PRIMARY INDUSTRIES
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REPT.BK.NO. 86/67

REAPPRAISAL OF JADE RESERVES COWELL JADE PROVINCE EYRE PENINSULA, SOUTH AUSTRALIA

GEOLOGICAL SURVEY

by

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SEPTEMBER 1986

D.M.E. No. 355/75

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DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 86/67
DME. NO. 355/75
DISK NO. 84

REAPPRAISAL OF RESERVES - COWELL JADE PROVINCE

ABSTRACT

Inferred reserves of 8 000 tonnes of jade per vertical metre are contained within 113 jade lenses in the Cowell Jade Province on Eyre Peninsula, South Australia. Down to an economic mining depth of 10 m, 80 000 tonnes of jade are inferred with 60 000 tonnes considered recoverable. A total of 82 jade outcrops on 20 mineral leases held by Cowell Jade Pty. Ltd. contain inferred reserves of 73 000 tonnes down to 10 m, with 55 000 tonnes recoverable. L.M., L.M., N.P., and C.P. Smith hold three mineral leases over 6 jade outcrops containing 2 000 tonnes down to 10 m, with 1 500 tonnes recoverable.

At an average value of $4/kilogram after deducting costs, value of rough graded jade on Cowell Jade Pty. Ltd. leases down to 10 m is $220 million compared to $6 million on the Smith's leases. Processing, crafting and polishing of jade artefacts will increase the value of jade significantly.

Excellent access and ease of mining of these large deposits make the Cowell Jade Province unique in the world.

Colours range from yellow green, through dark green to black. Cowell is probably the only commercial source of high quality black jade in the world. Colour variations, rind patterns and inclusions result in over 40 varieties that are marketable. Small quantities of translucent green, yellow and near-white jade have been found and there is a probability that larger quantities of these, and other colours will be found at Cowell as mining continues. With further mining, buried jade bodies will be uncovered and some of these may contain jade with unusual patterns, texture or colour similar to the world famous Cowell black jade with patterned rind.

Cowell black jade is simply and quickly polished. The high degree of polish which is produced consistently is possibly without equal.

INTRODUCTION

This reappraisal resulted from a request by Mr. G.J. Robertson (Managing Director, Cowell Jade Pty Ltd) for Australian Mineral Development Laboratories (AMDEL) to estimate the Company's jade reserves and their value. These data were required to assist negotiations with major organisations who are seeking to invest substantial funds in the Australian gemstone industry.

This report updates the only previous estimate of reserves at Cowell by Nichol (1977). Outcrop data are based on Table 2 in Barnes et al (1980) with modifications resulting from geological mapping and drilling in 1983-84 (Flint and Dubowski, 1986).

Data on the varieties of jade, their relative proportions, processing and prices were obtained from Cowell Jade Pty Ltd (Cowell Jade).

Only jade is considered in this report. The possible value of other rocks and minerals in the Cowell Jade Province such as marble and talc, which have uses as ornamental and carving stone, have not been considered.

Two mineralogically distinct varieties of jade occur in nature

- jadeite, a pyroxene group mineral
- nephrite, an amphibole group mineral - tremolite.

In this report, jade always refers to nephrite jade, the variety present near Cowell.

LOCATION

Cowell Jade Province as defined by Nichol (1977) is

> 'that area of approximately 9 km^2 extending southwards from Mount Geharty and encompassing all known occurrences of nephrite jade'.

Subsequently jade outcrops have been located at:

- Miltalie (Scott, 1983)
- Ullabidinie (Parker, 1981)
- Elbow Hill and
- north of Mount Geharty,

and Cowell Jade Province is now defined as

> 'Sections 111, 116 and 123, hundred Minbrie, county Jervois, in the Minbrie Range, 22 km north of Cowell on Eyre Peninsula, South Australia.'

GEOLOGY

Nichol (1977) and Parker (1981) described the geology of the Cowell jade deposits. Papers presented at the 7th Australian Geological Convention (AGC) (Flint et al., 1984) and 8th AGC (Flint and Dubowski, 1986) discussed aspects of the geology and jade formation as well as reviewing diamond drilling.

