Assessment of Mineral Resources in the Eden CRA Study Area

A report undertaken for the NSW CRA/RFA Steering Committee

27 February 1998

ASSESSMENT OF MINERAL RESOURCES IN THE EDEN CRA STUDY AREA

BUREAU OF RESOURCE SCIENCES

GEOLOGICAL SURVEY OF NSW
DEPARTMENT OF MINERAL RESOURCES

A report undertaken for the NSW CRA/RFA Steering Committee
Project Number NE 08/ES

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REPORT STATUS

This report has been prepared as a working paper for the NSW CRA/RFA Steering Committee under the direction of the Economic and Social Technical Committee. It is recognised that it may contain errors that require correction but it is released to be consistent with the principle that information related to the comprehensive regional assessment process in New South Wales will be made publicly available.

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This project has been jointly funded by the New South Wales and Commonwealth Governments. The work undertaken within this project has been managed by the joint NSW / Commonwealth CRA/RFA Steering Committee which includes representatives from the NSW and Commonwealth Governments and stakeholder groups.

The project has been overseen and the methodology has been developed through the Economic and Social Technical Committee which includes representatives from the NSW and Commonwealth Governments and stakeholder groups.

The collection of information and drafting of this report were undertaken cooperatively between officers of the Geological Survey of New South Wales and the Bureau of Resource Sciences:

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CONTENTS

Figures

CONTENTS

EXECUTIVE SUMMARY

This report has been prepared for the joint Commonwealth/State Steering Committee which oversees the comprehensive regional assessments of forests in New South Wales.

The comprehensive regional assessments (CRAs) provide the scientific basis on which the State and Commonwealth governments will sign regional forest agreements (RFAs) for the major forests of New South Wales. These agreements will determine the future of the State's forests, providing a balance between conservation and ecologically sustainable use of forest resources.

This report was undertaken to provide a regional assessment of the mineral resources of the Eden region, which occupies the southeastern corner of New South Wales. The assessment is based on the known mineral occurrences and resources of the region and on the potential for undiscovered mineral resources, based on mineral exploration, geology and other geoscientific information of the area.

The assessment of the mineral resource potential was conducted for the whole of the Eden region and is based on data and recent geological reports provided by the NSW Department of Mineral Resources (DMR). Professional staff of the Commonwealth Bureau of Resource Sciences (BRS), the Geological Survey of NSW (a division of DMR) collaborated in the preparation of the assessment. The Australian Bureau of Agricultural and Resource Economics (ABARE) provided an economic assessment of mineral resources and mining.

The methodology adopted by BRS and DMR to assess the mineral potential of the region followed that developed by the United States Geological Survey, which has been used for mineral resource assessments of forest areas in North America and elsewhere. This methodology identifies geological units (referred to as tracts) which could contain particular types of mineral deposits. An assessment of the potential resources of an area is then an estimate of the likelihood of occurrence of mineral deposits which may be of a sufficient size and grade to constitute a mineral resource.

In this study mineral potential tracts were identified for eleven types of metallic mineral deposits (which included different styles of gold, silver, base metal, tungsten, and tin deposition), for pyrophyllite (a mineral used in the ceramics industry) and for construction materials. The tracts were then combined to present a weighted composite mineral potential of the region. This result provides some perspective to the relative economic significance between different types of mineral deposits (an area with high potential for gold mineralisation would rate higher than an area with high potential for pyrophyllite, given the relative market prices of the two commodities).

Seven hardrock quarries, three construction sandpits and numerous pits winning unprocessed road materials currently operate in the Eden region, and mining of pyrophyllite occurs on a limited scale at Back Creek west of Pambula.

In the past, production of metals from the Eden region has been largely from alluvial and primary gold deposits and granite-hosted bismuth-molybdenum deposits. The study indicates that the highest potential for future discoveries is for epithermal gold-silver, granite-hosted gold, and slate-belt gold.

1. INTRODUCTION

The Eden region comprises an area of about 8100 square kilometres and occurs in the southeastern corner of New South Wales (Map 1). It extends from east of Bombala and Nimmitabel to the coast, and from the Victorian border to just north of Bermagui. Known mineral resources and potential (undiscovered) mineral resources have been assessed as part of the Comprehensive Regional Assessment (CRA) of the forest areas in the Eden region. This region is referred to in this report as ‘Eden’, or ‘the Eden region’.

The assessment of the mineral resources was conducted on a regional scale for the whole of Eden and is based on data and recent geological reports provided by NSW Department of Mineral Resources (DMR). Professional staff of the Bureau of Resource Sciences (BRS), the Geological Survey of NSW (a division of DMR), and the Australian Bureau of Agricultural and Resource Economics (ABARE) collaborated in the preparation of this assessment.

DMR reports on the Bega-Mallacoota 1:250 000 geological sheet (Lewis et al 1994), the Bega metallogenic 1:250 000 sheet (Herzberger and Barnes, 1975), Geology of New South Wales (Scheibner and Basden, 1996) and other published reports and unpublished reports by exploration companies were some of the sources of information on identified mineral resources in Eden. These reports describe the geology, mineral resources and mineral exploration of Eden.

Prior to the assessment of mineral resources, the DMR compiled the available geoscientific data for the region. Assembled data on which the mineral resource assessment is based include:

- an updated mineral occurrence dataset for the region,
- a seamless coverage of digital 1:250 000 geological maps for surface and solid geology, and
- magnetics and landsat images.

It is important to note that Eden has not been subjected to a regional coverage of detailed high resolution airborne geophysical survey; such surveys would generate new data and an improved understanding of mineral deposition in the region.

Conclusions published on the Lachlan Fold Belt in a 1995 issue of Economic Geology were also considered in this assessment.

Appendix C contains data documentation for mineral occurrence locations, geological and airborne geophysical data, and for mining tenements.

2. ADMINISTRATION OF MINING AND EXPLORATION TITLES

2.1 MINERAL EXPLORATION AND MINING

Mineral exploration and mining in New South Wales is principally governed by the Mining Act 1992. Exploration and mining for petroleum is governed by the Petroleum (Onshore) Act 1991. Both Acts are administered by the Department of Mineral Resources and provide for a range of conditions to be included in the tenures granted for exploration and mining to cover requirements for exploration and mining methods, professionalism in carrying out operations, reporting and care of environment, and to address land owner and occupier interests. The provisions of the Petroleum (Onshore) Act 1991 are rather similar to those of the Mining Act 1992 and will not be elaborated upon further.

Under the Mining Act 1992 there are three principal forms of title, *Exploration Licence*, *Assessment Lease* and *Mining Lease*. To cater for the smaller operations, a *Mineral Claim* is a title which can be granted for prospecting and mining in areas up to two hectares in size. In the opal fields an *Opal Prospecting Licence* can also be granted to assist in the search for opal within larger paddock size areas but these are short term titles, usually of 28 days duration.

Under the Mining Act, tenures for exploration and mining can be granted over both Crown and private land, and over both Crown and privately owned minerals. Although most minerals are owned by the Crown, there are cases, particularly where original land grants occurred in the 1800s, where the minerals were not reserved to the Crown in the land grants, and in those cases the minerals are owned privately.

2.1.1 Exploration Licences

Exploration Licences enable mineral exploration and prospecting to be undertaken. The size of areas which can be granted ranges from about 3 square kilometres (one unit) to about 300 square kilometres (100 units). A unit is an area bounded by a minute of longitude by a minute of latitude. Areas of more than 100 units can be granted in special cases. Exploration licences are normally granted for a period of two years and may be renewed for further periods. These licences allow for geological and geophysical surveying, sampling, drilling, trenching and other exploration techniques as applied for by the applicant. Before any private lands are entered under an exploration licence the owner and any occupier must be notified and an access agreement entered into by the exploration licence holder and the land owner and occupier. All exploration licences contain conditions, including ones specifying the amount required to be expended on exploration during the period of the licence. A security deposit must also be lodged to cover the exploration licence holder's obligations to comply with the licence conditions.

2.1.2 Assessment Leases

The *Assessment Lease* is a relatively new tenure for New South Wales having been introduced by the Mining Act 1992. The purpose of this tenure is to enable detailed evaluation of mineral deposits to be carried out after the normal period of exploration but where, for some special reasons, the project is not ready to be applied for under

Mining Lease. Such reasons can be of an economic nature eg. the deposit found is not presently economic to develop, or could be practical reasons such as a need to develop specific processing methods to extract a particular mineral from the host rock. There is no maximum size for an assessment lease, size and dimensions of areas being such as are necessary and appropriate. These titles can be granted for a period of five years and renewed for a further period of five years. Similar conditions on expenditure, reporting of progress and security are required as in exploration licences. Where access to lands is required appropriate access arrangements and consents must be obtained.

2.1.3 Mining Leases

Mining Leases are granted to enable mining operations to be carried out. There is no maximum size for a mining lease and dimensions and area can be such as are needed and appropriate for the particular mining operation. Mining leases are generally granted for a period of twenty one years but can be granted for longer or lesser periods, depending upon circumstances. Leases can be renewed. Mining leases enable operations, subject to appropriate conditions, to be undertaken by open cut (surface) or underground methods. Royalty is payable on all minerals recovered at the rate prescribed by the Mining Act 1992 or at such additional rates as may be specified. The holders of mining leases are required to lodge a security deposit with the Minister commensurate with the size of the mining operation to ensure compliance with conditions of the lease.

2.1.4 Compliance with Other Legislation

Applicants for and holders of titles under the Mining Act 1992 are required to comply with the provisions of other appropriate legislation such as the Environment Planning and Assessment Act 1979 and the endangered flora and fauna legislation. In particular, mining lease applicants are required under the Environment Planning and Assessment Act to obtain development consent before a mining lease can be granted under the Mining Act 1992. The lodgement of the development consent application normally includes the submission of an environment impact statement which is put on display for public comment as part of the application processing. Depending upon circumstances, a commission of inquiry to hear views about the particular project can be required and the recommendations of the inquiry are taken into consideration as to whether or not development consent should be granted and, if so, upon what conditions.

In granting mining leases, the views of all appropriate Government departments and authorities are obtained and appropriate conditions to meet respective requirements are formulated for inclusion in the lease documents.

Records of all titles and applications for titles under the Mining Act are kept by the Department of Mineral Resources as required by the Act.

2.2 CONSTRUCTION MATERIAL EXTRACTION

A number of State and Local Government agencies control the extraction of construction materials. Some materials, like clay and shale, are classed as minerals under the Mining Act 1992 and can be extracted under mining titles issued by the Department of Mineral Resources. Other materials such as sand and gravel, and crushed rock, can be extracted from Crown Land under titles issued by agencies such as State Forests and the Department of Land and Water Conservation. In each case, development consent must be obtained from the local Council before extraction can proceed.

Where construction materials are present on private land, they may be extracted by the land owner or by a private company which has an agreement with the land owner after obtaining development consent from the local Council.

The Department of Mineral Resources has a recognised and accepted role in assessing the State’s resources of construction materials and providing advice on their management and extraction. It is also responsible under the Mines Inspection Act 1901 (as amended) for ensuring the safe operation of the State’s mines and quarries.

3. GEOLOGICAL SETTING

The Eden region occurs within the Eastern Belt of the Lachlan Fold Belt (LFB) in south eastern Australia. Major geological and mineralising events are described in Table 1. The table is based on the work of Lewis et al. (1994) The geology of much of the region, particularly the heavily forested areas, is still not known in detail.

3.1 MAJOR EVENTS

Major geological events, rock units and mineralising events for the Eden region are:

3.1.1 Late Cambrian to Early Silurian

In the earliest phase of development of the Eden region, two separate terranes existed. They were the Mainland (Molong-Monaro) Terrane, the more extensive unit which covers most of the study area, and the Narooma Terrane of much more limited extent, mainly occurring north of the study area (Scheibner & Basden, 1996). Both terranes ranged in age from the Late Cambrian to Early Silurian and were accreted before the Late Silurian granite emplacement.

The earliest known deposition in the study area commenced with a monotonous sequence of sandstone and siltstone of the Adaminaby Group, deposited in a major turbidite fan system. These rocks are conformably overlain by a predominantly shaly sequence, the Bendoc Group.

A separate rock sequence, the Wagonga Group, deposited in the Narooma Terrane, is represented by abyssal oceanic sediment and mafic volcanics.

3.1.2 Early to Middle Silurian

On the Mainland Terrane an Early Silurian deformation (Benambran deformation, Table 1) caused folding and thrusting in Ordovician sequences resulting in the development of an angular unconformity in the west of the Eden region.

Following this deformation event, the Yalmy Group, a uniform progression of quartz-rich marine sandstones was deposited. Rare mafic volcanic detritus has been identified in the Yalmy Group. The rocks probably represent a (more proximal) turbidite facies with sediment input from the Wagga–Omeo belt to the west and north-west. Most areas show a progressive thinning of beds up-sequence as the sediment input decreased. Typically the rocks start with thick-bedded sandstone and become thinner-bedded and finer grained, finishing with fine sandstone or siltstone.

3.1.3 Middle Silurian to Early Devonian

A period of deformation (Quidongan) in the Middle Silurian is evident from an angular unconformity separating the Yalmy Group from the overlying Bredbo Group. This deformation caused some warping and broad folding. The areal extent and intensity of deformation is not known.

Deposition of the Bredbo Group was in a shallow marine basin probably caused by extensional tectonic activity which created widespread rifting with contemporaneous extrusive and shallow intrusive volcanic activity. The sequence consists of felsic volcanics, sandstone, siltstone and limestone. The main outcrops are west of the study area in the Cooma and Quidong areas.

The earliest basin deposits include thin calcareous mudstone, reefal limestone pods and reworked volcanic sandstone. These basal units are followed by several cycles of thick volcanic accumulations and monotonous thin-bedded mudstone/ashstone. Many of the volcanic units are rhyolitic to dacitic crystal-rich volcanic sandstone, a mix of primary (ignimbrite) and secondary deposits plus some lava flows. Green slaty shale forms most of the final depositional cycle. These are interbedded with reworked volcanic sandstone, massive limestone, fine feldspathic sandstone, shale and basalt flows.

Table 1: Summary of Geological and Mineralising Events

GEOLOGICAL TIMESCALE		AGE (Ma)	MAJOR GEOLOGICAL UNITS	MAGMATISM/VOLCANISM	MAJOR GEOLOGICAL EVENTS	MINERALISING EVENTS
Cainozoic	Quaternary	1.78	erosion and alluvial deposition			alluvial gold, diamonds?, diatomite
Cainozoic	Tertiary	65	Monaro volcanics	eruption of basalts		
Mesozoic	Cretaceous	141				Au in alkaline intrusives
Mesozoic	Jurassic	205		alkaline intrusive complex emplacement		
Mesozoic	Triassic	251				
Palaeozoic	Permian	298				
Palaeozoic	Carboniferous	354			Kanimblan deformation	slate belt Au
Palaeozoic	Devonian	410	Merrimbula Group Boyd Volcanic Complex	bimodal volcanism and A type granite intrusion	Tabberabberan deformation	sediment hosted Cu and U epithermal Au Ag slate belt Au
Palaeozoic	Silurian	434	Bredbo Group Yalmy Group	I and S type granite intrusions	Quidongan deformation	W Mo Sn veins porphyry Cu Au shear-hosted Au volcanogenic massive sulphides
Palaeozoic	Ordovician	490	Bendoc Group Adaminaby Group Wagonga Group	oceanic basalts	Benambran deformation	
Palaeozoic	Cambrian	545				

Ma - million years ago

Erosion has removed part of the group; however, the rocks at the top of the existing sequence are interpreted as the start of a post-volcanic late-basinal sand sheet. The Bredbo Group of this region extends through the late Silurian.

Intrusion of granite plutons related to the Bega and Berridale Batholiths occurred in the period from the Late Silurian to Early Devonian. The granites of the Lachlan Fold Belt have been the subject of major geochemical studies by Chappell, White and co-workers. They have classified the granites as S-type (derived from melting of sedimentary rocks) and I-type (derived from melting of igneous source rocks). A third type, A-type (alkaline type) also occurs in the Eden region, however the majority of the granites are I-type (Chappell et al, 1991).

Styles of mineral deposits developed during this phase of activity were:

- tungsten-molybdenum-bismuth mineralisation associated with granitic rocks,
- porphyry copper-gold and related styles related to granitic rocks
- volcanogenic massive sulphide base metal deposition associated with the Bredbo and Yalmy Groups,
- granite hosted gold deposits,
- tin deposits related to granitic intrusion,
- granitic rocks represent possible sources of hard rock aggregate and dimension stone,
- limestone deposits in the Bredbo Group,
- slate-belt gold associated with the Adaminaby and Yalmy Groups.

3.1.4 Early to Middle Devonian

A major compressional deformation (Tabberabberan deformation, Table 1), occurred in the Early to Middle Devonian and was responsible for crustal shortening by folding and thrust emplacement of metamorphic complexes such as the Jerangle Metamorphic Complex. Foliation of granites of the Berridale Batholith was also effected by this phase of deformation. Later activity included strike slip movement on the major transcurrent faults (Tantawangalo, Burragate, Berridale and Wadbilliga). The extent and styles of mineralisation related to this deformation are not well documented.

3.1.5 Middle to Late Devonian

By the Middle to Late Devonian the whole of the study area was a land mass with a moderate relief and possible shallow seas or large lake systems along the eastern margin. Extensional tectonism started in the Late Devonian along with rifting and bimodal volcanism (Boyd Volcanic Complex). The main areas of subaerial, mostly silicic, volcanism were along the eastern part of the Eden region. Inland, subaerial volcanics were erupted on to the areas around Bombala (west of the study area). Thick ignimbrite sheets were laid down as valley fill, coalescing and extending on to the surrounding plains. Basalt lava flows and clastic deposits developed as interbedded units. Intrusion of subvolcanic A-type granites (Gabo Island and Mumbulla Suites) was coeval with volcanism.

With the cessation of igneous and volcanic activity the area returned to a stable landmass with moderate relief, some rift valleys, plus shallow marine or lake conditions in the east. A change in climate led to the onset of fluvial conditions and deposition of the Merrimbula Group. Following the initial phase of fluvial deposition, typified by conglomerate, pebble sandstone, coarse sandstone and mudstone there was a rise in sea level. Most of the shallower areas were inundated and sediments typical of shallow marine to lagoonal conditions were deposited as the Bellbird Creek Formation. Further eustatic change reinstated the fluvial conditions, and the clastic deposits laid down indicate an orderly progression from sheet sand and mud of delta to a series of channel sand and overbank mud.

Known and possible styles of mineral deposition associated with this period are:

- epithermal gold-silver related to the Boyd Volcanic Complex,
- pyrophyllite in altered volcanics of the Boyd Volcanic Complex,
- sandstone-hosted copper and/or uranium, which may be present in the Merrimbula Group,
- felsic and mafic volcanics of the Boyd Volcanic Complex representing sources of hard rock aggregate.

3.1.6 Early Carboniferous to Jurassic

A significant period of compressional deformation (Kanimblan deformation, Table 1), during the Carboniferous generated a pattern of upright to slightly overturned moderate to tight folds with a series of imbricate thrust faults such as the Budawang Thrust System.

Mineral deposits associated with this period are:

- slate belt gold associated with Adaminaby Group rocks related to the Carboniferous deformation.

3.1.7 Jurassic to Cretaceous

The initial rifting of the Tasman Sea in the Middle Jurassic caused some underplating, heat generation and subsequent intrusion of monzonite, syenite and composite breccias. A Jurassic intrusion occurs at Jingera Rock (Jingera Rock Syenite Complex). The presence of a few trachyte dykes about Jingera Rock indicates that volcanic activity took place, but these rocks have been removed by erosion. Rifting of the Tasman Sea continued through to the Late Cretaceous when a second period of monzonite and syenite intrusion occurred at Tanja (Tanja Syenite Complex) and Mount Dromedary (outside the study area).

Styles of mineral deposition known to be associated, (or possibly associated) with rocks of this period are:

- gold in alkaline intrusions,
- tin and possibly gold associated with the Tanja Syenite Complex,
- nepheline syenite in the Jingera Rock Syenite Complex.

3.1.8 Tertiary to Recent

The Monaro Volcanics form a blanket of basalt lavas (of the alkali basalt–basanite–nephelinite association) which erupted from numerous small vents aligned along fracture zones to form a north–south trending tableland during the Eocene to Oligocene (about 50 to 25 million years ago). Lake and associated fluviatile sediments are usually preserved under the blanket basalt lava flows.

Quaternary deposits cover much of the map area. On land they are present either as valley fill, hillslope or alluvial fan deposits, aeolian deposits or residual soils. Along the coast there are a variety of deposit types such as tidal deltas, barrier sands, estuarine muds and shelf sediments.

Mineral deposit types associated with rocks of these periods are:

- diamonds and sapphires related to Tertiary igneous activity ,
- gold in Tertiary to Recent deep leads/placers,
- deposits of sand and gravel represent, a significant source of construction materials, and basalt is a source of aggregate,
- peat deposits in upland swamps,
- diatomite deposits associated with Tertiary volcanism,
- bauxite deposits on deeply weathered basalts,
- clay deposits associated with sub-volcanic lake sediments.

4. HISTORY OF MINING AND MINERAL EXPLORATION

The region has a history of over 140 years of mining for gold and base metals. About 200 mineral occurrences, deposits, and old mines have been recorded. Production figures and exploration details for all deposits are contained on mineral occurrence summary forms compiled by McEvilly (1997) and in the Department of Mineral Resources metallic mineral occurrence digital database METMIN. A brief history of mining in the area is outlined below.

Estimated total reef production of gold from the Eden region is in the order of 4000 kg. Alluvial gold has also been recovered but there is little recorded information. The only significant alluvial production came from two main fields, of which the most productive area of one (the Little Plains River workings) is outside the region. The other field, the Montreal alluvial workings, is situated on the extreme northern margin. A figure of 500 kg of alluvial gold production is suggested for the region, of which the Montreal workings produced in excess of 239 kg of gold.

Limited base metal mining has also been undertaken at various times. Lead, zinc, and copper production is recorded from a few isolated deposits but was not significant. Silver production was significant in the Wolumla and Yambulla Gold Fields but not elsewhere in the Eden region. Molybdenite is recorded in a number of places with the most significant deposits occurring at Whipstick. Limited tin production is recorded in the Cathcart and Bega areas.

Exploration expenditures in the Eden region for the period from 1969 to 1995 are shown in Figure 1.

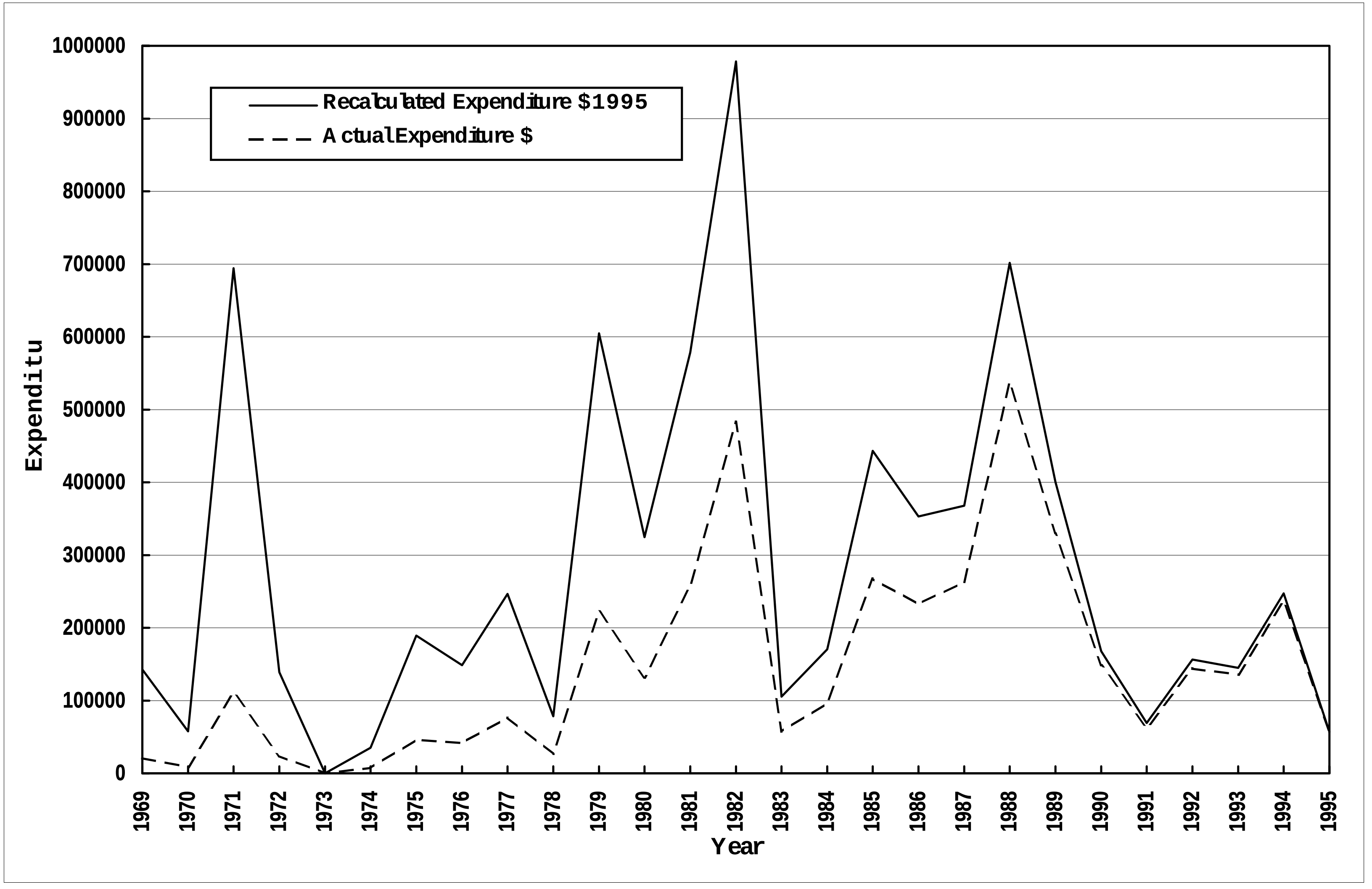


Figure 1: Exploration expenditure in the Eden region during 1969 - 1995.

5. KNOWN MINERAL RESOURCES AND MINERAL PRODUCTION

5.1 CURRENT QUARRYING AND MINING

Seven hard rock quarries, three construction sand pits and numerous pits winning unprocessed road materials currently operate in the Eden region (Figure 2). Mining of pyrophyllite occurs on a limited scale at the Back Creek Mine, west of Pambula. Remaining reserves are some 30 000 000 tonnes at various grades.

In the recent past, mining of industrial (filter) sand at Eden and peat at Killarney has been undertaken. Historically, phosphate has been mined at Wiles Phosphate Mine near Cathcart, chlorite (marketed as pyrophyllite) at Cobargo, kaolin at Greigs Flat and structural clay/shale near Tathra. Important industrial mineral deposits with potential for exploitation include the Back Creek pyrophyllite deposit and the Killarney peat deposit.

Significant construction material deposits currently supplying the study area are hard rock aggregate deposits near Nimmitabel (Tertiary basalt), Bombala (Tertiary basalt, Devonian granite) and Eden (Eden Volcanic Complex), and construction sand deposits at Nullica and Bega. In 1994-95 production of hard rock aggregate was about 170 000 tonnes and of construction sand was about 20 000 tonnes. An assessment of construction material availability and supply for the far south coast including the Eden study area (MacRae, 1994) indicated that shortages of major construction materials may occur in the area by the year 2000 unless new sources are developed. The development of a major hard rock aggregate quarry at Nimmitabel has alleviated potential supply shortfalls for the foreseeable future although shortages of other construction materials may occur by the year 2000.

Annual value of mineral production from some 20 quarries in the Eden region area is estimated at $4.8 million from records for 1994-95 and 1995-96 financial years (from information supplied to the Royalty Branch of the Department of Mineral Resources). Of this amount some 70% is from hard rock aggregate production, 20% is from unprocessed road materials with the remainder from construction sand, loam and pyrophyllite production. The actual value of production is considered to be greater than $4.8 million because some operations have not provided production records to the Department. Value of mineral production from State Forests is estimated at $1.2 million for 1995-96 financial year.

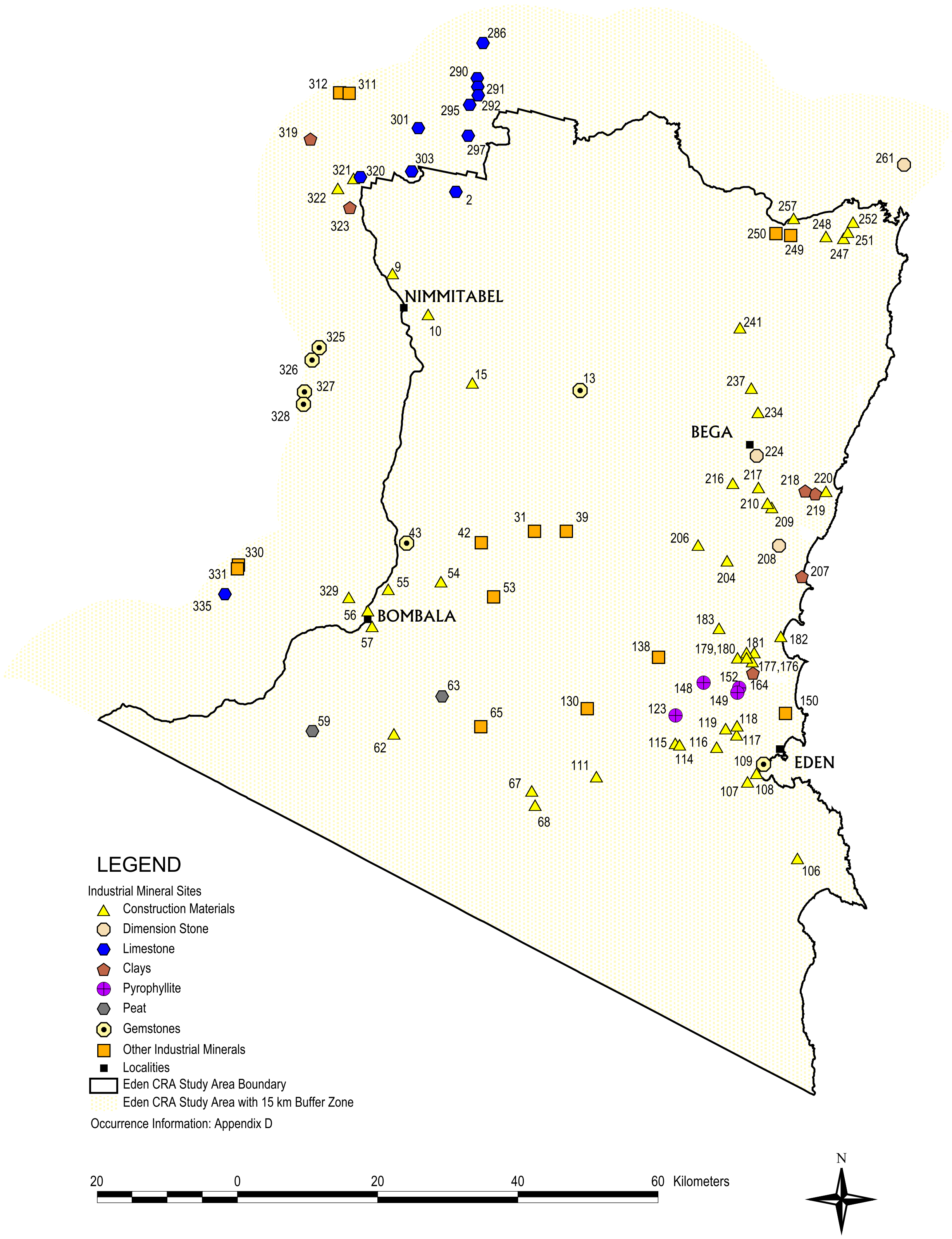
Reported resource figures from company reports are given in Table 2. The figures presented do not necessarily constitute reserves as defined by the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves.

