

# Nelson Bay River Iron Ore Conceptual Mine Study

March 2006

*Prepared for :*

**Zelos Resources NL**





**The Minserve Group Pty Ltd**  
ABN 43 010 995 767

TARINGA OFFICE  
Level 1, 1 Swann Road  
Taringa QLD 4068

CITY OFFICE (SMGC)  
Level 8, 82 Eagle Street  
Brisbane QLD 4001

p +61 7 3377 6700  
f +61 7 3377 6701

p +61 7 3229 2566  
f +61 7 3229 7649

Visit the website at [www.minserve.com](http://www.minserve.com) or email [consult@minserve.com.au](mailto:consult@minserve.com.au)

# **NELSON BAY RIVER IRON ORE CONCEPTUAL MINING STUDY**

**for**

## **ZELOS RESOURCE N.L.**

**13 March 2006**

## CONTENTS

		Page No.
1.	<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
2.	<b>INTRODUCTION.....</b>	<b>3</b>
	2.1 General.....	3
	2.2 Location and Access .....	3
	2.3 Topography and Climate .....	5
	2.4 Tenure and History.....	7
	2.5 Scope of Work .....	8
	2.6 Disclaimer .....	8
3.	<b>GEOLOGY .....</b>	<b>9</b>
	3.1 General.....	9
	3.2 Regional Geology.....	9
	3.3 Local Geology .....	9
	3.4 Iron Ore occurrence .....	12
	3.5 Resource Estimate .....	12
4.	<b>MINING .....</b>	<b>14</b>
	4.1 Introduction .....	14
	4.2 Mine Setting .....	14
	4.3 Mining Method .....	15
	4.4 Mine Design .....	15
	4.5 Mining Loss and Dilution.....	17
	4.6 Opencut Mining Limits.....	17
	4.7 Metallurgical Considerations .....	18
	4.8 Production Rates.....	19
	4.9 Environmental Considerations .....	19
5.	<b>COSTING .....</b>	<b>21</b>
6.	<b>RESULTS AND RECOMMENDATIONS .....</b>	<b>23</b>
7.	<b>ACKNOWLEDGEMENTS AND REFERENCES.....</b>	<b>25</b>
	7.1 Acknowledgements.....	25
	7.2 References .....	25



## TABLES

Table 3.1	Sectional Resource Interpretation for the Nelson River Iron Mineralisation .....	13
Table 4.1	Davis Table Recovery Results .....	18
Table 4.2	Nelson Bay River Magnetite Cross-Section Mining Reserves .....	20
Table 5.1	Magnetite Washery Sales 100,000t Order of Magnitude Operating Costs .....	22
Table 5.2	Magnetite Washery Sales 30,000t Order of Magnitude Operating Costs .....	22

## FIGURES

Figure 2.1	Project Location
Figure 2.2	Land Tenure and Land Use
Figure 3.1	Geological Map of the Project Area
Figure 4.1	Conceptual Mine Design

## APPENDICIES

Appendix 1	Amdel Petrology and Davis Tube Recovery Results February 2006
Appendix 2	Ausmelt and Zelos Resources Minismelter Correspondence



## 1. EXECUTIVE SUMMARY

The Nelson Bay River Iron Ore Conceptual Mining Study was commissioned by Zelos Resources N.L. (Zelos) to look at the opencut mining potential of the inferred resource of 4Mt of ore to a depth of 225m reported in the SMG Consultants Pty Ltd (SMGC) report, November 2005 (ref 1).

The inferred ore resource is based on three diamond drillhole intersections of the Nelson Bay River Iron Ore aeromagnetic anomaly in the central portion of EL41/2004. The resource consists of a magnetite ore zone contained in the basal 7.5m of an ultramafic dyke that is typically 20m to 40m thick, dips to the west at 60° and has a strike length of 600m.

The Minserve Group Pty Ltd (Minserve) was asked to look at the resource and develop an opencut design to produce a ROM product that would undergo beneficiation to a saleable product. Three process options were nominated by Zelos and an indicative order of magnitude costing of the perceived best case was to be used to provide order of magnitude project costs. Two options involved smelting to produce pig iron and one was the production of magnetite for use in coal washeries.

A 600m long open pit orebody has been defined by ground magnetic interpretation, surface mapping, and three cored drillholes. The northern limit is determined by the Nelson Bay River and the orebody is marginally open to the south.

The conceptual study mine design shows that opencut mining can proceed to a depth of 225m but that all waste would need to go to out-of-pit waste dumps due to the limited strike length of the pit and the need to keep a 1 in 10 access ramp open to the pit bottom. No waste dump design or location has been attempted for this conceptual study.

The conceptual study perceives that production of magnetite products for use in Australian (and Indonesian) coal mine washeries is the highest value market for Nelson Bay River magnetite. Currently central Queensland coal mines pay prices around \$250 to \$260 per tonne for delivered magnetite which is used in the coal washery heavy media separation process. Current suppliers are few in number with most magnetite supplies coming from Tasmania, New South Wales, Western Australia and Canada.

Annual magnetite supply requirements are limited and mining generally occurs on a small scale with mines producing around 50,000t/a to 100,000t/a. This would suit production from the Nelson Bay River Iron Ore resource.

Only broad metallurgical concepts have been addressed in this report. Zelos proposes to do this work in more detail during the next stage of the project in which they will develop process flowsheets and capital and operating costs for the various options under review.

The small scale of the proposed operation is suited to contract mining and processing. The mining production rate will be determined by the level of sales that can be sustained and the ability of a new supplier to break into the market. Current assessment is that 30,000t/a to 100,000t/a are likely achievable penetration targets.

The order of magnitude costing showed that based on the broad assumptions used, producing around 100,000t/a of magnetite is likely to be viable once all capital and operating costs have been taken into consideration. A pit depth of around 150m is also likely to give a better return than a pit that is 225m deep based on the high incremental stripping ratio and the increased costs that would be required to deepen the pit.

An opencut magnetite mine with processing/treatment plant providing 100,000t/a of coal washery product has potential to generate in excess of \$10M surplus cashflow per year over a 10 to 15 year mine life. Capital costs are estimated to range between \$10M to \$20M.

Preliminary concept studies of the Ausmelt process to produce 300,000t/a to 400,000t/a of pig iron indicate that, at a sales price of US\$200/t, such a project also has potential to generate significant annual cashflow surpluses based on processing costs of \$141/t of hot metal (thm). A capital cost for the Ausmelt facility has been estimated at \$120M. A mine life of 4 to 6 years is likely for this type of operation based on a 150m deep opencut.

The Nelson Bay River Iron Ore project is at an early stage of evaluation. An inferred resource has been estimated from only three cored drillholes. Metallurgical testwork and assays show encouraging results without being specifically tailored to the two products mentioned. Each has potential to be a viable operation if the ore is proven to be suitable for the purpose proposed.

Key areas for progressing the next stage of the project are perceived to include:

### **Geology**

- Additional cored drillholes to upgrade the resource to indicated or measured status
- Definition of the basal 7m ore zone and the magnetite distribution within the ore zone and the ore zone/waste interfaces.

### **Mining**

- Topography coverage for mine design and out-of-pit waste dumps
- Confirm geotechnical and mine design parameters
- Confirm environmental guidelines for mining.

### **Mineralogy/Metallurgy**

- Testwork to determine suitability of ore for supply to coal washeries and Ausmelt processes
- Flowcharts and recoveries/yields for the selected processes
- Capital and operating costs for the selected processes.

### **Marketing**

- Confirm market specifications and suitability of processes to meet specification
- Establish market windows of opportunity with regard to quantity and price for the selected processes.

### **Project**

- Establish project infrastructure requirements and costs
- Establish environmental requirements for the project
- Establish government and regulatory requirements framework for the project.

The conceptual study results support continuing the study evaluation to delineate opencut mining to 150m depth, resource definition to define the ore zone over the 600m strike length and determine metallurgical factors and recoveries to produce magnetite products suitable for sale to coal mine washeries or the Ausmelt process. Process flowsheets and capital and operating costs need to be provided to match these studies along with site infrastructure requirements and costs.

## 2. INTRODUCTION

### 2.1 GENERAL

This report has been commissioned by Zelos Resources N.L. (Zelos) to evaluate the potential for opencut mining of the Nelson Bay River Iron Ore Resource outlined by SMG Consultants Pty Ltd (SMGC) in their report "Nelson Bay River Licence EL 41/2004 Literature Study Report", November 2005 and subsequent work completed on the resource by Zelos and SMGC.

This report is to be read in conjunction with the above SMGC report which describes in detail the geology and geological setting of the resource and the basis for the estimation of the inferred resource estimates used for this study.

Zelos Resources N. L. is the new changed name of the company formerly called Zinico Resources N.L.

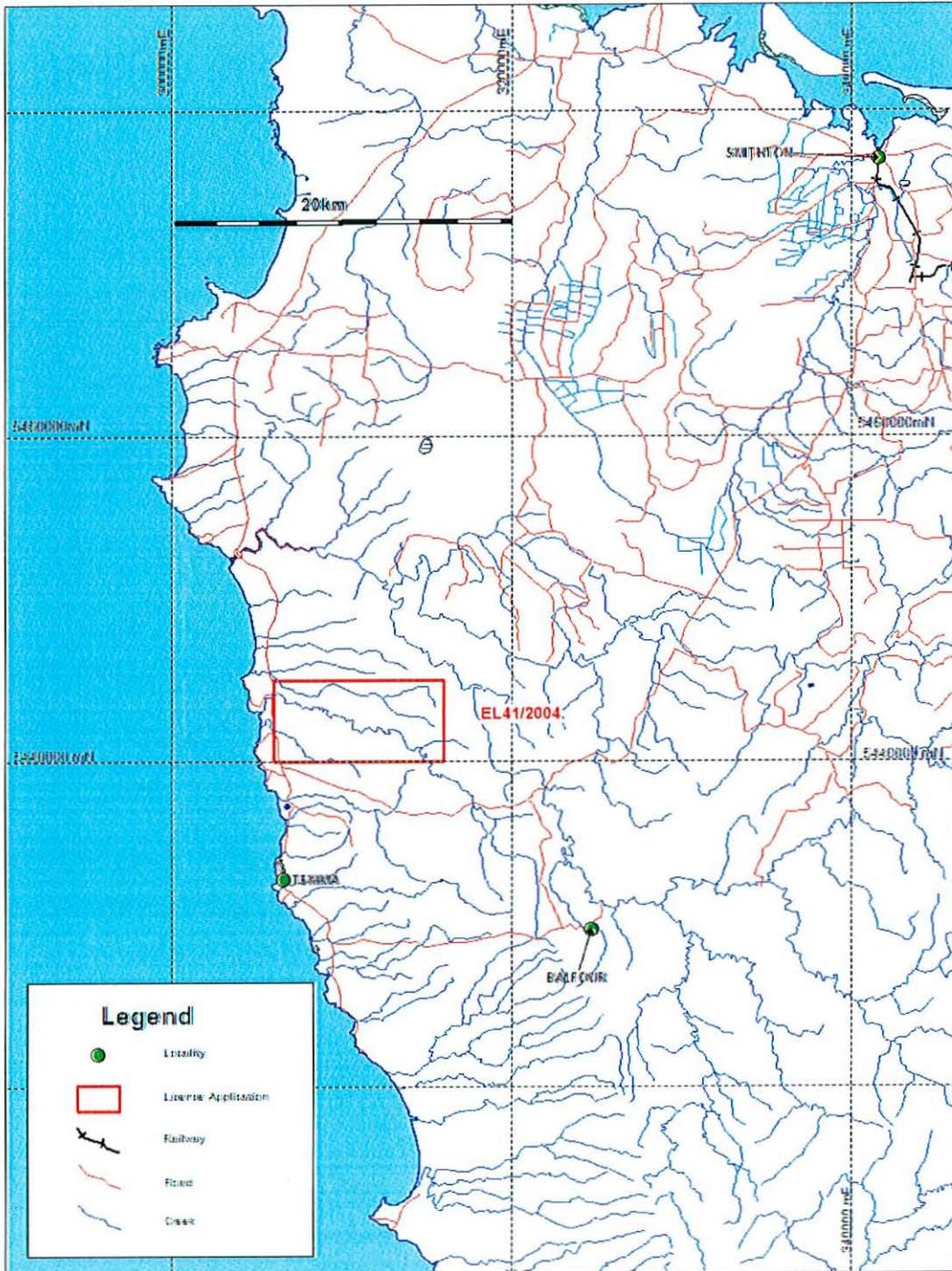
### 2.2 LOCATION AND ACCESS

The Nelson Bay River area is held under licence by Zinico Resources N.L. as EL 41/2004. Exploration licence EL 41/2004 covers 50km<sup>2</sup> and is located about 7km northeast of the small township of Temma, and about 60km southwest of Smithton in North West Tasmania (Figure 2.1).

Main road access to the property is via the Temma and Heemskirk roads and parts of the licence can be accessed by the Wuthering Heights forestry roads. Off-road access is potentially very difficult for parts of the EL.

The Nelson River Iron Prospect is accessible by foot from the Wuthering Heights forestry track. The original access has been environmentally rehabilitated but only requires minor work to restore vehicle access.

**Figure 2.1**  
**Project Location**



## 2.3 TOPOGRAPHY AND CLIMATE

The Nelson Bay River Iron Ore resource area lies within the central portion of EL 41/2004 (Figure 2.2).

