



MINERAL INDUSTRY QUARTERLY

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MINERAL EXPLORATION

Olympic Dam Copper/Uranium Prospect on Roxby Downs

Western Mining Corporation Holdings Group have reported that a permanent camp has been established and eight diamond drills were operating by the end of the quarter.

Diamond-drillhole RD24 was terminated at 1 150 m and significant mineralisation was intersected as follows:-

343- 649 m (306 m) at 1.1% Cu, 0.35 lbs/tonne U_3O_8

808-1 150 m (342 m) - assays not yet available

Diamond-drillhole RD29 (200 m northeast of RD17) in progress at a depth of 1 001 m intersected mineralisation from 379-453 m and 770-1 000 m but assays are not yet available.

Diamond-drillhole RD26 (800 m east of RD29) was completed at 680 m, without intersecting mineralisation.

The Foreign Investment Review Board has given approval to the arrangements entered into between Western Mining Corporation and BP Australia for the joint detailed exploration and development of the Roxby Downs deposits which provides for 51% Australian equity in the project.

In announcing this decision, the Commonwealth Government Acting Treasurer said that development of the project would provide substantial economic benefits for Australia including employment and export earnings, as well as regional development for South Australia.

Stuart Shelf

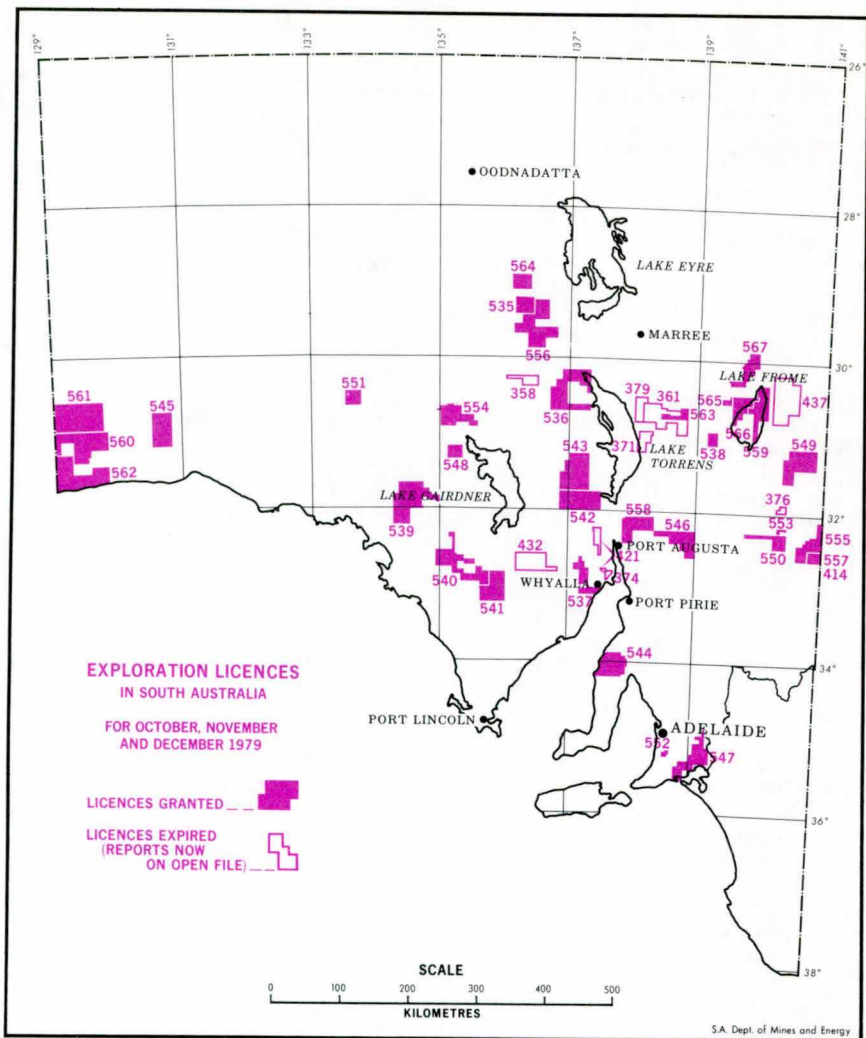
Diamond-drillhole ACD1 on the Acropolis Prospect, 25 km southwest of Olympic Dam, was completed by Western Mining Corporation Ltd at 1 098 m. An interval of 66 m from 924-990 m assayed 0.7% Cu, 0.07 lbs/tonne U_3O_8 .

The style of mineralisation is reported to be similar to that at Olympic Dam. Further drilling will be undertaken to evaluate this prospect.

Exploration Licences

Exploration Licences Granted October-December 1979

No.	Licensee	Term	Expiry	Area (km ²)
535	Newmont Pty Ltd and Getty Oil Development Co. Ltd	1 year	3.10.80	712
536	Western Mining Corp. Ltd	1 year	15.10.80	2358
537	Stockdale Prospecting Ltd	1 year	15.10.80	794
538	Dampier Mining Co. Ltd	1 year	24.10.80	294
539	Carpentaria Exploration Co. Pty Ltd	1 year	24.10.80	2494
540	Carpentaria Exploration Co. Pty Ltd	1 year	24.10.80	1909
541	Carpentaria Exploration Co. Pty Ltd	1 year	24.10.80	1304
542	CSR Ltd	1 year	24.10.80	1705
543	CSR Ltd	1 year	24.10.80	2107
544	North Broken Hill Ltd	1 year	24.10.80	1160
545	Bamboo Creek Gold Mines NL	1 year	12.11.80	1509
546	Swan Resources Ltd	1 year	12.11.80	1304
547	CRA Exploration Pty Ltd	1 year	12.11.80	1453
548	Mines Exploration Pty Ltd	1 year	12.11.80	440
549	Marathon Petroleum Australia Ltd	1 year	12.11.80	1521
550	CRA Exploration Pty Ltd	1 year	12.11.80	830
551	PNC Exploration (Aust.) Pty Ltd	1 year	12.11.80	455



552	Dampier Mining Co. Ltd	1 year	12.11.80	79
553	Esso Exploration & Production Aust. Inc.	1 year	12.11.80	76
554	Amoco Minerals Aust. Co.	1 year	12.11.80	1149
555	Australian Selection (Pty) Ltd	1 year	12.11.80	1058
556	Newmont Pty Ltd and Getty Oil Development Co. Ltd	1 year	12.11.80	1446
557	Marathon Petroleum Aust. Ltd	1 year	12.11.80	365
558	Swan Resources Ltd	1 year	12.11.80	1210
559	Commonwealth Aluminium Corp. Ltd	6 mths	12.05.80	1352
560	AO (Aust.) Pty Ltd	1 year	5.12.80	2345
561	AO (Aust.) Pty Ltd	1 year	5.12.80	3051
562	AO (Aust.) Pty Ltd	1 year	5.12.80	2104
563	Amoco Minerals Aust. Co.	1 year	5.12.80	393
564	Newmont Pty Ltd and Getty Oil Development Co. Ltd	3 1 year	5.12.80	648

565	BP Mining Development Aust. Pty Ltd, Oilmin NL, Transoil NL, Petromin NL, Mines Administration Pty Ltd, and Teton Exploration Drilling Co. Pty Ltd	1 year	17.12.80	166
566	BP Mining Development Aust. Pty Ltd, Oilmin NL, Transoil NL, Petromin NL, Mines Admini- stration Pty Ltd, and Teton Exploration Drilling Pty Ltd	1 year	17.12.80	960
567	BP Mining Development Aust. Pty Ltd, Oilmin NL, Transoil NL, Petromin NL, Mines Administration Pty Ltd, and Teton Exploration Drilling Co. Pty Ltd	1 year	17.12.80	805

Exploration Licences Surrendered or Expired

Reports which have been placed on open file, during the period include the following:

EL 212, 374 (Australian Selection (Pty) Ltd)

Percussion drilling (six holes totalling 810 m) and diamond drilling (one hole of 242 m) undertaken in the Tregolana area disclosed insignificant base-metal mineralisation in black shales at the base of the Tapley Hill Formation (Env. Nos 2658, 3201).

EL 251, 421 (Australian Selection (Pty) Ltd)

Percussion drilling (seven holes totalling 1 307 m) and diamond drilling (three holes totalling 542 m) undertaken in the Tent Hills and Tregolana areas disclosed weak base-metal mineralisation in black shales at the base of the Tapley Hill Formation (Env. Nos 2784, 3410).

EL 358 (Australian Selection (Pty) Ltd)

Following the drilling of a percussion-drillhole (PRE-1) to 200 m through Cretaceous sandy clays to 50 m, Andamooka Limestone to 130 m, Arcoona Quartzite to 180 m, and interpretation of structure over the Stuart Shelf, it was considered that the depth to basement, for justification of further drilling, was excessive north of Parakylia (Env. No. 3152).

EL 361 (Commonwealth Aluminium Corp. Ltd)

A base-metal target was outlined in the Beltana area by detailed mapping and stratigraphic studies, rock geochemical sampling, and geophysical surveying. The anomaly was tested by a 450 m diamond-drillhole, which intersected an Adelaidean sequence adjacent to the Ediacara Fault without disclosing mineralisation (Env. No. 3132).

EL 371 (Commonwealth Aluminium Corp. Ltd)

Ground magnetic and gravity surveys were undertaken to investigate a regional aeromagnetic anomaly in the Nilpena area. Drilling intersected possible Namba Formation and Eyre Formation equivalents, and was terminated at 312 m in lower Tertiary sands. Two bores (aggregate 58 m), drilled on the Lake Torrens Plains near Old Motpena to probe the Cainozoic sequence, failed to disclose the presence of trona (Env. No. 3171).

EL 376 (Esso Exploration and Production (Australia) Inc.)

An area of approximately 101 km² was relinquished from this tenement in the Kalabity area, where poorly outcropping metasediments and granitoids of the Willyama Complex are considered to be unprospective for base metals, following geological mapping and scintillometer traversing (Env. No. 3623).

