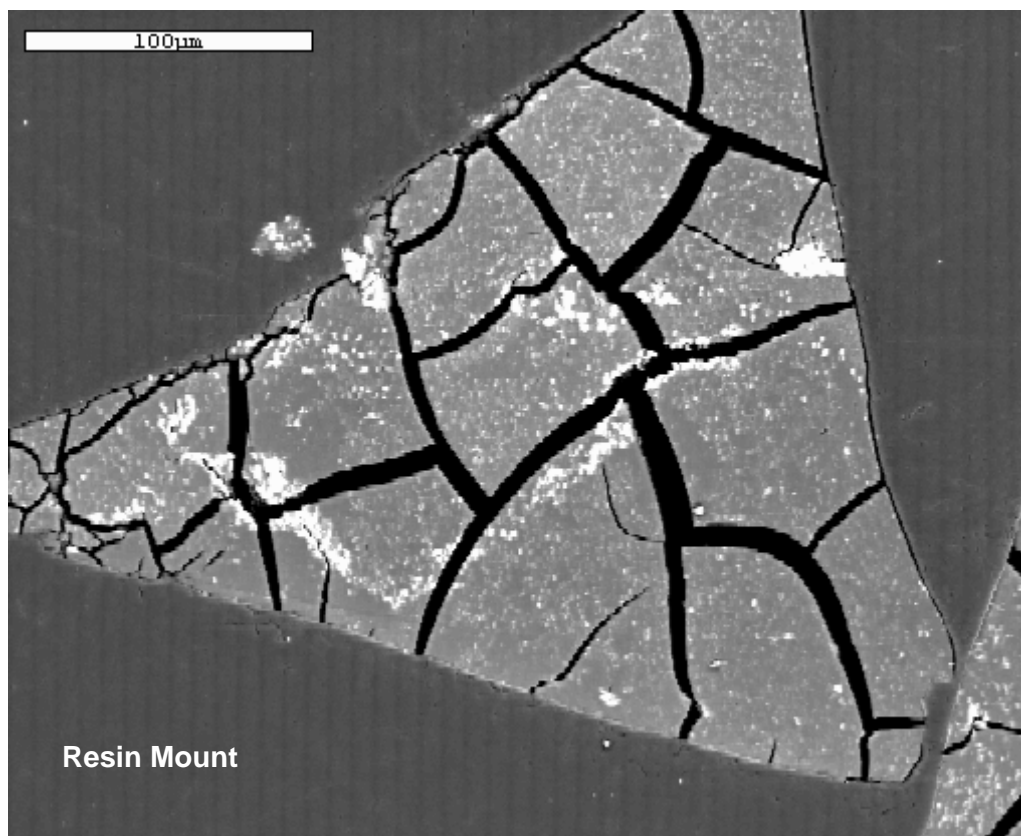
McKnight's SEM images showed that much of the sphalerite was very fine grained (<10 micron). He also detailed coarser forms (>100 micron) with colloform texture including colloform sphalerite overgrown by galena. It is believed this is the first time such textures have been noted in the Grieves clays. See Figures 5 & 6.

### 11.1.2 Results - K. Scott

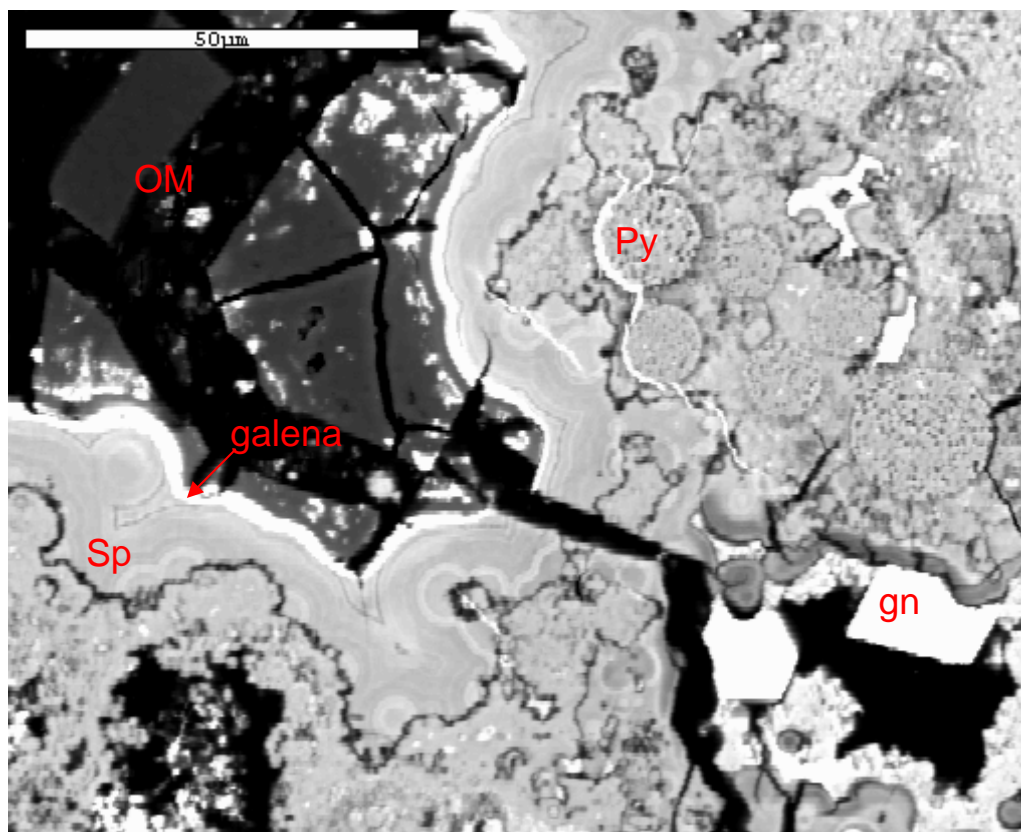
Keith Scott's examination of samples from pits 181 & 368 included isotopic analysis of the carbon. This was found to have an isotopic ratio ( $\delta^{13}\text{C}$ ) of  $-27\%$ , consistent with organic carbon found in sediments. His SEM images showed the sphalerite is finely distributed through the organic matrix which in places resembles coal.

