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MINERAL POTENTIAL
KING RIVER DELTA
MACQUARIE HARBOUR
TASMANIA

MICROFILMED

OPEN FILE

20 December 1987

AMG REFERENCE POINTS ADDED

SUMMARY

Mill tailings dumped into tributary at Mt Lyell copper mine, Queenstown, have formed a man-made delta at mouth of King River in sheltered bay, Macquarie Harbour. Over 120,000,000 tonnes have accumulated. Deposit grows about 1% annually while dumping continues.

Delta's mineral resources investigated by half-dozen domestic and foreign companies. Mt Lyell drilled upper 3 m of delta's exposed, inshore fifth to determine pyrite content. Holb/Aberdare made surficial survey of Harbour floor, then cored it; later studied delta's cobalt prospects, next those of sulphur; in 1985 as Elisna P/L sampled delta's top surface, below and above sea level, for gold. Cities Service, major US copper miner, drilled entire delta. Recently, Planet Resources/Cottesloe drilled upper half of emergent 20% of deposit, examining gold distribution. Most investigators also sponsored recovery tests and studies. Delta and components generally well-characterised as a result.

Delta extends from just above sea level at coast to water depth of 35 m at toe. Maximum thickness 32 m, average 7.5 m. Area, 8 sq km. Oxidising conditions in freshwater stratum from Harbour surface to depth of 8 to 11 m, reducing environment below: deposit layered similarly. Sediment sandy inshore to silty offshore. Average SG, about 1.67. Riverine sand under delta, black muds all over Harbour floor beneath and beyond delta apron.

Delta enriched in number of elements. Contents of sulphur, molybdenum, 45 to 55 x crustal abundance: gold, copper, 25 to 35 x; barium, rare earths, 10 to 15 x; cobalt, 3 to 5 times.

Sediment quartzose, chloritic: averages 5 to 6% pyrite. This sulphide relatively coarse-grained, well-liberated; contains all deposit's cobalt, roughly half of which is secondary. Copper occurs partly in chalcopyrite grains -- 50% of them locked in silicates and other non-sulphides- and partly in secondary form, plated on many of minerals comprising deposit. Most secondary copper, cobalt, form in lower, reducing two-thirds of delta; in upper layer, cobalt and possibly some copper being dissolved: Average 55% of gold present confined to sulphides, balance is free. Barite, monazite, other useful heavies, two-thirds locked.

Proved 100,000,000 tonnes of delta sediment contain 2,900,000 tonnes sulphur, over 125,000 tonnes copper and 8,000 tonnes

cobalt, plus at least 14 tonnes gold. Each of the 5- to 6,000,000 tonnes pyritic sulphide in the deposit runs some 50% S and carries approximately 6 kg copper, 1 1/4 kg cobalt and 1 1/2 g gold, at present worth a total of \$170 Australian.

King Delta exploitable at low cost because most mining and milling steps unnecessary; sediment represents ore, already stripped, extracted, crushed, stacked as prepared plant feed. Merely requires pumping by dredge to trailing beneficiation plant consisting of screens, cyclones, cones. Dense fifth of sediment containing 75 to 90% of deposit's sulphur, cobalt, and gold plus 30 to 40% of its copper, barite, monazite to be piped to concentrator at shore edge. Cleaned four-fifths from floating plant to be discharged in deep water south and southwest of delta. Projected mining rate, 5,000,000 mty: life, 20 years.

At shore facility further separation using spirals, other mechanical means plus flotation will yield sulphide concentrate for treatment at metallurgical plant elsewhere. Alternatively, concentrate may be toll processed, or sold as is.

Metallurgical stage will permit some of pyritic sulphur to be recovered in elemental state, a form easier to handle, transport, sell, than commoner derivative, sulphuric acid. Number of tried production methods available. Process used in Finland for 15 years converts 40% of sulphur to desired state. Canadian process converts 10% more. Norwegian reduction method converts up to 80% of total sulphur. European plant employing last procedure formerly produced 100,000 tons elemental sulphur per year.

Final step in treating delta concentrate involves retrieval of metals or metallic compounds, either from vapour phase or from cinder generated in sulphide roast, by standard LIX/electrowinning procedures.

Economics of proposed project attractive. Delta's extractable sulphur, gold, cobalt and copper worth minimum \$636,000,000 Australian at recent commodity prices and exchange rate. Bonuses likely from redefining deposit boundaries to raise grade and yield, also from iron oxide, barite, other probable byproducts. Estimated costs: \$120,000,000 capital and financing, \$368,000,000 operating. Should result in post tax profit of about \$74,000,000 or ca. \$3,700,000 per year at net rate of 15%. Apparent profitability confirms outcome of both economic analyses made by previous investigator, Cities Service. Cities calculated either copper and associated metals or contained sulphur sold for acid manufacture at 40% of brimstone price prevailing then would provide return of 15 to 17% after

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tax. Present scheme will combine these two contemplated by Cities, and will benefit further by yielding gold, a component Cities overlooked.

Gold, not subject to normal supply/demand relationship, readily disposed of. Though little market for sulphuric acid because of Australia's long-standing excess in production capacity, substantial demand exists for elemental sulphur. Commonwealth and NZ lack domestic reserves. The two countries buy all needed abroad at cost of more than \$100,000,000 per year. Sulphur from King Delta capable of meeting eighth to quarter of Australia's current requirement annually for 20 years. Strategic considerations ensure long-term export market for Nation's cobalt. Besides helping cut country's overseas trade deficit by reducing sulphur imports and raising cobalt sales, delta project will contribute significantly to Tasmania's gold and copper output.

Uniquely, mining phase itself will have positive effect, allowing acid tailings which now poison seventeen miles of river bed to be washed away, and valley floors restored. Delta -- artificial -- will disappear too, after sulphides, heavy metals abstracted, and cleaned sediment deposited in deep water. Harbour waters turbid from Gordon River discharge, and floor naturally toxic, essentially lifeless; thus electrically-driven dredge, pumps, separatory equipment unlikely to harm environment. Delta coast practically uninhabited. As mining to be confined to bay, and shore plant built on strip reclaimed from Harbour, project will not affect traditional land use.

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D E P O S I T

I

BACKGROUND

Location

Deposit comprises delta of western Tasmania's King River. Lies at northeast corner of land-locked Macquarie Harbour. Road distances: to village of Strahan, 5 km; Queenstown, 40 km; Burnie, 230 km; Hobart, 300 km.

Origin

Delta consists of tailings from Mt Lyell mine at Queenstown, approximately 10% river sediment from King catchment, and material of secondary origin. Massive sulphide deposits of Mt Lyell have accounted for nearly a quarter of Australia's total production of primary copper, for a third of all pyrite mined in Tasmania, and about a fifth of the State's output of gold and silver.

Delta has formed since turn of century when large-scale exploitation at Mt Lyell began. Deposit continues to be augmented by about 1,250,000 mt tailings per year. Operations at Mt Lyell scheduled to end in 1989. Recent rise in copper price may prolong mine life.

History

Several surveys made involving King Delta.

In 1970/72 Mt Lyell drilled upper 10 feet of inshore, exposed part to determine pyrite content. Planned to produce sulphuric acid for use in manufacture of superphosphate. Scheme abandoned when Government ended fertilizer subsidy.

Overseas group subsequently incorporated as Aberdare explored Macquarie Harbour in 1973, at reconnaissance scale: target, deposits of Kupferschiefer type at formative stage. Concentrations of base metals, silver or uranium accumulating in some such bodies may be profitable to mine because of economies in exploiting unconsolidated sediments free of overburden. Black muds of Harbour floor below sill depth do indeed prove high in secondary sulphide, enriched in cobalt, copper, other elements. Highest grades found at King River Delta however, where contents raised by addition of primary material in Lyell spoil.

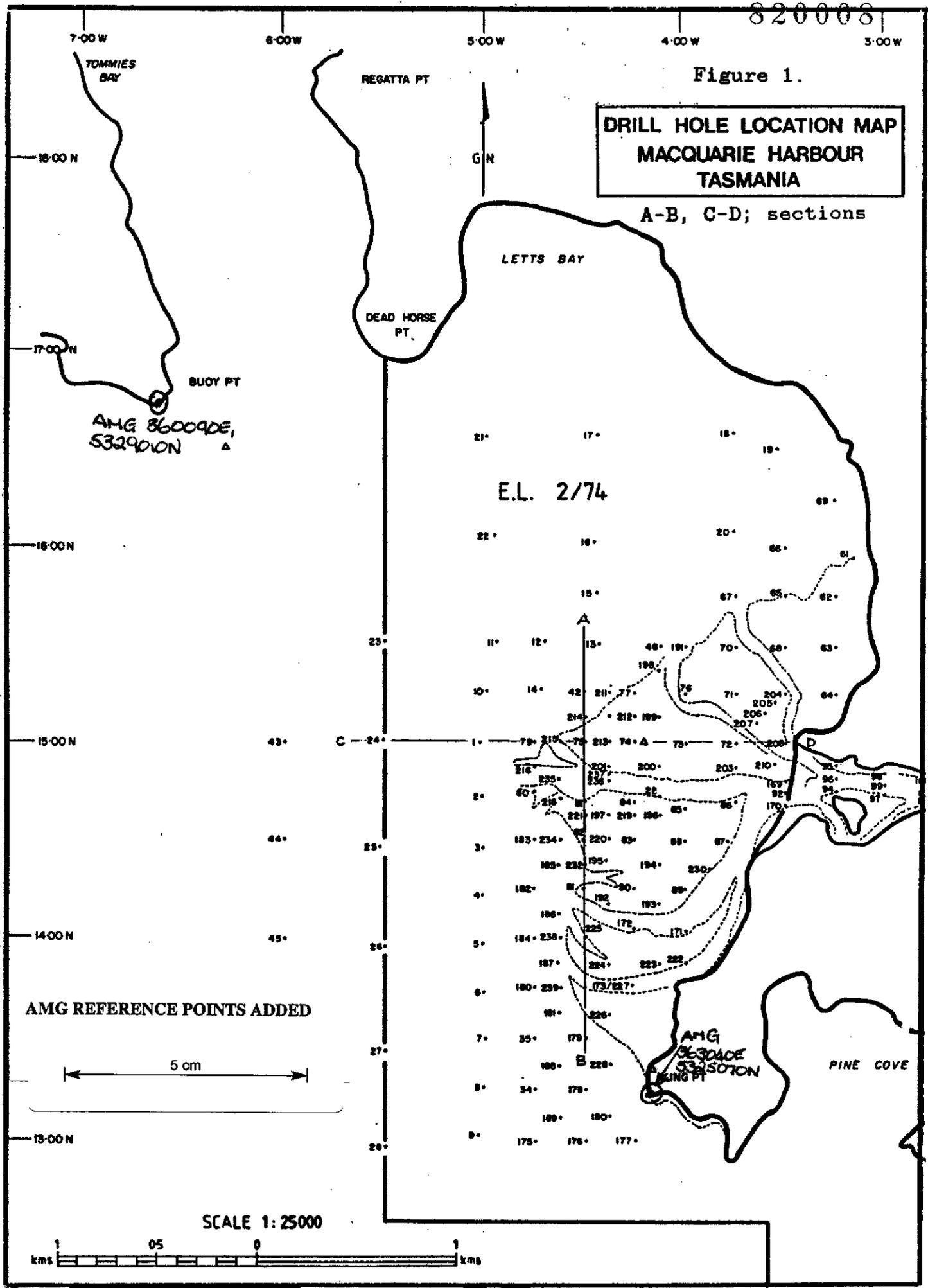
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Figure 1.

