INDEPENDENT REPORT

VALUE OF THE JAMESON CELL TO THE AUSTRALIAN ECONOMY 1990 - 2014

MANFORD PTY LTD
COAL TECHNOLOGY CONSULTANTS

By Dave Osborne PhD and Jeff Euston PhD

MANFORD Pty Ltd

Coal Technology Consultants

Studio 1, 3 Alice Street,
Wellington Point,
QLD 4160 Australia
Phone: +61 7 3010 9443
Mobile: +61 457 818 894

Independent Report

on

Value of the Jameson Cell to the Australian Economy

by

Dave Osborne
BSc, PhD, University of Newcastle on Tyne
Principal

and

Jeff Euston
BSc, PhD, Leeds. MBA Deakin
Coal technology consultant

23 April 2015

Contents

IMPORTANT NOTE

VALUE OF THE JAMESON CELL TO THE AUSTRALIAN ECONOMY

The Jameson Cell is used for the recovery of fine coal. It is also used in the recovery of metallic minerals of copper, lead, zinc, and gold; and for wastewater treatment, to remove blue-green algae from biological treatment plants; contaminants such as suspended solids, oils and fats from dairy and other food production facilities; and spent yeast from brewery wastes.

A true estimate of the value of the Jameson Cell to the Australian Economy should include all these applications. However, because the Cells are incorporated into systems with multiple purposes, it is not generally possible to assign an exact value to the benefits obtained by using the Jameson Cell

In the case of the coal recovered from the waste streams from coal preparation plants however, the tonnes of export coal can be calculated accurately, from publicly available data.

Accordingly, this report is concerned only with fine export coal, mainly used for steelmaking (metallurgical coal).

EXECUTIVE SUMMARY

Manford Pty Ltd has been requested by the University of Newcastle to validate available data and underlying assumptions made about the value of the Jameson Cell to the Australian economy. Manford's approach has been to review the calculations provided and offer advice on the validity of the assumptions. In addition, Manford Pty Ltd has drawn upon databases to which it has access, from which generic data can be extracted and summarised.

In the last 30 years the Australian coal industry has undergone almost exponential growth. This growth has been accompanied by the establishment of Australia at the forefront of coal preparation research, development and innovation. Increased efficiency of coal cleaning operations has been at the forefront of this development with a special emphasis on the recovery of the finest coal fractions once lost to tailings. Froth flotation is currently the only commercial process for the recovery of very fine coal and is widely practised. The development of the Jameson Cell and its application to coal preparation a quarter of a century ago, has presented operators with an efficient low cost option for recovering very fine coal. The first Jameson cells were installed in coal preparation in 1990 and since then over 40 coal preparation plants have either installed Jameson cells to treat coal previously lost to tailings into existing plants or have included them in the design of new plants.

Fine coal represents a proportion of the feed to a coal preparation plant, a proportion that depends on the type of plant, coal type and characteristics, and the coal product, either coking (metallurgical) or thermal coal. Jameson cells are designed based on volumetric flow and further assumptions are required to convert this design basis into tonnes of clean coal produced. A simple method of achieving the total value of coal produced by Jameson cell technology is to use the published installation list and the design flowrates to calculate the tonnes produced. This approach requires a number of informed assumptions to convert design volumetric flows to tonnes produced, the availability of the plant and the yield of clean coal produced.

It is the opinion of Manford Pty Ltd, and indeed of the Australian coal industry as a whole, that the Jameson Cell technology has made a considerable contribution to coal and mineral processing both in Australia and overseas. The largest and most significant market is in fine coal production in Australia.

The findings of this study are that the assumptions made are realistic and conservative and in the author's expert opinions the overall conclusions are sound. In summary,

- **Since the first installations in 1990 over 200 million tonnes of saleable coal have been produced from Jameson cells, coal which may otherwise have been lost to tailings.**
- **The value of this coal to the Australian economy is estimated to be $36 billion over the period from 1990 to the end of 2014.**

INTRODUCTION

Coal has for over thirty years been Australia's major export industry. Australia's prosperity is firmly linked to the production and export of coal with Australia being the world's second largest exporter of coal after Indonesia and is projected to be the largest exporter of coal by 2030[(1)]. A view of the impact of the coal economy in Australia is shown in Figure 1.

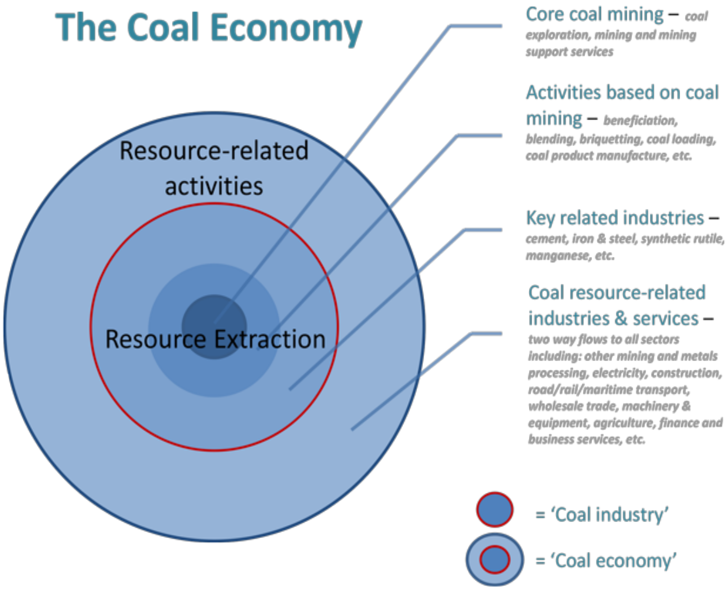


Figure 1. The coal economy in Australia[(2)]

In addition to the obvious benefits to the Australian economy it is estimated that for every person employed directly in the coal industry a further 3.7 people are indirectly employed making a total workforce of 180,000 in 2011 / 2012. Coal exports continue to increase from a level of 200,000,000 tonnes in 2000 / 2001 to over 300,000,000 tonnes in 2013 / 2014[(3)]. Key data taken from the Minerals Council of Australia is reproduced below[(4)]:

- 527 million tonnes of coal produced in 2012/2013.
- Australia is the world's 5th largest producer of coal.
- Australia is the world's second largest coal exporter.
- $38.6 billion in export earnings.
- $3.2 billion in royalty payments to the Australian government in 2012/2013.
- 54,900 people directly employed in the coal industry.
- More than 145,000 people indirectly employed.

The perceived negative effects of coal on the environment has impacted significantly on coal's reputation as an energy source and raw material. However, it is certain that coal will continue to form the backbone of world industrial demand for many years to come. The production of clean coal and the export of coal which is as free from contaminants as possible has been the subject of research in Australia, by coal companies, research institutions and government bodies for many years, and certainly long before the climate change debate emerged.

Coal preparation, or the washing of coal to remove contaminants, has been practiced in Australia since the earliest days of the industry. Australian practices in coal preparation have long been acknowledged as being world class and Australian coal research is regarded as leading the world in innovation and improved methods. This research has been carried out by the major mining companies either in their own facilities or via sponsorship of government bodies such as the CSIRO, ACARP (The Australian Coal Association Research Programme) and numerous academic institutions, in particular the University of Newcastle and the University of Queensland. The proximity of Newcastle to one of Australia's major mining regions of the Hunter Valley has encouraged the investigation of methods to improve coal preparation. In the area of coal preparation research has been innovative and diverse and has focussed on techniques to improve the recovery of clean coal from run of mine coal, the protection of the environment and the increased efficiency of coal preparation processes. Coal mining methods produce a mined product which tends to degrade after mining and with handling and transport to generate liquid slurry of fine particles of coal and waste material. This tailings stream contains valuable coal along with clays and shales associated with the coal deposits. Historically, coal preparation has endeavoured to process coal as fine as possible but there is a practical limit at which conventional gravity processes become ineffective.

THE TREATMENT OF FINES IN COAL PREPARATION

The only proven method for recovering coal product from these fines is via a process known as froth flotation. Froth flotation has been around for over 100 years and was originally developed at Broken Hill in Australia. Historically, the inclusion of froth flotation in a coal preparation plant was decided on coal quality and the response of the fine coal to conventional flotation equipment designs. The decision to treat the finest coal fractions often a commercial one but for many years the simplest solution was to dispose of the fine slurry as a waste stream in tailings dams.

Recovery of coal from tailings	
For	**Against**
Coal tailings contains valuable coal	Fine coal adds moisture to final product
Fine coal recovery reduces solids to tailings storage	Comparatively expensive processes
Moral responsibility to recover as much coal as possible	Existing processes high maintenance

In 1996, a report of ACARP (Australian Coal Association Research Programme (project C4047) [5] listed the perceived shortcomings of installed froth flotation equipment in coal preparation in Australia, which include:

- A wide range of equipment with unclear advantages from different designs.
- Poor air control as observed from periodic, extreme cell disturbance.
- Unpredictable scale-up performance
- Requirement for continual operator/metallurgical attention.
- Performance adversely affected as wear progresses.
- Lack of a universally applicable control strategy.
- Difficulty in optimizing for both recovery and ash content.

The ACARP report highlighted the need to recover fine coal and the need for the industry to look at ways to treat this waste stream. The Jameson flotation cell technology, which was at the time a relative newcomer, was identified as having considerable potential to address these discrepancies.

DEVELOPMENT OF THE JAMESON CELL

As the sophistication of the Australian coal industry increased in the 1980s with the development of the coal fields in the Bowen Basin of Queensland, the existing flotation technologies became inadequate for the larger plants. One of the last coal preparation plants to install these older technologies required 30 individual flotation cells each with an electric motor and complex feed, distribution and product collection launders. At this time there were a wide range of flotation devices available from many manufacturers based in designs which had seen little development for many decades. As stated previously, these deficiencies in existing technologies generally resulted in the decision not to recover fine coal in coal preparation plants.

The development of the Jameson Cell by Professor Graeme Jameson and his team at the University of Newcastle represented a completely new and innovative approach to coal flotation based on the principles of fluid dynamics. Proven advantages of the Jameson Cell are:

1. High throughput in a small area.
2. High concentrate grades.
3. Easy to operate and tune for feed variations.
4. Stable operation with minimum operator involvement.
5. Minimal maintenance.
6. Easy to install and commission.
7. Flexible cell designs.

In the Jameson Cell the process feed enters at the top of a vertical pipe known as a downcomer. The capacity of a single downcomer is known and scale up for large flow rates is achieved simply by increasing the number of downcomers as shown in Figure 2.

The Jameson Cell and its ongoing development has been the subject of numerous technical papers. The Jameson Cell brochure, published by Glencore Technology, is included as an Appendix to this report. A description of the continued development of the Cell are available on-line(6).

Commercialisation of the Jameson cell was undertaken by Mount Isa Mines Limited, under a license from the University of Newcastle. The company was later known as Xstrata Technology and subsequently Glencore Technology, after several takeovers. In the first 20 years over 300 units were sold to a range of industries in Australia and around the world. As the charts below show the major applications were in coal in Australia, while applications in mineral processing accounted for nearly 30%

of installations. Overseas installations were also significant with over 40% of installations outside of Australia.

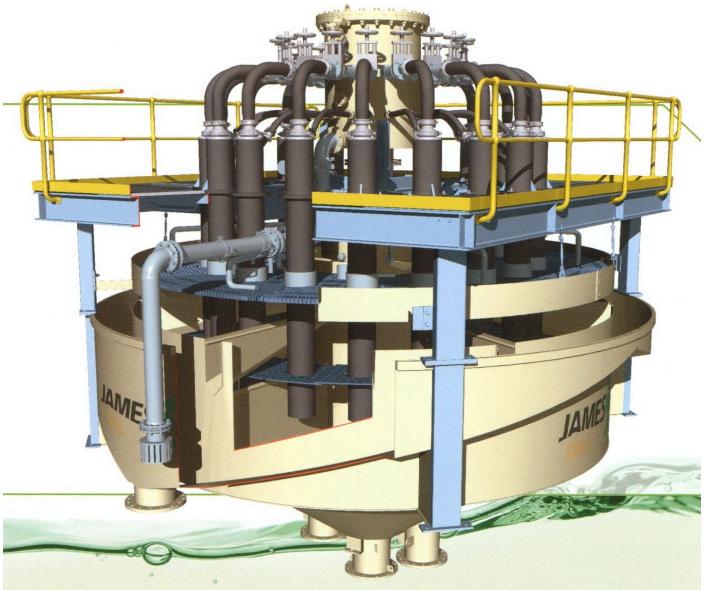


Figure 2. The Jameson cell showing the arrangement of downcomers.

