Assessment of Mineral Resources in the Upper North East CRA Study Area

A project undertaken as part of the NSW Comprehensive Regional Assessments

November 1999

ASSESSMENT OF MINERAL RESOURCES IN THE UPPER NORTH EAST CRA STUDY AREA

GEOLOGICAL SURVEY OF NSW
DEPARTMENT OF MINERAL RESOURCES

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

A project undertaken for
the Joint Commonwealth NSW Regional Forest Agreement Steering Committee
as part of the
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PROJECT SUMMARY

This report describes a project undertaken as part of the comprehensive regional assessments of forests in New South Wales. The comprehensive regional assessments (CRAs) provide the scientific basis on which the State and Commonwealth Governments will sign regional forest agreements (RFAs) for major forest areas of New South Wales. These agreements will determine the future of these forests, providing a balance between conservation and ecologically sustainable use of forest resources.

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

The assessment of the mineral resource potential was conducted for the whole of the Upper North East region and is based on data and recent geological reports provided by the NSW Department of Mineral Resources (DMR). Professional staff of the Australian Geological Survey Organisation (AGSO), the Geological Survey of NSW (a division of DMR) collaborated in the preparation of the assessment.

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

In this study mineral potential tracts were identified for 29 deposit types including seventeen types of metallic mineral deposits (which included different styles of gold, silver, base metal, tungsten, and tin deposition), for coal, coal seam methane, hydrocarbons (petroleum and gas), limestone, mineral sands, alluvial gemstones, and construction materials. The tracts were then combined to present a weighted composite mineral potential of the region. This result provides some perspective to the relative economic significance between different types of mineral deposits (an area with high potential for gold mineralisation would rate higher than an area with high potential for tungsten, given the relative market prices of the two commodities).

1. INTRODUCTION

Known mineral resources and potential (undiscovered) mineral resources have been assessed as part of the Comprehensive Regional Assessment (CRA) of the forest areas in the Upper North East region in New South Wales. This region is referred to in this report as the Upper North East region, UNER, or 'the region'.

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

The DMR has prepared numerous reports and publications which describe the geology and mineral resources of the UNER. The major Departmental reports and publications include Scheibner and Basden (1996), Barnes and Willis (1989), Flood, Kovarch and Moore (1994), Stroud et al. (1996), Brown and Stroud (1997), Brown, Brownlow and Krynen (1992), Gilligan et al. (1992), Barnes, Henley and Henley (1995), Henley and Barnes (1992), Brown (1995), and, Henley and Brown (1998).

Geological and tectonic interpretations of the New England Orogen abound with major collections of papers available in conference and synthesis volumes such as Flood and Runnegar (1982), Kleeman (1988), Flood and Aitchison (1993) and Ashley and Flood (1997).

Several hundred published papers and volumes relate to the mineral resources of the UNER. Reference to these can be found in the review reports listed above and through other bibliographic avenues. Review papers on mineralisation include Barnes et al. (1988), Gilligan and Barnes (1990) and Suppel, Barnes and Scheibner (1998).

In addition, there are in excess of one thousand company reports on the results of mineral exploration in the region. These reports are indexed and stored by the DMR and can be accessed through the Department's computerised information systems.

Prior to the assessment of mineral resources, the DMR assembled a comprehensive digital data set containing the best available geoscientific and support data for the region. Assembled data on which the mineral resource assessment is based include:

- a mineral occurrence database for the region with best available information to December 1997
- a seamless coverage of geology of the region at 1:250 000 scale equivalent,
- magnetics and landsat images
- digital elevation images shaded to emphasise geological structure
- stream sediment geochemical data over much of the region

It is important to note that most of the UNER has not been subjected to a regional coverage of detailed high resolution airborne geophysical surveys; such surveys would generate new data and allow major improvements in understanding of the geology and mineral deposition in the region. Appendix G contains data documentation information for mineral occurrence locations, geological and airborne geophysical data, and for mining tenements.

2. ADMINISTRATION OF MINING AND EXPLORATION TITLES

2.1 MINERAL EXPLORATION AND MINING

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

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

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

2.1.1 Exploration Licences

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

2.1.2 Assessment Leases

The *Assessment Lease* is a relatively new tenure for New South Wales having been introduced by the Mining Act 1992. The purpose of this tenure is to enable detailed evaluation of mineral deposits to be carried out after the normal period of exploration but where, for some special reasons, the project is not ready to be applied for under Mining Lease. Such reasons can be of an economic nature e.g. the deposit found is not presently economic to develop, or could be practical reasons such as a need to develop specific processing methods to extract a particular mineral from the host rock. There is no maximum size for an assessment lease; size and dimensions of areas being such as are necessary and appropriate. These titles can be granted for a period of five years and renewed for a further period of five years. Similar conditions on expenditure, reporting of progress and security are required as in exploration licences. Where access to lands is required appropriate access arrangements and consents must be obtained.

2.1.3 Mining Leases

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

2.1.4 Compliance with Other Legislation

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

In granting mining leases, the views of all appropriate Government departments and authorities are obtained and appropriate conditions to meet respective requirements are formulated for inclusion in the lease documents. Records of all titles and applications for titles under the Mining Act are kept by the Department of Mineral Resources as required by the Act.

2.2 CONSTRUCTION MATERIAL EXTRACTION

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

Where construction materials are present on private land, they may be extracted by the land owner, or by anyone having an agreement with the land owner, after obtaining development consent from the local Council or other relevant consent authority.

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

3. GEOLOGICAL SETTING

3.1 INTRODUCTION

The Upper North East Region (UNER) has a complex geological history extending from about 600 million years ago to the present. Rocks in the region have been brought together from sites of deposition as far away as sub-Antarctic areas. The region has undergone massive upheavals and some rock sequences which now abut were formed in different parts of the globe in settings ranging from volcanic island arcs to swampy basins. The area has been relatively stable as part of the Australian continent since about 200 million years ago but there have been periods of considerable volcanic activity most recently about 40-15 million years ago. Large parts of the region are now in an active erosional cycle but deposition of new sediments is occurring in many coastal lake and river systems.

The UNER covers rocks of the New England Orogen (or New England fold belt), the Clarence-Moreton Basin and associated sub-basins, and younger rocks of Tertiary and Quaternary age which overlie these major provinces. The New England Orogen is a major geological zone which extends from the Newcastle area north to Far North Queensland. The Orogen comprises many rocks which formed in highly active geological regions where sediments from the deep ocean were being subducted and thrust into the Australian land mass at that time. They were mixing with sediments formed from the eroding mountains and volcanoes which existed on the margins of the continent. The Orogen has a complex structural history and the sedimentary rocks are generally folded and regionally metamorphosed. The Orogen includes a major plutonic province and there are numerous intrusive units, generally felsic in character, as well as extrusive volcanic rocks of similar age and composition.

In the northeastern part of the UNER the Orogen rocks are overlain by relatively flat-lying sediments of the Clarence-Moreton Basin (C-MB) and underlying sub-basins. This major basin formed after the crust had stabilised. This basin covers the New England Orogen rocks completely just north of the Region and sedimentary units can be traced across to the west to join with units comprising the vast sedimentary basins of central Australia.

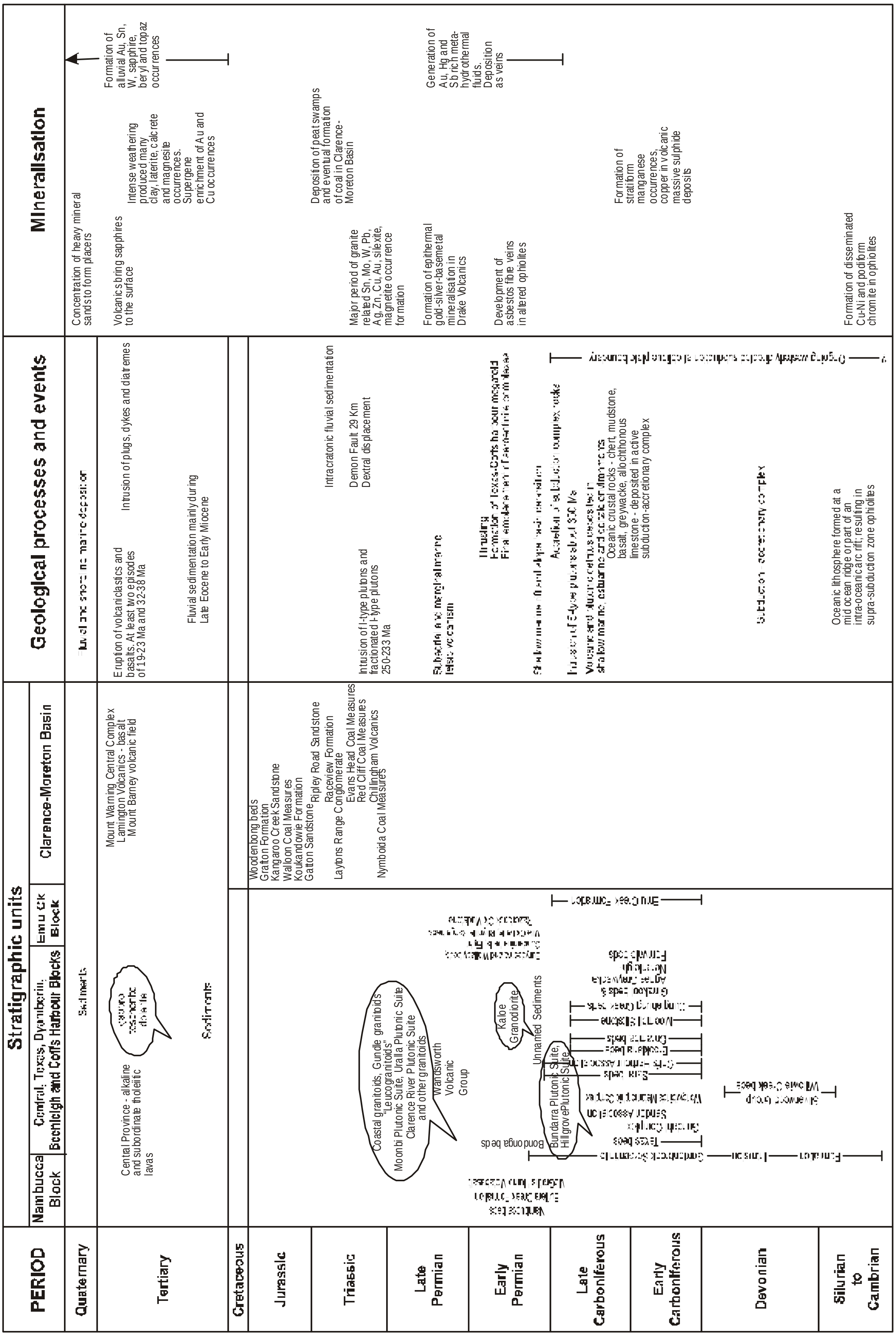
During the Tertiary Epoch basaltic volcanism occurred along eastern Australia and was related to the formation of the Tasman Sea. Remnants of very large continental basaltic shield volcanoes are present in the Region, the major one being the Tweed volcano centred at Mount Warning. There has been substantial erosion throughout the region since these volcanoes formed.

Erosion has produced a major escarpment which extends through the UNER. Huge gorge systems have developed and the material removed has been deposited in coastal regions in rivers and lakes and out to sea.

In order to describe the geological setting, a series of geological systems will be briefly described. These generally correspond with particular geological time intervals. The major geological systems and their important geological units are shown in Table 1 and a time space plot is shown in Text Diagram 1.

TABLE 1. MAJOR GEOLOGICAL SYSTEMS PRESENT IN THE UPPER NORTH EAST REGION

Geological system	Brief description
Recent	Deposits along present day streams, coast and inlets
Quaternary sediments	Coastal sediments, estuarine sediments, deposits along major and minor rivers
Tertiary volcanism	Major basaltic shield volcanoes now largely eroded
Tertiary sediments	Remnants of Tertiary land surface, commonly preserved beneath basalts
Clarence-Moreton basin (Late Triassic - Cretaceous)	Large complex intracontinental sedimentary basin
Surat basin	Largely to the west of the UNER, stratigraphically equivalent to the Clarence-Moreton basin
Warialda trough	To the west of the UNER
Gunnedah basin	West of the UNER
Late Permian volcanism	Extensive sub-aerial explosive volcanism, Wandsworth Volcanic Group and equivalents
New England batholith (Late Carboniferous - Early Triassic)	
Coastal belt (Triassic)	Triassic granitoids along the coast
Gundle belt (Triassic)	Triassic granitoids in the fall country
Leucogranitoids (Late Permian-Triassic)	Highly fractionated granitoids of undetermined I-type suites - highly mineralised
Moonbi Plutonic Suite (Late Permian-Triassic)	High K granitoids, highly fractionated members classed as leucogranitoids
Clarence River Plutonic Suite (Late Permian-Triassic)	Primitive high-Ca granitoids
Uralla Plutonic Suite (Late Permian)	Mixed I -S - type granitoids
High K granitoids (Permian?)	
Bundarra Plutonic Suite (Early Permian)	S-type largely undeformed leucocratic granitoids
Hillgrove Plutonic Suite (Late Carboniferous)	S-type, foliated
Hillgrove associated (Late Carboniferous)	S-type, foliated
Undetermined plutonic	Various undifferentiated, generally Permian to Triassic intrusives
Permian basins	Early - middle Permian conglomeratic wedges in older accretionary prism rocks
Permian sediments	Relatively undeformed sediments pre-dating Late Permian volcanism and plutonism
Nambucca block (Early Permian)	Early Permian. Structural block with sediments showing a distinct metamorphic and structural history, possibly an allochthonous terrain. Includes some metabasalts
Accretionary complex (Late Carboniferous and older)	Includes many complexly deformed and structurally dismembered oceanic rock sequences comprising fine mudstones, siltstones and cherts but also sedimentary wedges of continental derivation.
Emu Creek block (Late Carboniferous)	Relatively undeformed sediments with substantial volcanic component
Hastings block (pre Late Permian)	Tamworth belt equivalent rocks in the Hastings area
Tamworth belt (pre Late Permian - Devonian)	Forearc(?) sediments and volcanics, only gently folded, block faulted
Serpentinite (Latest activation, ?Permian)	Represented by the Gordonbrook Serpentinite belt in the UNER and the Great Serpentinite belt adjacent to the Peel Fault in the west



Text Diagram 1: Time-Space Plot for UNE CRA.

3.2 PRE LATE PERMIAN SEDIMENTARY & VOLCANIC SEQUENCES

The oldest rocks in the UNER are probably those of the Silverwood association, a group of rocks represented by a small area of sediments and volcanics in southern Queensland by the Silverwood Group and by the Willowie Creek beds north west of Jackadgery in the Region.

The Willowie Creek beds are Silurian or Devonian in age while the Silverwood Group rocks are considered to be Devonian in age. They are diverse in character, comprising andesitic and basaltic rocks along with fine to medium - grained lithic sediments. They appear to represent the remains of an island arc sequence. These rocks may be related to the island arc-related rocks of the Tamworth belt in the western part of the New England fold belt

Fine - grained sediments of Late Carboniferous age which have been deformed and subject to low grade regional metamorphism form an extensive terrane in the western parts of the UNER. The rocks appear to have formed on a continental slope or trench along a convergent plate boundary. Lithologies include fine grained oceanic mudstones, cherts, and siltstone, with some metabasalt (greenstone). The main units are the Texas beds, Neranleigh-Fernvale beds, Coffs Harbour association beds, Sandon beds and their equivalents and the Gundahl Complex. In most areas, the rocks have been subject to low grade regional metamorphism. However, in places, rocks which have been subject to high pressure regional metamorphism have been brought to the surface in small fault-bounded blocks, for example, rocks of the Wongwibinda Metamorphic Complex.

All of these rocks have been subject to considerable deformation. They show extensive internal folding and are commonly boudinaged such that it is often impossible to trace individual marker units for more than a few tens of metres.

Within the Carboniferous sequences are several small, fault-bounded basins of Early Permian sediments. These are less deformed and commonly contain continental debris. In places, metabasalt is present. Examples of these rocks include the Bondonga beds north of Torrington. Several lenses of limestone are also present.

3.3 EMU CREEK BLOCK

The Emu Creek Block is a restricted area of relatively undeformed sediments and volcanics lying to the north east of the Late Permian Drake Volcanics. These rocks are Early to Late Carboniferous in age and comprise a western unit with sandstone, siltstone and prominent conglomerate beds deposited in a shallow marine environment and an eastern unit of thick bedded sandstone, laminated to massive siltstone and conglomerate deposited in shallow marine, estuarine and deltaic environments. Both units include material derived from volcanic sources.

The Emu Creek Block does not show the intense deformation characteristic of the accretionary complex rocks of similar age and appears to have undergone a distinctly different depositional and tectonic history in the pre Late Permian.

3.4 SERPENTINITE

The Gordonbrook Serpentinite belt, on the western margin of the Clarence Moreton basin, is a dismembered ophiolite suite which has been serpentinised and intruded along a major terrane boundary. The unit is composed of serpentinised peridotites (mainly dunite and harzburgite) and pyroxenites This is a piece of highly altered oceanic crust that has been squeezed from great depths as the rocks expanded during hydration. Other serpentinite units in the New England region are all situated along major and probably deep crustal fractures and this unit is probably similarly situated although almost all structural boundaries are obscured by later intrusions and overlying sediments.

The age of the serpentinite is uncertain. The rocks are possibly as old as Devonian or Silurian or older when originally formed although their intrusion as serpentinites probably occurred during the Permian.

The Gordonbrook Serpentinite belt is overlain by the Late Permian Drake Volcanics and Mesozoic sediments of the Clarence Moreton basin. It is also intruded by Clarence River Suite plutonic rocks (see below).