Jade is associated with early Proterozoic meta-sediments of the Hutchison Group which have been subjected to upper amphibolite to localised granulite facies grade metamorphism. Major lithologies are quartzo-feldspathic gneiss, granite, quartzite, mica and hornblende schist, dolomitic marble and various calc-silicate rocks including calcite-chlorite schist, tremolitite, diopside rock, epidotite and talc schist.

The rocks are folded into tight isoclinal folds with a foliation that strikes northeast and dips steeply west. Jade is in lenticular masses associated with dolomitic marble and calc-silicate rock.

Parker (1981) recognised four periods of deformation in the Cowell Jade Province and considered jade formation to be associated with the last deformational event (D4) which produced fractures along which metasomatism occurred. This metasomatism consisted of movement of silica into and carbonate out of dolomitic marble.

Flint and Dubowski (1986) considered that jade bodies are of three types.

- conformable with lithological layering and developed within a talc-tremolite-chlorite alteration zone. This type includes the large lenses which are up to 65 m long and 3 m wide.
- restricted to cross fractures parallel to the axial plane of late stage cross warping. These are smaller lenses, up to 1 m wide, but contain the highest quality fine grained dark green to black jade and rarer translucent light green jade.
- minor patches formed by uralitisation of diopside rock.

MINING HISTORY, METHODS AND PRODUCTION

Jade was discovered in the Cowell Jade Province by H.A. Schiller in 1966, and a total of 113 jade outcrops are now known (Flint and Dubowski, 1986).

Mineral tenure in the Cowell Jade Province has had a complex history as detailed in Olliver (1983).

Present tenure is shown on Table I.

TABLE I

MINERAL TENURE - COWELL JADE PROVINCE

(As at 31 July 1986)

Tenement (ML)	Area (ha)	Jade outcrop Nos.	Expires
COWELL JADE PTY. LTD.			
3426	11.43	40-44	30/6/87
4128	18.75	6,37-39	9/9/87
4129	13.67	1-4, 92	9/9/87
4130	14.60	54-57	9/9/87
4131	3.57	61-68	9/9/87
4132	4.23	68-72	9/9/87
4217	16.50	16,18-32,93-97, 110,111	21/10/87
4338	11.00	-	9/12/87
4339	6.63	45,109	9/12/87
4340	2.48	58-60	9/12/87
4341	0.40	-	9/12/87
4381	5.60	33-36	6/8/88
4415	2.13	15,107,114	3/11/88
4532	2.03	9-12	9/3/93
4533	4.33	73-75	9/3/93
4577	2.00	81-83	9/3/91
4578	4.03	46-51	9/3/91
4579	0.83	7	9/3/91
4783	0.73	52	1/8/88
L.M., L.M., N.P. and C.P. SMITH (hereafter Smith)			
4634	0.43	15	22/8/92
4898	2.47	105,106,108	11/2/88
5255	2.0	90,112	12/2/92

Jade outcrops not covered by the above leases are: 5, 8, 13, 14, 17, 53, 76-80, 84-89, 91, 98-104, 113.

Cowell Jade hold 20 ML covering 82 (73%) of the 113 known jade outcrops. Of these, five outcrops are possibly mined out and although traces of jade are present, the quarries have been temporarily abandoned.

Smith holds tenure over 6 jade outcrops, 5% of the total.

All leases are renewable. Labour conditions on Cowell Jade leases are amalgamated, and under Regulation 57(4)(c) of the Mining Act 1971-1978 there is a production requirement of 20 tonnes of jade and/or talc from 1 May 1985 to 30 April 1987.

On 7 August 1980, all of sections 111, 116 and 123 hundred Minbrie including the road reserve traversing the said area, were reserved from operation of Parts IV, V, VI, VIA, VII and VIII of the Mining Act, 1971-1978. Because of this, no new mineral claims can be registered, nor can Exploration Licences be granted over the reserved area.

The Mining Act does apply to leases current within the reserved area.

Mining is carried out by opencast methods using earth moving equipment. Jade is hand picked and trucked to Cowell or Adelaide for processing. The good access and ease of mining make these jade deposits unique in the world.

Of the 113 known jade outcrops, at least 36 either have been quarried, or have some form of prospecting pit, with at least eleven considered mined out.

Production, based on returns submitted to SADME, up to December 1985 is shown on Table II.