DRILL HOLE LOCATION MAP
MACQUARIE HARBOUR
TASMANIA

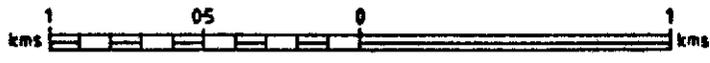
A-B, C-D; sections



AMG REFERENCE POINTS ADDED

5 cm

SCALE 1:25000



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Cities Service, US oil, gas and copper producer--brought in as partner-- sponsored closer study by Aberdare. This confirmed first phase results.

In 1975 Cities drilled delta fully (Figure 1) and commissioned process tests, as third phase. Found delta copper would cost less to produce than that from Company's porphyry deposit at Miami, in American southwest. Postponed mine construction at Macquarie Harbour awaiting rise in copper price. Cities later compelled to drop this and all other overseas minerals projects because of a corporate policy change.

Cities also showed pyrite component of Delta sediment may be extracted efficiently, cheaply. Due to oversupply of sulphuric could not dispose of deposit as source of material for acid manufacture. Elisna Pty Ltd, company Cities acquired to hold exploration licence, made over to Aberdare, plus tenement.

Work by latter concern established essentially all Delta cobalt in pyrite. Aberdare/Elisna and associate Terra Marine granted Union Oil of California option to develop deposit. Union began lab studies; withdrew when cobalt price, elevated by civil war in Zaire, receded.

Further investigation by Aberdare demonstrates entire delta surface, exposed and submerged, enriched in gold: concentration not high, but consistent, pervasive. Licence transferred to independent US explorer, Cottesloe Corporation; and Planet/Constellation, Australian natural resources group, attracted to participate and to determine gold distribution within delta.

Upper layers of inshore exposed section of deposit bored for Planet by contractor. All delta sediment penetrated proves to be enriched in gold.

Above surveys described in reports submitted to Government by respective companies: see appendix.

II

DELTA

Definition

Drilling, sample, assay, other test data of surveys described provide accurate picture of King Delta's configuration, composition. Drilling undertaken totals some 2500 m. About 1750 samples collected.

Sampling method employed in Mt Lyell delta study described in Company's annual reports on licence. Aberdare's Phase II samples of delta toe and rest of Macquarie Harbour collected by means of gravity corer; splits of all material cored lodged at Mines Department's Launceston lab when survey ended. Cities' samples for assay obtained by RC drilling: Figure 1. Samples collected in Aberdare's study of gold at delta surface dredged or dug; cuts lodged at Mines' lab. Planet's samples retrieved from augered holes by sludge pump; splits held by Mines.

Taking Cities' 2.5 m isopach as boundary, delta covers 8 sq km, extending 4 km NNE/SSW, 2.0 km ESE/WNW; see Figure 8. Thickness: 2.5 to 32 m, average 7.5 m. Volume: 60,000 cubic metres.

Apron of delta, 2.5 to 0 m thick, covers entire northern sixth of Macquarie Harbour.

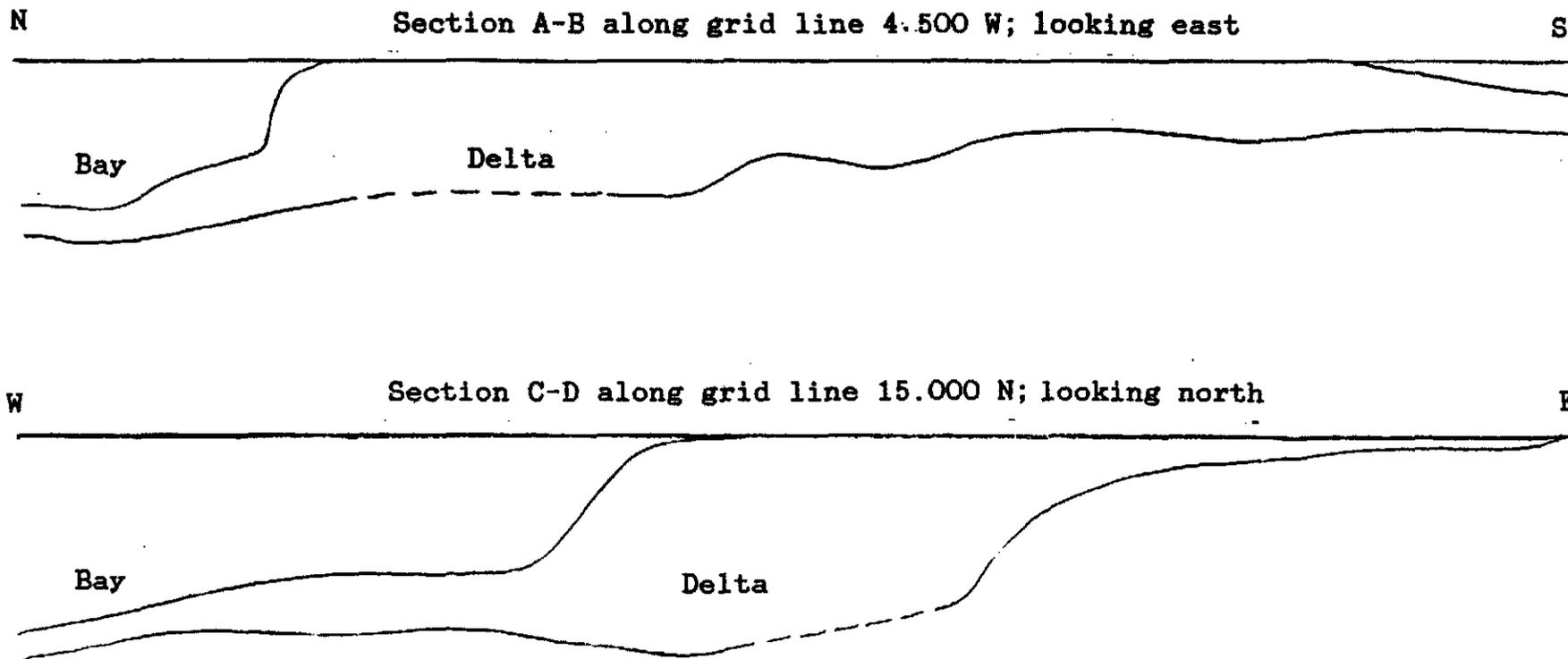
Delta semi-lunate in plan; outer face curved. Innermost fifth of area flat-topped, generally above water. Sediment thickens seaward to reach maximum under west edge of exposed top. Delta face descends at slope varying from 2 to 12°. Slope diminishes from 20 m below sea level outwards: see Figure 2.

Water depth over delta, 0 - 35 metres. Water fresh to salt. Freshwater/saltwater interface off delta typically at depth of 8 m. Harbour waters and floor below sill depth of 11 m largely stagnant, high in H₂S. No appreciable tide, swell or surf in Harbour; chop only.

Sediment in deposit sandy near King River mouth, silty towards outer edges of delta.

Figure 2. Cross sections, King River Delta, Macquarie Harbour western Tasmania

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Horizontal scale, 1:10,000. Vertical scale, 1:1000.

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Grainsize:	Microns	BSS Mesh	ASS Mesh	Delta Proper	Outer Edge
	+250	+ 60	+ 60	16%	
	+180	+ 85	+ 80	31%	
	+125	+120	+115	23%	25%
	-125	-120	-115	30%	75%

Sediment essentially unconsolidated, free of clays, boulders; thin localised developments of ironpan; occasional pebble bands, tree trunks.

Composition: quartzose sediment running average 14% heavy minerals.

Specific gravity of delta sediment varies, increasing shoreward. Mt Lyell determined values ranging from 1.566 to 1.890. Aberdare arrived at a figure of 1.574 for material from west edge of Delta's exposed top. Splits measured at Amdel by more accurate procedures give value of 1.625. Rough determination by Planet's contractor puts SG of material augered at 1.80. For reserve calculation of following pages average of 1.666 assumed, say 1.67.

Table 1. Average grades in sediment of King River Delta, Macquarie Harbour, western Tasmania

Element	Abundance, ppm		Concentration Delta x Crust
	Earth's Crust	Delta Sediment	
Ag	0.1	1.3	13
Co	23	87	3.7
Cu	45	1,255	27
Mo	1	46	46
Zn	65	185	2.8
As	2	30	15
Au	0.004	0.140	35
Ba	400	4,200	10.5
Ce & La	64	880	13.7
S	520	29,000	55
Sb	0.2	3	15
Se	0.09	3	33
Sn	3	15	5
Th	10	26	2.6
Li	2	15	7.5
W	1	30	30

III

CHEMISTRY

Contents of useful and other elements present in Delta sediment and in derivative splits and concentrates were measured in course of surveys listed. Several thousand determinations made. Bulk of analytical work handled by eight separate laboratories.

