CENTRAL HIGHLANDS COMPREHENSIVE REGIONAL ASSESSMENT

Minerals Assessment

CONTENTS

FIGURES

TABLES

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 resources in forested land,
- current and potential uses of forested land,
- economic value of 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 landuse 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. The report considers identified mineral deposits that border the region where such deposits signify the potential for the discovery of similar deposits in the region.

Supply of construction materials to Melbourne is currently the most significant extractive activity in the Central Highlands. The region was a major gold producer last century, and many old deposits have recently attracted exploration interest. In addition to current mining and exploration activities, the Central Highlands contains a few undeveloped mineral deposits (though currently production is planned only at the Morning Star deposit .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 including one by O'Shea, Whitehead, Buckley, and Lanzer 1992, Geology of Victoria (edited by Douglas and Ferguson 1988), and other published reports were some of the sources of information on identified mineral resources in the Central Highlands, and material from these reports is included in this assessment. These reports describe the geology, mineralisation and exploration of the Central Highlands. Industrial minerals in the Central Highlands are reported by McHaffie and Buckley (1995). The reports also contain summaries of past mineral exploration in the region. Conclusions published on the Lachlan Fold Belt in a recent issue of Economic Geology were also considered in this assessment.

It should be noted that the Central Highlands region has not been subjected to a detailed high resolution airborne geophysical surveys or to recent detailed (1:100 000 scale) geological mapping. Such 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.

The Central Highlands region covers portions of the 1:250 000 scale map sheets for Melbourne, Wangaratta, Warburton, Warragul and Queenscliff.

KNOWN AND POTENTIAL MINERAL AND EXTRACTIVE RESOURCES

GEOLOGICAL SETTING

The regional geological setting is shown on Maps 1 and 2, and the main geological and mineralising events are summarised in Tables 1a and 1b.

The Central Highlands area covers parts of two major geological provinces:

- **The Melbourne Zone** which is bounded by the Heathcote Fault zone (Map 2) in the west and the Mount Wellington Fault zone in the east (VandenBerg & Gray, 1988). Overall, this zone is 150 km wide and extends north-south for approximately 180 km. The sedimentary sequence consists of Cambrian greenstones, Middle to Late Ordovician black slates conformably overlain by Silurian to Middle Devonian quartz turbidites (sediments deposited by turbidity currents)(O'Shea et al 1992~~O'Shea and others 1992~~). The sequence is intruded by Late Devonian granitoids, and overlain, in part, by caldera volcanics which are derived from the same parent magma as the granitoids (ie co-magmatic).

- **The Gippsland Basin** - the northwestern portion of the Gippsland Basin lies within the Central Highlands area. The main sedimentary sequences within the area are the Strzelecki Group (Cretaceous) and the Moe Swamp Basin (Tertiary) (Map 2). Tertiary sediments deposited in the Latrobe Valley Depression, which are partly continuous with the Moe Swamp Basin sediments, lie to the south of the Central Highlands. The brown coal mining operations within the Latrobe Valley Depression, at Yallourn and Morwell, are located near the southern boundary of the Central Highlands.

The geological history, rock suites and mineralisation in the Central Highlands are summarised as follows:

<u>Cambrian sediments and volcanics (greenstones) (545 - 490 million years ago (Ma))</u>
Cambrian greenstones are the oldest rocks in the area. Originally these greenstones were thick accumulations of tholeiitic basalt, ultramafic lavas, interbedded volcaniclastic sediments, chert and dolerite. They accumulated in an oceanic island arc geological setting and represent part of the Cambrian oceanic crust.

The greenstones crop out as elongate, fault-bounded lenses and blocks immediately to the east of the Mount Wellington Fault zone. This is referred to as the Mount Wellington Greenstone Belt and it extends intermittently over a strike length of 150 km. The greenstones lie outside the eastern boundary of the Central Highlands (Map 1). Recent application of thin-skinned thrust tectonic model to Central Victoria suggest that these greenstones underlie the turbiditic sequence at depth throughout the Melbourne zone which also includes the Central Highlands .

Styles of mineralisation associated with these Cambrian greenstones include:
- epithermal gold mineralisation, eg Rhyolite Creek, Great Rand mine,
- small chromite deposits within formed during crystallisation of ultramafic rocks,
- copper mineralisation associated with Cambrian volcanics, and
- manganese and iron deposits (exhalative deposits) formed during hydrothermal exhalations in sedimentary environments on ancient sea floor.

<u>Ordovician sediments (490 - 434 Ma)</u>
During the Ordovician ~~there was deposition of~~ marine sediments, mainly sandstone, mudstone and shale <u>were deposited</u> in a deep-water sedimentary environment. Ordovician sediments of the Mount Easton Shale, crop out as fault-bounded slices along the Mount Easton and Mount Wellington Fault zones.

Silurian (434 - 410 Ma)
Sedimentation occurred along the eastern and western portions of the Central Highlands during this period. Along the western portion, siltstone, sandstone and mudstone with minor conglomerate form a belt of sediments extending north of Melbourne. In the eastern portion, Silurian sediments crop out as elongate belts parallel to the Mount Easton and Mount Wellington Fault zones (Maps 1 and 2).

Silurian and Middle Devonian (434 - 370 Ma)
Sandstone, siltstone and shale of the Silurian-Middle Devonian Norton Gully Sandstone, Walhalla Group, Serpentine Creek Sandstone, and Whitelaw Siltstone crop out over much of the eastern section of the Central Highlands (Map 1).

Silurian-Middle Devonian sediments (sandstone, siltstone and shale) also occur in the western portion of the area.

The main period of thrust faulting along the Heathcote Fault zone occurred during the Silurian (at approximately 420 Ma). Thrust faulting along the Mount Wellington Fault zone occurred in the Late Silurian - Early Devonian (approximately 410 - 400 Ma) (Foster, Kwak & Gray, 1996).

Early and Middle Devonian Tabberabberan Orogeny
During the Middle Devonian (385 - 370 Ma), folding and deformation associated with the Tabberabberan orogeny caused the cessation of sedimentation in the Central Highlands. This deformation resulted in regional folding, reverse faulting and widespread development of slaty cleavage within sediments throughout the entire area.

Slate belt type gold (with minor antimony) deposits were formed in structures related to the Tabberabberan Orogeny. Using the classification of gold deposits by Ramsay and Willman (1988), following types of slate belt gold deposits can be recognised in the region: sediment-hosted (eg. The Ringwood field); granitoid related (deposits associated with the Strathbogie granitoid in the northern part of the area); and dyke affiliated (The Walhalla-Woods Point province).

Middle Devonian Woods Point Dyke Swarm (387 ± 14 Ma)
A major phase of igneous activity during the Middle to Late Devonian commenced in the latter stages of the Tabberabberan deformation. Intrusion of the Woods Point dyke swarm (387 ± 14 Ma) (Ramsay and VandenBerg, 1986) in the Middle Devonian represented the initial phases of this igneous activity. The dykes intrude Middle Devonian sediments, and are in turn truncated by a Late Devonian ring dyke (O'Shea and others, 1992). The system of dykes occupy a zone more than 100 kilometres long trending north-northwest from Walhalla (Maps 1 and 2). The dykes range from hornblende peridotites to hornblende-free leucodiorite. They average 3 kilometres in length by 2 metres in width with local thickening up to 100 metres. These bulges within the dykes are the main focus of gold mineralisation.

A mantle origin for the dykes is likely because the more mafic intrusions contain magmatic gold, iron, copper and nickel sulphides together with platinoid group elements.

Gold mineralisation is associated with the Woods Point Dyke swarm and the deposits include some of Victoria's main gold mines (eg A1 mine, Cohen's Reef, Walhalla). Mineralisation occurs both in the dykes and in fault zones cutting the Palaeozoic sediments. Age-dating shows that gold mineralisation was synchronous with or deposited just after intrusion of the dyke swarm (Richards & Singleton, 1981).

Middle and Late Devonian Volcanics (385 - 354 Ma)
During this period there was extrusion of volcanic flows from a number of caldera complexes, mainly the Tolmie, Strathbogie, Marysville and Mount Dandenong felsic volcanic complexes.

Andesites, rhyodacites and rhyolites formed from calc-alkaline magmas and were co-magmatic with granodioritic intrusions, and acid to intermediate ring and radial dykes (O'Shea et al, 1992).

Middle and Late Devonian Granitoids (approximately 365 Ma)
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).

The main period of gold mineralisation within the Central Highlands probably 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 forms 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 and Early Carboniferous Mansfield Basin (370 - 344? Ma)
The Mansfield Basin lies outside the northeast boundary of the Central Highlands (Map 1). The basin sequence is mainly fluvio-lacustrine red-bed sediments (2 - 3 km thick) with minor acid volcanics which unconformably overlie older sediments of the Melbourne zone. Sedimentary 'red-bed type' copper mineralisation occurs within sandstone and shale (Ramsay & VandenBerg, 1986).

Carboniferous to end of Jurassic (354 - 141 Ma)
Folding and deformation of the rock sequence in the region occurred during the Carboniferous (Kanimblan deformation). From the end of this deformation through to the end of Jurassic times, the Central Highlands were above sea-level and the land surface was subjected to extensive erosion.

Early Cretaceous Strzelecki Group (141 - 98 Ma)
Strzelecki Group sediments, which are the basal sediments of the Gippsland Basin, were deposited in a large shallow water non-marine basin. The basin contained extensive flood plains with braided streams and a variety of sedimentary environments including fluvial, lacustrine and deltaic (Douglas, 1988). The main lithologies of the Strzelecki Group are feldspathic sandstone (arkose), mudstone, greywacke, conglomerate, carbonaceous layers and minor coal units.

The basal sandstone of the Strzelecki Group underlie sediments of the Moe Swamp Basin in the southeastern part of the Central Highlands and unconformably overlie deformed Palaeozoic sediments, and is a suitable host rock for sandstone-type uranium deposits. Carbonaceous plant material (including thin coal beds) within these sands provide the reducing environment necessary for uranium precipitation.

Tertiary (55 to 1.78 Ma)
The Moe Swamp Basin (Maps 1 and 2) and Latrobe Valley Depression form the northwestern lobe of the Gippsland Basin. Eocene to Pleistocene continental clastic sediments, volcanics and thick seams of brown coal fill these sedimentary basins and cover the intervening Haunted Hill Block which forms a concealed basement high and separates the two basins. Large deposits of brown coal accumulated during Tertiary times in slowly subsiding shallow water basins. The climate and geological conditions in these basins were suitable for the continuous formation of peat, in sufficient quantities for subsequent consolidation and upgrading into thick seams of brown coal (Gloe, Barton, Holdgate, Bolger, King and George, 1988).

The Moe Swamp Basin sequence includes seams of brown coal interbedded with, and overlying several thick flows of basalt (Thorpdale Volcanics), and overlain by clay, sand, and gravel

(Gloe et al, 1988). The brown coal seams range up to 36 metres thick. The Moe Swamp Basin sediments unconformably overlie Palaeozoic basement and sandstones of the Strzelecki Group.

The basal sediments of the Moe Swamp Basin are suitable host rocks for sandstone uranium deposits.

The Latrobe Valley Depression (outside the Central Highlands) contains thick seams of brown coal which are the basis for large-scale open cut mining operations in the Yallourn - Morwell area.

HISTORY OF MINING AND KNOWN MINERAL AND EXTRACTIVE RESOURCES

Eighty eight mineral occurrences, old mines and deposits in the Central Highlands region and the adjacent areas are shown on Map 2. The actual number of occurrences is much larger, many of which are gold occurrences within the various old goldfields also shown on the map.

The Central Highlands has had a long history of mineral exploration and discovery. Gold was discovered at Warrandyte and Andersons Creek about 50 km northeast of Melbourne in 1851 (Flett, 1970) and later at Queenstown. The Queenstown Goldfield covered the centres of One Tree Hill, Panton Hills, Diamond Creek and Warrandyte. The alluvials were worked for some years before hard rock or quartz reef mining became dominant. In the period 1851 to 1912, the field produced a minimum of 1150 kg of gold, the second largest producer in the Central Highlands region after the Woods Point-Walhalla sub-province.

After the discovery of gold at Andersons Creek in 1851, a series of gold discoveries ensued which radiated north and east from Melbourne over the following periods:

- the Emerald goldfield was discovered southeast of Melbourne in 1852 and gold was found at the Caledonia diggings (Queenstown GF) to the north in 1854; the Brittannia goldfield near Warburton to the east-southeast was found in 1859, the Alexandra Goldfield west of Mansfield in 1866, and the Big River Goldfield on a tributary of the Goulburn River was discovered in 1857 (Flett, 1970), and
- gold was found at Gaffneys Creek in 1859 by gold diggers travelling east from the Big River field to prospect other tributaries of the Goulburn River. Initially the alluvial mines were the principal producers. The entire Goulburn River tributary system yielded exceedingly rich returns, - 50 ounces to the paddock (approximately 12 feet by 12 feet) were reported, as were yields up to 150 oz per paddock from the Jordan River above the B-B Creek Junction (Christie, 1989).

The discovery of alluvial gold in the Gaffneys Creek-Woods Point area in 1859 was the beginning of the gold mining industry throughout the length of the Mount Useful Slate belt, from Walhalla in the south to Gaffneys Creek in the north (ie the Walhalla - Woods Point sub-province). This goldfield has proved the most important gold producer in the Central Highlands and production from most of the other (mainly alluvial) goldfields mentioned above eventually ceased.

The speculative quartz gold mining boom of the 1860s was in turn followed by decades of financial depression with many of the mines closed. In the early 1900s and during World War I there were periods marked by mining revival when higher grade shoots were encountered but the A1 was still the only profitable mine.

As the population of Melbourne increased, construction materials and industrial minerals, sourced from the Central Highlands, have become increasingly important.

METALS

Currently two very small scale hard rock gold mines are the only operating metallic mines in the Central Highlands. One is 8 km north-west of Alexandra, in the north of the Central Highlands, and the other is about 20 km north-west of Moe, in the south-east Central Highlands. These mines are worked intermittently and produced 0.204 kg and 0.290 kg of gold in 1995/96 (pers comm R Buckley, Minerals and Petroleum Victoria, 1997).

In contrast, over 100 gold mines have operated previously since the 1860's in the Woods Point-Walhalla gold sub province along the north-east margin of the Central Highlands. Many more past alluvial workings and hard rock mines are located across the Central Highlands region from the sub province into the suburbs of northeast Melbourne.

Gold

Some 11% of Victoria's total hard rock gold production has been from the Melbourne geological zone, most of which is in the Central Highlands. The major part of this 11% came from the 80 km by 10 km Woods Point-Walhalla-gold sub-province (Tan 1988, in O'Shea et al 1992~~O'Shea and others 1992~~). Hard rock gold production from the Woods Point-Walhalla sub-province, which lies along the northeast margin of the Central Highlands, amounts to over 99 tonnes since 1860. Assuming that a similar proportion of Victoria's alluvial gold production also came from the Central Highlands then the total gold production in the Central Highlands could have been of the order of 275 tonnes (ie 11% of the total Victorian production of 2500 tonnes). Recent production has been from deposits in the Gaffney's Creek area mined from 1968 to 1989 and the A1 Mine between (also near Gaffney's Creek) 1989 and 1992 (O'Shea et al~~and others~~ 1992). Table 7 shows available recorded gold production and remaining resources for gold deposits and occurrences in the Central Highlands. Map 2 shows some of the larger gold deposits and goldfields in the region which were worked in the past.

Mineralisation in the western and central parts of the Central Highlands is considered to have been emplaced high in the earth's crust in low temperature gold-antimony-quartz veins in Silurian to Devonian turbidite sediments. There is a strong correlation of Late Devonian granitoid related felsic dykes with gold-stibnite (antimony) occurrences in the west (BHP 1986a, in O'Shea et al 1992~~O'Shea and others 1992~~). Gold mineralisation in the eastern part of the region is mainly dyke related, as in the Woods Point-Walhalla gold sub-province, and associated with arsenopyrite and minor copper, lead and zinc sulphides. Gold of possible epithermal origin occurs in Cambrian acid volcanics at Rhyolite Creek just to the northeast of the Central Highlands (O'Shea et al~~and others~~ 1992).

Higher temperature mineralisation in the Woods Point-Walhalla gold sub-province is associated with Middle Devonian dykes of dioritic to granophyric composition intruded into Silurian to Devonian strongly folded and faulted marine sedimentary rocks. The dykes are usually long and thin but gold mineralisation has focused in occasional bulges up to 100 metres thickness. Nine of these bulges have been mined to depths of 600 to 800 metres (Kingstream Resources NL, in O'Shea et al 1992~~O'Shea and others 1992~~). The gold mineralisation is in quartz ladder veins and stockworks within the dyke rock and in surrounding sedimentary rocks.

There are over 100 old gold mines and occurrences in the Woods Point-Walhalla gold sub-province and the major mines were A1, Morning Star and Loch Fyne in the north and Cohen's Reef in the south (and just outside the southeast boundary of the Central Highlands). The biggest of these was Cohen's Reef which produced 46.6 tonnes of gold from 1.4 million tonnes of ore (33 grams per tonne ie. just over 1 ounce per tonne) between 1863 and 1914 from the Long Tunnel group of mines, just west of Walhalla town. Cohen's Reef was worked to a depth of 1,120 metres and was one of the richest in Australia (O'Shea et al 1992~~O'Shea and others 1992~~). The Cohen's Reef gold is in a laminated quartz vein(s) in sediments alongside the Cohen Dyke of diorite rock type. Current resources at Cohen's Reef contain over 2.5 tonnes of gold (Table 7).

More than 13 tonnes of gold has been mined at the A1 Mine, 3.4 tonnes at Loch Fyne Mine (near Matlock) and 27.4 tonnes at Morning Star Mine, near Woods Point (Mt Conqueror Minerals NL 1994). The ore mined for this gold was very rich by today's standards (25 to 30 grams per tonne), compared to recently delineated resources (Mt Conqueror Minerals NL 1994) at Morning Star containing more than 6.3 tonnes of gold at grades of 2 to 7 grams per tonne (Table 7). Drilling and refurbishment of the old underground workings continued in 1996 to further assess resources at Morning Star (Mt Conqueror Minerals NL 1996).

Some gold-quartz veining is associated with mafic to ultramafic dykes in the southern part of the Woods Point-Walhalla gold sub-province.

Apart from the Woods Point-Walhalla gold sub-province, 33 minor goldfields (Table 7, Map 2) have been identified by O'Shea and others (1992) in and adjacent to the Central Highlands. Some lie under the suburbs of Melbourne, including the small Ringwood and North Balwyn goldfields. Alluvial gold production commenced in these fields from 1850 to 1860 and progressed to minor hard rock production within 10 years. Recorded production was generally less than 100 kg of gold, commonly at high ore grades of more than 25 grams per tonne, from narrow quartz veins/reefs and/or diorite dykes in Silurian to Lower Devonian sandstones, siltstones and shales. Just to the northeast of the Central Highlands, low grade disseminated gold occurs in the Merton and Tallangalook goldfields associated with hornfels of the Strathbogie granodiorite. Mining here was generally to shallow depths of up to 60 metres but some reached over 100 metres depth. Current indicated and inferred resources at Golden Mountain, in the Tallangalook goldfield, are 1.3 million tonnes of rock at a gold grade of 1.5 grams/tonne (Duketon Goldfields NL Annual Report 1996).

Base metals, cobalt and manganese

The Thomson River copper deposit, just outside the southeast corner of the Central Highlands, is hosted by a gabbroic or pyroxenitic dyke thought to be part of the Woods Point (Walhalla) dyke swarm (Keays & Kirkland 1972). This deposit also contains nickel and platinum group elements. Mining was intermittent from 1864 for copper and by-product nickel, gold, platinum, palladium and silver. Total production from the deposit was 92.5 tonnes copper, 7.5 tonnes nickel, 3.75 kg gold, 5.75 kg platinum, 9.5 kg palladium and 32 kg silver. Remaining resources were reported as 62.5 tonnes copper, 2.25 kg gold, 4.25 kg platinum, 11 kg palladium and 19 kg silver (Ramsay & Willman 1988). The dyke swarm extends into the Central Highlands and deposits similar to the Thomson River deposit may be present in the Central Highlands.