3.5 LATE CARBONIFEROUS INTRUSIVES

The accretionary complex rocks of the Tablelands Complex were intruded by siliceous S-type granites during the Late Carboniferous. S-type granites have geochemical characteristics which suggest that they formed from the partial melting of relatively mature sediments. As a result they are distinctive aluminium rich compared to I-type granites (see below).

The Tablelands Complex rocks have been intruded by two S-type granite suites, the Bundarra Plutonic suite occurring at the western extremity of the UNER and the Hillgrove Plutonic suite and related rocks.

The Hillgrove Plutonic suite rocks comprise mainly foliated biotite monzogranites containing accessory garnet. They were intruded before regional deformation had ceased and as a result they show prominent internal foliations and some bodies are very elongate and fault bounded. The Hillgrove Plutonic suite rocks do not appear to have produced significant mineralisation. However, the rocks have been the passive hosts for substantial amounts of later vein-style mineralisation, especially in the Kookabookra - Bear Hill gold field and in the Rockvale area just south of the UNER.

The slightly younger (Early Permian) Bundarra Plutonic suite rocks typically comprise coarse - grained biotite -(cordierite) -(garnet) muscovite granite with abundant K-feldspar megacrysts. There are only a few mineral deposits associated with the Bundarra Plutonic suite to the south east of the UNER. The suite does not appear to show significant fractionation.

3.6 NAMBUCCA BLOCK

Immediately south of the UNER and present in restricted areas near the southern margin of the region are regionally metamorphosed and highly deformed metasedimentary rocks of the Nambucca Block. These rocks appear to have undergone a different tectonic and metamorphic history to the other sedimentary and volcanic rocks described above. They have reached a higher metamorphic grade and have been multiply deformed and now show distinctive low angle fabric in areas near the coast. The block is considered to comprise a section of crust which formed elsewhere and has been tectonically thrust against rocks of the Coffs Harbour association and the Central block (Sandon and Girrakool and other beds).

3.7 LATE PERMIAN VOLCANICS

The active tectonism and structural deformation which had occurred during and before the Early Permian was largely finished by the Late Permian. During the Late Permian to Early Triassic, the New England Orogen was probably in a mildly tensional tectonic setting and a several related thermal events produced a series of intrusive and extrusive felsic igneous rocks formed with differing chemical characteristics related mainly to source rock type and granitic fractionation.

During the Late Permian extensive explosive calc-alkaline volcanism from scattered volcanic vents produced vast sheets of ignimbritic tuffs and lavas originally covering much of the western parts of the Upper North East region. The eroded remnants of these volcanics can be found across the New England tableland from near Uralla, to north west of Inverell and to the Drake area in the north east and are collectively called the “Wandsworth Volcanic Group”. These volcanic rocks were deposited over thousands of square kilometres and were up to several kilometres thick. They were deposited mainly on land except in the Drake area where volcanics were deposited in a shallow marine setting. The most common rock types are rhyolitic to rhyodacitic in composition with few, in any, basic variants.

Few mineral deposits were related to the volcanism in terrestrial settings. However, in the Drake area, slightly more chemically primitive volcanic rocks were deposited into shallow seas and produced large hydrothermal systems in the hot volcanic pile. These hydrothermal systems caused extensive alteration of the rocks and widespread epithermal mineralisation.

3.8 LATE PERMIAN TO EARLY TRIASSIC INTRUSIVES

The Late Permian volcanics were the extrusive equivalents of large magmatic bodies which in many places cooled sub-surface to form what are now extensive areas of granitic rock. Several geochemically distinct suites of granites appear to have formed from the melting of differing types of rocks (variously volcanic rich detritus to sedimentary rocks) deep in the crust. These granite bodies formed in most instances several kilometres below surface but in places they have intruded the Late Permian volcanics suggesting that they extended close to the surface, perhaps as close as one to two kilometres in places.

The main geochemical suites recognised are called I-type granites and are derived from volcanic rich source rocks. In addition, there are several less well defined groupings of intrusives based on geochemical characteristics or spatial association. The suites and their main characteristics are listed in table 2.

TABLE 2: FEATURES OF MAJOR PLUTONIC SUITES IN NEW ENGLAND

Suite	Bundarra Plutonic Suite	Hillgrove Plutonic Suite	Uralla Plutonic Suite	Clarence River (Nundle) Plutonic Suite	Moonbi Plutonic Suite	Leucogranites ('Leucoadamellites')	Coastal belt granitoids	Gundle belt granitoids
Rock Types	Granite, monzo-granite, granodiorite	Granite, monzo-granite	Monzo-granite, minor monzonite	Granodiorite, diorite, leucogranite	Granite, monzo-granite, tonalite	Leucogranite granite, granodiorite	Granite, monzo-granite	Granite, monzo-granite, granodiorite, monzodiorite
Age	Late Carbon-iferous - Early Permian	Late Carbon-iferous - Early Permian	Middle-Late Permian	Middle-Late Permian	Middle-Late Permian	Late Permian-Early Triassic	Middle Triassic	Middle Triassic
Structure	Massive	Foliated	Massive	Massive	Massive	Massive	Massive	Massive
S- or I- type	S-type	S-type	I-S type	I-type	I-type	?I-type	I-type	I-type
Hornblende	Rare or absent	Rare or absent	Present	Present	Present	Absent - minor	Present	Present
Magnetite	Rare or absent	Rare or absent	Present	Present	Present	Rare or absent	Present	Present
Ilmenite	Present	Present	Present	Rare or absent	Rare or absent	Rare or absent		
Delta 18O	11.02-12.49	10.35-11.82	7.90-9.92	No data	7.70-9.12	6.39-9.60		
Initial 87Sr/86Sr	0.706-0.707	0.706-0.707	0.705-0.707	0.703-0.704	0.704-0.705	No data		
Other features	Cordierite-bearing, strongly S-type	Low Fe2O3/FeO, garnet-bearing		Low K2O, High CaO granitoids	Pink K-feldspar megacrysts, euhedral sphene	Granite minimum melt compositions high SiO2, high Rb/Sr		

There are numerous granitic bodies which are very silica rich and which have possibly formed by fractionation of magmas from the known, or other, suites. They have been generally called “leucogranites”. The leucogranites are not been assigned to particular suites on the basis of their geochemistry because the elements used to distinguish the suites have very low concentrations and distinction becomes difficult, if not impossible.

The plutonic suites are variably mineralised. The Clarence River plutonic suite bodies have copper, gold and magnetite skarns associated with them and minor other base metal mineralisation. This suite may be related to the mineralised Drake Volcanics.

The Uralla Plutonic suite rocks are, on the whole, poorly mineralised, although, like all granites, mineral deposits may occur near granite margins.

The Moonbi Plutonic suite rocks are variably mineralised. Mineralisation mainly comprises molybdenum and gold deposits associated with fractionated bodies or granite margins. Some of the richly mineralised leucogranites may be end members of this suite.

The leucogranites are widespread in the western parts of the Upper North East region. These rocks generally form boldly outcropping and ruggedly dissected terrains with thin, easily eroded and nutritionally poor soils. As a result they are commonly heavily forested, as opposed to many of the other suites which produce good soil and less extreme topography. This is because they weather more easily because of the higher ferromagnesian mineral content (biotite and hornblende) and feldspar content.

The leucogranites have been major mineralisers in the UNER. They have formed from either high degrees of granitic fractionation or from limited partial melting in source rock area. As a result some magmas contained extreme concentrations of elements such as tin and molybdenum. Upon crystallisation, these elements could not be accommodated in available geochemical sites in the limited number of ferromagnesian minerals in the rocks and were further concentrated into hydrothermal fluids which were progressively expelled from crystallising granites and concentrated around the granite margins where they formed mineral deposits. In a limited number of bodies, specifically the Mole Granite, Gilgai Granite, and Ruby Creek Granite/Stanthorpe Adamellite these processes led to the formation of thousands of mineral occurrences. These bodies have tungsten and tin deposits occurring in and close to the margins of the granite bodies. Base metal deposits are found surrounding the bodies at distances of up to many kilometres.

The Gundle and Coastal granitoids are relatively small in areal extent. They are amongst the youngest of the Permo-Triassic granitoids. Rock types range from granodiorites through monzonites to leucogranites. Numerous small mineral deposits are associated these bodies. The Gundle belt granitoids occur just south of the region while the Coastal belt granitoids are represented only two small bodies west of Coffs Harbour. These plutons appear to be barely unroofed which leaves open the possibility that there may be further unexposed bodies in the south eastern parts of the UNER.

3.9 MESOZOIC BASIN SEDIMENTARY SEQUENCES

By the end of the Triassic most of the major deformation and intrusive events which had culminated in the Carboniferous - Late Permian in the region were finished. In the west, a substantial mountain range was present comprising the deformed accretionary prism rocks, island arc sediments and volcanics, granites which intruded them and associated ignimbritic volcanics.

In north eastern NSW and southern Queensland an extensive intracratonic sedimentary basin developed. Called the Clarence-Moreton basin (C-MB) it is a composite of several structural basins. In NSW the basin developed in a region surrounded by mountain ranges with basin boundaries controlled by major structures. The basin appears to have formed after a period of oblique extension which ceased in the Late Triassic. Crustal cooling resulted in subsidence which in turn induced continental sedimentation. River, lake and swampy sediments developed across the basin. The carbon-rich sediments formed coal seams at several levels.

The oldest rocks exposed along the margins of the basin are the Early-Middle Triassic Nymboida Coal Measures in the south and the Chillingham Volcanics in the north east. These are unconformably overlain by the Late Triassic Ipswich Coal Measures and their equivalents in the north. These rocks are interpreted to be much more extensive in the basin sub-surface than is indicated by their limited areas of surface exposure.

The basin subsequently filled between the Early Jurassic to Early Cretaceous with a series of basin wide sedimentary sequences comprising coarse to fine grained lithic sediments with minor coals and rare basalt. The major stratigraphic units are the Bundamba Group, Walloon Coal Measures, Kangaroo Creek Sandstone and Grafton Formation. The sediments are interpreted to reach a maximum thickness of over four kilometres towards the central axis of the basin.

Coal occurs across the basin at several stratigraphic levels but has only been mined on a small local scale in NSW. Large deposits have been exploited in southern Queensland. There is substantial petroleum and coal seam methane potential in the basin.

3.10 TERTIARY SEDIMENTS & VOLCANICS

Few if any rock of Late Cretaceous age are preserved through the UNER suggesting widespread erosion. During the Tertiary period, terrestrial sediments were widely developed throughout the UNER over all of the existing basement rocks including those of the Clarence-Moreton basin. These sediments are generally poorly preserved and are most commonly found below later Tertiary volcanic rocks. It is common to find several metres of gravels, sands and muds at the base of Tertiary volcanic sequences. These gravels commonly contain heavy mineral concentrations and in several areas important gold or tin deposits are present, for example the large and very rich tin deposits in the Vegetable Creek deep lead at Emmaville. Lateritic horizons are developed in several areas including over the Grafton Formation and in the Inverell and Emmaville areas.

Rifting of the east coast of Australia began in the Middle Cretaceous and continued for much of the Tertiary. It eventually led to the formation of new oceanic crust underlying the Tasman Sea and the removal of some of the rocks originally bounding the region in the east. Some of these rocks are now represented by the Lord Howe rise. Tertiary volcanoes and fissure eruptions marked the culmination of this rifting. Most eruptives comprised basaltic flows and ashes although some centres include rhyolite, trachyte and related rocks types.

Several huge shield volcanoes were present in the New England region, and within the UNER many volcanic centres can be identified. Major volcanoes were centred in the Tweed area with Mount Warning situated at the centre of the eroded remnants of an extensive shield volcano. A similar but more deeply eroded volcano is present at Ebor, and several volcanic centres have been identified in the extensive basaltic sheets present in the Glen Innes to Inverell areas. Other volcanic centres appear to have been present at Mount Barney on the NSW - Queensland border, in the Baryulgil area where numerous trachytic plugs now form prominent peaks. There are small basaltic and gabbroic plugs related to this period of volcanism throughout the region. These are often recognisable as small, intense magnetic anomalies.

The Tertiary volcanics have age dates in the range 43 to 17 Ma in age. The rocks of the Tweed volcano are about 23 Ma old.

3.11 QUATERNARY SEDIMENTS

Quaternary sediments occur throughout the UNER in a variety of settings. Along the east coast extensive deposits of coastal sands and muds formed in a range of marine and estuarine environments including coastal lakes. Large areas of low lying coastal regions comprise Quaternary sediments which have infilled bays and estuaries. The sea level has been up to several metres above its present level in the Quaternary and coastal embayments filled with coastal sands and muds. Examples include the large valley filling plains between Casino and the coast and between Grafton and Yamba. Along the coast, prevailing northerly longshore drift has produced zeta-form beaches. Longshore drift combined with storm activity produced concentrations of heavy mineral sands in these coastal sediments.

Away from the coast, most rivers have some Quaternary sedimentation associated with them. In places large flood plains occur adjacent to rivers and comprise gravels, sand and mud deposited during floods. Throughout the New England tablelands and adjacent slopes erosion during the Quaternary has distributed heavy minerals such as gold, cassiterite and sapphires (corundum) into many streams. In places these minerals are concentrated into mineable deposits.

4. HISTORY OF MINING AND EXPLORATION

4.1 MINING HISTORY

4.1.1 Introduction

The Upper North East region is rich in mining heritage. Some of the first discoveries of gold in Australia were made in the area and what was probably the first silver deposit in New South Wales worked at a profit was discovered at Boorook. Prospecting and mining formed the foundation of many towns and settlements in the region although many have been all but abandoned. Emmaville and Torrington have extensive mining histories dating back to the first discovery of tin in the area. Lionsville and Solferino were once substantial goldfields towns but have now almost returned back to forest. The village of Drake was surrounded by many small satellite settlements before gold was discovered in the town.

Historically, mining tends to follow a pattern of discovery followed by periods of intensive activity for several years followed by a decline as the most easily recovered resources are exhausted. Interest then tends to focus on the larger deposits which have commonly been worked, or explored, intermittently to the present day. Several other features are apparent in the mining record. In some instances the commodity of interest has changed over time (e.g. at Kingsgate bismuth and tin followed by molybdenum and quartz crystals), and in some cases it was many years after initial discovery before development occurred (e.g. the Magword deposit, discovered in 1880 was not systematically developed until 1941). It is also apparent that mining and exploration are affected by prevailing commodity prices with a tendency to be able to mine lower grades in more recent times (e.g. deposits mined at Drake). This also means that some resources may not be developed on discovery but may be developed at a later date as commodity prices change (e.g. the Taronga tin deposit south of Emmaville).

The greatest mining activity occurred in the eighteen hundreds when many thousands of miners were spread throughout the region. Settlements which have developed or supported by mining in the Upper North East include Torrington, Emmaville, Stannum, Drake, Lionsville and many coastal settlements. The history of some of the more important mining centres is described briefly below.

4.1.2 Gold and silver fields

Rivertree

The Rivertree silver field lies to the east of Stanthorpe in the headwaters of the Clarence River. The field comprises numerous rich polymetallic silver lodes which were explored in the 1890s. The lodes contained from a few to about 6000 g/t silver and many percent lead. The field underwent only a short-lived period of activity severely restricted by problems in treating the mineralogically complex ore. Eventually only the richest ore was hand-picked and transported to Brisbane for treatment.

Boorook

Silver was discovered at Boorook in 1878 by Mr Thomas Horton, in the Golden Age mine which was, according to Andrews (1908) possibly the first deposit of silver ore worked at a profit in New South

Wales. Mining of the rich silver deposits continued until 1886. About 3.6 t of silver were produced (Bottomer 1986).

Drake

Drake has had many names including Fairfield and Timbarra. The area was first settled in 1843 and the town area was established as a resting place for teamsters bringing wool down the steep track from Tenterfield to the Clarence River (Snowden 1987) and serviced the numerous mining areas around it such as Lunatic, Boorook, Tooloom and Timbarra. Gold was discovered in the town itself in Plumbago Creek in 1886 by a travelling hawker, Samuel Costa. Subsequently many deposits were discovered throughout the land surrounding Drake. Many of the mines were initially very successful as there were rich secondary deposits near the surface. Mining was later hampered by the complex mineralogy of the ore which made treatment difficult and expensive. The area has remained an important centre for exploration and mining in the region with substantial mining operations having been undertaken as late as the 1980s.

The Drake Mining Division has produced about 2.5 tonnes of gold, and more than 4.4 tonnes of silver. The main producer deposits (or mines) were: Lady Jersey (530 kilograms gold); Mount Carrington area (300 kilograms gold); Adeline (200 kilograms gold); Lady Hampden (2.6 tonnes silver) and White Rock (1.5 tonnes silver) (Bottomer 1986). Many deposits have 0.5% to 5% total base metals in primary mineralisation. Around 10 000 tonnes of mixed sulphide ore were mined at Emu Creek and Red Rock by Mount Carrington Mines Ltd from 1969 to 1972 (Offenberg and Cohrane 1975). From 1979 to 1984 a joint venture between Aberfoyle Exploration and Mount Carrington Mines Ltd conducted exploration throughout the Drake area and outlined aggregate resources totalling 3.3 million t at 98 g/t Ag and 0.5 g/t Au (Mt Carrington Mines Ltd Annual Report 1984). Between 1988 and 1990 approximately 233 000 tonnes of ore with an average grade of 2.38 g/t gold and 7.44 g/t silver were mined from several deposits in the Mount Carrington area (Houston 1993) from several zones of mineralisation with an aggregate resource of 1.2 Mt averaging 2.16 g/t gold (Department of Mineral Resources 1988).

