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New South Wales Mining and Exploration Quarterly

No. 40

JULY 1993

FEATURE :
Energy resources in the Gunnedah Basin.

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DEPARTMENT OF MINERAL RESOURCES

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New South Wales Mining and Exploration Quarterly
No. 40

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CARTOGRAPHIC SUPERVISION:
Jim West, Deputy Chief Cartographer

PHOTOGRAPHY:
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GRAPHIC DESIGN:
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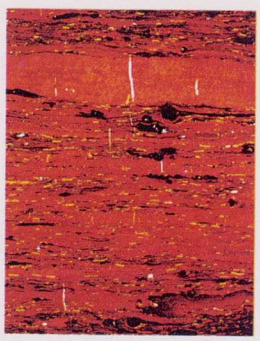
COVER PHOTO:
View up the boom of Marion 7820 walking dragline, Greenwood pit, Vickery mine (see page 11 of Feature)
Photo by David Barnes

COVER BACKGROUND:
Thin section of coal from the Hunter Valley. Transmitted light; field of view approx. 0.3 mm wide
Photo by David Barnes



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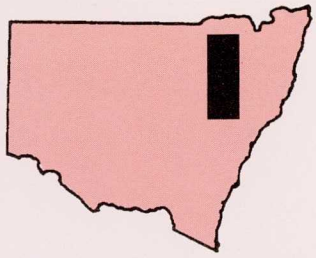
GUNNEDAH BASIN OVERVIEW



Exploration by the Department in the Gunnedah area over the last 20 years has shown that open cut coal resources are limited but that large underground resources are present. The Gunnedah Basin also offers excellent potential for the discovery and production of coalbed methane.

The Gunnedah Basin is located in central northern New South Wales, some 300 km north-north-west of the Port of Newcastle, to which it is connected by rail. The basin forms the central part of the Permian–Triassic Sydney–Gunnedah–Bowen Basin system which extends along the eastern margin of Australia (figure1). The basin is, in part, unconformably overlain by Jurassic strata of the Surat Basin.

The part of the Gunnedah Basin covered in this feature covers an area of approximately 15 000 km^2, extending from Narrabri in the north to the Liverpool Range in the south, and east to the Hunter–Mooki Fault System. The western limit is the inferred western limit of Permian sediments which runs roughly north–south through Rocky Glen (figure 2).

The Department of Mineral Resources has undertaken coal exploration in the Gunnedah Basin since 1974. Including the recent 1991 South Gunnedah Coal Exploration Program, the Department has drilled 164 cored holes in Authorisation 216 (figure 2). Between 1963 and 1985, 17 petroleum boreholes were drilled in the basin.

Currently there are two operating underground coal mines, Gunnedah and Preston Extended, and two open cut mines, at Vickery and Gunnedah, as well as two major open cut development proposals, Maules Creek and Boggabri.

The results of recent exploration carried out by the Department of Mineral Resources in the Benelabri, Hill 60, Mill Ridge and Caroona areas (South Gunnedah Coal Exploration Program) have enabled redefinition of the coal resource potential of the basin.

An exploration program to assess the coalbed methane potential of the basin has recently commenced.

In 1991 the Australian Geological Survey Organisation (formerly the Bureau of Mineral Resources) completed a deep seismic reflection profile across the Gunnedah Basin and the New England Fold Belt. The interpretation of this line is providing structural data for the basin.

Separate articles within this feature discuss these projects in more detail. Mine/proposal data are given in the '1993 New South Wales Coal Industry Profile', issued by the Department. The Department will publish a comprehensive Memoir on the Gunnedah Basin later in 1993.

GEOLOGY

A generalised stratigraphic column is shown in figure 3 and two correlation sections (figure 4) show the distribution of the stratigraphic units through the Gunnedah Basin.

The Permo-Triassic sedimentary sequence in the Gunnedah Basin onlaps deformed and metamorphosed rocks of the Lachlan Fold Belt in the west, and abuts the New England Fold Belt in the east along the east-dipping Hunter–Mooki Fault System. The outcrop of the Permo-Triassic sequence trends north-north-west from south of Quirindi to just north of Narrabri. Outcrop is generally poor due to a thick alluvial cover. The Jurassic sedimentary sequence of the Surat Basin unconformably overlies the Permo-Triassic sequence in the western half of the basin.

The Boggabri Ridge, a basement high, trends to the north-north-west and effectively divides the Gunnedah Basin into two parts: the Mullaley Sub-basin and the Maules Creek Sub-basin (figure 2).

The Permian and Triassic sediments of the Mullaley Sub-basin occupy a tough-like structure with a long axis trending north-north-westerly. The strata dip gently, typically in the order of a few degrees, with steeper dips occurring near the Hunter–Mooki Fault System and adjacent to intrusives.

Superimposed upon the regional dip are a number of minor folds which were mapped by petroleum exploration companies in the late 1950s and early 1960s.

The Early Permian strata of the Maules Creek Sub-basin occur as an easterly thickening wedge of sediment adjacent to the Hunter–Mooki Fault System. Late Permian and Triassic strata are absent from this sub-basin.

Faulting within the Mullaley Sub-basin appears to be relatively minor and associated, in many instances, with uplift due to Tertiary intrusions. In the Maules Creek Sub-basin, faulting has been identified in association with the Hunter–Mooki Fault System.

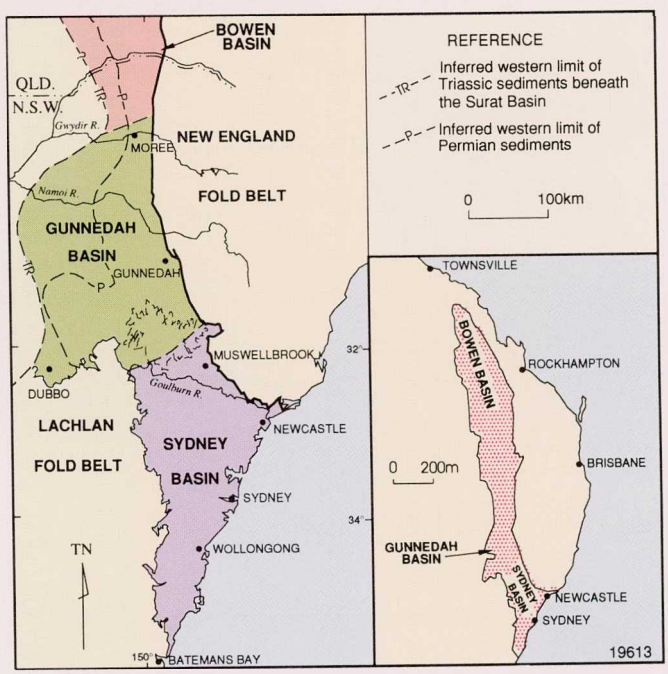


Figure 1. *The Sydney–Gunnedah–Bowen Basin in New South Wales*

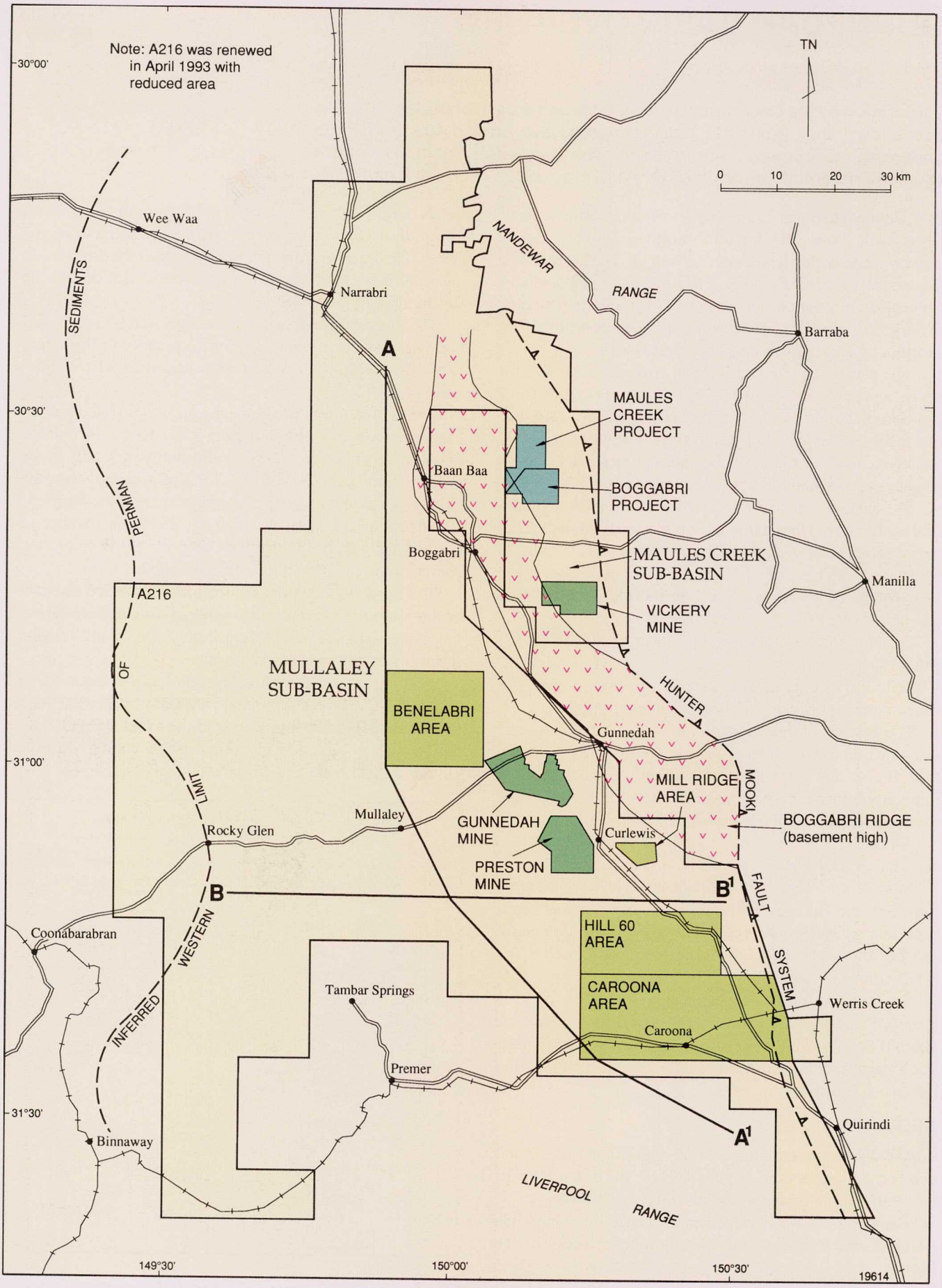


Figure 2. *Locality diagram, Gunnedah Basin*

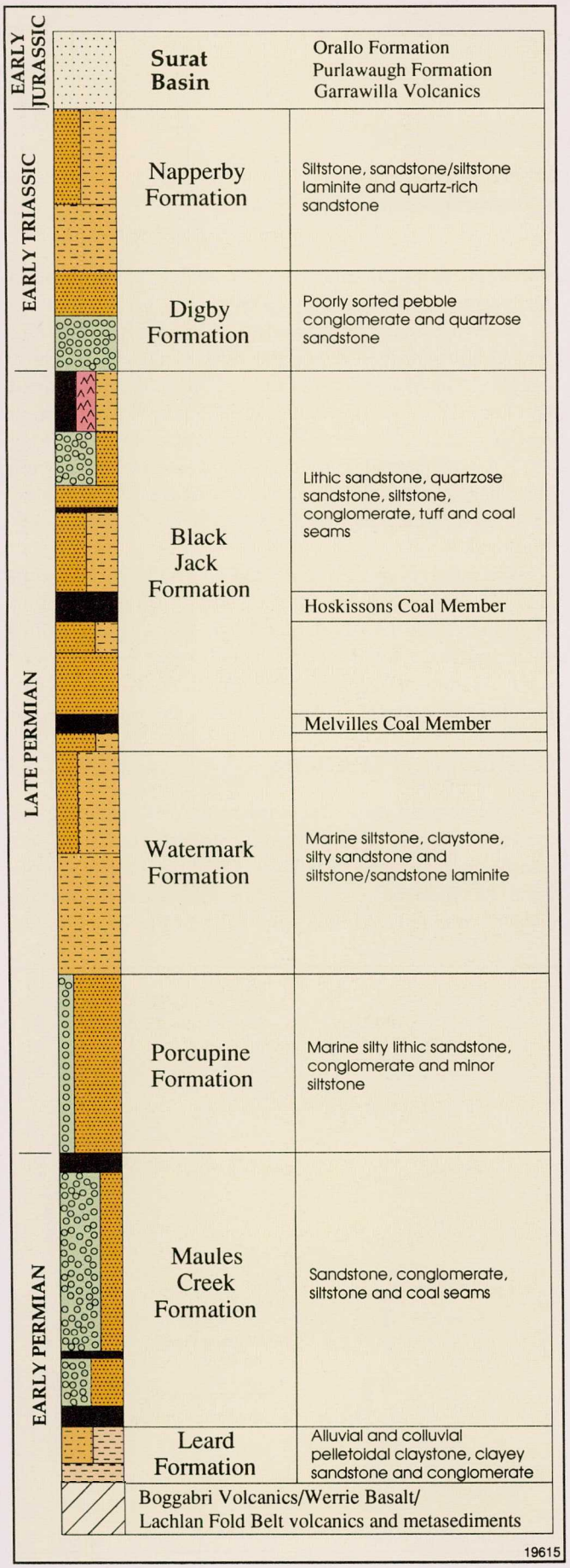


Figure 3. *Stratigraphic column, Gunnedah Basin*

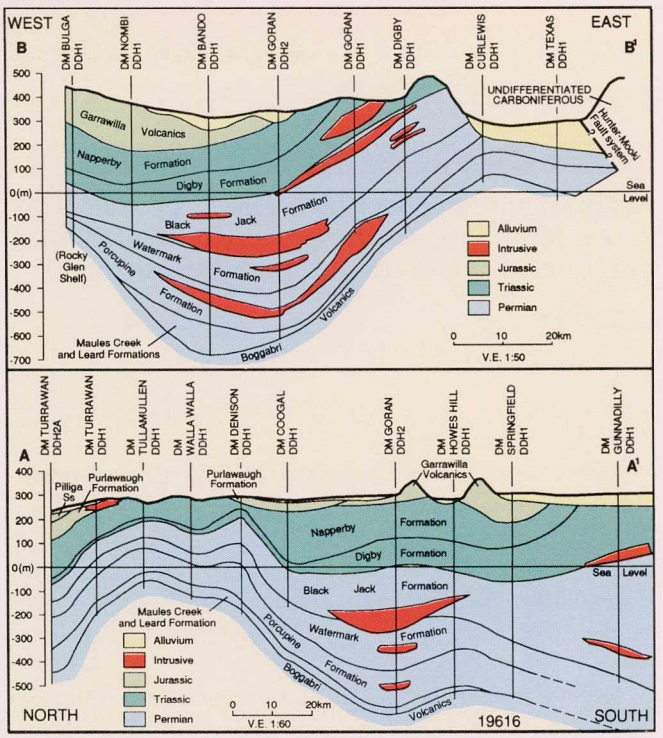
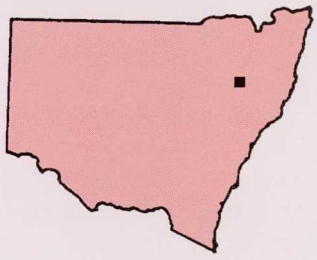


Figure 4. *Cross sections, Gunnedah Basin. For location see figure 2*

For further information contact Julie Moloney, Senior Geologist Singleton, on (065) 72 4200, Fax (065) 72 1201.

FEATURE

GUNNEDAH COAL MINE — PAST AND PRESENT*



At the Gunnedah coal mine, semi-soft coking coal and thermal coal are mined for the export market, both underground, from the Hoskissons seam, and by open cut from the Melvilles seam.

HISTORY

Coal was first discovered in the vicinity of Black Jack Mountain, Gunnedah (figure 5), by farmers when boring for water for agricultural purposes.

In 1877 a well 1 m x 1 m — 'Melville's Well' — was sunk near Wandabah Road, about 11 km south of Gunnedah in which 2 m of 'good steaming coal' was discovered. After further prospecting, mining commenced on the south-eastern slopes of Black Jack Mountain, and developed into Gunnedah Colliery No. 1 Entry (part of the present mining lease area, figure 5).

Gunnedah Colliery Co. Ltd was registered on 13 February 1899, and mining continued over many years, coal being supplied to Tamworth Power Station, railways, hospitals and abbattoirs into the 1960s.

In 1968 Gollin & Co. took over the company, and full mechanisation took place in 1971 with the opening of No. 2 Entry, west of Black Jack Mountain. A long-term contract was signed with the Japanese steel mills and the coal produced was sold on the export market as coking and special purpose coals.

Further purchases of continuous miners and shuttle cars were made, and No. 4 Entry, 700 m north-west of No. 2 Entry, was opened in 1976 when a fully integrated high-production mining operation came into being. A modern coal preparation plant came on stream in July 1978.

Peko-Wallsend Ltd acquired a 51% interest in April 1976, with Gollin and Co. Ltd retaining 49%. The new company, named Gollin Wallsend Coal Co. Ltd (GWCC), then owned the Gunnedah mine. The Gunnedah mine increased production and expanded its markets under this ownership until May 1982, when Consolidation Coal of Australia, a wholly owned subsidiary of Consolidation Coal Co. of the United States, acquired the controlling interest in GWCC from Peko-Wallsend.

The interests of Gollin and Co. Ltd and Consolidation Coal of Australia were purchased by Australian Mining Investments Ltd (AMI) during 1984. As a result, Gollin Wallsend Coal Co. Ltd became a wholly owned subsidiary of AMI. As from 19 December 1985, Gollin Wallsend Coal Co. Ltd changed its name to Gunnedah Coal Co. Ltd.

GUNNEDAH OPERATIONS

Since the acquisition of the company by AMI, production of the Hoskissons seam coal from the underground mine has steadily increased to a peak level of 663 000 tonnes run-of-mine (ROM) in the year ending June 1991. The production capacity was reduced in April 1991 and the underground

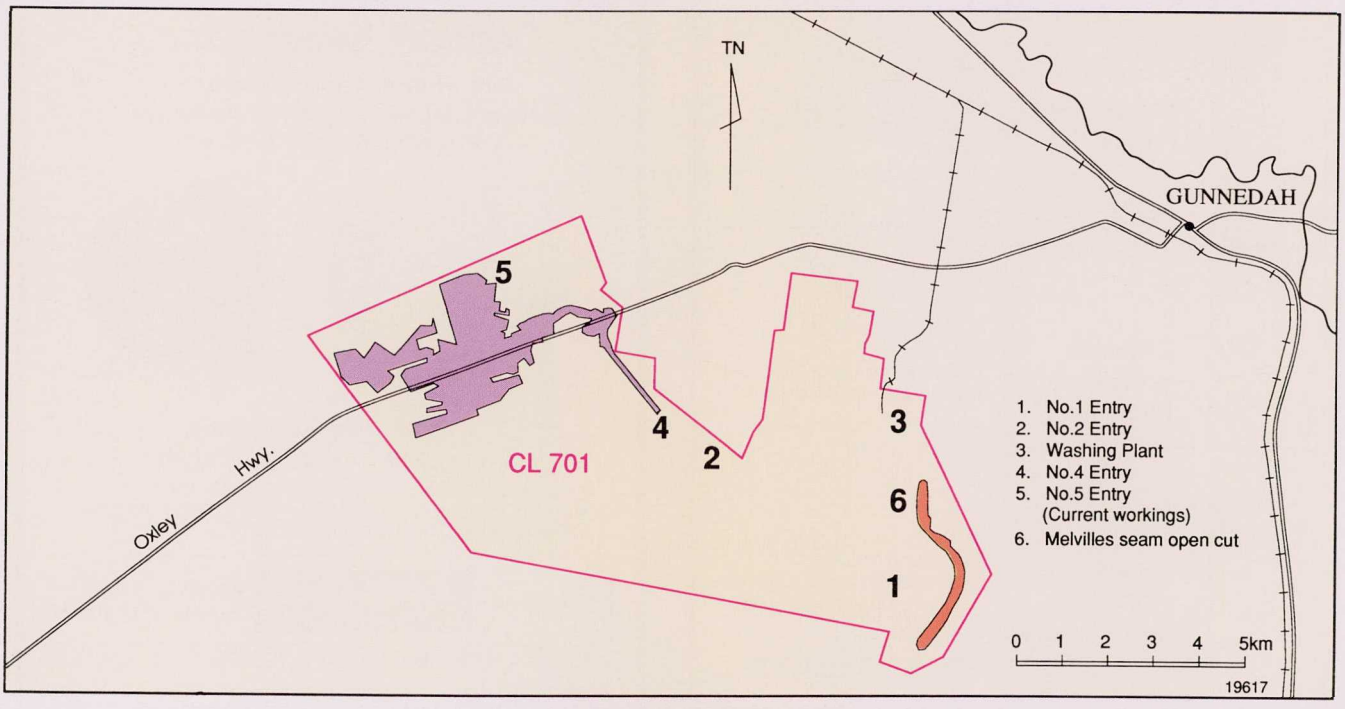


Figure 5. Gunnedah coal mine

* Article supplied by the Gunnedah Coal Co. Ltd

mine is now producing at an annual rate of 534 000 tonnes ROM resulting dominantly from pillar extraction. Coal is now produced from the No. 5 Entry (figure 5). It is delivered from the mine using a drift conveyor and then trucked to the preparation plant for washing, mainly in heavy medium cyclones and froth flotation cells.

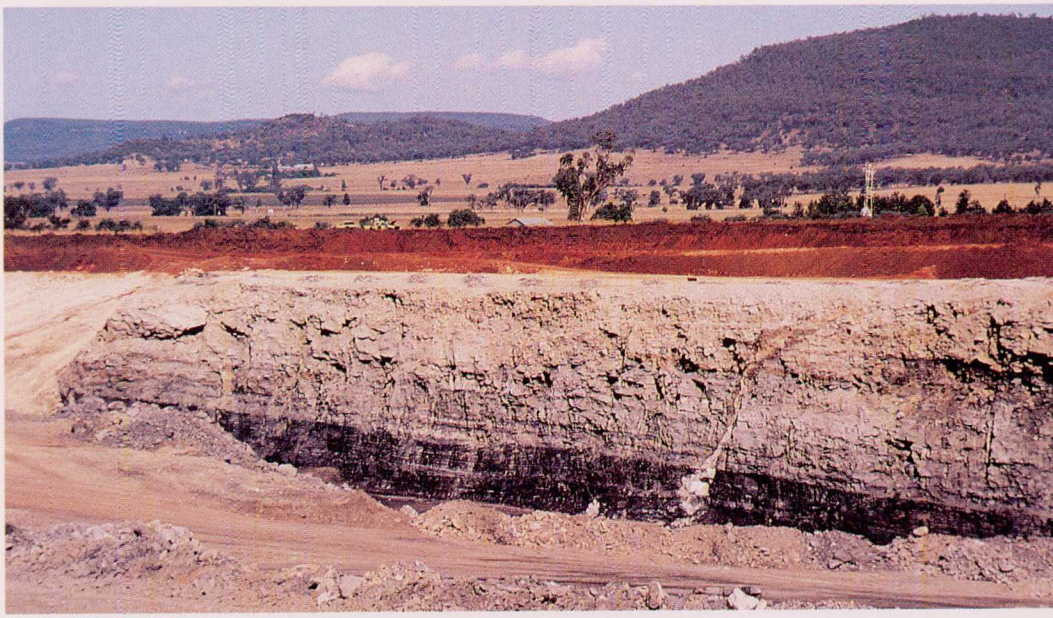
A small open cut was commenced in 1986, mining the Melville seam (figure 5), and is operating at 40 000 tonnes/month. At this level of production, the mining of the open cut resource will be completed in 1995/96.

Washed coal is trucked to the company's storage yard alongside the main railway line to Newcastle. Unit trains are loaded from the company's rail-loading bin, which is over a rail loop siding, and then the coal travels 320 km to the coal export loading facilities at the Port Waratah or Kooragang Coal Terminals at the Port of Newcastle.

The coal blends from the Hoskissons and Melvilles seams are sold to the Japanese steel mills and utilities as semi-soft coking coal, PCI (pulverised coal injection) coal or thermal coal.

The Gunnedah mine has been a major contributor to the region, with salaries and wages exceeding $10,000,000 per annum and other expenditure within the area greater than $7,000,000 per annum.

For further information contact Ralph Foster, Managing Director Gunnedah Coal Co. Ltd, on (02) 233 7855, Fax (02)233 1618.

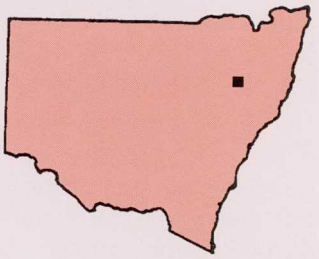


Before, during and after an overburden blast in the Melvilles seam open cut at the Gunnedah mine.
A dyke can be seen in the wall of the open cut.
View looking southerly; Preston mine in distance

Photos by David Barnes

FEATURE

PRESTON COAL MINE*



At the Preston coal mine an underground operation in the Hoskissons seam produces a high-energy, low-ash, low-sulphur thermal coal for both local and export customers plus specialised coals for specific applications.

The Preston mine is located at Curlewis, approximately 18 km south-west of Gunnedah (figure 2).

Preston Coal Co. Pty Ltd, a wholly owned subsidiary of Preston Coal Holdings Pty Ltd, owns and operates the mine. This company was formed in 1989 by several of the latter company's current executives and Europa Coal Australia Ltd (ECA). ECA is a subsidiary of Europa Minerals Group plc, a British mining finance house.

HISTORY

The Preston Coal Co. was formed in 1917 to operate the Centenary Colliery which had commenced mining on part of Preston's current lease in 1889 (figure 6). Centenary was renamed Preston Colliery and continued to operate until its closure in 1936. The present Preston mine opened in the northern part of the lease in 1941.

In 1969 the Preston Coal Co. was purchased by R.W. Miller Ltd which subsequently controlled the operation until 1986. In that year Coal and Allied Operations Pty Ltd took over management of R.W. Miller's mining and marketing activities.

On 30 June, 1989, the Preston Coal Co. was sold to Preston Coal Holdings Pty Ltd. This company was formed for the purpose of acquiring the Preston mine and further developing Preston's current and future potential.

MINING ACTIVITIES

The current underground mine is a bord-and-pillar operation in the Hoskissons seam (one of three occurring within the lease). Mining conditions are excellent and the seam is regular and thick, with up to 3.5 m of height being extracted.

The workforce comprises experienced underground miners who are proud of their good safety record and high efficiency. Mining equipment consists of three modern continuous miners supported by a fleet of shuttle cars and a high-capacity conveyor belt system. Rock bolting systems provide roof support during development operations. During pillar extraction, caving control is achieved by utilising three Voest-Alpine Breaker Line Supports. These massive crawler-mounted hydraulic 'chocks' ensure high safety and productivity levels and constitute the latest mining technology.

The mine's production capacity is 500 000 tonnes per annum. However, production has been reduced following retrenchments last year in response to poor export demand and prices.

PRESTON COAL

The coal produced from the mine is of a consistently high quality and provides prime thermal coal for export and local market requirements. This results from the regular structure of the roof and floor of the seam, and the unbanded and 'clean' nature of the coal itself.

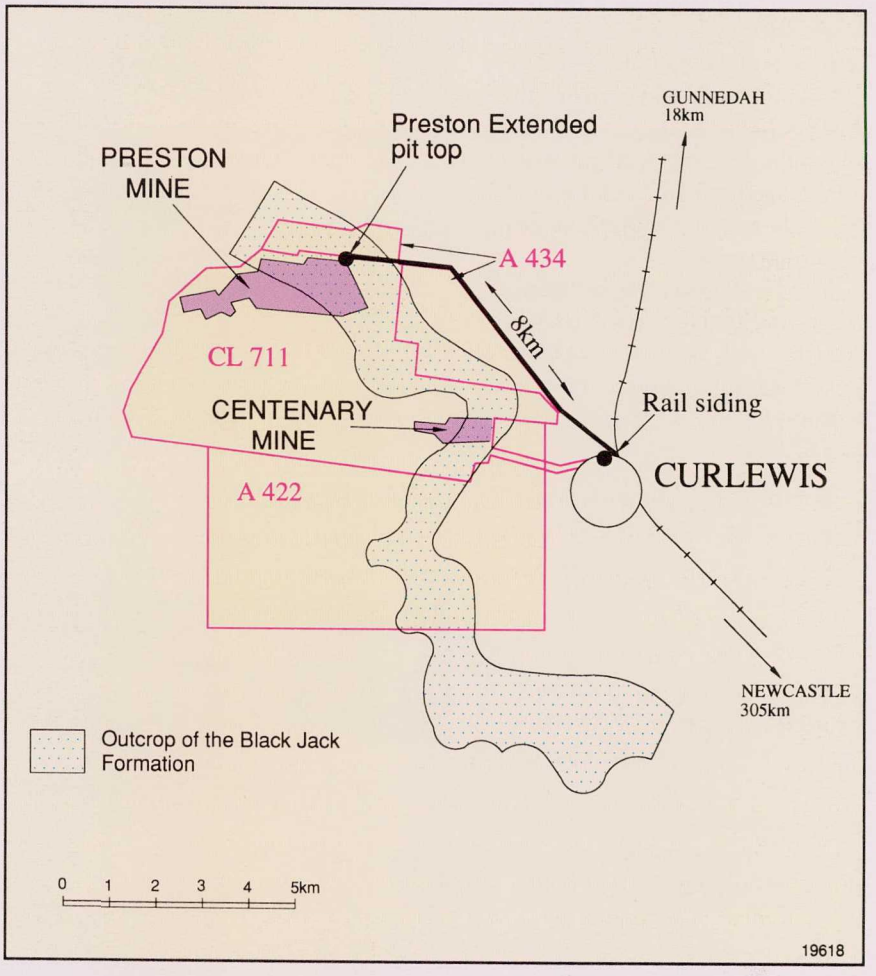


Figure 6. Preston coal mine

* Article supplied by Preston Coal Co. Pty Ltd

All production is carefully crushed and screened in the large and versatile plant on the surface to ensure consistent quality and sizing.

To ensure that there is no metallic contamination, all coal must pass under magnets and metal detectors at least twice before despatch.

Preston coal is a low-ash, low-sulphur, high-energy and high-volatile thermal coal and is used in steam-raising plants and general industrial furnaces and heating applications. It is a very clean coal due to its low sulphur, phosphorus and chlorine content. These properties combine with low nitrous oxide emissions from combustion to minimise erosion/ corrosion effects within plant equipment and to make the coal environmentally 'friendly'.

MARKETS

Export coal is road hauled 8 km to Preston's own rail-loading facility at Curlewis, where it begins a 305 km journey to Newcastle. The coal is carried by the State Rail Authority in 3200 tonne capacity unit trains to the Port of Newcastle

For many years Preston has provided high-quality coal and service to local industrial markets in the North-West and New England regions of New South Wales. Markets span a wide range of plant uses and include hospitals, abattoirs, food processors, textile manufacturers and brickworks.