There were some relatively large fragments of sphalerite (up to 1500 x 600 micron) in sample 181, but detailed analysis of these showed they were actually collections of tiny grains within the organic material (see Figures 7 & 8). Scott concluded:

"These results suggest that the sphalerite occurs as grains within an organic matrix, with the largest of these being about 30 x 15 microns. Pyrite and galena of somewhat similar size are also present in the samples. The intimate association of the sulphides with coal-like material suggested possible similarities to sulphides in lignite in palaeochannels."

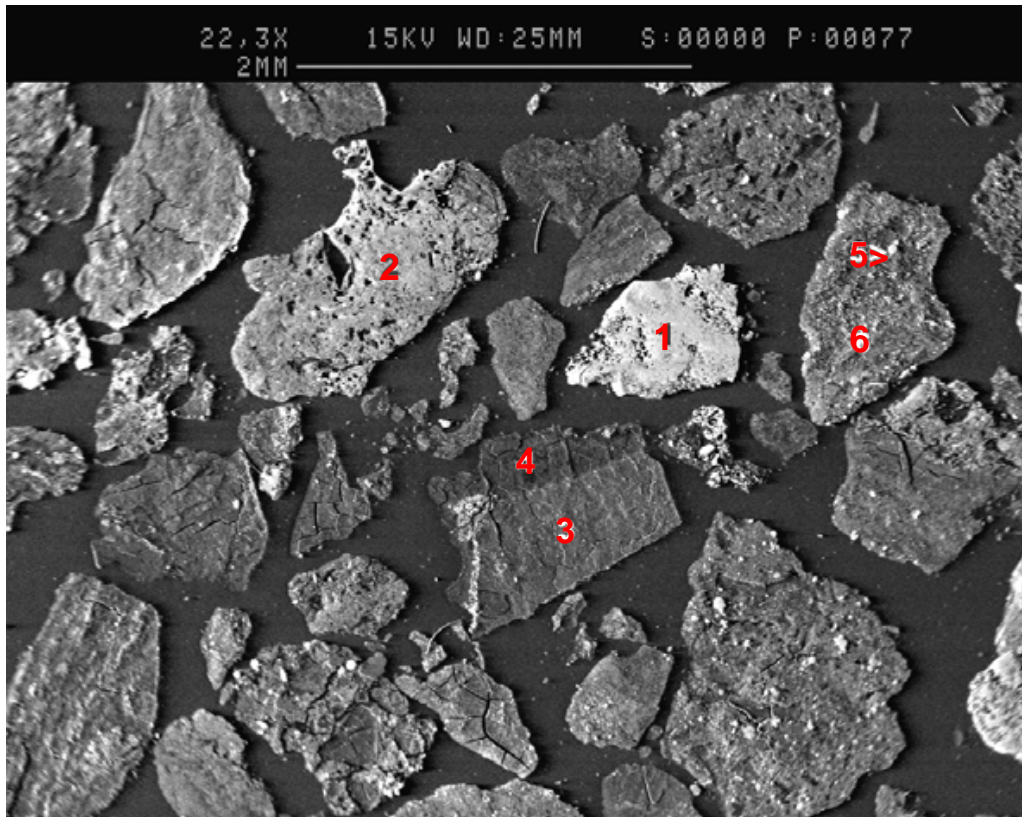


**Figure 5:** From S McKnight: SEM BSE image obtained from polished sections showing typical amorphous organic particles in samples provided. Note the desiccation cracks, bright spots are mainly sphalerite.



**Figure 6.** From S. McKnight: Colloform sphalerite with secondary galena overgrowth – SEM BSE image. OM = Organic Matter.





**Figure 7.** From S. McKnight: Backscattered electron image of fragments, Pit 181.  
1,2 = Sphalerite. 3,4 = Aluminosilicate. 5 = Pyrite. 6 = Sphalerite & Aluminosilicate.



**Figure 8.** From S. McKnight: Detail fragment 2 – sphalerite in organic matrix.

## 11.2 Mineralogy by G. McArthur

Sized assay pulps from all pits were sent by Ammtec to Gary McArthur in Burnie for sulphide liberation analysis of the various size fractions. Difficulty was experienced in mounting the samples due to the hygroscopic nature of the carbon. Initial examination indicated that normal fraction-by-fraction liberation analysis would be extremely difficult for such ultrafine-grained carbon-rich material. In the end only the >300 micron fraction in each sample was examined for the sulphide grain textures.<sup>2</sup>

In looking at the results below it must be borne in mind that Scott and McKnight's work indicated sulphide grains >300 micron are a small percentage of overall sulphides.

There was surprising variation in the textural forms of sphalerite and galena in the >300 micron fraction between the five pits:

**Pit 115:** Most sp was in <30 micron grains within sericite and clay.

**Pit 170:** Most sp was either <15 micron intergrowths with organics, coarse >1mm grains with gn inclusions, or colloform growths to 750 micron with included py framboids. Gn (<100 micron) occurred as euhedral veinlets in chlorite.

**Pit 181:** High-grade material with colloform sp to 750 micron as the dominant type, and ultrafine (<15 micron) sp-organics intergrowths as subordinate type. Gn mostly as ultrafine (<0.5 micron) semi-colloform grains within amorphous organics.

**Pit 264:** All sp as ultrafine intergrowths (<15 micron) in organics, clay and sericite.

**Pit 368:** No dominant sp form, most <100 micron and some <10 micron. Forms included colloform growths to 750 micron (with py framboids); <10 micron semi-colloform sp in amorphous organics; rhombic pseudomorphs to 65 micron in sericite/clay; brecciated grains to 200 micron with gn; and contorted coarse-grained fragments of sp (<100 micron) in organics/clay.<sup>3</sup> Gn occurred as <12 micron framboid replacements within colloform sp.

See Figure 9 A-C.