Figure 3, below summarises the growth in Jameson cell installations in coal. The recent rise in installation reflects not only the number of installations but the size of those installations and the ease of scale up of Jameson cell technology. One of the most recent installations at Anglo Coal's Grosvenor mine incorporates two banks of Jameson cells, each with 24 individual downcomers.

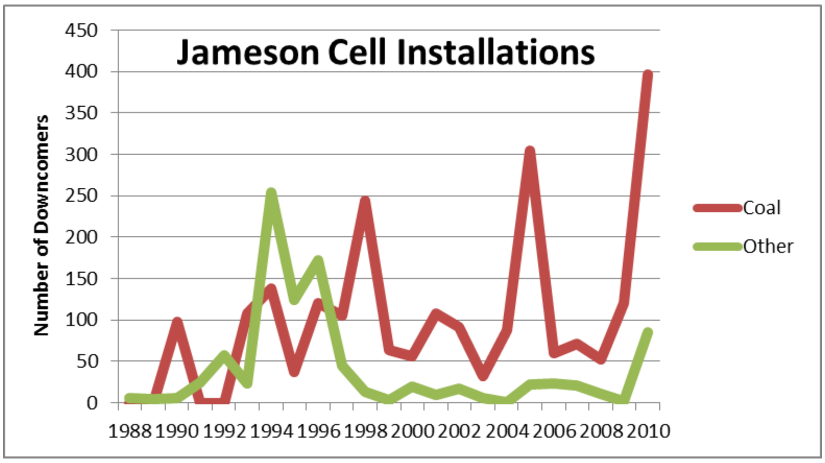


Figure 3. New Jameson cell installations by year, based on number of downcomers

Figures 4 and 5 below summarise the wide applicability range of Jameson cells across industries as diverse of coal preparation and solvent extraction of precious metals.

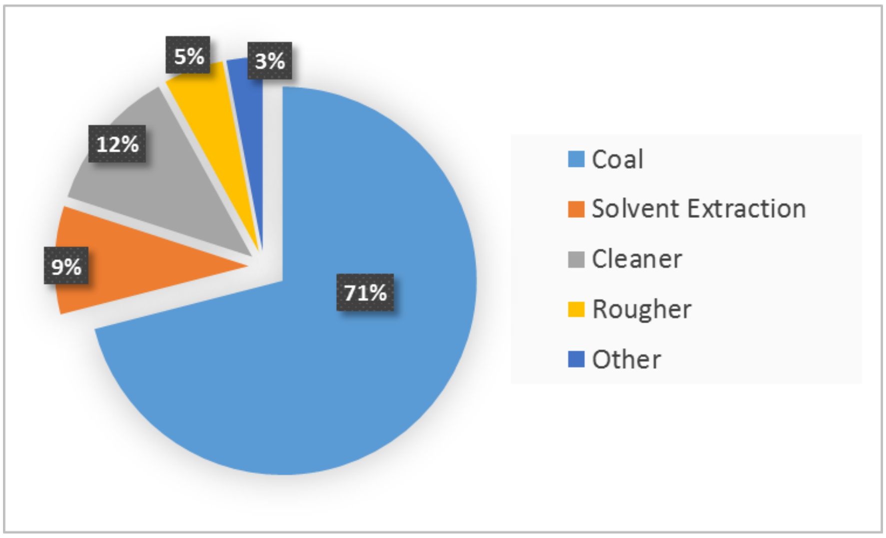


Figure 4. Jameson cell installations by application

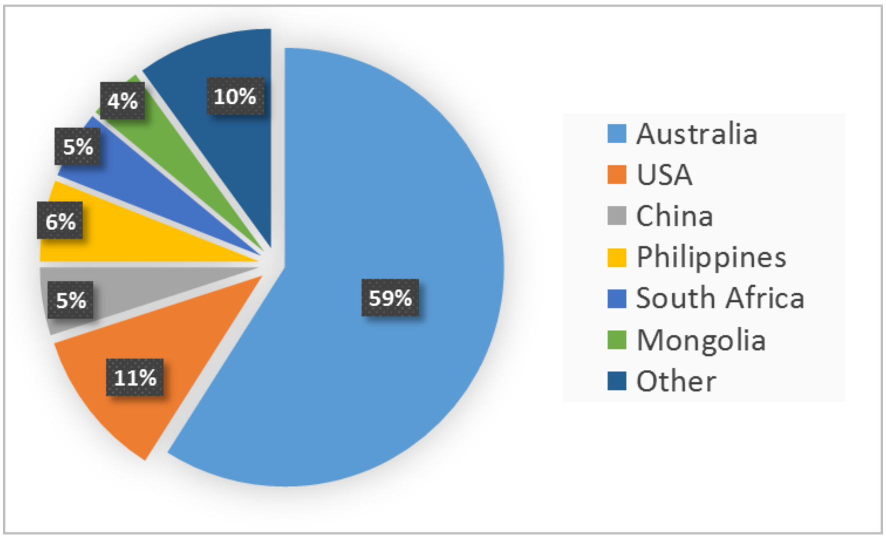


Figure 5. Jameson cell installations by country.

ESTIMATED FINE COAL PRODUCTION USING JAMESON CELL TECHNOLOGY

This report focuses on the application of Jameson Cell technology for fine coal processing and its contribution to the Australian coal industry over a period of 25 years. The fine coal recovered by the Cell is mainly exported, since it is predominantly the high-value coal used for steelmaking. As highlighted above, this application represents only a proportion of the total sales of Jameson cells, but it has been chosen as a data set for simplicity and the relative ease of information availability and accuracy. A full discussion of the value of the Jameson cell to mineral and coal processing should include the contribution to mineral processing from a global perspective and the value to Australian exports and international reputation.

Manford Pty Ltd was provided with an initial estimate of the value of fine coal produced using Jameson cell technology. We refer to this estimate as Scenario 1. It was based on the published installation list, attached as an appendix to this report. This installation list which is regularly updated contains detailed information on application and flow rate. Table 1 below summarises the data and its purpose for this evaluation.

Table 1. Explanation of data in the Jameson Cell Installation List, Appendix 1

Data	Purpose
Company	For categorisation
Operation	Identify coal installations
Country	Identify Australian installations
Cell Size	Size of the installation / number of individual downcomers to determine capacity
Number	Number of units. In conjunction with above used to calculate total size of installation
Date	Installation date to calculate production as a function of time
Flow [m^3/h]	Flow of coal laden slurry to the installation
Industry	Identify coal installations
Application	Identify coal applications

It is important to note that for the older installations the large majority will over the years have increased production and it is an industry trend in Australian coal preparation to extend production rates beyond the original equipment design. Ongoing technical improvements to the Jameson cell, the latest design being the Mark IV, have assisted end users to higher than design flow rates.

To convert the volumetric feed flows above into tonnes of fine coal produced it is necessary to make a number of assumptions, that are explained in Table 2.

Table 2. Assumptions made in the calculations

Parameter	Basis of Assumption
Feed Solids Fraction	A value of 5% solids by weight has been assumed. Coal preparation plants have a range of separation equipment which are water based. The resultant tailings slurry is typically between 5 and 10% solids depending on seam and coal quality. The authors believe that a value of 5% solids is low and a figure of 8% solids will better represent the industry average.
Yield Fraction	A coal yield of 60% was used in the initial estimate. Yield refers to the percent of feed which reports to the clean coal as a flotation product. Depending on coal type, typical fine coal yields will be from 40% to 80% with some cleaner coals regularly giving yields above 90%. The authors believe that a yield estimate of 50% is more conservative and should be used as the basis of the calculation.
Annual Availability	An availability of 82% has been used in these calculations which represents 300 days of operation per year. The authors believe that this figure represents a target value, routinely based on 7000 operating hours per year. Analysis based on 2013 data[1] suggests an actual value of 262 days or 71% availability should be used.
Ongoing production from installation	To the best of the author's knowledge two coal preparation plants have replaced Jameson cells with alternative technology, one in 2010 and the other around 2012. Another plant closed in the 1990s. These have been revised in our calculations. Other than these it is correct to assume that the reported production figures over the years are reasonable.
Design throughput	As mentioned above it is common practice to increase production by pushing feed rates beyond design parameters. There will be no plants which have decreased production since the Jameson cell installations and it is the author's belief that in the majority of cases the published flow rates will be a minimum and therefore conservative.
Proportion of thermal to coking coal.	A ratio of 25% thermal (power station) to 75% coking (metallurgical) coal has been assumed based on the Australian coal industry average. Coking coal must be cleaner than thermal coal and is less sensitive to product moisture. It is more common therefore to treat coking coal by froth flotation than thermal coal. This ratio may be conservative and result in a lower average price than stated.

Other Data

Coal Prices	Data obtained from ABARE Commodities June 2008. This data has been verified and updated.	2
Exchange Rates	Ozforex Foreign Exchange Services, USD to AUD data has been verified and confirmed.	3
CPI Data	Australian Bureau of Statistics data provided has been verified and confirmed.	4

Data Sources

1 A & B Mylec 2013 Coal Industry Survey and Database.
2 ABARE Commodities June 2008.
3 Ozforex Foreign Exchange Services.
4 Australian Bureau of Statistics

RESULTS

The annual value of the coal produced by the Jameson Cell was calculated as follows. In a given year, the number of cells and the flowrates for all operating installations were calculated using data from the Jameson Cell Installation List, Appendix 1. The production (tonnes) was valued using applicable prices for thermal coal and steelmaking coal from ABARE and other publicly available sources. The prices in USD/tonne were converted to AUD at the rates prevailing in the relevant year. The annual value was then converted to present day values, using CPI index factors from the ABS website.

Manford Pty Ltd has reviewed the spreadsheets and data estimates provided by Professor Graeme Jameson as scenario 1 and can make the following comments:

- A number of minor calculation errors were identified and corrected.
- The spreadsheet assumes ongoing production was constant for all years since installation. However, Catherine Hill Bay closed in the 1990s and in 2007 Rix's Creek ceased to use Jameson cells. A number of BMA sites installed alternative technologies in 2012 but it is likely that the majority of sites have increased throughput over the installation period.

The table below compares the data provided by Professor Jameson as Scenario 1 based on the published installed base. Scenario 2 uses data collected by Manford Pty. The annual data are shown in Appendix 3.

	Scenario 1 **Professor Jameson**	**Scenario 2** **Manford Pty Ltd**
Feed Solids Fraction %	5.0	8.0
Yield %	60	50
Annual Availability Fraction	0.82	0.71
Coking / Thermal	75%/25%	75%/25%
Tonnes of coal produced with Jameson Cells, to the end of 2014	201 million	233 million
Value of coal produced with Jameson Cells, to the end of 2014	$31.2 billion	$36.0 billion

The table shows that, from the introduction of the technology in 1990 until the end of 2014, Jameson cells produced over 233 million tonnes of clean coal with a value of $36 billion dollars.

CONCLUSIONS

It is the opinion of Manford Pty Ltd, and indeed of the Australian coal industry as a whole, that the Jameson Cell technology has made a considerable contribution to coal and mineral processing both in Australia and overseas. The largest and most significant market is in fine coal production in Australia. The findings of this study are that the assumptions made in Scenario 1 by Professor Jameson are realistic and conservative and in the author's expert opinions, that the total value is considerably higher than the original estimates.

Summary:

- **Since the first installations in 1990 over 200 million tonnes of coal have been produced from Jameson cells, coal which may otherwise have been lost to tailings.**
- **The value of this coal to the Australian economy is estimated to be $36 billion over the period from 1990 to the end of 2014.**

SELECTED REFERENCES

1 Coal Hard Facts. Published by the Minerals Council of Australia. www.minerals.org.au.

2 Sinclair Davidson and Ashton de Silva. The Australian Coal Industry – Adding Value to the Australian Economy, April 2013. [http://www.minerals.org.au/file_upload/files/reports/Att_8-2__2013-04-24_Coal_Economy_report-Sinclair_Davidson_report.pdf].