5.2 MAJOR HISTORIC MINING AREAS

5.2.1 Panbula Gold Field

The Panbula Gold Field was proclaimed in 1890 with total production between 1889 and 1965 around 1879 kg of gold, based on reported production and reasonable estimates for those years where accurate records are for some reason

Figure 2: Industrial Mineral and Construction Material Sites



deficient. The bulk of production occurred in the years 1892 to 1915. The available information for the Panbula Gold Field in comparison with some other areas is generally quite good. As is true in many gold fields, much ground was pegged in the initial rush and soon after abandoned when returns did not live up to expectations. This is evidenced by numerous smaller pits in the area. Some companies were floated simply by holding leases in the area, and with ensuing amalgamations, abandonments, and unreliable or absent production records, accurate locations and production figures are not always possible. With amalgamation of licences and connection of shafts on different licences underground, some records for larger mines include production from smaller ones.

Due to the fine grain size of the gold in all of the mines, a significant quantity was lost in local treatment by ordinary milling appliances, sometimes washed down the Pambula River in tailings, and for this reason ore was sometimes sent elsewhere for more efficient extraction. It was not until 1896 that the first cyanide treatment plants appeared on the field. The Falkner Mine was the richest and produced around 60% of the gold in the field.

Recent exploration drilling has returned a number of economic intersections in the area of the old mines, however no viable resource has yet been delineated. This of course does not preclude the possibility of an economic resource being delineated in the future.

5.2.2 Wolumla Gold Field

The Wolumla Gold Field was discovered in 1896 and worked until 1939 with the bulk of production between 1896 and 1908. Total recorded production is 668 kg of gold and 102 kg of silver. The workings include numerous adits, shafts, pits, costeans etc scattered throughout the field for much the same reasons highlighted in the discussion on the Panbula Gold Field. The adits mostly delve into the side of a hill subsequently called Mount Momsen around and on which most of the mines are located. The main producer however was the Pacific or Eureka Mine located just to the south with a recorded production of 345 kg gold. Recent exploration drilling in the area of Momsens Hill has defined an indicated resource of 75 000 tonnes at 0.75 g/t of gold, with economic grade intersections also being recorded in old mine areas to the east and south.

5.2.3 Yambulla Gold Field

Information on the Yambulla Gold Field is somewhat lacking in comparison to both the Wolumla and Panbula Gold Fields. Workings are scattered over a much wider area and production figures are limited or absent for some areas. The total recorded production for the field is around 760 kg of gold, mostly produced between 1899 and 1912. Silver is present in reasonable quantities in many of the historical assays but production is believed to be small. The majority of Au came from the Yambulla or Solomons Mine which produced around 252 kg of gold, possibly more. Recent exploration drilling has delineated a resource of 197 000 tonnes at 3.1 g/t of gold in the area of the old GL 7 mines, with some economic grade intersections recorded in other areas.

5.2.4 Montreal Alluvial Workings

The Montreal workings were in Quaternary beach sands and adjacent auriferous Tertiary gravels just north of Bermagui and produced in excess of 239 kg of gold. The bulk of production came from the gravels. The find was rich but limited in extent and was worked out quickly between 1880 and 1884. Workings include numerous shallow pits, shafts, adits, and drives within an outcrop of weakly consolidated gravels behind the beach. The sediments in Wallaga Lake to the west were also worked following the same lead, but production was hampered by heavy water problems. The source of the gold is believed to be the gold-bearing veins on Mount Dromedary.

5.2.5 Whipstick Molybdenite Mines

The bismuth-molybdenite deposits at Whipstick rank amongst the largest producers in the State. They were worked intermittently between 1891 to 1927, and 1941 to 1943. Gold and silver has been produced in small quantities also. Workings consist of numerous shafts, adits, and pits scattered over about 2 km. Estimated production is about 17 000 tonnes of ore, which yielded about 200 tonnes of bismuth and 100 tonnes of molybdenite concentrates (Weber, Paterson & Townsend, 1978). The deposits were originally worked for bismuth, gold, and silver, with production of molybdenite beginning in 1912. Minor amounts of uraninite (uranium oxide mineral) are disseminated in the ore zones (Willis and Stevens, 1971).

5.2.6 Mineral Exploration 1969 to 1995

Figure 1 shows exploration expenditure for the Eden study area between 1969 and 1995. Some of this expenditure relates to titles which are partly outside the Eden region. The bulk of exploration conducted since 1969 has been for gold, with limited exploration undertaken for base metals, molybdenite, platinum group minerals, pyrophyllite, and dimension stone. Note that exploration expenditure for the 1970s is understated due to missing records.

Areas which have received the most detailed investigations have been the historically more productive gold fields. The Pambula, Wolumla, and Yambulla areas received significant exploration attention during the 1980s, culminating in drilling programs which largely correspond to the peaks of 1982, 1985, and 1988. The sharp decline in expenditure which immediately follows the peaks of 1982 and 1988 corresponds to relinquishment of exploration licences primarily due to negative assessments of drilling results in these areas. The peaks of 1992 and 1994 reflect a resurgence of exploration interest in these historically productive areas. The peak of 1971 is in part due to exploration undertaken in the Quidong area, the focus of which lay outside the Eden Study Area.

Most other scattered gold occurrences have been investigated to a lesser extent over the period. There has been limited exploration conducted in the period for other metals (mainly copper, lead, zinc, and molybdenum), a minor amount of exploration has been undertaken for pyrophyllite in the Pambula area, and minor exploration has been undertaken for quality dimension stone throughout the Eden Study Area at various times.

Table 2: Identified Resources in the Eden Region

Name	Commodity	Status	Resource Amount
Wolumla Goldfield - Mount Momsen (198)	gold	prospect	75000 t @ 0.75 g/t
Yambulla Goldfield - Golden Rhine (73)	gold	prospect	197000 t @ 3.11 g/t
Crofts Hardrock Quarry (119)	hard rock aggregate	prospect	4.7 Mt
Heffernan-Milliner Quarry (118)	hard rock aggregate	prospect	10.4 Mt
Wheatleys Quarry (209)	hard rock aggregate	prospect	300000 t
Brogo Quarry (241)	hard rock aggregate	operating	100000 t
Ferndale Quarry (54)	hard rock aggregate	operating	150000 t
Greens Road Granite Quarry (248)	hard rock aggregate	operating	250000 t
Letts Mountain Road Quarry (67)	hard rock aggregate	operating	40000 t
Nicholsons Quarry (62)	hard rock aggregate	operating	1 Mt
Nimmitabel Quarry (9)	hard rock aggregate	operating	7.5 Mt
Nullica Quarry (116)	hard rock aggregate	operating	150000 t
Thompsons Basalt Quarry (55)	hard rock aggregate	operating	100000 t
Killarney Swamp Peat (63)	peat	prospect	3 Mm^3
Jacksons Bog Peat (59)	peat	prospect	112800 m^3
Back Creek Pyrophyllite Quarry (148)	pyrophyllite	operating	30 Mt
Bega South Sand Pit (Kingswood) (216)	sand - construction	operating	20000 t
Boydtown Sand Pit (107)	sand - construction	operating	100000 t
Narira Creek Sand Pit (252)	sand - construction	operating	5000 t
Nullica River Sand Pit (108)	sand - construction	operating	10000 t
Wolumla Creek Pit (208)	sand - construction	operating	2000 t
Eden Rubbish Tip (150)	silica - industrial sand	prospect	10000 t
South Pambula Soil Pit (181)	soil, loam	operating	10000 t

Table 2 (continued): Identified Resources in the Eden Region

Name	Commodity	Status	Resource Amount
Walshs Gravel Pit, Coral Park (204)	unprocessed construction materials	operating	2500 t
Wendts Quarry (247)	unprocessed construction materials	operating	35000 t
Pericoe Quarry (111)	unprocessed construction materials	operating	unknown
Nimmitabel (10)	unprocessed construction materials	operating	unknown
Old Letts Mountain Road Quarry (68)	unprocessed construction materials	operating	unknown
Thorn Hill Pit (217)	unprocessed construction materials	operating	unknown
Costins Pit (251)	unprocessed construction materials	operating	unknown
Pambula (177)	unprocessed construction materials	operating	unknown
Wheatley No 1 & 2 Pits (210)	unprocessed construction materials	operating	unknown
Tathra Pit (220)	unprocessed construction materials	operating	unknown
Culwulla Pit (234)	unprocessed construction materials	operating	unknown
Tomahawk Pit (15)	unprocessed construction materials	operating	unknown
Green Cape Road Quarry (106)	unprocessed construction materials	operating	unknown
Old Hut Creek Road Quarry (114)	unprocessed construction materials	operating	unknown

(9) Location number for Nimmitabel quarry as shown on Map 2. Locations for industrial minerals and construction minerals also shown on Figure 2.

6. MINERAL EXPLORATION AND LAND ACCESS

6.1.1 Mineral Exploration

Mineral exploration is a long term and ongoing process. Exploration is extremely costly, it is a commercially high risk activity, and areas often have to be explored many times over before the initial clue that leads to a discovery is found. Various types of fine grained low grade gold deposits can be particularly difficult to locate. In places disseminated gold and gold-copper deposits are associated with smaller high grade gold deposits which have been mined out as at Cadia and Peak Hill in NSW, at Kidston in Queensland, and Morning Star in Victoria.

The advent of Carbon-In-Pulp and Carbon-In-Leach gold extraction technologies in the 1970s provide examples of the way in which technological (and economic) change can affect exploration. These technologies dramatically changed the costs of gold recovery and also reduced the risks associated with exploration for gold-oxide ores by allowing gold to be mined profitably at much lower grades. This triggered intensive, Australia-wide exploration for bulk gold oxide deposits at considerably lower cut off grades than were previously considered economic (Blain 1992). Carbon-In-Pulp and Carbon-In-Leach processing are also used for treatment of low grade primary gold ores.

Persistent exploration and re-evaluation of the geology of a district can also lead to discoveries. The very promising Ridgeway gold-copper deposit near Cadia Hill is concealed by a blanket of Tertiary basalt and was recently discovered by a drilling program, 140 years after the first discoveries.

6.1.2 Land access

New information, new concepts and better understanding of geological processes continually change the perceived prospectivity of areas and regions. New models are continually being developed and refined. Continued access to land is therefore a significant issue for the mining industry and for future mineral development.

In order to examine the implications of alternative land access arrangements for exploration and mining in the region it is important to understand both the nature of exploration and its likely costs and benefits.

Generally, exploration can be defined as the process of searching for and assessing mineral deposits. Although discovery and delineation are the primary reasons for exploration, lack of discovery from an exploration program does not imply that the effort yielded no benefit. Information gained from exploration will usually increase the understanding of a region's geology.

From the perspective of a private firm, the potential benefits from an exploration program derive from the economic returns that will accrue from the discovery of an economic deposit. Because exploration is a high risk activity (that is, there is a small probability of any one venture being successful), companies will approach exploration in a sequential and systematic fashion. This enables the decision to abandon or keep exploring in the area to be made in a efficient manner. The typical sequence of events that underpin a modern exploration program are shown below.

> **MODERN MINERAL EXPLORATION: THE TYPICAL SEQUENCE OF EVENTS**
>
> **1. Global considerations**
>
> - Assessment of political stability
> - Assessment of security of title
> - Assessment of access and restrictions
> - Assessment of financial climate, restrictions or inducements
> - Determination of geoscientific framework and availability of information
>
> **2. Preliminary investigations**
>
> - Review regional geoscientific data (geology, geophysics, satellite imagery)
> - Formulation of geological concepts and selection of prospective areas
> - Examination of known mineralisation
>
> **3. Reconnaissance exploration**
>
> - Acquisition of exploration tenements
> - Collection and assessment of geoscientific data over the tenement
> - Examination of available regional geoscientific data
> - Conducting of geoscientific surveys required to augment available data
> - Selection of target areas, for more detailed exploration
>
> **4. Detailed exploration**
>
> - Detailed geoscientific surveys to detect and delineate anomalies
> - Drilling of anomalies in search of significant mineralisation
> - Delineation of mineral deposits by further drilling and other methods to determine configuration, approximate tonnage, grade, metallurgical characteristics of the deposits
> - Pre-feasibility studies
> - Acquisition of mining tenements, if justified, at appropriate stage of program.
>
> Source: ABARE, AGSO and BRS (1993).

The cost and duration of exploration programs will vary from company to company and across commodities. Clark (1996) suggests that the development of a typical major deposit (worldwide) involves a 5-20 year lead time. This estimate results from a typical 3-10 years exploration program prior to the mine development phase.

It is important to note that the exploration process starts with assessments of very large regions and is then systematically narrowed down as the exploration target becomes better defined. The direct costs facing explorers increase as the target area becomes smaller and exploration methods more intense. The environmental impact associated with exploration also increases as the area being explored becomes smaller and the exploration methods used become more invasive (for example, drilling).

Modern exploration, which is increasingly using remote sensing from satellites or aircraft, is able to proceed to surface phases with no land disturbance. The early stages of a surface exploration program involve activities such as mapping, geophysical measurements and geochemical sampling of stream sediments which are likely to have relatively little effect upon the environment. Follow-up investigations that would require other techniques and that may have some localised and temporary effects may include (see ABARE, AGSO and BRS (1993):

- rock chip sampling;
- collecting soil samples; and
- electrical, gravity, magnetic, seismic or radiometric ground surveys.

If the results of this work were positive, additional follow-up work probably would include some drilling. However, it should be noted that not all exploration results in drilling. In a submission to the Industry Commission 'Mining and Metals Processing' inquiry, the Australian Minerals Industry Council reported that less than 10 per cent of exploration projects in Australia reach the surface exploration phase, and only around one per cent reach the subsurface exploration phase (Industry Commission, 1991).

In contrast to exploration, mining itself generally involves greater disturbance to the land surface in the immediate area of the mine and could leave significantly changed landforms when mining is finished. Mining is generally therefore seen as posing greater difficulties in terms of compatibility with other uses. Many potential environmental effects of mining activities can be eliminated or mitigated, though at an additional cost. For example, water pollution is another potential threat to the environment from mining. However, this can be controlled by using well established techniques like impoundment and evaporation of tailings, sedimentation, filtration and pH neutralisation. Dust and noise control are also important in areas close to residences. Rehabilitation of mine sites at the completion of operations can restore many of the features of the landscape that existed before mining began, substantially assist the re-establishment of vegetation, and reduce the potential for pollution from the abandoned mine site.

7. MINERAL POTENTIAL ASSESSMENT METHODOLOGY

The mineral potential of the study areas has been assessed by determining the types of mineral deposits likely to be found within the geological framework known or believed to exist there. The general methodology used was developed by the United States Geological Survey (USGS), and has been used successfully for mineral resource assessments of forest areas in North America and elsewhere. This approach identifies geological units (tracts) which could contain particular types of mineral deposits. A summary of the qualitative assessment methodology is described in publications by Marsh, Kropschot and Dickinson (1984), Taylor and Steven (1983), and by Dewitt, Redden, Wilson and Buscher (1986).

A qualitative assessment of the potential resources of an area is an estimate of the likelihood of occurrence of mineral deposits which may be of sufficient size and grade to constitute a mineral resource. The term ‘mineral resource’ is restricted to material, the extraction of which is judged to be potentially viable in the next 25 years. Only the deposit types judged to be most likely to constitute significant resources in the region have been assessed in detail.

An assessment of potential mineral resources of a region combines knowledge of its geology, geophysics, geochemistry, mineral deposits and occurrences with current theories of mineral deposit genesis and results of mineral exploration. The assessment process requires a study of available geoscientific data to determine the history of geologic processes and environments. Geologic environments judged to have characteristics known to be associated with specific types of mineral deposits are then identified. In particular, the assessment draws on regional and local characteristics of mineral deposit models to establish whether or not specific types of mineral deposits are likely to occur.

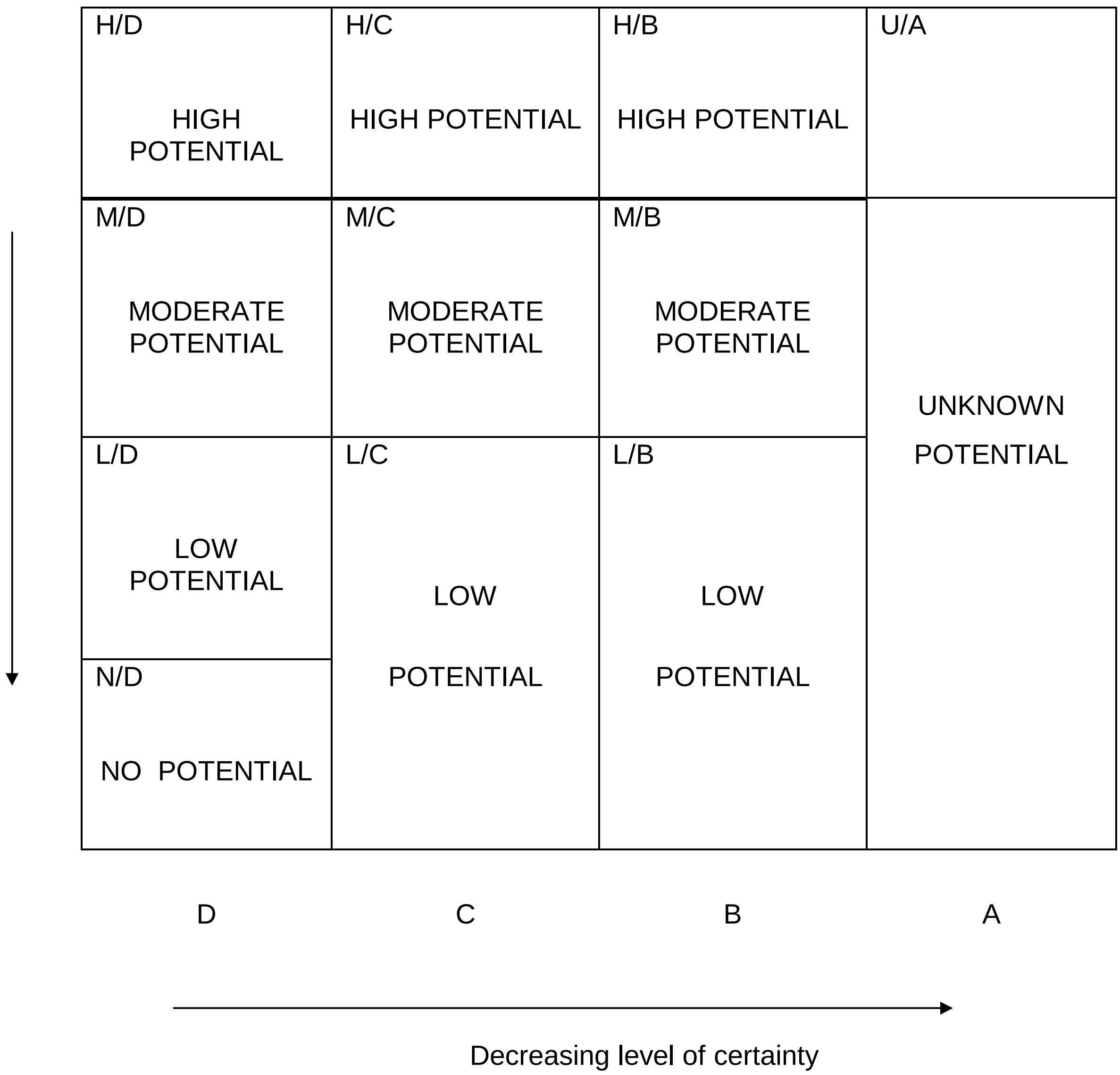
The mineral potential of an area, that is the likelihood of it having a particular type of mineral deposit, is ranked as high, moderate, low or unknown, based on professional judgments of geoscientists involved in the assessment. If there are insufficient data to classify the areas as having high, moderate or low potential then the mineral resource potential is categorised as unknown. To reflect the differing amounts of information available, the assessments of mineral potential are also categorised according to levels of certainty, denoted by letters A to D in order of increasing certainty (Figure 3). That is, A denotes the lowest level of certainty and D the highest. The method is described in more detail in Appendix A.

Assessments similar to the procedure used here in this report for the Eden region are commonly used by companies to choose the selection of areas for exploration. It is important to note, however, that the assessment of potential resources is subject to the amount and the quality of data available to the assessors. As geological knowledge of an area is never complete, it is not possible to have a ‘final’ assessment of potential mineral resources at any given time. The mineral resource potential of areas needs to be monitored and reassessed periodically to take account of new data, advances in geological understanding including new mineral discoveries. Advances in mineral exploration and mining technologies, and changes in mineral markets are other factors which may change the mineral resource potential of an area.

Because of incomplete geological knowledge, the discovery rate in Australia is roughly of the order of one mine for one thousand exploration programs. Thus areas are explored, often repeatedly, before a mineral deposit is found. Increased geological knowledge and other factors can result in discoveries of world class deposits both in highly prospective areas (eg Kanowna Belle near Kalgoorlie, WA; Century in the Mount Isa Inlier, Qld.) or in areas not previously known to be of very high potential (eg Olympic Dam on the Stuart Shelf, SA). Thus continued access to land for regulated exploration, which is a transient process rather than a long-term land use, is an important issue for the minerals industry and for future mineral development.

Geological areas (or 'tracts') in the Eden region, judged to contain geological environments permissive of the formation of specific types of mineral deposits are delineated and the mineral potential is ranked (see Figures 4 to 15).

Figure 3: Relationship between Levels of Resource Potential and Levels of Certainty



8. POTENTIAL MINERAL RESOURCES, EDEN REGION

Descriptive mineral deposit models used for qualitative broadscale assessment of the Eden are described in Appendix B. The favourable geological tracts for these types of mineralisation are indicated on Figures 4 to 15. The potential mineral resources are summarised in Table 3:

8.1 SLATE-BELT GOLD (FIGURE 4)

8.1.1 Tract Au1a/H/C

The tract includes Ordovician and Silurian (Yalmy Group) rocks (turbidite and their metamorphic equivalents) that are within 5 kilometres of granitoids and are also within 2 kilometres buffer zone of known faults. The presence of fault zones and proximity to granitoid bodies have been suggested to be the important factors controlling slate belt gold mineralisation. The potential in this tract is assessed to be high with a certainty level of C.

8.1.2 Tract Au1b/M-H/B

The tract includes Ordovician and Silurian (Yalmy Group) rocks (turbiditic and their metamorphic equivalents) that are within 2 kilometres of faults. It also includes areas with the same rocks that are within 5 km of granitoids.

Because the tract lacks the coincidence of all the three important geological factors that control mineralisation, its potential is assessed to be moderate to high with a certainty level of B.

8.1.3 Tract Au1c/M/B

The tract includes areas occupied by Ordovician and Silurian (Yalmy Group) rocks (turbiditic and their metamorphic equivalents). Similar rocks in the East Gippsland area to the south of the Eden region host several occurrences of gold. Detailed high-resolution, and low altitude geophysical survey in the East Gippsland area has revealed the presence of several shallow lying granitoid bodies intruding turbiditic rocks. It is possible that in the tract in Eden similar granitoids are also present.

The potential of the tract is assessed to be moderate with certainty level of B.

8.1.4 Tract Au1d/L-M/B

The tract includes granitoids within 2 km of faults. In Victoria although no large deposits have yet been found in granitoids several gold occurrences have been reported in and in proximity to granitoids.

The potential of the tract is assessed to be low to moderate with a certainty level of B.

8.2 EPITHERMAL GOLD-SILVER DEPOSITS (FIGURE 5)

8.2.1 Tract Au2a/H/B

The tract includes rocks of the Boyd Volcanic Complex. The rocks commonly show alteration typical of epithermal hydrothermal systems such as: potassic (adularia), propylitic, chloritic, sericitic, clay, pyrophyllite and silicification. Most known occurrence of epithermal gold (Pambula

Figure 4: Mineral potential tracts for slate belt gold deposits

Figure 5: Mineral potential tracts for epithermal gold-silver and pyrophyllite deposits

Gold Field) are located within altered rhyolites. In some prospects such as Mount Gahan Mine, Morning Star Hidden Treasure Mine, and Victory Mine, signs of deposition from near surface, geothermal systems have been reported. Mineral potential of the tract is assessed to be high with a certainty level of B.

8.2.2 Tract Au2b/M-H/B

This tract is delineated to include rocks surrounding the Boyd Volcanic Complex that host known epithermal gold occurrences. The presence of these occurrences is evidence that the epithermal system generated by volcanism associated with the Boyd Volcanic Complex also affected the surrounding rocks.

The tract has moderate to high potential for epithermal mineralisation with a certainty level of B.

Associated deposit types: subvolcanic porphyry copper-gold deposits

8.3 GOLD DEPOSITS ASSOCIATED WITH ALKALINE ROCKS (FIGURE 6)

8.3.1 Tract Au3a/H/B-C

The tract includes Jurassic and Cretaceous alkaline igneous complexes represented by rocks such as monzonite, trachyte, syenite, nepheline syenite, nepheline monzonite and banatite. These rocks were emplaced during rifting in Jurassic and Cretaceous times.

There are several primary and alluvial gold occurrences spatially associated with the Mount Dromedary Complex which is just outside the Eden region. Small areas of alkaline rocks similar to the Mount Dromedary Complex occur in the Eden region. However no gold occurrences are known to be spatially associated with these rocks. Potential for the tract is assessed to be high with a certainty level of C (in the Mount Dromedary Complex) and a certainty level of B (in rest of the tract).

8.3.2 Tract Au3b/M-H/B

This tract is delineated by outlining an area (2 to 4 kilometres wide) around relatively large alkaline complexes (Mount Dromedary and Tanja complexes). Near the Mount Dromedary Complex the zone includes a number of gold occurrences. Potential of the zone is assessed to be moderate to high with a certainty level of B.

8.4 GRANITE HOSTED GOLD DEPOSITS (FIGURE 7)

8.4.1 Tract Au4a/H/B

The tract is delineated based on the distribution of mineral occurrences in the Yambulla Gold Field. The mineralisation is hosted by coarse-grained biotite granite phase of the Bega Batholith. There is a strong association of mineral occurrences with the presence of N-S trending major faults. A 5 kilometre buffer around the faults contains all known occurrences. This buffer zone defines the tract and includes granitoids and turbiditic sequence of Ordovician age. Across the border in the East Gippsland CRA area there are a few gold occurrences hosted by granitoids belonging to the same batholith. Potential for this tract is assessed to be high with a certainty level of B.

8.5 PLACER GOLD DEPOSITS (FIGURE 8)

8.5.1 Tract Au5a/M/C

The tract includes all mapped areas of Quaternary sediments. Rocks in most of the Eden region have a potential to be primary sources of alluvial gold accumulation. The tract is assessed to have a moderate potential for alluvial gold with a certainty level of C.

8.5.2 Tract Au5b/L-M/B

This tract includes Quaternary alluvials which may occur within a hundred metre buffer around streams in the region. The tract is delineated by intersection of the above area with areas having known gold occurrences and/or having a potential for gold deposits (mineral potential tracts for slate belt gold, granite hosted gold, epithermal gold-silver, copper-gold porphyry and gold associated with alkaline rocks). There is also potential for placer gold in high level gravels and basalt covered palaeochannels. The tract includes a number of occurrences of gold.

Mineral potential of this tract is assessed to be low to moderate with a certainty level of B.

Figure 6: Mineral potential tracts for gold deposits associated with alkaline rocks

Figure 7: Mineral potential tracts for granite hosted gold deposits

Figure 8: Mineral potential tracts for placer gold deposits

8.6 PORPHYRY COPPER-GOLD DEPOSITS (FIGURE 9)

Tract CuAu1/M/B

The tract includes three tonalites within the Bega Batholith: Candelo, Pretty Point and Why Worry. The three are classified as I-type, mafic and unfractionated granitoids. The granites are neither strongly oxidised nor reduced (Blevin and Chappell, 1996). They are known to host a number of copper, gold, lead, zinc, silver occurrences. A 2 kilometre buffer around these granitoids is drawn to include known copper-gold occurrences in the area.

The tract also includes an extension of a similar tract in the East Gippsland CRA. The tract includes Ordovician turbiditic sediments and granitoids (I-type, mafic/felsic and unfractionated). A low-altitude, high-resolution geophysical survey in the East Gippsland CRA has revealed the presence of shallow-level granitoids. It is possible that they are also present in the tract. The tract also includes several known occurrences containing gold and base metals. The potential in the tracts for porphyry copper-gold mineralisation is moderate with certainty level of B.

8.7 VOLCANIC HOSTED MASSIVE SULPHIDE BASE METAL DEPOSITS (FIGURE 10)

8.7.1 Tract BM1a/M-H/C

The tract includes rocks of the Yalmy and Bredbo groups. These rocks were formed in the Silurian Quidong and Ngunawal basins. Most of the Ngunawal basin as well as the Quidong Basin rocks are outside the Eden region. The tract in the north-west of the area is part of the Ngunawal basin which merges in the NNE direction with Captains Flat-Goulburn Trough (Suppel and Scheibner, 1990), that hosts several volcanic massive sulphide occurrences and deposits.

The tract within the Eden boundary also contains several known occurrences of base metals. Skidmore Copper Mine (Cooma Copper Mine) is in the NW part of the tract but outside the Eden region. Here the mineralisation is localised at the contact between crystal tuff and shale.

Potential in the tract is assessed to be moderate to high with a certainty level of C.

8.7.2 Tract BM1b/M/B

Middle to late Silurian basins in the area extended in the NNE direction and occupied most of the western part of Eden region. A large part of the Silurian basin is now covered by Tertiary basalts. It is possible that the remnants of the basin are preserved underneath basalts. This tracts has been delineated based on above assumption. A buffer zone around the known mapped outcrops of rocks belonging to the Yalmy and Bredbo groups makes up the tract. The buffer zone is drawn taking into account the NNE strike direction of the rocks.

Potential of this tract is assessed to be moderate with a certainty level of B.

POTENTIAL OF ASSOCIATED DEPOSIT TYPES: GOLD ASSOCIATED WITH MASSIVE SULPHIDE MINERALISATION

Volcanic hosted massive sulphide deposits are often associated with significant gold mineralisation. Many massive sulphide deposits in Tasmania such as Que River and Hellyer belong to this category. Volcanic-hosted massive sulphide deposits in the Captains Flat-Goulburn and the Hill End Synclinorial zones also contain gold and silver mineralisation. Thus the above two tracts of volcanic hosted massive sulphide deposits also have an unknown potential for gold mineralisation.

8.8 TUNGSTEN MOLYBDENUM VEIN DEPOSITS (FIGURE 11)

8.8.1 Tract WMo1a/M-H/B-C

The Whipstick Adamellite is a highly fractionated and highly oxidised granite suite which is of either I or A type. It provides a highly favourable set of conditions for the formation of molybdenum deposits. The Whipstick deposits are evidence of the suitability of the Whipstick Adamellite as a potential source of molybdenum-bismuth deposits.