Variety of analytical methods used, including emission spectroscopy, XRF, AAS, ICPA, fire assay and wet chemical. Some differences in results depending on sample, lab, and technique, but otherwise general agreement.

Grades regarded as average for delta shown at Table I. Values tabulated for Cu, Zn, Co, Mo and Ag dependable, each embodying individual analyses of hundreds of samples representing entire deposit. Other values stemming from fewer, less representative samples, are approximations.

Within delta, grades range to about 35% below or above averages. Gold and copper grades decrease seaward from the King River mouth; those of cobalt and barium rise.

Copper distribution at the delta is depicted in Figure 3. Grade averages about 850 ppm Cu at the delta toe and about 1,700 ppm inshore.

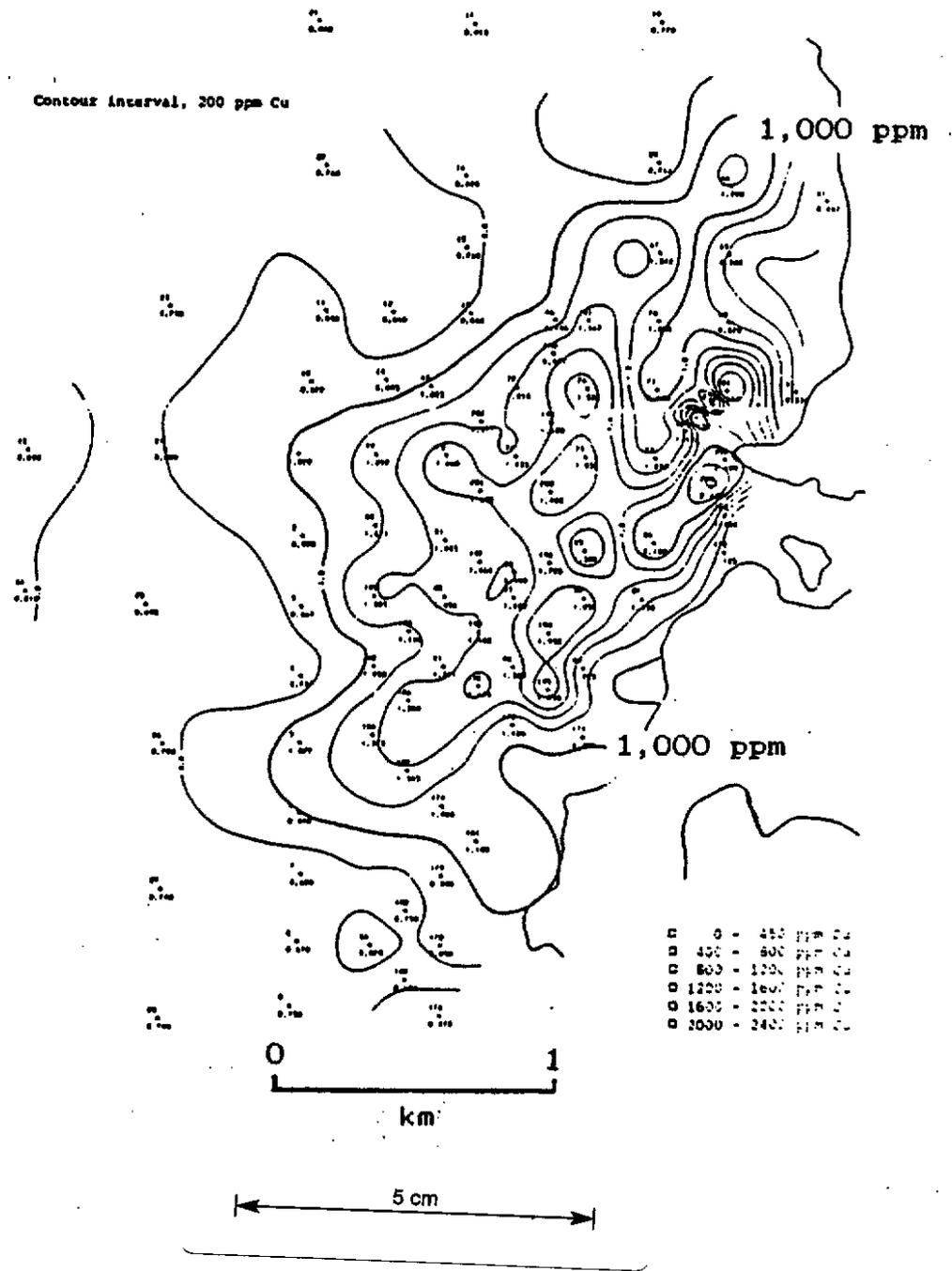
Gold grades of the delta's upper surface vary from 140 ppb Au over the toe through 170 ppb across the face to 210 ppb for the exposed top. Averages based on whole samples.

Planet drilling of upper few metres of exposed section yielded sample apparently lower in gold, but a third is barren sediment underlying delta, material which should be excluded from their grade computation. Second, finer-grained gold thought to comprise 30 to 40% of delta total was almost certainly lost in pumping sample from augerholes.

Discounting dilution by basal material but making no adjustment for pumping losses, uppermost 2.5 m Planet drilled averages 122 ppb Au, and 3 m beneath, 77 ppb.

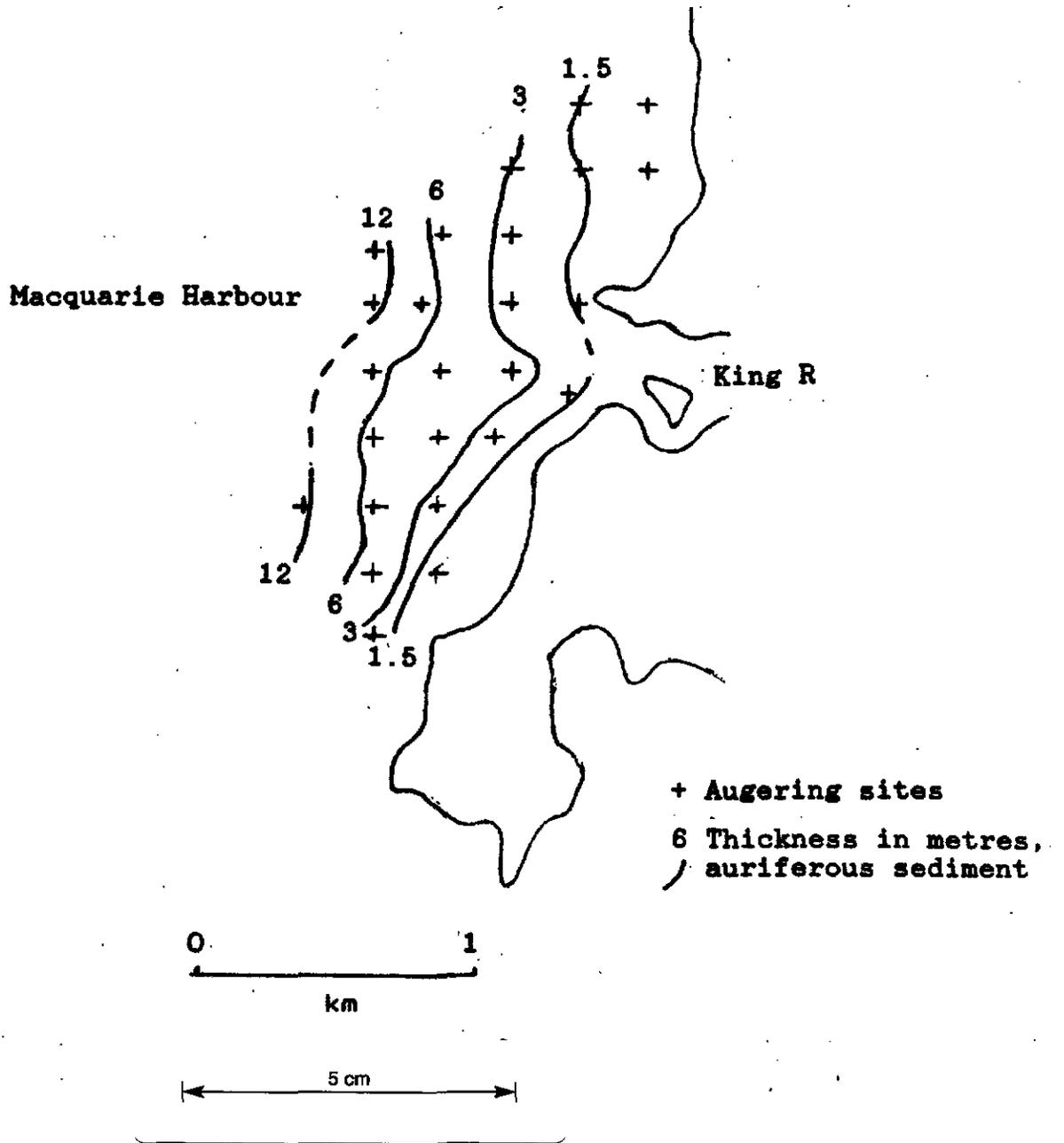
Note: Planet's deepest drillholes, unbottomed at 15 m, 16 m, terminate in mineral-bearing sediment assaying 130 ppb Au, despite maximum pumping in sample retrieval. (Figure 4)

Figure 3. Copper grade, King River Delta, Tasmania



Probably, gold content toward base of delta is above that at surface because percentage of riverine sediment -- likely source of free gold -- should be higher in deeper layers laid down when Lyell production and resultant tailings output were lower. Gold in tailings component of delta sediment also should rise at depth, as in past Lyell worked higher grade ore and recovered smaller proportions of precious metals.

Figure 4. Thickness of gold-bearing sediment, exposed section of King River Delta, Tasmania. Derived from sampling by Planet Resources Group.



IV

MINERALOGY

Heavy mineral suite comprises average seventh of delta mass; proportion rises inshore, falls offshore. Approximate constitution: 40% silicates; 40% sulphides; 13% iron carbonate, oxides and hydroxides; 7% miscellaneous.

Silicate component mainly sericite, chlorite. Sulphide component principally pyrite, some chalcopyrite, chalcocite?, plus minor bornite, sphalerite, molybdenite. Iron compounds chiefly siderite, haematite, limonite, goethite, small amount magnetite. Miscellaneous fraction, barite, monazite, zircon, apatite, rutile, leucoxene, chromite, tourmaline, topaz, cassiterite, gold.