A range of intermediate coal sizes can be produced in order to specifically meet the needs of the customer's coal stoker firing equipment. Coal-loading and despatch facilities at the mine allow for delivery by road transport or train to customers' plants.

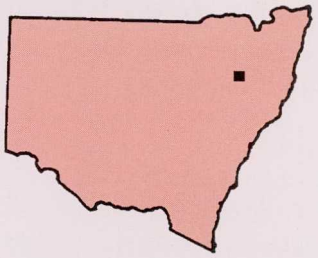
Back-up services provided to customers include experienced and professional advice on all aspects of coal combustion, including initial plant design, commissioning and on-going efficiency monitoring.

FUTURE DEVELOPMENTS

The current coal lease covers an area of 2600 hectares and coal reserves accessible by underground methods are sufficient for many years at current output levels. However, Preston is actively pursuing several new projects on both its current lease and in two adjoining areas (A422 and A434). On the lease and in A434 there is potential for open cut operations and this project is now in the planning stage.

A major extension of Preston's activities is also to be evaluated. Preston holds the Mount Martha Exploration Authorisation (A422) which covers a further 2660 hectares adjoining the mining lease on its southern boundary (figure 6). Following earlier aerial geophysical surveys and a preliminary drilling program, an extensive exploration program has been commenced to prove further reserves of both open cut and underground coal.

BOGGABRI COAL PROJECT*



At the Boggabri Coal Project, a 10 year program has been prepared in order to evaluate and develop a large open cut mine and possible underground mine in seams of the Maules Creek Formation.

The Boggabri lease area is located approximately 15 km north-east of the township of Boggabri (figures 2, 7).

Idemitsu Boggabri Coal Pty Ltd became the sole owner of the Boggabri Coal Project on 13 December 1991 after acquiring the interests of its joint venture partners, The Broken Hill Proprietary Co. Ltd (BHP) and Agipcoal Australia Pty Ltd. Following the acquisition, Muswellbrook Coal Co. Ltd, a wholly owned subsidiary of Idemitsu Kosan Co. Ltd (IKC), was appointed Project Manager. The geological data were handed over in mid February 1992, and a geological model has been produced together with a development program and options.

GEOLOGY

The economic coal seams within the Boggabri lease area belong to the Early Permian Maules Creek Formation. The seams dip gently to the east at 2° to 5°. The sequence contains 21 identifiable coal seams which generally split and thin to the east, with the sediments reaching a thickness of greater than 500 m.

RESOURCES

Total Indicated Resources for the lease area have been assessed at 550 million tonnes (Mt). Approximately 115 Mt have been identified as Mineable In situ Open Cut Reserves (overburden-to-coal ratio approximately 7.5:1), and 70 Mt as Mineable In situ Underground Reserves (depth of cover less than 200 m).

Boggabri coal is a premium-grade energy coal suitable for steam raising, gasification, PCI (pulverised coal injection) coal, formed coke manufacture and coal–oil mixtures. It has a high energy value and low ash (<10%). The coal is also low in sulphur, chlorine, phosphorus and trace elements, and has good ash fusion properties.

PROPOSED DEVELOPMENT

Following the geological evaluation and computer modelling a recommendation was made to IKC that a small trial open cut mine be developed quickly to allow evaluation of the mining conditions and to produce trial shipments for potential customers. It was envisaged that this trial mine would produce approximately 250 000 tonnes per annum for 3 to 5 years.

It was proposed that the **trial mine** be established in the north-west corner of the lease (figure 7), producing coal from the Braymont, Bollol Creek, Jeralong and Merriown seams. Confirmation drilling was undertaken during September 1992 and has provided a clear delineation of the trial mine area.

During November–December 1992 an economic evaluation of the trial mine was undertaken, together with a survey of proposed coal transportation routes. Meetings were held with the Narrabri Shire Council and local land owners to discuss the proposal.

BHP-Utah Coal Ltd carried out loxline drilling during September 1991 in the southern area of the lease. The drilling was to the Merriown seam which is the lowest seam in the sequence to subcrop within the lease. The results from this drilling indicated that the loxline was too deep to enable open cut mining to commence on the subcrop of this seam and possibly too shallow to enable underground mining to be developed as the average cover of overburden to the roof of the seam is 30 m while average seam thickness is 2.5 m.

An economic evaluation of this area indicates that **auger mining** utilising trenches is feasible (figure 7) and results in an equivalent strip ratio of approximately 3.5 to 1. At this stage it appears that this method of mining will commence once approvals are obtained and the coal transportation mode established.

For further information contact David Hicks, Project Manager, Idemitsu Boggabri Coal Pty Ltd, on (065) 43 2799, Fax (065) 42 5010.

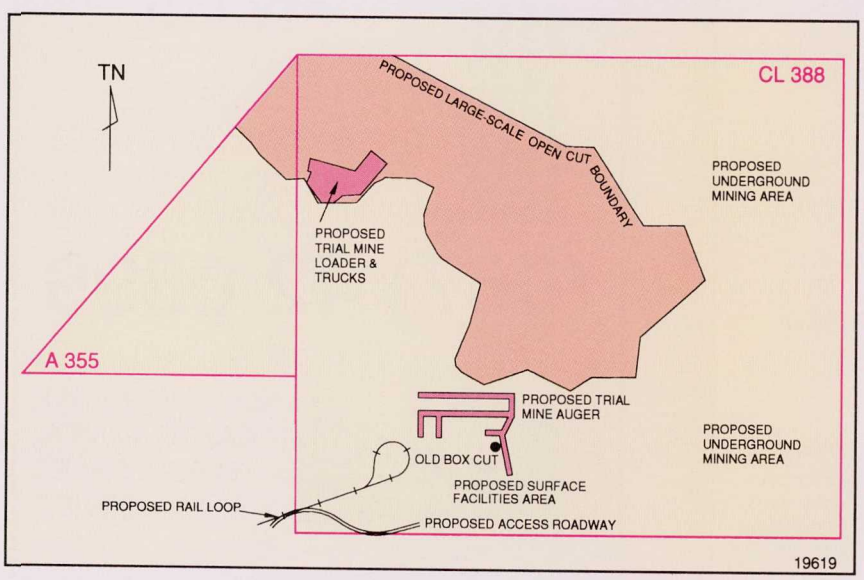


Figure 7. Boggabri Coal Project

* Article supplied by Muswellbrook Coal Co. Ltd

21st CENTURY TECHNOLOGY

COALSCAN RANGE EXTENDED

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MCI's corporate strategy is to remain at the cutting edge of technology. In line with this strategy, **MCI** announces the release of a new generation of **COALSCAN** on-line coal quality analysis systems.

The **COALSCAN Model 9500** is now available; this system incorporates a patented detection technique developed by A.E.R.E. at Harwell in the United Kingdom. This new system is known as the Harwell Spectrometer (H.S.) and confirms the status of each detected nuclear event as being either fully representative of the element which caused the event, or just noise in the energy spectrum. Up to two million counts a second are detected and pre-sorted using this technique.

The advantage of the H.S. system over standard detection methods is that the variation in the precision of the instrument, due to the random nature of nuclear counting statistics in the background noise, is eliminated. This gives a more stable calibration, over a wider range of coal types, than will ever be possible with conventional detection systems.

Figure 1 shows a typical spectrum for conventional, low efficiency, detectors. As can be seen, within the area of spectral interest (points A and B) there is little discrimination between the background countrate (noise) and the characteristic peaks (signal).

Figure 2 illustrates the well defined elemental peaks resulting in a vastly improved signal : noise ratio. Major peaks have been identified on the figure. Other elements are represented by the unnamed peaks.

The improvement in pulse detection discrimination utilising the H.S. system directly results in an improved system precision over conventional detector technology.

This new technology can be applied to most solid bulk materials, including coal, cement, bauxite and mineral concentrates and ores. Typical applications include product monitoring for Quality Assurance, stockpile management, blending and shipment monitoring, as well as process control.

MCI will be most willing to supply further technical information and is exhibiting at the Sixth Australian Coal Preparation Conference and Exhibition in Mackay during early September 1993. We look forward to seeing interested parties there.

CONVENTIONAL DETECTOR SPECTRUM

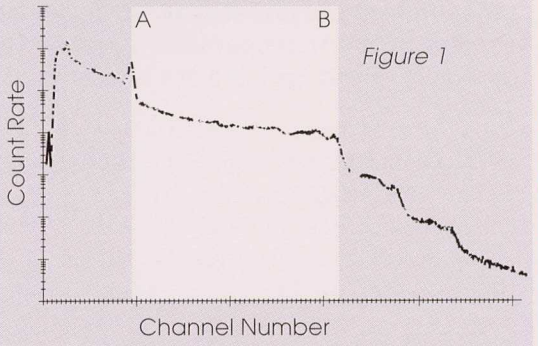


Figure 1

HARWELL SPECTROMETER SPECTRUM

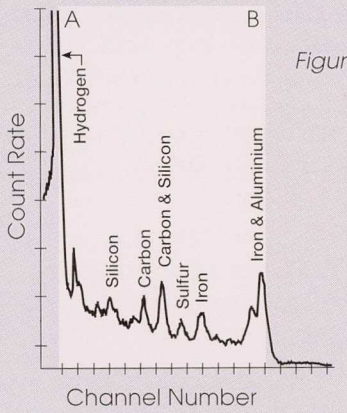
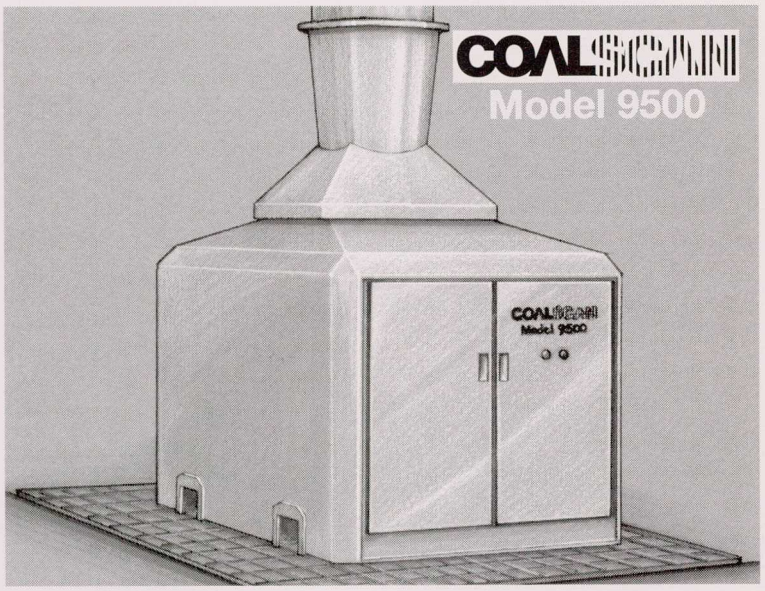


Figure 2



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Facsimile (07) 378 5898

USA
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Suite 300 Charleston WV 25303
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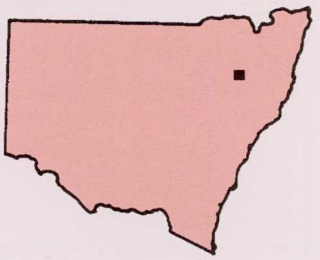
VICKERY COAL MINE AND MAULES CREEK COAL PROJECT*



The Vickery coal mine produces a low-ash thermal coal from two open cuts; underground reserves are also present. At the Maules Creek Coal Project an open cut operation is planned and underground resources are available. Both projects are in seams of the Maules Creek Formation.

CRA Ltd subsidiaries have been active in the Gunnedah Basin since the late 1970s. Novacoal Australia Pty Ltd currently manages the Vickery coal operation and the Maules Creek Project (figure 2) for CRA Ltd.

VICKERY MINE

In August 1990 the CRA Board gave approval for the commencement of open cut operations on the Vickery site (figure 8). The mine was developed at a cost of $60 million. It has a 6 year mine life at 1 million tonnes per annum and is currently operating with 60 people at approximately 700 000 tonnes per annum.

Total Vickery Measured plus Indicated Resources are approximately 310 million tonnes; however, the current open cut operation will only mine 7 million tonnes.

The mine equipment is:

* Marion 7820 Dragline - 28 m^3 bucket
* Komatsu PC 1600 Excavator
* Caterpillar 777 Trucks
* Caterpillar D10 Bulldozers
* Normal support equipment
* 120 tonnes per hour process plant

The mine is producing a low-ash thermal coal mainly from the Gundawarra seam. The coal is achieving good acceptance in Asian utilities and as PCI (pulverised coal injection) coal for steel mills.

Saleable product is trucked 20 km from the mine to the rail head and then a further 320 km by rail to the Port of Newcastle.

The Vickery operation is being used to set the marketing, productivity and rail freight arrangements for Maules Creek. The coal from Maules Creek and Vickery can be sold under the same marketing specifications.

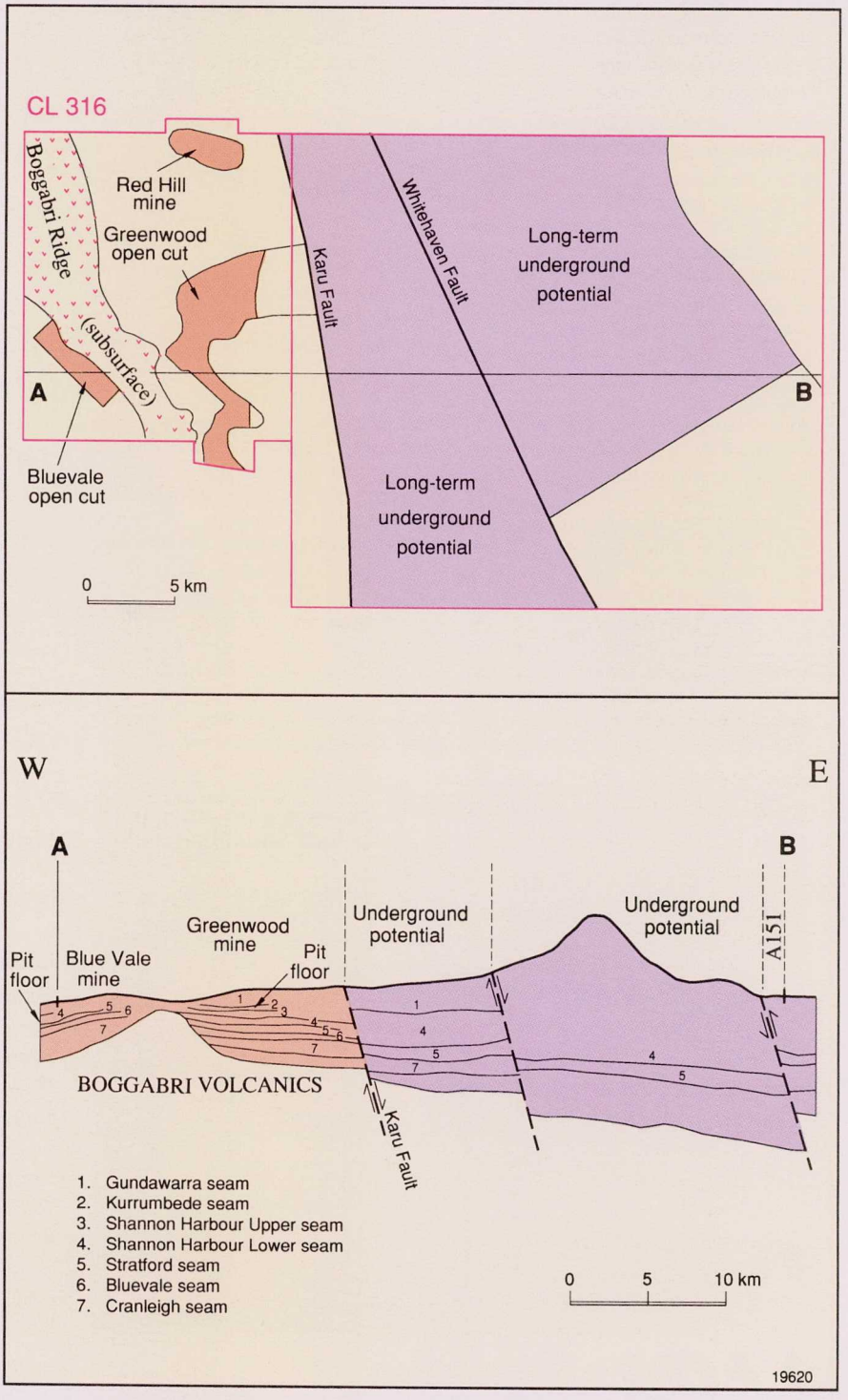
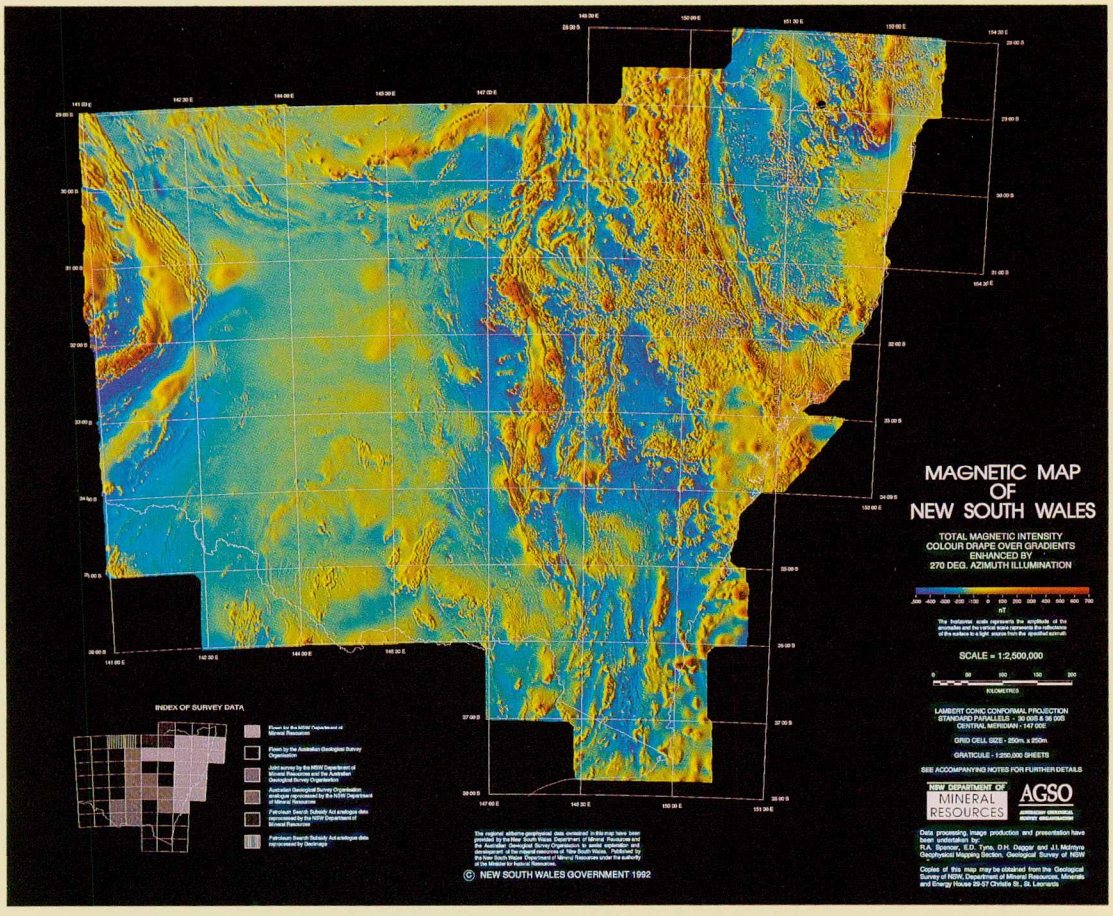


Figure 8. *Vickery coal mine. Lease layout and geological cross section*

* Article supplied by Novacoal Australia Pty Ltd

NEW RELEASE OF GEOPHYSICAL IMAGES FOR NSW

The New South Wales Department of Mineral Resources, in conjunction with the Australian Geological Survey Organisation, is now providing a new view of the State with the release of new map and digital compilations of the magnetics and gravity of New South Wales.



● MAGNETIC MAP OF NEW SOUTH WALES AT 1: 2 500 000 and 1:1 000 000 SCALE

Photographic Image Products

Total Magnetic Intensity Images: Greyscale and Greyscale with sun-angle illumination (only at 1:2 500 000 scale)
Pseudocolour with sun-angle illumination and low-level enhancement

Digital Magnetic Grid for New South Wales

Regional aeromagnetic data have been compiled as a single magnetic grid for New South Wales.
The digital grid uses a grid cell size of 250 m x 250 m and is available as an ERMapper compatible grid file.

● GRAVITY MAP OF NEW SOUTH WALES AT 1: 2 500 000 AND 1:1 000 000 SCALE

Photographic Image Products

Bouguer Gravity Image: Pseudocolour with sun-angle illumination.

Digital Gravity Data for New South Wales

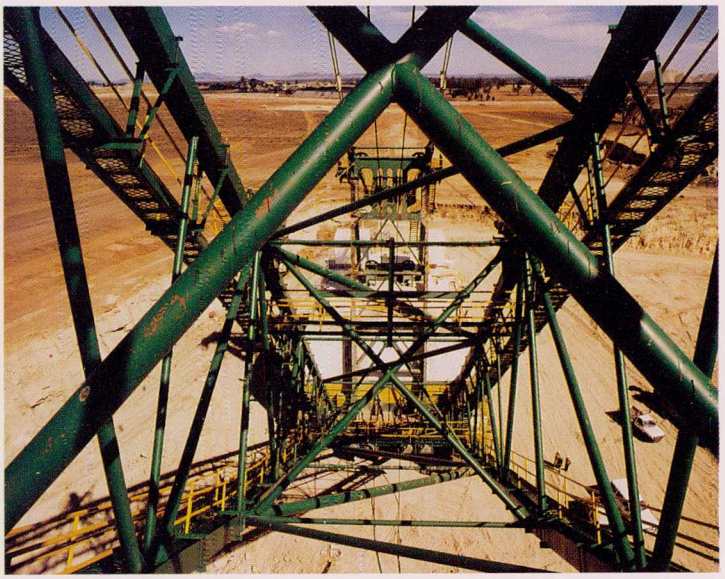
The New South Wales component of the National Gravity Database is available from AGSO.

PRICING:

1:2 500 000 scale image of Magnetic or Gravity Map (530 x 630 mm)	$ 150 plus P/H
1:1 000 000 scale image of Magnetic or Gravity Map (1250 x 1560 mm)	$ 350 plus P/H
Digital Magnetic Grid of New South Wales (in ERMapper format)	$5000 plus P/H

ORDERING INFORMATION FROM:

NSW Department of Mineral Resources, Counter Sales, 29-57 Christie St., St. Leonards, NSW. Ph: (02) 901 8888
Australian Geological Survey Organisation, AGSO Sales Centre, Constitution Ave., Canberra ACT. Ph: (06) 249 9519



View down the boom of Marion 7820 walking dragline working in the Greenwood pit, Vickery mine. View looking south

Vickery open cut shotfirer Bob Sharrock measuring the volume of ANFO (ammonium nitrate fuel oil explosive) being placed in a shothole in the southern end of Greenwood open cut

Photos by David Barnes

MAULES CREEK COAL PROJECT

The Maules Creek Project is 20 km north-west of Vickery (figures 2, 9). Novacoal currently holds a coal lease over the deposit and has completed all final feasibilities. It is likely that Maules Creek could be committed for construction in the next few years depending upon contract acquisition.

The Maules Creek deposit has Measured Resources of 650 million tonnes and Mineable In situ Reserves, both open cut and underground, of 310 million tonnes.

The first development will be an open cut operation which can be incrementally expanded up to 6 million tonnes per annum. The type of equipment necessary for the full operation is two 90 m^3 draglines, two 56 m^3 shovels and a fleet of 218 tonne trucks.

The Maules Creek operation can be expanded further by developing the underground resources by longwall methods.

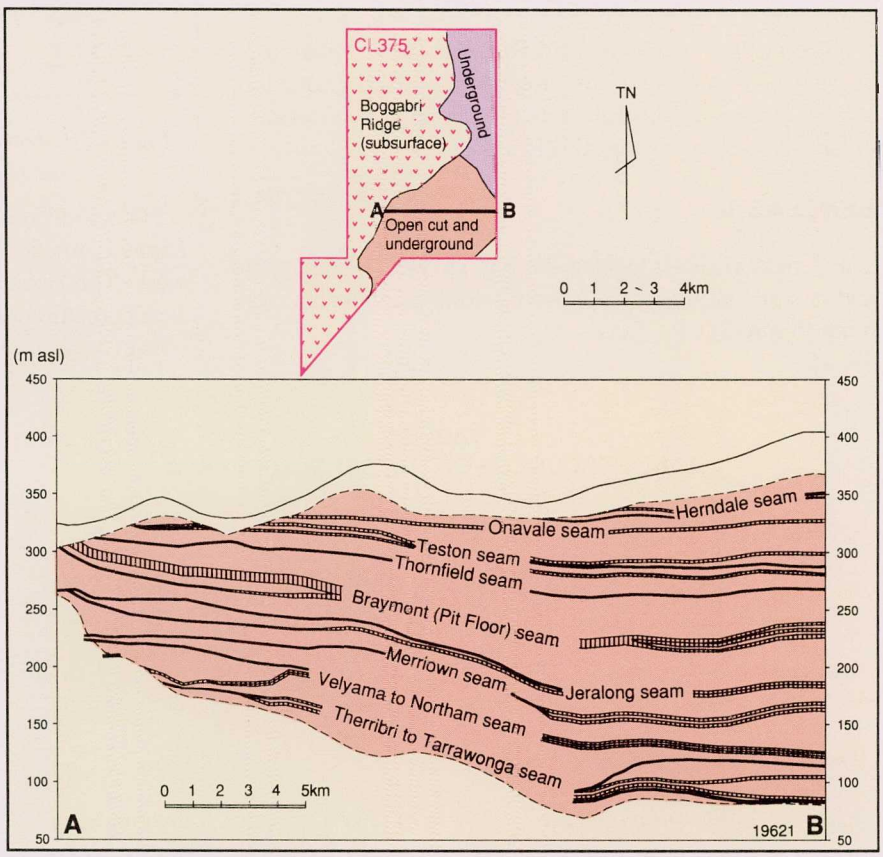
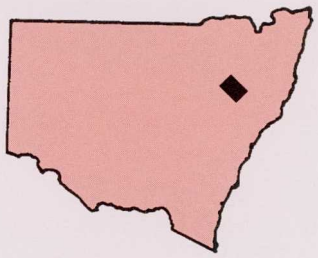


Figure 9. *Maules Creek Coal Project. Lease layout and geological cross section*

SOUTH GUNNEDAH COAL EXPLORATION PROGRAM



Recent departmental exploration to the west and south of Gunnedah has defined the potential for open cut and shallow underground coal resources in the Mill Ridge, Benelabri, Hill 60 and Caroona areas.

Earlier drilling by the Department of Mineral Resources in the 1970s and early 1980s had identified these four areas (figure 2) as targets for shallow coal resources. Twenty-three fully cored boreholes totalling 2285 m of drilling were completed in 1991.

MILL RIDGE

The Mill Ridge area is located 4 km east of Curlewis (figure 2). The ridge has a relief of up to 40 m above the surrounding black soil plains.

Previous drilling identified the Mill Ridge area as containing potential open cut and/or shallow underground coal resources in the Maules Creek Formation. These resources were believed to occur below the Porcupine Formation which crops out extensively at Mill Ridge. The previous exploration suggested that the Maules Creek Formation would be encountered at depths less than 100 m.

The three fully cored boreholes drilled at Mill Ridge (DM Mill Ridge DDH 1 to 3) commenced in the Porcupine Formation and terminated in volcanic basement rock.

The drilling results at Mill Ridge show that the coal-bearing Maules Creek Formation and the Leard Formation are not present at Mill Ridge and the Porcupine Formation onlaps the basement Boggabri Ridge.

BENELABRI

The Benelabri area is located about 15 km west of Gunnedah and is situated immediately north-west of Gunnedah coal mine (figure 2).

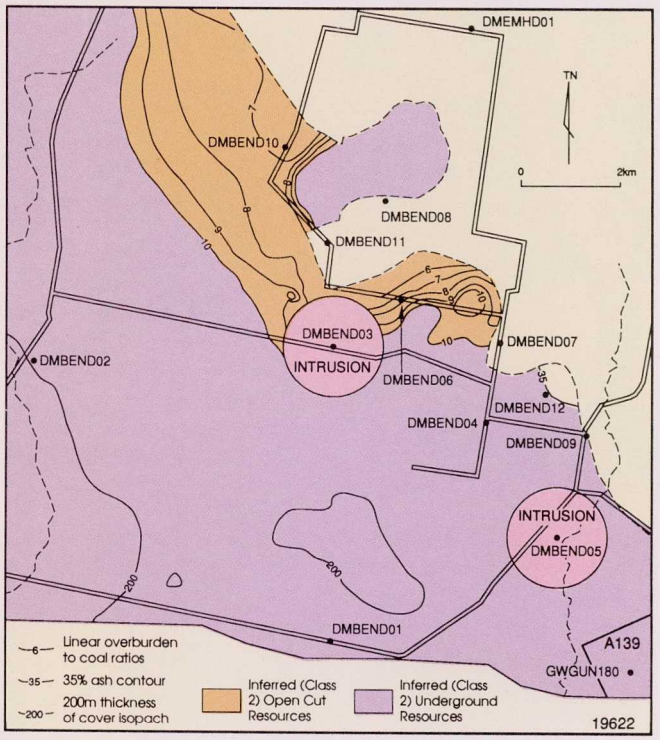


Figure 10. *Open cut and underground coal resources in the Hoskissons seam, Benelabri area*

Outcrop consists predominantly of the conglomeratic Digby Formation which dips at shallow angles to the south-west. This sequence is underlain by the coal-bearing Black Jack Formation which crops out poorly along the slopes of the hills in the area and is obscured by recent alluvial deposits on the surrounding extensive alluvial plains.

Nine fully cored boreholes were drilled to assess the potential open cut coal resources in the Hoskissons and Melvilles seams (DM Benelabri DDH 4 to 12). It was expected that these seams would be intersected at depths less than 100 m.

The Benelabri program identified underground resources in the Hoskissons and Melvilles seams and inferred the presence of an open cut resource in the Hoskissons seam (table 1, figure 10).

Igneous intrusions were intersected in several boreholes in the program and in Department and company exploration boreholes to the south-east and may adversely effect the coal resources in the Benelabri area.

