

Mineral Assessment

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INTRODUCTION

The aim of the regional assessment of minerals potential is to draw together new and existing information to aid the consideration of economic effects of forest use options to be considered in the development of the RFA. In particular this assessment contributes to the evaluation of:

- the nature of mineral resources in forested land,
- current and potential uses of forested land,
- economic value of mineral products,
- structure and regional significance of the mining industry, and
- resource, infrastructure and policy requirements for the establishment of minerals industries.

The National Forest Policy Statement recognises the need to consider access for mineral exploration and extraction activities in deciding on land use for public native forests. Access for mining and exploration varies with land tenure. Due to the incomplete nature of information on minerals resources and the fact that exploration is a dynamic information-gathering process, continued access to land is a significant issue for the mining industry and for future mineral development.

This report outlines: identified mineral deposits, the potential for a number of deposit types, indicators of the region's potential mineral value, and factors affecting this value. Mineral deposits outside but close to the boundary of the region (within 15 km) are noted if they are considered to have significance for mineral potential within the region. In this report the study area is referred to as 'the North East region' or as 'the region'.

The region was a major gold producer last century, and many old deposits have recently attracted exploration interest. Resources have been identified at a number of prospects within the region or just adjacent to it. The Golden Mountain prospect, located in the Hell's Hole gold field, appears to be the most significant prospect in the region. The ACI feldspar mine at Beechworth was recently opened in the North East region.

The region is highly to moderately prospective for a number of mineral deposit types and is therefore likely to contain a number of undiscovered deposits.

Where access for exploration is possible, both undeveloped and as yet undiscovered deposits may be mined in the future, subject to normal approval processes, and yield economic benefits.

The mineral resources assessment is based on data supplied by Minerals and Petroleum Victoria (MPV) and the latest geological reports. MPV reports used for the assessment include those on the Tallangatta, Wangaratta, Warburton and small portions of the 1:250 000 scale map sheet areas, the Geology of Victoria (edited by Douglas and Ferguson 1988), and reports on specific geological areas within the region such as the Melbourne Zone (O'Shea *et al* 1992) and the Mount Wellington area (VandenBerg *et al* 1995). These reports describe the geology, mineralisation and exploration of the North East region. Information on the industrial minerals in the North East region is derived in part from a report by McHaffie and Buckley (1995), seminar publications and from other sources.

Only parts of the North East region has been subjected to a detailed high resolution airborne geophysical surveys or to recent detailed (1:100 000 scale) geological mapping. Additional surveys are being planned by MPV and will generate new data which will lead to renewed mineral exploration and improved understanding of mineral deposition in the region.

KNOWN AND POTENTIAL RESOURCES OF METALLIFEROUS AND EXTRACTIVE MINERALS

GEOLOGICAL SETTING

The regional geological setting is shown on Map 1, and the main geological events and mineralising events are summarised in Tables 1a, 1b and 1c. In the North East region the Palaeozoic basement rocks are grouped into three structural. From west to east these zones are:

- Melbourne Zone
- Tabberabbera Zone,
- Omeo Zone

The Tabberabbera Zone is bounded on the west by the Mount Wellington Fault Zone which marks the eastern limit of the thick Silurian-Devonian marine Melbourne "Trough" sequence and has discontinuous exposures of the underlying Cambrian greenstone basement rocks. The Kiewa/Kancoona Fault zones mark the eastern limit of the Tabberabbera Zone and separates it from the Omeo Metamorphic Complex to the east.

Volcanic rocks and associated granite plutons of Silurian and Devonian age, form a large magmatic province. Volcanic cover rocks of Upper Devonian age occur within two large calderas. These are overlain by sediments which are part of the Howitt Province, a broad northwest-trending graben that continues almost to the coast at Bairnsdale.

Late Carboniferous and Permian rocks are mainly confined to the Ovens Graben in the northern part of the North East region.

In the northwest, the Palaeozoic rocks are covered by Tertiary sediments of the Murray Basin.

Melbourne and Tabberabbera Zones

The Palaeozoic rocks of the Melbourne and Tabberabbera Zones show a complex history of marine and subaerial sedimentation and volcanism interrupted by several major deformations and periods of granite intrusion. The final event was mild folding of molasse-type redbeds in the Carboniferous, after which there was prolonged erosion. In the Late Carboniferous and Permian, extensive glaciation was followed by deposition of thick marine mudstones, which are only preserved in several basins in the north and west of the region. Further erosion after the Permian resulted in a landscape of low relief by late Mesozoic times. The breakup of Gondwana in the Cretaceous caused uplift of several thousand metres to form the Eastern Highlands, which extend into the southern part of the region.

Cambrian volcanism and sedimentation (greenstones) (530-490 Ma): During the Cambrian period, basalt and andesite volcanic flows erupted on the sea floor over much of the area which is now Central Victoria. These flows alternated with episodes of quiet accumulation of pelagic shale, chert and deposition of volcanogenic sediments. This sequence of basic volcanics and sediments (referred to as 'greenstones') accumulated in an oceanic island arc geological setting and represent part of the Cambrian oceanic crust.

Styles of mineralisation associated with these Cambrian greenstones (the Barkly River Greenstone Belt) include:

- epithermal gold mineralisation, eg Rhyolite Creek, Great Rand mine
- small chromite deposits formed during crystallisation of ultramafic rocks,
- copper mineralisation associated with Cambrian volcanics,

- manganese and iron deposits (exhalative deposits) formed during hydrothermal exhalations in sedimentary environments on the ancient sea floor.

Ordovician deep marine sedimentation (490-430 Ma): At about the Cambro-Ordovician time boundary, a large submarine fan of sediments encroached into the region from the west, extending across most of Victoria and southeastern New South Wales. In the region, these rocks are represented by the Hotham Group which consist of sandstones and mudstones deposited by turbidity currents into the deep marine environment along the eastern margin of the Australian Craton. Thin chert beds were deposited in areas where turbidity currents were less common.

In the Late Ordovician, the region continued to be in a deep marine environment, and the main deposition was quiet accumulation of silt, mud and marine organisms on a deep anoxic seafloor. In the Tabberabbera Zone, the sediments are mainly black siliceous shales containing abundant graptolites. In the Melbourne Zone, a similar black shale sequence (Mount Easton Shale) was deposited during the same period.

Early Silurian Benambran Deformation (430-425 Ma): The Benambran Deformation appears to have been the main episode of carbonisation in much of eastern Victoria, including the Tabberabbera and Omeo zones, but left the Melbourne Zone rocks unaffected. During this event, the Ordovician rocks were tightly folded along northwesterly trending folds. High heat flow and upwelling of granite magma altered the deeply buried sediments in the east during low pressure metamorphism (Omeo Metamorphic Complex). Granite magma slowly moved towards the surface and began to metamorphose local country rock. In some places, the heat was sufficient to begin melting the sedimentary rocks, forming migmatites.

Early Silurian to Early Devonian marine sedimentation (430-385 Ma): Melbourne 'Trough': Deep marine sedimentation continued from the Late Ordovician through the Silurian into the late Early Devonian without interruption in the Melbourne 'Trough'. The Silurian and lower part of the Lower Devonian sequence consists of slowly deposited mudstone and fine-grained quartzose sandstone, known as the Jordan River Group. This is overlain by the Walhalla Group which is a thick sequence of well-bedded sandstone turbidites and mudstone, and minor conglomerate.

Middle Devonian Tabberabberan Deformation (385-380 Ma): In the Middle Devonian, the second major compressional deformation to affect the North East region, folded and faulted the rocks of the Melbourne Zone. The Mount Wellington Fault Zone and the Kancoona Fault Zone were formed at this time. Slate belt type gold (with minor antimony) deposits were formed in structures related to the Tabberabberan deformation. The following types of slate belt gold deposits can be recognised in the region: sediment-hosted; granitoid related; and dyke affiliated.

Middle to Late Devonian caldera volcanism (375-365 Ma): Violet Town and Wabonga calderas: The evolution of the Violet Town caldera was simple, with eruption of rhyolite lavas in what appear to have been small domes followed by caldera collapse and explosive eruption of the thick rhyolitic Violet Town Ignimbrite. The Wabonga Caldera is much more complex and began with deposition, in the late Middle Devonian, of fluvial conglomerates followed by the first collapse phase, with explosive eruption of ignimbrites (Hollands Creek Ignimbrite). This first phase was followed by block faulting and erosion prior to eruption of several thick ignimbrite sequences. Further block faulting and erosion took place prior to the main phase of Late Devonian fluvial sedimentation of the Mansfield Group.

During this period there were a number of granitoid intrusions, many of which were co-magmatic with caldera volcanics. The age of these intrusions cluster around 365 Ma (O'Shea *et al* 1992).

A period of gold mineralisation within the North East region took place during late to post-tectonic movements associated with these intrusions (O'Shea *et al* 1992). Gold deposits occur both in the granitoids and the adjacent deformed sediments. Gold mineralisation also occurs in breccia pipes and stockworks within granitoids and volcanics.

Tin, tungsten, molybdenum and bismuth occur as vein mineralisation associated with granitoid intrusions (Ramsay & VandenBerg 1986).

Late Devonian "redbed" style sedimentation (370-355 Ma): Mansfield Group: In the Late Devonian, a large river system deposited flood-plain sediments across much of the region. The sequence is broadly upward fining from conglomerate and sandstone in the basal Mount Timbertop Conglomerate, to predominantly red mudstones of the Devils Plain Formation. Sedimentary 'red-bed type' copper mineralisation occurs within sandstone and shale (Ramsay & VandenBerg 1986).

Early Carboniferous Kanimblan Deformation (350 Ma?): The Mansfield Group are largely undeformed within the Mansfield structural basin. The Rose River Fault along the northeastern margin of the basin is marked by a shear zone along which the Mansfield Group sediments have been upturned and in places overturned. The Barjarg Fault along the western margin of the Mansfield Basin is largely obscured by Cainozoic sediments.

Late Carboniferous to Early Permian sedimentation (300-285? Ma): At this time Australia lay near the South Pole and had a glacial climate. Glaciers were active in the area which is now North East region. The sediments deposited in the Ovens Graben (Boorhama Conglomerate and Urana Formation) are mainly tillite, slump deposits and sandstone and siltstone deposited by glaciers and sub-glacial streams, probably in a glaciomarine environment. In some areas, sediments were deposited in a marine environment.

Late Cretaceous break-up of Gondwana (ca 95-65 Ma): The geological history of the region during the last 100 millions years was controlled by the break-up of the Gondwana supercontinent, especially the separation of Australia from Antarctica and New Zealand. This began in the Mid-Cretaceous about 95 million years ago, when the Tasman Sea began to open, and major subsidence occurred in the Gippsland and Otway Basins. This was combined with major uplift of a broad belt to the north of the coastal plain, forming the great dividing range, whereas the area farther north was much lower and it became the Murray Basin.

Late Cretaceous to Recent stream incision, basaltic volcanism, block faulting, fluvial sedimentation (80? Ma-Recent): The Late Cretaceous uplift began a cycle of incision and lateral erosion by streams that continues at the present day. There were localised interruptions to this erosion cycle by eruption of basalts, and by block faulting in the Ovens Graben. After the break-up of Gondwana, mountainous landscape existed by Late Cretaceous or Palaeocene times in the area fringing the Murray Basin. In the late Eocene and Oligocene, basalts of the Older Volcanics were erupted onto an elevated plateau in the Tolmie area from which they flowed down valleys to the north. Block faulting in Miocene times created the Ovens Graben into which fluvial sediments were deposited.

Omeo Zone

The Omeo Zone occurs to the east of the Kiewa and Kancoona Fault Zones (Map 1).

Pre-Ordovician to Early Silurian (ca 500 - 430 Ma): The oldest rocks of the Omeo Zone are a sequence of sediments and volcanics which may have been deposited prior to the Ordovician period. These were regionally metamorphosed and complexly folded to form a series of high grade gneisses and migmatites (Bethanga Granite Gneiss) (Oppy *et al* 1995). These rocks occur to the north in the area around the Hume Reservoir and similar gneissic rocks extend to the south, along the east side of the Kiewa valley.

The most widespread rocks in the Omeo Zone are monotonous turbiditic sediments of the Hotham Group, which were deposited in a deep marine basin west of a volcanic arc (Packham 1987) in the Ordovician. The Hotham Group forms the basement and host to most of the post-Ordovician igneous and volcanic complexes, and graben structures.

Early Silurian Benambran deformation and widespread granite intrusion (ca 440 - 420 Ma): In the Early Silurian, the Hotham Group was folded and metamorphosed to form the Omeo Metamorphic Complex (OMC) (Morand 1990). Thickening of the crust during the Benambran Deformation probably caused partial melting of the metasedimentary rocks at depth, giving rise to numerous S-type granites which intruded into the area during the Silurian. Dyke swarms are associated with these granitic intrusions.

Middle to Late Silurian - Wombat Creek Graben (425 -410 Ma): Following the Benambran deformation, a graben structure developed at Wombat Creek (Bolger *et al* 1983). This graben was filled with interbedded successions of felsic volcanics and marine sediments including limestone. In different parts of the region, graben structures have been active sites for sedimentation and volcanism spanning Early Silurian to Late Devonian times (Orth *et al* 1995).

Late Silurian Bindian deformation (ca 410 Ma): The Bindian Deformation occurred at the end of the Silurian. The most significant structures formed by this deformation include the Kiewa and the Indi faults (Morand and Gray 1991). Silurian volcanics and sediments of the Wombat Creek graben were tightly folded. Silurian granites were also affected by this deformation, and many of the mineralised dyke swarms of the Bethanga (O'Shea 1979), Mitta Mitta, Walwa, and Tintaldra-Cudgewa areas (Bolger 1984) appear to have intruded parallel to Bindian age faults and fractures.

Early Devonian rifting and volcanism (410 - 395 Ma): Following the Bindian deformation, a major graben structure began to develop in eastern Victoria, when crustal thinning gave rise to a deep and broad basin known as the Buchan Rift (Orth *et al* 1995). The northern part of this rift extends into the NE portion of the region. After the initial deposition of conglomerates, a minor phase of intermediate volcanism, followed by voluminous subaerial silicic volcanism formed the Snowy River Volcanics (Orth *et al* 1995). The whole rift fill sequence is considered to be Early Devonian in age.

Middle Devonian Tabberabberan deformation (385 - 380 Ma): The Tabberabberan deformation produced widespread folding and deformation across eastern Victoria and volcanics and sediments of the Buchan Rift were also folded. During the Devonian granites intruded the Omeo Zone.

Late Devonian sedimentation and volcanism (ca380-355 Ma?): Following the Tabberabberan deformation a sequence of red sandstone, conglomerate and volcanics in graben structures and basins in eastern Victoria. Small outcrops of red fluvial sediments have been mapped in the Hume area in the northwest of the region (O'Shea 1979), and these are presumably part of the Late Devonian red bed sedimentation preserved in small graben structures.

Early Carboniferous Kanimblan deformation to Present day (ca355 - 0 Ma): Further east west compression during the Early Carboniferous Kanimblan deformation caused another episode of

fault reactivation, and the development of late, northeast trending faults, such as the Tawonga Fault. This fault offsets the Kiewa and Kancoona faults.

Since the Palaeozoic, the main geological events have been the intrusion and eruption of the Mount Leinster Igneous Complex in the Triassic. This suite of alkaline igneous rocks (alkali granite and syenites) intruded to subvolcanic levels, with associated voluminous pyroclastic flows. Since that time, the entire region has been uplifted and eroded, with periods of tholeiitic basalt eruption in the Tertiary (Older Volcanics).

Murray Basin

Fluvial sedimentation in the Murray Basin began in the Eocene (ca 55 Ma) within the region and has continued to the present day. Sediments were derived from erosion of the surrounding highlands. There were several episodes of basalt eruption during the Early Tertiary.

HISTORY OF MINING AND KNOWN RESOURCES OF METALLIFEROUS AND EXTRACTIVE MINERALS

Map 2 and Table 13 show 1994 mineral occurrences, old mines and deposits in the North East region. Most of the 1772 gold occurrences occur within 43 gold and tin fields. Another 168 occurrences and 16 goldfields are within a 15 kilometre buffer around the region. Exploration and mining has historically focused on gold, with some periods of significant tin production. Production of tungsten, fluorite and related minerals has been recorded and there are localised concentrations of minerals such as stibnite, bismuthinite, and some occurrences of tantalum and uranium minerals (Oppy *et al* 1995).

The largest feldspar quarry in Victoria is in operation near Beechworth in the central north part of the region, where feldspar is extracted from a biotite granite and used for glassmaking. Current gold mining operations are restricted to several small producers of less than one kilogram of gold per year with one larger operation, southwest of Falls Creek, that produced 5.8 kilograms of gold in 1996/97 (Minerals and Petroleum Victoria 1998). These are included in 29 current gold mining tenements in the region which experience intermittent mining activity.

METALS

Gold

Victoria's total gold production until 1988 was approximately 2450 tonnes of gold (Ramsay and Willman 1988), of which 60 per cent was alluvial and 40 per cent from primary (hard rock) sources (Ramsay 1995). The total recorded gold production for the Tallangatta 1:250 000 scale map sheet area (mostly within the eastern part of the region) during the period 1860-1992/93 was 36.2 tonnes of gold or about 1.5 per cent of Victoria's total gold production (Oppy *et al* 1995). Recorded gold production for the Wangaratta scale 1:250 000 map sheet area (covering much of the central and western parts of the region) is in excess of 85 tonnes (Maher *et al* 1997).

Recorded production for the numerous historical alluvial and primary (hard rock) gold mines and occurrences is shown in Table 8. Recent gold production of 1.9 kilograms occurred at Stringers Ridge, southeast of Beechworth, in 1993-94 and 22.3 kilograms were produced from the Williams United mine at Wandiligong from 1993 to 1995. Re-treatment of the old Great Southern Consols mine alluvial tailings, near Rutherglen, recovered 14.8 kilograms of gold in 1994-95. Alluvial tailings can contain significant quantities of very fine-grained gold that could not be recovered prior to the introduction of cyanide treatment (Maher *et al* 1997).

Recent exploration over old workings (Australian Goldfields NL 1997) for open pit resources in the Glen Wills-Sunnyside goldfield has resulted in the delineation of small gold resources

(see Table 7). A significant component of these resources contained in old tailings and waste dumps. The Glen Wills-Sunnyside goldfield lies within the larger Mount Wills goldfield (Map 2, goldfield no.32).

Recorded production from the Glen Wills-Sunnyside goldfield, from 1895 to 1952 is estimated at 6.5 tonnes with a further 416 kilograms produced to 1963. The gold ore mined was very rich (16 to 211 grams/tonne) by today's standards and was in quartz reefs and veins that occur in shears and fissures hosted by granite, phyllites and schists along the southeastern contact between the Silurian Mount Wills Granite and the Omeo Metamorphic Complex. The reefs average about 4 per cent sulphides (mainly pyrite and arsenopyrite) that contain a significant amount of finely divided refractory gold requiring roasting or bacterial leaching to oxidise the sulphides prior to gold extraction. Free gold is also associated with the sulphides. Metallurgical testing has indicated that modern processing techniques could achieve about 85 per cent gold recovery from the sulphide mineralisation (Australian Gold Mines NL 1994).

Remodelling of the small Golden Mountain resource (see Table 7) in the Hells Hole (Tallanglook) goldfield (Map 2, goldfield no.35) and preliminary metallurgical tests done in 1994 show the mineralisation to be amenable to heap leach gold extraction.

At the old Homeward Bound mine, east of Beechworth, a small gold resource was delineated in the early 1990's and an old adit beneath the old workings was refurbished with a view to new mining. The gold bearing quartz reef was discovered in 1865 and worked until 1880. Recorded production was about 950 kilograms of gold at an average grade of 21 grams/tonne (Xenolith Gold Ltd 1991).

About 27.4 tonnes of gold has been mined in the past at Morning Star Mine, near Woods Point (Mt Conqueror Minerals NL 1994), just to the south-west of the region. The ore mined for this gold was very rich (25 to 30 grams per tonne) by today's standards, compared to recently delineated resources (Mt Conqueror Minerals NL 1997) at Morning Star of disseminated gold type. These resources contain more than 10 tonnes of gold at grades of 2 to 7 grams per tonne (Table 7). Drilling of surface resources and refurbishment of the old underground workings continued in 1997 to further assess resources at Morning Star.

Low grade (less than 1 gram/tonne) shear zone-quartz stockwork gold ore was mined from mid 1989 to mid 1993 at Nagambie, just outside the northwest part of the region. Heap leach technology was used to extract the gold and the ore heap continued to produce gold in solution until March 1997. Production totalled 4,176 kilograms of gold (Register of Australian Mining 1991/92 to 1997/98).

Alluvial gold mining commenced in the early 1850's with panning of surface material, followed by shaft mining of deep lead deposits, then sluicing and finally dredging of large quantities of surface material by the turn of the century. Major past alluvial gold producers are discussed below.

Pliocene age gold bearing deep leads of the Chiltern-Rutherglen goldfield, in the central north of the region, were mined along a 48 kilometre length of buried ancient river valley. Shafts of 80-110 metres depth were sunk at intervals along the deep leads to mine gold bearing gravel layers up to 1 metre thick and 150 to 170 metres wide. Some of the gold was quite coarse with nuggets weighing up to 342 grams.

Shaft mining of fine to coarse gravels of the Pliocene age Ovens River deep lead, in the Bright-Harrietville goldfield commenced in 1861. There was some production from Recent to Pleistocene alluvial terrace gravels in higher tributaries of the Ovens River. Another major alluvial gold producer was the Pliocene age Mitta Mitta deep lead, in the central east of the

region. Significant gold has also been produced from alluvial terraces and shallow alluvial deposits along the Mitta Mitta River and other watercourses.

Some of the Recent age shallower leads (4 to 15 metres depth) of the Beechworth-Eldorado goldfield were comparatively rich, such as at Reid's Flat and Woolshed and deep leads of the Eldorado field were mined by shafts up to 60 metres below surface. About 27 million cubic metres of material at a grade of 0.081 grams per cubic metre was also dredge mined.

The primary source of this alluvial gold is gold bearing quartz veins in Hotham Group metasediments, Ordovician age Omeo Metamorphic Complex rocks, and Silurian and Lower Devonian I-type granites (Oppy *et al* 1995; Maher *et al* 1997).

Historical primary (hard rock) gold production was from numerous small mines located on quartz veins, reefs or stockworks in faults or fissures. A wide range of mining methods were used to extract the primary ore, including surface workings, shallow open pits, shafts, adits, winzes and drives. Ore grades were high, at 22 to 30 grams per tonne gold or more.

Gold mineralisation in the eastern part of the region is characterised by a moderate to high sulphide mineral content (pyrite, arsenopyrite, pyrrhotite), associated base metals sulphides, elevated silver levels and there were metallurgical difficulties of gold extraction from the ore. Higher temperature mineral assemblages are associated with the major pyrite-arsenopyrite-gold mineralisation phase. Relatively small but richer mineralised quartz reefs/veins are often associated with Lower Devonian age dioritic dykes.

In the central part of the region the primary gold mineralisation is in quartz veins typically about 1 metre thick with a low sulphide (mainly pyrite, arsenopyrite) and base metal sulphide mineral content. There were fewer metallurgical problems associated with gold recovery as the gold ore was mainly non-refractory. Mineral assemblages indicate a higher mineralisation temperature (250-400 degrees Celsius) than in the Melbourne zone, in the western part of the region (Oppy *et al* 1995).

Quartz vein gold of the Merton and Hells Hole (Tallangalook) goldfields, in the western part of the region, is hosted by variably contact metamorphosed Silurian and Devonian siltstone and sandstone close to the Strathbogie Granodiorite. Historical production from the Golden Mountain mines at Tallangalook (about 268 kg at 3.0 g/t) was from three open cuts and an unspecified number of underground workings associated with disseminated gold around two generations of fracture systems in high metamorphic grade pelitic hornfels.

Tin

There are 172 primary (hard rock) and alluvial tin occurrences in the region (see Map 2 and Table 13). Past tin production is shown in Table 10 and a tin-tantalite resource in Table 9.

Alluvial Tin Deposits

The Beechworth-Eldorado (Pilot Range) alluvial deposits were the largest source of tin in Victoria with over 9,900 tonnes produced (Table 10), mostly as by-product of alluvial gold mining (Nott 1988). The large size of these deposits is in apparent contradiction with the very small primary deposits in the area, but it is likely that they are the erosion products of larger primary deposits formed around the upper contacts of granites (eg. Pilot Range), which have been subsequently eroded away or that the primary tin deposits are concealed under basalt and other younger rock cover.

Cassiterite, sourced from nearby granite, was mined as a minor by-product in some Chiltern-Rutherglen deep lead gold mines, with a total production of 108.2 t of cassiterite (tin) concentrate reported. Other significant alluvial tin producing fields were Koetong, Mt Cudgewa and Surveyor's Creek. Minor alluvial production came from the Mitta Mitta, Mount Wills and

Thologolong gold/tin fields as a by-product of alluvial gold mining but tin in these fields was mainly of primary (hard rock) origin (Oppy *et al* 1995).

Small amounts of alluvial tin at Cockers Claim, Northeastern Gold and Tin Mining Co. mine and Ryan's Creek, in the south-west of the region, are probably sourced from the S-type Strathbogie granodiorite (Maher *et al* 1997).

Primary tin deposits

Primary greisen tin deposits in the eastern part of the region occur at the southern end of the elongate NNW trending Mt. Tallebung (NSW) - Albury - Mt. Wills Tin Province (Cochrane & Bowen 1974). These deposits are intimately associated with Middle Silurian to Lower Devonian aplite-pegmatite dykes, as in the Walwa and Mitta Mitta dyke swarms. Mineralisation is due to hydrothermal alteration (predominantly greisenisation), rather than direct crystallisation from a magmatic source. Significant tin deposits of this type occur in the Walwa and Mitta Mitta tinfields, which lie within the Omeo Metamorphic Complex. Production from the Walwa field has been the largest of any of the primary lodes in Victoria. Very similar mineralisation styles to the Walwa tinfield are recorded at the Burrowye, Dean Creek, Mt Wills and Mt Alfred tinfields (Oppy *et al* 1995).

Several primary tin vein occurrences are located in the region and they are closely associated with Silurian and Devonian granites. Minor tin has been produced from quartz veins associated with brittle fracturing at or near the contact of S and I-type granites and the Omeo Metamorphic Complex. Tin mineralisation at the Mt. Cudgewa-Koetong tinfields is hosted by Middle-Upper Silurian S-type granitoids whereas the Surveyor's Creek tinfield is hosted by the Upper Silurian ?I-type Boebuck Adamellite (Oppy *et al* 1995).

Small and low grade tin lodes are reportedly common in the Beechworth granitoid pluton (Pilot Range). Tin mineralisation occurs in quartz veins, chalcopyrite-garnet-tourmaline 'fissures' within granite and pegmatite veins within and adjacent to granites. Cassiterite may also occur as disseminations in the granite. The most significant lodes of tin occur at the Lone Hand and Hidden Friend shafts, which are hosted by the Woolshed Adamellite (Nott 1988).

Some "reef" type mineralisation is present in the Mitta Mitta field. Tin bearing dykes in the Mt Wills field have a different character and it is possible cassiterite (a tin oxide mineral) was directly precipitated from a magma (Oppy *et al* 1995) of the fractionated Mt Wills granite.

Molybdenum

There are 18 molybdenum occurrences in the region (Map 2 and Table 13).

The Everton Molybdenite Mine was the largest producer of the Everton molybdenite field and operated in the periods 1917–26, 1937–40 and 1942–44. The mine worked two porphyritic granodiorite pipes to depths of 45 m. Molybdenite occurs within and adjacent to quartz veins, in joints and as disseminations. It is often associated with pyrite and less frequently pyrrhotite, chalcopyrite and arsenopyrite (Waldon 1977 cited in Maher *et al* 1997). Total molybdenite production from the No. 1 ore body was 12,591 tonnes at 1.54 per cent between 1917–1940 (including 700 tonnes from No. 2 ore body) and 4,377 tonnes at 0.41 per cent between 1940 and 1944 (Kenny 1948 cited in Maher *et al* 1997).

Molybdenum deposits are predominantly confined to the margins of granitic intrusions, and are associated with late magmatic hydrothermal activity (Weston 1992 cited in Oppy *et al* 1995). Molybdenum in association with tungsten has been recorded at the Womobi Wolfram mine, where it is hosted by quartz veins within the Lower Devonian I-type Thologolong granite. At Simmond's Gap, near Bright, molybdenum occurs in quartz veins hosted by granite (Oppy *et al* 1995).

Low-grade, quartz vein-related and disseminated molybdenite occurs within the Everton Granodiorite, related dykes and contact-metamorphosed Ordovician Hotham beds in the Everton area, south west of Beechworth. These have been intermittently mined since about 1917.

Tungsten

There are 35 tungsten occurrences in the region (Map 2 and Table 13).

Recorded tungsten production in the region includes 5.2 tonnes from Keady's reef, Koetong in 1915, 29.1 tonnes from the Womobi Wolfram mine during the period 1919-1952, and 2.7 tonnes from various reefs during the period 1917-1918. The Womobi Wolfram lode is a series of mineralised fissure quartz reefs and hosted by the Lower Devonian Thologolong Granite (Oppy *et al* 1995), in the north-east of the region.

About 10 kilometres outside the south-east boundary of the region, some 90.4 tonnes of tungsten concentrate was produced from the Mt. Murphy Wolfram mine during the period 1908-1920. Wolfram occurs as pea to walnut size pieces in quartz veins hosted by the Omeo Metamorphic Complex, near the contact of the Buckwong Granodiorite.

Bismuth

There are 12 bismuth occurrences in the region (Map 2 and Table 13).

In Victoria bismuth usually occurs in lodes closely associated with granitoids and is often associated with tin and tungsten deposits. Bismuth has been recorded as a minor accessory to tungsten mineralisation at the Womobi Wolfram mine and to primary gold mineralisation from the Granya and Freeburch goldfields. Alluvial bismuth is an accessory to alluvial tin and gold in the Mt. Wills and the nearby Wombat Creek goldfields (Oppy *et al* 1995).

Bismuth and bismuthinite have been reported from placer deposits at Pennyweight Flat and may have been derived from the Everton molybdenite field or Mt Stanley where small quantities of bismuth occur with molybdenite (Maher *et al* 1997).

Base metals

There are many minor base metals occurrences in the region including a number of sedimentary copper occurrences (Maher *et al* 1997) in the Mansfield Basin, in the south-west of the region. Three hydrothermal cavity fill origin copper occurrences, associated with porphyry and diorite dykes, are located near Corryong in the north-east of the region (Oppy *et al* 1995). Copper production from major gold mines of the Bethanga goldfield is shown in Table 11.

In the south-east of the region, the Wombat Creek Graben contains a sequence of Silurian rocks similar to those in the Limestone Creek Graben, just to the south-east of the region. The Limestone Creek Graben hosts the small to medium sized Wilga and Currawong base metal deposits and these are the two largest in Victoria (Vandenberg 1988).

Base metal mineralisation within the Wombat Creek Graben is predominantly copper and lead mineralisation within limestone bedding planes, indicating a genetic origin similar to Mississippi Valley Type deposits. Lead has been recorded as remobilised veins at Silver Flat (and the adjacent Lower Dart River goldfield) typical of epigenetic hydrothermal cavity filling type deposits. Exploration in the Wombat Creek Graben has been mainly at a reconnaissance or regional level and minor vein type copper, lead and minor zinc mineralisation has been recorded at several localities (eg. Quart Pot, Silver Flat, Wombat Hole).

Base metal mineralisation has been recorded as an accessory to fluorite at the Pine Mountain mine, to tungsten-tin mineralisation at the Womobi Wolfram mine and to tin mineralisation at the Mt. Alwa mine. The Pine Mountain mine produced 6.4 tonnes of lead concentrate (and 51.8

tonnes of fluorite) in 1957 and 5240 tonnes of fluorite and an unknown amount of lead concentrate from 1918-1972. There are a number of other base metal occurrences scattered through the eastern part of the region and they are often associated with more important gold mineralisation in some of the goldfields. Nearly all base metal occurrences are of a hydrothermal cavity filling origin (Oppy *et al* 1997).

Exploration drilling in Cambrian rocks near Wrightly, in the central-west part of the region, intersected banded pyrrhotite-rhodonite-chert mineralisation with volcanogenic characteristics. In the south-west of the region, recent exploration has recognised volcanogenic gold-copper and gold-silver-barium mineralisation in altered calc-alkaline andesite lavas at Hill 800 about 40 km southeast of Mansfield (Maher *et al* 1997; Fraser 1998; Map 2).

Minor amounts of copper, lead, zinc and silver commonly occur with gold mineralisation in the Woods Point-Walhalla gold sub-province. The Woods Point-Walhalla dyke swarm extends partly into the North East region.

Antimony

There are 19 antimony occurrences in the region, including eight gold occurrences with minor antimony (Map 2 and Table 13).

Small lodes of stibnite occur in quartz veins at Hollands Creek near Toombullup, in the central west of the region. Veins are up to 1.5 metres thick, dip at 60° to the south east and have been traced over 15 metres. The Tatong Antimony Mine operated for three periods between about 1895 and 1925, and produced about 37 tonnes of fairly clean stibnite. Antimony veins also occur in rhyolite and rhyodacite ignimbrite of the Upper Devonian Tolmie Igneous Complex.