3 Queensland's Coal Mines and Advanced Projects, Department of Employment, Economic Development and Innovation, Queensland Government. [http://mines.industry.qld.gov.au/assets/qld-mining-update/coal.pdf].

4 Minerals Council of Australia, key facts and figures. [www.minerals.org.au/resources/coal/figures].

5 Sanders, D.J., and Williamson, M.M. Coal Flotation Technical Review, ACARP Project C4047, 1996. [http://www.acarp.com.au/abstracts.aspx?repId=C4047]

6 Jameson Cell: Wikipedia. [http://en.wikipedia.org/wiki/Jameson_cell].

THE AUTHORS

Dr David Osborne

Current Positions

Manford Pty Ltd	Coal Technology Manager and Director
Somerset International Australia	Managing Director

Background

Dr Osborne is a coal technology specialist with extensive global experience in coal preparation, quality assurance and technical marketing through direct involvement in all facets of the subject area. Internationally renowned with accredited engineering status in Australia and EU, numerous technical publications and memberships and active participation in international professional institutions and organisations. His skills include technical and commercial assessment of resources; ascertaining product value; project management; and supply chain management.

Dr Osborne is the author of a two volume publication, The Coal Handbook, focusing on cleaner coal production. This publication is regarded as the key reference source for modern coal technology.
He is the elected chairperson of the Australian Coal Standards committee and an active member of the Australian Coal Preparation Society (ACPS) and the Australian Coal Association Research Programme (ACARP).

Dr Osborne has held senior technical and advisory positions with the leading coal producers in Australia including Rio Tinto, Anglo American Coal and Xstrata .

From 2007, Dr Osborne spent two years in London with Anglo Coal providing global leadership in coal technology projects, technical marketing and operational activities of Anglo American's coal businesses around the world. In 2010, he returned to Australian and joined Xstrata Coal as Coal Technology group manager before being transferred to Xstrata Technology as coal technology manager where he advised on coal technology in house for major coal projects including Jameson Cell installations.

Dr Jeff Euston

Current Position

Somerset International Australia Manager, Business Development

Dr Euston has extensive experience in coal and mineral processing covering a range of disciplines from sales and business development through to research and product management. His specialist areas are in tailings treatment and flotation. He has over 20 years' experience of these processes in coal, mineral and waste treatment industries.

Dr Euston has conducted industry research at the BHP Central Research Laboratories. He has published and given presentations at a number of peer-reviewed international conferences on coal flotation in the Australian context.

In his most recent position, Dr Euston was the flotation product manager for FLSmidth. In this role he provided advice to end users on coal flotation in Australia and gained familiarity with the various coal flotation technologies, including many Jameson cell installations. He has designed and commissioned flotation circuits at several coal plants such as Rix's Creek, Stratford and Ashton Coal. He has carried out plant trials and performance evaluations at many of the coal flotation installations owned and operated by Xstrata Coal, Glencore Coal and Vale.

APPENDICES

1. Jameson Cell Installation List – Sourced from Glencore Technology website: www.jamesoncell.com/en/installations/.../jamesoncellinstallations.pdf.
2. Jameson Cell Brochure – Sourced from Glencore Technology website www.glencoretechnology.com/EN/.../brochure-zoilsandsbrochure_en.pdf.
3. Table showing the annual production of fine coal from Jameson Cells in Australia, 1990 – 2014, and the cumulative value.

Jameson Cell installations

Company	Operation	Country	Cell Size	No.	Date	Flow m^3/h	Industry	Application
Mount Isa Mines	Lead/Zinc Concentrator	Australia	J1900/3	2	1988	120	Lead/Zinc	Lead Slimes
Mount Isa Mines	Hilton	Australia	J1750/2	2	1989	240	Lead/Zinc	Low Grade Middlings
Mount Isa Mines	SX Plant	Australia	J1000/1	1	1989	40	Copper	SX-EW Electrolyte
Mount Isa Mines	Newlands Coal	Australia	R3515/7	6	1990	1080	Coal	Coal slimes
Mount Isa Mines	Newlands Coal	Australia	R3015/6	6	1990	1080	Coal	Coal slimes
Mount Isa Mines	Collinsville Coal	Australia	J3500/10	2	1990	*	Coal	Coal slimes
Posgold	Warrego	Australia	J1400/3	2	1990	120	Copper	Cleaner
Amalg Syndicate	Spargoville	Australia	J750/1	1	1991	80	Copper	Cleaner
Amalg Syndicate	Spargoville	Australia	J1000/1	1	1991	80	Nickel	Rougher
Mamut Copper	Ranau	Malaysia	J1750/3	1	1991	120	Copper	Cleaner
Mount Isa Mines	Hilton	Australia	J3000/10	1	1991	200	Copper	Cleaner
Mount Isa Mines	Hilton	Australia	J3000/10	1	1991	200	Lead/Zinc	Lead Cleaner
Amalg Syndicate	Spargoville	Australia	J1250/2	1	1992	80	Nickel	Rougher
Consolidated Murchison	Gravelotte	South Africa	J1600/4	1	1992	120	Antimony/ Gold	Cleaner
Consolidated Murchison	Gravelotte	South Africa	J800/1	1	1992	*	Antimony/ Gold	Cleaner
Consolidated Murchison	Gravelotte	South Africa	J1250/1	1	1992	*	Antimony/ Gold	Cleaner
Kidd Creek	Timmins	Canada	J2500/6	2	1992	480	Copper	Cleaner
Mount Isa Mines	Lead/Zinc Concentrator	Australia	J1900/3	2	1992	240	Lead/Zinc	Zinc Cleaner
Phelps Dodge	Morenci	USA	J6500/30	1	1992	1860	Copper	SX-EW Electrolyte
Western Mining Corp	Olympic Dam	Australia	J1000/2	1	1992	80	Copper	SX-EW Electrolyte
Aberfoyle	Gunpowder	Australia	R1513/2	1	1993	120	Copper	SX-EW Electrolyte
BMA	Blackwater	Australia	J3500/10	8	1993	2400	Coal	Coal slimes
Genmin	Impala Plats	South Africa	R1210/1	1	1993	120	Platinum	Scavenger
Girilambone Copper	Girilambone	Australia	J1750/3	1	1993	120	Copper	SX-EW Electrolyte
Mantos Blancos	Oxide Plant	Chile	J1250/1	1	1993	40	Copper	Rougher
Pasminco Metals	BHAS	Australia	J1000/1	1	1993	40	Copper	SX-EW Electrolyte
Philex Mining Corp	Philex Mine	Philippines	J3000/6	1	1993	240	Copper	Cleaner
Philex Mining Corp	Philex Mine	Philippines	J1250/3	1	1993	75	Copper	Recleaner
Western Mining Corp	Nifty Copper	Australia	J1750/3	1	1993	180	Copper	SX-EW Electrolyte
South Atlantic Ventures	Oracle Ridge	USA	J2500/4	1	1993	360	Copper	Cleaner scalper
Peabody	Nth Goonyella	Australia	J5000/14	2	1993	1680	Coal	Coal Fines
BMA	Goonyella	Australia	J5000/16	8	1994 / 2011^	3800	Coal	Coal Fines
Cleveland Potash	Cleveland	England	J3250/6	1	1994	900	Potash	Potash Slimes
Cons. Murchison	Gravelotte	South Africa	J1500/3	1	1994	30	Antimony/ Gold	Recleaner
Kenmare	Ancuabe	Mozambique	J800/1	1	1994	*	Graphite	Cleaner
Maricalum Mining	Sipalay	Philippines	R3330/8	4	1994	960	Copper	Rougher
Maricalum Mining	Sipalay	Philippines	R3330/8	2	1994	960	Copper	Scavenger
Maricalum Mining	Sipalay	Philippines	J3000/6	1	1994	360	Copper	Cleaner Scavenger
Maricalum Mining	Sipalay	Philippines	J2500/3	1	1994	180	Copper	Cleaner
Maricalum Mining	Sipalay	Philippines	J1750/3	1	1994	180	Copper	Recleaner
Mexicana	Cananea	Mexico	F2500/4	1	1994	240	Copper	SX-EW Electrolyte
Mexicana	La Caridad	Mexico	J3250/4	2	1994	250	Copper	SX-EW Electrolyte

Jameson Cell installations continued ...

Company	Operation	Country	Cell Size	No.	Date	Flow m³/h	Industry	Application
Minera Nor Peru	Quiruvilca	Peru	J1250/1	1	1994	35	Zinc	Cleaner
Minpro Ltd	Wollondilly	Australia	J3000/10	1	1994	600	Coal	Coal Fines
NICICO	Sar Cheshmeh	Iran	R1513/2	1	1994	120	Copper	SX-EW Electrolyte
North Ltd	Northparkes	Australia	J2750/8	1	1994	480	Copper	Cleaner
North Ltd	Northparkes	Australia	J2250/6	1	1994	360	Copper	Cleaner
North Ltd	Northparkes	Australia	J1500/3	1	1994	90	Copper	Cleaner
North Ltd	Northparkes	Australia	J1000/1	1	1994	30	Copper	Cleaner
PASAR	Smelter	Philippines	I1007/2	1	1994	120	Copper Slag	Scavenger
Phelps Dodge	Tyrone	USA	J6500/24	4	1994	1440	Copper	SX-EW Raffinate
Philex Mining Corp	Philex Mine	Philippines	J4000/16	1	1994	480	Copper	Cleaner Scavenger
Philex Mining Corp	Philex Mine	Philippines	R3330/8	2	1994	680	Copper	Rougher
Philex Mining Corp	Philex Mine	Philippines	R3330/8	2	1994	680	Copper	Scavenger
Western Mining Corp	Olympic Dam	Australia	J2000/3	1	1994	180	Copper	Cleaner
BMA	Riverside	Australia	J5000/14	1	1995 / 2011^	650	Coal	Coal fines
Compania Min. del Sur	Bolivor	Bolivia	R1818/4	1	1995	120	Zinc	Scavenger
Mexicana	Cananea ESDE I	Mexico	J5000/16	1	1995	1000	Copper	SX-EW Raffinate
Phelps Dodge	Morenci	USA	J6500/18	1	1995	1200	Copper	SX-EW Electrolyte
Philex Mining Corp	Philex Mine	Philippines	R3330/8	4	1995	2720	Copper	Rougher
Philex Mining Corp	Philex Mine	Philippines	R3330/8	4	1995	2720	Copper	Scavenger
Rio Tinto	Kestrel (formally Gordonstone)	Australia	J5000/10	2	1995	840	Coal	Coal fines
Rustenberg Platinum	Frank	South Africa	J1750/3	1	1995	180	Platinum	PGM Cleaner
Rustenberg Platinum	Waterval	South Africa	J1600/3	1	1995	180	Platinum	PGM Recleaner
Springlake Colliery	Dundee	South Africa	J2000/4	1	1995	240	Coal	Coal Fines
Western Mining Corp	Olympic Dam	Australia	R3520/8	2	1995	920	Copper	SX-EW Raffinate
Amalg Syndicate	Eloise	Australia	J1250/2	1	1996	80	Copper	Cleaner
ATCOM	Witbank	South Africa	J5000/8	2	1996	880	Coal	Coal Fines
BMA	Riverside	Australia	J5000/14	5	1996 / 2011^	3250	Coal	Coal Fines
BHP Hartley Platinum	Hartley	Zimbabwe	J500/1	1	1996	10	Platinum	SX-EW Raffinate
Mexicana	Cananea ESDE I	Mexico	J6500/20	1	1996	2000	Copper	SX-EW Raffinate
Minera Alumbrera	Bajo de la Alumbrera	Argentina	R5230/12	8	1996 / 2009^	1100	Copper	Cleaner
Minera Alumbrera	Bajo de la Alumbrera	Argentina	R5245/12	2	1996	1100	Copper	Recleaner
Minera Alumbrera	Bajo de la Alumbrera	Argentina	R5230/12	4	1996	1100	Copper	Cleaner Scavenger
Namib Lead	Zinc Plant	Namibia	J2250/4	1	1996	*	Zinc	Rougher
Namib Lead	Zinc Plant	Namibia	J1000/1	1	1996	*	Zinc	Cleaner
Namib Lead	Zinc Plant	Namibia	J800/1	1	1996	*	Zinc	Recleaner
Namib Lead	Zinc Plant	Namibia	J520/1	1	1996	*	Zinc	Third Cleaner