EL 379 (Commonwealth Aluminium Corp. Ltd)

Magnetic, gravity, and seismic surveys were undertaken to outline targets in the Mount James area (near Old Ediacara H.S.). Drillhole CT1 intersected Tertiary clays and sands to 306 m and was terminated in ?Adelaidean quartzite at 312 m. A second drillhole (MJ1), drilled to 480 m near old Mount James.H.S., was completed in Bunyeroo Formation

without disclosing significant base-metal mineralisation (Env. No. 3205).
EL 414 (Oilmin NL, Transoil NL and Petromin NL)

Regional aeromagnetic anomalies were investigated by ground magnetic, radiometric, soil geochemical, and track etch surveys without giving encouragement for further exploration for base metals in the area south of Mootooroo (Env. No. 3401).

EL 432 (Pancontinental Mining Ltd and Power Reactor and Nuclear Fuel Development Corp.)

Poor outcrop and lateritisation of the metasediments inhibited exploration for uranium in the area south of Nonning. The absence of Middle Proterozoic sandstone cover rock was considered to down-grade the potential for 'unconformity/vein-type' uranium mineralisation. The uranium anomalies, disclosed in radiometric surveys, were attributed to scavenging of uranium by iron and manganese (Env. No. 3413).

EL 437 (CRA Exploration Pty Ltd)

The tenement was secured to explore for sandstone-hosted uranium mineralisation in Tertiary and Mesozoic sediments, and for uranium/copper associated with volcanics on the northerly projection of the Benagerie ridge in the Lake Cootabarlow area. In the absence of any significant gravity anomalies, investigations were terminated (Env. No. 3462).

Exploration Activity

The area of the State covered by Exploration Licences is at an all time high with 169 Licences covering over 200 000 km². They represent expenditure commitments of \$10 million, excluding undertakings recently entered into by joint-venture partners WMC and BP to spend \$60 million in further exploration and evaluation on the Stuart Shelf.

The 54 companies engaged in exploration comprise major mining companies, small mining companies, international power utilities, industrial minerals groups, a few entrepreneurs, and oil companies. Two years ago, only five oil companies were involved in mineral exploration, holding ten per cent of the Licences, whereas there are now 20 oil companies engaged on 25 per cent of the Licences. This represents a significant trend to diversification of their interest in the search for energy minerals: coal, oil shale, and uranium.

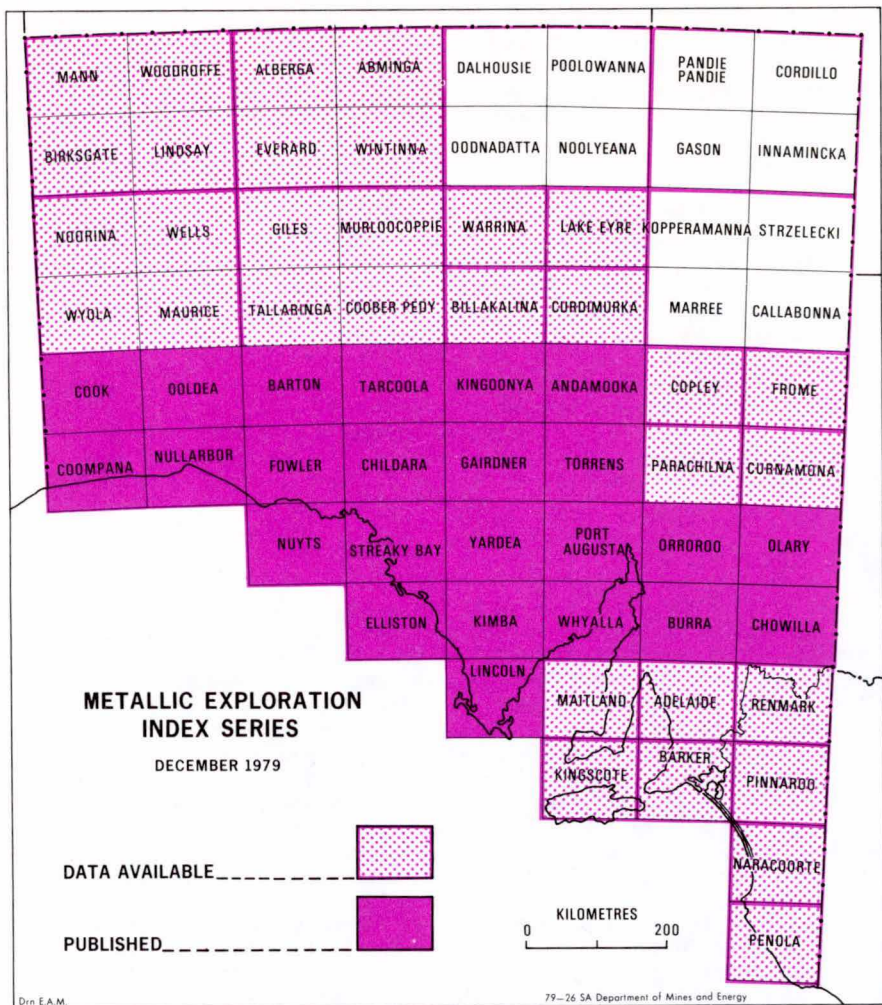
Uranium is the principal commodity of interest, being one of the major objectives in more than one half of the Exploration Licences, encouragement being given by recent discoveries and the recognition of a variety of virtually untested geologically favourable areas.

On the Stuart Shelf, the search for repetitions of the Olympic Dam type of copper/uranium/gold mineralisation has entered a second phase following the initial unsuccessful rush to test the most obvious targets. As the nature of the deposit becomes better established, exploration is being extended to possibly similar environments with similar geophysical responses more distant from the original discovery.

Current activity is not restricted to any region or commodity, it covers a range of metals, energy and industrial minerals, and gemstones, and is being conducted throughout the State.

Interest in exploration for oil shales and evaporitic industrial minerals has been stimulated by recent drilling operations of the Department of Mines and Energy in the Officer Basin.

The successes in Western Australia have prompted search in South Australia for diamonds and thirty tenements to explore for diamonds have been taken up since kimberlites were first recognised in County Kimberley and in the Tent Hills area by Anglo American Corp. (Australia) Ltd.



Dir. E.A.M.

79-26 SA Department of Mines and Energy

South Australian Mineral Production, 1978

Mineral Products	Quantity (tonnes)	Value (\$)
Iron Ore	2 340 168	21 062 000
Jaspilite	36 313	72 000
Natural Gas	2.68 x 10 ³ m ³	43 040 000
Copper (metal content)	12 631	10 793 000
Coal	1 585 419	10 015 000
Limestone (used as mineral).....	1 890 348	3 728 000
Gypsum	648 146	2 529 000
Salt	679 226	2 633 000
Clay	770 720	1 137 000
Zinc Ore	4 137	362 000
Dolomite (used as mineral)	610 658	1 343 000
Silica	114 840	684 000
Talc	14 070	289 000
Barite	12 836	511 000
Gold Ore	75	4 000

Lead Ore	158	12 000
Sillimanite	568	31 000
Damourite	1 505	41 000
Feldspar	1 539	43 000
Heavy-mineral concentrates	-	-
Phosphate Rock	9 996	58 000
Flint Pebbles	92	5 000
Magnesite	173	1 000
Jade	7	4 000
Ornamental Stones	55	14 000
Slate	145	1 000
Total Minerals		\$98 412 000

Construction Materials

Building Stone

Granite	3 121	366 000
Gravel	300	5 000
Limestone	17 112	176 000
Marble	2 026	230 000
Quartz	-	-
Sandstone	1 439	14 000
Slate	5 242	84 000

Sub-total

29 240 875 000

Aggregate, Ballast, Roadstone

Basalt	82 164	207 000
Dolomite	1 599 158	4 285 000
Granite	98 921	218 000
Gravel	806 012	631 000
Greywacke	81 855	306 000
Ironstone	53 506	53 000
Limestone	3 372 713	4 966 000
Quartzite	3 115 213	7 447 000
Rubble	2 090 475	1 075 000
Sand	2 808 138	5 422 000
Sandstone	418 802	343 000
Slate and Shale	71 074	44 000

Sub-total

14 598 031 24 997 000

Total Construction Materials

14 627 271 25 872 000

Total-All Products

(excluding opal)

124 284 000

Opal Production Estimate

35 000 000

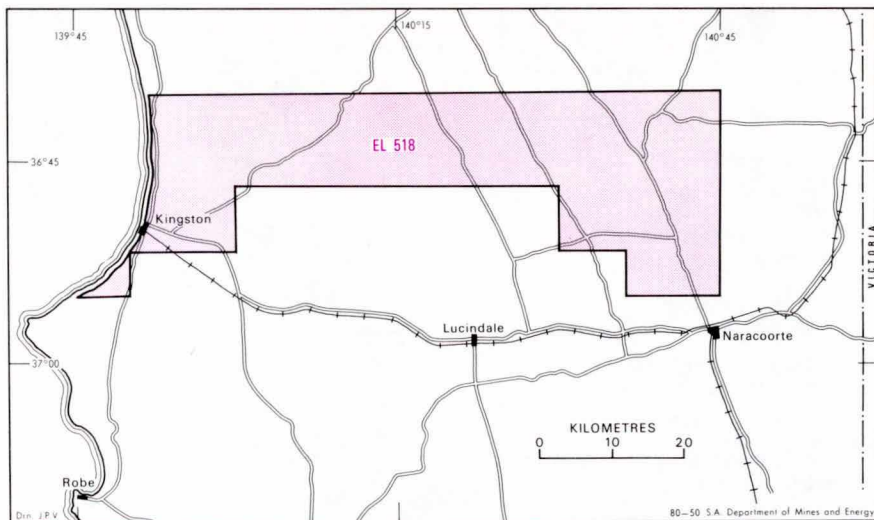
Total Mineral Production

\$159 284 000

Coal Discovery in the South—East

The Directors of WMC Holdings Ltd have announced that exploration drilling for coal in southeastern South Australia has indicated the existence of a deposit of brown coal approximately 20 km northeast of Kingston, the thickness of coal being approximately 10 m, with overburden varying from 40 m to 60 m.

Drilling to date is insufficient to calculate tonnages, but the extent and quality of the coal indicate that the find is of economic significance.