The Whipstick Adamellite including a buffer zone of 5 kilometres width has a moderate to high potential with a certainty level of C.

Other fractionated, felsic I-types in the area of the Bega Batholith are the Bondi Granite, The Figurehead Adamellite and the Wallagaraugh Adamellite which are all part of the Wallagaraugh

Figure 9: Mineral potential tracts for porphyry copper-gold deposits

Figure 10: Mineral potential tracts for volcanic hosted massive sulphide base metal deposits

Figure 11: Mineral potential tracts for tungsten-molybdenum vein deposits

Suite. The Wallagaraugh Suite is considered to have a moderate to high potential for tungsten-molybdenum vein deposits, but at a lower certainty level of B as tungsten-molybdenum occurrences have not yet been found in this suite.

8.8.2 Tract WMo1b/M/B-C

The Bemboka granite is a relatively unfractionated felsic I-type, which is considered to be only moderately prospective for molybdenum-bismuth deposits, however the numerous mineral occurrences indicate the granite may be a source of substantial molybdenum and bismuth.

Similarly the Brogo granodiorite contains the Black Range vein deposits which suggest that the latest stages of the granite were enriched in molybdenum and other areas around the granite must be considered reasonably prospective for vein-type deposits.

On the available data, the Bemboka granite and the Brogo granodiorite together with a buffer of 5 kilometres define a tract with a moderate potential having a certainty level of B to C.

8.8.3 Tract WMo1c/L/B

All other known granite bodies of the Bega Batholith in the Eden region have less potential to host mineralisation as they are not particularly fractionated and have either no or very few associated mineral occurrences.

All other identifiable granite bodies of the Bega Batholith including 5 km buffer have a low potential with certainty level of B.

8.8.4 Tract WMo1d/U/A

This tract includes the granites and 5 km buffer zone for which the available information is not enough to characterise their level of fractionation and oxidation states. The potential is unknown (certainty level is A).

8.9 TUNGSTEN SKARN DEPOSITS (FIGURE 12)

8.9.1 Tract Skrn1a/M-H/C

The tract is based on the intersection between a 5km wide zone surrounding Silurian/Devonian granitoids, and the Silurian Bredbo and Yalmy Groups sediments which are known to contain limestone sequences. Only a small area of this tract falls within the Eden region. The section of tract that lies within the Eden area lies adjacent to some regional north-south trending structures which may act as conduits for mineralising fluids.

The tract is considered to have a moderate to high potential with a certainty level of C.

8.9.2 Tract Skrn1b/M/B

This tract is based on the distribution of sediments of the Silurian Bredbo and Yalmy Groups sediments that are possibly present below Tertiary basalts and are within 5 km of granitoids.

The tract is considered to have a moderate potential with a certainty level of B.

POTENTIAL FOR ASSOCIATED SKARN DEPOSIT TYPES

The same tract also has potential for other types of skarn deposits including tin skarns, copper skarns (Cadia deposit, near Orange), gold skarns (eg Browns Creek deposit, outside the region) and iron (magnetite) skarns.

Due to the lack of known mineralisation, it is not possible to assess the potential for these types of skarns. Hence the potential for these associated types of skarn deposits is unknown.

8.10 TIN VEIN DEPOSITS (FIGURE 13)

8.10.1 Tract Sn/L/B

The tract is defined by the presence of highly fractionated granites within the Bega Batholith and the Dr George Granite which hosts the Tanja occurrences. However, the fractionated granites are oxidised (hence not prospective for vein tin), primary tin occurrences are lacking and secondary tin occurrences are small. On available evidence the potential for tin vein deposits is low (certainty level of B).

8.11 SEDIMENT HOSTED COPPER DEPOSITS AND SANDSTONE URANIUM DEPOSITS (FIGURE 14)

8.11.1 Tract CuU1a/L-M/B

The Twofold Bay Formation , Worange Point Formation and Ben Boyd Formation (Merrimbula

Figure 12: Mineral potential tracts for tungsten skarn deposits

Figure 13: Mineral potential tracts for tin vein deposits

Figure 14: Mineral potential tracts for sediment hosted copper deposits and sandstone hosted uranium deposits

Group) consist of poorly sorted red sandstones, conglomerates and red mudstone interbeds. These were deposited under oxidising conditions. Interbeds of khaki and green sandstones and shales indicate reducing conditions. The redox interface between these and the red sandstones represents a possible site for accumulation of sediment-hosted copper deposits and sandstone uranium deposits. There are no known evaporite beds within the Merrimbula Group, hence the potential for sediment hosted copper deposits is low to moderate. Because of the lack of significant uranium mineralisation in these redbeds, the tract has low to moderate potential for sandstone uranium deposits. Certainty level is B.

8.11.2 Tract CuU1b/L/B

This tract is based on the distribution of the Bellbird Creek Formation (Merrimbula Group) which comprises thinly bedded grey/brown sandstone, siltstone and mudstone. These sediments are considered to have a lower potential than the other members of the Merrimbula Group mentioned above because of the absence of red sandstones. The Bellbird Creek Group is considered to have a low potential for sandstone hosted copper deposits and sandstone uranium deposits. Certainty level is B.

8.12 CONSTRUCTION MATERIALS AND DIMENSION STONE (FIGURE 15)

Prospective rock types in the study area are spatially associated with the main population centres and are close to major transport routes.

8.12.1 Tract Conmat/M/B

All of the Eden region contains rock types that have potential for construction materials deposits. The potential for economic deposits of higher value construction materials in the Eden region is dependent on distances to markets on the coastal fringe (Bega, Eden, Merimbula) and to the west (Cooma) and north (Canberra, Moruya) of the study area. Location close to main haulage routes is also important.

Areas of felsic volcanics and basalt, and, to a lesser extent, granitoids and hornfelsed rocks provide potential for crushed hard rock aggregate. Granitoids have some potential for dimension stone, depending on the availability of high quality material within a particular rock unit. Potential for suitable sources of construction sand is best within Quaternary barrier sand along the coast and in Quaternary fluvial deposits. (note: Quarries for high quality dimension stone would not need to be close to existing haulage routes).

There is a distinct clustering of construction material sites around the major coastal townships (Bega, Pambula, Eden) and elsewhere along the main transport routes (e.g. near Nimmitabel and around Bombala). Main population centres and main transport routes were used to delineate the tract. Major roads, either highways or main connecting roads, were selected and buffered to 5 km. Towns were buffered to differing widths using the following scheme which is loosely based on population.

TOWN	BUFFER WIDTH
Bega, Pambula, Eden	15 km
Bombala, Merimbula	10 km
Candelo, Delegate, Bermagui South, Tathra, Pambula Beach	5 km

Important source rocks such as the Boyd Volcanics (mainly rhyolite), Tertiary Volcanics (basalt) and coastal sand deposits are included in the tract. The tract is considered to have moderate to high potential for higher value construction materials with a certainty level of B.

8.13 PYROPHYLLITE (FIGURE 5)

8.13.1 Tract Pyro/H/B

Devonian felsic volcanics of the Boyd Volcanic Complex occur along the coastal strip of the Eden study area and they define the extent of the tract. Alteration of these felsic volcanics to produce pyrophyllite has been identified in the largest outcrop area of the volcanics which is located west and north west of Eden.

8.14 POTENTIAL FOR OTHER COMMODITIES IN THE EDEN REGION

Peat

Extraction has previously occurred in the Eden region at Killarney, near Bombala, where large resources of peat are known to occur.

Figure 15: Construction materials and dimension stone

Peat occurrence in the Eden region is associated with Quaternary sedimentary deposits. Some peat/lignite beds occur within the Tertiary basalt sequence.

Limestone

Limestone occurrence in the Eden region is restricted to rocks of Late Silurian age in the Bredbo Group.

Diatomite

In NSW there is a strong association between diatomite occurrences and Tertiary volcanic rocks. A deposit of diatomite occurs near Cooma to the north west of the study area.

Occurrences of diatomite could be identified in association with Tertiary volcanics in the Eden region.

Nepheline syenite

Exploitable deposits need to be large, uniform in composition, generally medium to coarse grained, massive, amenable to beneficiation and have access to a major market (Harben & Kuzvat 1996).

Nepheline syenite intrusions occur within the Eden region.

Diamond

There are no known diamond occurrences within the Eden region. Minor occurrences of diamond in alluvial gravels have been reported west of the Eden region. Diamonds in north-eastern NSW are known to occur in association with alkaline basalt. A new model of diamond formation (Barron et al 1996) indicates that basanite, nephelinite and leucitite rock types are prospective for diamonds. These rock types occur in the Eden region but their distribution has not been mapped.

Bauxite

Minor bauxite deposits occur in association with Tertiary basalt in the Eden region.

8.15 SUMMARY OF POTENTIAL MINERAL RESOURCES, EDEN REGION

The potential mineral resources are summarised in Table 3 by type of deposit, level and certainty of mineral potential, area of mineral potential tracts, and proportion of the region covered by the tract and proportion of tract in existing national parks/reserves.

Mineral potential tracts were identified for 11 types of mineral deposits, for construction materials and for pyrophyllite. There may be some potential for another 8 commodities. Extraction sites for low unit value construction materials are often dictated by other land uses such as real estate developments and by costs of transport. For this reason, resources of construction materials are only shown where they are close to roads and population centres where there is likely to be demand for construction materials (ie interest areas).

The tracts of mineral potential for various types of mineral deposits (Figures 4 to 15) have been combined and summarised in three different ways in Maps 3, 4 and 5.

Map 3 is a ***composite mineral potential*** of the Eden region and shows the highest level of mineral potential assessed (in April 1997) for any particular area in the region (Figures 4 to 15). In this approach, tracts of lower mineral potential are obscured by the tract having the highest level of mineral potential in any particular area. In the Eden region, the areas of high and moderate to high mineral potential are for slate-belt gold in the north and southwest (Map 3, Figure 4); for epithermal gold-silver in the east in a zone passing through Merimbula and Eden (Map 3, Figure 5); and for granite hosted gold (high) and tungsten-molybdenum vein deposits (moderate-high) in central south along the Walla Walla Fault (Map 3, Figures 7, 11). A tract of moderate potential for porphyry copper-gold style deposits occurs east of the Tantawangalo Fault (Map 3, Figure 9). Tracts of moderate potential along the main roads and population centres are for construction materials and in the southwest of the region there is a moderate potential for porphyry copper-gold deposits.

There are very small areas of high and moderate to high potential for volcanic hosted massive sulphide base metals and tungsten skarn deposits in the northwest of the region and for gold in alkaline rocks in the eastern part of the region (Figures 6, 10 and 12).

Map 3 is a composite of mineral potential tracts for different types of mineral deposits that do not have equal economic values. For example, a tract with

Table 3: Summary of potential mineral resources as at June 1997

Deposit type	Ranking of deposit type	Mineral potential	Stand-ard score	Weight-ed score	Area of tract (sq km)	% of region covered by tract	% of tract in existing reserves
Slate belt gold	6	High	18	108	661.8	8.1	17.5
		Moderate-high	12	72	208.4	2.6	15.3
		Moderate	6	36	1154.8	14.2	17.9
		Low-moderate	2	12	2382.0	29.3	19.4
Epithermal gold–silver	7	High	18	126	239.0	2.9	20.4
		Moderate-high	12	84	644.8	7.9	23.2
Gold in alkaline rocks	4	High	18	72	9.0	0.1	81.2
		Moderate-high	12	48	1.3	0.0	0.0
Granite hosted gold	6	High	18	108	415.1	5.1	14.5
Alluvial gold	3	Moderate	6	18	205.5	2.5	11.6
		Low-moderate	2	6	901.5	11.1	18.4
Porphyry copper-gold	7	Moderate	6	42	1656.9	20.4	6.0
Volcanic hosted massive sulphide base metals	8	Moderate-high	12	96	28.5	0.4	0.0
		Moderate	6	48	59.2	0.7	0.0
Tungsten–molybdenum veins	4	Moderate-high	12	48	1057.4	13.0	25.9
		Moderate	6	24	2210.2	27.2	31.4
		Low	1	4	3434.3	42.2	22.0
Tungsten skarn	3	Moderate-high	12	36	32.3	0.4	0.0
		Moderate	6	18	13.0	0.2	0.0
Tin veins	3	Low	1	3	591.1	7.3	27.3
Sediment hosted copper and sandstone uranium	4	Low-moderate	2	8	1097.9	13.5	74.4
		Low	1	4	47.7	0.6	44.6
Construction materials	2	Moderate	6	12	4403.1	54.1	14.5
Pyrophyllite	2	High	18	36	239.0	2.9	20.4
Some potential also for peat, limestone, diatomite, nepheline syenite, diamonds, bauxite, and clay but no tracts drawn because of insufficient data.							

moderate to high potential for epithermal gold-silver may be considered to have a higher economic value than a tract with high potential for tin vein deposits.

Map 4 shows ***cumulative mineral potential*** of the Eden region. The mineral potential tracts in Figures 4 to 15 are superimposed to highlight areas with overlapping tracts. This presentation takes account of the diversity of mineral resource potential as well as the level of potential. This was done by allocating standard scores according to a subjective ranking of levels of mineral potential as follows: high potential (18), moderate-high (12), moderate (6), low-moderate (2), low (1), unknown potential (no score). Scores of overlapping tracts were added to derive a 'cumulative mineral potential' score. Areas with high cumulative scores indicate potential for more than one type of deposit (eg. moderate potential for tungsten skarn deposits (6) + moderate to high potential for disseminated gold (12) + high for slate-belt gold (18) = 36).

The cumulative mineral potential scores highlight the diversity of potential resources mainly in the southern and eastern parts of the Eden region where there are overlapping tracts for slate-belt gold, epithermal gold-silver, granite hosted gold, porphyry copper-gold deposits and tungsten-molybdenum vein deposits.

It should be understood that the areas with overlapping tracts highlighted by Map 4 emphasise the diversity of mineral potential. These areas are not necessarily more prospective than a single tract of high potential, for example, for epithermal gold-silver deposits. The relative economic significance of the tracts for different types of mineral deposits, as perceived by mining companies, would be influenced by their perceptions of prospectivity, future market conditions, land access and other factors.

A ***weighted composite mineral potential*** map (Map 5) was prepared in order to provide some perspective to the relative economic significance between different types of mineral deposits. In this approach, mineral deposits are indexed for their relative economic significance. For example, epithermal gold was given an index of 7 out of 10, while tin vein deposits have an index of 3 out of 10. A weighted mineral potential for a tract of moderate-high potential (standard mineral potential score of 12) for epithermal gold-silver (with a mineral deposit index of 7) would have a weighted score of 84 (12x7). Similarly a weighted mineral potential for a tract of high potential (18) for pyrophyllite (2) would have a weighted score of 36 (18x2). The weighted composite mineral potential map shows a greater differentiation of the areas of moderate-high mineral potential and high potential. Like the composite mineral potential map, the weighted composite potential map shows the highest level of weighted mineral potential as assessed in April 1997. Weighted scores for high potential range from 36 (pyrophyllite) to 126 (epithermal gold) and from moderate to high potential the weighted scores range from 36 (tungsten skarn deposits) to 96 (volcanic hosted massive sulphide deposits). It should be noted that although the lowest score for high potential is 36 (pyrophyllite), the pyrophyllite potential in the Eden region is obscured by tracts with higher weighted scores.

9. CONCLUSIONS

The assessment of the potential of the Eden region for mineral resources has utilised a methodology developed by the United States Geological Survey, which has been used for mineral resource assessments of forest areas in North Amenrica and elsewhere. Results of the assessment have been summarised and presented in three different forms:

- composite mineral potential - this highlights the highest level of mineral potential assessed for any particular area in the region. In this approach, areas of lower mineral potential for any one commodity are obscured (overlain) if another commodity has a higher mineral potential in the same area. In the Eden region, the areas of high mineral potential are for epithermal gold in the east in a zone passing through Merimbula and Eden, for granite-hosted gold and tungsten-molybdenum veins in an area in the central-south portion of the region, and for slate-belt gold in the north and southwest.
- cumulative mineral potential - this highlights areas where there is potential for a diversity of occurrences of minerals as well as the level of the potential. Cumulative scores are reached by adding the potentials for the occurrence of different styles of mineralisation for any particular area. Using this approach, the diversity of potential resources is highlighted mainly in the southern and eastern parts of the Eden region where there are overlapping tracts for slate-belt gold, epithermal gold-silver, granite-hosted gold, porphyry copper-gold deposits and tungsten-molybdenum vein deposits.
- weighted composite mineral potential - this technique provides some perspective to the relative economic potential of an area by considering the relative economic significance of the mineral commodity (for example, gold is more highly weighted than pyrophyllite, given the relative market prices of the two commodities). In this case, the areas with highest potential occur near the coast to the south of Eden township, between Eden and Merimbula and north of Merimbula to Tathra; there are also areas of high potential in the northeast, northwest, central-south and southwest of the region.

Past mineral production in the Eden region has been largely gold from alluvial and small primary gold deposits. Current mining activity is largely restricted to extraction of construction materials. The study shows that, on available evidence, the greatest potential for future discoveries in the region is for epithermal gold-silver (eastern part of the region from south of Eden to north of Merimbula), granite-hosted gold (central-south of the region), and gold within the slate belts (distributed in the north of the region and in the southwest).

APPENDIX A: METHODOLOGY FOR ASSESSMENT OF POTENTIAL (UNDISCOVERED) MINERAL RESOURCES

The mineral potential of the study areas has been assessed by determining the types of mineral deposits likely to be found under the geological conditions known or believed to exist there. The general methodology used, described below, was developed by the United States Geological Survey (USGS), and has been used successfully for mineral resource assessments of forest areas in North America and elsewhere. The qualitative methodology for the assessment of potential mineral resources is described by Marsh, Kropschot and Dickinson (1984), Taylor and Steven (1983), and by Dewitt, Redden, Wilson and Buscher (1986).

An assessment of the potential mineral resources of a region combines knowledge of the region's geology, geophysics, geochemistry, mineral deposits and occurrences with current theories of mineral deposit genesis and results of mineral exploration. The assessment process requires a study of available geoscientific data — for a region to small area, as required — to determine the history of geological processes and environments. Geological environments judged to have characteristics known to be associated with specific types of mineral deposits are then identified. In particular the assessment draws on regional and local characteristics of mineral deposit models to establish whether or not specific types of mineral deposits are likely to occur.

The mineral deposit models used in this assessment are generally those published by Cox and Singer (1986). These mineral deposit models are the systematic arrangements of information describing the essential attributes (properties) of groups or classes of mineral deposits. The models used are empirical (descriptive), the various attributes being recognised as essential even though their relationships are unknown. Each model encapsulates the common features of a group of deposits, as these are known from deposits around the world, and is constructed (as far as possible) to be independent of site-specific attributes not common to the group. The value of these models lies in the ability to apply what is known about a group of significant mineral deposits to the known geological environment of the area being assessed.

The assessment takes into account all of the features of the deposit models and whether these features can be recognised in the geoscientific data available for the area being assessed. Local and regional-scale features provide evidence as to whether the geological environment is conducive to, or permissive of, the formation of a given deposit type.

There are probably at least 70 styles of mineral deposits of economic or potential economic significance in Australia. These have distinct features and have formed in different ways. It is not feasible to apply models for all of these deposit classes systematically in each study area. Only the deposit types judged to be most likely to constitute economically significant resources in each area have been assessed in any detail. Where necessary, variations on USGS deposit models (Cox and Singer, 1986) can be made to better fit regional circumstances.

Qualitatively assessed potential resources

A qualitative assessment of the potential resources of an area is an estimate of the likelihood of occurrence of mineral deposits which may be of sufficient size and grade to constitute a mineral resource.

The mineral potential of an area is assessed for specific types of mineral deposits. For each type of deposit considered in a given area, the mineral potential is ranked in qualitative terms as 'high', 'moderate', 'low', 'no' or 'unknown', based upon professional judgements of geoscientists involved in the assessment. A qualitative mineral potential assessment is not a measure of the resources themselves. It cannot be classified according to the two dimensional ('McKelvey') diagram used for identified resources. For this reason the qualitatively assessed potential resources are shown in a separate box (Figure 3). The rankings are defined as follows:

H: An area is considered to have a high mineral resource potential if the geological, geophysical or geochemical evidence indicate a high likelihood that mineral concentration has taken place and that there is a strong possibility of specific type(s) of mineral deposit(s) being present. The area has characteristics which give strong evidence for the presence of specific types of mineral deposits. The assignment of high resource potential does not require that the specific mineral deposits types have already been identified in the area being assessed.

M: An area is considered to have a moderate mineral resource potential if the available evidence indicates that there is a reasonable possibility of specific type(s) of mineral deposit(s) being present. There may or may not be evidence of mineral occurrences or deposits. The characteristics for the presence of specific types of mineral deposits are less clear.

L: An area is considered to have a low mineral resource potential if there is a low possibility of specific types of mineral deposit(s) being present. Geological, geophysical and geochemical characteristics in such areas indicate that mineral concentrations are unlikely, and evidence for specific mineral deposit models is lacking. The assignment of low potential requires positive knowledge and cannot be used as a valid description for areas where adequate data are lacking.

N: The term 'no' mineral resource potential can be used for specified types of mineral deposits in areas where there is a detailed understanding of the geological environment and geoscientific evidence indicates that such deposits are not present.

U: If there are insufficient data to classify the areas as having high, moderate, low or no potential, then the mineral resource potential is unknown.

To reflect the differing amount of information available, the assessment of mineral potential is also categorised according to levels of certainty, denoted by letters A to D (Figure 3).

A: The available data are not adequate to determine the level of mineral resource potential. This level is used with an assignment of unknown mineral resource potential.

B: The available data are adequate to suggest the geological environment and the level of mineral resource potential, but either the evidence is insufficient to establish precisely the likelihood of resource occurrence or the occurrence and/or genetic models are not well enough known for predictive resource assessment.

C: The available data give a good indication of the geological environment and the level of mineral resource potential.

D: The available data clearly define the geological environment and the level of mineral resource potential.

APPENDIX B: MINERAL RESOURCE ASSESSMENT AND MINERAL DEPOSIT MODELS

Au1: SLATE-BELT GOLD DEPOSITS (MODEL 36A OF COX AND SINGER, 1986)

Model Description

Description of the model after Byron R. Berger

Approximate Synonyms:

Mesothermal quartz veins, Mother Lode veins, Turbidite-hosted gold veins, Slate belt gold veins, low sulphide gold-quartz veins.

Description: Gold in quartz veins and silicified lode structures, mainly in regionally metamorphosed rocks.

General References: Forde and Bell (1994); Robert (1995)

Geological Environment

Rock types: Greenstone belts; oceanic metasediments: regionally metamorphosed volcanic rocks, greywacke, chert, shale, and quartzite, turbidite-deposited sequences. Alpine gabbro and serpentine. Late granitic batholiths.

Age range: Precambrian to Tertiary.

Depositional environment: Continental margin mobile belts, accreted margins. Veins age pre to post-metamorphic and locally cut granitic rocks.

Tectonic setting(s): Fault and joint systems produced by regional compression.

Associated deposit types: Placer Au-PGE, Homestake gold. Fosterville-Nagambie style gold (stockworks).

Deposit Description:

Mineralogy: Quartz ± carbonates ± native gold ± arsenopyrite ± pyrite ± galena ± sphalerite ± chalcopyrite ± pyrrhotite ± sericite ± rutile. Locally tellurides ± scheelite ± bismuth ± tetrahedrite ± stibnite ± molybdenite ± fluorite. Gold-bearing quartz is greyish or bluish in many instances because of fine-grained sulphides. Carbonates of Ca, Mg, and Fe abundant.

Texture/structure: Saddle reefs, ribbon quartz, breccias, open-space filling textures commonly destroyed by vein deformation.

Alteration: Quartz + siderite and (or) ankerite ± albite in veins with possible halo of carbonate alteration. Chrome mica ± dolomite ± talc ± siderite in areas of ultramafic rocks. Sericite ± disseminated arsenopyrite ± rutile in granitic rocks.

Ore controls : Veins occur along regional high-angle faults, joint sets. Best deposits overall in areas with greenstone. High-grade ore shoots locally at metasediment-serpentine contacts. Disseminated ore bodies where veins cut granitic rocks. Carbonaceous shales and may be important. Competency contrasts, eg shale/sandstone contacts and intrusive contacts may be important.

Weathering: Abundant quartz chips in soil. Red limonitic soil zones. Gold may be recovered from soil by panning.

Geochemical signature: Gold best pathfinder in general; As, Ag, Pb, Zn, Cu may be useful.

Geophysical signature: Poorly defined generally, but magnetics may define important structures.

Examples:

Bendigo Goldfield, Australia	(Sharpe and MacGeehan, 1990)
Ballarat East Gold Deposits, Australia	(d'Auvergne, 1990)
Mother Lode, US	(Knopf, 1929)
Goldfields of Nova Scotia, Canada	(Malcolm, 1929)
Hill End	

Known deposits and prospects in the Eden region

Known deposits include those in the Nerrigundah Gold Field, just to the north of the Eden region, with the inferred structural control by the Budawang Thrust System just to the east. Reefs have been emplaced along faults, within tension gashes, or along fold crests as saddle and trough reefs. Reefs are hosted by phyllites and subgreywacke. Some reefs are associated with dykes. In similar goldfields in Victoria greasy, carbonaceous pyritic slate has been described as an ideal host of mineralisation, however the presence of similar sediments in the Nerrigundah area has not been demonstrated. It is generally considered that hydrothermal fluids responsible for this type of mineralisation are related to process of low-grade metamorphism of rocks.

Although gold mineralisation is thought to be predominantly related to Silurian and Devonian orogenies (Benambran, Quidongan and Tabberabberan) it is possible that some mineralisation is younger, related to the Kanimblan Orogeny (Carboniferous).

Spatial analysis of known occurrences shows that more than 95% are hosted by Ordovician turbidites and Silurian sediments of the Yalmy Group. Most occurrences also show a close spatial relation with faults. A 2 kilometre zone around faults contains around 42% of the occurrences. When the buffer zone around faults is increased to 5 kilometres, 95% of occurrences plot within that zone. Amongst faults, N-S trending faults seem to be more important. A 2 kilometre zone around these faults contains 33% occurrences, whereas a 5 kilometre zone contains almost 87% occurrences. Spatial proximity to granitoids is also an important factor controlling the distribution of these occurrences: 23% of occurrences are located within 5 kilometres of granitoids. These spatial relations have been used to delineate tracts and assess their mineral potential.

Assessment Criteria

Distribution of the turbidites and their metamorphic equivalents.
Presence of carbonaceous metasedimentary/sedimentary rocks within the turbiditic sequence.
Presence of granodiorites.
Presence of fault zones.
Intensive deformation of rocks and their metamorphism with signs of retrograde metamorphism.
Presence of primary and/or alluvial gold deposits and prospects.

Assessment

Tract Au1a/H/C

The tract includes Ordovician and Silurian (Yalmy Group) rocks (turbiditic and their metamorphic equivalents) that are within 5 kilometres of granitoids and are also within 2 kilometres buffer zone of faults. The presence of fault zones and proximity to granitoid bodies have been suggested to be the important factors controlling slate belt gold mineralisation. The potential in this tract is assessed to be high with a certainty level of C.

Tract Au1b/M-H/B

The tract includes Ordovician and Silurian (Yalmy Group) rocks (turbiditic and their metamorphic equivalents) that are within 2 kilometres of faults. It also includes areas with the same rocks that are within 5 km of granitoids.

Because the tract lacks the coincidence of all the three important geological factors that control mineralisation, its potential is assessed to be moderate to high with a certainty level of B.

Tract Au1c/M/B

The tract includes areas occupied by Ordovician and Silurian (Yalmy Group) rocks (turbiditic and their metamorphic equivalents). Similar rocks in the East Gippsland area to the south of the Eden region host several occurrences of gold. Detailed high-resolution, and a low altitude geophysical survey in the East

Gippsland area has revealed the presence of several shallow lying granitoid bodies intruding turbiditic rocks. It is possible that in the tract similar granitoids are also present. The potential of the tract is assessed to be moderate with certainty level of B.

Tract Au1d/L-M/B

The tract includes granitoids within 2 km of faults. In Victoria although no large deposits have yet been found in granitoids several gold occurrences have been reported in and in proximity to granitoids. The potential of the tract is assessed to be low to moderate with a certainty level of B.

Economic Significance

The slate belt type of gold deposits are one of the largest type of gold deposits and are important source of gold and silver. According to the grade and tonnage models for the low-sulphide gold -quartz veins (Cox and Singer, 1986) 90% of these deposits contain at least 0.001 million tonnes of ore; 50% contain at least 0.03 million tonnes and 10% contain at least 0.91 million tonnes. In 90% of these deposits ores contain at least 6 g/t gold; 50% contain at least 15 g/t gold and 10% contain 43 g/t gold.

Mineral potential for associated deposit types

Disseminated gold mineralisation

In many slate belt gold deposits, quartz veins and lodes are associated with low grade disseminated gold mineralisation. Significant mineralisation of this type has been reported at Nagambie in the Melbourne Zone and at Fosterville in the Bendigo-Ballarat Zone in Victoria. It is possible that conditions suitable for the formation of disseminated mineralisation also exist in the Eden region. However a lack of more detailed information prevents a reliable assessment of mineral potential of disseminated mineralisation.

Au2: EPITHERMAL GOLD-SILVER DEPOSITS (MODEL 25B OF COX AND SINGER, 1986)

Model Description

Description of the model after Dan L. Mosier, Takeo Sato, Norman J Page, Donald A. Singer, and Byron R. Berger

Approximate Synonym: Epithermal gold (quartz-adularia) alkali-chloride-type, polymetallic veins.

Description: Galena, sphalerite, chalcopyrite, sulfosalts, + tellurides + gold in quartz-carbonate veins hosted by felsic to intermediate volcanics. Older miogeosynclinal evaporites or rocks with trapped seawater are associated with these deposits.
General References: Buchanan (1980), White and Hedenquist (1990), Henley et al (1984), Berger and Bethke (1985)

Geological Environment:

Rock types: Host rocks are andesite, dacite, quartz latite, rhyodacite, rhyolite, and associated sedimentary rocks. Mineralisation related to calc-alkaline or bimodal volcanism.

Textures: Porphyritic.

Age range: Mainly Tertiary (most are 29-4 Ma.).

Depositional environment: Bimodal and calc-alkaline volcanism. Deposits related to sources of saline fluids in prevolcanic basement such as evaporites or rocks with entrapped seawater.

Tectonic setting(s): Through-going fractures systems; major normal faults, fractures related to doming, ring fracture zones, joints associated with calderas. Underlying or nearby older rocks of continental shelf with evaporite basins, or island arcs that are rapidly uplifted.

Associated deposit types: Placer gold, epithermal quartz alunite Au, polymetallic replacement., Porphyry Cu-Au

Deposit Description:

Mineralogy: Galena + sphalerite + chalcopyrite + copper sulfosalts + silver sulfosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodochrosite + barite ± fluorite ± siderite ± ankerite ± sericite ± adularia ± kaolinite. Specular hematite and alunite may be present.

Texture/structure: Banded veins, open space filling, lamellar quartz, stockworks, colloform textures.

Alteration: Top to bottom: quartz ± kaolinite + montmorillonite ± zeolites ± barite ± calcite; quartz + illite; quartz + adularia ± illite; quartz + chlorite; presence of adularia is variable.