TABLE II

TOTAL PRODUCTION BY OUTCROP TO DEC. 1985. - COWELL JADE PROVINCE

Outcrop	Current Tenement	Production (tonnes)
14	-	15
15	ML4415,4634	26.8
21-23	ML4217	0.2
24	ML4217	100
25-30	ML4217	88.5
33-36	ML4381	406
37-38	ML4128	0.1
40-44	ML3426	2.9
52	ML4783	1
53	-	38
54-57	ML4130	0.1
61-67	ML4131	0.3
69	ML4132	206
70-72	ML4132	0.02
76	-	149
17	-	↑
77-80	-	2
89,90,112	ML5255	↓
99,100	-	15
106	ML4898	1.5
107	ML4415	6
	TOTAL	1 058

One tonne of jade has been produced from the Miltalie jade deposit (Olliver, 1983).

Cowell Jade was formed in 1976 and has been the dominant producer since that time. Total production since 1978 has been 708 tonnes of which Cowell Jade has produced 571 tonnes, 81% of the total for 1978-1985. Since November 1979, when Cowell Jade acquired the leases of Australian (Nephrite) Jade Mines Ltd, total production has been 383 tonnes of which Cowell Jade produced 361 tonnes or 94% of the total for 1979-1985.

CONTINUATION OF JADE BODIES WITH DEPTH

Jade bodies typically have elongate, lensoid shapes in outcrop. Drilling and mining to date have supported the concept of irregular, lenticular masses. Depth information is lacking for most jade lenses.

The following three diamond drilling programs, totalling 356 m have been carried out in the Cowell Jade Province.

Year	Organisation	DDH	Total m
1970	ANEXA	1-6	144.91
1973	CENTAMIN	7-13	93.85
1983	SADME	14-17	117.28

Many early drillholes were unsuccessful, being sited on small outcrops and inclined westward parallel to regional layering. Successful drillholes were on large outcrops and inclined to the southeast-northeast.

DDH 6 at outcrop 55 intersected 1 m of jade 7 m below the surface to establish the continuation of the surface outcrop to at least that depth. The deepest trace of jade is in DDH 14 at outcrop 15 where a 0.2 m band, which cannot be directly related to outcrop, is 23 m below the surface.

The deepest jade exposed by quarrying is at outcrop 69 where jade is 6 m below the original surface and continues downwards.

Drilling and mining suggest that some jade bodies lens out rapidly with depth. Conversely, very narrow or non-outcropping jade can just as rapidly thicken and become economic to mine.

RESERVES

Because of the lack of depth information, reserve estimates are based on outcrop size. Table III details reserves calculated using the following four models for each jade outcrop. In all cases, specific gravity of 3.0 for jade has been used. Models 2, 3 and 4 were devised by Dr Frank Radke (AMDEL) during his independent estimation of reserves for Cowell Jade.

Model 1. Nichol (1974 and 1977) assumed a rectangular shape for jade outcrops.

Surface area = length (a) x breadth (b)

Reserves are calculated per vertical metre by projecting the surface area downwards.

Model 2. An elliptical shape is assumed for jade outcrops.

$$\text{Surface area} = \frac{\text{length}}{2}\left(\frac{a}{2}\right) \times \frac{\text{breadth}}{2}\left(\frac{b}{2}\right) \times \pi$$

$$= a \times b \times 0.7854.$$

Reserves are calculated per vertical metre by projecting the surface area downwards.

Model 3. Volume of jade body is calculated assuming an oblate spheroid (revolution about the short axis b and hence a = c).

$$\text{Volume} = {}^{4}/_{3}\ (\pi\ b\ a^{2})$$

Assuming that half of this disc shaped body is below ground surface, and half has been removed by erosion, reserves are calculated down to a depth of half the length of the long axis.

$$\text{Volume } V_1 = \tfrac{1}{2} \times {}^{4}/_{3}\ (\pi\ b\ a^{2})$$

Reserves within jade body in tonnes are

$$T_1 = V_1 \times 3.0.$$

Model 4. Volume of jade body is calculated assuming a prolate spheroid (revolution about long axis a and hence b = c).

$$\text{Volume} = {}^{4}/_{3}\ (\pi\ a\ b^{2})$$

Assuming that half of this cigar shaped body is below ground surface, reserves are calculated down to a depth of half the length of the short axis.

Volume $V_2 = \frac{1}{2} \times \frac{4}{3} (\pi a b^2)$

Reserves within jade body in tonnes are

$T_2 = V_2 \times 3.0$.