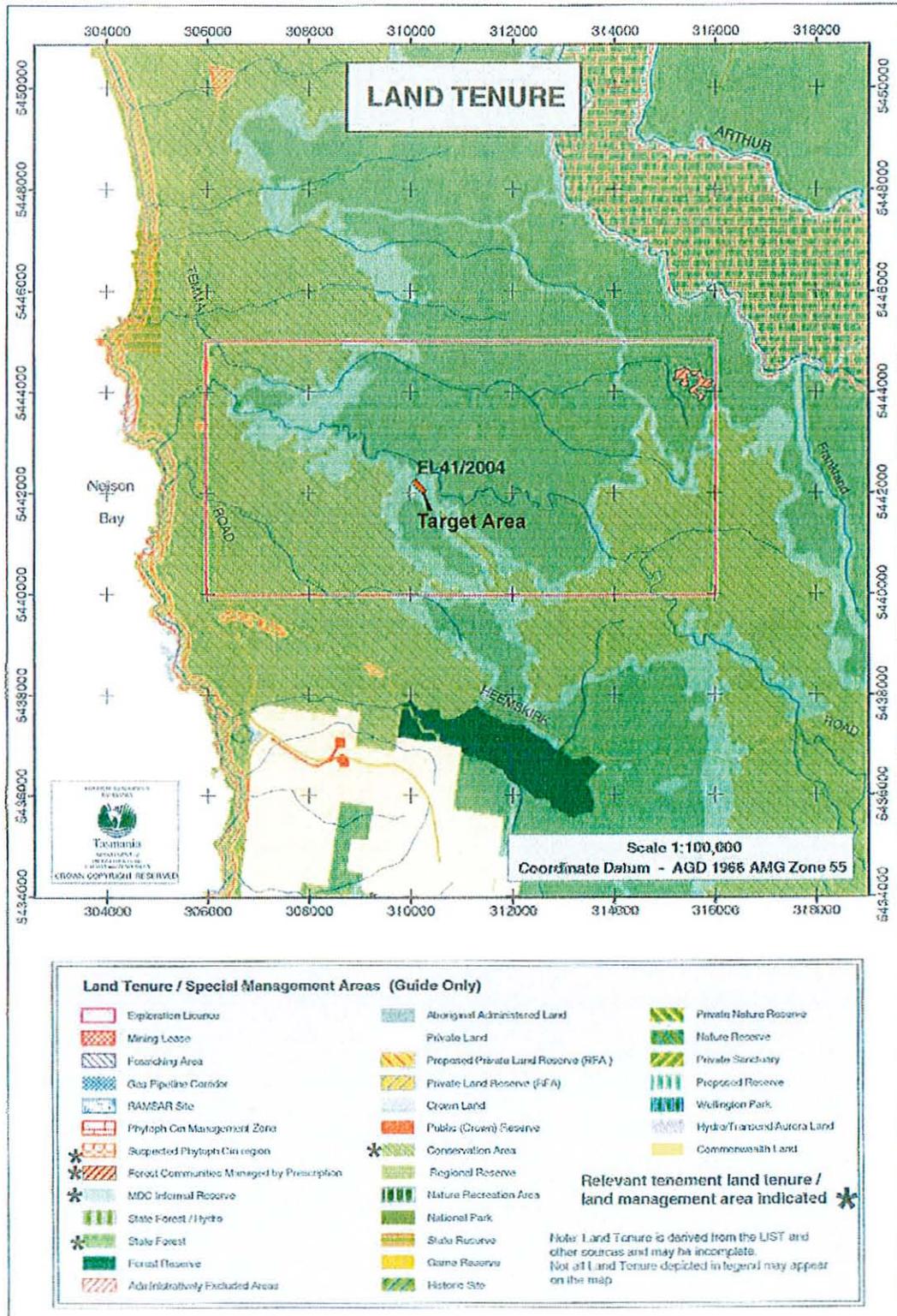
The western portion of the tenement is a peneplained hinterland adjacent to the coast with localised fossil sand dunes. Further to the east the terrain becomes more undulating with incision by creeks and major rivers draining from the east to the west. These include Sundown Creek, Sardine Creek and the Nelson Bay River.

Map coverage for the resource area is confined to state government 1:100,000 maps which show the iron ore resource area to be generally flat to undulating country some 90m to 100m above sea level. Past exploration work has been centred around the base line established by Pickands Mathers prior to 1972.

The climate is temperate with substantial annual rainfall typical of Western Tasmania. Temperature ranges from just above freezing in winter to a likely maximum of 30°C in summer.

Vegetation cover is a mixture of low level heath in the west of the licence and plantation forestry in the east of the area.

**Figure 2.2**  
**Land Tenure and Land Use**



## 2.4 TENURE AND HISTORY

Land tenure in Tasmania is based on a series of classifications that have resulted from the Regional Forestry Agreement Act (RFA).

In conjunction with other stakeholders' interests, this Act establishes what land is available for exploration and mining in defined areas such as State Forest. RFA land use categories that allow mineral exploration and mining include Nature Recreation Areas, Regional reserves and Conservation Areas. All planned activities are subject to a prior project review before they can commence.

Any exploration work program planned within any of the above three categories triggers the Mineral Exploration Working Group (MEWG) convened by MRT. MEWG reviews the planned work program and can make recommendations and/or modifications to the plan before it is approved. Mineral exploration/exploitation can also be approved for Forest Reserve areas not available for forestry use.

An MDC Informal Reserve is a forestry-related category that has very minor impact on mineral exploration. Nature Reserves, State Reserves and National Parks all exclude mineral exploration.

For the Nelson Bay River licence EL 41/2004, 55% of the tenement is classified as State Forest with 40% classified as a Conservation Area with the remaining 5% as an MDC informal reserve. A small 'forest community managed by prescription' occurs in the northeast corner of the tenement but information supplied by MRT indicates that this is not likely to be an impediment to mineral exploration.

MRT has informed Zinco N.L. that there are no mining leases within the property.

A map detailing the tenure and land use situation is included as Figure 2.2.

Peripheral to the southwest corner of the licence there are recorded areas of the plant disease *Phytophthora Cinnamomii*. Care must be exercised when working near these areas to avoid spreading the infestation. This generally refers to washing all field gear ranging from gumboots to heavy plant machinery when moving to new sites/locations.

Exploration in the area was first undertaken by Pickands Mather between 1966 and 1972. This identified the Nelson Bay River aeromagnetic anomaly which was tested with one diamond drillhole. This encountered magnetite 70m below surface.

In 1973 Australian and New Zealand Exploration Company concentrated on the nearby clean quartzites for the possible production of silica.

Between 1977 and 1984 CRA Exploration explored the area including a period (1981 to 1982) in which Geopeko were also involved. The main targets were gold and base metals. Ground magnetics and auger drilling during this period better delineated the Nelson Bay River Iron Ore feature.

Between 1986 and 1990 Bach Holdings explored the area and tested various Quaternary sand deposits for heavy minerals.

From 1997 to 2001 Pacific Nevada Mining Pty Ltd explored the area. They re-logged and sampled the 1967 drillhole and drilled two new drillholes. Work confirmed strike length of the main airborne/ground magnetic anomaly and the geological nature of the magnetic anomaly as a magnetite rich footwall zone in an ultramafic dyke dipping 60° to the west.

## 2.5 SCOPE OF WORK

The Minserve Group Pty Ltd was initially requested to look at providing a scoping study for the Nelson Bay River Iron Ore Resource. Further discussions determined that a conceptual mining study was more appropriate for the level of data and the amount of work that has been completed on the project. The scope of work was to look at the existing data, design an opencut mining operation and determine indicative costs to mine and process the ore.

The following steps are involved:

- Develop an opencut mining reserve
- Create an opencut design
- Select a method to produce a ROM mine product
- Look at processing costs
- Assess processing options and markets for saleable products
- Undertake indicative costing of perceived best case
- Produce order of magnitude project costs.

The initial Minserve study will be subject to input on metallurgy and marketing by others (Zelos) and a review of the data available on the beneficiation processes to be provided by Zelos as outlined in their original letter.

## 2.6 DISCLAIMER

This report has been prepared at the request of Zelos Resources N.L. to assist them to evaluate the feasibility of opencut mining of the Nelson Bay River Iron Ore Resource. The November 2005 SMGC geological report provided by the client relates to the latest geological interpretation of the resource. The report has not been audited by Minserve and has been used to provide quantities for this study.

Metallurgical test work and investigations commissioned by Zelos have also been used un-audited. These results have been taken at face value when deriving the amount of magnetite product produced following beneficiation of the ROM ore.

Order of magnitude operating costs were developed for the project based on broad cost assumptions. These have been used to generate operating cash surplus estimates independent of the capital cost of a site located beneficiation plant and infrastructure capital costs.

The studies and the data available are considered to be adequate for this conceptual level study. Projections contained in the study are representations of future matters based on assumptions that are subject to uncertainties and contingencies outside the control of Minserve. No representation is made that any forecast or projection will be achieved. No member of Minserve makes any representation or warranties to the accuracy, reliability or completeness of matters in this study beyond those stated in the study.

This report has been compiled by The Minserve Group member Alwyn Hyde-Page based on geology input by Simon Tear of SMGC.

### 3. GEOLOGY

#### 3.1 GENERAL

This section on geology is a selective summary of information from the report: Nelson Bay River Licence EL41/2004; Literature Study Report, November 2005 by Simon Tear of SMG Consultants Pty Ltd. Reference is made to the Nelson Bay River Iron Ore resource quantified in the report which forms the basis of the conceptual mining study. Whilst other potential open-cut magnetite occurrences are mentioned in the SMGC report, they are not quantified and therefore have not been used. Their potential is still to be quantified.

#### 3.2 REGIONAL GEOLOGY

The regional geology of the Nelson Bay River tenement consists of mixed Proterozoic siltstones, sandstones and carbonaceous mudstones of the Cowrie Siltstone, part of the Rocky Cape Stratotectonic Element.

#### 3.3 LOCAL GEOLOGY

Rocks in the Nelson Bay area comprise finely laminated, psammo-pelitic, Proterozoic-aged siltstones with medium grained sandstones/quartzites. The quartzites are clean, well sorted, and massive to thinly bedded and up to 200m thick.

A geological map (Figure 3.1) has been constructed by SMGC based on airborne geophysical data from the West Tasmania Mineral Reconnaissance Program (WTMRP).

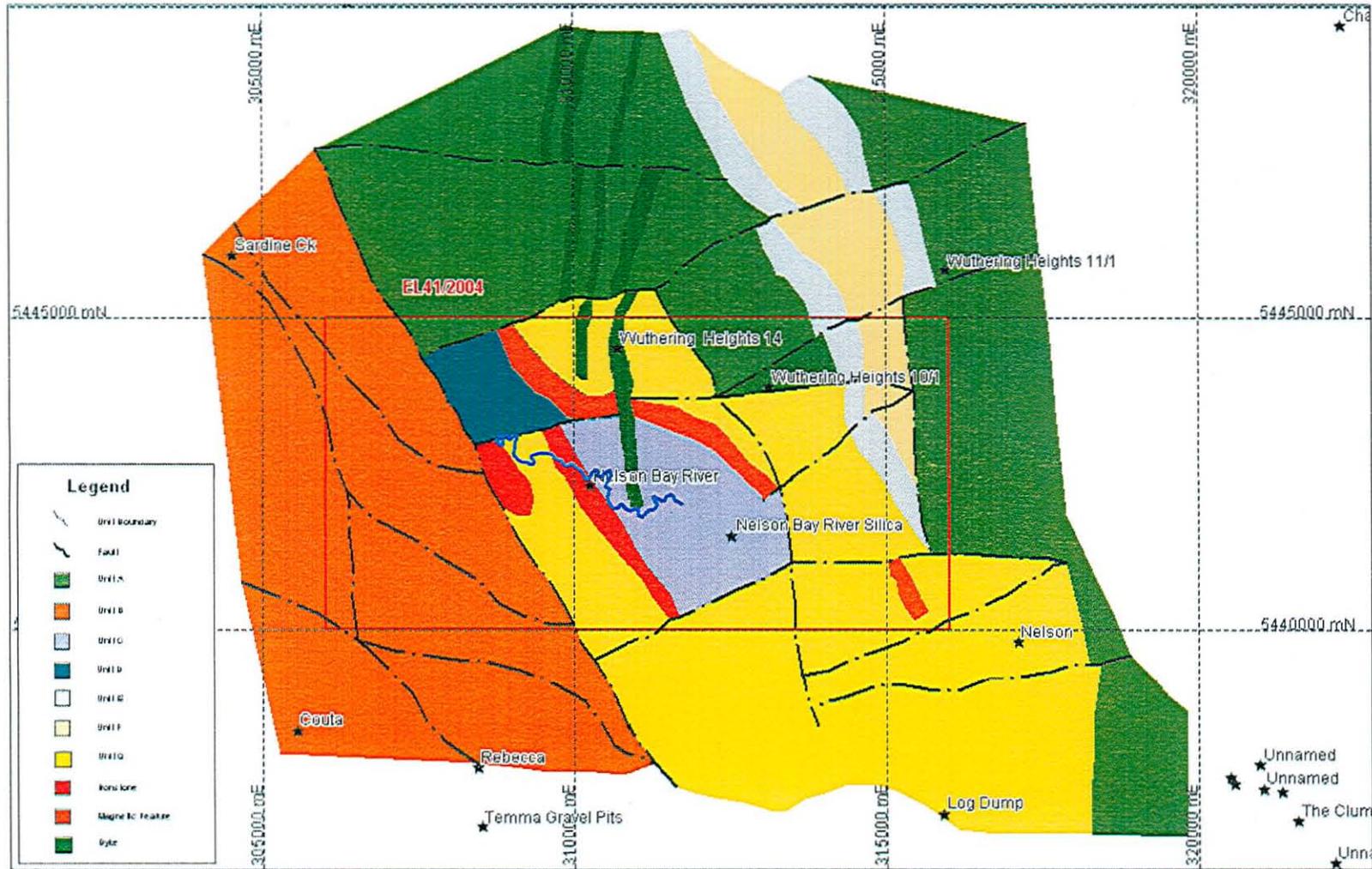
The key features of the new geology map for the general licence area are:

- A new set of geological units:
  - Unit A is a distinctly dappled unit in the 1VD image. It may correspond with the Wavy Lamina Unit at Balfour (Tear & Russell 1998)
  - Unit B corresponds to Carey's Epsilon Unit, interbedded siltstones. A distinctive unit in the 1VD image and this unit may be similar to Unit Q
  - Unit C is the core of the proposed anticline and may be similar to Unit Q
  - Unit D appears to be a distinctive unit in the 1VD image, belonging to no other unit
  - Unit E part of a magnetically distinct unit in the TMI image linked to Unit F
  - Unit F equates to the Scoured Channel Unit reported by Tear & Russell 1998, at Balfour. The unit corresponds to a discretely magnetic unit in the TMI image
  - Unit Q is a large area of rocks with similar features in the 1VD image. It is believed to be a mixed quartzite and siltstone unit
  - Magnetic Feature corresponds to a discrete magnetic feature that may be a folded part of the Ironstone, maybe a fault or some other unexplained unit
- The possibility of a plunging anticline adjacent to the Nelson River Iron anomaly, with the anomaly lying in the southwest limb of the anticline, possibly as a fault structure and/or as a folded dyke(?)
- A series of north-south striking dykes appear truncated near the Nelson River prospect

- The northern limb of the proposed anticline is visible as an approximately east-west to west-northwest striking magnetic anomaly
- A major northwest to north-northwest striking fault is inferred to pass through the western third of the licence with a second parallel fault interpreted 5km to the east. The former could be Carey's Lagoon River Fault. In between the two faults lies the Nelson River Iron feature with the same orientation. This orientation is also parallel to the Balfour Copper Trend. A second set of faults striking roughly east-northeast (to east-west) is also interpreted
- Part of the Balfour sequence occurs in the far north-east corner of the licence (based on magnetic correlation from Tear, 1996).



**Figure 3.1**  
**Geological Map of the Project Area**



### 3.4 IRON ORE OCCURRENCE

Within the Nelson Bay River Licence there are four mineral occurrences listed in the MRT database. The main one of interest to Zinco (Zelos) is the Nelson River Iron occurrence, with the remaining three being recorded instances of sand and gravel.