Minor amounts of copper, lead, zinc and silver commonly occur with gold mineralisation in the Woods Point-Walhalla gold sub-province.

Cobalt and manganese occur at Spotted Dog Creek (Tanjil) in the southeast of the Central Highlands.

Platinum group metals

Platinum group metals are associated with widespread non-economic copper-nickel sulphide mineralisation in the Woods Point-Walhalla gold sub-province (O'Shea and others, 1992). At least ten dykes are mineralised and for each 1% of copper there is 1 gram/tonne gold, 1 gram/tonne palladium and probably 1 gram/tonne platinum (Keays & Green 1974). Such mineralisation is known at the Shamrock, New Loch Fyne and Hunts mines. At East Walhalla Mine (just outside the southeast boundary), small amounts of ore were produced from three small open pits and a shallow shaft. No production data is available but samples taken in about 1917 assayed up to 0.6% copper, 2.93 grams/tonne platinum, 1.02 grams/tonne gold and 5.23 grams/tonne silver.

Antimony

Antimony is found in most of the gold occurrences in the western half of the Central Highlands and occurs in stibnite (antimony sulphide mineral). At some mines antimony ore was produced as a by-product of gold (see Table 7). At Steels Creek, 45 km northeast of Melbourne CBD, antimony ore was the main product and gold the by-product. Just outside the south-western boundary of the Central Highlands, in the Melbourne suburbs, a small antimony deposit occurs at Templestowe and about 3,500 tonnes of antimony concentrate containing minor gold was produced at Ringwood between 1869 and 1895 (O'Shea et al~~and others~~ 1992). Antimony-gold ore was mined at the Apollo, Golden Dyke, and Golden Dyke Extended mines in the Sunday Creek goldfield 55 km north of Melbourne.

Antimony ore has been extracted at the Big River mine in the northern part of the Woods Point-Walhalla gold sub-province. 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% - 53% antimony and about 500 kg of concentrate was produced (Bell 1964).

Tin, Tungsten, Molybdenum and Bismuth
A group of small tin fields is located in the central south of the Central Highlands. In the largest, tin and gold was sluice mined on the upper Latrobe River while tin was sluice mined at Beenak and Bunyip River in the smaller fields nearby to the west. Tin also occurs at Maindample, just to the north of the Central Highlands. Tungsten has been mined on a minor scale at Brittannia Creek and Wilks Creek in the central part of the Central Highlands.

Tin-tungsten occurs at Tin Creek in a small tin-tungsten field in the central north of the region. Molybdenum, bismuth and tungsten occur at Monkey Gully, near the northern boundary of the region.

Mercury
Cinnabar (mercury sulphide) is associated with gold deposits/occurrences of possible epithermal origin (Devonian age) in the western and central part of the Central Highlands (O'Shea et al 1992~~O'Shea and others 1992~~).

Bauxite
Bauxite mining for production of aluminium salts began in Victoria in 1919 near Thorpdale, just outside the southeast corner of the region. A little further south, Geelong Cement and Asko Chemicals mined bauxite until 1992 from the Paynes and Watkins deposits for use as an additive in cement manufacture. Resources at the Watkins and Paynes deposits are sufficient for many years at past production rates and Geelong Cement has found significant new resources near Paynes. At Watkins there is a substantial resource of high alumina clay beneath the bauxite (Nott 1988).

Total recorded bauxite production for Victoria since 1926 is about 200,000 tonnes and in 1991/92 was about 5000 tonnes (McHaffie & Buckley 1995).

A cluster of 40 deposits (including those mentioned above) lies about 20 km SW of Morwell, to the southeast of the Central Highlands, and include the only known deposits with economic significance in Victoria. About half have been identified as small residual deposits. The bauxite deposits were formed by deep weathering of basalt and tuffaceous volcanics (McHaffie & Buckley 1995) and similar rocks occur in the Central Highlands. Undiscovered deposits of bauxite may be present where bauxite weathering profiles have been developed on these rocks.

Estimated initial resources of the two largest deposits were about 200,000 tonnes of bauxite each and the other deposits contained less than 50,000 tonnes each. A substantial proportion of these resources have now been worked out (Nott 1988, in McHaffie & Buckley 1995).

NON METALS

As the population of Melbourne has increased, construction materials and industrial minerals have become increasingly important. Henshall, Hansen Associates and Read Sturgess & Associates (1992) valued quarry output, in a study area slightly bigger than the Central Highlands, to be over $51 million in 1991.

There are about 410 construction materials quarries or pits operating on a permanent or intermittent basis in the Central Highlands with another six applications being considered in the region. The major operations include a limestone/dolomitic-limestone quarry at Lilydale, and granite quarries at Tynong North and Garfield North. Major basalt quarries are at Kilmore East, Harkaway, Pakenham, Neerim and the Latrobe Valley. Major quarries for granite at Lysterfield and Greenvale, and basalt at Kilmore East and Harkaway lie just to the west of the Central Highlands. Similar rocks occur within the Central Highlands and some of these may provide a source for construction materials in the future. The Heatherton-Dingley area, just to the south of the Central Highlands (Figure 1), is a major Tertiary sands producer. Structural clay pits are located at Drouin on the southern boundary of the Central Highlands and Hallam just to the SW of the region.

Brown Coal

A large part of the brown coal bearing Moe Swamp Basin (sub basin of the Gippsland Basin) encroaches on the southeast corner of the Central Highlands. Massive sequences of sediments, including coal precursors, accumulated during slow, steady subsidence over most of the Tertiary. In the Moe Swamp Basin significant resources of brown coal are known to occur within two major coal seams of the Yarragon Formation. The Moe brown coal field, which lies mostly within the southeast portion of Central Highlands, has reserves of 104 million tonnes and resources of 573 million tonnes (including the 104 million tonnes of reserves) (Holdgate 1984). Further reserves of 200 million tonnes (Stanley 1986) are present in the Yarragon Formation near the town of Yarragon, just to the south of the region. Total resources for the Moe Swamp Basin are 773 million tonnes. No production has been recorded from the Moe Swamp Basin coals given the larger, more accessible brown coal deposits elsewhere in the Latrobe Valley.

Large coal resources are present within the Latrobe Valley Depression, part of the Gippsland Basin which borders the southeast edge of the Central Highlands. Total reserves for the Gippsland Basin have been estimated at 96,300 million tonnes, while total resources have been calculated at over 172,874 million tonnes (Gloe and Holdgate 1991).

Production for 1923-1995 from the Morwell, Yallourn, Yallourn North, Yallourn North Extension and Loy Yang mines totals 1,115,220,000 tonnes (Barton and others 1992, BRS estimate 1997). Brown coal in Victoria is mainly used for electricity generation but briquettes are also produced for industrial and domestic use.

Construction materials

Construction materials and other industrial mineral commodities are particularly significant as the Central Highlands occurs adjacent to the major population centre of Melbourne.

Hard rock is quarried from a number of sites around Melbourne (Figure 1), and used in crushed or broken form for road aggregate, concrete, railway ballast and other uses. The main types of rock used are basalt, granite, acid volcanics, hornfels, schist and sedimentary rock. Colluvial deposits (scree) and softer rocks such as sandstone and shale are used extensively for road making. Other land uses now severely constrain the development of new quarries within 60 km of Melbourne (McHaffie & Buckley 1995).

Basalt of the mid-Tertiary Older Volcanics is extractedmined from major quarries within the Central Highlands at Pakenham (40 km southeast of Melbourne), Neerim (85 km east of Melbourne) and the Latrobe Valley (50 km east of Melbourne). Rhyolite, rhyodacite, and dacite in the basal lavas of the Dandenongs Igneous Complex are quarried at a site 30 km east of Melbourne. Hornfels (rock hardened by heat and pressure) often found around the margins of igneous rock bodies is quarried at Greenvale (25 km north of Melbourne), Morang (25 km northeast of Melbourne), and Castella (45 km northeast of Melbourne). Granitic rocks are extracted at new quarries at Tynong North and Garfield North (70 km southeast of Melbourne). Sources for hornfels also occur at Greenvale and Lysterfield just to the west of the Central Highlands.

Hard rock resources are sufficient to supply the Melbourne area for 25 years (McHaffie 1991, in McHaffie & Buckley 1995).

Construction sand is commonly used in concrete, mortar, plaster, road base and asphalt mixes. Special uses include glass and fibreglass manufacture, metal casting moulds, sand blasting and filtering media. Tertiary floodplain and piedmont fluvial sand deposits form much larger sand resources than those of similar type, but more recent Quaternary age. Large resources of coastal dune sands exist to the south of the Central Highlands but their finer and more uniform grainsize means their use is restricted.

The Heatherton-Dingley area, 20 km southeast of Melbourne and just to the south of the region (Figure 1), is a major Tertiary sands producer. However, its resources of good quality concrete sand are largely depleted. Further south (45 km southeast of Melbourne), resources at Cranbourne-Langwarrin are also diminishing rapidly (McHaffie & Buckley 1995). Production in 1992/93 from Heatherton-Dingley and Cranbourne-Langwarrin decreased to just over 2 million tonnes from annual production rates of 3 to 4 million tonnes in previous years. New supplies of construction sand will need to be available in the future, which may come from potential resources in the Central Highlands. Major potential resource areas lie to the north of Trafalgar ~~(110 km east of)~~, and overlie the brown coal basins in the Latrobe Valley, in the southeast corner of the region.

Clay and clay shale are used in large quantities to make bricks, pipes and roofing tiles. Mottled kaolinitic/illitic clays lying above more pure kaolinitic clays in the Melbourne area (Figure 1) are particularly suitable for bricks.

Deep weathering (up to 30 metres around Melbourne) in late Cretaceous, early Tertiary and mid Tertiary times under hot, humid conditions formed significant residual clay deposits on Palaeozoic rocks. Other residual clays for structural use are derived from granites at Hallam (35 km southeast of Melbourne, just to the south of the Central Highlands), the Older Volcanics (basalt) at Cranbourne (south of the Central Highlands) and Mesozoic sedimentary rocks south of Drouin (85 km southeast of Melbourne, just south of the Central Highlands). Such clays may extend into the Central Highlands.

Erosion of the Cretaceous/Tertiary clays formed alluvial clay deposits later in the Tertiary and Quaternary ages. A relatively small deposit of this type at Campbellfield (15 km north of Melbourne,) is partly used for brick making. More extensive deposits are associated with brown coal at Morwell just outside the southeast corner of the Central Highlands and may extend into the Central Highlands as do the brown coal basins.

Resources of red firing clays are sufficient for at least 20 years but white firing types will require the development of more distant resources to the south-east of Melbourne. Melbourne roof tile makers have a sound resource base for the long term (McHaffie & Buckley 1995).

Limestone

Limestone quarrying and lime manufacturing has been carried out at Lilydale (about 35 km east of Melbourne) since 1878 and produces lime and associated products for industrial use. The Lower Devonian age Lilydale Limestone Member is the only known economic source of hard Paleozoic age limestone within 100 km of Melbourne. Overburden thickness and urban encroachment impose severe limits on quarry extension but resources are sufficient for the long term (McHaffie & Buckley 1995).

Quicklime produced at Lilydale is used in mortar, plaster, concrete, steel making, roads, agriculture, water/sewerage treatment animal feed and as a slagging agent. Rock not suitable for lime production is crushed and used in roads, paths and pipe laying. Ground limestone is used as an inert filler in paint and carpet backing.

Limestone is also extracted from the Boola Quarry (north of Tyers), just outside the southeast corner of the Central Highlands, for lime production in Traralgon. A high grade limestone body of about 1.6 million tonnes and up to 80 metres thick has been identified here (McHaffie 1980, in McHaffie & Buckley 1995). The Boola and old Tyers quarry lie in a 2.4 km long belt of limestone along the Tyers River. Further north along the eastern edge of the region, minor Devonian limestone resources at Coopers Creek (Evans Quarry) and Mansfield (Howes Creek), to the northeast of the region, have been worked for lime and ornamental stone, and there are limestone occurrences at Toongabbie (Marble Creek) and Licola (Serpentine Creek), both to the east of the region. These limestones occur in Devonian sedimentary rock sequences known to be widespread in the Central Highlands.

Parts of the Coopers Creek Limestone are potential quarryable sources of high to very high grade limestone. A major part of this limestone is in the Tyers Regional Park, outside the Central Highlands region ~~but the extractive industry is not necessarily excluded from the Park~~.

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.

Dolomite
Dolomite and dolomitic limestone is quarried as part of a major operation at Lilydale. The dolomitic material occurs as interbeds in the Lower Devonian Lilydale Limestone Member and is ground for agricultural use. Thicker dolomite beds (up to 30 metres thick) are known to occur beneath the quarry (McHaffie & Buckley 1995).

Diatomite
Diatomite is used for filtration in food and drink production and as a filter in paper, plastic, rubber and paint. Its high absorptive capacity allows its use as a carrier of hazardous waste.

Small diatomite deposits of Mickleham and Moranding lie just outside the western boundary of the Central Highlands to the north of Melbourne and are past producers. There is an unworked diatomite occurrence at Fairfield-Brunswick (Atkinson 1988), about five kilometres northeast of Melbourne CBD, just to the southwest~~SW~~ of the region.

Most diatomite deposits in Victoria were formed as lake sediments during lulls in Tertiary-Quaternary, basaltic volcanic activity. Moranding deposit is not associated with sediments and forms a layer up to 6.5 metres thick between two basalt lava flows. Inferred resources are about 12,000 tonnes (McHaffie & Buckley 1995). Basaltic rocks are common in the Central Highlands and could host similar diatomite deposits to those mentioned above.

Feldspar
Feldspar occurs as veins and segregations in Siluro-Devonian granite are located in the Upper Latrobe Valley at Nayook and Powelltown (about 75 km east of Melbourne). An occurrence in the Tynong granite pluton at Garfield North (60 km southeast of Melbourne) has attracted some exploration interest for feldspar (plagioclase) for use in glassmaking and ceramics (Tan & Atkinson 1988).

Mineral Sands

Small concentrations of ilmenite and zircon occur in alluvial sand at Acheron River near the centre of the region (McHaffie & Buckley 1995).

Wollastonite
Wollastonite occurs in skarn deposits formed by contact metamorphism (heating and pressurisation) of Late Silurian - Early Devonian calcareous sediments by small granodiorite intrusions at Toolangi (near the centre of the region) and the Strathbogie Granite body near Bonnie Doon, just outside the northern boundary of the region. The contact metamorphic margin of the Bulla Granite, just west of the region, also contains wollastonite. Similar contact metamorphic rocks are found in the central and eastern parts of the Central Highlands.

Resources of bauxite, diatomite, kaolin, peat, phosphate rock, pyrophyllite and silica are known to occur in areas adjacent to the Central Highlands region. Based on regional geology, undiscovered deposits of these minerals and extractive material may also be present. Information associated withn these minerals and extractive material is rpovided as follows.

Kaolin
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 ages generated extensive, thick kaolinitic surficial zones. These zones were then largely eroded away later in the Tertiary and Quaternary ages to form secondary kaolinitic clay deposits. Primary kaolinitic clay can be suitable for high quality porcelain, filler applications and other high-end uses, while secondary (or ball clay) clay contains other clay, mica and organic matter. The latter is often used for general ceramics such as white ware (eg. hand basins, bath tubs).

All known deposits of kaolin are outside the Central Highlands but undiscovered deposits may be present in the region.

Residual kaolinitic clays over granodiorite occur at Hallam (35 km southeast of Melbourne, just southwest of the Central Highlands) and is suitable for refractory bricks used in boiler linings. Past production of clay from a kaolinised granodiorite near Bulla (25 km NW of Melbourne, just to the west of the region) was pure enough to be used for medicinal purposes, and as a filler in paper, rubber and paint (McHaffie & Buckley 1995). Similar kaolin deposits may be associated with granitoids inside the Central Highlands.

A secondary kaolinitic clay deposit is known below the mid-Tertiary age Morwell No 1 brown coal seam in the Morwell open cut mine (just to the southeast of the region) and a similar, but less pure, secondary kaolinitic clay layer lies under the brown coal open cut at Yallourn (McHaffie & Buckley 1995). Similar clay seams are likely to be present in the Central Highlands as part of the brown coal bearing Moe Swamp Basin.

Campbellfield (15 km north of Melbourne, near the western boundary of the region) was a significant past producer of secondary quartz-kaolinite-mica clay preserved beneath basalt in a former river channel. The clay was used to make stone ware, pipes, tiles, firebricks, house bricks and pottery.

Victorian production of kaolin has averaged 145,000 tonnes/year (McHaffie & Buckley 1995).

~~***Mineral Sands***~~
~~Small concentrations of ilmenite and zircon occur in alluvial sand at Acheron River near the centre of the region (McHaffie & Buckley 1995).~~

Peat
Sedge peat (formed in reedy swamps) is produced for horticultural use and potting mixes from a peat swamp north of Yarragon on the southern edge of the Central Highlands. The silty peat

varies from 2 to 7 metres thick along a 2 km section of a stream. At Morwell, just to the southeast of the region, peat of thicknesses up to a few metres occurs in overburden above brown coal measures but its use in horticulture is limited because of acidity.

Other peat occurrences are at Cora Lynn, Macclesfield and Trafalgar East along the southern edge of the Central Highlands. Peat deposits to the south of the region in the Western Port area have been largely destroyed through drainage for agriculture and burning. Compaction through drainage may have occurred in possibly extensive peat deposits associated with the large Moe Swamp at the south eastern corner of the region.

Phosphate rock
A group of four minor deposits are located near Mansfield immediately to the northeast of the Central Highlands. Three of these occur at Howes Creek in Lower Devonian age phosphatic sediments where several hundred tonnes of material were mined prior to 1920. Devonian rocks are widespread in the Central Highlands

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. Areas of possible shelf sedimentary sequences occur in the Central Highlands but from the available information the potential for phosphate is unknown.

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 Central Highlands but their potential for phosphate deposits is unknown.

Precious and semi-precious stones
Sapphire, ruby, topaz, agate and amethyst have been found at Gembrook, about 60 km southeast of Melbourne. These are probably only of interest to fossickers (McHaffie & Buckley 1995).

More than three tonnes of quartz crystal was mined from a pegmatite mass at Tallangalook, just outside the northern boundary of the region, during World War II for use in radios. Similar pegmatite bodies could be associated with granitoid rocks in the Central Highlands.

Pyrophyllite
Pyrophyllite is associated with gold mineralisation in acid volcanics at Rhyolite Creek, just outside the northeast boundary of the region. Pyrophyllite may also be associated with volcanics in the southern area of the Central Highlands.

Silica
Silica sand is extracted at Cranbourne, just to the south of the Central Highlands, for use in foundry sands, ceramic sand, graded sand, and construction sands. Areas with potential for construction sands may also be sources of high grade silica sand within the Central Highlands. The Tynong granite at Garfield North, on the southern boundary of the region and overburden sands of the Latrobe Valley brown coal basin in the southeast of the region, are also potential silica sources.

Wollastonite
Wollastonite occurs in skarn deposits formed by contact metamorphism (heating and pressurisation) of Late Silurian - Early Devonian calcareous sediments by small granodiorite intrusions at Toolangi (near the centre of the region) and the Strathbogie Granite body near Bonnie Doon, just outside the northern boundary of the region. The contact metamorphic

~~margin of the Bulla Granite, just west of the region, also contains wollastonite. Similar contact metamorphic rocks are found in the central and eastern parts of the Central Highlands.~~

POTENTIAL MINERAL AND EXTRACTIVE RESOURCES

MINERAL POTENTIAL ASSESSMENT METHODOLOGY

The mineral potential of the Central Highlands 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, Kropschot and Dickinson (1984), Taylor and Steven (1983), and by Dewitt, Redden, Wilson and Buscher (1986).

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

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

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

Figure 3: Relationship between levels of resource potential and levels of certainty

H/D HIGH POTENTIAL	H/C HIGH POTENTIAL	H/B HIGH POTENTIAL	U/A
M/D MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/B MODERATE POTENTIAL	UNKNOWN POTENTIAL
L/D LOW POTENTIAL	L/C LOW POTENTIAL	L/B LOW POTENTIAL	
N/D NO POTENTIAL			

D (high) C B A (low)

Decreasing level of certainty

Assessments similar to the procedure used here in this report for the Central Highlands 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.