Wilson (1980) calculated reserves down to 5 m but no method of calculation is given.

Both Nichol (1977) and Wilson (1980) calculated reserves to a depth of 5 m based on quarry exposures and drilling data available at that time. Continued mining and the 1983 drilling have shown jade to continue to at least 7 m and an average working depth of 10 m is now considered reasonable.

Reserve estimates by Nichol (1977) and Wilson (1980) have been recalculated to 10 m on Table IV. Reserves are geological, and classed as inferred. Models 3 and 4 have a finite depth. For Model 4, jade does not persist below 5 m. For Model 3, the deepest jade is 32.5 m deep. Models 1 and 2 and Wilson expect jade to persist to depths beyond 10 m.

TABLE IV

RESERVES (TONNES) - COWELL JADE PROVINCE

	Model 1	Model 2	Model 3	Model 4	Wilson
Per vertical metre	10 200	8 000			
0 - 5 m	51 000	40 000	32 900	12 700	54 000
0 - 10 m	102 000	80 000	53 100	12 700	108 000
Total			78 000	12 700	

TABLE III

COWELL JADE PROVINCE - RESERVES - INDIVIDUAL OUTCROPS

Outcrop No.	TENURE Lease No.	Lease Holder	SURFACE DIMENSIONS(s) Length	Width	SURFACE AREA (m^2) Model 1	Model 2	RESERVES (tonnes) Model 1 (t/vert. metre)	Model 2 (t/vert. metre)	Model 3 (total t)	Model 4 (total t)	
1	ML 4129	Cowell Jade	20	3	60	47.1	180	141	942	141	
2	"	"	5	4	20	15.7	60	47	79	63	
3	"	"	12	3	36	28.3	108	84	339	85	
4	"	"	8	3	24	18.8	72	56	151	57	
5	"	Reserved	10	3	30	23.6	90	71	236	71	
6	ML 4128	Cowell Jade	35	2	70	55.0	210	165	1924	110	
7	ML 4579	"	60	1	60	47.1	180	141	2827	47	
8	"	Reserved	1	0.2	0.2	0.2	0.6	0.6	0.2	0.03	
9	ML 4532	Cowell Jade	5	1	5	3.9	15	12	20	4	
10	"	"	10	1	10	7.9	30	24	79	8	
11	"	"	45	7	315	247.4	945	742	11133	1732	
12	"	"	20	1	20	15.7	60	47	314	16	
13		Reserved	14	3	42	33.0	126	99	462	99	
14	ML 4597	Cancelled	10	2	20	15.7	60	47	157	31	Main outcrop mined out - 15 tonnes produced. Trace jade in quarry.
15	ML 4415	Cowell Jade	40	4	160	125.7	320	251	3351	335	
	ML 4634	Smith					160	126	1676	168	
16	ML 4217	Cowell Jade	8	8	64	50.3	192	151	402	402	
17	ML 4523	Cancelled	1	1	1	0.8	3	2	1	12	
18	ML 4217	Cowell Jade	1	1	1	0.8	3	2	1	1	
19	"	"	1	1	1	0.8	3	2	1	1	
20	"	"	1	1	1	0.8	3	2	1	1	
21	"	"	30	4	120	94.2	360	283	2827	377	
22	"	"	10	2	20	15.7	60	47	157	31	
23	"	"	15	3	45	35.3	135	106	530	106	
24	"	"	7	2	14	11.0	42	33	77	22	Possibly mined out - 100 tonnes produced. Trace jade in quarry.
25	"	"									Float Only - covers area $2m^2$
26	"	"	2	0.5	1	0.8	3	2	2	0.4	
27	"	"	10	7	70	55.0	210	165	550	385	
28	"	"	8	4	32	25.1	96	75	201	101	
29	"	"	17	5	85	66.8	255	200	1135	334	
30	"	"	12	2	24	18.8	72	57	226	38	
31	"	"	3	1	3	2.4	9	7	7	2	
32	"	"	14	1	14	11.0	42	33	154	11	
33	ML 4381	"	8	4	32	25.1	96	75	201	101	
34	"	"	4	1	4	3.1	12	9	13	3	
35	"	"	15	5	75	58.9	225	177	884	295	
36	"	"	65	3	195	153.2	585	460	9955	459	
37	ML 4128	"	14	3	42	33.0	126	99	462	99	
38	"	"	3	1	3	2.4	9	7	7	2	
39	"	"	1	1	1	0.8	3	2	1	1	
		SUB TOTAL					5160	4050	41485	5740	