Timbarra - Poverty Point

'Timbarra' is both the name of a river and the name of an area. Gold was discovered in the Timbarra or Rocky River in 1853. The name Timbarra also refers to the what is now commonly called the Timbarra Tableland, a peninsula of relatively flat country almost completely surrounded by deep river gorges. Extensive gold diggings can be found on the Timbarra tableland with the earliest and richest gold having been discovered in McLeod's Creek in the latter part of 1858 (Wilkinson 1980).

The Timbarra - Poverty Point goldfield was worked continuously from 1853 to 1886 and then sporadically until 1938. Most of the gold had been removed from this area before 1900 (Barnes et al. 1996). Carne (1889) recorded that the gold escort transported 71,059 oz (2200 kg) of gold between 1859 and 1866. Markham (1975a) garnished another 129 kg from various sources between 1867 and 1938 giving a total recorded production of 2329 kg. It is certain that much of the gold left the field privately so that a rough estimate of production could easily be double this figure. An indication of the richness of the field is the reference found in a letter by T. Horton Jnr of Drake, 1889 (Wilkinson 1980), which mentioned that each man made·£2,500 (over 19.6 kg) per year with only sufficient water for 13 weeks of sluicing per year.

Successive exploration has been carried out by Utah Development Co (1969), Newmont Pty Ltd (1974) and AOG Minerals Australia Pty Ltd (1981) targeting large tonnage, low grade gold resources in the vicinity of the Poverty Point mine. This earlier exploration considered the grade of 1.2 g/t subeconomic at the time. The area has been actively explored during the past decade by many joint venture companies (Barnes et al. 1996).

In 1997 Ross Mining Ltd the current owners began mine development of open cuts at the main Poverty Point workings and at Big Hill. "The Timbarra project has ore reserves totalling 327,700 ounces of gold based on three relatively shallow open-cuts known as Poverty, Big Hill and RMT. Gold mineralisation occurs as disseminations in specialised granites. The average grade is approximately 1 g/t gold and waste to ore ratios average approximately 1 for life of the mine. The gold production will be 50,000 to 60,000 ounces of gold per annum. Mining will be by conventional open cut methods. Processing will be carried out using heap leach techniques on ore crushed to minus 12mm. The gold extraction rate has been estimated at 90% over 90 days. The cash cost to produce an ounce of gold is estimated at A$265 per ounce". Ross Mining Ltd (1997a, b).

Lunatic

Gold is said to have been discovered at Lunatic in 1869 (Wilkinson 1980) and by 1871 its population had outstripped Drake. However the field was short-lived and by 1878 only four mines were reported as working. There is also a cluster of rich antimony veins in the area.

Tooloom and Pretty Gully

The first discovery of gold at Tooloom is credited to Billy May in about 1857 (Wilkinson 1980) and there were many separate diggings. This area produced some of the best nuggetty gold in the region including a 140 oz. nugget in 1859. Small scale mining has continued in the area to the present day and the area is popular with fossickers.

Lionsville - Solferino

A series of rich gold-bearing veins were discovered in 1871 by Paulo Marcolino, a prospector who had interests in Timbarra and Malara Tops (see Wilkinson 1980). Following an initial rush two villages sprang up a few kilometres apart adjacent to the main lodes, the Garibaldi reef and the Lombardy and Solferino reefs. Some rich patches of surface gold were found but the grades did not persist at depth. Mining occurred intermittently between 1871 and 1940 producing about 300 kg of gold. The towns survived for many years but are currently ghost towns regularly attracting more adventurous fossickers.

Cangai

The Cangai copper mine, located 10 km north west of Jackadgery, is one of the richest copper and gold mines in the region. This deposit was discovered in 1901 by J. Sellers and was subsequently mined by the Grafton Copper Mining Company Ltd from 1904 to 1917. A copper smelter was built and a substantial village with a sawmill developed. Recorded production is 5080 tonnes of copper, 52.7 kg of gold and 1035 kg of silver (Henley and Barnes 1992). The mine was unusual in that its discovery post-dated much of the initial mineral discoveries in New England. It had the distinction of paying its own way from ore produced from the mine and paid rich dividends to its shareholders as a result of the rich ore and the low production costs related to the self fluxing ore and that ore could be easily hauled downhill to the smelter. The mine prompted upgrades to roads and communications into the area.

Dalmorton and nearby fields

The Dalmorton gold field comprises a large area of scattered gold-bearing quartz veins (Henley and Barnes 1992). The scattering of working over a large area meant that there was little focus of activity and development comprised small settlements at each of the main deposit clusters. Alluvial deposits of gold were discovered and worked in the 1860s in many locations but it was not until 1871 that the first reef mining took place at the Union Reef south of Dalmorton. The village of Dalmorton was established on the Boyd River. Reefs continued to be discovered until after 1900. Mining in the area ceased at the Mount Remarkable mine in 1942.

Coramba - Orara

The Coramba - Orara goldfield covers a large area generally inland from Coffs Harbour (Gilligan et al. 1992). Gold was discovered in the Tallawudjah Creek area in 1881, subsequently in the Woolgoolga area in 1891, in the Coramba area in 1894 and the Bobo area in 1932. The discovery of gold in each area was generally followed by an intense period of mining activity lasting 1 to 5 years, with subsequent activity during periods of economic depression. The total recorded production from this field is about 1.25 tonnes of gold. Production peaked in 1897 when the Coramba area was in full production and the Beacon mines produced 227 kg gold (approximately $A 3 m value). The last period of systematic prospecting and mining was in the 1930s and there has only been limited exploration and mining since. In recent times one of the old mines has been developed as a tourist attraction.

Kookabookra and Bear Hill

These two settlements, north east of Armidale, are now barely recognisable as mining settlements but at one time they were busy supporting the local gold-mining industry. In 1890 the Department of Mines Annual report included the following descriptions: “The township of Kookabookra consists of two hotels, three stores, two butcher’s shops, police station, Court House, C.P.S. and Warden’s office combined, Public school, with an attendance of forty scholars. Population, about 120.... Bare Hill is situated about 5 miles from Kookabookra. ... About 120 men are continually employed. The township consists of one hotel, two stores, one butcher's shop, a public hall, a Public School, with an attendance of thirty-five children. Population about 300." The history of the mines and townships are described in detail in Newbury (1991).

4.1.3 Tin fields

Stanthorpe - Amosfield tin fields

The Stanthorpe - Amosfield tin fields straddle the NSW - Queensland border. Most mining occurred on the Queensland side of the border. Tin was reported in the area in 1854 by Joe Greer and leases taken out in 1872 although Reverend W.B. Clarke in a report describing the geology of the Darling Downs district in 1853 remarked on the occurrence of gemstones and tin ore in the area later called Stanthorpe (Denaro and Burrows 1992). Mining of the alluvial cassiterite deposits began in 1872 and 41800 t of concentrates were produced to 1882. Total recorded production for the Stanthorpe Mining District (Queensland) is 56 537 t of concentrate (Denaro and Burrows 1992). In the Stanthorpe, Wilsons Downfall and Amosfield areas in NSW, some 40 000 t of Sn concentrate have been won (Weber 1975).

Torrington - Emmaville

The Emmaville - Torrington area in the western parts of the Upper North East region has been major mining centre for more than a century. Tin was first discovered in Vegetable Creek in 1872 by Thomas Carlean. The alluvial and deep lead tin field proved to be extensive and the population grew rapidly. In 1880 Vegetable Creek was renamed Emmaville and the population was estimated at 900 Europeans and 1200 Chinese. In 1881 hard rock major tin lodes were discovered around Torrington including the Torrington, Butlers and Curnows lodes. In 1883 the post office at "The Mole" was renamed Torrington (Alt 1981).

The area around Emmaville and Torrington is one of the most richly mineralised areas in Australia and has been the highest tin producing area in NSW. Many thousand individual mine workings were developed on alluvial leads and lodes. Numerous small villages and settlements were established including Tent Hill, Stannum, Bismuth, Tungsten and The Gulf. By 1890 Emmaville was a prosperous town with a population of about 300 (Lobsey 1972).

Mining continued to be a major component of the local economy. In 1972 Emmaville had a population of about 500 and numerous small mines operated in the area. The dramatic collapse of tin prices in the early 1980s led to the demise of most small scale mining enterprises in the area. In its place the extensive mining heritage, as exemplified by the Ottery arsenic mine, and the abundance of a very broad range of minerals, consistently draws fossickers and tourists from across the country.

Tingha

The first discovery of economically workable tin deposits is credited to Joseph Wills who in 1870 sold some cassiterite he had found at Elsmore about 16 km north of Tingha. He had, according to Brown (1982) obtained tin specimens up to 5 years earlier. In 1871 the Sydney Morning Herald reported that " A large deposit of tin ore, of extreme richness, has been found in the Northern district near Inverell." Work on the Elsmore area (just outside of the Upper North East region) began almost immediately.

At about the same time, William Millis and Mr Fearby had found tin on the banks of Copes Creek on the Tiengah Run. Land was purchased and a town site surveyed in anticipation of a "rush". As Brown (1982) states: "Millis and Fearby called their town Tingha which appears to be the name of the Tiengah Run adapted to incorporate the word tin, the valuable mineral which was the reason for the town's existence".

At first the Tingha area was officially referred to as the Cope's Creek tin field but by 1872 with a mining rush in train the Tingha mining area was universally recognised. Between 1870 and 1872 workable tin deposits were found and mining commenced at Elsmore, Tingha, Vegetable Creek (Emmaville) and Quart Pot Creek (Stanthorpe) and in several other areas in NSW. These made Australia the largest tin producer in the world in the 1870s and 1880s and during these years the Tingha area was Australia's major tin producing district. Production peaked in 1883 when 3695 tonnes of tin ore were mined.

Unlike the Emmaville -Torrington area there were fewer hard rock lodes exploited at Tingha as, although present in large numbers, the lodes were rarely large enough to mine separately. In both areas however large additional deposits were found in “deep leads” where older Tertiary gravels had been preserved beneath basalt flows. A large polymetallic vein was discovered in 1890 west of Tingha at Howell and this lode sustained a small town. This deposit was worked intermittently until 1957.

Between 1893 and 1901 mining was in the doldrums in Tingha until the first tin dredge ever to be used in Australia started operations in Copes Creek. This led to a period of considerable activity with the construction of many dredges and the reworking of many of the areas which had previously only been hand mined. Dredging continued throughout the district at various levels well into the 1970s. One ambitious scheme in the 1920s involved building dams at Moredun between Guyra and Tingha and constructing water races 26 km to Tingha to provide a regulated water supply.

Kingsgate

Kingsgate has been a famous mineral locality since the probable discovery of tin in 1872 (England 1985). This field contains rich quartz pipes with molybdenum, bismuth, wolfram and tin minerals sometimes in huge crystalline masses (Brown 1995). The value of the mineral masses other than tin were not recognised until about 1877 and by 1880 the area was covered with leases with the intention of separating the valuable bismuth. Between 1883 and 1889, 219.8 metric tonnes of 45% bismuth concentrate were produced by Marks and Vickery who had bought out all the leases in 1883. Almost no molybdenite was saved. Intermittent mining followed but it was not until 1912 that molybdenite ore was purposely mined at Kingsgate. Despite record high prices during World War I apparently no mining for molybdenum took place. Intermittent mining continued until a price slump in 1920-1923. In World War II the Kingsgate mines were investigated as a possible source of piezoelectric quartz for radios and a small amount was produced. Small scale mining has occurred for short periods until recent times. Incomplete records indicate a total production of at least 348 metric tonnes of molybdenite and 200 tonnes of bismuth concentrate. Most interest in the area at present is as a mineral collecting locality. The spectacular crystals produced from the pipes attract mineral collectors from around the world.

Pheasant Creek

The Pheasant Creek tin field is situated in the Gibraltar Range National Park, mid way between Glen Innes and Grafton. Tin was found as Pheasant Creek in about 1872 (Wynn 1965) and considerable activity continued through the 1880s. Attempts at dredging in 1918 were not successful.

4.1.4 Other major mineral fields

Wild Cattle Creek

A large antimony deposit at Wild Cattle Creek east of Dorrigo (one of many in the area) was first prospected in 1890 and limited production occurred subsequently (Gilligan et al. 1992). Some work was carried out between 1927 and 1930, and in 1942. Between 1972 and 1974, $235 000 worth of antimony was produced. The Wild Cattle Creek deposits (Lower Bielsdown antimony project) have been actively investigated in recent times and reserves of 478 000 tonnes grading 2.62% antimony have been defined (data from exploration reports, Allegiance Mining NL (1994); see also Department of Mineral Resources, 1994). This may develop into a mining project in the future.

Magword

The Magword mine at Fishington, east of Guyra, is one of the larger antimony vein deposits in the region. It is unusual as it appears to be a single deposit without numerous smaller satellite deposits. The lodes were discovered in 1880, and apart from a small parcel of ore produced in 1907, there was no production until 1941. The mine was then worked successfully until 1954. Further production occurred in the period 1955-1969. During production a small mining settlement was established near the mine but this has since been abandoned.

Glen Innes - Inverell sapphires

The Glen Innes - Inverell area includes some of the richest sapphire-bearing creeks in the New England region and the area is famous for its abundant dark blue sapphires. Sapphire was first recorded in the Inverell area by Clarke in 1854 (Brown and Stroud 1993) where it was found in association with alluvial cassiterite. The first commercial mining of sapphires was in Frazers Creek in 1919. Mining slumped between 1930 and 1958. Large scale production commenced in the early 1960s due to the effects of improved marketing, better prices and increased demand (Brown and Stroud 1993, Brown 1995). Sapphire production peaked in the 1970s and early 1980s . Strong overseas competition and a fall in prices forced the closure of many mines during in the 1980s. Mining still occurs at many sites throughout the area, and sapphires are a major fossickers and tourist drawcard.

Baryugil asbestos

The Baryugil asbestos deposit was first developed during the 1914-1918 war and was again developed during the Second World War (MacNevin 1975, Brownlow 1989). Open-cut mining operations continued through until the late 1970s. Production of 19,400 t of fibre came from a large open cut developed at the mine. The mine site has recently been rehabilitated. A small village grew up near the mine and is still occupied.

Coastal heavy mineral sands

World class heavy mineral sand deposits occur along the eastern Australian coast and have been of particular importance between Broken Bay and Fraser Island (Winward, 1975; Morley, 1982). These sands occur along present beaches and beneath older dunes. The sands contain zircon, rutile, ilmenite, monazite and local concentrations of gold, tin and platinum.

Heavy mineral sands or black sands were obvious along the coast from the time of first settlement. These were initially only of interest were there were gold or platinum concentrations with the heavy minerals sand. Gold and platinum were discovered and worked in the Ballina and Evans Head area, particularly at Jerusalem Creek with McAuley’s lead being discovered in 1895 and worked intensively but on a small scale until about 1900. The Department of Mines Annual Report for 1890 reporting on the Lismore, Casino and Ballina Mining Divisions noted that: “The principal gold-mining operations were upon the several beaches between Ballina and Byron Bay, over 100 miners being at work there for weeks. It is only after heavy gales “beach mining” is taken up, and then only worked in a very small way - only fossicking. The sand is rich in places to give the good returns obtained by some claimholders, averaging, in one instance, 4 1/2 oz. per man of a party of four, for several weeks”. Later, leads of heavy minerals were found inland as fossil beach deposits.

The main heavy mineral sands industry developed much later and extended along much of coastal NSW north of Port Stephens. Production from 1933 to 1980 along the east coast totalled about 5.8 m t of rutile and 5.6 m t of zircon, with economic resources in 1980 estimated as 6.1 m t of rutile, 5.7 m t of zircon, 12.6 m t of ilmenite and 57,100 t of monazite (Morley 1982). Many coastal towns and villages were sustained by this industry in the era before large scale tourism. A large amount of infrastructure including roads, bridges and power supplies was developed with financial contributions from the industry. The heavy mineral sands industry essentially ended on a large scale when the NSW Labor government gazetted large areas of National Parks along the coast in the 1970s. Existing mining operations were allowed to continue in the National Parks under strict environmental controls for a further ten years. The last mineral sand mine under this regime closed in the Myall Lakes National Park in 1983. A limited number of heavy mineral sands operations continue outside of National Parks and reserves, and large reserves reman unmined in several national parks.

Nymboida coal

A small scale coal mining operation at Nymboida began in about 1909 and finished in 1958 with a total production of about 927 000 tonnes of coal (Wells 1995). The mine supported a small local community.

4.1.5 Other settlements and heritage items

Apart from the more significant mining fields, each mine site in the region, and there are more than a thousand of these, generally had some sort of small settlement established near the mine area. In many instances the only remains are stone or galvanised iron chimneys and scattered relics. Mining has also produced some interesting items such as water races which in some instances can extend for many kilometres. Examples of these include races from the Moredun dams to Tingha, the races to supply water to Poverty Point on the Timbarra tableland east of Tenterfield, races along the Sara River near Ballards Flat, Mann River in the Cherry Tree Creek area and in the southern parts of the Kingsgate mines. Old mining equipment and buildings are common in the Torrington area, especially near the Gulf, and provide significant tourism interest.

4.2 EXPLORATION HISTORY

The UNER contains numerous important mining fields where mining and exploration has been active for over a century. However the region has not in the past two decades had the intensity of modern exploration effort which has occurred in central western NSW and Broken Hill for example. As a result there are many areas which could be considered to be underexplored especially using modern geophysical techniques.

Exploration for mineral deposits is commonly cyclical and very much depends upon prevailing metal prices, perceived reward for effort, global trends, corporate strategies and to some extent fashion in relation to mineral deposit models considered as viable targets for exploration. For example, the global collapse of tin prices in the early 1980s led to a massive reduction of the region’s tin exploration and mining industries.