The Nelson River Iron occurrence is a 4km long, stratabound airborne magnetic feature confirmed in the WTMRP airborne surveys. Follow up ground magnetic work by Geopeko in the 1980's has shown that the airborne feature splits into two anomalies, a northern one and a southern one. In the field, the northern anomaly comprises at surface of an 800m long lode of granular aggregates of hematite and magnetite in an iron clay and/or siliceous matrix. At depth it becomes an "ultramafic dyke-like structure", up to 40m wide, containing a quartz-carbonate-magnetite-pyrite-garnet-chlorite-amphibole assemblage that dips 60° west and cross cuts stratigraphy at about 70°. The dyke is sub-parallel to the lithological strike. Alteration associated with the dyke consists of a "white mineral and olive coloured silicate, fibrous amphibole and green silicates". In addition dense clusters of garnet are reported at the ultramafics contact with the sediments. This mineral style has been linked in the past to Proterozoic iron formations similar to that which occurs at Tennant Creek (Newnham 2000).

Drill logs for NBR001, NBR002 and N401 show that there is a magnetite-rich footwall zone to the dyke, which in NBR001 has yielded a 7.3m zone at 46.5% iron from 221.1m, within an overall zone of 31m @ 35.8% iron from 199.5m. The geological description for this lode is "magnetite-actinolite/chlorite skarn and...sulphide-poor...". Core recoveries for this interval are 100% with the core being described as very competent. This footwall zone appears to be repeated in N401 (140m updip on the same section) and in NBR002 (200m to the south) where it appears to be more pyritic?

### 3.5 RESOURCE ESTIMATE

The following resource estimate has been prepared by Simon Tear of SMGC in the SMGC report, November 2005 (ref 1).

*A resource outline can be based on the geological information in the drillholes combined with the surface magnetic work and the geological mapping. Interpolated strike and downdip lengths can be ascribed to the drillhole intercepts to create a coherent body. An ore zone tonnage value was derived from an estimated density value of 4t/m<sup>3</sup> (magnetite is 5.1t/m<sup>3</sup> - 5.2t/m<sup>3</sup>).*

*A notional 30% Fe was used as a cut off for calculating the weighted averages for each drillhole intercept. Thus a simple sectional resource calculation is based on:*

- 1. The weighted average intercepts for the magnetite zone from the three drillholes.*
- 2. Assuming the iron assays represent magnetite.*
- 3. The Geopeko mapping (for geological continuity).*
- 4. The Geopeko ground magnetic survey (for geological continuity).*
- 5. Using an ore density of 4t/m<sup>3</sup>.*

**Table 3.1**  
**Sectional Resource Interpretation for the Nelson River Iron Mineralisation**

<b>Drillhole</b>	<b>Width (m)</b>	<b>Estimated True Width (m)</b>	<b>Strike (m)</b>	<b>Dip (m)</b>	<b>Fe Grade %</b>	<b>Volume (m<sup>3</sup>)</b>	<b>Ore Tonnes (t)</b>
N401	10	8.5	300	125	45.3	318750	1275000
NBR001	7.3	6	300	100	46.5	180000	720000
NBR002	9	7.5	300	225	34.7	506250	2025000
<b>Totals</b>							<b>4020000</b>

The values used in Table 3.1 generate a simple inferred iron ore resource of 4Mt @ 40% iron for 600m of strike length and 225m of dip length with an estimated true width of 7.5m (this is likely to give a magnetite product of some 2Mt).

A key assumption in the resource calculation is that all the iron in the assays is due to magnetite. This may not be fully correct as there are reports of other iron-bearing minerals present including actinolite, chlorite, pyrite and possibly siderite. It has been recommended that some initial metallurgical/mineralogical testwork is completed on the core to assess the mineralogical compositions of the core. There are no indications in the logs as to the relative abundance percentages of the iron minerals present.

Potential for additional resources for the northern magnetic feature lie mainly downdip, although some minor potential exists along strike to the north and south (up to 100m each way). The 31m @ 35.8% Fe zone in NBR001 contains a second high grade zone within the main part of the dyke as "massive to semi-massive magnetite and fibrous dark green actinolite". This zone contained 10.5m at 37.6% iron from 199.5m with bad core recoveries and at this stage, is considered unreliable other than as an indicator of potential resource.

Other potential exists with a second magnetic anomaly to the south and a small magnetic anomaly 1km to the west of the main northern feature. No explanation is offered as to what happens to the footwall zone between the northern and southern magnetic anomalies.

There are additional magnetic features in the WTMRP data that could indicate mineralisation e.g. 1km north of Nelson River and an anomaly in the far south east of the licence.

The licence area has three other mineral occurrences listed in the MRT MIRLOC database. These are Wuthering Heights 10/1, Wuthering Heights 14 and Nelson Bay River Silica and all are sand and gravel alluvial occurrences.

## 4. MINING

### 4.1 INTRODUCTION

This conceptual mining study is based on the limited information available and the inferred resource estimate from the SMGC November 2005 report. No detailed study of infrastructure requirements has been undertaken for the project which is based on open cut mining of the Nelson Bay River Iron Ore deposit. No detailed topography exists for the study area, no geotechnical investigations for the project area have been carried out and future work will need to address these issues and confirm the mine design parameters and assumptions made in this study.

### 4.2 MINE SETTING

The mine setting described refers only to the inferred Nelson Bay River Iron Ore resource covered in the SMGC November 2005 report. Key issues incorporated in the mining concepts based on the deposit characterisation are:

- The magnetite ore zone is the basal 7.5m of an ultramafic dyke which outcrops at the surface and dips to the west at an angle around 60°. The dyke is typically 20m to 40m thick
- The ore zone evaluated has a strike length of some 600m
- The northern limit to open pit mining is the Nelson Bay River
- The open pit orebody has been defined by ground magnetic interpretation, surface mapping, geophysical mapping and three cored drillholes
- The orebody extends some 100m to the north on the other side of the Nelson Bay River
- The Nelson Bay River is some 10m wide and occurs to the east of the deposit
- The Nelson Bay River is likely to impact on mining and the location of out-of-pit waste dumps
- The orebody is closed approximately 100m to the south of the defined resource
- The overburden consists of Proterozoic sediments dipping to the east at angles around 60° to 70°
- Depth to Base of Weathering is typically 10m to 25m
- The topography is gently undulating between 90m to 100m above sea level
- The floor of the ultramafic dyke is considered to be competent
- No significant groundwater inflows are anticipated.

### 4.3 MINING METHOD

A shovel and truck opencut mining method has been selected as the most appropriate way to mine the deposit. The steep 60° dip of the orebody means that it is best removed in horizontal slices. This is achieved by using a hydraulic excavator in backhoe mode loading rear dump trucks situated on the bench/flitch below it to maximise digger productivity.

The limited strike length of some 600m and the 60° dip mean that 1 in 10 gradient ramps out of the pit will be a constricting factor with the opencut mining method. Thus at a depth of say 200m some 2km of ramps will be needed to access ore in the bottom of the pit and this effectively precludes any opportunity to dump waste in-pit as part of the mining method. All waste will need to go to out-of-pit waste dumps. It has been assumed that all the waste and ore will need to be drilled and blasted as part of the mining operation. The limited resource available is deemed to be best suited to contractor mining operations.

### 4.4 MINE DESIGN

Mine design parameters are based on standard mine design practice for opencut mines. At a later date geotechnical investigations will result in the formulation of geotechnical guidelines for the project which will become the basis for mine design parameters.

Parameters used for this study are:

- Orebody dip - 60° to the west
- Overburden waste sediments dip 60° to 70° to the east
- Drill and blast highwall bench face slope - 70°
- Spoil angle of repose - 35°
- Bench height - 20m
- Catch berm width - 5m
- Catch berm interval - 20m
- Swell of ore 120% of in situ volume
- Swell of waste 120% of in situ volume
- Out-of-pit spoil dump height - 50m (suggested maximum)
- Out-of-pit spoil external face slope 1 in 6
- Out-of-pit dump intermediate berm at 10m
- Intermediate berm width - 10m
- Backhoe and truck flitch height 4m to 5m
- Access ramp width - 15m
- Access ramp gradient 1 in 10
- Relative density of waste - 2.6t/m<sup>3</sup>
- Relative density of ore - 4t/m<sup>3</sup>
- Details of the conceptual mine plan for a 225m deep pit are shown in Figure 4.1. This corresponds to the inferred geological resource described in Table 3.1.



## 4.5 MINING LOSS AND DILUTION

At this conceptual level of study, mining loss and dilution has not been taken into consideration because of the imprecise method of calculating magnetite content in the ore zone and the lack of knowledge of the distribution of the magnetite at the roof and floor contacts with the waste.

## 4.6 OPENCUT MINING LIMITS

Opencut mining limits are a function of project economics. These in turn are a function (amongst others) of mining costs, mining recovery, beneficiation processes and costs, government charges and royalties, transport costs and the product price received at the point of sale.

A first step in assessing opencut mining limits is to look at the effect of increasing depth increments on the quantity of ore and waste produced. A simple spreadsheet analysis was used to do this based on the typical opencut cross-section shown in Figure 4.1 for mining depths ranging from 50m to 250m over a strike length of 600m for the ore dipping at 60°. An ore thickness of 7.0m and a relative density of 4t/m<sup>3</sup> were used. An overall highwall angle of 55° has been used to allow for benches and the access ramp to the pit bottom. Magnetite product tonnage was calculated based on a 50% product yield from the in situ ore mined. Figure 4.1 shows the mine layout for a 225m deep mine. This has been taken as the base case limit for opencut mining.

Results of this analysis are shown in Table 4.1, Cross-Sections Mining Reserves. These results show the indicative tonnes of magnetite product and an indicative stripping ratio which does not include any endwall allowance for batters for the opencut.

- A 50m deep pit is likely to produce 485,000t of magnetite product at a stripping ratio greater than 2:1 m<sup>3</sup> of waste per tonne of product
- A 150m deep pit is likely to produce 1,455,000t of magnetite product at a stripping ratio greater than 6:1 m<sup>3</sup> of waste per tonne of product (some 10Mm<sup>3</sup> of waste)
- A 200m deep pit is likely to produce some 1,940,000t of magnetite product at a stripping ratio greater than 8:1 (some 18Mm<sup>3</sup> of waste)
- A 225m deep pit is likely to produce some 2,182,000t of magnetite product at a stripping ratio greater than 9:1 (some 22Mm<sup>3</sup> of waste).

The size of the deposit is only likely to support an opencut operation producing 2Mt or less of product and therefore the highest value price received for the product is likely to be the key determinant of whether mining is likely to be economic.

The best market (highest value) for the Nelson Bay River magnetite is deemed to be the production of magnetite concentrates for supply to coal washeries. Currently magnetite for this purpose is being provided to central Queensland coal mines at prices around \$250 to \$260 per tonne delivered to the mine. Current suppliers are few in number with most magnetite supplied from Tasmania, New South Wales, Western Australia and Canada?

Without prior known mining and processing costs for the deposit (including capital and infrastructure costs) it is not possible to be more precise and it was hoped that the above high magnetite prices will generate positive cash returns.

## 4.7 METALLURGICAL CONSIDERATIONS

Magnetite  $\text{Fe}_3\text{O}_4$  (72% Fe) deposits of igneous origin or association occur in most Australian states and are generally mined on a small scale (around 50,000t/a to 100,000t/a) mainly for coal washing and mineral separation (dense medium separation).

As part of the ongoing evaluation of the deposit in 2006, Zelos sent four samples of quarter diamond drill from hole NBR001 to Amdel for petrographic and mineralgraphic description and determination of magnetite by Davis Tube Recovery (DTR).

Table 4.1 shows the Davis Tube Recovery Results for the samples. This equates to 5.6m at 49.72% magnetite over the sample interval and 35.98% Fe in assay. The Amdel report is included as Appendix 1. The results in Table 4.1 support the inferred resource assumptions used in Table 3.1.

**Table 4.1**  
**Davis Table Recovery Results**

Sample Numbers		From	To	Interval	Wt% Magnetite Fraction
NBR001	PET 1	222.4m	223.1m	0.7m	53.5
NBR001	PET 2	223.1m	224.25m	1.15m	35.9
NBR001	PET 3	224.25m	225.4m	1.15m	60.2
NBR001	PET 4	225.4m	228m	2.6m	50.2

Current Australian magnetite producers for coal washery applications are Kara No1 Mine south of Burnie Tasmania which is capable of producing 60,000t/a – 100,000t/a? The mine is a joint venture, 50% Itochu Corporation and 50% Tasmanian Mines Ltd (ref 3).

Tallawang Mine north of Mudgee New South Wales with a production capacity of 100,000t/a? The process involves crushing, wet milling, grinding, sizing concentrating and drying. The owner is Unimin Australia Ltd which is owned by Unimin Corporation USA (ref 3).

A Western Australian mine is currently looking to sell 30,000t/a into the Australian coal washing market where the magnetite is a by product from a cobalt mine (ref 4).

Zelos Resources initially proposed looking at three treatment options:

- Magnetite concentrates for supply to coal washeries
- Magnetite pellets using a Savage River style process
- Production of pig iron using Hismelt or Ausmelt process.

Zelos proposed to do this work and the conceptual study has left these options open for Zelos to pursue.

Mr Andrew Firek of Zelos has been evaluating the treatment options and is following up initial inquiries with Ausmelt Limited with regard to their technology and the production of pig iron from a mini smelter based on Nelson Bay River ore. Ausmelt recommend a minimum production capacity of 300,000t/a for any iron smelting project to be viable. Capital for a facility of this type was estimated at \$120M on a pre-feasibility basis and smelter operating costs were estimated to be likely to be around \$141/t of hot metal (thm). The resulting pig iron product could be expected to sell for US\$220/t or around AU\$295/t.

Correspondence on the Ausmelt enquiries is included as Appendix 2.

Similarly, process flowsheets and capital and operating costs for the various options have been left for Zelos to determine after they have decided which of the options or combinations of options they wish to pursue and evaluate.

## 4.8 PRODUCTION RATES

Mining production rates for the deposit will affect the costs of production. In turn the production rate will be governed by the end market and how much of the product the market can take.

For magnetite sold into the coal washery dense media market a production rate of up to 100,000t/a may be achievable. Can this be supplemented with sales into other market areas which could be used to boost the annual mining production rate using these other product options? The viability of these options needs to be known for them to be evaluated.

Assuming a production rate of 100,000t/a of product then the deposit to a depth of 150m could provide some 14 years of product at a stripping ratio above 6m<sup>3</sup> of waste per tonne of product (Table 4.2) after endwall batters are included.

If the annual production rate were 200,000t/a of product, resources would be mined out to the 150m depth in seven years and to a depth of 200m in ten years. In the last case the resource would be mined at a stripping ratio greater than 9m<sup>3</sup> of waste per tonne of product after endwall batters are included.

Market supply forces will determine the actual production rate that can be sustained by the deposit. The window of market demand is not known and the cost to produce and supply this amount to individual minesites is also yet to be determined.