Xstrata Technology Australia
Level 10, 160 Ann St
Brisbane QLD 4000, Australia
Tel +61 7 3833 8500
jamesoncell @xstratatech.com

Xstrata Technology Chile
Alcántara 200, Of. 1202
Las Condes, Santiago, Chile
Tel +56 2 478 22 11
jamesoncell@xstratatech.com

Xstrata Technology Canada
10th Floor, 700 West Pender Street
Vancouver, BC V6C 1G8, Canada
Tel +1 604 699 6400
jamesoncell @xstratatech.com

Xstrata Technology South Africa
Suite 19, Private Bag X1,
Melrose Arch 2076, South Africa
Tel +27 71 606 4667
jamesoncell @xstratatech.com

Xstrata Technology
European Representative
United Kingdom
Tel +44 (0) 203 560 8564
jamesoncell xstratatech.com

Company	Operation	Country	Cell Size	No.	Date	Flow m^3/h	Industry	Application
Portman Mining	Burton Downs	Australia	J5000/14	2	1996	1600	Coal	Coal Fines
Queensland Nickel	Yabulu Refinery	Australia	I1513/1	1	1996	60	Nickel	SX-EW Electrolyte
Sanyati	Sanyati	Zimbabwe	J750/1	1	1996	30	Copper	SX-EW Raffinate
Steel Auth India	Chasnalla	India	R3015/6	1	1996	150	Coal	Coal Fines
Bulong Nickel	Bulong	Australia	R3520/8	1	1997	400	Cobalt	SX-EW Raffinate
Bulong Nickel	Bulong	Australia	J600/1	1	1997	15	Cobalt	SX-EW Electrolyte
CIM Resources	Stratford	Australia	J5000/16	2	1997 / 2007^	1200	Coal	Coal Fines
Coal Operations Australia Limited	Catherine Hill Bay	Australia	J5000/14	1	1997	900	Coal	Coal Fines
Kenmare	Ancuabe	Mozambique	J2250/4	1	1997	*	Graphite	Graphite
Moranbah North Coal	Moranbah North	Australia	J5000/10	6	1997/ 2012^	2740	Coal	Coal Fines
Murrin Murrin Operations	Murrin Murrin	Australia	J1250/1	1	1997	*	Cobalt	SX-EW Raffinate
Murrin Murrin Operations	Murrin Murrin	Australia	J1250/1	1	1997	*	Zinc	SX-EW Raffinate
Murrin Murrin Operations	Murrin Murrin	Australia	J350/1	1	1997	*	Cobalt	SX-EW Electrolyte
Ok Tedi Mining Ltd	Talc Flotation	Papua New Guinea	E2534/6	2	1997	*	Copper	Talc Reverse Float Rougher
Ok Tedi Mining Ltd	Talc Flotation	Papua New Guinea	J1750/3	2	1997	*	Copper	Talc Reverse Float Cleaner
PASAR	Smelter	Philippines	J600/1	1	1997	15	Copper Slag	Cleaner
Rio Tinto	Renco	Zimbabwe	J650/1	1	1997	*	Gold	Cleaner
Solmil		Bolivia	E1708/2	1	1997	30	Zinc	Rougher
Western Mining Corp	Bwana Mkubwa	Zambia	J1600/3	1	1997	125	Copper	SX-EW Electrolyte
Western Mining Corp	Olympic Dam	Australia	I2420/4	1	1997	200	Copper	SX-EW Electrolyte
A T Massey	Marfork	USA	J5000/16	4	1998	2000	Coal	Coal Fines
Rustenburg Platinum	Amandelbult	South Africa	J1200/1	1	1998	*	Platinum	Cleaner
Kasese Cobalt Company	Kasese	Uganda	R1315/1	3	1998	*	Cobalt	SX-EW Electrolyte
Minera Maria	Mariquita	Mexico	Z3300/6	1	1998	300	Copper	SX-EW Electrolyte
Mount Isa Mines	Oaky Creek Coal	Australia	R5230/12	6	1998 / 2006^	3000	Coal	Coal Fines
Portman Mining	Burton Downs	Australia	J5000/14	2	1998	1600	Coal	Coal Fines
R & P	Keystone	USA	J5000/16	1	1998	1200	Coal	Coal Fines
Rustenberg Platinum	Waterval	South Africa	J1600/3	1	1998	*	Platinum	Cleaner
Sedgman	Pawnee	USA	J5000/16	1	1998	1000	Coal	Coal Fines
Vigo Coal	Columbia	USA	J5000/16	1	1998	900	Coal	Coal Fines
Carbontronics	Lynnville	USA	J5000/16	1	1999	*	Coal	Coal Fines
Gibralter	Gibraltar Fine Coal Plant	USA	J5000/16	1	1999	*	Coal	Coal Fines

Xstrata Technology Australia
Level 10, 160 Ann St
Brisbane QLD 4000, Australia
Tel +61 7 3833 8500
jamesoncell @xstratatech.com

Xstrata Technology Chile
Alcántara 200, Of. 1202
Las Condes, Santiago, Chile
Tel +56 2 478 22 11
jamesoncell@xstratatech.com

Xstrata Technology Canada
10th Floor, 700 West Pender Street
Vancouver, BC V6C 1G8, Canada
Tel +1 604 699 6400
jamesoncell @xstratatech.com

Xstrata Technology South Africa
Suite 19, Private Bag X1,
Melrose Arch 2076, South Africa
Tel +27 71 606 4667
jamesoncell @xstratatech.com

Xstrata Technology
European Representative
United Kingdom
Tel +44 (0) 203 560 8564
jamesoncell xstratatech.com

Jameson Cell installations continued ...

Company	Operation	Country	Cell Size	No.	Date	Flow m^3/h	Industry	Application
Mount Isa Mines	Lead/Zinc Concentrator	Australia	E1732/4	1	1999	140	Lead/Zinc	Lead Cleaner Scalper
Ohio Valley Coal	Ginger Hill	USA	J5000/16	1	1999	*	Coal	Coal Fines
Ohio Valley Coal	Pleasant Ridge	USA	J5000/16	1	1999	*	Coal	Coal Fines
The Daniels Co.	Sugar Camp (Black Beauty)	USA	J5000/16	1	1999	*	Coal	Coal Fines
Warkworth Mining Limited	Warkworth	Australia	J5000/16	4	1999	2500	Coal	Coal Fines
Glencore	Yauliyacu	Peru	E1732/4	1	2000	250	Lead/Zinc	Scavenger
Mexicana	Cananea ESDE II	Mexico	J7250/10	1	2000	2800	Copper	SX-EW Raffinate
Mexicana	Cananea ESDE II	Mexico	Z3300/6	1	2000	350	Copper	SX-EW Electrolyte
Mount Isa Mines	Oaky Creek Coal	Australia	B6500/24	1	2000	1500	Coal	Coal Fines
Australian Preminum Coal	Coppabella	Australia	B5000/16	2	2001	1600	Coal	Coal Fines
Israel Chemicals Ltd	Dead Sea Works	Israel	J1250/1	1	2001	60	Potash	Cleaner
Mount Isa Mines	Copper Concentrator	Australia	E2514/3	1	2001	140	Copper	Talc Prefloat Cleaner
Mount Isa Mines	Copper Concentrator	Australia	E2532/6	1	2001	255	Copper	Slag Cleaner
Wesfarmers	Curragh	Australia	J5400/18	6	2001	4400	Coal	Coal Fines
Big Ben Holdings	Rix's Creek	Australia	J5000/16	1	2002	1200	Coal	Coal Fines
First Quantum Minerals	Bwana Mkubwa	Zambia	R3250/6	1	2002	300	Copper	SX-EW Electrolyte
Big Ben Holdings	Bloomfield	Australia	J5000/16	1	2002	1200	Coal	Coal Fines
Rio Tinto	Hail Creek	Australia	B6000/20	3	2002	2640	Coal	Coal Fines
Avgold	Fairview	South Africa	Z1100/1	1	2002	40	Gold	Pyrite Gold
Western Mining Corp	Olympic Dam	Australia	J7250/10	1	2002	3000	Copper	SX-EW Raffinate
Macarthur Coal	Moorvale	Australia	B5000/16	1	2003	860	Coal	Coal Fines
Shanxi Fenxi Coal Mine Group	Liuwan Coal Mine	China	J5000/16	1	2003	830	Coal	Coal Fines
Lang Xang Minerals Limited	Sepon Copper Project	Laos	E2514/3	2	2003	60	Copper	Cleaner
MBS	Demonstration plant	Bulgaria	E0606/1	1	2004	30	Copper	SX-EW Electrolyte
Fengfeng Group Co. Ltd	Matou	China	J5000/16	2	2004	1700	Coal	Coal Fines
Jixi Coal Mine Group	Pinggang	China	J5000/16	1	2004	1090	Coal	Coal Fines
Shanxi Fenxi Coal Mine Group	Shuguang	China	J4500/12	1	2004	760	Coal	Coal Fines
Jiaozuo Coal Mine Group	Jiaozuo	China	J5000/16	1	2004	925	Coal	Coal Fines
Jiaozuo Coal Mine Group	Jiaozuo	China	J4500/12	1	2004	125	Coal	Coal Fines

Xstrata Technology Australia
Level 10, 160 Ann St
Brisbane QLD 4000, Australia
Tel +61 7 3833 8500
jamesoncell @xstratatech.com

Xstrata Technology Chile
Alcántara 200, Of. 1202
Las Condes, Santiago, Chile
Tel +56 2 478 22 11
jamesoncell@xstratatech.com

Xstrata Technology Canada
10th Floor, 700 West Pender Street
Vancouver, BC V6C 1G8, Canada
Tel +1 604 699 6400
jamesoncell @xstratatech.com

Xstrata Technology South Africa
Suite 19, Private Bag X1,
Melrose Arch 2076, South Africa
Tel +27 71 606 4667
jamesoncell @xstratatech.com

Xstrata Technology
European Representative
United Kingdom
Tel +44 (0) 203 560 8564
jamesoncell xstratatech.com

Company	Operation	Country	Cell Size	No.	Date	Flow m^3/h	Industry	Application
Zinifex	Century Mine	Australia	B6500/22	1	2005	800	Lead/Zinc	Carbon Prefloat Cleaner
Foxleigh Mining	Foxleigh	Australia	B6000/20	2	2005	2400	Coal	Coal Fines
Rio Tinto	Hail Creek	Australia	B6000/20	3	2005	2700	Coal	Coal Fines
Shanxi Fenxi Coal Mine Group	Shuyui	China	J4500/12	2	2005	*	Coal	Coal Fines
Xstrata Coal	Newlands Coal	Australia	B6000/20	4	2005	4400	Coal	Coal Fines
Jellinbah Resources	Jellinbah	Australia	B6000/20	1	2005	1200	Coal	Coal fines
AMCI	Carborough and Isaac Creek	Australia	B6000/20	2	2005	1700	Coal	Coal Fines
AMCI	Camberwell	Australia	B6000/20	2	2005	2040	Coal	Coal Fines
Shanxi Fenxi Coal Mine Group	Xin Yang	China	J6500/24	2	2006	*	Coal	Coal Fines
N.M. Heilig BV	EMO Rotterdam	The Netherlands	J4500/12	1	2006	350	Coal	Coal/Iron
Consolidated Murchison	Gravelotte (Palabora)	South Africa	E2532/6	1	2006	240	Antimony/ Gold	Rougher Scalper
Teck Cominco	Red Dog	USA	B5400/18	1	2006	440	Lead/Zinc	Carbon Prefloat Cleaner
Macarthur Coal	Moorvale Upgrade	Australia	B5000/16	1	2007	680	Coal	Coal Fines
Macarthur Coal	Middlemount	Australia	B5000/16	1	2007	680	Coal	Coal Fines
Shell Canada Energy	Albian Sands	Canada	J1500/1	3	2007	*	Oil sands	Bitumen
Oxiana	Prominent Hill	Australia	B5400/18	1	2007	710	Copper	Cleaner Scalper
Lake Vermont Coal Resources Pty Ltd	Lake Vermont	Australia	B6000/20	2	2007	2200	Coal	Coal Fines
Felix Resources	Yarrabee	Australia	B5000/16	2	2008	1700	Coal	Coal Fines
Vale	Carborough Downs Expansion	Australia	B6000/20	1	2008	1000	Coal	Coal Fines
Syncrude	Base Plant	Canada	8 x 500mm downcomers	1	2008	*	Oil sands	Bitumen Middlings
Rio Tinto	Kennecott Utah Copper	USA	X1080/1	1	2008	30	Copper	SX-EW Electrolyte
Vale Inco	Clarabelle Mill	Canada	Z1600/1	1	2008	60	Copper	Cleaner Scalper
Xstrata Nickel	Cosmos	Australia	Z1600/1	1	2008	60	Nickel	Rougher
Moolarben Coal Operations Pty Ltd	Moolarben	Australia	B6000/20	4	2009	2800	Coal	Coal Fines
Barberton Mines	Sheba	South Africa	Z1200/1	2	2009	100	Gold	Cleaner
Energy Resources LLC	UHG Mongolia - Stage 1	Mongolia	B6000/20	2	2009	2400	Coal	Coal Fines
Riversdale Mining	Benga	Mozambique	B6000/20	2	2010	2200	Coal	Coal Fines
Wesfarmers	Curragh	Australia	B6000/20	6	2010	3750	Coal	Coal Fines
PanAust	Phu Kham	Laos	B6500/24	1	2010	970	Copper	Cleaner scalper