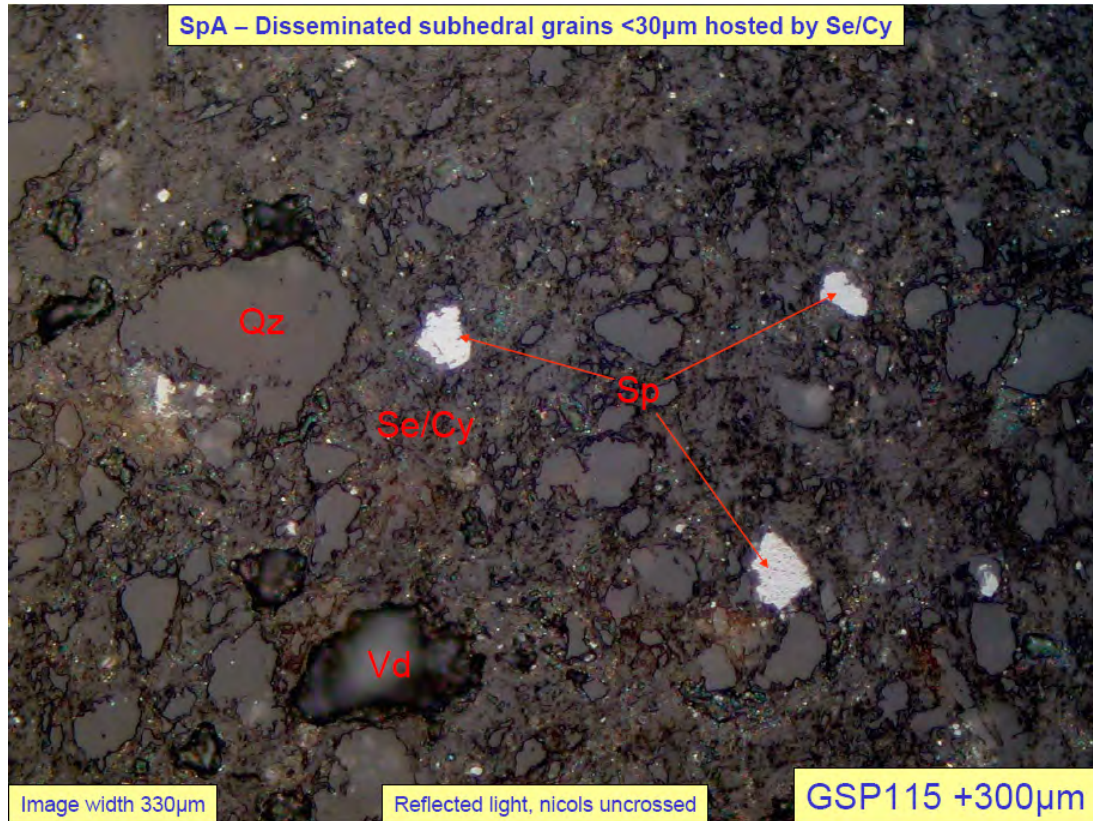
McArthur concluded the sphalerite and galena would be extremely difficult to liberate due to their fine grain size and association with organics: "flotation concentration is unlikely to be economic." Only the coarsest >1mm types of sphalerite (seen in Pit 170) and galena (in Pit 181), and which he presumed to be remobilized veins, would be able to be liberated at reasonable grain sizes.

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<sup>2</sup> In view of the difficulties the author asked that all fractions be examined for Pit 181 only, but this was not possible.

<sup>3</sup> These last three forms of sp may be the only evidence noted for detrital sulphides directly released from the hard-rock mineralization in the underlying limestone.





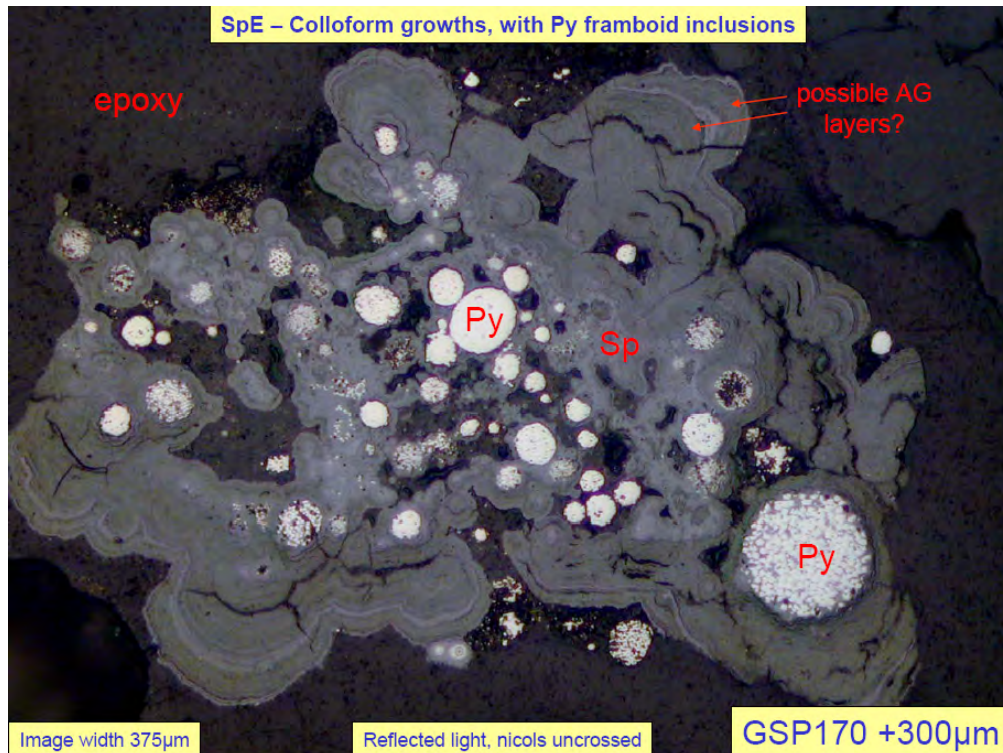
**Figure 9A** From G. McArthur: Major sphalerite type in Pit 115. Se = Sericite. Cy = Clay. Qz = Quartz. Vd = Void.