40	ML 3426	Cowell Jade	3	2	6	4.7	18	14	14	9	Small surface outcrops 40,41,42 and 44 possibly
41	"	"	1	0.1	0.1	0.1	0.3	0.2	0.1	0.008	mined out. 3 tonnes produced.
42	"	"	3	2	6	4.7	18	14	14	9	
43	"	"	9	2	18	14.1	54	42	127	28	
44	"	"	4	3	12	9.4	36	28	38	28	
45	ML 4339	"	0.2	0.2	0.04	0.03	0.1	0.1	0.006	0.006	
46	ML 4578	"	11	1	11	8.6	33	26	95	9	
47	"	"	5	2	10	7.9	30	24	39	16	
48	"	"	10	2	20	15.7	60	47	157	31	
49	"	"	18	1	18	14.1	54	42	254	14	
50	"	"	4	3	12	9.4	36	28	38	28	
51	"	"	0.5	0.2	0.1	0.1	0.3	0.2	0.04	0.02	
52	ML 4783	"	5	1	5	3.9	15	12	20	4	
53	ML 4524	Cancelled	0.2	0.02	0.004	0.003	0.01	0.009	0.0006	0.00006	Possibly mined out. 38 tonnes produced.
54	ML 4130	Cowell Jade									Float only
55	"	"	30	2.5	75	58.9	225	177	1767	147	
56	"	"	41	3	123	96.6	369	290	3961	290	
57	"	"	7	1	7	5.5	21	16	38	5	
58	ML 4340	"	-	-	-	-	-	-	-	-	Dimensions not known
59	"	"	-	-	-	-	-	-	-	-	" " "
60	"	"	.7	2	14	11.0	42	33	77	22	
61	ML 4131	"	20	1	20	15.7	60	47	314	16	
62	"	"	-	-	-	-	-	-	-	-	Float only
63	"	"	15	6	90	70.7	270	212	1060	424	
64	"	"	2	0.2	0.4	0.3	1	1	0.6	0.1	
65	"	"	1	0.2	0.2	0.2	0.6	0.6	0.2	0.03	
66	"	"	1	0.1	0.1	0.1	0.3	0.2	0.1	0.008	
67	"	"	35	10	350	274.9	1050	825	9621	2749	
68	"	"	20	3	60	47.1	180	141	942	141	
69	ML 4132	"	42	4	168	131.9	504	396	5542	528	
70	"	"	14	2	28	22.0	84	66	308	44	
71	"	"	-	-	-	-	-	-	-	-	No dimensions
72	"	"	20	8	160	125.7	480	377	2513	1005	
73	ML 4533	"	7	1	7	5.5	21	16	38	5	
74	"	"	2	0.2	0.4	0.3	1	1	0.6	0.1	
75	"	"	24	2	48	37.7	144	113	905	75	
76	ML 4534	Cancelled	8	5	40	31.4	120	94	251	157	Possibly mined out. 149 tonnes produced.
77	ML 4525	"	1	1	1	0.8	3	2	1	1	
78	"	"	10	3	30	23.6	90	71	236	71	
79	"	"	10	5	50	39.3	150	118	393	196	
80	"	"	10	3	30	23.6	90	71	236	71	
81	ML 4577	Cowell Jade	21	3	63	49.5	189	148	1039	148	
82	"	"	6	2	12	9.4	36	28	56	19	
83	"	"	3	0.2	0.6	0.5	2	1	1	0.1	
84	ML 4559	expired	1	1	1	0.8	3	2	1	1	
85	ML 4668	cancelled	2	0.5	1	0.8	3	2	2	0.4	
86	"	"	2	1	2	1.6	6	5	3	2	
87	"	"	2	0.5	1	0.8	3	2	2	0.4	
88	"	"	1	1	1	0.8	3	2	1	1	
89	ML 4522	"	1	1	1	0.8	3	2	1	1	
		SUB TOTAL					4509	3537	30107	6287	