Cobalt confined to pyrite. Electron probe study indicates pyrite grains in specimens examined partly devoid of element, other parts carry 0.75 to 3.4% Co. In main, this observation refers to primary pyrite and cobalt.

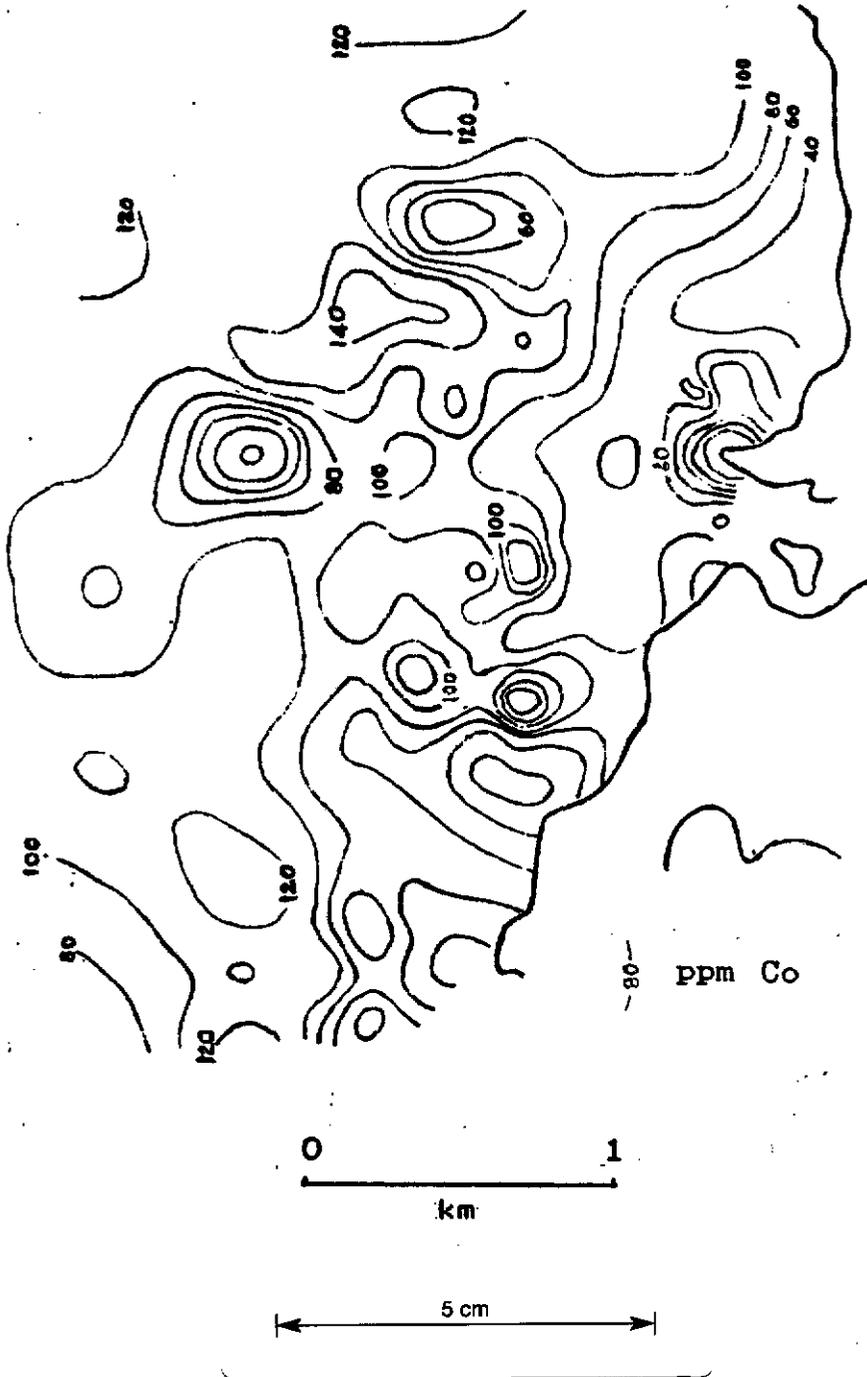
Estimated 40% of cobalt in deposit secondary, probably occurring as layer of cobalt sulphide on surfaces of primary and secondary pyrite found in lower-lying delta sediment, particularly that below 8 to 11 m depth. Thus sediment at King River mouth runs about 55 ppm Co whereas, offshore, averages approximately 115 ppm. Effect illustrated in Figure 5, showing cobalt distribution delta-wide.

Deposition of cobalt in reducing environment at depth possibly balanced by solution of element in Queen/King river bed and upper parts of delta, an oxidising realm.

Roughly two-thirds of delta's copper found in particles of chalcopyrite introduced via Lyell tailings. Other third thought to comprise secondary copper deposited as thin films on grains of most mineral species making up deposit. Process appears to operate throughout delta but presumably more marked at depth, further from shore, where it may offset some of grade drop produced by decrease in percentage of primary copper present.

Delta gold probably occurs in two states, an estimated 55% exsolved in pyrite, and other sulphides?, the rest free. Occurrence inferred from several considerations and test results. Gold distribution does not duplicate fully that of sulphur or copper in splitting sediment on basis of varying density, particle size.

Figure 5. Cobalt grade, King Delta, Tasmania



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In flotation, higher proportion of gold lost than of sulphur. Amalgamation recovers only some of total gold. Lyell gold losses too small to account for grade at delta. Figure 6 shows proportion of exsolved gold to cobalt and thus, by association, to primary sulphide.

Barium of deposit in the sulphate, barite. Rare earths resident in monazite.

Most of silver thought secondary: may occur as halide.

Delta sediment fairly well sorted and sized, with majority of heavy minerals conspicuously finer in grain size than bulk of quartzose and other silicate particles.

Figure 7 displays distribution of elements concentrated in deposit, according to size of host particles. Note similarity of cobalt and sulphur graphs, and association of most metallic elements shown with particles under 38 microns in diameter; such association specially marked in case of silver.

Degrees of liberation lowest towards coastal margin of deposit where sediment coarsest grained; increase seaward with fall in average grain size.

Useful components of delta commonly occurring as relatively large grains -- pyrite for example, barite, apatite and magnetite -- all well-liberated. Delta's chalcopyrite and zircon, medium- to fine-grained, partially locked. About 60% of chalcopyrite occurs in other material, mainly in quartz, chlorite, mica, haematite; some in magnetite, pyrite. Monazite, rutile, typically fine-grained at delta, poorly liberated.

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Slope: 100 ppm Co ~ 110 ppb Au
200 ppm Co ~ 220 ppb Au

