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## MINING ENGINEERING - UNDERGROUND

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The Snowden mining team provides engineering services in the **evaluation, design, development** and **management** of underground mines. Our close interaction with Snowden resource geologists and geotechnical engineers allows us to assess the **practical mining implications** associated with resource models and the surrounding rock mass. Our work ranges from due diligence audits, completion tests and conceptual capacity studies, to classified ore reserve estimation at JORC standards, full feasibility studies and detailed mine design for a wide range of commodities and mining methods.

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### Major clients include:

- Anglo Gold Ashanti
- Aquarius Platinum
- Batavia Mining
- BHP Billiton
- Gold Fields
- Lion Ore Australia
- Placer Dome
- Ridge Mining
- Rio Tinto
- Teck Cominco

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### Consulting skills:

- Open pit and underground cut-over point analysis
- Cut-off grade optimisation using STOPESIZOR, Snowden's underground optimisation package
- Mining and access method studies
- Underground stoping and development designs
- Mining equipment selection
- Mine services and infrastructure
- Life of mine development and stoping schedules
- Mine ventilation analysis
- Operating and capital cost estimation
- Ore reserve estimation
- Risk analysis using conditional simulation

## **Projects include:**

### **Gold Fields**

#### **Gold Fields operations, World wide**

Snowden carried out an external audit for Gold Fields of their operating mines. These include Beatrix, Driefontein, and Kloof in South Africa, Tarkwa and Damang in Ghana, and St Ives and Agnew in Australia. The project was carried out by 10 Snowden staff acting in four teams, plus two reviewers, between mid-July and mid-August, 2005. This audit will be repeated in February 2007.

Snowden has also carried out a Competent Persons Report for Gold Fields for all their operating mines.

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#### **(Agnew Gold Mine) Leinster, Australia**

Snowden provided management strategies for in-pit waste tipping, and long-term protection of the main zone escape-way and ventilation return breakthrough into Waroonga open pit.

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### **BHP Billiton**

#### **Olympic Dam Operation, Australia**

Snowden has enjoyed a long relationship with ODO and during this time has completed and participated in several projects at ODO.

Snowden completed a pre-feasibility study for underground mining of the Southern Mining Areas at ODO. As part of this project Snowden completed more than a thousand detailed stope designs, plus associated development layouts. Previous work for ODO had included a review of stope performance and generation of reserve conversion factors.

Currently, Snowden is assisting with long term mine planning at Olympic Dam. From time to time Snowden has also provided site based assistance for various day-to-day mine planning and design functions including ring designs, cable bolt designs, barricade designs and development designs. Assistance is also being provided for conceptual design management.

Snowden also assisted with the recent Mine Area Design project which included an update of the reserve conversion factors.

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#### **Cannington, Australia**

Snowden conducted an audit to determine the compliance of Cannington's Safety Management System and its implementation with the relevant legislation.

### **Perseverance, Australia**

Snowden reviewed the 2004 Perseverance mine Ore Reserve estimation and reporting process and documentation for correctness and JORC compliance.

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## **LionOre Australia**

### **Maggie Hays, Australia**

Snowden conducted a mining feasibility study for the Maggie Hays nickel sulphide deposit. The mining method incorporated the use of sublevel caving for the extraction of both massive and disseminated mineralised zones. Snowden also provided follow up assistance with Ore Reserve estimate updates.

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### **Black Swan, Australia**

Snowden provided assistance and mentoring in a review of potential mining of low grade areas. Snowden also provided mentoring to LionOre staff for the ore reserve process.

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### **Lake Johnston Operations, Australia**

Snowden is facilitating and co-leading business improvement projects at Lake Johnston Operations.

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### **Wedge Tail, Australia**

An assessment of underground options including decline, starter pit and shaft was conducted by Snowden.

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### **North Well, Australia**

Snowden prepared an underground scoping study and cost estimate for North Well, as well as pit optimisation for surrounding pits.

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## **Serabi Mining**

### **Palito, Brazil**

Snowden assisted Serabi with AIM listing documents for their Palito project in Brazil. Snowden is providing ongoing mine planning assistance for the Palito Gold Mine.

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## **Agincourt Resources**

### **Andorinhas, Brazil**

Snowden assisted Agincourt Resources with an underground mining study, including initial pit optimisation, underground cut-off optimisation, and mine design scheduling and cost estimation.