Location plan of EL 518 held by WMC

Detailed drilling to evaluate the Kingston deposits and reconnaissance drilling in South Australia and western Victoria are continuing.

Exploration is being undertaken in the Murray and Otway Basins by WMC, Adelaide Brighton Cement Ltd, Dampier Mining Co. Ltd and Thiess Bros Pty Ltd

URANIUM

Seaham Explorations Pty Ltd

Seaham Explorations Pty Ltd have reported the discovery of uranium mineralisation in silcrete exposed in low erosional escarpments on EL 497, in the Pruville Hut-Mulgaria area.

Mount Victoria Prospect

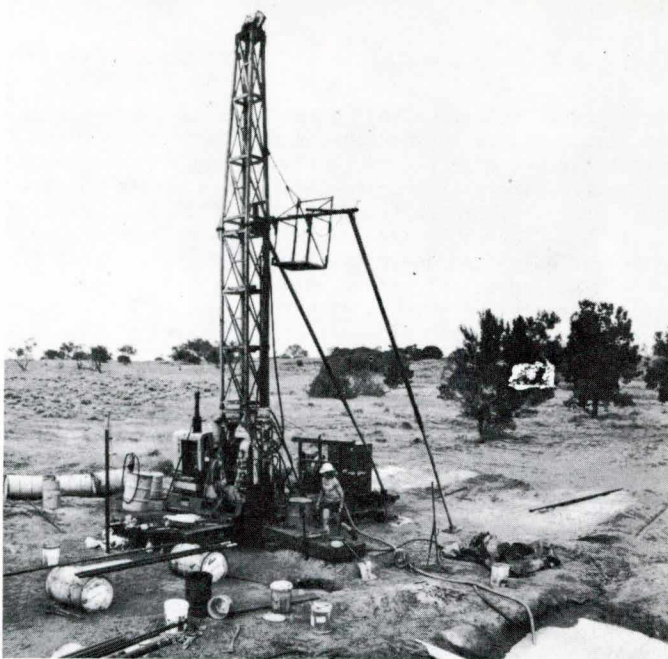
North Flinders Mines Ltd is reported to have undertaken an economic evaluation of the Mount Victoria uranium prospect where there are reserves of 84 000 tonnes of mineralised rock with grades ranging from 5.0-8.7 lbs of uranium oxide per tonne. Development by mining 22 000 tonnes of ore a year, initially from an open cut, is under consideration.

Beverley Prospect

The Chairman of Oilmin NL has announced that Amdel have been engaged to prepare an environmental impact statement on mining of the Beverley uranium prospect. Feasibility studies previously undertaken are being revised.

Honeymoon Prospect

The General Manager of CSR Ltd has revealed that consideration was being given to the partners which include CSR, 21.7%; MIM Holdings Pty Ltd 49%; and Teton Exploration Drilling Co. Pty Ltd, to the construction of a \$2 million pilot plant to determine the commercial feasibility of



Drilling at Roxby Downs (by permission Adelaide Advertiser)

in-situ leaching of the uranium deposit with contained reserves of 2 400 tonnes. The plant, which will employ about 50 people, will be built this year. If successful, full-scale development at an estimated cost of \$30 million could be expected.

Uranium Enquiry

A six-member Legislative Council Select Committee on Uranium Resources has been appointed to report on:

- developments in Australia and overseas since the completion of the Ranger Enquiry in 1977, which have a bearing on the mining, development, and further processing and sale of South Australian uranium resources;
- the safety of workers involved in the mining, milling, transport, further treatment, and storage of uranium in South Australia.

The Committee, proposed by the Leader of the Opposition in the Legislative Council, Mr Sumner, consists of Messrs Burdett, Cameron, Cornwall, Foster and Milne.

Uranium Enrichment

Urenco-Centec has made a detailed submission to the State Government for the construction of a \$500 million uranium enrichment plant in South Australia. The Technical Director of Urenco-Centec (Mr J. Parry) said that site clearance could take place in 1982-83 and be in production by 1988, employing 500 in the construction phase and 100 when in operation.

Safe Disposal of High-Level Nuclear Wastes*

(by A.E. Ringwood, Aust. Nat. University).

Abstract

The elements occurring in high-level nuclear reactor wastes can be safely immobilised by incorporating them within the crystal lattices of the constituent phases of a synthetic rock, SYNROC. Close structural

* Text of an address delivered to the Adelaide Branch of the Australasian Institute of Mining and Metallurgy on 18th October 1979.

analogs of these phases ('hollandite', perovskite and zirconolite) occur in nature, and have survived for periods of 20-2000 million years in geological conditions far more extreme than would be encountered in any proposed radwaste repository. Accelerated leaching tests in water and saline solutions show that SYNROC is unaffected after 24 hours at extreme conditions (up to 900°C and 5000 bars). The combination of these leaching results with the geological evidence for long-term stability indicates that SYNROC should be capable of safely immobilising high-level wastes for periods exceeding one million years when buried in a suitable geological repository. The problem of safe disposal of high-level nuclear wastes is believed to be intrinsically solvable.

Introduction

Nuclear reactors produce a wide range of highly radioactive fission products and actinide elements ('radwastes') that need to be isolated from the biosphere for a period which may be as long as a million years. It is widely assumed that this objective can be achieved by burial of the wastes in a suitable geological repository. There are three primary barriers which then operate to prevent the radwastes from re-entering the biosphere; namely, the local geological environment, the containment system for the wastes, and the nature of the waste form itself.

Geological Barrier

Radwastes can be returned to the biosphere via leaching and circulation of groundwaters. The geological environment of the repository should therefore minimise this possibility. Ideally, the time for groundwater transport of nuclides to the surface should be greater than the time for decay of radionuclides to safe levels. Accordingly, a highly impermeable rock system would be most suitable. Moreover, any pathways in the system should be such that the surfaces along which groundwater solutions travel are able to absorb, precipitate, and via ion exchange processes, greatly delay the migration of radionuclides toward the surface. Rock systems containing clay minerals, in particular, are likely to be most effective in this regard.

There are several different kinds of geological environments under study in various countries with the objective of finding repositories which satisfy these requirements. Bedded salt deposits and salt domes are under consideration in the United States and Germany, whilst crystalline rocks and granites are candidates in Canada and in Sweden. Shales, mudstones, and even the deep-ocean floor all have their advocates. No single kind of rock system is likely to prove uniquely desirable, because all environments have their advantages and disadvantages. However, most earth scientists presently engaged in studying this problem believe that the problem is intrinsically solvable, i.e. that there are very good prospects of finding repositories with the properties needed to keep nuclear reactor wastes out of the biosphere for the required time period.

Containment Barrier

It is highly desirable to surround the radwaste with a locally-engineered environment, which acts to prevent the access of groundwater. An effective procedure would be to surround the waste form with a thick casing of a metal, which is in thermodynamic equilibrium with the geochemical environment of the repository rock system. Fyfe (1977) has proposed the use of copper canisters because there are certain areas in the world where native copper has been in equilibrium with the local geological environment (altered basaltic lava flows) for many hundreds of millions of years. It follows that copper-encased wastes should display considerably long-term integrity in these particular geological environments. The Swedish KBS authorities have adopted this approach and are proposing to encase spent fuel rods in thick cylinders of copper

prior to burial in granitic rock. Bird and Ringwood (1978) advocated the use of a canister made of Ni₃Fe alloy surrounded by a crushed serpentinite overpacking. In nature, Ni₃Fe alloys occur in 60 million year old serpentinised periodotites thereby demonstrating the potential long-term stability of Ni₃Fe canisters in a suitable geological environment.

Immobilisation Barrier

It is believed that in addition to the above two barriers, the inherent immobilisation potential of the waste form itself should be optimised. It is possible to design certain waste-form materials which are exceptionally inert, and which possess enormous resistance to leaching by groundwaters. Ideally, the waste form itself should be capable of withstanding groundwater leaching for a period of at least 1 million years without any significant degree of dissolution. This report discusses this strategically important immobilisation barrier.

The sciences most directly relevant to the problems of radwaste burial within the earth are those of geochemistry and geology. Unfortunately, many people involved in the disposal of radwaste have not always had the required expertise in these areas of science. The nuclear power establishment in the US and Europe, in particular, has been largely controlled by nuclear physicists and engineers, whose proposed geological waste disposal strategies have sometimes appeared to be rather naive. Both the proponents and opponents of nuclear power, even though they may not be earth scientists, should at least attempt to understand the relevant geological and geochemical background to the waste disposal problem, if rational evaluations are to be made.

Immobilisation of High-Level Radwastes in Glass

In the following discussion, it is assumed that used fuel rods are to be reprocessed and fissile materials recovered. This is currently the preferred policy in Europe, and it is suspected that ultimately it will be the policy adopted by other countries, including the United States.

After reprocessing and calcining, the wastes consist of unwanted fission products, actinide elements and processing contaminants, as listed in Table 1. The waste disposal strategy currently favoured by the nuclear power establishment is to incorporate about 25 weight % of radwaste calcine into a borosilicate glass, a typical composition of which is given in Table 2. The borosilicate glass would be poured into stainless steel cylinders, which would be sealed and then buried in an appropriate geological repository.

Table 1. Typical composition of high level radwaste calcine.

<u>Fission Products</u>	<u>Mole %</u>
Rare earth elements Zr, Mo, Ru, Cs, Pd, Sr, Ba, Rb	78
<u>Actinides</u> U, Th, Am, Cm, Pu, Np	1-2
<u>Others</u> (including some processing contaminants) P, Na, Hg, Bi, Si, Tc, Rh, Te	20

Table 2. Composition of typical high-zinc borosilicate glass.

	<u>Wt %</u>
SiO ₂	27.3
B ₂ O ₃	11.1
ZnO	21.3
Na ₂ O + K ₂ O	8.1
MgO + CaO + SrO + BaO	5.9
Radwaste	26.3

However, there are major objections to the use of glass as an immobilisation medium. Borosilicate glasses are highly metastable materials and they are extremely reactive in the presence of water or steam at elevated pressures and temperatures. Studies both in our laboratory and at other scientific centres (Ringwood *et al.*, 1979; McCarthy *et al.*, 1978) have shown that extensive devitrification and alteration of borosilicate glasses occurs on time scales of a few hours, when the glasses are subjected to the effects of water at 300-400°C, and pressures of 300 to 1000 atmospheres. Microprobe analysis shows that elements such as caesium and uranium which were originally present have been very largely leached out of the devitrified region. Moreover, peripheral layers are physically disintegrated.