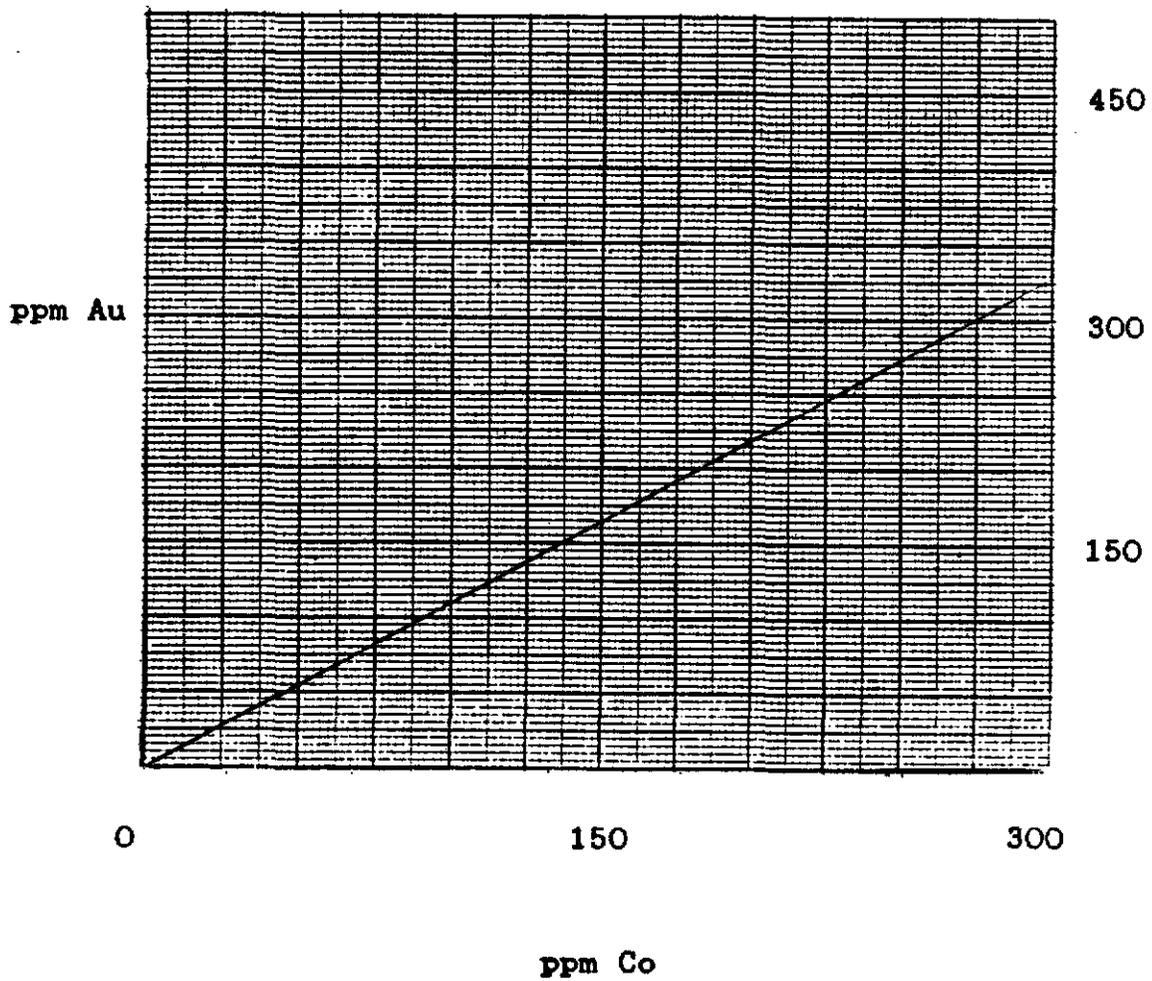
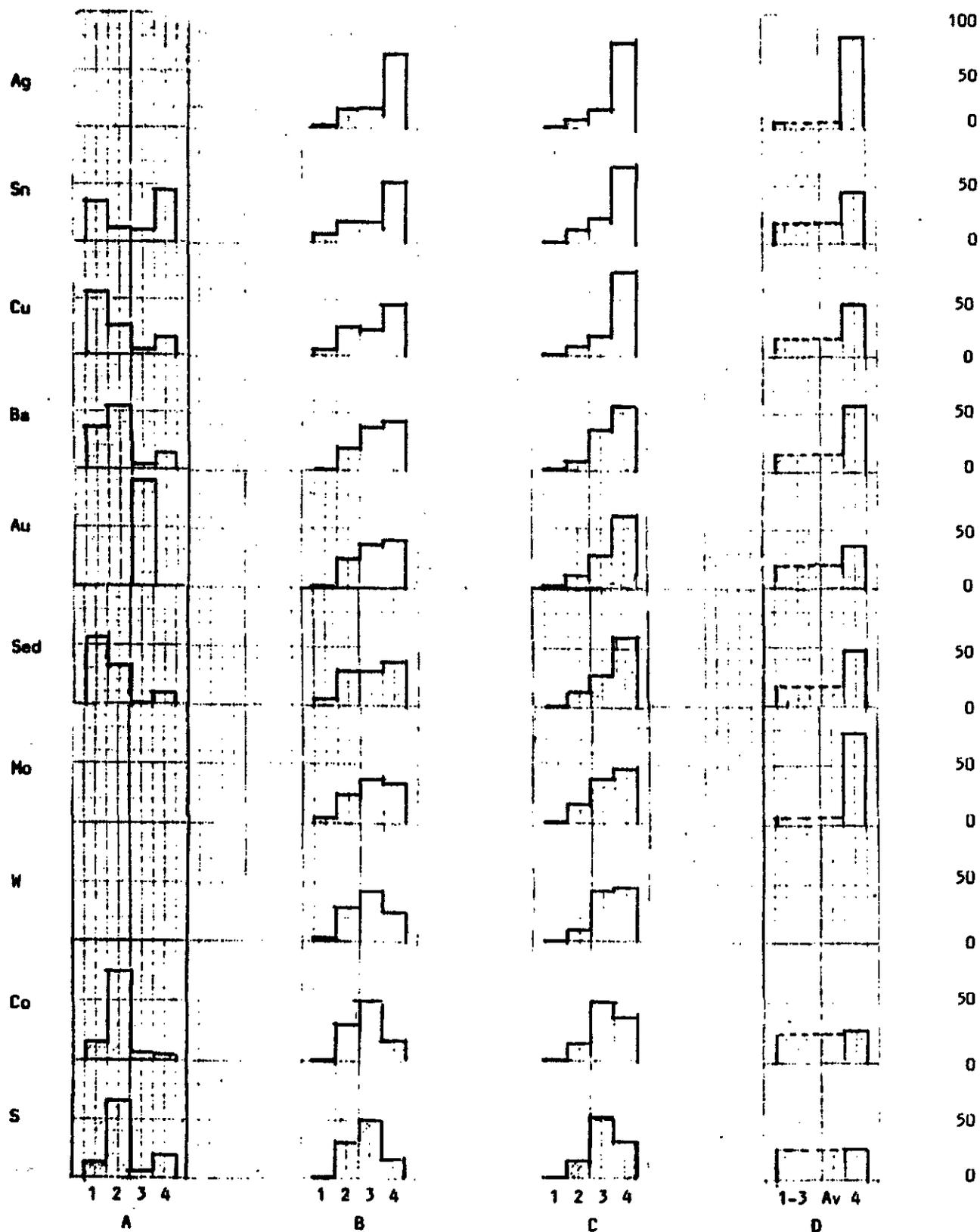


Figure 6. Gold/cobalt proportions in King Delta sulphide.

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Figure 7. Elemental Distribution in Weight Percent, King Delta Sediment



1 +150 microns
 2 -150 + 38 μm
 3 -38 + 10 μm
 4 - 10 microns

A Mines' Sample, 0 fathoms
 B Andel Composite, 9 fathoms
 C Andel Composite, 17 fathoms
 D Cities' Sample, pre-ground

(A-D: reference 1985 Annual Report)

CONTENT

On completion of 1975 drilling campaign Cities Service put King Delta sediment reserve at 100,000,000 mt proved, plus 25,000,000 mt probable: density, cut-off thickness not stated. Cities' isopach map reproduced at Figure 8.

Data given here, Section II, show volume of deposit within Cities' 2.5 m isopach is 60,000,000 cubic metres and likely density is 1.67 gm/cc for sediment in place. This defines 100,000,000 mt proved reserve.

Tailings added since 1975 estimated to amount to extra 15,000,000 mt. No reduction needed for small fraction carried into bay because approximately balanced by deposition at delta of riverine sediment derived naturally.

Further reserve of probable category made up of sediment lying seaward of cut-off isopach and by additional material at delta base. Existence of latter likely as some thirty percent of Cities' bores, mainly deeper holes, failed to penetrate full thickness of deposit.

Quantities of delta's principal elements and minerals in situ shown below.

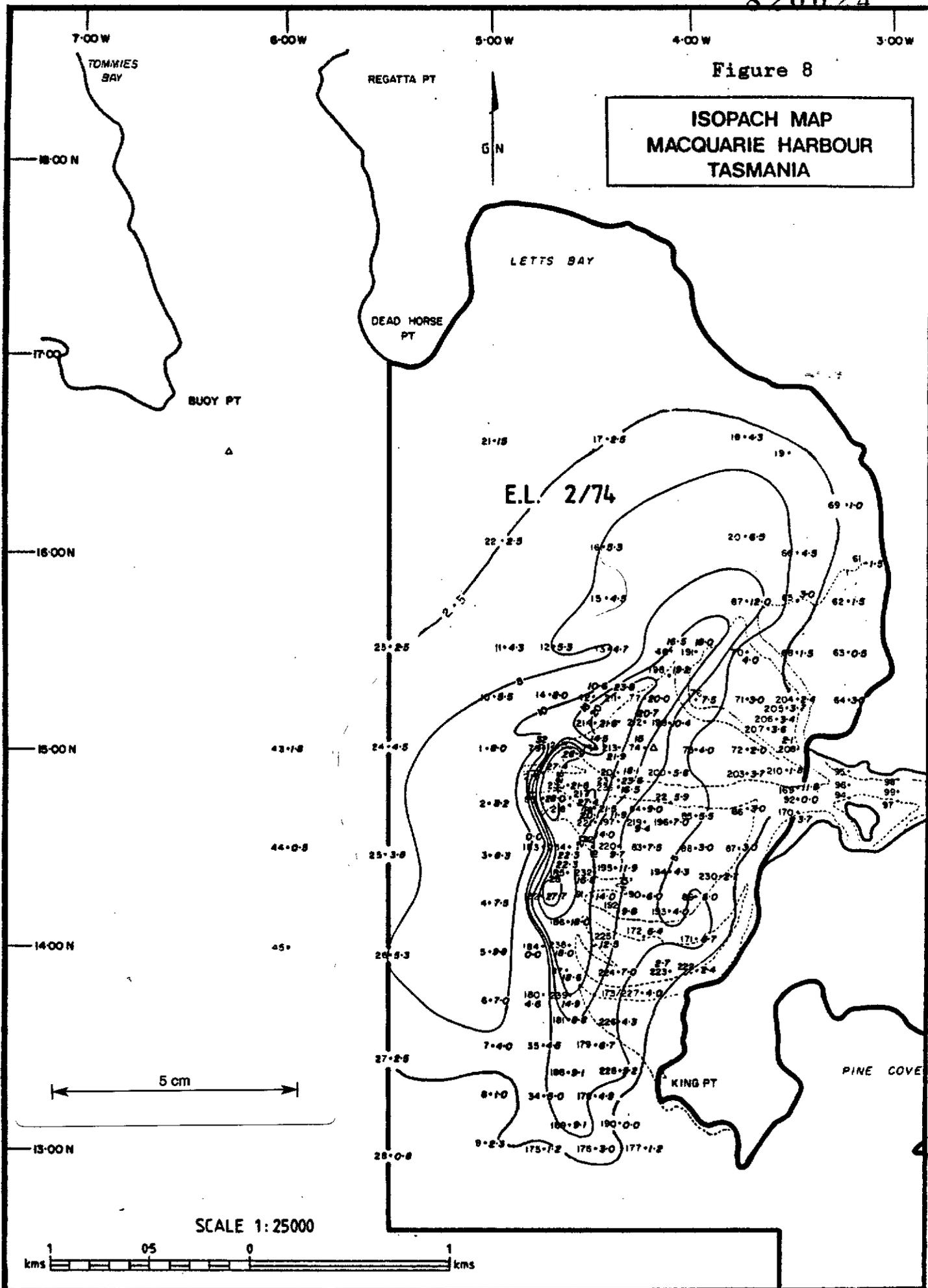
Table 2. Contained reserve: King Delta, Tasmania

Element /Mineral	Grade	Total in 100 M mt
Au	140 ppb	14,000 kg
S	2.9 %	2,900,000 mt
Co	87 ppm	8,700,000 kg
Cu	1,255 ppm	125,500,000 kg
Mo	46 ppm	4,600,000 kg
Ag	1.3 ppm	130,000 kg
Barite	7,000 ppm	700,000 mt
Monazite	2,000 ppm	200,000 mt

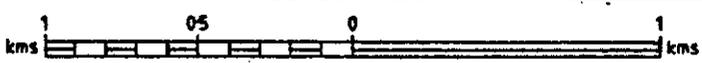
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Figure 8

ISOPACH MAP
MACQUARIE HARBOUR
TASMANIA



SCALE 1:25000



EXPLOITATION

VI

MINING

Sediment of King Delta effectively a minerals deposit already bared, drilled, blasted, mined, milled, stacked at water's edge. Material can be fed to processing plant almost as is. Profitable production possible, using standard treatment methods, because grade disadvantage cancelled by mining stages avoided. Further, working large deposit will introduce economies of scale.