The current buoyant coal market in Australia offers a good opportunity for new suppliers of magnetite for coal washeries to enter the market in Australia and Indonesia.

## 4.9 ENVIRONMENTAL CONSIDERATIONS

The proximity of the Nelson Bay River to the opencut mining area limits the area adjacent to the pit available for out-of-pit waste dumps. The steep 60° dip of the ore and the limited strike length of 600m means that all waste mined must go to out-of-pit waste dumps.

The location and size of these dumps have not been determined but the cost of mining and placing waste in dumps has been allowed for in the costing. More detailed topography coverage of the area is needed before design can proceed.

Rainfall and water management issues such as the need to bund areas of the project to prevent inundation need to be addressed.

The presence of pyrite and sulphides with the ore is noted in the geological report. Studies have not been done to determine the potential for waste and ore to become acid forming and require encapsulation within dumps.

Land use, out-of-pit waste dumps, rehabilitation and related topics need to be defined. These are likely to cover mining and out-of-pit waste dumping issues, land use and rehabilitation criteria, final void issues, water management and capital MRT specific issues, royalties and departmental requirements.

**Table 4.2  
Nelson Bay River Magnetite Cross-Section Mining Reserves**

LOCATION	DEPTH		IRON ORE ZONE			ORE STRIKE LENGTH		MAGNETITE MINING RESERVES		WASTE		Mineable	Product
	Total m	weathered m	thickness m	R D t/m <sup>3</sup>	dip deg	length m	Insitu Ore Tonnes t x10 <sup>3</sup>	Project Recovery	Product Tonnes t x10 <sup>3</sup>	H/wall angle deg	Area m <sup>2</sup>	Strip Ratio m <sup>3</sup> /t	Strip Ratio m <sup>3</sup> /t
Typical Cross Section	50	0	7.0	4	60	600	970	50%	485	55	1,597	1.0	2.0
	100	0	7.0	4	60	600	1,940	50%	970	55	6,388	2.0	4.0
	150	0	7.0	4	60	600	2,910	50%	1,455	55	14,373	3.0	5.9
	175	0	7.0	4	60	600	3,395	50%	1,697	55	19,563	3.5	6.9
	200	0	7.0	4	60	600	3,880	50%	1,940	55	25,551	4.0	7.9
	225	0	7.0	4	60	600	4,365	50%	2,182	55	32,338	4.4	8.9
	250	0	7.0	4	60	600	4,850	50%	2,425	55	39,924	4.9	9.9

## 5. COSTING

Indicative order of magnitude costing has been undertaken to determine the factors that will affect the viability of opencut mining and highlight the factors that will have the greatest impact on mining/project costs.

This was done by constructing a spreadsheet to look at annual operating costs for a range of production rate cases.

Minserve has been able to put together price information for the supply of magnetite for coal washing. This is perceived to offer the best case for the exploitation of the resource. We perceive there is a potential opportunity for the Nelson River Bay Iron resource to supply this market. Annual supply and demand tonnages will be key factors that will affect how this might be achieved.

Order of magnitude costs have been used based on the following initial assumptions:

- Coal washery magnetite product sale price ex Zelos minesite - \$200/t
- Magnetite product sale price for other products ex Zelos minesite - \$60/t
- Cost of mining opencut ore - \$3.00/t
- Magnetite product recovered from ore – 50%
- Cost of waste mined and dumped out-of-pit - \$7.00/m<sup>3</sup>
- Other site related costs per product tonne - \$3.00/t
- Ore processing cost per product tonne - \$12.00/t.

The above costs have been used to determine annual operating costs for a range of production rates and sales scenarios.

Table 5.1 shows order or magnitude annual costs, annual revenue and annual operating surpluses based on the supply of 100,000t/a of coal washery magnetite product for minesite production rates of 100,000t, 150,000t and 200,000t of magnetite product per year.

The table shows that the 100,000t/a, the 150,000t/a and the 200,000t/a production cases all generate operating cash surpluses where sales are based on 100,000t/a being sold to coal washeries with any excess product sold at \$60per tonne.

In Table 5.2 only 30,000t/a has been assumed to be sold to coal washeries and this significantly lowers the revenue received for each case. The 200,000t/a of magnetite case produces a cash deficit.

The annual operating surpluses shown in Tables 5.1 and 5.2 must cover the capital costs for the project. This includes the cost of site infrastructure and the treatment plant. These capital costs have yet to be determined.

Simple order of magnitude operating cost analyses for a 100,000t/a operation producing magnetite products for coal washeries at a realised minegate sales price of \$200/t show that such an operation is likely to be profitable after capital costs for the project have been taken into consideration.



## 6. RESULTS AND RECOMMENDATIONS

The order of magnitude costing shows that the project is likely to be viable if it can produce suitable magnetite for the lucrative coal washery market and can capture a share of this market sufficient to justify the operation. Currently central Queensland coal mines pay prices around \$250 to \$260 per tonne for delivered magnetite which is used in the coal washery heavy media separation process. Current suppliers are few in number with most magnetite supplies coming from Tasmania, New South Wales, Western Australia and Canada.

The amount of waste excavated to mine the ore will increase significantly with depth due to the 60° dip of the ore. Markets and processing costs will need to be better defined to provide a more accurate appraisal of the project. The conceptual study mine design shows that opencut mining can proceed to a depth of 225m but that all waste would need to go to out-of-pit waste dumps due to the limited strike length of the pit and the need to keep a 1 in 10 access ramp open to the pit bottom. No waste dump design or location has been attempted for this conceptual study.

Current results are encouraging and the project is likely to be viable if high value products can be produced.

The economic depth for mining is likely to be less than the 225m contained in the November 2005 geological report.

The order of magnitude costing showed that based on the broad assumptions used, producing around 100,000t/a of magnetite for coal washeries is likely to be viable once all capital and operating costs have been taken into consideration. A pit depth of around 150m is also likely to give a better return than a pit that is 225m deep based on the high incremental stripping ratio and the increased costs that would be required to deepen the pit.

Only broad metallurgical concepts have been addressed in this report. Zelos proposes to do this work in more detail during the next stage of the project in which they will develop process flowsheets and capital and operating costs for the various options under review.

No treatment plant capital costs or minesite infrastructure costs have been estimated for the project. Order of magnitude capital costs have been used. Zelos have commissioned Ore Pro Pty Ltd-Bond Bros Contracting Pty Ltd to provide cost estimates for the construction of (1) A Process Plant to produce magnetite fines for coal washeries and (2) A Process Plant to produce pellets. This information will be used to produce an addendum to the report to update project cost estimates.

Project viability has been assessed on the basis of the surplus operating cash generated from the case studies costed being sufficient to pay for the capital items and generate an acceptable profit.

The conceptual study results support continuing the study evaluation to delineate opencut mining to 150m depth, resource definition to define the ore zone over the 600m strike length and determine metallurgical factors and recoveries to produce magnetite products suitable for sale to coal mine washeries. Process flowsheets and capital and operating costs need to be provided to match these studies along with site infrastructure requirements and costs.

An opencut magnetite mine with processing/treatment plant providing 100,000t/a of coal washery product has potential to generate in excess of \$10M surplus cashflow per year over a 10 to 15 year mine life. Capital costs are estimated to range between \$10M to \$20M.

Preliminary concept studies of the Ausmelt process to produce 300,000t/a to 400,000t/a of pig iron indicate that, at a sales price of US\$200/t, such a project also has potential to generate significant annual cashflow surpluses based on processing costs of \$141/t of hot metal (thm). A capital cost for the Ausmelt facility has been estimated at \$120M. A mine life of 4 to 6 years is likely for this type of operation based on a 150m deep opencut.

It is recommended that minesite coal washery prices for delivered magnetite be verified and that specifications for these products be determined. Results of this study need to be reviewed once these new prices have been established.

Process flowsheets need to be progressed for the various options under review and metallurgical recoveries, capital costs and operating costs determined for project evaluation studies.

Surface maps and topography for the resource area need to be produced in digital form and in sufficient detail to support ongoing studies and resource evaluation.

Environmental issues need to be defined and investigations/studies progressed to meet future study requirements. These area likely to cover mining and out-of-pit waste dumping issues, land use and rehabilitation criteria, final void issues, water management, MRT issues and requirements.

The Nelson Bay River Iron Ore project is at an early stage of evaluation. An inferred resource has been estimated from only three cored drillholes. Metallurgical testwork and assays show encouraging results without being specifically tailored to the two products mentioned. Each has potential to be a viable operation if the ore is proven to be suitable for the purpose proposed.

Key areas for progressing the next stage of the project are perceived to include:

### **Geology**

- Additional cored drillholes to upgrade the resource to indicated or measured status
- Definition of the basal 7m ore zone and the magnetite distribution within the ore zone and the ore zone/waste interfaces.

### **Mining**

- Topography coverage for mine design and out-of-pit waste dumps
- Confirm geotechnical and mine design parameters
- Confirm environmental guidelines for mining.

### **Mineralogy/Metallurgy**

- Testwork to determine suitability of ore for supply to coal washeries and Ausmelt processes
- Flowcharts and recoveries/yields for the selected processes
- Capital and operating costs for the selected processes.

### **Marketing**

- Confirm market specifications and suitability of processes to meet specification
- Establish market windows of opportunity with regard to quantity and price for the selected processes.

### **Project**

- Establish project infrastructure requirements and costs
- Establish environmental requirements for the project
- Establish government and regulatory requirements framework for the project.

## 7. ACKNOWLEDGEMENTS AND REFERENCES

### 7.1 ACKNOWLEDGEMENTS

This report has relied on the general project summary information and geology provided by Simon Tear of SMGC referenced below.

Information on the Ausmelt process and Zelos Resources correspondence in this area has been provided by Dr Andrew Firek of Zelos. Appendix 2 contains pertinent correspondence on this subject.

### 7.2 REFERENCES

1. Simon Tear, SMG Consultants – Nelson Bay River Licence EL41/2004 Literature Study Report, November 2005.
2. Australian Mines Atlas Iron Ore Fact Sheet, [www.australianminesatlas.gov.au](http://www.australianminesatlas.gov.au).
3. Australian General Mining Year Book, Australian Mining Services 2004 and 2005 published by Australian Mining Series Pty Ltd.
4. Dr Eugene Gallagher, The Minserve Group Pty Ltd, personal notes, February 2006.



**APPENDIX 1**

**Amdel Petrology and Davis Tube Recovery Results  
February 2006**

**Table 1**  
**Davies Tube Recovery Results**  
 (Source: Simon Tear, February 2006)

Sample No.	Weight (g)		Wt %	From	To	%mag metres
	Initial	Magnetic Fraction	Magnetic Fraction			
NBR001 PET1	20.42	10.92	53.5	222.4	223.1	37.43389
NBR001 PET2	19.97	7.16	35.9	223.1	224.25	41.23185
NBR001 PET3	24.65	14.83	60.2	224.25	225.4	69.18661
NBR001 PET4	18.00	9.04	50.2	225.4	228	130.5778
NBR001 PET4 (Dup)	23.43	11.35	48.4		Total	278.4301

Assay results

	From	To	Fe %	Fe m%
NBR001	222.4	224	49.9	79.84
NBR001	224	225	50.3	50.3
NBR001	225	226	50.1	50.1
NBR001	226	227	47.9	47.9
NBR001	227	228.4	47.6	66.64
				294.78

Equates to  
 5.6 m  
 @  
 49.72 % Magnetite  
 which equates to  
 35.98 % Fe in assay

6 m  
 @  
 49.13 % Fe from assay results  
 which would equate to  
 67.90 % Magnetite

Therefore 13.2% Fe is attributable to other minerals  
 ie siderite (48.2% Fe), ankerite (16.2% Fe), chlorite (high iron variety 25-33% Fe) and actinolite (12.8% Fe)

**REPORT N1759PE06**

**PETROLOGY AND DTR OF FOUR SAMPLES**

A.B.N. 30 008 127 802

Telephone (Aust): (08) 8416 5200  
(Int): 61 8 8416 5200  
Facsimile (Aust): (08) 8352 8243  
(Int): 61 8 8352 8243

Gate 1 Brown Street  
Thebarton  
South Australia 5031  
AUSTRALIA

PO Box 338  
Torrensville Plaza  
South Australia 5031  
AUSTRALIA

---

15 February 2006

Zelos Resources NL  
Level 3  
2 Bligh Street  
SYDNEY NSW 2000

Attention: Luke Vanzino/Wes Harder

## **REPORT N1759PE06**

### **PETROLOGY AND DTR OF FOUR SAMPLES**

YOUR REFERENCE:	Samples received 20 Jan 2006 (QBL60612)
SAMPLE IDENTIFICATION:	NBR001 PET1 to PET2
MATERIAL:	4 quarter core samples
DATE RECEIVED:	20 January 2005
PROJECT MANAGER:	Frank Radke

**Frank Radke**  
**Senior Mineralogist**

FR : ek

## 1. INTRODUCTION

Four samples of quarter diamond drill core were submitted by Zelos Resources NL for petrographic and mineragraphic description and determination of magnetite content by Davis Tube Recovery (DTR). Amdel quotation of 5 January 2006 applies to this work.

## 2. PROCEDURE

Each of the four samples represent an interval of diamond drill core. A small section of a few inches was selected for petrographic and mineragraphic examination. Polished thin sections were made of the sample and examined by transmitted and reflected light microscopy. The hand specimens were tested with dilute hydrochloric acid for the presence of calcite but no calcite was detected.

The remaining sample was used for Davis Tube Recovery (DTR) to determine its magnetite content using the following procedure:

- Crush the entire sample to -3.35 mm
- Split out about 150 g to pulverise in a ring pulveriser
- Pulverise the sample for 150 seconds
- Wet screen the sample at 75µm
- Pulverise the oversize for 4 seconds per 5 g of oversize
- Repeat screening and pulverising until less than 5 g of oversize remain
- Split out approximately 20 g for DTR testwork
- Discard the tailing (non-magnetic fraction)
- Collect, filter, dry and weigh the concentrate (magnetic fraction)

The conditions for the DTR testwork are as follows:

- Stroke frequency           60/minute
- Stroke length               38 mm
- Magnetic field strength   3000 gauss
- Tube angle                 45 degrees
- Tube diameter             25 mm
- Water flow rate           540 ml/minute
- Washing time             15 minutes or until tailings are clear, whichever is longer

## 3. DTR RESULTS

The DTR results and percentage of magnetic product in these samples as determined by DTR are given in Table 1. The magnetic product would consist mainly of magnetite but assays would be required to determine its precise composition.