Although the UNER contains many thousands of deposits and occurrences, there have been relatively few new mineral deposit discoveries over the past twenty years. This, and perceived notions of the difficulty of exploration in a region dominated by rugged heavily forested or closely settled terrain especially with large areas of National Parks has, to some extent, reduced exploration interest. This is despite the geological factors which suggest that many important mineral deposits remain to be discovered. It could be reasonably argued that the known distribution of mineral deposits throughout the region could be regarded as a sample of mineral deposits in the crust in the area which is fortuitously explored at the present day land surface. It may well be that there is a similar distribution of undiscovered deposits at depths ranging for tens to several hundred metres below the present land surface.

The major mineral fields have all been subject to some exploration and some areas, notably the Drake area, and the Emmaville - Torrington area have been subject to sustained exploration. Many of the mineral fields have only been explored with a view to find extensions of known mineralisation with effort focussed on old mine workings. There has been only limited conceptual or model-driven exploration. This generally depends upon an understanding of the geological parameters which have caused mineral deposits to form and then searching for these geological factors irrespective of whether there are known examples of this deposit type in the area being explored.

Exploration has been undertaken using the full range of techniques available. There have been numerous stream sediment surveys but in most instances there has been little sophisticated interpretation of the results.

Geophysical techniques have been limited in their use. There are only low quality regional geophysical surveys available at present over most of the UNER. Detailed airborne surveys have been conducted by companies over the Drake Volcanics and in limited areas elsewhere, particularly surrounding the Mole Granite. The Department of Mineral Resources AEROFIND spatial database indexes areas covered by geophysical surveys.

The lack of high quality regional geophysical coverages and geological mapping has meant that many areas have not been subject to any significant exploration. These areas generally do not have any major known mineral deposits. However, this does not mean that they have no mineral potential.

The range of techniques applied are listed in the following table (Table 3):

TABLE 3: RANGE OF TECHNIQUES APPLIED IN MINERAL EXPLORATION

Technique			Applied mainly in search for
Alteration studies			Basemetals, tin, gold
Costeaning			Sapphires, tin
Drilling	Augering	Hand	Heavy mineral sands, sapphires, tin
Drilling	Augering	Machine	Heavy mineral sands, sapphires, tin
Drilling	Diamond		Basemetal, gold, tin
Drilling	RAB Rotary air blast		Basemetal, gold
Drilling	RC Reverse circulation		Gold, sapphire
Geochemistry	BCL Bulk cyanide leach		Gold
Geochemistry	BLEG Bulk leach extractable gold		Gold
Geochemistry	Ridge and spur		Tin, basemetals, gold
Geochemistry	Rock chip		Tin, basemetals, gold
Geochemistry	Soil		Tin, basemetals, gold
Geochemistry	Stream sediment		Tin, basemetals, gold
Geochemistry	Whole rock		Tin, basemetals, gold
Geological mapping	Detailed		All commodities
Geological mapping	Regional		All commodities
Geophysics	Airborne magnetics		Renison-type tin, basemetals, diamonds
Geophysics	Airborne radiometrics		Tin, gold
Geophysics	DIGEM		Basemetals
Geophysics	EM		Renison-type tin, basemetals
Geophysics	Ground magnetics		Renison-type tin, basemetals
Geophysics	Ground radiometrics		Renison-type tin, basemetals
Geophysics	IP		Renison-type tin, basemetals
Geophysics	SIROTEM		Renison-type tin, basemetals
Gridding			All commodities
Heavy mineral studies			Diamond, sapphires
Literature survey			All commodities
Petrology			Gold, tin, diamonds, basemetals
Structural studies			Gold, tin
Track building			All commodities

As indicated by figure 1, showing exploration titles, most activity has been focussed on known mineral deposit fields. Some areas of known mineralisation are not currently held under exploration title, but over time all mining fields can be expected to be revisited as part of the on-going exploration process.

Exploration licences in NSW are held as a series of geographically-defined blocks. Exploration companies are committed to spend a defined amount on exploration related to the number of blocks held in a given exploration title. As a result, mineral exploration represents a significant regional industry irrespective of mineral deposit discovery.

TABLE 4: LIST OF EXPLORATION LICENCES IN THE UNE REGION (JUNE 1998)

Title	Mineral Group	Holder
EL2619	1	ROSS MINING NL
EL3127	6	CLUFF MINERALS (AUSTRALIA) PTY LTD
EL3788	1	ROSS MINING NL
EL3848	6	PRESALA PTY LTD
EL3936	6	P.J.McSHARRY & ASSOCIATES PTY LTD
EL4160	1	ROSS MINING NL
EL4175	1	ROSS MINING NL
EL4459	1	CENTRAL WEST GOLD NL
EL4614	1	AURALIA RESOURCES PTY LIMITED
EL4634	1	GOLDRAP PTY LTD
EL4672	1	TARA CITY MINING PTY LTD
EL4673	1	TARA CITY MINING PTY LTD
EL4708	1	AURALIA RESOURCES PTY LIMITED
EL4712	1	AURALIA RESOURCES PTY LIMITED
EL4761	6	GREAT NORTHERN MINING CORPORATION NL
EL5013	1	NEW ENGLAND TIN NL
EL5032	1	NEW ENGLAND TIN NL
EL5057	6	DESERTSTONE NL
EL5058	6	DESERTSTONE NL
EL5059	6	DESERTSTONE NL
EL5122	1	NEW ENGLAND TIN NL
EL5157	1	NEW ENGLAND TIN NL
EL5190	1	ROSS MINING NL
EL5223	6	DESERTSTONE NL
EL5251	1	NEW ENGLAND TIN NL
EL5252	1	ROSS MINING NL
EL5305	1 6	MCINTOSH, RODERICK SKINNER
EL5307	1	KITSON, LEONARD
EL5385	1	ROSS MINING NL
EL5389	1	MALACHITE RESOURCES NL
EL5395	6	GREAT NORTHERN MINING CORPORATION NL
EL5401	1	ROSS MINING NL
EL5403	1	PROBE RESOURCES NL
EL5407	1	KINGS MINERALS NL
EL5427	1	TOOLOOM GOLD PTY LIMITED
EL5438	6	GREAT NORTHERN MINING CORPORATION NL
EL5442	1	MALACHITE RESOURCES NL
EL5445	1, 2, 6	TOPALITE RESOURCES PTY LTD
EL5455	6	DIAMOND VENTURES EXPLORATION PTY LTD
EL5456	6	DIAMOND VENTURES EXPLORATION PTY LTD
EL5457	6	DIAMOND VENTURES EXPLORATION PTY LTD
EPL1050	1	KEMLO, KENNETH GARRY
EPL1082	1	CAPRICORNIA PROSPECTING PTY LTD
EPL1084	1	CAPRICORNIA PROSPECTING PTY LTD
EPL1085	1	CAPRICORNIA PROSPECTING PTY LTD
EPL1086	1	CAPRICORNIA PROSPECTING PTY LTD
EPL1099	1	ROSS MINING NL
EPL1100	1	ROSS MINING NL
EPL1101	1	ROSS MINING NL
EPL1135	1	McKISSOCK, JOHN ANDREW
PEL9	PETROLEUM	OIL COMPANY OF AUSTRALIA LIMITED
PEL13	PETROLEUM	OIL COMPANY OF AUSTRALIA LIMITED
PEL16	PETROLEUM	CARLITA HOLDINGS PTY LTD
PEL426	PETROLEUM	OIL COMPANY OF AUSTRALIA LIMITED

Note: As titles are constantly changing, reference should be made to the Department of Mineral Resources for lists of current titles.

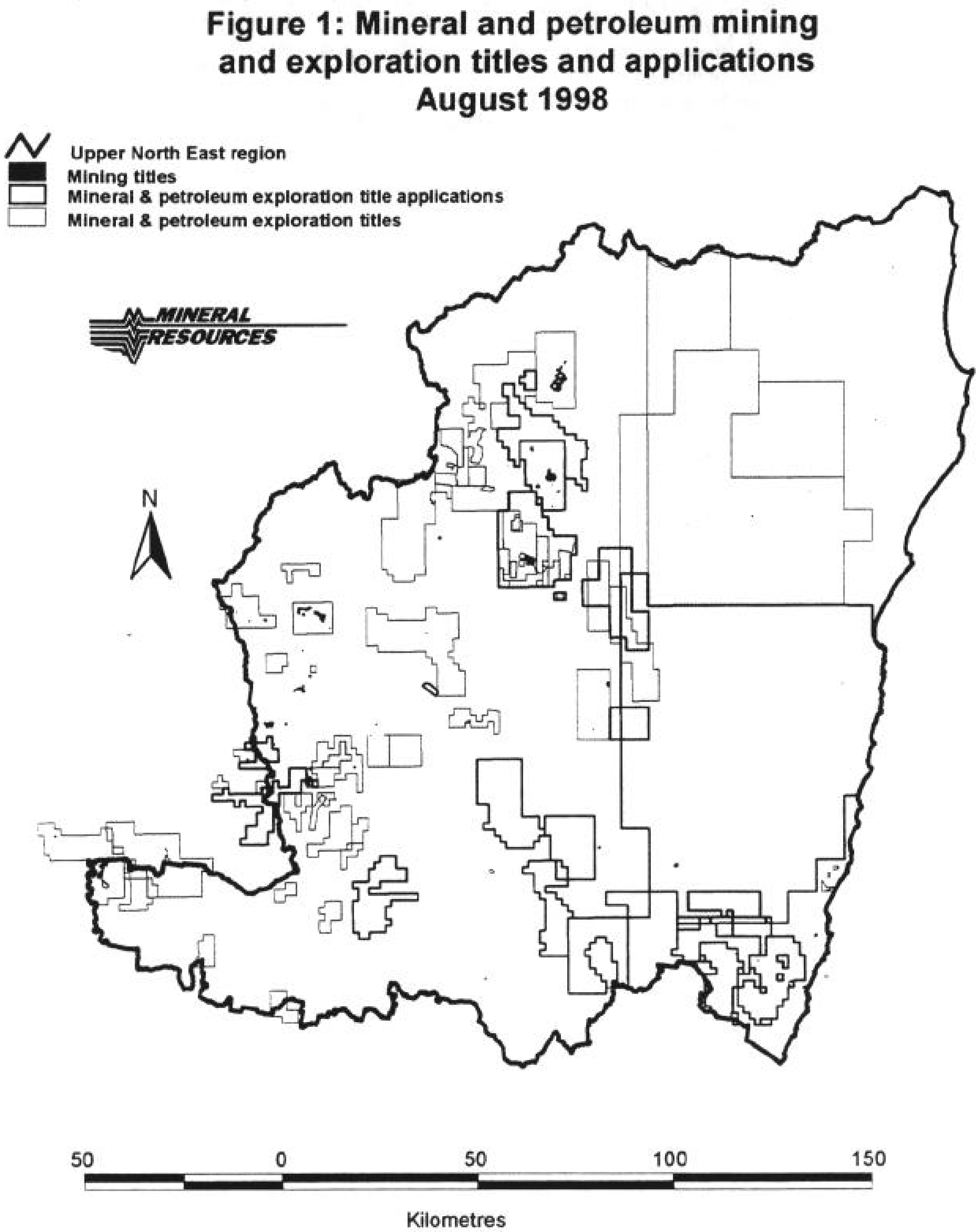


Figure 1: Mineral and petroleum mining
and exploration titles and applications
August 1998
Upper North East region
Mining titles
Mineral & petroleum exploration title applications
Mineral & petroleum exploration titles
MINERAL RESOURCES
N
50
0
50
100
150
Kilometres

4.2.1 The value of exploration

Exploration for mineral deposits can be considered as a significant input into the regional economy independent of the results of the search for minerals. The NSW Department of Mineral Resources keeps detailed records of exploration expenditure undertaken by exploration licence holders. These records indicate that expenditure for metallic and industrial minerals within the UNER has varied between about $1.5m to $2.5m per year during the past decade. In addition, exploration for petroleum related products in the Clarence Moreton basin is in the order of $0.5m per year. Actual figures vary dramatically from year to year. The variation relates to prevailing economic conditions, commodity prices, the development of new geological and mineral deposit models and the availability of new data such as detailed geophysical or geological and metallogenic data.

5. KNOWN MINERAL RESOURCES AND MINERAL PRODUCTION

Extractive industries represent a major activity in the Upper North East region. Department of Mineral Resources information indicates that there are at least 150 extractive operations in the UNE including 17 hard rock quarries, 15 construction sand pits, one pit producing ironstone road base and numerous pits winning unprocessed road materials in the region. Advice from Local Government indicate a much higher level of activity, with possibly as many as 350 sites probably active. Part of the discrepancy arises because official production statistics aggregate public sector activity by producer, and data on the numerous individual sites operated by local government are not available individually. Discrepancies further arise from incompleteness in official production statistics and because data from Local Government includes some sites registered under SEPP 37 that may no longer be active.

Current mining activity included winning of clay/shale at Bexhill (near Lismore), Tatham (near Casino), Coombell (south of Casino), South Grafton, Nymboida and Glen Innes for brickmaking; sandstone near Woodburn for dimension stone, granite near Tenterfield and Dundee for dimension stone, industrial silica at Bolivia near Torrington and sapphire at sites south of Emmaville. In addition, a limestone mine at Tabulam near Drake, is on care and maintenance and is expected to reopen in the near future.

In the recent past, there has been mining of mineral sands near Tweed Heads and Ballina, emerald near Torrington, and gold in the Tabulam area. Important industrial mineral deposits with potential for exploitation include the limestone near Tabulam and Tenterfield, silexite near Torrington, probably sapphires in the Glen Innes district and widespread granites and sandstone deposits (potential dimension stone sources). Widespread clay/shale resources of the Clarence-Moreton Basin are especially promising if gas were to be developed commercially, because together they could underpin development of a major brick-making industry to serve Brisbane (existing supplies depleting and suffering land-use pressures), the Gold Coast and the North Coast.

Construction material production in the UNE region is substantial. Records of the Royalty Branch, Department of Mineral Resources indicate that in 1996-97, production comprised 580,000 t ($4.16M) of sand and gravel (possibly 100,000t is mislabelled unprocessed materials), 1.34 Mt ($14M) of hard rock, and 1.1 Mt ($6.7M) of unprocessed materials. Major deposits currently supplying the region include hard rock aggregate deposits near Tweed Heads, Lismore, Ballina, Coraki, Casino, Coffs Harbour and Glen Innes, and construction sand or sand and gravel deposits at Cobaki, Chinderah, Tyagarah, Suffolk Park, Bungawalbin, Mount Doubleduke, Maclean, Grafton and possibly Tenterfield. An assessment of construction material availability and supply for the North Coast including the UNE the region (Brownlow, 1994) indicates long term shortages of supply, especially for construction sand. Many of the existing sources of supply will need to be replaced within a few decades (some will last longer), and therefore future access to resources will be a critically important issue. In that regard, resources in forests virtually represent a strategic reserve that is likely to become increasingly important owing to land-use pressures outside forests. For example, hard rock resources in forests near Bucca Creek are critical for long term security of supply in the Coffs Harbour area, and quartz sandstone deposits of the Clarence-Moreton Basin (especially Kangaroo Creek Sandstone) are especially important as sources of ironstone (for road base), crushed sandstone, outwash sand and friable sandstone.

Annual value of mineral production from some 150 operations in the Upper North East region area is estimated at $29.2 million from records for 1996-97 (DMR Royalty Branch). Of this amount some 73% is from hard rock aggregate production, 14% is from unprocessed road materials, 10% from construction sand. Actual value of production is considered to be greater than the amount recorded because some operations have not provided production records to the Department. Recorded value of mineral production from State Forests in 1996-97 is $215 000 from 8 quarries however estimated at value of mineral production is likely to be about $0.5 million production from numerous quarries in State Forests has not been provided.

Metallic mining at Timbarra is due to commence shortly. In 1997 Ross Mining Ltd the current owners began mine development of open cuts at the main Poverty Point workings and at Big Hill. “The Timbarra project has ore reserves totalling 327,700 ounces of gold based on three relatively shallow open-cuts known as Poverty, Big Hill and RMT. Gold mineralisation occurs as disseminations in specialised granites. The average grade is approximately 1 g/t gold and waste to ore ratios average approximately 1 for life of the mine. The gold production will be 50,000 to 60,000 ounces of gold per annum. Mining will be by conventional open cut methods. Processing will be carried out using heap leach techniques on ore crushed to minus 12mm. The gold extraction rate has been estimated at 90% over 90 days. The cash cost to produce an ounce of gold is estimated at A$265 per ounce” (Ross Mining Ltd, 1997a, b).

Reported resources amounts from company reports and environemtnal impact statements are given in Tables 5 and 6. The reported amounts do not necessarily constitute reserves as defined by the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves.