**Figure 9B** From G. McArthur: Major sphalerite type in Pits 170 & 264. CM = Carbonaceous Matter.



**Figure 9 A-C Sphalerite Textural Forms**



**Figure 9C** From G. McArthur: Major sphalerite type in Pits 170 & 181. AG = Amorphous Gel (organic)

## 12. ORGANIC PETROLOGY

Organic material in grab samples from Pits 181 (South Block of the zinc clay deposit) and Pit 264 (North Block) was examined by Neil Sherwood of CSIRO Petroleum, NSW, for vitrinite reflectance and maceral types. Sherwood's report appears in Appendix 1. Results can be summarized as follows:

Because of the abundance of organic matter and low vitrinite reflectance, both samples can be classified as peats. The organic matter is almost entirely of the vitrinite maceral group, derived from the woody parts of terrestrial plants and commonly exhibits cell structure. Sherwood (pers comm.) considers this material to be young (Late Tertiary at the oldest) with no evidence for older carbon (ie: Ordovician). There were traces of charcoal fragments in the Pit 181 sample, undoubtedly from bushfires that commonly sweep this area of Tasmania.

Because of the low degree of diagenesis Sherwood anticipated volatile yield of the Grieves vitrinite would be >65%. He considered that the behaviour of the material upon combustion would be, in part, comparable to that of Victorian brown coals, although the Grieves material is slightly lower rank and has lower liptinite content.

Sherwood determined his Pit 181 sample contained 70% organic matter (essentially all vitrinite), 25% sulphides and 5% clay/silt. The sulphides (largely sphalerite) mainly occurred as fine disseminations within the vitrinite, commonly along cell boundaries – see photomicrograph 3 in Appendix 1.

The Pit 264 sample contained 88% vitrinite, 7% sulphides and 5% clay/silt. Although the sulphides again mainly occurred as fine disseminations within the vitrinite, about one-third of the vitrinite was barren of sulphides – see photomicrograph 4 in Appendix 1.

### 13. DISCUSSION & CONCLUSIONS

The metallurgical testing programme has been successful in that it has provided clear answers to the main questions that were posed, viz:

1. Can the surficial zinc clays at Grieves be treated in the Rosebery mill?
2. Can gravity separation produce a sphalerite concentrate for Risdon refinery?

In both cases the answer has been an emphatic no.

Although the mineralogical studies did unequivocally prove virtually all the zinc occurs as low-iron sphalerite, the flotation tests demonstrated that the sulphides cannot be successfully floated from the material by conventional means. This is due to interference from the majority organic component and the fact that most of the sulphide grains are ultrafine and occur within the organics. Not only are recoveries unacceptably low, reagent usage is forced up to impractical and uneconomic levels.

One of the key findings of the flotation testing was the negative effect Grieves clay had on the metallurgical performance of Rosebery ore. The Rosebery mill normally attains zinc recoveries in the 91-93% range. The Ammtec tests on the 9:1 blend of Rosebery ore and Grieves clay obtained zinc recoveries averaging 77%.

A simple calculation demonstrates the significance of these figures. Rosebery mines about 750,000tpa at a head grade of 13% Zn, producing around 90,000tpa of zinc-in-concentrate at 92% recovery. Suppose 85,000tpa of Grieves clay grading 4.5% Zn was added to the mill feed in a 9:1 blend for an overall zinc recovery of 77-80%:

Rosebery only:	98,000tpa contained Zn, 90,000tpa recovered Zn
Rosebery/Grieves blend:	102,000tpa contained Zn, 80,000tpa recovered Zn.

***This shows that if Grieves clay was treated at Rosebery the amount of zinc lost from the mill circuit would be more than double that contained in the clay brought in. (Recovery only has to go down 4% for zinc production to be in deficit.)***

Clearly, an untenable situation. The exercise does more than demonstrate that the clay cannot be considered for treatment at Rosebery. It highlights the efficiency and fine balance of the Rosebery mill, suggesting only ore with Rosebery characteristics (not necessarily the grade) should be considered as additional feed for this mill. Not only the Grieves clays are unsuitable - the underlying hard-rock ore at Grieves is also ruled out. Even if sphalerite-dominant parts of this complex of zinc species could be mined the ore is unlikely to be totally free of zinc silicates and carbonates or the clayey wallrocks, all of which could potentially cause mayhem in the Rosebery mill.

Gravity separation trials on the zinc clays were equally conclusive, demonstrating that the fine sphalerite cannot be separated by this method. Most of the shaking table and Falcon concentrator tests showed no actual concentration. In the tests that did, the recoveries were poor and the grade increase minimal.

Economic recovery of the zinc in the clays may still be possible, but neither conventional flotation nor gravity separation are viable methods for consideration.



It is concluded that both the Grieves clays and the underlying hard-rock mineralization cannot be treated in any existing Zinifex infrastructure. They would have to be treated in a stand-alone facility. The small size, modest grade and limited potential for increasing the identified resources (acknowledged by both Rio Tinto and Allegiance), would seem to make this unlikely to be an economic proposition on a scale of interest to Zinifex.

Geologically, the testing programme has not provided such clear-cut answers. It is apparent the clays are an active heavy-metal trap with fine Zn, Fe and Pb sulphides depositing from meteoric water and "growing" in gel-like organic material. The metals are clearly sourced from the known Zn-Pb deposit in the underlying limestone.

However, the origin of the clay itself is rather enigmatic. CSIRO determined it can be classed as peat with likely behaviour on combustion comparable to Victorian brown coals. In the pits the clay appeared to be the rotten top on the steeply-dipping limestone. Although the latter and its associated facies contain some carbon, the carbon in the clays is apparently more recent and derived from surface vegetation. *Some sort of "organic replacement" of decomposed limestone seems indicated.*