## 4. PETROGRAPHIC AND MINERAGRAPHC DESCRIPTIONS

All four of these samples are banded iron formation comprised largely of magnetite intergrown with varying amounts of tremolite, a degraded mica, carbonate and quartz. Samples PET1 and PET4 are similar containing abundant tremolite while Samples PET 2 and PET3 have lower tremolite contents and higher proportions of carbonate and quartz. Although some of the carbonate in these samples could represent original carbonate, most is thought to be an alteration product replacing silicate minerals including tremolite and micaceous minerals. This replacement is most pronounced sample PET3 in which the tremolite and fibrous micaceous minerals have been almost completely replaced by carbonate, which in some areas exhibits ghosts or pseudomorphs after the pre-existing mineral. Quartz is also thought to be an alteration product associated with the carbonate alteration. Both the carbonate and quartz tend to be concentrated in magnetite rich bands as linings along fractures in magnetite crystals and as interstitial intergrowths between magnetite crystals.

A brown phyllosilicate called degraded mica in samples PET1, PET2 and PET4 or degraded biotite in sample PET3 is present in these rocks. It is thought to be mica such as biotite, which has been largely replaced by chlorite but it could represent another phyllosilicate or possibly a brittle mica.

These samples contain trace levels of sulphides comprised mainly of chalcopyrite and iron sulphides comprised of pyrite, marcasite and pyrrhotite. The pyrrhotite occurs only as inclusions in magnetite and is thought to be a metamorphic mineral. The chalcopyrite occurs both as inclusions in magnetite and as intergrowths with minerals interstitial to magnetite and is thought to be both a metamorphic mineral and an alteration product. The pyrite and marcasite generally form porous appearing aggregates, which are considered to be an alteration product and possibly represent altered pyrrhotite. Some areas of the pyrite have a well polished character which is considered to be due to recrystallisation of porous pyrite. Arsenopyrite was seen in Sample PET2 as large crystals approximately a millimetre in size.

All four of these samples are thought to represent banded iron formation originally comprised mainly of magnetite and tremolite with minor amounts of a mafic phyllosilicate, which show varying degrees of alteration to carbonate and minor quartz with very small amounts of sulphide. This alteration is most pronounced in sample PET3 and least pronounced in samples PET1 and PET4.

**SAMPLE:** NBR001 PET1

**ROCK NAME:** Banded iron formation

**HAND SPECIMEN:** This is a weakly banded rock containing dark grey to black magnetite rich bands separated by pale grey to greenish grey bands. The banding is generally on a scale of about 1 cm.

**POLISHED THIN SECTION:**

An optical estimate of the constituents gives the following:

Mineral	%	Origin
Tremolite	45	Metamorphic
Magnetite	35	Metamorphic
Degraded (?) mica	15	Alteration
Carbonate	5	Alteration/(?) metamorphic
Chlorite	Trace -1	Metamorphic
Quartz	Trace -1	Alteration
Chalcopyrite	Trace	(?) alteration
Pyrite	Trace	(?) alteration
Marcasite	Trace	Alteration
Hematite	Trace	Alteration

This sample consists of magnetite crystals distributed through a matrix comprised of tremolite intergrown with an interstitial brown phyllosilicate termed degraded mica in the above list of minerals. Magnetite forms anhedral to subhedral crystals which are between 0.05 and 0.6 mm in size with most of the magnetite having a grain size of about 0.1 mm. The banding noted in hand specimen is due to concentrations of magnetite within the darker bands. The tremolite forms deformed crystals up to approximately 1 mm in length showing evidence of granulation producing aggregates with a much finer grain size. The degraded mica forms flaky aggregates generally below 0.2 mm located interstitially between tremolite crystals. This mineral has a highly variable birefringence ranging from moderate birefringence to very low birefringence and is thought to be a mica (possibly phlogopite or biotite) showing partial replacement by a colourless, weakly birefringent chlorite. The rock also contains pleochroic green chlorite flakes up to 0.3 mm in length, which generally occur as inclusions or marginal intergrowths to magnetite. This mineral has been termed chlorite in the above list of minerals.

Carbonate forms disseminated grains and aggregates ranging up to 0.3 mm in size. The carbonate is concentrated in some magnetite rich bands as interstitial intergrowths between magnetite and as fracture linings within magnetite crystals. The carbonate has not been positively identified but is thought to be magnesite or dolomite. Minor quartz was noted as narrow fracture fillings within magnetite bands.

Traces of chalcopyrite, pyrite and marcasite form disseminated anhedral grains below 0.1 mm in size which are concentrated in magnetite rich bands as fine intergrowths with interstitial and vein type carbonate and quartz. The pyrite and marcasite form crystals with a porous appearing texture and in some aggregates are intergrown with each other. Hematite was noted as a rare marginal intergrowth to magnetite and is a replacement product of magnetite.

This is a banded iron formation comprised mainly of magnetite and tremolite with moderate amounts of degraded mica. The rock shows evidence of deformation along with the development of carbonate and quartz veining with trace levels of sulphides comprised of chalcopyrite and iron sulphides (pyrite and marcasite).

**SAMPLE:** NBR001 PET2

**ROCK NAME:** Banded iron formation

**HAND SPECIMEN:** This is a mottled rock containing black magnetite rich aggregates generally below 5 mm in size distributed through a pale grey matrix. The polished thin section was cut from an area containing a somewhat higher proportion of magnetite than most of the core interval.

**POLISHED THIN SECTION:**

An optical estimate of the constituents gives the following:

Mineral	%	Origin
Magnetite	25	Metamorphic
Degraded (?) mica	25	Alteration
Tremolite	20	Metamorphic
Carbonate	20	Alteration/(?) metamorphic
Quartz	5	Alteration
Goethite	3	Alteration
Hematite	1	Alteration
Arsenopyrite	Trace -1	Alteration
Chalcopyrite	Trace	Metamorphic/alteration
Pyrrhotite	Trace	Metamorphic
Marcasite	Trace	Alteration
Pyrite	Trace	Alteration

The polished thin section was cut from a region containing more magnetite than the bulk of the sample. The magnetite crystals are between 0.05 and 1.5 mm in size with most of the magnetite crystals between 0.1 and 0.8 mm in size. The magnetite crystals generally have angular, broken appearing shapes with some exhibiting weakly subhedral shapes. Many of the subhedral crystals are fractured and veined.

The magnetite crystals are distributed through a highly variable matrix with a banded character containing some bands with concentrations of tremolite and other bands with concentrations of degraded mica or carbonate. Quartz also tends to be concentrate in a band several millimetres wide. The tremolite forms crystals up to 0.6 mm long, which exhibit a weakly developed preferred orientation parallel to the mineralogical banding. The degraded mica forms flakes up to 0.2 mm in length, which are concentrated in aggregates up to 0.5 mm in size. This degraded mica consists mainly of a colourless, weakly pleochroic chlorite but it does contain some birefringent areas, which could represent remnant biotite. The carbonate is concentrated in bands up to several millimetres wide as granular mosaics with a typical grain size below 0.15 mm. The carbonate has not been positively identified but is probably dolomite or magnesite.

The quartz forms granular aggregates with a grain size below 0.15 mm. Quartz tends to be concentrated as irregular veins and fracture linings in magnetite. Quartz also occurs as rims or partial rims around magnetite. Much of the quartz veining or rimming magnetite forms intergrowths with a lamellar texture perpendicular to the magnetite crystals. Finely granular carbonate also occurs as interstitial intergrowths between magnetite crystals and as fracture linings in magnetite.

Goethite forms narrow linings along vague foliation lamellae within degraded mica bands and lenses. Hematite forms marginal intergrowths to magnetite and is a replacement product of magnetite. The hematite intergrowths are generally between 0.05 and 0.2 mm in size.

Arsenopyrite crystals between 0.2 and 1 mm in size are concentrated in a band with a fractured and deformed character. Traces of chalcopyrite, marcasite and pyrite form anhedral disseminated grains below 0.1 mm in size. All of the pyrite and marcasite and most of the chalcopyrite form intergrowths with minerals located along fractures in magnetite crystals or in material interstitial to magnetite crystals. A small proportion of the chalcopyrite and all of the pyrrhotite form inclusions in magnetite

crystals. The marcasite and pyrite typically form poorly polished aggregates and could represent altered pyrrhotite.

This is a banded iron formation comprised mainly of magnetite, tremolite, carbonate and a degraded phyllosilicate which now consists mainly of chlorite. The sample shows evidence of deformation with fracturing of magnetite crystals and deformation effects in tremolite. The carbonate, quartz and most of the sulphides are thought to be an alteration product possibly associated with the deformation. Pyrrhotite and some of the chalcopyrite occur as inclusions in magnetite and are thought to be an original metamorphic mineral. Arsenopyrite is locally present as large crystals associated with deformed areas. The marcasite and pyrite could represent original pyrrhotite, which has been replaced by iron sulphides.

**SAMPLE:** NBR001 PET3

**ROCK NAME:** Banded iron formation

**HAND SPECIMEN:** This sample consists mainly of magnetite with some paler coloured bands up to about 1 cm in size, which range in colour from a milky grey to a brownish grey.

**POLISHED THIN SECTION:**

An optical estimate of the constituents gives the following:

Mineral	%	Origin
Magnetite	65	Metamorphic
Carbonate	25	Alteration/(?) metamorphic
Degraded biotite	5	Alteration
Quartz	3	Alteration
Tremolite	1	Metamorphic
Chalcopyrite	Trace -1	Metamorphic/alteration
Pyrite	Trace -1	Alteration
Marcasite	Trace	Alteration
Pyrrhotite	Trace	Metamorphic

This sample consists mainly of magnetite, which generally forms crystals between 0.05 and 0.8 mm in size and is concentrated in polycrystalline areas up to several millimetres wide. The magnetite rich areas consist mainly of magnetite with only small amounts of other minerals along grain boundaries between the magnetite crystals.

The polished thin section includes some bands containing concentrations of carbonate intergrown with degraded biotite, quartz and minor tremolite. The carbonate forms a finely granular mosaic with a maximum grain size of about 0.2 mm with some fibrous textured areas which appear to represent a replaced phyllosilicate. Tremolite is partially replaced by granular carbonate leaving remnants of tremolite and ghosts after tremolite crystals. Quartz is intergrown with the carbonate as finely granular aggregates. Some quartz has a columnar texture where it is located marginal to magnetite crystals as fracture linings or vein fillings.

Some bands contain concentrations of an intensely pleochroic brown phyllosilicate which is probably biotite. In some areas this phyllosilicate has a translucent, reddish brown colour believed to be due to alteration. The colour appears to be due to finely intergrown goethite although no goethite could be detected in reflected light.

Sulphides comprised of chalcopyrite, pyrite, marcasite and pyrrhotite are disseminated through the rock. The chalcopyrite forms anhedral grains up to 0.2 mm, which are generally intergrown with the carbonate although a small proportion of chalcopyrite forms small (below 0.05 mm) inclusions in magnetite. Pyrite and marcasite form anhedral grains and aggregates up to 0.2 mm in size and tend to be concentrated in a band as intergrowths with carbonate. A small proportion of pyrite forms recrystallised appearing crystals and aggregates with anhedral to weakly subhedral shapes. Pyrrhotite was noted only as inclusions in magnetite, which are below 0.05 mm in size.

This rock is banded iron formation showing evidence of alteration with the development of carbonate and quartz along with minor sulphides comprised of chalcopyrite and iron sulphides (pyrite and marcasite). Some of the carbonate could be an original metamorphic mineral at most is thought to be a replacement product of pre-existing silicates (tremolite and a probable phyllosilicate). The pyrrhotite and some of the chalcopyrite are thought to be primary metamorphic minerals but the pyrite and marcasite as well as most of the chalcopyrite are associated with the carbonate and are thought to be associated with the carbonate alteration.

**SAMPLE:** NBR001 PET4

**ROCK NAME:** Banded iron formation

**HAND SPECIMEN:** This rock contains dark grey to black, magnetite rich bands separated by pale greenish grey bands. The banding is generally between 1 and several millimetres in width.

**POLISHED THIN SECTION:**

An optical estimate of the constituents gives the following:

Mineral	%	Origin
Tremolite	45	Metamorphic
Magnetite	30	Metamorphic
Degraded (?) mica	10	Alteration
Carbonate	8	Alteration/(?) metamorphic
Quartz	5	Alteration
Chalcopyrite	1	Alteration/metamorphic
Pyrite	Trace -1	Alteration
Chlorite	Trace	Metamorphic
Marcasite	Trace	Alteration
Hematite	Trace	Alteration
Pyrrhotite	Trace	Metamorphic

This sample consists of a magnetite and tremolite intergrowth containing bands rich in magnetite or tremolite. The magnetite crystals are generally between 0.1 and 2.5 mm in size and are concentrated in bands up to several millimetres wide. In some bands the large magnetite crystals have fractured characters.

The tremolite forms crystals up to 1.5 mm in length with evidence of deformation including bent and broken shapes and granulation to form fibrous aggregates. The tremolite crystals have a random orientation.

Carbonate forms granular aggregates concentrated in the magnetite rich bands. Much of the carbonate occurs as interstitial linings or vein fillings in magnetite.

Sulphides comprised of chalcopyrite, pyrite and marcasite are disseminated through the rock as anhedral grains and aggregates up to about 0.3 mm in size. Most of the chalcopyrite is intergrown with the tremolite and carbonate and a small proportion occurs as inclusions in magnetite. The pyrite and marcasite form irregular patches with a poorly polished, porous texture that could represent altered pyrrhotite. A small proportion of the pyrite forms well polished areas believed to be due to recrystallisation of porous pyrite. Pyrrhotite was noted only as small (below 0.05 mm) inclusions in magnetite.

A pleochroic green chlorite forms flakes between 0.05 and 0.1 mm in size, which are included within magnetite. The magnetite shows minor marginal replacement by hematite.

This is a banded iron formation much like Sample NBR001 PET1 although this sample has a slightly higher sulphide content than Sample NBR001 PET1.

## TABLES

## **APPENDIX 2**

### **Ausmelt and Zelos Resources Minismelter Correspondence**

## Memorandum

**To:** Zelos Resources NL Board  
**From:** Andrew Firek  
**Date:** 14/03/2006  
**Re:** Minismelter for Nelson Bay River Project (NBR)– additional comments

---

The attached letter from Ausmelt describes with  $\pm 30\%$  accuracy capital and operating costs for a minismelter based on Nelson Bay River ore. The letter together with another document will be sent to engineers preparing the Nelson Bay River Project Scoping Study.

Capital for a facility of this type was estimated at A\$120 M on a pre-feasibility basis.

It was assumed that a 63% Fe concentrate is fed to the furnace and the quoted figures relate to tonnes of hot metal (thm).

The amount of produced pig iron (not quoted in the letter) would be in the range of 230,400 tpa, and with pig iron lately attracting a U\$10/t premium over iron scrap, it could be sold for U\$220-240/t.

Assuming a U\$220/t selling price the annual profit from selling pig iron would be:

$$U\$(220-106)/t \times 230,400\text{tpa} = U\$ 26,265,600 / 0.75 \text{ A\$/U\$} = \text{A\$ } 35,020,800\text{pa,}$$
indicating that the capital cost could be recouped in 3 years.

Cat Coal could be used as a fuel and reductant.