The mechanisms of dissolution and attack by water vapour are very complicated and not a great deal is known about these processes. Because there are multiple reaction mechanisms, it is not realistic to extrapolate from leaching tests done at, e.g. 70°C for periods of only hours or days, to the long-term behaviour of borosilicate glasses over hundreds of thousands of years.

Until very recently, the nuclear power establishments in some countries proposed burying wastes only ten years after reprocessing so that the glass cylinders would have had centreline temperatures of 300°C or more. In most geological repositories, it is virtually impossible to guarantee that water will not gain access to the waste form, particularly after the repository has been sealed. Under these conditions, with temperatures of a few hundred degrees, and lithostatic pressures of a few hundred bars, there is no confidence in the integrity of the glass. Alteration and loss of hazardous radionuclides would occur on very short time scales indeed. This is far from being a satisfactory disposal method.

During the last couple of years, there have been policy revisions made by the advocates of glass immobilisation in some countries. Whereas previously, they were advocating 25 weight % loading of radwaste in glass followed by burial ten years after removal of the spent fuel from the reactor, now they are proposing aging the glasses for 40 years prior to burial, and also, much lower loadings of radwaste, e.g. 10% (KBS, 1978). This is aimed at reducing the temperatures in the cylinders to about 100-120°C to minimise the likelihood of hydrothermal corrosion. However, even under these more moderate conditions, the integrity of glass cannot be firmly guaranteed for very long periods of time.

Many scientists involved with waste immobilisation do not consider that this is a serious situation, because they have never regarded the integrity of the waste form as a key barrier for preventing radwaste reaching the biosphere. They instead believe that the geological barrier and the container barrier will suffice. Yet it is possible to design an immobilisation barrier which is virtually millions of times safer than glass, and which, in itself, should be sufficient to prevent radwaste contamination of the biosphere. In view of public concern over the hazards of radwaste disposal, there seems to be no excuse for not developing systems with a redundancy of primary fail-safe barriers, each of which is optimised.

The SYNROC Process for HLW Immobilisation

The strategy used has been to optimise the immobilisation barrier provided by the waste form itself. Thus the SYNROC process (Ringwood, 1978) was developed, whereby radwaste elements are incorporated as dilute solid solutions in the minerals of a titanate ceramic or synthetic rock. This material possesses an extreme degree of stability and leach resistance compared to glass, and is not prone to the problems accompanying glass devitrification.

When a mixture of oxides with the composition shown in Table 3 is hot-pressed at temperatures around 1300°C it recrystallises to form a unique titanate ceramic composed of three main phases: 'hollandite'

($BaAl_2Ti_6O_{16}$), perovskite ($CaTiO_3$), and zirconolite ($CaZrTi_2O_7$). The phase chemistry of SYNROC has been well-characterised by detailed electron microprobe studies. These phases are extremely inert, insoluble, refractory minerals, and it was shown experimentally that they have the capacity to accept radwaste elements into their crystal lattices, thereby immobilising them for long periods of time, in just the same way that familiar radioactive elements like uranium, thorium and rubidium, which occur in nature, are immobilised in the crystal lattices of natural minerals like zircon and feldspar. Experiments have shown that the SYNROC waste form would readily accept waste-loadings of 10%, while at the same time, it would have the flexibility to tolerate considerable compositional variations in the waste stream, which is a highly desirable feature.

Table 3. Model bulk composition of SYNROC titanate ceramic, and typical chemical compositions of constituent phases (waste-loading is zero).

	SYNROC	'Hollandite'	Zirconolite	Perovskite
TiO ₂	60.4	73.2	48.4	58.1
ZrO ₂	9.9	0.3	32.0	0.5
Al ₂ O ₃	11.0	12.6	3.3	0.3
CaO	13.9	0.3	16.1	41.1
BaO	4.2	12.3	-	-
NiO	0.6	1.5	-	-
	<u>100.0</u>	<u>100.2</u>	<u>99.8</u>	<u>100.0</u>

In some experiments, SYNROC has been doped with 22 radwaste elements, and the distributions of these elements between the various phases has been studied in detail. These confirmed that these elements become uniformly dispersed through the crystal lattice of particular host phases, where they occupy stable lattice sites, forming dilute solid solutions. It has been demonstrated that nearly all elements in radwaste can be securely locked up in SYNROC crystal lattices in this way. A few, like phosphorus, end up as minor accessory minerals, e.g. phosphates. Table 4 summarises the host phases for the important radionuclides. Each separate phase is the host for a particularly hazardous species: caesium goes into 'hollandite', the actinides, including plutonium, go into zirconolite, and strontium goes into the perovskite phase.

Table 4. Summary of experimental data showing host phases for principal HLW elements in SYNROC.

(a) Major Phases

'Hollandite'		Zirconolite	Perovskite
$BaAl_2Ti_6O_{16}$		$CaZrTi_2O_7$	$CaTiO_3$
Cs ⁺	Mo ⁴⁺	U ⁴⁺ and M ⁴⁺ actinides	Sr ²⁺
K ⁺	Tc ⁴⁺	Th ⁴⁺	(U ⁴⁺ and M ⁴⁺ actinides)
Rb ⁺	Cr ³⁺	Zr ⁴⁺	
(Na ⁺)	Ni ²⁺	Rare Earths ³⁺ + Y ³⁺	(Rare Earths ³⁺)
Ba ²⁺	Fe ²⁺	M ³⁺ actinides	(M ³⁺ actinides)
		Na ⁺	

(b) Accessory Phases

Phosphate (Ba,Ca)₃(PO₄)₂

Metal (may alloy with Ni container) Pd, Ru, Rh, Te.

The partition behaviour of radwaste elements in SYNROC minerals is well understood in terms of the long-established principles of crystal chemistry and mineralogy. The 'hollandite' phase which is the host for caesium, has a crystal structure very similar to that of rutile, which is one of the most insoluble and inert minerals known in nature. A close structural analog of 'hollandite' is the mineral priderite, which occurs in Western Australia in rocks which are 20 million years old and which has therefore demonstrated the ability to survive in the natural environment for very long periods. Zirconolite is also an extremely refractory and inert mineral, and serves as the host for the rare earth elements and for the actinides. Natural zirconolites occur in mafic and alkaline rocks which are over 2000 million years old. Perovskite is likewise inert, and natural samples have also been found in extremely ancient rocks.

Thus there is direct evidence from nature that the three key SYNROC minerals have survived for periods of 20 to 2000 million years in a variety of geological and geochemical environments far more extreme than would be encountered in any proposed radwaste repository. It is this fact, which gives confidence in the long-term stability of SYNROC and in its capacity to immobilise radwaste elements for long enough to permit their safe decay.

Accelerated Leaching Tests

Accelerated leaching tests on SYNROC minerals have been carried out at very high pressures and temperatures. These are not meant to reproduce repository conditions, but rather to obtain results on the relative stabilities of various waste forms on a laboratory time scale. Because reaction rates increase exponentially with temperature, then, a relatively short leach at very high pressures and temperatures in the laboratory is roughly equivalent to leaching for very long periods of time, under less-extreme repository conditions. Both pure water and saline solutions were used in the tests. Borosilicate glasses proved to be highly unstable, rapidly decomposing in a few hours at temperatures over 300°C and pressures over about 300 bars. These results leave little confidence in the long-term integrity of borosilicate glass at repository temperatures of about 100-150°C.

On the other hand, SYNROC doped with uranium, caesium, and strontium has been subjected to hydrothermal leaching in both pure water and saline solutions at 1 000 atmospheres pressure and temperatures of 400°C, 500°C, 600°C, 700°C and 800°C. There is no measurable loss of Cs, U or Sr from the host minerals, no ion-exchange with sodium, and the mechanical properties of the ceramic are in no way changed. SYNROC was then subjected to leaching at 900°C and 5 000 atmospheres (conditions which no naturally-occurring rock could withstand for more than a few minutes) and again virtually no mineralogical alteration was observed. Finally, at 1 000°C and 5 000 atmospheres pressure, the first signs of substantial alteration occurred. The 'hollandite' phase began to corrode in thin surface layers, although the interiors of crystals remained intact. Moreover, the zirconolite and perovskite phases retained uranium and strontium quantitatively.

These simple but dramatic experiments show that SYNROC titanates are remarkably resistant to leaching and ion-exchange processes under hydrothermal conditions in geological - geochemical environments. Because reaction rates increase exponentially with temperature and double every 10°C, to a first approximation there are enormous differences in stability relative to borosilicate glass - a factor of millions.

Radiation Damage

Experiments to date on SYNROC have involved only non-radioactive isotopes and concern has been expressed regarding the effects of radiation damage on the crystal lattices of SYNROC minerals. Experiments are now in progress to investigate this problem. However, there is a large body of data already available on the effects of radiation damage to

natural minerals; radiation damage does not usually cause large increases in the leachability of radioactive elements providing these occur in stable lattice sites. For example, uranium occurring in many zircon crystals has not been leached out in periods of two billion years, despite very intense radiation damage, although its decay-product, lead, which is not so readily accommodated in the zircon lattice, may be easily lost.

The actinides, which are the source of the damaging radiation, occur mainly in the zirconolite phase of SYNROC. In nature, zirconolite is known to have retained up to 20% of uranium for over 500 million years, despite intense radiation damage. This is equivalent to more than 25 times the accumulated alpha particle flux that SYNROC zirconolite would receive over a million years. It is on the basis of the evidence provided by natural minerals, that one can be reasonably confident in the retentive behaviour of SYNROC phases. It is of course essential to substantiate this conclusion by experiments upon synthetic zirconolite subjected to intense radiation damage under controlled laboratory conditions.