Antimony occurs as stibnite hosted by quartz veins in the Mt. Wills and Mitta Mitta goldfields. The small Carry On mine, in the Mitta Mitta goldfield, produced 33.5 tonnes of antimony concentrate from 1914 to 1945.

Antimony ore has been extracted at the Big River mine in the northern part of the Woods Point-Walhalla gold sub-province, just south-east of the region. Several adits and open pits have been excavated on small reefs in sedimentary rocks adjacent to an early Devonian lamprophyre dyke. Ore samples taken in 1964 assayed 43 per cent to 53 per cent antimony and about 500 kg of concentrate was produced (Maher *et al* 1997).

Silver

Goldfields in the eastern part of the region have a high silver content and significant silver production as a by-product of gold mining. This includes 53.8 kg of silver from the Maude and Yellow Girl mine, in the Mt Wills goldfield, during the period 1962-1967 and 136.7 kg of silver from the New Bethanga Gold Mine, in the Bethanga goldfield, during the period 1907-1908.

Silver has been recorded in association with lead at a number of localities including the Danes Creek Ag-Pb lode, Victoria Ag-Pb lode, Silver Flat, Quartz Pot Flat, Pine Mountain mine and the Mammoth Complex. Silver associated with galena, is generally hosted by fissure quartz veins and breccias at or near the contact of major faults.

Platinum group metals

Platinum group metals are associated with widespread non-economic copper-nickel sulphide mineralisation associated with the dyke swarm of the Woods Point-Walhalla gold sub-province (O'Shea *et al* 1992). A small portion of this sub-province extends into the North East region but most of it lies to the south-west of the region. At least ten dykes in the sub-province are mineralised, and for each 1 per cent of copper there is 1 gram/tonne gold, 1 gram/tonne palladium and probably 1 gram/tonne platinum (Keays & Green 1974).

NON METALS

Feldspar

Feldspar for glassmaking is being mined about four kilometres south-west of Beechworth, in biotite granite of the Pilot Range Granite Complex. Approximately 60,000 tonnes/year of material will be mined to produce high quality feldspar (Mathrick 1998). This is the largest feldspar mine in Victoria.

At Sheep Station Creek, 3 km east of Beechworth, an orthoclase feldspar proven reserve of three million tonnes has been delineated in the leucocratic Beechworth Granite. Pilot plant tests have yielded a relatively clean, low iron, quartz-feldspar product suited to glass manufacture.

Industrial tests indicate that massive orthoclase feldspar in a pegmatite dyke at Tallangalook, in the central south-west of the North East region, is suitable for use in the manufacture of ceramics. Similar pegmatite dykes have been reported from Huon Hill, Mount Pilot and Mount Lady Franklin in the Beechworth-Albury-Wodonga area (Maher *et al* 1997). Small-scale production is reported from feldspar-rich dykes which intrude schist of the Omeo Metamorphic Complex at Huon Hill. These are up to 30 metres thick and can be traced for 550 metres (McHaffie & Buckley 1995).

A resource of 750 tonnes has been inferred for two parallel, near-vertical pegmatite dykes at Kookaburra Creek (Tan & Atkinson 1988). Dykes contain very large feldspar crystals, with accessory tourmaline and muscovite. The largest dyke is 150 metres long and averages 60 centimetres thick (McHaffie & Buckley 1995).

Other significant occurrences of feldspar are at Koetong Creek and Tallangatta, which are hosted by dykes (McHaffie & Buckley 1995).

Construction materials

There are 25 active or intermittently active construction materials quarries, not including numerous smaller pits used for minor rural road maintenance. Construction materials worth at least \$20.5 million were extracted in the region in 1994/95 (Maher *et al* 1997).

Much of the construction material activity is concentrated in the north of the North East region near the larger population centres of Albury-Wodonga and Wangaratta, and along the Hume Highway to Melbourne. At Glenrowan large quantities of Glenrowan Granite are extracted for aggregate, road base and fill and a small quantity was mined for dimension stone (Maher *et al* 1997).

The Murray Valley flood plain near Wodonga is a major source of river sand and gravel from deposits up to 30 metres thick (Bowen 1988). Quaternary age Coonambidgal Formation clay and sand is extracted from the Murray, Broken and Ovens Rivers close to Albury, Everton and Wangaratta and is used for aggregate, fine sand, concrete, fill and road base. Small amounts of clay were also extracted for brick making (Maher *et al* 1997). River gravels in old gold sluicing tailings dumps on the Mitta Mitta and Ovens Rivers have been used locally for road construction (Oppy *et al* 1995).

Shale, mudstone and sandstone of the Hotham Group near Glenrowan, Chiltern and Benalla are used for aggregate, road base and fill. Siluro-Devonian age sandstone is extracted for aggregate, fill and road base near Euroa and Karn (Maher *et al* 1997).

Contact metamorphosed rock (hornfels) of the Hotham Group is also used as aggregate (Maher *et al* 1997) and is extracted at Chiltern. Crushed hornfels has been sourced from the Walwa Road Quarry for road building and maintenance.

Near Violet Town, Devonian age rhyodacite is used for road base and aggregate (Maher *et al* 1997). Phyllitic shale has been quarried on the Mitta Mitta North road and at the junction of Mitta Mitta and Yabba Roads (Oppy *et al* 1995).

Dimension Stone

The North East region has several currently inactive quarries and occurrences of various types of dimension stone (Map 2 and Table 13):

Locality	Type
Beechworth	Granite
Mt Mittamatite and Pine Mountain	Granite
Strathbogie	Granite
Tallangatta Porphyry	Granite
Tamnick Gap	Granite
Yackandandah	Granite
Ghin Ghin (Davis)	Slate
Mansfield (Howes Creek)	Limestone
Mitchell Creek (Howqua)	Slate

Various intrusions in the Pilot Ranges, in the north of the region, were used extensively for building in Beechworth between 1857 and 1864. They display a range of colours and textures and some of these rock types may be suitable for use as dimension stone.

The Yackandandah Granite was used last century for building in and around Yackandandah. The rock has a number of colours and textures, including a mylonitic foliation in the Kancoona Fault zone and is worthy of further investigation.

Glenrowan Granite and Taminick Gap Granite within the Warby Ranges (located just outside the region) were quarried for dimension stone used in buildings in Glenrowan, Wangaratta and Melbourne as recently as 1991. The rock is pyritic and irregular jointing means blocks are generally small. These properties, together with the exclusion of quarrying in large outcrop areas covered by the Warby Ranges State Park make development potential low.

The Pine Mountain even-grained pink granite outcrops near Corryong, in the north-east of the region. Much of the intrusion is highly jointed but the north-west corner of the intrusion displays a jointing pattern favourable to use as dimension stone. Part of the Pine Mountain granite lies outside the Burrowa-Pine Mountain National Park and has potential as a yet unused source of dimension stone.

Porphyry dykes in the Tallangatta area have a history of extraction and use as dimension stone, particularly for monument building in Melbourne. The dykes range in colour from red, red-brown to green and have a classic porphyry texture, with large cream to white rhombic feldspars, often zoned with white cores and corroded quartz set in a finer-grained matrix. Numerous dyke swarms occur at Tallangatta, Cudgewa, Walwa, Bullioh and other localities and while their extensive jointing detracts from large volume uses some of the dyke rocks may be suitable for monument construction (King and Weston 1997).

Fluorite

Victoria's only fluorite production has been from the Pine Mountain mine, near Walwa in the north of the region, which produced 5240 tonnes of fluorite during the period 1918-1972. The Pine Mountain mine has ore reserves of 75 000 tonnes of 100 per cent CaF₂, assuming 75 per

cent recovery and in excess of a million tonnes of low grade ore. Fluorite has been recorded at a number of other localities including Sandy Creek, Walwa, Womobi Wolfram mine, the Tin Hut and Granya View lodes in the Granya goldfield and an isolated occurrence in the Mitta Mitta goldfield (Oppy *et al* 1995).

There are 20 fluorite occurrences in the region (Map 2 and Table 13).

Precious and semi-precious stones

Map 2 and Table 13 show 38 gem and semi-precious gemstone occurrences and Table 12 indicates general localities for gems and semi-precious gems.

In excess of 78 diamonds were recovered during mining of deep lead deposits of gold and tin within the Eldorado, Beechworth and Chiltern-Rutherglen goldfields. Most of these diamonds are derived from alluvial gravels in Reedy Creek from Wooragee to Eldorado and many were recovered from the Woolshed Creek portion of Reedy Creek (Birch and Henry 1997). The two largest diamonds (6 and 8.2 carats) in the region were from the Beechworth goldfield but most other diamonds weighed less than 0.5 carats and they mostly occur in deep leads and gravels in streams that have drained granite of the Pilot Range (Maher *et al* 1997). Further east at Sebastopol, diamonds cemented in Pliocene gravels were reported.

Diamonds within the Chiltern-Rutherglen goldfield came principally from a patch of wash at 115 metres depth on the Prentice Lead worked by the Great Southern Gold Mining Co. Diamonds have also been reported from Pilot Creek, the Indigo Lead and the Lancashire Lead.

Sapphire, topaz, zircon and quartz crystal have been extracted from shallow leads in the Toombullup goldfield, in the central part of the region. Rock crystal, citrine, cairngorm and amethyst are common in Reids Creek and such ornamental stones were commonly found in old alluvial workings of the Woolshed Valley, north of Beechworth. Small strongly coloured amethyst crystals have also been found near Springhurst and Eldorado (Stone 1988).

Several belts of Ordovician carbonaceous black shale and slate, containing primary and secondary phosphate minerals, crop out near Cheshunt, in the central part of the region southeast of Benalla. These are called the Edi-Cheshunt turquoise fields (includes Whitfield) and were worked between 1893 and 1921. Turquoise occurs as compact veins up to 2 cm thick in these belts, which can be traced intermittently for about 30 km.

Similar rocks host the Greta South turquoise fields (includes Ryans Creek), where turquoise occurs in small veinlets or patches in brecciated slate and has been worked from a series of small workings spread over a distance of 500 metres (McHaffie & Buckley 1995).

Limestone

Minor resources of Devonian limestone have been worked for lime and ornamental stone at Howes Creek, south-west of Mansfield. Limestone deposits of Silurian and Devonian age have been recognised at Morass Creek and Wombat Creek, in the south-east of the region.

The Silurian Wombat Creek Group limestone occurs as west-north-west trending lenses near the junction of Gibbo River and Wombat Creek. A 70 metre thick deposit of limestone occurs at Wombat Creek, west of the Mitta Mitta - Gibbo River junction, and contains 97 per cent CaCO₃. The Wombat Creek Group limestones are mostly bioclastic, ranging from grainstones to packstones and in some places are dolomitised and silicified (VandenBerg 1988).

Phosphate rock

The ten phosphate occurrences in the region are confined to the Benalla-Mansfield area. Six are located around Mansfield and three of these occur at Howes Creek in Lower Devonian age phosphatic sediments where several hundred tonnes of material were mined prior to 1920. The other four occurrences are turquoise (a secondary phosphate mineral) localities (see Precious and Semi Precious Stones section).

Concentrations of phosphate rock were sought in both phosphate enriched Early Ordovician and Cambrian sediments and in Early Devonian sediments in the Mansfield area. Although not rich enough nor large enough to be economic, the mineralised beds coincide with similar enrichments in sediments of the same age worldwide.

Quartz Crystal

Laing *et al* (1977) report mining of quartz crystals from coarse-grained biotite granite at the Crystal King Mine near Tallangalook for use in radio transmitters during the 1940s. A recent upsurge in interest in quartz crystals for ornamental and "new-age healing" purposes has led to reworking of this deposit (McHaffie & Buckley 1995).

Barite

A barite lode occurs seven kilometres south-east of Walwa, within a narrow porphyry dyke intersecting the Corryong Granite. Barite has also been recorded at Thowgla and Gibbo River. Fluorite-barite mineralisation is associated with north-west trending high silica dykes on the southern contact of the Pine Mountain Adamellite (Oppy *et al* 1995)

Calcite

At Boxwood a large calcite vein in Cambrian dolerite has been worked for use in agriculture and plaster (McHaffie & Buckley 1995).

Wollastonite

Wollastonite has been recognised around the margin of the Strathbogie Granodiorite, north of Bonnie Doon, and at Chesney Vale where calcareous sandstone (McHaffie & Buckley 1995) has been metamorphosed (heated and pressurised).

Pyrophyllite

Pyrophyllite is associated with gold mineralisation in acid volcanics at Rhyolite Creek, in the south-west of the region, and with porphyry of the Mammoth Complex, just to the south-east of the region (McHaffie & Buckley 1995).

Talc

Talc production of 83 tonnes during 1948-49 came from crushed and faulted margins of a Cambrian greenstone (diabase) in the Howqua Hills, in the south east of the region (Bowen 1988).

POTENTIAL MINERAL AND EXTRACTIVE RESOURCES

MINERAL POTENTIAL ASSESSMENT METHODOLOGY

The mineral potential of the North East region 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 styles of mineralisation. A summary of the qualitative assessment methodology is described in publications by Marsh *et al* (1984), Taylor and Steven (1983), and by Dewitt *et al* (1986).

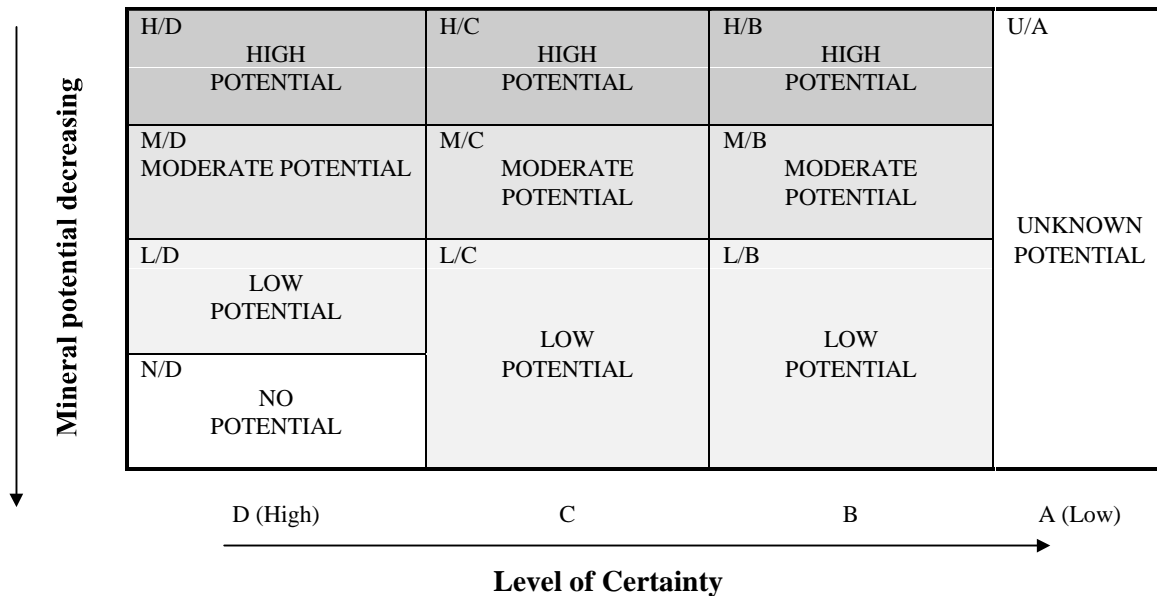
A qualitative assessment of the potential resources of an area is an estimate of the likelihood of occurrence of mineral deposits which may be of sufficient size and grade to constitute a mineral resource. The term ‘mineral resource’ is restricted to material, the extraction of which is judged to be 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-D in order of increasing certainty (Figure 2). 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 North East region are commonly used by companies to select 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.

Figure 2: Relationship between levels of resource potential and levels of certainty



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 in Yilgarn, WA; Century in the Mount Isa Inlier, Qld.) or in areas not previously known to be of very high potential (eg Olympic Dam on 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 North East region, judged to contain geological environments permissive of the formation of specific types of mineral deposits have been delineated and their mineral potential ranked (Figures 3 to 18).

MINERAL AND EXTRACTIVE POTENTIAL IN THE NORTH EAST

Descriptive mineral deposit models used for qualitative broadscale assessment of the North East region are described in Appendix B. The favourable geological tracts for these types of mineralisation are indicated on Figures 3 to 18. The potential mineral resources are summarised in Table 2 and are described below as follows:

Table 2: Summary of potential mineral resources as at April 1998

Deposit type	Mineral potential	Certainty level	area of tract (sq km)	% of region covered by tract	% of tract in Exempt Crown Land*
Slate belt gold	High	B-C	14287	61.7	16.1
	Moderate	B	1067	4.6	<0.1
	Low-moderate	B	3464	14.9	11.1
Disseminated gold	Moderate-high	B	14287	61.7	16.1
	Low-moderate	B	1067	4.6	<0.1
	Low	B	3464	14.9	11.1
Alluvial gold	Low-moderate	B	5190	22.4	2.0
Epithermal gold-silver	Moderate-high	B-C	3142	13.6	13.2
Porphyry copper-gold	Moderate-high	B	102	0.4	0.1
	Moderate	B	739	3.2	17.6
Volcanic associated massive sulphide base metals	High	B-C	105	0.5	26.1
	Moderate-high	B-C	237	1.0	63.4
Volcanic associated massive sulphide gold	High	B-C	105	0.5	26.1
	Moderate	B-C	237	1.0	63.4
Tin veins	Moderate	B-C	3751	16.2	16.5
	Low-moderate	B	2960	12.8	9.5
Tin greisen	Moderate	C	211	0.9	<0.1
	Low-moderate	B-C	1460	6.3	18.8
	Low	B	1519	6.6	11.5
Tungsten-molybdenum veins	Moderate	B-C	966	4.2	4.4
	Low-moderate	C	5453	23.5	14.7
Tungsten skarn	Moderate	B	472	2.0	3.5
Nickel-copper deposits	Moderate-High	B	474	2.0	1.3
Sediment hosted copper	Moderate	C	680	2.9	0.9
	Low-moderate	B	418	1.8	68.6
Sandstone uranium	Low-moderate	C	1098	4.7	26.7
Dimension stone	Moderate	B	4082	17.6	10.7
	Unknown	A	11721	50.6	21.2
Feldspar	Moderate	B	2609	11.3	7.3
	Low-moderate	B	5996	25.9	18.3
	Unknown	A	935	4.0	20.1
Limestone	Low-moderate	C	1193	5.2	6.3
Kaolin	Moderate	B	5193	22.4	2.0

*Exempt Crown land in this column comprises National and State Parks, Wilderness and Reference Areas.

Gold

Tract Au1a/H/B-C Slate belt gold (Figure 3): The tract is delineated based on the distribution of Ordovician, Silurian, Siluro-Devonian and Devonian turbidites and their metamorphic equivalents (in places overlain by younger sediments). The tract also incorporates dyke swarms (Woods Point; Mitta-Mitta, Tintalra-Cudgewa, Walwa, and other smaller dyke swarms in the Benambra gold province) and low to moderately magnetic responses which are interpreted to be associated with dyke swarms (Maher *et al* 1997). The tract contains more than 80 per cent of primary gold occurrences and a large number of alluvial deposits.

Mineral potential of the tract is assessed to be high with a certainty level of B-C.

Tract Au1b/M/B (Figure 3): The tract includes areas of Quaternary rocks of Shepparton Formation which overlies Ordovician, Silurian and Devonian sedimentary rocks in the Ovens Valley. Because the Quaternary cover is reported to be thick, mineral potential of the tract is assessed to be moderate with a certainty level of B.

Tract Au1c/L-M/B (Figure 3): The tract includes Silurian and Devonian granitoids which are known to host 14 per cent of the known primary gold occurrences. It also includes several occurrences of alluvial gold. North-northwest and northeast trending faults in granitoids are known to have played a role in the distribution of primary gold mineralisation.

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

Tract Au2a/M-H/B Disseminated gold deposits (Figure 4): This tract is identical to the high potential tract (tract Au1a/H/B) for slate belt gold deposits and contains the most favourable environment for the emplacement of slate-belt gold mineralisation as outlined under the previous section for slate-belt gold. The presence of slate belt gold occurrences and the fact that it has a high potential for the presence of more deposits of this type indicates that the tract has a potential for disseminated gold deposits.

Mineral potential for disseminated gold deposits in the tract is assessed to be moderate to high with a certainty level of B.

Tract Au2b/L-M/B (Figure 4): The tract is identical to the moderate potential tract (tract Au1b/M/B) for slate belt gold deposits. It represents Quaternary rocks of the Shepparton Formation in the Ovens Valley with a greater thickness of the cover rocks over favourable Ordovician, Silurian and Devonian sedimentary and metasedimentary rocks. Hence mineral potential of this tract is assessed to be low to moderate with a certainty level of B.

Tract Au2c/L/B (Figure 4): The tract is identical to the low to moderate potential tract (Au1c/L-M/B) for slate-belt gold deposits. Main rocks in the tract are Silurian and Devonian granitoids which are known to host several occurrence of primary slate-belt gold. The potential for slate-belt gold in the tract has been assessed to be low to moderate. Deposits of disseminated gold may be associated with the slate belt gold and on the available evidence the tract has a low potential for disseminated gold deposits with a certainty level of B.

Tract Au3/L-M/B Alluvial gold deposits (Figure 5): Distribution of Tertiary and Quaternary sediments has been used to delineate this tract. The region hosts numerous slate-belt gold and disseminated gold deposits and occurrences which are potential source of alluvial gold. The tract contains numerous occurrences of alluvial gold.

The tract also includes areas which are favourable for deep and shallow leads such as Chiltern and Rutherglen.

There is widespread distribution of primary sources of gold in the region. However, alluvial gold is relatively easy to find as compared to concealed primary deposits. The region has been subjected to intensive prospecting for alluvial gold and a major proportion of the alluvial deposits probably have been located. It is concluded that the region has a low to moderate potential (with a certainty level of B) for alluvial gold.

Tract Au4a/M-H/B-C Epithermal gold-silver (Figure 6): Geological environments which are favourable for the formation of epithermal style deposits are defined by the Cambrian volcanics in the north-northwest trending Barkly River Greenstone Belt in the south western part of the region and by Devonian subaerial felsic volcanic and volcanoclastic complexes in the central north of the region.

The volcanic complexes include the Strathbogie Igneous Complex, Tolmie Igneous Complex and the Wellington Rhyolite which occur in a number of medium sized calderas such as the Violet Town Caldera, and the Wabonga Caldera. The Early Devonian Volcanics of the Jemba Rhyolite are formed in the Burrowa Caldera. The Murtagh Creek Rhyolite and the Sheevers Spur Rhyodacite occur in the northern part of the Wombat Creek Graben.

Mineral occurrences of epithermal gold-silver mineralisation have not been recorded within the areas of Devonian complexes, but several epithermal gold-silver occurrences are known in the Barkly River Greenstone Belt. The tract is interpreted to have a moderate to high potential for epithermal gold-silver deposits with a certainty level of B to C.

Base metals

Tract CuAu1a/M-H/B Porphyry copper gold deposits (Figure 7): The tract is defined by relatively oxidised I-type granitoids (Everton Granodiorite and Murmungee Granite). It is possible that these two granitoids are related to a larger body, the presence of which is revealed at shallow depths by high resolution aeromagnetics. Everton Granodiorite is reported to host low-grade molybdenite mineralisation (Maher *et al* 1997)

The tract also contains alkaline igneous rocks of the Triassic Mount Leinster Igneous Complex. Although there are no known occurrences associated with them, similar alkaline rocks in Tasmania and New South Wales are reported to host gold mineralisation.

Mineral potential in the tract is assessed to be moderate to high with a certainty level of B.

Tract CuAu1b/M/B (Figure 7): The tract includes early Silurian and Devonian I-type and a few S-type, mafic granitoids with a high aeromagnetic response indicative of their possible oxidised state. These include the Barrimboola, Big Hill, Boebuck, Corryong, Mt Angus, Mt Mittamatite, Mt Selwyn, Niggerheads and Spion Kopje Granitoids.

The tract also includes areas where high-resolution aeromagnetics indicates the presence of magnetic granitoids at shallow depths. A small area at the south-eastern margin of the Strathbogie granitoid is also included in the tract, because it contains some copper occurrences that show features similar to copper-porphyry mineralisation (T Dickson, Victorian Geological Survey, pers. comm.).

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

Tract BM1a/H/B-C Volcanogenic massive sulphide deposits (VMS) (Figure 8): This tract delineates areas of Cambrian metabasalts, gabbro and sediments that have potential for volcanogenic base metal and gold/silver deposits. The Cambrian Mt Wellington greenstone belt in the region has not been fully explored for the presence of these precious metals deposits (Maher *et al* 1997) and mineralisation of this type is known in similar rocks to the south of the North East region. Potential for VMS base metal deposits appears more favourable in the southern part of the tract (Jamieson area).

The tract is thought to have high potential for volcanogenic base metal deposits, with a certainty level of B-C.

Tract BM1b/M-H/B-C (Figure 8): The tract consists of Silurian and Devonian marine volcanic and sedimentary rocks deposited in the Wombat Creek Graben. Minor vein or Mississippi Valley type base metal occurrences in the Wombat Creek Graben may indicate potential for concealed VMS deposits in the graben rock units of Silurian age. VMS type base metal

deposits (Wilga and Currawong) are known to occur in a similar stratigraphic sequence in the Limestone Graben to the south of the North East region.

Devonian Dartella Group acid volcanics and sediments in the northern part of the Graben show some signs of exhalative mineralisation (Ramsay 1988) and may conceal underlying marine volcanic/sedimentary Silurian rocks with potential for VMS deposits. The upper part of the Snowy River Volcanics and overlying Devonian limestones/sediments also have potential for VMS deposits. Thus all these Devonian units have been included in the tract.

Potential for economic volcanic hosted massive sulphide deposits is considered to be moderate to high with a certainty level of C for the Silurian rocks and B for the Devonian rock units.

Tract Au5a/H/B-C (Figure 8): This tract coincides with the tract BM1a/H/B-C for volcanic associated massive sulphide deposits. The tract contains several occurrences of base metals with gold values. The potential of the tract is assessed to be high with a certainty level of B to C.

Tract Au5b/M/B-C (Figure 8): This tract coincides with the BM1b/M-H/B-C tract for volcanic associated massive sulphide deposits. The tract contains Silurian submarine volcanic rocks that host massive sulphide deposits of Wilga and Currawong near Benambra located in the Limestone Creek Graben. These deposits are known to have up to 1.3 g/t gold (Allen and Barr *et al* 1990). For reasons similar to those outlined in the above tract, the potential of this tract is assessed to be Moderate with a certainty level of B to C.

Tracts BM2a/M/C Sediment hosted copper deposits and sandstone uranium deposits (Red bed subtype) (Figure 14): The tracts for sediment hosted copper and sandstone uranium are defined by the extent of the late Devonian redbed sequences in the Mansfield Basin and the Mount Typo Basin to the north east of the Mansfield Basin. The highest concentration of known copper occurrences is in the Mansfield and Mount Typo Basins. Interfaces of reducing and oxidising environments in the redbeds together with structural traps in the basin and faults in the underlying basement rocks provide favourable settings for deposition of copper, silver and less frequently uranium from metal-bearing solutions. On the available evidence from exploration data, the redbeds in the Mansfield Basin are assigned a moderate potential for small deposits of copper and silver with a certainty level of C.

Tract BM2b/L-M/B (Figure 14): The tract is defined by the extent of the Macalister Basin to the south of the Mansfield Basin. The full extent of reduced beds within the redbeds in the Macalister Basin is not known but exploration data suggest that copper occurrences in the Macalister Basin are less common than in the Mansfield and Mount Typo basins. Hence, the redbeds in the basin are considered to have a lower potential of low to moderate with a certainty level of B.

Tract U/L-M/C (Figure 14): The tract is defined by the extent of the Mansfield, Mount Typo and Macalister basins, which contain redbed sequences. Anomalous concentrations of uranium, sometimes associated with the copper occurrences have been recorded in them. However, uranium mineralisation appears to be less widespread. Airborne uranium channel radiometric anomalies are generally low for the redbed sequences but can be locally high in the vicinity of some of the copper occurrences.

On the available information the potential for small sandstone uranium deposits is low to moderate at the interfaces of reducing and oxidising conditions in the redbeds in all of the basins with a certainty level of C.

Tungsten, Tin

Tract Sn1a/M/B-C Tin vein deposits (Figure 9): This tract is defined by the presence of reduced, felsic and fractionated granites and by the distribution of known tin vein occurrences. Granites of both the Koetong Suite and the Beechworth pluton are known to be reduced. Primary and secondary occurrences are associated with each of the bodies and also with the Mt Wills Granite and the eastern part of the Pinnibar/Mt Boebuck body. Alluvial lodes associated with the Beechworth pluton are extensive. The tract also incorporates a 5km buffer around the granites and captures most of the known tin vein occurrences.

The above granites are considered to have a moderate potential with a certainty levels of B-C.

Tract Sn1b/L-M/B (Figure 9): This tract is delimited by the Strathbogie Adamellite and Mt Buffalo granite plus the extent of known tin fields that relate to aplite-pegmatite dyke swarms which intrude the Omeo Metamorphic Complex.

The granites are felsic and fractionated, but have a stronger magnetic response than those granites mentioned in the previous tract, suggesting that they may be more oxidised. No primary or alluvial tin occurrences are associated with the Mt Buffalo body and there are two small alluvial tin occurrences on the eastern side of the Strathbogie Adamellite.

Aplite-pegmatite dykes hosted by the Omeo Metamorphic Complex host mineralisation in the Mitta Mitta and Walwa tin fields. Although greisens are the dominant form of mineralisation there is some “reef” type mineralisation within the tinfield at Mitta Mitta.

Given the information above, the tract is assessed to have a low-moderate potential with a certainty level of B.

Tract Sn2a/M/C Greisen tin deposits (Figure 10): This tract is defined by the extent of known tinfields that relate to aplite-pegmatite dyke swarms which intrude the Omeo Metamorphic Complex.

The abundance of aplite-pegmatite dykes and numerous greisen style occurrences within the dykes indicate that primary sources of tin were present over a wide area and processes of greisenisation were commonly in action. There is significant potential for subcropping dykes to contain greisen tin deposits.

This tract is assessed as having a moderate potential with a certainty level of C.

Tract Sn2b/L-M/B-C (Figure 10): This tract is defined by the presence of reduced, felsic and fractionated granites. It includes members of the Koetong Suite, the Beechworth Pluton as well as the Chesney Vale, Mt Wills, Barjarg, Pine Mountain and Thologolong bodies. The eastern section of the Pinnibar/Mt Boebuck body is also included in this tract.

Of the above granites only the Beechworth Pluton is known to contain greisen style occurrences, although the Koetong granites do contain unmapped dykes that could provide favourable sites for greisen deposits. Granites belonging to the Koetong Suite as well as the Mt Wills and Pinnibar bodies have primary tin occurrences associated with them but not in the form of greisen deposits. Alluvial occurrences are also present in the vicinity of these primary deposits.

This tract is assessed as having a low-moderate potential with a certainty level of B-C.

Tract Sn2c/L/B(Figure 10): This tract is delimited by the Strathbogie Adamellite and Mt Buffalo granite which although fractionated and felsic, and in the case of the Strathbogie body apparently reduced, have stronger magnetic signatures than granites noted above. No known primary occurrences are known from either of these bodies, although there are minor alluvial occurrences located on the eastern limb of the Strathbogie Adamellite.

This tract is assessed as having a low potential with a certainty level of B.

Tract W-Mo1a/M/B-C Tungsten-molybdenum vein deposits (Figure 11): The tract is based on the distribution of fractionated but relatively oxidised, syn - to late orogenic, I-type and/or S-type granitoids; on presence of granitoids with moderate to intense magnetic response on high-resolution aeromagnetics; and on the distribution tungsten, molybdenum and bismuth prospects. The tract includes the Everton Granodiorite, the Murmungee Granodiorite (of which the Everton granodiorite is probably an offshoot), the Mt Angus body, the Mt Pinnibar/Boebuck Adamellite and the Buckwong Granite. Also included within the tract are molybdenum-bearing pipes at Everton and the Mount Murphy tungsten deposit in the Buckwong Granite. These two deposits are the most significant tungsten and molybdenum deposits in Victoria.

This tract is assessed to have a moderate potential for tungsten-molybdenum deposits with a certainty level of B-C.

Tract W-Mo1b/L-M/C (Figure 11): This tract contains felsic, fractionated S- and I-type granitoids which, on indirect evidence such as aeromagnetics, appear to have intermediate oxidation and fractionation levels. It includes the Mt Buffalo, Pine Mountain, Thologolong, Anglers Rest, and Mt Wills bodies, the granites of the Chesney Vale area and the Strathbogie suite. These bodies generally have low magnetic signatures suggesting that they are neither strongly oxidised or reduced. Significant tungsten mineralisation is hosted by the Thologolong body at Womboi and a minor occurrence has been noted in the Chesney Vale granites.

The Strathbogie Suite, and the Koetong Granites are considered to be reduced but the Bonnie Doon tungsten occurrence is sited on the southern edge of the Strathbogie pluton. Similarly there are numerous tungsten occurrences associated with the Koetong Granites, which may indicate that the granites are only moderately reduced and fractionated. Alternatively the tungsten occurrences may be related to unmapped dykes as are other occurrences north of the Beechworth pluton.