23<sup>rd</sup> February 2006

Mr Andrew Firek  
Zelos Resources  
Level 3, 2 Bligh Street  
Sydney  
NSW 2000

(sent by e-mail)

Dear Mr Firek,

Following on from our telephone conversation earlier this week, I am writing in response to some of the questions you raised:

***Minimum operating capacity***

Whilst there are always some exceptions due to fundamentally low-priced raw materials, or perhaps downstream processing advantages, in general terms we have found that a production capacity of at least 300,000tpa is required for any iron smelting project to be viable. We are pursuing a pig iron development of our own at the moment which we have pitched at 400,000tpa in order to generate attractive economics.

***Capital/opex***

The table below summarises consumables for the Ausiron<sup>®</sup> technology using typical Australian iron ore fines at about 63% Fe. The coal used is a good quality bituminous coal that is ideal for smelting operations of this nature. Whilst coal and ore prices have inevitably moved since this table was developed, you can readily adjust for this with your own assumed unit costs.

Bear in mind that we do not require coking coals, and there is no requirement for feed preparation. Ore can be delivered direct to the furnace as fine concentrates, through to typical -10mm fines. (Top size for feed material is about 25mm).

Capital for a facility of this type was estimated at \$120 M on a pre-feasibility basis. This cost includes the ironmaking facility and associated power generating equipment, but not any stockpiling facilities for raw materials. The oxygen facility for combustion air enrichment is assumed as an "over the fence" supply costed into opex rather than capex. Power generated by waste gases from the smelting process is used to cover the power requirements of the ironmaking facility and the oxygen plant, with surplus power available for sale.

Production Capacity: 385,000tpa		
Coal (as rec'd)	915 kg / thm (@ \$60/t)	\$54.90 / thm
Ore	1585 kg / thm (@ \$35/t)	\$55.48 / thm
Flux	290 kg / thm (@ \$25/t)	\$7.25 / thm
Oxygen	620 Nm <sup>3</sup> / thm (@ \$30/t)	\$26.43 / thm
Power	internally generated	
Misc consumables		\$7.20 / thm
Fixed costs		\$15.10 / thm
Power credits	30 MW+ (@ 4c / kWh)	\$24.92 / thm
<b>Total operating cost (AUD)</b>		<b>\$141 / thm</b>
		<b>(USD) \$106 / thm</b>

**Feed qualities:**

The process is tolerant to iron ore impurities such as phosphorus, zinc and alkali metals. There is no real minimum limit on ferrous content in the feed, however unless the feed is extremely low-cost, it is unlikely that an economic outcome would be achieved using feed at Fe levels below 58%, say.

Our typical requirements for coal are:

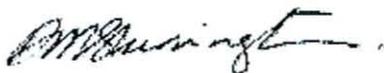
Volatile content	< 28%
Ash	< 15%
Moisture	< 5%

We also look for the ratio of fixed carbon to volatiles to be > 2.5.

I hope these responses provide the input you need to progress your pre-scoping study work. I have also included some background information on our Ausiron<sup>®</sup> technology, and a comparison of the Ausiron<sup>®</sup> and Hismelt<sup>®</sup> technologies for your general interest.

I look forward to your determinations on the capability of your resources to support an iron production facility, potentially using our technology.

Yours sincerely,



David Sherrington  
Ausiron Manager  
Ausmelt Limited.

# The AusIron® Direct Smelting Technology

David Sherrington, Ross McClelland and Greg Campbell

## Introduction

The AusIron® process for direct ironmaking is based on Ausmelt's successful Top Submerged Lance (TSL) technology, which has been applied throughout the world to process a variety of non-ferrous metals including lead, tin, zinc, copper, nickel, gold/silver and platinum group metals.

Over twenty commercial facilities have been constructed worldwide for the non-ferrous industry, where the technology meets the operating requirements of high reliability and ease of operation at low capital costs.

Ausmelt patented the AusIron® technology as a natural progression into the ferrous industry, building on the experience gained over the last 20 years of TSL technology development.

AusIron's® attributes include simplicity of operation, a low capital cost structure, direct use of raw materials and high operating efficiency.

A demonstration plant has been purpose built, and substantially trialled over more than 18 months providing the operating and engineering know-how required for successful commercial application.

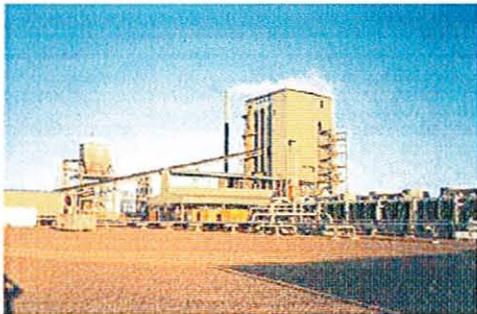


Figure 1: Demonstration Plant.

## The AusIron® Process

The AusIron® process is a single stage bath smelting process that directly converts iron ore and other ferrous materials to produce molten pig iron, using coal as both fuel and reductant (see Figure 2).

Iron ore, fluxes and reductant coal are fed to the furnace through ports in the furnace roof. Ore and fluxes dissolve rapidly in the furnace slag bath, whilst reductant coal reacts with iron oxides contained in the slag to produce iron product.

Gaseous smelting products together with reductant coal volatiles are completely combusted immediately above the bath using oxygen-enriched air, to maximise energy capture within the furnace.

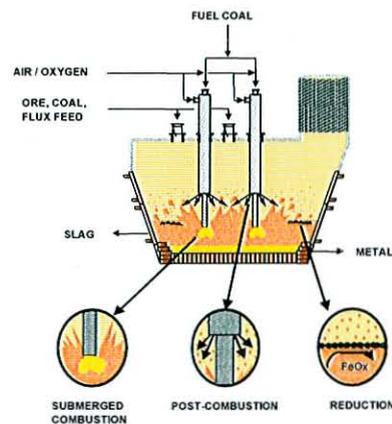


Figure 2: The AusIron® Process

The furnace energy demand is satisfied by submerged combustion of additional coal at the tips of multiple top submerged lances. Submerged combustion of fuel provides significant process benefits:

- 1) The energy supplied is directly transferred to the furnace slag bath for maximum efficiency.
- 2) Submerged combustion provides effective bath mixing promoting high smelting rates.
- 3) The cascade of slag droplets caused by combustion products enhances post-combustion energy recovery, as well as efficient capture of feed materials.

The use of multiple lances allows full utilisation of the available furnace bath area, maximising productivity, with each lance forming its own effective process zone. The lances are fitted

with shrouds for delivery of oxygen-enriched air for post-combustion above the bath. This 'distributed' post-combustion system results in efficient mixing of air and fuel gases and is key to the effective and complete combustion of fuel within the furnace.

Shroud position and nozzle design are configured to achieve maximum return of post-combustion energy to the process. Flexibility in process operating parameters allows tuning of process performance online.

To accommodate the intense process conditions, the furnace side-walls, roof and lances are water-cooled.

Furnace waste gases exit through a cooled duct that forms part of an energy recovery system (waste heat boiler), raising steam for subsequent power generation. Gases are then cleaned before being exhausted to atmosphere. An ID fan in the waste gas train is used to control furnace pressure at slightly less than atmospheric, providing a clean and safe furnace environment.

Product metal and slag accumulate in the vessel, and are tapped independently.

## Demonstration Plant

A nominal 15,000 tpa demonstration plant was constructed during 2000, and began operations in November of that year. Since then, seven test campaigns have been completed providing the technical and engineering data required for commercial furnace design and implementation.

The demonstration plant is a standalone facility. Raw materials are delivered from stockpiles to feed bins by front-end loader, and from there are individually metered on to a common furnace feed belt. An inline pugmill is used to aggregate fines present in the feed and ensure efficient capture by the process. The furnace feed belt delivers the material directly to the process via feed ports in the furnace roof.

Fuel coal is screened from the raw coal supply, dried and ground in an air swept hammer mill and delivered to the lance fuel coal pneumatic injection systems

The Auslron® demonstration furnace incorporates two lances with individual lance hoist and positioning systems.

Furnace waste gases are ducted from the furnace to an evaporative spray cooler before cleaning through a bag filter and being exhausted to atmosphere. At demonstration plant scale, energy recovery from these gases is not feasible.

The plant is operated on a continuous 24h basis (2 x 12-hour shifts) with a total workforce of 25 personnel.

## Demonstration Plant Operation.

### Raw Materials:

The demonstration plant directly processes haematite ore fines, as delivered from the mine site.

Typical ore feed specifications are given in Table 1

Table 1: Ore Analysis.

Component	%	Sizing	%
Fe <sub>2</sub> O <sub>3</sub>	88.57	+10 mm	6.2
SiO <sub>2</sub>	4.79	+1 mm	54.1
Al <sub>2</sub> O <sub>3</sub>	2.14	+500 µm	8.0
P	0.05 to 0.09	-500 µm	31.7

Two grades of coal have been used to date at the demonstration plant – the first, a commercial high fixed carbon coal used as both fuel and reductant, and the second, a sub-bituminous coal used as fuel coal (see Table 2).

Table 2: Coal Analysis.

	High F.C. Coal	Sub Bituminous Coal
Fixed Carbon	65.5	43.5
Volatiles	21.0	43.5
Moisture	2.0	5.0
Ash	11.5	8.0
GCV (MJ/kg)	31.15	26.92

Limestone and dolomite (both uncalcined) have been used as fluxes in all demonstration plant trials.

## Plant Performance

Typical operating conditions for the demonstration plant furnace are given in the following tables.

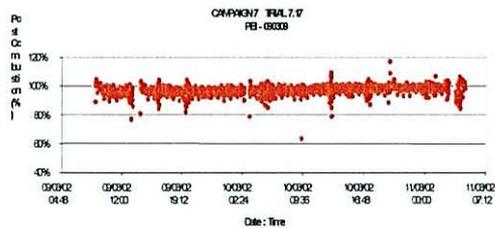
**Table 3: Typical Operating Parameters.**

Lance Oxygen Enrichment	50 – 55 %
Shroud Oxygen Enrichment	30%

**Table 4: Slag Chemistry.**

Element	Target	Range
Temperature	1450 °C	1440 - 1480°C
CaO/SiO <sub>2</sub>	1.15	1.10 - 1.20
Fe	4.0	3.0 - 5.0

Controlling oxygen-enriched air supply to the lance shrouds enables control of post-combustion levels in the region 95-100%. A small flow of dilution air at the inlet to the furnace offtake ensures full combustion of furnace waste gases.



**Figure 3: Post Combustion Control.**

The demonstration plant has produced in excess of 2000t of pig iron product and achieved production rates close to 50% above design, with further production improvements limited only by waste gas handling facilities. Much of the product has been sold for use in local foundry operations.

Coal consumption has been demonstrated at less than 1400 kg/thm. Put in proper context, this is achieved in a small-scale, heavily cooled furnace with heat losses in excess of 10 GJ/thm compared to commercial furnace scale where heat losses less than 2 GJ/thm would be expected.

## Product Quality

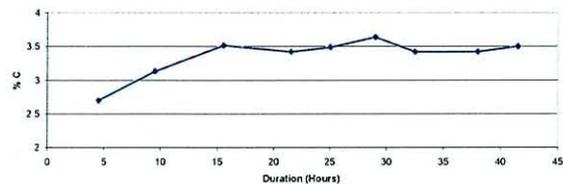
Table 5 shows standard product quality targets for demonstration plant operation.

**Table 5: Hot metal Chemistry.**

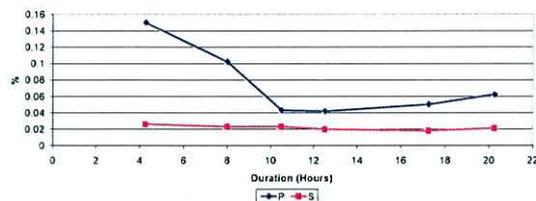
Element	Target (%)	Range (%)
Carbon	3.5	2.5 - 4.2
Silicon	0.025	0.02 - 0.04
Sulphur	0.04	0.02 - 0.08
Phosphorus	< 0.08	0.06 - 0.12

Metal carbon levels can be controlled within the given range, and is typically targeted to 3.5% during demonstration plant trials (see Figure 4).

Product phosphorus and sulphur contents are also controlled, as is shown in Figure 5



**Figure 4: Metal Carbon Control.**



**Figure 5: Phosphorus and Sulphur Control.**

**Table 6: Source of P and S.**

Source	P (%)	S (%)
Coal	57	93
Ore	42	5
Fluxes	1	2

At the start of each period of operation, metal phosphorus levels are generally high as a result of fuel coal combustion at the lance tips, used to maintain furnace temperature during downtime. Once smelting operations are established, the

phosphorus content reduces quickly. A feature of demonstration scale operations, where coal consumption levels are high, is that the majority of phosphorus input to the furnace comes from the coal. (see Table 6).

### **Engineering Development**

Whilst Ausmelt has significant experience in design of furnace equipment for non-ferrous applications, one major area of development has been water-cooled lances suited to the high operating temperatures experienced in iron-making. The demands of submerged combustion with its combination of high thermal and mechanical loadings provided a unique challenge for designers. The current lance design, featuring intense tip cooling, has been developed and proven through demonstration plant operation, together with efficient cooling systems to ensure safe operation and lance integrity.

Demonstration plant operation has also allowed design requirements for furnace cooling panels to be established as a basis for commercial systems design.

An online mass and energy balance model has been developed to provide operators with direct feedback on furnace performance parameters for improved operating efficiency, and early identification of developing problems in what is a fast moving process.

### **Taking the next step...**

Ausmelt has successfully commercialised its Top Submerged Lance process in a wide variety of non-ferrous applications, in each case successfully scaling up pilot operations using scale up factors at times in excess of 200.

Empirical relationships developed over this period, accumulated know-how from similar non-ferrous applications, such as tin smelting where Ausmelt is the recognised world leader, together with experience directly obtained from current demonstration plant operations provides a solid platform for commercial application of the Auslron® technology.

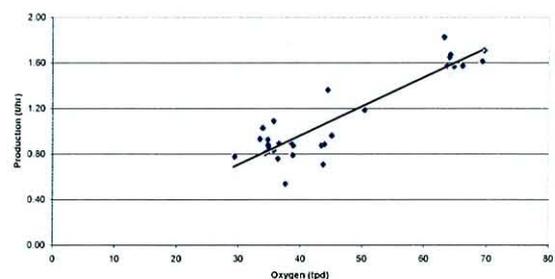
Ausmelt's scale-up methodology is based around a careful balance of furnace and process design parameters to eliminate any fundamental

changes in process operation. The development of a 'process zone' around each lance allows the Auslron® technology to scale up on the basis of both equipment size and number of lances.

For the Auslron® technology where fuel efficiency is an important commercial requirement, the impact of furnace scale on efficiency needs to be taken into account. This is achieved by assessing the 'heat transfer efficiency' (based on the difference between furnace waste gas and bath temperatures) of demonstration plant operations and predicting commercial operation based on achieving similar efficiency levels. As a check on the validity of these projections, predicted commercial furnace waste gas temperatures are also assessed.