Conclusion

If society is to benefit from the uses of nuclear power, there is really no excuse for not utilising the most advanced technologies in order to safeguard future generations from the attendant radiological hazards. In the light of experiments described herein, it cannot be claimed that borosilicate glasses are adequate as immobilisation media. It has been demonstrated that the titanate ceramics produced by the SYNROC process are themselves capable of acting as a major barrier which can prevent radwastes from entering the biosphere. The technology for SYNROC production is presently available, and because of its simplicity and the fact that it is radiologically a much cleaner process, it may well prove economically superior to borosilicate glass manufacture. A key factor is that the SYNROC process is based on an understanding of the manner in which nature immobilises dangerous radioactive elements on a vastly greater scale than has ever been contemplated by the nuclear industry. Moreover, nature has shown that it is possible to safely immobilise radioactive elements for periods which are thousands of times longer than needed for the decay of industrial radwaste.

So it is for these reasons that one can be confident that SYNROC has the capacity to immobilise radwaste and prevent it from entering the biosphere. One must acknowledge that nuclear power nevertheless is still confronted by some major and genuine problems. The proliferation issue is particularly difficult. However, waste disposal should no longer be regarded as a really key problem because, in principle, it can be solved. The opponents of nuclear power should not, in good conscience, emphasise the waste disposal issue as a principal justification for their opposition.

References

- Bird, J. and Ringwood, A.E., 1978. Container for radioactive nuclear waste materials. US Patent Application No. 878113.
- Fyfe, W.S., 1977. Abstract. *Geol. Soc. Am.*, 9, Annu. Meet. 983.
- KBS (Kärn-Bränsle-Säkerhet), 1978. Handling of spent nuclear fuel and final storage of vitrified high level reprocessing waste. *Report by Nuclear Fuel Safety Project to Swedish Government*. Ultraoffset AB SOLNA.
- McCarthy, G.J., White, W., Roy, R., Scheetz, B., Komarnani, S., Smith, D. and Roy, D., 1978. Interactions between nuclear wastes and surrounding rock. *Nature, Lond.*, 273: 216-217.
- Ringwood, A.E., 1978. *Safe Disposal of High Level Nuclear Reactor Wastes: A New Strategy*. Australian National University Press, Canberra.
- Ringwood, A.E., Kesson, S.E., Ware, N.G., Hibberson, W.S. and Major, A., 1979. Immobilisation of high level nuclear reactor waste in SYNROC. *Nature, Lond.*, 278: 219-223.

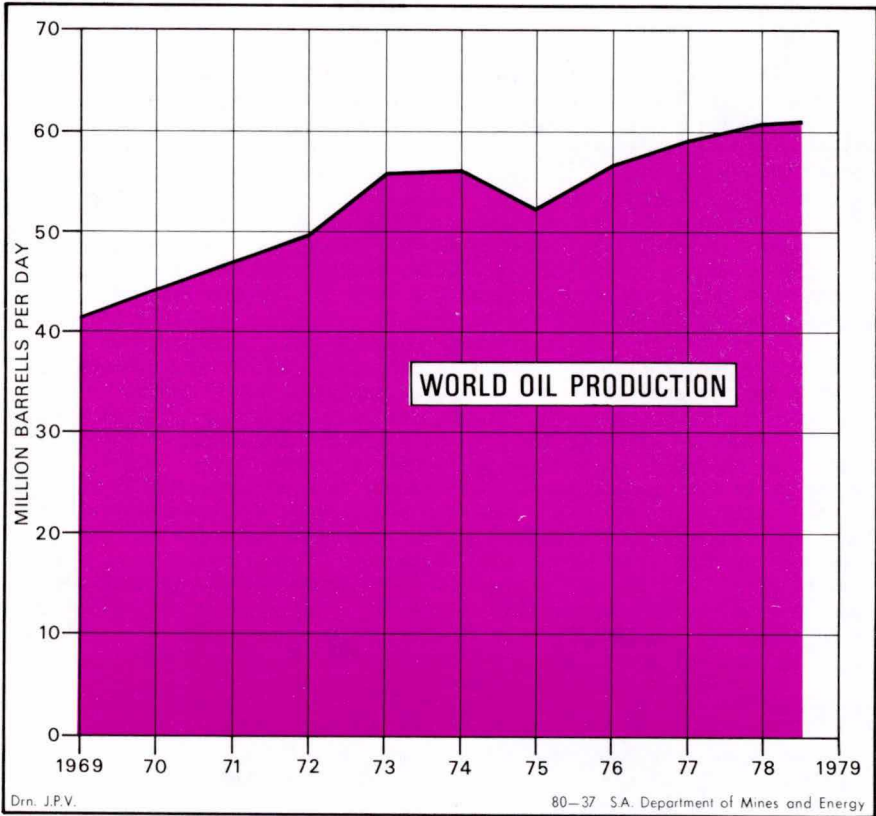
PETROLEUM NEWS

Cooper Basin

Wells drilled during the quarter are as follows:-

	<u>Completed</u>	<u>T.D. (m)</u>	<u>Status</u>
Wilpinnie No. 1	12.11.79	2355	Shut in gas well
Nappacoongee No. 2	13.12.79	1983	Dry

Wilpinnie No. 1, situated approximately 3 km south of Nappacoongee No. 1 was a sole-risk well drilled by SAOGC. The well flowed gas at a rate of 51 000 cubic metres per day from the top of the Early Permian Patchawarra Formation. Nappacoongee No. 1 recovered 61 m of oil and 1 006 m of gas-cut water from a drill-stem test in the middle-lower Jurassic. The Permian section was dry.



Ocean Endeavour

The semi-submersible offshore oil drilling platform, Ocean Endeavour, one of four Australian built rigs, which was completed in 1975, was towed from Port Lincoln on 2nd December bound for the North Sea. The move follows a decision by the Australian Industry Development Corp. and Ampol Petroleum to each sell their 25% interests in the rig to Canam Drilling.

Petroleum Exploration Research

The South Australian Department of Mines and Energy has received a grant of \$26 000 from the National Energy Research Development and Demonstration Council for the design and evaluation of a laboratory technique for the rapid evaluation of non-marine petroleum source rocks.

The use of pyrolysis-gas chromatography will be investigated as a means of characterising organic matter and of measuring its hydrocarbon generating potential, in cuttings from exploration wells.

From this information, it will be possible to determine the direction which further exploration should take. Commercial systems have been established which aim to provide this type of information, but they are expensive, and of uncertain value in non-marine sedimentary rocks.

The technique being developed by Dr. David McKirdy is expected to be more rapid and to have a direct application to petroleum exploration in non-marine sedimentary rocks in South Australia (in the Cooper, Pedirka, Officer, Eromanga and Otway Basins and elsewhere). Initially, development of the technique will be concerned with assessment of the Cooper Basin.

Security of Gas Supplies

Mr. Trevor Watkins, Chief Engineer of the South Australian Gas Company, has recently been overseas studying the feasibility of constructing a liquefied natural gas storage as an emergency back-up to existing supplies from the Cooper Basin.

There is a need for a storage near Adelaide, since the city depends upon gas supplies brought from the Cooper Basin by the Moomba-Adelaide Pipeline for electricity generation and domestic, commercial and industrial heating. Gas pipelines operate at high pressures and high-stress levels in the pipeline steel, and are therefore susceptible to damage from outside agencies. Further, a storage near the centre of demand can be used for peak shaving, i.e., to supply gas from storage when the demand is at its maximum and thus effectively increase the capacity of the pipeline. Under optimum conditions, it might be possible to operate the pipeline at a constant load all year round, fully utilising its capacity, and thus decreasing cost of operation.

Two schemes have been proposed; the liquefied natural gas (LNG) storage, which is being investigated by the South Australian Gas Company, and storage in a Tertiary aquifer below the North Adelaide Plains near Virginia, which is being investigated by the South Australian Department of Mines and Energy on behalf of the Pipelines Authority of South Australia.

The two schemes have very different characteristics. For a similar capital cost, an underground storage would hold more gas, be able to deliver it at a higher rate, and enable the pipeline to operate at maximum capacity. A liquefied natural gas storage has the advantage of accepting gas from the pipeline, by sea from the North West Shelf, or conceivably by road from Melbourne, where such a storage has been constructed.

COMPANY NEWS

Adelaide Brighton Cement Co. Ltd

The company will spend \$6 million on expansions at Birkenhead that include building of a 30 000 tonnes capacity silo having a loading rate of 1 000 tonnes per hour. Modifications to M.V. Accolade will include a new unloading system capable of handling its doubled capacity.

BHP Co. Ltd

A contract has been won to supply 180 000 tonnes of fine iron ore, worth \$2.8 million, to the Natural Gas Authority of Thailand for use as a heavy-density aggregate in the manufacture of concrete for construction of an offshore pipeline.

Santos Ltd

The group's share of natural gas production was 16 032 terajoules in the September quarter - 16.1% above that of the previous quarter. Exploration expenditure rose from \$750 800 to \$1.3 million, while \$1.5 million was spent on plant and production facilities.

Alliance Oil Development NL

AOD's share of gas production increased from 250 938 to 296 388 gigajoules in the September quarter, while exploration expenditure was down from \$103 194 to \$85 374.

CSR Ltd

Through its subsidiary AAR Ltd, CSR Ltd will farm into WMC Ltd's interest in the Pedirka Basin (Licences PEL 5 and 6) by expenditure of \$4 million on seismic surveys and drilling by 1982.

Mines Administration Pty Ltd and CSR are engaged in uranium exploration in the Lake Frome area and in joint development of the Honeymoon deposits.

On the Sturt Shelf, \$1.3 million is to be spent by 1982 on copper exploration over a large area centred on the Cattle Grid copper mine at Mount Gunson.

Additional staff are being recruited to undertake the expanding operations.

OPAL

Precious Stones Claims

Amendments to the regulations, which provide for identification plates, were gazetted on 18th October. There is now a requirement for a miner in pegging a precious stones claim to purchase a set of plates and attach one to each post of the claim. A leaflet outlining the principles of identification plates is available from Departmental offices on the opal fields.