This tract is considered to have low-moderate potential for hosting tungsten-molybdenum deposits with a certainty of C.

Tract W/M/B Tungsten skarn deposits (Figure 12): The tract is delineated by the distribution of calcareous rocks within 5km of favourable oxidised S and I-type granitoids. This includes areas to the south of the Strathbogie plutonic suite, and areas in proximity to the Chesney Vale Granite. Tungsten occurs at Bonnie Doon on the southern edge of the Strathbogie pluton.

This tract includes a number of wollastonite-bearing skarns and/or hornfels.

However, because the tract does not contain any reported skarn scheelite occurrences, the potential of the tract is assessed as moderate with a certainty level of B.

Potential for other skarn-related deposits

Skarns with associated copper mineralisation have been reported from the Morass Creek area to the north of Benambra within the 15 km buffer zone. They are associated with Triassic syenite and quartz porphyry intrusives of the Mount Leinster Complex. Hence, the region has some

potential for copper skarns but the available information is not sufficient to delineate a tract or assign a potential.

Tract NiCu/M-H/B Nickel copper deposits (Figure 13): The tract includes the Woods Point Dyke Swarm which has the potential to host small copper nickel deposits of the Thomson River type where ever thickenings or bulges in the dykes occur. The dykes contain mineralisation characteristic of this model type (synorogenic Ni-Cu) and hence the entire known outcrop area of the Woods Point Dyke Swarm is assessed as having moderate to high potential with a certainty level of B.

Construction materials and Industrial minerals

Higher value construction materials Construction materials (No figure provided): The potential for economic deposits of higher value construction materials in the North East region exists where suitable rock materials occur within viable transport distances of population centres. The viable transport radius around a centre increases with population size because of the economies of scale of supplying a larger market and better road networks around larger centres (refer Appendix B). Deposits near good transport routes (eg the Hume Highway) with access to distant population centres may also be viable.

Suitable rock types for higher value construction materials are granite, acid to basic volcanics and hornfels rocks. While potential for suitable bodies of construction sand, clay and clay shale lies within Quaternary and Tertiary age sediments. Areas of deeply weathered pre-Tertiary shales may also have potential for clay shales suitable for brick/tile making and other uses. However, such areas could not be delineated on the available data.

Lower value construction materials (No figure provided): Most of the rock types in the region have potential for lower value construction materials in their fresh or weathered state; and soil, sand and gravel are widespread across the region. Suitable materials are mainly used for secondary road building and extraction of material usually occurs in close proximity to these roads. The materials include: (1) rippable sandstone, shale, schist, weathered granite and other rock, (2) sand and gravel, (3) soil and calcrete.

Tract Dimst1a/M/B Dimension stone deposits (Figure 15): The tract includes Silurian and Devonian granitoids (Beechworth, Corryong, Koetong, Mt Bruno, Mt Mittamatite, Pine Mountain, Strathbogie, Trawool and Yackandandah). The tract also includes Ordovician Mt Easton Shales and Devonian Humevale Siltstone. These rocks host one or more known quarries and/or occurrences of dimension stone. More detailed information is required on the physical and chemical properties of the rocks to assess more accurately their suitability as dimension stones. Hence potential of the tract is assessed to be moderate with a certainty level of B.

Tract Dimst1b/U/A (Figure 15): The tract is defined by the presence of Silurian and Devonian granitoids, Tertiary volcanics, limestone and sandstone bearing formations and Ordovician sedimentary/metasedimentary rocks. These rocks are similar to the rocks that define the above tract but lack known quarries or occurrences. Hence the tract is assessed to have an unknown potential.

Tract Felds1a/M/B Feldspar deposits (Figure 16): The tract includes Silurian and Devonian granitoids (Beechworth, Koetong, Lady Franklin, Strathbogie, and Thologolong). These rocks host one or more known mines and/or occurrences of feldspar. Although quarries and/or occurrences of feldspar are present in these rocks, more detailed information is required on their physical (fracturing, jointing, cavities) and chemical properties (concentration of potassium, sodium and iron) to assess more accurately their suitability as source for high quality feldspar. Hence potential of the tract is assessed to be moderate with a certainty level of B.

Tract Feldsp1b/L-M/B (Figure 16): The tract is defined by the presence of pegmatite and aplite dykes. In addition to dykes which have been mapped, high-resolution aeromagnetics have been used to delineate a north-northwest trending zone of dyke swarms. The zone extends 75 kilometres to west and 35 kilometres east of the Kancoona Fault. Dykes show low to moderately magnetic responses trending northwest (Maher *et al* 1997). The dykes in the tract are known to have a few known occurrences of feldspar suitable for glass and ceramic industries. The Woods Point dyke swarm is not included in the tract as these dykes are more mafic.

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

Tract Feldsp1c/U /A (Figure 16): The tract includes all known granitoids which are not part of the tract with moderate potential. It also includes alkaline igneous rocks of the Triassic Mount Leinster Igneous Complex. Available geological information does not allow to assess their potential. Hence the tract is considered to have an unknown potential.

Tract Lst/L-M/C Limestone deposits (Figure 17): The tract is defined by the Silurian-Devonian sedimentary rocks, which may contain limestones. The tract includes the Howes Creek deposit near Mansfield and the limestones in Wombat Creek Graben.

The tract is considered to have a low to moderate potential for limestone/dolomitic limestone deposits with a certainty level of C.

Tract Kao/M/B Kaolin deposits (Figure 18): Primary (or residual) kaolin forms by in-place weathering of feldspar-rich rocks such as granite, gneiss, arkose or some sediments. Deep weathering under hot, humid conditions (McHaffie 1992, in McHaffie & Buckley 1995) in Victoria during the late Cretaceous and early Tertiary periods generated extensive, thick kaolinitic surficial zones. These zones were then largely eroded away later in the Tertiary and Quaternary to form secondary kaolinitic clay deposits.

The kaolin tract is delineated on the distribution of Tertiary and Quaternary sediments in which secondary clay deposits may occur. Lack of information at the scale of this assessment precludes the delineation of remaining primary Tertiary kaolin deposits developed on granitic or favourable sedimentary rocks.

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

Diamonds

The potential for diamonds is unknown.

Phosphate

Thorough exploration of prospective areas across Victoria by a number of companies in the mid 1960's did not delineate any economic resources. The potential for discovery of significant phosphate deposits in Victoria would appear to be very low compared to that, for example, in Queensland or the Northern Territory (McHaffie & Buckley 1995). Devonian sediments of possible shelf facies environment occur in the North East region but their potential for phosphate deposits is unknown.

SUMMARY OF POTENTIAL FOR METALLIFEROUS AND INDUSTRIAL MINERALS, AND CONSTRUCTION MATERIALS IN THE NORTH EAST

Mineral potential tracts were identified for 14 types of mineral deposits and 4 types of industrial mineral and construction materials deposits.

The tracts of mineral potential for various types of mineral deposits (Figures 3 to 18) have been combined and summarised in two different ways in Maps 3 and 4. Extraction sites for low value construction materials are often dictated by other land uses such as real estate developments and by costs of transport. Mineral potential tracts for construction materials are not included in the combined mineral potential Maps 3 and 4.

Map 3 is a composite of mineral potential tracts over the North East region and shows the highest level of mineral potential assessed (in April 1998) for any particular area in the region (Figures 3 to 18). Where tracts for different types of deposits overlap, this area is assigned the highest potential level of all the overlapping tracts. In this approach, the tract having the highest mineral potential in any particular area obscures tracts of lower mineral potential.

Most of North East region is covered by a tract of high potential for deposits of slate-belt gold, with smaller tracts of high potential for volcanic associated massive sulphide deposits in the southwest of the region (Map 3, and Figures 3 and 8). This tract includes 43 goldfields which generated the past gold production and the tract represents the area in the region where gold discoveries may be made. Tracts of moderate to high potential for disseminated gold deposits coincide with the high potential tract for slate belt gold (Figure 3). Areas of moderate to high potential are occupied by tracts for epithermal gold and silver in the western part of the region, west and south of the Violet Town Caldera and in the Wombat Creek Graben in the east of the region (Figure 6). A small tract of moderate to high potential for porphyry copper-gold deposits occurs east of Wangaratta and other small tracts of moderate potential for porphyry copper-gold are present in the eastern part of the region but are obscured by tracts of higher potential (Map 3, Figure 7). Additional areas of moderate to high potential for nickel-copper deposits underlie the high potential slate belt gold tract in the far south west of the region along the Mount Wellington Fault Zone (Figure 13).

Areas of moderate potential in the western part of the region are for sediment hosted copper (Map 3, Figure 14) and dimension stone (Figure 15) in the Mansfield and Mount Typo Basins. The tracts of moderate potential for dimension stone extend south of Mansfield Basin and are also present in the eastern part of the region north of the Wombat Creek Graben. Areas of moderate potential on Map 3 in the north east of the region are largely for tin vein and tin greisen deposits (Figures 9 and 10) and for alluvial gold (Figure 5) around Wangaratta. Other areas of moderate potential for deposits of alluvial gold, tungsten molybdenum veins, tungsten skarn, feldspar and kaolin (Figures 5, 11, 12, 16 and 18) are largely concealed by tracts of higher mineral potential.

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 moderate to high potential for slate belt gold may be considered to have a higher economic value than a tract with moderate to high potential for dimension stone.

The mineral potential tracts in Figures 3 to 18 are superimposed on Map 4 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). In those areas where tracts overlap, the scores are added and this cumulative score is assigned to

overlapping areas. For example where there is an overlap of high potential for slate belt gold (score 18), moderate potential for vein type tin (score 6) and moderate potential for dimension stone (score 6) then this area will have a cumulative potential score of 30.

It should be understood that the areas with overlapping tracts highlighted by Map 4 emphasise the diversity of deposit types and their mineral potential, but these areas are not necessarily always more prospective than a single tract of high potential, for example, slate-belt gold. As with Map 3, the relative economic potential of different deposit types has not been accounted for. 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.

On Map 4 the cumulative mineral potential scores of ≥ 30 reflect the widespread potential of slate belt gold and disseminated gold deposits throughout the North East region. The area with a high cumulative score in the region (up to 72) occurs west and north of Beechworth. The high score in this part of the region is due to the cumulated scores of potential for eight types of deposits: slate belt and disseminated gold deposits (high potential score of 18 and moderate potential score of 12 respectively), porphyry copper-gold deposits (12), two types of tin deposits (moderate potential score of 6 each), tungsten-molybdenum vein deposits (6), deposits of feldspar (6) and dimension stone (6). This area includes the ACI feldspar mine which is the largest mining operation in the region. Other areas with high cumulative scores in the eastern half of the region indicate those areas where in addition to potential for slate belt and disseminated gold deposits there is also potential for deposits of tin and tungsten-molybdenum deposits. In the part of the region west of Wangaratta and Mount Buller the areas of higher cumulative scores occur where in addition to potential for slate belt gold and disseminated gold there is also potential for deposits of nickel-copper, and volcanic associated gold and base metals south and southeast of Mansfield, tungsten skarn deposits along the southern margin of the region northwest of Mansfield and epithermal gold and tin north of Mansfield.

CURRENT EXPLORATION, MINING AND EXTRACTION ACTIVITIES AND POTENTIAL ECONOMIC VALUE

The potential economic value of the region's mineral resources is affected by a number of factors including: mineral prospectivity; geological knowledge base and intensity of data over the region, timing and significance of discoveries; future metal prices and mining costs; and rules and regulations governing exploration and mining.

The mineral potential assessment provides an indication of areas of land which are more likely to be most prospective for particular minerals. However, an assessment of the potential value of mineral resources in these areas is not possible without an estimate of the number and type of deposits likely to occur in a particular region. Therefore it has not been possible to compare the 'mineral' value of particular areas of land that have been assessed as prospective for minerals with other land (whether prospective or not). These limitations, when combined with the dynamic information-gathering nature of exploration, have significant implications for land access arrangements for exploration and mining in these areas.

Current and historical exploration expenditures provide some indication of the potential value of the undiscovered mineral resources of the North East. 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, given the uncertainty, different risk attitudes of companies and the difficulty of exploration, expenditures only provide an approximation of true prospectivity. Sometimes deposits are found in previously unprospective areas when new ideas or technology are applied where little previous exploration has occurred.

EXPLORATION

While there are presently no significant operating metallic mineral mines in the North East, exploration expenditure totalled about \$9.3 million in 1996-97. Much of this amount (about \$6 million) was directed at locating feldspar occurring within granite in the Beechworth district. The other major commodity target was gold, with a little interest in base metals.

EXPLORATION PRIOR TO 1965

Alluvial gold was discovered at the present site of Beechworth in 1852. Major goldfields established during the early days included Rutherglen, Chiltern, Beechworth, Harrietville, Bright, Wandiligong, Freeburgh, Mt. Wills and Bethanga. Mining of alluvial gold was extended with the arrival of low-cost alluvial dredges or floating large scale processing plants on pontoons which were introduced in the 1890s and early 1900s.

EXPLORATION FROM 1965 TO THE PRESENT

An Exploration Licence system was introduced by the Department of Mines and Industrial Development in the mid 1960s which allowed exploration of larger areas than would normally have been covered by a mining lease, search permit or a prospecting area licence. This greatly facilitated company-scale exploration for minerals.

Exploration in some areas has been hampered by rugged topography, difficult access and at times severe weather. Hence, at least some exploration programs in the region may have been ineffective and significant mineral deposits may remain undetected and a number of quite prospective areas remain, to a large degree, untested. Since 1965, about 330 Exploration Licences have been granted over the North East region or its margins (Figure 19).

The exploration targets sought since 1965 have varied in accordance with relative metal prices, perceived prospectivity, relative recovery costs of metals and new exploration paradigms or mineral deposit models. Until the mid 1960s, the gold price was fixed (under and for a short time after) the Bretton-Woods system at a relatively low level compared with its post 1980 price, although base metal prices were relatively strong in the 1960s and 1970s. Commodities explored for in the region include gold, silver, copper, lead, zinc, platinoids, tin, tungsten, molybdenum, antimony, mercury, uranium, tungsten, feldspar, fluorite and phosphate.

During the mid to late 1960s reef gold mineralisation was targeted by Planet Mining Co. concentrating on old mine workings in the Wandiligong region, while alluvial gold was sought by North Broken Hill Ltd and others, in the Chiltern and Wodonga Flats region and the Murray River Valley area.

The mining boom of the late 1960's led to a record (up till then) 15 Exploration Licences being applied for during 1970. During the period 1965 to 1977, the area attracted about 100 companies most of whose exploration targets were either base metals or tin/tungsten. However, a small proportion of companies were exploring for alluvial gold and some also for reef gold. In 1966, IMC Development Co explored for phosphate near Mansfield and in 1972-1973 CRA Exploration Pty Ltd and others, were exploring for uranium. Diamond was first targeted by explorers in 1977.

After the lull in exploration activity around 1975, the period 1978 to 1983 witnessed a growth in exploration activity based on strong interest in tin and also in base metals and gold within the region. Tin has been explored for in Chiltern, Eldorado, Beechworth, Mitta Mitta River, Koetong, and Walwa areas. Tungsten has often been included in tin exploration programs. Exploration for base metals was stimulated by WMC Ltd's 1978 announcement of the discovery of the Wilga-Currawong volcanic associated base metal deposits in the area east of

Benambra. In the mid to late 1970s, sedimentary copper (and uranium) was targeted in the Mt Typo basin and in the red bed sedimentary sequence of the Mansfield Basin by the Northern Mining Corporation N.L., Jennings Mining, and Urangesellschaft Australia Pty Ltd / Northern Mining Corporation, and, in the early 1980s, by CRA Exploration Pty Ltd.

Exploration activity peaked in 1982 when 21 Exploration Licences were granted. Interest in tin/tungsten during the period 1978-1983 was mainly due to the then sustained high prices for tin and the known occurrence of tin in the region, and also to the high gold price (about 15 per cent of the exploration programs were for gold).

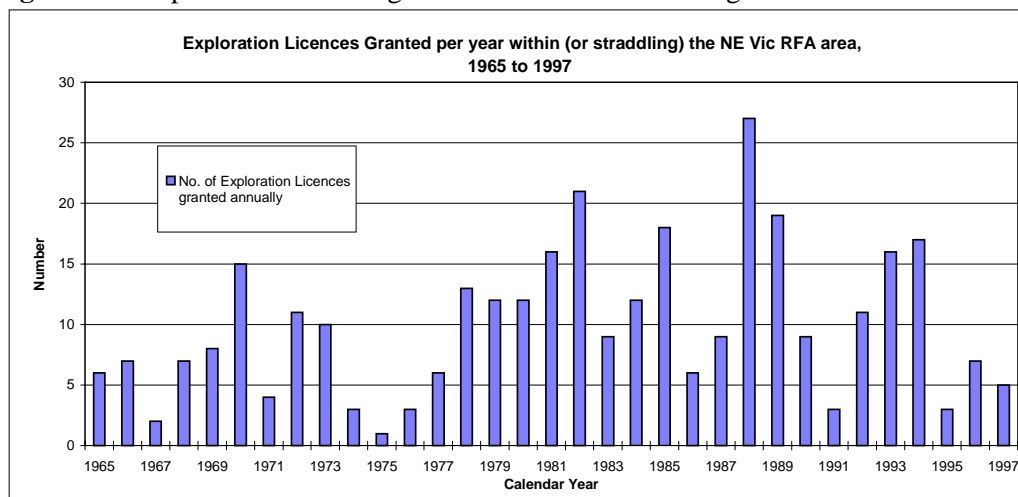
Although exploration for gold in the region began comparatively slowly, it intensified throughout the late eighties and early nineties. Exploration targets included bulk low-grade gold targets comprising either slate belt gold, disseminated gold in sediments or volcanics, and encompassed both greenstone-hosted and sediment-hosted gold types as well as granitoid-related and dyke-related types.

From 1984 to the end of 1997, the major exploration focus over the area has been for gold and about 160 Exploration Licences were granted during this time. The number of Exploration Licences granted fluctuated from 6 in 1986 to 27 in 1988 — the highest number of licences granted in any year — to just 3 in 1991, and 17 in 1994 before subsiding to around 5 per year. About 90 per cent of exploration was directed at gold, diamond was sought during 1991-1993 and about 5 per cent of exploration was for base metals.

In the 1980s BHP Minerals Ltd and others were exploring for both reef and alluvial gold in the Ovens Valley and Bucklands River region, in the Chiltern region, and also north of Mansfield, to locate Witwatersrand style gold mineralisation, while Freeport Australia Inc. targeted vein/stockwork gold mineralisation in the Dookie area (to the north west of the region) and CRA Exploration Pty Ltd sought sediment hosted reef gold mineralisation in the Euroa, Dookie and Cooe areas.

By the end of the 1980s there had been a dramatic rise in gold exploration, with many companies exploring for all types of gold mineralisation. Ashton Mining Ltd was looking for alluvial and epithermal gold and tin in the Eldorado area and others concentrated on known deep leads and lodes at Gobur, while other companies worked in the Buckland Valley region and in the Swanpool area looking for alluvial deposits. Continental Resources and Norgold Ltd worked in the Toombullup area searching for bulk lode low grade gold deposits.

Figure 19: Exploration licences granted for the North East region



At the beginning of 1990 gold exploration eased off somewhat and diamonds became a popular target. Nevertheless, exploration continued for stockwork gold mineralisation in the vicinity of Myrtleford, and Perserverance Mining Pty Ltd concentrated their efforts in Longwood and Euroa for possible extensions of the Nagambie Goldmine.

In the mid 1990s Harvest Exploration Pty Ltd/Cracow Resources Ltd carried out similar work to Perserverance Pty Ltd by looking for extensions of the Nagambie Goldmine near Violet Town and RGC Exploration Pty Ltd explored for intrusive related gold deposits at Dookie.

Molybdenum has been a minor target for exploration by companies within the region with the majority of exploration targeting the Everton molybdenum mine area and near Beechworth, and at Benambra.

Tungsten mineralisation has often been targeted alongside tin within the region, but to a lesser extent.

Platinoids have been geochemically assayed for by companies that have primarily targeted other commodities such as base metals and gold in greenstone belts.

Diamonds within possible kimberlitic targets of the Wooragee Valley were targeted around 1977 by Northern Mining Corporation and Freeport Australia Inc. Also in the late 1970s, other companies directed their attention to the Chiltern and Eldorado deep leads in search of alluvial diamonds. Dampier Mining Co. Ltd conducted exploration for alluvial diamonds near Wodonga and Beechworth and Northern Mining Corporation N.L. tried to locate kimberlitic sources of diamonds near Yackandandah. In the 1990s diamond exploration took place for kimberlitic rocks near Wooragee, and near Beechworth and within volcanic breccia pipes at Jimmy Creek, Koetong.

Fluorite was explored for by ICI Australia Ltd in the mid to late 1970s in the Warby Ranges area, where mineralisation was associated with quartz veins within Upper Ordovician marine sediments.

Glass grade feldspar was sought in the early 1980s by ACI Resources Ltd within Middle - Upper Devonian intrusives near Beechworth to locate a site suitable to produce glass grade feldspar. This preliminary work has led to the development of the ACI Resources Ltd Beechworth Feldspar Mine.

At the time of this assessment, there were 31 active exploration licences in the North East region (Figure 1), distributed among 23 companies. In 1996-97, total exploration expenditure in North East region was about \$9.3 million (Minerals and Petroleum Victoria 1997), being \$1.8 million on Exploration Licences and \$7.5 million on exploration under Mining licences (Tables 3 and 4).

Table 3: Mineral exploration expenditure on Exploration Licences, North East region (1996-97 dollars)

Year	North East region exploration expenditure (\$)	Victorian exploration expenditure MRD Act (\$)	North East region exploration, as a % of Victorian exploration expenditure
1991-92	615 056	11 200 000	5.5
1992-93	660 434	16 300 000	4.0
1993-94	1 680 117	20 400 000	8.2
1994-95	919 431	43 400 000	2.1
1995-96	910 368	35 600 000	2.6
1996-97	1 799 314	37 600 000	4.8
Totals	6 584 720	164 500 000	4.0

Note: Figures include private mineral exploration expenditure on Exploration Licences, as derived from Mineral and Petroleum Victoria records. Expenditure expressed in current dollars in each financial year have been converted to constant 1996/97 dollars using changes in the consumer price index.

Of the 31 exploration licences in the region, there are many prospects where resources have been identified and exploration has proceeded to more advanced.

Resources have been identified at a number of prospects within the region or just adjacent to it. New Holland Mining NL are currently exploring for gold and base metals at their Hill 800 prospect, about 40 km southeast of Mansfield (Map 2). The Golden Mountain prospect, located in the Hell's Hole gold field, appears to be the most significant known prospect in the region. It lies just inside the study area at the northern end of the Walhalla–Woods Point–Gaffneys Creek–Jamieson gold belt, 45 kilometres north west of Mansfield. Duketon Goldfields NL is conducting a feasibility study for an open cut development of the deposit. Measured, indicated and inferred resources total 1 million tonnes at an average grade of 1.9 g/t. The low grade ore may be amenable to heap leaching.

Mining licence expenditure

In addition to expenditure on exploration licences there has been significant expenditure on mining licences in the North East region, which includes expenditure on further exploration and developmental activities (Table 4), even though no substantial metal mining activity is being undertaken in the North East region. For metallic minerals, and gold in particular, most of this expenditure has been on mining licences which overlie historical workings. The greater part of exploration and development from 1995-96 results from the development of a feldspar mining operation by ACI Limited and subsequent exploration to assess further resources.

Table 4: Expenditure on Mining Licences in the North East region (1996-97 dollars)

Year	Mining licence exploration expenditure (\$)	Mining licence other expenditure (\$)	Total expenditure mining licences (\$)	Number of mining licences
1991-92	499 074	147 742	646 815	3
1992-93	308 962	161 818	470 780	7
1993-94	917 497	243 445	1 160 942	20
1994-95	390 215	1 456 386	1 846 600	28
1995-96	948 305	1 229 771	2 178 076	34
1996-97	7 539 840	8 170 858	15 710 698	36
Totals	10 603 893	11 410 020	22 013 911	Totals

Note: Figures derived from Mineral and Petroleum records. Expenditure expressed in current dollars in each financial year have been converted to constant 1996/97 dollars using changes in the consumer price index.

MINING AND QUARRYING

Quarrying is a major activity in the region, with 25 construction material quarries in operation from which at least \$20.5 million of construction material was extracted in 1994-95 (Maher *et al* 1997).

In addition, the feldspar mining operation and associated mining expenditure outlined above has dominated mining licence expenditure over the last few years. The re-development on a very small scale of old quartz crystal workings for the domestic and international gem market is also planned on two licences in the region, however there are no significant operating metallic mineral mines in the study area.

Sand and hard rock quarries supplying the construction needs of the Albury-Wodonga region and the Hume Highway dominate industrial mineral production in North East Victoria. Most of the quarries in North East region are situated on private land, so are unlikely to be affected by the outcomes of the RFA . Quarries are often located on private land because construction materials in Victoria are owned by the land owner, not (as in the case of minerals) exclusively by the Crown. This provides an incentive for quarry operators to develop their operations on private land.

The quarries located on public land often contain higher valued materials (for example, dimension stone) which are relatively scarce.

ACI Limited

ACI Industrial Minerals is an arm of ACI Limited, the glass manufacturer, and operates a feldspar mine located about 4 kilometres south west of Beechworth. ACI Limited uses the feldspar as a fluxing agent in the fabrication of glass. The Beechworth resource is essentially a granite deposit consisting of two thirds feldspar and one third silica. The value of the domestically produced feldspar to ACI Limited is as a substitute for imported glassmaking minerals. ACI Limited is investigating the feasibility of exporting the mine product, however, transport costs may prove prohibitive (Discovery, February 1998, p. 17).

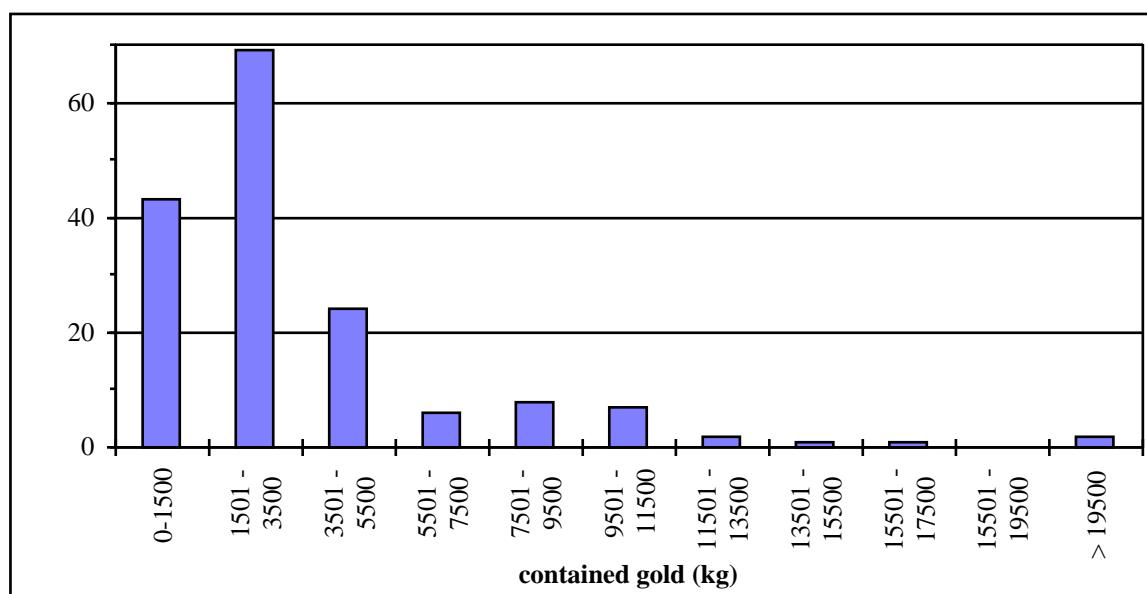
The mine and processing plant, constructed for \$8.5 million, was commissioned in September 1997 and directly employs 5 people full time (Discovery, February 1998, p. 17).

CASE STUDY: SLATE BELT GOLD AND THE NAGAMBIE MINE

While the resource assessment found that the region is prospective for slate belt gold deposits, no assessment was made of the potential number or size of undiscovered slate belt gold deposits that may lie within the North East region. However, the size of identified slate belt gold deposits in Victoria (which contain virtually all the gold mined in Victoria to date) provide an indication of the potential size of undiscovered slate belt gold deposits that may lie within the region.

Of the 163 Victorian slate bed gold deposits surveyed by Bowen (1974), 85 per cent had a total production of between 1000 and 6228 kilograms (Figure 21). The Nagambie mine, which lies just outside the study area and recently closed after production of 4185 kilograms (Register of Australian Mining), provides an example of a gold deposit within this range. Moreover, the Nagambie mine was found close to a small rural town and the history of the Nagambie operation provides a useful insight into the effect that such a mine (if found in the North East region) could have on local towns and regional economies.

Figure 21: Production from slate belt gold deposits in Victoria, 1857–1974



The Nagambie gold deposit was discovered in 1985 by Frank Green of East Union Prospecting (Hughes 1990). Perserverance Corporation acquired the title over the area in 1987 and began a program of drilling to delineate a resource of 7 million tonnes at a 1.2 grams per tonne gold grade using a 0.4 grams per tonne cut off grade (Hughes 1990). Ore was mined from July 1989 until June 1993, however spraying of the heap leach to extract minor amounts of gold continued until March 1997. The mine generated gross revenues of around \$74 million over the eight year mine life. Direct employment and gross revenue flows from the mine over its operating life are shown in Table 6.

Table 6: Gross revenue and direct employment, Nagambie Gold Mine. Real 1995-96 dollars

Year	Gross revenue (\$)	Direct employment (no.)
1989	2 663 377	90
1990	25 129 676	178
1991	18 095 995	105
1992	12 370 433	125
1993	11 155 253	34
1994	3 387 699	32
1995	1 251 428	21
1996	351 320	14

Source: J. Kelly, Perserverance Corporation Ltd, personal communication, February 1997.

Adding to the net economic benefits associated with the rents from production (not calculated in this report), the Nagambie mine also generated considerable indirect benefits which have been detailed by Sinclair (1991):

- It was estimated that the mine resulted in the stimulation of an additional 73 jobs in Victoria and 7.5 jobs within the Nagambie region through indirect employment multiplier effects.
- Perserverance spent \$465 000 on local infrastructure, which included upgrading the electricity relay station and road improvements. These enabled a \$1.5 million mushroom farming business to establish in the area which created eight new jobs in the region. These benefits are in addition to the multiplier effects described above.
- The mine introduced a variety of workers into the region, increasing the diversity and level of skill in the Nagambie region's occupational structure (31 of the mines' employees were new residents to the area). In addition, the population growth in the region was around 4.5 per cent over the period 1989-91 — reversing the previous trend of population decline in the area.

Mines like Nagambie may be temporary (three to ten years life in many cases) but it is apparent that these projects — in addition to bringing economic benefits to the local and wider economies during their operating life — also provide infrastructure and demographic benefits to smaller communities, which can have lasting effects.

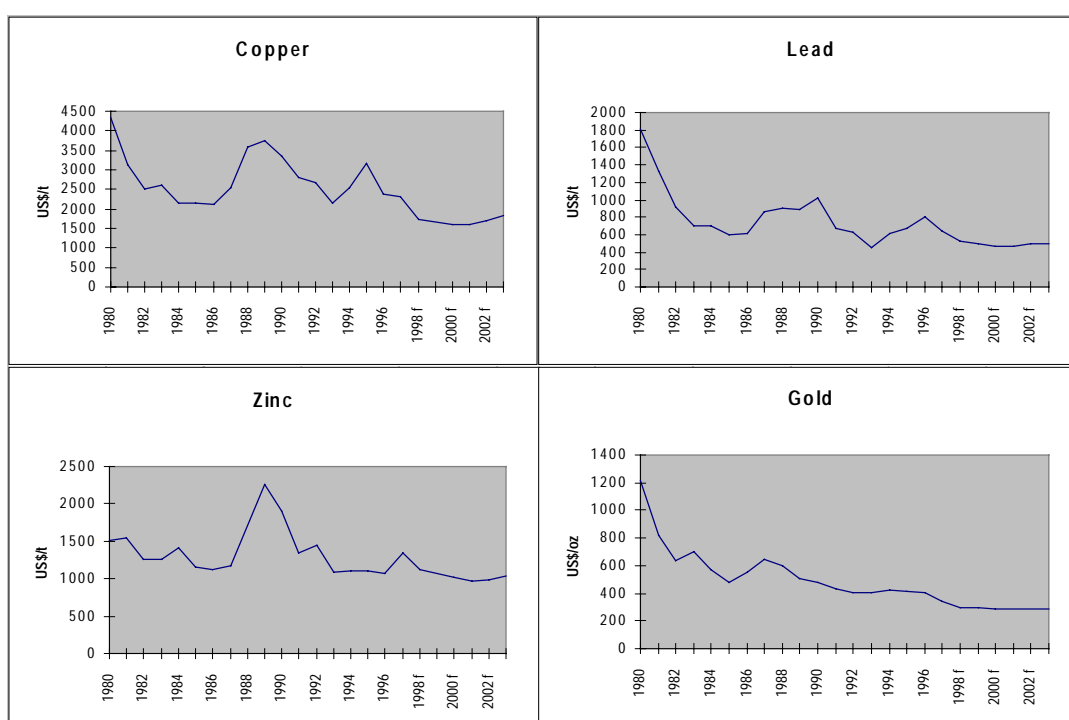
OUTLOOK FOR MINERAL PRODUCTION

Developments in world metals markets will greatly affect development opportunities for the minerals industry in the North East region. The outlook for the gold and base metal markets is reviewed in this section. Detailed market outlook assessments for the medium term are given in Allen and Clarke (1998) and Haine (1998) for gold and base metals, respectively.