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## **Discovery Nickel**

### **Maun, Botswana**

Snowden conducted a preliminary mining assessment of the Maun project to assess the mineability of the deposit and identify the requirements for a viable project.

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## **Hill End Gold**

### **Hill End Gold project, Australia**

Snowden provided mining engineering advice on the recommencement of underground mining operations at the Hill End Gold Project.

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## **Oxiana Limited**

### **Golden Grove, Australia**

Snowden has contributed to continuous improvement projects using Six Sigma tools with considerable success. Snowden is also providing technical assistance with the recommencement of operations at the Scuddles mine.

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## **Rio Tinto and Roche Mining**

### **Argyle, Australia**

Snowden has contributed to several continuous improvement projects using Six Sigma tools. Projects include shotcrete improvement, drill and blast improvement and training of personnel in continuous improvement techniques.

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## **Rio Tinto**

### **North Parkes, Australia**

Snowden personnel have played a part in the North Parkes E48 pre-feasibility study. This work included production ramp up and ground support trials.

Snowden provided engineering personnel to collect information and monitor the progress of the E48 block cave exploration development.

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## **Placer Dome**

### **South Deeps, South Africa**

Snowden participated in an international review panel, the purpose of which was to provide comfort to the South Deeps Gold Mine JV partners that the resource and reserve estimation work had been done diligently and was representative of the insitu resource.

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## **Anglo Gold Ashanti**

### **Mponeng, South Africa**

An ore reserve audit was carried out by Snowden at Mponeng.

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### **Tau Lekoa, South Africa**

An ore reserve audit was carried out by Snowden at Tau Lekoa.

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## **Confidential client**

### **Norseman, Australia**

Snowden undertook a due diligence review of Norseman operations for a potential purchaser.

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## **Batavia Mining**

### **Deflector, Australia**

Snowden initially completed a scoping study which included underground optimisation and design, open pit optimisation and design together with mining cost estimation, mine scheduling and evaluation.

Following on from the scoping study Snowden have undertaken a feasibility study to take the project through into development.

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## **Lonmin**

### **Marikana, South Africa**

An ore reserve audit was carried out by Snowden at Marikana.

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## **EROC**

### **Telfer, Australia**

Snowden provided long term mine scheduling support at Telfer. The project involved the scheduling of contractor development of Telfer Deeps.

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## **Terra Gold**

### **Maud Creek, Australia**

Snowden created conceptual stope and development designs for development of Maud Creek resource in the Northern Territory.

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## **Northern Gold**

### **Cosmo Deeps, Australia**

Snowden completed a review of the underground project at Cosmo Deeps in the Northern Territory.

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### **Zappopan, Australia**

Snowden undertook a high level review of the Zappopan and Cosmo Deeps resources for the purpose of NI 43-101 requirements

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## **Aquarius Platinum**

### **Marikana, South Africa**

Snowden conducted a scoping study to assess the viability of underground mining for the Marikana platinum deposit. Later work by Snowden entailed a conceptual study to determine the benefit of combined open pit and underground mining using open pit truck and shovel and underground room and pillar stoping methods. The study included resource estimation and mining feasibility studies using Datamine software.

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### **Everest South, South Africa**

Optimisations, designs and schedules for proposed open pit and underground mines were developed by Snowden as part of a feasibility study. Snowden identified the optimum and practical change over point from pit to underground, completed detailed mine designs, production and cost schedules, and also determined and costed mining infrastructure requirements. Snowden also assisted with the preparation of open pit and underground contracts and more recently re-optimised the Everest South open pit based on updated constraints.

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## **Sally Malay Mining**

### **Sally Malay, Australia**

Snowden completed the open pit and underground mine design for the Sally Malay nickel-copper-cobalt ore body as part of the project feasibility study. The study included design, schedule and costing of the mining operations as well as a detailed geotechnical assessment of the rock mass and possible impact on the mining method.

A separate mining study investigating different methods to optimise a combined open pit and underground mine was also conducted by Snowden. The team assessed the best size for the pit and whether the underground access should be in or outside of the pit.

Additional Snowden work for Sally Malay included pit optimisation, plus detailed design work for haul road and dam wall layouts and other various engineering tasks.