Ore controls: Through-going or anastomosing fracture systems. High-grade shoots where vein changes strike or dip and at intersections of veins. Hanging-wall fractures are particularly favourable.

Weathering: Bleached country rock, goethite, jarosite, alunite--supergene processes often important factor in increasing grade of deposit.

Geochemical signature: Higher in system Au + As + Sb + Hg; Au + Ag + Pb + Zn + Cu; Ag + Pb + Zn, Cu + Pb + Zn. Base metals generally higher grade in deposits with silver. W + Bi may be present.

Geophysical signatures:

Examples:

Pajingo, Australia	(Bobis et al, 1996)
Creede, United States	(Steven and Eaton, 1975; Barton and others, 1977)
Pachuca, Mexico	(Geyne and others, 1963)
Toyoha, Japan	(Yajima and Ohta, 1979)

Known deposits and prospects in the Eden region

Most known occurrences of this style of mineralisation are those associated with the Boyd Volcanic Complex and are confined to the Budawang rift. The Pambula Gold Field, the Sugarloaf Mountain deposits, and deposits in the Wolumla Gold Field (in part) are included in this deposit type. Mineralisation is associated with faults and zones of brecciation, with quartz veins and associated stockworks, zones of chalcedony and massive quartz veins in rhyolitic and rhyodacitic volcanics.

Assessment Criteria

Distribution of intrusive/extrusive complexes representing a predominantly subaerial complex of volcanic and volcaniclastics of silicic to mafic composition (Boyd Volcanic Complex).
Presence of favourable structures such as generally N-S trending shear zones or 'fissures', in some cases intersected by E-W faults or shear zones; caldera with ring fractures; and zones of brecciation.
Presence of alterations such as: silicification, propylitic, chloritic, sericitic and argillic.
Presence of mineral prospects having features similar to epithermal precious-metal deposits.

Assessment

Tract Au2a/H/B

The tract includes rocks of the Boyd Volcanic Complex consisting of basalts, rhyolites and intercalated breccias, conglomerates, sandstones, and siltstones. They exhibit many characteristics of deposition on a terrestrial landform controlled by extensional (rift) faulting. The rocks commonly show alteration typical of epithermal hydrothermal systems such as: potassic (adularia), propylitic, chloritic, sericitic, clay, pyrophyllite and silicification. Most known occurrence of epithermal gold (Pambula Gold Field) are located within altered rhyolites. In some prospects such as Mount Gahan Mine, Morning Star Hidden Treasure Mine, and Victory

Mine, signs of deposition from near surface, geothermal systems have been reported. Mineral potential of the tract is assessed to be high with a certainty level of B.

Tract Au2b/M-H/B

This tract is delineated to include rocks surrounding the Boyd Volcanic Complex that host known epithermal gold occurrences. The presence of these occurrences is evidence that the epithermal system generated by volcanism associated with the Boyd Volcanic Complex also affected the surrounding rocks.

The tract has moderate to high potential for epithermal mineralisation with a certainty level of B.

Economic Significance

Epithermal gold-silver deposits are important sources for gold and silver. Grade/tonnage models for deposits of this type (Cox and Singer, 1986) indicates that 90% of deposits contain more than 0.065 million tonnes of ore, 50% more than 0.77 million tonnes and 10% contain more that 9.1 million tonnes. In 90% of these deposits ores have at least 2.0 grams per tonnes gold and 10 grams per tonne silver. The ores in 50% of these deposits have at least 7.5 grams per tonne gold and 110 grams per tonne silver. In 10% of these deposits the ores have at least 27 grams per tone gold and 1300 grams per tonne silver.

Potential of associated deposit types

In recent years, detailed exploration of epithermal systems in Australia, Canada, Papua New Guinea and Philippines has revealed a transition of these systems at depth into porphyry systems with copper, gold and molybdenum mineralisation (Panteleyev, 1988). Examples include Wafi (Papua New Guinea); Red Dome - Mungana, Anastasia, and Cadia (Eastern Australia). It is possible that the epithermal system in the tract might also contain porphyry systems at depths of a few kilometres.

Au3: GOLD ASSOCIATED WITH ALKALINE INTRUSIVES

Model Description

Description of the model by S.Jaireth, R. Bottrill & J. Taheri

Description: Fine grained gold and sulphides in brecciated stockworks in syenite and alkaline porphyries.

General References: Sillitoe (1991), Bonham (1988).

Geological Environment:

Rock Types: Host rocks are alkaline porphyries: syenites, monzonites and latites

Textures: Porphyritic: medium grained.

Age Range: Cretaceous in Tasmania, but may be of any age.

Depositional Environment: Alkaline porphyries intruding thick sedimentary sequences.

Tectonic Setting(s): Stable platform or foreland-interior basin, shelf margin.

Associated Deposit Types: Carlin-style gold, kaolin, placer gold.

Deposit Description:

Mineralogy: Gold/electrum, auriferous pyrite, chalcopyrite ± scheelite ± magnetite ± pyrrhotite ± Au/Ag tellurides ± molybdenite ± galena ± sphalerite ± arsenic minerals in a gangue of quartz/chalcedony ± calcite ± fluorite.

Texture/Structure: Stockworks, breccia pipes

Alteration: Silicification, argillisation, K-silicate

Ore Controls: Fracturing.

Weathering: Oxidation of pyrite to limonite and jarosite.

Geochemical and Geophysical Signature: Au, Ag, variable As, Cu, Pb

Examples:

Zortman-Landusky, United States	(Bonham, 1988)
Golden Sunlight, United States	(Bonham, 1988)
Ortiz, New Mexico	(Bonham, 1988)
Young-Davidson, Canada	(Sillitoe, 1991)

Known deposits and prospects in the Eden region

The Mount Dromedary area, just to the north of the Eden region, contains a number of rich but narrow late stage gold-silver-bismuth veins associated with the intrusion of the Mount Dromedary Igneous Complex. Significant alluvial mining has also taken place from a number of streams and fossil placers draining Mount Dromedary.

Assessment Criteria

1. Presence of Cretaceous alkaline intrusives such as the Mount Dromedary Complex.
2. Distribution of hard rock and alluvial gold prospects and deposits.

Assessment

Tract Au3a/H/B-C

The tract includes Jurassic and Cretaceous alkaline igneous complexes represented by rocks such as monzonite, trachyte, syenite, nepheline syenite, nepheline monzonite and banatite. These rocks are emplaced during rifting in Jurassic and Cretaceous times.

There are several primary and alluvial gold occurrences spatially associated with the Mount Dromedary Complex which is just outside the Eden region. Small outcrops of alkaline rocks similar to the Mount Dromedary Complex occur in the Eden region. However There are no reported gold occurrences associated with these. Potential for the tract is assessed to be high with a certainty level of C (in the Mount Dromedary Complex) and a certainty level of B (in rest of the tract).

Tract Au3b/M-H/B

This tract is delineated by outlining an area (2 to 5 kilometres) around relatively larger alkaline complexes (Mount Dromedary and Tanja complexes). Near the Mount Dromedary Complex the zone includes a number of gold occurrences. Potential of the zone is assessed to be moderate to high with a certainty level of B.

Economic Significance

No reliable resource information for this type of gold deposit is known. The Mount Dromedary gold mine which operated between 1878 and 1910 produced 318.5 kg gold. The average grade of the ore was 30 to 60 g/t (Herzberger and Barnes, 1975).

Au4: GRANITE HOSTED GOLD DEPOSITS

Model Description

Preliminary description only.

Approximate Synonyms:

Description: Gold-silver and minor base metals in quartz veins and silicified lode structures, in sheared granitoids.

General References: Herzberger, Barnes and Bowman (1978)

Geological Environment

Rock types: Late stage granitic batholiths.

Age range: Late Silurian to Early Devonian in Lachlan Fold Belt.

Depositional environment: Veins and alteration zones of granitoids.

Tectonic setting(s): Brittle-ductile nature of deformation. Fault and joint systems produced in regional compressional and transpressional settings.

Associated deposit types: Placer Au-PGE, disseminated gold in granite, gold bearing skarn.

Deposit Description:

Mineralogy: Quartz ± carbonates ± native gold ± pyrite ± arsenopyrite ± galena ± sphalerite ± chalcopyrite ± cerargyrite ± sericite. Locally tellurides ± bismuth ± stibnite ± molybdenite ± fluorite.

Texture/structure: Quartz reefs, veins, breccias, some open-space filling.

Alteration: Quartz veining, silicification, sericitisation, epidotisation. Minor calcite. Minor argillite alteration associated with veinlets.

Ore controls : Gold occurs in quartz veins, in shear zones, in joint and fracture systems and with disseminated sulphide mineralisation in alteration zones surrounding these. Intersecting structures are locally important.

Weathering: Red limonitic soil zones. Gold may be recovered from soil by panning.

Geochemical signature: Gold best pathfinder in general; As, Ag, Pb, Zn, Cu may be useful.

Geophysical signature: Poorly defined generally, but magnetics may define important structures.

Examples:

Majors Creek gold deposits, Braidwood.

Known deposits and prospects in the Eden region

A number of gold deposits and mines occur in the Yambulla area. Mineralisation is intimately associated with quartz-sulphide veinlets or sulphide-filled fractures and disseminations within generally E-W trending shear zones

Assessment Criteria

1. Presence of favourable regional and local structures.
2. Presence of alterations such as silicification, sericitisation and epidotisation.
3. Presence of granodiorites.
4. Presence of mineral occurrences having similar features to known granite hosted gold deposits.

Assessment

Tract Au4a/H/B

The tract is delineated based on the distribution of mineral occurrences in the Yambulla Gold Field. The mineralisation is hosted by coarse-grained biotite granite phase of the Bega Batholith. There is a strong association of mineral occurrences with the presence of N-S trending major faults. A 5 kilometre buffer around the faults contains all known occurrences. This buffer zone defines the tract and includes granitoids and turbiditic sequence of Ordovician age. Across the border in the East Gippsland CRA there are a few gold occurrences hosted by granitoids belonging to the same batholith. Potential for this tract is assessed to be high with a certainty level of B.

Economic Significance

There is limited resource information for this type of deposits. The Yambulla Gold Field is known to have produced 760 kg of gold between 1899 and 1912. Recent exploration drilling has delineated a resource of 197 000 tonnes at 3.1 g/t of gold in the area of the old G7 mines.

Au5: PLACER GOLD (MODEL 39A OF COX AND SINGER, 1986)

Model Description

Modified after Warren E. Yeend

Approximate Synonym:

Description: Elemental gold as grains and (rarely) nuggets in gravel, sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, aeolian, and (rarely) glacial deposits. Alluvial deposits may be concealed by significant thicknesses of younger sedimentary rocks or volcanics. Such concealed placer deposits are known as deep-leads.

General References: Boyle (1979), Wells (1973), Lindgren (1911).

Geological Environment:

Rock types: Alluvial gravel and conglomerate, usually with white quartz clasts. Sand and sandstone of secondary importance.

Textures: Coarse clastic.

Age range: Cainozoic. Older deposits are known but their preservation is uncommon.

Depositional environment: High-energy alluvial where gradients flatten and river velocities lessen, as at the inside of meanders, below rapids and falls, beneath boulders, and in vegetation mats. Winnowing action of surf caused Au concentrations in raised, present, and submerged beaches.

Tectonic setting(s): Tertiary conglomerates along major fault zones, shield areas where erosion has proceeded for a long time producing multicycle sediments; high-level terrace gravels.

Associated deposit types: Black sands (magnetite, ilmenite, chromite); Platinum group elements, yellow sands (zircon, monazite). Au placers commonly derive from various Au vein-type deposits but also other gold deposits, eg. porphyry copper-gold, gold skarn, massive sulphide deposits and replacement deposits.

Deposit Description:

Mineralogy: Au, commonly with attached quartz or limonite, rarely attached to sulphides and other gangue minerals. Associated with quartz and heavy minerals, which may include: rutile, ilmenite, chromite, magnetite, limonite, pyrite, zircon, monazite, tourmaline, cassiterite, platinum-iron alloys and osmium-iridium alloys.

Texture/Structure: Usually flattened with rounded edges, also flaky or flour gold (extremely fine grained); rarely angular and irregular (“crystalline”), very rarely equidimensional nuggets.

Ore controls: Highest Au values at base of gravel deposits in various gold "traps" such as natural riffles in floor of river or stream, fractured bedrock, slate, schist, phyllite, dykes, bedding planes, all structures trending transverse to direction of water flow. Au concentrations also occur within gravel deposits above clay layers that constrain the downward migration of Au particles.

Geochemical signature: Anomalous high amounts of Ag, As, Hg, Sb, Cu, Fe, S, and heavy minerals magnetite, chromite, ilmenite, hematite, pyrite, zircon, garnet, rutile. Au nuggets have decreasing Ag content with distance from source.

Geophysical signature: Seismic methods define buried channels or deep leads.

Examples:

Sierra Nevada, United States	(Lindgren, 1911; Yeend, 1974)
Victoria, Australia	(Knight, 1975)

Known deposits and prospects in the Eden region

Gold occurs in a number of places in gravels and other alluvial sediments scattered about the Mount Dromedary-Narooma area, just north of the Eden region. The Montreal goldfield contained gold in beach sands reworked from auriferous gravel terraces southeast of Wallaga Lake. Alluvial gold has also been mined from a number of streams and rivers in the hinterland which in some instances have been traced to mineable lodes upstream. The Nerrigundah Gold Field produced at least 781 kg alluvial gold shed from slate-belt quartz veins in surrounding Adaminaby Group rocks. One alluvial occurrence of gold with dubious alluvial sapphire and diamond is also reported from the Eucumbene area, to the northwest of the region.

It is possible that there are deep leads concealed by younger sediments and Tertiary basalts.

Assessment Criteria

1. Presence of gold -bearing source rocks.
2. Distribution of alluvial, eluvial, fluvio-glacial and lacustrine deposits.
3. Distribution of Quaternary sediments.
4. Distribution of alluvial gold prospects and deposits.

Assessment

Tract: Au5a/M/C

The tract includes all mapped areas of Quaternary sediments. Rocks in most of the Eden region have a potential to be primary sources of alluvial gold accumulation. The tract is assessed to have a moderate potential for alluvial gold with a certainty level of C.

Tract: Au5b/L-M/B

This tract includes Quaternary alluvials which may occur within a hundred metre buffer around streams. The tract is delineated by intersection of the above area with areas having known gold occurrences and/or having a potential for gold deposits (mineral potential tracts for slate belt gold, granite hosted gold, epithermal gold-silver, copper-gold porphyry and gold associated with alkaline rocks). The tract includes a number of occurrences of gold.

Mineral potential of this tract is assessed to be low to moderate with a certainty level of B.

Economic significance

According to global grade and tonnage data these deposits are usually small. 90% of them have at least 0.022 million tonnes or ore, 50% at least 1.1 million tonnes and 10% have more than 50 million tonnes of ore (Cox and Singer, 1986). The ores in 90% deposits contain at least 0.084 g/t gold, in 50% deposits the ores have at least 0.2 g/t gold and 10% deposits contain more than 0.48 g/t gold.

CuAu: PORPHYRY COPPER-GOLD DEPOSITS (MODEL 20C OF COX AND SINGER, 1986)

Model Description

Description of the model after Dennis P. Cox

Description: Stockwork veinlets of chalcopyrite, bornite, and magnetite in porphyritic intrusions and coeval volcanic rocks. Ratio of Au (ppm) to Mo (percent) is greater than 30

General References: Sillitoe (1979, 1989)

Geological Environment:

Rock Types: Tonalite to monzogranite; dacite, andesite flows and tuffs coeval with intrusive rocks. Also syenite, monzonite, and coeval high-K, low-Ti volcanic rocks (shoshonites).

Textures: Intrusive rocks are porphyritic with fine- to medium-grained aplitic groundmass.

Age Range: Palaeozoic to Quaternary.

Depositional Environment: In porphyry intruding coeval volcanic rocks. Both involved and in large-scale breccia. Porphyry bodies may be dykes. Evidence for volcanic center; 1-2 km depth of emplacement.

Tectonic Setting(s): Island-arc volcanic setting, especially waning stage of volcanic cycle. Also continental margin rift-related volcanism.

Associated Deposit Types: Porphyry Cu-Mo; Gold-porphyry; epithermal Ag-Au, gold placers.

Deposit Description:

Mineralogy: Chalcopyrite ± bornite; traces of native gold, electrum, sylvanite, and hessite. Quartz + K-feldspar + biotite + magnetite + chlorite + actinolite + anhydrite. Pyrite + sericite + clay minerals + calcite may occur in late-stage veinlets.

Texture/Structure: Veinlets and disseminations.

Alteration: Quartz ± magnetite ± biotite (chlorite) ± K-feldspar ± actinolite, ± anhydrite in interior of system. Outer propylitic zone. Late quartz + pyrite + white mica ± clay may overprint early feldspar-stable alteration.

Ore controls: Veinlets and fractures of quartz, sulphides, K-feldspar magnetite, biotite, or chlorite are closely spaced. Ore zone has a bell shape centred on the volcanic-intrusive center. Highest grade ore is commonly at the level at which the stock divides into branches.

Weathering: Surface iron staining may be weak or absent if pyrite content is low in unweathered rocks. Copper silicates and carbonates. Residual soils contain anomalous amounts of rutile.

Geochemical signature: Central Cu, Au, Ag; peripheral Mo. Peripheral Pb, Zn, Mn anomalies may be present if late sericite pyrite alteration is strong. Au (ppm):Mo (percent) >30 in ore zone. Au enriched in residual soil over ore body. System may have magnetic high over intrusion surrounded by magnetic low over pyrite halo.

Geophysical signature:

Examples:

Goonumbla, Australia	(Heithersay et al, 1990)
Panguna, Papua New Guinea	(Clark, 1990)
Ok Tedi, Papua New Guinea	(Rush and Seegers, 1990)
Dizon, Philippines	
Dos Pobres, United States	(Langton and Williams, 1982)
Copper Mountain, Canada	(Fahrni and others, 1976)

Known deposits and prospects in the Eden region

Scattered copper, copper-molybdenum-gold, and copper-gold prospects with some features similar to copper porphyry systems exist at various localities within the Bega Batholith. Such prospects are reported to be associated with multiphase magnetic I-type granite or diorite stocks, sills and dykes with alteration typical of porphyry systems. Known and suspected deposits include those around the Jindabyne area 45 kilometres west of Eden where several occurrences of vein and disseminated copper -gold systems occur in association with I-type phases of Kosciusko and Berridale Batholith.

Assessment Criteria

1. Distribution of Silurian and Siluro-Devonian granitoids.
2. Presence of porphyry-related wall-rock alterations.
3. Magnetic lows on the aeromagnetic map.
4. Presence of geochemical anomalies.
5. Oxidation state of granites (I-type and/or magnetite series)
6. Presence of mineral prospects having features similar to porphyry copper deposits

Assessment

Tract CuAu/M/B

The tract includes three tonalites: Candelo, Pretty Point and Why Worry. The three are classified as I-type, mafic and unfractionated granitoids. The granites are neither strongly oxidised nor reduced (Blevin and Chappell, 1996). They are known to host a number of copper, gold, lead, zinc, silver occurrences. A 2 kilometre buffer around these granitoids is drawn to include known copper gold occurrences in the area.

The tract also includes areas in the south-west part of the Eden region. This area is an extension of a similar tract in the East Gippsland CRA. The tract includes Ordovician turbiditic sediments and granitoids (I-type, mafic/felsic and unfractionated). A low-altitude, high-resolution geophysical survey in the East Gippsland CRA has revealed the presence of shallow-level granitoids. It is possible that they are also present in the tract. The tract also includes several known occurrences containing gold and base metals. The potential in the tracts for porphyry copper-gold mineralisation is moderate with certainty level of B.

Economic Significance

Generally these deposits are important sources of copper and gold. The grade/tonnage model (Cox and Singer, 1986) for porphyry copper gold deposits indicate that 90% of these deposits contain at least 25 million tonnes of ore, 50% contain at least 100 million tonnes and 10% contain at least 400 million tonnes. In 90% of these deposits ores contain at least 0.35 wt% copper and 0.2 ppm gold, in 50 % of the deposits ores have at least 0.5 wt% copper and 0.38 ppm gold and in 10% of the deposits the ores contain at least 0.72 wt% copper and 0.72 ppm gold. One of the largest deposits of this type is the Goonumbla group of deposits in NSW which contains 30 million tonnes of ore with 0.91 wt% copper and 0.63 ppm gold (Heithersay et al., 1990)

Potential of associated deposit types

In recent years, detailed exploration of epithermal systems in Australia, Canada, Papua New Guinea and Philippines has revealed a transition of these systems at depth into porphyry systems with copper, gold and molybdenum mineralisation (Panteleyev, 1988). Hence, subvolcanic porphyry copper-gold deposits may occur at depths of up to a few kilometres below the tract for epithermal gold.

In addition, subvolcanic intrusions related to the Gabo and Mumbulla Suites may occur within the epithermal gold tract. However, no tract is drawn here to cover these possible subvolcanic intrusions.

BM1: VOLCANIC HOSTED MASSIVE SULPHIDE DEPOSITS (MODEL 28A OF COX AND SINGER, 1986)

Model Description

Description of the model after Donald A. Singer

Approximate Synonym: Noranda type, volcanogenic massive sulphide, felsic to intermediate volcanic type.

Description: Copper- and zinc-bearing massive sulphide deposits in marine volcanic rocks of intermediate to felsic composition.

General References: Ishihara (1974), Franklin and others (1981), Hutchinson and others (1982), Ohmoto and Skinner (1983), Large (1992); Allen and Barr (1990).

Geological Environment:

Rock types: Marine rhyolite, dacite, and subordinate basalt and associated sediments, principally organic-rich mudstone or shale. Pyritic, siliceous shale. Some basalt.

Textures: Flows, tuffs, pyroclastics, breccias, bedded sediment, and in some cases felsic domes.

Age range: Archaean through Cainozoic.

Depositional environment: Hot springs related to marine volcanism, probably with anoxic marine conditions. Lead-rich deposits associated with abundant fine-grained volcanogenic sediments.

Tectonic setting(s): Island arc. Local extensional tectonic activity, faults, or fractures. Archaean greenstone belt.

Associated deposit types: Epithermal quartz-adularia veins in Japan are regionally associated but younger than Kuroko massive sulphide deposits. Volcanogenic Mn, Algoma Fe.

Deposit Description:

Mineralogy: Upper stratiform massive zone (black ore)--pyrite + sphalerite + chalcopyrite ± pyrrhotite ± galena ± barite ± tetrahedrite - tennantite ± bornite; lower stratiform massive zone (yellow ore)--pyrite + chalcopyrite ± sphalerite ± pyrrhotite ± magnetite; stringer (stockwork) zone--pyrite + chalcopyrite (gold and silver). Gahnite in metamorphosed deposits. Gypsum/anhydrite present in some deposits.

Texture/structure: Massive (>60 percent sulphides); in some cases, an underlying zone of ore stockwork, stringers or disseminated sulphides or sulphide-matrix breccia. Also slumped and redeposited ore with graded bedding.

Alteration: Adjacent to and blanketing massive sulphide in some deposits--zeolites, montmorillonite (and chlorite?); stringer (stockwork) zone--silica, chlorite, and sericite; below stringer--chlorite and albite. Cordierite and anthophyllite in footwall of metamorphosed deposits, graphitic schist in hanging wall.

Ore controls: Toward the more felsic top of volcanic or volcanic-sedimentary sequence. Near center of felsic volcanism. May be locally brecciated or have felsic dome nearby. Pyritic siliceous rock (exhalite) may mark horizon at which deposits occur. Proximity to deposits may be indicated by sulphide clasts in volcanic breccias. Some deposits may be gravity-transported and deposited in palaeo depressions in the seafloor. In Japan, best deposits have mudstone in hanging wall.

Weathering: Yellow, red, and brown gossans. Gahnite in stream sediments near some deposits.

Geochemical signature: Gossan may be high in Pb and typically Au is present. Adjacent to deposit-enriched in Mg and Zn, depleted in Na. Within deposits--Cu, Zn, Pb, Ba, As, Ag, Au, Se, Sn, Bi, Fe.

Geophysical signatures:

Examples:

Benambra, Australia	(Allen and Barr, 1990)
Mt. Lyell, Australia	(Hills, 1990)
Rosebery, Australia	(Lees et al, 1990)
Furutobe, Japan	Hideo Kuroda 1983)
Brittannia, Canada	(Payne and others, 1980)
Buchans, Canada	(Swanson and others, 1981)

Woodlawn, New South Wales (McKay and Davies, 1990)

Known deposits and prospects in the Eden region

There are many prospects and deposits close to the northwestern boundary of the Eden region in the Cooma area. These prospects are hosted by Late Silurian volcanics and include Harnett, Peak View, Birchams, Billilingra. These deposits lie within the Bredbo Group sediments of the Hill End -Cooma Zone. Occurrences such as Peak View and Skidmore are hosted by Silurian sediments of the Yalmy Group and Devonian rocks of the Bredbo groups. Deposition of the Bredbo Group rocks in the area took place in a NNE basin (the Ngunawal Basin) and was related to rifting in Middle to Late Silurian time. Subaerial to submarine bimodal volcanism (though dominantly felsic) was associated with rifting and the emplacement of granitoids. One of the prospects, Ram's Head occurs in the Bredbo Group and is just outside the Eden region.

At the deposits gossanous zones and exhalites are generally hosted within a sequence of rhyolitic to dacitic crystal-rich volcanic sandstones and minor siltstones. Within the area numerous base metal anomalies and sub-economic deposits have been found.

Assessment Criteria

1. Distribution of rocks belonging to marine volcanic and sedimentary sequence (the Bredbo Group).
2. Distribution of known base metal deposits and mineral occurrences.

Assessment

Tract BM1a/M-H/C

The tract includes rocks of the Bredbo Group. These rocks were formed in the Silurian Quidong and Ngunawal basins. Most of the Ngunawal basin as well as the Quidong Basin rocks are outside Eden region but are within the 15 kilometre buffer zone. The tract in the north-west of the area is part of the Ngunawal basin which merges in the NNE direction with Captains Flat-Goulburn Trough (Suppel and Scheibner, 1990), that hosts several volcanic massive sulphide occurrences and deposits.

The tract within the Eden region boundary also contains several known occurrences of base metals. Skidmore Copper Mine (Cooma Copper Mine) is in the NW part of the tract just outside the Eden region. Here the mineralisation is localised at the contact between crystal tuff and shale. Potential in the tract is assessed to be moderate to high with a certainty level of C.

Tract BM1b/M/B

Middle to late Silurian basins in the area extended in the NNE direction and occupied most of the western part of Eden region. A large part of the Silurian basin is now covered by Tertiary basalts. It is possible that the remnants of the basin are preserved underneath basalts. This tract has been delineated based on above assumption. A buffer zone around the known mapped outcrops of rocks belonging to the Bredbo Group make up the tract. The buffer zone is drawn taking into account the NNE strike direction of the rocks. Potential of this tract is assessed to be moderate to high with a certainty level of B.

Economic Significance

Volcanic-hosted massive sulphide deposits are significant sources for copper, lead and zinc. Some of these deposits can also have up to a few tens of ppm of gold and few hundreds of ppm of silver. Global grade/tonnage models for this type of deposits indicate that 90% of these deposits have more than 0.12 million tonnes of ore, 50% have more that 1.5 million tonnes and 10% have more than 18 million tonnes. Similarly 90% of these deposits the ores have more than 0.45% copper, 50 % have more than 1.3% copper and 2.0% zinc and 10% have more than 3.5% copper , 8.7% zinc and 1.9% lead.

Potential of associated deposit types:

Gold associated with massive sulphide mineralisation

Often volcanic hosted massive sulphide deposits are associated with significant gold mineralisation. Many massive sulphide deposits in Tasmania such as Que River and Hellyer belong to this category. Volcanic-hosted massive sulphide deposits in the Captains Flat-Goulburn and the Hill End Synclinorial zones also contain gold and silver mineralisation. Thus the above two tracts of volcanic hosted massive sulphide deposits also have an unknown potential for gold mineralisation.

Irish style base metal mineralisation

Deposition of the Bredbo Group rocks took place in shallow marine basins which became deeper to the north. Limestone forms a significant part of the succession represented by the Quidong Limestone. Sedimentation was associated with subaerial to submarine bimodal volcanism (though dominantly felsic). The sequence is intruded by a sill-like porphyry. Rifting and the extensional tectonic setting, shallow marine conditions, the presence of carbonates and the signs of concomitant intrusive activity indicates an environment that was favourable for the formation of Irish-style base metal sulphide deposits. In East Gippsland similar geological environment existed in the Early Devonian Boulder Flat Graben and at Buchan, although the amount of volcanics in the Boulder Flat Graben is not large. The Errinundra Group of rocks in the Boulder Flat Graben host several base metal occurrences showing features similar to the Irish-style base metal deposits. Hence it is possible that during the deposition of the Bredbo Group rocks in the Eden region there existed conditions favourable for Irish-style base metal deposits. However, in view of the absence of lead-zinc occurrences and the predominance of submarine volcanism in the Bredbo Group it is concluded that the potential for Irish-style base metal deposits is unknown.

WMo: TUNGSTEN-MOLYBDENUM VEINS (MODEL 15A, COX AND SINGER, 1986)

Model Description

Description of the model after D. P. Cox and W. C. Bagby

Approximate Synonym: Quartz-wolframite veins (Kelly and Rye, 1979).

Description: Wolframite, molybdenite, and minor base-metal sulphides in quartz veins

Geological Environment:

Rock types: Monzogranite to granite stocks intruding sandstone, shale, and metamorphic equivalents.

Textures: Phanerocrystalline igneous rocks, minor pegmatitic bodies, and porphyroaphanitic dykes.

Age range: Palaeozoic to late Tertiary.

Depositional environment: Tensional fractures in epizonal granitic plutons and their wallrocks.

Tectonic setting(s): Belts of granitic plutons derived from remelting of continental crust. Country rocks are metamorphosed to greenschist facies.

Associated deposit types: Sn-W veins, pegmatites.

Deposit Description:

Mineralogy: Wolframite, molybdenite, bismuthinite, pyrite, pyrrhotite, arsenopyrite, bornite, chalcopyrite, scheelite, cassiterite, beryl, fluorite; also at Pasto Bueno, tetrahedrite-tennantite, sphalerite, galena, and minor enargite.

Texture/structure: Massive quartz veins with minor vughs, parallel walls, local breccia.

Alteration: Deepest zones, pervasive albitisation; higher pervasive to vein-selvage pink K-feldspar replacement with minor disseminated REE minerals; upper zones, vein selvedges of dark-gray muscovite or zinnwaldite (greisen). Chloritisation. Widespread tourmaline alteration at Isla de Pinos.

Ore controls: Swarms of parallel veins cutting granitic rocks or sedimentary rocks near igneous contacts.

Weathering: Wolframite persists in soils and stream sediments. Stolzite and tungstite may be weathering products.

Geochemical signature : W, Mo, Sn, Bi, As, Cu, Pb, Zn, Be, F.