Infrastructure exists to permit successful exploitation of delta reserve. All-weather road linked to sealed State system bounds northern edge of licence area: see Figure 9. Aerodrome and small port close by at Strahan. Labour, housing, office space available locally and at Queenstown, particularly after Mt Lyell ceases mining. Marine facilities, Strahan and Hobart. Engineering, other services at Hobart, Burnie, Launceston, Melbourne. Process water abundant, fresh or brack, from King River, Macquarie Harbour respectively. Relatively low cost electric power via HEC grid from Lower Gordon, planned King River and other generating stations.

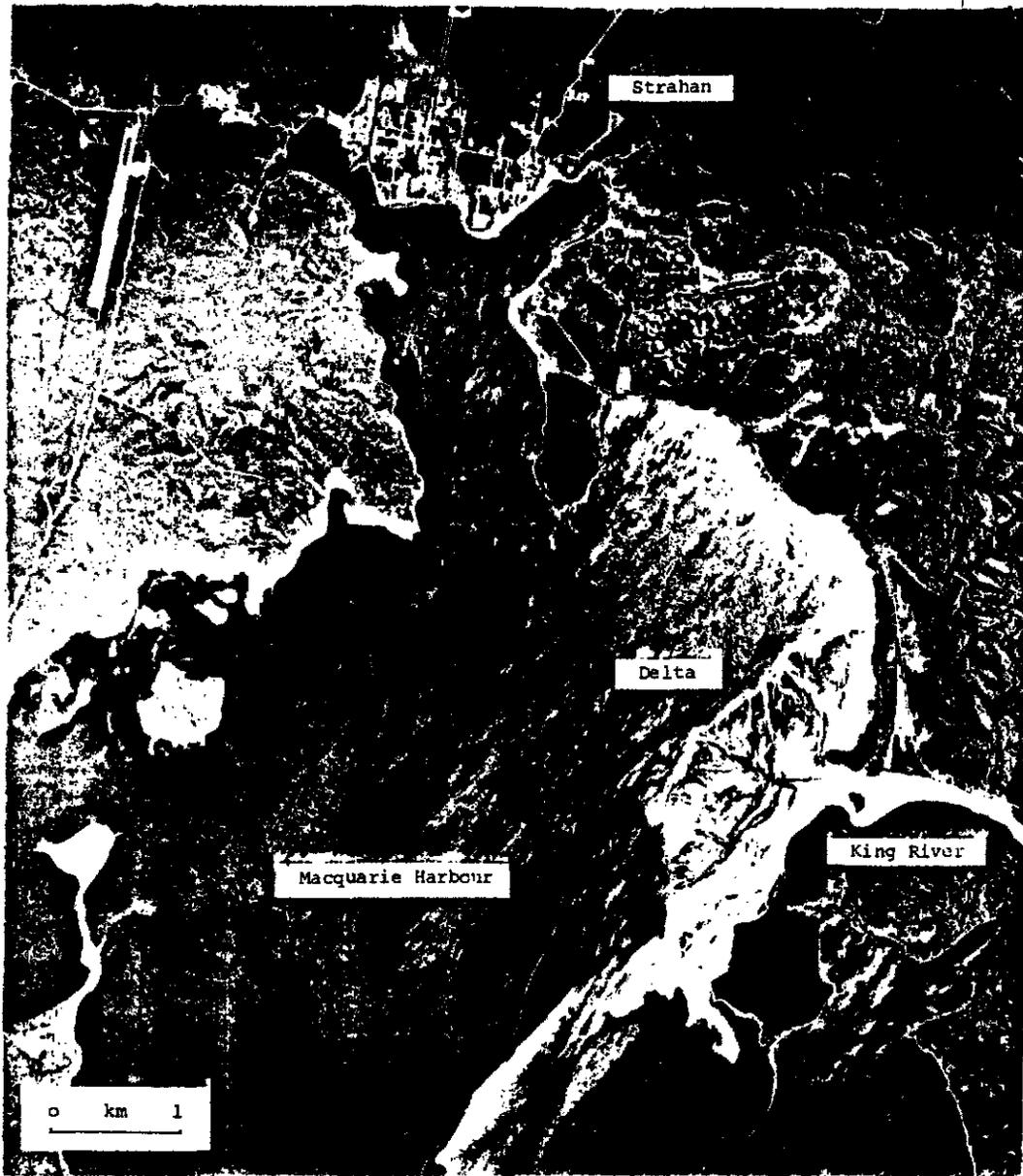
Most efficient way of transferring delta sediment to treatment plant on coast, by means of dredge and pipeline. Preconcentrator at dredge head will reduce quantity of sediment to be sent ashore. Dredging and slurry pumping least expensive form of bulk handling. Ideal for delta's protected location, unconsolidated sand and silt.

Extraction best accomplished by suction dredge or dredge with pump at intake. Preconcentrator to consist of barge-mounted screen and cyclones, or screen and cones, star separators, other gravity equipment. Barge to be moored aft dredge. Suitable dredges, cones, spirals made and sold by Australian beach-mining companies.

Cleaned 80% of sediment, remaining after toxic slimes and densest seventh abstracted at preconcentrator, to be deposited via pipeline on deep floor of Macquarie Harbour immediately south and southwest of delta; discharge below surface.

Proved reserve sufficient to sustain exploitation at rate of 5,000,000 mty for twenty years. Required throughput, dredge and preconcentrator, 1,000 mth or 600 cmh; capacity, say 1,200 tph or 720 cmh. Preconcentrate production, 200 mth.

Figure 9. King River Delta, Macquarie Harbour,



5 cm

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Lab tests indicate delta fifth pumped ashore capable of retaining approximately 90% of total sulphur and cobalt, and at least 75% of gold, 30% of copper. Calculated grade of such material 525 ppb Au, 13.05% S, 390 ppm Co, 1,880 ppm Cu.

VII

TREATMENT

Three-stage process planned for fraction of King Delta sediment pumped shore. Stage I, requiring further separation by mechanical means, on site, and Stages II and III, calling for pyrometallurgy and hydrometallurgy/electrowinning respectively, to be undertaken elsewhere at dedicated or toll processing facility, alternatively at plant buying Stage I sulphide concentrate. Flowsheet proposed, Figure 10.

Stage I provides for second screening or hydrocycloning, and for optional milling of oversize with return of product to screen/cyclone circuit.

Screen/cyclone products to sulphide flotation. Flotation tailings washed and pumped back to join barren discharge from barge plant or, as option, to extension of shore plant consisting of spirals, magnetic and electrostatic separators, additional flotation cells, to recover variously, barite, monazite?, free gold.

Stage II treatment aimed at production of elemental sulphur from sulphide concentrate of Stage I. Several candidate processes, all commercially proved.

The Outokumpu, used in Finland for some fifteen years and later in Botswana, converts 40% of pyritic sulphur to elemental state.

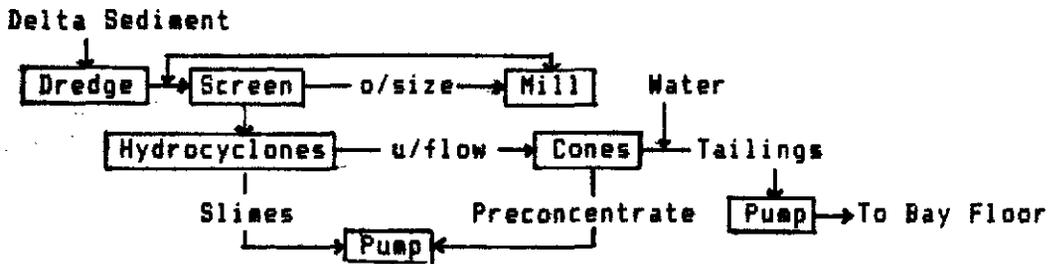
In the Noranda process, formerly employed at a Canadian plant, pyrite heated to 540°C in an oxygen-free atmosphere emits half its sulphur in elemental, recoverable form.

The Orkla process involves smelting pyrite in presence of carbonaceous reducing agent. About 80% of contained sulphur retrievable elementally. Process used in past in Spain, Scandinavia. Latter operation yielded up to 100,000 t sulphur per year.

Stage III treatment to recover gold, cobalt, copper (minor molybdenum?, silver?) from ferruginous cinder generated in Stage II smelting operation. Metals extracted by liquid ion exchange procedures and electrowinning, or chemically from leach liquors as metallic compounds.

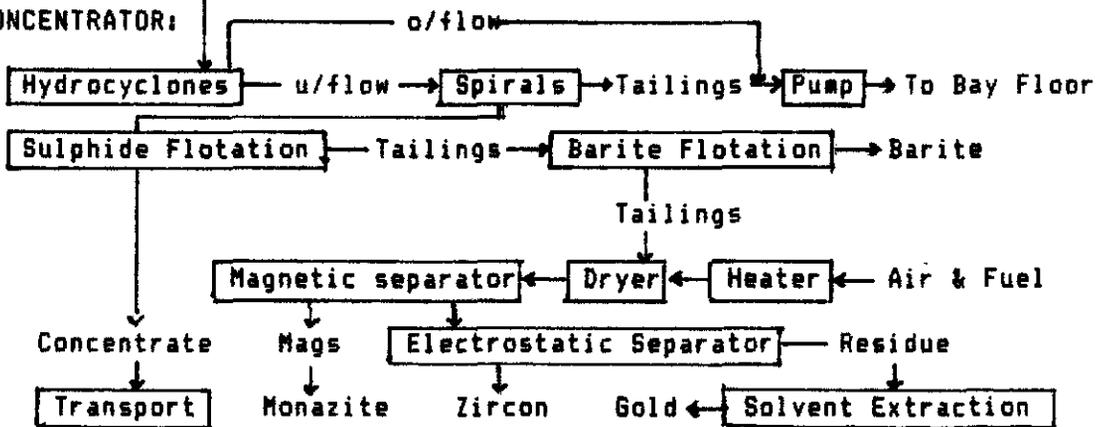
Anticipated production based on exploitation of delta deposit at rate of 5,000,000 mty shown in Table 3.