Xstrata Technology Australia
Level 10, 160 Ann St
Brisbane QLD 4000, Australia
Tel +61 7 3833 8500
jamesoncell @xstratatech.com

Xstrata Technology Chile
Alcántara 200, Of. 1202
Las Condes, Santiago, Chile
Tel +56 2 478 22 11
jamesoncell@xstratatech.com

Xstrata Technology Canada
10th Floor, 700 West Pender Street
Vancouver, BC V6C 1G8, Canada
Tel +1 604 699 6400
jamesoncell @xstratatech.com

Xstrata Technology South Africa
Suite 19, Private Bag X1,
Melrose Arch 2076, South Africa
Tel +27 71 606 4667
jamesoncell @xstratatech.com

Xstrata Technology
European Representative
United Kingdom
Tel +44 (0) 203 560 8564
jamesoncell xstratatech.com

Company	Operation	Country	Cell Size	No.	Date	Flow m^3/h	Industry	Application
Equinox Minerals	Lumwana	Zambia	B5400/18	1	2010	930	Copper	Cleaner scalper
Energy Resources LLC	UHG Mongolia - Stage 2	Mongolia	B6000/20	2	2010	2400	Coal	Coal Fines
Gloucester Coal Ltd	Stratford Expansion	Australia	B5000/16	1	2010	*	Coal	Coal Fines
Xstrata Copper	Collahuasi	Chile	J5000/10	1	2010	1320	Copper	SX-EW Raffinate
Kazakhmys	Kazakhmys Group Concentrators	Kazakhstan	J500/1	1	2010	6	Copper/ Zinc	Rougher / Cleaner Scalper
*	*	Canada	E2532/6	2	2010	*	Potash	Cleaner
Anglo American (AAMC)	Capcoal Lake Lindsay	Australia	B6500/24	1	2010	*	Coal	Coal Fines
Rio Tinto Coal Australia	Kestrel Mine Extension	Australia	B6000/20	3	2011	3100	Coal	Coal Fines
Newcrest Mining Limited	Telfer	Australia	E3432/8	2	2011	700	Copper	Cleaner Scalper
Lake Vermont Coal Resources Pty Ltd	Lake Vermont Expansion	Australia	B6000/20	2	2011	2200	Coal	Coal Fines
Cobar Management Pty Ltd	CSA Mine	Australia	E1732/4	1	2011	190	Copper	Cleaner
Energy Resources LLC	UHG Mongolia - Stage 3	Mongolia	B6000/20	2	2011	2400	Coal	Coal Fines
Macarthur Coal	Middlemount	Australia	B5000/16	1	2011	660	Coal	Coal Fines
MMG	Dugald River	Australia	B5400/18	1	2011	320	Lead/Zinc	Carbon Prefloat Cleaner
MMG	Dugald River	Australia	E2532/6	2	2011	150	Lead/Zinc	Cleaner
Peabody Energy	Codrilla	Australia	B5000/16	2	2011	630	Coal	Coal Fines
HudBay Minerals	Constancia	Peru	E2514/3	1	2012	150	Copper	Molybdenum
HudBay Minerals	Constancia	Peru	Z1200/1	1	2012	20	Copper	Molybdenum
Xstrata Coal	Bulga	Australia	E2532/6	1	2012	250	Coal	Coal Fines
Arcelor Mittal	Vostochnaya	Kazakhstan	J6500/24	2	2012	1500	Coal	Coal Fines
Syncrude	Base Plant	Canada	8 x 500mm downcomers	3	2012	*	Oil sands	Bitumen Middlings
Anglo American (AAMC)	Grosvenor	Australia	B6500/24	2	2012	*	Coal	Coal Fines
MMG	Century	Australia	E4232/10	1	2013	400	Lead/Zinc	Cleaner
Cobar Management Pty Ltd	CSA Mine	Australia	E4232/10	1	2013	300	Copper	Cleaner Scalper
Hillgrove Mines Pty Ltd	Hillgrove	Australia	Z1200/1	1	2013	20	Antimony/ Gold	Cleaner
Hillgrove Mines Pty Ltd	Hillgrove	Australia	Z1200/1	1	2013	10	Antimony/ Gold	Cleaner
Glencore	Mt Isa	Australia	B5400/18	1	2013	500	Copper	Cleaner Scalper
TOTAL				**331[#]**				

* Data withheld or not available
^ Installation upgraded to latest design
[#] Application Summary: 161 Coal, 116 Base and Precious Metals, 41 SX-EW, 13 other

Xstrata Technology Australia
Level 10, 160 Ann St
Brisbane QLD 4000, Australia
Tel +61 7 3833 8500
jamesoncell @xstratatech.com

Xstrata Technology Chile
Alcántara 200, Of. 1202
Las Condes, Santiago, Chile
Tel +56 2 478 22 11
jamesoncell@xstratatech.com

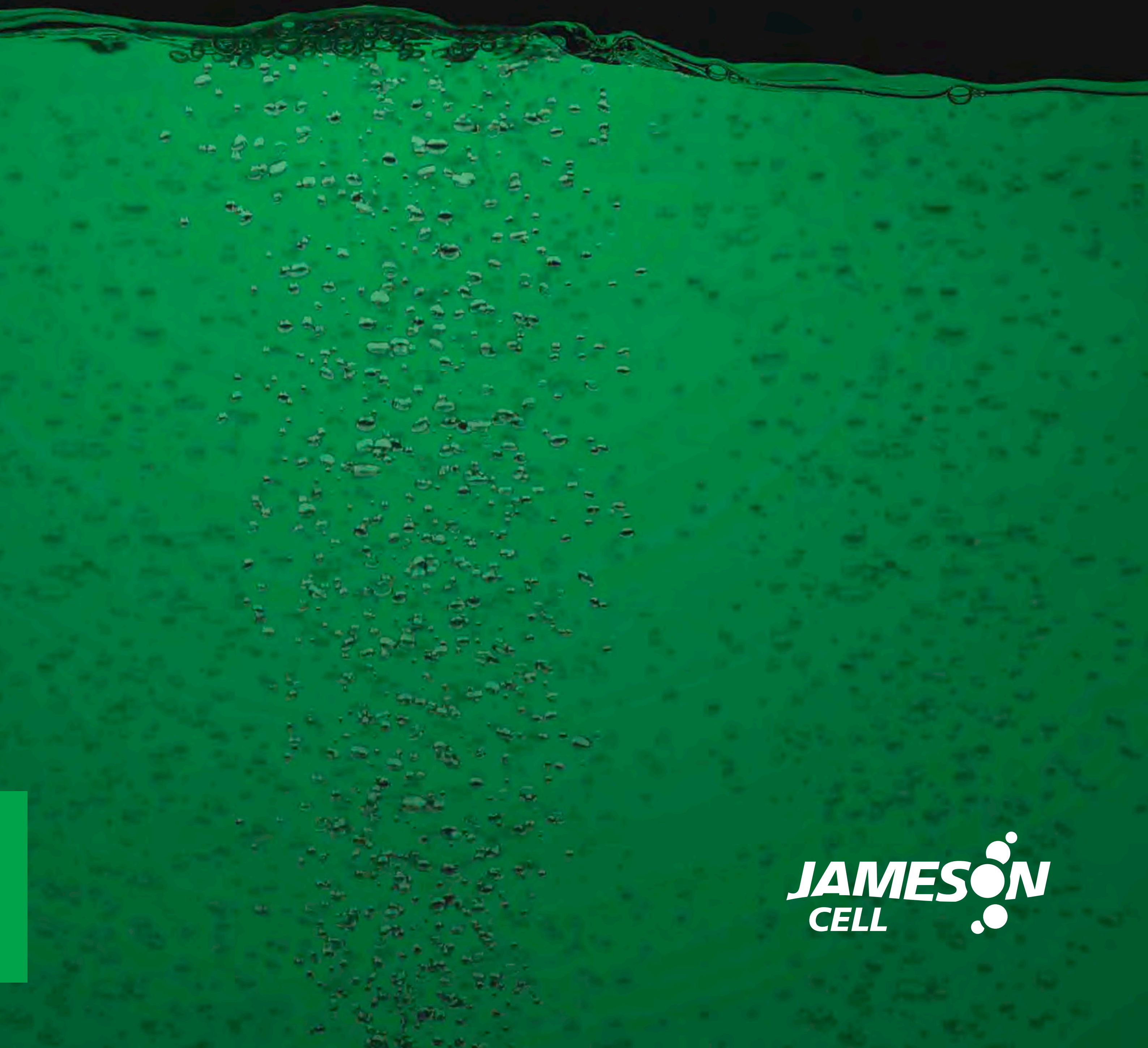
Xstrata Technology Canada
10th Floor, 700 West Pender Street
Vancouver, BC V6C 1G8, Canada
Tel +1 604 699 6400
jamesoncell @xstratatech.com

Xstrata Technology South Africa
Suite 19, Private Bag X1,
Melrose Arch 2076, South Africa
Tel +27 71 606 4667
jamesoncell @xstratatech.com

Xstrata Technology
European Representative
United Kingdom
Tel +44 (0) 203 560 8564
jamesoncell xstratatech.com

JAMESON CELL
RISING TO THE CHALLENGE

Robust, efficient, high intensity flotation technology.



JAMESON CELL

JAMESON CELL
RISING TO THE CHALLENGE

The Jameson Cell is an efficient, low maintenance, high intensity flotation technology for new plants or low cost plant expansions.

About Jameson Cell

The Jameson Cell technology was invented in the late 1980s to overcome the design and operating inadequacies of column and conventional cells. From its first commercial installation in 1989 it has been continuously improved to make it more robust and easy to use. The latest, Mark IV Jameson Cell, combines the original advantages of small bubble size and small footprint with the new low maintenance and operator-friendly designs.

The Jameson Cell is an innovative flotation process driven by fluid mechanics. The advantages of modern Jameson Cells are:

» Consistent fine bubble generation without requiring external equipment or spargers.
» Intensive mixing with small bubbles achieving rapid flotation without mechanical agitation.
» High throughput in small tanks.
» Froth washing to maximise concentrate grade in a single flotation stage.
» Fast response and easy process control for a wide range of product grades and recoveries.
» Steady operation and performance irrespective of changes in feed flow.
» No moving parts, simple to install and maintain with excellent availability.

B6000/20 (Mark IV) Jameson Cell at Lake Vermont, Australia.