90	ML 5255	N.P. Smith	14	3	42	33	126	99	462	99	
91		Reserved	2	0.3	0.6	0.5	2	1	1	0.1	
92	ML 4129	Cowell Jade	40	5	200	157	600	471	6283	785	
93	ML 4217	"	3	0.5	1.5	1.2	4	3	3	0.6	
94	"	"	2	0.5	1	0.8	3	2	2	0.4	
95	"	"	11	1	11	8.6	33	26	95	9	
96	"	"	4	0.5	2	1.6	6	5	6	0.8	
97	"	"	6	1	6	4.7	18	14	28	5	
98	ML 4523	Cancelled	8	1.5	12	9.4	36	28	75	14	
99	ML 4568	"	1.5	0.5	0.8	0.6	2	2	0.9	0.3	) Possibly mined out.
100	"	"	-	-	-	-	-	-	-	-	Float only.) 15 tonnes produced.
101		Reserved	2	0.3	0.6	0.5	2	1	1	0.1	
102		"	1	0.5	0.5	0.4	1	1	0.4	0.2	
103		"	-	-	-	-	-	-	-	-	Dimensions not known.
104		"	1.5	0.5	0.8	0.6	2	2	0.9	0.3	
105	ML 4898	Smith	0.2	0.1	0.02	0.02	0.06	0.05	0.003	0.002	
106	"	"	0.5	0.1	0.05	0.04	0.2	0.1	0.02	0.004	
107	ML 4415	Cowell Jade	5	0.5	2.5	2.0	7	6	10	1	
108	ML 4898	Smith	0.2	0.1	0.02	0.02	0.06	0.05	0.003	0.002	
109	ML 4339	Cowell Jade	2	0.2	0.4	0.3	1	1	0.6	0.1	
110	ML 4217	"	1	1	1	0.8	3	2	1	1	
111	"	"	4	1	4	3	12	9	13	3	
112	ML 5255	N.P. Smith	2	0.5	1	0.8	3	2	2	0.4	Possibly mined out. 2 tonnes produced.
113		Reserved	5	1	5	4	15	12	17	4	
		SUB TOTAL					876	687	7002	924	
		TOTAL Tonnes/vert m					10544	8274			
		Total tonnes							78594	12951	
Less outcrops possibly mined out - total 322 tonnes produced (14,24,40,41,42,44,53,76,99,100,112)							299	234	554	257	
		REMAINING RESERVES	Total/vert m				10200	8000			
			Total tonnes						78000	12700	
			To 15 m				51000	40000	32900	12700	
			To 10 m				102000	80000	53100	12700	

COMPARISON OF RESERVE MODELS

Both spheroid methods of reserve calculation consider only those lenses exposed on the surface, and assume continuity down to the depth of the spheroid.

For Model 3 (oblate spheroid), depths are down to 30 m in the case of large outcrops such as 7, 36 and 55. There is no evidence to prove or disprove that jade lenses persist to this depth.

Conversely with Model 4 (prolate spheroid), maximum depth of jade is 5 m for outcrop 67 with most other outcrops only 1 or 2 m deep and much shallower than depths established by mining.

Neither spheroidal model is considered reasonable in calculating ore reserves.

The method of projecting surface area downwards and calculating reserve per vertical metre is considered more appropriate for the Cowell Jade Province as this method provides for the lensing out of jade bodies and the appearance of new ones.

Mining and drilling have shown jade to lens out, in some cases very rapidly, with depth but loss of these reserves is compensated, in places, by development of buried previously unknown jade bodies. In the quarry on outcrops 34-36 (ML 4381), mining operations have uncovered two or three jade lenses that did not outcrop, and these have contributed substantially to production.

Of the two surface area projections; Model 2, using an elliptical shape for the jade bodies, more closely approximates the true shape. Thus the preferred model for calculation of reserves is Model 2.

Using the preferred model, inferred reserves of jade to 10 m are

	tonnes
. All outcrops Cowell Jade Province	80 000
. Outcrops held by Cowell Jade	73 000
. Outcrops held by Smith	2 000
. Outcrops outside mining tenements	5 000

Therefore, Cowell Jade hold 91% of inferred reserves and Smith holds 3%.