GOLD

Historical and projected real gold prices are shown in Figure 20. It can be seen that real gold prices have experienced a clear declining trend since 1980. This trend in price reflected important changes in the structure of the world gold market which are expected to continue into the coming decade. Over this period annual gold consumption (measured by net additions to stock holdings) declined, whilst annual non-investment gold consumption (mainly jewellery) increased. The growth in world consumption of non-investment gold has stemmed mainly from changes in a number of developing economies (notably India and China), as incomes in these countries increased. Although non-investment gold consumption has increased faster than world mine production (tending to increase prices), real prices have been prevented from rising by concurrent sales of investment gold bars and coins (by governments and private investors).

Figure 20 Real base metals and gold prices (1996-97 dollars)



The changing patterns in gold holding and consumption behaviour which underlie the easing real price are expected to continue into the medium term. However, it is envisaged that real price falls will be mitigated by three important market influences. First, the official sector faces strong incentives (collectively) to control the rate at which their extensive holdings of monetary gold are sold (and replaced with higher yielding alternative reserve assets). These incentives stem from the requirements of central banks to maintain international financial stability, and the prospect of faster disposal rates rapidly eroding the prices received and therefore returns from such sales. In addition, recent currency crises may provide encouragement for official purchases in some countries.

Second, demand for non-investment gold use (primarily jewellery) is expected to continue growing strongly, in response to lower gold prices and higher incomes in developing economies which have strong cultural affinities for gold jewellery consumption, notwithstanding shorter-term economic disruption in Asia. Third, downward pressures on price will be moderated to the extent that lower prices bring about slower growth of world gold mine output, although it is clear that the gold mining industry is continuing to lower its costs.

Overall, the forecast for strong world demand for gold is expected to be met by expanding mine supply and from official and investment sources. While periodic market imbalances are likely, particularly some shorter-term price volatility, the easing trend in real prices seen over the past two decades is expected to be maintained at least over the medium term.

BASE METALS

Asia accounted for 27 per cent of world base metals consumption in 1997, compared with 19 per cent in 1980. Japan's share declined marginally in this period, but the share of developing Asian countries more than doubled. However, with the current economic downturn in parts of Asia, the share of developing Asian countries is expected to fall slightly in the short term. Over the medium to longer term, Asia's share of world base metals consumption is projected to increase, reflecting a resumption of relatively fast economic growth in these countries.

The developed market economies, which accounted for around 58 per cent of world base metals consumption in 1997, are assumed to continue to expand. Thus, demand for base metals in these countries is expected to continue to grow. 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 1997. However, consumption levels in these economies are projected to gradually recover in line with increased economic growth rates.

Overall, world consumption of base metals increased by 1.7 per cent in 1997 and is estimated to grow by a further 1.6 per cent in 1998. 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 estimated to rise in 1998. World refinery production of the three base metals is expected to keep pace with increases in mine 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 2000 as low cost mines, primarily copper mines in Chile and zinc and lead mines in Australia, commence production. However, these rises are expected to be partially offset by the closure of some older, high cost, producers which are likely to become uneconomic with projected lower prices, particularly for copper.

Over the longer term, continuing technological developments can be expected to place downward pressure on costs. Thus, together with projected demand growth, the long term downward trend in real prices experienced for each of the base metals is expected to continue. Price projections to 2003 are shown in Figure 20.

LEGISLATION AND LAND ACCESS

Access to land is an important issue for exploration and mining. The implications of the RFA for exploration and mining in the North East region are not yet known.

It is important to note that no area can ever be classified as unproductive and no assessment of potential mineral resources can ever be considered 'final'. New information, new concepts and better understanding of geological processes continually change the perceived prospectivity of a region and the availability, usefulness and implication of these can change over time. There are also dynamic aspects to market information that will affect perceptions of a region's prospectivity, for example mineral prices and extraction costs may change substantially over time.

The nature of access for mineral exploration and mining has a large bearing on the level, and type of exploration and mining that occurs in a region. Transparent and well-defined access

arrangements reduce uncertainty and facilitate exploration and mining activities. Access provisions of relevant legislation are outlined below.

More detailed discussions of resource access issues relating to exploration, mining and environment can be found in Industry Commission (1991), Cox, Beil and Waring (1994) and in Murray, Cox and Allen (1995).

LEGISLATION AND REGULATION RELEVANT TO EXPLORATION, MINING AND EXTRACTIVES

In Australia ownership of mineral resources and control of mineral exploration and development largely lies in the hands of the state and territory governments. The Commonwealth government has control over mining and exploration activities outside three nautical miles offshore and over radioactive substances in the Northern Territory. It also exercises its constitutional powers to exert control over the way states and territories access and use their mineral resources.

The principal legislation covering mining and exploration licences in Victoria is the *Mineral Resources Development Act 1990* (MRDA) which was amended in 1993 and 1994. This Act is the responsibility of the Minister for Agriculture and Resources and is administered by the Victorian Department of Natural Resources and Environment. It sets out the rules for granting licences and attaining approval to start operations.

All exploration and mining activities are subject to a range of environmental requirements before, during and after the life of the project, including:

- lodging a rehabilitation bond, before starting an exploration or mining program, to serve as a security should the company be unable to satisfy its rehabilitation liability,
- exploration and mining is subject to standard conditions, and where appropriate supplementary site-specific conditions,
- regular reporting of exploration activities,
- mining and exploration only starting after a work plan has been approved and other approvals obtained, and
- monitoring of environmental management activities by government officers.

Under the MRDA there are four main land types:

- private land,
- exempt Crown land (for example, National Parks, State Parks and Wilderness Areas),
- restricted Crown land (for example, flora and fauna reserves and historic reserves), and
- unrestricted Crown land (for example State forests).

No exploration or mining activities can be carried out on exempt Crown land, unless the licence was in place before the land became exempt. The approval of the Minister for Conservation and Land Management is required before exploration or mining can be carried out on restricted Crown land. On unrestricted Crown land the Minister for Conservation and Land Management's consent is not required, however the Minister must be consulted. Work can start on private land once the consent of the owner and occupier is obtained or compensation arrangements are made.

The principal legislation covering extractive industries in Victoria is the *Extractive Industry Development Act 1996* (EIDA), which provides for granting work authorities for extractive operations. The four main land types under the EIDA are the same as those in the MRDA. Land owner consent is required before extractive activities can be undertaken on freehold land and land manager consent for operations on Crown land.

Mining and exploration is currently excluded from approximately 15 per cent of the land in the North East region (Table 5). The consent of the Minister for Conservation and Land Management is required for exploration and mining to be carried out on restricted Crown land which is around four per cent of the region.

Table 5: Land use categories as a proportion of total land area, North East Region

Land use category	Area (ha)	Proportion of the North East Region (%)
Exempt Crown land	342 750	15
Restricted Crown land	93 300	4
Unrestricted Crown land	818 000	35
Freehold land	1 064 100	46
Totals	2 318 150	100

Source: NRE, Victoria.

NATURE OF EXPLORATION AND MINING

Mineral exploration is the assessment of the earth's crust to determine if mineral deposits which can be commercially mined are present. Mining is the commercial extraction of mineral deposits from the earth's crust. Whilst there is often a close relationship between exploration and mining, they are effectively two quite separate activities.

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

The potential benefits for a private firm from an exploration program derive from the economic returns that will accrue from the discovery of an economic deposit. Given that 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 an efficient manner.

The cost and duration of exploration programs vary from company to company and across commodities. Clark (1996) suggested that the development of a typical major deposit (worldwide) involves a five to twenty year lead time. This estimate results from a typical three to ten years exploration program before the mine development phase.

Exploration is primarily an information gathering process so it is necessarily dynamic, and 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 for continuing exploration 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 (eg in highly prospective areas such as Kanowna Belle in Yilgarn, WA and Century in the Mount Isa Inlier, Qld or in areas not previously known to be of very high potential eg Olympic Dam on Stuart Shelf, SA). Further, changing economic conditions (for example, changes in metal prices or the costs of extraction) affect the expected returns from exploration and can significantly affect the level and type of exploration.

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, drilling), unless special steps are taken to reduce such impacts.

Exploration methods used in the North East region include:

- Regional reconnaissance using remote sensing techniques such as satellite imagery, aerial photography and regional mapping. This exploration phase has little, if any, impact on the land. Activities may cover hundreds of square kilometres in order to identify areas of exploration interest. Geological mapping involves the search for and examination of rock outcrops and exposures in a licence area.
- Sampling in the field which usually involves taking small rock chip, soil or stream sediment samples. Samples are typically obtained by shovel, hand auger or hammer. More intensive sampling and localised mapping may also be carried out using trenches or small pits. All of the above may occur on a surveyed grid.
- Geophysics uses a range of techniques to look for anomalous physical properties indicating structures or mineralisation not visible at the surface. The geophysical properties being assessed include magnetism, electrical conductivity, resistivity or capacitance; gravity; natural radioactivity or seismic properties. Surveys can be airborne for regional surveys, or ground based. The impact of ground-based survey is generally very low, but will vary depending upon the extent of grid and track development required.

The above methods are broadscale in scope and provide information that builds up a picture of where mineralisation is most likely to occur. The most economical way to assess in detail the possible presence of an ore body is by drilling, which may be supplemented by bulk sampling:

- Drilling is usually carried out by truck mounted equipment to yield samples for mineralogical, chemical or metallurgical analysis. Drill holes are usually around 10 cm in diameter. Follow-up-drilling may be required should earlier drilling show positive results. The impact of drilling on the environment depends on the openness of the vegetation and the topography. Usually drilling rigs are able to be manoeuvred around trees or the drill hole relocated to avoid disturbance of trees. A small level pad, typically around 6 metres square, may need to be constructed to accommodate the drilling rig.
- Bulk sampling gives another level of confidence in the drilling results particularly when gold is not evenly dispersed throughout the ore and coarsely grained. The 'nugget-effect' can give rise to misleading reserve assessments and large samples are needed to overcome it. Bulk samples are usually excavated from a site, typically less than 5 metres deep and 10 metres square.

Rehabilitation of areas disturbed by exploration is required in Victoria.

Compared with exploration, mining generally covers relatively small areas 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 seen as posing greater difficulties in terms of compatibility with other land uses.

Many potential environmental effects of mining activities can be eliminated or mitigated, though at a cost to the mining company. Relatively limited areas of land are disturbed by the operation of a mine. However, off-site impacts such as water pollution may represent a potential threat to the environment and must be carefully managed. This can be controlled by using techniques such as impoundment and evaporation of tailings, sedimentation, filtration and pH neutralisation. Rehabilitation of mine sites is mandatory in Victoria. Modern site rehabilitation, at the completion of operations, can restore many of the features of the landscape that existed before mining began, substantially, replacing and assisting the re-establishment of vegetation and reducing the potential for pollution from the former mine site.

All mining projects in Victoria require approval under local government planning controls or by preparation of an Environmental Effects Statement. Both processes provide for public input and independent scrutiny of projects. Detailed assessments of impacts on natural values is a routine aspect of mining approvals. Such assessments may include impacts on flora and fauna, water supply, catchment management and public safety.

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Table 7 Resources in gold deposits of the North East region

Map2 Gold -field Locn <i>/Min. Occur. Locn</i>	GOLDFIELD Mine/prospect	MATERIAL (tonnes)	GRADE (g/t)	GOLD (kg)	AS AT:	SOURCE
16,17 96	BEECHWORTH- MYRTLEFORD Homeward Bound Indicated Includes: Proved	 306,000 156,000	 15.2 25	 4651	 30/11/1990 30/11/1990	 MINMET (1998) MINMET (1998)
30 148	BRIGHT- WANDILIGONG Sambas mine Proved	 10,000	 30	 300	 9/8/1989	 MINMET (1998)
120	Williams United	25,000	18	450	28/10/1987	MINMET (1998)
32 134 - 135	MOUNT WILLS Glen Wills- Sunnyside (United Brothers mine - Maude & Yellow Girl mine) Indicated Inferred Tailings/Dumps Measured Indicated	 16,000 140,000 113,000 107,000	 9.8 12.7 2.6 5.3	 157 1,778 294 567	 30/6/1997 30/6/1997 30/6/1997 30/6/1997	 Austn. Goldfields NL (1997) Austn. Goldfields NL (1997) Austn. Goldfields NL (1997) Austn. Goldfields NL (1997)
35	HELLS HOLE Golden Mountain Measured Indicated Inferred	 556,250 155,000 291,750	 1.8 2.1 2.1	 1001 326 613	 31/12/1997 31/12/1997 31/12/1997	 Duketon Goldfields NL (1997) Duketon Goldfields NL (1997) Duketon Goldfields NL (1997)
39 200	HOWQUA Great Rand mine	 215,000	 6	 1290	 24/6/1994	 Transkal Gold NL (1994)
41 304	GAFFNEYS CREEK – WOODS POINT (mainly outside NE Victoria region) Morning Star mine (just to SW of NE Victoria region) Surface/near surface Measured incl. Proved	 630,000 106,000	 1.9 2.4	 1197	 18/7/1997 18/7/1997	 Mt Conqueror Minerals (1997) Mt Conqueror Minerals (1997)

Map2 Gold -field Locn <i>Min. Occur. Locn</i>	GOLDFIELD Mine/prospect	MATERIAL (tonnes)	GRADE (g/t)	GOLD (kg)	AS AT:	SOURCE
305	Indicated	792,800	2.2	1744.16	18/7/1997	Mt Conqueror Minerals (1997)
	Inferred	599,800	2.2	1319.56	18/7/1997	Mt Conqueror Minerals (1997)
	Underground					
	Measured	194,000	7.2	1396.8	18/7/1997	Mt Conqueror Minerals (1997)
	incl. Proved	69,000	11.6		18/7/1997	Mt Conqueror Minerals (1997)
	Indicated	164,000	7.3	1197.2	18/7/1997	Mt Conqueror Minerals (1997)
	Inferred	819,000	3.9	3194.1	18/7/1997	Mt Conqueror Minerals (1997)
	A1 Mine					
	Inferred	25,000	15.3	383	1993	Broken Hill Holdings (1993)
	Inferred	414,000	4.3	1,780	1993	Broken Hill Holdings (1993)
	Inferred	150,000	na	na	1993	Broken Hill Holdings (1993)
	"Pre-resource"	60,000	na	na	1993	Broken Hill Holdings (1993)

Table 8 Recorded past gold production from goldfields, tinfields and gold deposits of North East region (after Oppy *et al* 1995, Table 7; Maher *et al* 1997; other sources as indicated)

Map 2 Gold -field Locn/ <i>Min. Occur. Locn</i>	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
207	Nagambie			4,176	1989-1997	Register of Australian Mining 1991/92 to 1996/97
1	CHILTERN – RUTHERGLEN (mainly within NE Victoria region)					
	Alluvial deep lead deposits					
	Barambogie Lead			1228	1894-1902	
	Chiltern Valley Lead			9,919	1870-1920	
	Prentice Lead			31,903	1888-1916	
	Primary			2,893	1864-1996	
	Incl. Magenta		14.0	307		
	Golden Bar		16.4	387		
	Residual			23	1864-1996	
2	BETHANGA – TALGARNO (mainly within NE Victoria region)					
	Alluvial					
	Incl. Unknown Alluvial #1894-96			3.7	1894-1896	

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
	Unknown Alluvial #1903			3.2	1903	
	Primary					
	Incl. Bethanga Line Reef	580	48.7	28.3	1877-1879	
	Empress of India Line	1580	33.7	53.2	1876-1879	
	Excelsior Line	3184	17.5	55.7	1876-1886	
	Gift Line	1885	31.9	60.1	1877-1890	
	Bethanga Goldfields	47442+		2176.2	1895-1905	
	New Bethanga GM	8595	16.7	143.9	1907-1911	
	Public Crushing Co.	4623	27.1	125.3	1876-1877	
	TOP 7 PRIMARY GOLD PRODUCERS:	67889+		2642.7	1876-1911	
	GOLDFIELD TOTAL:	75544+		2909.8	1876-1910	
3	MOUNT ALFRED - WALWA TINFIELD					
4, 6, 7, 8	KOETONG NORTH TINFIELD					
5	GRANYA FIELD					
	Border City Reef	2432	21.4	52.0	1882-1911	
	Bungil Reef	3933	15.4	60.4	1879-1900	
	Endeavour Reef	685	32.4	22.2	1880-1881	
	Granya Reef	18377	20.2	371.8	1881-1909	
	Mt. Firebrace Reef/Dyke	6462	6.8	43.8	1879-1948	
	TOP 5 PRODUCERS	31890	17.3	550.2	1879-1948	
	GOLDFIELD TOTAL	50156	20.3	1015.9	1878-1948	
9	CUDGEWA CREEK					
10	MT ELLIOT - CORRYONG					
	Alluvial					
	Incl. Aust. Tin Mining Co.			2.0	1913-1914	
	Unknown Alluv #1889-1915 (incl. Thowgla Creek)			101.1	1889-1915	
	Primary					
	Incl. Fenby's Reward Reef	393	47.5	18.7	1897-1911	
	Hopeful Corryong View	414	49.0	20.3	1897-1912	
	Just in Time Reef	292	66.7	19.4	1897-1909	
	Mt. Elliot Mine	2397	26.8	64.3	1903-1910	
	New Chum Reef/Dyke	761	162.3	123.5	1892?-1911	
	TOP 5 PRIMARY GOLD PRODUCERS	4256	57.8	246.2	1897-1912	
	GOLDFIELD TOTAL	6339	88.1	558.5	1884?-1916	

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
11,12, 13	KOETONG SOUTH TINFIELD					
14	JARVIS CREEK					
	Golden Ball Reef/Dyke	301	11.1	3.3	1877-1878	
	GOLDFIELD TOTAL	418	17.4	7.2	1877-1907	
15	HUON HILL					
16,17	BEECHWORTH- MYRTLEFORD					
	Alluvial			11,906		
	Incl. Eldorado Lead			6,995	1858-1955	
	Wooragee Lead			341	1907-1917	
	Baarmutha Lead			668	1904-1946	
	Rocky Mountain Lead			1,404	1877-1921	
	Woolshed Valley Lead			375	1905-1911	
	Myrtleford			377	1907-1920	
	Primary			3,806		
	Incl. Happy Valley		29.2	1003		
	Homeward Bound mine		21	950	1865-1880	
	Residual			52		
18	SANDY CREEK					
	Alluvial					
	Sandy Creek			25.7	1891-1915	
	Primary					
	A1 Odell's Mine	4	1005.8	3.7	1891-1892	
	Conner's Reef	203	77.6	15.8	?<1888	
	Grasshopper Reef/Dyke	2746	30.4	83.4	?1904-1905	
	Honeysuckle Reef/Dyke	459	15.4	7.1	1904	
	Morning Star Reef	0		38.9	?<1898	
	TOP 5 PRODUCERS	3413	43.6	148.8	1891-1905	
	GOLDFIELD TOTAL	3429	44.8	153.7	1891-1905	
19,20	MOUNT CUDGEWA TINFIELD					
21	THOWGLA CREEK	77	20.3	1.6	1897-1911	

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
22	BUNROY CREEK					
23	MITTA MITTA Alluvial Mammoth HG Sluicing (Granite Flat Goldfield) Union & Pioneer Claims Unknown Alluvial #1889-1915 Buffalo Hydraulic Sluicing R. Enever T. Enever Eskdale Dredging Goid Placers La Fontaine Mitta Mitta Bucket Dredging Primary Double Knock Mine Dream Reef Golden Star Mine Highland Chief Reef/Mine Iona Mine Premier Mine Swan's Reef Tallandoon Reef/Mine Incl. Granite Flat Field Empress of India Mine Goldfield Total Incl. Lightning Creek Field Snowy Creek Mine Goldfield Total TOP 10 PRODUCERS GOLDFIELD TOTAL			8.4 441.2 305.6 33.9 17.2 4.4 2.3 0.8 16.5 167.2 143 1652 3656 464 316 1384 1160 1086 2130 3072 574 582 12565 33519	1887-1888 1860-1913 1889-1915 ?-1900 1907-1913 1909-1910 1912-1913 1904 1906-1916 1907-1913 1906-1914 ?<1898 1907-1914 1897-1903 1933-1945 1899-1912 ?<1898 1897-1900 1876-1884 1876-1934 1916-1934 ? 1897-1945 1876-1950	
24	DART RIVER – ZULU CREEK Alluvial Unknown Alluvial #1889-1905 Primary Incl. Dark River Reef La Mascotte Mine Mountain View Mine Young Australian Reef	814 954 949 294	21.1 44.5 27.5 39.6	17.2 42.5 26.1 11.6	1885-1889 1883-1888 1885-1934 1884-1904	

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
25	Incl. Lower Dart Field					
	Clara Reef	152	24.7	3.8	1884-1887	
	Morning Star Reef	410	20.2	8.3	1883-1884	
	Pioneer Mine	266	25.1	6.7	1884-1886	
	Dart River Primary Gold Total	1592	26.4	42.0	1881-1887	
	Incl. Zulu Field					
	Albion Reef	352	22.6	8.0	1881-1885	
	Just-in-Time Lode	144	53.7	7.7	1881-1882	
	Native Youth Reef	241	40.4	9.7	1882-1885	
	(Prince) Leopold Reef	464	47.2	21.9	1881-1890	
	Wild Boar Mine	297	37.3	11.1	1884-1886	
	Zulu Primary Gold Total	2588	38.1	98.7	1881-1890	
	TOP 12 PRIMARY GOLD PRODUCERS	5548	33.4	185.2	1881-1904	
	GOLDFIELD TOTAL	7882	59.6	470.0	1881-1934	
	GIBBO RIVER					
	(mainly within NE Victoria region)					
	Alluvial					
	Agamemnon Gold Sluicing Co.			0.5	1904	
	Primary					
	Saltpetre United Co.	314	13.3	4.2	1889	
	GOLDFIELD TOTAL	314	13.3	4.2	1889	
	KIEWA RIVER/RUNNING CREEK (TAWONGA)					
	Tawonga Gold Mine	2602	7.2	18.7	1949-1952	
	GOLDFIELD TOTAL	3015	7.0	21.1	1884?-1951	
	BENALLA					
	TOOMBULLUP					
	BRIGHT-WANDILIGONG-HARRIETVILLE & BUCKLAND					
	Alluvial (dredging/sluicing)					
	Buckland		0.17	2,749	1902-1920	
	Incl. Altona	1 890	0.15	276	1915-17	

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
	Buckland River	3 340	0.20	670	1902–20	
	Buckland River South	1 370	0.22	301	1903–14	
	Buckland Star	2 600	0.08	225	1909–16	
	Kia Ora No.1	1,970	0.14	271	1906–13	
	Kia Ora No.2	2,190	0.16	351	1906–16	
	Phoenix	2 740	0.21	655	1903–19	
	Bright-Wandiligong				1902-1921	
	Incl. Enterprise	2,960	0.16	470	1905–14	
	Junction No.1	2,200	0.15	332	1906–15	
	Junction No.2	>2,450	0.16	536	1906–21	
	Morses Creek	1,650	0.27	443	1905–07	
	Ovens Valley	>2,790	0.17	568	1903–06	
	Perserverance	-	-	603	1902–11	
	Porepunkal	>2,560	0.09	412	1908–20	
	Smoko	-	-	475	1906–16	
	Primary			10,797		
	Buckland					
	Incl. Red Jacket		40.7	245		
	Alta		38.3	102		
	Bright-Wandiligong					
	Oriental		14.4	1829		
	London & Myrtle		36.7 & 18.1	673		
	Williams United		?	284		
	Biplane Reef/Mine	6924	117.0	16.9	1920-1925	
	Crescent Reef/Mine	8128	186.6	23.0	1890-1899	
	Jackass Reef/Mine	1826	188.5	103.2	1878-1889	
	Johnson Reef/Mine	18537	207.3	11.2	1867-1914	
	Monarch Reef/Mine	3300	129.5	39.3	?1901- 1916	
	Mons Meg Reef/Mine	4349	266.7	61.3	1880-1926	
	Red Robin Mine	4009	210.3	52.5	1940- 92/93	
	Rose,Thistle & Shamrock Mine	119175	2422.1	20.3	1861-1933	
	Sambas Reef/Mine	41781	1377.1	33.0	1910- 91/92	
	United Miners Reef	33908	611.9	18.0	1867-1884	
	Birthday Reef/Mine	2976	58.9	19.8	1876-1881	
	Blowfly Reef	687	51.7	75.2	1879-1891	
	Ebenezer Reef/Mine	2069	87.3	42.2	1861-1877	
	Elgin Reef/Mine	487	153.6	315.7	1860-1865	

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
31	English & Welsh Reef	4135	106.0	25.6	1872-1881	
	Hillsborough Reef/Mine	12987	309.6	23.8	1873-1904	
	New Moon Reef	1382	52.0	37.6	1869-1871	
	Richardson Reef/Mine	3117	217.7	69.8	1860-1872	
	Try Again Reef/Mine	8288	192.7	23.3	1870-1911	
	Wallaby Reef/Mine	7186	198.4	27.6	1868-1872	
	Cornish Reef/Mine	1485	52.2	35.1	1860-1884	
	Hibernian Reef/Mine	377	18.7	49.7	1860-1876	
	Homeward Bound Reef	12802	183.7	14.4	1870-1877	
	Magpie Reef/Mine	5966	184.6	30.9	1871-1906	
	Mt. Orient Reef/Mine	9605	203.1	21.1	1879-1925	
	Reliance Reef/Mine	6661	144.2	21.6	1860-1879	
	Smoko Reef/Dyke	445	18.2	40.9	1870-1900	
	Sultana Reef	660	13.6	20.6	1867-1877	
	Victoria Reef	1512	73.0	48.3	1861-1885	
	Woolshed Reef/Mine	2378	97.8	41.1	1861-1916	
	Residual			179		
	BIG RIVER					
	32 MT. WILLS (mainly within NE Victoria region)					
	Alluvial					
	Neptune Hydraulic Sluicing			29.8	1900-1907	
	Cooper			0.2	1955	
	Primary					
	Antiope workings	6107	46.5	284.0	?1898-1918	
	Democrat Reef	14281	45.8	653.7	1895-1912	
	Gentle Annie Mine	1740	140.8	245.0	1896-1915	
	Livingstone Reef/Tunnel	4052	50.3	203.8	1893-1924	
	Maude & Homeward Bound Mine	27722	30.6	847.5	1899-1911	
	Maude and Yellow Girl Mine	179409	14.3	2573.8	1932-1968	
	Maude Reef	10794	36.4	392.9	?1895-1923	
	Meerscham Mine	3555	91.8	326.5	1897-1915	
	United Bros. Reef/ mine	52835	20.1	1059.4	1892?-1904	
	Yellow Girl Mine	4118	93.4	384.7	1903-1915	
	TOP 10 PRODUCERS	304613	22.9	6971.3	1892-1968	
	GOLDFIELD TOTAL	318445	24.6	7840.8	1892-1968	
33	MOUNT FAINTER					

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
34	BUCKLAND RIVER					
35 & 36	HELLS HOLE(TALLANGALOOK) & MERTON Alluvial Devil's River Primary Golden Mountain Woolf's Mine Bonnie Doon Mine		na 2.5	4356 na 354 96	1857 - ? 1887-90 1857 - ? "	O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992)
37	GHIN GHIN GOLDFIELD Alluvial gold City of Melbourne Red Line Providence Mc Leish's Reef		na 62 to 93 62 to 93 62 to 93 8	na na na na na	1867 - ? " " " "	O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992)
38	DELATITE RIVER					
39	HOWQUA GOLDFIELD & HOWQUA RIVER CHROMIUM FIELD Great Rand & Howqua United mines	300 – 1,000	Up to 30		1860's- 1880s 1863- late 1880's	Transkal Gold NL (1994)
40	COBUNGRA RIVER (partly within NE Victoria region)					
41	WOODS POINT/WALHALLA GOLD SUB PROVINCE (mostly outside North East region): Gaffney's Creek Goldfield (just SW of NE Vic region) A1 Mine Rose of Denmark Mine Woods Point Goldfield (just SW of NE Vic region) Morning Star Mine BB Quartz Mine United Gleesons Mine		25 26 12 31 24.5 26.4 na	15,552 13,000 1,831 31,103 27,371 55 880	1857-1992 since 1863 na na na na	Noble Resources NL (1994) O'Shea <i>et al</i> (1992) <u>grade</u> : Bowen (1974) Alcaston Mining NL (1994) Mt Conqueror Minerals (1994) Fethers G (1996) O'Shea <i>et al</i> (1992)

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
42	YEA (mainly outside NE Victoria region) Alluvial gold Providence Reef Flat Lead Constitution Hill Boundary Creek Carriers Lead		na 28 7.8 to 41.5 na na na na	na 198 na na na na	1851 - ? 1859 - ? " " " "	O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992)
43	MANGALORE (mainly outside NE Victoria region)					
44	INDI RIVER (adjacent to NE Victoria region)					
45	BUCKWONG CREEK & DINNER CREEK (adjacent to NE Victoria region)					
46	CROOKED RIVER/GRANT/HIGH PLAINS (adjacent to NE Victoria region)					
47	BLACK RIVER (adjacent to NE Victoria region) Wye's Creek Reef Standard Reef New Standard Reef Golden Fleece Reef Weber's Reef		9 to 620 na na na -	na na na na na	1866 - ? " " " "	O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992)
48	JERUSALEM CREEK (adjacent to NE Victoria region) Alluvial gold		na	na	1871 - ?	O'Shea <i>et al</i> (1992)
49	SNOBS CREEK – THORNTON (adjacent to NE Victoria region) Alluvial gold Thornton Mine		na na	na na	1854 - ? 1868 - ?	O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992)
50	ALEXANDRA/GOBUR – GODFREYS CREEK (adjacent to NE Victoria region) Galatea Mine Gemba Mine Strathmore Mine		83 54 na	10.5 0.8 na	1870-74 na 1866 - ?	O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992) O'Shea <i>et al</i> (1992)

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
51	TEA TREE CREEK (adjacent to NE Victoria region) Alluvial gold		na	na	1860 - ?	O'Shea <i>et al</i> (1992)
	Welcome Mine		27	218	1859 - ?	O'Shea <i>et al</i> (1992)
	Jonien's Reef		62 to 155	na	"	O'Shea <i>et al</i> (1992)
	Enniskillen Reef		62 to 155	na	"	O'Shea <i>et al</i> (1992)
	Dunrobin Reef		62 to 155	na	"	O'Shea <i>et al</i> (1992)
	German Jack's Reef		62 to 155	na	"	O'Shea <i>et al</i> (1992)
	Old Man's Mine		8 to 16	na	"	O'Shea <i>et al</i> (1992)
52	KING PARROT CREEK (adjacent to NE Victoria region) Alluvial gold		na	na	1851 - ?	O'Shea <i>et al</i> (1992)
	Fortune's Mine		31	0.2	"	O'Shea <i>et al</i> (1992)
	Matthew's Mine		6 to 15	na	"	O'Shea <i>et al</i> (1992)
	Timm's Reef		39 to 55	na	1864 - ?	O'Shea <i>et al</i> (1992)
	Gibb's Reef		na	na	"	O'Shea <i>et al</i> (1992)
	King's Reef		na	na	"	O'Shea <i>et al</i> (1992)
53	THE TRIANGLES (adjacent to NE Victoria region) Triangle Reefs		na	na	1859 - ?	O'Shea <i>et al</i> (1992)
54	STRATH CREEK (adjacent to NE Victoria region) Alluvial gold		na	na	1851 - ?	O'Shea <i>et al</i> (1992)
	Sailor's Jack Reef		32 to 210	na	1859 - ?	O'Shea <i>et al</i> (1992)
	Don Maurice Mine		3 to 180	na	"	O'Shea <i>et al</i> (1992)
55	REEDY CREEK (adjacent to NE Victoria region) Alluvial gold		na	na	1856 - ?	O'Shea <i>et al</i> (1992)
	Prince of Wales Reef		65	5.6	1881-1909	O'Shea <i>et al</i> (1992)
	Empress Reef		na	na	"	O'Shea <i>et al</i> (1992)
	Kaiser Reef		na	na	"	O'Shea <i>et al</i> (1992)
	Evening Star Reef		na	na	"	O'Shea <i>et al</i> (1992)
	Langridge Reef		na	na	"	O'Shea <i>et al</i> (1992)
	Crown Reef		na	na	"	O'Shea <i>et al</i> (1992)
	Doyles Reef		na	na	"	O'Shea <i>et al</i> (1992)
	Tonsil Mine		na	3 to 31	"	O'Shea <i>et al</i> (1992)
	Leviathan Mine		na	3 to 31	"	O'Shea <i>et al</i> (1992)

Map 2 Gold -field Locn/ Min. Occur. Locn	GOLDFIELD Mine/prospect	ORE (tonnes)	GRADE (g/t)	GOLD (kg)	PERIOD	OTHER SOURCE
56	MITCHELLSTOWN (adjacent to NE Victoria region)					
57	NAGAMBIE (adjacent to NE Victoria region)					
58	TAMLEUGH (adjacent to NE Victoria region)					
59	HONEYSUCKLE CREEK (adjacent to NE Victoria region)					
	MISCELLANEOUS					
	Angler's Rest Field: Leviathan Reef	505	15.3	7.7	1903	
	Gentle Annie Field: Mt. Onslow Reef	-		62.2	?<1907	
	Wombat Creek			2.1	1932	
	Wombat Hyd. Sluicing Co.			2.1	1932	

Table 9 Other mineral resources of the North East region

Map2 Minera I Occur. Locn	MINE/QUARRY/ PROSPECT	MATERIAL (tonnes)	GRADE	CONT- AINED COMM- ODITY	AS AT:	SOURCE
3	Walwa Tin-Tantalite prospect Inferred	6,800,000	0.19% tin 60g/t tantalite	12,920 tonnes tin 408 tonnes tantalite	13/11/1985 13/11/1985	MINMET (1998) MINMET (1998)
10	Pine Mountain mine	75 000	100% CaF ₂	75 000 fluorite	1974	Oppy <i>et al</i> (1995) p95

Table 10 Recorded tin production of the North East region (after Nott 1988)

Map2 Locn	TINFIELD/OCCURRENCE	TIN CONCENTRATE (tonnes)	PERIOD
16,17 4,6,7, 8,11, 12,13 3 32 1 19,20 23 1 3	TINFIELD:		
	Beechworth-Eldorado	9180	1854-1979
	Koetong	192	1872-1964
	Walwa	164.3	1882-1968
	Mt. Wills	158	1890-1914
	Chiltern	80	1873-1920
	Mt. Cudgewa	66.9	1873-1919
	Mitta Mitta	33.9	1910-1929
	Rutherglen	28.2	1906-1917
	Mt. Alfred	N/A	1881-1882
	MINERAL OCCURRENCE:		
77	Surveyor's Creek	20	1913-1918
6	Burrowye	2.4	1924-1936
	Falls Creek	N/A	1890-1900
	TOTAL	9925.7	1854-1979

Table 11: Recorded copper production for the major gold mines of Bethanga goldfield (Map2, goldfield no.2)

MINE/PROSPECT	PRODUCTION		PERIOD
	ORE (tonnes)	CONC. (tonnes)	
Bethanga Goldfields	?	25	1903
New Bethanga Gold Mine	2647	72	1907-1908
Various #1880-1882	?	90	1880-1882
Wallace-Bethanga Co.	?	196	1883-1895
TOTAL	?	383	1880-1908

Table 12: Gem and semi-precious gemstone occurrences of the North East region

Locality	Agate	Amethyst	Chalcedony	Chert	Corundum	Diamond	Emerald
Beechworth	X	X	X		X	X	
Chiltern		X				X	
Tatong/Toombullup				X	X		X
Glenrowan/ Taminick/Greta	X			X			
Locality	Garnet	Jasper	Quartz	Sapphire	Topaz	Tourmaline	Zircon
Beechworth	X	X	X	X	X	X	X
Chiltern	X		X	X	X		X
Tatong/Toombullup		X		X	X	X	X
Glenrowan/ Taminick/Greta			X				

Source: McHaffie and Buckley (1995).