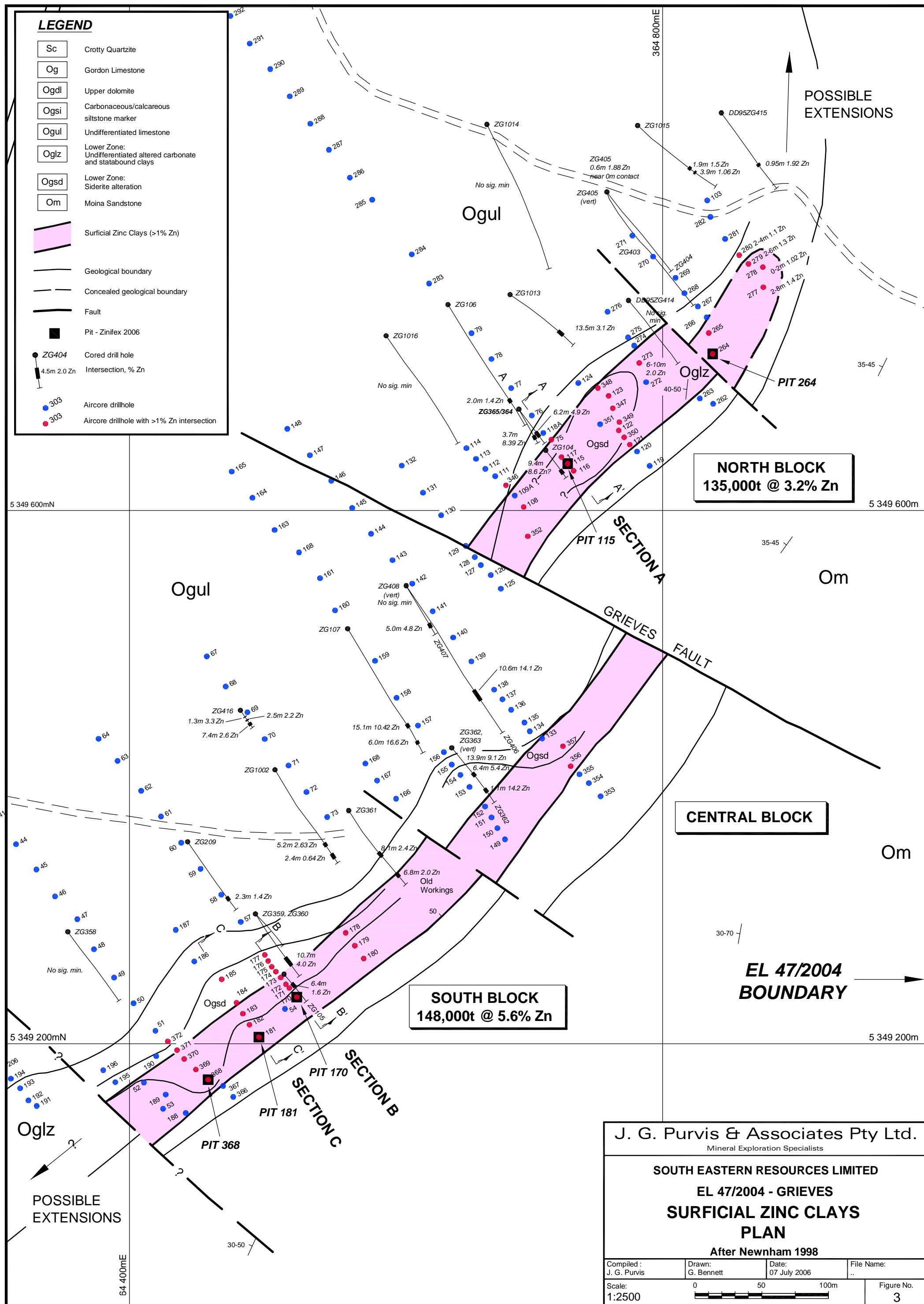
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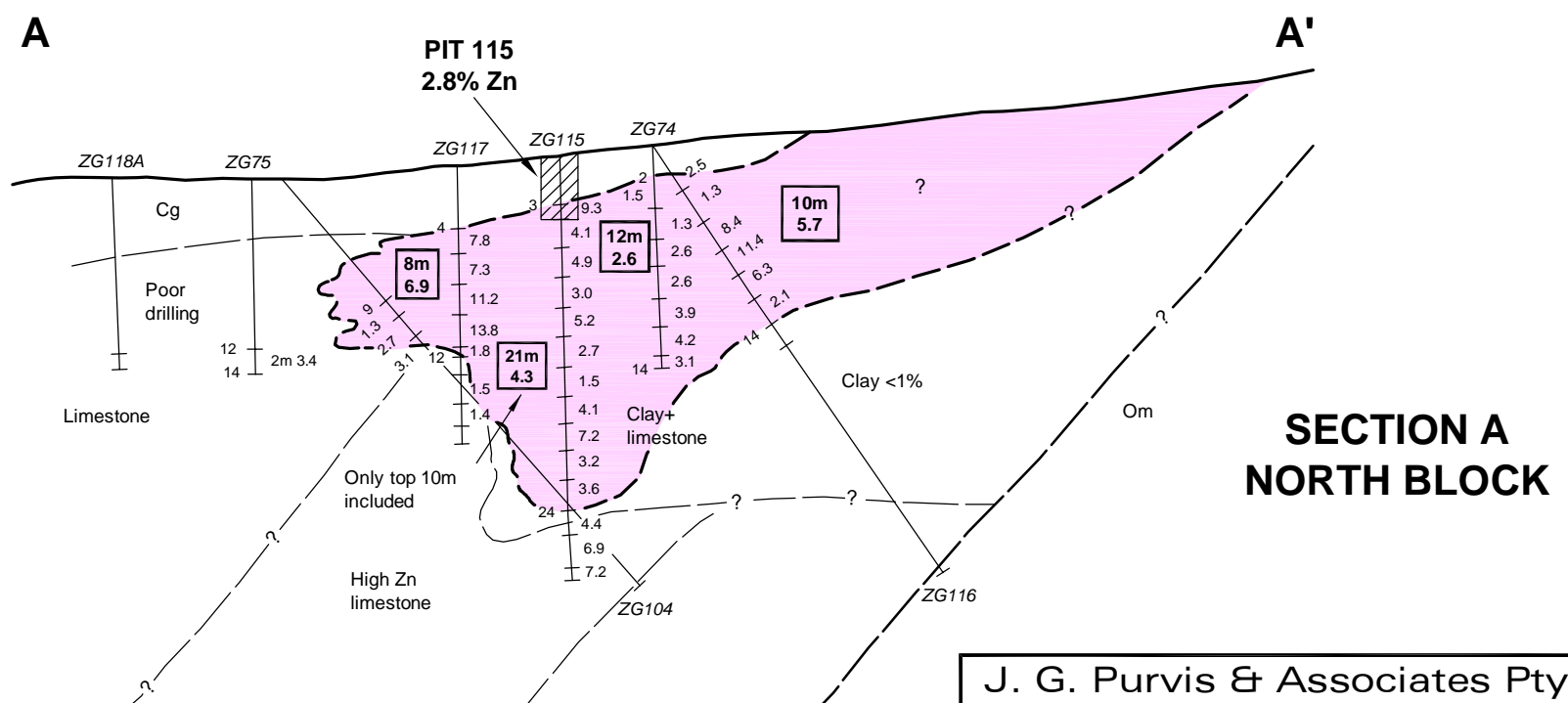