Reserve calculations are influenced overwhelmingly by large outcrops. Outcrop area and reserves of the six largest outcrops (11, 36, 67, 69, 72 and 92) and the 23 largest outcrops (six previous plus 1, 6, 7, 15, 16, 21, 23, 27, 29, 35, 55, 56, 63, 68, 75, 79 and 81) are given on Table V as a percentage of total reserves.

TABLE V

RESERVES OF LARGEST OUTCROPS - COWELL JADE PROVINCE

Outcrops	Area (m^2)	Reserves to 10 m (tonnes)	% of total reserves
6 largest	1 090	32 700	40
23 largest	2 126	63 780	77

20% of the outcrops contain 77% of the inferred reserves. With the exception of outcrop 79 and part of outcrop 15, Cowell Jade hold mining leases over all of the largest outcrops.

WORLD RESERVES

Published information on reserves is scarce except for estimates for British Columbia and Yukon Territory (Leaming, 1978) and for Taiwan (Li-Ping Tan et al., 1978). In many places such as New Zealand and China, jade is 'harvested' from river gravel and alluvial deposits. Hence, reserves are impossible to estimate.

Fengtien, Taiwan

In Taiwan, nephrite forms irregular bodies on the hanging and footwall contacts of a serpentinite band through ultramafic rock. In general, only the topmost hangingwall contact of the first serpentinite band has been mined, but seven bands are known.

Calculation of an inferred resource of nephrite is based on projecting the last 20 years production from the top layer to the remaining unexplored serpentinite layers (Li-Ping Tan et al., 1978) using the following:-

- 8 000 tonnes total production of Fengtien nephrite since 1961, predominantly from the uppermost serpentinite layer.
- There are at least five layers of serpentinite, presumed to contain nephrite, not yet explored.
- Favourable host rocks extend over an area twice as large as the mining area as at 1977.

Therefore, inferred resource of nephrite is

Production 1961-1981 x No. of layers x Extent of host rock

= 8 000 x 5 x 2

= 80 000 tonnes.

The following four points are relevent in comparing this Taiwan inferred resource with inferred reserves at Cowell.

- More recent production from Taiwan has declined markedly because of exhaustion of nephrite near the surface.
- Production of Fengtien nephrite has already been from underground mining.
- Explosives are required to recover nephrite causing 60-99% wastage of nephrite and an average recovery rate of only 10%.

- The inferred resource may be increased, as well as upgraded to inferred reserves by a combination of extensive exploration and improved mining methods.

British Columbia and Yukon Territory, Canada

Leaming (1978) provided the following:

probable reserves	24 700 tonnes
possible resource	74 000 tonnes

Probable reserves include large talus boulders as well as in-situ deposits which can be measured.

Possible resource included undiscovered deposits which are based solely on the presence of geologically favourable areas such as contacts of serpentinised ultramafics near alluvial nephrite. Hence this figure may contain large errors. By including ultramafic bodies for which there were no known nephrite occurrences, possible resource could be increased to 79 000 tonnes.

Based on past mining experience, 10% of the nephrite is regarded as commercial grade. Tonnages of commercial grades are:

Probable reserves:	2 500 tonnes
Possible resource:	7 900 tonnes

With 1976-77 production levels of 300 tonnes/year (Leaming, 1978), reserves were adequate for only 8-10 years at that time. For long term viability, upgrading is required of at least part of the possible resource to probable reserves.

Reserves at Cowell compare favourably with both Taiwan and Canada, particularly with regard to confidence level of the reserve estimates, and confirm that Cowell Jade Province is one of the most important jade deposits in the world.

JADE CHARACTERISATION AND QUALITY

Jade from the Cowell Jade Province occurs in a wide variety of colours and textures, but consists predominantly of medium to fine grained, greenish-yellow to green hues grading to black. Some twenty different colours have been recorded, and these coupled with textural variations, zoning, attractive inclusions and combinations thereof, give more than forty possibly marketable varieties. The colour of Cowell jade has been proven to be a function of the total iron content which varies between 1.4 and 7.9 percent (Nichol, 1975). Several chemical analyses show no significant differences in composition between Cowell nephrite and various New Zealand nephrites, where the association between colour and total iron content is also demonstrated (Finlayson, 1909).

The commercial value of jade depends on colour and degree of polish, the latter being determined by grain size and texture. Cowell black jade is perhaps unique in its ability to be highly polished by simple lapidary techniques without development of 'orange peel' textures, typical of some nephrite from other world localities. Very fine grained Premium Black takes a superb, mirror-like polish, superior to the polish produced on jade from elsewhere. The degree of polish that is consistently produced on black jade is possibly without equal.