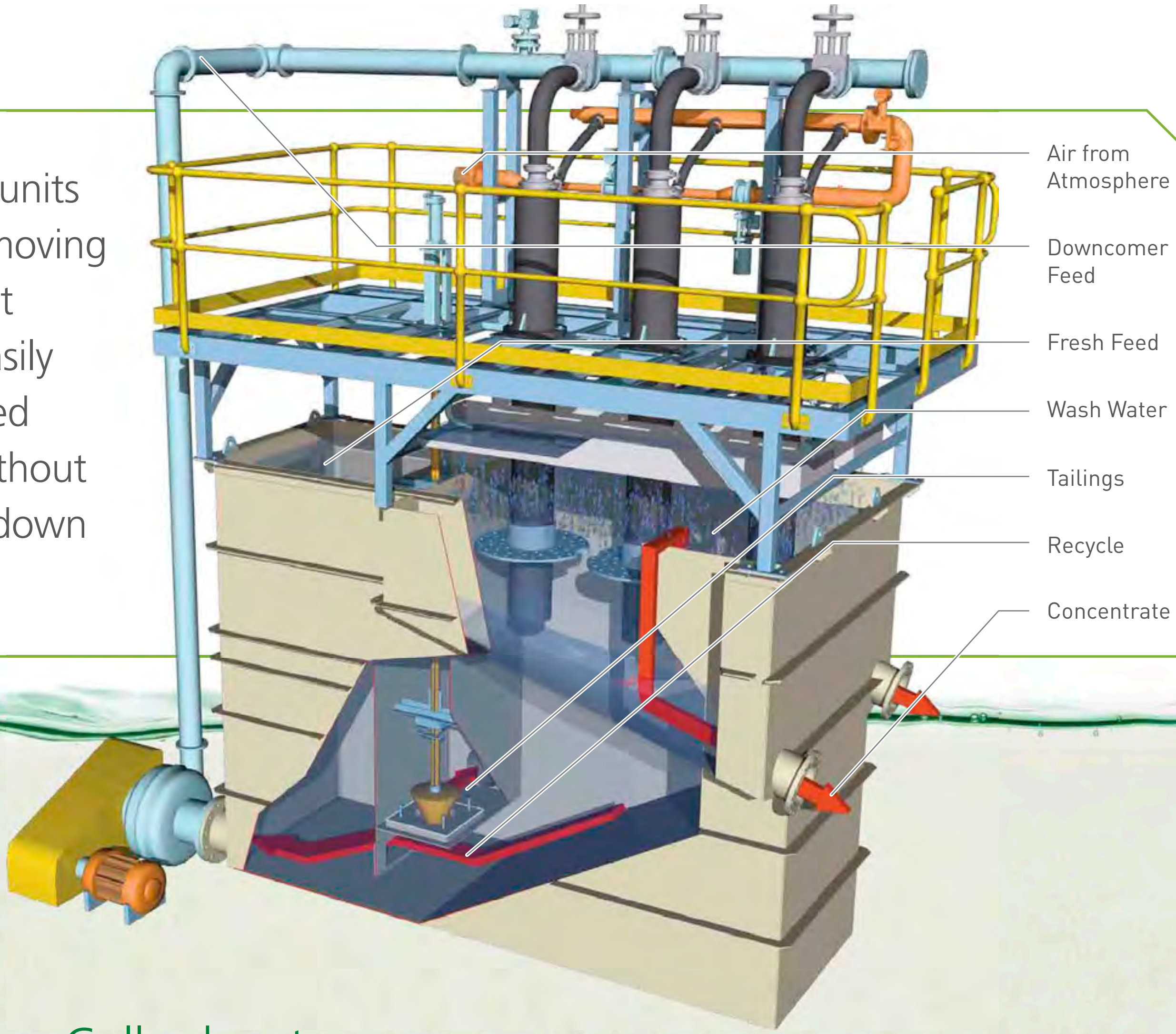
The Jameson Cell can treat a large amount of material in a small footprint. Cell designs are flexible to suit a number of industries, making it ideal for any new project and a great option for low cost plant expansions.

In the first 20 years of commercialisation nearly 300 Jameson Cells were installed, treating a wide range of materials including coal, base and precious metals, potash, bitumen, graphite and recovering organic in solvent extraction processes.

The Jameson Cell is also an ideal technology for non-sulfide and industrial minerals and reverse flotation of silica in iron ore processing.

XT provides accurate cell design and scale up, engineering, manufacturing, flotation circuit design and review, installation support, cell commissioning and ongoing technical support from our experienced team of flotation, operating and engineering specialists.

Flotation units with no moving parts, that can be easily maintained online without shutting down the cells.



» Jameson Cell advantages

1. HIGH THROUGHPUT IN SMALL FOOTPRINT

Consistent generation of fine bubbles provides significantly more bubble surface area for flotation than alternative technologies. High carrying capacities allow large tonnages to be treated in a small volume.

2. HIGH CONCENTRATE GRADES

Fine air bubbles, intense mixing, high bubble loading and efficient froth washing ensures superior grade concentrates compared to mechanical cells. Liberated and fast floating particles can be recovered to a final concentrate in one step, transforming traditional flowsheet designs.

3. EASY TO TUNE – QUICK TO RESPOND

High intensity means fast kinetics and less time required to reach steady state after process changes.

4. STABLE OPERATION

The Jameson Cell quickly reaches equilibrium and can continue operating if feed supply is interrupted. Tailings recycle eliminates negative effects of fluctuating feed flow to give constant downcomer flow, consistent performance and simple startup. The cell operates at a constant feed pressure and the hydrodynamic action inside the downcomer, essential for particle collection, is always consistent.

5. MINIMAL MAINTENANCE – HIGH AVAILABILITY

No moving parts and no external air supply keeps maintenance simple and low cost. The highest wear component, the slurry lens orifices has a wear life in excess of 5 years. Downcomer maintenance can be performed while the cell is operating, in under 10 minutes.

6. EASY TO INSTALL AND COMMISSION

There are no rotors, compressors or blowers to install or operate. A feed pump is the only equipment that needs power. Commissioning is quick and simple. The cell can reach design capacity quickly after commissioning.

7. FLEXIBLE CELL DESIGNS

Cells are sized to accommodate the design flowrate based on the number of downcomers. The tank can be designed to fit into restricted spaces, making it ideal for retrofits/replacement and expansion projects. Materials of construction are flexible and cells can be fabricated to suit the needs of the client and application.

"The simple installation and small footprint is ideal for circuit expansions."

OPERATING PRINCIPLES

The Jameson Cell consistently produces fine bubbles and intense mixing between air and slurry. This means fast, efficient flotation.

While the principle of using air bubbles to recover particles is the basis of the technology, it is the way air bubbles are generated and how the bubbles and particles interact that make Jameson Cells unique.

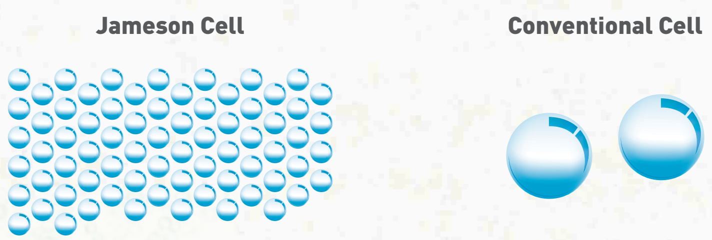
In the Jameson Cell, particle-bubble contact takes place in the downcomer. The tank's role is froth-pulp separation and may incorporate froth washing to assist in obtaining product grade.

With no agitators, blowers or compressors Jameson Cell installation is simple and operation is extremely energy efficient. Power consumption is much lower than the equivalent mechanical or column flotation cell. The energy for flotation is simply delivered by the conventional feed pump.

Optimal Jameson Cell performance is maintained by delivering a constant volumetric flowrate of pulp to each downcomer. While operating plants experience fluctuating process flows, the Jameson Cell is equipped with a tailings recycle system, that automatically compensates for feed variations. In addition to maintaining consistent and optimal downcomer operation, the tailings recycle improves metallurgical performance by giving particles multiple 'passes' through the downcomer contacting zone. The Jameson Cell's ability to provide better selectivity and to control entrainment means product grade is not affected.

Stainless steel wash water system in coal flotation.

How much bubble surface area will 1 mm^3 of flotation give you?



Jameson Cell	Conventional Cell
Mean Air Bubble Diameter – 0.3 mm Total Mean Surface Area – 20 mm^2	Mean Air Bubble Diameter – 1.0 mm Total Mean Surface Area – 6 mm^2

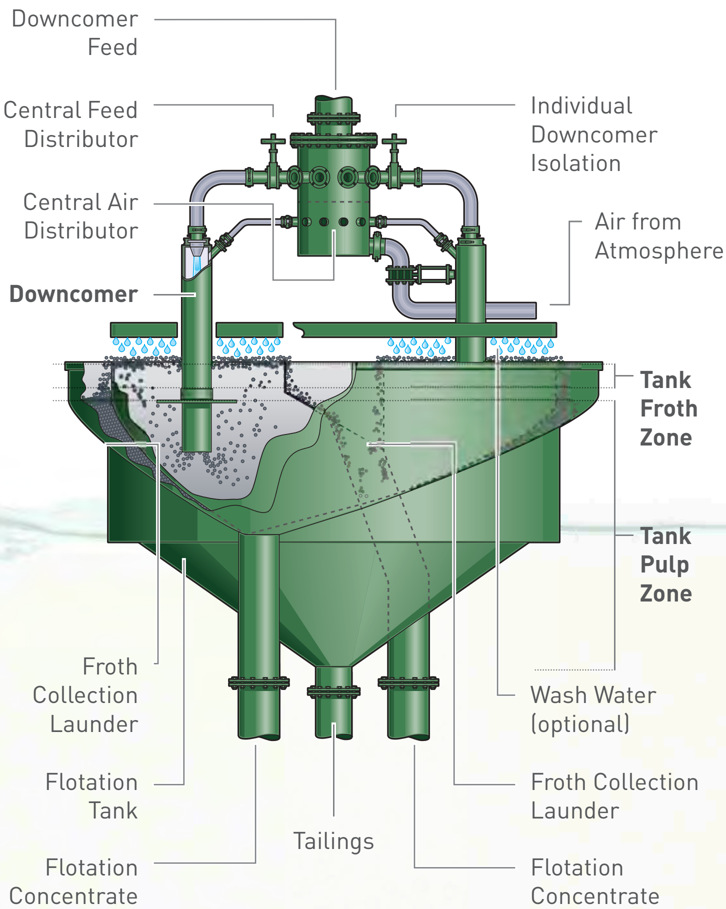
The Cell

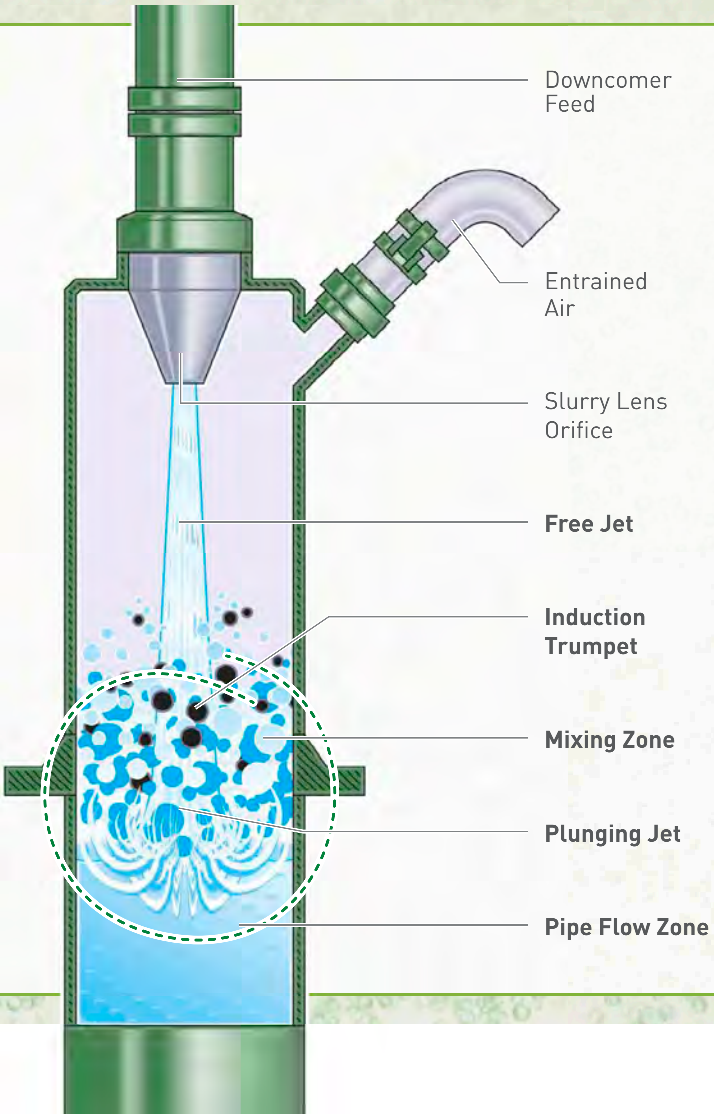
A Jameson Cell consists of three main zones: the downcomer, the tank pulp zone, and the tank froth zone.