Examples:

Pasto Bueno, Peru	(Landis and Rye, 1974)
Xihuashan, China	(Hsu, 1943; Giuliani, 1985; and personal visit)
Isla de Pinos, Cuba	(Page and McAllister, 1944)
Hamme District, United States	(Foose and others, 1980)
Round Mountain, United States	(Shawe and others, 1984)
Chicote Grande, Bolivia	
Aberfoyle	

Known deposits and prospects in the Eden region

The dominant form of mineralisation in the region is disseminations of molybdenite in aplitic/pegmatitic dykes with bismuth commonly present. Less common are quartz veins in granites, aplites/pegmatites or sediments overlying intrusive bodies.

The largest deposits of molybdenum-bismuth are the Whipstick deposits which occur in pipe-like bodies in altered granite. The Whipstick deposits are situated in the Whipstick Adamellite, a highly fractionated A- or I-type granitoid, mostly within 100m of the granite sediment contact. About 200t of bismuth concentrates and 100t of molybdenum concentrates were produced from about 17 000t of ore (Weber et al 1978).

The Black Range occurrences are disseminations in large quartz veins within the Brogo Granodiorite.

Within the Bemboka Granodiorite, the largest body in the Bega Batholith, disseminated molybdenite occurrences in aplite and pegmatite dykes are very common. Occurrences within vein material are less common and a few contain significant amounts of wolframite. The alignment of the Tantawangalo occurrences in the Bemboka granite suggests a strong structural control for some of the mineralisation.

The granites of the Bega Batholith have been characterised by Chappell and Blevin (1995) as being relatively oxidised. Most recorded tungsten-molybdenum-bismuth occurrences and all the major ones within the Bega Batholith are within a few hundred metres of granite-sediment contacts.

Several other minor occurrences are present within the area, associated with various granite bodies and a few in vein deposits in sediments or metasediments. These occurrences are isolated and rare within the remaining individual granite bodies.

Assessment Criteria

1. Distribution of syn to late orogenic, oxidised I-type and/or S-type fractionated granitoids.
2. Distribution of tungsten, molybdenum and bismuth prospects.

Assessment

Tract WMo1a/M-H/B-C

The Whipstick Adamellite is a highly fractionated body of either I or A -type, with unusual chemical features such as the predominance of Na over K. The incompatible nature of molybdenum in oxidised granite suites and the high degree of fractionation undergone by the Whipstick body provide a highly favourable set of conditions for the formation of molybdenum deposits. The Whipstick deposits are evidence of the suitability of the Whipstick Adamellite as a potential source of molybdenum-bismuth deposits.

In general tungsten and molybdenum vein deposits are distributed in the contact metamorphic aureole of granitoids that can extend up to a few kilometres from the parent granitoid. Often some deposits are found up to a distance of 10 kilometres from the known outcrops of granitoids (see e.g. Leaman and Richardson, 1989; Pohl and Gunther, 1991). A 5 kilometre buffer around granitoids is used in this assessment.

Whipstick Adamellite including a 5 km buffer - moderate to high potential/certainty level C.

Other fractionated, felsic I-types in area are the Bondi Granite, The Figurehead Adamellite and the Wallagaraugh Adamellite which are all part of the Wallagaraugh Suite. However no molybdenum-tungsten occurrences associated with these.

Wallagaraugh Suite - moderate to high potential/certainty level B.

Tract WMo1b/M/B-C

The Bemboka Granodiorite has substantial number of molybdenum-bismuth mineral occurrences as well as a couple of tungsten occurrences. These occurrences are associated with very late stage aplites and pegmatites of the granite. The granite itself is a relatively unfractionated felsic I-type, which is considered to be only moderately prospective for molybdenum-bismuth deposits, however the numerous mineral occurrences indicate the granite may be a source of substantial molybdenum and bismuth.

Bemboka Granodiorite including buffer of 5 kilometres - moderate potential/certainty level B.

The Brogo Granodiorite is an unfractionated, mafic I-type and would usually considered relatively unprospective for molybdenum/bismuth mineralisation. The presence of the Black Range vein deposits suggest that the latest stages of the granite were enriched in molybdenum and other areas around the granite must be considered reasonably prospective for vein-type deposits.

Brogo Granodiorite including buffer of 5 kilometres - moderate potential/certainty level C.

Tract WMo1c/L/B

All other known granite bodies of the Bega Batholith in the Eden region have less potential to host mineralisation as they are not particularly fractionated and have either no or very few associated mineral occurrences.

All other identifiable granite bodies of Bega Batholith including buffer of 5 kilometres - Low potential/certainty level of B.

Economic Significance

According to grade and tonnage models for tungsten deposits, 90% deposits contain at least 0.045 million tonnes of ore, 50% at least 0.56 million tonnes and 10% at least 7 million tonnes. In these type s of deposits, 90% contain at least 0.6 wt% WO_3, 50% at least 0.9 wt% WO_3 and 10% at least 1.4 wt% WO_3 (Cox and Singer, 1986).

W: TUNGSTEN SKARN DEPOSITS (MODEL 14A OF COX AND SINGER, 1986)

Model Description

Description of the model after D. P. Cox

Description: Scheelite in calc-silicate contact metasomatic rocks.

Approximate Synonyms: Scheelite skarns of the tin-tungsten type (Solomon & Groves, 1994).

General References: Kwak (1987), Einaudi and Burt (1982).

Geological Environment:

Rock Types: Tonalite, granodiorite, quartz monzonite; limestone.

Textures: Granitic, granoblastic.

Age Range: Mainly Mesozoic, but may be any age.

Depositional Environment: Contacts and roof pendants of batholith and thermal aureoles of apical zones of stocks that intrude carbonate rocks. Adjacent to fault zones which intersect the intrusion and the carbonate host rocks.

Tectonic Setting(s): Orogenic belts. Syn-late orogenic.

Associated Deposit Types: Sn-W skarns, Zn skarns.

Deposit Description

Mineralogy: Scheelite ± molybdenite ± pyrrhotite ± sphalerite ± chalcopyrite ± bornite ± arsenopyrite ± pyrite ± magnetite ± traces of wolframite, fluorite, cassiterite, and native bismuth.

Alteration: Diopside-hedenbergite + grossular-andradite. Late stage spessartine + almandine. Outer barren wollastonite zone. Inner zone of massive quartz may be present.

Ore Controls: Carbonate rocks in thermal aureoles of intrusions. Fault which intersect the intrusion and the carbonate beds have acted as conduits to the mineralising fluids, particularly faults which pre-date the intrusion.

Geochemical Signature: W, Mo, Zn, Cu, Sn, Bi, Be, As.

Examples:

King Island, Australia	(Solomon and Groves, 1994)
Pine Creek, United States	(Newberry, 1982)
MacTung, Canada	(Dick and Hodgson, 1982)
Strawberry, United States	(Nokleberg, 1981)

Known deposits and prospects in the Eden region

There are no known skarn deposits or prospects within the Eden area. However some minor tungsten mineralisation has been recognised related to granites in the Eden area. These include the Creewah wolframite mine (Wolfram Wonder mines) and Hammond and Standens claims.

Assessment Criteria

1. Presence of differentiated Siluro-Devonian granitoids.
2. Palaeozoic carbonate rocks intruded by the granitoids.

Assessment:

Tract Skrn1a/M-H/C

The tract is based on the intersection between a 5km wide zone surrounding Silurian/Devonian granitoids, and the Silurian Bredbo and Yalmy Groups sediments. The Bredbo Group is known to contain limestone sequences. Only a small area of this tract falls within the Eden boundary, most falls within the buffer zone. The section of tract that lies within the Eden area lies adjacent to some regional north-south trending structures which may act as conduits for fluids. The tract is considered to have a moderate to high potential with a certainty level of C.

Tract Skrn1b/M/B

This tract is based on the distribution of sediments of the Silurian Bredbo and Yalmy Groups sediments that are possibly present below Tertiary basalts and are within 5 km of granitoids. The tract is considered to have a moderate potential with a certainty level of B.

Potential for associated deposit types

The same tract also has potential for other types of skarn deposits including tin skarns, copper skarns (eg. Cadia deposit near Orange), gold skarns (eg. Browns Creek deposit, which is outside the region) and iron (magnetite) skarns.

Due to the lack of known mineralisation, it is not possible to assess the potential for these types of skarns. Hence the potential for these associated types of skarn deposits is unknown.

Economic Significance

According to grade/tonnage models for tungsten skarn deposits, 90% of deposits contain at least 0.05 million tonnes of ore, 50% at least 1.1 million tonnes and 10% at least 22 million tonnes. In these types of deposits, 90% contain at least 0.34% WO_3, 50% at least 0.67% WO_3 and 10% at least 1.4% WO_3 (Cox and Singer, 1986).

King Island is one of the world's largest tungsten skarn deposits. Estimated pre-mining resources for King Island orebodies: 16.9 Mt ore averaging 0.78% WO_3 . Total production to date 10.67 Mt ore averaging 0.61% WO_3.

Sn: TIN VEINS (MODEL 15B OF COX AND SINGER, 1986)

Model Description

Description of the model after B. L. Reed

Approximate Synonym: Cornish type lodes.

Description: Simple to complex quartz-cassiterite ± wolframite and base-metal sulphide fissure fillings or replacement lodes in ore near felsic plutonic rocks.

General Reference: Solomon and Groves (1994), Hosking (1974), Taylor (1979).

Geological Environment:

Rock Types: Close spatial relation to multiphase granitoids; specialised biotite and(or) muscovite leucogranite common; pelitic sediments generally present.

Textures: Common plutonic textures.

Age Range: Palaeozoic and Mesozoic most common; may be any age.

Depositional Environment: Mesozonal to hypabyssal plutons; extrusive rocks generally absent; dykes and dyke swarms common.

Tectonic Setting(s): Foldbelts and accreted margins with late orogenic to postorogenic granitoids which may, in part, be anatectic; regional fractures common.

Associated Deposit Types: Sn greisen, Sn skarn, and replacement Sn deposits.

Deposit Description:

Mineralogy: Extremely varied; cassiterite ± wolframite, arsenopyrite, molybdenite, hematite, scheelite, beryl, galena, chalcopyrite, sphalerite, stannite, bismuthinite; although variations and overlaps are ubiquitous, many deposits show an inner zone of cassiterite ± wolframite fringed with Pb, Zn, Cu, and Ag sulphide minerals.

Texture/Structure: Variable; brecciated bands, filled fissures, replacement, open cavities.

Alteration: Sericitisation (greisen development) ± tourmalisation common adjacent to veins and granite contacts; silicification, chloritisation, hematisation. An idealised zonal relation might consist of quartz-tourmaline-topaz, quartz-tourmaline-sericite, quartz-sericite-chlorite, quartz-chlorite, chlorite.

Ore Controls: Economic concentrations of tin tend to occur within or above the apices of granitic cusps and ridges; localised controls include variations in vein structure, lithologic and structural changes, vein intersections, dykes, and cross-faults.

Weathering: Cassiterite in stream gravels, placer tin deposits.

Geochemical Signature: Sn, As, W, B are good pathfinder elements; elements characteristic of specialised granites (F, Rb, Be, Nb, Cs, U, Mo, REE).

Examples:

Cornwall, Great Britain	(Hosking, 1969)
Herberton, Australia	(Blake, 1972)
Torrington, NSW	
Stanthorpe, Qld	

Known Mineral Deposits

Known Sn bearing deposits in the area are very small, uneconomic concentrations of cassiterite in recent alluvium at Wiles, Messiers and Cathcart. Some primary mineralisation has been recorded at the Tanja occurrences in the east of the region and minor cassiterite reported from the Wyndham No 2 Mo-Bi workings at Whipstick.

Assessment Criteria

1. Distribution of Late Devonian highly fractionated granitic intrusions within the Bega Batholith and Dr George Granite with a 2 kilometre buffer.
2. Distribution of Tin prospects.

Assessment

Tract Sn1a/L/C

The tract is defined by the presence of highly fractionated granites within the Bega Batholith and the Dr George Granite which hosts the Tanja occurrences. The granites of the Bega Batholith have been characterised by Blevin and Chappell (1995) as relatively oxidised, which restricts the development of tin deposits. Very few of the Bega Batholith granites are fractionated and those that are contain magnetite and are oxidised. The lack of primary tin occurrences also suggests the area is not particularly prospective for tin deposits. Secondary alluvial occurrences are small and given the large volume of granite available as a source these are not particularly encouraging signs of primary mineralisation.

The tract is considered to have a low potential with a certainty level of B.

Economic Significance

According to grade and tonnage models for tin vein deposits, 90% of deposits contain at least 0.012 million tonnes of ore, 50% at least 0.24 million tonnes and 10% at least 4.5 million tonnes. In these types of deposits, 90% contain at least 0.7% Sn, 50% at least 1.3% Sn and 10% at least 2.3% Sn (Cox and Singer, 1986).

CuU: SEDIMENT HOSTED COPPER DEPOSITS and SANDSTONE URANIUM DEPOSITS (MODELS 30B and 30C OF COX AND SINGER, 1986)

Description of model 30B - Sediment Hosted Copper

Model Description

Description of the model modified after Dennis P. Cox

Approximate Synonym: Sandstone Cu, Zambian Copper, Zechstein Copper, sedimentary copper; includes Cu-shale (Lindsey, 1982); "Stratiform" copper.

Description: Deposit broadly conformable, stratabound; "stratiform" or mostly parallel to enclosing sediments; disseminated copper sulphides in reduced beds of a red-bed sequence.

General References: Sawkins (1984), Tourtelot and Vine (1976), Gustafson and Williams (1981).

Geological Environment:

Rock Types: Host Rocks include sandstones, siltstones, shales, carbonaceous pyritic shales, dolomites and/or limestones. Associated rocks include basal conglomerate, red shale and siltstone (red-bed sequence), gypsum/anhydrite, stromatolites and algal laminated dolomite, mafic intrusives and/or mafic basement. Red-bed sequence containing green or grey shale, siltstone, and sandstone. Thinly laminated carbonate and evaporite beds. Local channel conglomerates. Some deposits in thinly laminated silty dolomite.

Textures: Algal mat structures, mudcracks, crossbedding and scour-and-fill structures.

Age Range: Palaeoproterozoic to Neoproterozoic (especially in Australia). Also Phanerozoic (mainly Permian but as young as Miocene overseas).

Depositional Environment: Fault bounded graben/trough, or basin margin or epicontinental shallow-marine basin near palaeo-equator; shallow water lagoonal or lacustrine sediments, partly evaporitic on the flanks of basement highs; sabkha terrains. High evaporation rate. Basal sediments highly permeable.

Tectonic Setting(s): Extensional setting, ie. intra-cratonic rift; intracontinental rift or aulacogen; failed arm of triple junction of plate spreading. (Passive) continental margin. Major growth faults.

Associated Deposit Types: Basalt copper, Unconformity-type uranium; Sandstone uranium, Tsumeb copper and Kipushi type Cu-Pb-Zn.

Deposit Description:

Mineralogy: Fine to medium grained spatially zoned assemblages comprising chalcopyrite, bornite, digenite, djurleite, chalcocite, ± native silver, minor pyrite with associated carrollite, vaesite, minor sphalerite, tennantite, trace galena, and Ge, U & Ni minerals.

Texture/structure: Disseminated, intergranular; rarely sub-massive; occasionally in sedimentary breccia. Often rimming and partially replacing coarse dolomite and quartz, and cementing carbonate and quartz grains in sandstone. Generally replacing earlier formed pyrite which may be framboidal or colloform.

Alteration: Little visible alteration. May be evidence of liesegang-ring structures indicating redox solution front mixing in red hematitic fine clastics; some dolomitisation, silicification, chloritisation, & K-feldspar enrichment in some cases. Green, white, or grey (reduced) colour in some red beds where present. Regionally metamorphosed red beds may have purple colour.

Ore Controls: Adjacent to, and unconformably overlying, older basement highs; mineralisation at top of the first cycle of a fining-upward conglomerate to shale red-bed sequence. Evidence of pre-existing pyrite or trapped bi-sulphides in pore spaces at the first reduced horizon above the base of the rift sequence, and/or the presence of gypsum or other evaporites associated with stromatolitic hypersaline carbonate rocks (dolomite or ferroan dolomite) at top of first cycle. Presence of copper-rich mafic basement rocks, rift tholeiites or mafic intrusives within the rift sequence. Presence of potential ore fluid aquifers eg. Basal permeable sandstones and/or major faults; occurrence of reduced environment such as algal mats; abundant biogenic sulphur &/or pyritic sediments. Presence of evaporites or evaporite pseudomorphs is indicative of potential sulphur source to form metal sulphides. Evidence of cross-faults, embayments, closed basins/sub-basins during sedimentation plus evidence for growth faults in the vicinity of active basement highs where rapid changes in sedimentary units/facies occur is considered favourable. Such facies changes are considered to provide a contrast in permeability and oxidation states thus forming physical and chemical traps.

Weathering: Surface exposures may be completely leached. Low sulphur systems such as these do not tend to produce very substantial or massive gossans, with weathering of sulphides leaving perhaps only remnant limonite with cuprite or malachite/azurite or chrysocolla.

Geochemical Signature : Cu, Co, Ag, U, Zn, Ge. Gold and PGE's not common.

Geophysical signature: IP can be effective. Weak radioactivity occurs in some deposits.

Examples:

Mount Gunson, Australia	(Tonkin and Creelman, 1990)
Mammoth (Gunpowder), Australia	
Mount Oxide, Australia	
Kupferschiefer, Germany	(Wedepohl, 1971)
White Pine, USA	(Brown, 1971)
Western Montana (Belt), USA	(Harrison, 1972, 1982)
Kamoto, Zaire	(Bartholome and others, 1976)

Known deposits and prospects in the Eden region:

Several small occurrences of copper mineralisation occur in sandstones and conglomerates of the Merrimbula Group cropping out on the coast about 6 km north east and also south east of Eden. Although these are only small occurrences, they may indicate potential for sediment hosted copper deposits within these redbeds.

Thirty six occurrences of copper mineralisation have been recorded in Devonian redbeds of the Mansfield Basin, about 150 km west of the Eden region. Anomalous uranium values have been recorded at six localities in these rocks (Nott, 1988).

Assessment Criteria

1. Anoxic marine or lacustrine rocks in contact with continental redbeds.
2. Presence of redbeds and evaporites
3. Rift environment could be important
4. Presence of source rock for copper: immature redbeds with labile detritus derived from rift-related basalts or other copper bearing rocks or minerals.
5. For giant deposits such as in Zambia exceptional conditions that could generate large fluid flow systems is important. Such systems could be generated by compressional forces resulting from collision events. These produced large gravity-driven fluid flow. In other areas, intrusions can also generate thermally-driven fluid flow systems.

Description of model 30C - Sandstone uranium deposits

Description of the model after Christine E. Turner Peterson and Carroll A. Hodges

Approximate Synonyms: Tabular U ore, roll front U.

Description: Microcrystalline uranium oxides and silicates deposited during diagenesis in localised reduced environments within fine- to medium-grained sandstone beds; some uranium oxides also deposited during redistribution by ground water at interface between oxidised and reduced ground.

General References: Turner-Peterson and Fishman (1986), Granger and Warren (1969).

Geological Environment:

Rock Types: Host rocks are feldspathic or tuffaceous sandstone. Pyroclastic material is felsic in composition. Mudstone or shale commonly above and/or below sandstones hosting diagenetic ores.

Textures: Permeable--medium to coarse grained; highly permeable at time of mineralisation, subsequently restricted by cementation and alteration.

Age Range: Most deposits are Devonian and younger. Secondary roll-front deposits mainly Tertiary.

Depositional Environment: Continental-basin margins, fluvial channels, braided stream deposits, stable coastal plain. Contemporaneous felsic volcanism or eroding felsic plutons are sources of U. In tabular ore, source rocks for ore-related fluids are commonly in overlying or underlying mud-flat facies sediments.

Tectonic Setting(s): Stable platform or foreland-interior basin, shelf margin; adjacent major uplifts provide favourable topographic conditions.

Associated Deposit Types: Sediment-hosted V may be intimately associated with U. Sediment-hosted Cu may be in similar host rocks and may contain U.

Deposit Description:

Mineralogy: Uraninite, coffinite, pyrite in organic-rich horizons. Chlorite common.

Texture/Structure: Stratabound deposits. Tabular U--intimately admixed with pore-filling humin in tabular lenses suspended within reduced sandstone. Replacement of wood and other carbonaceous material. Roll front U--in crescent-shaped lens that cuts across bedding, at interface between oxidised and reduced ground.

Alteration: Tabular--Humic acid mineralising fluids leach iron from detrital magnetite-ilmenite leaving relict TiO_2 minerals in diagenetic ores. Roll front--Oxidised iron minerals in rock up-dip, reduced iron minerals in rock down-dip from redox interface.

Ore Controls: Permeability. Tabular--Humin or carbonaceous material the main concentrator of U. Roll front--S species, "sour" gas, FeS_2. Bedding sequences with low dips; felsic plutons or felsic tuffaceous sediments adjacent to or above host rock are favourable source for U. Regional redox interface marks locus of ore deposition.

Weathering: Oxidation of primary uraninite or coffinite to a variety of minerals, notably yellow carnotite as bloom in V-rich ores.

Geochemical and Geophysical Signature: U, V, Mo, Se, locally Cu, Ag. Anomalous radioactivity from daughter products of U. Low magnetic susceptibility in and near tabular ores.

Examples:

Colorado Plateau, United States	(Fischer, 1974)
Grants, United States	(Turner-Peterson and Fishman, 1986)
Texas Gulf Coast, United States	(Reynolds and Goldhaber, 1983)

Known deposits and prospects in Eden region

No uranium deposits recorded within the Eden region. Uraninite is disseminated through the primary molybdenum - bismuth ores at the Whipstick deposit.

Assessment Criteria

1. Distribution of sediments of the Merrimbula Group. These contain sequences of Devonian 'redbed' sandstones which indicate environmental conditions suitable for the accumulation of sandstone uranium deposits.

2. Distribution of Siluro-Devonian granitoids which are potential source rocks for uranium.

Assessment for Sediment hosted copper deposits and Sandstone uranium deposits

CuU1a/L-M/B

The Twofold Bay Formation , Worange Point Formation and Ben Boyd Formation (Merrimbula Group) consist of poorly sorted red sandstones, conglomerates and red mudstone interbeds. These were deposited under oxidising conditions. Interbeds of khaki and green sandstones and shales indicate reducing conditions. The redox interface between these and the red sandstones represents a possible site for accumulation of sediment hosted copper deposits and sandstone uranium deposits. There are no known evaporite beds within the Merimbula Group, hence the potential for sediment hosted copper deposits is low to moderate. Because of the lack of significant uranium mineralisation in these redbeds, the tract has low to moderate potential for sandstone uranium deposits. Certainty level is B.

CuU1b/L/B

This tract is based on the distribution of the Bellbird Creek Formation (Merrimbula Group) which comprises thinly bedded grey/brown sandstone, siltstone and mudstone. These sediments are considered to have a lower potential than the other members of the Merrimbula Group mentioned above because of the absence of red sandstones. The Bellbird Creek Group is considered to have a low potential for sandstone hosted copper deposits and sandstone uranium deposits. Certainty level is B.

Economic significance

Sandstone copper deposits are one of the world's major sources of copper . A substantial amount of Australian and world copper continues to come from this type of deposit. Large and significant copper mines at Gunpowder (Mammoth) in northwest Qld and the deposits in the Mount Gunson area, SA together with the old mines at Burra and Kapunda in SA are all examples of this type.

CONMAT: CONSTRUCTION MATERIALS AND DIMENSION STONE

Model Description

New South Wales Geological Survey.

Approximate Synonyms

The term extractive resources is used as a synonym for construction materials, particularly in the sense of resources not covered by mining legislation.

Various terms are used for construction aggregates depending on size and specific use. Such terms include hard rock aggregate, coarse aggregate, crushed and broken stone, rip rap, decorative aggregate, prepared road base, fine aggregate, construction sand, sand and gravel, river stone, shingle.

Descriptive terms for clays used in construction include clay/shale, structural clay, brick clay, low cost clay, stoneware clay, pipe clay, terra cotta clay.

Dimension stone is also referred to as building stone, ornamental stone or monumental stone depending on its end use.

General References

Carr (1994), Holmes, Lishmund & Oakes (1982).

Deposit Description

Hard rock aggregate: In the study area the main types of rock used for hard rock aggregate are basalt, granitoids, felsic volcanics, and hornfels, alluvial deposits (fluvial gravel). Softer rocks such as sandstone and shale can also be used for some applications.

Construction sand: In the study area the main source of construction sand is Quaternary marine barrier sand deposits or Quaternary floodplain deposits.

Clay/shale: The main source in the study area is weathered fine grained rock types such as shale or phyllite.

Dimension stone: Extensive outcrop of granitoid rocks in the Eden study area offer potential for quarrying of dimension stone.

Known Operating Deposits

*Hard Rock Aggregate***:**

Basalt from:
Nimmitabel Quarry (5 km north of Nimmitabel)
Thompsons Quarry (5 km north of Bombala)
Heffernan-Milliner Quarry (8km north west of Eden)

Rhyolite from:
Nullica Quarry (10km west of Eden)
Pambula Quarry (5km south west of Pambula)
Crofts deposit (8km north west of Eden)
O'Callaghan Quarry (8km north west of Eden)

Hornfels from:
Lefts Mountain Rd Quarry (40 km west of Eden)
Granitoids from:
Greens Road Quarry (6 km east of Cobargo)
Brogo Quarry (16 km south of Cobargo)
Ferndale Quarry (12 km northeast of Bombala)
Nicholsons Quarry (17 km south of Bombala)

Construction Sand:

Kingswood Pit on the Bega River (6 km south of Bega)
Boydtown Pit (2 km west of Boydtown)
Nullica River Pit (1 km northwest of Boydtown)

Assessment Criteria

Prospective rock types in the study area are spatially associated with main population centres and close to major transport routes.

Assessment

Tract Conmat/M/B

All of the study area contains rock types that have potential for construction materials deposits. The potential for economic deposits of higher value construction materials in the Eden region is dependent on distances to markets on the coastal fringe (Bega, Eden, Merimbula) and to the west (Cooma) and north (Canberra, Moruya) of the study area. Location close to main haulage routes is also important.

Areas of felsic volcanics and basalt, and, to a lesser extent, granitoids and hornfelsed rocks provide potential for crushed hard rock aggregate. Granitoids have some potential for dimension stone, depending on the availability of high quality material within a particular rock unit. Potential for suitable sources of construction sand is best within Quaternary barrier sand along the coast and in Quaternary fluvial deposits.

There is a distinct clustering of construction material sites around the major coastal townships (Bega, Pambula, Eden) and elsewhere along the main transport routes (eg. near Nimmitabel and around Bombala). Main population centres and main transport routes were used to delineate the tract. Major roads, either highways or main connecting roads, were selected and buffered to 5 km. Towns were buffered to differing widths using the following scheme which is loosely based on population.

TOWN	BUFFER WIDTH
Bega, Pambula, Eden	15 km
Bombala, Merimbula	10 km
Candelo, Delegate, Bermagui South, Tathra, Pambula Beach	5 km

Important source rocks such the Boyd Volcanics (mainly rhyolite), Tertiary Volcanics (basalt) and coastal sand deposits are included in the tract. The tract is considered to have moderate potential for higher value construction materials with a certainty level of B.

Economic Significance

Compared to metallic commodities, for example, construction materials are low unit value commodities which are generally exploited in bulk with limited processing. Transport costs contribute significantly to the delivered cost of low cost extractive resources and, therefore, it is important to obtain large quantities of such resources as close as possible to the market centre. Increased transport costs associated with the need to use more distant resources result in increased raw material prices which are inevitably passed on to the consumer. Their use in construction, road building and related uses is an integral part of modern urban living and therefore supplies need to be assured for orderly development.

Hard rock is quarried from a number of sites throughout the Eden region for use in ready mixed concrete, road base, sealing aggregate, and other uses. Available reserves of hard rock aggregate are estimated at about 9.2 million tonnes which is sufficient to supply the Eden region and adjacent areas for 23 years (based on demand forecast in MacRae 1994).

Construction sand is commonly used in ready mixed concrete, mortar, fill, horticulture, concrete products and asphalt mixes. Sand production in the study area was some 20,000 tonnes in 1995/96. Available reserves are estimated at some 135,000 tonnes and thus is considered to be sufficient to supply the study area for about 6 years at current extraction rates.

PYRO: PYROPHYLLITE

Model Description

New South Wales Geological Survey.

Synonyms

Agalmatolite (Brazil), roseki (Japan), wonderstone (South Africa).

General References

Ciullo & Thompson (1994), Harben & Bates (1990), Harben (1995), NSW Department of State Development (1991); Holmes, Lishmund & Oakes (1982).

Geological environment

Rock types: Hydrothermally or metasomatically altered felsic volcanics; metamorphosed volcanic ash; less commonly in schist derived from metamorphism of volcanic ash.

Age range: Palaeozoic to Cainozoic.

Tectonic setting: Commonly in rocks formed in continental and island arc volcanic zones.

Associated deposit types: Epithermal mineralising systems.

Deposit Description

Mineralogy. Pyrophyllite is a hydrous alumino silicate, $Al_20_3.4SiO_2.H_20$.

Texture/structure: Massive spherulitic aggregates of small crystals, radiating large needle-like crystals or fine-grained foliated lamellae with a platy cleavage.

Alteration: Hydrothermal alteration of host rock producing masses of pyrophyllite which may be zonal, pod-like or irregular in form.

Examples

Mitsuishi and Goto mines, Japan
Wan-Do and Nohwa-Do mines, Republic of Korea
Glendon and Robbins mines, USA
Botobolar, near Mudgee, NSW

Known deposits in the Eden region

Back Creek, near Pambula, NSW
Yowaka, near Pambula, NSW
Sugarloaf Mountain, west of Eden, NSW

Assessment criteria

1. Presence of Devonian rhyolitic volcanics.
2. Presence of areas of hydrothermal alteration.

Assessment

Tract Pyro/H/B

Devonian felsic volcanics of the Boyd Volcanic Complex occur along the coastal strip of the Eden study area and they define the extent of the tract. Alteration of these felsic volcanics to produce pyrophyllite has been identified in the largest outcrop area of the volcanics which is located west and north west of Eden. The pyrophyllite tract coincides with the high potential of the epithermal gold tract.

Economic significance

New South Wales is the only Australian state producing pyrophyllite. Annual production of about 1100 tonnes is from deposits at Back Creek and Botobolar (NSW Department of State Development 1991). The Back Creek Mine is the major producer of pyrophyllite in Australia producing about 1 000 tonnes annually.

World production of some 2.2 million tonnes is dominated by Japan and South Korea (Harben 1995). Pyrophyllite is used in refractories, whiteware, foundry mould dressings, pesticides, paint, plastics, rubber, cement, fibreglass and soap.

Other mineral commodities

Peat

Peat is any partially decomposed plant matter that has accumulated under water or in a water-saturated environment. It is formed in swamps, bogs and other wetlands in favourable conditions for profuse plant growth. Large deposits of peat occur in the cold climate regions of the world, particularly Russia, northern Europe and Canada (Harben 1995). Peat is used as a soil additive.

Peat is currently extracted at Wingecarribee Swamp, near Moss Vale in NSW. Extraction has previously occurred at Killarney, near Bombala, in the Eden region where large resources of peat are known to occur.

Peat occurrence in the Eden region is associated with Quaternary sedimentary deposits.

There are minor lignite deposits beneath and interbedded with the Tertiary basalts (eg Coal Pit Creek NW of Bombala, and Coal Hole on the headwaters of the Towamba River).