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## **Byrnecut Mining**

### **Boschfontein, South Africa**

Snowden assisted Byrnecut with their mining tender for this project in South Africa. Detailed designs were created in Surpac and production mining schedules were prepared in Mine Works Planner.

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### **Telfer, Australia**

A development schedule produced by Snowden was used by Byrnecut for their tender estimate. The schedule was created using Mine Works Planner and included the requirement to meet the completion dates for the development of five separate portions of the mine.

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### **Khandiza, Uzbekistan**

Snowden produced a mining concept study for the Khandiza zinc deposit in Uzbekistan. Underground mining methods were developed for the ore body using Nicholas selection criteria. A preliminary mine layout was also designed for the purpose of cost estimation by Byrnecut.

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## **Sons of Gwalia**

A report for mine design guidelines and procedures for underground mine planning was produced by Snowden. The report identified the risks associated with mine design input parameters, including geology, geotechnical parameters, hydrology and metallurgy. Check lists were developed to help manage the risks. The mine planning procedure included mining method selection, materials handling systems, stope layouts, equipment selection, scheduling and reserve estimation.

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## **Herald Resources**

### **Dairi Zinc, Australia**

Snowden completed a mine design and costing report for Herald Resources. The mine planning work included design and costing of underground development, mining method selection, truck haulage estimates and the provision of mining services for production scheduling and reserve estimation. The report also identified the geotechnical and mine planning areas requiring additional information and work to increase the confidence levels for a future feasibility study.

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## **Giants Reef Mining**

### **Chariot Mine, Australia**

A life of mine plan based on long-hole stoping was prepared by Snowden. This included development and stoping layouts, cost projections and production schedules. Stopesizer was used to identify the optimal mining inventory for different equipment driven by minimum mining width considerations for different parts of the resource. Additional work by Snowden included mine planning and management services, a pit optimisation, underground development layouts, stope design and a production database.

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## **Xstrata Copper**

### **Ernest Henry, Australia**

Snowden prepared the resource models and conducted a conceptual mine planning and feasibility study for the Ernest Henry underground project.

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## **Fox Resources**

### **Radio Hill, Australia**

Snowden reviewed Fox Resource's mining study for the Radio Hill Nickel mine. The study involved reviewing the stope shapes and extraction methods to be applied for the Ore Reserve estimate. A geotechnical analysis was also carried out on areas that were considered to be of high stability risk due to the proposed stoping method.

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### **Sholl and Whundo, Australia**

Using supplied resource models, Snowden completed a preliminary study to assess the viability of open pit extraction, with underground mining of deeper resources, for the Sholl nickel and Whundo copper deposits.

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## **Ridge Mining**

### **Blue Ridge Platinum Mine**

Optimisations, designs and schedules for the underground mine were developed by Snowden as part of a feasibility study. Snowden completed detailed mine designs, production and cost schedules, and also determined and costed mining infrastructure requirements.

A scoping study assessment was conducted by Snowden to increase the Blue Ridge West mining inventory by including the adjacent Millenium platinum deposit. Inventory was also increased to include BRW reef areas within the Millenium lease boundary.

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Snowden also assisted Blue Ridge to prepare contract documents for the underground mining contract.

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## **TeckCominco**

### **Lennard Shelf, Australia**

Snowden assisted with the Lennard Shelf reopening study which involved a pre-feasibility study analysis of three main deposits incorporated in the Lennard Shelf operations. Snowden's role involved stope optimisation of remaining resources, design, scheduling and costing of economic mining inventory, and financial analysis of the project. The study also involved detailed cost estimation for four of the main stages of the mining process including mining, processing, ship loading and administration.

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## **Trident Project and Mining Services**

### **Cannington, Australia**

Snowden assisted Trident with pump station designs and layouts, backfill systems and general development designs for the Cannington expansion.

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## **Tritton Resources**

### **Tritton, Australia**

An operational review with additional detailed scheduling was conducted by Snowden.

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## **Goldstar Resources**

### **Bogoso/Prestea, Ghana**

Snowden prepared a scoping study to assess the viability of underground mining at the Bogoso/Prestea operation in Ghana.

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## **Cobar Management Pty Ltd**

### **CSA Mine, Australia**

Snowden developed a five year mine schedule for the CSA mine. Development and production activities were scheduled including the sequencing of stope extraction and backfill placement. The project also included determination of the production rate.

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