TABLE 5: IDENTIFIED METALLIC MINERAL RESOURCES

PROSPECT NAME	COMMODITY	RESOURCE	UNIT	CATEGORY	AVERAGE GRADE
Boorolong Mo Mine	Bi, Mo	44,500	tonne	exploration result	0.07% Bi, 0.145% Mo
Muirs Mine	Au	20,000	tonne	indicated	3.8 g/t Au
Poverty Point Combined	Au	1,285,000	tonne	unknown	0.92 g/t Au
Big Hill Mine	Au	7,160,000	tonne	unknown	0.96 g/t Au
Hortons Mine	Au	270,500	tonne	unknown	2.64 g/t Au
RMT	Au	1,346,200	tonne	unknown	1.06 g/t Au
Blacks Mine	Au	800,000	tonne	inferred	15 g/t Au
Just-In-Time Mine	Zn	70,000	tonne	inferred	0.7% Zn
Nogrigar Ck Chromite	Cr	200	tonne	inferred	35% Cr
Chromite B	Cr	20,000	tonne	inferred	39.7% Cr
Pound Flat	Sn	300,000	m3	inferred	0.016% Sn
Pound Flat Prospect	Sn	2,250,000	tonne	inferred	0.12% Sn
Glen Eden Mines	Mo, W	30,000,000	tonne	inferred	0.1% Mo, 0.17% W
Diggers Creek	Au	363,000	m3	inferred	1.5 g/m3 Au
John Bull Reef	Au	228,000	tonne	inferred	1.5 g/t Au
Mount Remarkable	Au	130,800	tonne	inferred	18.5 g/t Au
Pine Creek Lode	Au	63,650	tonne	inferred	2.8 g/t Au
Sara River Alluvials	Au	1,780,000	m3	inferred	0.4 g/m3 Au
Webbs Consols	Ag, Pb, Zn	2,000		inferred	225g/t Ag, 8% Pb, 10% Zn
Tangoa Prospect	Ag, Pb, An	30,000	tonne	proved	10g/t Ag, 7% Pb, 7% Zn
Conrad Mine	Ag, Cu, Pb, Sn, Zn	1,000,000	tonne	inferred	673g/t Ag,2% Cu, 10% Pb, 2% Sn, 6% Zn
**Drake Field	Au	3.3	Mt	unknown	98g/t Ag, 0.5 g/t Au
Hilltop prospect	Au	20,000	m3	unknown	0.87g/t Au
East Britain prospect	Sn	392,680	m3	measured	1.09kg/m3 Sn
Ottery mine	Sn	15,000	tonne	inferred	3% Sn
Taronga prospect	Sn	46,818,000	tonne	measured	0.14% Sn
Great Britain deposit	Sn	2,453.6	tonne	measured	450ppm Sn
Mt Everard	W	95,800	tonne	proved	0.1% W
Butlers lode	Sn	56,895	tonne	inferred	1% Sn
Dutchmans & Harts	Sn	28,346	tonne	inferred	1% Sn
Wallaroo lode	Sn	15,200	tonne	inferred	1% Sn
Curnows Sn lode	Sn	4,670	tonne	inferred	1% Sn
Specimen Hill	Sn	18,000	tonne	probable	0.5% Sn
Farmers deposit	Sn	250,000	m3	exploration result	1.2kg/m3 Sn
Upper Brushy Creek alluvials	Sn	13,200	tonne	inferred	2.2kg/m3 Sn
Torny mine	Ag, Cu, Pb, Sn, Zn	51,000	tonne	inferred	466g/t Ag, 0.1% Cu, 11.9% Pb, 0.2% Sn, 2.3 % Zn
Burra silver mine	Ag, Zn	60,000	tonne	inferred	933g/t Ag, 20% Zn

**Drake Field: Between 1988 and 1990 some 233,000 tonnes of ore at an average grade 2.38g/t Au & 7.44g/t Ag were mined from this resource (Houston 1993).

TABLE 6A: IDENTIFIED INDUSTRIAL MINERAL AND CONSTRUCTION MATERIAL RESOURCES IN OPERATING SITES

Operation Name	Commodity	Amount	Unit	Category
Tuckombil Quarry	coarse aggregate - hard rock	1,300,000	t	Indicated
Boral Teven Quarry	coarse aggregate - hard rock	8,000,000	t	Indicated
Foxs Quarry	coarse aggregate - hard rock	6,125,000	m3	Indicated
Lucas Quarry	coarse aggregate - hard rock	3,146,000	t	Indicated
Woolgoolga Quarry	coarse aggregate - hard rock	2,800,000	m3	Indicated
Chadburns Quarry	coarse aggregate - hard rock	380,000	m3	Indicated
Blakebrook Quarry	coarse aggregate - hard rock	3,600,000	m3	Indicated
Terranora Quarry	coarse aggregate - hard rock	1,860,000	t	Indicated
Wilcocks Quarry	coarse aggregate - sandstone	2,400,000	m3	Unknown
North Boambee Quarry	coarse aggregate - shale	15,500,000	t	Indicated
Landrigans Quarry	coarse aggregate - shale	3,400,000	m3	Indicated
James Creek Road	clay, clay/shale – structural	80,000	t	Inferred
Eungella	gravel - fluvial	300,000	m3	Unknown
Newrybar Sand Pit	sand - construction	450,000	m3	Indicated
Picks Sand Pit	sand - construction	285,000	m3	Indicated
Armstrongs Sand Pit	sand - construction	100,000	m3	Indicated
Gillies Sand Pit	sand - construction	120,000	m3	Indicated
Batsons Suffolk Park Quarry	sand - construction	4,000,000	m3	Measured
Bundagen sand Pit	sand - construction	70,000	m3	Indicated
Martins Pit	sand - construction	25,000	m3	Indicated
Dowes Pit	sand - construction	80,000	m3	Unknown
Wandering Star Resort	sand - construction	100,000	m3	Unknown
Wandering Star Resort	sand - construction	100,000	m3	Unknown
Stotts Island (Site A)	sand - construction	1,000,000	m3	Indicated
Dodds Island Sand Deposit	sand - construction	1,500,000	m3	Indicated
Chinderah	sand - construction	1,500,000	m3	Indicated
Bakers sand Quarry	sand - construction	900,000	m3	Indicated
Chinderah Road	sand - construction	400,000	m3	Indicated
Terranora Inlet	sand - construction	15,000	m3	Indicated
Bolivia Quartz Mine	silica - industrial	750,000	t	Unknown
Stokers Quarry	unprocessed construction materials	333,000	m3	Indicated
Gibson Bros Pit	unprocessed construction materials	100,000	m3	Indicated
Eatons Pit	unprocessed construction materials	390,000	m3	Indicated
Montis Quarry	unprocessed construction materials	1,500,000	t	Indicated
Leela Quarry	unprocessed construction materials	2,500,000	m3	Indicated
Gundar Quarry	unprocessed construction materials	40,000	m3	Indicated
Tuckers ironstone	unprocessed construction materials	500,000	m3	Indicated
Pelican Creek Road Quarry	unprocessed construction materials	250,000	m3	Indicated
Chamberlains Quarry	unprocessed construction materials	60,000	m3	Indicated
McDonalds Quarry	unprocessed construction materials	730,000	m3	Indicated
Turcatos Quarry	unprocessed construction materials	1,000,000	m3	Indicated
Mackney	unprocessed construction materials	354,000	m3	Indicated
Gittoes Quarry	unprocessed construction materials	1,170,000	t	Indicated
Ebzerys Pit	unprocessed construction materials	75,000	m3	Unknown
Rangers Valley	unprocessed construction materials	50,000	m3	Unknown
Two Mile Road Pit	unprocessed construction materials	50,000	m3	Unknown
Dairy Pit	unprocessed construction materials	30,000	m3	Indicated

TABLE 6A (CONTINUED): IDENTIFIED INDUSTRIAL MINERAL AND CONSTRUCTION MATERIAL RESOURCES IN OPERATING SITES

Operation Name	Commodity	Amount	Unit	Category
McCliftys Pit	unprocessed construction materials	20,000	m3	Indicated
76 Km Pit	unprocessed construction materials	30,000	m3	Indicated
Bluff Pit	unprocessed construction materials	30,000	m3	Indicated
Bartletts Quarry	unprocessed construction materials	1,790,000	t	Indicated
Marks Quarry	unprocessed construction materials	450,000	t	Unknown
Mudges Quarry	unprocessed construction materials	200,000	m3	Unknown
O'Keefes No 1	unprocessed construction materials	200,000	t	Indicated
Brims Quarry	unprocessed construction materials	940,000	t	Indicated
Reeves Quarry	unprocessed construction materials	200,000	m3	Unknown
Kanes chert Quarry	unprocessed construction materials	500,000	m3	Indicated
Taggets Quarry	unprocessed construction materials	83,000	m3	Indicated
Singhs Quarry	unprocessed construction materials	300,000	t	Indicated
Buglers Quarry	unprocessed construction materials	300,000	t	Indicated

TABLE 6B: IDENTIFIED INDUSTRIAL MINERAL AND CONSTRUCTION MATERIAL RESOURCES, SITES NOT OPERATING

Operation Name	Commodity	Amount	Unit	Category
PWD Ilarwill Quarry	coarse aggregate - armour stone	400,000	m	Unknown
PWD Rileys Hill Quarry	coarse aggregate - armour stone	50,000	m	Unknown
Nerasko Quarry site	coarse aggregate - hard rock	2,700,000	m	Indicated
Cedar Point Quarry site	coarse aggregate - hard rock	2,500,000	m	Indicated
Round Mountain site	coarse aggregate - hard rock	7,400,000	t	Indicated
Quarry A	coarse aggregate - sandstone	873,000	m	Indicated
Slys Old Pit	coarse aggregate - sandstone	3,250,000	t	Indicated
Williams Pit	decorative aggregate - crushed	300,000	t	Indicated
Fine Flower Mine	iron oxides – magnetite	700,000	t	Inferred
Fine Flower No 2	iron oxides – magnetite	20,000	t	Inferred
Tabulam Limestone Deposit	limestone	10,000,000	t	Inferred
Unnamed	friable sandstone	2,550,000	t	Indicated
North Creek	sand - construction	120,000	m	Indicated
Wiltons Pit	sand - construction	40,000	m	Indicated
Goldens Bundadgen Sand	sand - construction	70,000		Unknown
6 Mile Swamp	sand - construction	800,000	m	Indicated
Romiaka Channel North	sand - construction	25,000	m	Unknown
Romiaka Channel South	sand - construction	25,000	m	Unknown
Unnamed	sand - construction	300,000	m	Indicated
Hickey Island	sand - construction	165,000	m	Indicated
Unnamed	sand - construction	350,000	t	Indicated
Chinderah Road	sand - construction	400,000		Unknown
Tweed Heads South	sand - construction	89,460	m	Unknown
Kingscliff West	sand - construction	260,000	m	Indicated
Bakers Road Quarry	sand - construction	834,500	m	Indicated
Nobles site	sand - construction	300,000	m	Indicated
Area 5 (S)	sand - construction	460,000	m	Indicated
Area 5 (N)	sand - construction	460,000	m	Indicated
Bismuth Mine	topaz	90,000		Inferred
Burnt Hut	topaz	300,000		Indicated
Mont Everard	topaz	195,000		Indicated
Wild Kates & Urens Workings	topaz	70,000		Indicated
Fielders Hill	topaz	67,000		Indicated
Western Margin Silexite Body	topaz	555,000		Inferred
Wolfram Hill	topaz	102,000		Indicated
Myocum Quarry	unprocessed construction materials	75,000	m	Indicated
Left Bank Quarry	unprocessed construction materials	780,000	m	Indicated
Archibalds	unprocessed construction materials	180,000	m	Indicated
Riches Quarry	unprocessed construction materials	525,000	m	Indicated
Perkins Pit	unprocessed construction materials	600,000	m	Indicated
Collins Corndale Quarry	unprocessed construction materials	568,000	m	Indicated
Balesfords Quarry	unprocessed construction materials	225,000	m	Indicated
Hellyars Quarry	unprocessed construction materials	100,000	m	Indicated
Slys Pit	unprocessed construction materials	725,000	t	Indicated
Campbells Quarry	unprocessed construction materials	430,000	t	Indicated
Emu Park Quarry	unprocessed construction materials	40,000	m	Unknown
Pollards Quarry	unprocessed construction materials	150,000	m	Indicated

TABLE 6B (CONTINUED): IDENTIFIED INDUSTRIAL MINERAL AND CONSTRUCTION MATERIAL RESOURCES, SITES NOT OPERATING

Sandersons Quarry	unprocessed construction materials	840,000	m	Indicated
Chilcotts Quarry	unprocessed construction materials	400,000	t	Indicated
TSC Kinnears Pit	unprocessed construction materials	550,000	m	Unknown
Burringbar Quarry	unprocessed construction materials	1,250,000	t	Indicated
Harrys Road Quarry	unprocessed construction materials	70,000	m	Unknown
O'Keefes No 2 Quarry	unprocessed construction materials	340,000	t	Indicated
Reeves Pit (N)	unprocessed construction materials	25,000	m	Indicated
Duroby Quarry	unprocessed construction materials	200,000	t	Indicated

6. MINERAL EXPLORATION AND LAND ACCESS

6.1 MINERAL EXPLORATION

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

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

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

6.2 LAND ACCESS

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

In order to examine the implications of alternative land access arrangements for exploration and mining in the region it is important to understand both the nature of exploration and its likely costs and benefits. Generally, exploration can be defined as the process of searching for and assessing mineral deposits. Although discovery and delineation are the primary reasons for exploration, lack of discovery from an exploration program does not imply that the effort yielded no benefit. Information gained from exploration will usually increase the understanding of a region’s geology.

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

Modern mineral exploration: the typical sequence of events

1. Global considerations

Assessment of political stability

Assessment of security of title

Assessment of access and restrictions

Assessment of financial climate, restrictions or inducements

Determination of geoscientific framework and availability of information

2. Preliminary investigations

Review regional geoscientific data (geology, geophysics, satellite imagery)

Formulation of geological concepts and selection of prospective areas

Examination of known mineralisation

3. Reconnaissance exploration

Acquisition of exploration tenements

Collection and assessment of geoscientific data over the tenement

Examination of available regional geoscientific data

Conducting of geoscientific surveys required to augment available data

Selection of target areas, for more detailed exploration

4. Detailed exploration

Detailed geoscientific surveys to detect and delineate anomalies

Drilling of anomalies in search of significant mineralisation

Delineation of mineral deposits by further drilling and other methods to determine configuration, approximate tonnage, grade, metallurgical characteristics of the deposits

Pre-feasibility studies

Acquisition of mining tenements, if justified, at appropriate stage of program.

Source: ABARE, AGSO and BRS (1993).

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

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

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

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

If the results of this work were positive, additional follow-up work probably would include some drilling. However, it should be noted that not all exploration results in drilling.

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

7. MINERAL POTENTIAL ASSESSMENT METHODOLOGY

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

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

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

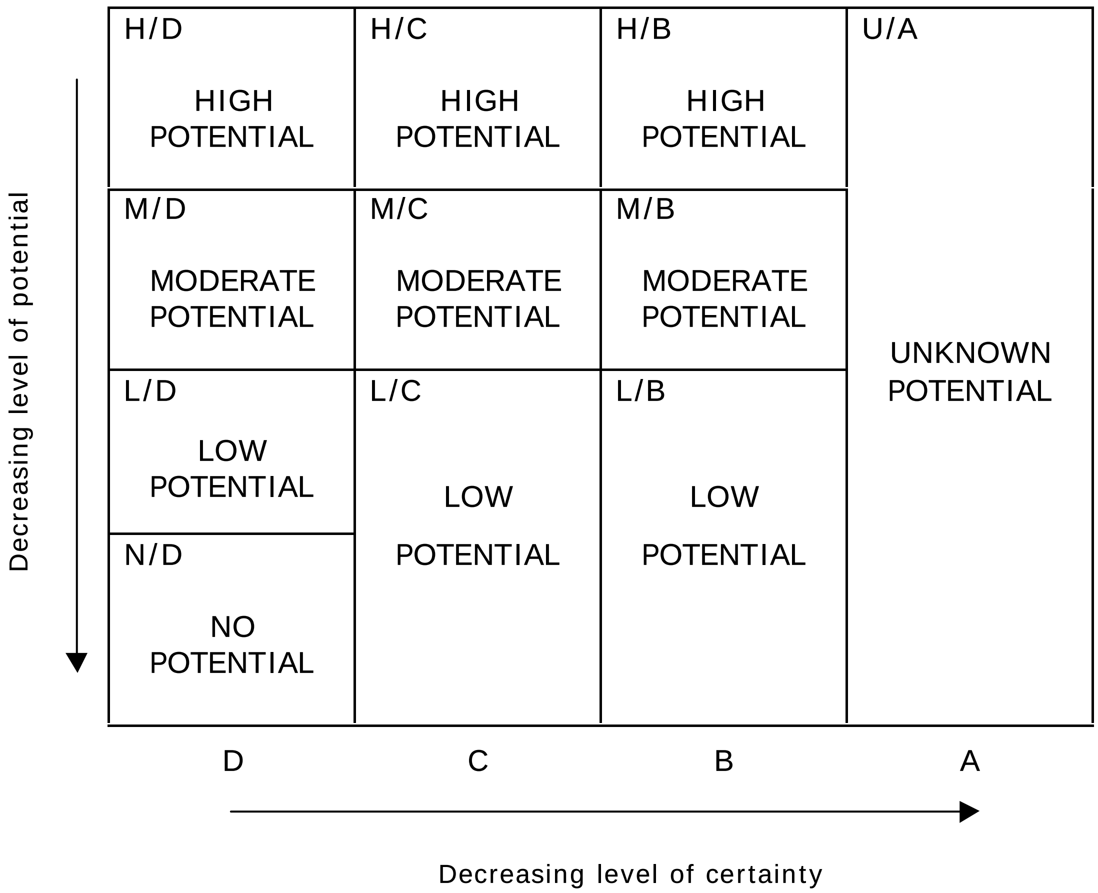
The mineral potential of an area, that is the likelihood of it having a particular type of mineral deposit, is ranked as high, moderate, low or unknown, based on professional judgments of geoscientists involved in the assessment. If there are insufficient data to classify the areas as having high, moderate or low potential then the mineral resource potential is categorised as unknown. To reflect the differing amounts of information available, the assessments of mineral potential are also categorised according to levels of certainty, denoted by letters A to D in order of increasing certainty (Figure 2). That is, A denotes the lowest level of certainty and D the highest. The method is described in more detail in Appendix A.