The **Downcomer** is the heart of the Jameson Cell where intense contact of air bubbles and particles occur. Feed is pumped into the downcomer through the slurry lens orifice, creating a high-pressure jet. The jet of liquid shears and entrains air from the atmosphere. Removal of air inside the downcomer creates a vacuum, causing a liquid column to be drawn up inside the downcomer. The jet plunges into the liquid column where the kinetic energy of impact breaks the air into fine bubbles which collide with the particles. The very high interfacial bubble area and intense mixing, results in rapid particle attachment to the air bubbles and high cell carrying capacities.

The **Tank Pulp Zone** is where mineral laden bubbles disengage from the pulp. The design velocities and operating density in this zone, keep particles in suspension without the need for mechanical agitation. Due to the rapid kinetics and separate contact zone in the downcomer, the tank is not sized for residence time, so tank volumes are much smaller than equivalent mechanical and column cells. Jameson Cells are contact dependent, not residence time dependent.

In the **Tank Froth Zone** the grade of the concentrate is controlled by froth drainage and froth washing. Cells are designed to ensure an efficient, quiescent zone that maximises froth recovery. Froth travel distance and concentrate lip loadings are integral to the tank design.





The Downcomer

The downcomer is where bubble-particle collision, attachment and collection occur. The different hydrodynamic regions of the downcomer are the Free Jet, Induction Trumpet, Plunging Jet, Mixing Zone and Pipe Flow Zone.

Free Jet: Slurry passing through the slurry lens orifice under pressure creates the Free Jet which shears the surrounding air and entrains it into the slurry.

Induction Trumpet: The Free Jet impinges on the slurry in the downcomer. The impact creates a depression on the liquid surface and results in air being channelled into the area at the base of the Free Jet.

Plunging Jet: High shear in the jet breaks the entrained air into a multitude of very fine bubbles (0.3 to 0.5 mm in diameter) which are carried downwards in the downcomer.

Mixing Zone: The Plunging Jet transfers momentum to the surrounding mixture, creating recirculating eddies of aerated liquid for intense bubble-particle collision and attachment.

Pipe Flow Zone: Beneath the Mixing Zone, a region of uniform multiphase flow exists. The downward liquid velocity counteracts the upward flow of mineral laden air bubbles. The air bubbles and particles pack together to form a downward moving expanded bubble-particle bed. The dense mixture of bubbles and pulp discharge at the base of the downcomer and enters the tank pulp zone where the mineral laden bubbles disengage from the pulp.

ENGINEERING

Continuous design improvements have resulted in a flotation technology with high availability, long component life and low operating costs.

Jameson Cell engineering

Incorporating Jameson Cell technology into your flowsheet means you do not just get a piece of equipment – you get years of flotation experience and know-how to ensure the latest generation of technology is integrated optimally in your plant.

From the initial enquiry through to project implementation, fabrication, installation, commissioning and training, our engineering team develops a flotation system that works.

Our input does not stop after commissioning and training. XT engineers provide expert technical assistance to help assess and optimise the flotation performance of your Jameson Cell.

Mark IV Jameson Cell downcomers.

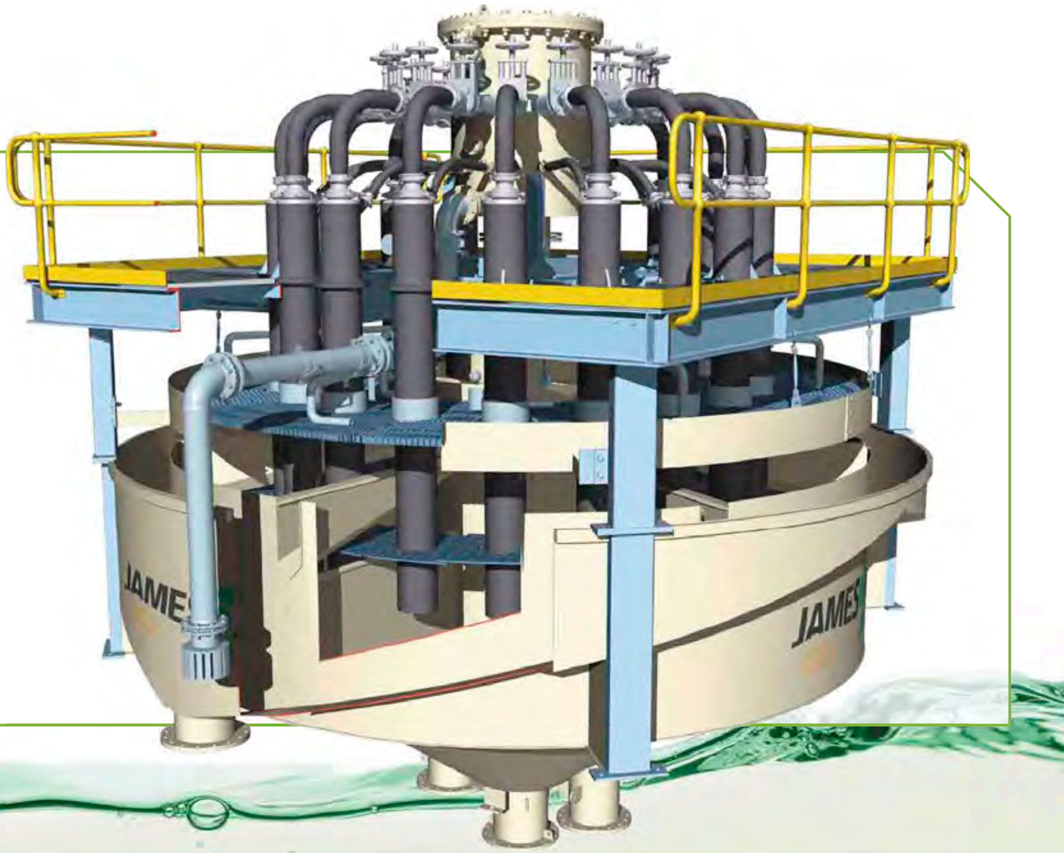
Trial assembly of B5400/18 Jameson Cell for Red Dog (Alaska, USA) prior to shipment.

Specifications

Model[1]	Cell shape	Flotation tank dimensions (m)	Number of downcomers	Typical fresh feed flowrate (m^3/h)[2]
All-in-one cells (with internal tailings recycle)				
Z1200/1	Circular	1.2	1	50
E1714/2	Rectangular	1.7 x 1.4	2	100
E2514/3	Rectangular	2.5 x 1.4	3	150
E1732/4	Rectangular	1.7 x 3.2	4	200
E2532/6	Rectangular	2.5 x 3.2	6	300
E3432/8	Rectangular	3.4 x 3.2	8	400
E4232/10	Rectangular	4.2 x 3.2	10	500
Circular cells (requiring external tailings recycle)				
B4500/12	Circular	4.5	12	600
B5000/16	Circular	5	16	800
B5400/18	Circular	5.4	18	900
B6000/20	Circular	6	20	1000
B6500/24	Circular	6.5	24	1200

1 Standard cell sizes listed. Other cell sizes and shapes can be designed to meet specifications of client and project.
2 Cell sizing based on volumetric flowrate only and may vary depending on application, specific duty and flowsheet design. Carrying capacity and lip loading considerations may alter cell sizing.

High throughput capacity in a small footprint providing a simple and flexible installation.



Jameson Cell maintenance

The maintenance benefits of the Jameson Cell technology are:

- No moving parts.
- Safe to maintain.
- Easy access to serviceable components.
- Wear parts can be changed on the run.
- No special tools required for routine inspection and maintenance procedures.
- No lubricants required.
- Slurry lens orifice has a long service life (+3 to +5 years) under normal operating conditions.
- Long service life for other wet end wear parts under normal operating conditions.

Jameson Cell maintenance is minimal and relies on monitoring process conditions and conducting periodic inspection. Inspections are quick and can be completed without tools and during cell operation.

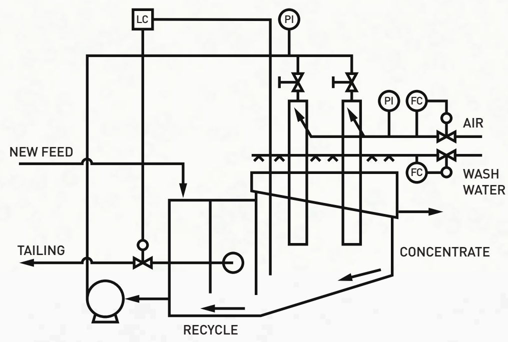
Layout and control systems

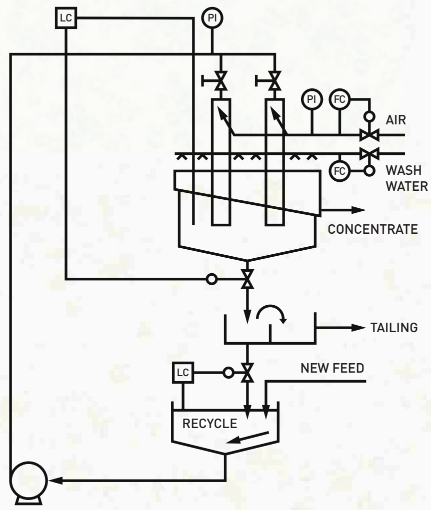
Jameson Cells come complete with all necessary valves, instrumentation and control philosophy for simple integration into your control system.

All critical process parameters required for optimising flotation performance are automated, monitored and controlled.

Internal Recycle Control

Internal Recycle Control with integral cell, pump and tailings recycle boxes for installation on one level.





External Recycle Control

External Recycle Control allows for maximum flexibility in plant layout utilising gravity flow of products to the next stage.

» ACCURATE DESIGN

Direct scale up from laboratory and pilot scale testwork is proven. Using Jameson Cell technology in your flowsheet significantly reduces project risk.

Jameson Cell L500/1 pilot plant test rig.

Accurate testwork and scale up is essential for optimal plant performance. The hydrodynamic conditions for particle collection inside the downcomer and separation in the tank are identical between laboratory, pilot plant and full scale Jameson Cells. Scale up is direct and proven.

XT has the operational experience and expertise to supply Jameson Cells to meet project design criteria and ensure effortless flowsheet integration. Using pilot or laboratory scale test units, we can design a testwork program to suit your needs. If Jameson Cell testwork is not practical we can use our extensive body of knowledge, testwork and full scale data to recommend a system suitable for you. In many cases, standard laboratory based testwork, using mechanical cells, can be used for Jameson Cell sizing.

Testwork Options

XT can recommend and organise batch laboratory tests using a L150/1 laboratory unit or continuous onsite testwork using an L500/1 pilot plant test rig. All Jameson Cell test rigs come complete with auxiliary equipment including downcomer assembly, pump box with tailings recycle arrangement, feed pump, wash water system, control panel, valves and instrumentation.

Continuous onsite pilot plant testing produces the most reliable results for design and simulates full scale operation.

The benefits of onsite testwork include:

- Ability to test a representative stream from the existing plant and to assess flotation performance with variations in plant feed.
- Ability to investigate and understand the effect of process variables on flotation performance. Process parameters can be deliberately manipulated to assess performance over the entire grade-recovery range.
- Flexibility to perform as many tests as desired to 'prove up' design.

Scale Up

In conventional or column flotation, scale up factors are required when using laboratory or pilot plant results for full scale design. These factors account for variations in cell geometry, mixing patterns (short circuiting) and energy intensity between the different sized units. The scale up factors can also change depending upon the duty, feed characteristics and flotation kinetics.

No scale up factors are required for the Jameson Cell design. This is because the jet velocity, air entrainment and hydrodynamic conditions for mixing are identical across different sized cells from laboratory to full scale. The operating principle and parameters of the downcomer are exactly the same irrespective of cell size. For large cell sizes simply more downcomers are used. Direct scale up has been proven across different applications including coal, base and precious metals, solvent extraction and industrial minerals.


Four B6000/20 Jameson Cells in coal flotation at Moorlaben, Australia.


B6500/22 Jameson Cell in carbon prefloat cleaning at Century Zinc, Australia.