~~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.~~

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 Central Highlands, judged to contain geological environments permissive of the formation of specific types of mineral deposits have been~~are~~ delineated and thier mineral potential ~~is~~ ranked (see Figures 4 to 15).

MINERAL AND EXTRACTIVE POTENTIAL IN THE CENTRAL HIGHLANDS

Descriptive mineral deposit models used for qualitative broadscale assessment of the Central Highlands are described in Appendix B. The favourable geological tracts for these types of mineralisation are indicated on Figures 4 to 15. The potential mineral resources are summarised in Table 2 and are described below as follows:

Table 2: Summary of potential mineral resources as at November 1996

Deposit type	**Mineral potential**	**Certainty level**	**area of tract** (sq km)	**% of region covered by tract**	**% of tract in existing reserves**
Coal	High	B	330	2.9	4.9
Slate belt gold	High	B	6340	56.1	14.9
Construction materials	High	B	67	0.6	0.1
	Moderate–high	B	534	4.7	1.7
Disseminated gold	Moderate–high	B	6340	56.1	14.9

Epithermal gold–silver	Moderate–high	B	1254	11.1	36.3
Kaolin	Moderate–high	B	2170	19.2	5.4
Nickel–copper deposits	Moderate–high	B	790	7.0	24.8
Alluvial gold	Moderate	B	2119	18.8	5.6
Skarn scheelite	Moderate	B	1823	16.1	11.7
Sandstone uranium	Moderate	C	361	3.2	5.9
Tin veins	Low–moderate	B	5235	46.3	17.4
Tungsten–molybdenum veins	Low–moderate	B	5235	46.3	17.4
Limestone	Low–moderate	C	4217	37.3	17.1
Bauxite	Low	C	310	2.7	0.3

Gold

Tract Au1/H/B Slate belt gold (Figure 4): The tract is based on the distribution of Ordovician, Silurian, Siluro-Devonian and Devonian turbidites and their metamorphic equivalents. These rocks are favourable for hosting slate-belt vein gold mineralisation. The tract also contains known slate-belt vein deposits and the known occurrences of *disseminated gold deposits*. The tract includes part of the Wellington Fault zone known to host the Woods Point-Jamieson goldfield associated with the Woods Point Dyke Swarm. A major part of the tract is in the vicinity of Devonian granitoids which include the I-type granitoids.

The tract is assessed to have a high potential for slate-belt gold with a certainty level of B with areas of high potential occurring within the Woods Point-Jamieson goldfield.

Tract Au2/M-H/B Disseminated gold (Figure 4): As for the slate-belt gold deposits, the tract is based on the distribution of Ordovician, Silurian, Siluro-Devonian and Devonian turbidites and their metamorphic equivalents. These rocks are favourable for hosting slate-belt vein gold mineralisation with a potential to form haloes of disseminated and stockwork gold mineralisation around mineralised veins.

The tract is assessed to have a moderate to high potential for deposits of disseminated gold with a certainty level of B.

Tract Au3/M/B Alluvial gold (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 gold for alluvial deposits.

The tract also includes areas which are favourable for deep and shallow leads. It has been reported that areas in the southern part of the region which are covered by Tertiary volcanics overlie Tertiary alluvial sediments which are favourable for deep leads (Buckley, pers~~onal~~ comm~~unication~~, Minerals and Petroleum~~Energy~~, Victoria.).

From the widespread distribution of primary sources of gold in the region it is concluded that the region has a moderate potential (with a certainty level of B) for alluvial gold deposits. Areas in close proximity to primary slate belt and disseminated gold deposits also have a moderate to high potential for deep lead gold.

Tract Au4/M-H/B Epithermal gold and silver (Figure 6): The tract contains intrusive, volcanic and volcaniclastic 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. The structures comprise the Cerberean

Cauldron, the Acheron Cauldron and the Black Range Ring Dykes. Although there are no proven ring dykes or arcuate fractures in the Dandenongs Igneous Complex, its structure is thought to be analogous with that of the Acheron Cauldron (Marsden, 1988). However no large scale hydrothermal alterations typical of epithermal systems have been reported in these rocks. Similarly, no mineral occurrences of epithermal gold-silver mineralisation are recorded. Hence the tract is interpreted to have a moderate to high potential for epithermal gold-silver deposits with a certainty level of B.

Greenstones of the Barkley River Greenstone belt may underlie the Central Highlands region at depth. The potential of epithermal mineralisation in such greenstones, if present, is unknown.

The tract for epithermal gold-silver deposits has an unknown potential for porphyry copper deposits.

Tungsten, Tin

Tract W/M/B Skarn scheelite (Figure 7): In the Central Highlands, tungsten-tin prospects at Tin Creek near Buxton and at Monkey Gully near Limestone southeast of Yea are associated with small high-level recently unroofed granitoids. These prospects are similar to the Rossarden and Storeys Creek type tungsten-tin quartz mineralisation of north east Tasmania. The tract is defined by the intersection of a 5 kilometre zone surrounding the granitoids with limestone-bearing sedimentary sequences.

There is a moderate potential for skarn scheelite deposits with a certainty level of B.

Tracts Sn/L-M/B and W-Mo/L-M/B Tin veins and Tungsten-molybdenum veins (Figure 8): This tract has been delineated based on the distribution of Late Devonian granitoids and an additional buffer of 5 kilometres around the granitoids within the Central Highlands region. The extent of metamorphic aureoles around some intrusives indicate that they may be even more extensive at relatively shallow depths.

Although the reduced nature of the granites is favourable for the formation of primary deposits of tin none have been recognised within the field area except as trace cassiterite at the Tin Creek deposit. The lack of apparent fractionation within most of the large granitoids in the Central Highlands appears to limit their potential to be a source of primary tin mineralisation.

Many small intrusives similar to those that host the tungsten occurrences are present in the Central Highlands around both the Marysville and Dandenong igneous complexes, however the degree to which they have been fractionated is unknown.

The tract is considered to have low to moderate potential for tin veins and tungsten-molybdenum veins with a certainty level of B.

Base metals

Tract NiCu/M-H/B Nickel-copper deposits (Figure 9): The Woods Point dyke swarm has the potential to host small copper nickel deposits as at Thomson River 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.

Uranium

Tract: U/M/C Sandstone uranium (Figure 10): The tract is based on the distribution of Lower Cretaceous Strzelecki Group and Tertiary sediments of the Moe Swamp Basin (Gippsland Basin).

These sediments were deposited in a reducing environment and contain carbonaceous plant material and interbedded coal layers and are suitable host rocks for sandstone uranium deposits.

Devonian granitoids and volcanics within the Melbourne Zone contain low levels of uranium and provide a possible source of uranium for the formation of sandstone uranium deposits.

The potential for this type of deposit is reduced because of the low background levels of uranium in the source rocks and on the available information the potential for sandstone uranium deposits is moderate with a certainty level of C.

Bauxite
Bxt/L/C Bauxite (Figure 11): The tract is delineated based on the distribution of Tertiary volcanics which include tholeiitic and minor alkaline basalts. Deep weathering of these can produce bauxite deposits. Based on the available information the potential of bauxite deposits is assessed to be low with a certainty level of C

Coal
Tract Coal/H/B (Figure 12): The tract has been delineated by the boundary of the Moe Swamp Basin, of which approximately two thirds lies within the Central Highlands area, and the Latrobe Valley Depression which lies just outside the Central Highlands area. It contains large areas of Late Tertiary and Quaternary sediments which overlie extensive coal seams.

Known resources for the Moe Swamp Basin are very large. Drilling has confirmed the presence of the coal seams at depth within the Yarragon Formation over a wide area with resources of economic interest identified at both the Moe Monocline in the east and at Yarragon in the west. It is possible that structures at depth that are not recognised at the surface, such as the Moe Monocline, could cause thickening of the coal seams which would improve their economic viability.

Given the detailed information above, a high potential for coal deposits with a certainty level of B is indicated for the tract.

Limestone/dolomite
Tract Lst/L-M/C Limestone (Figure 13): Silurian-Devonian sedimentary rocks, which may contain limestones, are present throughout the Darraweit Guim and Mount Easton Geological Provinces (McHaffie & Buckley 1995), which include the Central Highlands. The Lilydale limestone deposit (35 km east of Melbourne) contains some dolomitic horizons.

Known deposits occur in Siluro-Devonian undifferentiated marine sediments and Early Devonian marine sediments along, and just outside, the eastern boundary of the Central Highlands and it is the presence of these sediments throughout the Central Highlands that delineates the tracts.

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

Kaolin
Tract Kao/M-H/B Kaolin (Figure 14): 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.

On the available information there is moderate to high potential for secondary kaolin deposits with a certainty level of B.

Construction materials
Tract Conmat1a/H/B(Figure 15): Most of the Central Highlands rock types have high potential for lower grade/value construction materials in their fresh or weathered state; and soil, sand and

gravel are widespread across the Central Highlands. Suitable materials are mainly used for secondary road building and include:

- rippable sandstone, shale, schist and other rock,
- volcanic scoria and tuff,
- sand and gravel, and
- soil and calcrete.

This tract has high potential for lower value construction materials deposits, with a certainty level of B.

Tract Conmat1b/M-H/B (Figure 15): The potential for economic deposits of higher value construction materials in the Central Highlands, are delineated by areas of granite, basalt, acid to intermediate volcanics, and hornfels rocks which provide potential for crushed hard rock. Basalt and granitic rock areas have potential for dimension stone, depending on the availability of high quality material within a particular rock body. Potential for suitable bodies of construction sand, clay and clay shale lie within Tertiary and Quaternary age sediments.

Areas of special interest for possible future hard rock and sand construction materials extraction delineated by McHaffie & Buckley (1995) are shown in Figure 3. Hard rock resources are sufficient to supply the Melbourne area for 25 years (McHaffie 1991, in McHaffie & Buckley 1995). Resources of red firing clays are sufficient for at least 20 years but white firing types will require the development of more distant resources to the south-east of Melbourne. Melbourne roof tile makers have a sound resource base for the long term (McHaffie & Buckley 1995).

Diamonds
The potential for diamonds is unknown.

Phosphate
Very small amounts of Ordovician and large areas of Devonian marine sedimentary sequences equivalent to those that host the phosphate deposits just outside the region (near Mansfield)~~area~~ are also present within the region. Large areas of possible shelf sedimentary sequences also occur in the region. However no phosphate occurrences have been reported in the region. The potential for phosphorite deposits in the region is considered to be unknown.

SUMMARY OF MINERAL AND EXTRACTIVE POTENTIAL IN THE CENTRAL HIGHLANDS

Mineral potential tracts were identified for 11~~thirteen~~ types of mineral deposits and 3 types of extractive deposits. Because the Central Highlands is close to a major population centre, the region is also an important current and future source for construction materials such as hard rock, gravel, sand and clay. Extraction sites for low unit value construction materials are often dictated by other land uses such as real estate developments and by costs of transport. Areas where construction materials may be extracted in future, ‘interest areas’, are shown on Figure 1.

The tracts of mineral potential for various types of mineral deposits (Figures 4 to 15) have been combined and summarised in two different ways in Maps 3 and 4. Parts of the tracts for construction materials (Fig 15), which are in the interest areas in Figure 1 are also included in Maps 3 and 4.

Map 3 is a composite of mineral potential tracts over the Central Highlands and shows the highest level of mineral potential assessed (in December 1996) for any particular area in the region (maps 4 to 14). In this approach, tracts of lower mineral potential are obscured by the tract having the highest level of mineral potential in any particular area. Most of the Central Highlands is covered by a tract of high potential for deposits of slate-belt gold, with smaller tracts of high potential for brown coal confined to the southeast part of the region (Map 3 and

Figures 4 and 12). Tracts of moderate to high potential for epithermal deposits of gold and silver are in the central part of the region and areas of moderate to high potential for kaolin are closely associated with sediments in the current drainage systems (Map 3 and Figures 6, 14). A few tracts of low to moderate potential for tin veins and tungsten-molybdenum veins are in the southern and northwestern part of the region (Map 3 and Figure 8).

Tracts of moderate to high potential for disseminated gold (Figure 4) and nickel-copper deposits (Figure 9) are obscured by tracts of high potential. Similarly tracts of moderate potential for alluvial gold, tungsten skarn, sandstone type uranium (Figures 5, 7 and 10) are obscured by tracts of higher potential. Other tracts which are obscured by tracts of higher potential are low to moderate potential tracts for deposits of tin veins, tungsten-molybdenum veins, limestone, dolomite(Figures 8, 13) and tracts of low potential for bauxite (Figure 11).

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 epithermal gold may be considered to have a higher economic value than a tract with high potential for coal.

The mineral potential tracts in Figures 4 to 14 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). Scores of overlapping tracts were then added to derive a 'cumulative mineral potential' score. Areas with high cumulative scores indicate potential for more than one type of deposit (eg. moderate potential for tungsten skarn deposits (6) + moderate to high potential for disseminated gold (12) + high for slate-belt gold (18) = 36).

It should be understood that the areas with overlapping tracts highlighted by Map 4 emphasise the diversity of mineral potential, but these areas are not necessarily more prospective than a single tract of high potential, for example, slate-belt gold. The relative economic significance of the tracts for different types of mineral deposits, as perceived by mining companies, would be influenced~~dictated~~ by their perceptions of prospectivity, future market conditions, land access and other factors. Maps 3 and 4 cannot therefore be used as an indication of the relative economic potential for minerals of different areas of the Central Highlands.

The cumulative mineral potential scores highlight the diversity of potential resources in the northeastern portion of the Central Highlands where there are overlapping tracts of potential for deposits of slate-belt and disseminated gold, nickel-copper and limestone/dolomite. Areas around granitoids are highlighted for overlapping potential for deposits of slate-belt and disseminated gold, tungsten skarns, tin veins, tungsten-molybdenum veins and limestone/dolomite. The granitoids themselves have the lowest scores as the potential in these rocks is restricted to tracts of low to moderate potential for deposits of tin veins and for tungsten-molybdenum veins.

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; timing of discoveries; future metal prices and mining costs; and rules and regulations governing exploration and mining. Ideally, an economic assessment of a region's known and potential mineral resources would involve an estimation of the value of the right to explore and mine. Unfortunately, due to data limitations, this has not been possible. However the major factors affecting potential economic value are outlined, and some indicators of that value are examined.

The mineral resource assessment provides an indication of which land is likely to be prospective for 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.

EXPLORATION

While there are presently no significant operating metallic mineral mines in the Central Highlands, expenditure on exploration and mining licences totalled $1.8 million in 1995-96. Commodities being explored for were gold, base metals and antimony.

EXPLORATION PRIOR TO 1965

The Woods Point-Walhalla region was prospected intensively from the early 1860s and intermittently into the late 1890s during several mining booms. Nonetheless, except for the work conducted by Government geologists, most of the early prospecting results were never recorded. Early prospecting was principally for gold, but copper was also included following the discovery in 1864 of the Thompson River copper deposit. Some tin prospecting was also carried out in the Howqua, Jamieson and Goulburn Rivers but this was largely unsuccessful. The first modern regional exploration work began in 1965 (Planet Mining Co. Ltd, Exploration Licences 12 and 13).

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 much larger areas than would normally be covered by a mining lease, search permit or a prospecting area licence.

Exploration in some areas has been hampered by rugged topography, difficult access and at times severe weather. Drilling in the area is difficult and some geochemical samples taken for analysis have subsequently been found to be either invalid or unreliable. Hence at least some exploration in the region has been ineffective and significant mineral deposits may remain undetected and a number of quite prospective areas remain, to a large degree, untested.

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. Commodities explored for include gold, silver, base metals, platinoids, antimony, mercury, uranium, tungsten and phosphate.

The exploration targets sought have varied over the thirty year period up to the present, in accordance with relative metal prices; perceived prospectivity; relative costs of recovery of certain metals, and new exploration paradigms or mineral deposit models.

During the mid 1960s, the gold price was fixed at a relatively low level, although base metal prices were strong. Hence the principal commodity targets sought during this period were copper, lead and zinc, although high-grade vein-type gold was also sought as it could be worked profitably provided costs were relatively low.

Phosphate was sought by IMC Development Co around 1966 to 1967 and by Mines Exploration in the early 1970s, in the Phosphate Hill area near Mansfield~~. 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. Areas of possible shelf sedimentary sequences occur in the Central Highlands but from the available information the potential for phosphate is unknown~~.

Mafic copper-nickel was sought by various companies in the Coopers Creek area in 1969/70, and in subsequent periods.

Tin and molybdenum deposits associated with granitoids, were sought in the late 1970s.

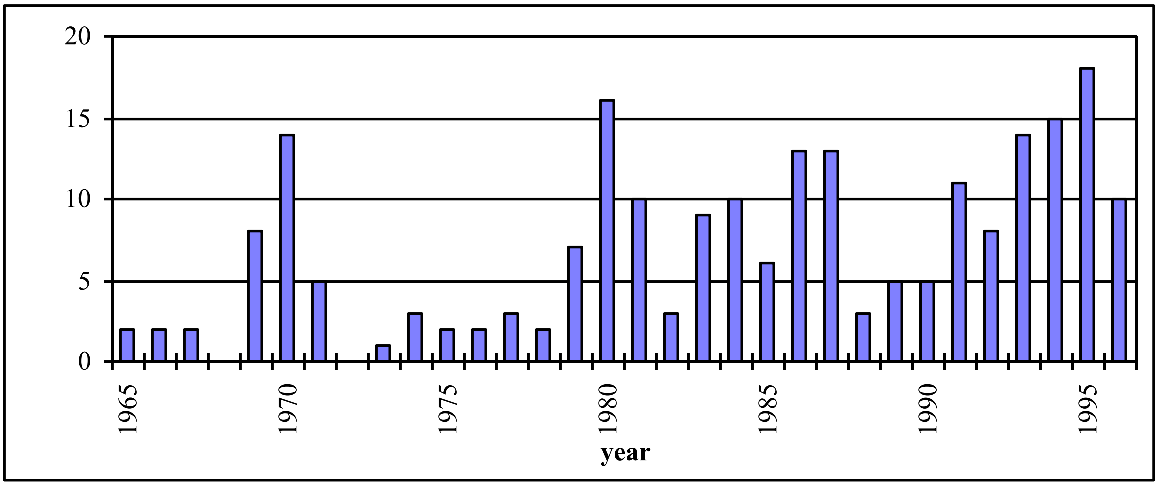
Since 1965, about 220 Exploration Licences (ELs) have been applied for either over the Central Highlands proper, or the adjacent areas as shown on Maps 1 and 2. None have to date led to a profitable mine being established. The mining boom of the late 1960's led to a record (up to that time)14 ELs being applied for during 1970.

The Gaffneys Creek-Woods Point-Walhalla area has attracted most exploration in the Central Highlands over the last 30 years. When the gold price rose dramatically in 1979/1980, exploration for gold began slowly but intensified throughout the late eighties and early nineties. Exploration targets included bulk low-grade gold targets comprising either 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.

In the early 1980s to 1986, BHP was prospecting for large low grade gold-quartz-stockwork type mineralisation in fractured sandstones or breccia around the Mt Piper- Broadford area in northern the Central Highlands.

The number of new ELs applied for annually rose sharply to 16 in 1980, declined and then increased to 13 each year in 1986 and 1987. Recently, the number of new ELs applied for in 1993 increased to 14, and then to 15 in 1994 and rose again to peak at 18 in 1995 (Figure 16). The estimate for the number of new ELs applied for during 1996 is put at 10 and exploration activity appears to have slowed down in 1996.

Figure 16: Exploration licence applications for the Central Highlands region



In general, exploration activity and expenditure over the Central Highlands reached a cyclic peak in 1995 with respect to both expenditure ($1.93 million) and the proportion spent on the Central Highlands (over 6%) compared with total exploration expenditure over the whole state. In almost all cases, gold has been the major exploration target. Recent deposit models also include volcanic-hosted epithermal gold deposits of possible Cambrian age, as well as intrusion related gold in Devonian calcareous and carbonaceous sediments (possible "Carlin"-type)

Company exploration activity in the Central Highlands currently is focused on the search for primary gold mineralisation in Devonian dykes (slate belt gold type as at Woods Point) and to a minor extent, base metals (particularly copper, lead, zinc-[nickel]) covering the Cambrian greenstones and the dyke swarms in the eastern portion of the region, particularly between Walhalla and Jamieson.