TABLE 1
COAL RESOURCES OF THE BENELABRI AREA

Underground resources (Inferred Class 2)

Seam	Resources	Raw ash	Av. RD	Thick.	Depth to base	Washed (1.6RD) Yield	Ash
Hoskissons	100-500 Mt	25-35%	1.5	2-3 m	<300 m	80%	13-16%
Melvilles	100-500 Mt	20-35%	1.5	1.5-3.0 m	<240 m	80%	15-19%

Open cut resources (Inferred Class 2)

Seam	Resources	Raw ash	Av. RD	Thick.	Depth to base	Linear o/burden : coal ratio range
Hoskissons	100-500 Mt	30-35%	1.6	5.0-7.2 m	<100 m	6:1 to 10:1

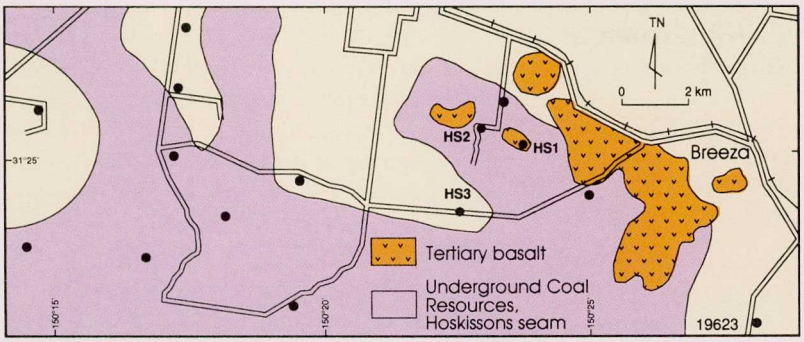


Figure 11. Underground coal resources in the Hoskissons seam, Hill 60 area

TABLE 2
COAL RESOURCES OF THE HILL 60 AREA

Underground resources (Inferred Class 1)

Seam	Resources	Raw ash	Thick.	Depth to base
Hoskissons	430 Mt	25-35%	2-8 m	<250 m
Melvilles	350 Mt	20-35%	2-3.5 m	<200 m

HILL 60

The Hill 60 area is located approximately 6 km west of Breeza and 25 km south of Gunnedah (figure 2).

Black Jack Formation sediments crop out on hills in the area and underlie recent alluvium which forms extensive plains. The Digby Formation crops out to the west of the area. Tertiary basalts occur on Mount Watermark and are widespread in the eastern portion of the Hill 60 area (figure 11).

Three fully cored boreholes were drilled to assess the potential for shallow deposits of coal resources in the Hoskissons and Melvilles seams in the Black Jack Formation (DM Hill 60 DDH 1 to 3). Two boreholes (DDH 2 and 3) intersected up to 105 m of Black Jack Formation; DM Hill 60 DDH 1 interested basalt and was terminated at 50 m.

Only the Melvilles and Hoskissons seams were considered to have sufficient thickness and lateral continuity to have resource potential (table 2).

The extent of Tertiary intrusions in the area exposed at the surface and intersected in boreholes could downgrade the coal resources in the area.

CAROONA

The Caroona area is located approximately 30 km south of Gunnedah (figure 2).

The Black Jack Formation and the Digby Formation crop out in the central to north-western parts of the area (figure 12). The Caroona area is dominated by alluvial plains and is bounded on the east by the Mooki Fault.

Eight fully cored boreholes were drilled to assess the coal resources of the area (DM Doona Point DDH 1, 2; DM Caroona East DDH 1 to 6; figure 12).

The Hoskissons, Caroona, Howes Hill, Breeza, Clift and Springfield seams contain underground and open cut resources; the Melvilles seam has underground resources.

The highest potential for future underground mine development exists in the basal working section of the Hoskissons seam which contains a low-ash, raw coal product suitable for thermal applications (figure 12, tables 3-5).

Open cut resources exist east of the Mooki River (figure 12, table 5). No open cut resources were considered to exist in the Melvilles seam because it has split and deteriorated eastward. Linear overburden to coal ratios are estimated to be

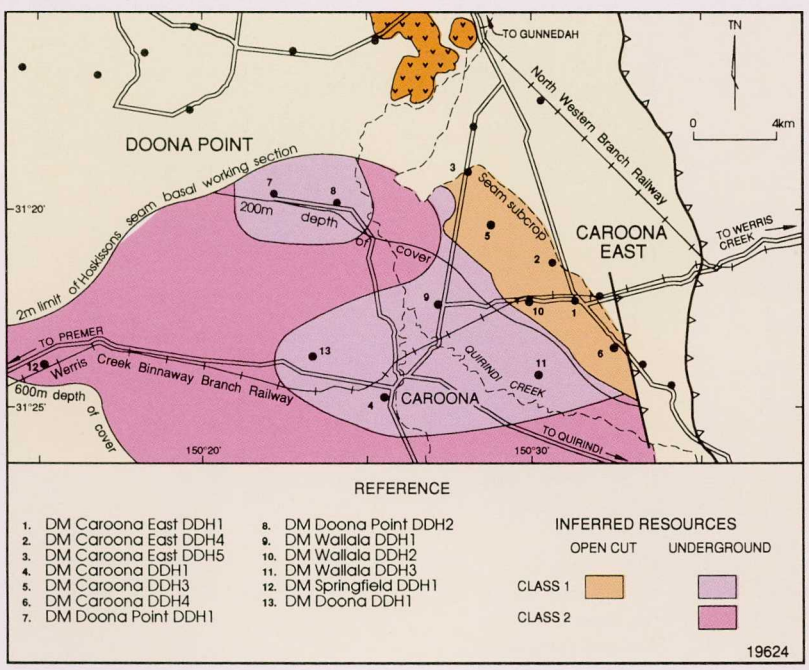


Figure 12. Open cut and underground coal resources in the Hoskissons seam, Caroona area

TABLE 3
RAW COAL QUALITY, BASAL WORKING SECTION OF THE HOSKISSONS SEAM, CAROONA AREA

Borehole name	Depth to floor (m)	Thick. (m)	Ash (ad,%)
DM Caroona DDH 1	392.6	2.85	8.8
DM Caroona DDH 3	105.0	2.75	13.2
DM Caroona DDH 4	136.7	3.68	35.1
DM Caroona East DDH 1	115.2	3.58	10.1
DM Caroona East DDH 4	82.4	3.63	9.4
DM Caroona East DDH 5	60.9	1.58	17.3
DM Doona Point DDH 1	177.6	3.37	17.0
DM Doona Point DDH 2	167.8	4.56	13.6
DM Doona DDH 1	402.0	4.05	13.0
DM Springfield DDH 1	569.0	3.08	18.2
DM Wallala DDH 1, 1A	271.1	2.46	12.7
DM Wallala DDH 2	150.4	3.77	8.8
DM Wallala DDH 3	314.4	3.95	7.8

TABLE 4
WASHED COAL QUALITY, BASAL WORKING SECTION OF THE HOSKISSONS SEAM, CAROONA AREA

Borehole	Depth to floor (m)	Thick. (m)	Float fract.	Yield (%)	Moist. (ad, %)	Ash (ad) (%)	Vol. mat. (ad,) (%)	CSN	Total sulph. (ad)	Spec. energy (MJ/kg) (gad)
DM Caroona	115.2	3.58	CF1.4	69.5	3.4	7.0	34.8	1 1/2	0.35	n.d
East DDH 1			CF1.6	98.4	3.4	9.9	32.0	1 1/2	0.31	28.39
DM Caroona	82.4	3.63	CF1.4	82.6	3.7	7.8	33.4	1	0.33	n.d.
East DDH 4			CF1.6	98.9	3.6	8.9	32.6	1/2	0.32	28.76
DM Caroona	60.9	1.58	CF1.4	31.7	3.7	7.3	35.3	3 1/2	0.48	n.d.
East DDH 5			CF1.6	94.7	3.7	14.7	29.0	1/2	0.32	26.73
DM Doona	177.6	3.37	CF1.4	72.9	3.1	6.9	36.4	1	0.42	n.d.
Point DDH 1			CF1.6	86.8	3.0	8.8	35.2	1	0.40	29.50
DM Doona	167.8	4.56	CF1.4	77.1	3.5	6.7	35.4	1	0.38	n.d.
Point DDH 2			CF1.6	91.0	3.2	8.6	35.2	0	0.36	39.33

6:1 or greater. Washability tests show that at CF 1.60 RD the coal will contain an average ash content of 14-15% at average yields of 75-80%.

An open cut resource of 150 million tonnes at depths less than 100 m and linear overburden to coal ratios generally less than 5:1 is present in the north-east of the area (figure 12). This resource contains raw ash of 15-32% which will wash to a product of 14-15%, with yields of 75- 80% at CF 1.60 RD. The basal 1.6- 3.6 m section of the Hoskissons seam will produce a raw coal thermal product with an ash content of 9-17%.

For further information contact Julie Moloney, Senior Geologist, Singleton Office, on (065) 72 4200, Fax (065) 72 1201.

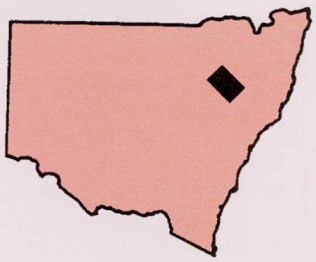
TABLE 5
COAL RESOURCES OF THE CAROONA AREA

	Resources (Mt)	Raw ash (%)	Average thick. (m)
Underground resources (Inferred Class 1)			
A. Shallow resources (<200 m depth of cover)			
Springfield seam	55	25-31*	2.5
Clift seam	5	25-32*	2.0
Breeza seam	20	25-30*	2.0
Howes Hill seam	50	15-20	2.0-3.6
Caroona seam	34	17-28	2.0-3.3
Hoskissons seam basal working section	105	8-18	2.0-5.0
Melvilles seam	180	24-26	2.2
Lower Melvilles seam	30	22-35	2.0-2.7
B. Deep resources (200 - 600 m depth of cover)			
Springfield seam	0	-	-
Clift seam	245	13-28	2.0-4.6
Breeza seam	0	-	-
Howes Hill seam	15	15-23	2.0
Caroona seam	210	17-28*	2.4-3.0
Hoskissons seam basal working section	490	7-17	2.0-4.0
Melvilles seam	0	-	-
Lower Melvilles seam	55	30-35*	2.0-2.7
Underground resources (Inferred Class 2)			
A. Shallow resources (<200 m depth of cover)			
Springfield seam	10-100	25-31*	2.5
Clift seam	10-100	25-30*	2.0-4.6
Breeza seam	0	-	-
Howes Hill seam	1-10	15-20*	2.0-3.6
Caroona seam	0	-	-
Hoskissons seam basal working section	10-100	25-35	3.0-4.0
Melvilles seam	0	-	-
Lower Melvilles seam	0	-	-
B. Deep resources (200 - 600 m depth of cover)			
Springfield seam	10-100	25-30	2.5
Clift seam	100-500	13-30	2.0-4.6
Breeza seam	100-500	25-35*	2.0
Howes Hill seam	0	-	-
Caroona seam	100-500	20-28	2.0-3.3
Hoskissons seam basal working section	100-500	15-18	3.0-4.0
Melvilles seam	500-1000	25-29	2.0-3.0
Lower Melvilles seam	10-100	25-30*	2.0-2.7
Open cut resources (Inferred Class 1)			
A. <5:1 linear overburden to coal ratio			
Springfield seam	0	-	-
Clift seam	0	-	-
Breeza seam	5	20-25	1-2
Howes Hill seam	25	15-23	2.2-3
Caroona seam	40	20-22	2-3
Hoskissons seam	160	10-35	9-11
B. 5:1 to 10:1 linear overburden to coal ratios			
Springfield seam	5	>30	2
Clift seam	30	17-28	1-1.8
Breeza seam	35	25-30	2-3.8
Howes Hill seam	90	15-22	3-3.5
Caroona seam	45	19-22	2-3
Hoskissons seam	400	8-35	11-16

* Inferred quality

FEATURE

COAL RESOURCE DEVELOPMENT POTENTIAL, GUNNEDAH COALFIELD



In order to assist in regional planning, the coal resource development potential of the Gunnedah Coalfield has been defined on the Gunnedah Coalfield Coal Development Potential Plan.

Exploration by the Department of Mineral Resources during the past 20 years (table 6) has shown that open cut coal resources in the Gunnedah Coalfield are limited but that large underground resources exist in the north and south of the coalfield.

In order to prepare the Plan (figure 13) a review of all borehole data and geological reports was undertaken. Major reference reports are listed in table 7 (note that the results of earlier drilling programs are incorporated in later reports).

RESOURCE CATEGORIES

The plan shows open cut and underground coal resource development potential within a framework of likely timing:

* **Short term** — Exploration of the deposit is at an advanced stage and a conceptual mine plan has been developed.
* **Medium term** — Exploration of the deposit indicates a coal resource with potential development constrained by infrastructure and/or market conditions.
* **Long term** — Exploration of the deposit indicates a coal resource less attractive than in other areas due to constraints such as lower quality, depth or distance, OR initial exploration has indicated coal resource potential but further exploration is required to prove the deposit.

Categorisation of the deposits into a time frame is subjective and likely to vary with changes to market conditions; some medium-term developments may occur faster than anticipated and some projects may not proceed at the anticipated rate.

RESOURCE DELINEATION

* **Open cut coal resources** are delineated where coal occurs between the surface and 200 m of cover and with linear overburden to coal ratios of less than 10:1; coal seams have less than 35% raw ash and a minimum seam thickness of 0.3-0.5 m.
* **Underground coal resources** are delineated where coal occurs between the surface and 600 m and where the shallower coal has an overburden ratio greater than 10:1; coal seams have a potential minimum working section thickness of 1.5 m with a raw ash value of less than 35%.

Coal resource development potential has been discounted in areas

* of identified major structural disturbance,
* with significant intrusions and coal cindering, and
* where lack of data precludes development assessment.

For information on the development potential of specific areas contact Julie Moloney, Senior Geologist, Singleton Office, on (065) 72 4200, Fax (065) 72 1201.

TABLE 6
DEPARTMENTAL DRILLING IN THE GUNNEDAH BASIN 1974-1991

Year	No. of holes	Total length (m)	Area
1974	4	1 570	Narrabri–Weetaliba
1974	2	355	Maules Creek
1975	1	170	Narrabri
1975	1	402	North-east of Coonabarabran
1976	6	1 700	Maules Creek
1976	5	1 970	Gunnedah
1977	3	1 265	Caroona
1981	4	436	Boggabri town drilling
1981-82	67	29 281	Gunnedah regional program
1982	12	2 960	Breeza
1984-85	41	8 576	Narrabri (with the Electricity Commission of NSW)
1991	23	2 285	South Gunnedah

TABLE 7
MAJOR REFERENCE REPORTS, DEPARTMENTAL DRILLING IN THE GUNNEDAH BASIN

Topic	Report
Caroona area, geology and coal resources	CGB1992-033
Benelabri area, geology and coal resources	CGB1992-035
Mill Ridge area, geology and coal resources	CGB1992-031
Caroona–Breeza area, alluvial deposits	CGB1992-034
Hill 60 area, geology and coal resources	CGB1992-032
Breeza area, preliminary assessment	CGB1983-056
Narrabri area, coal resources	CGB1987-002
Boggabri–Maules Creek, basic data report	GS1978/252

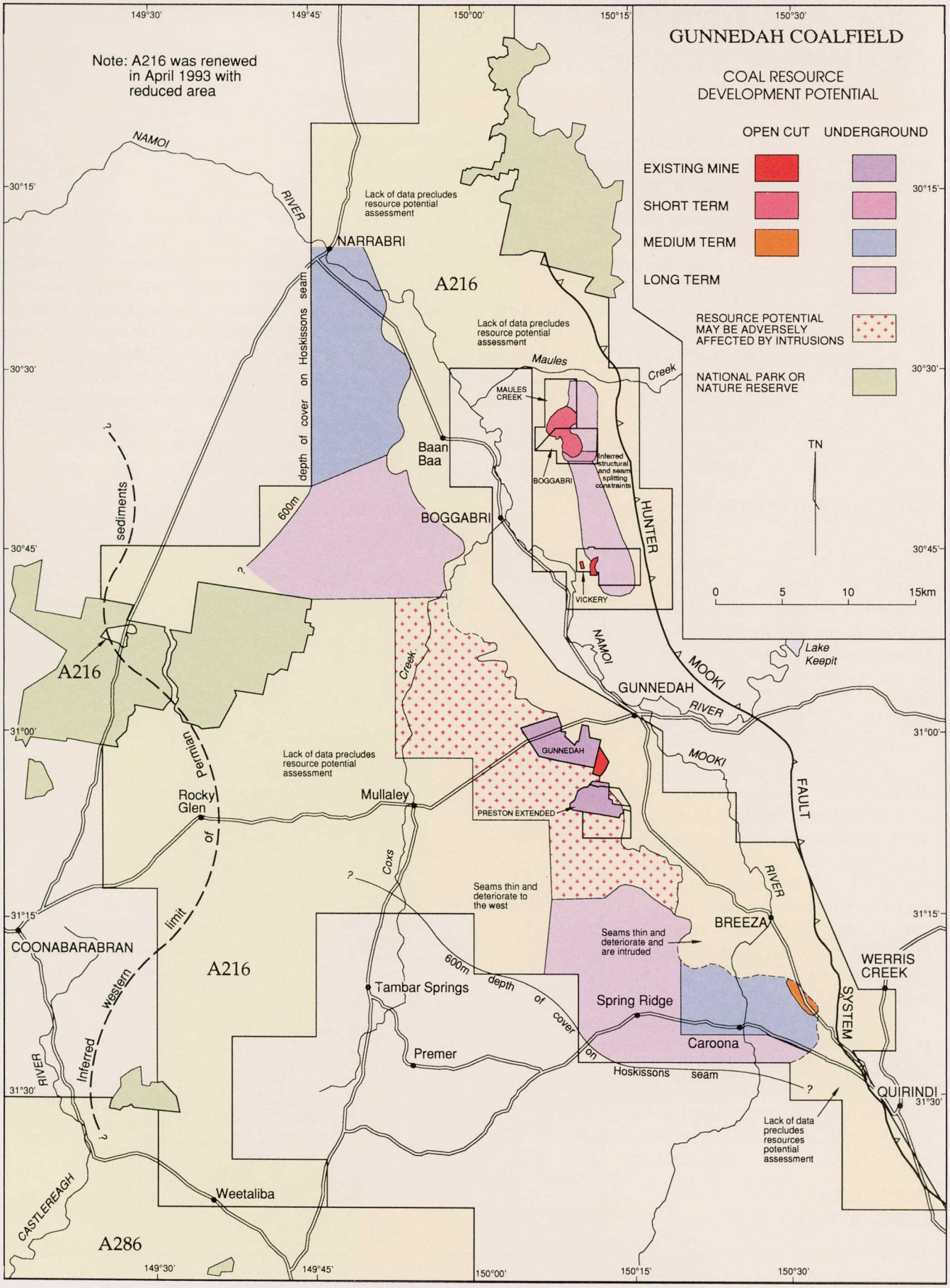
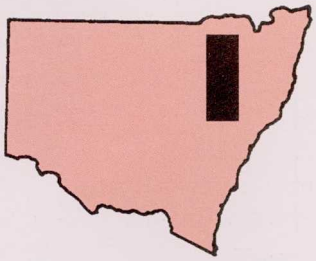


Figure 13. *Gunnedah Coalfield Coal Development Potential Plan*

FEATURE

COALBED METHANE IN THE GUNNEDAH BASIN*



The coalbed methane potential of the eastern Gunnedah Basin and the Murrurundi Trough is about to be tested, with the Black Jack Formation to be the primary exploration target.

Petroleum Exploration Licence 1 (1991 Act), located in the eastern part of the Gunnedah Basin (figure 14), is to be evaluated by Australian Coalbed Methane Pty Ltd (ACM) in joint venture with Pacific Power. Under a proposed agreement, Pacific Power will have a 20% participating interest, with ACM as project manager retaining 80% equity.

ACM is a wholly owned subsidiary of Carbon Minerals N.L. The public flotation of Carbon in 1980 was sponsored by Magnum Resources Ltd, the company which discovered and developed the Vickery coal deposit (later acquired by the CRA group) north-east of Gunnedah. ACM thus has historical links with hydrocarbon exploration in the Gunnedah Basin.

EXPLORATION MOTIVATION

While stand-alone coalbed methane (CBM) production (as opposed to drainage for coal mining safety purposes) has yet to be viably demonstrated on any significant scale outside the United States, motivation for its pursuit in eastern Australia, and most particularly in New South Wales, is high, and is very much in the national interest. As the only mainland state without indigenous petroleum resources, and faced with the prediction that New South Wales will need additional gas perhaps as early as 1998 (but certainly no later than 2001 after which date the existing contract provides for declining deliveries), all exploration avenues must be vigorously pursued. This need is heightened by the clear need to contain 'greenhouse' gas emissions from sources such as coal-fired power generation.

These factors led ACB, after a period of background research, to seek active participation in CBM exploration in this State, firstly with the acquisition of PEL 286 (granted in May 1992 and adjoining to the south of PEL 1), then with application for the Gunnedah tenement.

GEOLOGICAL CONSIDERATIONS

Although technically contiguous with the Sydney Basin proper, the Gunnedah Basin shows some notable differences in both its depositional and post-depositional history. These differences, in combination with its effectively untested potential for CBM, make the Gunnedah Basin a significant, albeit 'grass-roots', exploration target. The basin contains areas of vast individual and aggregate coal thicknesses, and there is thus no shortage of methane 'source rocks'. On the basis of both geophysical and drill hole data, the Gunnedah Basin has undoubtedly been subject to a high level of intrusive igneous activity within the Permian sequence. Where seams are directly intruded, the effect on CBM potential will in most cases be deleterious; however, subsurface data suggest the

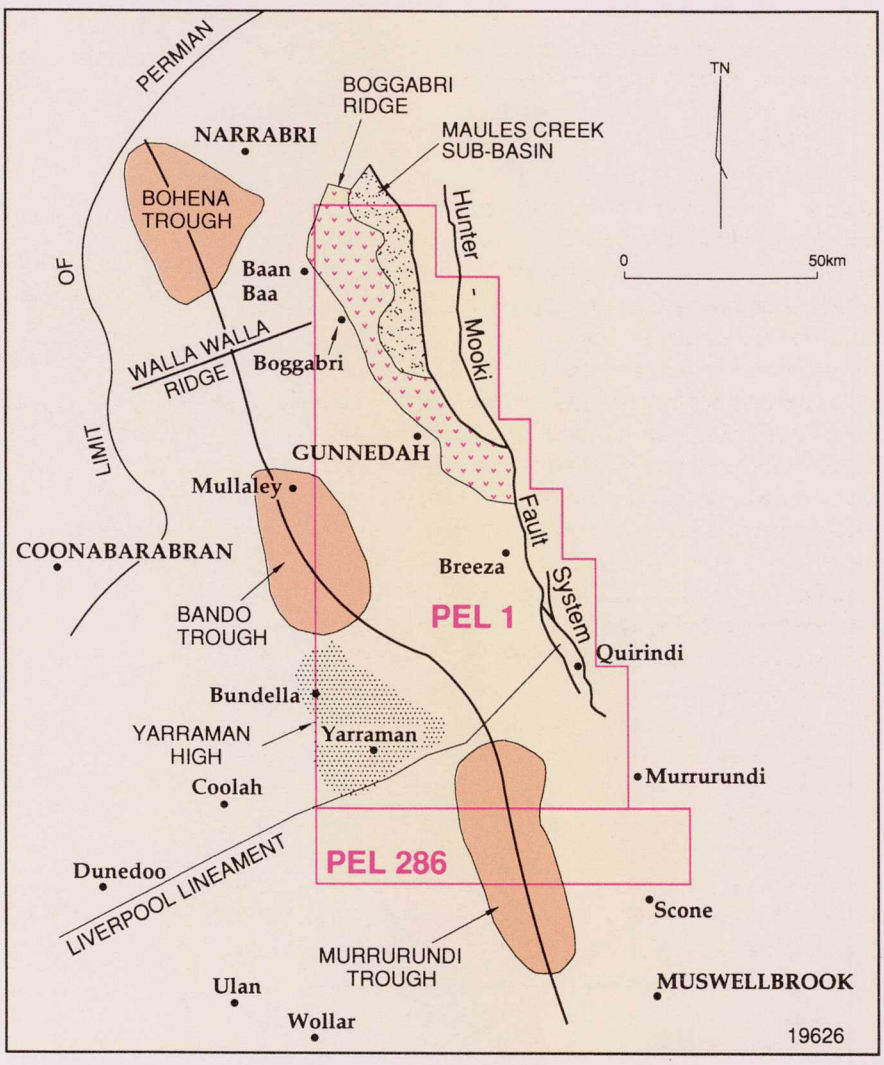


Figure 14. Location of PELs 1 and 286 in the Gunnedah Basin

* Article supplied by Earth Resources Australia Pty Ltd

development of purely 'interseam' intrusives in the Gunnedah Basin to be more common than for the Sydney Basin proper, where coal seams are by far the favoured loci for intrusions. In such circumstances where seams are not directly intruded, the potential for modest, more regional and thus more predictable coal rank increase on adjacent seams may be enhanced, in turn increasing potential for CBM.

There is also evidence that interseam clastic sequences of the Gunnedah Basin, unlike the almost ubiquitously 'tight' clastics of the Sydney Basin coal measures, may in places offer excellent reservoir potential both for methane of coal seam origin, and for hydrocarbons from other source rocks, particularly in the Black Jack and Watermark Formations. The suggestion that the high liptinite content of the Hoskissons seam may additionally constitute a 'conventional' petroleum source provides an interesting 'double play' in this context.

Other aspects which will be assessed by ACM will be the potential for increased coal rank, accompanied by induced fracture porosity and the possibility for repetition of coal sequences, in the vicinity of the Hunter–Mooki Fault System which flanks the eastern margin of the tenement. Demonstrable rank increases, (from regional R_o around 0.7 to greater that 1.0) have been recorded elsewhere in seams in the structural imbrication zone adjacent to and beneath the Hunter Fault. Interpreted linear features elsewhere in the basin also offer fracture potential.

ACM plans to commence an initial CBM assessment well in the first year of tenure of PEL 1, and although final decisions regarding the siting of this first hole must await final processing of the existing data, it is probable that it will target the Black Jack Formation in the southern part of the tenement, where structure contour and isopach data show that the Black Jack Formation (and particularly the Hoskissons seam) attains its maximum development at depths regarded as optimal for methane development, and additionally is an area of previously recorded (but inadequately assessed) gas flows. In the extreme south of the area, and extending to the south of the Liverpool Range (Liverpool Lineament) there is a total lack of subsurface data; however, it would appear, based on trends from the south coupled with those from the north, that the Bando Trough and the Murrurundi Trough are structurally contiguous features (albeit offset by the Yarraman High and the Liverpool Lineament?) with substantial development of the Wittingham Coal Measures/Black Jack Formation sequence predicted beneath the Liverpool Range and within PEL 286.

On the basis of the observed trends, the Black Jack Formation may have a maximum development well in excess of 400 m thick in this region, with concomitant development of aggregate coal thickness, particularly of the Bayswater/Hoskissons seam. There is clearly a very high probability for intrusive igneous activity in the region; however, the principal conduits for the Liverpool Range basalts may well be localised by east-west linear features (?fault/s) in this region.

Work proposed by ACM both in the southern part of PEL 1, and particularly within PEL 286 which is postulated to embrace the maximum development of the Murrurundi Trough, will make an important contribution to the knowledge of this potentially significant but largely unknown region.

Other areas within PEL 1 currently considered to be potentially important for CBM are:

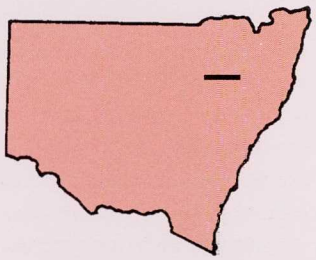
* The Maules Creek Sub-basin in the north-east of the tenement, where there is rapid thickening of the sequence towards (and beneath) the Hunter–Mooki Fault System, accompanied by massive coal development.
* In the vicinity of Mullaley, where the Maules Creek Formation, at depths of around 1000 m, shows local thickening prior to onlapping a local basement high further south.
* Near Breeza where there is a further thickening of the Maules Creek Formation. Although the thickness of cover in this region is somewhat less than optimum, effects of the Hunter–Mooki structure need to be assessed.

INITIAL EXPLORATION PROGRAM

Assessment of existing data will be completed with an emphasis on structural and depositional reinterpretation. Within the first year of tenure, drilling will commence on a 1000 m fully cored and fully tested exploration well. As noted above, this initial well will probably be located in the Murrurundi Trough in the southern part of the area, with final sitting based on the interpretive work.

For further information contact Mal Bunny, Principal Consultant, Earth Resources Australia Pty Ltd, on (02) 436 0747, Fax (02) 437 6294.

GUNNEDAH BASIN DEEP SEISMIC LINE



A deep seismic line across the Gunnedah Basin has provided clear images of the internal structure of the basin and its basement.

As part of the National Geoscience Mapping Accord, a project entitled 'Sedimentary Basins of eastern Australia' is being conducted jointly by the Australian Geological Survey Organisation (AGSO, formerly Bureau of Mineral Resources, BMR), the Geological Survey of Queensland and the New South Wales Department of Mineral Resources (Geological Survey and Coal & Petroleum Geology Branches). Co-operation and support is being provided by the CSIRO, universities and industry.

AIM OF THE PROJECT

The aim of the project is to develop an integrated analysis of the resource-rich Bowen, Gunnedah and Surat Basins by focusing on their sedimentary, structural, tectonic and thermal histories in order to assess their economic potential for hydrocarbon discovery. As part of this project, the then BMR in early 1991 acquired a deep seismic reflection profile across the Gunnedah Basin and into the New England Fold Belt to the east.

The purpose of the line was to assess:

* the relations between the Gunnedah Basin and that part of the Lachlan Fold Belt which crops out along the western margin of the basin;
* the structure of the Gunnedah Basin and its sub-basins, and of basement below the basin;
* the relationship between the eastern margin of the Gunnedah Basin and the New England Fold Belt to the east; and
* the structural relationships in the western part of the New England Fold Belt in order to provide a framework for the interpretation of the evolution of the Gunnedah Basin.