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

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 (e.g. Kanowna Belle near Kalgoorlie, WA; Century in the Mount Isa Inlier, Qld.) or in areas not previously known to be of very high potential (e.g. Olympic Dam on the Stuart Shelf, SA). Thus continued access to land for regulated exploration, which is a transient process rather than a long-term land use, is an important issue for the minerals industry and for future mineral development.

Geological areas (or ‘tracts’) in the Upper North East region, judged to contain geological environments permissive of the formation of specific types of mineral deposits are delineated and the mineral potential is ranked (see Figures 3 to 31).

FIGURE 2:
RELATIONSHIP BETWEEN LEVELS OF RESOURCE POTENTIAL AND LEVELS OF CERTAINTY



8. POTENTIAL MINERAL RESOURCES

Descriptive mineral deposit models used for qualitative broad scale assessment of the Upper North East region are described in Appendix B. The favourable geological tracts for these types of mineralisation are indicated on Figures 3 to 31. The potential mineral resources are summarised in Table 7 and are described below.

8.1 HYDROCARBONS (OIL AND GAS) (FIGURE 3)

The criteria used to delineate mineral potential tracts include the presence of Triassic and Jurassic sedimentary rocks with accumulated minimum thickness of 300 metres of sedimentary rocks; the presence of underlying organic-rich source rocks and the determined source rock maturity >0.7% vitrinite reflectance.

Tract Hcarb1a/M-H/D

The tract includes identified reservoir rocks with defined traps based on seismic data of variable quality. The presence of source rocks is highly likely. On available evidence the tract is considered to have a moderate to high potential for hydrocarbons. The certainty of D is based on the identification of structure from seismic data and moderate level of confidence in the presence of reservoir and source rocks.

Tract Hcarb1b/M/B

The tract includes source rocks and potential reservoir rocks with sufficient cumulative thickness and adequate maturity to have generated oil or gas capable of accumulating in structural or stratigraphic traps. The certainty of B is based on limited petroleum well data and seismic line kilometres indicating the possible presence of source and reservoir units throughout the tract. The presence of hydrocarbons in most petroleum wells indicates a good level of confidence and moderate potential for hydrocarbons.

Tract Hcarb1c/L-M/B

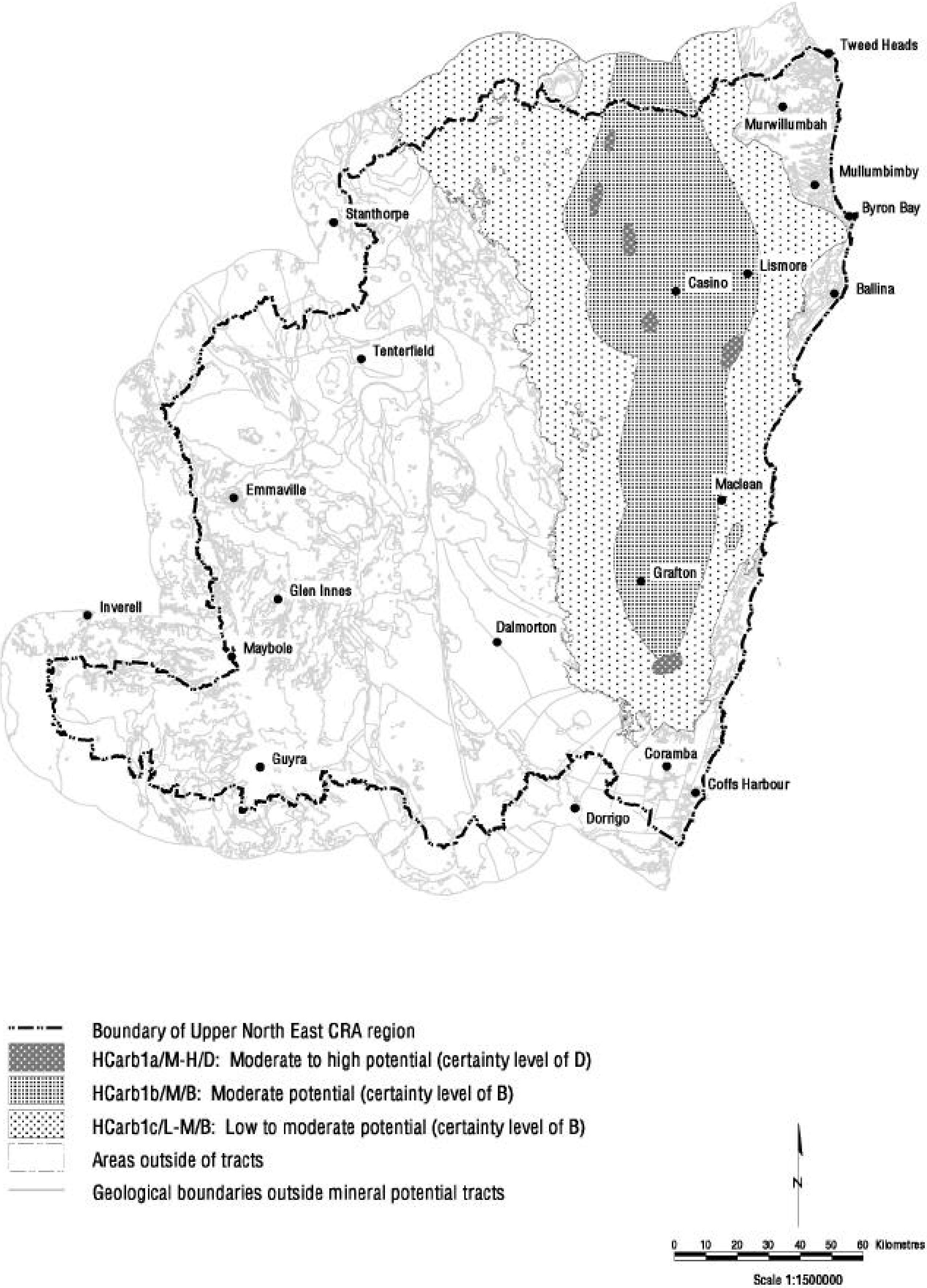
The tract has lower potential for presence of sufficient coal/coaly shale content in source rocks as well as lower source rock maturity. There is low to moderate potential for a resource as reservoir rocks are less likely to be present close to the basin margin, the likelihood of source rocks being present and reservoir traps formed. The certainty of B is based on a low level of penetrative drillhole data and very limited data to indicate the presence of source rocks such as the Nymboida Coal Measures beneath the tract.

8.2 COAL SEAM METHANE (FIGURE 4)

Tract CSMeth1a/H/C

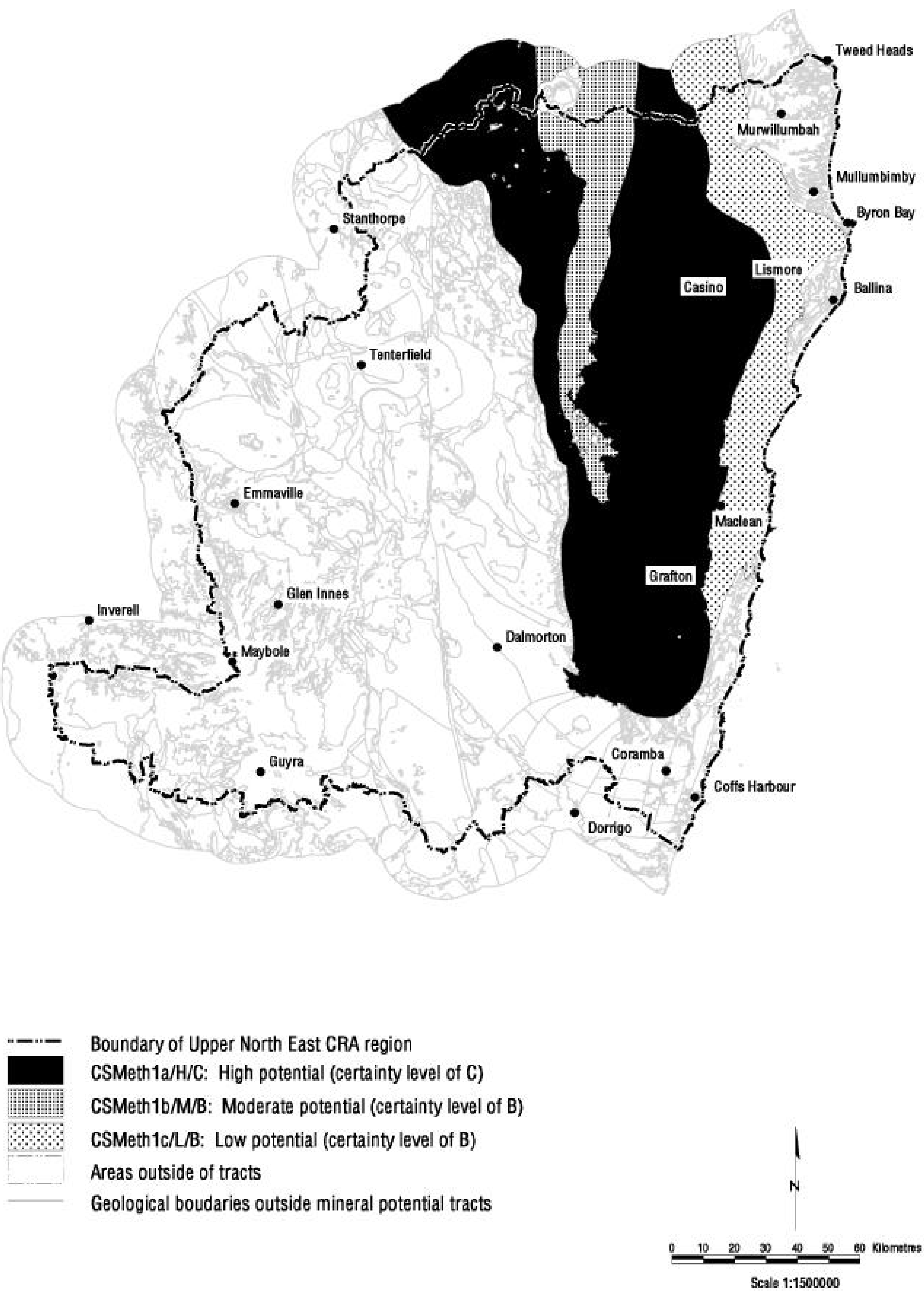
The tract is defined by the presence of coal seams within both the Walloon Coal Measures and the possible presence of the Nymboida/Ipswich Coal Measures. Depth of cover should be sufficient to retain gas within the coal seam (a minimum of 100 metres). The coal seams within the tract are expected to have adequate maturity to have generated gas and therefore are defined in zones where the organic matter within the coal seams has a vitrinite reflectance of greater than 0.6%. A certainty of C is based on the moderate level of knowledge of the presence of reservoir rocks and limited data available on gas quantity and quality within the Walloon Coal Measures.

Figure 3. Mineral potential tracts for hydrocarbons (oil and gas).



Boundary of Upper North East CRA region
HCarb1a/M-H/D: Moderate to high potential (certainty level of D)
HCarb1b/M/B: Moderate potential (certainty level of B)
HCarb1c/L-M/B: Low to moderate potential (certainty level of B)
Areas outside of tracts
Geological boundaries outside mineral potential tracts

Figure 4. Mineral potential tracts for coal seam methane.



Tract CSMeth1b/M/B

The tract may contain sufficient cumulative coal thickness within the Ipswich or Nymboida Coal Measures and within the tract such coal is more likely to occur at depths shallower than 1000 metres. Coal seams within the Walloon Coal Measures are likely to be at shallow depth or absent in this tract. The certainty of B is based on the poor level of knowledge regarding the depth and gas content of the Walloon Coal Measures and a complete lack of data regarding the presence of the Nymboida Coal Measures. The tract has a moderate potential for coal seam methane.

Tract CSMeth1c/L/B

The tract may contain sufficient cumulative coal thickness within the Ipswich or Nymboida Coal Measures. Within the tract such coal is more likely to occur at depths greater than 1000 metres due to the moderate to steep dips anticipated throughout this tract. Outcropping Ipswich Coal Measures are known from Evans Head and Red Cliff. Coal seams within the Walloon Coal Measures are unlikely to be a target as they are at shallow depth or absent in this tract. The tract has a low potential for coal seam methane. A certainty of B is based on a very low level of data relating to the presence of the Nymboida/Ipswich Coal Measures and moderate data for the Walloon Coal Measures.

8.3 PORPHYRY COPPER-GOLD DEPOSITS (FIGURE 5)

Tract CuAu1a/M/B-C

The tract embraces intrusives of the Clarence River plutonic Suite. Additional areas around the Bruxner Adamellite and the Jenny Lind Granite represent subsurface extensions of these bodies interpreted from high-magnetic responses on aeromagnetics. The tract also includes areas around Tooloom, where aeromagnetics shows the presence of a subsurface granitoid body, associated with alluvial gold occurrences and significant geochemical anomalies (Au+Cu+Sb+As). At Snapes, mafic intrusives occur, and possibly also in the subsurface, together with moderately significant geochemical anomalies. The tract also includes granitoids of the Sheep Station Creek Complex and the Billys Creek Tonalite. These are I-type, magnetic granites and are associated with moderate to high levels of geochemical anomalism. The tract exhibits evidence of gold and copper anomalism within these intrusives where exposed. This tract is assessed as having moderate potential with a certainty level of B-C.

Tract CuAu1b/L-M/B

Intrusives of the Permo-Triassic Moonbi Plutonic Suite (fractionated I-type oxidised granites) define this tract and include the Undercliffe Falls Adamellite, the Herries and Bungalla Adamellites, Mount Mitchell Monzogranite, Newton Boyd Granodiorite and an unnamed granitoid north of Dalmorton which belongs to this Suite. The tract hosts most known occurrences of disseminated gold and is assessed as having low-moderate potential with a certainty level of B.

8.4 EPITHERMAL GOLD (FIGURE 6)

Tract Au1a/H/C

The tract includes volcanic, volcaniclastic rocks of the Drake Volcanics and the overlying sedimentary rocks of the Gilgurry Mudstone. Both these units host significant epithermal deposits of the region (69 out of 70 known occurrences). The rocks show typical epithermal-style alterations. They also host several occurrences of alluvial gold. The tract is also characterised by high levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. Hence mineral potential of the tract is assessed to be high with a certainty level of C.

Tract Au1b/M/B

The tract is defined by a 5 kilometre buffer on the eastern side of the Drake Volcanics included in the tract Au1a/H/C. The buffer approximates the extent of the epithermal system generated by volcanic-plutonic event associated with the Drake Volcanics. It includes rocks of the Emu Creek Formation which hosts a number of gold occurrences. However the available information is not sufficient to suggest that they are of epithermal affiliation. The tract also includes Tertiary and Quaternary rocks at the margin of the Clarence-Moreton Basin, that have a potential to host favourable rocks (either the Drake Volcanics or the Emu Creek Formation) for hosting epithermal mineralisation. The tract is characterised by moderate to high levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. The potential of the tract is thus assessed to be moderate with a certainty level of B.

Figure 5. Mineral potential tracts for porphyry copper-gold deposits.