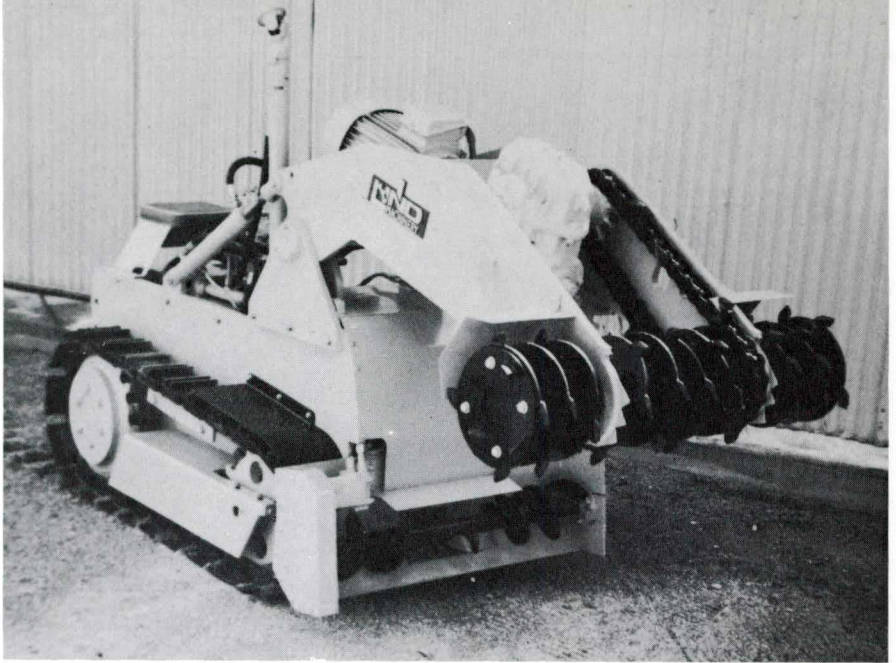
Cooper Pedy

New desalination equipment to be installed at Cooper Pedy later this year will increase the town's supply of treated water by about 60 per cent; its cost will be about \$110 000.

Tunnelling Machines

In 1978, the opal mining industry agreed that in the interest of greater efficiency the improvised tunnelling machinery in use at that time required substantial modification.

Lind Enterprise of Adelaide who had previously converted tractors



Tunnelling machine manufactured by Lind Enterprise Pty Ltd
Negative 31571

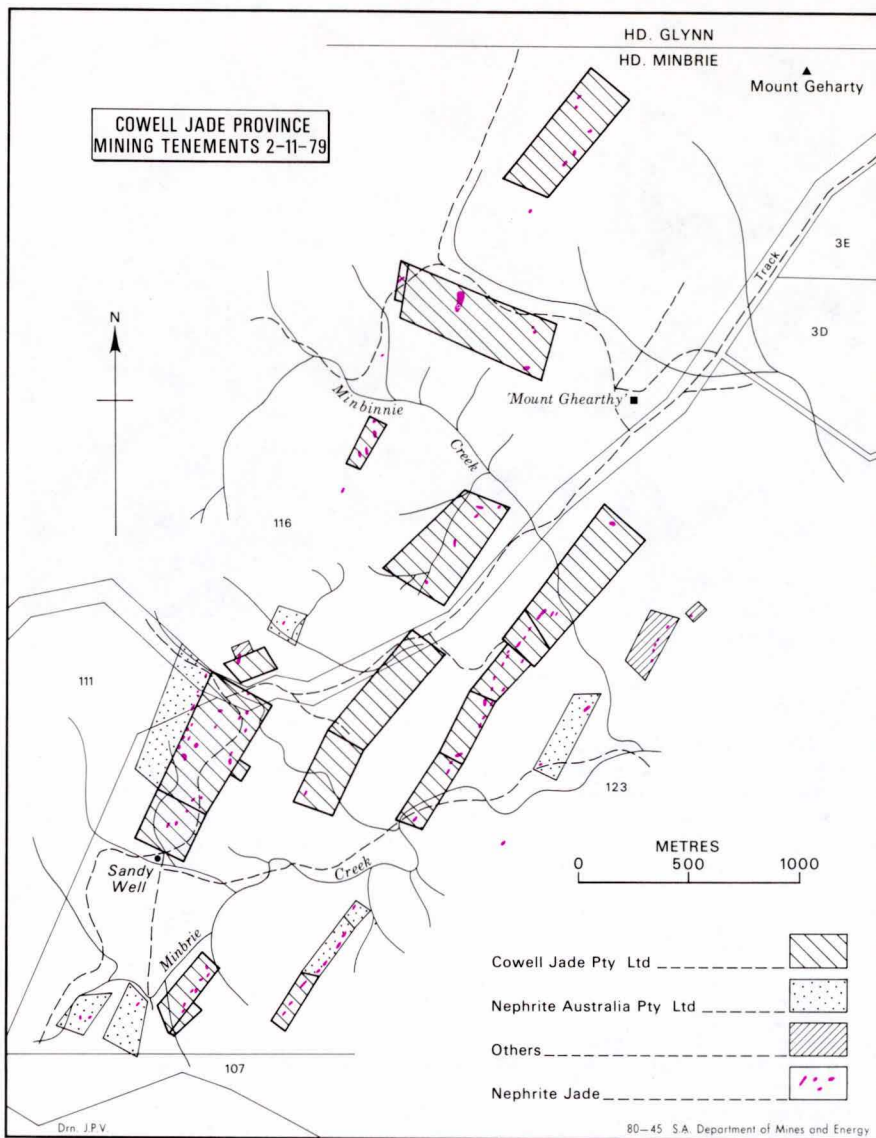
for mining use began development of machinery designed specifically for opal mining use. After two years of development, the company now produces a machine which can tunnel at a rate of 3 metres per hour and which can be dismantled and lowered into 1 metre diameter shaft. Tunnelling speed however, is dependent on the efficiency of the blower system and in larger form can be adapted for use in coal and other mining activities.

The machine is powered by a 50 kVA alternator and has a 12 volt lighting for safety.

JADE

The following developments have rationalised the industry and are expected to permit further steady growth of this promising mining venture.

- The Chairman of Cowell Jade, Mr Graham Robertson, announced that Cowell Jade had by share allocation acquired the seven leases held by Australian (Nephrite) Jade Mines Pty Ltd. Cowell Jade now hold in excess of 90 per cent of the inferred reserves within the province.
- Development of two deposits by Cowell Jade has revealed increased reserves of high-quality jade. Thus, jade outcrop 32 will be an important source of green jade in the future. Outcrop 69 of high-quality black jade has produced approximately 50 tonnes and substantial reserves remain. With depth, the jade became less jointed with blocks up to 12 tonnes being mined. The recovery of such large blocks is being examined.
- Cowell Jade has placed a parcel of shares with Hong Kong and London interests to raise \$87 500 for enlargement of the company's workshop facilities at Cowell. The workshop employs three men in cutting, slabbing, and polishing the product. **19**



FURTHER PROCESSING OF GEMSTONES

The Australian Minerals and Energy Council and the Commonwealth State Industry Ministers' Conference established a Standing Joint Study Group on Raw Materials Processing in 1978 to encourage further processing of raw materials in Australia. A report by the Working Party established to examine the potential for further processing of gemstones has recommended that:

- tax averaging provisions currently applicable to primary producers be extended to apply to miners of gemstones;
- the definition of *processed* gemstones used by the Export Development

- Grants Board in determining eligibility for export assistance be redefined to relate only to forms ready for mounting in jewellery;
- the cost of training cutters be eligible for assistance under training schemes such as NEAT or SYETP for the whole period of training;
 - approval for, and possible assistance be given to the importing of skilled overseas cutters for limited periods to provide in-house training of local cutters;
 - marketing facilities be investigated to encourage orderly development of the industry by securing better prices for the miners through increased competition and by assisting local processors secure access to rough stone;
 - in negotiations for the establishment of a diamond mining industry in Western Australia, Government has regard to the benefits that would arise from the establishment of an industry for processing diamonds.

ENERGY POLICY FOR SOUTH AUSTRALIA

The Minister of Mines and Energy, Mr Roger Goldsworthy, in outlining the Government's energy strategy for South Australia, said in the House of Assembly on 18th October that strong management of the State's existing energy resources was called for, together with encouragement for the discovery and development of additional energy resources and incentives for research and development of alternative energy sources and energy conservation.

The local energy situation is one of imbalance. Coal deposits, which represent more than one half of energy reserves satisfy only one quarter of current energy demand. Evaluation of alternatives to the Leigh Creek deposits needs to be undertaken to determine how they can best be utilised.

Natural gas from the Cooper Basin constitutes about 4 per cent of the State's presently known energy reserves, but accounts for one-third of energy usage. Supplies for Adelaide are not assured beyond 1987.

The known reserves of petroleum liquids, associated with natural gas, constitute about 1 per cent of energy reserves, while petroleum products constitute about 40 per cent of energy usage. LPG reserves amount to 90 million barrels, while the crude oil and condensate of the Cooper Basin constitute 5 per cent of Australia's liquid petroleum reserves.

The Government has allocated \$31.5 million for an accelerated program of exploration in the Cooper Basin by the South Australian Oil and Gas Corporation over the next three years, for seismic surveys and the drilling of at least 22 wells. This recognises the need to explore virgin structures, as well as extend the known fields.

The Redcliff petrochemical project is a major priority, offering development opportunity for the Port Augusta/Port Pirie/Whyalla area, and the very real strengthening of the economy, because of the financial impact of the complex and the role that its output will play in import substitution. The liquids pipeline to be constructed as part of the project, at an estimated cost of more than \$50 million, will make the Cooper Basin liquids available for refining and use.

The options for processing and utilisation of South Australian coals are to be investigated and a bulk sample of Wakefield coal is being procured for combustion tests. Reserves of coal sufficient for the requirements of the Port Augusta power stations have been established at Leigh Creek, but their recovery will necessitate mining to much greater depths than at present. During the next six years, \$60 million will be spent on purchase of mining equipment, while the township of Leigh Creek will be relocated 13 km to a site known as Leigh Creek South at a cost of \$36 million. Construction of a new 500 MW power station at Port



New town site for Leigh Creek

(by permission Adelaide Advertiser)

Augusta will involve expenditure in excess of \$300 million over the next five years.