Exploration for gold is also focused around the Devonian Cerberean volcanic in the central part of the region.

Current and historical exploration expenditures provide some indication of the potential value of the undiscovered mineral resources of the Central Highlands. This is because a decision to invest in exploration is based largely on a company's perception of the mineral potential of an area. That is, exploration expenditure will tend to be higher in areas of higher perceived mineral potential. However, because of uncertainty and dynamics of exploration, different risk attitudes of companies and difficulty of exploration, expenditure only provides an approximation of true prospectivity. Perceptions of sovereign risk (the risk of policy changes affecting returns to investment after an investment has been made) also affect exploration expenditure.

At the time of this assessment, there were 34 active exploration licences in the Central Highlands region (Figure 2), distributed among 20 companies. In 1995-96 exploration expenditure in the Central Highlands was about $1.8 million (Minerals and Petroleum Victoria, 1997), which represented around five per cent of expenditure in that year on exploration for base metals and gold on Victorian exploration expenditure in that year (Table 3).

Table 3: Total mineral exploration expenditure, Central Highlands

Year	Central Highlands exploration expenditure ($)	Victorian exploration expenditure MRD Act ($ million)	Central Highlands exploration, as a % of Victorian exploration expenditure

1991-92	462 362	10.0	4.6
1992-93	633 178	14.7	4.3
1993-94	1 982 268	18.7	10.6
1994-95	2 490 854	41.1	6.1
1995-96	1 813 581	35.1	5.2
Totals	**7 382 243**	**119.6**	**6.2**

Note: Figures include private mineral exploration expenditure on Exploration and Mining Licences, as derived from Mineral and Petroleum Victoria records.

Of the 34 exploration licences in the region, there are many prospects where resources have been identified and exploration has proceeded to more advanced stages.

Jericho

The Jericho Project is in the Walhalla–Woods Point–Gaffney's Creek–Jamieson gold belt (Figure 2). Previous mining activities in the project area, mostly conducted between 1861 and 1940, recovered substantial quantities of alluvial gold from a number of rivers in addition to gold from quartz reefs at several locations. In the three years since an exploration licence was granted for the Jericho prospect, Osprey Gold NL has spent $280 000 on exploration and has budgeted $450 000 for 1997-98 (G.H. Fethers, Osprey Gold NL, pers comm, 14 February 1997).

MINING AND EXTRACTIVES

Recent production has come from deposits in the Gaffney's Creek area mined from 1968 to 1989 and the A1 Mine between (also near Gaffney's Creek) 1989 and 1992 (O'Shea et al 1992~~O'Shea and others 1992~~). Currently two small scale hard rock gold mines are the only operating metallic mines in the region.

While no substantial mining activity currently is being undertaken in the Central Highlands there has been significant expenditure on mining licences (Table 4). Most of this expenditure occurs on mining licences which overlie historical workings and where production is anticipated to occur at some stage. Exploration being undertaken on such mining licences is generally at an advanced stage, involving detailed assessment of a resource (K. Weston, Minerals and Petroleum Victoria, pers comm, March 1997).

Table 4: Expenditure on Mining Licences in the Central Highlands

Year	Mining licence exploration expenditure ($)	Mining licence other expenditure ($)	Total expenditure mining licences ($)	Number of mining licences
1991-92	328 658	73 714	402 372	23
1992-93	286 678	4 851 064	5 137 742	26
1993-94	1 358 629	1 224 040	2 562 669	28
1994-95	563 126	1 838 980	2 402 106	33
1995-96	518 924	1 501 091	2 020 015	31
Totals	**3 056 015**	**9 488 889**	**12 544 904**	

Note: Figures derived from Mineral and Petroleum records. Mining licence exploration expenditure included in Table 3.

Of the mining licences within the area, only at the Morning Star project (Figure 2) have sufficient resources been identified to proceed toward a mining feasibility study, which is currently being undertaken. The Morning Star deposit has produced over 883 000 ounces of gold since 1862 at an average grade of 24.5 grams per tonne (Wilkinson 1986), although most of this gold was produced from the mine last century.

Around $3.5 million has been spent on exploration of the Morning Star deposit, including mine dewatering and refurbishment of the old mine shaft. With current resource estimates, it is likely that future mining of the opencut and underground resource would occur over a period of four to five years (R. Bird, Mount Conqueror Minerals NL, pers comm, February 1997).

Potential future economic benefits of the Morning Star project have not been estimated. However, if the current resource of 234 000 ounces was extracted over five years, this would equate to annual gross revenues of around $23 million. Using the 1995 average industry gross margin (Australian spot price less industry average total cost) it is found that such production, were it to start today, would have a present value of almost $16 million, using a 5 per cent discount rate.

This figure gives an order of magnitude estimate of the potential direct benefits from the project. To estimate the actual potential net economic benefits of the project it would be necessary to gather project specific cost and production data. In addition, it is likely that such a large project would produce indirect benefits that would not be reflected in producer returns alone — for example, the benefits of reduced unemployment or stimulated production in other markets.

It is estimated that, in the first half of 1996, around 3.5 million tonnes of construction material was quarried in the area at a gross value of some $41.1 million. Henshall Hansen Associates *et al.* (1992) estimated that 186 people were directly employed in the 31 quarries within the Central Highlands in 1991, of which 19 people were employed in the three quarries on public land (although the area used in their study was slightly larger than the boundary used for this report). The main industrial mineral resources produced in the Central Highlands are sand, hard rock, clay and limestone. Construction materials and other industrial mineral commodities are particularly significant as the Central Highlands is close to Melbourne.

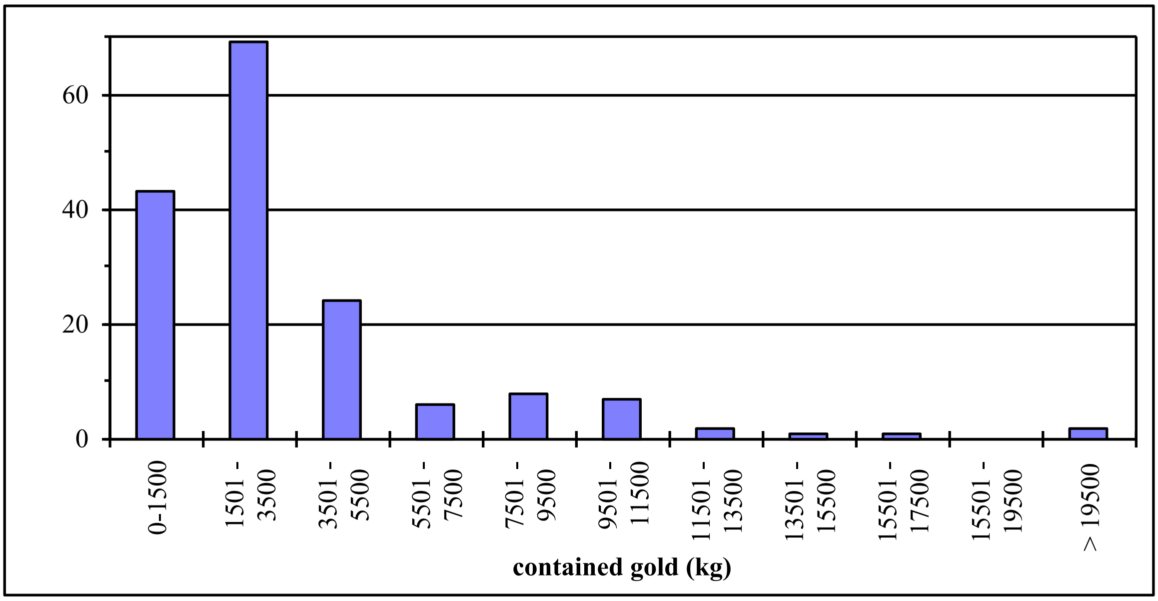
As most titles for the extraction of construction materials in the Central Highlands are situated on private land (Figure 1), they are unlikely to be affected by the outcomes of the Regional Forest Agreement. Quarries are often located on private land in Victoria because construction materials are owned by the land owner, and not (as in the case of minerals) exclusively by the Crown. This provides an incentive for quarry operators to develop operations on private land.

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 Central Highlands. 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 163 Victorian slate bed gold deposits surveyed by Bowen (1974), 85 per cent had total production of between 1000 and 6228 kilograms (Figure 17). The Nagambie gold mine (just outside the study area) recently closed after production of 4185 kilograms. The case history of the Nagambie operation provides a useful insight to the effect that a mine lying within this range could have on local towns and regional economies, if found in the Central Highlands.

Figure 17: Production from slate belt gold deposits in Victoria, 1857–1974



The Nagambie gold deposit was discovered in 1985 and in 1987 a resource of 7 million tonnes at a 1.2 grams per tonne gold grade was delineated by the Perseverance Corporation Ltd (Hughes 1990). The mine operated from July 1989 until December 1996 and minor amounts of gold are still being extracted from leach residues. 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 5.

Table 5: 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, Perseverance Corporation Ltd, personal communication, February 1997.

In addition to the net economic benefits associated with the rents from production (not calculated in this report), the Nagambie gold 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,
- Perseverance spent $465 000 upgrading local infrastructure including the electricity relay station and road improvements which enabled a $1.5 million mushroom farming business to be established, creating eight new jobs (in addition to the multiplier effects above), and
- the mine brought new workers into the region (31 mine employees were new residents), increasing the diversity and level of skill in the Nagambie region's occupational structure,

population growth in the region over the period 1989–91 was around 4.5 per cent — reversing the previous trend of population decline in the area.

Although mines like Nagambie may be temporary (3–10 years life in many cases) it is apparent that in addition to bringing economic benefits to the local and wider economies during their operating life, these projects also provide infrastructure and demographic benefits to smaller communities, which can have lasting effects.

OUTLOOK FOR MINERAL PRODUCTION

Developments in world metals markets will have a large bearing on development opportunities for the minerals industry in the Central Highlands. Base metals (copper, lead and zinc) and gold are the focus of current exploration activity in the Central Highlands. As a consequence, the outlook for these markets is emphasised in this section. Detailed market outlook assessments for the medium term are given in Haine and Roarty (1997) and Middleton and Allen (1997) for base metals and gold, respectively.

BASE METALS

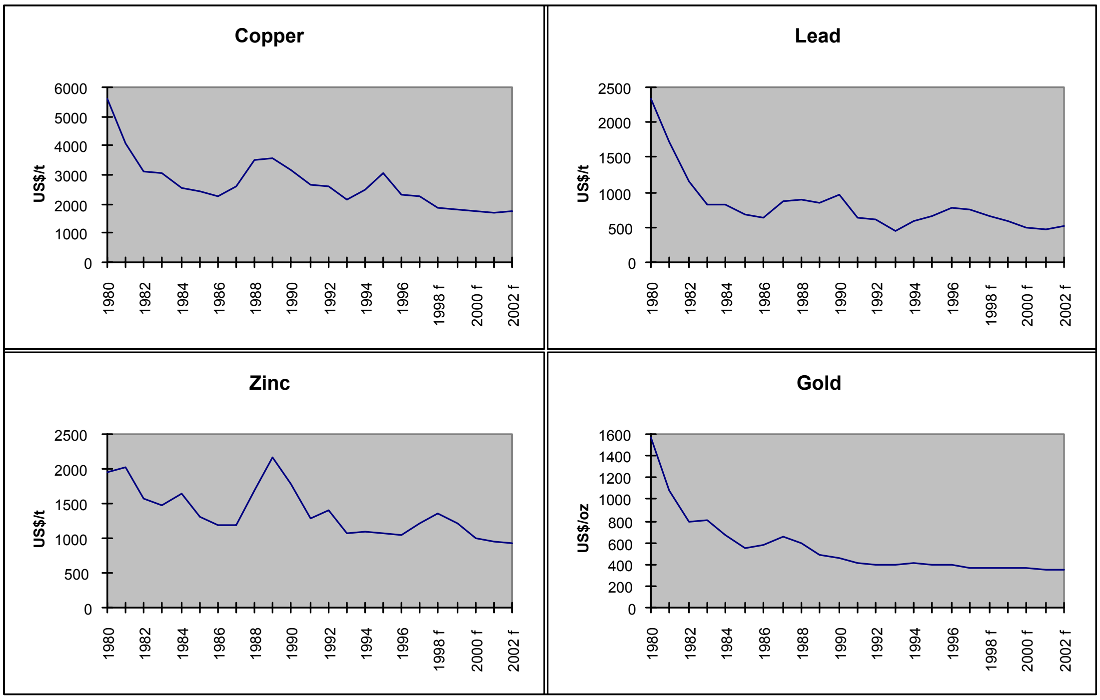
Asia accounted for 27 per cent of world base metals consumption in 1996, compared with 19 per cent in 1980. While Japan's share declined marginally in this period, the share of developing Asian countries more than doubled and is projected to rise further over the medium to long term, reflecting relatively fast economic growth in these countries. However, the developed market economies, which accounted for around 55 per cent of world base metals consumption in 1996, are assumed to continue to expand. Demand for base metals in these countries is therefore expected to continue to grow, although at a slower rate than for the Asian countries. In contrast, the share of global base metals consumption in the countries of the former Soviet Union and eastern Europe fell from 22 per cent in 1980 to 13 per cent in 1996. However, consumption levels in these economies are projected to recover in line with increased economic growth rates.

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

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

Over the longer term, continuing technological developments can be expected to place downward pressure on costs. Together with projected demand growth, the long term downward trend in real prices experienced for each of the base metals is therefore expected to continue. Price projections to 2002 are shown in figure 18.

Figure 18: Real base metals and gold prices (In 1995-96 dollars)



GOLD

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

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

Continued growth in world gold consumption is expected to be largely met by increased gold production from emerging producers and further sales of official sector reserves. The development of high quality gold deposits in the emerging gold producing regions together with the continued adoption of new technologies in traditional producing regions are expected to place downward pressure on costs. Over the medium to longer term, real gold prices are therefore expected to remain relatively flat and may possibly decline slightly (Figure 18).

LEGISLATION AND LAND ACCESS

Access to land is an important issue for exploration and mining. At this stage the implications of the RFA for exploration and mining are not known.

It is important to note that no area can ever be classified as unprospective 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 implications 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 on 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. Other relevant legislation includes the Mineral Resources (Titles) Regulations, 1991.

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 work plan and other approvals being obtained, and
- site visits and monitoring of environmental management activities by government officers.

Under the MRDA there are four main land types:

- private land,
- exempt Crown land,
- restricted Crown land, and
- unrestricted Crown land.

No exploration or mining activities can be carried out on exempt Crown land, unless the licence was in place before the land became exempt, and 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 principle 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 15 per cent of the land in the Central Highlands CRA region (Table 6). 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 a further three per cent of the region.

Table 6: Land use categories as a proportion of total land area, Central Highlands

Land use category	Area (ha)	Proportion of Central Highlands (%)
Private land	503 000	44
Exempt Crown land	164 000	15
Restricted Crown land	31 000	3
Unrestricted Crown land	431 000	38
Total Central Highlands	1 129 000	100

Source: Minerals and Petroleum, Victoria

NATURE OF EXPLORATION AND MINING

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.

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.

Because of incomplete geological knowledge, the discovery rate in Australia is roughly of the order of one mine per thousand exploration programs. Thus areas are explored, often repeatedly, before a mineral deposit is found.

Although discovery and delineation are the primary reasons for exploration, lack of discovery from an exploration program does not imply the effort yielded no benefit. Information gained from exploration will usually increase the understanding of a region's geology. There are many cases where information gained from both successful and unsuccessful exploration programs was later used to locate mineral deposits that were either overlooked by, or were not the target of, past 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).

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

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 Central Highlands 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.

In contrast to 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 uses.

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.

Many potential environmental effects of mining activities can be eliminated or mitigated, though at a cost to the mining company. Given the relatively limited areas of land disturbed by the operation of a mine, water pollution often represents the major potential threat to the environment from mining. 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.

REFERENCES

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

Abele, C., 1988, Central Coastal Basins *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 303-322.

Alcaston Mining NL *in* Greenchip Management Pty Ltd, 1994, Re-creating history: the new gold rush - the Victorian Gold Book 1994.

Atkinson, P. L., 1988, Diatomite *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 566-567.

Banks, D. A. 1986, Hydrothermal chimneys and fossil worms from the Tynagh Pb-Zn deposit, Ireland, *in* Andrew, C. J., Crowe, R. W. A., Finlay, S., Pennel, W. M., & Pyne, J. F., eds., Geology and Genesis of Mineral Deposits in Ireland: Dublin, Irish Association for Economic Geology, pp. 441-448.

Barrie, J. 1965, *in* Mcleod, I.R., (Editor) Australian Mineral Industry: The Mineral Deposits. Platinum group metals: 39, 487-494. Bureau of Mineral Resources, Geology and Geophysics, Bulletin 72, 690p.

Barron, L. M., Lishmund, S. R., Oakes, G. M., & Barron, B. J., 1994, Subduction diamonds in New South Wales: implications for exploration in eastern Australia: SW Geological Survey Quarterly Notes, 94, pp.1-23.

Barton, C.M., Bolger, P.F., Holdgate, G.R., Thompson, B.R., & Webster, R.L., 1992, The Brown Coal Geology of the Gippsland Basin. Gippsland Basin Symposium. The Australasian Institute of Mining and Metallurgy:Melbourne.

Battey, G.C., Miezitis, Y., & McKay, A.D., 1987, Australian uranium resources. Bureau of Mineral Resources, Geology and Geophysics. Resource Report 1. AGPS Canberra.

Berger, B. R., & Bethke, P. M. (eds.) 1985, Geochemistry of epithermal systems: Reveiws in Economic Geology, v. 2.

Blevin, P.L., & Chappell, B.W., 1995, Chemistry, Origin and Evolution of Mineralized Granites in the Lachlan Fold Belt, Australia: The metallogeny of I- and S-Type Granites: Economic Geology, v. 90, pp. 1604-1619.

Blissett, A. H., 1962, Zeehan one mile geological map series, Geological Survey Exploration Report, Department of Mines Tasmania, Copper-Nickel, pp. 246-251.

Bobis, R. E., Jaireth, S., Morrison, G. W. 1996, The anatomy of Carboniferous epithermal ore shoot at Pajingo, Queensland: Setting, zoning, alterations, and fluid inclusions: Economic Geology, v. 90, pp. 1776-7198.

Bowen, K. G., 1974, An analysis of gold production data for Victorian reef and deep lead mines, in Papers Presented at the Conference on Gold Deposits in Victoria. Mines Department Report 1974/12.

Bowen, K.G., 1988, Economic Geology - uranium *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne p. 596.

Boyle, R.W., Brown, A.C., Jefferson, C.W., Jowett, E.C., & Kirkham, R.V., (Editors) 1989, Sediment-hosted Stratiform Copper Deposits. Geological Association of Canada, Special Paper 36.

Brakel, A.T., 1989, Sydney Basin: Permian coal measures stratigraphy and sedimentation in Permian Coals of Eastern Australia. Bureau Of Mineral Resources Bulletin 231, pp. 9-41.

Broken Hill Holdings, 1993, Annual Report for 1993.

Buchanan, L. J. 1981, Precious metal deposits associated with volcanic environments in the southwest; Arizona Geol. Soc. Digest, v. 14, pp. 237-261.

Carr, D. D., & Rooney, L. F., 1983 Limestone and dolomite, *in* ed., Lefond, S. J., Industrial Minerals and Rocks (5th Edition), American Institute of Mining, Metallurgical and Petroleum Engineers Inc, pp. 833-868.

Cochrane, G.W., 1971, Tin Deposits of Victoria. Geological Survey of Victoria Bulletin 60, pp. 72.

Consolidated Victorian Mines NL, 1994, Annual Report for 1994.