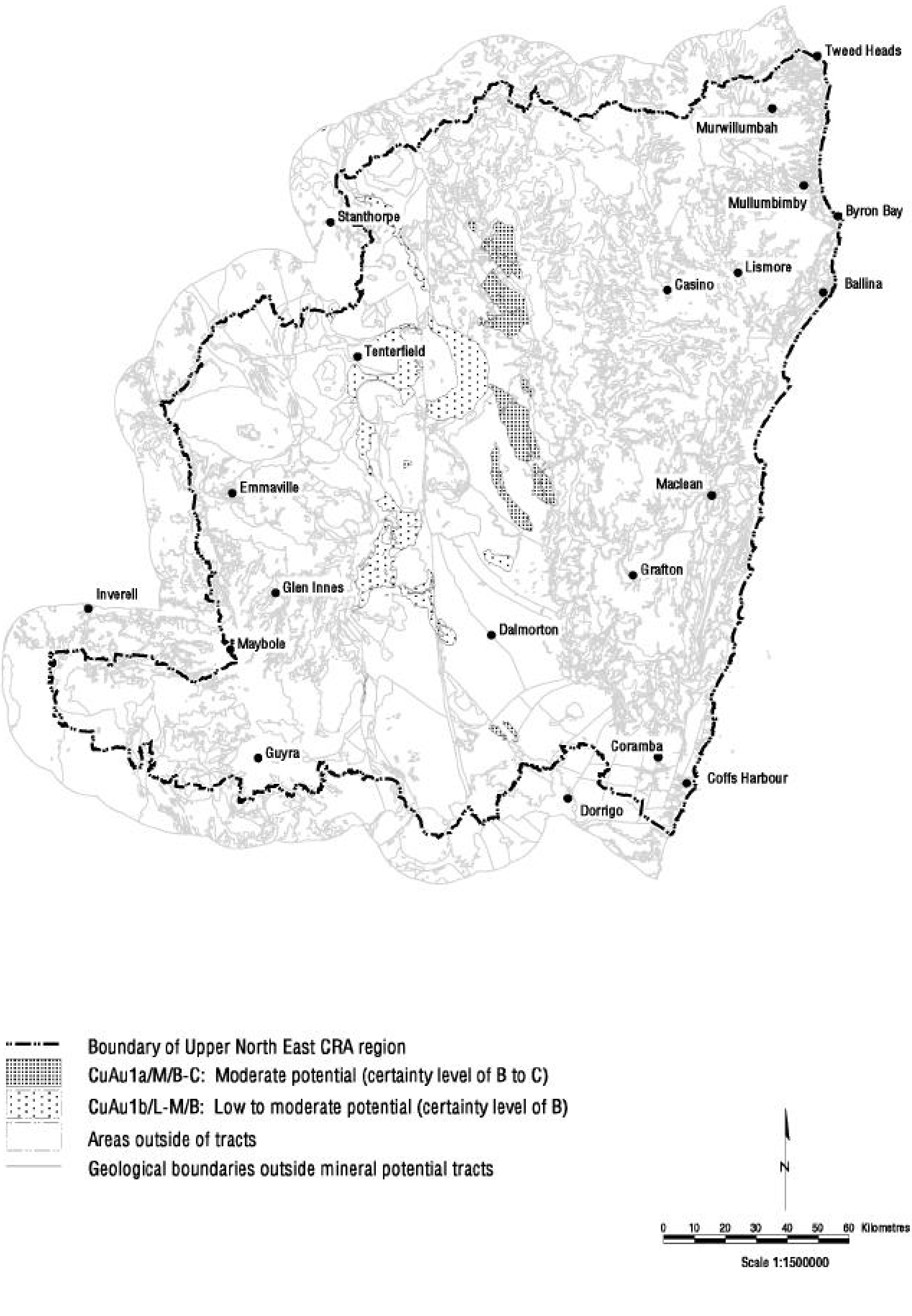
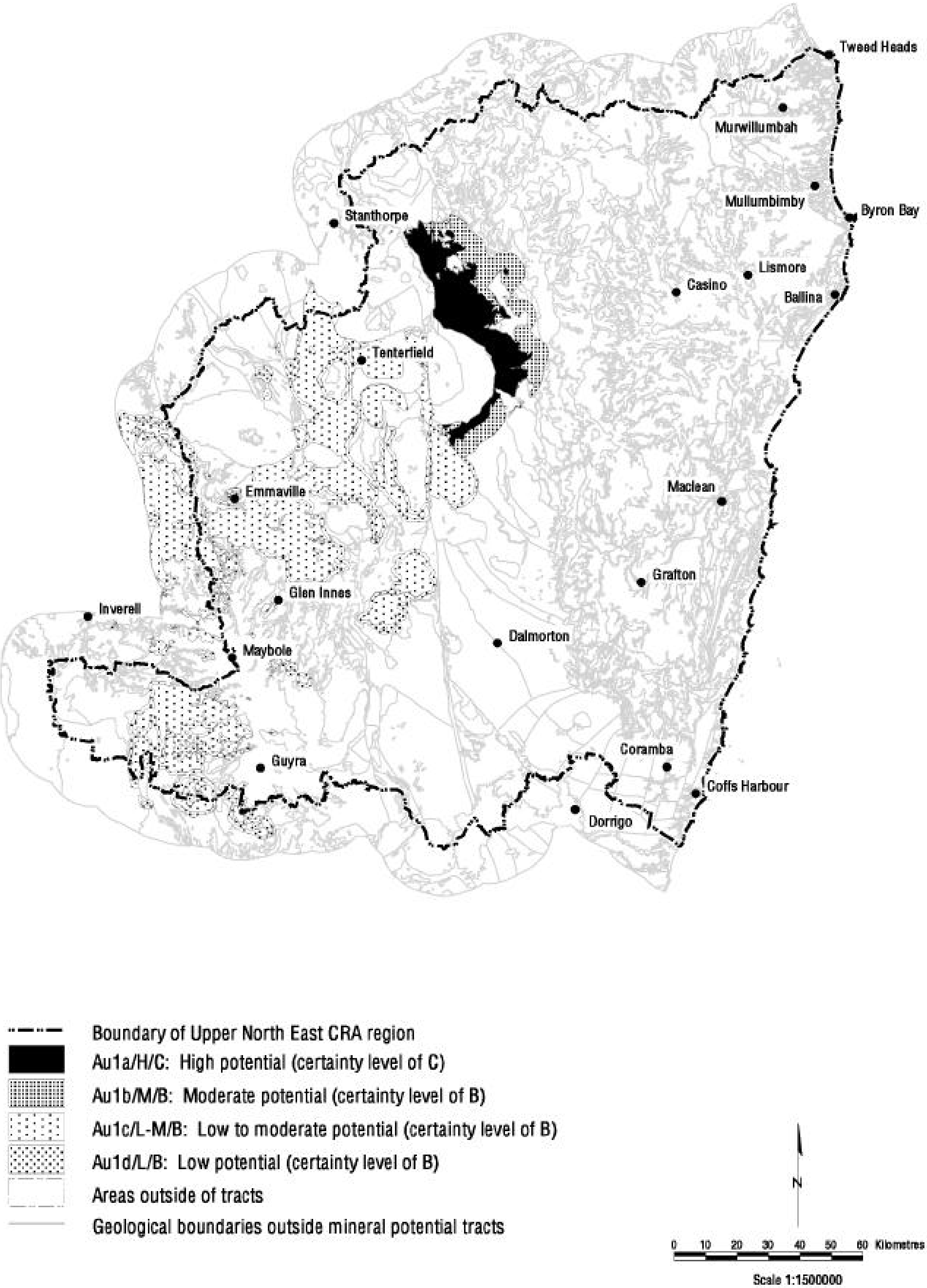


Figure 6. Mineral potential tracts for epithermal gold deposits.



Tract Au1c/L-M/B

The tract is defined by the presence of the rocks of the Wandsworth Volcanic Group excluding the Drake Volcanics and the Gilgurry Mudstone. Unlike the Drake Volcanics which are more mafic, the rocks of the Wandsworth Group do not contain as many, high level, co-magmatic, felsic intrusions (stocks and dykes) which might be an important factor in generating and maintaining epithermal systems. The volcanics in the tract do not contain any notable epithermal mineralisation but locally are characterised by low to moderated levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. Mineral potential of the tract is assessed to be low to moderate with a certainty level of B.

Tract Au1d/L/B

The tract is defined by a one kilometre buffer around the Wandsworth Volcanic Group rocks of the tract Au1c/L-M/B to delineate the extent of a possible epithermal system generated by the volcanic system. As the mineral potential of the tract defined by the volcanics has been assessed to be low to moderate (see tract Au1c/L-M/B), the potential of the buffer is assessed to be low with a certainty level of B.

8.5 GRANITOID RELATED DISSEMINATED GOLD DEPOSITS (TIMBARRA STYLE) (FIGURE 7)

Tract Au2a/H/B

The tract includes I-type, fractionated granitoids (The Stanthorpe Adamellite). They are classified as the Stanthorpe subtype of the larger Stanthorpe Granite Group (Blevin and Chappell 1996). The $Fe2O3/Fe3O4$ ratio of a few samples indicates a low oxidation state and on the aeromagnetics they appear as magnetic lows. They contain all the known occurrences of this type including Poverty Point, RMT, Big Hill and Hortons. In the areas of known occurrences they show sericitic and chloritic alteration. The tract is locally characterised by moderate levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. The potential of the tract is assessed to be high with a certainty level of B.

Tract Au2b/M-H/B

The tract includes I-type, fractionated granitoids (Billyrimba Leucoadamellite, Bolivia Range Leucoadamellite, Bungulla Adamellite, Clive Adamellite, Mackenzie Adamellite, Nonigton Leucoadamellite, Pyes Creek Leucoadamellite, Undercliff Falls Adamellite and an Unnamed complex at Sugarloaf). These granitoids belong to the Bugualla and Stanthorpe types of the larger Stanthorpe Granite Group (Blevin and Chappell 1996). The $Fe2O3/Fe3O4$ ratio of a few samples indicates a low oxidation state and on the aeromagnetics they appear as magnetic lows. The tract also contains areas of moderate to high levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. They don’t host any known occurrences of disseminated gold but contain occurrences of alluvial gold. However the granitoids are geochemically and petrologically similar to those outlined the tract Au2a/H/B and could have crystallised from similar felsic melt. Hence the mineral potential of the tract is assessed to be moderate to high with a certainty level of B.

Tract Au2c/L/B

The tract incudes all other I-type granites and leucoadamellites except the highly magnetic Clarence River Plutonic Suite which have been assessed to have a moderate potential to host porphyry copper-gold deposits. These granites have variable magnetic response on the aeromagnetics and could be responsible for low to moderate levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. They could also be the source of several occurrences of alluvial gold. The tract however does not host any known occurrences of disseminated gold hence the potential is assessed to be low with a certainty level of B.

8.6 HEAVY MINERAL SANDS (FIGURE 8)

Tract HMS1a/H/C-D

This tract includes present day beach and dune sands and also includes older dune and swamp deposits on the coastal plain where the presence of heavy mineral sands has been defined by drilling and/or is an extension of these known areas. On available information there is a high potential, with a certainty of C, for heavy mineral concentrations of sufficient size to be of economic interest. Such deposits may contain small amounts of gold. The heavy mineral concentrations may occur largely within the older dune systems and in fossil shoreline sediments and in strandlines resting on basement rocks.

Figure 7. Mineral potential tracts for granitoid related disseminated gold deposits (Timbarra style).

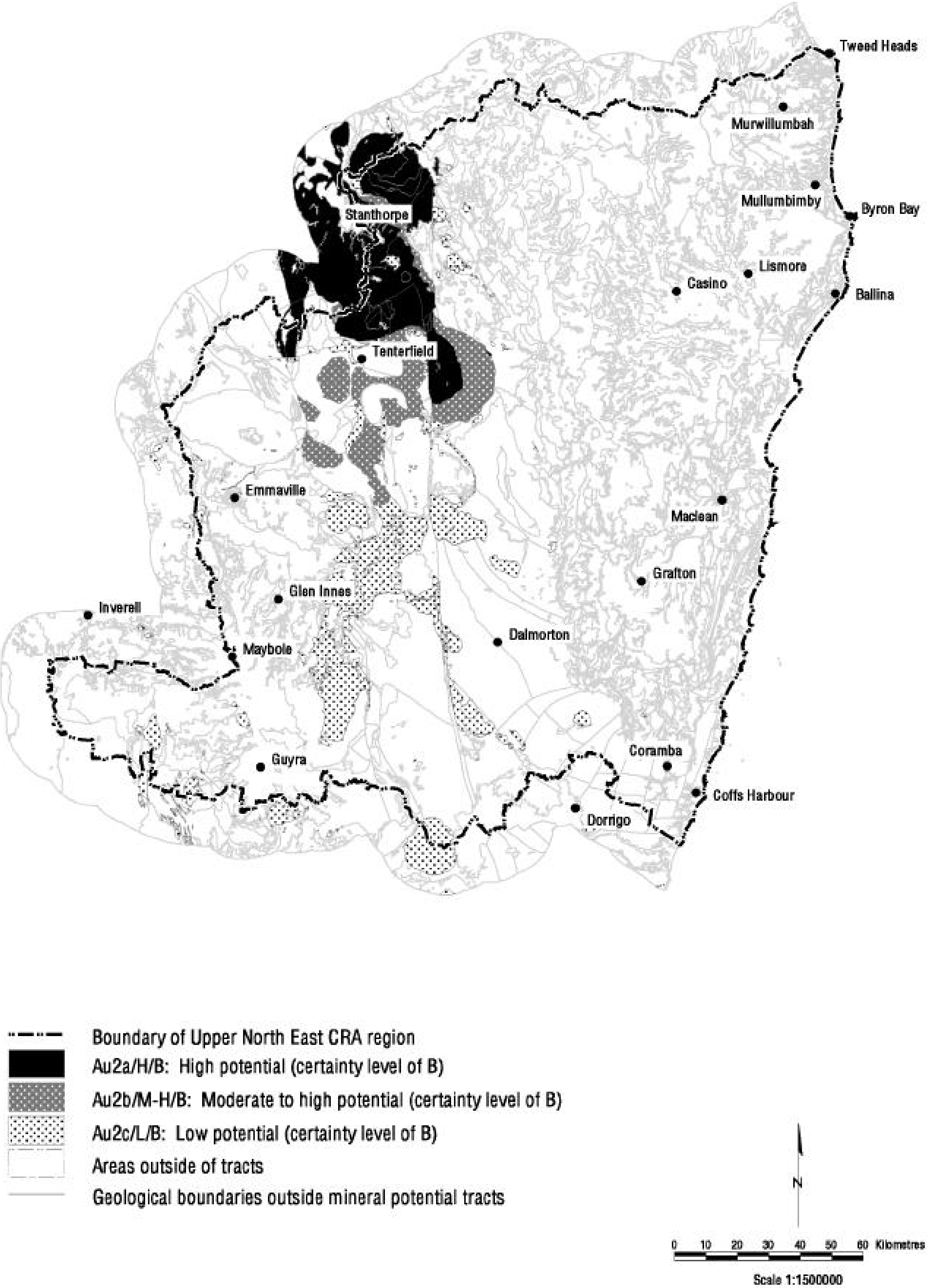


Figure 8. Mineral potential tracts for heavy mineral sand.

Tract HMS1b/M-H/C

The tract covers Quaternary (Pleistocene and Recent) sandy sediments in areas where heavy mineral sands are known to have been mined out, but where extensions or lower grade halos could be possible or become mineable by improved technology. This tract is assessed on available information as having moderate to high potential, with a certainty of C, for heavy mineral concentrations of sufficient size to be of economic interest.

Tract HMS1c/M/B

The tract covers Quaternary sediments close to the present or palaeoshore lines. There is a moderate potential, with a certainty of B, for heavy mineral concentrations of sufficient size to be of economic interest. If heavy mineral concentrations are present in above tracts, they may also contain trace amounts of gold.

8.7 OPEN CUT COAL (FIGURE 9)

Tract Coal1a/M-H/B-C

The tract has moderate to high potential and is defined by the presence of Walloon Coal Measures at outcrop and at depths with opencut potential where geological structure indicates shallow dip and the anticipated thickness of the main coal sequence may be of mineable thickness. The tract covers an area on the western side of the basin, north of Urbenville and extending northerly into Queensland. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. A certainty of B for this tract is due to poor quality data with no subsurface data.

A further tract with moderate to high potential is located in the central northern part of the basin extending from Nimbin north to Tyalgum. This tract is defined by the presence of Walloon Coal Measures at outcrop and at depths with opencut potential where geological structure indicates shallow dip and the anticipated thickness of the main coal sequence may be of mineable thickness. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. A certainty of C is based on moderate quality data including previous mining.

Tract Coal1b/M/C

The tract of moderate potential for open cut coal is defined by the presence of Walloon Coal Measures at outcrop with opencut potential and the thickness of the main coal sequence is likely to be less than 15 metres. The tract extends around the majority of the basin edge from Urbenville in the north west, to Glenreagh in the south and along the eastern side of the basin as far north as the Coraki-Lismore area. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. Areas overlain by Quaternary sediments are not excluded. A certainty of C is based on moderate quality data.

Another tract with moderate potential for locating opencut coal is defined by the presence of Nymboida Coal Measures at outcrop and at possible depths no greater than 100 metres. The tract is located at the south western margin of the basin. It is bounded by the Martin Fault in the north and extends south east into the Towallum area. A certainty of C is based on a moderate level of borehole data and previous mining at Nymboida Colliery.

8.8 VOLCANOGENIC MASSIVE SULPHIDE BASE METALS (FIGURE 10)

Tract BM1a/M/C

The tract includes the accretionary-prism rocks of the ophiolitic assemblage consisting of mafic and felsic volcanics and volcaniclastics and their metamorphic equivalents. It also includes sedimentary and metasedimentary rocks formed in proximity to submarine volcanic environment. The best markers of these environments are cherts, jaspers, manganese-rich sedimentary facies and magnetite rich rocks. The tract also includes all the known occurrences of volcanic associated massive sulphide mineralisation. Mineral potential of the tract is assessed to be moderate with a certainty level of C.

Figure 9. Mineral potential tracts for open cut coal deposits.