The question of energy conservation is seen as being dependent on public education, Government example, and research and development. Provision has been made for expenditure of \$109 000 on the National Energy Conservation Program, including an advertising campaign, a booklet for motorists, public relations activities, leaflets, and manuals on management for industry and commerce. An energy information centre will be established to provide advice to the public on the use and conservation of energy.

Other initiatives include reduction of State Government fuel consumption by 10 per cent, use of smaller, more fuel efficient vehicles, assessment of energy recovery from domestic, industrial and other wastes in the metropolitan area, and study of the processing options for Cooper Basin liquids, including utilisation of LPG as a petrol substitute.

An allocation of almost \$300 000 has been made for funding research projects through the State Energy Research Advisory Committee. A further \$120 000 has been allocated to support development of the Flinders electric vehicle by subsidising purchase of 12 electric vans for technical and economic evaluation of performance.

Through the Department of Mines and Energy, appropriate relationships are being maintained with refiners and major users regarding energy supply, availability and distribution, and the Commonwealth Government in the Commonwealth/State Oil Supplies Liaison Committee and the National Petroleum Advisory Committee. The South Australian Energy Council provides advice to the Government on energy conservation, development and co-ordination of existing energy supplies, development and utilisation of energy resources, rationalisation of final uses of energy, and research into alternative energy sources. Consultative groups are to be established to advise on the use of liquid fuels and the use of energy in buildings.

Thus, faced with the twin challenges of budgetary constraint and a demanding energy situation, the Government is adopting a most positive approach - new exploration is to be undertaken, planning for Redcliff is

proceeding, uses of available coals are to be investigated, a national campaign on energy conservation is being supported, the Government is actively setting an example in energy conservation, research and development are being actively and materially encouraged, and energy management is being strengthened.

ENERGY RESEARCH

South Australian Government grants for energy research totalling almost \$180 000 were announced recently by the Minister of Mines and Energy, Mr Goldsworthy.

Ten grants were recommended by the State Energy Research Advisory Committee (SENRAAC). Other research projects will be announced later.

Of the ten projects, five are new and five are ongoing and have received previous funding by SENRAAC. Details of the projects are as follows:

- \$22 153 to the Flinders Institute for Energy Studies for development of a tracking concentrator solar system for use in the temperature range 130^o-180^oC. It is expected that the concentrating collectors will be used jointly with flat-plate solar collectors to provide process hot water and steam for industrial processes.
- \$22 340 to the Energy Resources Group (South Australian Institute of Technology) to develop and monitor a demonstration domestic solar air-conditioning system under a variety of load conditions. The project is expected to stimulate and provide technical data for further development of solar air-conditioning technology.
- \$12 500 to the University of Adelaide (Chemical Engineering Department) for development of an air-conditioning system which can operate without the use of substantial electrical energy. This project has the potential to lead to significant reductions in the demand for electrical energy.
- \$500 to the South Australian Institute of Technology (Whyalla) to design and construct a radiative, space cooling system for use in dry, hot climates;
- \$7 000 to the Watt Engine Research and Development Group for the design, construction, and development of an alternative internal combustion engine. Preliminary tests have shown that the Watt engine will operate at a higher rate of fuel efficiency than conventional internal combustion engines.
- \$25 000 to the University of Adelaide (Department of Mechanical Engineering) to investigate a means of increasing the turbulent mixing of fuels and hence improve combustion efficiency and stability;
- \$32 000 to the Flinders University Institute for Energy Studies to develop and test batteries for electric vehicle propulsion;
- \$5 700 to the Energy Resources Group (South Australian Institute of Technology) to add to an insolation measuring station at the Institute, the establishment of which was funded by a previous Government grant. The measurement of insolation data is important for solar energy project design.
- \$18 419 to the Electric Vehicle Centre (Flinders University) for construction of a diagnostic dynamometer capable of accurately measuring the parameters of an electric vehicle in a laboratory. Such testing will be important in the further development of electric vehicles.
- \$34 000 to the South Australian Gas Company for conversion of a fleet of 25 vehicles to use compressed natural gas (CNG) as fuel. This demonstration project is expected to provide industry with an analysis of CNG technology.

\$6 500 as a supplementary grant for a joint South Australian Institute of Technology/Roseworthy Agricultural College project to design and construct a test prototype methane generator based on effluent from piggeries.

ELECTRIC VEHICLES

NERDDC Grant

The South Australian Department of Mines and Energy will receive Federal funding of \$40 000 from the National Energy Research Development and Demonstration Council to develop a battery exchange facility for electric vehicles.

The facility will be developed at the Thebarton site and is expected to be in operation by about May. The prototype will be operated in conjunction with the Government's electric vehicle demonstration fleet and will include a driver operated battery exchange lift, battery-pack rechargers, and maintenance equipment.

Later, it is intended to extend the system to service stations in the Adelaide metropolitan area to provide support infrastructure for commercial vans using electric vehicles technology developed in South Australia.

EVE-80

In announcing receipt of NERDDC funding, the Minister of Mines and Energy, Mr Goldsworthy, said international recognition of South Australia's initiatives to develop electric vehicle technology was reflected in the response to the Electric Vehicle Exposition to be held in Adelaide August 26th-29th, when 400 delegates were expected, including some of the world's leading researchers in the field.

The Exposition will be held at Flinders University, and on the opening day, international developments in electric vehicles will be discussed by speakers from the United States, Japan, and Britain, as well as Australia. The Deputy Director of the Australian National Energy Office, Dr D.J. Ives, will present a paper on the place of electric vehicles in Australian energy policy, and Mr G. Wicken, who leads electric vehicle demonstration in the United Kingdom, will present another.

The second day will cover battery systems for traction applications and speakers will include Dr Lars Ojefors (Swedish National Development Company), Dr M. Stanley Whittingham (Director of Exxon Research and Engineering in the United States), and Professor K.V. Kordesch (Graz University in Austria).

The third day of the Exposition will examine the market for electric vehicles, when papers will be delivered by Mr G. Harding (Lucas Industries in the United Kingdom), and Professor G.J. Hwang (National Tsing Hua University, Taiwan).

The closing day will examine the continuing development of electric vehicles, performance testing, safety, maintenance, and infrastructure.

There will be a display of electric vehicles and several newly developed battery power sources. Vehicles so far offered for public demonstration include a Bedford conversion one-tonne van from Lucas Industries, a two-and-one-half tonne van, the 'Silent Karrier', from Chloride Batteries in the United Kingdom, the Flinders University electric vehicle, and the Gosden vehicle from New South Wales.

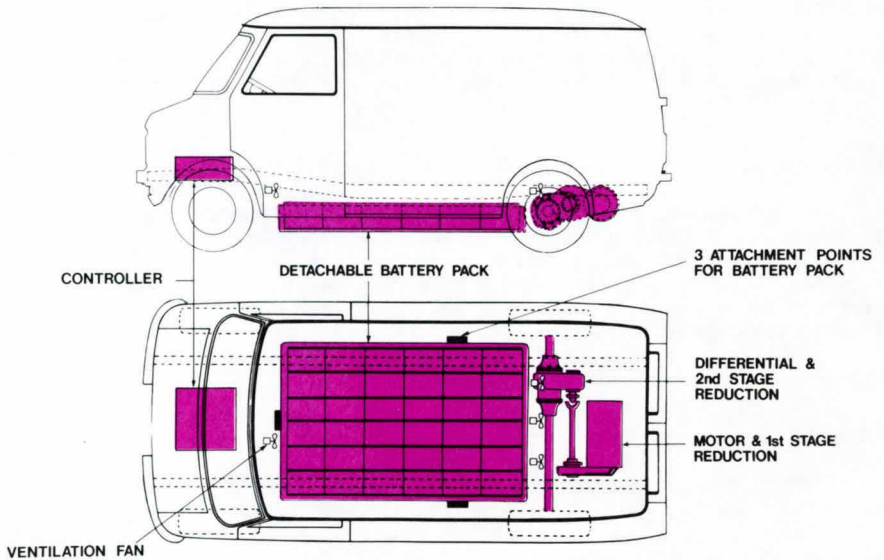
The South Australian Government is being assisted in organising the Electric Vehicle Exposition by the CSIRO, the Australian Electric Vehicle Association, Flinders University, the Australian Lead Development Association, and the Adelaide Convention Bureau.

The Government is planning the event as an international exposition to give Australians an opportunity to see what is available now, or will be in the near future, on local and world markets.



Lucas electric van

Negative 31570



Lucas Electric Van

Lucas Industries of Australia provided the Departments of Mines and Energy, Public Buildings, and Highways with a prototype one-tonne electric van for a demonstration trial during December. Constructed by the UK parent company, it utilises Lucas technology in a Bedford CF series van, the same as is used for the Flinders electric vehicle.

MINING AMENDMENTS

Following amendments to the Mining Act in 1978, variations to the Regulations gazetted on 18th October included definition of otherwise 'extractive minerals' to be considered as 'minerals' when used for prescribed purposes such as chemical, cement and glass manufacture, and application procedures for Retention Leases (these were referred to in more detail in MIQ No. 10).

SYMPOSIA AND CONFERENCES

Mining Symposium

The Australian Academy of Technological Sciences held a mining symposium in Adelaide on 11th-12th October. Following the Official Opening by Sir Henry Somerset an address was given by Professor E.A. Rudd, 'Australian Mineral Resources in the World Scene'. Papers were presented by the following:-

Exploration	—	Dr D. Haynes, Western Mining Corp. Ltd Dr R. Mazzuchelli, Western Mining Corp. Ltd Mr H. Rutter, BHP Co. Ltd
Mining	—	Mr R.T. Madigan, Hamersley Holdings Ltd Mr J.B. Oliver, Western Mining Corp. Ltd
Beneficiation	—	Prof. F. Aplan, Pennsylvania State University Mr N. Jackson, Amdel
Extractive Metallurgy	—	Prof. H. Kellogg, Columbia University, NY Dr R.W. Pickering, Consultant
Environmental aspects	—	Prof. B.G. Wixson, University of Missouri-Rolla Mr J.E. Coaldrake, A.A. Heath and Partners Pty Ltd

Gawler Craton Symposium

The symposium, which was held at AMF on 11th December and organised by the South Australian Division of the Geological Society of Australia, was attended by 180 geologists, with 58 companies represented. It embraced the Archaean, Early and Middle Proterozoic rocks of the Gawler Craton, their igneous, metamorphic and structural evolution, and stratigraphic relationships.