**Table 13 Mineral occurrences, old mines and deposits of the North East region
(see Map 2)**

Locn No.	Name	Easting	Northing	Commodity
1	WOMOBI	538208	6018695	FL
2	WOMOBI WOLFRAM	538200	6018700	W, BI, CU, F
3	WALWA TIN	563900	6020900	SN
4	UNNAMED REEF	569500	6017200	W
5	WALWA	570800	6016400	BA
6	BURROWYE TIN	551400	6014800	SN
7	FLAGGY CREEK	541700	6012600	SN
8	SANDY CREEK	570200	6013200	FL
9	PINE MOUNTAIN - GRANITE	574300	6013400	GR (DST)
10	PINE MOUNTAIN	575500	6009600	FL, PB, AG,
11	UNNAMED NO. 2 REEF	548700	6009700	W
12	UNNAMED NO. 2 REEF	548700	6009700	W
13	UNNAMED NO. 3 REEF	549300	6009500	W
14	UNNAMED NO. 4 REEF	549900	6009700	W
15	UNNAMED NO. 4 REEF	549900	6009700	W
16	UNNAMED NO. 5 REEF	550000	6009300	W
17	PLEASANT CREEK	534300	6009100	SN
18	JIMMEYS CREEK	543300	6007100	SN
19	UNNAMED NO. 6 REEF	540300	6006500	W
20	UNNAMED NO. 6 REEF	540300	6006500	W
21	KOETONG CREEK	538500	6004600	FS, BI
22	UNNAMED CREEK	543100	6005300	SN
23	ROPER'S REEF	544200	6004900	SN, W
24	MCINTRYE REEF	544300	6005000	SN
25	ROPER'S AND O'DOUGHLIN'S REEF	544400	6005000	SN, W
26	KEADY'S REEF	544300	6004500	W, SN
27	FIREBRACE CREEK	529300	6001300	AU
28	JUMPING MOSES REEF	521400	6003300	AU
29	MOUNT LADY FRANKLIN	475600	6003800	FS
30	UNNAMED LEAD	490600	6002300	AU
31	HUON HILL	493200	6001400	FS
32	KOOKABURRA CREEK	478600	6001800	FS

Locn No.	Name	Easting	Northing	Commodity
33	UNNAMED REEF	483300	6001200	AU
34	UNNAMED REEF	483020	6001110	AU
35	UNNAMED REEF	483290	6000990	AU
36	GOLDEN EAGLE MINE	475470	6001370	AU
37	INDIGO CREEK WOLFRAM MINE	474600	6001200	AU W
38	WOLFRAM	471390	5997350	W
39	UNNAMED REEF	475620	5995120	AU
40	INDIGO PIONEER MINE	475770	5994700	AU
41	UNNAMED REEF	476020	5994550	AU
42	UNNAMED LIMONITE DEPOSIT	477220	5992980	FE
43	BEECHWORTH-HOMEWARD BOUND	484788	5989205	AU
44	TALLANGATTA	520100	5991400	FS, BI
45	DARBYSHIRE SIDING	536074	5999548	FS
46	KOETONG CREEK UPPER	544200	5998600	SN
47	MILDERN'S NO.2. REEF	539400	5997100	AU, SN, W
48	MILDERN'S NO.1. REEF	540100	5996600	SN, W
49	MILDERN'S NO.3. REEF	540000	5995400	AU, SN, W
50	UNKNOWN ALLUVIAL	544000	5993000	SN
51	REWARD COPPER	573200	5998800	CU
52	MOUNT MITTAMATITE - GRANITE	577400	5998700	GR (DST)
53	UNNAMED NO. 1 DYKE	581200	5999150	CU
54	UNNAMED NO. 2 DYKE	581200	5999200	CU
55	CORRYONG	580819	5993258	CU
56	CUDGEWA CREEK	562700	5992600	AU
57	UNNAMED NO. 1 REEF	534600	5986200	SN, W
58	UNNAMED REEF	534600	5986300	W
59	MACKLANS REEF	532300	5985700	AU
60	WILL REEVES REEF	532200	5983300	AU
61	THE BLUFF REEF	534300	5981500	AU
62	TALLANGATTA - PORPHYRY	545100	5981900	GR (DST)
63	GRASSY CREEK	547600	5980000	SN
64	EASTERN LODE	551000	5978800	SN, W
65	MT. CUDEGWA CREEK PLATEAU	552300	5979000	SN
66	LOG BRIDGE CREEK	565300	5977000	AU
67	MYSTERY REEF NO.1	583800	5984600	AU
68	MT. UNICORN	589000	5977500	AG, CU, ZN
69	MT. MORGAN PROSPECT	583000	5972500	CU, PB, ZN, AG
70	MT. ONSLOW REEF	585900	5970600	AU
71	WHEELER'S CREEK	574400	5963900	AU
72	FARDEN'S CREEK	595500	5966800	AU, SN
73	CAMP CREEK	595100	5966800	AU, SN
74	SUNDAY CREEK	594800	5966800	AU, SN
75	ALLUVIAL FLAT	594700	5966600	AU, SN
76	UNNAMED SLUICED AREA	595500	5966600	AU, SN
77	SURVEYORS CREEK	594460	5966163	SN
78	TIN CREEK	593800	5965600	AU, SN
79	ETHEL JANE REEF	588700	5957500	AU
80	EMU	585050	5948750	AU
81	VICTORIA AG-PB LODE	556700	5951500	AG,AU,PB, CU
82	GRANITE FLAT	539002	5950617	AU, CU
83	LONE HAND REEF	522250	5948800	AU
84	MILLARD AND SMYTH LINE	522250	5948800	AU
85	BULLHEAD TIN	525200	5973300	SN
86	CARRY ON REEF	518300	5969800	SB
87	A1 ODELL'S	514200	5974900	AU, ZN
88	HIDDEN FRIEND	462400	5978580	SN
89	LONE HAND TIN MINE	462480	5978700	SN
90	GEMSTONE LOCALITY	467480	5977750	GS
91	TIN LODE	467500	5977900	SN

Locn No.	Name	Easting	Northing	Commodity
92	ACI FELDSPAR MINE	468600	5975400	FS
93	BEECHWORTH	468700	5975450	GR (DST)
94	HODGSON RIVER	467240	5972210	AU
95	YACKANDANDAH	488700	5973300	GR (DST)
96	HOMEWARD BOUND MINE	485100	5971180	AU
97	SHAFT	461680	5970360	MO
98	SHAFT	461710	5970220	MO
99	EVERTON MOLYBDENITE MINE	462100	5970200	MO
100	SHAFT	462320	5970120	MO
101	SHAFT	461920	5970080	MO
102	SHAFT	462080	5970040	MO
103	SHAFT	462200	5970000	MO
104	SHAFT	461820	5969920	MO
105	SHAFT	461620	5969780	MO
106	SHAFT	462050	5969810	MO
107	SHAFT	462070	5969720	MO
108	SHAFT	462090	5969510	MO
109	MOUNT STANLEY	482200	5965400	MO
110	HODGENS RIVER	470330	5954740	AU
111	GLENROWAN/TAMINICK/GRETA	436000	5961000	GS
112	SANDSTONE QUARRY	406020	5951790	SS (DST)
113	GRETA SOUTH	428000	5944200	PH
114	RYANS CREEK	428000	5944200	PH
115	TURQUOISE MINE	480450	5943000	GS
116	BUCKLAND STAR DREDGE	489160	5936730	AU
117	ALTONA DREDGE	489410	5935410	AU
118	PERSEVERENCE DREDGE	487570	5932230	AU
119	GRAND CENTRAL DREDGE	487300	5931880	AU
120	WILLIAMS UNITED MINES PTY LTD	498530	5929000	AU
121	SIMMOND'S GAP	510400	5928600	BI, MO
122	UNKNOWN REEF	523200	5937800	AU
123	DONOVAN'S CREEK	556900	5940050	AG, AU, CU,
124	UNKNOWN NO.10	527000	5931800	AU
125	UNKNOWN NO.9	525000	5929700	AU
126	UNKNOWN NO.11	527300	5929800	AU
127	UNKNOWN NO.12	528200	5930200	AU
128	UNKNOWN NO.14	530500	5928800	AU
129	UNKNOWN NO.13	529700	5928300	AU
130	UNNAMED NO.1 DYKE	541200	5930800	SN
131	UNNAMED NO.2 DYKE	542900	5929900	SN
132	UNKNOWN NO.3	536800	5926000	AU
133	UNKNOWN NO.4	538200	5924500	AU
134	UNITED BROTHERS REEF	543200	5923700	AU, SB
135	MAUDE AND YELLOW GIRL	542200	5920600	AG, SB, AU,
136	UNNAMED REEF	528600	5926600	W
137	UNKNOWN NO.8	527100	5926000	AU
138	UNNAMED REEF	516200	5921800	AU
139	UNKNOWN REEF	511850	5920800	AU
140	UNNAMED ALLUVIAL	517400	5920800	AU
141	UNNAMED ALLUVIAL	517600	5919300	AU
142	ANACONDA PROSPECT	525300	5920300	AU
143	UNNAMED REEF	529300	5920200	AU
144	UNNAMED REEF	527300	5917800	AU
145	UNNAMED REEF	521900	5915200	AU
146	UNNAMED REEF	518600	5914100	AU
147	UNNAMED REEF	517100	5913400	AU
148	SAMBAS	504500	5913850	AU
149	CHAMPION	509500	5913000	AU
150	CALLIOPE REEF	510000	5913000	AU

Locn No.	Name	Easting	Northing	Commodity
151	RAZORBACK LINE	510900	5912800	AU
152	GOVERNMENT GRANT REEF	511000	5912500	AU
153	MOUNTAINEER REEF	512000	5912000	AU
154	RED ROBIN	513800	5911650	AU, PB
155	ONE ALONE LINE	512500	5911100	AU
156	UNNAMED REEF	517300	5912000	AU
157	UNNAMED REEF	519000	5912900	AU
158	UNNAMED REEF	521100	5913200	AU
159	UNKNOWN REEF	529000	5911500	AU
160	UNKNOWN REEF	523800	5908500	AU
161	UNKNOWN REEF	520800	5909000	AU
162	UNKNOWN REEF	513900	5909200	AU
163	RUBY CREEK	510800	5908000	AU
164	TALGARNO	510800	5908000	AU
165	MOUNT SMYTHE	507100	5904700	FS
166	MYSTERY REEF NO. 2	505900	5905800	AU
167	EDI/CHESNUT	453200	5927700	GS
168	EDI-CHESNUT	453900	5926600	PH
169	WHITFIELD	453900	5926600	PH
170	TATONG ANTIMONY MINE	426200	5922800	SB
171	PARADISE FALLS	453200	5919500	CU
172	SPRING CREEK	412400	5919700	CU
173	SPRING CREEK	412400	5919700	ZN
174	STRATHBOGIE	394000	5920000	GR (DST)
175	TALLANGALOOK	408200	5917300	FS
176	TATONG/TOOMULLUP	435000	5914000	GS
177	TURRAMURRA	429300	5910700	CU
178	CRYSTAL KING MINE NO 7 SHAFT	402010	5916690	GS
179	CRYSTAL KING MINE NO 4 SHAFT	403400	5915350	GS
180	CRYSTAL KING MINE NO 6 SHAFT	403820	5915620	GS
181	CRYSTAL KING MINE NO 5 SHAFT	403480	5915320	GS
182	CRYSTAL KING MINE	403030	5914900	GS
183	TALLANGALOOK	402600	5915000	GS
184	CRYSTAL KING MINE NO 8 SHAFT	402610	5914980	GS
185	CRYSTAL KING MINE NO 8 SHAFT	402690	5914960	GS
186	CRYSTAL KING MINE NO 2 SHAFT	402310	5914830	GS
187	CRYSTAL KING MINE NO 1 SHAFT	402330	5914800	GS
188	CRYSTAL KING MINE NO 3 SHAFT	402360	5914750	GS
189	BONNIE DOON	398300	5912200	W
190	GOLDEN MOUNTAIN MINE	399690	5911820	AU
191	HEYFIELD REEF	390300	5907200	SB
192	PHOSPHATE HILL (MANSFIELD)	414499	5897903	PH
193	HOWES CREEK (WAPPAN)	411796	5893603	PH
194	HOWES CREEK (GOUGHS)	413199	5891200	PH
195	MANSFIELD (HOWES CREEK)	412770	5890574	LST
196	HOWES CREEK (GRIFFITHS)	414397	5889503	PH
197	RED HILL	437311	5887575	PH
198	HOWQUA HILLS	438214	5885584	TC
199	CAMERON CREEK	442317	5882729	CU
200	GREAT RAND MINE	440900	5882140	AU
201	MITCHELL CREEK (HOWQUA)	440702	5875295	DST
202	JAMIESON RIVER (QUICKSILVER CREEK)	438196	5868598	HG
203	GANNANS (GANNAN)	433800	5866601	SB
204	RHYOLITE CREEK	446441	5862342	PP
205	GHIN GHIN (DAVIS)	358099	5888899	DST

Outside North East region Boundary...				
Locn No.	Name	Easting	Northing	Commodity
206	TRAWOOL	339986	5890950	DST
207	NAGAMBIE	348339	5925952	AU
208	CHESNEY VALE	418700	5969700	W
209	UNNAMED FLOURITE OCCURRENCE	430890	5971540	FL
210	GRANITE QUARRY	431490	5972300	GR (DST)
211	TAMINICK GAP	431500	5972400	GR (DST)
212	UNNAMED FLOURITE OCCURRENCE	427210	5974640	FL
213	UNNAMED FLOURITE OCCURRENCE	430250	5974900	FL
214	UNNAMED FLOURITE OCCURRENCE	427710	5976310	FL
215	UNNAMED FLOURITE OCCURRENCE	427600	5976810	FL
216	UNNAMED FLOURITE OCCURRENCE	428710	5976930	FL
217	UNNAMED FLOURITE OCCURRENCE	428740	5977170	FL
218	UNNAMED FLOURITE OCCURRENCE	427030	5977490	FL
219	WARBY RANGES	427200	5977700	FL
220	UNNAMED FLOURITE OCCURRENCE	426760	5977830	FL
221	KILLAWARRA	430300	5982500	PB
222	UNNAMED FLOURITE OCCURRENCE	430310	5982480	FL
223	UNNAMED FLOURITE OCCURRENCE	430720	5982720	FL
224	UNNAMED FLOURITE OCCURRENCE	430810	5983600	FL
225	UNNAMED FLOURITE OCCURRENCE	430200	5984600	FL
226	PEECHELBA	425500	5992100	PH
227	Oakey Hill Lodes	481818	6025902	AU
228	Stoney Park Lodes	482281	6025171	AG, AU
229	UNNAMED	482588	6025127	AU
230	UNNAMED	483529	6019039	AU
231	MOORWATHA	477535	6017773	AU
232	UNNAMED	479954	6016869	AU
233	UNNAMED	485605	6016913	AU
234	UNNAMED	491429	6016677	AU
235	Portuguese Gully	493609	6016146	AU
236	BORDER CITY	491060	6015479	AU
237	UNNAMED	488701	6014267	AU
238	Bungowannah	486870	6014254	AU
239	Soudan (Splitters Creek)	486063	6013055	AU
240	GOLDEN LEAF	486342	6012511	AU
241	Scammell and Rojo	487432	6013068	AU
242	W Jones and Party	491530	6014392	AU
243	UNNAMED	493349	6014959	AU
244	MAY DAY	494178	6014960	AG, AU
245	WEALANDS	494459	6014139	AU
246	ONE TREE HILL REEF	496108	6013519	AU
247	ETHIOPIAN	493829	6013219	AU
248	CHINA CLAIM	493369	6013130	AU
249	BLACK RANGE	494775	6012487	AU
250	ALBURY COMMON	491120	6009545	UNSPECIFIED
251	Nail Can Hill (Cherry Tree Lode)	489761	6009066	AU
252	UNNAMED	515231	6020761	AU
253	UNNAMED	514417	6019742	AU
254	TOONALOOK	515261	6017467	AS, AU
255	Mclurgs Gully	522486	6025947	SN
256	UNNAMED	522040	6025116	SN
257	Mullengandra (Jupiter) (Bright Star)	522590	6024671	SN
258	WOOLINDINA REEF	527795	6015950	BI, MO, W
259	Wymah, No 1 Reef, No 2 Reef, Williams Reef, Apple Tr	528081	6014951	BI, MO, W
260	Mclures Swamp	531969	6028425	SN
261	HOME FLAT CREEK	536678	6023537	AU, SN
262	Bourkes Flat (Lower Basin Creek)	541136	6025769	AU, SN
263	LOCK UP FLAT	536556	6035694	SN

Locn No.	Name	Easting	Northing	Commodity
264	UPPER BASIN CREEK DORA DORA	541078	6030894	AU, SN
265	SPRING CREEK	542512	6034292	SN
266	BUCKEEN CREEK	548307	6030513	AS, SN
267	MARACKET	550614	6027971	SN
268	MOUNT PAYNTER, MAIN LODE, HILLSIDE LODE, CRAWFORDS L	556750	6026392	AS, AU, SN, W
269	MOUNT PAYNTER NO 7 AND NO 8 LODES	557591	6025211	SN
270	SWAMP CREEK	557115	6026944	SN
271	MUSGRAVE LODES	559018	6037658	CU, SN, W
272	UNNAMED	559832	6037841	AS
273	HOLMANS REEF	560400	6036295	AG, PB
274	CARBOONA	565258	6034708	AG, FL, PB, ZN
275	GADDS COPPABELLA FREEHOLD	565718	6034616	AG, PB
276	COPPABELLA CONSOLS	565632	6034062	AG, CU, PB, ZN
277	COPPABELLA BLOCKS	568017	6032901	AG, PB
278	GREAT COPPABELLA BOULDER	569688	6030637	AG, CU
279	VALLEY (ROTHSCHILD) (CASH DOWN) (BANK OF ENGLAND)	571464	6026906	AG, AU, PB, ZN
280	HORSE CREEK	564072	6025643	SN
281	HORSE CREEK LODES	563630	6024271	SN
282	UNNAMED	563635	6023905	SN
283	PEEP O DAY REEF	575692	6024298	AG, AU
284	ISABELLA REEFS, ISABELLA, BRANCH, NEW, CENTRAL, HIDD	572243	6021797	AG, AS, AU
285	MACGILVRAYS	597601	6008174	AU
286	MT. MURPHY WOLFRAM	588800	5935400	W
287	MORASS CREEK	561700	5929300	CU, WOL
288	WOMBAT HOLE	561800	5929400	AU, CU, AG, P
289	SILVER FLAT	561200	5930800	PB, AG
290	GIBBO RIVER	559498	5931597	AG, BA, CU, PB
291	MITTA MITTA RIVER	559000	5931700	CU
292	WOMBAT CREEK	556800	5932900	LST (DST)
293	RALSTONS LODE	556597	5932803	PB, AG, CU
294	SPELLINGS LODE	555900	5933300	AG, CU, PB
295	QUART POT FLAT	555904	5933296	CU, PB
296	INVISIBLE REEF	548900	5921528	SN
297	SLOANS REEF	549700	5920300	AU
298	LEVIATHAN REEF	549200	5920200	AU
299	UNNAMED DYKE	545200	5920950	SN
300	UNKNOWN REEF	536600	5919300	AU
301	UNKNOWN REEF	534400	5917800	AU
302	BINGO MUNJIE NORTH (OMEIO)	547246	5904760	TC
303	UNKNOWN REEF	531300	5905700	AU
304	MORNING STAR	433479	5841423	AU
305	A1 MINE	429450	5848800	AU
306	SPECIMEN CREEK	415698	5846998	SB
307	BIG RIVER (ENOCHS POINT)	420298	5853801	AU, SB
308	WILD DOG CREEK	411900	5854304	AU, SB
309	CASTLE DOUGLAS (EILDON)	400197	5879405	AU, SB
310	MONKEY GULLY (LIMESTONE)	368699	5878606	MO

Table 14: Active construction materials quarries in North East region

Map 2 Locn	NAME	COMMODITY
1	Wodonga	SAND/GRAVEL
2		GNEISS
3	Chiltern	HORNFELS
4		SAND/GRAVEL
5		SCHIST
6		SAND/GRAVEL
7		GRANITE
8		SEDIMENTARY
9		SAND/GRAVEL
10	Glenrowan	GRANITE
11		SEDIMENTARY
12		SAND/GRAVEL
13		SAND/GRAVEL
14		SAND/GRAVEL
15	Violetown	BASALT OLD
16		SAND/GRAVEL
17		LIMESTONE
18		HORNFELS
19		SAND/GRAVEL
20		RHYODACITE
21		SLATE
22		SAND/GRAVEL
23		SAND/GRAVEL
24		SAND/GRAVEL
25		SAND/GRAVEL

Figure 3: Mineral potential tracts for slate-belt gold deposits

Figure 4: Mineral potential tracts for disseminated gold deposits

Figure 5: Mineral potential tracts for alluvial gold

Figure 6: Mineral potential tracts for epithermal deposits for gold and silver

Figure 7: Mineral potential tracts for porphyry copper-gold deposits

Figure 8: Mineral potential tracts for volcanic associated massive sulphide base metal deposits

Figure 9: Mineral potential tracts for tin vein deposits

Figure 10: Mineral potential tracts for tin greisen deposits

Figure 11: Mineral potential tracts for tungsten-molybdenum deposits

Figure 12: Mineral potential tracts for tungsten skarn deposits

Figure 13: Mineral potential tracts for nickel copper deposits

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

Figure 15: Mineral potential tracts for dimension stone deposits

Figure 16: Mineral potential tracts for feldspar deposits

Figure 17: Mineral potential tracts for limestone deposits

Figure 18: Mineral potential tracts for kaolin deposits

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, *et al* (1986).

The qualitative method is essentially the first step of the 'Three Step Method' used for quantitative assessments of potential mineral resources that was thoroughly evaluated and subsequently supported by a panel of experts in 1993 (Harris and Rieber, 1993). There has been no quantitative assessment in the North East region.

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 be 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 qualitative assessment methodology is described by Marsh, Kropschot and Dickinson (1984), Taylor and Steven (1983), and Dewitt, *et al* (1986).

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, Lode gold veins.

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

General References: Forde and Bell (1994); Hodgson, Love and (1993)

Geological Environment

Rock types: Greenstone belts; oceanic metasediments: regionally metamorphosed volcanic rocks, greywacke, chert, shale, and quartzite, esp. 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 \pm carbonates \pm native gold \pm arsenopyrite \pm pyrite \pm galena \pm sphalerite \pm chalcopyrite \pm pyrrhotite \pm sericite \pm rutile. Locally tellurides \pm scheelite \pm bismuth \pm tetrahedrite \pm stibnite \pm molybdenite \pm 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 \pm albite in veins with possible halo of carbonate alteration. Chromian mica \pm dolomite \pm talc \pm siderite in areas of ultramafic rocks. Sericite \pm disseminated arsenopyrite \pm 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, United States	(Knopf, 1929)
Goldfields of Nova Scotia, Canada	(Malcolm, 1929)

Known Deposits and Mineral Occurrences in the North East region

The area hosts a large number of gold prospects and deposits which form part of three major gold provinces in Victoria (from west to east): Melbourne Gold Province, Harrietteville Dargo gold Province and Benambra Gold Province (Map 2). In all three gold provinces four major quartz reef types are recognised (Kenny, 1953 cited in Ramsay and Willman, 1988):

- Fissure reefs which are generally lenticular and discordant to bedding and occur fissure planes (e.g. Mons Meg, Monarch Samabs);
- Bedded reefs which are generally laminated and parallel to bedding (e.g. Rose Thistle and Shamrock);
- Reefs associated with dykes. They either truncate the dyke or occur sub-parallel to one wall of the dyke (e.g. Red Robin, Big Gun Extended);
- Spurry reefs are tension gashes, irregular quartz fissures and stockworks (e.g. Crescent Mine).

Using the classification of gold deposits by Ramsay and Willman (1988), following types of gold deposits can be recognised in the area: sediment/metasediment-hosted, Granitoid hosted/related; and Dyke hosted/affiliated. Quartz veins are predominantly hosted by Middle to Upper Ordovician metasediments (lower greenschist facies metamorphism). Locally Cambrian/Ordovician Bethanga Gneiss in the Benambran Gold Provinces also hosts mineralised quartz reefs.

Geological studies in the area and other gold fields in Victoria fail to recognise any single geological factor controlling mineralisation. The factors and the age of mineralisation seem to vary from area to area with a combination of two or more factors (structural, lithological, magmatic, geochemical) becoming important in several areas. In addition to the well-documented structural control (faults, fissure, dilatational jogs, and fold hinges) it is possible that some form of lithological control was important in some areas. For instance, in the Benambra Gold Province greasy, carbonaceous pyritic slate has been described as an ideal host of mineralisation. Similarly in the Ballarat East goldfield it is suggested that mineralisation is often localised by the presence of "indicator beds" (O'Shea *et al* 1994). The greenschist facies metamorphism might also be an important factor in the formation of gold mineralisation. In some gold provinces in Victoria which include some gold fields in the region the presence of dyke swarms is an important ore-localising factor. Dykes in the Woods Point Dyke Swarm in the southern extension of the region hosts rich gold mineralisation.

Gold deposits in the region belong to two gold provinces: Harrietteville-Dargo and Benambra. Gold mineralisation in the Harrietteville-Dargo province is structurally defined by a corridor extending from the Mount Wellington Fault Zone (now Governor Fault) in the west, to the Kancoona Fault in the east (Gray, 1988 cited in Maher *et al* 1997). Most veins lie within a 15

kilometre zone west of the Kancoona Fault suggesting some structural control. For example in the Bright-Wandiligong gold field many veins lie within a 20 km by 4 km zone which trends north-northwest, parallel to the Kancoona fault (Maher *et al* 1997). Mineralised veins in most gold fields in the province are also often hosted by dykes.

In the Benambran gold province gold mineralisation shows spatial association with north-northwest trending major faults such as the Tallangatta Creek Fault and dyke swarms. For example in the Mitta Mitta Gold Field is spatially associated north-northwest trending Mitta Mitta Dyke Swarm. Similarly gold mineralisation in the Mt. Elliott-Corryong and Cudgewa gold fields are spatially associated with north and northeast trending Tintaldra-Cudgewa Creek dyke swarms. Dart River and Zulu Creek gold fields the Tintaldra-Cudgewa dyke swarm hosts mineralised veins. In the Granya gold field, three generations of dyke swarms cut the Granya Adamellite out of which gold mineralisation is reported to be associated with northeast and north trending dykes (Oppy *et al* 1995).

Some reefs close to the eastern margin of the Melbourne gold province and occupying the southwest margin of the region are associated with dykes of the Woods Point Dyke Swarm.

Recent geophysical studies in three gold fields (Stawell, St Arnaud and Beaufort) has revealed that they share two common characteristics. All are hosted within weakly but distinctly magnetic units than the surrounding rock, and all lie about 2 km or less from the edge of a nonmagnetic granite, possibly felsic I-type intrusion (Moore, 1996). In the region a similar spatial association is also observed. Mineralised veins are often hosted by them and are found within their thermal halo.

Spatial analysis of the distribution of primary mineralisation in the region shows that a 70 kilometre corridor to the west of the Kancoona Fault contains 57 per cent of known occurrences; area of dyke swarms including those interpreted from aeromagnetism include 83 per cent of occurrences; granitoids in the area host 14 per cent of the known occurrence whereas a 25 per cent of the occurrences are within 5 kilometres of the granitoids. Thus Kancoona Fault and dyke swarms are the two most important features controlling spatial distribution of primary gold mineralisation in the region.

Generally, slate-belt gold mineralisation is associated with Middle-Late Devonian Tabberabbera deformation and metamorphism. However, recent studies in the Tabberabberan zone (Benambran gold province) show that mineralisation is of Middle Silurian- Early Devonian (late Benambran-Bindian) age (Morand and Gray, 1991 cited in Oppy *et al* 1995). A more accurate date is estimated in areas where gold veins cut dyke swarms. For example dykes in the Woods Point Dyke Swarm are dated to have been emplaced in around 380 Ma. (Middle Devonian) which means that gold mineralising event in dyke-related environment was post Middle Devonian.

Assessment Criteria

1. Distribution of the Ordovician, Silurian and Devonian turbidites and their metamorphic equivalents.
2. Presence dyke swarms.
3. Presence of major north-northwest trending fault zones.
4. Presence of Silurian and Devonian granitoids (I-type).
5. Presence of primary and/or alluvial gold deposits and prospects.

Assessment:

Tract Aul/H/B-C

The tract is delineated based on the distribution of:

- Ordovician, Silurian, Siluro-Devonian and Devonian turbidites and their metamorphic equivalents.
- Dyke swarms (Woods Point; Mitta-Mitta, Tintaldra-Cudgewa, Walwa, and other smaller dyke swarms in the Benambra gold province). Low to moderately magnetic responses trending northwest are interpreted to be associated with dyke swarms (Maher *et al* 1997). This information is used to delineate a north-northwest trending zone of dyke swarms. The zone extends 75 kilometres to west and 35 kilometres east of the Kancoona Fault.
- Quaternary Shepparton Formation, which is known to contain relatively small windows of Ordovician, Silurian and Devonian turbidites which have a potential to host slate belt gold mineralisation. Such windows are known to exist in the Chiltern-Rutherglen gold field and in the Nagambie gold deposit within 10 kilometres of the region. The Chiltern-Rutherglen is also known to host significant deep lead gold (Swensson, 1990). Available geological maps (1:250000) do not show all of the windows of favourable rocks.

As mentioned above the tract contains more than 80 per cent of primary gold occurrences and a large number of alluvial deposits.

Mineral potential of the tract is assessed to be high with a certainty level of B to C.

Tract Au1b/M/B

The tract includes areas of Quaternary rocks of Shepparton Formation in the Ovens Valley. Quaternary rocks in the tract can also contain windows of Ordovician, Silurian and Devonian sedimentary rocks, but because the Quaternary cover is reported to be thick, mineral potential of the tract is assessed to be moderate with a certainty level of B.