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

Cronan, D.S., 1992, Marine Minerals in Exclusive Economic Zones. Chapman and Hall, London, Melbourne, pp. 67-82.

d'Auvergne, P. B. 1990, Ballarat East gold deposit, *in* Hughes, F. E., ed. Geology of the Mineral Deposits of Australia and Papua New Guinea, Australasian Institute of Mining and Metallurgy: Melbourne, pp. 1277-1278.

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

Douglas, J.G., 1988, Gippsland Basin, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne pp. 228 - 234.

Doyle, J.F., Balfe, P.E., Barton, C.M., Holdgate, G.R., Bolger, P.F., Black, T.M., Bowman, R.G., & Sutcliffe, G., 1986, Geological Setting of Deposits *in* ed., Martin, C. H. Coal Mining Practice, Monograph 12., The Australasian Institute of Mining and Metallurgy:Melbourne, pp. 29-52.

Duketon Goldfields NL., 1996, Quarterly Report to End September, 1996.

Fethers G (1996) Exploration and Drilling at Jericho in Minerals on the Move Conference 1996, Victoria

Flack, D.S. 1967, Platinum. Mineral Industries of New South Wales, Summary Report Series, 33 Geological Survey of NSW.

Forde, A., & Bell, T. H. 1994, Structural control of mesothermal vein hosted deposits in Central Victoria Australia: Ore Geology Reviews, v. 9, pp. 33-59

Foster, D.A., Kwak,T.A.P., & Gray, D.A., 1996, Timing of Gold Mineralisation and relationship to Metamorphism, Thrusting, and Plutonism in Victoria, *in* eds., Hughes, M. J., Ho, S. E., & Hughes, C. E., Recent developments in Victorian geology and mineralisation, Australian Institute of Geoscientists, Bulletin No. 20, , p 49 - 52.

Gillies, A. L., 1990, Nagambie gold deposit, *in* Hughes, F. E., ed. Geology of the Mineral Deposits of Australia and Papua New Guinea, Australasian Institute of Mining and Metallurgy: Melbourne, pp. 1299-1301.

Gloe, C.S., & Holdgate, G.R., 1991, Geology and Resources, *in* ed. Durie, R. A., The Science of Victorian Brown Coals: structure, properties and consequences of utilisation, Coal Corporation of Victoria (Butterwoth Heinemann), pp. 1-43.

Gloe, C.S., 1984, The geology, discovery and assessment of the brown coal deposits of Victoria, in ed. Woodcock, J. T., Victoria's Brown Coal Monograph II - a huge fortune in chancery, The Australasian Institute of Mining and Metallurgy:Melbourne, pp. 79-109.

Gloe, C.S., Barton, C.M., Holdgate, G.R., Bolger, P.F., King R.L., & George, A.M., 1988, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp.498 - 513.

Gloe, C.S., Barton, C.M., Holdgate, G.R., Bolger, P.F., King, R.L. & George, A.M., 1988, Brown coal *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne pp. 498 - 510.

Graves, M. C., & Zentilli, M. 1982, A review of the geology of gold in Nova Scotia, *in* Hodder, R. W., & Petruk, William, eds., Geology of Canadian Gold Deposits: The Canadian Institute of Mining and Metallurgy, Special Volume 24, pp. 233-242.

Guilbert, J.M. and Park, C.F. (1986). The Geology of Ore Deposits. W.H. Freeman and Company, New York, pp. 985.

Harben, P. W., & Bates, R. L., 1990, Carbonate rocks, *in* Industrial Minerals: Geology and world deposits. Industrial Minerals Division. Metal Bulletin plc. London, pp 41-48.

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

Harrington, H.J., Brakel, A.T., Hunt, J.W., Wells, A.T., Middleton, M.F., O'Brien, P.E., Hamilton, D.S., Beckett, J., Webber, C.R., Radke, S., Totterdell, J.M., Swaine, D.J., & Schmidt, P.W., 1989, in eds. Harrington et al., Permian Coals of Eastern Australia, Bureau Of Mineral Resources Bulletin 231. pp. 412.

Henley, R. W., 1991, Epithermal gold deposits in volcanic terranes, in ed. Foster, R. P., Gold metallogeny and exploration, Blackie: Glasgow and London, pp. 133-164.

Hill, M., 1988, Phosphate *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 580 -581.

Hoatson, D. M., Wallace, D. A., Sun, S-S., Macias, L. F., Simpson, C. J., & Keays, R. R., 1992, Petrology and platinum-group-element geochemistry of Archaean layered mafic-ultramafic intrusions, west Pilbara Block, Western Australia, Bureau of Mineral Resources, Geology and Geophysics, Bulletin 242, pp. 320.

Hodgson, C. J., Love., D. A., & Hamilton, J. V. 1993, Giant mesothermal gold deposits, *in* Whiting, B. H., Hodgson, C. J., & Mason, R., eds. Giant Ore Deposits. SEG SP-2

Holdgate, G.R., 1984, Stratigraphy, structure and brown coals of the Moe area. Aust. Coal Geology, v. 5, pp. 1-12.

Hora, D., 1992, Primary Kaolin *in* ed. Lefebure, D. V., & Ray, G. E., 1995, Deposit Profiles and Resource Data for Selected British Columbia Mineral Deposits. British Columbia Geological Survey Branch unpublished report.

Horvath, J., 1957, The results of diamond drilling of the copper nickel deposits at north Dundas, near Zeehan, Tasmania. Records Bureau of Mineral Resources of Australia, 1957/98.

Intrepid Mining Corporation NL, 1996, Annual Report for 1996.

Intrepid Mining Corporation NL *in* Greenchip Management Pty Ltd, 1994, Re-creating history: the new gold rush - the Victorian Gold Book 1994.

Keays, R. R., & Green, A. H., 1974, An analysis of gold production data for Victorian reef and deep lead mines *in* Papers Presented at Conference on Gold Deposits in Victoria. Mines Dept of Victoria report 1974/12.

Keays, R. R., & Kirkland, M. C., 1972, Hydrothermal mobilisation of gold from copper-nickel sulphides and ore genesis at Thomson River copper mine, Victoria, Australia: Economic Geology, vol 67, pp 1263-1275.

Kwak, T. A. P. 1987, W-Sn skarn deposits and related metamorphic skarns and granitoids. Developments in Economic Geology, 24. Elsevier.

Kwak, T. A. P., & Roberts, C., 1996, Sandstone-hosted gold deposits, Victoria: a new exploration target, *in* eds., Hughes, M. J., Ho, S. E., & Hughes, C. E., Recent developments in Victorian geology and mineralisation, Australian Institute of Geoscientists, Bulletin No. 20, pp. 63- 69.

Marsden, M. A. H., 1988, Upper Devonian - Carboniferous, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 146-194.

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

McConachy, G. W., and Swensson, C. G., 1990, Fosterville goldfield, *in* Hughes, F. E., Ed. Geology of the Mineral Deposits of Australia and Papua New Guinea, Australasian Institute of Mining and Metallurgy: Melbourne, pp. 1297-1298.

McHaffie, I.W. and Buckley, R.W., 1995, Industrial minerals and rocks of Victoria, Geological Survey of Victoria Report 102, pp 209.

McLaughlin, R.J.W., 1988, Central Victorian Cauldron Volcanic Province, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 151-168.

Moore, D. H. 1996, Geophysical signatures of gold deposits in western Victoria, *in* eds., Hughes, M. J., Ho, S. E., & Hughes, C. E., Recent developments in Victorian geology and mineralisation, Australian Institute of Geoscientists, Bulletin No. 20, p. 19-23.

Mount Conqueror Minerals NL *in* Greenchip Management Pty Ltd., 1994, Re-creating history: the new gold rush - the Victorian Gold Book 1994.

Mount Conqueror Minerals NL, 1996, Annual Report for 1996.

Noble Resources NL *in* Greenchip Management Pty Ltd (1994) Re-creating history: the new gold rush - the Victorian Gold Book 1994.

Nott, R. J., 1988, Bauxite. *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 593-594.

Nott, R.J., 1988, Mineral Deposits Related to Granitoids *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 586 - 590.

Nott, R.J., 1988, Economic Geology - Tungsten, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne pp. 589 -590.

O'Brien, P.E., 1989, Bowen Basin beneath the Surat Basin in in Permian Coals of Eastern Australia. Bureau Of Mineral Resources Bulletin 231, pp. 93-105.

O'Shea, P.J., Whitehead, M., Buckley, R., & Lanzer, L.A, 1992, Primary Gold Mineralisation Potential in the Melbourne Zone of the Lachlan Fold Belt, Central Victoria. Energy and Minerals Victoria, Unpublished report 1992/31.

Owen, H. B., 1954, Bauxite in Australia. Bureau of Mineral Resources, Geology & Geophysics Bulletin 24, pp 98-99.

Patterson, S.H., 1967, Bauxite reserves and potential aluminium resources of the world: U.S. Geological Survey Bulletin 1228, pp. 176.

Patterson, S.H.,1984, Bauxite and nonbauxite aluminium resources and production--An update, in Jacob, Leonard, Jr., ed., Bauxite--Proceedings of the 1984 Bauxite Symposium, Los Angeles, California: New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, pp. 3-30.

Perkin, D. J. 1990, Compendium of ore deposit models, Bureau of Mineral Resources, Geology & Geophysics, Unpublished report.

Plimer, I.R., 1987, Fundamental parameters for the formation of granite-related tin deposits: Geologische Rundschau, v. 71, pp. 23-40.

Ramsay, W. R. H., & Wilman, C. E. 1988, Gold *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 454- 482.

Ramsay, W.R.H., & VandenBerg, A.H.M., 1986, Metallogeny and tectonic development of the Tasman Fold Belt System in Victoria: Ore Geology Reviews v. 1, pp. 213 - 257.

Richards, J. R., & Singleton, O. P., 1981, Palaeozoic Victoria: igneous rocks, ages, and their interpretation: Journal of the Geological Society of Australia, v. 28, pp. 395-421.

Sharpe, E. N., & MacGeehan, P. J. 1990, Bendigo goldfield, *in* Hughes, F. E., ed. Geology of the Mineral Deposits of Australia and Papua New Guinea, Australasian Institute of Mining and Metallurgy: Melbourne, pp. 1287-1296.

Solomon, M. & Groves, D. I. 1994, The geology and origins of Australia's mineral deposits, Oxford Monographs on Geology and Geophysics, Oxford University Press, Oxford, pp. 951.

Stanley, D.R. 1986, Brown Coal Resources of Victoria, An Overview: Geological Survey Of Victoria, Unpublished Report 1986/25.

Strong, D.F., 1988, A Model for Granophile Mineral Deposits *in* eds., R.G. Roberts, R. G., & P.A. Sheahan, P. A., Ore Deposit Models. Geological Association of Canada, pp. 59-66.

Tan, S. H., & Atkinson, P. L., 1988, Feldspar, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 567-568.

Taylor, R. G., 1979, Geology of Tin Deposits. Elsevier, New York, pp. 543.

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

Thornett, J.R. 1981, The Sally Malay deposit: Gabbroid associated nickel copper sulfide mineralisation in the Halls Creek mobile zone, Western Australia: Economic Geology, v. 76, p. 1565-1580.

Tomlinson, K. M., 1990, Cohen's Reef gold deposit, Walhalla, *in* Hughes, F. E., ed. Geology of the Mineral Deposits of Australia and Papua New Guinea, Australasian Institute of Mining and Metallurgy: Melbourne, pp. 1303-1305.

Traves, D.M., & King, D., (eds.) 1975, Economic Geology of Australia and Papua new Guinea: 2. Coal, The Australasian Institute of Mining and Metallurgy, Monograph 6, pp. 398.

Turner, G., 1996, The Barkley River greenstones - a new mineral province in eastern Victoria, *in* eds., Hughes, M. J., Ho, S. E., & Hughes, C. E., Recent developments in Victorian geology and mineralisation, Australian Institute of Geoscientists, Bulletin No. 20, p. 71-89.

VandenBerg, A.H. M., 1988, Silurian-Middle Devonian, in Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 103-146.

VandenBerg, A.H.M., & Gray, D.R., 1988, Structure and Tectonics - Melbourne Zone, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 11 - 18.

White, A.J.R., & Chappell, B.W., 1988, Granites *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 427-439.

White, N. C., & Hedenquist, J .W., 1990, Epithermal environments and styles of mineralisation: variations and their causes, and guidelines for exploration: Journal Geochemical Exploration, v. 36, pp. 445-474.

Whiting, R. G., & Bowen, K. G., 1976, Economic geology - gold, *in* Douglas, J. G., & Ferguson, J. A., eds., Geology of Victoria, Geological Society of Australia: Melbourne, pp. 434-451

Williams, W. M. 1943, Bauxite in Tasmania, Bulletin Imperial Institute London, v. 41, pp 196-200.

table 1a

table 1b

Table 7 Goldfields and gold deposits of the Central Highlands and adjacent areas

RESOURCES:

Map 2 Locn No	Area/Deposit Name / Category	Material (tonnes)	Gold Grade (g/t)	Gold (kg)	As at:	Source
25	**WOODS POINT/WALHALLA GOLD SUB PROVINCE (mostly inside the Central Highlands):**					
	Morning Star					
	Surface	1,470,000	1.3	2,793	1997	Goodz and Associates (1997)
	Underground	712,000	6.3	4,486	1997	Goodz and Associates (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	unknown	unknown	1993	Broken Hill Holdings (1993)
	"Pre-resource"	60,000	unknown	unknown	1993	Broken Hill Holdings (1993)
	Cohens Reef **(adjacent to the Central Highlands)**					
	Resource	550,000	5.1	2,805	1996	Intrepid Mining Corp (1996)
28	**TALLANGALOOK GOLDFIELD (adjacent to the Central Highlands):**					
	Golden Mountain					
	Indicated & Infer'd	1,300,000	1.5	1,950	1996	Duketon Goldfields NL (1996)

PAST PRODUCTION:

Map 2 Locn No	Area/Deposit Name	Gold Grade (g/t)	Gold (kg)	Period	Source
25	**WOODS POINT/WALHALLA GOLD SUB PROVINCE (mostly inside the Central Highlands):**				
	Woods Point/Walhalla Gold Sub Province		99,000	1860-1989	O'Shea and others (1992)
	includes:				
	Gaffney's Creek Goldfield:	25	15,552	1857-1992	Noble Resources NL (1994)
	includes:				
	A1 Mine	26	13,000	since 1863	O'Shea and others (1992) grade: Bowen (1974)
	Rose of Denmark Mine	12	1,831		
	Woods Point Goldfield:	31	31,103	na	Alcaston Mining NL (1994)
	includes:				
	Morning Star Mine	24.5	27,371	na	Mt Conqueror Minerals (1994)
	BB Quartz Mine	26.4	55	na	Fethers G (1996)
	United Gleesons Mine	na	880	na	O'Shea and others (1992)
	Matlock Goldfield:				
	Loch Fyne Mine	24	3,419	na	O'Shea and others (1992)
	All Nations Mine	na	4,105	na	

Map 2 Locn No	Area/Deposit Name	Past Production Gold Grade (g/t)	Gold (kg)	Period	Source
25 (cont)	***Donnelly's Creek Gold Field:***				
	Toombon Mine	23	1,384	1872-97	O'Shea and others (1992)
	Donnelly's Creek Reefs	na	809	1863-1909	Alcaston Mining NL (1994)
	includes:				
	Bismark Mine	48	357	na	Alcaston Mining NL (1994)
	Edwards Hill Mine	22	183	na	Alcaston Mining NL (1994)
	WESTERN AND CENTRAL PARTS OF CENTRAL HIGHLANDS AREA:				
	(Production amounts shown below are minimum only as recorded data is often incomplete)**				
1	***Mount Piper Goldfield (adjacent to the Central Highlands):***			na	
2	***Kilmore Goldfield (adjacent to the Central Highlands):***				
	Alluvial gold	na	na	1851 - ?	
	Larry Bourke's Reef	5.9	33	1864-69	O'Shea and others (1992)
	Goldie Mine	9.7		1868-88	O'Shea and others (1992)
		13.5	-	1930's	O'Shea and others (1992)
	- tailings	4.6	na	"	
	Goldie Deep Lead	na	na	na	
3	***Donnybrook (Darraweit Guim) Goldfield (adjacent to the Central Highlands):***				
	Kalkallo mine	157	48	na	
4	***Sunday Creek Goldfield:***				
	Alluvial gold	na	na	1860-72	
	Apollo	31 to 93	na	1865 - ?	O'Shea and others (1992)
		** 8 to 30% antimony			
	Golden Dyke	17	na	1899	O'Shea and others (1992)
		** 6% antimony			
	Golden Dyke Extension (Christina)				O'Shea and others (1992)
5	***Reedy Creek Goldfield:***				
	Alluvial gold	na	na	1856 - ?	
	Prince of Wales Reef	5.6	65	1881-1909	O'Shea and others (1992)
	Empress Reef	na	na	"	O'Shea and others (1992)
	Kaiser Reef	na	na	"	O'Shea and others (1992)
	Evening Star Reef	na	na	"	O'Shea and others (1992)
	Langridge Reef	na	na	"	O'Shea and others (1992)
	Crown Reef	na	na	"	O'Shea and others (1992)
	Doyles Reef	na	na	"	O'Shea and others (1992)
	Tonsil Mine	3 to 31	na	"	O'Shea and others (1992)
	Leviathan Mine	3 to 31	na	"	
6	***Strath Creek Goldfield:***				
	Alluvial gold	na	na	1851 - ?	O'Shea and others (1992)
	Sailor's Jack Reef	32 to 210	na	1859 - ?	O'Shea and others (1992)
	Don Maurice Mine	3 to 180	na	"	O'Shea and others (1992)

Map 2 Locn No	Area/Deposit Name	Past Production Gold Grade (g/t)	Gold (kg)	Period	Source
7	***Mount Marianne - The Triangles Goldfield:***				
	Triangle Reefs	na	na	1859 - ?	O'Shea and others (1992)
8	***Yea Goldfield:***				
	Alluvial gold	na	na	1851 - ?	O'Shea and others (1992)
	Providence Reef	28	198	1859 - ?	O'Shea and others (1992)
	Flat Lead	7.8 to 41.5	na	"	O'Shea and others (1992)
	Constitution Hill	na	na	"	O'Shea and others (1992)
	Boundary Creek	na	na	"	O'Shea and others (1992)
	Carriers Lead	na	na	"	O'Shea and others (1992)
9	***Tea Tree Creek Goldfield:***				
	Alluvial gold	na	na	1860 - ?	O'Shea and others (1992)
	Welcome Mine	27	218	1859 - ?	O'Shea and others (1992)
	Jonien's Reef	62 to 155	na	"	O'Shea and others (1992)
	Enniskillen Reef	62 to 155	na	"	O'Shea and others (1992)
	Dunrobin Reef	62 to 155	na	"	O'Shea and others (1992)
	German Jack's Reef	62 to 155	na	"	O'Shea and others (1992)
	Old Man's Mine	8 to 16	na	"	O'Shea and others (1992)
10	***King Parrot Creek Goldfield:***				
	Alluvial gold	na	na	1851 - ?	O'Shea and others (1992)
	Fortune's Mine	31	0.2	"	O'Shea and others (1992)
	Matthew's Mine	6 to 15	na	"	O'Shea and others (1992)
	Timm's Reef	39 to 55	na	1864 - ?	O'Shea and others (1992)
	Gibb's Reef	na	na	"	O'Shea and others (1992)
	King's Reef	na	na	"	O'Shea and others (1992)
11	***Whitlesea Goldfield:***	na	na	na	O'Shea and others (1992)
12	***Yarrambat Goldfield:***				
	Golden King No 1Mine	12.6	48	1940-48	O'Shea and others (1992)
	Golden Crown Mine	26	66	1939-45	O'Shea and others (1992)
		6	77	1948-50	O'Shea and others (1992)
	Golden Stairs Mine	12.7	30	1928-42	O'Shea and others (1992)
13	***Anderson's Creek - Queenstown Goldfield:***				
	Alluvial gold	na	na	1851 - ?	O'Shea and others (1992)
	Warandyte workings				
	Caledonia Mine	31	397	1905-09	O'Shea and others (1992)
	Yarra Tunnel Reef	62	19	1869-88	O'Shea and others (1992)
	Pigtail Reef	62	58	1875-81	O'Shea and others (1992)
	Victory Reef	up to 6200	na	"	O'Shea and others (1992)
	Diamond Creek Mine	na	1,870		Bowen (1974)