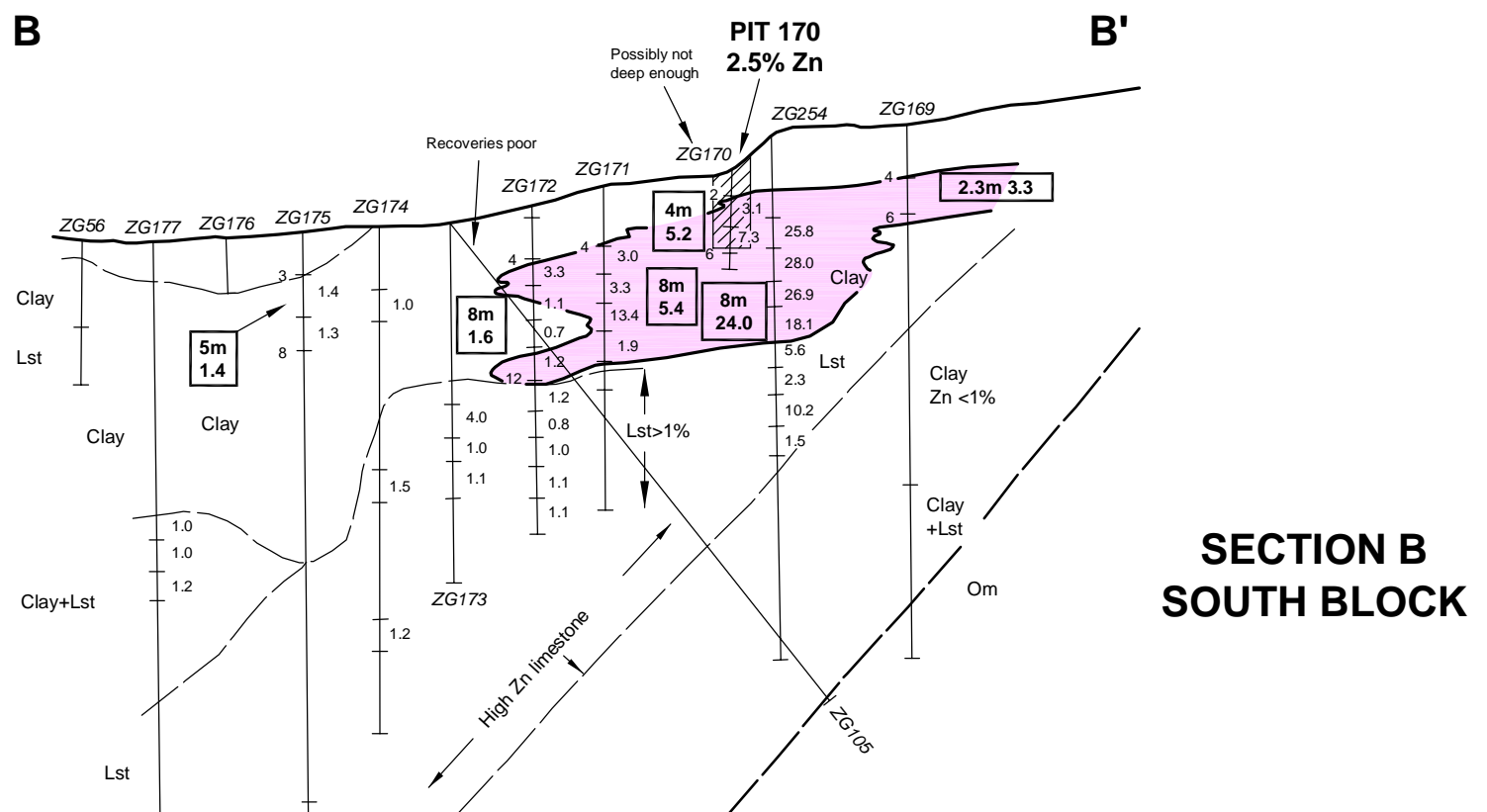
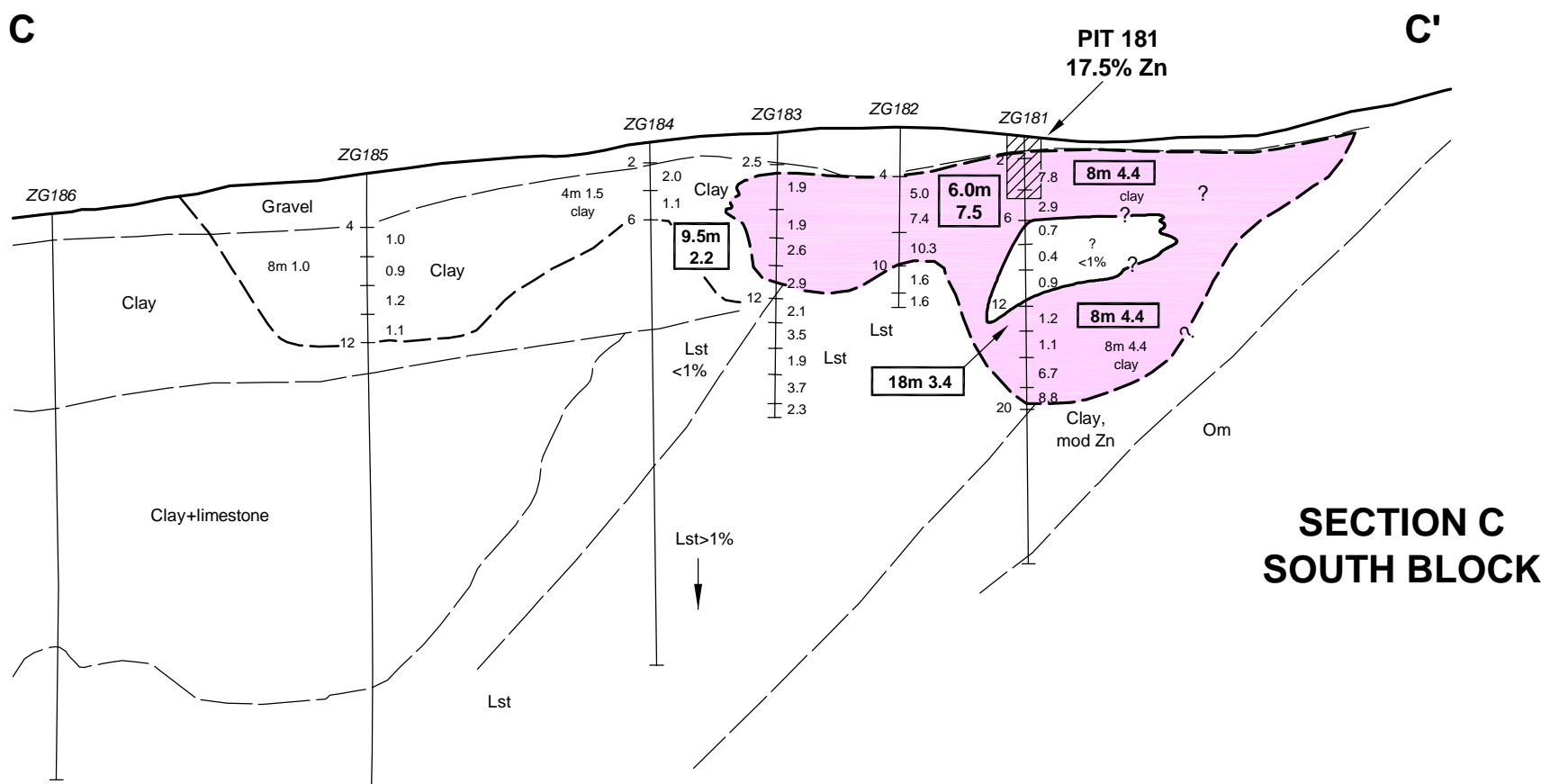
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