Tract Au1c/L-M/B

The tract includes Silurian and Devonian granitoids which are known to host 14 per cent of the known primary gold occurrences. It also includes several occurrences of alluvial gold. Often granitoids are intersected by north-northwest and northeast trending faults which are known to have played a role in the distribution of primary gold mineralisation.

Mineral 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 /tonnage models for the low-sulphide gold -quartz veins (Cox and Singer, 1986) 90 per cent of these deposits contain at least 0.001 million tonnes of ore; 50 per cent contain at least 0.03 million tonnes and 10 per cent contain at least 0.91 million tonnes. In 90 per cent of these deposits ores contain at least 6 g/t gold; 50 per cent contain at least 15 g/t gold and 10 per cent contain 43 g/t gold.

Au2: DISSEMINATED GOLD DEPOSITS

Model Description

Approximate Synonyms: Sandstone-hosted gold deposits. Low-grade disseminated gold deposits, Stockwork gold deposits.

Description: Disseminated gold in altered rocks in proximity to known slate-belt gold veins.

General References: Montoya *et al* (1995); Kwak and Roberts (1996).

Geological Environment

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

Age range: Precambrian to Tertiary. In Victoria most deposits are of Palaeozoic age.

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: Slate-belt gold veins, Placer Au-PGE, Homestake gold.

Deposit Description

Mineralogy: Mineral composition similar to that in typical state-belt gold deposits. Mineralisation represented by sulphides (pyrite, arsenopyrite, chalcopyrite, sphalerite, stibnite) and gold in altered rocks containing carbonates, quartz, sericite and chlorite. In some deposits sulphides form spheroids or framboids with anomalously high concentration of zinc, copper, nickel, gold, antimony, lead, arsenic and lead.

Texture/structure: Stockwork and zones of dissemination in jogs in shears.

Alteration: Assemblages containing carbonates (calcite, siderite, sideroplesite, and ankerite), phengitic sericite, ripidolitic chlorite, and sulphides (pyrite, chalcopyrite, auriferous arsenopyrite and sphalerite) occurring within about 100-150 metres of major textures. Silicification is either mild or absent.

Ore controls: Mineralised zones along fold axes, and fault and shear zones. Individual deposits in jogs created by shears obliquely cross previously-formed anticlines and synclines. Some occur near 'chokes' in structures. For some deposits presence of dykes is a characteristic feature.

Weathering: Limonitic zones over primary sulphide mineralisation. However gold concentration is lower than in primary mineralisation.

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

Geophysical signature:

Examples:

Nagambie, Australia	(Gilles, 1990)
Fosterville, Australia	(McConachy and Swensson, 1990)
Peru	(Montoya <i>et al</i> 1995)

Known Deposits and Mineral Occurrences in the North East Region

Although haloes of disseminated mineralisation in Victoria are known to be associated with major slate-belt vein deposits, they have acquired economic importance only recently because of the possibility of their mining by small-scale, heap-leaching techniques. Within the North East region there are no major deposits of this type.

Some gold occurrences in the Chiltern-Rutherglen gold field are reported to have features similar to sandstone-hosted disseminated gold deposits with gold reported to be occurring in sandstone and shale pebbles in leads and outcrops. Locally economic grade, stockwork mineralisation was mined at shallow levels of mineralised quartz reefs (e.g. Magenta Reef, Maher *et al* 1997).

A number of important known occurrences of this type occur within the 15 kilometre buffer zone. The most significant of these are the Morning Star gold mine and the Nagambie mine. Mineralisation in the Woods Point-Jamieson goldfield is associated with Middle Devonian dyke swarm intruding into Lower Devonian sediments deformed and metamorphosed to lower greenschist facies during Tabberabberan orogeny. The dykes are primarily of dioritic and lamprophyric composition and are altered and sheared close to the zones of mineralisation. Recent exploration has revealed disseminated mineralisation in the vicinity of ladder veins where the dyke is bleached because of alteration.

In the Nagambie gold deposit, mineralisation is hosted by a thick sequence of Silurian-Devonian turbidites protruding through flat lying Quaternary sediments of the Shepparton Formation. Economically significant mineralisation occurs along the crest of an anticline. Mineralisation is in the form of quartz veins, stringers and stockworks (Gillies, 1990)

A number of well-know deposits of this type occur outside the region. The most well known of this is Fosterville in the Bendigo-Ballarat Gold Zone. Although these deposits have been studied in some detail no clear single geological factor appears to control this type of mineralisation. Important geological factors include (Kwak and Roberts, 1996): structural (shear and fault zones in particular jogs where shear obliquely cross previously formed folds), lithological (relatively porous sandstone and/or interbedded black shale, and magmatic (presence of K-feldspar-quartz porphyritic dykes).

Assessment Criteria

1. Tracts with mineral potential for slate belt gold mineralisation.
2. Distribution of the Ordovician, Silurian and Devonian turbidites and their metamorphic equivalents.
3. Presence of dykes
4. Presence of fault zones.
5. Presence of slate-belt gold veins.
6. Presence of bleached and altered rocks.
7. Presence of alluvial and deep lead gold deposits and prospects.

Assessment:

Tract Au2a/M-H/B

This tract is identical to the high potential tract (tract Au1a/H/B) for slate belt gold deposits and contains the most favourable environment for the emplacement of slate-belt gold mineralisation such as: the presence of deformed and metamorphosed Ordovician, Silurian and Devonian turbidites; presence of Devonian dyke swarms; presence of Silurian and Devonian granitoids. The tract also includes more than 83 per cent of all known occurrences of primary gold in the region. The tract also includes gold occurrences of the Chiltern-Rutherglen gold field which have been reported to have features similar to the sediment hosted gold deposits. The presence of slate belt gold occurrences and the fact that it has a high potential for the presence of more deposits of this type indicates that the tract has a potential for disseminated gold deposits.

The tract also contains areas occupied by Quaternary rocks of the Shepparton Formation which are known to have windows of Ordovician, Silurian and Devonian turbidites. One of such windows in the 15 kilometre buffer zone of the region hosts Nagambie gold deposit which is an important disseminated gold deposit.

Mineral potential for disseminated gold deposits in the tract is assessed to be moderate to high with a certainty level of B.

Tract Au2b/L-M/B

The tract is identical to the moderate potential tract (tract Au1b/M/B) for slate belt gold deposits. It represents Quaternary rocks of the Shepparton Formation in the Ovens Valley where a greater thickness of the cover rocks means that favourable Ordovician, Silurian and Devonian sedimentary and metasedimentary rocks will not be intersected at shallower levels. Hence mineral potential of this tract is assessed to be low to moderate with a certainty level of B.

Tract Au2c/L/B

The tract is identical to the Low to moderate potential tract (Au1c/L-M/B) for slate-belt gold deposits. Main rocks in the tract are Silurian and Devonian granitoids which are known to host several occurrence of primary slate-belt gold. As the potential for slate-belt gold in the tract has been assessed to be low to moderate it is suggested that the tract has a low potential for disseminated gold deposits with a certainty level of B.

Au3: 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, eolian, and (rarely) glacial deposits.

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, areaomite); 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, areaomite, 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, dikes, 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, areaomite, 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 Mineral Occurrences in the North East Region

There are numerous localities in the region where alluvial gold was mined.

In addition to the typical placer deposits, the region is also favourable for the presence of deep and shallow lead placer gold. Deep and shallow leads are quite common elsewhere in Victoria.

Deep leads are buried gold placers which formed at various times during the Cainozoic and were later buried under alluvium or basalt or both. In Victoria some leads are preserved under Eocene? Older Volcanics, some are under Pliocene-Pleistocene basalt. Most of the deep lead concentrations were formed along valleys draining inland from the main divide and were later modified during Cainozoic uplift and consequent stream rejuvenation. The largest and best known leads in the region are near Chiltern and Rutherglen. Similar leads are also reported around Ballarat in the Avoca and Loddon valleys (Swensson, 1990).

Assessment Criteria

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

Assessment:

Tract Au3/L-M/B

Distribution of Tertiary and Quaternary sediments has been used to delineate this tract. The region hosts numerous slate-belt gold and disseminated gold deposits and occurrences which are potential source of alluvial gold. The tract contains numerous occurrences of alluvial gold.

The tract also includes areas which are favourable for deep and shallow leads such as Chiltern and Rutherglen.

There is widespread distribution of primary sources of gold in the region. The region has been subjected to intensive prospecting for alluvial gold and a major proportion of the alluvial deposits probably have been located. It is concluded that the region has a low to moderate potential (with a certainty level of B) for alluvial gold.

Au4: 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, chalcopryrite, 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), Berger and Bethke (1985), White and Hedenquist (1990), Henley *et al* (1991).

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 + chalcopryrite + copper sulfosalts + silver sulfosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodoareosite + barite ± fluorite ± siderite ± ankerite ± sericite ± adularia ± kaolinite. Specular haematite 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 <i>et al</i> 1996)
Creede, United States	(Steven and Eaton, 1975; Barton <i>et al</i> 1977)
Pachuca, Mexico	(Geyne <i>et al</i> 1963)
Toyoha, Japan	(Yajima and Ohta, 1979)

Known Deposits and Mineral Occurrences in the North East Region

Known occurrences of epithermal gold-silver deposits in the region are limited to a north-northwest trending Barkly River Greenstone belt. These occurrences are reported to show features characteristic of epithermal mineralisation. The most important of these are the Hill 700-800 prospects (Turner, 1996). Most prospects and anomalies are hosted by Cambrian andesitic and rhyolitic volcanics. Mineralisation at Hill 800 is of a disseminated to massive replacement style with no discrete veins. At Hill 800 silicification is seen as chert lenses or clasts, disseminations and quartz veining is uncommon, and is post mineralisation (Turner, 1996). In none of these prospects typical epithermal style alterations have been reported.

The Rhyolite Creek prospect in the same area is known to have several pervasive argillic alteration zones characterised by the presence of pyrite and pyrophyllite. Mineralisation is in the form of stockwork veins which are flattened by shear strain. A second type of mineralisation comprises lenses of massive sulphide hosted by a siliceous breccia within volcanoclastic sediments. The prospect is thought to be analogous to other deposits at Temora, Peak Hill and near Junee in New South Wales all of which are considered to be formed from high sulphidation, high temperature, acid and probably magmatically derived fluids (Vanden Berg *et al* 1995 cited in Turner, 1996).

Assessment Criteria

1. Distribution of intrusive/extrusive complexes represents a predominantly subaerial complex of volcanic and volcanoclastics of silicic to mafic composition.
2. Presence of favourable structures such as caldera with ring fractures and zones of brecciation.
3. Presence of alterations such as: silicification, propylitic, chloritic, sericitic and argillic.
4. Presence of mineral prospects having features similar to epithermal precious-metal deposits.

Assessment

Tract Au4a/M-H/B-C

The tract contains two areas favourable for epithermal gold-silver deposits. One of them is defined by Cambrian volcanics that form the north-northwest trending Barkly River Greenstone Belt in the south western part of the region. The tract includes small areas where the presence of greenstone rocks is deduced from the interpretation high-resolution aeromagnetics. The belt hosts a number of known occurrences which have features similar to epithermal gold-silver deposits (Turner, 1996).

The second favourable environment is represented by Devonian S-type and A-type (Jemba Rhyolite), subaerial felsic volcanic and volcanoclastic complexes such as the Strathbogie Igneous Complex, Tolmie Igneous Complex, Wellington Rhyolite, Jemba Rhyolite, Murtagh Creek Rhyolite, Sheevers Spur Rhyodacite and the Snowy River Volcanics.

The Upper Devonian volcanic complexes occur in a number of medium size calderas: the Violet Town Caldera, and the Wabonga Caldera. The Early Devonian Volcanics of the Jemba Rhyolite are formed in the Burrowa Caldera and derived from A-type magma (Maher *et al* 1997). Both the Murtagh Creek Rhyolite and the Sheevers Spur Rhyodacite occur in the northern part of the Wombat Creek Graben.

Most calderas are bound by ring faults. The volcanics of the Wabonga caldera are intruded by small stocks of granodiorite porphyry along the marginal fault and on one of the internal faults (Maher *et al* 1997). The presence of stocks is significant because they could have played an

important role in keeping up the geothermal gradient thereby assisting in the maintenance of a geothermal system generated around caldera complexes.

Thus the tract contains intrusive, volcanic and volcanoclastic rocks favourable for generating epithermal systems. More importantly the tracts has favourable structures such as calderas, ring and radial fractures characteristic of several well-known mineralised epithermal systems. However no large scale hydrothermal alterations typical of epithermal systems have been reported in these rocks. Although no mineral occurrences of epithermal gold-silver mineralisation have been recorded within the areas of Devonian complexes, several epithermal gold-silver occurrences are reported from within the Barkly River Greenstone Belt. Hence the tract is interpreted to have a moderate to high potential for epithermal gold-silver deposits with a certainty level of B to C. Certainty level is lower in areas where aeromagnetism is the basis for delineating greenstone rocks.

Economic Significance

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

CuAu1: PORPHYRY COPPER-GOLD DEPOSITS (MODEL 20C OF COX AND SINGER, 1986)

Model Description

Description of the model after Dennis P. Cox

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

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 (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 \pm 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 \pm magnetite \pm biotite (chlorite) \pm K-feldspar \pm actinolite, \pm anhydrite in interior of system. Outer propylitic zone. Late quartz + pyrite + white mica \pm 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 centered 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 protore. 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 <i>et al</i> 1990)
Panguna, Papua New Guinea	(Clark, 1990)
Ok Tedi, Papua New Guinea	(Rush and Seegers, 1990)
Dizon, Philipines	
Dos Pobres, United States	(Langton and Williams, 1982)
Copper Mountain, Canada	(Fahrni <i>et al</i> 1976)

Known Deposits and Mineral Occurrences in the North East Region

The region does not host any major occurrence of this type. However, low-grade molybdenite mineralisation in the Everton molybdenite field is interpreted to be related to Everton Granodiorite which is a highly oxidised (magnetic), I-type felsic granitoid. The Everton granodiorite represents a late phase of the nearby Murmungee Granite, test drilling in which has revealed the presence of patchy gold mineralisation (Maher *et al* 1997). A few copper occurrence near the south-eastern edge of the Strathbogie Granitoid could also represent porphyry style mineralisation.

Assessment Criteria

1. Distribution of I-type relatively oxidised granitoids, mostly Devonian rarely Silurian.
2. Distribution of alkaline igneous rocks of the Mount Leinster Complex.
3. Presence of porphyry-related wall-rock alteration.
4. Strongly or moderately magnetic granitoids visible on the aeromagnetic map.
5. Presence of geochemical anomalies.
6. Presence of mineral prospects having features similar to porphyry copper deposits

Assessment

Tract: CuAu1a/M-H/B

The tract is defined by relatively oxidised I-type granitoids (Everton Granodiorite and Murmungee Granite). It is possible that these two granitoids are related to a larger body, the presence of which is revealed at shallow depths by high resolution aeromagnetics. Everton Granodiorite is reported to host low-grade molybdenite mineralisation (Maher *et al* 1997)

The tract also contains alkaline igneous rocks of the Triassic Mount Leinster Igneous Complex. Although there are no known occurrences associated with them, similar alkaline rocks in Tasmania and New South Wales are reported to host gold mineralisation.

Mineral potential in the tract is assessed to be moderate to high with a certainty level of B.

Tract: CuAu1b/M/B

The tract includes Early Silurian and Devonian I-type and a few S-type, mafic granitoids with a high aeromagnetic response indicative of their possible oxidised state. These include the Barrimboola, Big Hill, Boebuck, Corryong, Mt Angus, Mt Mittamatite, Mt Selwyn, Niggerheads and Spion Kopje granitoids.

The tract also includes areas where high-resolution aeromagnetics indicates the presence of magnetic granitoids at shallow depths. A small area at the south-eastern margin of the Strathbogie granitoid is also included in the tract, because it contains some copper occurrences that show features similar to copper-porphyry mineralisation (Tom Dickson, pers. Comm.).

The tract is assessed to have a moderate potential with a 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 of ore and 10% contain at least 400 million tonnes. In 90% of these deposits, the ore contains at least 0.35 wt % copper and 0.2 ppm gold, in 50 % of the deposits, ore contains at least 0.5 wt % copper and 0.38 ppm gold and in 10% of the deposits the ore contains 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)

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

Model description

Description of the model modified after Donald A. Singer, in Cox and Singer (1986).

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

Description: Copper, lead, zinc, silver, gold bearing massive sulfide deposits in marine volcanic rocks of intermediate to felsic composition.

General References: Ishihara (1974), Franklin *et al* (1981), Hutchinson *et al* (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: Archean to 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. Archean greenstone belt.

Associated deposit types: Epithermal quartz-adularia veins in Japan are regionally associated but younger than Kuroko 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 sulfide-matrix breccia. Also slumped and redeposited ore with graded bedding.

Alteration: Adjacent to and blanketing massive sulfide 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 centre 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 sulfide clasts in volcanic breccias. Some deposits may be gravity-transported and deposited in paleo 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.

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.

Examples:

Benambra, Australia	Allen and Barr (1990)
Golden Grove, Australia	Frater (1983)
Mt. Lyell, Australia	Hills (1990)
Rosebery, Australia	Lees <i>et al</i> (1990)
Thalanga, Australia	Gregory <i>et al</i> (1990)
Brittania, Canada	Payne <i>et al</i> (1980)
Buchans, Canada	Swanson <i>et al</i> (1981)
Kidd Creek, Canada	Walker <i>et al</i> (1975)
Furutobe, Japan	Hideo Kuroda (1983)

Known Deposits and Mineral Occurrences in the North East Region

In the south-east of the region, the Wombat Creek Graben contains a sequence of Silurian rocks similar to those in the Limestone Creek Graben, just to the south-east of the region. These two grabens are remnants of the Cowombat Rift (Vandenberg 1988). Wilga and Currawong are the two largest known VMS deposits in Victoria and occur in the Limestone Creek Graben.

In the Wombat Creek Graben, the marine acid Mitta Mitta volcanics are overlain by the marine sediments of the Wombat Creek Group. A similar rock sequence occurs in the Limestone Creek Graben where the Thorkidaan Volcanics are overlain by the shallow marine, sedimentary Cowombat Siltstone and then Gibsons Folly Formation turbiditic sediments containing interbedded discontinuous dacitic, andesitic, basaltic volcanic units and minor porphyritic rhyolite bodies. The deep marine volcanic component of the Gibsons Folly Formation was conducive to the formation of VMS deposits as evidenced by the presence of the Wilga and Currawong deposits and other minor VMS mineralisation. Available data shows no volcanic rock component in the Wombat Creek Group but interbedded volcanic units may occur at depth and provide prospectivity for concealed VMS style deposits.

Devonian Dartella Group acid volcanics and sediments occupy the northern part of the Wombat Creek Graben and show few signs of exhalative mineralisation (Ramsay 1988). The Devonian age Snowy River Volcanics in eastern Victoria contain volcanogenic iron-manganese deposits with some elevated gold assays, and the upper part (Spring Creek Member) exhibits volcanic exhalative lead-zinc mineralisation and iron formations. At least some of the mineralisation in the overlying Devonian limestones and sediments (with minor volcanics) of the Buchan and Errinundra Groups is thought to be of volcanic exhalative origin (Ramsay 1988).

Exploration in the Wombat Creek Graben has been mainly at a reconnaissance or regional level and minor vein type copper, lead and minor zinc mineralisation has been recorded at several localities (eg. Quart Pot, Silver Flat, Wombat Hole) in the Wombat Creek Graben (Oppy *et al* 1997).

Exploration drilling in Cambrian rocks near Wrightly, in the central-west part of the region, intersected banded pyrrhotite-rhodonite-chert mineralisation with volcanogenic characteristics.

In the south-west of the region, recent exploration has recognised volcanogenic gold-copper and gold-silver-barium mineralisation in altered the calc-alkaline andesite lavas at Hill 800 near Jamieson (Maher *et al* 1997, Fraser 1998).

Cambrian age deep sea floor tholeiitic metabasalts, gabbro and sediments elsewhere in the Mt Wellington Fault Zone in the central western part of the region offer potential for volcanogenic precious metals deposits similar to the Stawell gold deposit in western Victoria.

Most Australian VMS base metals deposits are hosted by volcanic/sedimentary rock packages of calc-alkaline geochemical character. Cambrian andesites, andesitic agglomerates and tuffaceous sediments of this geochemical type occur near Jamieson, in the central south-west of the region and extend southward out of the region towards Licola. The Licola andesites are geochemically similar to the Cambrian Mount Read Volcanics of western Tasmania, which host major VMS base metal deposits (Crawford 1988).

Assessment criteria

1. Distribution of volcanic and sedimentary rocks (Ev, Eus;Smv, Smvm, Suw; Dldc, Dldm, Dlds, Dls, Dlv) deposited in a marine environment.
2. Distribution of known base metal occurrences.
3. Distribution of Cambrian rocks and sediments.

Assessment

Tract BM1a/H/B-C

This tract delineates areas of Cambrian metabasalts, gabbro and sediments that have potential for volcanogenic base metal gold/silver deposits. The Cambrian Mt Wellington greenstone belt in the region has not been fully explored for the presence of these precious metals deposits (Maher *et al* 1997) and mineralisation of this type is known in similar rocks to the south of the region. Potential for VMS base metal deposits appears more favourable in the southern part of the tract (Jamieson area). The tract includes small areas where the presence of Dookie greenstones has been interpreted from high-resolution aeromagnetics.

The tract is thought to have high potential for volcanogenic base metal deposits, with a certainty level of B-C.

Tract: BM1b/M-H/B-C

The tract consists of Silurian and Devonian marine volcanic and sedimentary rocks deposited in the Wombat Creek Graben. The Mitta Mitta Volcanics and the overlying Silurian Wombat Creek Formation are not known to host VMS mineralisation and the latter appears devoid of the prospective intermediate volcanic/sedimentary sequences known in the Gibsons Folly Formation of the Limestone Creek Graben. However, the minor vein or Mississippi Valley type base metal occurrences in the Wombat Creek Graben may derive from, and indicate potential for, concealed VMS deposits in the graben rock units of Silurian age. Volcanogenic massive sulphide deposits are known to occur in a similar stratigraphic sequence in the Limestone Graben to the south of the North East region.

Devonian Dartella Group acid volcanics and sediments in the northern part of the Graben show some signs of exhalative mineralisation (Ramsay 1988) but more importantly they may conceal underlying marine volcanic/sedimentary Silurian rocks with potential for VMS deposits. The upper part of the Snowy River Volcanics and overlying Devonian limestones/sediments also have potential for VMS deposits. Thus all these Devonian units have been included in the tract.

Potential for economic volcanic hosted massive sulphide deposits is considered to be moderate to high with a certainty level of C for the Silurian rocks and B for the Devonian rock units.

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 Synclinal zones also contain gold and silver mineralisation. Mineral occurrences in the Jamieson Window of Cambrian volcanic and volcanoclastic rocks have been reported to have returned gold values.

Assessment

Tract: Au5a/H/B-C

This tract coincides with the tract BM1a/H/B-C for volcanic associated massive sulphide deposits. The tract contains several occurrences of base metals with gold values. The potential of the tract is assessed to be high with a certainty level of B to C.

Tract: Au5b/M/B-C

This tract coincides with the BM1b/M-H/B-C tract for volcanic associated massive sulphide deposits. The tract contains Silurian submarine volcanic rocks that host massive sulphide deposits of Wilga and Currawong near Benambra located in the Limestone Creek Graben. These deposits are known to have up to 1.3 g/t gold (Allen and Barr *et al* 1990). The potential of this tract is assessed to be Moderate with a certainty level of B to C.

Economic significance

Volcanic-hosted massive sulphide deposits are significant sources for copper, lead and zinc. Global grade/tonnage models for this type of deposit indicate that 90% of these deposits have more than 0.12 million tonnes of mineralisation, 50% have more than 1.5 million tonnes and 10% have more than 18 million tonnes. Similarly, 90% of these deposits 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.

Fifty percent of this deposit type grade more than 0.16 grams/tonne gold and 13 grams/tonne silver, while 10% have more than 2.3 grams/tonne gold and 100 grams/tonne silver.

BM2: SEDIMENT-HOSTED COPPER DEPOSITS(REDBED SUBTYPE)

Model Description

Description of the model modified after Dennis P. Cox ; and after Kirkham 1995

Approximate Synonym: Sandstone Cu, Zambian Copper, Zechstein Copper, sedimentary copper; includes Cu-shale (Lindsay, 1982); "Stratiform" copper. Kirkham (1995) subdivides sediment hosted copper deposits into the 'Kuperschiefer' and the 'Redbed' subtypes.

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), Kirkham (1995).

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 paleo-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, i.e. 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, \pm 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 sulfur &/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.

In typical redbed subtype copper deposits, the redbed sequence consist of successive cycles of fluvial sediments starting with coarser reduced and permeable sandstones at the base of the cycle and grading to fine grained oxic, less permeable shales and siltstones near the top of the cycle. The best concentrations of copper and silver are near the base in the more permeable sandstones at reducing/oxidising interfaces.

Typical redbed copper deposits such as Dorchester and Nacimiento are much smaller than the Kupferschiefer subtypes. The much larger deposits at Dzhezkazgan and Revett Formation included in this subtype by Kirkham (1995) involve large scale invasion of reducing solutions into the redbeds resulting in extensive oxidising/reducing interfaces where copper is deposited.

Examples:

Kupferschiefer subtype:

Mount Gunson, Australia	
Mammoth (Gunpowder), Australia	
Mount Oxide, Australia	
Kupferschiefer, Germany	(Wedepohl, 1971)
White Pine, United States	(Brown, 1971)
Western Montana (Belt), United States	(Harrison 1972, 1982)
Kamoto, Zaire	(Bartholome <i>et al</i> 1976)

Redbed subtype:

Dorchester, New Brunswick	
Nacimiento, New Mexico	(Woodward, <i>et al.</i> 1974)
Dzhezkazgan district, Kazakhstan	
Revett Formation, Montana	
Corocoro, Charcarilla, Bolivia	

Known Deposits and Mineral Occurrences in the North East Region

Minor occurrences of sediment hosted copper, with or without uranium and vanadium have been located by exploration at several localities in the Lower Carboniferous terrestrial sediments of the Mansfield and Mount Typo Basins. The copper is concentrated in locally reduced grey and green sediments within a dominantly oxidised fluvio-lacustrine red bed sequence. Some 36 copper occurrences have been located in one cupriferous sandstone unit and three cupriferous shale units. Near the surface the mineralisation consist of malachite with lesser chrysocolla and sulphides. The mineralised sandstone unit averages 19m in thickness with a strike length of 10 km but individual mineralised beds were only 20 to 30cm thick and discontinuous with grades of 1-1.5% copper. Grades in cupriferous shales are lower. No uranium minerals were visible but anomalous concentrations of uranium were located at six localities.

Sediment hosted copper mineralisation was also located in similar interbedded redbed/reduced sediment sequences in the Mount Typo Basin north east of the Mansfield Basin at Mount Pleasant. Green-grey micaceous sandstone up to 25cm thick contains abundant malachite and azurite in thin bedded seams a few millimetres thick. Average grade of representative samples were 4.65% copper, 38 ppm silver, 539 ppm uranium and 290 ppm vanadium. Drilling located mineralisation only in one hole.

Sediment hosted copper has also been located at a few locations in the Avon and the Mitchell River Basins south of the Mansfield Basin but exploration in early 1970's failed to locate economic deposits.

It was considered that the occurrences in the Mansfield Basin are similar to red bed copper-uranium-vanadium mineralisation in other parts of the world but the small size of the Mansfield Basin makes the chance of economic deposits unlikely (Nott, 1988). However similar redbed type rocks in other basins to the south and north east of the Mansfield Basin indicate that prior to erosion, the redbed sequence was far more extensive.

Assessment Criteria

1. Presence of interbedded redbeds and reduced sediments
2. Presence of copper occurrences and copper anomalies
3. Presence of fault and fold structures in the basement and the basin sediments

Assessment

Tracts: BM2a/M/C

The tracts for sediment hosted copper and sandstone uranium are defined by the extent of the late Devonian redbed sequences in the Mansfield Basin and the Mount Typo Basin to the north east of the Mansfield Basin. The highest concentration of known copper occurrences is in the Mansfield and Mount Typo Basins. Interfaces of reducing and oxidising environments in the redbeds together with structural traps in the basin and faults in the underlying basement rocks provide favourable settings for deposition of copper, silver and less frequently uranium from metal-bearing solutions. On the available evidence from exploration data, the redbeds in the Mansfield Basin are assigned a moderate potential for small deposits of copper and silver with a certainty level of C.

Tract: BM2b/L-M/B

The tract is defined by the extent of the Macalister Basin to the south of the Mansfield Basin. The full extent of reduced beds within the redbeds in the Macalister Basin is not known but exploration data suggest that copper occurrences in the Macalister Basin are less common than in the Mansfield and Mount Typo basins. Hence, the redbeds in the basin are considered to have a lower potential of low to moderate with a certainty level of B.

Economic significance

Redbed copper deposits of major significance are in Kazakhstan and there are important deposits in Revett Formation in Montana. Elsewhere known sediment hosted copper deposits of the redbed type are relatively unimportant as compared to the giant sediment hosted copper deposits of the Kupferschiefer subtype in Europe and in Zambia and Zaire. Some of the redbed type copper deposits have high silver content (e.g. Revett Formation) which makes them economically more attractive.

Elsewhere in the world, sediment hosted copper deposits represent major sources for copper and uranium respectively.

Sn1: 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 \pm wolframite and base-metal sulfide fissure fillings or replacement lodes in or 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: Paleozoic 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 \pm 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 \pm wolframite fringed with Pb, Zn, Cu, and Ag sulfide minerals.

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

Alteration: Sericitisation (greisen development) \pm 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)

Known Deposits and Mineral Occurrences in the North East Region

Several primary tin occurrences are located in the North East region. They are closely associated with Silurian and Devonian granites which are subdivided into three basement terranes: the Howqua Basement Terrane (HBT), the Wagga Basement Terrane (WBT) and the Melbourne Basement Terrane (MBT).

In the WBT the Walwa and Mitta Mitta tin fields consist of dominantly greisen-style deposits although some “reef” type mineralisation is present in the Mitta Mitta field. Tin bearing dykes in the Mt Wills field have a different character and it is possible cassiterite was directly precipitated from a magma, the fractionated Mt Wills granite being a likely source.

Tin mineralisation also occurs in quartz veins within both S- and I-type granites, and near contacts with enclosing metasediments. Occurrences of this type are present at Koetong, Mt Cudgewa and Surveyors Creek.

In NSW granites of the WBT also host the much larger Ardlethan tin deposits in NSW.

Small and low grade tin lodes are reportedly common in the Beechworth pluton (Pilot Range), part of the HBT. Tin mineralisation occurs within the granites in quartz veins and in chalcopyrite-garnet-tourmaline ‘fissures’. It is unclear whether cassiterite also occurs as disseminations in the granite. The most significant lodes of tin occur at the Lone Hand and Hidden Friend shafts which are hosted by the Woolshed Adamellite.

There are no primary deposits of tin associated with the granites of the MBT in Northeastern Victoria. However the source of small amounts of alluvial tin at Cockers Claim, Northeastern Gold and Tin Mining Co. and Ryan’s Creek is probably the Strathbogie Granodiorite.

Alluvial Tin Deposits:

The Beechworth-Eldorado (Pilot Range) alluvial deposits have been the largest source of tin in Victoria estimated at 11 405t of concentrates, mostly as by-product of alluvial gold mining. The large size of these deposits is in apparent contradiction with the very small primary deposits in the area, but it is likely that they are the eroded remnants of larger primary deposits formed around the upper contacts of granites which have been subsequently eroded away. A lack of roof pendants also suggests that granites of the Beechworth Pluton have been eroded to intermediate levels.

Assessment Criteria

1. Distribution of fractionated, reduced, S or I type, late orogenic to postorogenic granitoids intrusions (either outcropping or at shallow depth).
2. Presence of tin-bearing aplite-pegmatite dyke swarms.
3. Subsurface distribution of granitoids - veins are within the 5 km granite buffer.
4. Distribution of tin occurrences.

Assessment

Tract: Sn1a/M/B-C

This tract is defined by the presence of reduced, felsic and fractionated granites

Granites of both the Koetong Suite (including the Granya and Burrowye bodies) and the Beechworth pluton are known to be reduced. The Beechworth pluton is more strongly fractionated than granites of the Koetong Suite, but the Koetong granites are still relatively fractionated. Primary and secondary occurrences are associated with each of the bodies although co-tungsten/tin mineralisation is only present at Koetong. Alluvial lodes associated with the Beechworth pluton are extensive.

A number of tin bearing dykes occur immediately to the east of the fractionated and felsic Mt Wills Granite. The granite has a weak magnetic response and descriptions of tin occurrences in the area suggest that mineralisation has taken place directly from a magmatic source rather than greisenised dykes (as is common in the Mitta Mitta dyke swarm). The Mt Wills body is an obvious possible source of this mineralisation.

The above granites are considered to have a moderate potential with a certainty level of C.