Map 2 Locn No	Area/Deposit Name	Past Production Gold Grade (g/t)	Past Production Gold (kg)	Period	Source
13	***Anderson's Creek - Queenstown Goldfield (cont'd):***				
	Panton Hills workings	na	280	1854 - ?	O'Shea and others (1992)
	Carters Reef	93 - 310	na	"	O'Shea and others (1992)
	BoomersReef	up to 310	na	"	O'Shea and others (1992)
	Jenny Linn Reef	23	na	"	O'Shea and others (1992)
	One Tree Hill workings	na	233	"	O'Shea and others (1992)
	Alluvial gold	very rich - nuggets up 3.2kg		1851 - ?	O'Shea and others (1992)
	Buck Reef	20	67	1866-73	O'Shea and others (1992)
	Moonlight Reef	27	na	1854 - ?	O'Shea and others (1992)
	Swedish Reef	124	na	"	O'Shea and others (1992)
14	***Steels Creek Goldfield:***				
	Alluvial gold	na	na	1867-95	O'Shea and others (1992)
	Antimony concentrate	58	0.2	1899	O'Shea and others (1992)
		** also 62% antimony or 1,860kg antimony metal			
	Antimony concentrate	11	0.007	1936	O'Shea and others (1992)
		** also 47% antimony or 282kg antimony metal			
15	***Kinglake Goldfield:***	na	na	na	
16	***Murrundindi Goldfield:***				
	Galatea Reef	39	2	1866 - ?	O'Shea and others (1992)
		23	3	"	O'Shea and others (1992)
	George Higinbottom Reef	93	na	"	O'Shea and others (1992)
17	***North Balwyn Goldfield (adjacent to the Central Highlands):***				
	Koonung Creek Reef	31	na	na	O'Shea and others (1992)
18	***Ringwood Goldfield (adjacent to the Central Highlands):***				
	Ringwood Mine				
	Antimony concentrate	up to 70	na	1869-95	O'Shea and others (1992)
19	***Emerald-Nicholson Goldfield:***	na	na	na	
20	***Hoddles Creek Goldfield:***	na	na	na	
21	***Upper Yarra-Warburton Creek Goldfield:***				
	Alluvial gold	na	na	1859 - ?	O'Shea and others (1992)
	Reefton	620	na	1874 - ?	O'Shea and others (1992)
22	**Crossover-Neerim Goldfield:**				O'Shea and others (1992)
	Alluvial gold	na	na	1864 - ?	O'Shea and others (1992)
	Albian Reef	na	na	"	
	Happy Go Lucky Reef	na	na	"	

Map 2 Locn No	Area/Deposit Name	Past Production Gold Grade (g/t)	Gold (kg)	Period	Source
23	***Tanjil (Russells Creek) Goldfield:***				
	Alluvial gold	na	>50kg	1859 - ?	Murray (1880, 1916)
	Reef gold	3 to 90	na	"	O'Shea and others (1992)
24	***Tyers River Goldfield:***				O'Shea and others (1992)
	Alluvial gold	na	na	1859 - ?	O'Shea and others (1992)
25	**Woods Point/Walhalla Gold Sub Province (see above)**				
26	***Black River Goldfield (adjacent to the Central Highlands):***				
	Wye's Creek Reef	9 to 620	na	1866 - ?	O'Shea and others (1992)
	Standard Reef	na	na	"	O'Shea and others (1992)
	New Standard Reef	na	na	"	O'Shea and others (1992)
	Golden Fleece Reef	na	na	"	O'Shea and others (1992)
	Weber's Reef	-	na	"	O'Shea and others (1992)
27	***Merton Goldfield (adjacent to the Central Highlands):***			na	
28	***Tallangalook Goldfield (adjacent to the Central Highlands):***				
	Alluvial gold - Devil's River	na	na	1857 - ?	O'Shea and others (1992)
	Golden Mountain	2.5	96	1887-90	O'Shea and others (1992)
	Woolf's Mine			1857 - ?	O'Shea and others (1992)
	Bonnie Doon Mine			"	O'Shea and others (1992)
29	***Alexandra-Gobur-Godfrey's Goldfield:***				
	Galatea Mine	83	10.5	1870-74	O'Shea and others (1992)
	Gemba Mine	54	0.8	na	O'Shea and others (1992)
	Strathmore Mine	na	na	1866 - ?	O'Shea and others (1992)
30	***Acheron Goldfield:***				
	Alluvial gold	na	na	1854 - ?	O'Shea and others (1992)
31	***Snobs Creek Goldfield:***				
	Alluvial gold	na	na	1854 - ?	O'Shea and others (1992)
	Thornton Mine	na	na	1868 - ?	
32	***Jerusalem Creek Goldfield:***				
	Alluvial gold	na	na	1871 - ?	O'Shea and others (1992)
33	***Ghin Ghin Goldfield (adjacent to the Central Highlands):***				
	Alluvial gold	na	na	1867 - ?	O'Shea and others (1992)
	City of Melbourne	62 to 93	na	"	O'Shea and others (1992)
	Red Line	62 to 93	na	"	O'Shea and others (1992)
	Providence	62 to 93	na	"	O'Shea and others (1992)
	Mc Leish's Reef	8	na	"	O'Shea and others (1992)

Table 8 Mineral occurrences, old mines and deposits for the Central Highlands and adjacent areas (see Map 2)

Locn No.	Name	Commodity
1	Cunninghams Lode (Tyakk)	Gold, antimony
2	Apollo (Clonbinane Sunday Creek)	Gold, antimony
3	Old Mans Hope (Doogalook Yea)	Gold, antimony
4	Golden Crown (Yarrambat)	Gold, antimony
5	Diamond Creek	Gold, antimony
6	Allens Reef (Queenstown)	Gold, antimony
7	One Tree Hill	Gold
8	Steels Creek (Yarra Glen)	Gold, antimony
9	Gem	Gold, antimony
10	Neerim (Crossover)	Gold
11	Neerim South (Jindivick)	Gold
12	Spotted Dog Creek (Tanjil)	Gold, cobalt manganese
13	Tanjil (Spotted Dog Creek)	Gold
14	Morning Star (Woods Point)	Gold, antimony
15	Specimen Creek	Antimony
16	Gaffneys Creek	Gold
17	Big River (Enochs Point)	Gold, antimony
18	Wild Dog Creek	Gold, antimony
19	Blue Gum (Eildon)	Gold, antimony
20	Castle Douglas (Eildon)	Gold, antimony
21	Trawool	Dimension stone - granite
22	Morang	Dimension stone - granite
23	Lilydale	Dimension stone - marble
24	Lysterfield (Dandenong)	Dimension stone - granite
25	Coopers Creek (Evans Quarry)	Limestone
26	Macclesfield	Peat
27	Yarragon	Coal, peat
28	Trafalgar East	Coal, peat
29	New Loch	Copper, platinum group metals, gold
30	Shamrock	Copper, nickel, platinum group metals, gold
31	Hunts	Copper, platinum group metals, gold
32	Acheron River	Mineral sand
33	Lilydale	Limestone
34	Toolangi	Wollastonite
35	Tynong (Garfield North)	Feldspar
36	Nayook	Feldspar
37	Monkey Gully (Limestone)	Molybdenum, bismuth, tungsten
38	Tin Creek	Tin, tungsten
39	Wilks Creek	Tungsten
40	Britannia Creek (Bullock Creek)	Tungsten
41	Beenak	Tin
42	Upper Latrobe River	Tin, gold
43	Bunyip River	Tin
44	Gembrook	Gem stones
45	Heyfield Reef	Gold, antimony
46	Egans Reef (Merton)	Gold, antimony
47	Kilmore	Gold, antimony
48	Templestowe	Antimony
49	Templestowe	Gold

50	Calendonia (Andersons Creek)	Gold, antimony
51	Ringwood	Gold, antimony
Locn No.	**Name**	**Commodity**
Outside Central Highlands boundary ...		
52	Cohens Reef (Walhalla)	Gold
53	Gannans (Gannan, Kevington)	Antimony
54	Ghin Ghin (Davis)	Dimension stone - siltstone
55	Bulla (Broadmeadows)	Dimension stone - granite
56	Tynong	Dimension stone - granite
57	Cora Lynn	Peat
58	Coalville	Coal
59	Morwell	Coal, peat
60	Thomson River	Copper, platinum, palladium, gold, silver
61	East Walhalla	Copper, cobalt, platinum group metals, silver
62	Maynards Gully	Copper
63	Moranding	Diatomite, feldspar
64	Mickleham	Diatomite
65	Bulla	Kaolin
66	Bulla	Wollastonite
67	Campbellfield	Kaolin
68	Fairfield-Brunswick	Diatomite
69	Ringwood	Kaolin
70	Hallam	Kaolin
71	Yallourn	Coal, kaolin
72	Morwell	Kaolin
73	Tyers River (Boola)	Limestone
74	Toongabbie (Marble Creek)	Limestone
75	Licola (Serpentine Creek)	Limestone
76	Howes Creek	Limestone
77	Phosphate Hill (Mansfield)	Phosphate
78	Bonnie Doon	Wollastonite
79	Maindample	Tin
80	Bulla	Magnesite
81	Rhyolite Creek	Pyrophyllite
82	Jamieson River (Quicksilver Creek)	Mercury
83	Devon Meadows	Unspecified
84	Barkly River	Unspecified
85	Griffiths [Howes Creek]	Unspecified
86	Goughs [Howes Creek]	Unspecified
87	Wappan	Unspecified
88	Golden Mountain	Gold

Table 9: Construction materials quarries and occurrences in the Central Highlands and adjacent areas (see Figure 1)

Locn. No.	Name	Commodity(s)	A = active
1		Clay	A
2		Rhyodacite	A
3	Lilydale	Limestone/dolomitic limestone	A
4	Dandenongs Igneous Complex (Montrose)	Rhyodacite	A
5		Hornfels	A
6		Clay/clay shale	A
7	Packenham	Basalt	A
8	Packenham	Clay/clay shale	
9	Packenham	Basalt	
10	Tynong North	Granite	
11	Tynong North	Gravel	
12	Tynong	Granite	A
13	Garfield North	Granite	A
14		Sand/gravel	A
15		Sand/gravel	A
16		Hornfels	A
17		Basalt	A
18		Basalt	A
19	Neerim	Basalt	A
20	Latrobe Valley	Peat	A
21	Latrobe Valley	Sand/gravel	
22	Latrobe Valley	Sand/gravel	A
23	Latrobe Valley	Sand/gravel	A
24	Latrobe Valley	Sand/gravel	A
25	Latrobe Valley	Sand/gravel	A
26	Latrobe Valley	Sand/gravel	A
27	Coopers Creek	Limestone	
28		Sand/gravel	A
29		Sand/gravel	A
30		Sand/gravel	A
31		Sand/gravel	A
32		Sand/gravel	A
33		Sand/gravel	A
34		Basalt	
35		Sand/gravel	A
36		Scoria	A
37		Basalt	
38		Sedimentary rock	A
39		Basalt	A
40	Craigieburn	Clay/clay shale	A
41	Craigieburn	Clay/clay shale	A
42		Basalt	A
43		Basalt	A
44		Hornfels	A
45		Basalt	A
46	Campbellfield	Clay/clay shale	A
47		Basalt	A
48		Quartzite	A
49		Granite	

50	Castella	Hornfels	
Locn. No.	**Name**	**Commodity(s)**	**A = active**
Outside Central Highlands boundary ...			
51		Quartzite	A
52		Clay/clay shale	A
53		Clay/clay shale	A
54		Clay/clay shale	A
55		Clay/clay shale	A
56		Clay/clay shale	A
57		Clay/clay shale	A
58		Rhyodacite	A
59	Heatherton - Dingley	Sand/gravel	A
60		Sand/gravel	A
61	Lysterfield	Granite/hornfels	A
62	Hallam	Clay/clay shale	A
63	Harkaway	Basalt	A
64	Cranbourne	Sand/gravel	A
65	Cranbourne	Sand/gravel	A
66	Cranbourne	Sand/gravel/clay	A
67	Langwarrin	Sand/gravel/clay	A
68	Langwarrin	Sand/gravel	A
69		Clay/clay shale	A
70		Sand/gravel	A
71		Sand/gravel/clay	A
72		Sand/gravel	A
73		Sand/gravel	
74		Sand/gravel/sed. rock	A
75		Basalt	A
76		Sand/gravel	A
77		Sand/gravel	A
78		Sand/gravel	
79		Sedimentary rock	A
80		Sand/gravel	A
81		Basalt	A
82		Clay/clay shale	A
83		Limestone	
84		Sand/gravel	A
85		Basalt/limestone	A
86		Sand/gravel	A
87		Sand/gravel	A
88		Quartz	A
89		Sand/gravel	A
90		Sand/gravel	
91		Slate	A
92		Sand/gravel	
93		Sand/gravel	A
94		Basalt	A
95	Kilmore East	Basalt	A
96		Basalt	
97	Greenvale	Granite	
98		Basalt	
99	Campbellfield	Clay	A
100		Sand/gravel/clay	A

101		Basalt	A

Figure 1: Construction materials quarries, occurrences and interest areas

Figure 4: Mineral potential tracts for slate-belt and 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 skarn scheelite deposits

Figure 8: Mineral potential tracts for tin veins and tungsten-moylbdenum veins

Figure 9: Mineral potential tracts for nickel-copper deposits

Figure 10: **Mineral potential tracts for sandstone hosted uranium**

Figure 11: Mineral potential tracts for lateritic bauxite deposits

Figure 12: Mineral potential tracts for brown coal deposits

Figure 13: Mineral potential tracts for limestone deposits

Figure 14: Mineral potential tracts for kaolin deposits

Figure 15: Mineral potential tracts for construction materials

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

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

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 Central Highlands.

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, Redden, Wilson and Buscher (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.

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

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

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

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

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

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

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

Examples:

Bendigo Goldfield, Australia, Victoria. (Sharpe and MacGeehan, 1990)
Ballarat East Gold Deposits, Australia, Victoria. (d'Auvergne, 1990)
Mother Lode, US, California (Knopf, 1929)
Goldfields of Nova Scotia,
CNNS (Graves, & Zentilli, 1982)

Assessment Criteria

1. Distribution of the Ordovician, Silurian, Silurian-Devonian turbidites and their metamorphic equivalents.
2. Presence of granodiorites and dyke swarms
3. Presence of fault zones.
4. Presence of primary and/or alluvial gold deposits and prospects.

Known deposits and mineral prospects in the Central Highlands

The area contains several mineral deposits and occurrences of this type. They constitute two main gold provinces: the Walhalla-Woods Point province in the eastern part of the area, geologically associated with Mount Wellington Fault Zone and the Melbourne province in the western part of the area. Within the Walhalla-Woods Point province two NNW trending goldfields are delineated: The Walhalla-Aberfeldy Goldfield in the south and the Matlock-Woods Point-Jamieson goldfield in the north.

Using the classification of gold deposits by Ramsay and Willman (1988), following types of slate belt gold deposits can be recognised in the area: sediment-hosted (eg. The Ringwood field); granitoid related (deposits associated with the Strathbogie granitoid in the northern part of the area); and dyke affiliated (The Walhalla-Woods Point province).

The most significant deposits (such as Cohen's Reef and Morning Star) are 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 minerlisation. Within the dykes Edwards (cited in Ramsay and Willman, 1988) recorded reefs within or along the walls of dykes (eg. Morning Star, A1), and reefs in fault planes spatially associated with dykes (eg. Cohen). However there are reefs (bedded and fault-related) and spurs and stockwork mineralisation with no direct spatial association with dykes.

Geological studies in the area and other goldfields 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, geochemical) becoming important in several areas. Recent geophysical studies in three goldfields (Stawell, St Arnaud and Beaufort) has revealed that they share two common characteristics. All are hosted within weakly but distinctly more 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). Some gold occurrences in the Central Highlands region also show similar association with Devonian granitoids

Assessment Criteria

1. Distribution of the turbidites and their metamorphic equivalents.
2. Presence of granodiorites and dykes
3. Presence of fault zones.
4. Presence of slate-belt gold veins.
5. Presence of bleached and altered rocks.
6. Presence of primary and/or alluvial gold deposits and prospects.

Assessment: Tract Au1/H/C

The tract is delineated based on the distribution of Ordovician, Silurian, Siluro-Devonian and Devonian turbidites and their metamorphic equivalents. These rocks are favourable for hosting slate-belt vein gold mineralisation. The tract also contains known slate-belt vein deposits and the known occurrences of disseminated gold deposits. The tract includes part of the Wellington Fault zone which hosts the Woods Point-Jamieson goldfield associated with the Woods Point Dyke Swarm. A major part of the tract is also occupied by Devonian granitoids which include I-type granitoids.

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

Economic Significance

The slate belt type of gold deposits include 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% of these deposits contain at least 0.001 million tonnes of ore; 50% contain at least 0.03 million tonnes and 10% contain at least 0.91 million tonnes. In 90% of these deposits ores contain at least 6 g/t gold; 50% contain at least 15 g/t gold and 10% contain 43 g/t gold.

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 (1994); 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 serpentine. 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 metes 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, Victoria.. (Gilles, 1990)
Fosterville, Australia, Victoria (McConachy and Swensson, 1990)
Peru (Montoya et al, 1995)

Known deposits and mineral prospects in the Central Highlands

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 Central Highlands area there are number of known occurrences of this type, the most significant of which is the Morning Star gold mine in the Woods Point-Jamieson goldfield. Mineralisation in most deposits within this field 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 minerlisation.

The intrusives are generally of up to 2 metres in width but locally pipe-like bulges up to 1000 m wide are developed apparently associated with zones of cross folding or shearing (Ramsey and Williams, 1988). In the Morning Star deposit mineralised reefs are within or along the walls of the dykes and form ladder veins in dyke bulges. Recent exploration has revealed disseminated mineralisation in the vicinity of ladder veins where the dyke is bleached because of alteration.

Disseminated and stockwork mineralisation also occurs in the Cohen's reef gold deposit, Walhalla where haloes up to 10 m wide are developed around veins in the shear zone (Tomlinson, 1990).

A number of well-know deposits of this type occur outside the Central Highlands area. These include Nagambie in the Melbourne Zone and Fosterville in the Bendigo-Ballarat 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. Distribution of the turbidites and their metamorphic equivalents.
2. Presence of granodiorites and dykes
3. Presence of fault zones.
4. Presence of slate-belt gold veins.
5. Presence of bleached and altered rocks.
6. Presence of primary and/or alluvial gold deposits and prospects.

Assessment: Tract Au2/M-H/B

As for the slate-belt gold deposits, the tract is based on the distribution of Ordovician, Silurian, Siluro-Devonian and Devonian turbidites and their metamorphic equivalents. These rocks are favourable for hosting slate-belt vein gold mineralisation with a potential to form haloes of disseminated and stockwork gold mineralisation around mineralised veins.

The tract is assessed to have a moderate to high potential with a certainty level of B with areas of high potential occurring within the Woods Point-Jamieson goldfield.

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, US, California	(Lindgren, 1911; Yeend, 1974)
Victoria, Australia, Victoria.	(Knight, 1975)

Known deposits and mineral prospects in the Central Highlands

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

In addition to the typical placer deposits, the Central Highlands 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 are in the Avoca and Loddon valleys, around Ballarat and in north eastern Victoria near Chiltern and Rutherglen. The Central Highlands region does not contain any known occurrence of deep leads.

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.
6. Distribution of Tertiary volcanics overlying Tertiary sediments.

Assessment: Tract Au3/M/B

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

The tract also includes areas which are favourable for deep and shallow leads. It has been reported that areas in the southern part of the Central Highlands region which are covered by Tertiary volcanics overlie Tertiary alluvial sediments which are favourable for deep leads (Buckley, pers. commu.)

In the north-eastern part of the Central Highlands region, in an area within 15 km buffer zone Upper Devonian fluvial sediments containing conglomerate might be suitable for palaeo placers of gold.