PRELIMINARY RESULTS

Line BMR91.GO1, roughly east–west in trend, runs for 253 km from near the western edge of the Gunnedah Basin, through Boggabri, along the Boggabri–Manilla road to Manilla, and then further east via the Halls Creek and Glenbarra roads (figure 15). Although interpretation of the seismic reflection profile is not yet completed, preliminary results are already to hand and have been published in *AGSO Research Newsletter* **17** (October 1992) and in the proceedings volume of the conference entitled 'New England Orogen, Eastern Australia' held at Armidale in February 1993 (figure 16). The three main features of these preliminary data are:

* The seismic reflection profile has provided a clear image of the internal structure of the Gunnedah Basin, confirming the presence of the Maules Creek Sub-basin to the east and

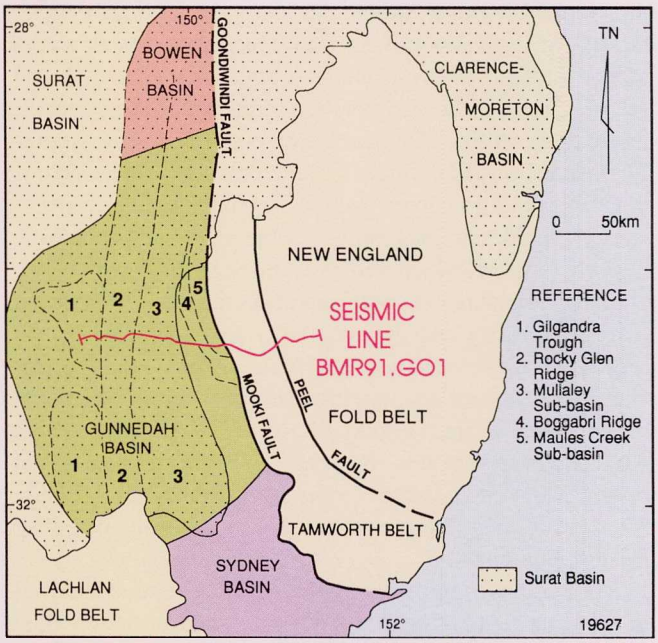


Figure 15. *Locality diagram, Gunnedah Basin deep seismic line*

the Mullaley Sub-basin in the west. Both are shallow basins floored by volcanics and are separated by the intervening Boggabri Ridge. Seismic data across the Gilgandra Trough, west of the Rocky Glen Ridge, shows an extremely thin sedimentary succession in this area.

* In the Late Permian and Triassic, the Devonian to Carboniferous Tamworth Belt in the western part of the New England Fold Belt developed into a foreland fold–thrust belt that was thrust westwards over the 'missing' continental margin arc of the New England Fold Belt and also over the eastern margin of the Gunnedah Basin which developed largely as a foreland basin west of that orogen. Figure 16 shows that the Gunnedah Basin extends some 15 km east of the trace of the Mooki Fault which marks the surface boundary between the Gunnedah Basin and New England Fold Belt. Burial of Permian sedimentary rocks to depths of up to 5 km below the gently (c. 10°) east-dipping Mooki Fault raises interesting possibilities for hydrocarbon prospectivity sites below the overthrust New England Fold Belt.
* Within the New England Fold Belt, the Peel Fault is a major structure separating the external part of the orogen (a foreland fold–thrust belt developed from a forearc basin on the west) from the internal part to the east which consists of multiply deformed and multiply metamorphosed accretionary wedge rocks intruded by granites.

Contrary to most previous ideas, the seismic reflection data suggest that this fundamental contact is west dipping, and that the Peel Fault is an east-dipping high-level splay or back-thrust off a west-dipping thrust. Implications of this interpretation are that rocks of the Lachlan Fold Belt underlie all of the Gunnedah Basin and extend under the New England Fold Belt as far east as the Peel Fault. Evidence for the Lachlan Fold Belt basement is provided by Cambrian to Silurian sedimentary fault slivers along the Peel Fault and Cambrian ages of disrupted ophiolite slivers along the fault.

For further information contact Dr Russell Korsch, Principal Research Scientist at AGSO, phone (06) 249 9495, Fax (06) 249 9972; Dr Richard Glen, Senior Research Scientist, Geological Survey of New South Wales, phone (02) 901 8346, Fax (02) 901 8256; or Jeff Beckett, Principal Geologist, Coal & Petroleum Geology Branch, Singleton, phone (065) 72 4200, Fax (065) 72 1201.

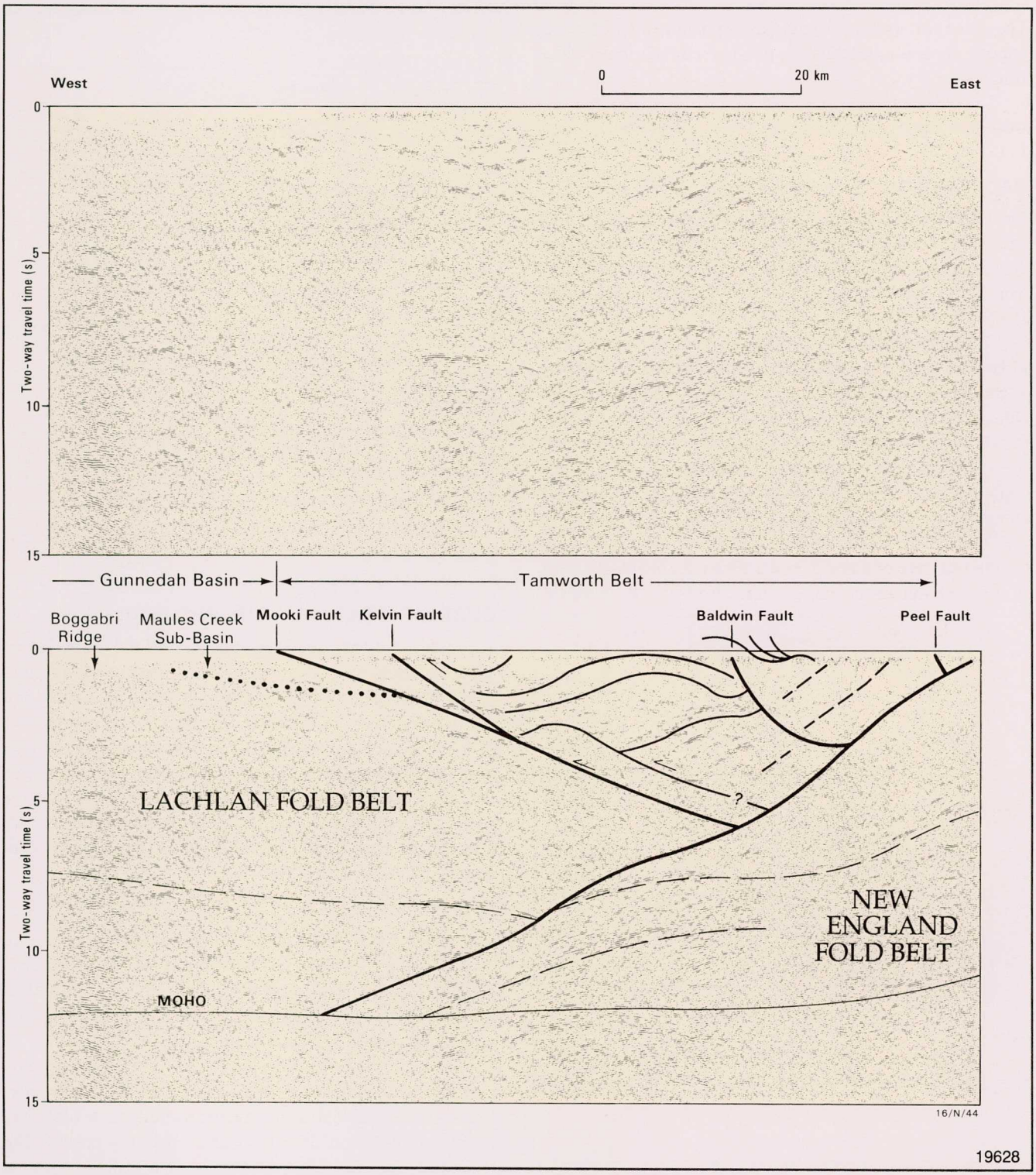
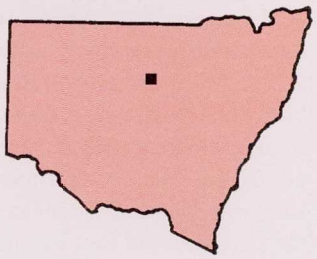


Figure 16. *Portion of the deep seismic reflection survey and preliminary interpretation across the eastern Gunnedah Basin and Tamworth Belt part of line BMR91.GO1*

NEW TECHNOLOGY REVIVES THE GIRILAMBONE MINE*



The Girilambone mine is the first copper mine in New South Wales to use bacterial heap leaching and solvent extraction electrowinning for the processing of its chalcocite copper ore, and will be the world's first stand-alone high-grade chalcocite ore heap leaching operation.

The mine will produce cathode copper metal instead of copper concentrate, thus by-passing conventional metal smelters.

The Girilambone copper deposit is located 44 km north-west of Nyngan in central western New South Wales (figure 17).

BACKGROUND

The Girilambone deposit was discovered in the late 1870s and mining commenced in 1880. Between 1881 and 1910 approximately 80 000 tonnes of copper ore were produced from several shafts on the property. Operations ceased 1917.

The Girilambone copper project is being developed by a joint venture between Straits Resources Pty Ltd, a subsidiary of Straits Engineers Contracting Pty Ltd of Singapore, and Nord Australex Nominees Pty Ltd, a subsidiary of Nord Pacific Ltd of Bermuda. The project will produce an average of 14 000 tonnes of London Metal Exchange (LME) Grade A copper cathodes from an average of 750 000 tonnes of ore per annum over a scheduled mine life of 5.5 years.

Details of the geology, mineralisation and proposed mining techniques were outlined in an earlier article (*Minfo* **33**, p. 6). A cross section through the open cut is shown in figure 18.

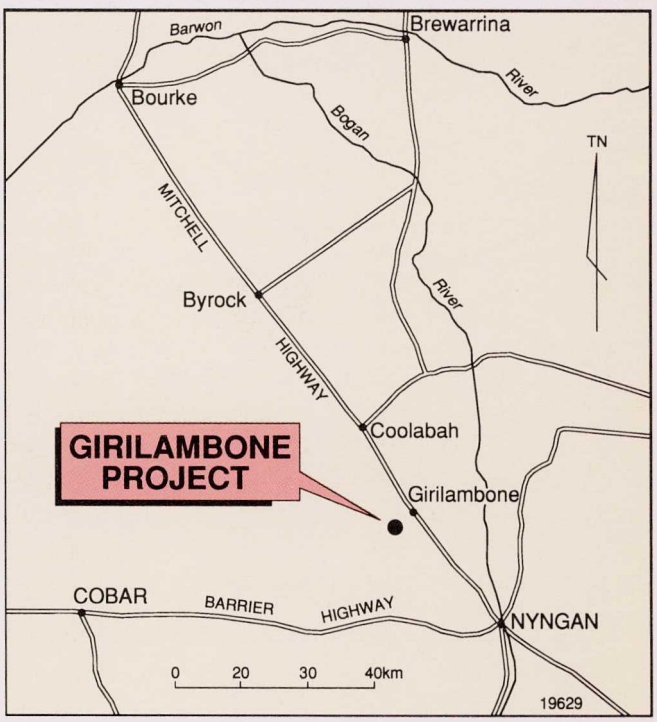


Figure 17. *Locality diagram, Girilambone copper mine*

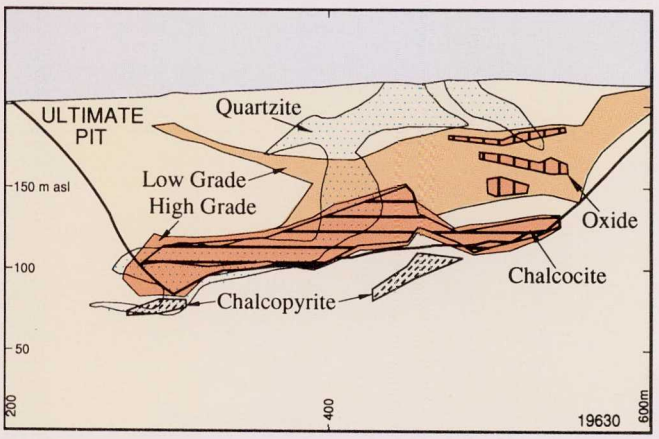


Figure 18. *Cross section through the open cut*

RESERVES

Nord's drilling programs in 1990 and 1991 delineated a Measured and Indicated Resource of 8.7 million tonnes of 1.4% Cu at 0.2% cutoff grade. Current open cut mining reserves (at a 0.5% copper cutoff) are 4.1 million tonnes at 2.2% Cu with an additional 2.5 million tonnes of lower grade material at 0.34% Cu. The overall striping ratio is 2.5 to 1 (waste to ore).

CURRENT STATUS OF THE PROJECT

A mining lease was granted in August 1992, and in September 1992 contracts were awarded for construction and mining. Construction and operations are ahead of schedule, and mining of gold ore, waste rock and copper ore is in progress. The crusher station has been commissioned and the first heap leach pad has been loaded with crushed ore. A pipeline and associated pumping equipment to bring water to the mine site from the Bogan River, some 26 km away, are operational. Practical completion of the processing plant was scheduled for early May 1993.

ORE PROCESSING

The ore is about 30% copper mineralisation amenable to acid leaching and 70% chalcocite ore suitable for bacterial leaching. Further chalcopyrite mineralisation occurs below the base of the open cut but is not amenable to leaching and may be recovered at a later stage.

The processing plant design (figure 19) has focused on minimising capital costs. The project has a relatively short life and the solvent extraction/electrowinning route offers the lowest combination of capital and operating costs. The technology is modern, but at the same time, reliable and time tested.

* Article compiled from information supplied by Nord Australex Nominees Pty Ltd

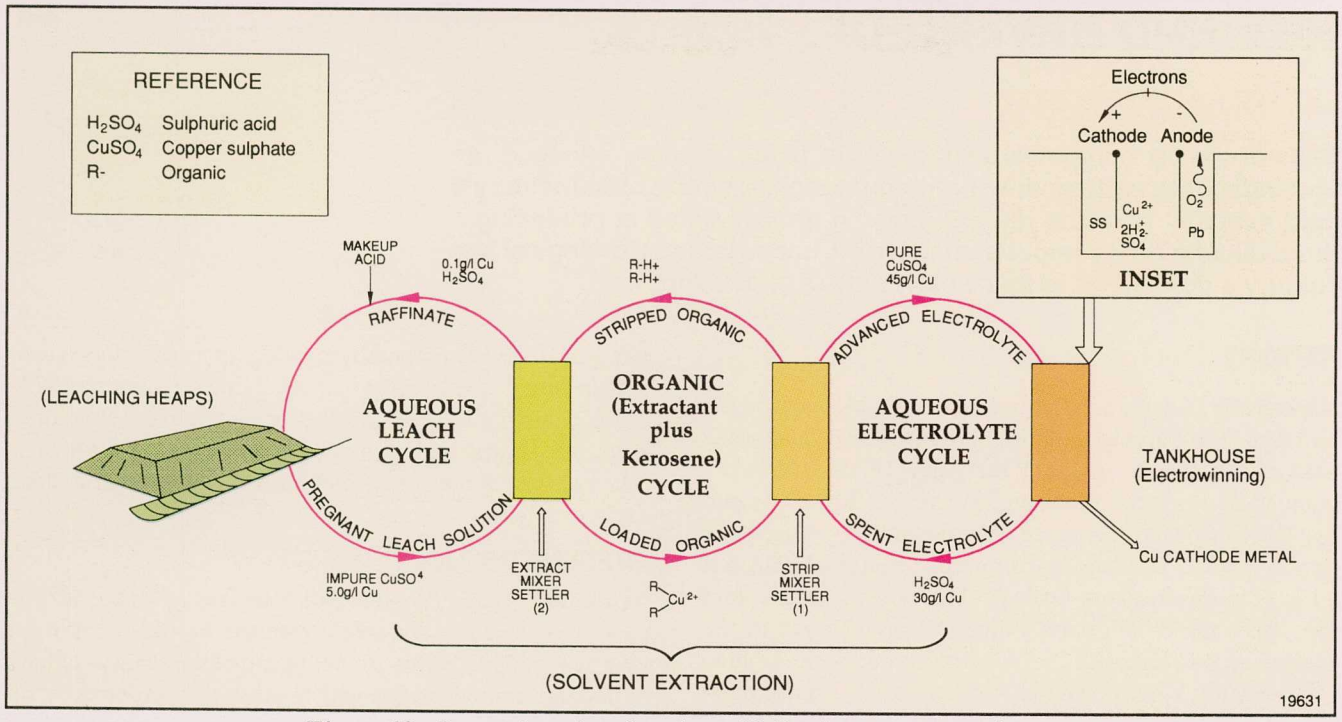


Figure 19. *Processing plant flowsheet, Girilambone copper project*

Ore preparation will consist of crushing to 100% -30 mm, with 80% being crushed to -12 mm, followed by transport of the crushed ore on a conveyor system and stacker for delivery to heaps for leaching on impermeable membrane pads.

In the **aqueous leach cycle,** oxide heaps will be stacked in 5 m lifts. Chalcocite heaps will be placed in 5 m lifts with an air introduction system piped underneath the ore in order to enhance oxygen supply to the leaching reaction.

Leaching solutions are to be distributed over the heaps by drip emitter systems. A weak solution of sulphuric acid will be used for leaching. The leaching solutions will pass through the ore, reacting with acid soluble copper minerals to form copper sulphate solutions ('pregnant' solution) containing copper at an average grade of 4.8 g/L.

Leaching testwork has demonstrated high copper extractions for all ore types except chalcopyrite. Chalcocite (which is also a copper sulphide) is leachable, but it requires a bacterial contribution to provide ferric sulphate for leaching purposes. The bacteria, thiobacillus ferro-oxidans, are naturally occurring and thrive in the presence of oxygen and moisture in an acidic environment. They obtain energy by oxidising iron sulphides to ferric sulphate, which is turn acts as the leachant of copper from the chalcocite in the presence of weak sulphuric acid. The chalcocite leaching duration time is anticipated to be 160 days to achieve an average of 78% recovery (82% in the laboratory). Malachite and other copper oxides simply require weak acid for copper leaching, and leaching times of 80 days are expected in order to achieve an average 83% recovery.

Leaching of the chalcocite will generate excess acid. This excess acid will be used to leach the low-grade oxide reserves, making possible the economic recovery of copper from these reserves and also disposing of excess acid that would otherwise have to be neutralised at added cost.

The copper-rich pregnant solution will be pumped to solvent extraction, where it will be contacted with an **organic** phase comprising a copper-extracting reagent being carried in a high-flashpoint (typically 80°C) kerosene diluent, producing a 'loaded organic' containing copper. The resulting barren solution, referred to as raffinate, is recycled to the heaps to repeat the process of leaching after being re-acidified.

In the **aqueous electrolyte cycle**, loaded organic from the extraction phase will flow to the 'strip section' where it will be contacted counter-currently with high acid content spent electrolyte from the electrowinning section. Kerosene and reagent will separate in this process and be recycled back to the extraction section. Copper will be concentrated into an acidic electrolyte solution containing 45 g/L Cu which will be pumped to the electrowinning tankhouse. This strong electrolyte has now been purified and upgraded, suitable for the production of copper by electrowinning.

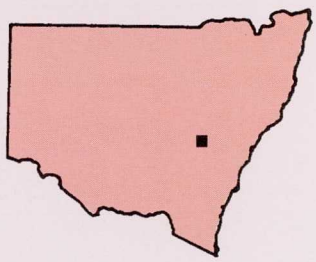
In the **electrowinning tankhouse**, copper will be plated out of solution by low-voltage direct current on to stainless steel sheets to form copper cathodes; depleted solution will recycle to solvent extraction for a repeat of the process. The anodes are made of a lead/calcium/tin alloy. About every 7 days the cathodes will be pulled out of electrolyte solution and the copper cathode physically separated from the stainless steel sheets which will then be returned to the electrolyte solution. Cathode copper is at least 99.99% pure and will meet LME Grade A standards.

MARKETING

Cathodes will be directed at domestic and export markets.

For further information contact Mark Welch, Project Manager, Nord Australex Nominees Pty Ltd, on (02) 565 1655, Fax (02) 565 1308.

HILL END REVISITED*



State-of-the-art computer technology is being used to enhance the understanding, and assist in the interpretation, of details of last century's gold mines at Hawkins Hill, Hill End. A project aimed at producing a three-dimensional computer image of the underground workings of last century's gold mines is in the early stages of development.

HISTORY

Historically, Australia's first reef mining took place on the Hill End–Tambaroora Gold Field (early 1850s) and at the peak of the 'boom' years of the early 1870s Hill End's population was second to that of Sydney's. It could be said that Hill End owes it existence to the reef mining whereas the former town of Tambaroora, primarily an alluvial field, has all but disappeared into history. The world's largest gold specimen, the Holtermann 'Nugget', was brought to the surface at Hawkins Hill in 1872 from within the 'Golden Quarter Mile', a phrase originating from the riches uncovered in a relatively small piece of real estate. The Sydney Stock Exchange has its roots in the boom days of Hill End.

Photographs were taken of the western slopes of Hawkins Hill (and Hill End environs) by a photographer named Beaufoy Merlin during several visits to the Hill End area around 1872. These photographs show the clustering of surface structures atop the shafts and adits together with outbuildings (blacksmiths, whims, etc.) and portray the 'ants nest' like surface activities.

PRESENT PROJECT

At present, visitors to the Hill End site can take in the panoramic scenes and see evidence of old workings. However, many visitors are not aware of the scale or extent of underground workings which led to the permanency of Hill End or its claim to fame. Thus, the current project has as its focus the presentation of computer graphics showing the extent of underground workings so that the visitor can

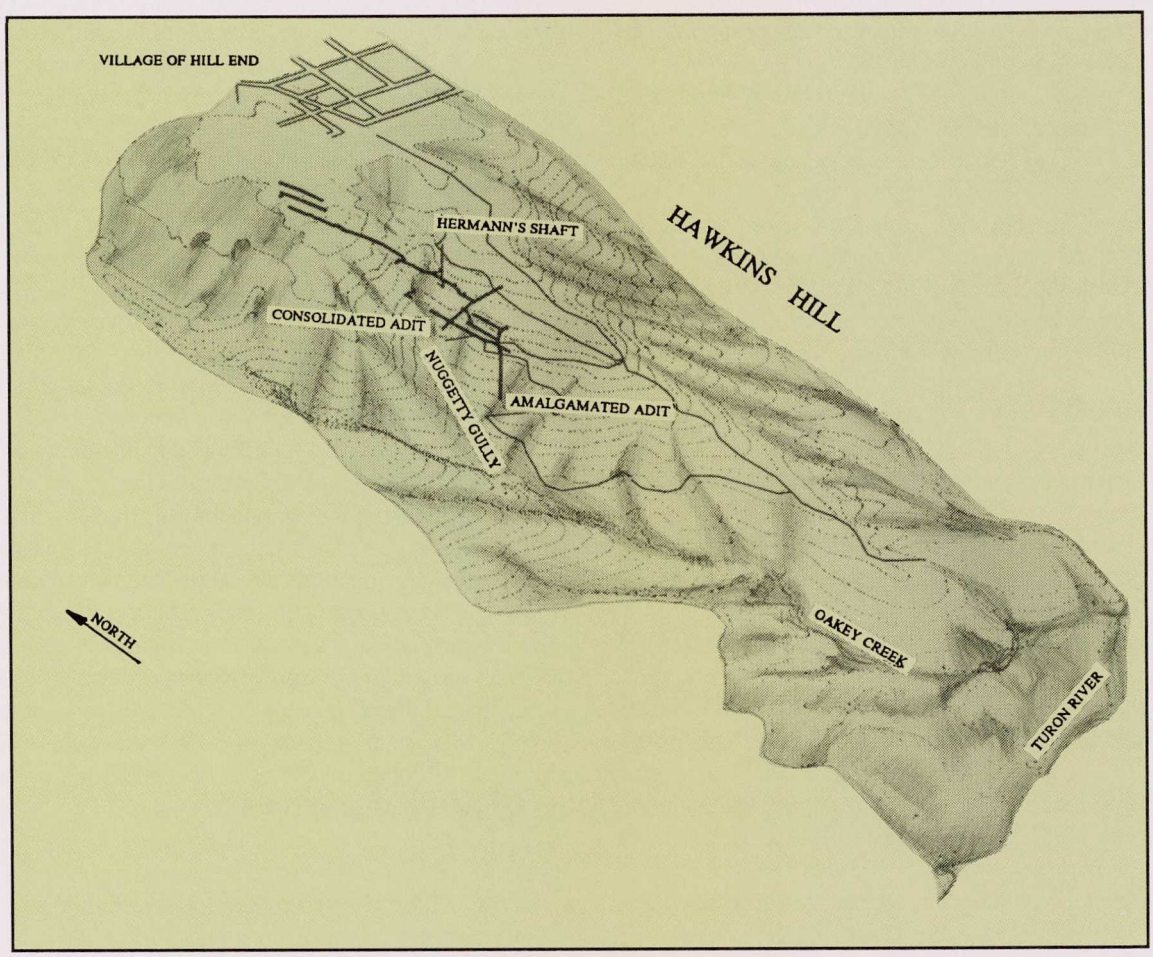
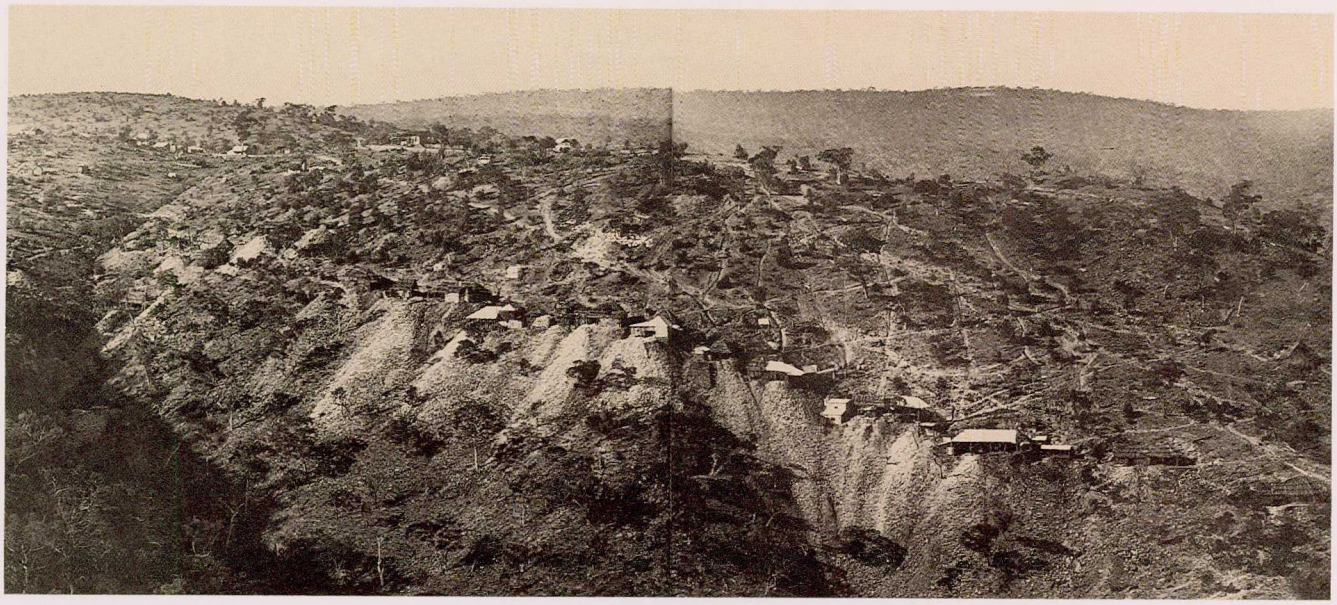


Figure 20. *Preliminary computer graphics showing views of some tunnels within the western slopes of Hawkins Hill*

* Article supplied by the School of Civil Engineering, Sydney Institute of Technology



Surface structures at Hawkins Hill from Merlins Lookout c. 1872

Photo by Beaufoy Merlin

appreciate the scale of workings and contemplate the hardship, toil, industry, isolation, perseverance and mania of the early miners.

Students of the School of Civil Engineering, Sydney Institute of Technology, Ultimo, studying either the Associate Diploma in Civil Engineering or the Associate Diploma in Structural Engineering, can elect to do Computer Graphics and Applications in which instruction is given in the use of computer-aided drafting software. Practical exercises based on historical documents have been set and the experience gained from interpreting these documents and developing a three-dimensional computer model has been highly stimulating and rewarding for those involved in the project. Historical data, including mine survey records, mine managers reports, Annual Reports, photographs and newspaper articles, are being collated in order to allow the production of individual mine details and a composite of all workings on the famed Hawkins Hill.

Available information relating to each claim is being entered into a database. Separate drawing files will be produced for individual mine shafts or tunnels. A composite will then be produced, with all individual files being imported into a master file containing images of the surface of the hill. Using computer-aided drafting techniques, the position of the 'camera' and the 'target' are able to be manipulated to obtain views of any part of the image (hill) from any point in space.

It is intended that the computer graphics be displayed together with Merlin's photographs, mounted so that the visitor will be able to take in the image of both the surface structures and the underground workings. By viewing the composite of photograph and computer image (proposed to be mounted on a photo-metallic information plaque located at the site where Merlin took his photographs — Merlins Lookout), the viewer will be able to examine the 1870s photographs showing the clustering of surface structures, the computer images of the underground workings and also the present scene from the lookout.

Several meetings have been held in order to call for sponsorship which would generate funding to allow further research to take place. Positive interest has been expressed by many organisations and efforts are continuing to find sponsors so that a comprehensive coverage of the workings at Hawkins Hill can be realised.

The methodology applied to the project shows potential for assisting in the interpretation and management of any current and/or future underground mining operations where a 'total' picture is required of hidden workings. Mining exploration, ventilation schemes and safety aspects can be treated via computer-generated three-dimensional images of the workings. Orebodies or veins can be mapped and the extent of workings graphically illustrated. Database information can be called to give yield/tonnages/volumes/costings, etc. Simulated 'walk-thru' type displays are possible.

Further information regarding the project can be obtained from Richard Shaw at the School of Civil Engineering, Sydney Institute of Technology, phone (02) 217 3649, Fax (02) 217 4007.

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PRECIOUS METALS REFINERY*

A precious metals refinery in Sydney uses a high-grade circuit to recover precious metals from copper tankhouse slimes and mine dorés; a low-grade circuit processes copper-based electronic scrap containing precious metals.

Pacific Precious Metals Ltd was established in 1988 to build and operate an integrated precious metals refinery. The refinery was commissioned in late 1989 and it is capable of servicing customers from a wide variety of industries that utilise or generate precious metals.

Pacific Precious Metals Ltd is a wholly owned subsidiary of MIM Holdings Ltd. The company operates two main refining circuits with the primary objective of adding value to precious metals generated by the MIM Group.

HIGH-GRADE CIRCUIT

Tankhouse slimes are formed during the electrolytic production of refined copper. These slimes contain gold, silver, platinum and palladium in varying proportions, together with other impurities.

Copper tankhouse slimes are sampled and assayed at the refinery before being smelted into a silver doré using top-blown rotary converters. The silver doré is cast into anodes for silver refining in Balbach-Thum electrolytic cells. The pure silver output is cast into silver bars or granules for sale.

A gold mud is collected from the Balbach-Thum cells. The gold mud is upgraded through Miller chlorination before dissolution in aqua regia. Pure gold and a platinum/palladium residue is then recovered by precipitation. The gold output is sold in 400 oz bars or as granules.

Additional revenue is earned from the high-grade circuit by adding various other materials at different stages in the process. Other feed materials would typically include mine doré which is essentially an alloy of gold with silver, and silver from photographic processing which is usually collected by scrap processors in the form of a flake or slime.