Cowell Jade mined to date lacks the apple and emerald green colours of some overseas deposits and dark green to black varieties predominate. Because of the lack of vivid green colours wrongly believed by many to be typical of nephrite, there has been reluctance by some people to accept Cowell jade. Aggressive marketing of the more spectacular and rarer varieties, particularly jade with rind patterns and dendritic inclusions which greatly enhance the appearance of the polished article, is required to overcome this reluctance. Fine grained high quality black jade is also eagerly sought. The only other limited source of black jade is Edwards Mountain, Wyoming, U.S.A. (Madison, 1979).

Very minor inclusions of other minerals such as chrysotile, epidote, hematite, goethite, pyrite cubes and tremolite rosettes can enhance the overall appearance of the polished jade. But in most cases, inclusions detract from the appearance, and reduce

the degree of polish that can be attained.

Under present marketing strategies, Cowell jade is presented in three main varieties:

Green nephrite jade
Black nephrite jade
Premium Black nephrite jade.

Jade is sorted by primary slabbing of individual jade blocks in order to evaluate colour and homogeneity. Of the total calculated inferred jade reserves, dark green and black varieties are by far the most abundant.

Rough jade is sold by the kilogram at prices related to quality. Unusual or premium quality material, which is specially graded and prepared, commands the highest prices.

VALUE OF JADE

Of the total 80 000 tonnes of jade inferred to 10 m, not all is recoverable. Some will be lost during mining while other material will be either too coarse or too fractured to be saleable. Markets have now been established for the lower grades of material and even the poorest quality can be sold as ornamental stone. Based on a conservative recovery of 75%, recoverable inferred reserves down to 10 m,

total 55 000 tonnes on Cowell Jade leases

total 1 500 tonnes on Smith leases.

Based on prices supplied by Cowell Jade, value of rough jade varies from $200/tonne for ornamental stone to $60 000/tonne for Premium Black.

Based on experience to date, relative proportions of each jade type are listed on Table VI, with amounts and value recalculated on a per tonne basis.

TABLE VI

PROPORTIONS AND VALUES OF DIFFERENT JADE TYPES

COWELL JADE PROVINCE

Type	Relative proportion (%)	kg. per tonne	Value ($) per kg.	Value ($) per tonne
Premium Black	1	10	60	600
Black	5	50	40	2 000
Green - black	10	100	20	2 000
Green	10	100	5	500
Seconds and ornamental	74	740	0.2	148

Total value of rough jade/tonne in situ is $5 250

From this, cost of mining, transport, sawing and grading must be deducted to determine value of jade as sold.

Because of the simple nature of open cast operations, mining costs are low, and although costs will increase with depth, an estimated $50/tonne would adequately cover mining and transport.

The cost of sawing, slabbing and grading is difficult to determine but $1 200/tonne is considered reasonable.

By deducting mining and treatment costs, jade ready for sale ex stockpile is worth $4 000/tonne, or $4/kg.

Thus based on inferred reserves, the value of saleable jade down to 10 m is:

- $220 million on Cowell Jade leases
- $ 6 million on Smith leases.

Since discovery in 1966, production has averaged 50 tonnes/year. Sales are now increasing and a figure of 100 tonnes/year is considered reasonable. With greater world knowledge and acceptance of Cowell jade, sales totalling 300 tonnes/year are possible.

Therefore, revenue from sales of rough jade, after deducting costs could be

at 100 tonnes/year - $0.4 million/year
at 300 tonnes/year - $1.2 million/year

Selected jade is processed into jewellery and carvings, the finished articles attracting between 5 and 50 times the value of the rough jade. However, consideration of the additional revenue available from processed jade is beyond the scope of this report.

RECOMMENDATIONS

All jade outcrops should be mapped geologically to enable surface dimensions and hence jade reserves to be determined more accurately.

This mapping will also provide data to calculate the relative proportions of the various jade types present in the Cowell Jade Province.

Quarries should be mapped after each mining operation so as to reconcile reserve statements with production and to provide data on the continuity of jade bodies with depth. This will enable modification and verification of the models used for reserve calculation.

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