Granites within the area that have weak magnetic signatures, are felsic, fractionated and not known to be strongly oxidised include the Barjarg, Pine Mountain, Thologolong and Chesney Vale granites. Only Thologolong has alluvial occurrences closely associated with it - no primary occurrences are associated with these granites.

The Pinnibar/Mt Boebuck/Boebuck body is mafic, but is described as having a very felsic core. It is notable that the western half of the body has a very strong magnetic signature while the eastern part of the granite has a very low magnetic response, suggesting the presence of two separate granitic bodies. It is in the eastern body that a primary occurrence of tin is found in quartz veins at the contact with surrounding rocks at Surveyor's Creek. Several alluvial occurrences also occur in the Surveyor's Creek area though not all are directly downstream of the known primary occurrence, suggesting that other unknown primary deposits may exist.

These granites are considered to have a moderate potential with a certainty level of B.

Tract Sn1b/L-M/B

This tract is delimited by the Strathbogie Adamellite and Mt Buffalo granite plus the extent of known tinfields that relate to aplite-pegmatite dyke swarms which intrude the Omeo Metamorphic Complex.

The Mt Buffalo granite is felsic and fractionated but has a stronger magnetic response than those granites mentioned above suggesting that it may be more oxidised. No primary or alluvial tin occurrences are associated with the Mt Buffalo body.

The Strathbogie Adamellite is known to have small, highly fractionated bodies within the main body. It has been described as reduced but there is a stronger magnetic signature around the centre of the main body. There are two small alluvial tin occurrences located on the eastern arm of the granite body which they are probably derived from.

Aplite-pegmatite dykes hosted by the Omeo Metamorphic Complex host mineralisation in the Mitta Mitta and Walwa tinfields. Although greisens are the dominant form of mineralisation there is some “reef” type mineralisation within the tinfield at Mitta Mitta.

Given the information above, the tract is assessed to have a low-moderate potential with a certainty level of B.

Economic Significance

According to grade/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).

Sn2: TIN GREISEN DEPOSITS (MODEL 15C OF COX AND SINGER, 1986)

Model Description

Description of the model after B. L. Reed

Description: Disseminated cassiterite, and cassiterite-bearing veinlets, stockworks, lenses, pipes, and breccia in greisenised granite.

General Reference: Reed (1982), Solomon & Groves (1994)

Geological Environment

Rock Types: Specialised biotite and(or) muscovite leucogranite (S-type); distinctive accessory minerals include topaz, fluorite, tourmaline, and beryl. Tin greisens are generally post-magmatic and associated with late fractionated melt.

Textures: Common plutonic rock textures, miarolitic cavities may be common; generally nonfoliated; equigranular textures may be more evolved (Hudson and Arth, 1983); aplitic and porphyritic textures common.

Age Range: May be any age; tin mineralisation temporally related to later stages of granitoid emplacement. Tasmanian deposits are associated with Devonian-Lower Carboniferous granitoids.

Depositional Environment: Mesozonal plutonic to deep volcanic environment.

Tectonic Setting(s): Foldbelts of thick sediments ± volcanic rocks deposited on stable cratonic shield; accreted margins; granitoids generally postdate major folding.

Associated Deposit Types: Quartz-cassiterite sulfide lodes, quartz-cassiterite ± molybdenite stockworks, late complex tin-silver-sulfide veins.

Deposit Description

Mineralogy: Cassiterite, molybdenite, arsenopyrite, beryl, wolframite, bismuthinite, Cu-Pb-Zn sulphide minerals and sulphostannates. Gangue mineralogy includes quartz, \pm fluorite, calcite, tourmaline, muscovite and topaz.

Texture/Structure: Exceedingly varied, the most common being disseminated cassiterite in greisens, and quartz veinlets and stockworks (in cupolas or in overlying wallrocks); less common are pipes, lenses, and tectonic breccia.

Alteration: Incipient greisen (granite): muscovite \pm chlorite, tourmaline, and fluorite. Greisenised granite: quartz-muscovite-topaz-fluorite, \pm tourmaline (original texture of granites retained). Greisen: quartz-muscovite-topaz \pm fluorite \pm tourmaline \pm sulphides (typically no original texture preserved). Tourmaline can be ubiquitous as disseminations, concentrated or diffuse clots, or late fracture fillings. Greisen may form in any wallrock environment, typical assemblages developed in aluminosilicates.

Ore Controls: Greisen lodes located in or near cupolas and ridges developed on the roof or along margins of granitoids; faults and fractures may be important ore controls.

Weathering: Granite may be "reddened" close to greisen veins. Although massive greisen may not be economic as lodes, rich placer deposits form by weathering and erosion.

Geochemical Signature: Cassiterite, topaz, and tourmaline in streams that drain exposed tin-rich greisens. Specialised granites may have high contents of SiO_2 (>73 percent) and K_2O (>4 percent), and are depleted in CaO, TiO_2 , MgO, and total FeO. They are enriched in Sn, F, Rb, Li, Be, W, Mo, Pb, B, Nb, Cs, U, Th, Hf, Ta, and most REE, and impoverished in Ni, Cu, Cr, Co, V, Sc, Sr, La, and Ba.

Examples:

Lost River, United States	(Dobson, 1982; Sainsbury, 1964)
Anchor Mine, Australia	(Solomon and Groves, 1984)
Erzgebirge, Czechoslovakia	(Janecka and Stenprok, 1967)

Known Deposits and Mineral Occurrences in the North East Region

Significant greisen tin deposits occur in the Walwa and Mitta Mitta tinfields which lie within the Omeo Metamorphic Complex. The Omeo Metamorphic Complex has been intruded by aplite-pegmatite dyke swarms which host abundant tin mineralisation, dominantly as greisen lodes. Production from the Walwa field has been the largest of any of the primary lodes in Victoria. Very similar mineralisation styles to the Walwa tinfield are recorded at the Burrowye and Mt Aldes tinfields.

Small and low grade tin lodes are reportedly common in the Beechworth pluton (Pilot Range), part of the Howqua Basement Terrane. Mineralisation occurs as disseminations in greisen lodes as well as in chalcopryrite-garnet-tourmaline 'fissures'.

Assessment Criteria:

1. Presence of tin-bearing aplite-pegmatite dyke swarms.
2. Distribution of fractionated, reduced, S or I type, late orogenic to postorogenic granitoids intrusions (either outcropping or at shallow depth).
3. Distribution of greisenised granite
4. Presence of greisen and alluvial tin.

Assessment

Tract: Sn2a/M/C

This tract is defined by the extent of known tinfields that relate to aplite-pegmatite dyke swarms which intrude the Omeo Metamorphic Complex.

The abundance of aplite-pegmatite dykes and numerous greisen style occurrences within the dykes indicate that primary sources of tin were present over a wide area and processes of greisenisation were commonly in action. There is significant potential for subcropping dykes to contain greisen tin deposits.

This tract is assessed as having a moderate potential with a certainty level of C.

Tract Sn2b/L-M/B-C

This tract is defined by the presence of reduced, felsic and fractionated granites. It includes members of the Koetong Suite, the Beechworth Pluton as well as the Chesney Vale, Mt Wills, Barjarg, Pine Mountain and Thologolong bodies. The eastern section of the Pinnibar/Mt Boebuck body is also included in this tract.

Of the above granites only the Beechworth Pluton is known to contain greisen style occurrences, although the Koetong granites do contain unmapped dykes that could provide favourable sites for greisen deposits. Granites belonging to the Koetong Suite as well as the Mt Wills and Pinnibar bodies have primary tin occurrences associated with them but not in the form of greisen deposits. Alluvial occurrences are also present in the vicinity of these primary deposits.

This tract is assessed as having a low-moderate potential with a certainty level of B-C.

Tract Sn2c/L/B

This tract is delimited by the Strathbogie Adamellite and Mt Buffalo granite which although fractionated and felsic, and in the case of the Strathbogie body apparently reduced, have stronger magnetic signatures than granites noted above. No known primary occurrences are known from either of these bodies, although there are minor alluvial occurrences located on the eastern limb of the Strathbogie Adamellite.

This tract is assessed as having a low potential with a certainty level of B.

Economic Significance

According to grade/tonnage models for tin greisen deposits, 90% of deposits contain at least 0.8 million tonnes of ore, 50% at least 7.2 million tonnes and 10% at least 65 million tonnes. In these types of deposits, 90% contain at least 0.17% Sn, 50% at least 0.28% Sn and 10% at least 0.47% Sn (Cox and Singer, 1986).

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

General Reference: Solomon and Groves (1994)

Geological Environment

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

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

Age range: Paleozoic 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 selvages of dark-grey 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 <i>et al</i> 1980)
Round Mountain, United States	(Shawe <i>et al</i> 1984)
Chicote Grande, Bolivia	

Known Deposits and Mineral Occurrences in the North East Region

Tungsten and molybdenum mineralisation in Northeastern Victoria is known from each of the Wagga Basement Terrane, the Howqua Basement Terrane and the Melbourne Basement Terrane. In addition, some of the occurrences are associated with the I-type granites of the Boggy Plains Supersuite which are independent of basement terrane boundaries.

Primary tungsten and molybdenum occurrences in the Wagga Basement Terrane are closely associated with S-type Silurian granitoids, although some occurrences are known from the Devonian I-type Thologolong granite. At Womboi wolframite, as well as minor bismuth, molybdenum, tin and other mineralisation is hosted by quartz veins in the Thologolong granite, possibly a member of the Boggy Plain Supersuite. Similar quartz vein hosted tungsten, molybdenum and bismuth mineralisation occurs to the east of Womboi at the Woolondina, Wymah, Williams and Apple Tree reefs in the Silurian S-type Koetong Granite in the buffer zone. Other occurrences associated with the Koetong Granite within the Northeastern Victoria area are small, scheelite and wolframite bearing quartz veins such as at Keady's Reef and Mt Cudgewa. At Mt Cudgewa veins cut across the contact of the Koetong Granite with metasediments of the Omeo Metamorphic Complex. Minor molybdenum mineralisation is also present in quartz veins hosted within Silurian granite at Simmond's gap

The Mt Murphy Wolfram mine, situated south west of the area in the buffer zone, is the most significant tungsten deposit in Victoria. Tungsten mineralisation, dominantly as wolframite although some scheelite is present, is located within N-NE trending quartz veins hosted by the Omeo Metamorphic Complex, which overlies the Silurian S-type Mount Murphy pluton.

In the Howqua Basement Terrane molybdenum and tungsten mineralisation is associated with I-type Devonian granitoids. The Everton deposit is the most significant molybdenum deposit in Victoria and is associated with the I-type Everton Granodiorite. Molybdenum mineralisation is located in two-concentric pipe deposits within porphyritic granodiorite which surround barren cores of quartz biotite porphyry. Molybdenum is present within and around quartz veins and disseminated in the host granodiorite.

Minor molybdenite is present in quartz veins at Kitchington Creek, lying within the Mount Stanley Granite.

Primary occurrences of tungsten are also known from Indigo Creek and the Lady Rose Mine within Omeo Metamorphic Complex in quartz veins.

At Pennywight Flat bismuth and bismuthite are present in placer deposits probably derived from Mt Stanley or Everton.

Bonnie Doon is the only recorded occurrence of primary tungsten in the Melbourne Basement Terrane within the area.

Assessment Criteria

1. Distribution of fractionated, syn to late orogenic, I-type and/or S-type granitoids.
2. Presence of granitoids with moderate to intense magnetic response on high-resolution aeromagnetics.
3. Distribution of tungsten, molybdenum and bismuth prospects.

Assessment:

Tract: W-Mo1a/M/B-C

This tract is defined by the presence of oxidised S and I -type granitoids. It includes the Everton Granodiorite, the Murmungee Granodiorite (of which the Everton granodiorite is probably an offshoot), the Mt Angus body, the Mt Pinnibar/Boebuck Adamellite and the Buckwong Granite.

Significant molybdenum-bearing pipes at Everton indicate that this likely offshoot of the Murmungee body was probably at least partly fractionated and probably highly oxidised. The relatively high oxidation state is also suggested by a strong magnetic signature associated with the mapped extent of the body. The relative oxidation state of the Buckwong Granodiorite is unknown but it is very probably the source of the Mount Murphy tungsten deposit. These two deposits are the most significant tungsten and molybdenum deposits in Victoria.

The extent of the Murmungee granodiorite at depth is known from both drill core and its strong magnetic signature. Accessory sphene and magnetite in the body indicate that it is highly oxidised. The proximity of the Everton pluton and its similarity to the Murmungee body suggests that it may be an offshoot of the larger Murmungee body. Even though the Murmungee body itself is not fractionated, other offshoots or internal smaller bodies may have significant potential to host molybdenum/tungsten mineralisation. The Mt Angus pluton, further to the south, has similar geochemical features to the Murmungee Granodiorite, although no known mineralisation is associated with it.

Further to the east the Mt Pinnibar/Boebuck Adamellite is also very strongly magnetic, on its western side and is a zoned pluton with a very felsic core.

This tract is assessed to have a moderate potential for tungsten-molybdenum deposits with a certainty level of B-C.

Tract W-Mo1b/L-M/C

This tract contains felsic, fractionated S- and I-type granites whose oxidation state is not known to be reduced.

It includes the Mt Buffalo, Pine Mountain, Thologolong, Anglers Rest, and Mt Wills bodies, the granites of the Chesney Vale area and the Strathbogie suite. These bodies generally have low magnetic signatures suggesting that they are neither strongly oxidised or reduced. Significant tungsten mineralisation is hosted by the Thologolong body at Womboi and a minor occurrence has been noted in the Chesney Vale granites.

The Strathbogie suite, including the Trawool and Barjarg granite, is considered to be reduced as evidenced by the presence of accessory ilmenite, however there is a single occurrence of tungsten at Bonnie Doon on the southern edge of the Strathbogie pluton. Within the main Strathbogie Adamellite there are smaller, highly fractionated bodies which may have potential to host tungsten-molybdenum mineralisation.

The Koetong granites are also included in this tract because although they are known to be relatively reduced, there are numerous tungsten occurrences associated with these granites, suggesting they are not strongly reduced or fractionated.

Two small areas drawn around known vein hosted tungsten mineralisation in the Omeo Metamorphic Complex, to the north of the Beechworth pluton, are included in this tract to account for other possible occurrences which may be related to hidden or unmapped dykes.

This tract is considered to have low-moderate potential for hosting tungsten-molybdenum deposits with a certainty of C.

Economic Significance

According to grade/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 types 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. Tasmanian deposits are associated with Devonian - Early Carboniferous intrusions

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 \pm molybdenite \pm pyrrhotite \pm sphalerite \pm chalcopyrite \pm bornite \pm arsenopyrite \pm pyrite \pm magnetite \pm 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, Tasmania.	(Solomon and Groves, 1994)
Pine Creek, US, California	(Newberry, 1982)
MacTung, Canada, British Columbia.	(Dick and Hodgson, 1982)
Strawberry, US, California	(Nokleberg, 1981)

Known deposits and mineral occurrences in the North East region

There are no known scheelite skarn deposits in the North East region.

However, minor occurrences of skarns and/or hornfels containing wollastonite are known to occur. In particular, wollastonite occurs north of Bonnie Doon in contact metamorphosed Siluro-Devonian calcareous rocks on the southern margin of the Strathbogie Granite. Also, a small copper-wollastonite garnet skarn has been found in the Morass Creek valley in a limestone within the Wombat Creek Group. It is either associated with a Silurian granitoid or with a quartz feldspar intrusion of possible Triassic age (Mount Leinster complex). A magnetite and pyrite bearing garnet skarn is known from the same general area associated with a Triassic syenite phase intruding limestone near the Pyles Limestone deposit.

At Chesney Vale, 35 km WSW of Wangaratta, calcareous sandy shale of the middle Ordovician Hotham Group has been contact metamorphosed by a phase of the Chesney Vale Granite to produce a vesuvianite and calcite skarn assemblage.

Granitoids which are associated with tungsten-molybdenite vein mineralisation are known in the region (eg Strathbogie granite, Chesney Vale Granite) and these granitoid bodies have the potential to generate tungsten skarns or calcic hornfels where they might come into contact with limestone bearing formations or calcareous rocks.

Assessment Criteria

1. Presence of fractionated, oxidised relatively magnetic granitoids.
2. Presence of granitoids with moderate to intense magnetic response on high resolution aeromagnetics.
3. Distribution of calcareous horizons and limey beds
4. Presence of skarns or calcic hornfels (eg. wollastonite, garnet, scapolite bearing phases).
5. Occurrences of tungsten, molybdenite or tin/bismuth mineralisation.
6. Granitoids with a potential for tungsten-molybdenite vein mineralisation

Assessment

Tract: W/M/B.

The tract is delineated by the distribution of calcareous rocks within 5km of favourable oxidised S and I-type granitoids. This includes areas to the south of the Strathbogie plutonic suite, and areas in proximity to the Chesney Vale Granite. Tungsten occurs at Bonnie Doon on the southern edge of the Strathbogie pluton.

This tract includes a number of wollastonite-bearing skarns and/or hornfels.

However, because the tract does not contain any reported skarn scheelite occurrences, the potential of the tract is assessed as moderate with a certainty level of B.

Potential for other skarn-related deposits

Skarns with associated copper mineralisation have been reported from the Morass Creek area to the north of Benambra within the 15 km buffer zone. They are associated with Triassic syenite and quartz porphyry intrusives of the Mount Leinster Complex. Hence, the region has some potential for copper skarns but the available information is not sufficient to delineate a tract or assign a potential.

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% WO₃, 50% at least 0.67% WO₃ and 10% at least 1.4% WO₃ (Cox and Singer, 1986).

King Island is one of the world's largest tungsten skarn deposit. Estimated pre-mining resources for King Island orebodies: 16.9 Mt ore averaging 0.78% WO₃. Total production to date 10.67 Mt ore averaging 0.61% WO₃.

The known tungsten skarn deposits within North East region are small. At the Wilks Creek mine, a total of 8 tonnes of wolframite/scheelite concentrate has been produced from the largest quartz vein which was between 0.08 and 0.36m in thickness (Nott, 1988).

NiCu: SYNOROGENIC-SYNVOLCANIC NICKEL-COPPER (MODEL 7A OF COX AND SINGER, 1986)

Model Description

Description of the model modified after Norman J Page.

Approximate Synonyms: Ni-Cu in mafic rocks; Stratabound sulphide-bearing Ni-Cu; gabbroid associated Ni-Cu.

Description: Massive lenses, matrix and disseminated sulphide in small to medium sized gabbroic intrusions in fold belts and greenstone belts.

General References: (Hoatson *et al* 1992), Ross and Travis (1981), Marston *et al* (1981).

Geological Environment

Rock Types: Host Rocks include norite, gabbro-norite, pyroxenite, peridotite, troctolite, and anorthosite, hornblendite, forming layered or composite igneous complexes.

Textures: Phase and cryptic layering sometimes present, rocks usually cumulates.

Age Range: Archaean to Tertiary, predominantly Archaean and Proterozoic; Cambrian in Tasmania, Devonian in Victoria..

Depositional Environment: Intruded synvolcanically or tectonically during orogenic development of a metamorphosed terrane containing volcanic and sedimentary rocks.

Tectonic Setting(s): Mobile belts; metamorphic belts, greenstone belts.

Associated Deposit Types: Stratiform mafic-ultramafic Ni-Cu (Stillwater); Stratiform mafic-ultramafic PGE (Merensky Reef, Bushveld Complex); placer areaomite -PGM.

Deposit Description

Mineralogy: Pyrrhotite + pentlandite + chalcopyrite \pm pyrite \pm Ti-magnetite \pm Cr-magnetite \pm graphite; with possible by-product Co and PGE's.

Texture/Structure: Predominantly disseminated sulphides in stratabound layers up to 3m thick; commonly deformed and metamorphosed so primary textures and mineralogy may be modified.

Alteration: Alteration (serpentinisation, etc.) can be marked in this deposit type.

Ore Control: Sulphides may be near the basal contacts of the intrusion but are generally associated more with gabbroic dominated rather than basal ultramafic cumulates.

Weathering: May be recessive if altered; may form nickeliferous laterites over the ultramafic portions in low latitudes.

Geochemical Signature: Ni, Cu, Co, PGE, Cr.

Geophysical Signature: Strong magnetic signature where not extensively serpentinised.

Examples

Sally Malay, Western Australia.	(Thornett, 1981)
Radio Hill, Mount Sholl, Western Australia.	(Hoatson <i>et al</i> 1992)
Rana, Norway	(Boyd and Mathiesen, 1979)
Moxie pluton, US, Massachusetts.	(Thompson and Naldrett, 1984)
Cuni deposits (Five mile), Australia, Tasmania.	(Blissett, A. H., 1962; (Horvath, J., 1957)

Known Deposits and Mineral Occurrences in the North East Region

There are no known occurrences of nickel-copper in the region. However, in the Central Highlands CRA region immediately to the south, a few deposits and occurrences of this type have been recorded in the Woods Point Dyke Swarm. The dyke swarm continues north westerly into the North East region. The most well-known deposit in Central Highlands is the Thomson River copper mine (Coopers Creek copper mine). The nickel and copper mineralisation occurs in "bulges" or thickenings in the width of the dyke generally in the vicinity of a series of drag

folds in what appears to be an en echelon arrangement. Disseminated and massive copper nickel sulphides occur within diorite/hornblendite dyke,

A number of gold mines located in these dykes of the Woods Point swarm have produced copper and platinoids as by-products. Principal amongst these are Hunt's, the Shamrock and Morning Star mines. Copper and platinoid production have not been recorded.

Assessment Criteria

1. Presence of mafic rocks or altered mafic rocks in the area (Thomson River is hosted by the more mafic members of the dyke swarm eg hornblendite).
2. Presence of stratabound nickel copper sulphide mineralisation in gabbro/dolerite sills associated with ultramafic complexes.

Assessment

Tract: NiCu/M-H/B

The tract includes the Woods Point Dyke Swarm which has the potential to host small copper nickel deposits of the Thomson River type where ever thickenings or bulges in the dykes occur. The dykes contain mineralisation characteristic of this model type (synorogenic Ni-Cu) and hence the entire known outcrop area of the Woods Point Dyke Swarm is assessed as having moderate to high potential with a certainty level of B.

Economic significance

The gabbroid associated stratabound nickel copper sulphide deposit type has been of little commercial importance in North East region in the past. However, this deposit type is of world significance overseas as a important source of nickel and as a source of strategically important PGE's.

U: SANDSTONE URANIUM (MODEL 30C OF COX AND SINGER, 1986)

Model Description

Description of the model after Areaistine 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 TiO₂ 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, FeS₂. 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:

Honeymoon, Beverley South Australia.	(Battey, Miezeitis and McKay, 1987)
Colorado Plateau	(Fischer, 1974)
Grants, US, New Mexico	(Turner-Peterson and Fishman, 1986)
Texas Gulf Coast	(Reynolds and Goldhaber, 1983)

Known Deposits and Mineral Occurrences in the North East Region

There are no known occurrence of sediment-hosted uranium in the region, although anomalous concentrations of uranium were located at six localities within the Mansfield Basin.

Similarly, at Mount Pleasant, in the Mount Typo Basin (north east of the Mansfield Basin), green-grey micaceous sandstone up to 25cm thick contains abundant malachite and azurite in thin bedded seams a few millimetres thick. Drilling in one hole located uranium, vanadium

mineralisation along with copper and silver (Average grade of representative samples were 4.65% copper, 38 ppm silver, 539 ppm uranium and 290 ppm vanadium).

Assessment Criteria:

1. Presence of interbedded redbeds and reduced sediments
2. Presence of uranium occurrences and anomalies.
3. Presence of uranium-bearing granitoids and volcanic source rocks

Assessment

Tract: U/L-M/C

The tract is defined by the extent of the Mansfield, Mount Typo and Macalister basins, which contain redbed sequences. Anomalous concentrations of uranium, sometimes associated with the copper occurrences have been recorded in them. However, uranium mineralisation appears to be less widespread. Airborne uranium channel radiometric anomalies are generally low for the redbed sequences but can be locally high in the vicinity of some of the copper occurrences.

Secondary uranium mineralisation has been recorded within granitoids in the Ballarat-Bendigo zone and in the Omeo Zone (Bowen, 1988). Within the Melbourne Zone, the Granitoids and volcanics have low uranium contents. These rocks may provide a source of uranium for deposition as sandstone type deposits.

It was considered that the occurrences in the Mansfield Basin are similar to red bed copper-uranium-vanadium mineralisation in other parts of the world but the small size of the Mansfield Basin makes the chance of economic deposits unlikely (Nott, 1988). However similar redbed type rocks in other basins to the south and north east of the Mansfield Basin indicate that prior to erosion, the redbed sequence was far more extensive.

On the available information the potential for small sandstone uranium deposits is low to moderate at the interfaces of reducing and oxidising conditions in the redbeds in all of the basins with a certainty level of C.

Economic significance

Elsewhere in the world, sediment hosted copper and sandstone type uranium deposits represent major sources for copper and uranium respectively.

CONMAT: CONSTRUCTION MATERIALS

Model Description

After New South Wales Geological Survey.

Approximate Synonyms

The term extractive resources is used as a synonym for construction materials. 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.

Known Deposits and Mineral Occurrences in the North East Region

Much of the construction material activity is concentrated in the north of the North East region near the larger population centre of Albury-Wodonga and Wangaratta, and along the Hume highway to Melbourne. At Glenrowan large quantities of Glenrowan Granite are extracted for aggregate, road base and fill and a small quantity was mined for dimension stone (Maher *et al* 1997).

The Murray Valley flood plain near Wodonga is a major source of river sand and gravel from deposits up to 30 metres thick (Bowen 1988). Quaternary age Coonambidgal Formation clay and sand is extracted from the Murray, Broken and Ovens Rivers close to Albury, Everton and Wangaratta and is used for aggregate, fine sand, concrete, fill and road base. Small amounts of clay were also extracted for brick making (Maher *et al* 1997). River gravels in old gold sluicing tailings dumps on the Mitta Mitta and Ovens Rivers have been used locally for road construction (Oppy *et al* 1995).

Pleistocene age alluvial clay deposits along the Ovens and Mitta Mitta river valleys, in the north-eastern half of the region, and the Goulburn River valley, along the south-west boundary of the region, thicken northwards and become very extensive along the Murray River plains. They have been used for brick making at Shepparton, to the north-west of the region, and at Euroa for tile manufacture (Ferguson and Atkinson 1988).

Shale, mudstone and sandstone of the Hotham Group near Glenrowan, Chiltern and Benalla are used for aggregate, road base and fill. Siluro-Devonian age sandstone is extracted for aggregate, fill and road base near Euroa and Karn (Maher *et al* 1997).

Contact metamorphosed rock (hornfels) of the Hotham Group is also used as aggregate (Maher *et al* 1997) and is extracted at Chiltern. Crushed hornfels has been sourced from the Walwa Road Quarry for road building and maintenance.

Near Violet Town, Devonian age rhyodacite is used for road base and aggregate (Maher *et al* 1997). Phyllitic shale has been quarried on the Mitta Mitta North road and at the junction of Mitta Mitta and Yabba Roads (Oppy *et al* 1995).

Assessment Criteria

1. Presence of soft or weathered rock.
2. Presence of Tertiary and Quaternary soil and sediments.
3. Presence of granite, acid to basic volcanics and hornfels.
4. Proximity to construction material markets/end use points and viable transport routes.

Assessment

Higher value construction materials

The potential for economic deposits of higher value construction materials in the North East region exists where suitable rock types, gravels sands and clays occur within viable transport distances of population centres. The viable transport radius around a centre increases with population size because of the economies of scale of supplying a larger market and better road networks around larger centres. Deposits near good transport routes such as the Hume Highway and other major roads, with access to distant population centres may also be viable. Major population centres around which there would be a higher demand for construction materials include Albury-Wodonga, Wangaratta, Benalla, Euroa, Seymour, Beechworth, Corryong, Mansfield and Myrtleford

Lower value construction materials

Most of the rock types in the North East region have potential for lower value construction materials in their fresh or weathered state; and soil, sand and gravel are widespread across the region. Suitable materials are mainly used for secondary road building and extraction of material usually occurs in close proximity to these roads. The materials include: (1) rippable sandstone, shale, schist, weathered granite and other rock, (2) sand and gravel, (3) soil and calcrete.

Economic Significance

Construction materials, like many other industrial minerals, have a low value per unit of volume and transport costs contribute significantly to their delivered cost. Thus it is essential that they are accessible in large quantities close to urban areas for use in construction, paving, water reticulation and many other uses which are the an integral part of modern living.

Fundamental infrastructure, such as road and railway networks, depend on widespread availability of crushed rock, sand, clay and other materials for their construction and maintenance. Similarly, major and minor aircraft runways and ports are all built with a significant input of construction materials.

Construction sand is commonly used in concrete, mortar, plaster and asphalt mixes. Special uses include glass and fibre glass manufacture, metal casting moulds, sand blasting and filtering media. Clay and clay shale are used in large quantities to make bricks, pipes and roofing tiles.

DIMST: DIMENSION STONE (GRANITE, BASALT, LIMESTONE , MARBLE, SANDSTONE, AND SLATE)

Model Description

Description of the model after Hora (1992)

Approximate Synonyms: Freestone, building stone.

Description: Geological materials suitable for dimension stone uses.

General References: Hora (1992); Bacon (1987, 1989); Sharples (1990).

Geological Environment

Rock Types: Intrusive and extrusive of mafic, felsic and ultramafic, and alkaline composition. Limestones, sandstone, shales, and phyllites.

Age Range: Precambrian to Tertiary.

Depositional Environment and Tectonic Setting: Synorogenic and postorogenic plutonic intrusions. Post orogenic volcanics. Sedimentary marine and continental rocks. Metasedimentary and Meta-igneous rocks that have undergone contact and/or regional metamorphism.

Deposit Description

Mineralogy: Typical of granites, basalts, limestone, marbles, sandstone, shales, phyllite etc.

Texture/structure: Massive, bedded, porphyritic, hornfelsic, spotted.

Alteration: Effect of weathering: Structural deterioration, decrease in strength and durability. In limestones and marbles weathering results in variety of karst features. Marbles with silicate components (tremolite, phlogopite, garnet) might significantly deteriorate in durability and strength. Effects of metamorphism: granites could change into gneiss, which may also be quarried as dimension stone. Limestone and marble undergo recrystallisation resulting in more massive beds, sometimes with enhanced colours and texture features and more suitable for polish.

Ore controls: Frequency of joints. Common types of granite can afford some 20% waste, only rare and attractive varieties waste up to 80% of quarried rock. For marbles and limestones and sandstones, thick bedding (> 1 metre), absence of fractures and joints, absence of inhomogeneities like chert, and other type of silica staining components like sulphides, absence of intrusive sills and dikes, absence of solution cavities in carbonate rocks.

Weathering: Leads to structural deterioration and decrease in strength and durability.

Geochemical signatures: Nil

Geophysical signatures: Resistivity has been used to identify low fracture densities in granites and karst features in limestones and marbles.

Examples

Known Deposits and Mineral Occurrences in the North East Region

The region hosts several important quarries of various types of dimension stone which are listed in the table below as follows:

Locality	Type of dimension stone
Beechworth	Granite
Mt Mittamatite and Pine Mountain	Granite
Strathbogie	Granite
Tallangatta Porphyry	Granite
Tamnick Gap	Granite
Trawool	Granite
Yackandandah	Granite
Ghin Ghin (Davis)	Slate
Mansfield (Howes Creek)	Limestone
Mitchell Creek (Howqua)	Slate

Assessment Criteria

1. Distribution of suitable granitoids, and alkaline igneous rocks.
2. Distribution of sedimentary and metasedimentary rocks such as marble, limestone, sandstone, shale and phyllite.
3. Presence of known quarries and occurrences.

Assessment

Tract: Dimst1a/M/B

The tract includes Silurian and Devonian granitoids (Beechworth, Corryong, Koetong, Mt Bruno, Mt Mittamatite, Pine Mountain, Strathbogie, Trawool and Yackandandah). The tract also includes Ordovician Mt Easton Shales and Devonian Humevale Siltstone. These rocks host one or more known quarries and/or occurrences of dimension stone.

More detailed information is required on the physical (fracturing, jointing, karsts, thickness of beds) and chemical properties (heterogeneities such as chert and other staining substances) of these rocks to assess more accurately their suitability as dimension stones. Hence potential of the tract is assessed to be moderate with a certainty level of B.

Tract: Dimst1b/U/A

The tract is defined by the presence of Silurian and Devonian granitoids, Tertiary volcanics, limestone and sandstone bearing formations and Ordovician sedimentary/metasedimentary rocks. These rocks are similar to the rocks that define the above tract but lack known quarries or occurrences. Hence the tract is assessed to have an unknown potential.

Felds: FELDSPAR

Model Description

Approximate Synonyms:

Description: Feldspar in granites, pegmatites, syenites and nepheline syenite.

General References: Kauffman and van Dyke (1994); McHaffie and Buckley (1995)

Geological Environment

Rock Types: Intrusive and extrusive rocks of felsic and alkaline composition and aplite and pegmatite dykes.

Age Range: Precambrian to Tertiary.

Depositional Environment and Tectonic Setting: Synorogenic and postorogenic plutonic intrusions. Post orogenic volcanics. Some river, dune and beach sand also contain commercially important concentration of feldspar.

Deposit Description

Mineralogy: Typical of granites and pegmatites.