DREDGE & BARGE-MOUNTED PRECONCENTRATOR:

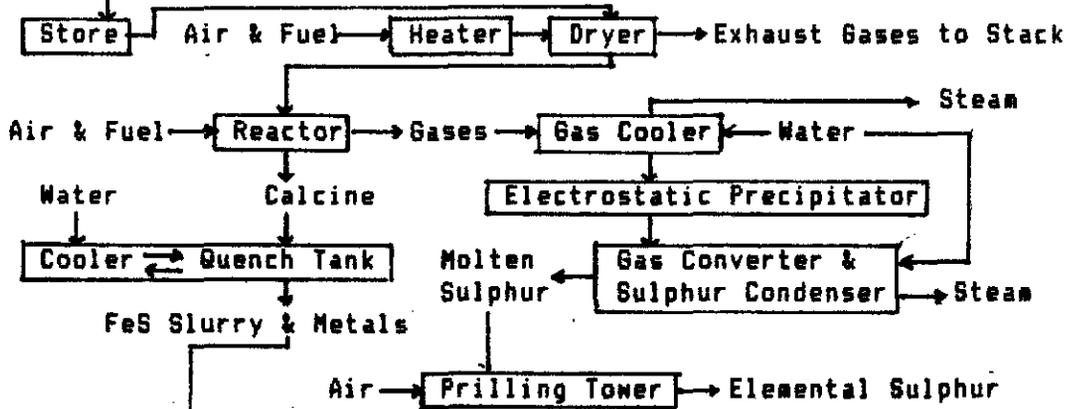


Preconcentrate slurry to shore plant

SHORE CONCENTRATOR:



PYROMETALLURGY:



HYDROMETALLURGY:

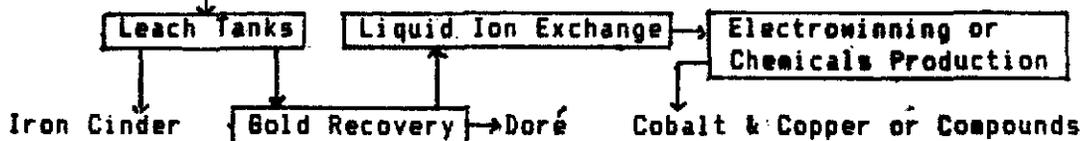


FIGURE 10. PROPOSED FLOWSHEET, KING DELTA PROJECT, TASMANIA

Table 3. Estimated yield: King Delta, Tasmania

Element	Grade	Total in 100 M mt	Recovery likely	Quantity recoverable	Annual production
Au	140ppb	14,000kg	70%	9,800kg	490kg
S	2.9%	2,900,000mt	36%*	1,044,000mt	52,000mt
Co	87ppm	8,700,000kg	75%	6,525,000kg	326,000kg
Cu	1,255ppm	125,500,000kg	25%	31,375,000kg	1,568,000kg

*recovery of ca. 70% if Orkla process employed; would yield 101,500 mty for total of 2,030,000 mt over 20 years.

VIII

ECONOMICS

Cities' 1976 comparison of porphyry copper and their expected delta production costs, cited in Section I, appears in Table 4. "Cu equivalent" refers to deposit's Cu + Zn + Co + Mo. Cities considered that at copper price of US\$ 0.80/lb, metals recovery of 75%, and sulphuric acid sold at \$10/ton, operation would return after-tax profit of about 15%. Estimate based on bulk flotation of all delta sediment.

Table 4. Comparison of a Conventional Porphyry Mining/
Milling/Smelting Operation with Cities' Proposed
Tasmania Copper Operation

	Conventional Porphyry	Tasmania Copper
Orebody	Hard Rock	Unconsolidated Sediment
Grade	0.5% Cu equiv.	0.25% Cu equiv.
Daily ore production	40,000 tons	40,000 tons
Type mining	Conventional open pit	Dredge
Processing		
a. Crushing & grinding	Yes	No
b. Flotation	Yes - standard	Yes - tank
c. Metallurgy	Pyro	Hydro
Capital required	\$200 million (not including smelt- ing & refining)	Estimated \$40-60 million (includ- ing refining)
Operating costs/ton ore mined		
Mining	\$ 3.31	\$1.55
Crushing & grinding	\$.63	\$.05
Flotation	\$.80	\$.12
Smelting, refining & transportation	\$.60	\$.90
	\$ 1.28	\$.48

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Table 5. 1977 forecast by Cities Service International: economics of King Delta pyrite production.
Based on value of \$50/ton contained sulphur.

13:23CUT	MINERALS GROUP PYRITE CONCENTRATE BASE CASE(50) PROJECT ANALYSIS										TAS#50 06/10/77	
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	AVERAGE	TOTAL
PROD. VOL.--	0	0	0	160000	160000	160000	160000	160000	160000	160000	160000	3200000
SALES VOL.--	0	0	0	160000	160000	160000	160000	160000	160000	160000	160000	3200000
GROSS SALES	0	0	0	8001	8001	8001	8001	8001	8001	8001	8001	160020
DISCOUNTS	0	0	0	1	1	1	1	1	1	1	1	20
FREIGHT	0	0	0	1	1	1	1	1	1	1	1	20
NET SALES	0	0	0	7999	7999	7999	7999	7999	7999	7999	7999	15990
RAW MATERIALS	0	0	0	768	768	768	768	768	768	768	768	15360
INVENTORY ADJ.	0	0	0	0	0	0	0	0	0	0	0	0
G&A	0	0	0	150	150	150	150	150	150	150	150	3000
COST OF GOODS	0	0	0	918	918	918	918	918	918	918	918	18360
DEPR. & WRITEOFFS	0	0	0	331	331	331	331	331	331	331	229	5296
NET OPERATING INC.	0	0	0	6750	6750	6750	6750	6750	6750	6750	6852	136324
TAXABLE INC.(BK)	0	0	0	6750	6750	6750	6750	6750	6750	6750	6852	136324
INCOME TAX	0	0	0	3037	3037	3037	3037	3037	3037	3037	3033	61336
NET INCOME	0	0	0	3713	3713	3713	3713	3713	3713	3713	3769	74988
+ DEPRECIATION	0	0	0	331	331	331	331	331	331	331	229	5296
+DEF. INC. TAX	0	0	0	0	0	0	0	0	0	0	0	0
-CAP. EXPENDITURES	2000	2000	1300	0	0	0	0	0	0	0	0	5300
-WOK. CAP. CHG.	0	0	0	700	0	0	0	0	0	0	0	700
+ RECOUP & OTHER	0	0	0	0	0	0	0	0	0	0	0	704
CASH FLOW	-2000	-2000	-1300	3344	4044	4044	4044	4044	4044	4044	3993	74988
CUM. CASH FLOW	-2000	-4000	-5300	-1956	2083	6132	10175	14220	18264	22308	0	74988
NET ON ASSETS EMPL.	0	0	0	70	65	70	74	79	85	92	0	0

OPERATING LIFE OF 20 YEARS

TOTAL CASH PRODUCED--(\$000)	30284.0	PROFITABILITY INDEX--PERCENT	37.4
TOTAL INVESTMENT--(\$000)	6000.0	PAYOUT FROM STARTUP--YEARS	1.5
ULTIMATE ROI--PERCENT	1338.1	PAYOUT FROM FIRST INVEST.--YEARS	4.5
AVE. ANNUAL ROA EMPL	97.3	NET PRESENT VALUE 12%--(\$000)	15350.5

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In 1977 Citicorps showed extraction of delta's pyrite as raw material for use in manufacture of sulphuric acid economically attractive assuming concentrate valued at rate of US\$20/t of contained sulphur. Estimated profitability after tax: 17.5% at sulphur price of \$20/t, 29% at price of \$35/t, 37.4% at price of \$50/t. For Citicorps' analysis of projected operation at latter price see Table 5.

Citicorps found no buyer for deposit because of Australia's excess acid production. However, Aberdare since has established that a substantial market for sulphur in elemental form exists, domestically and in New Zealand: also, that there are proven processes, formerly in use overseas, permitting production of such sulphur from pyrite.

In addition, Aberdare discovered delta contains widespread gold concentration. Estimated 55% of gold resident in deposit's sulphide component, along with all cobalt, some copper, other metals.

Present commodity prices warrant exploiting delta's sulphur, gold, cobalt and copper: see Table 6. Figures tabulated based on recovery rates given in preceding sections.

Table 6. Approximate value, sediment and preconcentrate, King Delta, Tasmania

Element	Commodity Price US\$/Unit	Price AS/Unit*	Sediment in place A\$/mt	Pre-con A\$/mt	Extract- able A\$/mt raw sediment	Percent of \$6.36
Au	480/t.o.	657	2.96	11.09	2.07	33
S	125/mt	178	5.16	23.23	1.86	29
Co	7.00/lb	10	1.92	8.64	1.44	23
Cu	1.00/lb	1.43	3.96	5.93	0.99	15
Total			14.00	48.89	6.36	100

*A\$1.00 = US\$ 0.70

Comparing gross figures derived from unit totals of line above indicates reduction in value expected to result from dredging and all subsequent processing.

Gross value	A \$
100,000,000 mt sediment, in situ	1,400,000,000
20,000,000 mt preconcentrate	978,000,000
100,000,000 mt reserve, extractable fraction	636,000,000

Cost of equipment required for delta project given below.

Table 7. Estimated capital costs, King Delta project, Tasmania

	Million Dollars Australian		Total
	Initial	Replacement	
Dredge, barge-mounted preconcentrator, pumps, piping	14	9	23
Shore plant; gravity and other mechanical separators; flotation	12	6	18
Transport system; pyrometallurgical unit	40	17	57
Hydrometallurgical plant	7	2	9
Total	73	34	107

Following table presents probable cost and profit.

Table 8. Estimated unit costs and projected return, King Delta project, Tasmania

Australian dollars/mt delta sediment			
Extractable value of useful components of delta sediment, from Table 6			6.36
Working costs	Capital	Operating	Total
To dredge, preconcentrate, pump	0.23	0.68	0.91
Shore-based concentrate production	0.18	0.58	0.76
Pyrometallurgy & sulphur generation	0.57	1.90	2.47
Metals/chemicals production & sale	0.09	0.65	0.74
Total	1.07	3.81	4.88
Income			1.48
Taxes, royalties*			.74
Net income			.74
*Overall rate of 50% takes into account tax-free gold, royalty-free pyrite			

Return of 74 cents on total cost of \$4.88 represents profitability of approximately 15% after tax. Pay-out would average A\$3,700,000 annually over 20-year mine life.