The demonstration plant has clearly shown the benefit of consistent and controlled furnace operation on process efficiency and further improvements are expected commercially as a result of operation in a production environment.

Oxygen enrichment provides a natural means for increasing the operating intensity of the Auslron® furnace. This has been clearly demonstrated in operating trials with shroud enrichment levels of 30% typically used in operation (see Figure 6).



**Figure 6: Demonstration Plant Production Increase with Oxygen Enrichment.**

Based on projected commercial performance, and expected opportunities for improvement through commercial operation, a target operating window has been developed for the technology (see Figure 7). The performance characteristics for a nominal 0.5 Mtpa facility processing iron ore fines, based on the lower heat transfer and oxygen enrichment levels are provided in Table 7. This represents the projected entry level for commercial facilities. Also given are performance characteristics based on higher

efficiency and oxygen enrichment levels. This establishes the range of performance potentially available from such a facility. In the commercial environment where technology development must go hand in hand with production requirements, this provides necessary flexibility whereby production targets can be achieved through a combination of furnace efficiency improvements and sensible use of oxygen enrichment.

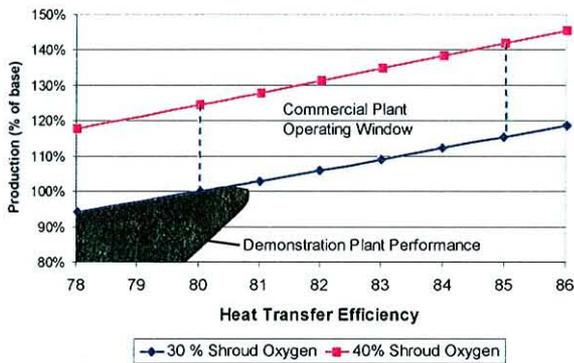


Figure 7: Commercial Progression

Even at the entry point of the operating window, the AusIron® process ensures effective coal utilisation through power generation directly from the furnace waste gases. Set against the performance of the most efficient coal fired power stations, the combination of both iron production and power generation from a commercial AusIron® furnace represents an effective and efficient use of coal.

Table 7: Predicted Commercial Plant Performance.

	Base Case	Optimised Operation
Coal Consumption (kg/thm)	850	700
Iron Production (ktpa)	500	690
Oxygen Consumption (Nm <sup>3</sup> /thm)	507	460
Oxygen Demand (tpd)	1100	1400
Power Production (MW)	54	50
Power Use* (kWh/thm)	260	180

\* Excluding Oxygen Plant

Whilst on paper, opportunities exist for fuel efficiency improvements through ore and/or air preheating using furnace waste gases, Ausmelt's experience shows that such enhancements typically result in significantly reduced operating availability, and diversion of effort that negates their value if allowed to coincide with furnace development. The key to successful technology commercialisation is to limit risks as far as possible, and simplify installed systems. This approach means that the viability of the first commercial AusIron® installation will depend on project circumstances that can harness the value of both the metal product and by-product power, a small price to pay for successful commercialisation.

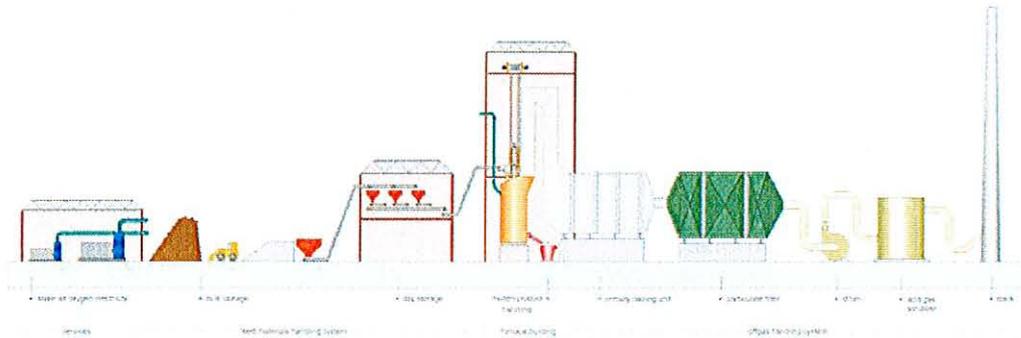
### What AusIron® offers...

Development of the AusIron® technology is geared towards meeting the needs of today's steel industry where productivity, flexibility, operating efficiency and streamlined production methods are necessary to remain competitive. Reliance on economies of scale that requires commitment of large amounts of capital provides a significant hurdle for implementation of new production capacity.

The absence of complex feed preparation systems or additional unit operations for ore reduction, together with straightforward low-pressure furnace operation provides immediate benefits in reduced production costs. Complete combustion of fuel within the smelting furnace allows direct coupling to waste heat recovery and power generation equipment, avoiding the need for associated fuel gas handling and low CV gas combustion systems. Expensive sub-systems such as air preheating are also not required (see Figure 8).

Ausmelt is committed to cost-effective implementation of its technologies. Ausmelt supplies only core proprietary equipment, furnace control and operating systems, and other related services to its clients, allowing the bulk of plant equipment to be procured in a competitive and cost effective manner.

Streamlining the process flowsheet, the absence of expensive sub-systems, and flexibility in plant engineering and supply can only result in significant overall capital cost reduction.



**Figure 8: Generic AusIron® Plant**

Lance based operations provide significant operating flexibility with the lances able to be quickly withdrawn from the furnace to allow safe access to both the furnace and lances for maintenance. The furnace can be idled for long periods if required, using lance tip combustion to maintain the furnace bath. If necessary, the furnace can be easily drained and operations restarted by simply melting solid slag to re-establish the furnace bath, and commencing production.

Hot metal product from the AusIron® furnace is suited to use in both electric and oxygen based steel-making operations. The emphasis on reduced capital costs offers the opportunity for relatively small scale use as a hot metal supplier to electric arc furnace operations, or as incremental capacity in integrated facilities.

The simple and direct feed configuration allows processing of waste products from existing operations. Ausmelt has carried out substantial pilot work processing electric arc furnace dusts in particular and work is currently in progress to commercially produce pig iron from ferrous residues generated by the mineral sands industry.

The AusIron® technology offers a new opportunity for steel-makers to add value to their operations.



**The Minserve Group Pty Ltd**  
ABN 43 010 995 767

TARINGA OFFICE  
Level 1, 1 Swann Road  
Taringa QLD 4068

CITY OFFICE (SMGC)  
Level 8, 82 Eagle Street  
Brisbane QLD 4001

p +61 7 3377 6700  
f +61 7 3377 6701

p +61 7 3229 2566  
f +61 7 3229 7649

Visit the website at [www.minserve.com](http://www.minserve.com) or email [consult@minsolve.com.au](mailto:consult@minsolve.com.au)

**ADDENDUM TO  
NELSON BAY RIVER IRON ORE  
CONCEPTUAL MINING STUDY**

**for**

**ZELOS RESOURCES N.L.**

**22 March 2006**

## CONTENTS

		Page No.
<b>1.</b>	<b>INTRODUCTION.....</b>	<b>1</b>
<b>2.</b>	<b>DISCUSSION OF ORE PRO ANALYSIS .....</b>	<b>1</b>
<b>3.</b>	<b>COSTING OF OPTIONS.....</b>	<b>2</b>
<b>4.</b>	<b>RESULTS .....</b>	<b>2</b>
<b>5.</b>	<b>CONCLUSIONS.....</b>	<b>2</b>

## TABLES

		Page No.
Table 1	Indicative Project Costs based on 35% Product Recovery.....	3
Table 2	Indicative Project Costs based on 50% Product Recovery.....	4

## APPENDIX

Appendix 1	Ore Pro Pty Ltd Conceptual Design and Cost Analysis Letter dated 17 March 2006
------------	--





### 3. COSTING OF OPTIONS

An attempt has been made to look at the three options being reviewed using common data and assumptions. To cover the disparity of recoveries assumed by respondents it was decided to look at one set of costs based on a product recovery of 35% for magnetite as a percent of the ore mined and a second case based on a product recovery of 50%.

For the coal washery magnetite product case annual product tonnes of 100,000t, 150,000t and 200,000t were used along with their equivalent waste to ore ratio to generate waste cubic metres and mining costs for each case.

For the pellet product case and the Ausmelt case an annual production rate of 150,000t/a was used.

Common waste removal costs, ore mining costs and site related costs were used for each case. Extra ore processing costs of \$1.00/t were used for the Ausmelt case.

Annual minegate operating cost and annual operating surpluses were calculated for each case. Project surpluses were calculated for each case and its defined mining pit reserve.

In the case of the Ausmelt process the operating cost provided of \$141/t of hot metal (thin) was adjusted by deducting the ore cost of \$55/thm as this was assumed to be covered in the mining costs.

Indicative project costs based on a 35% product recovery are shown in Table 1.

Indicative project costs based on a 50% product recovery are shown in Table 2.

In both sets of results no allowance has been made for project site infrastructure, government charges, royalties, and transport to the buyer or marketing. Results therefore only give an order of magnitude cost or value consistent with the indicative or perceived conditions at an early stage of investigation.

### 4. RESULTS

Study results confirm the likely viability of the coal washery magnetite product option and the iron ore pellet supply option as being the better options for the Nelson Bay River Iron Ore resource as it is presently defined. The Ausmelt option is likely to require a bigger resource base.

The better ranking of the coal washery product and the iron ore pellet option is due to their lower capital requirements and their lower processing operating costs when compared to the Ausmelt pig iron case.

Tables 1 and 2 show the critical nature of product recovery when determining project economics. This needs to be better defined for each process.

### 5. CONCLUSIONS

Based on the costing assumptions used in this study the Magnetite concentrate for supply to coal washeries option and the option to produce magnetite pellets using a Savage River Style process appear to be the better options. Both generate positive operating cash surpluses that would be expected to make them economically viable.

Project options analysed for Zelus use different assumptions and different product recoveries. These need to be brought back to a common base. Metallurgical investigations are needed to define the product recovery for each process and the ore feed for the resource.

This addendum has looked at the three project options using two product recovery values viz 35% and 50%. Table 1, based on a 35% product recovery, indicates that both the magnetite for washeries product and the iron ore pellet product are likely to be cashflow positive for a 150m deep opencut operation. Both should become viable mining operations.

Table 2, based on a 50% product recovery, indicates that Ausmelt pig iron product is also likely to be cashflow positive for a 150m deep opencut operation and that it would not be as economically rewarding as the other two options.

**Table 1  
Indicative Project Costs based on 35% Product Recovery**

Coal Washery Magnetite				Pellet Product			Ausmelt Product			
Product Tonnes	t	100,000	150,000	200,000	Product Tonnes	t	150,000	Product Tonnes	t	150,000
Pit depth	m	100	150	225	Pit depth	m	150	Pit depth	m	150
Mining Pit Resrve	t	969,948	1,454,923	1,939,897	Mining Pit Resrve	t	1,454,923	Mining Pit Resrve	t	1,454,923
Product to Waste Ratio	m <sup>3</sup> /t	5	6	9	Product to Waste Ratio	m <sup>3</sup> /t	6	Product to Waste Ratio	m <sup>3</sup> /t	6
Product Recovery	%	35%	35%	35%	Product Recovery	%	35%	Product Recovery	%	35%
Waste Mined	m <sup>3</sup>	1,714,286	3,085,714	6,942,857	Waste Mined	m <sup>3</sup>	3,085,714	Waste Mined	m <sup>3</sup>	3,085,714
Mill Feed	t	285,714	428,571	571,429	Mill Feed	t	428,571	Mill Feed	t	428,571
Product Tonnes	t	100,000	150,000	200,000	Product Tonnes	t	150,000	Product Tonnes	t	150,000
Waste Removal unit cost \$/m <sup>3</sup>	\$6.00				Waste Removal unit cost \$/m <sup>3</sup>	\$6.00		Waste Removal unit cost \$/m <sup>3</sup>	\$6.00	
Waste Mining cost		\$10,285,714	\$18,514,286	\$41,657,143	Waste Mining cost		\$18,514,286	Waste Mining cost		\$18,514,286
Ore mining unit cost \$/t	\$3.00				Ore mining unit cost \$/t	\$3.00		Ore mining unit cost \$/t	\$3.00	
Ore Mining cost		857,143	1,285,714	1,714,286	Ore Mining cost		1,285,714	Ore Mining cost		1,285,714
Ore Processing unit cost \$/t	\$12.00				Ore Processing unit cost \$/t	\$13.00		Processing unit cost \$/t of product	\$86.00	
Ore Processing cost		3,428,571	5,142,857	6,857,143	Ore Processing cost		5,571,429	Ore Processing cost		12,900,000
Other site costs unit cost \$/t	\$3.00				Other site costs unit cost \$/t	\$3.00		Other site costs unit cost \$/t	\$3.00	
Other site costs		300,000	450,000	600,000	Other site costs		450,000	Other site costs		450,000
Annual Mine Gate Cost		\$14,871,429	\$25,392,857	\$50,828,571	Annual Mine Gate Cost		\$25,821,429	Annual Mine Gate Cost		\$33,150,000
Magnetite Washery Product \$/t	\$200.00				Magnetite Pellet Product \$/t	\$200.00		Ausmelt Pig Iron Product \$/t	\$295.00	
Annual Revenue \$		\$20,000,000	\$30,000,000	\$40,000,000	Annual Revenue \$		\$30,000,000	Annual Revenue \$		\$44,250,000
Annual Mine Gate Surplus		\$5,128,571	\$4,607,143	-\$10,828,571	Annual Mine Gate Surplus		\$4,178,571	Annual Mine Gate Surplus		\$11,100,000
Project Mine Gate Surplus		\$49,744,499.19	\$44,686,910.84	-\$105,031,560.97	Project Mine Gate Surplus		\$40,529,988.90	Project Mine Gate Surplus		\$107,664,278.20
Project Treatment Plant Capital	\$	\$15,000,000	\$15,000,000	\$15,000,000	Project Treatment Plant Capital	\$	\$20,000,000	Project Treatment Plant Capital	\$	\$120,000,000
<b>Surplus</b>		<b>\$34,744,499</b>	<b>\$29,686,911</b>	<b>-\$120,031,561</b>	<b>Surplus</b>		<b>\$20,529,989</b>	<b>Surplus</b>		<b>-\$12,335,722</b>