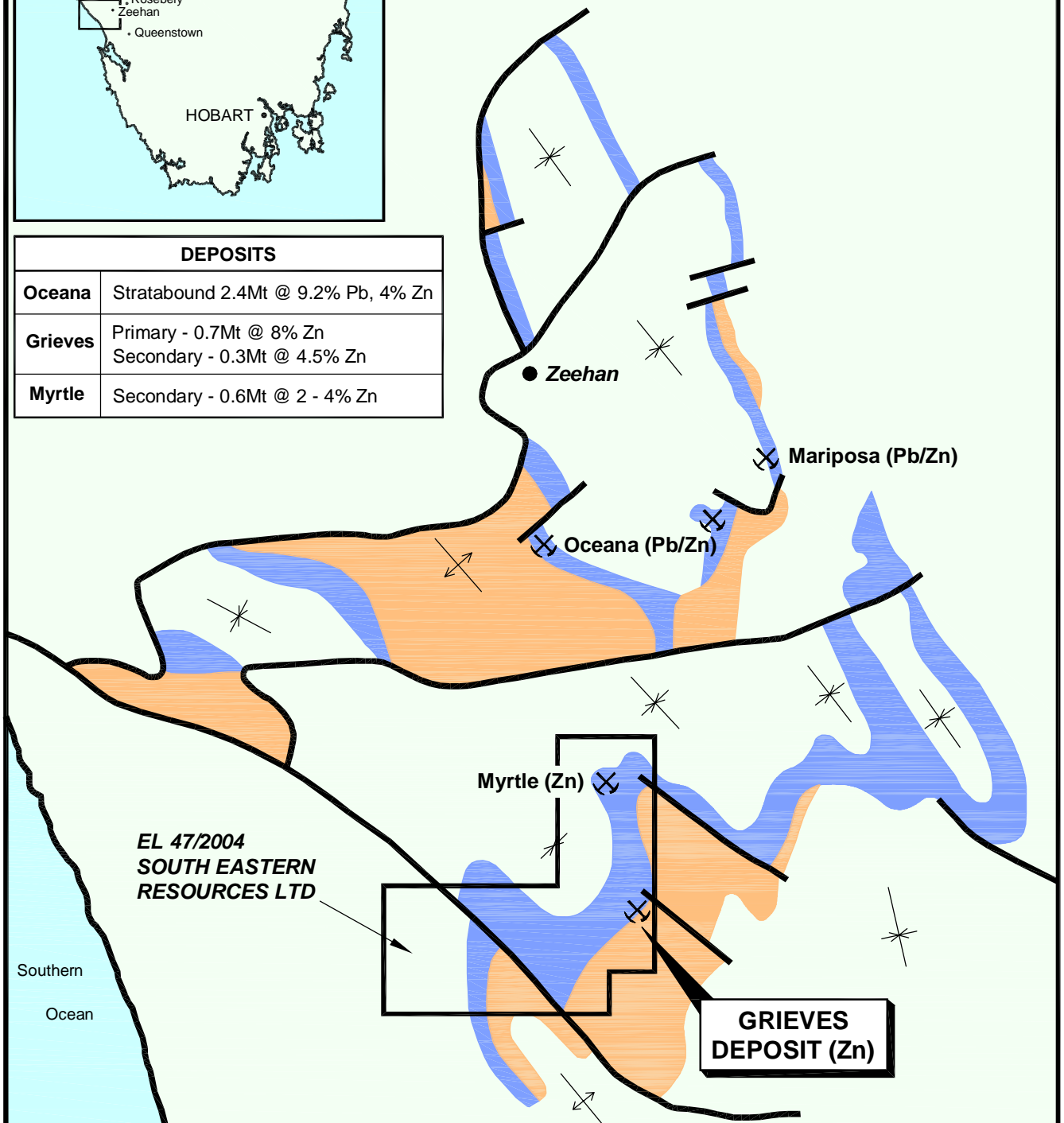
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**SURFICIAL ZINC CLAYS**  
**SECTIONS**  
After Newnham 1998