Limestone

Limestone deposits form as the result of biogenic accumulation of calcium carbonate ($CaCO_3$) typically as coral reefs in a relatively shallow marine environment. Limestone has a wide range of uses in cement making, lime manufacture, agriculture, as a metallurgical flux, or as a construction aggregate. State production in 1994/95 was 4.0 million tonnes.

Limestone occurrence in the Eden study area is restricted to rocks of Late Silurian age in the Bredbo Group.

Diatomite

Diatomite is a siliceous sedimentary rock primarily composed of remains of diatoms. Commercial diatomite deposits generally contain 86 % to 94 % silica. Major producers are the United States, Russia and France. World production is 1.4 million tonnes (Harben & Kuzvat 1996). Diatomite's main use is in filtration of suspended solids from fluids but is also used as a filler, an absorbent, in insulation and in agriculture.

In NSW diatomite is produced at Barraba which accounts for the bulk of Australian production which is some 11,000 tonnes per annum. In NSW there is a strong association between diatomite occurrences and Tertiary volcanic rocks. A deposit of diatomite occurs near Cooma to the north west of the study area.

Additional occurrences of diatomite could be identified in association with Tertiary volcanics in the study area.

Nepheline syenite

Nepheline syenite is an igneous rock characterised by the presence of the feldspathoid mineral nepheline. Other major constituents are sodic plagioclase and microcline. Although a relatively common rock type, commercial production only occurs in three countries, Canada, Norway, and Russia (Harben & Kuzvat 1996). It is used mainly in glassmaking and to a lesser extent in ceramics, as a filler in paints and pigments. In Russia aluminium is extracted from it and the by products are used in cement making.

Exploitable deposits need to be large, uniform in composition, generally medium to coarse grained, massive, amenable to beneficiation and have access to a major market (Harben & Kuzvat 1996).
Nepheline syenite intrusions occur within the study area.

Diamond

There are no known diamond occurrences within the Eden region. Minor occurrences of diamond in alluvial gravels have been reported west of the Eden region. Diamonds in north-eastern NSW are known to occur in association with alkaline basalt. A new model of diamond formation (Barron et al 1996) indicates that basanite, nephelinite, leucitite rock types are prospective for diamonds. These rock types occur in the Eden region but their distribution has not been mapped.

Bauxite

Bauxite is a mixture of hydrated aluminium oxide minerals, particularly gibbsite, boehmite, and diaspore (Holmes, Lishmund & Oakes 1982). NSW is poorly endowed with bauxite deposits compared to other States, the bauxite generally developed as the result of lateritic weathering of Tertiary basalt (Holmes, Lishmund & Oakes 1982).

Minor bauxite deposits occur in association with Tertiary basalt in the Eden region study area.

APPENDIX C: METADATA SHEETS

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA geological coverage
	Custodian	Department of Mineral Resources
CONTACT ADDRESS	**Contact organisation**	Department of Mineral Resources New South Wales Geological Survey Minerals Assessment Program
	Contact position	Greg MacRae, Geologist
	Mail address	PO Box 536
	Suburb	St Leonards
	State	New South Wales
	Postcode	2065
	Telephone	02-9901 8341
	Facsimile	02 9901 8753
	Email address	macraeg@nswgs.nsw.gov.au
DESCRIPTION	**Abstract**	The Eden CRA geology coverage is derived from the Bega-Mallacoota 1:250,000 geological map (Lewis & Glen 1995) which was created in ARC/INFO by the Cartographic Branch of the NSW Geological Survey. Additional geological information included in the digital coverage was derived from the explanatory notes for the Bega-Mallacoota geological sheet (Lewis, Glen et al. 1994). A geological coverage is fundamental to the assessment of the mineral potential of the Eden study area; and an important abiotic substrate layer in assessing environmental and heritage values.
	Keywords	geology, geological map, lithology, stratigraphy, faults, structure.
	Geographic extent	Eden Region CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden study area in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Polygon coverage
DATASET CURRENCY	**Beginning date**	1987
	Ending date	1993

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView
	Computer operating system	UNIX, DOS
	Dataset size	About 2 Mb
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None
DATA QUALITY	**Lineage**	A continuous topologically structured geological coverage was created in ARC/INFO for the Eden Comprehensive Regional Assessment study area using the Bega - Mallacoota 1:250 000 geological coverage. The original mapping for the Bega - Mallacoota 1:250 000 geological sheet was digitised using INFORMAP software from compilations at 1:100,000 scale by the Cartography Branch of the NSW Geological Survey into the MRLIS graphic database. Some detailed mapping was digitised at 1:25,000 scale. This digital linework was then converted into a topologically structured ARC/INFO coverage by the Cartography Branch of the NSW Geological Survey.
	Positional accuracy	Geological boundaries and/or faults shown in the coverage were mapped at 1:25,000 scale and compiled at 1:100,000 scale. Most boundaries can be considered to have a spatial accuracy of between 20 and 500 metres with the majority of boundaries being located with an accuracy in the 50 to 200 metres range. It is impossible to effectively map many geological contacts with more accuracy. This is because many geological boundaries are themselves gradational, and many are poorly exposed or not exposed. Most geological maps are created by interpolations between a limited number of actual ground observations. Interpolation may be assisted by reference to air photos, topographic maps, geophysical data and satellite. The geological reliability is the confidence which could be assigned to the mapped geology versus actual geology. Many parts of the map coverage include rugged and remote areas, where there has been little detailed geological mapping. As a result, most of the coverage could be considered to have a moderate to good geological reliability. It is estimated that for 90% or more of the area of the coverage, the actual unit present will correspond to that shown on the geological map.

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Attribute accuracy	The descriptive information for geological units in the Eden CRA study area was derived from the Bega-Mallacoota 1:250,000 geological sheet and the accompanying geological notes. The data were compiled in an MS Access 2.0 database and transferred to an INFO table linked by letter symbol to the geological coverage. Attributes are considered to have better than 90% accuracy.
	Logical consistency	The geological data was been subject to thorough checking during compilation of the published map. The digital compilation has been subject to checking although this has not been as rigorous as for the published map.
	Completeness	The completeness of the geological coverage prepared for the Eden CRA study is good as the datasets used to derive the coverage have been subjected to publication standard editorial appraisal.
NOTES	**Notes**	References LEWIS, P.C., GLEN, R.A., PRATT, G.W. & CLARKE, I. 1994. *Bega - Mallacoota 1:250 000 Geological Sheet SJ/55-4, S/J55-8: Explanatory Notes,* 148 pp, 8 pls. Geological Survey of New South Wales, Sydney. LEWIS P.C., & GLEN, R.A. 1995. *Bega - Mallacoota 1:250 000 Geological Sheet SJ/55-4, SJ/55-8. Second edition.* Geological Survey of New South Wales, Sydney.
METADATA DATE	**Metadata date**	30th June, 1997
METADATA COMPLETED BY	**Metadata sheet compiled by**	Greg MacRae
FURTHER INFORMATION	**Further information**	

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA Metallic Mineral Occurrences
	Custodian	Department of Mineral Resources
CONTACT ADDRESS	**Contact organisation**	Department of Mineral Resources New South Wales Geological Survey Minerals Assessment Program
	Contact position	Greg MacRae, Geologist
	Mail address	PO Box 536
	Suburb	St Leonards
	State	New South Wales
	Postcode	2065
	Telephone	(02) 9901 8341
	Facsimile	(02) 9901 8753
	Email address	macraeg@nswgs.nsw.gov.au
DESCRIPTION	**Abstract**	The Eden metallic mineral occurrences dataset has been compiled as part of the Eden Region Comprehensive Regional Assessment (CRA). A metallogenic mineral occurrence dataset is fundamental to the assessment of metallic mineral potential of the Eden study area. Datasheets have been compiled for each occurrence recording the nature, distribution and size of mineral occurrences. Information has come from reports prepared by the Department of Mineral Resources and exploration companies, from academic journals and other sources. The Eden CRA dataset comprises 192 point records plus 72 point records in the 15 km buffer zone.
	Keywords	mineral occurrence, metalliferous deposit, mineral resources, mining geology, resource assessment, mineral exploration, mining history.
	Geographic extent	Eden CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden CRA in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Point coverage
DATASET CURRENCY	**Beginning date**	December 1996
	Ending date	April 1997

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET STATUS	**Progress**	Updated
	Maintenance and update frequency	Periodic update
DATASET ENVIRONMENT	**Software**	MS Access 2.0, ArcView, ARC/INFO.
	Computer Operating System	DOS, UNIX
	Dataset size	MS Access format: 2.2 Mb; ASCII: 26Kb
ACCESS	**Available format types**	Hard copy data sheets (MS Access 2.0 Occurrence Summary Form), MS Access 2.0 database, ArcView, ARC/INFO.
	Access constraints	Some occurrences recorded in the dataset are from reports for existing exploration and mining titles and are therefore confidential.
DATA QUALITY	**Lineage**	This work is a recompilation of metallic occurrences in the Eden study area and makes substantial use of an earlier dataset (Herzberger & Barnes 1975). Information has been compiled from a range of Departmental publications and unpublished reports. Exploration reports held by the Department of Mineral Resources provide a major informational source, as do Annual Reports of the Department of Mines. In addition to Departmental material, information has been obtained from academic journals, unpublished university theses, and publications of other government agencies. Other information sources include newspapers and periodicals, and company annual reports and prospectuses. Some of the deposits recorded from the available literature have been visited by Departmental geologists and their observations have been incorporated into the mineral occurrence data record. In some instances, there are no historical records and only field observations have been reported. Each mineral occurrence record has references to the source of the data presented for that record.
	Positional accuracy	The positional accuracy of mineral occurrences in the dataset varies from better than 100m to greater than 1000m. Most deposits are located to an accuracy of about 100-250m. The data are located using a 13 figure AMG coordinate. Any obviously misplaced points identified from existing data were corrected during this compilation. Some points may be inaccurately located due to errors in grid coordinates, although this would only relate to less than 5% of records.

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Attribute accuracy	For a significant number of occurrences, data have been compiled only from historical sources with no systematic field verification by companies or Departmental geologists. As a result, the data for these deposits can be expected to be less complete and less accurate than those examined in the field. Some attributes are interpretive rather than descriptive and some variation in interpretation can be expected. For example, the ore genesis attribute is not always consistent for deposits of some types (generally those which are inherently less well understood or more complex).
	Logical consistency	There should be a high degree of logical consistency in the data as information on a particular deposit does not depend upon other information in most cases. There may be some mismatch between the mineral deposits data and geological mapping data, especially in the description of host rocks. This may be due to slight spatial mismatches between the datasets, or due to the level of detail used to describe a deposit at any specific locality.
	Completeness	Occurrences were selected on the basis of presence of identified minerals of economic interest, generally on the basis of records from past mining activity and mineral exploration, The general situation is that the larger or more important the occurrence, the better is the descriptive information. Soil and stream sediment geochemical and geophysical anomalies have not been included. Significant assay results from rock sampling and drilling are important in determining some occurrences, with lower "cut-off' levels being used for selection. The cut-off for gold (in the absence of other information) in rock samples and drilling is about 1.0 gram per tonne. A significant number of historical occurrences, perhaps 30%, have probably not been identified in the Eden Region CRA. It is likely that some (historical) occurrences will be documented as the result of further company exploration and/or departmental investigations in areas of old workings, and also in areas where there are at present no recorded workings at all.
NOTES	**Notes**	References HERZBERGER G.A. BARNES R.G. & BOWMAN H.N. 1978. *Bega 1:250,000 Metallogenic Map SJ/55-4: Mine Data Sheets and Metallogenic Study*, 345+40 pp. Geological Survey of New South Wales, Sydney.

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
METADATA DATE	**Metadata date**	1/04/97
METADATA COMPLETED BY	**Metadata sheet compiled by**	R.P. McEvilly
FURTHER INFORMATION	**Further information**	

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA Industrial Mineral Occurrences
	Custodian	Department of Mineral Resources
CONTACT ADDRESS	**Contact organisation**	Department of Mineral Resources New South Wales Geological Survey Minerals Assessment Program
	Contact position	Greg MacRae, Geologist
	Mail address	PO Box 536
	Suburb	St Leonards
	State	New South Wales
	Postcode	2065
	Telephone	02-9901 8341
	Facsimile	02 9901 8753
	Email address	macraeg@nswgs.nsw.gov.au
DESCRIPTION	**Abstract**	The Eden CRA dataset has been selected from the New South Wales Geological Survey's INDMIN database of industrial mineral occurrences, using 1:100,000 map sheet and local government area. An industrial mineral occurrence data set is fundamental to the assessment of industrial mineral potential in the Eden study area. All localities were converted to AMG coordinates in Zone 55 using ARC/INFO software. This dataset was intersected with the Eden CRA boundary using ArcView GIS software to produce the dataset for the Eden CRA study area. The dataset comprises 66 records plus 26 occurrences with the 15 km buffer zone. The INDMIN database comprises all known industrial mineral and construction material occurrences in NSW including operating sites, identified resources, and non-operational sites. Sites are located spatially by AMG grid references.
	Keywords	industrial minerals, extractive resources, construction materials, aggregates, non metalliferous deposits, quarry.
	Geographic extent	Eden Region CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden study area in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Point coverage

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET CURRENCY	**Beginning date**	1994
	Ending date	1997
DATASET STATUS	**Progress**	Current
	Maintenance & update frequency	Continuous
DATASET ENVIRONMENT	**Software**	INDMIN: MS Access 2.0 Eden CRA industrial mineral occurrences: MS Excel 5, ASCII.
	Computer operating system	DOS
	Dataset size	Eden CRA industrial mineral occurrences: 32 kb NSW Geological Survey's INDMIN: 7.1 Mb
ACCESS	**Available formats**	MS Access, ASCII, MS Excel, Dbase
	Access constraints	None
DATA QUALITY	**Lineage**	A data set of industrial mineral sites (including construction materials) has been produced for the Eden CRA study area covering parts of the Bega and Mallacoota 1:250,000 sheets in south eastern New South Wales. The data in the industrial minerals occurrence theme has been obtained from the New South Wales Geological Survey's industrial mineral occurrence database, INDMIN. Data in INDMIN has been derived from sources such as technical reports of the NSW Geological Survey and the Department of Mineral Resources, environmental impact statements, data held local and State government authorities, industrial mineral operators, and mineral exploration reports. The Eden CRA dataset comprises 66 industrial mineral occurrence sites. An additional 26 sites occur in the 15 km buffer zone. Field inspection has been undertaken for about 60% of sites, primarily operating construction material quarries.

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Positional accuracy	The positional accuracy of the Eden CRA dataset varies from 50 metres to within 500 metres. Generally positional accuracy is in the range 100 to 250 metres. Sites subject of field inspection or technical reports have better positional accuracy. All sites have some surface extent, and many have a surface extent of several hundred metres square but all are represented by a single point location with an AMG grid reference. Localities have generally been plotted onto standard topographic sheets to determine a 13 figure AMG coordinate. Some locations have been determined by GPS (global positioning system).
	Attribute accuracy	The level of attribute accuracy for the industrial mineral occurrence data set decreases from high for operating sites which have been inspected or are subject of technical reports to low for disused sites known only by location and surface extent.
	Logical consistency	Logical consistency for the data set is variable since numerous sources, reflecting a range of technical detail, have been used in compilation of the data set. Sites subject of field inspection have a high degree of logical consistency.
	Completeness	The completeness of coverage of sites within the Eden CRA study area is considered good. Completeness of data for each site is best for operating sites which have been inspected and/or have been subject of technical reports. The remainder of the data set mainly covering disused sites is incomplete to varying degrees.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	30th June, 1997
METADATA COMPLETED BY	**Metadata sheet compiled by**	Greg MacRae
FURTHER INFORMATION	**Further information**	

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA Mineral Potential Tracts (12 maps)
	Custodian	Mineral Resources and Energy Branch, Bureau of Resource Science
CONTACT ADDRESS	**Contact organisation**	Bureau of Resource Science PO Box E11 Kingston, ACT 2604
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	PO Box E11
	Suburb	Kingston
	State	ACT
	Postcode	2604
	Telephone	06-2725173
	Facsimile	06- 2724161
	Email address	sjaireth@mailpc.brs.gov.au
DESCRIPTION	**Abstract**	Mineral Potential Tracts are based on the Bega-Mallacoota 1:250,000 geological map (Lewis & Glen 1995) which was created in ARC/INFO by the Cartographic Branch of the NSW Geological Survey. Delineation of tracts and the assessment of mineral potential is based on a methodology adapted from that used by the United States Geological Survey. For description of methodology see the report. Database of Metallic Mineral Occurrences and information on the granite chemistry are used to delineate tracts. Description of deposit models, assessment criteria and brief description of tracts are included in the main report. Twelve maps represent potential of thirteen deposit types. These maps are fundamental in assessing mineral potential of the Eden CRA.
	Keywords	Mineral potential
	Geographic extent	Eden Region CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden study area in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Polygon coverage
DATASET CURRENCY	**Beginning date**	1997
	Ending date	1997

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView3
	Computer operating system	UNIX, DOS
	Dataset size	About 2 Mb
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None
DATA QUALITY	**Lineage**	The maps are delineated using the Bega - Mallacoota 1:250 000 geological coverage. For information about the geology coverage, see the metadatasheet for the geological coverage.
	Positional accuracy	See metadatasheet for the geological coverage.
	Attribute accuracy	See metadatasheet for the geological coverage.
	Logical consistency	See metadatasheet for the geological coverage.
	Completeness	See metadatasheet for the geological coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	30th July, 1997
METADATA COMPLETED BY	**Metadata sheet compiled by**	Subhash Jaireth
FURTHER INFORMATION	**Further information**	

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA Composite Mineral Potential
	Custodian	Mineral Resources and Energy Branch, Bureau of Resource Science
CONTACT ADDRESS	**Contact organisation**	Bureau of Resource Science PO Box E11 Kingston, ACT 2604
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	PO Box E11
	Suburb	Kingston
	State	ACT
	Postcode	2604
	Telephone	06-2725173
	Facsimile	06- 2724161
	Email address	sjaireth@mailpc.brs.gov.au
DESCRIPTION	**Abstract**	Composite Mineral Potential Map is a collation of mineral potential tracts of thirteen deposit types. The map has been created by using Spatial Analyst of ArcVIew 3. It represents the highest level of mineral potential assessed (in July 1997) for any particular area in the Eden CRA region.
	Keywords	Composite Mineral potential
	Geographic extent	Eden Region CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden study area in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Polygon coverage
DATASET CURRENCY	**Beginning date**	1997
	Ending date	1997
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView3 (Spatial analyst)
	Computer operating system	UNIX, DOS
	Dataset size	About 500 Kb
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None
DATA QUALITY	**Lineage**	The map is drawn based on individual tract maps for thirteen deposits types, which were delineated using the Bega - Mallacoota 1:250 000 geological coverage. For information about the geology coverage, see the metadatasheet for the geological coverage.
	Positional accuracy	See metadatasheet for the geological coverage.
	Attribute accuracy	See metadatasheet for the geological coverage.
	Logical consistency	See metadatasheet for the geological coverage.
	Completeness	See metadatasheet for the geological coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	30th July, 1997
METADATA COMPLETED BY	**Metadata sheet compiled by**	Subhash Jaireth
FURTHER INFORMATION	**Further information**	

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA Cumulative Mineral Potential
	Custodian	Mineral Resources and Energy Branch, Bureau of Resource Science
CONTACT ADDRESS	**Contact organisation**	Bureau of Resource Science PO Box E11 Kingston, ACT 2604
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	PO Box E11
	Suburb	Kingston
	State	ACT
	Postcode	2604
	Telephone	06-2725173
	Facsimile	06- 2724161
	Email address	sjaireth@mailpc.brs.gov.au
DESCRIPTION	**Abstract**	Cumulative Mineral Potential Map is a collation of mineral potential tracts of thirteen deposit types. The map has been created by using Spatial Analyst of ArcVIew 3. It takes account of the diversity of mineral resource potential. Standard scores according to a subjective ranking of levels of mineral potential for overlapping tracts are added to derive a cumulative score. Areas with high cumulative scores indicate potential for more than one deposit type.
	Keywords	Cumulative Mineral potential
	Geographic extent	Eden Region CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden study area in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Polygon coverage
DATASET CURRENCY	**Beginning date**	1997
	Ending date	1997
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView3 (Spatial analyst)
	Computer operating system	UNIX, DOS
	Dataset size	About 500 Kb
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None
DATA QUALITY	**Lineage**	The map is drawn based on individual tract maps for thirteen deposits types, which were delineated using the Bega - Mallacoota 1:250 000 geological coverage. For information about the geology coverage, see the metadatasheet for the geological coverage.
	Positional accuracy	See metadatasheet for the geological coverage.
	Attribute accuracy	See metadatasheet for the geological coverage.
	Logical consistency	See metadatasheet for the geological coverage.
	Completeness	See metadatasheet for the geological coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	30th July, 1997
METADATA COMPLETED BY	**Metadata sheet compiled by**	Subhash Jaireth
FURTHER INFORMATION	**Further information**	

RACAC Project Name: Eden Region CRA **Project No: NE 08/ES**

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Eden Region CRA Weighted Composite Mineral Potential
	Custodian	Mineral Resources and Energy Branch, Bureau of Resource Science
CONTACT ADDRESS	**Contact organisation**	Bureau of Resource Science PO Box E11 Kingston, ACT 2604
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	PO Box E11
	Suburb	Kingston
	State	ACT
	Postcode	2604
	Telephone	06-2725173
	Facsimile	06- 2724161
	Email address	sjaireth@mailpc.brs.gov.au
DESCRIPTION	**Abstract**	Weighted Composite Mineral Potential Map is a collation of mineral potential tracts of thirteen deposit types. The map has been created by using Spatial Analyst of ArcVIew 3. It represents the highest weighted level of mineral potential assessed (in July 1997) for any particular area in the Eden CRA region. Every deposit type is assigned a score on a scale of 1 to 10 by a panel and reflects the relative importance of deposit types. For the weightings of individual deposit types see the report.
	Keywords	Weighted Composite Mineral potential
	Geographic extent	Eden Region CRA study area (as defined by RACAC) plus a 15 km buffer zone bordering the inland boundary of the Eden study area in NSW.
	Bounding coordinates	The bounding coordinates, including the 15 km buffer are: 149.15°/36,25°, 150.15°/32.25°, 148.70°/36.98°, 150.03°/37.52°.
	Type of feature	Polygon coverage
DATASET CURRENCY	**Beginning date**	1997
	Ending date	1997
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView3 (Spatial analyst)
	Computer operating system	UNIX, DOS
	Dataset size	About 500 Kb
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None
DATA QUALITY	**Lineage**	The map is drawn based on individual tract maps for thirteen deposits types, which were delineated using the Bega - Mallacoota 1:250 000 geological coverage. For information about the geology coverage, see the metadatasheet for the geological coverage.
	Positional accuracy	See metadatasheet for the geological coverage.
	Attribute accuracy	See metadatasheet for the geological coverage.
	Logical consistency	See metadatasheet for the geological coverage.
	Completeness	See metadatasheet for the geological coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	30th July, 1997
METADATA COMPLETED BY	**Metadata sheet compiled by**	Subhash Jaireth
FURTHER INFORMATION	**Further information**	

APPENDIX D: MINERAL OCCURRENCES, OLD MINES, DEPOSITS, AND CURRENT OPERATIONS WITHIN THE REGION

DEPOSIT/ OCCURRENCE	EAST (AMG)	NORTH (AMG)	MINERAL DEPOSIT/OCCURRENCE NAMES	MAJOR (MINOR) COMMODITIES
1	711550	5974600	Rams Head	Zn (Cu,Pb,Ag)
2	711950	5973400	Kybean Limestone Deposit	limestone
3	715202	5972493	Wissenks Limonite Show	Fe (Cu)
4	710342	5970041		Au,Ag (Pb,Cu)
5	710342	5970041		Au,Ag
6	710525	5970033	Clinton Reef	Au (Ag,Cu,Pb)
7	710525	5970033		Au,Ag (Pb,Cu)
8	723661	5966834	Mowitts Swamp Mine	Au,Pb,Cu
9	702900	5961800	Nimmitabel Basalt Quarry	hard rock aggregate
10	708000	5956000	Nimmitabel	hard rock aggregate
11	729187	5950040	JK Mine	Cu,Pb,Zn (Ag,Sb)
12	730645	5947691	Fultons Lead-Silver Show	Pb,Ag,Zn (Cu,Au)
13	729600	5945100	Bemboka Sapphire Deposit	sapphire
14	732179	5942776	Polocks Ck Mines	Cu,Au (Pb)
15	714300	5946200	Tomahawk Pit	unprocessed construction materials
16	714190	5940500		Au (Cu)
17	714320	5940450		Au (Cu)
18	714500	5940500		Au (Cu)
19	714250	5939600	Bull Mountain	Au,Cu (Pb,Zn)
20	717800	5939700	Clarkes Claim	Mo
21	715646	5934772	Creewah Wolframite Mines	W (Bi,Mo,Au)
22	736910	5928941	Solomons Copper Show	Cu (Pb,Zn,Ag,Au)
23	736666	5927487	Candelo Molybdenum Show	Mo
24	733853	5928062	Tantawangalo Lead & Copper Mine	Pb,Cu (Zn,Ag,Au)
25	725200	5926800	Knoxs Claims	Mo
26	725200	5926700	Hammonds Claim	Mo
27	722200	5926100	Taylor & Adams Deposit	Mo
28	718934	5925849	Hammond & Standens Claim	W,Mo
29	717800	5925700	Summerells Deposit	Mo
30	720559	5925324	Wiles Tin Mine	Sn
31	723110	5925034		barite
32	722300	5924600	Bassetts Claims	Mo,Bi
33	722729	5924684	Knoxs ML2	Mo
34	723500	5924300	Fishers Claim	Mo
35	724500	5924400	Tarlingtons deposit	Mo
36	724800	5924100	Jessops Claim	Mo
37	723795	5923907	Knoxs ML4	Mo
DEPOSIT/	**EAST**	**NORTH**	**MINERAL DEPOSIT/OCCURRENCE NAMES**	**MAJOR (MINOR) COMMODITIES**

OCCURRENCE	(AMG)	(AMG)		
38	724300	5923600	Fultons ML8	(Mo)
39	727685	5925026	Tantawangalo Lookout Deposit	barite (Pb)
40	731469	5923586	Tantawangalo Gold Lease	Au
41	721221	5923649	Messiers Tin Dredging Lease	Sn (Au)
42	715538	5923429	Wiles Phosphate Mine	phosphates
43	704900	5923300	Bibbenluke Agate Occurrence	silica,gems
44	721328	5921814		Sn
45	721997	5920322	Cathcart Tin Workings	Sn (Au)
46	723295	5918528	Fultons ML1	Mo
47	728925	5917469	Mt Darragh Mine	Pb,Ag
48	732358	5916410	New Station Creek Gold Mine	Au (Cu,Pb,Ag,Zn)
49	735670	5914623	Myrtle Creek Copper Prospect	Cu,Pb
50	729373	5912874	New Station Creek Lead Mine	Pb,Ag,Au
51	726770	5916278	Copper Creek Mineralisation	Cu,Ag
52	723884	5912921	Mcdonalds Prospect	Mo
53	717318	5915667	Whitby Barite Show	barite,Pb
54	709800	5917900	Ferndale Quarry	hard rock aggregate
55	702300	5916800	Thompsons Hardrock Quarry	hard rock aggregate
56	699400	5913800	Bombala Sand Pit	sand - construction
57	700033	5911542	Hospital Hill Quarry	quartzite
58	693191	5901124		W
59	691500	5896600	Jacksons Bog Peat	peat
60	682200	5895200	Craigie Alluvials	Au
61	683200	5891200	Craigie Bog Prospect	Au
62	703100	5896200	Nicholsons Hardrock Quarry	hard rock aggregate
63	710000	5901500	Killarney Swamp Peat	peat
64	715000	5904600	Tingys Plain Gold Mine	Au,Ag
65	715443	5897170	Wog Wog Mountain	Mo,feldspar
66	720432	5893939		Au (Ag)
67	722800	5888100	Letts Hardrock Quarry	hard rock aggregate
68	723270	5886040	Old Letts Mountain Quarry	hard rock aggregate
69	725220	5882160		Au
70	725720	5881160		Au
71	725900	5881160	AMA Mine	Au
72	725511	5879814	Spion Kop Workings	Au
73	725450	5879750	Golden Rhine	Au
74	725503	5879631		Au
75	725499	5879540		Au
76	725499	5879540		Au
77	725682	5879532		Au
78	725682	5879532		Au
79	725221	5879460		Au
DEPOSIT/ OCCURRENCE	**EAST (AMG)**	**NORTH (AMG)**	**MINERAL DEPOSIT/OCCURRENCE NAMES**	**MAJOR (MINOR) COMMODITIES**

80	725495	5879448		Au
81	725480	5879400	Walz & McCloys Mine	Au
82	725491	5879357		Au
83	725530	5879310	Duchess of York	Au (Ag)
84	725680	5879310	Welcome Stranger Mine	Au
85	725780	5879310	Haughs Federal Mine	Au,Pb
86	725857	5879341		Au (Pb)
87	725930	5879460		Au
88	724065	5879579		Au
89	724350	5879550	Yambulla Gold Mine	Au (Ag)
90	723720	5879100		Au
91	723520	5878970		Au
92	723720	5878960		Au
93	723430	5878670		Au
94	723930	5878670		Au
95	719850	5878500	Timbillica Reefs	Au (Ag)
96	724695	5877835	Granite Boulder Mine	Au
97	728600	5877950	Wallagaraugh River Alluvials	Au
98	728500	5877800		Au,Ag
99	724884	5875813	Stanley Creek	Au
100	721811	5874570	Old Nungatta	Au
101	726234	5873102	Stevens	Au (Pb)
102	720119	5871347	Razorback Mine	Au
103	725432	5869292	Defiance Mine	Au
104	726425	5868975		Au
105	727857	5863881	Buckles Mines	Au (Ag)
106	760650	5878460	Green Cape Road Quarry	unprocessed construction materials
107	753500	5889400	Boydtown Sand Pit	sand - construction
108	754800	5890600	Nullica River Sand Pit	sand - construction
109	755800	5891800	Twofold Bay Amethyst Occurrence	silica,gems
110	742681	5889798		Au
111	732000	5890100	Pericoe Quarry	hard rock aggregate
112	741251	5892787		Au
113	742881	5892353		Au
114	743830	5894700	Old Hut Creek Road Quarry	unprocessed construction materials
115	743210	5894900	Ben Boyd Quarry	unprocessed construction materials
116	749100	5894300	Nullica Hardrock Quarry	hard rock aggregate
117	751980	5896100	O'Callaghans Hardrock Quarry	hard rock aggregate
118	752050	5897400	Heffernan-Milliners Quarry	hard rock aggregate
119	750400	5896950	Crofts Hardrock Quarry	hard rock aggregate
120	739117	5896447	Sawyers Shaft	Mo
121	738573	5896562	Stoney Creek Prospect	Mo
DEPOSIT/ OCCURRENCE	**EAST (AMG)**	**NORTH (AMG)**	**MINERAL DEPOSIT/OCCURRENCE NAMES**	**MAJOR (MINOR) COMMODITIES**
122	738570	5898667	Egan Peaks Prospect	Mo