**Table 2**  
**Indicative Project Costs based on 50% Product Recovery**

Coal Washery Magnetite				Pellet Product			Ausmelt Product			
Product Tonnes	t	100,000	150,000	200,000	Product Tonnes	t	150,000	Product Tonnes	t	150,000
Pit depth	m	100	150	225	Pit depth	m	150	Pit depth	m	150
Mining Pit Resrve	t	969,948	1,454,923	1,939,897	Mining Pit Resrve	t	1,454,923	Mining Pit Resrve	t	1,454,923
Product to Waste Ratio	m <sup>3</sup> /t	5	6	9	Product to Waste Ratio	m <sup>3</sup> /t	6	Product to Waste Ratio	m <sup>3</sup> /t	6
Product Recovery	%	50%	50%	50%	Product Recovery	%	50%	Product Recovery	%	50%
Waste Mined	m <sup>3</sup>	1,200,000	2,160,000	4,860,000	Waste Mined	m <sup>3</sup>	2,160,000	Waste Mined	m <sup>3</sup>	2,160,000
Mill Feed	t	200,000	300,000	400,000	Mill Feed	t	300,000	Mill Feed	t	300,000
Product Tonnes	t	100,000	150,000	200,000	Product Tonnes	t	150,000	Product Tonnes	t	150,000
Waste Removal unit cost \$/m <sup>3</sup>	\$6.00				Waste Removal unit cost \$/m <sup>3</sup>	\$6.00		Waste Removal unit cost \$/m <sup>3</sup>	\$6.00	
Waste Mining cost		\$7,200,000	\$12,960,000	\$29,160,000	Waste Mining cost		\$12,960,000	Waste Mining cost		\$12,960,000
Ore mining unit cost \$/t	\$3.00				Ore mining unit cost \$/t	\$3.00		Ore mining unit cost \$/t	\$3.00	
Ore Mining cost		600,000	900,000	1,200,000	Ore Mining cost		900,000	Ore Mining cost		900,000
Ore Processing unit cost \$/t	\$12.00				Ore Processing unit cost \$/t	\$13.00		Processing unit cost \$/t of product	\$86.00	
Ore Processing cost		2,400,000	3,600,000	4,800,000	Ore Processing cost		3,900,000	Ore Processing cost		12,900,000
Other site costs unit cost \$/t	\$3.00				Other site costs unit cost \$/t	\$3.00		Other site costs unit cost \$/t	\$3.00	
Other site costs		300,000	450,000	600,000	Other site costs		450,000	Other site costs		450,000
Annual Mine Gate Cost		\$10,500,000	\$17,910,000	\$35,760,000	Annual Mine Gate Cost		\$18,210,000	Annual Mine Gate Cost		\$27,210,000
Magnetite Washery Product \$/t	\$200.00				Magnetite Pellet Product \$/t	\$200.00		Ausmelt Pig Iron Product \$/t	\$295.00	
Annual Revenue \$		\$20,000,000	\$30,000,000	\$40,000,000	Annual Revenue \$		\$30,000,000	Annual Revenue \$		\$44,250,000
Annual Mine Gate Surplus		\$9,500,000	\$12,090,000	\$4,240,000	Annual Mine Gate Surplus		\$11,790,000	Annual Mine Gate Surplus		\$17,040,000
Project Mine Gate Surplus		\$92,145,102.96	\$117,266,767.88	\$41,125,814.37	Project Mine Gate Surplus		\$114,356,922.52	Project Mine Gate Surplus		\$165,279,216.26
Project Treatment Plant Capital \$		\$15,000,000	\$15,000,000	\$15,000,000	Project Treatment Plant Capital \$		\$20,000,000	Project Treatment Plant Capital \$		\$120,000,000
<b>Surplus</b>		<b>\$77,145,103</b>	<b>\$102,266,768</b>	<b>\$26,125,814</b>	<b>Surplus</b>		<b>\$94,356,923</b>	<b>Surplus</b>		<b>\$45,279,216</b>

**APPENDIX 1**

**Ore Pro Pty Ltd  
Conceptual Design and Cost Analysis Letter  
dated 17 March 2006**



# ORE PRO *Pty Ltd*

ACN: 109 631 263

PO Box 1586  
OSBORNE PARK WA 6917  
Telephone: (08) 9244 1564  
Facsimile: (08) 9244 1394

17<sup>th</sup> March 2006

Zelos Resources NL  
Level 3  
2 Blight St  
Sydney  
NSW 2000

Attention : Mr C Hagan

## **Zelos Resources NL - Nelson Bay Iron Ore Project**

### **Conceptual Design & Cost Analysis for 500,000tpa ROM Magnetite Concentrator & Pelletizing Plant**

Dear Mr Hagan,

Further to your request outlining cost estimates relating to a magnetite concentrator plant and iron ore pellet production facilities for the Tasmanian located Nelson Bay Iron Ore Project, please find outlined Ore Pro's comments and recommendations.

#### **1 Annual Magnetite Concentrate Production**

Zelos Resources, Nelson Bay Iron Ore Project has a reported JORC compliant inferred resource of 4 million tonnes magnetite averaging 30% - 40% Fe<sub>3</sub>O<sub>4</sub> and at the proposed throughput of 500,000tpa, has the potential of producing in excess of 163,000 tpa magnetite concentrate or alternatively, taking the concentrate to a premium iron ore pellet product.

The primary requirement for feasibility purposes for magnetite plant design, is the assessment of overall plant weight recovery i.e. percentage of magnetite in the feed and the expected yield of that material to concentrate.

The % magnetite in the feed is measured using a Davis Tube apparatus whereby a sample of ground magnetite ore is washed across a magnetic field with the retained magnetite and waste material analyzed. Test data is recorded as a weight recovery (DTR Wt Rec) i.e. the % of feed retained as concentrate and for the Nelson Bay Iron Ore Project this has been assessed at between 30 - 40% Fe<sub>3</sub>O<sub>4</sub>.

This resource grade analysis is comparable with other West Australian based magnetite resources, namely :

Mt Gibson Iron Ltd	~46% Fe <sub>3</sub> O <sub>4</sub>
Grange Resources Ltd	~37% Fe <sub>3</sub> O <sub>4</sub>

Gindalbie Metals Ltd	~34% Fe <sub>3</sub> O <sub>4</sub>
Cape Lambert Iron Ore Ltd	~32% Fe <sub>3</sub> O <sub>4</sub>
Polaris Metals NL	~50% Fe <sub>3</sub> O <sub>4</sub>
Midwest Corporation Ltd	~35% Fe <sub>3</sub> O <sub>4</sub>

<b>Nelson Bay Magnetite Recovery Assumptions</b>	
DTR Wt Recovery	35%
Wt recovery after pit dilution	34.3% (assuming ~2% dilution)
Plant magnetite yield	95%
<b>Overall plant Wt Recovery</b>	<b>32.6%</b>

From the above it can be concluded that at the proposed ROM feed rate of 500,000tpa Nelson Bay magnetite ore and at an effective 32.6% overall Wt recovery, ~163,000tpa of magnetite concentrate will be available for either heavy media production (coal industry) or iron pellet production.

## 2 Process Plant – Concentrator

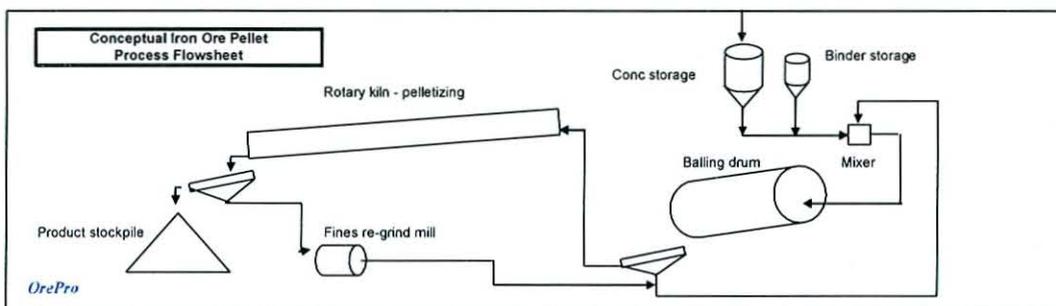
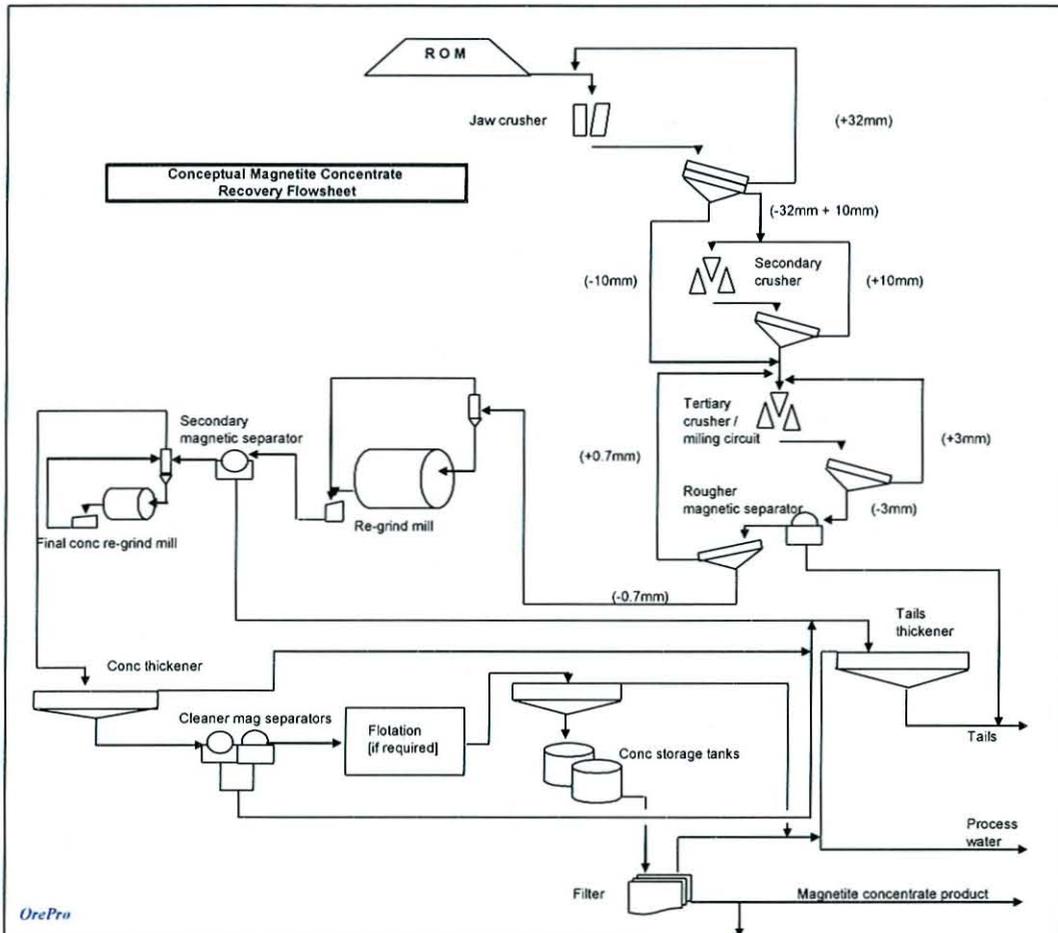
With available information and based on Ore Pro's knowledge and experience, a conceptual 500,000tpa ROM operation treating 30 – 40% Fe<sub>3</sub>O<sub>4</sub> ore consisting of crushing, beneficiation and concentration from an open pit operation would include:

- ROM ore storage facility - open pad complete with FEL feed bin arrangement and feeder
- Primary crusher [jaw crusher], scalping screen and associated ore transportation
- Secondary crusher[cone], screen and associated conveyor belts
- Tertiary crushers and associated screen facilities (large circulating loads may dictate replacement of tertiary crushers with milling circuit)
- Primary magnetic concentrators including concentrate ball mill (open circuit)
- Secondary magnetic separators and cyclones
- Concentrate ball mill (fine grind – closed circuit) including concentrate thickener
- Tails thickener, tailings pumps and process water collection and storage
- Cleaner magnetic concentrators, thickener and concentrate storage tank(s)
- Possible flotation circuit for contaminant (S & P) removal

Based on the above process flowsheet and excluding mining, stripping, ore transportation, waste management and utilities and pending a thorough site review and detailed geological and metallurgical analyses of the Nelson Bay deposit, estimated overall capital cost including design, construction and commissioning will be \$15 million (+/- 20%)

The above assumptions are dependant on critical geological and metallurgical parameters and it is recommended that a thorough testwork programme be implemented to confirm process details and allowances for plant optimization i.e. :

- Blast and mining techniques for optimum ROM feed size
- Waste strip ratio and impact of pit dilution on overall magnetite recoveries
- Crushing Work Index of ROM feed
- Ball mill Bond Work Index of ROM feed
- Quartz / magnetite association
- Grind size optimization for acceptable SiO<sub>2</sub> liberation and Fe<sub>3</sub>O<sub>4</sub> recovery
- Contained contaminants i.e. Sulphur and Phosphorus and removal thereof (flotation)



**Conceptual Process Flowsheets – Concentrate & Pellet production**

## 2 Pellet Processing Plant

Pellet production from magnetite concentrate is an alternate option, and should studies outline this as being economically feasible, Ore Pro's conceptual process design includes :

- Concentrate filters and concentrate storage facilities
- Binder handling and storage facilities (dependant on binder source and selection)

- Concentrate and binder feeders
- In-line belt-type mixer
- Balling drum - green pellet production
- Roller screen conveyor (closed circuit)
- Green pellet drying, pre-heating and induration (propriety rotary kiln process)
- Cured pellet sizing including re-grind mill facility
- Product storage & loading facilities

Based on the above process assumptions and pending detailed geological and metallurgical analyses including pelletizing and pilot plant optimization trials, the estimated capital cost of this palletizing plant excluding utilities and producing iron ore pellets of acceptable world market quality is \$20 million (+/- 20%).

### **3 Iron Ore Pellet Grade**

Determination of ultimate magnetite concentrate grade and therefore saleable pellet quality can only be realized pending detailed metallurgical testwork with Ore Pro capable of assisting with the development and implementation of such a test programme outlining process design criteria and ultimate plant optimization.

The two primary markets for iron ore pellets are blast-furnace (BF pellets) and direct reduction furnace (DR pellets) with the main distinction between the two products determined primarily by the contained SiO<sub>2</sub> & Al<sub>2</sub>O<sub>3</sub> and S & P contaminants..

As a rule of thumb, pellets containing a higher SiO<sub>2</sub> percentage favour the BF market whereas magnetite pellets with a combined SiO<sub>2</sub> & Al<sub>2</sub>O<sub>3</sub> concentration of < 2% favour DR applications.

From data to date, Nelson Bay magnetite ore should readily up-grade to 65% - 68% Fe<sub>t</sub> in both concentrate and iron ore pellet products with acceptable contaminant concentrations of sulphur and phosphorus controllable by flotation if required.

### **4 Conclusion**

Based on preliminary investigations, estimated capital equipment costs for the two process options are indicative to within 20% and pending the completion of further testwork covering aspects relating to process options, geological, metallurgical and analytical analyses, will vary accordingly.

Ore Pro trusts the information provided adequately covers the capital estimations and conceptual process design requirements and should Zelos Resources require additional information, please do not hesitate to contact the company.

Yours sincerely,

**Paul Rundel**  
**General Manager - Operations**