From the widespread distribution of primary sources of gold in the Central Highlands region it is concluded that the region has a moderate potential (with a certainty level of B) for alluvial gold. Areas in close proximity to primary slate belt and disseminated gold deposits also have a moderate to high potential for deep lead gold.

*Au4: EPITHERMAL GOLD-SILVER DEPOSITS (MOD*EL 25B OF COX AND SINGER, 1986)
Model Description

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

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

Description: Galena, sphalerite, chalcopyrite, sulfosalts, + tellurides + gold in quartz-carbonate veins hosted by felsic to intermediate volcanics. Older miogeosynclinal evaporites or rocks with trapped seawater are associated with these deposits.

General References: Buchanan (1980), 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 + chalcopyrite + copper sulfosalts + silver sulfosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodoareaosite + 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, Queensland.	(Bobis et al, 1996)
Creede, US, Colorado.	(Steven and Eaton, 1975; Barton and others, 1977)
Pachuca, Mexico.	(Geyne and others, 1963)
Toyoha, Japan.	(Yajima and Ohta, 1979)

Known deposits and mineral prospects in the Central Highlands

There are no known occurrences of epithermal gold-silver deposits in the Central Highlands region. However, the Barkley River Greenstone belt in the north-eastern part of the 15 km buffer is reported to have a number of occurrences interpreted 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 volcaniclastic 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 volcaniclastics 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 Au4/M-H/B

The central part of the region is occupied by Devonian Marysville and Dandenongs igneous complexes. The Marysville Igneous Complex has three main components - the Cerberean Cauldron, the Acheron Cauldron and the Black Range Ring Dykes. Although there are no proven ring dykes or arcuate fractures in the Dandenongs Igneous Complex, its structure is thought to be analogous with the that of the Acheron Cauldron (Marsden, 1988).

The cauldrons are characterised by an overwhelming volumetric predominance of mostly crystal-rich ignimbrites of andesitic, rhyolitic to rhyodacitic types. The formation of volcanics is closely associated with the emplacement of intrusives (granodiorite, porphyritic granodiorite and porphyritic granites) which form stocks and ring dykes. Both Cerberean and Acheron cauldrons are marked by several ring and radial fractures. There is also evidence for an earlier small caldera, with associated ring dyke on the eastern side of the Cerberean Cauldron (Birch et al., cited in Marsden, 1988).

Although no large scale hydrothermal systems has been reported in the area, volcanics and intrusives show local biotitic and chloritic alteration.

The magmas responsible for the formation of igneous complexes belong to a calc-alkaline series and the basic magmas are generally high-potassium shoshinitic types, characteristic of post orogenic regions.

The distribution of cauldron-related igneous complex is the main geological feature for delineating the tract in the central part of region. The Strathbogie Igneous Complex to the north of the Central Highlands region contains terrestrial rhyolitic and rhyodacitic volcanics which are also indicative of favourable geological setting for epithermal gold-silver mineralisation.

Thus the tract contains intrusive, volcanic and volcaniclastic 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. Similarly, no mineral occurrences of epithermal gold-silver minerlisation are recorded. Hence the tract is interpreted to have a moderate to high potential for epithermal gold-silver deposits with a certainty level of B.

Adjoining the eastern boundary of the Central Highlands region are Cambrian volcanics in the Barkley River Greenstone belt which hosts prospects interpreted to be similar to epithermal gold-silver deposits. The rocks in the belt are considered to be geochemically similar to the Cambrian Mt. Read Volcanics in western Tasmania (Crawford, 1988, cited in Turner, 1996). Recent application of thin-skinned thrust tectonic model to Central Victoria suggest that these greenstones underlie the turbiditic sequence at depth throughout the Melbourne zone which also includes the central Highlands region. Cambrian volcanics are exposed only along the western margin of CRA region and based on available information it is difficult to assess their extent under the turbiditic sequence in the region. Hence the potential of Cambrian epithermal mineralisation in the region is unknown.

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% of deposits contain more than 0.065 million tonnes of ore, 50% more than 0.77 million tonnes and 10% contain more that 9.1 million tonnes. In 90% of these deposits ores have at least 2.0 grams per tonnes gold and 10 grams per tonne silver. The ores in 50% of these deposits have at least 7.5 grams per tonne gold and 110 grams per tone silver. In 10% of these deposits the ores have at least 27 grams per tone gold and 1300 grams per tonne silver.

Mineral Potential of Associated Deposits

Porphyry copper-gold deposits

There are no known occurrences of Porphyry copper gold mineralisation in the Central Highlands region, but the tract for epithermal gold-silver deposits has the potential to host porphyry copper gold deposits.

The tract for epithermal deposits is constituted by Upper Devonian igneous complexes related to cauldron setting. The igneous complexes comprised andesites, rhyodacites and rhyolites. As was mentioned above, magmas responsible for the formation of igneous complexes belong to a calc-alkaline series and the basic magmas are generally high-potassium shoshinitic types, characteristic of post orogenic regions.

It is well documented now that epithermal systems are often underlain at depth by porphyry copper ± gold systems. This transition is well documented in Mount Leyshon and Pajingo deposits in Queensland and Temora deposit in New South Wales. This its is possible that similar systems are present at depth within cauldron complexes. However the S-type nature of granitoids and volcanics in these complexes is not a favourable signature. On the other hand the shoshonitic composition of magmas could be significant because porphyry copper-gold systems in New South Wales seem to be associated with high-potassium shoshinitic magma. Thus the available information does not allow to assess the mineral potential of these deposits in the Central Highlands region.

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

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

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

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

Examples:

King Island, Australia, 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 prospects in the Central Highlands

Within the Central Highlands, tungsten-tin prospects are associated with Upper Devonian magmatism. At the Wilks Creek mine, wolframite and lesser scheelite with tourmaline and pyrite occur in narrow steeply dipping quartz veins (and sheeted quartz vein systems) within rhyodacite and granodiorite of the Marysville Igneous Complex. Other similar tungsten prospects occur at Tin Creek near Buxton, and at Monkey Gully near Limestone, east of Yea. These prospects are associated with small high-level, recently unroofed, S-type granodiorites. Scheelite the dominant ore mineral in these deposits together with trace cassiterite at Tin Creek and molybdenite at Monkey Gully. These deposits are similar to the Rossarden and Storeys Creek W-Sn quartz mineralisation of northeast Tasmania.

Tungsten occurrences at Brittania Creek are related to Upper Devonian granitoids in the Warburton Granodiorite.

Assessment Criteria

1. Presence of differentiated Upper Devonian granitoids.
2. Palaeozoic carbonate rocks intruded by the granitoids.
3. Deposits are commonly developed above a shelf in the granitoid contact. For tin-tungsten skarn deposits in western Tasmania, the 2km subsurface granite contour (as determined by modelling of gravity data) has been used to define the prospective zone for these deposits.

Assessment: Tract W/M/B

The tract is based on the following geological features:
- a 5km wide zone surrounding the Upper Devonian granitoids,
- the main Palaeozoic sedimentary sequences within the Central Highlands which have interbedded carbonate units were identified.

The tract is defined by the intersection of the 5km zone surrounding the granitoids with the limestone-bearing sedimentary sequences.

Based on the available mapping and descriptions of the known tungsten mineralisation, there is moderate potential for skarn scheelite deposits with a certainty level of B.

Potential for associated deposit types

The same tract also has potential for other types of skarn deposits including tin skarns, copper skarns, gold skarns and iron (magnetite) skarns.

From the available geological descriptions of the known mineralisation, is not possible to assess the potential for these types of skarns. Hence the potential for these associated types of skarn deposits is unknown.

Economic Significance

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

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

The known tungsten skarn deposits within the Central Highlands 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).

Recorded production from the tinfields within the Central Highlands CRA are:
Upper Latrobe River Tinfield - 6 tonnes of tin concentrates,
Beenak deposit - 1 tonne of tin concentrates.

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

Description of the model after B. L. Reed

Approximate Synonym: Cornish type lodes.

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

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

Geological Environment:

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

Textures: Common plutonic textures.

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

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

Alteration: Sericitization (greisen development) ± tourmalization common adjacent to veins and granite contacts; silicification, chloritization, hematization. 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, Queensland. (Blake, 1972)

Known Deposits and Mineral Prospects in the Central Highlands

Granitoids which outcrop extensively in the Central Highlands region lie to the west of the I-S line. They are of Late Devonian (370 -360 Ma) age (Ramsay and VandenBerg, 1986) and some are found in association with co-eval volcanics indicating their high level of emplacement. The granitoids are of similar age to that of the Pilot Range pluton in northeastern Victoria which lies within the Wagga tin belt and is the source of the Beechworth alluvial and lode deposits. Tin mineralisation in the Wagga tin belt, which lies to the north of the Central Highlands, is associated with fractionated granites of both I- and S-type.

There are no known primary occurrences of tin in the Central Highlands region. Several old, minor alluvial tin fields are located around the fractionated Tynong granite of the Central Victorian Magmatic Province.

Assessment Criteria

1. Distribution of fractionated, reduced, S or I type, late orogenic to postorogenic granitoids intrusions (either outcropping or at shallow depth).
2. Subsurface distribution of granitoids (as determined by modelling of gravity data) - veins are within the 4 km granite isobath, many being within the 1 km contour.
3. Distribution of tin occurrences.

Assessment - Tract Sn/L-M/B

This tract has been delineated based on the distribution of Late Devonian granitoids and an additional buffer of four kilometres around the granitoids within the Central Highlands region. The extent of metamorphic aureoles around some intrusives indicate that they may be even more extensive at relatively shallow depths.

Granitoids belonging to the Melbourne Basement Terrane (White and Chappell 1988) of both S- and I-type occur within the Central Highlands area. Most granitoids of the Melbourne Basement Terrane are highly reduced, as is evidenced by the presence of ilmenite, although the relative oxidation states of numerous small intrusives are unknown. The Tynong and parts of the Strathbogie granite have undergone significant fractionation, while the remainder of the large intrusive bodies are unfractionated . Again, the degree to which fractionation has occurred within many of the smaller intrusives is unknown.

The very small deposits at Beenak, Bunyip River and Upper Latrobe River which occur within the aerial extent of the Tynong Granite are hosted by recent alluvial sediments associated with channels which have sourced cassiterite from the Tynong pluton and concentrated the mineral via sedimentary processes.

Although the reduced nature of the granites is favourable for the formation of primary deposits of tin none have been recognised within the field area except as trace cassiterite at the Tin Creek deposit. The lack of apparent fractionation within most of the large granitoids in the Central Highlands appears to limit their potential to be a source of primary tin mineralisation.

The tract is considered to have low to moderate potential for tin deposits 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).

W-Mo: TUNGSTEN-MOLYBDENUM VEINS (MODEL 15A, COX AND SINGER, 1986)
Model Description

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

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

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

Geological Environment:

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

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

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 albitization; higher pervasive to vein-selvage pink K-feldspar replacement with minor disseminated REE minerals; upper zones, vein selvages of dark-gray muscovite or zinnwaldite (greisen). Chloritization. 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, US, North Carolina. (Foose and others, 1980)
Round Mountain, US, Nevada. (Shawe and others, 1984)

Known Deposits and Mineral Prospects in the Central Highlands

At Wilks Creek near Marysville wolfram and scheelite are found in a sheeted quartz vein system within porphyritic granodiorite and rhyodacite of the Marysville Igneous Complex. Mineralisation is very low grade and working of veins has been very minor. Scheelite also occurs in several small, high level, recently unroofed S-type granodiorites at Tin Creek (with minor cassiterite) and Monkey Gully (with minor molybdenum). Other minor occurrences are at Mount Cunningham (W, Mo) and Warburton (W).

All mineral occurrences are closely spatially related to high level granitoids of Late Devonian age.

The age and style of mineralisation at Monkey Gully and Tin Creek is thought to be similar to that of the Aberfoyle tin-tungsten deposits in northeast Tasmania.

Assessment Criteria

1. Distribution of fractionated syn to late orogenic, I-type and/or S-type granitoids.

2. The distribution of this type of vein mineralisation is related to the subsurface distribution of granitoids as determined by modelling of gravity data. They lie within the 4 km granite isobath, and many are within the 1 km isobath (Green, 1990). The vein mineralisation may also occur in the granitoid.
3. Distribution of tungsten, molybdenum and bismuth prospects.

Assessment: Tract W-Mo/L-M /B

This tract has been delineated based on the distribution of Late Devonian granitoids with an additional buffer of four kilometres within the Central Highlands region. The extent of metamorphic aureoles around some intrusives indicate that they may be even more extensive at relatively shallow depths.

Both S- and I- type granitoids of the Melbourne Basement Terrane (White and Chappell 1988) occur within the Central Highlands. Granitoids vary from mafic to very felsic but in general are highly reduced. The Tynong pluton and parts of the Strathbogie Adamellite are fractionated with the remaining large granitoids unfractionated. Numerous small granitoid bodies as well as the Black Range Ring Dyke within the area remain unclassified in terms of their S- or I- type status and the degree to which they have been fractionated.

Small high level intrusions around the Marysville Igneous Complexes which host the tungsten occurrences provide a focus for mineralisation. Trace cassiterite at Tin Creek and trace molybdenite at Monkey Gully associated with these closely related high level intrusives may indicate that the intrusives are neither strongly reduced nor oxidised.

Many small intrusives similar to those that host the tungsten occurrences are present in the Central Highlands around both the Marysville and Dandenong igneous complexes, however the degree to which they have been fractionated is unknown.

Based on the above information it is concluded that the tract has a low - moderate potential for tungsten-molybdenum deposits with a certainty level of B.

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 type s of deposits, 90% contain at least 0.6 wt% WO_3, 50% at least 0.9 wt% WO_3 and 10% at least 1.4 wt% WO_3 (Cox and Singer, 1986).

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 ± pyrite ± Ti-magnetite ± Cr-magnetite ± 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 et al, 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 prospects in the Central Highlands

In Thomson River copper mine (Coopers Creek copper mine) 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.

Cu / Ni sulphides also occur in shear zones in country rock (shales) -associated with calcite/quartz gangue. Part of dyke swarm of generally thin elongate dykes with average width(?1m) and up to 30m and more wide. Sulphides include chalcopyrite, pentlandite, pyrrhotite, pyrite, cubanite, chalcocite, arsenopyrite, galena, sphalerite, tetrahedrite, sperrylite.

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

The East Walhalla copper and platinum mine produced small amounts of ore from three small open-cuts and a short underlay shaft, but no production details are known.

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 Woods Point dyke swarm 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 and it has a certainty level of B.

Economic significance

The gabbroid associated stratabound nickel copper sulphide deposit type has been of minor commercial importance in Tasmania 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 TiO_2 minerals in diagenetic ores. Roll front--Oxidised iron minerals in rock up-dip, reduced iron minerals in rock down-dip from redox interface.

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

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

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

Examples:

Honeymoon, Beverley South Australia. (Battey, Miezitis 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 prospects in the Central Highlands

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.

Assessment Criteria

1. Presence of sandstones deposited in a reducing environment and containing carbonaceous plant material or interbedded coal layers,
2. Presence of uranium-bearing granitoids which are a possible source for uranium which could be dissolved by circulating groundwater and precipitated at redox interfaces within the sandstone.

Assessment Tract: U/M/C

The tract is drawn based on the distribution of Lower Cretaceous Strzelecki Group and Tertiary sediments of the Moe Swamp Basin (Gippsland Basin).

The Lower Cretaceous sandstones of the Strzelecki Group were deposited in a reducing environment and unconformably overlie Palaeozoic basement sediments and granitic rocks. They contain carbonaceous plant material and interbedded coal layers (Douglas, 1988) and are suitable host rocks for sandstone uranium deposits. Similarly, the Tertiary basal sandstones of the Childers Formation (Moe Swamp Basin) contain interbedded coal layers and are also suitable host rocks for sandstone uranium deposits.

Palaeochannels eroded into the basement would localise the inflow of oxidised groundwaters containing dissolved uranium. Uranium precipitation occurs at redox interfaces (roll-fronts) within the sandstone beds.

Devonian granitoids and volcanics within the Melbourne Zone contain low levels of uranium. These provide a possible source for the formation of sandstone uranium deposits. However, the potential for this type of deposit is reduced because of the low background levels of uranium in the granites.

On the available information the potential for sandstone uranium deposits is moderate with a certainty level of C.

COAL: COAL DEPOSITS
Model Description

Description of Coal-bearing sedimentary sequences

Approximate Synonyms:

Description: Coal measures

General References: Harrington (1989), Traves, King and Knight (1975), Doyle et al (1986)

Geological Environment

Rock types: Coal measures interbedded with various terrestrial and marine sedimentary sequences.

Age Range: Carboniferous to Tertiary

Depositional Environment: Peat swamps behind coastal barrier systems or within structural depressions further inland; swamps and peat bogs associated with and marginal to alluvial fans and deltaic plains; fluvial flood plains; lacustrine; lagoonal. Depositional environment must be free from frequent incursions of clastic sediments or oxygenated waters, thus environments are generally low energy, anoxic and occur in fresh - brackish waters.

Tectonic Setting: Small rifts and valleys, marginal and intracontinental sedimentary basins. Coal deposition is generally closely related to marine transgression and/or regression. Deposits are dominantly terrestrial, with marine influence common.

Associated deposit types: Oil Shale?

Deposit Description:

Mineralogy/Composition: Coal composition varies depending on depositional environment and extent of coalification.
Brown Coal - Moisture content 50-70%, dry weight: 60-75% Carbon,
Bituminous Coal - Moisture content 5-10%, dry weight: 80-90% Carbon
Anthracite - Moisture content 2-5%, dry weight: 90-95% Carbon
(After Doyle et al 1989)

Dominant component of coals are macerals and ash. Macerals are the organically derived components of coal. The major components of coal ash are silicate and sulfide minerals.

Texture/structure: Generally laterally continuous seams. Can have various textures relating to sedimentary processes such as fluvial channels or marine incursion. Differing environments of deposition and subsequent decay and decomposition of plant material can also result in differing lithotypes and banding within seams. Jointing in deformed coals?

Ore Controls: Limits of sedimentary basins; deformation subsequent to coalification; faults in basement; local structure and differential compaction of coal seams may influence location of depocentres.

Examples:

Gippsland Basin, Australia, Victoria. (Barton et al 1992)
Sydney Basin, Australia, New South Wales. (Bracket 1989)
Bowen Basin, Australia, Queensland. (O'Brien 1989)

Known Deposits and Mineral Prospects in the Central Highlands

Within the south east corner of the Central Highlands area lies a small section of the Gippsland Basin which contains massive resources of brown coal of Eocene to Miocene age. The Gippsland basin first developed as a rift basin during the Early Cretaceous. Rifting related to the separation of Antarctica from Australia recommenced during the Late Cretaceous initiating a long period of relatively stable and continuous subsidence which led to the deposition of large sedimentary sequences including thick coal seems.

The boundary of the Central Highlands region cuts through the Moe Swamp Basin, a sub-basin of the Gippsland Basin. Limits of the Moe Swamp Basin are the Yallourn Monocline in the east, the Darnum Monocline in the west and the Yarragon Monocline in the south. The northern edge of the basin is represented by Tertiary cover wedging out against a southward dipping Paleozoic basement.

The host of the major coal seems in the basin is the Yarragon Formation which contains interbedded sands, clays and coal. Two major brown coal seems of 5-15m and 25-36m thickness respectively, as well as several very thin seams, are present within the Yarragon Formation near the township of Moe. The thickness of coal sequences of economic interest is largely controlled by the upthrown edge of the Moe Monocline in the east and a similar structure near Yarragon in the west of the basin. Reserves of brown coal in the Yarragon Formation for the Moe coalfield are 104 million tonnes (Gloe 1979) which mostly lie within the area. Reserves in the Yarragon Formation near the township of Yarragon are 137 million tonnes (Gloe 1979) which lie in the buffer zone.

Thin coal seams are found interbedded within sands, clays and volcanics in the eastern part of the Moe Swamp Basin within the Thorpdale Volcanics, which underlies the Yarragon Formation. Similarly thin interbeds of coal, gravel, sand and clay are found in the Childers formation which underlies the Thorpdale Volcanics.