123	743248	5898771	Sugarloaf Pyrophyllite Occurrence	pyrophyllite
124	744550	5898550	Davis Claim	Au
125	744500	5897950	Sugarloaf Mountain Pyrophyllite	pyrophyllite
126	744325	5897800	Prospectors Mine	Au (Ag)
127	744550	5897600		Au
128	744760	5897200		Au
129	747200	5899710	Blockbuster Anomaly	Au
130	730652	5899732		barite
131	730191	5899660		Au
132	728776	5903014	Copper Hill Mine	Cu (Ag,Pb)
133	728567	5904579	Reedy Creek Mine	Au,Cu
134	734577	5901672	Umbacks Shaft	Au
135	737456	5902650	Jingera Rock Prospect	Fe,Cu
136	736897	5904595		Au,Cu
137	735823	5905189	Red Hill Gold Mine	Au
138	740800	5907100	Whipstick Occurrence	garnet
139	740800	5907020	Young & Reids Workings	Mo,Bi
140	740800	5906780	Whipstick Mine	Mo,Bi (Ag,Au)
141	740700	5906550	Bismuth shaft No 1	(Mo,Bi)
142	740600	5906500	Wyndham No 1	(Mo,Bi)
143	741300	5906780	Mt Metallic Mine	Mo,Bi (Mn,Au,Ag)
144	741450	5906800	Turbets Shaft Workings	Mo,Bi
145	741550	5906800	Pheasants Nest Mine	Mo,Bi (Au,Ag)
146	741300	5906600	Bismuth Shafts No 2 & 3	(Mo,Bi)
147	741400	5906500	Wyndham No. 2	Mo,Bi (Sn,Au,Ag)
148	747200	5903500	Back Creek Pyrophyllite Quarry	pyrophyllite
149	752050	5902050	Yowaka Extended	pyrophyllite
150	758900	5899100	Eden Rubbish Tip	silica sand - industrial
151	761639	5898703	Lennards Island Prospect	Cu (Au,Ag)
152	752289	5902758	Yowaka Quarry	pyrophyllite
153	753750	5903000	Brassknocker Mine	Au
154	753110	5903950	Southern Cross Mine	Au
155	753050	5904050	Mt Lewisson Mine	Au (Ag)
156	752950	5904300	Great Southern Mine	Au
157	752925	5904420	Black & Berrys Workings	Au
158	753130	5904412	Britisher Workings	Au
159	752925	5904500	Falkner Mine	Au
160	753130	5904600	Hidden Treasure Mine	Au

DEPOSIT/ OCCURRENCE	EAST (AMG)	NORTH (AMG)	MINERAL DEPOSIT/OCCURRENCE NAMES	MAJOR (MINOR) COMMODITIES
161	753250	5904600	Blands Freehold Mines	Au
162	753850	5904600	Vulcan Mine	Au
163	753850	5904710	The Ethel Mine	Au
164	754250	5904867	Greigs Flat Clay Deposit	other,clay
165	753250	5904691	Bartleys Happy Moments Mine	Au
166	753300	5904690	Bulldog Workings	Au
167	753225	5904750	Diorite-Killaloe Mine	Au
168	753523	5905112	The Gem Mine	Au
169	752900	5904850	Victory Mine	Au
170	752850	5904850	Morning Star Mine	Au
171	752850	5904900	Mount Gahan Mine	Au
172	752616	5904941	Killarney Mine	Au
173	752250	5904900	Maxwells Block	Au
174	752450	5905350	Speculation Mine	Au
175	752950	5905400	Brittania Mine	Au
176	754230	5906500	Pambula Hardrock Quarry	hard rock aggregate
177	753400	5907100	Pambula	unprocessed construction materials
178	751835	5906577	Pambula North Prospect	Au
179	752100	5907100	South Pambula Quarry	hard rock aggregate
180	753400	5907800	Pambula River	sand - construction
181	754500	5907800	South Pambula Soil Pit	loam
182	758300	5910100	Merimbula Airport Sand Pit	sand - construction
183	749500	5911300	Pambula Pit	sand - construction
184	745226	5913307	Chalkhills Molybdenite Prospect	Mo
185	753100	5913900	Merimbula Find	Au (Ag)
186	750100	5917420	Wolumla South	Au
187	750050	5917625	Bellbird Hill	Au (Ag)
188	749900	5917650		Au
189	749850	5917800		Au
190	749795	5917925	Pacific Gold Mine	Au
191	749850	5918040	New Venture Mine	Au (Ag)
192	749700	5918100	Victory Mine	Au
193	749850	5918140		Au
194	749350	5918200	McDonald Proprietary Mine	Au,Ag
195	749950	5918250	Furnace Saddle	Au,Ag
196	749910	5918300	Ocean View	Au (Ag)
197	749700	5918310	Meakers Gold Mine	Au (Ag)
198	749795	5918324	Mount Momsen Mine	Au (Ag)
199	749700	5918325	Murphys Tunnel	Au
200	749600	5918325	Nancy Lee Mine	Au (Ag)
DEPOSIT/ OCCURRENCE	EAST (AMG)	NORTH (AMG)	MINERAL DEPOSIT/OCCURRENCE NAMES	MAJOR (MINOR) COMMODITIES

201	749400	5918325		Au
202	749795	5918500		Au
203	749200	5918603	The Eclipse Mine	Au
204	750600	5920900	Walshs Gravel Pit Coral Park	unprocessed construction materials
205	749150	5921800	Mount Misery	Au
206	746500	5923100	Wolumla Creek Pit	sand - construction
207	761284	5918585	Merimbula Clay Deposit	clay/shale - structural
208	758000	5923000	Merimbula	dimension stone - slate
209	757000	5928500	Wheatleys Quarry	hard rock aggregate
210	756400	5929100	Wheatley No 1 & 2 Pits	unprocessed construction materials
211	754600	5929600	Finucane & Edwards Claim	Mo
212	754500	5929950	Scotts Reef	Mo
213	755334	5929544	Black Range	Mo (Bi)
214	755500	5929544	Gleesons Claim	Mo
215	754600	5931200		(Mo)
216	751400	5931900	Bega South Sand Pit (Kingswood)	sand - construction
217	755100	5931300	Thorn Hill Pit	unprocessed construction materials
218	761700	5930800	Tathra Clay Pit	clay/shale - structural
219	763152	5930408	Tathra Clay Pit	clay/shale - structural
220	764700	5930800	Tathra Pit	unprocessed construction materials
221	762284	5933740	Vimy Ridge Gold Mine	Au (Ag)
222	762478	5934006		Au
223	763857	5934132		Au
224	754853	5935803	Bega Quarry	dimension stone - granite
225	765132	5936184		Au
226	765833	5937620		Au
227	762094	5937959		Au
228	762497	5938858		Au
229	761580	5938804		Au
230	762608	5939311	New Hope	Au
231	763076	5939566	Star Of The East	Au
232	764139	5940895	Sandy Creek Mine	Au
233	763617	5941557	Tanja Tin Deposit	Sn (Au)
234	755000	5942000	Culwulla Pit	unprocessed construction materials
235	763640	5944303	Royal George Reef	Au (Cu,Pb)
236	764474	5944543		Au
237	754100	5945500	Brogo Sand & Gravel Pit	river,gravel
238	747720	5946706	Robinsons Copper Show	Cu (Ag,Pb)
239	747720	5946706	Scotland Yard Copper Show	Cu (Pb)
240	763339	5948069	Douchs Mine	Au
241	752450	5954070	Brogo Hardrock Quarry	hard rock aggregate
242	755285	5954721	Moloneys Copper Show	Pb,Zn,Cu
DEPOSIT/ OCCURRENCE	**EAST (AMG)**	**NORTH (AMG)**	**MINERAL DEPOSIT/OCCURRENCE NAMES**	**MAJOR (MINOR) COMMODITIES**
243	743919	5958763	Puen Buen Alluvial Workings	Au

244	760036	5963312	Coolagolite Creek Mines	Au
245	762534	5963941	Coolagolite Mine	Au (Mn,Cu)
246	767804	5965187	Charmichael Mine	Au
247	767200	5966800	Wendts Quarry	unprocessed construction materials
248	764700	5967100	Greens Road Granite Quarry	hard rock aggregate
249	759647	5967173	Cobargo Barite Deposit	barite
250	757553	5967443	Cobargo Chlorite Deposits	chlorite
251	767800	5967700	Costins Pit	unprocessed construction materials
252	768600	5969100	Narira Creek Sand Pit	sand - construction
253	769315	5970990	Dignams Creek Mine	Au,Ag

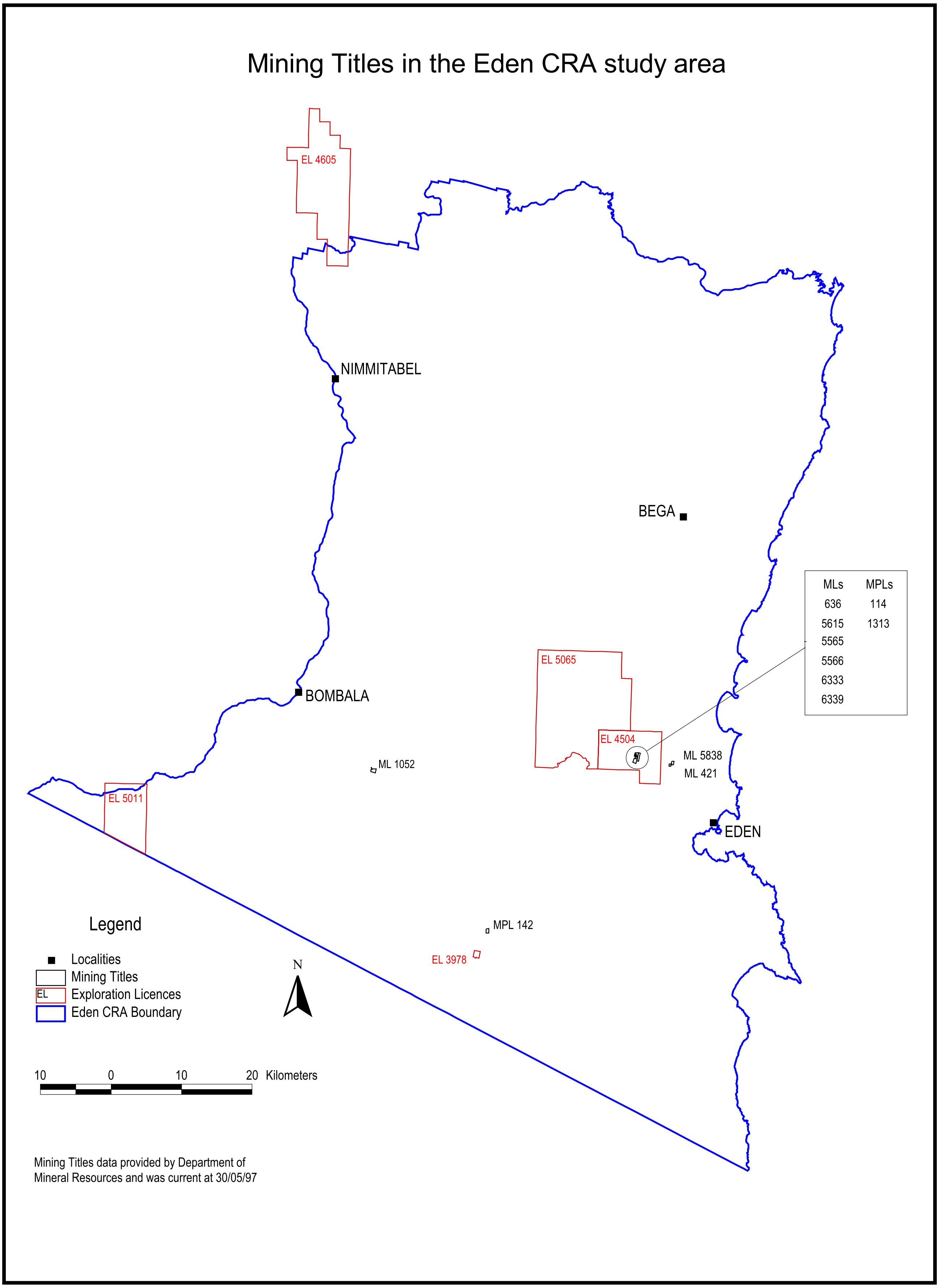
APPENDIX D (cont.): MINERAL OCCURRENCES, OLD MINES, DEPOSITS, AND CURRENT OPERATIONS OUTSIDE THE REGION

DEPOSIT/ OCCURRENCE	EAST (AMG)	NORTH (AMG)	MINERAL DEPOSIT/OCCURRENCE NAMES	MAJOR (MINOR) COMMODITIES
254	774750	5966807		Au
255	774800	5967450	Australian Star	Au
256	775286	5968715	Montreal Alluvial Workings	Au
257	760100	5969700	Cobargo Tip	unprocessed construction materials
258	772957	5973168	Karea Creek Alluvials	Au
259	778435	5974268	Lake View Mine	Au
260	776144	5976076	Little Dromedary Copper Prospect	Cu
261	775816	5977249	Central Tilba	dimension stone - granite
262	772146	5977183	Surprise Reef	Au (Ag)
263	770867	5977236	Western Dromedary Workings	Au (Ag,Bi,Cu)
264	770996	5978147	Little Wonder Mine	Au
265	770996	5978147	Mt Dromedary Gold Mine	Au (Ag,As)
266	778721	5978200	Northern Dromedary Workings	Au
267	778704	5978560	Victoria Extended Mine	Au (As)
268	780953	5979285	Loaders Beach	Au
269	779917	5980351	Corunna Lake	Au (Ag)
270	776736	5986333	Punkally Creek Alluvial Workings	Au
271	775654	5986743	Reids Mine	Au
272	773811	5986453	Rats Head Creek Alluvial Workings	Au
273	758773	5988081	Hopkins Mine	Au
274	752515	5991727	Sawtells Mine	Au
275	751644	5990573	Queensland Utopia Gold Mine	Au
276	751644	5990573		Au
277	752097	5990462	River View Mine	Au
278	752097	5990462		Au
279	752097	5990462		Au
280	751990	5990101		Au
281	747384	5987178	Brassknocker Gold Mine	Au
282	740000	5997000	Belowra Molybdenite Prospect	Mo (Bi)
283	729214	5983810	Bumberi Gold Show	Au (Ag)
284	715467	5996640	Big Badja Silver Mine	Ag (Pb,Au)
285	716762	5994757		Ag,Pb (Cu)
286	715800	5994600	Undoo Limestone Deposit	limestone
287	712442	5994294	Big Badja River Alluvial Workings	Au
288	709660	5992550	Kruschen Prospect	Au
289	716000	5992200	Umeralla Mountain Prospect	Pb (Zn,Cu)
290	715000	5989600	Umaralla Limestone Northern Deposit	limestone
DEPOSIT/	EAST	NORTH	MINERAL DEPOSIT/OCCURRENCE NAMES	MAJOR (MINOR) COMMODITIES

OCCURRENCE	(AMG)	(AMG)		
291	715050	5988350	Umaralla Limestone Central Deposit	limestone
292	715150	5987150	Umaralla Limestone Southern Deposit	limestone
293	711900	5987700		Cu (Au,Ag,Cu,Zn)
294	713900	5986100	New Gossan	Pb,Zn (Cu,Ag)
295	713900	5985800	Mount Pleasant Limestone Deposit	limestone
296	713200	5982400		Pb (Au,Ag,Cu,Zn)
297	713700	5981400	The Rivers Limestone Deposits	limestone
298	711950	5978650	Two Eagles	Pb,Zn,Au (Cu)
299	711700	5978100	Mousepatch Gossan	Au (Pb)
300	706500	5983100	Gurubang	Au,Pb,Zn
301	706600	5982500	Numeralla (Carlaminda) Limestone	limestone
302	704000	5980000	Square Range	Au (Zn,Pb,Cu)
303	705600	5976300	Dangelong Limestone Deposits	limestone
304	702000	5990100	Glenfurgus	Zn,Pb (Au)
305	701750	5989200	Skidmore East Prospect	Pb,Zn (Au,Cu)
306	700100	5990500	Skidmore North Prospect	Cu (Au)
307	700764	5988463	Skidmore Copper Mine	Cu,Au (Ag)
308	698298	5988564	Black Peak	Au
309	698040	5986745	Dartmoor Mine	Cu (Zn,Pb,Ag)
310	698302	5986460	Dartmoor East Mine	Zn,Pb,Cu (Ag)
311	696696	5987441		barite
312	695326	5987498	Black Rock	barite (Zn)
313	694493	5987258	MacKenzies 1 & 2 shafts	Au (Pb,Ag,Cu)
314	693960	5987646	Blake & Party	Au (Cu)
315	693960	5987646		Au
316	694519	5987897	No 1 North	Au,Cu (Pb,Zn,Ag)
317	694511	5987714	Prospectors Claim	Au,Cu (Pb,Zn,Ag)
318	694523	5987988	Star Of The North	Au (Pb,Cu)
319	691200	5980900	Cooma Bentonite Deposit	bentonite
320	698325	5975475	Rock Flat Traventine Deposit	limestone
321	697400	5975350	Rock Flat Basalt Quarry	hard rock aggregate
322	695132	5973965	Gladstone Quartzite Quarry	quartzite
323	696846	5971149	Rock Flat Clay Pit	other,clay
324	688900	5961150	Rock Lodge	Au (Ag,Cu)
325	692400	5951200	McLaughlin Sapphire Occurrence	sapphire
326	691400	5949400	Garlands Sapphire Occurrence	sapphire
327	690300	5944900	Nimmitabel Sugarloaf Sapphire Deposit	sapphire
328	690200	5943100	Bungee Sapphire Occurrence	sapphire
329	696700	5915700	Bombala Pit	unprocessed construction materials
330	680900	5920200		barite (Pb)
331	680794	5919668		barite (Pb)
332	678200	5917250	Adams Zone	Au,Pb,Zn (Cu)
DEPOSIT/ OCCURRENCE	**EAST (AMG)**	**NORTH (AMG)**	**MINERAL DEPOSIT/OCCURRENCE NAMES**	**MAJOR (MINOR) COMMODITIES**

333	680650	5917100	Paragon Gossan	Au (Cu,Pb,Zn)
334	679490	5916629	Belmore Mine	Pb,Cu (Au,barite)
335	679000	5916100	Quidong Limestone Deposit	limestone
336	680961	5914904	Clarkes Reef	Pb,Zn (Cu,Au)
337	680700	5914450	Reids Shaft	Au (Ag)
338	680747	5914181		Fe,Mn (Cu)
339	681000	5906200	Nelbothery Workings	Au
340	680400	5906300	Delegate River Alluvials	Au
341	661033	5908696	Blue Star	Cu (Au)
342	660557	5908259		Au
343	659891	5907646		Au
344	660168	5905531	Blue Bell	Au
345	661070	5905219	Black Moriah	Au
346	655016	5904833	Currowong Creek Manganese Deposit	Mn
347	655776	5901140	Southern Cross Reef	Au
348	658854	5900373	Meads Reef	Au
349	658473	5900023	NSW Reef	Au
350	658652	5899924	Concordia Reef	Au

APPENDIX E


Mining Titles in the Eden CRA study area
EL 4605
NIMMITABEL
BEGA
MLs
MPLs
636
114
5615
1313
5565
5566
6333
6339
EL 5065
BOMBALA
EL 4504
ML 5838
ML 421
ML 1052
EL 5011
EDEN
Legend
Localities
Mining Titles
EL
Exploration Licences
Eden CRA Boundary
N
MPL 142
EL 3978
10
0
10
20
Kilometers
Mining Titles data provided by Department of
Mineral Resources and was current at 30/05/97

Holders of Mining Titles in the Eden CRA study area as at 30th May, 1997

Title	Commodities	Holder
ML 421	antimony, copper, gold, lead, pyrophyllite, silver, talc, zinc	Pyrophyllite Corporation
ML 5615	antimony, copper, gold, lead, pyrophyllite, silver, zinc	Pyrophyllite Corporation
ML 5565	antimony, copper, gold, lead, pyrophyllite, silver, talc, zinc	Pyrophyllite Corporation
ML 6333	antimony, copper, gold, lead, pyrophyllite, silver, zinc	Pyrophyllite Corporation
ML 5566	antimony, copper, gold, lead, pyrophyllite, silver, zinc	Pyrophyllite Corporation
MPL 1313	antimony, copper, gold, lead, silver, zinc	Pyrophyllite Corporation
MPL 114	antimony, copper, gold, lead, silver, zinc	Pyrophyllite Corporation
ML 1052	peat	Bombala Peat P/L
MPL 142	none; (treatment of tailings)	Jack Nilsson Trevillian
ML 5838	fireclay, gold, kaolin, pyrophyllite, talc	Tibor Szery
ML 636	antimony, copper, gold, lead, pyrophyllite, silver, zinc	BHP Refractories
ML 6339	antimony, copper, gold, lead, pyrophyllite, silver, zinc	BHP Refractories

ML = mining lease; MPL = mining purposes lease

Holders of Exploration Titles in the Eden CRA study area as at 30th May, 1997

Title	Commodities	Holder
EL 3978	Group 1 (metallic elements)	Ronald Alan Jones
EL 5011	Group 1 (metallic elements)	Zephyr Minerals NL
EL 5065	Group 1 (metallic elements)	Eddaglide P/L
EL 4504	Group 1 (metallic elements)	Eddaglide P/L
EL 4605 **	Group 1 (metallic elements)	Denehurst Ltd

EL = exploration licence

** EL partly within the Eden CRA study area

REFERENCES

The papers cited by Cox and Singer, 1986, are not included in the following list of references and can be located in Cox and Singer, 1986.

ABARE, AGSO and BRS, 1993, Shoalwater Bay Military Training Area - Resource Assessment. Australian Bureau of Agricultural and Resource Economics, Australian Geological Survey Organisation and Bureau of Resource Sciences. Commonwealth of Australia. 288 pp.

Barron, L.M., Lishmund, S.R., Oakes, G.M., Barron, B.J. & Sutherland, F.L. 1996, Subduction model for the origin of some diamonds in the Phanerozoic of eastern New South Wales. *Australian Journal of Earth Sciences 43,* 257-267.

Blain, C.B. 1992. Is exploration becoming more cost effective? Paper presented at the National Agricultural and Resources Outlook Conference, Canberra, 4-6 February.

Carr, D.D. (Ed), 1994, *Industrial Minerals and Rocks* (6th Edition) Society for Mining, Metallurgy, and Exploration Inc. Littleton.

Chappell, B.W., English, P.M., King, P.L., White, A.J.R. & Wyborn, D. 1991, Granites and Related Rocks of the Lachlan Fold Belt (1:250,000). Bureau of Mineral Resources, Australia.

Ciullo, P.A. & Thompson C.S. 1994, *Pyrophyllite* in Carr DD (Ed) *Industrial Minerals and Rocks* (6th Edition) Society for Mining, Metallurgy, and Exploration Inc. Littleton.

Clark, A.L. 1996, Structural changes in global mineral supply — Australia's changing role. Paper presented at the National Agricultural and Resources Outlook Conference, Canberra, 6-8 February.

Cox, D.P., & Singer, D.A., 1986, Mineral Deposit Models. United States Geological Survey Bulletin 1693, pp. 379.

Dewitt, E., Redden, J.A., Wilson, A.B. & Buscher, D. 1986, Mineral resource potential and geology of the Black Hills National Forest, South Dakota and Wyoming. United States Geological Survey Bulletin 1580.

Harben, P.W. & Bates, R.L. 1990, *Industrial Minerals. Geology and world deposits.* Industrial Minerals Division, Metal Bulletin PLC, London.

Harben, P.W. & Kuzvat, M. 1996, *Industrial Minerals Global Geology.* Industrial Minerals Information Ltd, Surrey.

Harben, P.W. 1995, *The Industrial Minerals HandyBook* (2nd Edition). Industrial Minerals Division, Metal Bulletin PLC, London.

Harris, D. & Rieber, M. 1993, Evaluation of the United States Geological Survey's Three-Step Assessment Methodology. Unpublished Report submitted to the United States Geological Survey, University of Arizona, Tucson.

Herzberger, G.A. & Barnes, R.G. 1975, Mine data Sheets to accompany Metallogenic map, Bega 1;250000 Sheet, SJ 55-4. Geological Survey of New South Wales.

Herzberger, G.A., Barnes, R.G. & Bowman, H.N. 1978, Bega 1:250 000 Metallogenic Map SJ 55-4 — Mine Data Sheets and Metallogenic Study, 345 + 40 pp. Geological Survey of New South Wales, Sydney.

Holmes, G.G., Lishmund, S.R. & Oakes, G.M. 1982, A review of industrial minerals and rocks in New South Wales. *New South Wales Geological Survey - Bulletin 30.*

Industry Commission 1991, Mining and Minerals Processing in Australia, Volume 2: Commentary, Statistics and Analysis, AGPS, Canberra.

Leaman, D.E. & Richardson, R.G. 1989, The granites of west and north-west Tasmania - a geophysical report. Geological Survey Bulletin 66, Tasmania Department of Mines.

Lewis, P.C., Glen, R.A., Pratt, G.W. & Clarke, I. 1994, Bega-Mallacoota 1:250 000 Geological Sheet SJ/55-4, SJ/55-8: Explanatory Notes, 148 pp, 8 pls. Geological Survey of New South Wales, Sydney.

MacRae, G.P. 1994, Construction material resources of the Batemans Bay - Eden Bombala - Berridale Area. *New South Wales Geological Survey - Report GS1994/093* (unpubl.).

Marsh, S.P., Kropschot, S.J. & Dickinson, R.G. 1984, Wilderness mineral potential. Professional Paper United States Geological Survey 1300.

McEvilly, R.P. 1997, Mineral occurrence data compilation for the Bega-Mallacoota 1:250,000 sheets. New South Wales Geological Survey, Report GS1997/395 (unpubl.)

McKay, W.J. & Davies, R.H. 1990, Woodlawn - a Synthesis of Exploration and Structural Geology. in Geological Aspects of the Discovery of Some Important Mineral Deposits in Australia (Eds. KR Glasson and JH Rattigan)Australasian Institute of Mining & Metallurgy. Monograph 7, pp211-218.

Nott, R.J. 1988, Sedimentary copper. *in* Geology of Victoria. (Ed. J.G. Douglas and J.A. Ferguson), pp 595-596.

NSW Department of State Development 1991, Industrial Minerals Development Strategies: Industry Task Force Report.

Pohl, W., Gunther, M.A., 1991, The origin of Kibaran (late Mid-Proterozoic) tin, tungsten and gold quartz vein deposits in Central Africa: a fluid inclusion study. Mineral. Deposita, 26, pp. 51-59.

Robert, F. 1995, Quartz-carbonate vein gold. *in* Geology of Canadian Mineral Deposit types (Eds O.R. Eckstrand, W.D. Sinclair and R.I. Thorpe) Geological Survey of Canada. pp 350-366.

Scheibner, E. & Basden, H. (eds), 1996, Geology of New South Wales - Synthesis. Volume 1, Structural Framework. Geological Survey of New South Wales, Memoir Geology 13(1) 295 pp.

Suppel, D.W. & Scheibner, E. 1990, Lachlan Fold Belt in New South Wales—regional geology and mineral deposits, in Geology of the Mineral Deposits of Australia and Papua New Guinea (Ed. FE Hughes), pp. 1321 - 1327 (The Australasian Institute of Mining & Metallurgy: Melbourne).

Taylor, R.B. & Steven, T.A. 1983, Definition of mineral resource potential: Economic Geology, v. 78, pp. 1268–1270.

Weber, C.R., Paterson, I.B.L. & Townsend, D.J. 1978, Molybdenum in NSW. *New South Wales Geological Survey, Mineral Resources* 43.

Willis, J.L. 1974, Mining History of Gold Deposits of the Far South Coast, NSW. *New South Wales Geological Survey, Bulletin* 24.

Willis, J.L. & Stevens, B.P.J. 1971, Uranium *in* The Mineral Industry in New South Wales, Geological Survey of New South Wales 1971.

ADDENDUM 1

AN ECONOMIC ASSESSMENT OF SELECTED FOREST USES IN THE EDEN REGION OF NEW SOUTH WALES: INTERIM REPORT

Mineral resources and mining (Chapter 5) only

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Mineral resources and mining

Figures

Tables

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Mineral resources and mining

Construction mineral production from quarries (hard rock, sand, silica and propylite) are at present the only significant active mining operations in the Eden RFA region. However, the region contains a number of known mineral deposits, mineral occurrences and exploration prospects. In addition, the region has a long history of mining, and has been assessed as geologically prospective for a variety of deposit types. Provided access for exploration is allowed, at some time in the future these identified and undiscovered deposits may be mined and yield economic benefits.

This potential economic value is affected by a number of factors, including: the mineral prospectivity of the region; the timing of discoveries; future metal prices and mining costs, and the rules and regulations which govern exploration and mining. Ideally, an economic assessment of a region’s known and potential mineral resources would involve an estimation of the value of the right to explore and mine in that region. Unfortunately, because of data limitations, this has not been possible. However, the major factors affecting potential economic value are outlined and some indicators of that value are examined.

1 Mineral resources assessment

As part of the CRA of the Eden RFA region, a regional scale study of identified and potential mineral resources was undertaken by the Bureau of Resource Sciences (BRS) and the NSW Department of Mineral Resources (DMR). The assessment of mineral potential utilised existing data, mainly from published DMR reports, unpublished exploration company reports and updated digital coverages of mineral occurrences, surface geology and soils and recent satellite magnetic and visual imagery (see Bureau of Resource Sciences and NSW Department of Mineral Resources 1997).

The BRS and DMR assessment found that the Eden RFA region contains a number of identified mineral deposits and mineral occurrences. Those mineral occurrences for which resource estimates are available are shown in table 1.

In terms of potential (undiscovered) mineral resources, the BRS and DMR found that the Eden RFA region is prospective for a number of deposit types as shown in table 2. The BRS and DMR assessment first identified tracts, or areas within the region that are prospective for a particular deposit type. For each tract, the likelihood of mineral deposits occurring within it is ranked as either high, moderate, low, zero or unknown. These assessments are then categorised according to the level of certainty with which they are made, with A denoting the lowest level of certainty and D the highest. This ranking system is shown in figure A.

Limitations of the assessment

It is important to note that while the mineral resource assessment provides an indication of which land is likely to be prospective for minerals, no assessment of the potential value of mineral resources in these areas is possible without an estimate of the number of deposits likely to occur in a particular region. Although the BRS and DMR maps of mineral prospectivity allow for some comparison of relative economic potential between areas, the assessment methodology does not enable the actual value of an area, in terms of mineral potential, to be estimated. These limitations, when combined with the dynamic information gathering nature of exploration, have significant implications for the efficacy of any proposed land access arrangements for exploration and mining in these areas, and are discussed later in this report.

2 Exploration activity and expenditure in the Eden RFA region

Current and historical exploration expenditures provide some indication of the potential value of the undiscovered mineral resources of the Eden RFA region. This is because a decision to invest in exploration is based largely on a company’s perception of the mineral potential of an area. That is, exploration expenditure will tend to be higher in areas of higher perceived mineral potential. However, because of the uncertainty, different risk attitudes of companies and difficulty of exploration, expenditures will only provide an approximation of true prospectivity. Sometimes deposits are found in previously unprospective areas through the application of new ideas or technology where little previous exploration has occurred. Perceptions of sovereign risk (the risk of policy changes affecting returns to investment after an investment is made) also affect exploration expenditure.