The refinery currently has the capacity to produce approximately 300,000 ounces of gold and 2,500,000 ounces of silver per annum.

LOW-GRADE CIRCUIT

Precious metals have several unique properties which make them virtually indispensable for the electronics industry. Precious metals are used extensively in electronic devices in the form of plated connectors, solders, bonding wires, circuitry and contacts. Scrap arises first as a normal by-product of fabrication and secondly through the scrapping of old equipment.

Pacific Precious Metals Ltd is the main refiner of electronic scrap in Australia. The key to the efficient recovery of the precious metals is through smelting the material in the Mount Isa copper smelter in order to recover the copper before recovering the precious metals in the resulting copper refinery tankhouse slimes.

Tapping precious metals from a rotary furnace at Pacific Precious Metals' refinery

Photo by David Barnes

The electronic scrap is reduced into a homogenised form to enable accurate sampling and assaying before it is sent to the Mount Isa copper smelter. Combustible elements are burnt in an incinerator which includes sophisticated gas-cleaning facilities in compliance with an Environment Protection Authority licence. The material is then milled to crush and liberate precious metals entrapped in ceramic and other components. After milling and blending, the homogenised material is sampled through a sampling tower which separates the material into fines and metallic fractions. The fines fraction is sampled in rotary samplers and the metallic fraction is melted in large induction furnaces to ensure representative sampling.

The refinery processes approximately 1000 tonnes per annum of precious metal bearing electronic scrap.

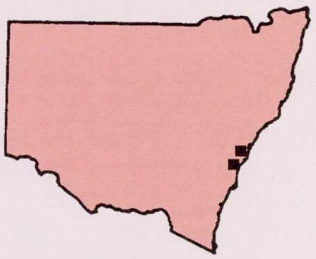
LABORATORY SERVICES

Accurate assay results are required by both customers and the refinery, and a sophisticated in-house laboratory is registered with the National Association of Testing Authorities. Traditional fire assay methods combined with wet chemical and modern instrumental techniques (such as cupellation, precision weighing and atomic absorption spectrometry and X-ray fluorescence) ensure fast and accurate assays.

Pacific Precious Metals Ltd is still a relatively new company with the capacity to expand all its production processes. For further information contact, Tony Pearce, General Manager, on (02) 319 7866, Fax (02) 698 8752.

* Article supplied by Pacific Precious Metals Ltd

VALUE-ADDED MINERAL PRODUCTS FROM RESIDUES AND EFFLUENTS*



Commercial operations at Marrickville and Unanderra are treating metal-bearing residues containing selenium, tin, zinc, copper and lead to produce value-added mineral commodities.

HydroMet Operations Ltd has developed a number of commercially successful processes for the treatment of mine and industrial waste materials such as slags, dusts, sludges, slimes, tailings, spent liquors and other wastes and scraps to recover valuable mineral products and produce environmentally stable residues.

BACKGROUND

Mining and mineral processing companies are usually mainly interested in the extraction and purification of specific metals which occur in small concentrations in ores and at slightly higher levels in concentrates. Large amounts of waste materials are produced by mining, smelting, refining and other aqueous chemical processes. These wastes often contain materials of economic value together with materials which may be hazardous or toxic and therefore environmentally unsafe.

Industrial liquid effluents are generally not permitted to be discharged into oceans or rivers, unless the discharge is almost equivalent to natural concentrations. Similarly, solid wastes are not permitted to be dumped as land fill unless the relevant industry can demonstrate that the material does not release deleterious leachate or gaseous discharge into the environment. Complying with such regulations for disposal of effluent demands significant capital expenditure. This has resulted in many industries becoming uncompetitive in the international market, and caused a number of companies to consider closing down their operations on economic grounds. In Australia, many industries are currently stockpiling significant quantities of complex hazardous residues and effluents. In some instances the technology to treat these residues does not exist; in other cases the cost of treatment is so high that processing becomes uneconomical. Lack of advanced technology in this field has compounded the problem.

EXPERTISE DEVELOPED

Over the past few years HydroMet has developed expertise in the following areas:

* The commercialisation of specialised research and development projects associated with metals and minerals industries.
* The processing and refining of waste metals and minerals and the extraction of valuable chemicals contained therein.
* The development of value-added products from the chemicals extracted from residues and concentrates.
* The commercial exploitation of hydrometallurgical mineral and metal processing technology in order to identify synergistic opportunities in the metals and minerals processing industries.
* The company has established a research and development facility providing advice, service and use of facilities on a contractual basis.

OPERATING PROCESSES

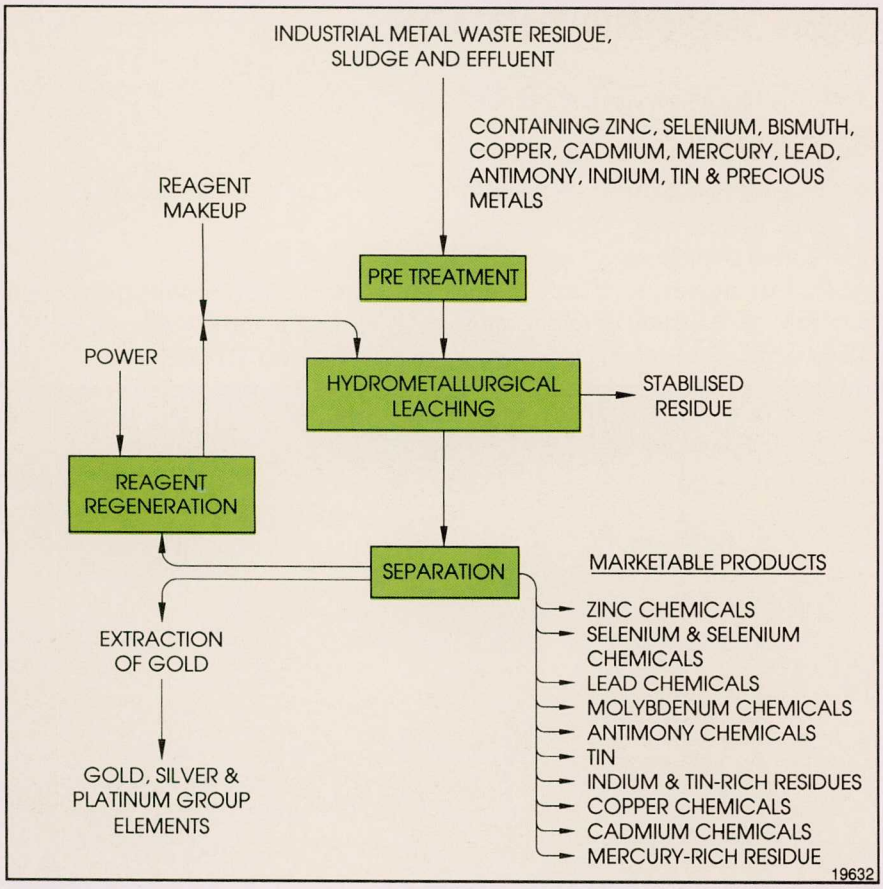
A number of commercially successful operating processes have been developed and provide high-purity metals and chemicals for both export and local markets. These processes include:

* Extraction of selenium from waste residue and production of approximately 150 tpa high-purity selenium and selenium chemicals.
* Production of antimony chemicals from antimony–gold-bearing concentrate.
* Production of 300 tpa of high-purity tin from tin-bearing sludges and residues.
* Treatment of 6000-7000 tpa of zinc, lead and copper smelter residues for production of value-added commodities: approximately 5000 tpa zinc sulphate, copper chemicals and upgraded lead residues.
* Stabilisation of arsenic-bearing residues.
* Extraction of mercury from smelter residues and production of mercury chemicals.
* Production of approximately 500 tpa high-purity nickel sulphate.
* Selective extraction of mercury from copper–gold concentrates.
* Application of halide leaching technology for treating electronic scrap and anode slimes to recover gold, copper and other metals.
* Production of zinc oxide from tailings dam water.

HydroMet is currently investigating expansion of its operations at Unanderra and in the Newcastle region.

Some of the treatment processes for waste residues are summarised schematically in figure 21. The processes are all hydrometallurgically based, and both acidic halide and caustic

* Article compiled from information supplied by HydroMet Operations Pty Ltd

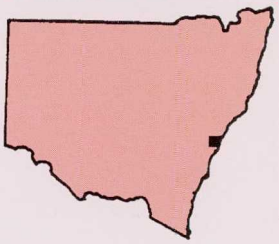


leaching systems are adopted, depending on the quality of feed material. An oxidant may also be added to improve the leaching if necessary. Specific metals or elements are selectively dissolved and recovered using various separation techniques such as chemical precipitation, crystallisation, solvent extraction and electrowinning. The metals are recovered either as salts or pure metals. Further processing to meet market demands can also generate residues that are acceptable feedstocks for base-metal smelters. Environmentally safe final waste products are achieved in all the processes and can be disposed of in waste dumps.

For further information on HydroMet's activities contact Lakshman Jayaweera, Director-Operations, HydroMet Operations Ltd, phone (02) 517 1188, Fax (02) 519 9468.

Figure 21. *Hydrometallurgical treatment of waste residues*

MINI STEEL MILL COMMENCES PRODUCTION



The mini steel mill, located at Rooty Hill in Sydney, was officially opened on Friday 20 November 1992 by the Premier, the Hon. John Fahey M.P.

The mill, which is owned and operated by BHP Steel, uses electric arc furnaces and modern technology to recycle scrap steel. When production reaches full design capacity, the mill will produce 250 000 tpa of commercial-grade steel billets for rolling into reinforcing Y-bar and light structural angles and flats. Environmental safeguards, including emission control and noise attenuation, are incorporated in all buildings.

All employees (currently about 100, rising to 180 after the final commissioning stage) have agreed to a 'single union agreement' — the first of its kind for BHP Steel. The agreement means that BHP Steel will negotiate with just one union, the Federation of Industrial Manufacturing and Engineering Employees (FIMEE), which represents all steelmakers working at the mill. The agreement will effectively eliminate demarcation problems and encourage flexible working arrangements for both workers and management.

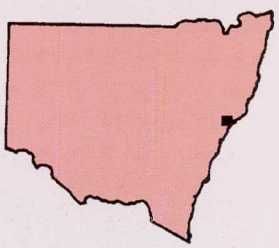
The second stage of the minimill development involves the construction of a steel rolling mill. This work is planned for completion by the end of 1994. At present, steel billets are despatched to BHP Steel's rolling mills at Newcastle, Brisbane and Geelong.

For further information, contact Paul Atkinson, Minimill Manager, phone (02) 675 9999, Fax (02) 675 9900.

Steel blending in an electric arc furnace at the BHP mini steel mill

Photo courtesy BHP Steel

TOMAGO ALUMINIUM PLANT — THIRD POTLINE OPENING



Nine years to the day after Tomago Aluminium Co. Pty Ltd's plant was officially opened, the Premier, the Hon. John Fahey M.P., presided over the official opening ceremony of the third potline on 5 March 1993 (refer to *Minfo* **31**, p. 8 for more details of the plant and the expansion).

The $700 million expansion will boost the plant's aluminium output from 240 000 tpa to 380 000 tpa. To cater for the increased capacity, other areas of the plant have also been scaled up. The substation has been expanded to deliver 620 MW of power, up from 400 MW. Most buildings and general facilities have undergone expansion, including the casthouse (installation of a second Gautschi ingot chain), electrode production and bake oven furnaces (capacity 180 000 anodes/year), paste house and rodding shop. Most of the expansion was completed before the end of 1992.

The smelter expansion will be very beneficial to the community of the Hunter and surrounding regions by directly increasing employment opportunities. Potline 3's construction workforce peaked at 1200 people; there are 200 additional permanent jobs at the smelter (increasing total direct employment from approximately 1000 to 1200 employees). The Port of Newcastle will also receive additional benefits due to increased imports (raw materials) and exports (finished products). The third potline will also lead to significant additional indirect employment outside the smelter, equal to a 'job flow-on' of about 600 (400 within the Hunter region).

Commissioning of Potline 3's 280 electrolytic pots began in November 1992. Assuming commissioning work continues to schedule, full capacity will have been reached by May 1993. The additional 140 000 tpa of aluminium produced will be exported to Asia, increasing Tomago Aluminium's annual Australian export earnings from $500 million to $800 million.

For further information, contact Sue Bartlett, Community Relations Officer, Tomago Aluminium Co. Pty Ltd, phone (049) 66 9669, Fax (049) 66 9218.

THE 'MINERAL CLAIM' TITLE

The new Mining Act, which commenced on 21 August 1992, has introduced the 'Mineral Claim' which should be of interest to both large and small mining companies and the individual mining operator.

The new Mineral Claim has several improvements and advantages over the 'claim' of the old Mining Act 1973. These improvements include:

* Mineral Claims can be granted over a mixture of Crown and private lands (the old 'claim' could only be granted over limited types of Crown land).
* Mineral Claims can be granted over areas up to 2 ha in size (the old 'claim' was limited to an area of 0.25 ha).
* Mineral Claims can be granted for a period of up to 5 years and renewed for further periods of 5 years (the old 'claim' tenure was a title renewable in the month of June each year and could only be renewed for 12 months at a time).
* Whereas 'claims' could not be granted over areas reserved, dedicated, etc. for public purposes (e.g. State Forests, Travelling Stock Reserves), Mineral Claims can be granted over such areas so long as the written consent of the body controlling such lands is obtained.
* If a Mineral Claim application relates to private land it must be accompanied by the written consent of the owner and occupier of the land to the granting of the Mineral Claim.

There are many instances where a viable mining operation could be conducted on one, or possibly two Mineral Claims. The legislation allows two Mineral Claims to be held by the same person or company in a single mining division.

For example, a number of the State's dimension stone operations are conducted in sites of 2-4 ha in size. The new Mineral Claim title, it appears, would be ideal for operations of this nature and size.

The Department is processing all applications for titles under the Mining Act much more quickly than previously. For example, the current Corporate Plan target is for 80% of all applications for Mining Leases to be processed in not greater than 18 months. With the improved steps introduced by the Mining Act 1992, Mineral Claims (even though they can now be granted for larger areas, for longer periods and for a mixture of Crown and private lands) will still be able to be processed much more quickly than Mining Leases.

Anyone thinking of making a Mining Lease application in respect of smaller sized operations should carefully consider the alternative of the Mineral Claim. Information on how to apply for Mineral Claim titles is available from the Department's Mineral Resources Administration Branch or any Mining Registrar.

The New South Wales Government and the Department of Mineral Resources are keen to foster interest and growth in the development of mineral resources of the State. The Mineral Claim title is seen as one means by which this aim can be facilitated in a practical sense.

It should be noted that the old 0.25 ha size, 12 month term, etc. will still apply to opal mining operations within the Mineral Claim Districts of Lightning Ridge and White Cliffs.

For further information contact Alex Ramsland, Manager Mineral Resources Administration Branch, phone (02) 901 8483, Fax (02) 901 8493.

EXPLORATION AND MINING TITLES BROCHURES UPDATED

The Department has revised and updated its series of information handouts dealing with the procedures for lodging applications for titles under the Mining Act 1992. These free brochures now cover how to lodge applications for exploration licences, assessment leases, mining leases and mineral claims.

Separate brochures cover Group 9 minerals (coal and oil shale) and all other minerals. While coal is now covered by the Mining Act 1992, there are different aspects in the handling of coal titles compared with other minerals.

Three other brochures have also been revised and updated in accordance with the Mining Act 1992. These brochures are:

* A Guideline to Titles under the Mining Act
* Information for Assistance of Arbitrators, Applicants and Landholders in the Matter of Access to Lands for Exploration
* Common Questions and Answers about Exploration and Mining Titles and Activities

These brochures are also free of charge and are of assistance not only to applicants for and holders of titles under the Mining Act, but also to landholders, solicitors and land agents.

The brochures can be obtained from the Information Counter and from the Mineral Resources Administration and Coal and Petroleum Administration Branches at the Department's Head Office, St Leonards, or from Mining Registrars and Regional Offices of the Department.

For further information contact Alex Ramsland, Manager Mineral Resources Administration Branch, phone (02) 901 8483, Fax (02) 901 8493, or Jon Hawke, Manager Coal and Petroleun Administration Branch, on (02) 901 8508, Fax (02) 901 8520.

REGISTER OF MINERALS DEVELOPMENT OPPORTUNITIES

The **Register of Minerals Development Opportunities** has attracted considerable interest to date. The register, which is maintained by the Minerals Development Section of Mines Inspection Branch, comprises a list of exploration, mining and minerals processing projects in New South Wales in which companies are seeking investment and/or joint venture participation.

Currently there are 22 listed ventures covering a diverse range of exploration, mining and value-added minerals processing projects.

Mining/exploration projects include base metals and gold, mineral sands, opals, vermiculite, zeolites and bentonite.

Value-added minerals processing projects include synthetic rutile, high-tech rare earth magnets, fused minerals and refractories, base metals, cement and dimension stone.

Companies and project proponents who would like to register specific minerals-based opportunities, or any companies which are interested in obtaining data and contact details on available investment opportunities should phone David Barnard, Development Officer, on (02) 901 8463, or Fax (02) 901 8468.

EXPLORATION LICENCES

EXPLORATION LICENCES GRANTED JANUARY–MARCH 1993

No.	Mining Div'n*	Holder	Area$	Expiry date+	Min grp#
4471	OR	CRA Exploration P/L	31.0U	10.01.95	6
4472	OR	CRA Exploration P/L	47.0U	10.01.95	1
4473	OR	Campbell, Terrance	1.0U	11.01.95	2
4474	AR	Dennis, Noel Norman	4.0U	12.01.95	1
4475	OR	CRA Exploration P/L	24.0U	18.01.95	6
4476	OR	CRA Exploration P/L	60.0U	18.01.95	1
4477	OR	CRA Exploration P/L	8.0U	18.01.95	6
4478	AR	Geoservices P/L	98.0U	24.01.95	1
4479	CO	Dominion Gold Operations P/L	100.0U	28.01.95	1
4480	AR	Uralla Gold P/L	14.0U	01.02.95	1
4481	OR	Fraser Mining Co. P/L	40.0U	02.02.95	6
4482	OR	Fraser Mining Co. P/L	5.0U	02.02.95	6
4483	BH	Helix Resources N.L.	100.0U	02.02.95	6
4484	BH	Helix Resources N.L.	100.0U	02.02.95	6
4485	BH	Helix Resources N.L.	100.0U	02.02.95	6
4486	BH	Helix Resources N.L.	100.0U	02.02.95	6
4487	OR	Evans, Sydney Benton	1.0U	02.02.95	1
4488	WA	Helix Resources N.L.	100.0U	04.02.95	1
4489	OR	Helix Resources N.L.	97.0U	07.02.95	6
4490	OR	CRA Exploration P/L	36.0U	01.03.95	6
4492	SY	Pacific Waste Management P/L	2.0U	10.3.95	5
4493	CH	C'Est Ca Internationale P/L	38.0U	21.03.95	1
4494	SY	Mogul Mining N.L.	90.0U	24.03.95	6

REFERENCE

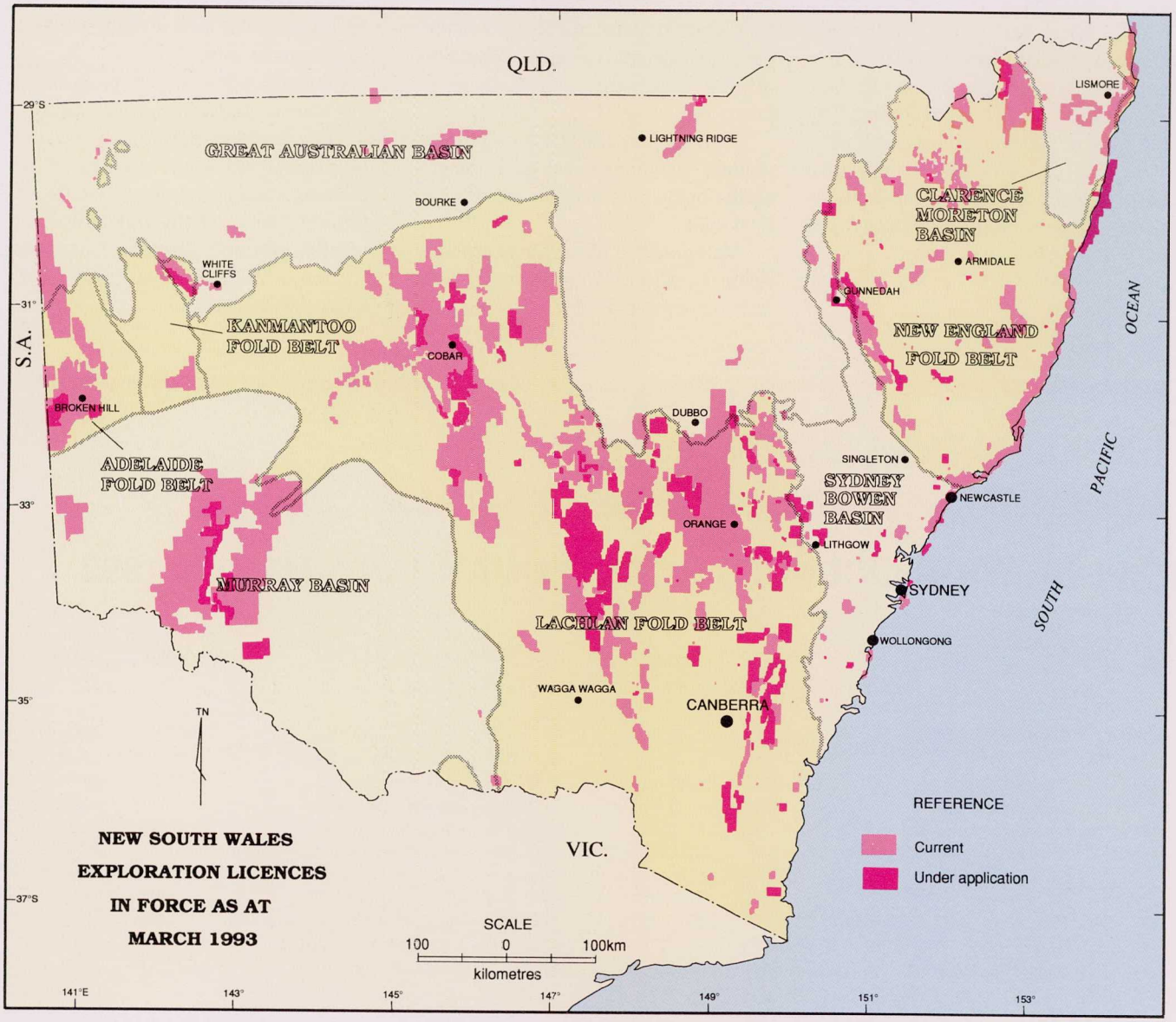
* AR Armidale
BH Broken Hill
CH Coffs Harbour
CO Cobar
IN Inverell
LR Lightning Ridge
OR Orange
SI Singleton
SY Sydney
WA Wagga Wagga

\# Group 1 - Elemental minerals (metallics)
Group 2 - Non-metallics
Group 3 - Semi-precious stones
Group 4 - Hard rock minerals
Group 5 - Clay minerals
Group 6 - Diamond, sapphire
Group 7 - Opal

$U = Graticular system units

+ ELs with passed expiry dates may either be subject to renewal applications or continue by virtue of "flow on" applications

EXPLORATION LICENCES IN FORCE MARCH 1993



SUMMARIES OF TERMINATED EXPLORATION LICENCES

EXPLORATION LICENCES CANCELLED/EXPIRED JANUARY–MARCH 1993

Reports on theseELs are no longer confidential; note that reports on EPLs are generally not included.

EL 2766 **CRA Exploration P/L**

Location: 5 km NW of Cobar

Objective: Copper, gold

Exploration was for Cobar type deposits. Following the interpretation of airborne geophysical and remote sensed data and geochemical sampling, rotary cored (RC) drilling was carried out on a number of targets. Results were poor with the best intersection being 4 m at 0.2% Cu at the Ring Neck prospect.

EL 3137 **Newcrest Mining Ltd**

Location: 10 km W of Bowning

Objective: Gold

The early Devonian Mountain Creek [Volcanics] and overlying Kirawin [Formation] was explored for epithermal style gold mineralisation. Regional stream sediment and rock chip sampling defined an area of anomalous gold and arsenic at the Sugarbag Hill prospect but drilling intersected only low-grade mineralisation. The

best intersection was 4 m at 0.27 g/t Au. Higher grade feeder zones may possibly be associated with a granitic intrusion emplaced to the south of EL 3137 under considerable thicknesses of Kirawin [Formation].

EL 3244 **CRA Exploration P/L**

Location: 40 km W of Cobar

Objective: Cobar type base and precious metals

CRA flew an aeromagnetic survey and conducted a regional structural study; Pasminco then took over exploration under a joint venture agreement. Rotary air blast (RAB) drilling over a 'high strain' zone gave no significant anomalies. Surface lag sampling at the new Tank grid identified a coincident lead (100 ppm) and gold (40 ppb) anomaly but in-fill sampling failed to enhance the anomaly. Reconnaissance mapping and lag sampling over the remainder of the licence gave no significant results.

EL 3254 **Newcrest Mining (WA) Ltd**

Location: 10 km SE of Blayney

Objective: Gold

A regional program of stream sediment, soil and rock chip geochemistry was followed by drilling at two prospects. At the Bright Star mine prospect, RC percussion drilling intersected potentially economic gold grades (6 m at 3.52 g/t Au and 13 m at 2.2 g/t Au) associated with thin quartz veins in schists and phyllites, but there is little potential. for locating a sizable deposit

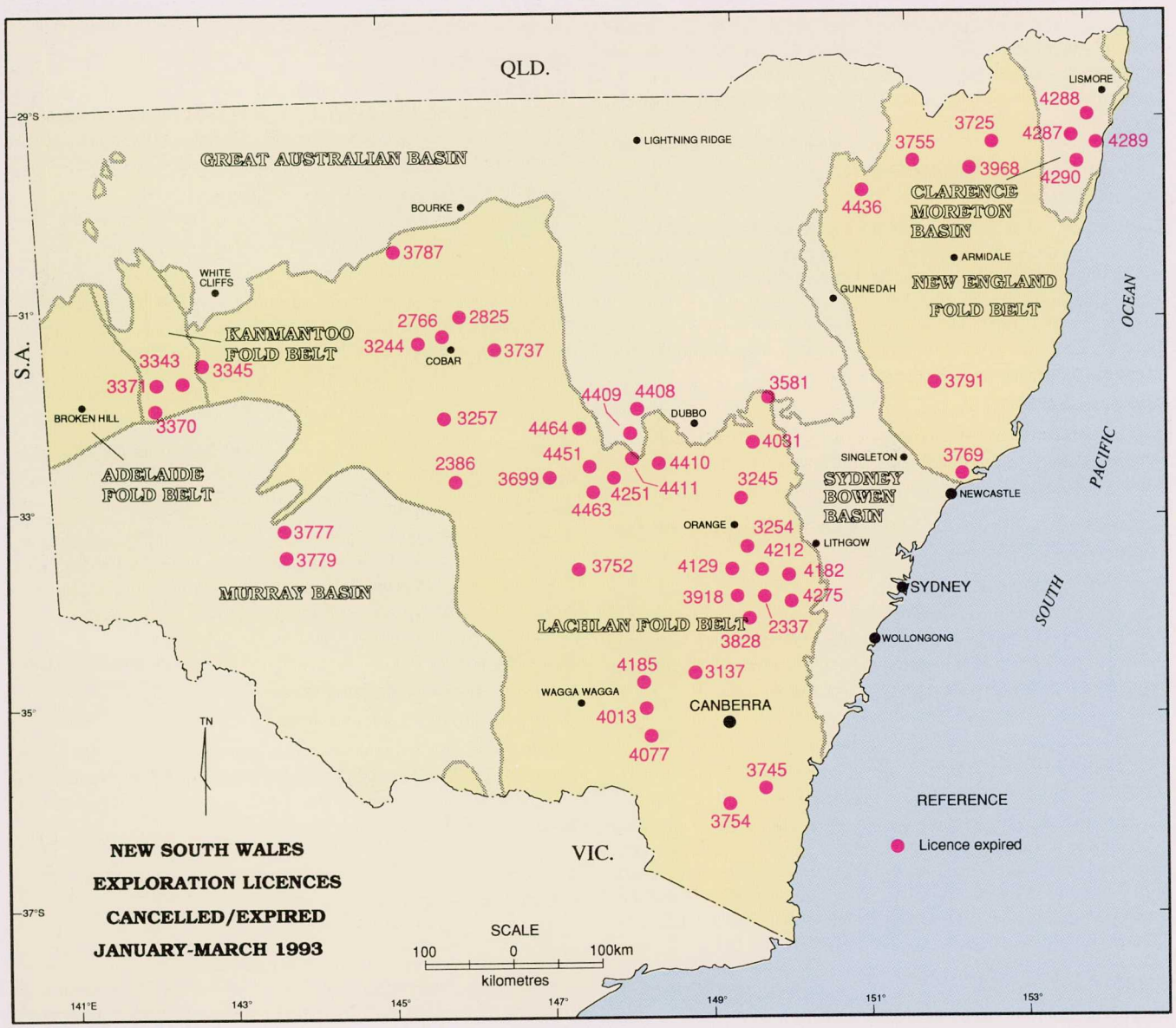
Interpretation of new aeromagnetic data suggests that a blind intrusive complex underlies the Moorilda area. Surface indications of differentiated, porphyry type intrusions and old gold workings suggest potential for buried gold mineralisation associated with this complex.

ELs 3343, 3345, 3370, 3371 **CRA Exploration P/L**

Location: 100 km E of Broken Hill

Objective: Base metals and gold

Exploration was designed to find base metal and gold deposits associated with discrete magnetic anomalies, and to assess known mineral deposits. No significant new mineralisation was discovered. Two diamond drill holes at the Scopes Range lead–zinc prospect intersected broad sections of trace to very low grade (<0.5%) galena. Sampling at the Bilpa copper–gold prospect indicated that its potential to host a large body of mineralisation is low.



EL 3581 — **Lachlan Resources N.L.**

Location: Leadville

Objective: Gold and base metals

Ground magnetic surveying and soil sampling over several aeromagnetic anomalies gave no encouraging results. Rock chip sampling was undertaken at five old mines, and sampling at the old Strikeys mine, 5 km SW of Leadville gave results of up to 0.75% Pb and 0.11 ppm Au.

EL 3737 — **Dowmill P/L**

Location: 1 km N of Canbelego

Objective: Gold

Soil and bedrock sampling delineated a discontinuous weak gold anomaly offset approximately 300 m to the east of the northern trend of the Mount Boppy gold deposit. RAB drilling gave no significant gold values and it was concluded the anomaly is due to erosional dispersion from the Mount Boppy deposit.

EL 3745 — **J.R. Wilson**

Location: 40 km SE of Captains Flat

Objective: Alluvial gold

The licence covered Currambene Creek. Hand sampling located gold in gravel horizons near bedrock. A number of test pits subsequently completed either failed to locate any significant gold or collapsed during construction without reaching the basal gravels.