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Scale: 1:500		Figure No. 4	



 **RENISON  
BELL MINE  
(Sn)**

DEPOSITS	
<b>Oceana</b>	Stratabound 2.4Mt @ 9.2% Pb, 4% Zn
<b>Grieves</b>	Primary - 0.7Mt @ 8% Zn Secondary - 0.3Mt @ 4.5% Zn
<b>Myrtle</b>	Secondary - 0.6Mt @ 2 - 4% Zn



-  Ordovician Limestone
-  Ordovician Clastics
-  Major Basement Fault
-  Disused Lead/Zinc Mine or Deposit
-  Syncline, Anticline

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**LOCATION PLAN**

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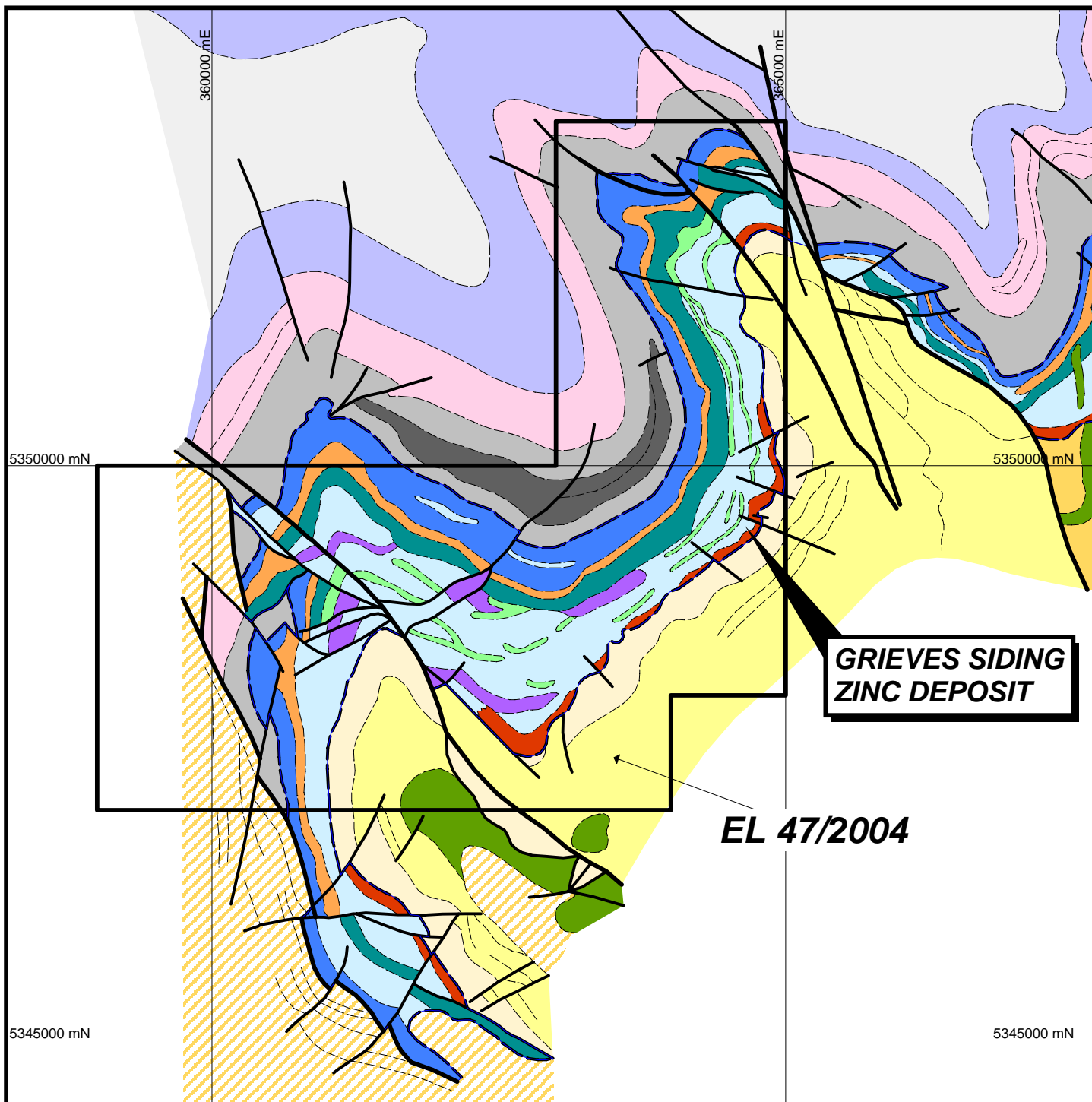
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**1**





**GRIEVES SIDING  
ZINC DEPOSIT**

**EL 47/2004**

## LEGEND

### Lithostratigraphy

- |  |                                      |
|--|--------------------------------------|
|  | Undifferentiated Sediments           |
|  | Bell Shale                           |
|  | Florence Quartzite                   |
|  | Austral Creek Siltstone              |
|  | Keel Quartzite                       |
|  | Amber Slate                          |
|  | Crotty Quartzite                     |
|  | Unidentified Unit (Crotty Quartzite) |
|  | Upper Dolomite                       |
|  | Limestone                            |
|  | Siltstone Unit                       |
|  | Middle Dolomite Unit                 |
|  | Argillaceous Unit                    |
|  | Dolomitic Unit                       |
|  | Siderite Unit                        |
|  | Moina Sandstone                      |

### Age

- |          |  |                          |                   |
|----------|--|--------------------------|-------------------|
| Permian  |  | Owen Conglomerate        | Cambro-Ordovician |
| Devonian |  | Sediments                | Cambrian          |
|          |  | Mafic Units              |                   |
|          |  | Magnetic Units           | Undifferentiated  |
| Silurian |  | Gordon Limestone Contact |                   |
|          |  | Lithological Contact     |                   |
|          |  | Major Fault              |                   |
|          |  | Fault                    |                   |

Ordovician

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**EL 47/2004 - GRIEVES**

**GEOLOGY**

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0 0.5 1 2 km

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2