Expenditure on exploration has varied somewhat over the last 20 years. Over this period, the highest level of expenditure occurred in 1988 and is estimated at $713 000 (1995-96 dollars). More recently, exploration expenditure was an estimated $58 000 in 1995 (table 3). The levels of exploration expenditure have varied over the years in response to changing commodity prices, geological prospectivity, mining costs and ease of land access. In the 1970s high prices for base metals inspired some exploration for zinc, copper and lead in the study area and some minor interest remains in prospecting for these metals. However, mining in the Eden RFA region has historically been based around gold and current exploration activity continues to reflect this.

There were five active exploration licences covering parts of the Eden RFA region at end of May 1997. The licences were distributed among 4 companies and the minerals being explored for are gold, copper, lead and zinc. Gold has been the focus of recent metallic mineral exploration, with most exploration taking place in the vicinity of old workings. Also, a minor level of interest remains in base metals (Suppel, D., NSW Department of Mineral Resources, personal communication, August 1997).

Gold exploration has generally taken place in the vicinity of historical workings, such as the Wolumla, Pambula and Yambulla Gold Fields. A total of 760 kilograms of gold are recorded to have been extracted from the Yambulla field between 1899 and 1912. Known resources at the now inactive Golden Rhine Mine, which occurs in the Yambulla Gold Field, and associated leases amount to 197 000 tonnes at 3.11 grams per tonne to 60 metres. Around 680 kilograms of gold and 102 kilograms of silver have been recorded as extracted from the Wolumla Gold Field. Some 75 000 tonnes of indicated resources of low grade ore (0.75 grams per tonne) remain in the ground at the Mount Momsen workings, also inactive, in the Wolumla field. Total production of gold from the Pambula Gold Field amounts to around 1879 kg, with the bulk of production occurring between 1892 and 1915.

Gold mineralisation in the Wolumla and Pambula fields occurs in epithermal type gold deposits. The Peak Hill deposit in central NSW, similar in size to the Pambula Gold Field, is an example of an epithermal type gold deposit upon which mining operations have re-commenced as a result of exploration around old workings. Characteristics of the Peak Hill Mine are used in the hypothetical mine example discussed below.

3 Current mining activities

Industrial and construction mineral quarrying is the major mining activity in the region, with 13 quarries currently in operation (table 1). There are currently no significant operating metallic mineral mines in the study area.

The main industrial mineral resources produced in the Eden RFA region are hard rock, sand and pyrophyllite. Pyrophyllite can substitute for talc in filler-type applications (such as in rubber and plastics) and is also used in refractory applications (such as kiln linings) and in whiteware ceramics (including vitreous china).

4 Outlook for mining in the Eden RFA region

Developments in world metals markets will have a large bearing on development opportunities for the minerals industry in the Eden RFA region. The outlook for the gold and base metal markets is presented in this section. Detailed market outlook assessments for the medium term are given in Middleton and Allen (1997) and Haine and Roarty (1997) for gold and base metals, respectively.

Base metals

Asia accounted for 27 per cent of world base metals consumption in 1996, compared with 19 per cent in 1980. While Japan's share declined marginally in this period, the share of developing Asian countries more than doubled and is projected to rise further over the medium to long term, reflecting relatively fast economic growth in these countries.

However, the developed market economies, which accounted for around 55 per cent of world base metals consumption in 1996, are assumed to continue to expand. Demand for base metals in these countries is therefore expected to continue to grow, although at a slower rate than for the Asian countries. In contrast, the share of global base metals consumption in the countries of the former Soviet Union and eastern Europe fell from 22 per cent in 1980 to 13 per cent in 1996. However, consumption levels in these economies are projected to recover in line with increased economic growth rates.

Overall, world consumption of base metals increased by 1.5 per cent in 1996 and is forecast to grow by a further 3.1 per cent in 1997. Reflecting expected trends in world economic growth and industrial production, world base metals consumption is projected to increase at around 2.0–2.5 per cent a year over the medium term, easing gradually over the longer term.

World mine supply of the three base metals is forecast to rise in 1997. World refined copper production is forecast to increase particularly strongly, with more modest increases forecast for refined zinc and lead production. A number of large committed and planned development projects are expected to be the major contributors to the projected rise in base metals supply over the next few years. Substantial increases are projected up to the end of 1999 as low cost mines, primarily from Chile for copper, and Australia for zinc and lead, commence production.

Over the longer term, continuing technological developments can be expected to place downward pressure on costs. Together with projected demand growth, the long term downward trend in real prices experienced for each of the base metals is therefore expected to continue. Price projections to 2002 are shown in figure F.

Gold

Over the next five years, world gold consumption is projected to increase at an average rate of around 3.5 per cent a year, largely as a result of expected further growth in demand for jewellery in developing countries. Further liberalisation of gold trade policies in a number of Asian developing countries, such as India and China, may also contribute to increased world demand for gold over the medium to long term.

World gold production is expected to increase strongly over the next five years, with particularly strong growth from emerging producer regions such as Asia, Africa (excluding South Africa) and South America. The shift in the location of world gold production is expected to occur in response to increased environmental constraints in traditional gold provinces and increased political stability and policy reform in a number of developing countries where gold prospectivity is relatively high. The release of gold from official sector reserves is also expected to continue, and possibly increase, over the medium term.

Continued growth in world gold consumption is expected to be largely met by increased gold production from emerging producers and further sales of official sector reserves. The development of high quality gold deposits in the emerging gold producing regions together with the continued adoption of new technologies in traditional producing regions are expected to place downward pressure on costs. Over the medium to longer term, real gold prices are therefore expected to remain relatively flat and may possibly decline slightly (figure B).

5 Economic assessment of development options

The establishment of a comprehensive, adequate and representative (CAR) reserve system in the Eden RFA region as part of the RFA could result in changes to access arrangements to land currently available for exploration and mining. At this stage the areas of native forest and the conditions of access to forest areas that may be required for a CAR reserve system have not been determined. As such, an examination of the implications of the RFA for mining in the Eden RFA region has not been possible at this stage. However, a case study is examined in order to provide some insights to the potential economic costs of restricting access to native forest lands for exploration and mining. In addition, aspects of the nature of exploration and mining that have the potential to affect the efficiency of land access options are outlined.

Case study: Epithermal gold and the Peak Hill mine.

Although it is has not been possible to assess the expected value of undiscovered mineral resources, an indication of the order of magnitude of potential benefits from an economic deposit being discovered can be provided. The Peak Hill gold mine, located in central west NSW, provides a basis for examining the potential benefits that may flow from mineral exploration in Eden, as parts of the region are considered prospective for this type of deposit (epithermal gold). The information derived from this exercise is limited in that it is purely hypothetical, and the results are provided only to give an indication of what an economic epithermal gold in the region could be worth if a deposit of the same size and grade were discovered. This information cannot be used to infer anything about the expected value of undiscovered resources in the region.

Evaluation methodology

An estimate was made of the present value of before tax profits from a Peak Hill style deposit, were it discovered today and developed. This value would represent the economic benefits from such a project if the input prices used reflect the full marginal social cost of their use and no other indirect benefits are produced that are not captured in before tax net revenue. However, some regional benefits are likely to arise — for example, creating additional regional employment: 41 full-time and 2 casual employees (including contractors) currently work on the Peak Hill — and flow-on effects to other regional industries could be expected. Hence, this analysis does not necessarily capture the entire range of the benefits that such a project would generate, but certainly provides an indicative order of magnitude.

It is also important to note that the financial evaluation undertaken here is not a feasibility study of a potential mining operation, nor an attempt at a full social cost benefit analysis of allowing a mining project to proceed. Rather, this analysis produces some indication of the net economic benefits that such mine would produce, were it discovered today and subsequently developed. Because it is assumed in this analysis that the cash flows occur with certainty, a real risk free discount rate of 5 per cent is used. This represents the forecast long term real prime rate. However, in this exercise it is assumed that this rate is also equal to the social rate of time preference for consumption, as would occur with fully competitive markets, given that there no taxes or other distortions in the economy (see Department of Finance 1991, p. 55). Were a mining company to examine the economic feasibility of such a project then other (mutually exclusive) investment options would have to be factored into the analysis and hence the perceived riskiness of the expected cash flows from the project would need to be considered. This would most likely result in smaller valuations being generated from a company perspective.

The Peak Hill mine

Peak Hill is operated and majority owned by Alkane Exploration NL. It is an epithermal gold deposit and, of the operating mines in NSW, is the most similar in geological terms to deposit types assessed as most prospective in Eden. Around $4 million is estimated to have been spent over three years on exploration at the site (Chalmers, I., Alkane Exploration NL, personal communication, July 1997) prior to the mine re-opening in March 1996.

Alkane is extracting gold from the ore by heap leaching and carbon-in-pulp/carbon-in-leach technology. Alkane expects the average cost of gold produced over the life of the mine to be around $380 per ounce in 1997 dollars. (Chalmers, I., Alkane Exploration NL, personal communication, 25 July 1997). This cost estimate has been used in the analysis. Average costs early in the operation were somewhat higher, reflecting the cost of extracting the initial quantity of ore required to instigate the heap leaching process. The capital and pre-mining development costs amounted to $6 million in 1996. Alkane is currently constructing a pilot dump-leaching facility to extract gold from lower grades of ore, which could be a further source of revenue at a lower marginal cost. However, this has not been incorporated into this simulation and costs may be somewhat overstated as a result.

Until 1916, approximately 1925 kilograms of gold were extracted from the site from 475 kilotonnes of ore, indicating an average grade of 4 grams per tonne of gold. From 1916, mining at Peak Hill has been sporadic and only relatively minor quantities of ore extracted. Since the 1960s, a number of companies have prospected for gold on the site. (G.R. Meates and Associates 1994). For the sake of the hypothetical mine examined here, ore extracted prior to the current operation has not been included. As a result, this analysis substantially understates the present value of a discovery of an epithermal deposit of the same size and grade as the original Peak Hill deposit. However, such high grades of gold in close proximity to the surface are less likely to have remained undiscovered to the present day. In that respect, the current Peak Hill operation is perhaps a better analogue for examining the potential economic benefits of a future epithermal gold discovery in the region.

Key assumptions

The hypothetical mine is based on a number of assumptions; the main ones are shown in table 4. The resource size is taken to be the largest current estimate of gold resources (including proven, measured, indicated and inferred resources). It is quite possible that ultimately the deposit will turn out to be even greater in size. The mine life is determined by the rate of extraction, which is taken to be 600 000 tonnes per annum, that chosen by Alkane in developing the mine. Based on discussions with Alkane, the average grade of the ore is assumed to be 1.7 grams per tonne, of which 75 per cent is assumed to be recovered (Chalmers, I., Alkane Exploration NL, personal communication, July 1997).

The historical cost and production profile of Peak Hill is used for the initial stages in the model. Operating costs beyond the first year are estimated to be $368 per ounce of gold (in 1995-96 dollars) and are assumed to remain constant in real terms over the life of the mine. The revenue stream is calculated from ABARE forecasts of the real Australian dollar gold price to 2002, given in table 5, after which the real price of gold is assumed to be constant.

Results

It is estimated that a Peak Hill type deposit, if developed today, would have a net present value (before tax profits) of approximately $8 million, assuming a discount rate of 5 per cent per annum. The analysis is based on an estimation of average cost provided by the company and the total proven, indicated and inferred resources as at March 1997. For an indication of the sensitivity of the analysis to the deposit size, a scenario with a deposit size of 1.63 Mt (currently proven reserves) was examined. Under this scenario, the project is estimated to be marginally uneconomic on the basis of before tax net profits.

Descriptive statistics of the worldwide occurrence of epithermal gold deposits are presented in table 6. The size of the hypothesised deposit is around average, however, as the median is less than the mean, the distribution is skewed towards small deposits. The distribution of deposit grades is similarly skewed, however, in this case the hypothesised deposit grade is lower than both the mean and the median.

The nature of exploration

Exploration can be defined as the process of searching for and assessing mineral deposits. Although discovery and delineation are the primary reasons for exploration, lack of discovery from an exploration program does not imply that the effort yielded no benefit. Information gained from exploration will usually increase the understanding of a region’s geology. There are many cases in Australian exploration history where information gained from previous work (successful or unsuccessful) was later used to locate mineral deposits that were either overlooked by earlier explorers, or were not the target of exploration located in regions where prospectivity (based on previous geoscientific understanding) was considered low.

Because exploration is primarily an information gathering process it is necessarily dynamic, so that most regions can never be regarded as ‘completely explored’. Many recent Australian discoveries have occurred in known mineral provinces that have been the subject of exploration efforts for over 100 years. There are a number of reasons why exploration has continued in such areas. Technology and scientific understanding of geological processes continue to develop with time. These advances not only encourage exploration in areas where prospectivity was previously considered low, but also lower the costs and increase the efficiency of exploration. In addition, changing economic conditions (for example, changes in metal prices or the costs of extraction) affect the expected returns from exploration and can have a significant impact on the level, and type, of exploration.

Environmental impact of exploration and mining

It is important to note that the exploration process starts with assessments of very large regions and is then systematically narrowed down as the exploration target becomes better defined. The direct costs facing explorers increase as the target area becomes smaller and exploration methods become more intense. The environmental impact associated with exploration also increases as the area being explored becomes smaller and the exploration methods used become more invasive (for example, close drilling), unless special (costly) steps are taken to reduce such impacts.

In contrast to exploration, mining itself generally involves greater disturbance to the land surface in the immediate area of the mine, and may leave changed landforms when mining is finished. Mining is generally therefore seen as posing greater difficulties in terms of compatibility with other uses.

Many potential environmental effects of mining activities can be eliminated or mitigated, though at a cost to the mining company. Given the relatively limited areas of land disturbed by the operation of a mine, water pollution often represents the major potential threat to the environment from mining. However, this can be controlled by using techniques such as impoundment and evaporation of tailings, sedimentation, filtration and pH neutralisation. Modern rehabilitation of mine sites at the completion of operations restores many of the features of the landscape that existed before mining began, substantially replacing and assisting the re-establishment of ecosystems and reducing or eliminating the potential for pollution from the former site of the mine. It is important to remember that in the context of the long time frames being considered for environmental protection, mining is a transient activity; the land used is relinquished after a period of time, allowing it to be used for other purposes. There are examples of mined out locations being included in national parks, used for forestry and being part of water catchment areas.

Land access issues for exploration and mining

Access to land is an important issue for exploration and mining in Eden. At this stage the implications of the RFA for exploration and mining in Eden are not known. However, based on present access arrangements, there are two broad options available: first, completely disallowing exploration and mining within designated forest reserves; and second, allowing exploration and the possibility of mining subject to relevant approval and operating conditions.

From an economic perspective, a decision to ban exploration and mining from a region should only be taken if the assessed present and future costs of exploration to society (including all environmental, recreation and other costs) are greater than any assessed present and future benefits that may accrue to society from exploration and mining in the region. This condition is unlikely to be met where non-invasive exploration and mining techniques are used. However, where there are unique and highly valued environmental characteristics and the environmental costs of mining itself are likely to be high, the incentive to explore these areas will be low if mining companies know they will have to meet these costs. It is important to gather information about the range of attributes and values of areas which offer alternative uses, such as environmental attributes and conservation values of an area as well as the mineral potential of the area and the mining options for those resources.

There are dynamic aspects to information about environmental and mineral values, and the availability, usefulness and implications of this information can change over time. Continuing advances of the kind seen in environmental research, exploration geoscience and mining technologies may render information obsolete and previous land use decisions may need to be periodically reconsidered. There are also dynamic aspects to market information that will affect its relevance over time. Mineral prices and extraction costs, for example, may change substantially over time. Similarly, the value of particular environmental resources may change through time.

These information problems raise important questions about the suitability of decisions that close off the option to explore for minerals. Given the high degree of uncertainty that surrounds the value of undiscovered mineral resources (and other competing resource uses), policies which allow for additional information to be collected are likely to be preferred in most cases. The welfare of current and future generations of Australians is likely to be reduced by constraining environmentally responsible exploration activity in that it reduces the knowledge and options society has to choose from. Even when environmental costs associated with mining seem prohibitively high, future extraction technologies may provide environmentally sound resource use alternatives.

Economic policies for exploration and mining

Investment and production decisions of mining companies are influenced by any factors that have an impact on the future long run profitability of mining activities, including the costs of uncertainty associated with instability in resource access arrangements. The costs of access to land containing mineral and other natural resources will influence the internationally competitive development of Australia's mineral resources.

In principle, cost effective access to a natural resource is likely to be achieved where property rights to the resource are clearly defined and are enforceable, transferable and excludable (Rose 1997). If private property rights are to offer socially optimal access to a resource, the property right must cover all the benefits and costs from all the potential uses of the resource, including for example environmental damage. Any transfer of public lands to private lands would need to take into account the distributional consequences of the creation of these property rights to ensure that all parties affected by the change in access rights share in the net social benefits obtained from the transfer. The issues involved in assigning an effective property right are further elaborated in Rose (1997).

To ensure that investment is carried out most efficiently, governments need to manage costs and uncertainty associated with the rules and regulations applying to exploration and mining. There are three key requirements for efficient decision making to occur under regulation.

- First, transparent and predictable processes for government approval are required. These processes would cover both obtaining approval for exploration and the means by which companies move from exploration to mining.

- Second, clear expectations are required of the environmental standards to be met by mining companies in particular areas. These standards would cover the exploration, extraction and rehabilitation stages of mining operations and would vary according to the environmental sensitivity of areas.

- Third, procedures and liabilities must be clearly delineated to change resource access rights if new information on the opportunity costs of access becomes available.

With such environmental regulations in place, the mining industry would then invest in exploration and mining operations which are assessed to be profitable, taking into account the costs of environmental compliance among other factors. More detailed discussions regarding resource access issues relating to exploration, mining and the environment can be found in ABARE (1990), Industry Commission (1991) and Cox (1994, 1997).

References

ABARE 1990, *Forestry and Conservation: An Examination of Policy Alternatives*, ABARE Submission to the Resource Assessment Commission, AGPS, Canberra.

——1997a, *Economic Implications of Forest Resource Use options in Tasmania*, ABARE report to the Department of Primary Industries and Energy, Canberra, April.

——1997b, *An Economic Assessment of Selected Forest Uses in the Central Highlands of Victoria: Interim Report*, ABARE report to the Department of Primary Industries and Energy, Canberra, April.

Australian Bureau of Statistics 1996, *Actual and Expected Mineral Exploration*, cat. no. 8412.0, Canberra (and previous issues).

Bureau of Resource Sciences and NSW Department of Mineral Resources 1997, *Eden Comprehensive Resource Assessment: Mineral Resource Assessment*, Draft, Bureau of Resource Sciences, Canberra.

Cox, A. 1994, 'Land access for mineral development in Australia', in Eggert, R. (ed.), *Mining and the Environment: International Perspectives on Public Policy*, Resources for the Future, Washington DC, pp. 21-55.

——1997, Minerals resource access – issues in multiple resource use, ABARE paper presented at the National Agricultural and Resources Outlook Conference, Canberra, 4–6 February 1997, pp. 45-55.

Cox, D.P. and Singer, D.A. (eds) 1986, *Mineral Deposit Models*, Bulletin 1963, US Geological Survey, Denver, Colorado.

Department of Finance 1991, *Handbook of Cost Benefit Analysis*, AGPS, Canberra

G.R. Meates and Associates 1994, 'Peak Hill Gold Project', Minfo, 43, pp. 20-3.

Haine, I. and Roarty M. 1997, 'Outlook for base metals', in Outlook 97, Proceedings of the National Agricultural and Resources Outlook Conference, Canberra, 4–6 February, vol. 3, *Minerals and Energy*, ABARE, Canberra, pp 389–409.

Industry Commission 1991, *Mining and Minerals Processing in Australia*, vol. 3, *Issues in Detail*, Report no. 7, AGPS, Canberra.

Middleton, S. and Allen, C. 1997, 'Gold – a world of change', in *Outlook 97*, Proceedings of the National Agricultural and Resources Outlook Conference, Canberra, 4–6 February, vol. 3, *Minerals and Energy*, ABARE, Canberra, pp. 323–33.

Rose, R. 1997, 'Tradeable quotas for efficient natural resource management', in *Outlook 97*, Proceedings of the National Agricultural and Resources Outlook Conference, Canberra, 4–6 February, vol. 1, *Commodity Markets and Resource Management*, ABARE, Canberra, pp 107–15.

Table 1: **Identified mineral resources and operating mines and quarries in the Eden RFA region.**

Name	**Commodity**	**Status**	**Resource Size**
Nimmitabel Quarry	hard rock aggregate	operating	7.5 Mt
Nicholsons Quarry	hard rock aggregate	operating	1 Mt
Ferndale Quarry	hard rock aggregate	operating	150000 t
Greens Road Granite Quarry	hard rock aggregate	operating	250000 t
Nullica Quarry	hard rock aggregate	operating	150000 t
Brogo Quarry	hard rock aggregate	operating	100000 t
Thompsons Basalt Quarry	hard rock aggregate	operating	100000 t
Letts Mountain Road Quarry	hard rock aggregate	operating	40000 t
Back Creek Pyrophyllite Quarry	pyrophyllite	operating	30 Mt
Boydtown Sand Pit	sand - construction	operating	100000 t
Bega South Sand Pit (Kingswood)	sand - construction	operating	20000 t
Nullica River Sand Pit	sand - construction	operating	10000 t
South Pambula Soil Pit	soil, loam	operating	10000 t
Wendts Quarry	construction materials	operating	35000 t
Yambulla Gold Field Golden Rhine	gold	prospect	197000 t @ 3.11 g/t
Wolumla Gold Field Mount Momsen	gold	prospect	75000 t @ 0.75 g/t
Heffernan-Milliner Quarry	hard rock aggregate	prospect	10.4 Mt
Crofts Hardrock Deposit	hard rock aggregate	prospect	4.7 Mt
Wheatleys Quarry	hard rock aggregate	prospect	300000 t
Killarney Swamp Peat	peat	prospect	3 Mm^3
Jacksons Bog Peat	peat	prospect	112800 m^3
Eden Rubbish Tip	silica - industrial sand	prospect	10000 t

Source: BRS & DMR (1997)

Table 2: **Summary of BRS and NSW DMR mineral assessment of the Eden RFA region [a]**

Deposit type	Probability of occurrence	Certainty level [b]	Economic significance
Epithermal gold	High	C	6
	Moderate-high	B	
	Moderate	B	
	Low-moderate	B	
Epithermal gold–silver	High	B	7
	Moderate-high	B	
Gold in alkaline rocks	High	B-C	4
	Moderate-high	B	
Granite hosted gold	High	B	6
Alluvial gold	Moderate	C	3
	Low-moderate	B	
Porphyry copper-gold	Moderate	B	7
Volcanic hosted massive sulphide base metals			
	Moderate-high	C	8
	Moderate	B	
Tungsten–molybdenum veins	Moderate-high	B-C	4
	Moderate	B-C	
	Low	B	
Tungsten skarn	Moderate-high	C	3
	Moderate	B	
Tin veins	Low	C	3
Sediment hosted copper and sandstone uranium	Low-moderate	B	4
	Low	B	
Construction materials	Moderate	B	2
Pyrophyllite	High	B	2

a Assume potential also for peat, limestone, diatomite, nepheline syenite, diamonds, and bauxite but no tracts drawn because of insufficient data.

b The mineral potential of an area (the likelihood of it containing a particular type of mineral deposit) is ranked as high, moderate, low or unknown. These assessments are then categorised according to the level of certainty with which they are made, with 'A' denoting the lowest level of certainty and 'D' the highest.

Source: BRS & DMR (1997)

Table 3: **Exploration expenditure on non-production leases** (1995-96 dollars)

	Eden RFA region exploration lease expenditure	**NSW base metals and gold exploration expenditure [a]**	**Eden RFA region exploration expenditure as a percentage of NSW non-production lease base metal and gold exploration expenditure [b]**
	$	$'000	%
1987	374134	na	na
1988	713262	na	na
1989	406854	28800	1.5
1990	170607	32400	0.6
1991	70182	32100	0.2
1992	158893	38700	0.4
1993	147165	31800	0.4
1994	251510	43800	0.6
1995	57997	50100	0.1

a Includes some exploration other than base metals and gold exploration; however, base metals and gold are the principal exploration targets for all 5 currently active exploration leases.

b Non-production lease exploration expenditure in NSW was estimated by applying the ratio of expenditure on non-production leases to total exploration expenditure for Australia in the relevant year to total NSW exploration expenditure.

Source: Australian Bureau of Statistics 1996c; MacRae, G.P., Department of Mineral Resources (NSW), personal communication, 12 August 1997

Table 4: **Assumptions for financial analysis of a Peak Hill type deposit**

Total resource	Mt	3.6
Ore mined	Mt/yr	0.6
Average grade	g/t	1.7
Recovery rate	%	75.0
Capital expenditure	A$m	5.8
Average operating cost a	A$/oz	368.0

Table 5: **Gold price assumptions** (1995-96 dollars)

	1997	1998	1999	2000	2001	2002–05
A$/oz	440	450	465	466	464	460

Source: Middleton, S., ABARE, personal communication, June 1997

Table 6: **Descriptive statistics for worldwide epithermal gold deposits a**

	Unit	Minimum	Maximum	Mean	Median
Deposit Size	Mt	0.007	106.994	5.8	0.698
Average grade b	g/t	0	58	8.8	3.525

a Based on the Comstock and Creede deposit models.

b Some of the deposits in the Comstock and Creede models of mineralisation are mined for other minerals, such as silver.

Source: Cox and Singer (1986)

Figure A: Relationship between Levels of Resource Potential and Levels of Certainty

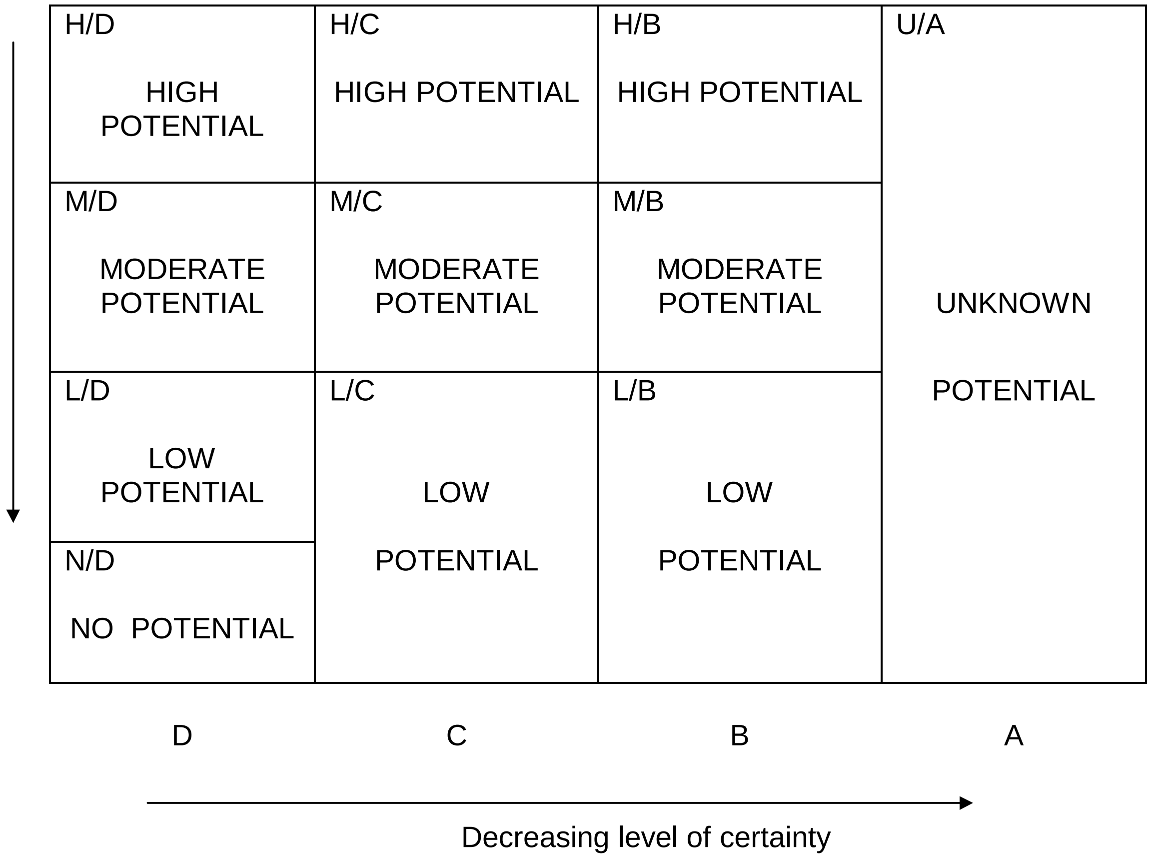
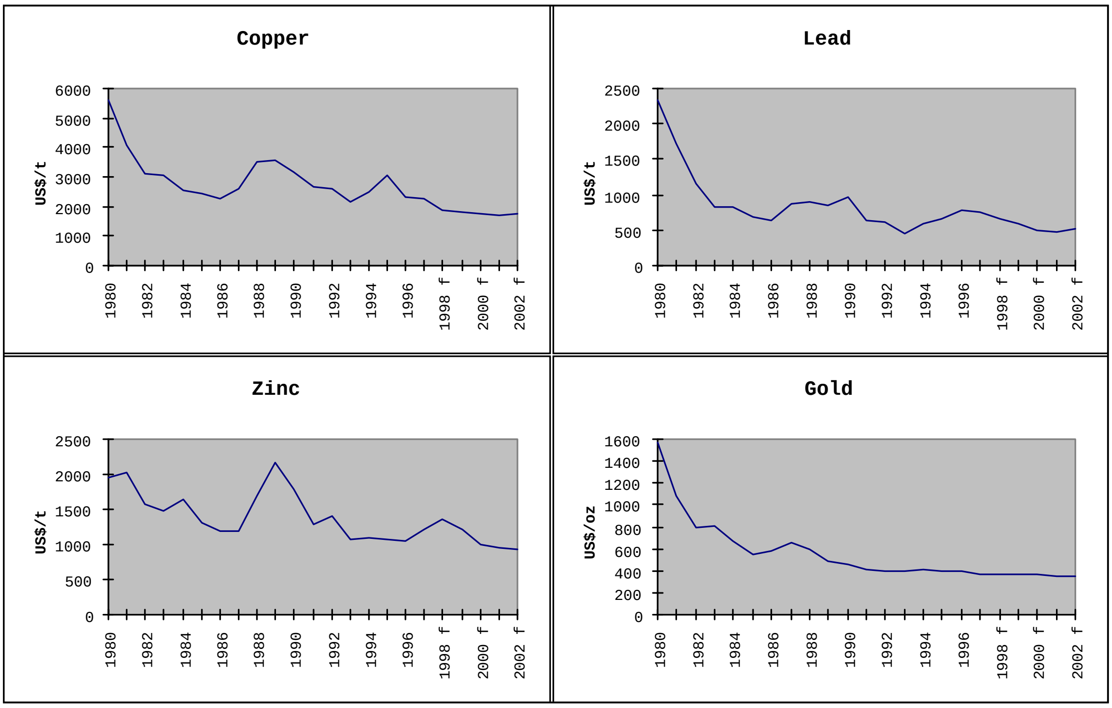


Figure B: **Real base metals and gold prices** (1995-96 dollars)



Source: Middleton and Allen (1997) and Haine and Roarty (1997)