EL 3752 — **Newcrest Mining (WA) Ltd**

Location: 20 km NE of West Wyalong

Objective: Gold

This licence was selected on the basis of proximity to the Gilmore Suture and consequent prospectivity for high-level hydrothermal gold deposits. Fifteen holes were drilled on aeromagnetic anomalies without any encouraging results.

EL 3791 — **G.A., J.L., & V.J. Wright**

Location 80 km NW of Gloucester

Objective: Gold

The holders reported the recovery of 26 ounces of gold from sampling but considered that the occurrences are not of sufficient grade or distribution to justify further work.

EL 3918 — **Cluff Resources Pacific Ltd**

Location: 50 km S of Orange

Objective: Diamonds

With the closure of the company's heavy media separation plant at Copeton, plans to carry out stream sediment sampling for diamonds and diamond indicators at locations of known diamond occurrences along the Abercrombie River were abandoned.

EL 3968 — **Arimco N.L.**

Location: 20 km NE of Glen Innes

Objective: Tin, tungsten, molybdenum, gold

No exploration was carried out on this title. Early Permian rhyolites are intruded by the Late Permian New England Batholith. The rhyolites host the Glen Eden molybdenum–tin–tungsten deposit. Arimco previously worked on this area under another title and had concluded that further diamond drilling was necessary to fully test the area.

ELs 4013, 4077, 4185 — **Newcrest Mining Ltd**

Location: 15 km W, NNW and SSW of Tumut

Objective: Gold

These licences covered the central and western parts of the Tumut Synclinorial Zone. Initial work downgraded the prospectivity of much of the area while highlighting broad zones of mineralisation at the Big Ben and Morning Star prospects (EL 4013). Subsequent exploration indicated that these were unlikely to host significant gold mineralisation.

EL 4031 — **Cluff Resources Pacific Ltd**

Location: 20 km S of Gulgong

Objective: Diamonds

With closure of the company's heavy media separation plant at Copeton, plans to carry out bulk sampling at various locations in the old Cudgegong diamond field were abandoned.

EL 4129 — **Trunkey Mining P/L**

Location: 30 km S of Blayney

Objective: Gold and base metals

This licence surrounded the Kempfield barite prospect and 'flowed on' from the earlier EL 1160. No work was done during the term of EL 4129.

EL 4182 — **T. Hanna & G. Harris**

Location: 15 km SW of Oberon

Objective: Sapphire

This five-unit licence was taken out over the Hopes Creek area worked by Chinese in the 1860s for gold and sapphire. Corundum with poor-grade sapphire was recovered from a 20 m^3 bulk sample at one site. Thick sticky clays hindered sampling of other sites.

EL 4251 — **Helix Resources N.L.**

Location: Fifield

Objective: Vermiculite

This licence was taken out to explore for vermiculite within the mafic/ultramafic Murga [Intrusive Complex]. Rock-chip sampling and visual examination failed to reveal any such mineralisation. A ground magnetic traverse failed to locate any hidden mafic/ultramafic bodies.

EL 4275 — **Cluff Resources Pacific Ltd**

Location: Burraga

Objective: Diamonds

Basalt plugs and reported diamond occurrences in this area follow a east–west trend and there are similarities with the Bingara and Copeton fields. Planned bulk sampling was not done due to the closure of Cluffs treatment plant at Copeton.

ELs 4287-4290 — **Consolidated Rutile Ltd**

Location: Maclean–Woodburn area

Objective: Rutile, zircon and ilmenite

Drilling of Middle to Late Cainozoic sediments forming the coastal plain between Grafton and Casino did not encounter any significant accumulation of heavy minerals. Rutile and zircon values were all less than 0.001%.

EL 4436 — **Danamore P/L**

Location: 6 km SE of Bingara

Objective: Gold

The Spring Creek gold prospect, a moderately flat-lying easterly dipping mineralised shear/fault zone, was evaluated. A review of previous exploration data indicated a potential oxide resource of 22 000 tonnes at 1.8 g/t Au. Although considered too small to be viable, there is a possibility that this resource may be suitable for a small leaching operation.

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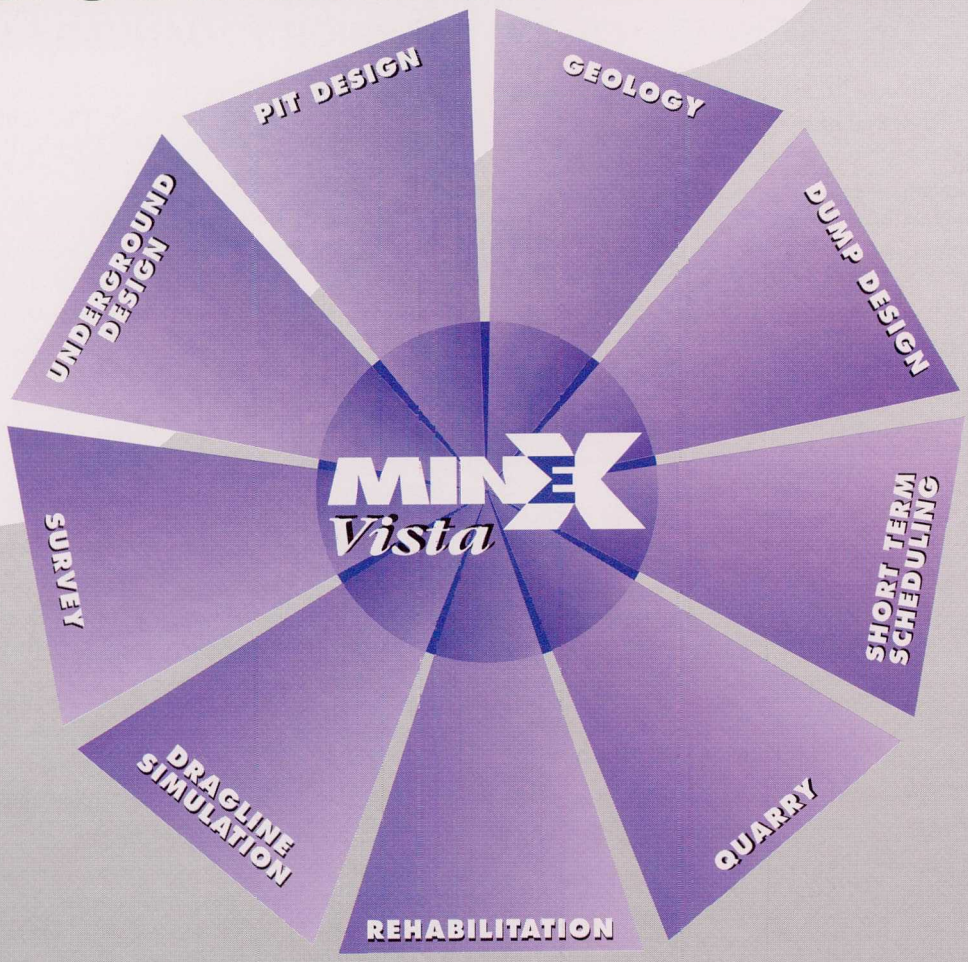

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BOWRAL HEAD OFFICE
Mr Pat Hanna
Telephone (048) 61 2122
Facsimile (048) 61 3902

PERTH
Ms Annette McIlroy
Telephone (09) 242 4433
Facsimile (09) 242 4466

DENVER USA
Mr Peter Christensen
Telephone (303) 988 1183
Facsimile (303) 988 4493

Other Exploration Licences cancelled or expired

At the time of compilation, final reports had not been received for the following licences:

ELs 2337, 2386, 2825, 3245, 3257, 3699, 3725, 3754, 3755, 3769, 3777, 3779, 3787, 3828, 4212, 4408, 4409, 4410, 4411, 4451, 4463, 4464.

EXPLORATION LICENCES TERMINATED PRIOR TO JANUARY 1993

EPL 892 **Ajax Joinery P/L and Goldrim Mining Australia Ltd**
Location: 25 km SW of Bathurst
Objective: Gold

This licence lies immediately south of the Caloola Creek gold deposit and was acquired to test for extensions of that mineralisation. Reconnaissance located hydrothermally altered schists (?originally acid volcanics) but no evidence of gold mineralisation was found.

EL 1405 **Eromanga Hydrocarbons N.L.**
Location: 30 km NE of Armidale
Objective: Gold

This licence surrounded the Comet gold mine (also known as the Phoenix mine) which is held by other interests under ML 755. This mine works a 1-3 m thick quartz–pyrite vein in granite. The vein carrys 8-12 g/t Au with associated pyrite and accessory arsenopyrite. Soil geochemistry, induced polarisation (IP) geophysics and drilling indicated that the Comet mineralisation extends down dip and along strike into EL 1405. Underground testing showed these extensions to be ore grade, averaging 9.4 g/t Au over 1.03 m. A mining lease application has been lodged to cover these extensions.

EL 1629 **North Broken Hill Ltd**
Location: 25 km W of Goulburn
Objective: Gold and base metals

This licence and adjacent EPLs covered the Wet Lagoon–Bredalbane area which contains a sequence of mineralised Silurian volcanics exhibiting similarities to the volcanics hosting the Woodlawn and Captains Flat deposits. Widespread disseminated base metal mineralisation, small discontinuous bodies of massive sulphides and gold mineralisation were located. The most significant mineralisation occurs at the Wet Lagoon South prospect where drill intersections of 11.3 m at 3.9 g/t Au and 7.0 m at 1.0 g/t Au were encountered. While no significant massive sulphide bodies have been found, there is still potential for deeply buried deposits.

ELs 2526, 2665 **Horizon Gold N.L.**
Location: 20 km E of Bredbo
Objective: Gold

These licences were taken out to find additional reserves for the Cowarra gold mine. Diamond and percussion drilling tested lenses of mineralisation along a 20 km shear zone. Gold was intersected in a number of holes, with the best intersection being 1 m at 16.25 g/t Au at the Fiery Creek prospect. Drilling was thought to be too widely spaced to fully test the area and potential still exists for the discovery of small high-grade pods of mineralisation.

EL 3365 **P. & A. Turnbull**
Location: 20 km W of Bingara
Objective: Gold

This licence covered the Bingara diamond–gold field. Auger drilling and costean sampling were conducted at a number of prospects. A small resource of around 2500 m^3 at 0.7 grams of gold per loose cubic metre and minor amounts of gem-quality zircon was identified at the Eaglehawk prospect. Very small quantities of gold and zircon were found at the Surface Hill and Gympie Flat prospects. Evaluation of this licence was complicated by the prior existence of EL 3325 over the same area being explored by Cluff Minerals (Aust.) Ltd for diamonds. The Turnbulls have terminated their interest in the area and EL 3325 is still current.

ELs 3654, 3657, 3658 **BHP Minerals Ltd**
Location: 35 km SW of Broken Hill
Objective: Lead–zinc, copper–gold massive sulphide deposits

Airborne electromagnetic (EM) surveying (GEOTEM) defined a small number of conductors which were tested by ground SIROTEM. One conductor, co-incident with old workings, anomalous geochemistry and surface indications of thin sulphide lenses, was drill tested. The conductor was not intersected and was interpreted as being caused by a relatively minor lens of mineralisation

EL 3673 **Delta Gold N.L.**
Location: 85 km N of Cobar
Objective: Gold

Geochemical testing of several prospects, including RAB drilling in the Gunderbooka mine area, gave only weak, anomalous results. Work then focussed on the Parkes prospect where four RC percussion holes were drilled. One hole intersected mineralisation with a best assay result of 160 ppm Cu, 430 ppm Pb, 1450 ppm Zn, 50 ppm Ag and 1.9 ppm Au. There remain untested targets at the Parkes prospect.

EL 3834 **Peko-Wallsend Operations Ltd**
Location: 5 km NW of Emmaville
Objective: Silver

This licence replaced previous EL 1739 which was held by Electrolytic Zinc Co. of A'asia Ltd. It was taken out to enable the possible sale to a local mining entrepreneur of mullock heaps at Collistons silver mine for retreatment. The purchase did not eventuate and no exploration was undertaken.

EL 3837 **Newcrest Mining Ltd**
Location: 10 km W of Peak Hill
Objective: Gold

This licence was acquired to explore Ordovician volcanic sequences for copper and gold, but no exploration was carried out.

EL 4111 **Dominion Gold Operations Ltd**
Location: 30 km SW of Forbes
Objective: Gold and base metals

Exploration for porphyry style or epithermal style stockwork gold deposits targeted a semi-circular aeromagnetic feature with internal linear lows and adjoining subcrop of silica–pyrite alteration. Geological reconnaissance was followed by soil sampling which gave low results, although geochemical trends remain open to the north-west.

ELs 4207, 4208, 4209 **Baxter-Brown Exploration N.L. &**
Location: 70 km W of Inverell **Moonstone Mines N.L.**
Objective: Alluvial diamonds

This group of licences collectively straddled the Gwydir River downstream from historic diamond workings at Bingara. No work was performed but exploration within adjacent EL 3415 indicated little potential in this region.

EL 4252 **Peko-Wallsend Operations Ltd**

Location: 55 km N of Condobolin

Objective: Gold and base metals

Exploration on this two-unit licence was limited to outcrop mapping and minor rock chip sampling. Moderately anomalous gold, lead and arsenic results were recorded from sheared, slightly silicified rhyolites of the Mineral Hill Volcanics.

EL 4253 **Peko-Wallsend Operations Ltd**

Location: 54 km N of Condobolin

Objective: Gold and base metals

Detailed mapping of this one-unit licence identified rhyolites and volcaniclastics of the Mineral Hill Volcanics, but failed to reveal any alteration or mineralisation.

PART RELINQUISHMENT REPORT

Reports covering partial relinquishment of title, and which have been placed on open file, include the following:

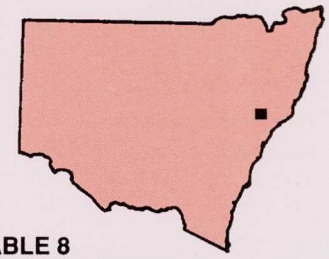
EL 2767 **Alkane Exploration N.L.**

Location: 20 km S of Dubbo

Objective: Rare metal and rare earth mineralisation

The relinquished area is covered in part by surficial deposits and little is known of the bedrock geology. A trachytic intrusion within the south-east part of the licence was rock chip sampled but no significant rare metal or rare earth mineralisation was detected.

ON-LINE COAL ANALYSER*



A $30.5 million expansion program at the Coal and Allied Operations Pty Ltd's Hunter Valley Coal Preparation Plant (HVCPP) completed during 1992 included the installation of the first on-line coal analyser of its kind in Australia.

The expansion, which increased the capacity of the plant by 50%, from 900 to 1350 tonnes per hour, was designed to meet the increased production from the Hunter Valley mine.

The coal analyser (figure 22) provides a quantified gamma ray spectrum of the elemental composition of the coal by neutron activation. The analyser has been housed in the pre-existing sampling room of the preparation plant and provides sample analyses at the rate of 100 tonnes per hour.

The analyser is particularly useful in determining the coal's environmental performance. It can provide elemental analysis of what will be in the coal ash and emission discharge when the coal is burned. Analyses from the analyser meet or exceed all Australian Standards requirements (table 8). The analyser also allows for maximum yield of saleable product because the washery plant can be adjusted in relation to the immediate results from the analyser.

The analyser is built and calibrated by the Gamma-metrics Corporation in the United States, where it has enjoyed widespread application in the coal industry. Australian installations are co-ordinated by the AMICAL Group of companies.

For further information contact Terry Callaghan, Manager, Hunter Valley Coal Preparation Plant, on (065) 76 0100, Fax (065) 76 1072.

TABLE 8
REPEATABILITY PERFORMANCE, ON-LINE COAL ANALYSER

Parameter	Units	Range	Repeatability ASTM Std[1,2]	Repeatability Analyzer[3]
COAL				
Sulphur	Wt %	0-2%	±0.05	±0.02
		2% plus	±0.10	
Ash	Wt %	0-12%	±0.30	±0.24
		12% plus	±0.50	
Moisture	Wt %	5% plus	±0.30	±0.10
Calorific value	Btu/lb	unlimited	±50±31	
CEMENT				
CaO	Wt %		±0.30	±0.18
SiO_2	Wt %		±0.24	±0.16
Fe_2O_3	Wt %		±0.15	±0.01
Al_2O_3	Wt %		±0.30	±0.09
MgO	Wt %		±0.24	±0.24

1. For coal, intralab repeatability standard, taken from ASTM Volume 05.05 (1986).
2. For cement, maximum allowable difference among three analyses, taken from Part 13, C114, Book of ASTM Standards.
3. Average one-sigma (one standard deviation) values taken from several sets of 10 minute analyses performed on static material.

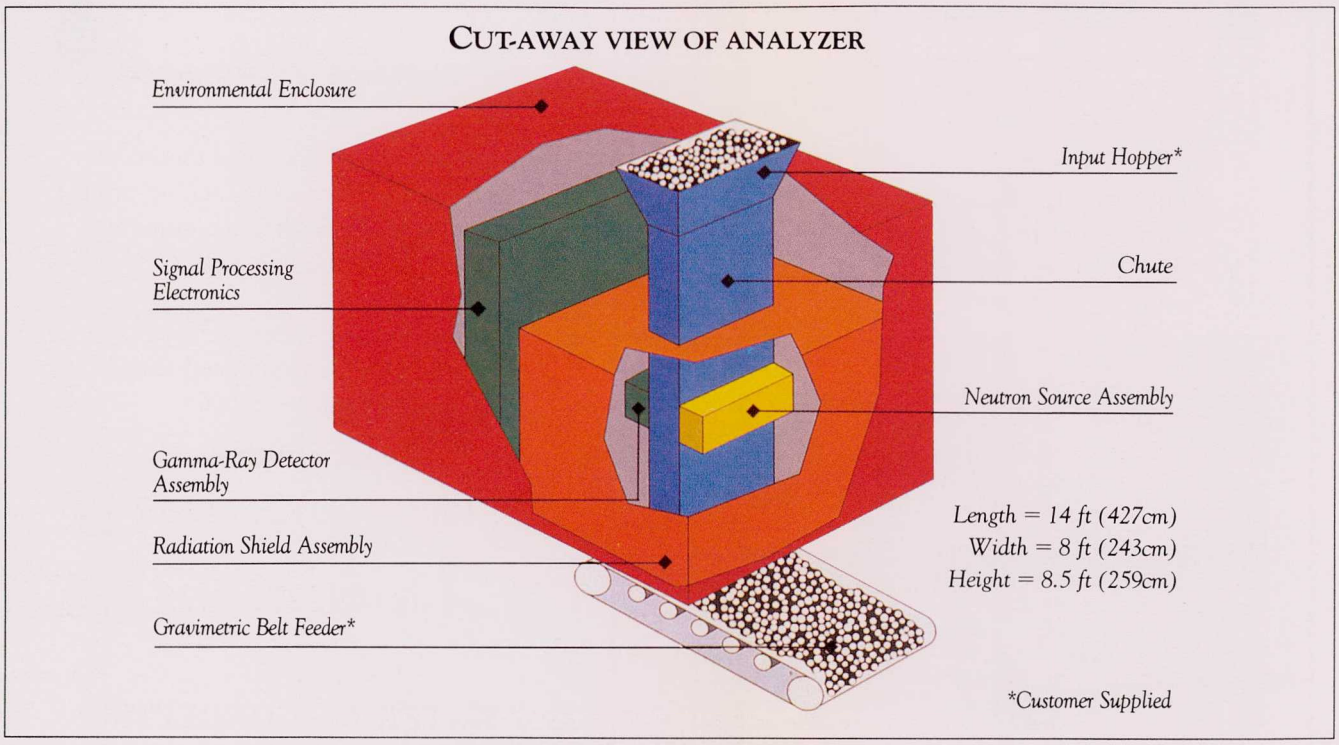
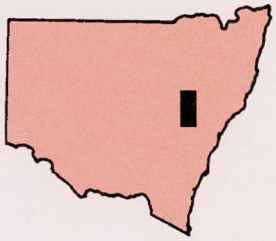


Figure 22. *Cut-away view of the coal analyser*

* Article compiled from information supplied by the Amical Group of companies and Coal and Allied Operations Pty Ltd

WESTERN COALFIELD COAL INFORMATION SEMINAR



Encouraged by the success of the inaugural Gunnedah Coal Information Seminar in September 1992, the Department of Mineral Resources organised a similar day for the Western Coalfield. This seminar was held in Lithgow on 17 February 1993 in conjunction with Lithgow City Council.

The seminar was opened by Mr T. Haraldson, then Chairman of the New South Wales Coal Association and Chief Executive of Coal and Allied Industries Ltd. Mr Haraldson informed the meeting that the Australian coal industry is much more dependent on its export sales than other large exporting countries which have a much more significant domestic market. Australia exports 66% of its total production and must therefore be internationally competitive for the industry to thrive. Mr Haraldson explained that export thermal coal trade is forecast to increase by 76% between 1992 and 2005, with Australia likely to retain its market share if it is able to remain competitive. Improved flexibility of minesite operations, reduction in costs and regulation, and streamlining the structure in which the industry operates, are areas for attention.

Mr B. Mullard, Chief Coal Geologist, Department of Mineral Resources, discussed the potential of the Western Coalfield which is predominantly a producer of thermal coal. He stressed that there are limited coal resources of appropriate quality to support new mining developments in the Lithgow area, apart from Mount Airly and Running Stream. Bylong and areas near Rylstone may have some potential in the future. However, most of the coal resources in the Western Coalfield have been incorporated into National Parks.

Mr R. Garland, Assistant General Manager (Western), Pacific Power, explained the restructuring of Pacific Power in his talk 'Competitive Coal Supplies to Regional Electricity Generators'. The Western group (Wallerawang and Mount Piper) can only maintain its share of the electricity market if it is competitive with other power stations. Given that 52% of its costs are fuel, i.e. coal, coal contract prices are extremely important.

Mr Garland referred to residents' concerns over public road haulage of coal to the power stations. He indicated that rail facilities will be an important factor to consider when the next round of contracts is negotiated in 1997. At present, 20% of coal is transported to the power stations by public road, although Mr Garland rejected a suggestion that Pacific Power had breached any commitment to the community by accepting public road haulage.

The Mayor of Lithgow, Alderman G. Martin, expressed the concerns of residents at the level of public road haulage at present and the potential for this percentage to escalate.

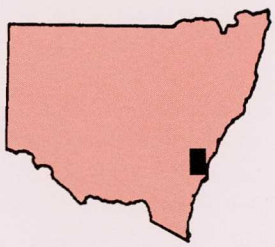
Speakers for Rylstone and Mudgee Councils gave generally positive presentations of their dealings with the coal industry. Mr A. Northey, Shire Clerk, Mudgee Council, outlined the benefits of employment, both direct and indirect, associated with the Ulan coal mine. This diversification of industry has been beneficial to the growth and prosperity of Mudgee.

In the afternoon session, speakers from almost all mines in the Western Coalfield gave brief reports on their operations. They also discussed their plans for the future and problems which they might face.

Both morning and afternoon sessions were followed by a vigorous period of questions. Over 130 people attended the seminar, with a particularly strong industry representation. It is intended to hold similar seminars in the future.

For further information contact Mike Armstrong, Principal Geologist Southern and Western, on (02) 901 8506, or Denis Casey, Executive Officer (Coal), on (02) 901 8511, Fax (02) 901 8520.

SOUTHERN COALFIELD COAL INFORMATION SEMINAR



The Department of Mineral Resources, in conjunction with the Wollondilly Shire Council, is hosting an Information Seminar for the Southern Coalfield. The Seminar will be held in the Campbelltown Catholic Club, Camden Road, Campbelltown on Tuesday, 20 July 1993, from 10 am to 3 pm.

The seminar is modelled on similar days held at Lithgow and Gunnedah, each of which attracted attendances of about 150 people.

The seminar will provide an opportunity for the coal industry to inform the wider community of its status and outlook. At the same time, community representatives such as the local councils will be able to present their concerns to a representative cross section of the coal industry. A number of organisations will present papers on aspects of planning related to the coal industry.

The seminar will be opened by Dr Garry Lowder, Director-General of the Department of Mineral Resources.

Admission is free and a light lunch will be provided.

For further information contact Mike Armstrong, Principal Geologist Southern and Western Coalfields, on (02) 901 8506 or Denis Casey, Executive Officer (Coal), on (02) 901 8511, Fax (02) 901 8520.

USE AND ABUSE OF THE CONCEPT OF DRAW ANGLE

The **angle of draw** is the angle between the vertical and the line drawn from the edge of the extraction panel to the point of zero subsidence on the surface (figure 23). The line denotes the extent of ground movement on the surface in relation to the goaf edge.

Even though the draw angle to the point of zero movement is the theoretical definition, such a definition creates the problem of measureability. As a subsidence curve is asymptotic to the original surface (i.e. reaches zero at infinity), zero subsidence cannot be measured in principle. A small finite subsidence is therefore taken to represent the limit beyond which subsidence effects are negligible. In Europe, a cutoff movement of 20 mm is generally taken as the limit beyond which subsidence effects are negligible.

The practical definition of draw angle therefore is the angle between the vertical and the line drawn from the edge of the extraction panel to the point on the surface at which the subsidence is negligible.

PROTECTION PILLAR ON THE BASIS OF DRAW ANGLE

The concept of draw angle is used extensively for determining the size of coal pillars under structures or for determining how close to structures mining can be undertaken without inflicting subsidence damage.

Draw angle by definition is the limit of mining-induced ground movement. When it is applied to determine the size of the protection pillar required to protect a structure from subsidence damage, it is assumed that the structure cannot accommodate any ground movement larger than 20 mm. This assumption is not always correct as many structures can accommodate much larger movements. The application of the draw angle concept for determining the size of pillars to protect structures which can accommodate movements larger than 20 mm, therefore, leads to larger than optimum pillar sizes.

In summary, the universal application of the draw angle concept for fixing protection pillars for all types of structures irrespective of their capacity to accommodate movements appears to be an abuse of the concept and leads to unnecessary sterilisation of coal.

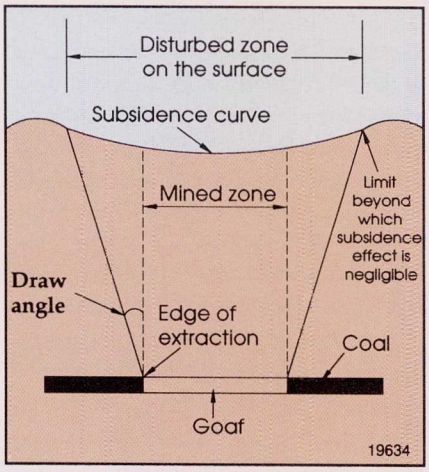


Figure 23. The concept of draw angle

PROTECTION PILLAR ON THE BASIS OF LIMITING DAMAGE

If it is accepted that almost all structures can accommodate some movement without damage, the size of protection pillars can be fixed on the basis of this acceptable movement. The draw angle corresponding to the acceptable movement would be less than the draw angle corresponding to no movement, leading to smaller protection pillars and to larger coal recovery.

Different classes of structures exhibit different capacities to withstand ground movement without damage. For example, ordinary dwellings can withstand a much higher level of movement compared with the level of movement acceptable to a dam wall. Figure 24 illustrates the point. The more the acceptable subsidence, the less the distance of the extraction panel from the structure and the less the draw angle.

This approach of choosing a level of subsidence corresponding to the ability of a structure to be protected has led to the development of different draw angles for fixing the size of coal pillars under different classes of structures in Europe.

The approach, however, requires knowledge of the level of movement that can be accommodated by different classes of structures without damage. This is an area which civil and structural engineers can assist the mining industry.

LIMITATIONS OF DRAW ANGLE

At shallow mining depths, protection pillars based on an appropriate draw angle may not give complete protection. Cracks developed over the goaf due to large tensile strains may travel outside the goaf even though these movements may be small. Therefore, when surface cracking is likely to develop, a more detailed study than just draw angle considerations may be required to ensure complete protection.

One can argue that the draw angle concept is based on subsidence, whereas structural damage depends on horizontal and vertical differential movements, and therefore the concept is not strictly valid as a tool for fixing the size of protection pillars. However, as other deformations depend upon the level of subsidence in many cases (but not always), controlling subsidence generally means controlling other deformations, and the draw angle based on subsidence appears to be quite adequate in most cases. Nevertheless, in cases where large deformations occur in spite of small subsidence, a more thorough examination may be required.

For further information contact Dr Lax Holla, Principal Subsidence Engineer, on (02) 901 8593, Fax (02) 901 8584.

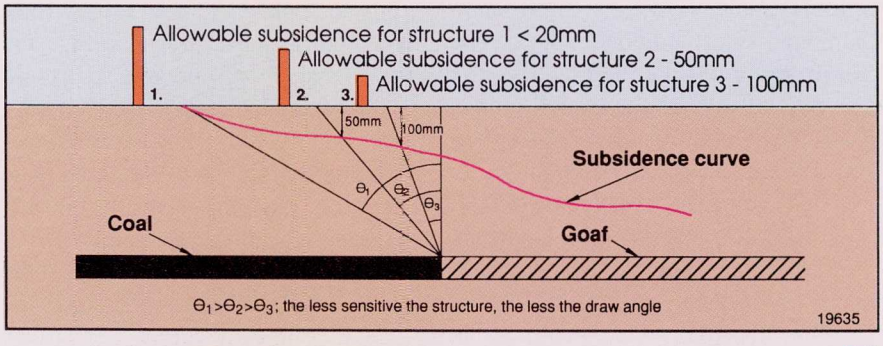


Figure 24. The concept of draw angle for limiting damage

CHANGES TO COAL MINE OWNERSHIP

Table 9 lists the major changes to coal mine ownership which have occurred since 30 September 1992 (correct as at 31/3/93). Table 10 lists the corporate restructuring which has occurred since 30 September 1992 (correct as at 31/5/93).