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Capital and operating costs stated are derived from figures originally provided by Cities Service, Mineral Deposits and other reliable industry sources: figures have been increased 2 1/2 fold to allow for inflation, etc.

Return in Table 8 buffered against higher costs in that extractable value assigned to sediment is a minimum, likely to be improved upon. If, on other hand, increases in extractable value realised and stated costs obtain, return and profitability will rise. Rise in value expected from higher grade, better recovery rates, credits from additional byproducts.

For example, redefining deposit by dropping lower grade sediment from northern, western, southern margins of deposit - and from base within 2-m isopach where lowest samples of Cities' drillholes fully intersecting deposit include some barren underlying material - will raise average sulphur and metals contents.

With respect to recovery, substitution of the Orkla process for the Outokumpu method assumed in tables of this report may generate about twice as much sulphur. Likewise, use of new K-process or other halide-based extraction technique may well prove to recover a greater proportion of gold present than conventional practice would allow, at lower cost moreover.

Additional credits may result from part recovery of other elements and minerals naturally concentrated in delta sediment, for instance molybdenum and silver, barite and monazite. Treatment of pyrite to yield sulphur will generate several million tonnes ferruginous cinder. After other metals are removed some of it may be usable, added to Savage River product for instance.

IX

DEMAND

Overall demand picture favourable for three of the four principal commodities to be produced by exploitation of King Delta deposit.

Sulphur

Market prospects for sulphur produced from sulphides at localities in southeastern Australia particularly attractive. Neither Commonwealth nor New Zealand has significant indigenous reserves of elemental sulphur. Respectively, they import about 400,000 and 200,000 mt sulphur per year: see Table 9. All comes from North America. With sulphur averaging A\$175/mt, the two countries together spent the equivalent of \$110,000,000 on the commodity in 1986.

Both countries have large trade deficits and strong incentives to reduce overseas spending of this nature. Sulphur is one of the few mineral substances they each import in bulk which could be produced wholly in Australia. King Delta pyrite, readily extracted and concentrated, and carrying enough gold, cobalt and copper to cover much of cost of recovering elemental sulphur from it, constitutes nucleus for this projected industry. At tabulated recovery rate of 36%, sulphur from delta pyrite would meet an eighth of Australia's current sulphur demand annually for twenty years.

Table 9. Sulphur statistics; '000 mt

	1982	1983	1984	1985	1986
World production		50,472	51,884	54,856	55,000
Australian imports			470	392	410
New Zealand imports	256	206			

Sulphur production of two countries above being negligible, import figures may be taken to represent recent demand.

About three-quarters of all sulphur consumed in making fertilizer and other chemicals used in agriculture. As no quick, major change in Australian farming practice anticipated, future demand likely to approximate present one.

US Bureau of Mines predicts global sulphur demand will grow 3.4% annually till end of century. FAO and World Bank put likely growth in sulphur supply required for phosphatic fertilizer manufacture at 4% yearly over same period.

Gold

Australian produces more than enough of this metal to meet domestic needs. Demand for gold of Commonwealth origin thus essentially world demand. Theoretically, world supply of primary gold amounting to some 50,000,000 troy ounces in 1986 is adequate, particularly as primary total augmented by about 7,000,000 t.o. recovered from scrap.

Supply of the metal expected to outstrip demand for another five to ten years until new, low grade, surface deposits in or coming into production are depleted. Thereafter, effects of diminishing production at Transvaal and OFS mines may cause shortfall.

Demand growth until end of millenium put at average of 1.8% per year by US Bureau of Mines, but large swings likely above and possibly below demand projection. These occasioned by events such as today's monetary crisis, or by political and labour unrest in South Africa.

Cobalt

Australia is a net exporter of cobalt. Worldwide supply and demand are expected to remain in balance, broadly, till the year 2,000. Average annual growth in demand up to that date estimated to be 3.7%.

War or civil disturbance in Central Africa, source of 75% of western world's new cobalt, could cause supply shortages temporarily. In eyes of main consumers -- USA, Japan, West Germany, countries with no or poor domestic reserves -- this consideration puts premium on sources in stabler areas like Australia.

In long run, fall-off in demand for copper and nickel probably will reduce the quantity of cobalt available because nearly always it is the concentration of one or other of the former two metals which determines whether a reserve will be exploited. The King Delta deposit, dependent on sulphur and gold demand not on copper or nickel needs, is an exception -- a lucky one in this sense.

Copper

Free world mine capacity far exceeds average demand for the metal. The imbalance is of long standing and is likely to persist, despite today's temporary shortage. Growth in copper demand in the US averages about 1.9% per year.

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Extracting copper from King Delta sediment is warrantable only because it may be recovered as a byproduct at cost below value of the quantity reclaimed.

Table 10. Gold, cobalt, copper statistics

	Au	Co	Cu

World primary production, 1986	50,000,000to	35,100st	8,110,000mt
Australian primary production, 1986	2,400,000to	3,000st	260,000mt
Tasmanian primary production, 1983/4	439,000to		25,000mt
Projected annual production, King Delta	15,750to	360st	1,570mt

In summary, exploitation of King Delta should provide for 12% or more of Australia's sulphur import, will raise the Nation's cobalt output by like amount, and its production of gold and of copper by approximately half a percent each. Latter two contributions would boost Tasmanian production some 5% per commodity.

Projected demands large enough to absorb anticipated supply from delta, particularly with regard to strategic considerations affecting sulphur and cobalt.

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IMPACT

Most large-scale undertakings have negative as well as positive effects. King Delta project appears unique in that risk of environmental damage, generally a major hazard in mining schemes, is practically absent. To contrary, exploitation of the deposit should reverse usual trend, not altering environment adversely but instead restoring to nearly pristine state a river system and coastal area gravely degraded by poisonous spoil produced over nearly a century's activity by Mt Lyell.

Two other unusual aspects favour approval and inception of delta scheme. First, mine site invades no permanent land, only man-made feature, mostly lying below sea level; even exposed section inundated periodically. Second, floor of Macquarie Harbour naturally toxic over last few thousand years at least, thus not subject to damage offshore mining could inflict on typical, ventilated, biologically-productive bay system.

To amplify --

Lyell tailings, an estimated 150,000,000 mt in total, now clog whole length of Queen/lower King River from mine to valley mouth, and blanket almost entire northern sixth of Macquarie Harbour. Formerly, King River some 20 m deep at Teepookanah, four miles above mouth. Tailings and overlying river water acidic, high in metals, inimical to all life except that of sulphide bacteria. Trees on river banks killed, others dying as spoil and water levels rise over blocked valley floor.

After Lyell operations and tailings disposal to Queen cease, King River will gradually deepen channel across delta, allowing valley tailings to be washed into Macquarie Harbour. But process likely to take some decades, and natural erosion of bulk of delta bracketing main distributary will be considerably slower.

Exploitation of deposit, calling for dredging, then for redispisal of cleaned sediment on Harbour floor to south and southwest should greatly accelerate both delta removal and valley flushing.

Planned disposal area well east of shipping lane between Straham and Gordon River/Harbour entrance. Floor, 20 to 25 m below sea level, deep enough to permit distribution of sediment. Discharge from preconcentrator to be below surface to minimise spread of suspended fines.

Turbidity that might be produced not a serious threat because of large amount resulting from fines introduced by Gordon and other rivers. Chop generated by prevailing westerlies erodes Paleocene siltstones of Harbour's eastern shore, producing additional turbidity of natural origin.

Macquarie Harbour below sill depth a reducing environment, except at Gordon mouth. Deepest watermass semi-stagnant, depleted in oxygen. Bottom muds dark, malodorous, high in organic matter, H_2S , authigenic sulphides, and in molybdenum, lead, arsenic, cobalt, other poisonous metals. The muds extend into Birch Inlet, far beyond depositional limit of Lyell tailings. Also found beneath tailings of delta's deep-water apron. Sediment of same characteristics and chemistry still evident at base of 5-metre cores from Harbour centre, material which at accumulation rate estimated was laid down several thousand years ago.

These Harbour muds contain and permit existence of anaerobic organisms but otherwise lifeless, or essentially so.

On bottom at Harbour margins above sill depth, small black flounder, stunted shellfish occasionally encountered: but no known natural or commercial hatcheries anywhere in bay, and no commercial fishing.

Follows from above that operation of dredge and preconcentrator with pumps and other hydraulic systems driven by electric motors will have no adverse effect on Harbour waters or floor.

Shore concentrator to be largely mechanical, again using electrical power for pumps, cyclones, screens, magnetic separators, thus no risk of dangerous discharge to water or air. Sulphide- and, if employed, barite-flotation media to be recycled and carefully contained.

As no drilling or blasting required, and a little or no milling or use of conveyor belts, both offshore and onshore operations should be quiet, akin to those of conventional beach mining.

Two small farms and three houses lie near northern boundary of delta deposit. Twenty to thirty holiday shacks and retirement homes at Dead Horse Point, several kilometres away from proposed dredging and shore operations; but no other community nearer than Strahan. From Strahan, Delta and precincts out of sight and earshot.

Materials handling and all or nearly all concentrating stages to be wet, thus no dust problem anticipated.

Operations will increase road traffic between shore site and Strahan but should not have other marked impact of negative kind.

Shore plant to be erected on raised area built partly from cleaned sediment at coastal edge of delta. Will not impinge on existing dry land or necessitate tree-felling, other clearing. Short access road probably required, plus power and water lines etc.

Impact of sulphur extraction unit not determinable until additional details regarding site and circuitry available.

To recapitulate, negative aspects of mining delta and producing concentrates minor only and far outweighed by gains. Major beneficial effect of project on environment will be removal of unsightly spoil, now disfiguring and poisoning bed and banks of Queen River and lower King River over distance of seventeen miles.

If the project does not go ahead, this blot on Tasmania's landscape and mining record will remain evident for next half-century at least.

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A P P E N D I X

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*Appendices of these reports include copies of assay and other test data produced by Australian Mineral Development Laboratories.