Texture/structure: Massive, bedded, porphyritic in granites and syenites, and massive, blocky and graphic in pegmatites.

Alteration: Effect of weathering: Weathering affects physical properties (fracturing, cavities) as well as the concentration of K_2O , Na_2O and Al_2O_3 . It can also introduce iron from the surrounding rocks lowering the quality and suitability for glass industry.

Ore controls: Feldspar for glass making needs to have 4-6% K_2O , 5-7% Na_2O , 19% Al_2O_3 and $< 0.08\%$ Fe_2O_3 . The ceramic industry prefers K-feldspar that has 5-14% K_2O and $< 0.07\%$ Fe_2O_3 . Nepheline syenites provide K-feldspar of better quality for glass and ceramic industry than granites and pegmatite.

Weathering: Leads physical and chemical degradation. In some cases weathering can assist in the generation of feldspathic sands.

Geochemical signatures: Nil

Geophysical signatures: Resistivity has been used to identify low fracture densities in granites and karst features in limestones and marbles.

Examples:

Known Deposits and Mineral Occurrences in the North East Region

The regions hosts several important mines and occurrences of feldspar. These are listed in the following table:

Locality	Type of Source Rock
Beechworth	Beechworth Granite
Corbetts Flat	Pegmatite
Derbyshire sidings	Koetong Granite
Huon Hill	Pegmatite
Koetong Creek	Thologolong Granite
Kookaburra Creek	Pegmatite
Mt Lady Franklin	Lady Franklin Granite
Mt Pilot	Beechworth Granite
Mt Smythe	Pegmatite
Sheep Station Creek	Beechworth Granite
Tallangalook	Strathbogie Granite
Tallangatta	Pegmatite

Assessment Criteria

1. Distribution of suitable granitoids, alkaline igneous rocks, pegmatite and aplite dykes.
2. Presence of known mines and occurrences.

Assessment

Tract: Felds1a/M/B

The tract includes Silurian and Devonian granitoids (Beechworth, Koetong, Lady Franklin, Strathbogie, and Thologolong). These rocks host one or more known mines and/or occurrences of feldspar.

Although mines and/or occurrences of feldspar are present in these rocks, more detailed information is required on their physical (fracturing, jointing, cavities) and chemical properties (concentration of potassium, sodium and iron) to assess more accurately their suitability as source for high quality feldspar. Hence potential of the tract is assessed to be moderate with a certainty level of B.

Tract: Feldsp1b/L-M/B

The tract is defined by the presence of pegmatite and aplite dykes. In addition to dykes which have been mapped, high-resolution aeromagnetics has been used to delineate a north-Northwest trending zone of dyke swarms. The zone extends 75 kilometres to west and 35 kilometres east of the Kancoona Fault. Dykes show low to moderately magnetic responses trending northwest (Maher *et al* 1997). The Woods Point dyke swarm is not included in the tract as these dykes are more mafic.

The dykes in the tract are known to have a few known occurrences of feldspar suitable for glass and ceramic industries.

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

Tract: Feldsp1c/U /A

The tract includes all known granitoids which are not part of the tract with moderate potential. It also includes alkaline igneous rocks of the Triassic Mount Leinster Igneous Complex. Available geological information does not allow to assess their potential. Hence the tract is considered to have an unknown potential.

Lst: LIMESTONE

Model Description

Description of the model after D. Hora (1992).

Approximate Synonyms: Limerock, cement rock, calcium carbonate.

Description: Limestone deposits of economic importance were partly or wholly biologically derived from seawater and accumulated in a relatively shallow marine environment. Environment of deposition determines the size, shape and purity of the carbonate rock. Limestone deposits are frequently of large areal extent and may be of considerable thickness (several hundred metres).

General References: Carr & Rooney (1983); Harben & Bates (1990)

Geological Environment

Rock types: Limestone

Age range: Late Proterozoic to Holocene.

Depositional environment: Belts of shallow sea water sediments.

Tectonic setting(s): Continental shelf and subsiding marginal marine basins.

Associated deposit types: Deposits of dolomitic limestones and dolomites.

Deposit Description

Mineralogy: Limestone is a sedimentary rock consisting of 50% or more of calcite (CaCO_3), and dolomite ($\text{CaMg}(\text{CO}_3)_2$). There is a complete gradation from impure limestone to high calcium limestone (>95% CaCO_3). In dolomites, the mineral dolomite is the major carbonate, which usually forms by replacement of calcite. Common impurities in carbonate rocks include clay, quartz sand, chert, and organic matter.

Texture/structure: Massive, bedded.

Alteration: Groundwater dissolution results in karst cavities, frequently filled with clay.

Ore controls : Highly sought white limestones for mineral fillers are usually a product of the contact or regional metamorphic process. Maximum limitations of overburden: Extremely varied depending on the end use. Limestones are known to be mined underground even for uses like cement production.

Weathering: solutions weathering results in a variety of karst landforms in most climatic areas, but intensifies with warmer climate.

Geochemical signature:

Geophysical signature: Resistivity has been used to identify karst features in covered terrain.

Examples

Silurian Marulan and Wombeyan Limestones of NSW;
Tertiary Eucla Basin limestones, e.g. Nullarbor Limestone of W.A and S.A; Tertiary Batesford Limestone and Gambier Limestone of Victoria and S.A.

Known Deposits and Mineral Occurrences in the North East Region

The North East region hosts only a few minor deposits of limestone. The most well-known is Mansfield (Howes Creek) associated with Lower Devonian sedimentary rocks of the Walhalla Group. A minor occurrence of limestones is reported in the Wombat Creek Graben, near Benambra. At Boswood, 6 km east of Dookie, a large pure calcite vein traversing Cambrian dolerite was worked to produce lime for use in agriculture and plaster. Outside the region, limestones of similar age host the Lilydale deposit (about 35km east of Melbourne), which is one of largest limestone deposits in Victoria.

Assessment Criteria

1. Presence of Silurian-Devonian marine sedimentary rocks.
2. Presence of known occurrences of limestone and marble.

Assessment

Tract Lst/L-M/C

The tract is defined by the Silurian-Devonian sedimentary rocks, which may contain limestones. The tract includes the Howes Creek deposit near Mansfield and the limestones in Wombat Creek Graben.

The tract is considered to have a low to moderate potential for limestone/dolomitic limestone deposits with a certainty level of C.

Economic Significance

Limestone/dolomitic limestone, like many other industrial minerals, have a low value per unit of volume but it is essential that they are accessible in large quantities close to urban areas for use in construction. Thus competing land uses are a constant pressure on the availability of these resources. Other uses are in agriculture, roads and fillers for paper and plastic. Production in Victoria has fluctuated between 2.5 and 3 million tonnes since 1969/70 but dropped below 2 million tonnes in the early 1990's.

Limestone/dolomitic limestone deposits usually need to be either outcropping or near surface to be economic to extract. Distance from markets is also an important factor in the viability of a limestone/dolomitic limestone deposit as transport makes up a substantial proportion of product costs.

Kao: KAOLIN

Model Description

Description of the model after Hora D (1992).

Synonyms: Primary kaolin, secondary kaolin.

General References: Harben and Bates (1990); Lefond (1985)

Geological environment

Rock types: kaolinised feldspathic rocks, ranging in composition from granites to diorites with their volcanic equivalents. Secondary alluvial kaolinitic clays.

Age range: Upper Cretaceous to Eocene.

Tectonic setting: Down-faulted sedimentary basins.

Depositional environment: Interior basins and flat alluvial plains with basement composed of feldspathic rocks. Alteration of feldspathic rocks by hydrothermal and/or residual weathering. Also feldspathic volcanic rocks may be the host for kaolin deposits, particularly where faults may provide the channels for circulating ground waters. Secondary alluvial clays eroded from primary deposits laid down in Tertiary and Quaternary river channels and lakes.

Associated deposit types: Fireclay, bentonite, coal, ceramic and cement "shales".

Deposit Description

Mineralogy: Kaolin, quartz, feldspar, with minor biotite and hornblende.

Alteration mineralogy: n/a.

Ore controls: Unconformity and fractured basement rocks.

Examples

Axedale, Victoria	McHaffie and Buckley, 1995
Weipa, Queensland	Schaap, 1990

Known Deposits and Mineral Occurrence in the North East Region

There are no known occurrences or deposits of kaolin in the region.

Assessment criteria:

1. Presence of Tertiary deep weathering (primary deposits) profile.
2. Presence of feldspar rich rocks.
3. Tertiary and Quaternary unconsolidated sediments (secondary deposits).
4. Presence of known occurrences.

Assessment

Tract: Kao/M/B

Primary (or residual) kaolin forms by in-place weathering of feldspar-rich rocks such as granite, gneiss, arkose or some sediments. Deep weathering under hot, humid conditions (McHaffie 1992, in McHaffie & Buckley 1995) in Victoria during the late Cretaceous and early Tertiary periods generated extensive, thick kaolinitic surficial zones. These zones were then largely eroded away later in the Tertiary and Quaternary to form secondary kaolinitic clay deposits.

The kaolin tract is delineated on the distribution of Tertiary and Quaternary sediments in which secondary clay deposits may occur. Lack of information at the scale of this assessment precludes the delineation of remaining primary Tertiary kaolin deposits developed on granitic or favourable sedimentary rocks.

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

Economic significance

Kaolin, like many other industrial minerals, have a low value per unit of volume but it is essential that they are accessible in large quantities close to urban areas for use in industry and construction. Thus competing land uses are a constant pressure on the availability of these resources.

APPENDIX C : MINERAL RESOURCES METADATA SHEETS

VIC: Geological maps database

Organisation Department of Natural Resources and Environment
Minerals and Petroleum Victoria

Abstract:

The geological maps database is a digital version of the 1: 250 000 scale geological maps of Victoria.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: Victorian 1: 250 000 Geological maps database

Data Set Short Title: Vic GEOL.

Jurisdiction: Victoria

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum
Victoria

Publication Date: Dec 1995

Acknowledgements:

References:

Dataset Description

Abstract:

The Geological Maps Database is a digital version of the 1: 250 000 scale geological maps of Victoria that were compiled during the 1970s and 1980s. Some areas have been updated from more recent 1: 100 000 scale mapping.

Search Words: Geosciences, Geology

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List: See attached listing

Contact Information

Contact Organisation: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Contact Position: Manager, Geological Mapping

Contact Person: Peter O'Shea

Contact Address: PO Box 500, East Melbourne, Vic 3002

City: Melbourne

State: Victoria

Contact Phone: 03 9412 5093

Contact Fax: 03 9412 5155

Contact Email: peter.oshea@nre.vic.gov.au

Dataset Currency and Status

Beginning Date: 1970

Ending Date: 1992

Progress: In progress

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital - polygon, Hardcopy - Maps

Output Data Format: Digital - polygon, Hardcopy - Maps

Native Data Format: Available in Genemap, MapInfo or ArcView formats

Access Constraints:

Dataset Quality

Lineage Summary: Derived from 1: 250 000 scale geological maps

Scale: 1:250 000

Resolution: 250

Cell Size:

Positional Accuracy: ± 250 m

Attribute Accuracy: Data is accurate at time of map compilation to the best knowledge of the people compiling the map, given the state of geological knowledge.

Logical Consistency: Data identified from field mapping and aerial photography interpretation at 1: 250 000 scale.

Completeness: As above

Additional Information:

Attribute List: - see attached listing

Metadata Contact Information

Metadata Date: 11 July 1996

Metadata Contact Person: Roger Buckley

Metadata Contact Organisation: DNRE, MPV

Metadata Contact Email: roger.buckleyr@nre.vic.gov.au

Attribute List

Unit: The abbreviated formal rock unit id. code (eg. Emv)

Unit No.: Used only for granitoid plutons. The number quoted is that defined by White *et. al.*, Petrology of Igneous Rocks. In J.G. Douglas & J. A. Ferguson, (eds) *Geology of Victoria*. Geological Society of Australia, Victoria Division. Melbourne, pp. 427-451.

Name : The formal name fo the rock unit/formation/member.
Description & Description 1:
A brief description of the unit.

AUSTRALIA: Mineral Occurrence Database (MINLOC)

Organisation: Mineral Resources Branch

Abstract:

Compilation of data for the MINLOC database began in 1989 and now contains information on about 50 000 mineral occurrences and deposits. Information for each location includes location co-ordinates, name of occurrence, and commodity(ies) of economic interest. The information in the database covers about 94% of the Australian continent.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: Mineral occurrence database (MINLOC)

Data Set Short Title: MINLOC

Jurisdiction: Australia

Custodian: Bureau of Resource Sciences (BRS)

Publication Date:

Acknowledgements: Mineral Resources Branch (MRB)

References:

Dataset Description

Abstract: Compilation of data for the MINLOC database began in 1989 and now contains information on about 50 000 mineral occurrences and deposits. Information for each location includes location co-ordinates, name of occurrence, and commodity(ies) of economic interest. The information in the database covers about 94% of the Australian continent.

Search Words: MINERALS Mineral Deposits, MINERALS Mine Sites

Location Description: Australia

Spatial Domain

North Bounding Coordinate: -9.5

East Bounding Coordinate: 112.5

South Bounding Coordinate: -44.0

West Bounding Coordinate: 154.0

Bounding Polygon:

Attribute List: Mineral occurrence/deposit location name; location co-ordinates; mineral commodity(ies) present

Contact Information

Contact Organisation: MRB, BRS, DPIE

Contact Position: Geologist

Contact Person: Brian Elliott

Contact Address: Bureau of Resource Sciences

City: Canberra

State: ACT

Contact Phone: 02 6272 4433

Contact Fax: 02 6272 4161

Contact Email: BGE@mailpc.brs.gov.au

Dataset Currency and Status

Beginning Date: 1989

Ending Date:

Progress: In Progress

Maintenance and Update Frequency: 2-3 times per year

Dataset Storage and Format

Stored Data Format: Digital - Point

Output Data Format: Hardcopy - Printed Map; Hardcopy - Other

Native Data Format: Oracle - RDBMS (Relational Database)

Access Constraints: No Access Constraints

Dataset Quality

Lineage Summary: Each datapoint has reference to the source

Scale: 1:250 000

Resolution:

Cell Size:

Positional Accuracy: 3 Grades of accuracy: 10 to 100 metres; 100 to 1000 metres; 1 to 10 kilometres.

Attribute Accuracy: Each data point is tagged with precision

Logical Consistency: Cross checking of datasets, Overlays of maps, User feedback

Completeness: 94% of Australia was covered on first pass basis

Additional Information:

Metadata Contact Information

Metadata Date: 20 Jun '1996'

Metadata Contact Person: Brian Elliott

Metadata Contact Organisation: Mineral Resources Branch, BRS, DPIE

Metadata Contact Email: BGE@mailpc.brs.gov.au

VIC: Magnetics database

Organisation Department of Natural Resources and Environment
Minerals and Petroleum Victoria

Abstract:

Magnetic data over North East Victoria is mostly recent low altitude, close line spacing data flown by the Geological Survey of Victoria and the Australian Geological Survey Organisation. Several datasets were used, including the Tallangatta, Corryong, and Wangaratta datasets.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: North East Victoria region aeromagnetic data

Data Set Short Title:

Jurisdiction: Victoria

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Publication Date: TALLANGATTA - 1995; CORRYONG – 1996; WANGARATTA – 1997

Acknowledgments:

References:

Dataset Description

Abstract:

Magnetic data over North East Victoria is a mosaic of several airborne surveys, mostly recent low altitude, close line spacing data flown by the Geological Survey of Victoria and the Australian Geological Survey Organisation. Several datasets were used, including the Tallangatta, Corryong, and Wangaratta datasets.

Search Words: Minerals, Geophysics

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List:

Contact Information

Contact Organisation: Department of Natural Resources and Environment;
Minerals and Petroleum Victoria

Contact Position: Manager Geophysics, Geological Survey of Victoria

Contact Person: Alan Willocks

Contact Address: PO Box 500, East Melbourne, Vic 3002

City: Melbourne

State: Victoria

Contact Phone: (03) 9412 5131

Contact Fax: (03) 9412 5155

Contact Email: alan.willocks@nre.vic.gov.au

Dataset Currency and Status

Beginning Date: TALLANGATTA - 1995; CORRYONG – 1996; WANGARATTA – 1997

Ending Date: As above

Progress: All complete.

Maintenance and Update Frequency:

Dataset Storage and Format

Stored Data Format: Digital - Database; Hardcopy - Maps, Reports

Output Data Format: Digital: Mapinfo, ERMapper, TIFF, DS ASCII: **Hardcopy:** Plotted maps, Report, Transparency

Native Data Format: none

Access Constraints:

Dataset Quality

Lineage Summary:

TALLANGATTA - Line spacing 200m, height 80m

CORRYONG - Line spacing 200m, height 80m

WANGARATTA - Line spacing 200m, height 80m

Scale: 1:250,000

Metadata Contact Information

Metadata Date: 21 January 1997

Metadata Contact Person: Alan Willocks, Manager Geophysics

Metadata Contact Organisation: Department of Natural Resources and Environment, Minerals and Petroleum, Victoria.

Metadata Contact Email: alan.willocks@nre.vic.gov.au

VIC: Mining tenements

Organisation Department of Natural Resources and Environment
Minerals and Petroleum Victoria

Abstract:

The mining tenements database provides information and location of both current and expired exploration licences and mining licences in Victoria.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: Victorian Mining and Exploration Tenements

Data Set Short Title: VICEL

Jurisdiction: Victoria

Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Publication Date: 21 November 1996

Acknowledgements:

References:

Dataset Description

Abstract: The VICEL data set is derived from the corporate GEDIS system, and as such represents a snapshot in time of continually changing data. The database provides an outline of current and expired Exploration Licences and Mining Licences together with information on dates held and licences.

Search Words: Minerals Mining and Exploration Leases

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List: see later

Contact Information

Contact Organisation: Department of Natural Resources and Environment

Contact Position: Senior GIS Technical Specialist

Contact Person: Rob Lane

Contact Address: PO Box 500, East Melbourne, Vic 3002

City: Melbourne

State: Victoria

Contact Phone: 03 9412 5070

Contact Fax: 03 9412 5151

Contact Email: rob.lane@nre.vic.gov.au

Dataset Currency and Status

Beginning Date: Nov 1996

Ending Date:

Progress: Complete

Maintenance and Update Frequency: Daily (source dataset) Not planned
(this dataset)

Dataset Storage and Format

Stored Data Format: Digital - Polygon, Digital-Database

Output Data Format: Digital - Polygon, Digital - database, hard copy - maps;
hard copy - reports

Native Data Format: Distributed Via CD or disk or on-line for subscribers

Access Constraints:

Dataset Quality

Lineage Summary: Sourced from accurate topographic maps

Scale: 1:25000

Resolution: 25

Cell Size:

Positional Accuracy: + 25 metres

Attribute Accuracy: All information is accurate as far as MPV is concerned.

Logical Consistency:

Completeness: Complete for State of Victoria

Additional Information:

Metadata Contact Information

Metadata Date: 21-January 1997

Metadata Contact Person: Rob Lane

Metadata Contact Organisation: Minerals and Petroleum Victoria

Metadata Contact Email: rob.lane@nre.vic.gov.au

Attribute List

elcurr.

These files include the location and details of current Exploration titles (as at 21st November 1997).

Number	The Exploration Licence title number.
Type	The title type (El. for Exploration Licence, MP for an area excluded from title applications during the Moratorium period).
No. Renewed	The number of times the title has been renewed.
Applicant	The name of the title applicant.
Priority	The title priority date.
Granted	Date the title was granted.
Expiry	Date the title is due for renewal/expiry.
Moratorium	Date the moratorium period expires.
Area	The area of the title in square kilometres.
Municipality	The municipal shire in which the title lies.
Status	The status fo the title (CURRE for current, RENEW for under renewal, APPLI for under application).
DCNR.	Region: The Department of Conservation and Natural Resources region in which the title lies.

elhist

Title	The Exploration Licence title number
Applicant	The name of the title applicant.
Granted	Date the title was granted.
Expiry	Date the title is due for renewal/expiry.
Renewed	The number of times the title has been renewed.
Area sq. km	The area of the title in square kilometres.
Municipality	The municipal shire in which the title lies.
Commodity target	The commodity target.
Expenditure	The amount of exploration expenditure reported to the Department. Exploration expenditure figures in square brackets ([]) indicate expenditure was jointly reported with several Exploration Licences not listed.

CONFID: Appears where the details of the report are still confidential.

Mapping, Ground geophysics, Air geophysics, Lit survey, Drilling Indicates if mapping, ground geophysical surveys, air-borne geophysical surveys, geochemical sampling surveys, literature surveys or drilling was recorded in the exploration activities.

Target (cont-cont2) Brief description of the commodities and style of mineralisation sought.

mlcurr

This file contains data giving an image of the currently held Mining titles (as of 20th October, 1995). Details of the titles can be viewed by opening the mlcurr.tab file (if not already opened), choosing the Info tool button in the Main Button Pad and clicking within the title you wish to inquire.

The information displayed is:

Number	The Mining title number.
Type	The title type (DL for Development Lease, ESP for Extractive Search Permit, LIC for Extractive Industry Licence, LSE for Extractive Industry Lease, MAL for Mining Area Licence, MIN for Mining Licence, ML for Mining Lease, MRC for Miners Right Claim, and TRL for Tailings Removal Licence.
No. Renewed	The number of times the title has been renewed.

Applicant	The name of the title applicant.
Priority	The title priority date.
Granted	Date the title was granted.
Expiry	Date the title is due for renewal/expiry.
Area	The area of the title in hectares.
Municipality	The municipal shire in which the title lies.
Status	The status of the title (CURRE for current, RENEW for under renewal, APPLI for under application).
DCNR Region	The Department of Conservation and Natural Resources region in which the title lies.

Vic Mine Database

Organisation: Department of Natural Resources and Environment Minerals and Petroleum Victoria

Abstract:

The VicMine database contains information on mines, prospects and mineral occurrences in Victoria.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: VicMine Database

Data Set Short Title: VicMine

Jurisdiction: Victoria

Custodian: DNRE, MPV

Publication Date: Nov 1996

Acknowledgments:

References: Weston, K.S., 1992, Minerals Of Victoria 1:1 000 000 map report, Geological Survey Report 92.

Dataset Description

Abstract:

The VicMine database provides information on location, geology, production and resources of mines, prospects and mineral occurrences in Victoria.

Search Words: Minerals, Mineral Deposits

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List: See list below

Contact Information

Contact Organisation: Department of Natural Resources and Environment,
Minerals and Petroleum Victoria

Contact Position: Manager, Mineral Resources

Contact Person: Roger Buckley

Contact Address: PO Box 500, East Melbourne, Vic 3002

City: Melbourne

State: Victoria

Contact Phone: 03 9412 5025

Contact Fax: 03 9412 5155

Contact Email: roger.buckley@nre.vic.gov.au

Dataset Currency and Status

Beginning Date: 1990

Ending Date: 1997

Progress: In progress

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital - DXF

Output Data Format: Digital - ASCII, Digital-DXF, Digital-MapInfo ; Hardcopy - report

Native Data Format: Digital - Point

Access Constraints:

Dataset Quality

Lineage Summary: Data derived from literature with minor field checks.

Scale: 1:25 000 to 1:1000 000

Resolution: 25 to 1000 metres

Cell Size:

Positional Accuracy: Varies according to source, + 1 km to + 25 m.

Attribute Accuracy: As derived from literature review and geological appraisal from minor field checks.

Logical Consistency: Data compiled to best of ability given available resources.

Completeness: Dependent on available data in literature.

Additional Information:

Metadata Contact Information

Metadata Date: 21 January 1997

Metadata Contact Person: Roger Buckley

Metadata Contact Organisation: Department of Natural Resources and Environment, Minerals and Petroleum Victoria

Metadata Contact Email: roger.buckley@nre.vic.gov.au

Attribute list

NO

Every minerals occurrence has a unique identifying number for each mine/prospect/mineral location.

COMMODITY

Gives the commodities produced, in abbreviated form.

COMMODITY DESCRIPTION

Describes in words the commodity code of the previous field

COMMODITY GROUP

Gives the field type of the commodity, eg Tin field, brown coal field, etc.

FIRST COMMODITY

Main commodity produced at that site.

FIRST COMMODITY DESCRIPTION

Explanation in words of the commodity code of the previous field.

FIRST COMMODITY TYPE

MET, FUEL or IND

FIRST COMMODITY TYPE DESCRIPTION

Explanation in words of the commodity type code of the previous field.

RESOURCE CLASS

MAJ, MIN or OCC

RESOURCE CLASS DESCRIPTION

Explanation in words of the resource class code of the previous field.

MAPSHEET NO

Standard 1:100 000 map sheet number.

ZONE

AMG zone 54 or 55

LOCATIONAL ACCURACY

1, 2 or 3

LOCATIONAL ACCURACY DESCRIPTION

Explanation in words of the location accuracy code of the previous field.

GEDIS REFERENCE NO

Minerals & Petroleum Victoria corporate reference database number.

GOLD PRIMARY PRODUCTION KG

Hard rock (primary) gold production from the site, as cited in references, primarily Bowen & Whiting 1976. 0 indicates unknown production.

GOLD ALLUVIAL PRODUCTION KG

Alluvial gold production from the site, as cited in references, primarily Bowen & Whiting 1976. Would generally be significantly understated from actual due to lack of official records. 0 indicates unknown production

GOLD TOTAL PRODUCTION KG

Sum of primary and alluvial gold production from the site. 0 indicates

unknown production

COMMENTS

Any further relevant information.

Roger Buckley
Manager Mineral Resources
Geological Survey Victoria
Ph. 9412-5025 fax 9412-5155
Email: roger.buckley@nre.vic.gov.au

VIC: Mineral Potential Tracts (16 maps)

Organisation Mineral Resources and Energy Branch, Bureau of Resource Science

Abstract:

Mineral Potential Tracts are assessed for their mineral potential based on 1:250,000 geological, geophysical and mineral occurrence datasets of the CRA region.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: Mineral Potential Tract Maps

Data Set Short Title: Mineral Potential Tract Maps

Jurisdiction: Victoria

Custodian: Mineral Resources and Energy Branch, Bureau of Resource Science

Publication Date: May, 1998

Acknowledgements:

References:

Dataset Description

Abstract: Mineral Potential Tracts are based on the Bendigo, Bairnsdale, Melbourne, Tallangatta, Warburton, Wangaratta, Jerilderie and Wagga 1:250,000 geological maps. The tracts were created in ArcInfo/Arcview by the Mineral Resources and Energy Branch, Bureau of Resource Sciences. 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. Sixteen maps represent the potential of nineteen deposit types.

These maps are fundamental in assessing mineral potential of the NE Victoria CRA.

Search Words: Mineral potential

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List: See attached listing

Contact Information

Contact Organisation: Mineral Resources and Energy Branch, Bureau of Resource Sciences

Contact Position: Senior Research Scientist

Contact Person: Subhash Jaireth

Contact Address: PO Box E11, Kingston ACT 2604

City: Canberra

State: ACT

Contact Phone: 02-62725173

Contact Fax: 02- 62724161

Contact Email: sjaireth@brs.gov.au

Dataset Currency and Status

Beginning Date: 1997

Ending Date: 1998

Progress: Complete

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital – ArcInfo; Digital – ArcView3a

Output Data Format: Digital – ArcInfo; Digital – shapefiles in ArcView3a; Hardcopy - report

Native Data Format: ArcInfo/ArcView

Access Constraints:

Dataset Quality

Lineage Summary: Derived from 1:250 000 scale geological maps, geophysical, geochemical, mineral occurrence and other datasets of the CRA region.

Scale: 1:250 000

Resolution:

Cell Size: 250mx250m

Positional Accuracy: See metadata sheet for Geology

Attribute Accuracy: 250mx250m

Logical Consistency: See metadata sheet for Geology

Completeness: Complete as per assessments in May 1998

Additional Information:

Metadata Contact Information

Metadata Date: 7 July 1998

Metadata Contact Person: Subhash Jaireth

Metadata Contact Organisation: Bureau of Resource Sciences

Metadata Contact Email: sjaireth@brs.gov.au

Attribute List

'Tract name_pot – expressed in numerical symbols (low =1, low to moderate=2, moderate=6, moderate to high=12, high=18, unknown=0). Certainty – levels of increasing certainty from A to D (for details see technical report)

Vic Composite Mineral Potential

Organisation Mineral Resources and Energy Branch, Bureau of Resource Science

Abstract:

Composite mineral potential shows the highest level of mineral potential of an area

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: Composite mineral potential

Data Set Short Title: Composite mineral potential

Jurisdiction: Victoria

Custodian: Bureau of Resource Sciences

Publication Date: May 1998

Acknowledgments:

References:

Dataset Description

Abstract:

Composite Mineral Potential Map/Dataset is a collation of mineral potential tracts of nineteen deposit types. The map was created by using Spatial Analyst Extension of ArcView3a. It represents the highest level of mineral potential assessed (in May 1998) for an area in the CRA region

Search Words: Composite mineral potential

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List: See list below

Contact Information

Contact Organisation: Bureau of Resource Sciences

Contact Position: Senior Research Scientist

Contact Person: Subhash Jaireth

Contact Address: PO Box E 11, Kingston ACT 2604

City: Canberra

State: ACT

Contact Phone: 02 62725173

Contact Fax: 02 62724161

Contact Email: sjaireth@brs.gov.au

Dataset Currency and Status

Beginning Date: 1997

Ending Date: 1998

Progress: Complete

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital – ArcInfo; Digital – ArcView3a

Output Data Format: Digital – ArcInfo; Digital – shapefiles in ArcView3a; Hardcopy - report

Native Data Format: Digital - ArcInfo

Access Constraints:

Dataset Quality

Lineage Summary: The map is derived from individual tract maps for nineteen deposit types, which were delineated using 1:250,000 geological, geophysical and mineral occurrence datasets of the CRA region.

Scale: 1:250,000

Resolution:

Cell Size: 250mx250m

Positional Accuracy: See metadata sheet for Geology.

Attribute Accuracy: 250mx250m

Logical Consistency: See metadata sheet for Geology.

Completeness: Complete as per assessments in May 1998

Additional Information:

Metadata Contact Information

Metadata Date: 7 July 1998

Metadata Contact Person: Subhash Jaireth

Metadata Contact Organisation: Bureau of Resource Sciences

Metadata Contact Email: sjaireth@brs.gov.au

Attribute list

Important attributes are:

Grid_code – numerical code representing levels of mineral potential (low = 1, low to moderate = 2, moderate = 6, moderate to high = 12, high = 18)

Vic Cumulative Mineral Potential

Organisation Mineral Resources and Energy Branch, Bureau of Resource Science

Abstract:

Cumulative mineral potential shows the diversity of levels of mineral potential for an area.

Contents:

[Citation Information](#)

[Dataset Description](#)

[Spatial Domain](#)

[Contact Information](#)

[Dataset Currency and Status](#)

[Dataset Storage and Format](#)

[Dataset Quality](#)

[Metadata Contact Information](#)

Citation Information

Data Set Title: Cumulative mineral potential

Data Set Short Title: Cumulative mineral potential

Jurisdiction: Victoria

Custodian: BRS

Publication Date: May 1998

Acknowledgments:

References:

Dataset Description

Abstract:

Cumulative Mineral Potential Map/Dataset is a collation of mineral potential tracts of nineteen deposit types. The map was created by using Spatial Analyst Extension of ArcView3a. It takes account of the diversity of mineral resource potential. Standard scores based on 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.

Search Words: Cumulative mineral potential

Location Description: North East Victoria, Victoria

Spatial Domain

North Bounding Coordinate: -35.796

East Bounding Coordinate: 148.295

South Bounding Coordinate: -37.617

West Bounding Coordinate: 144.959

Bounding Polygon:

Attribute List: See list below

Contact Information

Contact Organisation: Bureau of Resource Sciences

Contact Position: Senior Research Scientist

Contact Person: Subhash Jaireth

Contact Address: PO Box E 11, Kingston ACT 2604

City: Canberra

State: ACT

Contact Phone: 02 62725173

Contact Fax: 02 62724161

Contact Email: sjaireth@brs.gov.au

Dataset Currency and Status

Beginning Date: 1997

Ending Date: 1998

Progress: Complete

Maintenance and Update Frequency: Irregular

Dataset Storage and Format

Stored Data Format: Digital – ArcInfo; Digital – ArcView3a

Output Data Format: Digital – ArcInfo; Digital – shapefiles in ArcView3a; Hardcopy - report

Native Data Format: Digital - ArcInfo

Access Constraints:

Dataset Quality

Lineage Summary: The map is derived from individual tract maps for nineteen deposit types, which were delineated using 1:250,000 geological, geophysical and mineral occurrence datasets of the CRA region.

Scale: 1:250,000

Resolution:

Cell Size: 250mx250m

Positional Accuracy: See metadata sheet for Geology.

Attribute Accuracy: 250mx250m

Logical Consistency: See metadata sheet for Geology.

Completeness: Complete as per assessments in May 1998

Additional Information:

Metadata Contact Information

Metadata Date: 7 July 1998

Metadata Contact Person: Subhash Jaireth

Metadata Contact Organisation: Bureau of Resource Sciences

Metadata Contact Email: sjaireth@brs.gov.au

Attribute list

Important attributes are:

Grid_code – numbers represent cumulative mineral potential (for details see the Technical Report)