» Technology partnership concept

The Jameson Cell has been continuously developed and improved from experiences at client's and Glencore's own operating sites. The result is more than just flotation equipment, it is years of experience and know-how that is incorporated into our design and recommendations.

Our Technology Partnership concept is the vehicle that makes this body of knowledge and experience available to you, enabling your company to achieve the full potential benefits of the Jameson Cell Technology.

- XT has an ongoing technical relationship with users.
- We facilitate interchange of learning's between users.
- Glencore has been using Jameson Cell technology as a core part of its' own processing operations since the 1980s.
- Our extensive operating experience combined with the latest equipment and process development produces a package that delivers rapid technology transfer to your operation.

XT

XT develops, markets and supports technologies for the global mining, coal, mineral processing, industrial minerals, oil sands and metals extraction industries. It has offices in Australia, South Africa, Europe, Canada, Russia, China and Chile, and is a wholly owned subsidiary of Glencore, a major global diversified mining group.

For further information please visit www.xt-t.com.

20 years of development

The first Jameson Cells were a big improvement on columns but they still needed to be more robust to better suit operating conditions.

XT's operators and engineers have worked with Jameson Cell users for 20 years to continuously improve the robustness and reliability of the Jameson Cell.

Two decades of significant advances have culminated in the latest model, the Mark IV Cell. The Mark IV Jameson Cell incorporates:

- Feed recycle systems to ensure stable cell and downcomer operation and optimum performance independent of feed fluctuations. The cell operates consistently even when feed stops.
- Low wear, high discharge coefficient slurry lens orifice.
- Flexible feed nozzle allows quick and easy inspection and perfect alignment of the plunging jet to maximise metallurgical performance.
- Upgraded above-froth or in-froth wash water system.

The first Jameson Cells were installed in Mount Isa to address the inadequacies of flotation columns.

APPLICATIONS

B5400/18 Jameson Cell in copper cleaner scalper flotation at Prominent Hill, Australia.

Jameson Cells in Base and Precious Metals Flotation

The integration of Jameson Cell technology into a flowsheet produces a robust and efficient plant requiring less cells, equipment and space. Consistent fine bubble generation, high intensity mixing and froth washing allow Jameson Cells to recover minerals quickly and at superior concentrate grades compared to mechanical cells. The Jameson Cell's ability to treat large throughputs in a small footprint makes them perfect for inclusion into retrofit and expansion projects.

The Jameson Cell is particularly suited for:

» Removal of naturally hydrophobic gangue (carbon and talc) at the head of the flotation circuit where Jameson Cells act as roughers or rougher cleaners minimising entrainment of the valuable minerals to the 'throw away' concentrate that mechanical cells simply cannot match.

» Pre-roughing (rougher scalper) and roughing duties where selectivity and froth washing produce a high grade concentrate. The recovery in one Jameson Cell is usually equivalent to several mechanical cells. When the feed contains liberated, fast floating mineral particles, the Jameson Cell produces final grade product reducing the number of cells required for downstream processing.

» Pre-cleaning (cleaner scalper) duties where the Jameson Cell recovers the fast floating minerals producing a final grade concentrate. In this duty the Jameson Cell takes the load off downstream processing reducing the required size of the conventional cleaning circuit. A pre-cleaning Jameson Cell offers a quick, simple and cost effective solution for plants needing additional cleaner capacity.

» When mechanical cleaning circuits are unable to consistently produce final grade concentrates due to entrained gangue, the Jameson Cell with its superior selectivity and froth washing can produce the required final concentrate grade.

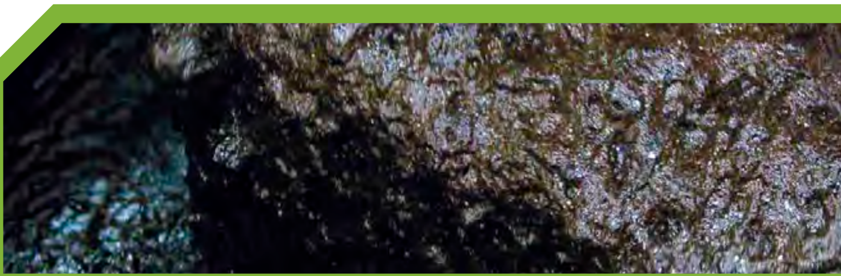
Jameson Cells are installed in copper, gold, copper-gold, lead-zinc-silver, nickel and platinum operations throughout the world.

Jameson Cells in Coal Flotation

In a Coal Handling and Preparation Plants (CHPP), gravity separation techniques are used to separate coal from ash. At fine particle sizes (below 500 μm) gravity separation is inefficient and flotation is required. Early coal operations used conventional flotation technology however high throughputs and strict product ash requirements made the circuits complex and inefficient with inconsistent performance.

The Australian Coal Industry served as a rigorous testing ground for the Jameson Cell in the 1980s culminating in the first full scale Jameson Cell coal installation at Newlands in 1990. The Jameson Cell is now the industry standard with over 100 coal cells installed by 2010 in Australia alone. The fine bubble size, high intensity and froth washing ability offer major advantages over conventional cells for recovery of the highly hydrophobic, fast floating coal fines. These advantages provide superior, more consistent flotation performance, lower ash concentrates and high recovery. Coupled with high throughputs, small footprint, simple installation and high availability the Jameson Cell has set the standard for installations in the coal industry. The largest installation at Curragh (Australia) treats over 5 Mtpa of coal fines using only twelve cells. Jameson Cells are also installed in coal operations in Africa, North America, Asia and Europe and their simple integration into modular plants has meant the advantage of Jameson Cells are now extended to the recovery of coal fines in tailings dams.

B6000/20 Jameson Cells at Hail Creek, Australia.



Jameson Cells in Oil Sands

Following years of development and testing in oil sands flotation the first full scale Jameson Cell downcomers were installed into oil sands processing in 2009. The fine bubbles and intense mixing results in efficient bubble-particle contact producing high grade bitumen froth at high recoveries in a single stage. Superior process performance, no moving parts and higher availability are fundamental to the selection of Jameson Cells over alternative technologies for retrofits, expansions and new projects. High capacity Jameson Cells with large scale downcomers accommodate the large tonnages mined and treated in this industry.

Jameson Cells in Industrial Minerals

Jameson Cell technology was introduced into the industrial minerals industry in 1993 to recover potash ‘slimes’. In a cleaning duty, a single stage Jameson Cell can replace banks of mechanical cells and achieve final grade at maximum recovery. A retrofit installation reported energy savings of up to 76% when replacing 16 mechanical cells with one Jameson Cell. Savings are also achieved in reduced circuit footprint, wear parts and maintenance.

Flotation of semi-soluble salt minerals, such as phosphate, fluorite and calcite, are controlled by surface chemistry where selection of appropriate reagents and conditioning methods drive recovery. Once hydrophobic, the minerals are fast floating making conditions in the Jameson Cell perfect for recovering these minerals. In these applications, Jameson Cells have been designed for roughing, scavenging and cleaning duties.

Jameson Cells in Solvent Extraction

Jameson Cells recover organic from electrolyte and raffinate streams in copper, cobalt, nickel, platinum and zinc solvent extraction (SX) circuits worldwide. In electrolyte duties, the Jameson Cell removes organic contamination from the electrolyte stream in the tank house which would otherwise cause organic “burn” degrading electro-won copper cathodes. In raffinate duties, the Jameson Cell recovers organics that would be lost in the extraction process. Organic is a major operating cost and if recovered can be treated and reused in the process.

The fine bubbles and high intensity make the Jameson Cell extremely efficient, and the only viable flotation technology for capturing the extremely low concentrations of organic droplets.

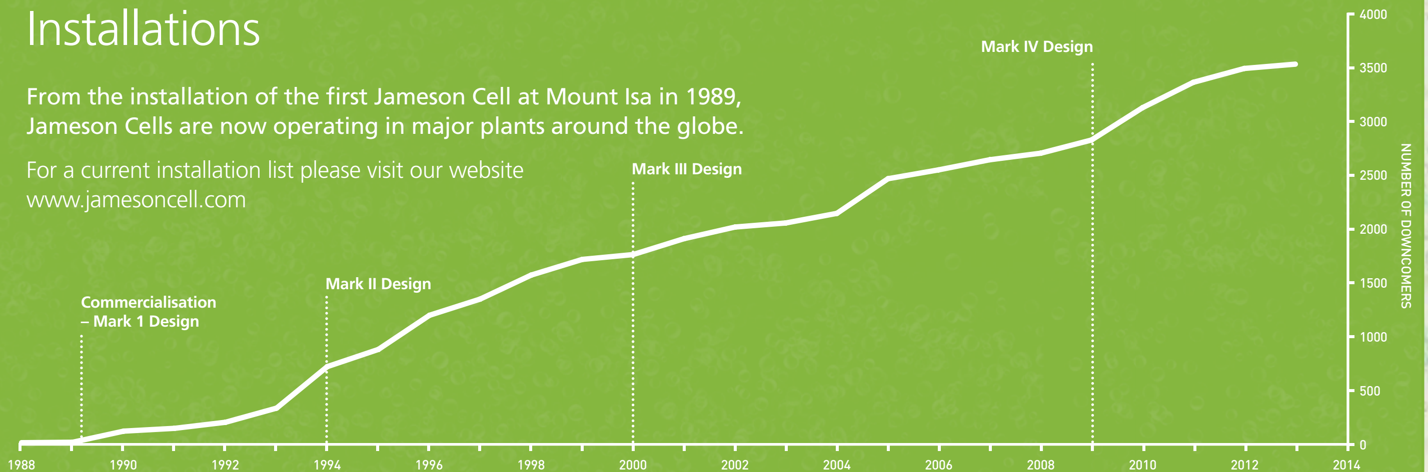
Jameson Cells for SX duties are fabricated in stainless steel or fibreglass reinforced plastic (FRP) and incorporate features specific to the application. The high flowrates and absence of particles allow large downcomers with multiple liquor lenses and flat-bottomed tanks to be used, minimising capital and installation costs. The biggest operating cell, a J7250/10 recovering organic from 3000 m³/h of raffinate at Olympic Dam’s copper SX plant in Australia, was commissioned in 2003.

J7250/10 Jameson Cell at Cananea, Mexico.

Installations

From the installation of the first Jameson Cell at Mount Isa in 1989, Jameson Cells are now operating in major plants around the globe.

For a current installation list please visit our website www.jamesoncell.com



Expertise in Technology

Glencore operates mines throughout the world. Tough testing grounds that make our process technologies the best on earth.

XT Australia
Level 10, 160 Ann St
Brisbane QLD 4000, Australia
Tel +61 7 3833 8500 · Fax +61 7 3833 8555

XT Chile
Alcántara 200 of. 1202 Las Condes,
Santiago CP7550159 Chile
Tel +56 2 2478 22 11 · Fax +56 2 2478 22 30

XT Canada
10th floor, 700 West Pender St, Vancouver,
British Columbia V6C 1G8
Tel +1 604 699 6400 · Fax +1 604 689 4719

XT South Africa
Suite 19, Private Bag X1,
Melrose Arch 2076, South Africa
Tel +27 71 606 4667 · Fax +27 86 646 9570

XT Europe
Level 4, 50 Berkeley Street
London, W1J 8HD, United Kingdom
Tel +44 771356 3353

XT Russia and CIS
Lesnaya Plaza, Office 505, 4, 4th Lesnoy Pereulok
125047, Moscow, Russia
Tel +7 916 710 8993

www.jamesoncell.com
www.xt-t.com

A GLENCORE COMPANY

XTT 2363G 04/14

Appendix 3

Annual production of the Jameson Cell and value of export coal produced.

Year	Annual production (millions tpa)	Cumulative value of coal produced (AUD billions)
1990	0.7	0.1
1991	0.7	0.1
1992	0.7	0.2
1993	1.7	0.4
1994	2.3	0.6
1995	2.7	0.9
1996	3.5	1.2
1997	4.6	1.6
1998	5.3	2.1
1999	5.9	2.7
2000	6.3	3.3
2001	7.8	4.1
2002	9.1	5.1
2003	9.3	5.9
2004	9.3	6.8
2005	12.9	8.8
2006	12.9	10.8
2007	13.9	12.5
2008	14.6	16.2
2009	15.3	19.9
2010	17.5	22.8
2011	19.8	26.9
2012	20.7	30.9
2013	20.7	33.6
2014	20.7	36.0