Only the two major coal seams within the Yarragon Formation are considered to be of economic importance. These two seems and the thinner beds in the Thorpdale Volcanics are correlated with the Yallourn and Morwell seams of the Latrobe Valley respectively. The Yallourn and Morwell seams are massive, well defined deposits of coal which support large mining operations just outside the Central Highlands area, within the buffer zone.

Lying just to the southwest of the Central Highlands area within the buffer zone is part of the Western Port Basin which contains thin coal seems within the Older Volcanics and the Baxter Formation.

Assessment Criteria

1. Presence of the coal bearing formations.
2. Evidence for coal at depth, either drill or boreholes or evidence from gravity surveys.
3. Proximity of known coal deposits.

Assessment: Tract Coal/H/B

The tract has been delineated by the boundary of the Moe Swamp Basin, of which approximately two thirds lies within the area, and the Latrobe Valley Depression which lies just outside the area. It contains large areas of Late Tertiary and Quaternary sediments which overly extensive coal seems.

Known resources for the Moe Swamp basin are very large. Drilling has confirmed the presence of the coal seems at depth within the Yarragon Formation over a wide area with resources of economic interest identified at both the Moe Monocline in the east and at Yarragon in the west. It is possible that structures at depth that are not recognised at the surface, such as the Moe Monocline, could cause thickening of the coal seems which would improve their economic viability.

Lying largely within the buffer zone and bordering the Moe Swamp Basin, the Latrobe Valley Depression is known to contain over 150, 000 M tonnes of coal . Due to the presence of the large, economic coal bodies the geology and form of coal deposits of is extremely well known.

The correlation of the coal seems in the Moe Swamp basin with the Yallourn and Morwell seems of the Latrobe Valley Depression indicates that they had a similar depositional environment. It is thought that peat forming swamps of the Moe and Latrobe Valley Depressions formed in structural depressions inland of coastal barrier systems. Lakes are thought to have surrounded and intertongued with the peat swamps forming a buffer which prevented the influx of oxygenated waters and sediments into the swamps. The prolonged, relatively stable subsidence of the Gippsland basin allowed the massive vertical accumulation of peat material over long periods of time.

Given the detailed information above a high potential for coal deposits with a certainty level of C is indicated for the tract.

Within the buffer zone to the southwest of the area lies Western Port Basin. The basin developed at the same time and under a similar tectonic regime to the Gippsland basin. The form of the Tertiary sequences within the basin at depth is very complex. However in outcrops thin seems of coal are present indicating that conditions conducive to coal formation were present at some stages of the basin's development.

Given the available information on the Western Port Basin the potential for coal deposits in high with a certainty level of B.

Economic Significance

Brown coal from Victoria is dominantly used for the state's electricity generation. Briquettes are also produced for industrial and domestic use.

Bxt: LATERITIC TYPE BAUXITE DEPOSITS (MODEL 38B BY COX AND SINGER, 1986)
Model Description

Description after Sam H. Patterson

Approximate Synonym: Aluminium ore (Patterson, 1967).

***Description*:** Weathered residual material in subsoil formed on any rock containing aluminium.

General Reference:: Patterson (1984).

Geological Environment:

Rock Types: Weathered rock formed on aluminous silicate rocks.

Textures: Pisolitic, massive, nodular, earthy.

Age Range: Mainly Cainozoic, one Cretaceous deposit known.

Depositional Environment: Surficial weathering on well-drained plateaus in regions with warm to hot and wet climates. Locally deposits in poorly drained areas low in Fe due to its removal by organic complexing.

Tectonic Setting(s): Typically occurs on plateaus in tectonically stable areas.

Associated Deposit Types: Overlain by thin "A" horizon soil, underlain by saprolite (parent rock in intermediate stages of weathering).

Deposit Description:

Mineralogy: Mainly gibbsite and mixture of gibbsite and boehmite; gangue minerals hematite, goethite, anatase, locally quartz

Texture/Structure: Pisolitic, massive, earthy, nodular.

Alteration: Aluminous rocks are altered by weathering to bauxite.

Ore Controls: Thoroughly weathered rock, commonly erosional boundaries of old plateau remnants.

Weathering: Intensive weathering required to form bauxite. Bauxite continues to form in present weathering environment in most deposits.

Geochemical Signature: Al, Ga.

Geophysical Signature:

Examples:

Weipa, Australia, Queensland. Schapp (1990)

Assessment Criteria

1. Distribution of basalts and dolerites.
2. Distribution of Tertiary weathering profiles.
3. Distribution of Tertiary grabens

Tract: Bxt/L/C

The tract is delineated based on the distribution of Tertiary volcanics which include tholeiitic and minor alkaline basalts. Deep weathering of these can produce bauxite deposits. Based on the available information the potential of bauxite deposits is assessed to be low with a certainty level of C

Economic Significance

Deep weathering of Lower Tertiary Older Volcanics near Boolara and in the Mirboo North area have the potential to produce bauxite deposits. The relatively small resource of bauxite known in the area is currently used to make cement and only limited remaining resources are known to be still available.

Ls: LIMESTONE
Model Description
Description of the model after D. Hora (1992).

Approximate Synonyms: Lime rock, 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 ($CaMg(CO_3)_2$). 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, eg. Nullarbor Limestone of W.A and S.A; Tertiary Batesford Limestone and Gambier Limestone of Victoria and S.A.

Known deposits
Lilydale (about 35km east of Melbourne)
Boola Quarry (north of Tyers), just outside the southeast corner of the Central Highlands.
Coopers Creek (Evans Quarry), eastern edge of the Central Highlands.
Mansfield (Howes Creek), to the northeast of the Central Highlands.
Toongabbie (Marble Creek) and Licola (Serpentine Creek) occurrences, both to the east of the Central Highlands.

Assessment Criteria:
Presence of Silurian-Devonian marine sedimentary rocks.

Assessment: Tract Lst/L-M/C
Silurian-Devonian sedimentary rocks, which may contain limestones, are present throughout the Darraweit Guim and Mount Easton Geological Provinces (McHaffie & Buckley 1995), which include the Central Highlands. The Lilydale limestone deposit (35km east of Melbourne) contains some dolomitic horizons.

Known deposits occur in Siluro-Devonian undifferentiated marine sediments and Lower Devonian marine sediments along, and just outside, the eastern boundary of the Central Highlands and it is the presence of these sediments throughout the Central Highlands that delineates the tracts.

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, in this case mainly Melbourne, is also an important factor in the viability of a limestone/dolomitic limestone deposit, as transport makes up a substantial proportion of product costs. Although the Lilydale deposit has sufficient resources for the medium to long term for a number of uses, the distance factor will have to be overcome to source limestone/dolomitic limestone from the more distant deposits at the southeast corner and northeast margin of the Central Highlands. Limestone extraction recently commenced from the Boola Quarry (north of Tyers), just outside the southeast corner of the Central Highlands, for lime production in Traralgon (130km east of Melbourne on the southern boundary of the Central Highlands).

KAO: KAOLIN
Model Description
Description of the model after Hora D (1992).

Synonyms: Primary kaolin, secondary kaolin.

General References: Harben and Bates (1990); Hora (1992); Lefond (1985)

Geological environment:
Rock types: Kaolinized feldspathic rocks, like 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: Fire clay, 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: Weipa, Australia, Queensland
Pittong, Australia, Victoria
Lang Bay, Sumas Mountain, British Columbia, Canada
Germany
Czechoslovakia.

Known deposits
Primary deposits are known on weathered granodiorite at Hallam (35km southeast of Melbourne on the southern boundary of the Central Highlands) and kaolinised granodiorite near Bulla (25km NW of Melbourne, just to the west of the Central Highlands) is a past producer.

Secondary kaolinitic clay deposits are known below the mid-Tertiary age Morwell No 1 brown coal seam in the Morwell open cut mine and at nearby Yallourn under the brown coal open cut (both just to the southeast of the Central Highlands). Campbellfield (15km north of Melbourne, on the western boundary of the Central Highlands) was a significant past producer of secondary quartz-kaolinite-mica clay preserved beneath basalt in a former river channel cut through white, bleached Silurian shale.

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 brown coal basins.
5. Presence of known occurrences.

Assessment: Tract Kao/M-H/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.

The tract is considered to have a moderate to high potential for kaolin deposits 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.

Victorian production of kaolin has averaged 145,000 tonnes/year (McHaffie & Buckley 1995).

CONMAT: CONSTRUCTION MATERIALS AND DIMENSION STONE

Hard rock: The main types of rock used are basalt, granite, acid volcanics, hornfels, schist and sedimentary rock. Colluvial deposits (scree) and softer rocks such as sandstone, shale, schist, scoria and tuff are also extracted.

Construction sand: Found in Tertiary age floodplain and piedmont fluvial deposits and smaller Quaternary equivalents. Significant dune sand deposits of Quaternary age occur to the south of the Central Highlands.

Clay and clay shale: Deep weathering (up to 30 metres around Melbourne) in late Cretaceous, early to mid Tertiary times under hot, humid conditions formed significant residual clay deposits on Paleozoic rocks. Erosion of the Cretaceous/Tertiary clays formed alluvial clay deposits at intervals during the rest of Tertiary and into the Quaternary age.

Known deposits

Hard rock:

Basalt from:
Kilmore East (55km north of Melbourne)
Harkaway (40km southeast of Melbourne)
Packenham (40km southeast of Melbourne)
Neerim (85km east of Melbourne)
Latrobe Valley (50km east of Melbourne)
Acid volcanics from the Dandenongs Igneous Complex 30km east of Melbourne.
Hornfels from:
Greenvale (25km north of Melbourne)
Morang (25km northeast of Melbourne)
Lysterfield (50km southeast of Melbourne)
Castella (55km northeast of Melbourne).
Granitic rocks from:
Greenvale and Lysterfield areas
Tynong North and Garfield North (both 70km southeast of Melbourne).

Construction Sand:

Heatherton-Dingley, 20km southeast of Melbourne just south of the Central Highlands.
Cranbourne-Langwarrin, 50km southeast of Melbourne and south of the Central Highlands.
Trafalgar, 110km E of Melbourne on the south boundary of the Central Highlands.
Latrobe Valley, in the southeast corner of the Central Highlands.

Clay and clay shale:

Hallam, 35km southeast of Melbourne on the southern boundary of the Central Highlands.
Cranbourne, 50km southeast of Melbourne and south of the Central Highlands.
Drouin, 85km southeast of Melbourne on the southern boundary of the Central Highlands.
Campbellfield, 15km north of Melbourne on the west Central Highlands boundary.

Assessment Criteria:

1. Presence of soft or weathered rock.
2. Presence of Tertiary and Quaternary soil and sediments.
3. Presence of granite, basalt, acid to intermediate volcanics, and hornfels.

Assessment: Tract Conmat1a/H/B

Most of the Central Highlands rock types have high potential for lower grade/value construction materials in their fresh or weathered state; and soil, sand and gravel are widespread across the Central Highlands. Suitable materials are mainly used for secondary road building and include:

(1) rippable sandstone, shale, schist and other rock
(2) volcanic scoria and tuff
(3) sand and gravel
(4) soil and calcrete

This tract has high potential for lower value construction materials deposits, with a certainty level of B.

Assessment: Tract Conmat1b/M-H/B
The potential for economic deposits of higher value construction materials in the Central Highlands, are delineated by areas of granite, basalt, acid to intermediate volcanics, and hornfels rocks which provide potential for crushed hard rock. Basalt and granitic rock areas have potential for dimension stone, depending on the availability of high quality material within a particular rock body. Potential for suitable bodies of construction sand, clay and clay shale lie within Tertiary and Quaternary age sediments.

Areas of special interest for possible future hard rock and sand construction materials extraction delineated by McHaffie & Buckley (1995) are shown in Figure 3. Hard rock resources are sufficient to supply the Melbourne area for 25 years (McHaffie 1991, in McHaffie & Buckley 1995). Resources of red firing clays are sufficient for at least 20 years but white firing types will require the development of more distant resources to the south-east of Melbourne. Melbourne roof tile makers have a sound resource base for the long term (McHaffie & Buckley 1995).

The tract is considered to have a moderate to high potential for higher value construction materials with a certainty level of B. This tract also has high potential for lower value construction materials deposits (Conmat1a), with a certainty level of B.

Economic Significance:
Construction materials, 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, paving, water reticulation and many other uses which are the an integral part of modern living.

Hard rock is quarried from a number of sites around Melbourne then crushed or broken for use in road aggregate, concrete, railway ballast and other uses. Other land uses now severely constrain the development of new hard rock quarries in within 60km of Melbourne (McHaffie & Buckley 1995). Total hard rock resources are sufficient to supply the Melbourne area for 25 years (McHaffie 1991, in McHaffie & Buckley 1995).

Construction sand is commonly used in concrete, mortar, plaster, road base and asphalt mixes. Special uses include glass and fibreglass manufacture, metal casting moulds, sand blasting and filtering media. Sand production in 1992/93 from Heatherton-Dingley and Cranbourne-Langwarrin decreased to just over 2 million tonnes from levels of 3 to 4 million tonnes annually in previous years.

Large resources of coastal dune sands exist to the south of the Central Highlands but their finer and more uniform grainsize means their use is restricted.

Clay and clay shale: are used in large quantities to make bricks, pipes and roofing tiles. Mottled kaolinitic/illitic clays lying above more pure kaolinitic clays in the Melbourne area (Figure 3) are particularly suitable for bricks.

DIAMOND
There are no known diamond deposits within the Central Highlands.

However, if Cambrian volcanics and greenstones are related to subduction tectonics there may be some possibility of a diamondiferous igneous rock intrusion being preserved in these rocks, consistent with the model proposed by Barron and others (1994) for the origin of the Copeton-Bingara alluvial diamonds in northeast New South Wales. Even though such Cambrian rocks outcrop in a small area just to the east of the Central Highlands they are probably buried at considerable depth beneath Ordovician to Devonian rocks within the rest of the Central Highlands (VandenBerg and others 1988). Hence the potential for diamond in the region is unknown.

PHOSPHATE
Phosphate rich deposits, or phosphorites, form on continental shelves in regions of upwelling ocean water, usually within 40 degrees latitude of the (paleo) equator and are generally closely associated with limestones or organic rich sediments. No phosphate occurrences have been found within the Central Highlands area. Phosphate occurrences are located just outside the area within Ordovician and Devonian sediments of the Melbourne Trough. These are not even marginal in terms of their economic viability.

Very small amounts of Ordovician and large areas of Devonian marine sedimentary sequences equivalent to those that host the phosphate deposits just outside the area are also present within the region. Other large areas of possible shelf sedimentary sequences also occur in the region. However no phosphate occurrences have been reported in the region. The potential for phosphorite deposits in the region is considered to be unknown.

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

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: Central Highlands, Victoria

Spatial Domain

North Bounding Coordinate: -35.45
East Bounding Coordinate: 147.0
South Bounding Coordinate: -39.12
West Bounding Coordinate: 144.0
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 2145, MDC, Fitzroy Vic 3065
City: Fitzroy
State: Victoria
Contact Phone: 03 9412 7871
Contact Fax: 03 9412 7803
Contact Email: osheap@wizza.agvic.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: Data is Crown Copyright

Dataset Quality

Lineage Summary: Derived from 1: 250 000 scale geological maps
Scale: 250 000
Resolution: 250
Cell Size:
Positional Accuracy: $\pm$ 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: buckleyr@wizza.agvic.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

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 Sceince
City: Canberra
State: ACT
Contact Phone: 06 272 4433
Contact Fax: 06 272 4161
Contact Email: BGE@mailpc.brs.gov.au

Dataset Currency and Status

Beginning Date: 1989
Ending Date: '19--'
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: 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: Crosschecking 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 the Central Highlands is mostly 1970s era BMR data. Several datasets were used, including the Melbourne, Warburton, Warragul, Aberfeldy - Walhalla & Mt Wellington datasets.

Contents:

Citation Information

Data Set Title: Central Highlands magnetic data
Data Set Short Title:
Jurisdiction: Victoria
Custodian: Department of Natural Resources and Environment, Minerals and Petroleum Victoria
Publication Date: MELBOURNE - 1983; WARRAGUL - 1984, WARBURTON - 1977, MT WELLINGTON - 1993, ABERFELDY - WALHALLA 1985
Acknowledgements:
References:

Dataset Description

Abstract: Magnetic data over the Central Highlands is a mosaic of several airborne surveys, mostly BMR data collected in 1977 - 1984, as well as the small Mt Wellington and Aberfeldy - Walhalla surveys, south of Jamieson towards Walhalla.
Search Words: Minerals, Geophysics
Location Description: Central Highlands, Victoria

Spatial Domain

North Bounding Coordinate: -37.0
East Bounding Coordinate: 147.0
South Bounding Coordinate: -38.75
West Bounding Coordinate: 144.0
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 2145, MDC Fitzroy, Vic 3065
City: Melbourne
State: Victoria
Contact Phone: (03) 9412 7862
Contact Fax: (03) 9412 7803
Contact Email: willocksa@wizza.agvic.gov.au

Dataset Currency and Status

Beginning Date: MELBOURNE -1983
WARBURTON - 1977
WARRAGUL - 1984
MT WELLINGTON - 1993
ABERFELDY - WALHALLA - 1985
Ending Date: As above
Progress: All complete.
Maintenance and Update Frequency: Northern part of MELBOURNE sheet being resurveyed in more detail in 1997.

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, Transparence
Native Data Format: none
Access Constraints: Crown copyright reserved

Dataset Quality

Lineage Summary:
Scale: MELBOURNE -Line spacing 1500m, height 150m
WARBURTON - Line spacing 1500m, height 1800m
WARRAGUL - Line spacing 1500m, height 150m
MT WELLINGTON - Line spacing 200m, height 100m
ABERFELDY - WALHALLA - Line spacing 250m, height 90m

Metadata Contact Information

Metadata Date: 21011997
Metadata Contact Person: Alan Willocks, Manager Geophysics
Metadata Contact Organisation: Department of Natural Resources and Environment, Minerals and Petroleum,Victoria.
Metadata Contact Email: willocksa@wizza.agvic.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

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: Central Highlands, Victoria

Spatial Domain

North Bounding Coordinate: -37.0
East Bounding Coordinate: 147.0
South Bounding Coordinate: -38.45
West Bounding Coordinate: 144.0
Bounding Polygon:
Attribute List: see later

Contact Information

Contact Organisation: Department of Natural Resources and the Environment
Contact Position: Manager, GEDIS
Contact Person: Brian Wright
Contact Address: PO Box 2145, MOC, Fitzroy 3065

City: Fitzroy
State: Victoria
Contact Phone: 03 9412 7911
Contact Fax: 03 9412 7442
Contact Email: wrightb@wizza.agvic.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: Crown copyright reserved

Dataset Quality

Lineage Summary: Sourced from accurate topographic maps
Scale: 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: Brian Wright/Roger Buckley
Metadata Contact Organisation: Minerals and Petroleum Victoria
Metadata Contact Email: wrightb@wizza.agvic.you.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.	RegionThe 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 theDepartment. Exploration expenditure figures in square brackets ([]) indicate expenditure was jointly reported with several Exploration Licences not listed.
CONFID:	appears where the details fo 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 fo 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

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 provider information on location, geology, production and resources of mines, prospects and mineral occurrences in Victoria.
Search Words: Minerals, Mineral Deposits
Location Description: Central Highlands, Victoria

Spatial Domain

North Bounding Coordinate: -37.0
East Bounding Coordinate: 147.0
South Bounding Coordinate: -38.45
West Bounding Coordinate: 144.0
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 2145, MDC

City: Fitzroy 3065
State: Victoria
Contact Phone: 03 9412 7935
Contact Fax: 03 9412 7803
Contact Email: buckleyr@wizza.agvic.gov.au

Dataset Currency and Status

Beginning Date: 1990
Ending Date: 1996
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: Crown copyright

Dataset Quality

Lineage Summary: Data derived from literature with minor field checks.
Scale: 25 000 to 1 000 000
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: buckleyr@wizza.agvic.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 mapsheet 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. 9412-7935fax 9412-7935
email buckleyr@wizza.agvic.gov.au

Figure 2: Land tenure and exploration licenses