TABLE 9
RECENT CHANGES TO COAL MINE OWNERSHIP IN NEW SOUTH WALES

Colliery	Previous interest		New interest	
Glendell	Renison Goldfields Ltd	100%	Liddell Coal Pty Ltd	100%

TABLE 10
RECENT CHANGES TO COAL COMPANY OWNERSHIP IN NEW SOUTH WALES

Company	Old ownership		New ownership	
Liddell Coal Pty Ltd	Savage Resources Ltd	56.5%	Savage Resources Ltd	56.5%
	Marian Mining Pty Ltd	33.5%	Marian Mining Pty Ltd	16.5%
	Mitsui Matsushima Aust. Pty Ltd	10%	Mitsui Matsushima Aust. Pty Ltd	27.5%
Costain Resources Ltd	Costain Group Plc	100%	Peabody Resources (UK) Ltd	100%
Coal and Allied Industries Ltd	CRA Ltd	36.2%	CRA Ltd	70%
	UBE Industries Ltd	11.0%	UBE Industries Ltd	11%
	Nissho Iwai Corp.	7.6%	Nissho Iwai Corp.	7.6%
McIlwrath McEachern Ltd	TNT Ltd	46%	Cyprus Minerals Co.	91.3%
	AMP Society	13.6%		
	Sir Ian Potter	16%		
	GPG Plc	7.4%		

COAL AUTHORISATIONS/EXPLORATION LICENCES MARCH 1993*

No.	Holder	Nearest town
A6	Dep. Mineral Resources	Campbelltown
A48	Austen & Butta Ltd	Lithgow
A72	Novacoal Australia P/L Mitsubishi Development P/L	Jerrys Plains
A81	Navidale P/L Toyota Tsusho Mining (Australia) P/L DIA Coal Mining P/L	Camberwell
A102	Dep. Mineral Resources	Muswellbrook
A104	Electricity Commission of NSW	Lithgow
A129	Agipcoal Australia P/L MIM Exploration P/L	Denman
A142	Electricity Commission of NSW	Lithgow
A168	Electricity Commission of NSW	Muswellbrook
A170	Genders Mining P/L	Capertee
A171	Bayswater Colliery Co. P/L	Muswellbrook
A172	Bayswater Colliery Co. P/L	Jerrys Plains
A173	Drayton Coal P/L	Muswellbrook
A175	Coalex P/L	Ben Bullen
A176	Muswellbrook Coal Co. Ltd	Muswellbrook
A203	Dep. Mineral Resources	Raymond Terrace
A208	Genders Mining P/L	Capertee
A216	Dep. Mineral Resources	Gunnedah
A219	Newcastle Wallsend Coal Co.	Bulga
A230	Dep. Mineral Resources	Rylstone
A232	Western Main Collieries P/L	Capertee
A238	Electricity Commission of NSW	Ravensworth
A248	Australian Iron & Steel P/L	Menangle
A250	Mitsubishi Development P/L The Coal Cliff Collieries P/L	Oaklands
A256	The Bellambi Coal Co. Ltd	Aberdeen
A261	Esso Australia Resources Ltd	#
A262	Esso Australia Resources Ltd	Warkworth
A263	Dep. Mineral Resources	Wollombi
A278	Dep. Mineral Resources	Mittagong
A281	Dep. Mineral Resources	Camden
A285	Dep. Mineral Resources	Toronto
A286	Dep. Mineral Resources	Gulgong
A287	Austen & Butta Ltd	Bylong
A298	Electricity Commission of NSW	Robertson
A307	Hartley Valley Coal Co. P/L	Lithgow
A309	Ulan Coal Mines Ltd	Ulan
A311	B.M.I. Mining P/L	Gloucester
A315	B.M.I. Mining P/L	Gloucester
A321	Genders Mining P/L	Capertee
A324	Clutha Coal P/L	Ben Bullen
A342	Austen & Butta Ltd	Bylong
A349	Austen & Butta Ltd	Sutton Forest
A352	Blue Circle Southern Cement Ltd	Clandulla
A353	Agipcoal Australia P/L MIM Exploration P/L	Jerrys Plains
A355	Idemitsu Boggabri Coal P/L	Boggabri
A360	Dep. Mineral Resources	Rylstone
A373	Wambo Mining Corporation P/L	#
A382	Blue Circle Southern Cement Ltd	Moss Vale
A388	The Coal Cliff Collieries P/L	Oaklands
A394	Mitsubishi Development P/L Novacoal Australia P/L	Muswellbrook
A404	Newcom Collieries P/L	Morisset
A405	Dep. Mineral Resources	Cooranbong
A409	Clutha Springvale Ltd Samsung Development (Aust.) P/L	Wallerawang
A410	Novacoal Australia P/L	Picton
A412	Genders Mining P/L	Ilford
A414	Blue Circle Southern Cement Ltd	Kandos
A419	Newcastle Wallsend Coal Co. P/L	Cessnock
A420	Clutha Coal P/L	Ben Bullen
A422	Preston Coal Co. P/L	Gunnedah
A423	Hunter Valley Coal Corporation	Ravensworth
A424	Dep. Mineral Resources	Campbelltown
A427	Coalcliff Collieries P/L	Appin
A428	Ulan Coal Mines Ltd	Gulgong
A429	Hunter Valley Coal Corp. P/L	Singleton
A430	Dep. Mineral Resources	Ulan
A434	Preston Coal Co. P/L	Gunnedah
A435	Coal & Allied Operations P/L	Singleton
A436	Coal & Allied Operations P/L	Singleton
A437	Bayswater Colliery Co. P/L	Muswellbrook
A438	Costain Australia Ltd	Muswellbrook
A439	Esso Australia Resources Ltd	Singleton
A444	Wambo and United Mine Workers	Singleton
A445	Newcastle Wallsend Coal Co.	Boolaroo
A446	FAI Mining Ltd	Toronto
A449	Dep. Mineral Resources	Ulan
A450	Saxonvale Coal P/L	Bulga
A451	Coalex P/L	Lithgow
A454	MIM Exploration P/L Agip Coal Australia P/L	Denman
A459	Coal & Allied Operations P/L	Aberdeen

EL No.	Mining Divn	Applicant
4470	Sydney	Australian Iron & Steel P/L
4491	Singleton	FAI Mining, Chelsea Coal P/L, Tai Heiyd Aust. P/L, Kokankogyo Aust. P/L

AUTHORISATION APPLICATIONS

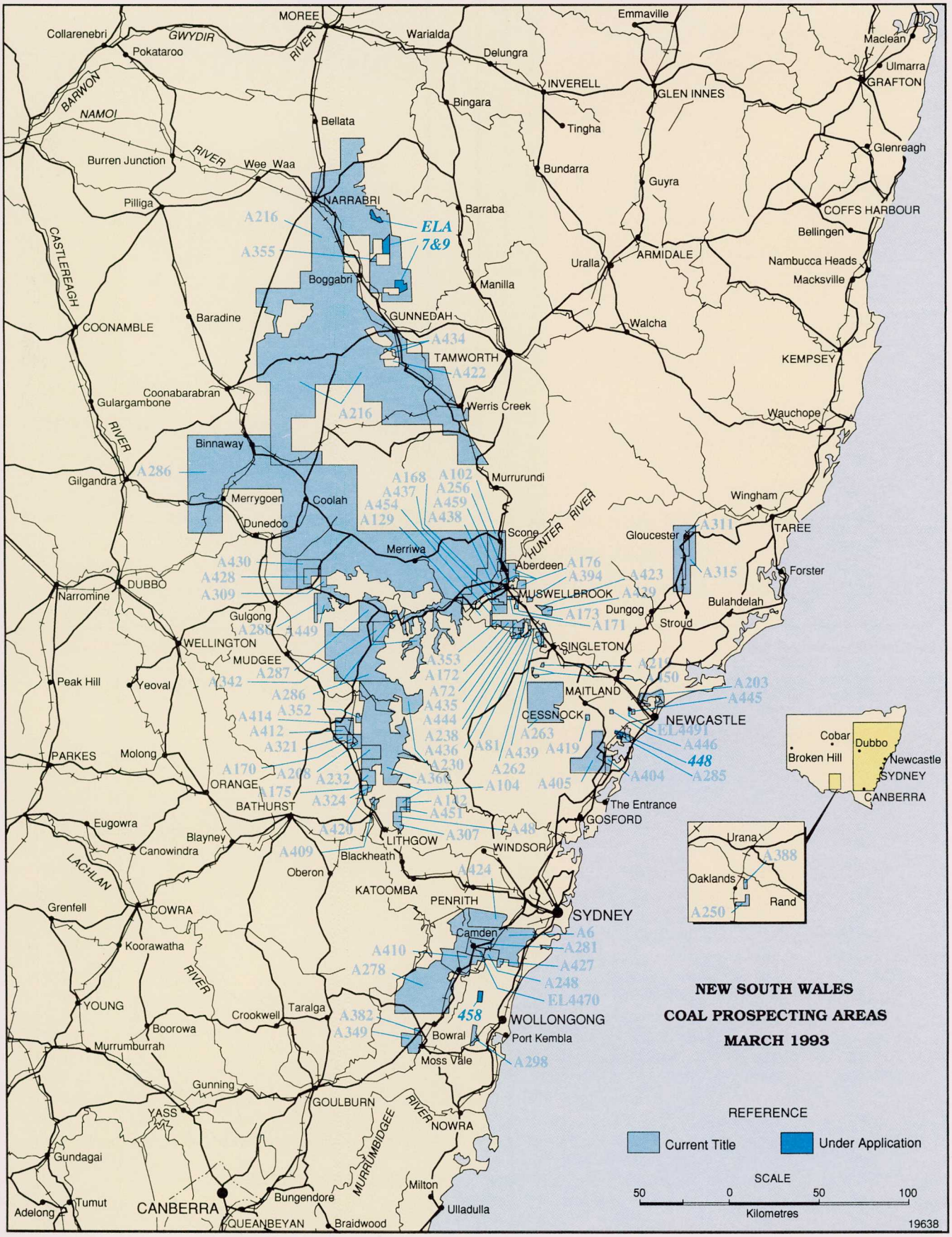
No.	Applicant	Nearest town
448	Elcom Collieries	Toronto
458	Australian Iron & Steel P/L	Bargo

EXPLORATION LICENCE APPLICATIONS

No.	Mining Divn	Applicant
7	Armidale	Novacoal Australia P/L
9	Armidale	Novacoal Australia P/L

Note: Section 21A Authorisations are not listed. # Section 20 Authorisation or EL over colliery holding (not shown in diagram)

* The Coal Mining Act 1973 was repealed and the Mining Act 1992 proclaimed on 21 August 1992. Under the new Act, Coal Authorisations are replaced by Exploration Licences for Group 9 minerals - coal.


MOREE
Collarenebri
GWYDIR RIVER
Pokataroo
Warialda
Delungra
Emmaville
Maclean
Ulmarra
GRAFTON
INVERELL
GLEN INNES
BARWON
NAMOI
RIVER
Bingara
Bellata
Tingha
Glenreagh
Burren Junction
Wee Waa
Bundarra
Guyra
NARRABRI
Pilliga
Barraba
COFFS HARBOUR
Bellingen
CASTLEREAGH
ELA 7&9
A216
A355
Uralla
ARMIDALE
Nambucca Heads
Macksville
Boggabri
Manilla
COONAMBLE
Baradine
GUNNEDAH
Walcha
A434
TAMWORTH
KEMPSEY
A422
Coonabarabran
Gulargambone
Werris Creek
Wauchope
RIVER
A216
Binnaway
A286
Gilgandra
A168
A102
Murrurundi
A437
A256
A454
A459
Merrygoen
Coolah
Wingham
A129
A438
Dunedoo
Scone
HUNTER RIVER
Gloucester
A311
TAREE
Merriwa
A430
A176
A423
A315
Forster
A428
Aberdeen
A394
DUBBO
Narromine
A309
MUSWELLBROOK
A439
Bulahdelah
Dungog
A173
Gulgong
A171
Stroud
A281
A449
WELLINGTON
SINGLETON
MUDGEE
A353
A172
A287
A342
A72
A203
Peak Hill
Yeoval
A286
A435
A445
MAITLAND
A352
A414
CESSNOCK
NEWCASTLE
A444
A412
A238
A263
EL4491
A321
A436
A81
A439
A419
A446
PARKES
Molong
A230
448
A170
A208
A232
A262
A404
A285
ORANGE
A175
A104
A405
A324
BATHURST
The Entrance
Eugowra
GOSFORD
A420
A307
A48
Blayney
LITHGOW
WINDSOR
Canowindra
A409
Blackheath
LACHLAN
Oberon
A424
KATOOMBA
PENRITH
Grenfell
COWRA
SYDNEY
Camden
A6
Koorawatha
A410
A281
A278
A427
RIVER
A248
EL4470
YOUNG
Crookwell
Taralga
458
WOLLONGONG
Boorowa
A382
A349
Bowral
Port Kembla
Murrumburrah
Moss Vale
A298
Gunning
GOULBURN
YASS
RIVER
NOWRA
MURRUMBIDGEE
Gundagai
Milton
Tumut
Bungendore
Ulladulla
Adelong
CANBERRA
QUEANBEYAN
Braidwood
Cobar
Dubbo
Broken Hill
Newcastle
SYDNEY
CANBERRA
Urana
A388
Oaklands
Rand
A250
NEW SOUTH WALES
COAL PROSPECTING AREAS
MARCH 1993
REFERENCE
Current Title
Under Application
SCALE
50 0 50 100
Kilometres
19638

PETROLEUM EXPLORATION LICENCES MARCH 1993

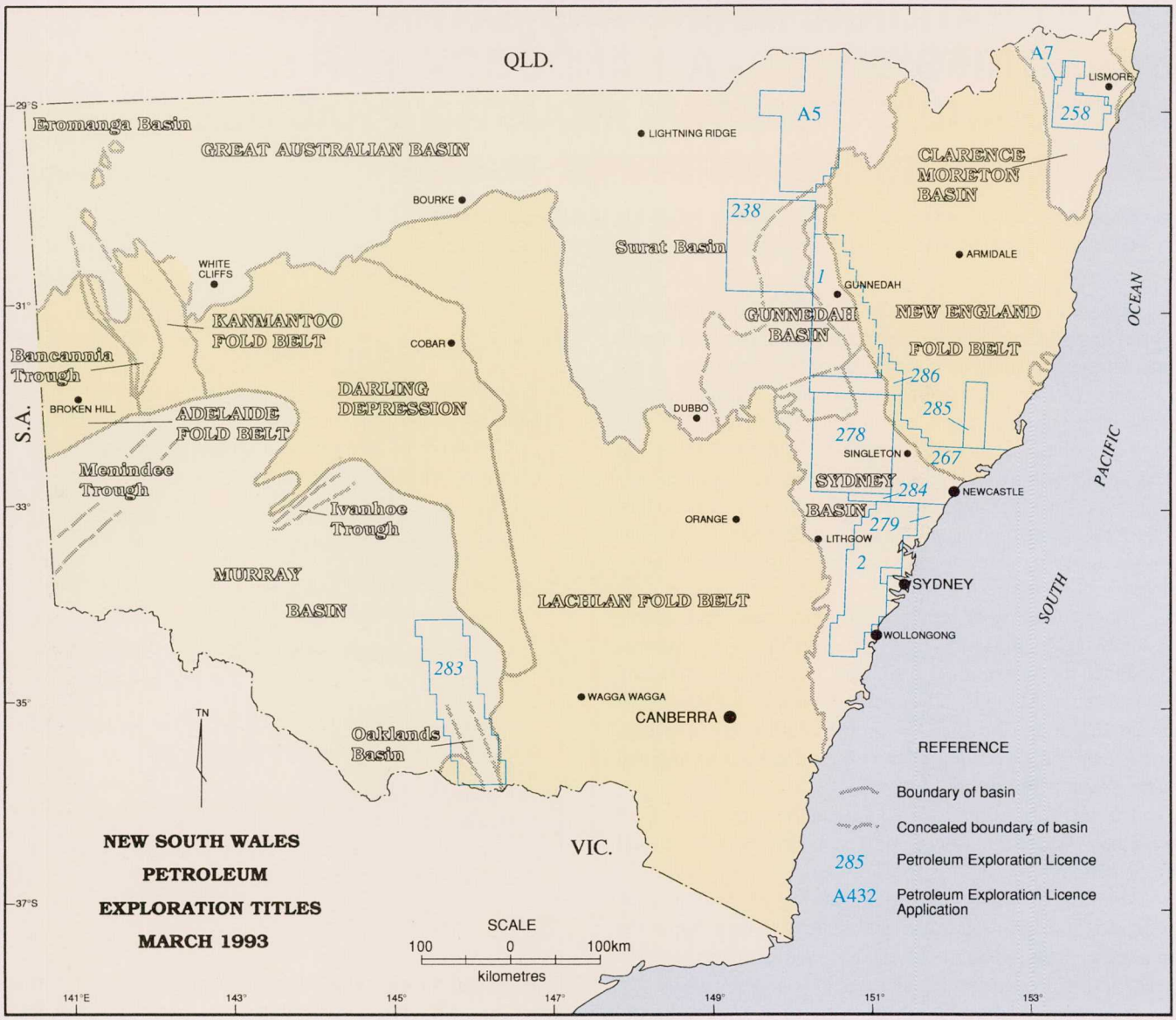
PETROLEUM EXPLORATION LICENCES

No.	Holder	Area (km²/blocks)⁺	Expiry date#
PEL 238	Petroleum Securities P/L, Great Southland Petroleum P/L	9148	31.08.1993
PEL 258	St Barbara Mines Ltd, Claremont Petroleum N.L. Basco Energy Inc., Charterhall Petroleum N.L.	2920	6.01.1993
PEL 267	Sydney Oil Co. (NSW) P/L, Government Insurance Office of NSW	6815	19.01.1993
PEL 278	The Electricity Commission of NSW	5300	16. 04.1993
PEL 279	The Electricity Commission of NSW	1800	16. 04.1993
PEL 283	Bannerblock P/L, Golvom P/L	10000	9.04.1993
PEL 284	The Electricity Commission of NSW	446	15.04.1994
PEL 285	The Electricity Commission of NSW	1730	15.04.1993
PEL 286	Australian Coalbed Methane P/L	2435	6.05.1993
PEL 1	Australian Coalbed Methane P/L	127B	10.02.1999
PEL 2	Amoco Australia Petroleum Co., International Oil P/L	120B	28.03.1999

⁺ Total area, i.e. area available plus exclusions where relevant. # Title continues where valid renewal application has been lodged.

PETROLEUM EXPLORATION LICENCE APPLICATIONS

No.	Applicant	Area (blocks)	Appln date
PELA 5	Petroleum Securities P/L, Bow Valley (Aust.) Ltd	127B	27.01.1993
PELA 7	Oil Co.of Australia Ltd, Claremont Petroleum N.L., St Barbara Mines Ltd	41B	29.03.1993



PETROLEUM EXPLORATION UPDATE

SYDNEY BASIN (ONSHORE)

Amoco Australia Petroleum Co. has completed two boreholes in PEL 260. Duncans Creek 1 was drilled at Wallacia with a total depth of 1260 m and Avon River 1 at Cordeaux with a total depth of 657 m. Amoco is currently drilling a third borehole, North Castlereagh 1, near Richmond.

SYDNEY BASIN (OFFSHORE)

Santos Ltd and Ampolex Ltd applied for cancellation of their Petroleum Exploration Permit P10 on the offshore Sydney Basin. The surrender of the permit was effective from the 24 January 1993.

DARLING DEPRESSION

The moratorium on the Darling Region closed on the 19 March. No applications were received for the area. The area is now open for exploration and any exploration applications will be given consideration as received.

CLARENCE–MORETON BASIN

AGL Petroleum Operations Pty Ltd has relinquished PELs 259 and 282. The area has been advertised for competitive application, with applications closing on 30 April 1993. The Clarence–Moreton Basin is considered to have excellent potential for the discovery of gas and possibly oil.

The region also has coal seam methane potential, with many gas shows having been associated with coal seams.

DRAFT NATIONAL MINING AND EXTRACTIVE INDUSTRIES CODE — A 'HANDBOOK' FOR SAFE MINING AND EXTRACTIVE INDUSTRY PRACTICE

A discussion draft was released in March 1993 for public comment. It addresses health and safety issues in non-coal mining operations.

It is essential that the mining industry achieves the highest possible standards and performance in occupational health and safety, primarily for the benefit of those working in the industry, but also to ensure its continued viability, as the community derives major economic support from mining.

This objective can be achieved only with the full support and co-operation of employers and industry associations, employees and trade unions, and relevant Government bodies. The development and promulgation of informative guidelines should assist in addressing adverse criticism of the industry's health and safety performance.

The Conference of Chief Inspectors of Mines is accountable to ANZMEC for the timely development of up-to-date national standards for safe mining. ANZMEC, the Australian and New Zealand Minerals and Energy Council, is the national forum of State and Territory Government Ministers of Minerals and Energy portfolios together with the Commonwealth and New Zealand Ministers.

The aim is to produce a final draft at the begining of 1994 which provides for national safety standards, guidelines and certification.

The first draft was developed from the base of common regulatory prescription but is not intended to be a regulation in another form. The intention is to enable the removal of prescriptive detail from legislation.

It is proposed to combine into one document the experiences and practices from a wide range of mining activities in order to guide practitioners in the mining industry. The proposal attempts to preserve advice based on lessons from the past, while allowing each site to determine how it meets the broader requirements.

It has been common for mining legislation, to date, to be prescriptive but uninformative. Prescriptive legislation is generally inflexible and discourages practitioners from investigating their own risk potential and arriving at a solution which best suits their need and better protects personnel under the circumstances which prevail at a site. On the other hand, a simple performance statement gives no help or guidance for a Manager assessing operational risks and taking appropriate action; nor are employees informed of hazards.

An attempt has been made to say why certain actions are common, and what factors should be taken into account when varying from those actions, rather than being bald statements which do not give an insight into the hazard being addressed.

The draft applies to each mine, including mineral exploration sites, quarries, dredging sites, open cut and underground mines and all extractive industries, but not to coal mines. (The New South Wales coal mining industry has formed a tripartate working group of practical mine operators who are currently considering what would be an appropriate safety culture for the New South Wales industry in the early part of the 21st century. The outcomes of these deliberations will guide the directions of safety legislation and practice for the future.).

The proposed objectives are:

* to develop a national set of mining and extractive industries safety standards which can be readily understood by employees, self-employed operators, owners, managers, the Inspectorates and the public;
* to promote effective systems of assessing and managing risks to safety and health on or in the mine;
* to foster consultation on safety and health between employees, managers and Inspectors of Mines;
* to provide a mechanism which will assist in the development of mining safety and health legislation;
* to stand as a general reference document for guidance to safe and healthy working practice; and
* to provide a minimum standard for certification of managers of mines and as a corollary to provide a means for universal acceptance of managers and other certification across all borders.

Early feedback has indicated a range of views as to the role of the document as a Handbook, Code or Guidelines in the context of the various State legislative regimes. The extent to which any of the document or parts of it may be called up by legislation in some form has also been a focus of much comment received to date. Some useful suggestions have also been made regarding the format and style of the presentation.

A second draft may be produced in mid-1993 based on this early feedback. Nevertheless, detailed comment on the first draft will still be used to refine its content.

Comment which is received by 30 September 1993 will be incorporated into a final draft co-ordinated by Chief Inspectors from all States and Territories of Australia, from New Zealand and from Papua New Guinea.

The discussion draft addresses the following issues:

- General provisions
- Management
- Employees/other persons
- Inspectors
- Welfare facilities
- Personal protection
- Safety and stability of workings
- Explosives
- Power
- Ventilation
- Hazardous substances
- Buildings/structures
- Equipment/machinery
- Shafts/winding
- Emergencies

A rough timetable for industry review is as follows:

1993	
March	Distribute draft via respective Chief Inspectors of Mines (CIM).
April	Industry consideration and preparation for their meeting in each interested sector of the mining industry.
May	Interested sectors meet and respond to their co-ordinator (CIM).
June	CIMs review comment and schedule a tripartite meeting. Report to ANZMEC.
July	CIMs co-ordinate responses
August	Comments received by co-ordinator (CIM New South Wales).
September	Compile responses and circulate to CIMs.
October	Consider and endorse refined Handbook (subject to any changes as agreed). Report to ANZMEC. Revise and produce final draft National Handbook if agreed by ANZMEC.
1994	Print, release, distribute. Refine annually.

Submissions or requests for further information can be referred to Graham Terrey, Chief Inspector of Mines, on (02) 901 8470, Fax (02) 901 8468.

SULPHIDE ORE DUST EXPLOSIONS

When air containing coal dust, methane, organic dust and/or flammable vapors explodes, catastrophic damage and major loss of life can occur. The results of such explosions and the mechanisms of initiation are well documented and researched.

Explosions caused by airborne particles of sulphide ore dust have an equal potential for damage. Four of the major underground mines in New South Wales have experienced sulphide ore dust explosions immediately after blasting rock containing sulphide minerals. Such explosions in underground mines in Australia have caused extensive damage and loss of production, and at least three mine deaths have been attributed to sulphide ore explosions in Canada.

In early 1990, the Australian Mineral Industry Research Association Ltd (AMIRA), with financial support from the mining industry, commenced the co-ordination of research into the prevention of sulphide dust explosions. Dr R. Enright was engaged by AMIRA as Research Leader. The Department of Mineral Resources has supplied sulphur dioxide monitors and instrumentation expertise for measuring the concentrations of sulphur dioxide in mines participating in this research.

Extensive test work had been conducted under laboratory conditions to gain basic data and to determine the tendency of different sulphide ore dusts to explode. The majority of current research is being conducted under operating conditions in underground mines throughout Australia.

Traditional techniques used for the prevention of sulphide ore dust explosions, such as limestone atmosphere inerting, use of water sprays and use of a specific detonator delay series, are now being challenged. The role of stemming and the initiation of unconfined explosives are also being investigated.

A better understanding of sulphide ore dust explosions has enabled the development of operating guidelines intended to prevent damage to property and injury to persons. They include information on the training of personnel, prediction based on observation and related events, prevention procedures and general safety.

For further information and copies of the guidelines, contact Graham Terrey, Chief Inspector of Mines, on (02)901 8470, Fax (02)901 8468.

SIGNIFICANT INCIDENT REPORT — OXYGEN/ACETYLENE TORCH

A plant operator at a quarry sustained burns to his hand when a flashback occurred as he turned on an oxygen/acetylene bottle. The flashback spread from the torch along the hoses and into the acetylene bottle. Although the injuries were of a relatively minor nature, the potential was there for a serious accident.

The accident occurred after the operator was instructed by the boilermaker to check the acetylene bottle because the flame appeared to extinguish itself when the oxygen/acetylene torch was lit. When the operator turned the regulator handle on the acetylene bottle, a flashback occurred into the bottle, blowing out the fusible plugs and burning the acetylene. It was at that point that the operator sustained burns to his hand.

The oxygen/acetylene bottles were situated on the back of a truck but there was no damage to the truck as a result of the burning acetylene.

RECOMMENDATIONS

As a result of the incident, the Mines Inspection Branch made the following recommendations:

* Both oxygen/acetylene bottles and torches should be fitted with flashback arrestors when in use.
* Safety refresher or induction courses on the handling and use of oxygen/acetylene equipment should be undertaken by experienced and new employees.
* An approved 'Code of Practice for Oxygen and Acetylene Use in Mines' is to be distributed to all mines in New South Wales.

Upon investigation of the incident, it was found that there were no flashback arrestors (non-return valves) on the bottles or torch. It was also determined that the flashback occurred due to the low pressure in the acetylene hose. This low pressure resulted in a burning-back of the flame into the blowpipe. When the regulator was opened the flame burnt back into the acetylene bottle.

The **Code of Practice for Oxygen and Acetylene Use in Mines** has been approved by the Mines Inspection Branch of the Department of Mineral Resources. Copies of the code are available from the Mines Inspection Branch at Head Office, St Leonards.

For further information contact Peter Diamantes, Regional Inspector of Mines, on (02) 901 8455, Fax (02) 901 8468.

OPEN CUT COAL MINE WINS SAFETY COMMITMENT AWARD

The State Minerals Advisory Council's inaugural Safety Commitment Award has been won by **Drayton Coal Pty Ltd**, a Hunter Valley open cut coal miner with 550 employees. Drayton's win was announced by the Minister for Mines, the Hon. Ian Causley MP, at Martin Place during a presentation which featured a New South Wales Mines Rescue Service demonstration to Sydney lunchtime crowds.

From a field of three close finalists, Drayton won the prestigious new Award by demonstrating outstanding commitment to safety. This was evidenced by the company's ability to change, ability to continue to improve its statistical record over a considerable period and the depth of the participation and responsibility on the part of its workforce towards safety.

Equal Merit Awards were given to **Exxon Coal and Minerals Australia Ltd** and **Camberwell Coal Pty Ltd** for their achievements in safety commitment.

Camberwell is a new and relatively small open cut coal mine, employing 110 people and situated at Singleton in the Hunter Valley. Production started in March 1991. While demonstrating a similarly comprehensive commitment to safety as Drayton , its methods, such as personal and team accountability, have been tailored to its own situation. Some of the judges commented that Camberwell's innovative approach could well become a benchmark for future ventures.

Exxon's entry included its open cut and underground coal mines at Ulan, north of Mudgee, and its open cut mine at Lemington and the Mount Thorley Coal Loader, both near Singleton. This 'package' has a combined workforce of nearly 1000 people. Exxon's statistical record has shown an excellent turn-around since it took responsibility for these operations and demonstrates a strong line management safety culture.

The Judging Panel was made up of senior safety representatives from industry, government and unions. They noted that the chief executive officers of all three finalists were strongly and visibly committed to the success of their safety policies and to the greatest achievable safety for their workforce.

For further information contact Sally Crossing, Executive Officer of the Council, on (02) 901 8886, Fax (02) 901 8405.

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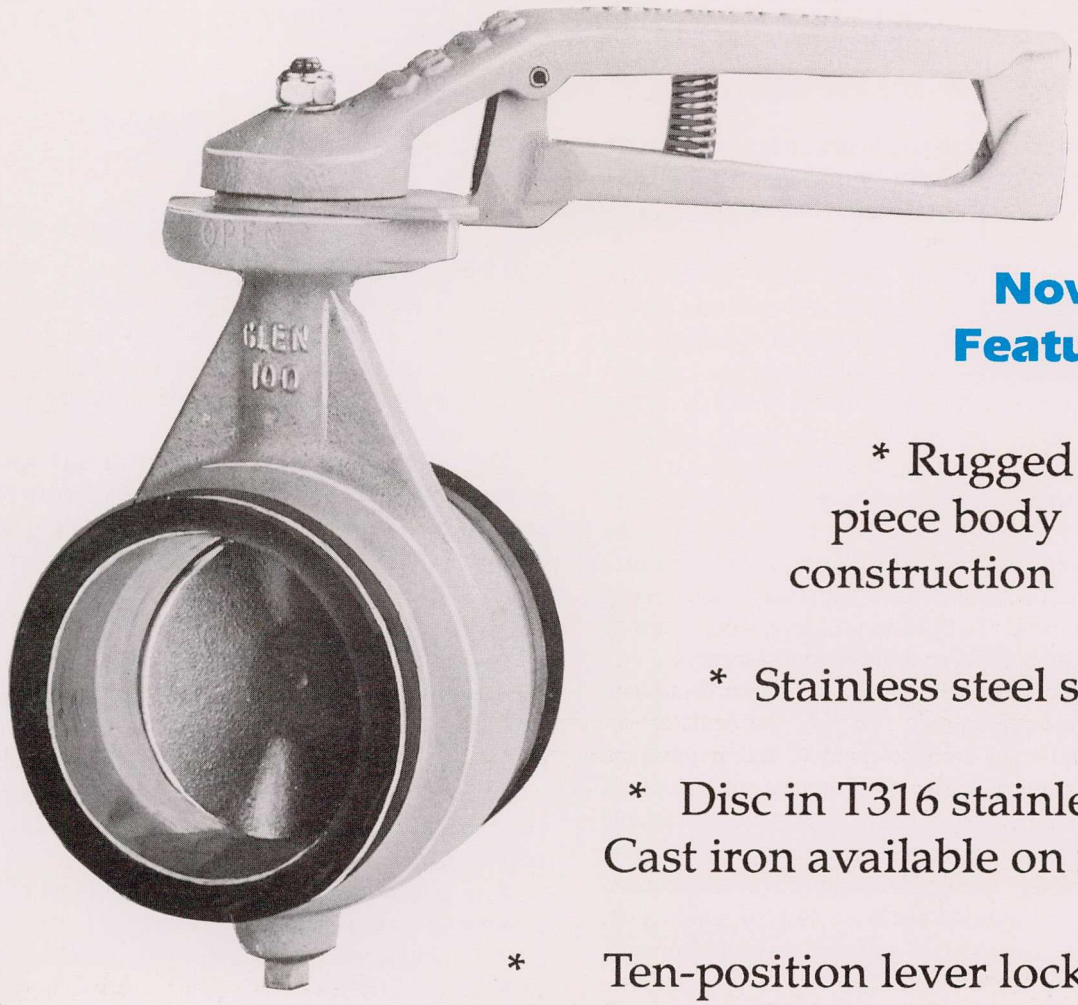

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NEW SOUTH WALES COAL ASSOCIATION OCCUPATIONAL HEALTH AND SAFETY WORKSHOP

The opening address to the Workshop, held on 31 March 1993 at the Parramatta Parkroyal Hotel, was given by the Hon. Ian Causley, Minister for Natural Resources. The address is reproduced below.