Cores from stratigraphic drillholes were also displayed at the Core Library of the Department of Mines and Energy.

Mining Seminar

Thirty teachers attended a four-day seminar on the 'Mining and Petroleum Industry' held from 19th-23rd November at AMF.

The conference was initiated and financially supported by the mining industry, AMF, Department of Mines and Energy, and the Education Department.

Uranium Enrichment

Most modern nuclear power stations require enriched uranium, in which the natural U^{235} level of 0.7 per cent has been raised to about 3 per cent. Enrichment is a major step in the nuclear fuel cycle. West Germany, Holland and Britain have developed the gas centrifuge enrichment process and through a unique international industrial enterprise, Urenco-Centec, provide requirements for nuclear station operators.

The centrifuge process, because of its low-energy requirement and viability at small scale, is the most attractive option for the future, and is under serious consideration in Australia as an adjunct to the uranium mining industry.

The activities of Urenco-Centec, and a review of enrichment processes, were presented by Dr R.B. Kehoe, Business Development Manager, Urenco-Centec to a meeting of the Institute of Engineers on 10th December.

RECENT PUBLICATIONS AND REPORTS

Bulletin No. 49

Regional stratigraphic analysis of the Gidgealpa Group, Southern Cooper Basin, Australia (R.C.N. Thornton).

Report of Investigations No. 50

Eocene to Miocene stratigraphy of the Willunga Embayment (B.J. Cooper).

Quarterly Geological Notes No. 72

Buried valley profiles, Mount Lofty Botanic Gardens (J.C. Beal).

Examination of bores near the Gawler River, Northern Adelaide Plains (D. McPharlin).

Megabreccia in Burra Group, Worumba Anticline (W.V. Preiss).

Brochures

Underground Water in the Mount Gambier Area

Volcanoes of the Mount Gambier Area

Aboriginal Sites in South Australia

Selected Unpublished Reports

RB 79/6 - Opal at Stuart Creek, Charlie Swamp and Yarra Wurta Cliff. Report No. 1. Geological investigation and Calweld drilling of the Stuart Creek Precious Stones Field (L.C. Barnes)

RB 79/58 - Reaphook Hill scholzite deposit (W.S. McCallum)

RB 79/90 - A geophysical interpretation with depths to magnetic basement - TALLARINGA, GILES and MURLOOCPPIE 1:250 000 sheets (B. Finlayson)

RB 79/98 - Steelley's barite deposit - Linke Lode, Flinders Ranges (D.C. Scott)

RB 79/118 - Chrysoprase and moss agate deposits, Mount Davies, Northwest Province (C.H.H. Conon)

RB 79/120 - Gravity and magnetic measurements over a diapiric structure near Quorn (J. Iredale and L.P. Hough)

RB 79/124 - Baila Hill amazonite deposit - Koppio (P.D. Johnson)

RB 79/142 - Port Macdonnell and Southend township water supply prospects (P.C. Smith)

Special Publication

A source book for the South Australian portion of the Officer Basin (G.M. Pitt and B.C. Youngs). This report contains over 200 references, a keyword index, and plans showing the areas covered. (Cost approx. \$7 plus postage).

Recent Geophysical Publications

Bouguer Gravity Anomaly Maps

Bopeechee (6338)	-	1:100 000
Wangianna (6438)	-	1:100 000

Aeromagnetic Maps of Total Intensity

1:100 000 scale maps

Pasmore	6835
Benagerie	6935
Lake Charles	7035
Cowell	6230

1:50 000 scale maps

Arno	6230-III
Cowell	6230-I
Mangalo	6230-IV
Wilton	6330-IV

Republished Company Aeromagnetic Survey Data

	<u>Scale</u>	<u>Locality</u>
Bureau of Mineral Resources	1: 50 000	Middleback Ranges
Samedan Oil Corp. EL 333	1:100 000	Billakalina Homestead
Kennecott Exploration (Aust.) Pty Ltd EL 345	1: 50 000	Nickil (Mt Purvis)
Australian Mining Corp. Ltd SML 270	1:100 000	Peake and Dennison Ranges

Standard 1:250 000 scale maps

ADELAIDE/REMARK AND BARKER/PINNAROO

The Bureau of Mineral Resources have released total magnetic intensity contours and total count contours over both areas.

Stacked profiles of the radioaltimeter, total count, and potassium, uranium and thorium channels are available for both areas.

IT HAPPENED 100 YEARS AGO

From the 'Adelaide Observer', 6th December 1879:-

Gold Near Woodside. - From a correspondent at Woodside we have received the following:- 'Mr. A. Mitchell is still prospecting with very encouraging results. I visited the diggings recently, and found him with two of his men engaged washing a load of dirt, which yielded gold in payable quantities. I was informed that on the day previous to my visit three ounces of gold was taken from about one ton of dirt. The general impression here is that there is a rich deposit of gold in the neighbourhood. One gentleman who is well up in gold mining has applied for a right to search for minerals in an old road adjoining the section from which the gold is being taken by Mr. Mitchell'.

IT HAPPENED 50 YEARS AGO

From the 'Adelaide Advertiser', 14th December 1929:-

'An announcement was made in October that the formation of a company to take over radium mining properties in Cornwall, Australia and Czecho Slovakia, had been delayed because of financial disturbances in London. The directors of the Australian Radium Corporation, Mount Painter (S.A.), have now received advice from their

London agent that the Cornish syndicate is prepared to continue with the flotation, and leave out Czecho Slovakian interests. The latest proposal is to form a company with a capital of £1 250 000, and to buy the Australian company's interests for £50 000 in cash and 300 000 shares. The syndicate requires an option for four months, and is prepared to pay a deposit of £1 000, and to pay £5 000 on exercising the option, with two months to complete the purchase.

The directors of the Australian Radium Corporation have agreed to the terms of the option'.

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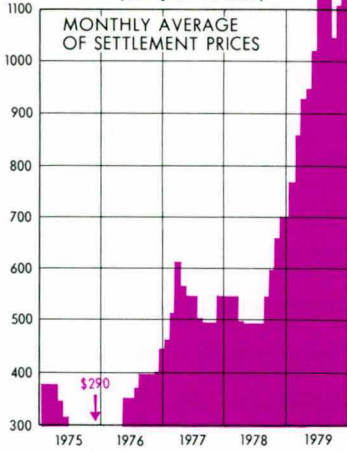
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AUSTRALIAN LEAD PRICE
(\$A per tonne)

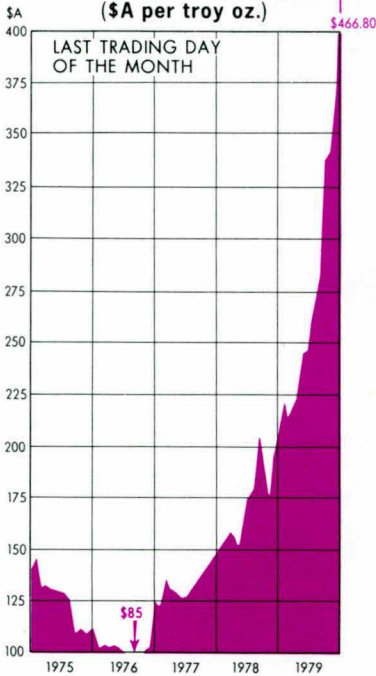


METAL PRICE MOVEMENTS

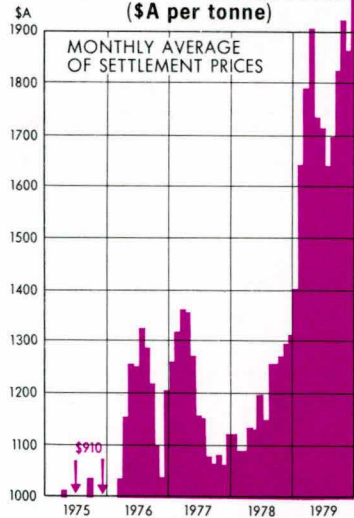
AUSTRALIAN ZINC PRICE
(\$A per tonne)



AUSTRALIAN GOLD PRICE
(\$A per troy oz.)



AUSTRALIAN COPPER PRICE
(\$A per tonne)



S.A. Dept. of Mines and Energy

PEOPLE IN THE INDUSTRY

JOHN COPPING, previously Resident Manager, Kwinana Nickel Refinery, has been appointed Manager, Olympic Dam Project by WMC.

LEE PARKIN, Chairman of the Board of Management of Amdel, and JOHN ZEHNDER, Managing Director of Santos Ltd, have been appointed to the Board of the SA Oil and Gas Corporation.

BILL SCHRODER, Managing Director of Adelaide Brighton Cement Ltd, has been appointed Chairman of the Redcliff Steering Committee.

PETER ARDEN has been transferred by WMC to its Greenhill Road office to work on the Stuart Shelf Joint-Venture project.

ROB ROBSON has accepted a three-year contract with the International Bauxite Association in Jamaica.

CHRIS ANDERSON has joined Hamersley Mining Ltd in Perth.

IAN YOULES has left Robertson Research to establish an Adelaide office for Oilmin NL.

MALCOLM MASON has been transferred by Seltrust Mining from Port Augusta to Perth.

JOE JOYCE has been transferred by Stockdale Prospecting Ltd from their Orroroo base to Carnarvon.

AFMECO PTY LTD have established an office in Whyalla.

PAUL WESTCOTT has resigned from his position as a mining engineer with the Electricity Trust of South Australia to join Longworth and McKenzie in Sydney.

PETER JONES has been transferred from Alice Springs to supervise the operations of Stockdale Prospecting Ltd, based at Orroroo.

ALLAN BRASH and ELPIDIO REIS have opened an Adelaide office for Shell Minerals Exploration (Aust.) Pty Ltd.

JIM BOWERING has resigned from the Department of Mines and Energy to join Santos Ltd.

S.A. DEPARTMENT OF MINES AND ENERGY 191 GREENHILL ROAD, PARKSIDE 5063

COVER PHOTO:

Coffin Bay Lime Sand Quarry Operations

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