Welcome, on behalf of the New South Wales Coal Association, to the **1993 Occupational Health and Safety Workshop**. The theme of this Workshop — **Integrating Safety and Business** — is a reflection of the inherent importance of safety to the conduct of any industry.

To be successful, a business must set meaningful strategic goals in order to plan and monitor its operations. The importance of that process is only increased in difficult economic times. A significant part of the process is the effective management of safety and health of the workforce so as to reduce, as far as practicable, unplanned losses arising from injury or illness. To be most effective, safety must be integrated with other aspects of managing a business.

There is no doubt that safety can impact on business where it hurts — on the bottom line.

An examination of amounts paid in recent years on worker's compensation claims within the coal industry shows that these costs are currently close to $1 per tonne of saleable coal produced. These are a direct safety cost — money that is lost by the industry. There are also indirect costs associated with work-related injuries such as: loss of production, equipment repair costs, costs of replacement personnel and a host of others.

Various estimates have placed the total cost of work-related injury and illness at four to seven times the worker's compensation direct cost. It is certain that losses of from $4 to $7 per tonne are a recipe for mine closure, for loss of jobs and ultimately a less vital New South Wales economy.

I invite all of you here today to reflect on the situation at your mine and consider, given the price that your coal attracts, whether a safety-related loss of even $1 per tonne is a sustainable situation.

I am heartened that in recent years the New South Wales coal industry has made significant improvement in its safety performance. This is evidenced by a 65% improvement in the industry lost time injury frequency rate over the period 1983/84 through 1991/92 and reflects a great deal of credit on the efforts of many people.

Unfortunately, due largely to a time lag introduced by common law procedures in relation to worker's compensation, the fruits of the industry's labours are not immediately available. There have, however, been significant reductions in worker's compensation premiums, and, provided there is sufficient continued industry effort, the containment of these costs seems assured.

For the sake of the health and safety of workers and the economic future of the industry, it is in the all-round interests of workers and management to do their utmost to reduce work- related injuries and illness.

I think it is fair to say that some mines are now producing favourable safety results that would have been thought impossible 5 years ago. The industry has shown both a willingness and capacity to introduce more rigourous systems of health and safety management than are provided by simply following legislation.

This is just as well, for the big picture for the industry sees it exposed to increasing international competitive pressures, coupled with pressure from customers for quality and confidence in supply. To put it bluntly: either you are amongst the best or you are out of the game.

* * * *

As well as the profitability of business, there is a need for a business to be compatible with and hopefully enhance the society in which it operates. In addition to the dollar value of safety, there is an increasing community awareness of the unacceptability of disease, injury or death arising from employment.

Any industry only borrows its workforce from the community. It is increasingly expected to return workers in a condition that they can fully participate in and strengthen the community. That is not the case if workers are debilitated through illness, maimed through injury, or, in the worst case, killed.

Any industry must be able to demonstrate that it is capable of managing risks to safety and health arising from its activities. Those employed by an industry must have assurance that effective safety and health management measures are in place — as it is they who must face the risks of the workplace.

Such assurance may take the form of the legislative environment in which an industry functions — or may be evidenced by the visible commitment of the industry to health and safety. That commitment must be backed up by systems, procedures and review processes. The way an industry does this is reflected by what might be termed the **safety culture** of an industry.

The legislative environment and the industry culture are complementary — with the appropriate role of legislation being to reinforce, but not seeking to override, the demonstrated commitment and capability of an industry to manage its own affairs while maintaining the public interest.

There is a balance between what must be imposed by regulation and what can reasonably be left to responsible organisations to self regulate.

Personally, I would rather be the Minister for a trustworthy industry in relation to safety, than be forced to be heavy handed with restrictive legislation the size of a phone book.

I suspect that workers who start from day one with a proper safety culture mentally, appreciate their job far more than those who are unhappily compelled by some government rules.

In November 1992 I was pleased to receive a presentation from the Joint Safety Review Committee, a body comprising membership from all sectors of the coal industry and the Coal Mining Inspectorate. This group is undertaking the difficult task of forming a consensus industry position.

Through rational processes, it is seeking to identify the balance between what should be legislative requirements and the capacity of the coal industry to self regulate its safety and health management. I wish them well in their endeavours and remain supportive of this industry-based process of self determination.

* * * *

In perusing the program for the next 2 days I noted the significant, external focus of a number of the papers and activities. I think it entirely appropriate that the coal industry be exposed to alternate models for occupational safety and health management, and feel confident that the industry can adapt, and adopt to its own advantage, the best that other industries have to offer.

Of particular interest are the lessons from the Piper Alpha disaster. On reflection, an oil rig in the North Sea is not dissimilar to an underground coal mine — they both provide isolated, hazardous environments that people must travel to and from, and work in. True, the hazards are different, but I would expect that rigourous and effective safety and risk management methods developed in one sphere may well be applicable and useful in another.

Another pleasing aspect of the program are the number of items devoted to ergonomic issues. I have heard that some coal mining equipment has an availability of around 40% — so it is down more than it is working. The question is posed: is it down because it is not inherently strong enough for the task, or because of inappropriate actions of operators?

The performance of systems can be degraded as operators battle to compensate for things they can't see; dangers they fear may be imminent; things they can't reach; controls that don't operate as expected; equipment that can't be safely lifted, moved or serviced; or if they have to continue without essential information.

The study of the interaction between people and their work environment, together with their behaviour, provides fertile ground for the solution of these problems and makes apparent the close relationship between safety and productivity.

It is appropriate that one of the workshop topics addresses what might be called the 'silent epidemic' — that is the problem of noise, and noise-induced hearing loss. During 1991/92 there were 547 worker's compensation claims resulting from noise-induced hearing loss in the New South Wales coal industry. The total cost of these claims is around $2.9 million for that 1 year.

As well as the dollar cost there are human costs in the degradation of quality of lifestyle. This is of inestimable value to those affected. The reduction of a human sense, through hearing loss, also has impact on safety with a lessening of the ability to sense danger and so, it appears a suitable and timely topic for discussion.

* * * *

This is the thirteenth annual safety workshop conducted by the New South Wales Coal Association. I understand that the Workshop has evolved during that time to a point where it is now a significant venue for the expression and development of New South Wales coal industry safety culture.

I am sure that both the formal and informal activities of the next 2 days will enhance that culture — but I remind you that it is not what is said in here that really counts but rather what is done out there, at the 'coal face'.

As a collective business, the New South Wales coal industry is vitally important to the economic future of this State. The effective integration of safety into your business is of critical importance to the well-being not only of the industry, but the State as a whole.

It is with great pleasure that I declare the 1993 Occupational Health and Safety Workshop open, with an expectation that it will contribute positively to the future of the New South Wales coal industry.

SCHOOLS LINK PROGRAM*

The Schools Link Program establishes links between specific mining industry operations and secondary schools.

The program, which has been devised jointly by the New South Wales Chamber of Mines, Metals and Extractive Industries, the New South Wales Coal Association and the Australian Mining Industry Council, aims:

* to give students hands-on experience with the day-to-day issues such as environmental monitoring, site rehabilitation, resource audits and exploration and
* to assist teachers in their task of bridging the gap between theoretical classroom exercises and the real world of resource planning, use and conservation.

BENEFITS

For schools, the benefits include:

* improving the relevance of the curriculum;
* raising the level of motivation and attainment of students;
* improving students' skills and the equal employment opportunities and career guidance available for them;
* improving the motivation, morale, self-esteem and professionalism of teachers;
* better cross-fertilisation between business culture and school culture;
* improving the image of the school.

For companies the benefits include:

* a balanced viewpoint is provided on the role of the mining industry;
* students take a positive view of mining into the community;
* staff development of company personnel in terms of training and marketing skills;
* possession of workforce skills and business requirements in the future workforce.

AN EXAMPLE

A link has been established between Blayney High School and the Climax Management Pty Ltd operation at the Sheahan Grants mine.

Blayney is a country town in the western region of New South Wales with a small school population. The gold mining company was new to the town and no previous contact had been established between the participants. The link between them has proven successful.

Objectives

From the company's perspective, the objectives were to achieve a better image in the local community for the mining industry

* by establishing a good relationship between the school and the company,
* by influencing students' perceptions about mining and
* by developing good attitudes towards the workplace.

The school personnel had identified the need to increase the relevance of students' learning experience in the classroom by injecting experiences and expertise from industry in the local community and by bringing representatives to the classroom.

Activities

The types of activities undertaken include the following:

* Inspection by Year 11 **geography** classes in the context of catchment management and environmental controls.
* Individual **geography** students working with the mine in developing their senior geography projects for the HSC.
* **Agriculture** students propagating seedlings to be planted in the spring at the mine restoration site by the students (Climax Management provided the finance for irrigation and propagation equipment).
* Senior students **surveying** areas of the mine site.
* **Technical drawing** students gaining hands-on experience of technical equipment.
* **Mathematical** students being introduced to the computer facilities of the company.
* Senior **chemistry** students gaining practical experience at the mine site.
* Year 8 **Australian studies** classroom visit from mine manager, to show slides of the history of gold mining at Junction Reefs and to talk about gold mining history in general.
* Year 12 **biology** students visiting the mine site to examine environmental considerations of mining.
* Junior **art** classes working on a mural of impressions of Sheahan Grants mining processes over the year for display at the school.

Effectiveness

The effectiveness of the program is measured by increased local public support for the mining industry, which the company measured at 95%.

The company is confident that the original objectives are being achieved by:

* changed perspectives on the industry in the local community;
* the attitudes of students to the workplace being influenced by the activities undertaken;
* the relationship between the school staff and the mining staff being enhanced.

*Article compiled from material supplied by the New South Wales Chamber of Mines, Metals and Extractive Industries

Blayney High School students participating in rehabilitation program at the Sheahan Grants mine
Photo courtesy Climax Management Pty Ltd

A better understanding of schools in the 1990s and of the world of business and industry has been of benefit to all participants.

Success factors

The major factors which have been identified as contributing to the success of this industry–school link include:

* The commitment shown by key industry and school personnel.
* The agreement that quality time for students was of greater significance than bureaucratic documentation of the program.
* Open, honest communication and strong relations between the personnel involved.

The much-publicised success of the link has led to the establishment of six additional links within the extended community. This has avoided the overuse of the mine as a resource base and has established links which may continue when the mine is no longer viable or is closed down.

HOW YOUR COMPANY CAN GET INVOLVED

The Chamber of Mines has a full-time education adviser, Mr Simon Andrews, to provide advice on how best to develop a school link. Simon, an experienced teacher who has worked closely with industry to establish effective link programs, can suggest activities appropriate to specific situations. Please contact Simon Andrews on phone (02) 247 5384, Fax (02) 223 1215.

MINFO DISTRIBUTION LIST

Minfo is distributed gratis on request to nominated people and/or positions with companies, organisations or institutions and to readers with an interest in the mineral industry. To be added to the list, please return a copy of the form to Minfo Editor, Department of Mineral Resources, PO Box 536, St Leonards 2065.

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DEPARTMENTAL REGIONALISATION — SINGLETON OFFICE

The Department of Mineral Resources has provided a variety of services to the mining industry on a regional level for many years. In recent times the Department has vigorously pursued a policy of regionalisation in order to provide a more efficient and effective service to its clients.

As a result of the regionalisation policy, the Singleton Office has undergone a number of changes, including an increase in staff to 21, more extensive services, and faster turnaround for services provided to the mining industry and public.

The Singleton Office provides services to an area extending from Singleton to Newcastle, Muswellbrook, Gunnedah, Boggabri and Ulan, plus the coal operations at Ashford near the Queensland border.

The Singleton Regional Office can be divided into three functional areas: Coal & Petroleum Geology Branch, Coal & Petroleum Administration Branch and Coal Mining Inspectorate & Engineering Branch.

COAL AND PETROLEUM GEOLOGY BRANCH

A prime function of the Coal & Petroleum Geology Branch is to identify and assess resources of coal, industrial minerals and construction materials in the northern coalfields. The Branch undertakes regional resource assessments and maintains a comprehensive coal and petroleum resource information system.

Another important function is the technical assessment of prospecting operations carried out under the Mining Act and provision of advice on resource issues for potential coal mine developments.

The Branch also investigates and makes recommendations in areas of land use resolution. These investigations may involve drilling or other resource assessment techniques.

Specific services the Coal & Petroleum Geology Branch provides include:

* Land use policy advice.
* Coalfield overviews.
* Exploration and land use drilling.
* Information supply.
* Resource allocation.
* Exploration of new areas.
* Inventory of coal resources.

The Singleton Coal & Petroleum Geology Branch consists of five staff. Enquiries on any matters in this Branch can be directed to Jeff Beckett, Principal Geologist, on (065) 72 4200, Fax (065) 72 1201.

COAL AND PETROLEUM ADMINISTRATION BRANCH

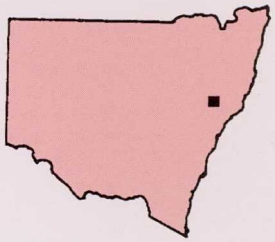
The role of this Branch is to provide service to the Minister, Government, industry and the community in allocating, processing, issuing and maintaining coal and petroleum exploration and mining titles. In addition, the Branch provides guidance to project proponents about legislation and procedures to assist in responsible mining development.

The Singleton Office provides Hunter Valley industry with the same services as those available at Head Office in Sydney, including access to the computerised mining titles data base. Advice on non-coal titles matters is also available.

Accessibility of advice, convenience in lodging applications and the opportunity to have applications vetted on lodgement are major advantages available to industry due to the regionalisation of Coal & Petroleum Administration Branch functions.

Specific services the Coal & Petroleum Administration Branch provides include:

* Details of existing mining and exploration titles.
* Administration of authorisations/ leases.
* Advice on applications and the requirements for the granting of exploration and mining titles.
* Acceptance of applications under the Mining Act.



* Organisation of Planning Focus meetings and facilitation of new project approvals.
* Advice to the public regarding mining titles, including the organisation of solicitors' searches.
* Co-ordination of responses to references from other organisations.

The Singleton Coal & Petroleum Administration Branch consists of six staff. Enquiries on any matters in this Branch can be directed to David Agnew, Regional Manager (Northern), on (065) 72 4200, Fax (065) 72 1201.

COAL MINING INSPECTORATE AND ENGINEERING BRANCH

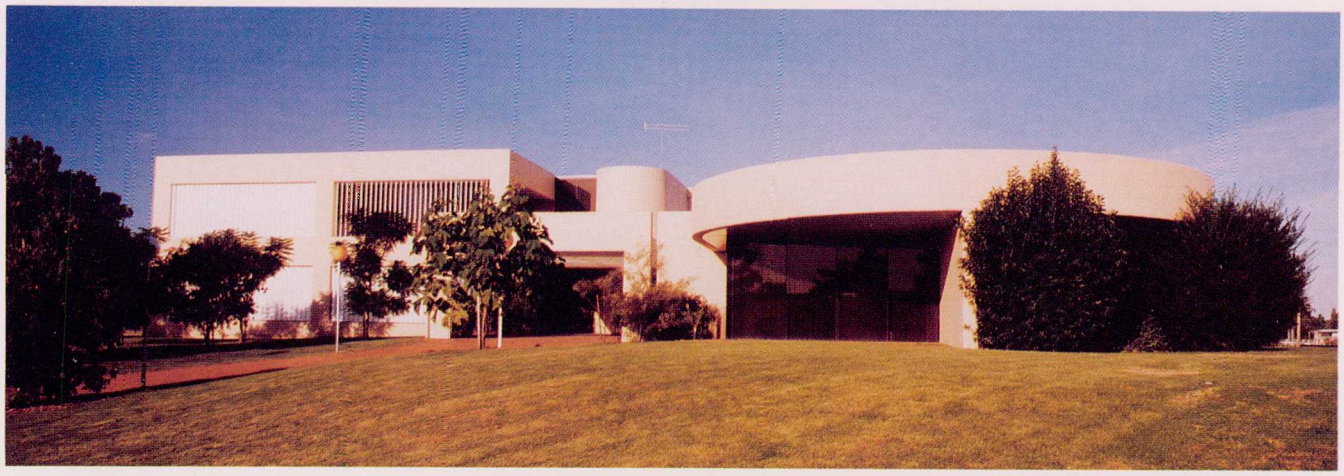
The function of the Branch is to promote best practice in coal mine safety and environmental management

The coal inspectorate at the Singleton Office provides direction, assistance and audit/assessment in respect of safety, health and welfare in coal mines and also in improving environmental management. Engineering risk assessment techniques and rigorous team-based safety accident investigation techniques are utilised to reduce accidents and injuries.

The engineering function of the Office deals with activities associated with mine development, from the assessment stage through exploration and production, to the cessation of operations and rehabilitation.

Specific services the Coal Mining Inspectorate & Engineering Branch provide include:

* Inspection of coal mines on behalf of the government, public and workforce with regard to safety and the environment.
* Investigation of accidents and injuries at coal mines to ascertain causal factors with a view to prevention of similar incidents.



The Singleton Office is located in the Joint Coal Board Building in Civic Avenue
Photo by David Barnes

* Administration of coal lease conditions under the Mining Act for compliance.
* Review of proposed mining developments for resource recovery and acceptability with regard to the environment.
* Investigation of complaints from the public and mine workforce.
* Administration of approval procedures for recovery of coal from both underground and open cut mines.
* Liaison with industry, regional councils and other Government departments to resolve land use issues.
* Assistance to the coal industry to improve safety.
* Conduct of examinations for statutory supervisory positions in the coal industry.
* Assessment and approval to Australian Standards and statutory requirements of new equipment and materials.

The Singleton Coal Mining Inspectorate & Engineering Branch consists of ten staff. Enquiries on any matters in this Branch can be directed to Tony Morgan, Senior Inspector of Coal Mines, on (065) 72 1899, Fax (065) 72 1201.

STATE ENVIRONMENTAL PLANNING POLICY — CONTINUED MINES AND EXTRACTIVE INDUSTRIES

In November 1991, the New South Wales Court of Appeal delivered a judgement concerning the operations of a limestone quarry at Yessabah, west of Kempsey. This judgement made it clear that the quarry, which relied on continuing use rights under the Environmental Planning and Assessment Act 1979, could not be extended laterally beyond its limits as it stood on 3 February 1986 without the operator first obtaining development consent. An argument that the area occupied by ancilliary facilities and mineral reserves could be considered to be part of the 'continuing use' area was rejected by the Court.

Because it is almost impossible for a quarry or open cut mine to continue to operate without extending laterally, the judgement meant that virtually all quarries and open cut mines which rely for planning approval on continuing use rights cannot continue to operate without first obtaining development consent.

To address this problem, the Minister for Planning proposes to introduce a **State Environmental Planning Policy (SEPP) — Continued Mines and Extractive Industries**. The policy will provide for a moratorium period of 2 years and 3 months during which mines and quarries operating under continuing use rights may continue to operate at production rates commensurate with those of the recent past.

Before the moratorium period expires, operators will be expected to obtain the development consent necessary for them to continue legal operations beyond that period. The SEPP also provides that some quarries and mines for which limited expansion of production is proposed, and which are considered to be likely to have relatively minor impact on the environment, will not be designated development. Consequently, development consent applications for such operations will be required to be accompanied by a statement of environmental factors rather than by a full environmental impact statement.

For a mine or quarry to qualify as a 'continued operation' under the policy, operators will need to establish that it:

* was purported to be operated by virtue of continuing use rights (i.e. it was lawfully commenced before the introduction of an environmental planning instrument which permitted the operation only with development consent),
* has not since been abandoned,
* does not have a current development consent and
* is prevented from expanding because of the restrictions imposed by Section 109 (2) of the Environmental Planning and Assessment Act.

In addition, affected operators will have to register with the relevant local council in the first 3 months of the moratorium, submitting information to support the claim that the operation qualifies and indicating the volume of material produced annually since 1 July 1986.

For further information, contact Sam Haddad, Assistant Director, Department of Planning, phone (02) 391 2002, or the Regional Director in the relevant area.

1993 ENVIRONMENTAL COMPETITIONS

This year's **Award for Environmental Excellence in the New South Wales Minerals Industry** has reconfirmed its formal link with the **Enviromine Schools Competition**. Both of the 1992 awards for these initatives were presented by the Governor, His Excellency Rear Admiral Peter Sinclair, at a special function in November last year.

The **Enviromine Schools Competition** uses as the basis for its entries the 'bank' of Highly Commended projects identified by the Environmental Excellence Award over the previous 3 years. Award and Highly Commended winners co-operate in spreading the good news about their achievements by supplying interested school classes with information on their successful environmental management.

Schools entries for the 1993 award are to be in the form of Class Reports which examine the nature and effectiveness of the environmental management techniques employed by at lease one of the listed companies. A class may investigate its local mine or quarry if it prefers. Winning entries will be displayed alongside entries of the industry award winners at The Earth Exchange. Entries close on 1 September.

Nominations for the **Award for Environmental Excellence** were called for earlier in the year, and entries should be received by the State Minerals Advisory Council by 30 July. Any queries about either of these Awards should be addressed to Sally Crossing, Executive Officer of the Council, on (02) 901 8886, Fax (02) 901 8405.

STOP PRESS — NSW MINERALS CONFERENCES

As part of ongoing initiatives to attract further investment in the development of the State's mineral resources, the Department will host two prestigeous conferences over the next 12 months: the **'New South Wales — The State of Exploration' Seminar** on 18 November 1993 and the **Second Minerals Investment Opportunities Conference** on 19 May 1994.

Both conferences will be held at the Sheraton-Wentworth Hotel, Sydney.

Further details will be published in the October 1993 issue of *Minfo*. Enquiries: David Barnard, Development Officer, phone (02) 901 8463, Fax (02) 901 8468.

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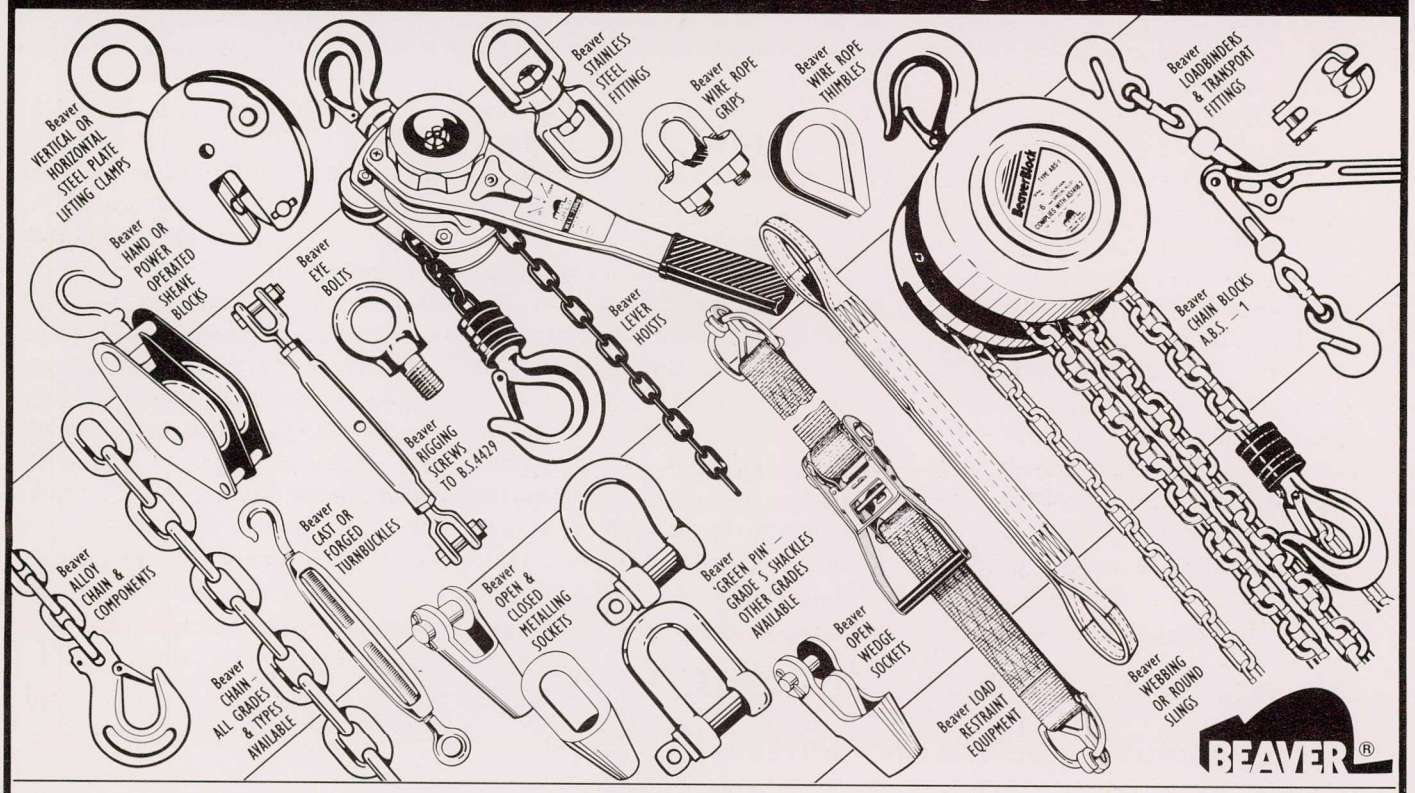

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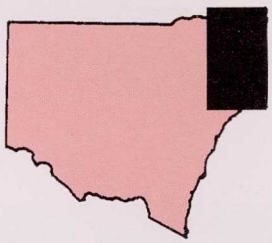

A conference dealing with the geology of the New England Fold Belt was held at the University of New England on 1-3 February 1993, following on from the two previous conferences held in 1982 and 1988. The New England Fold Belt comprises an important group of rocks located along the eastern margin of eastern Australia, from Newcastle in the south to Townsville in the north.

There were four keynote papers and 32 standard papers presented orally, and about 25 poster papers. About 120 people attended, including academics, exploration company geologists and consultants, students, and geologists from governments departments.

The Department of Mineral Resources was well represented by geologists from the Sydney, Singleton and Armidale offices, several of whom gave oral presentations. The Department took the opportunity to display the recently issued Dorrigo–Coffs Harbour and Tamworth–Hastings 1:250 000 Metallogenic Maps, plus the proof of the Manilla–Narrabri map.

One of the most significant new pieces of work was the deep seismic profile across the far southern part of the fold belt. The deep seismic data have lead to a number of reinterpretations of this part of the fold belt (refer to p. 22 herein), particularly the margin with the Lachlan Fold Belt, the structure of the Tamworth Belt, the configuration of the serpentinite belt associated with the Peel Fault, the orientation of the Peel Fault, the structures within the metasediments east of the Peel Fault and the thickness and structure of the western margin of the Bundarra Plutonic Suite.

Other significant work reported included that of the University of Queensland, especially in structural geology and proposed future work on granites. Macquarie University reported a major study into the relationship of the fold belt to its associated basins. Significant structural and metamorphic investigations by the University of Newcastle have led to a radical re-interpretation of mid Permian deformation and Permian tectonics.

A number of papers on granitoids of the Hillgrove Plutonic Suite and their associated mineralisation were presented. Limits to the age of the Hillgrove plutonism have now been established and the relationship to mineralisation is much better known.

A symposium volume of 669 pages contains extended abstracts of 73 papers. Copies of the volume are available from the Secretary, Department of Geology and Geophysics, University of New England, Armidale, NSW 2351, phone (067) 73 2860 , Fax (067) 71 2898 at a cost of $80.00 including postage.

NEW DEPARTMENTAL PUBLICATIONS

1993 MINING INDUSTRY DIRECTORY

A brand-new edition of the **New South Wales Mining Industry Directory** will be available in July. This high-quality 240 page colour publication is a comprehensive guide to the mining industry in the State (excluding coal), and will be invaluable to anyone working in or with the industry.

In response to feedback from readers, this new edition of the Directory has been greatly improved. Cross referencing and indexing have been expanded, and the various sections of the Directory have been colour-coded to improve accessibility of information. Presentation and layout have also been improved, and the publication is attractively illustrated with maps, photos and graphics.

A number of new sections have been added, resulting in the Directory being 25% bigger than last year. The Directory is divided into six major sections, with contents as follows:

* **Section 1**: Industry overview, mining industry awards, new mining legislation, Schools Link Program and maps of major metallic mines and industrial mineral deposits.
* **Section 2**: Profiles of major mines, mining dossiers (listing the State's operating mines by Mining Divisions, alphabetically and by commodity), and lists of quarries and exploration companies. Mine information includes details of operating companies and contacts, mine site location and mine manager, commodities mined, and number of surface and underground staff.
* **Section 3**: Government and industry organisations, education and training organisations, consultants, mineral processing operations and a calendar of major mining events (conferences, exhibitions etc.).
* **Section 4:** Product and services index, suppliers index.
* **Section 5**: Information about the Department of Mineral Resources, including structure and functions, key contacts, offices and services which they provide, and publications and maps available.
* **Section 6**: Company, subject and advertisers' indexes.

The major lists contained in the Directory are also available for the first time in electronic format on a floppy disc for PCs. The lists are in dBase 4, allowing users to format them to suit their own needs, and then to output the information as lists or labels etc., as required. Discs are not available separately, but can be bought with copies of the Directory.

Copies of the 1993 Directory are available from the Information Counter (see page 61), price $40 for the Directory; $90 for the Directory + disc sold together.

PUBLICATIONS RELEASED JANUARY–MARCH 1993

QUARTERLY NOTES
No. 90 (Annual subscription post free $12.00) $3.00

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Early Ordovician graptolite from the Peak Hill district, by L. Sherwin
Mineral deposits of the Newton Boyd and Grafton 1:100 000 sheet areas, by H.F. Henley

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