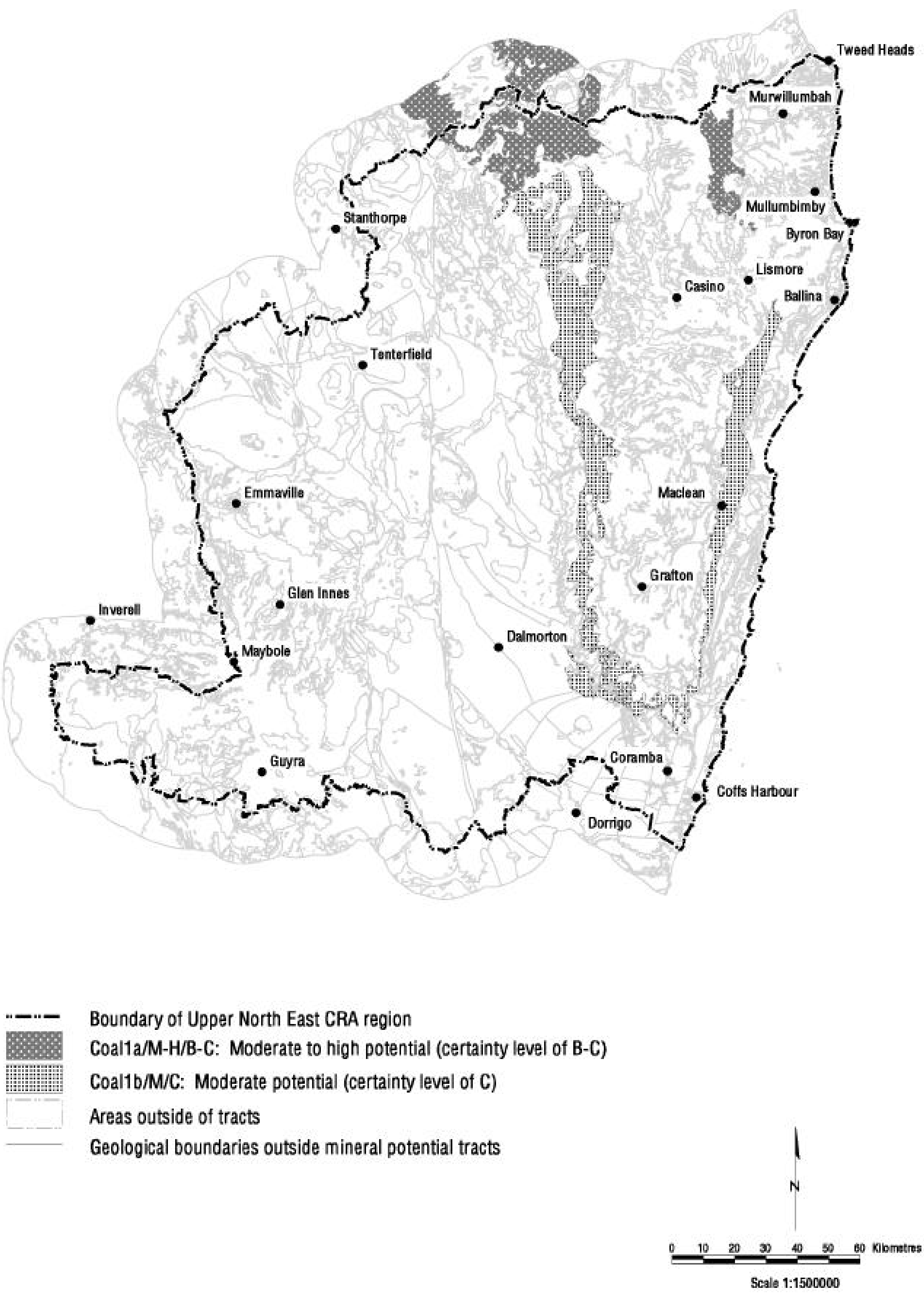
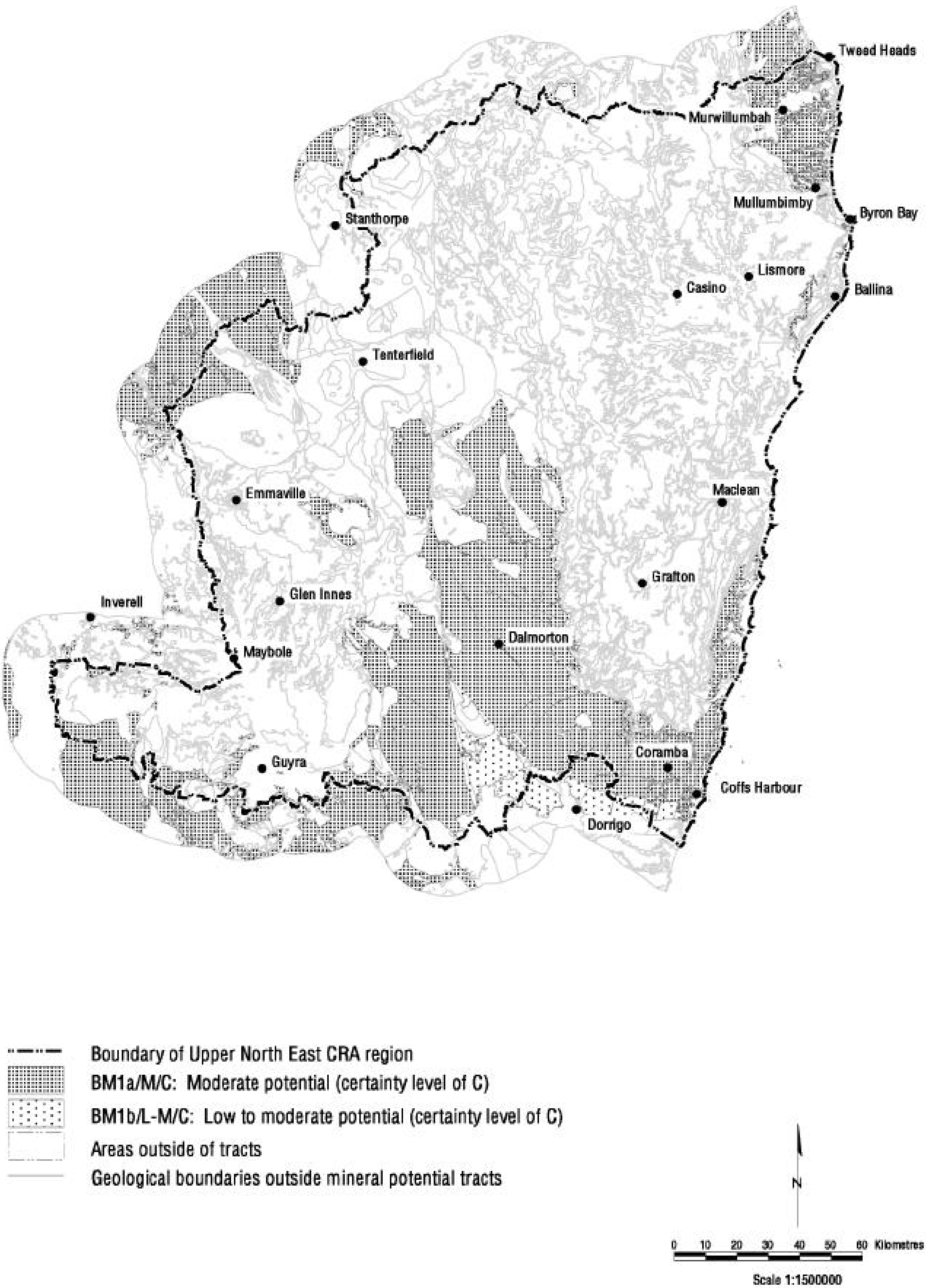


Figure 10. Mineral potential tracts for volcanic associated massive sulphide deposits.



Tract BM1b/L-M/C

The tract includes the rest of the accretionary-prism rocks which are not reported to have chert or jasper horizons but are indicative of a general ophiolitic-related geological environment. The tract does not host any known mineral occurrences of volcanic associated massive sulphides. However these rocks have features which are indicative broad ophiolitic assemblage. It is also possible that these rocks host some distal volcanic-massive sulphide mineralisation. Hence the potential of the tract is assessed as low to moderate with a certainty level of C.

8.9 METAHYDROTHERMAL VEIN GOLD-ANTIMONY VEIN DEPOSITS (FIGURE 11)

Tract Au3a/H/B

This tract consists of metasediments of early Triassic or older age and Permo-Carboniferous S-type granitoids within two kilometres of known faults. Over 95% of known gold-antimony-quartz vein occurrences lie within the tract. Potential for the discovery of economic gold-antimony-quartz vein deposits in this tract is high with a certainty level of B.

Tract Au3b/M-H/B

This tract includes metasediments of early Triassic or older age and S-type granitoids not within two kilometres of a known fault, where unmapped faults with undiscovered surface or concealed gold-antimony-quartz vein deposits may occur. Potential for such deposits is considered moderate to high with a certainty level of B.

Tract Au3c/L-M/B

This tract delineates areas where Tract Au3a extends beneath Tertiary basaltic lavas and the Mesozoic age cover rocks to depths of 1000 metres along the western, southern and north-eastern margins of the Clarence-Moreton Basin. A similar zone is defined around a “window” of the older metasediments of the Mt Barney Beds on the central northern edge of the UNER. Detection of gold-antimony-quartz vein deposits by geophysics and drilling is possible.

Potential for such concealed economic gold-antimony-quartz vein deposits under Mesozoic and Tertiary rocks is considered low to moderate with a certainty level of B.

Where metasediments of early Triassic or older age and S-type granitoids occur outside Tract Au3a and appear to extend under Mesozoic and Tertiary rocks potential for economic gold-antimony-quartz vein deposits is unknown, with a certainty level of A.

Disseminated gold deposits often occur as lower grade halos around higher grade metahydrothermal gold-low sulphide or antimony-gold vein-quartz deposits. Significant mineralisation of this type occurs in Bendigo-Ballarat and Melbourne Zones in Victoria. Conditions suitable for formation of such halo deposits may have existed in the UNER but a lack of relevant detailed data prevents a reliable assessment of their mineral potential.

8.10 UNDERGROUND COAL (FIGURE 12)

Tract Coal2a/M/B

The tract is defined by the presence of Walloon Coal Measures at depths no greater than 300 metres to the top of the formation. The tract has moderate potential for underground coal only. This tract is generalised to the outcrop extent of the Kangaroo Creek Sandstone which overlies the coal measures and has a thickness of between 200 and 500 metres. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. Areas overlain by Quaternary sediments are not excluded. Certainty of B is based on poor quality data with borehole spacing between 20 and 30 kilometres.

Figure 11. Mineral potential tracts for metahydrothermal gold-antimony vein deposits.

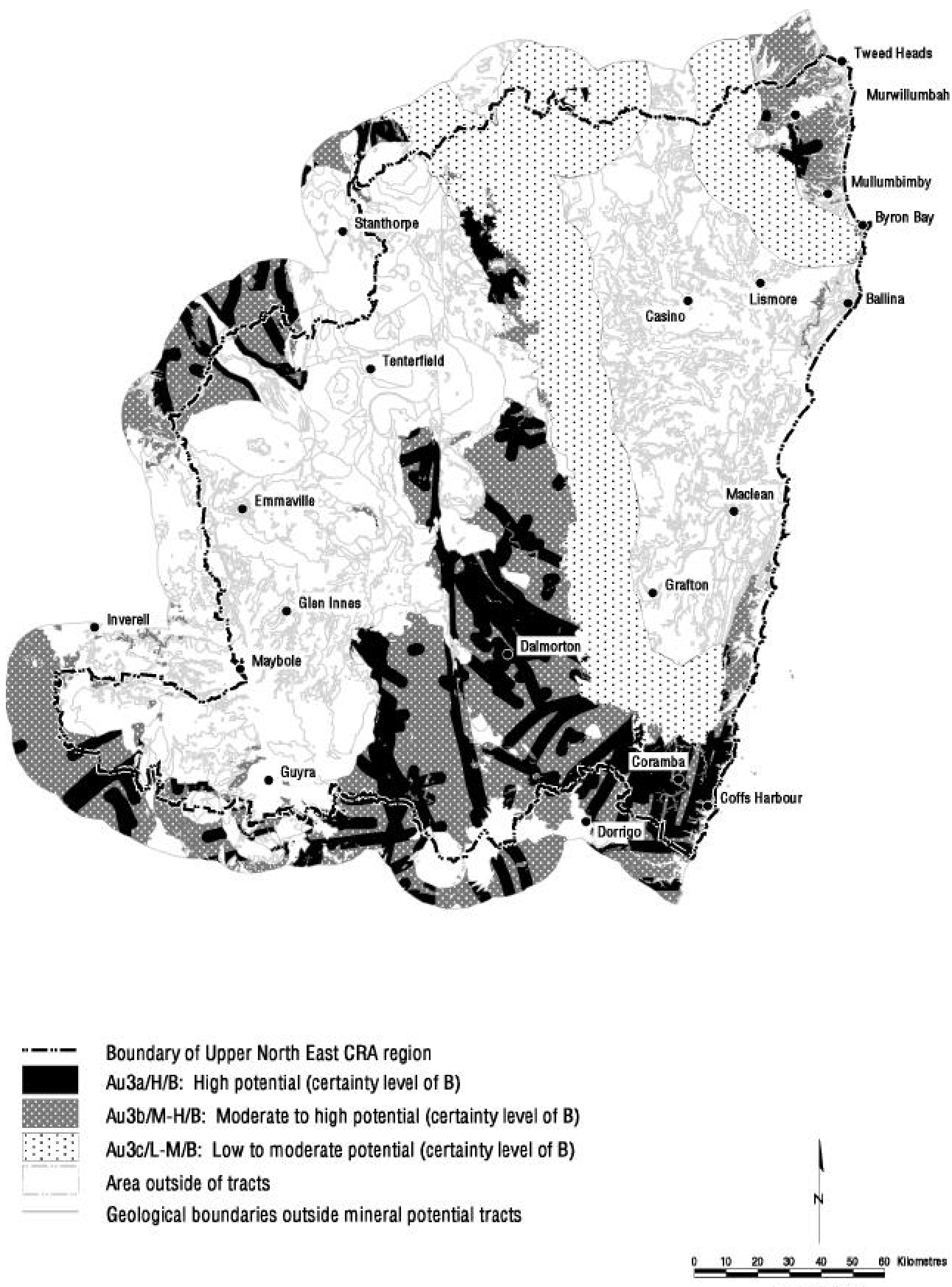
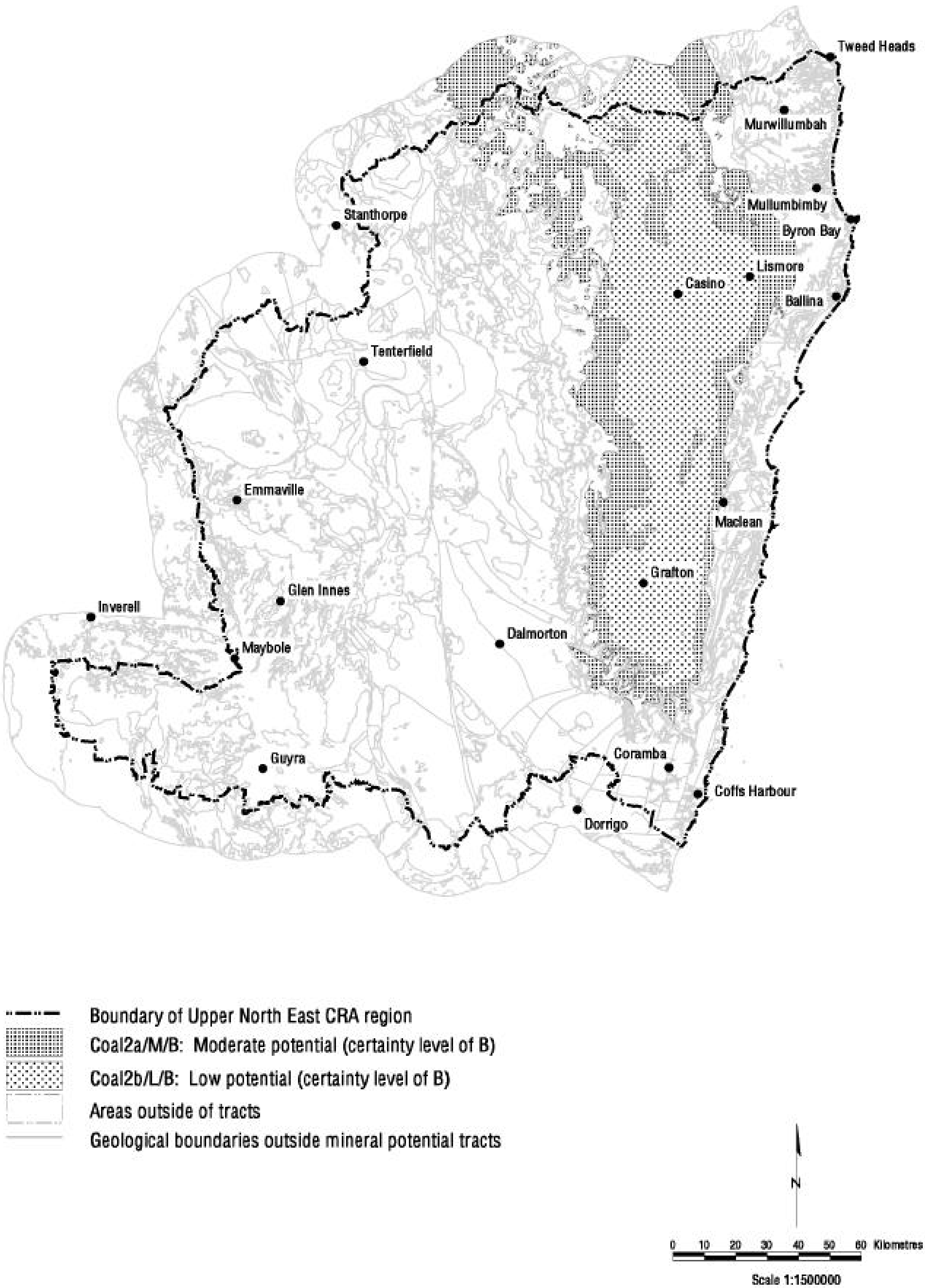


Figure 12. Mineral potential tracts for underground coal deposits.



A second tract with moderate potential is defined by the probable presence of Walloon Coal Measures with similar quality to shallower coal seams within the same region. Within this tract the Walloon Coal Measures are overlain by extensive Tertiary volcanic flows with a depth of cover no greater than 300 metres to the top of the formation. This tract occurs mainly in the north western part of the basin from Mummulgum north to the Woodenbong area where extensive Tertiary volcanic flows overlie the Walloon Coal Measures. A certainty of B is based on the probable presence of Walloon Coal Measures but with a lack of knowledge due to lack of subsurface data.

A third tract delineates areas with moderate potential for underground coal and is defined by the possible presence of Nymboida Coal Measures at mineable depth beneath the lower Bundamba Group, downdip from the mapped outcrop extent to an approximated depth of 300 metres. The tract is terminated to the north east by the Martin Fault. A certainty of B is based on the lack of any subsurface data.

Tract Coal2b/L/B

The tract is defined by the probable presence of Walloon Coal Measures at depths greater than 300 metres to the top of the formation. This tract is generalised to the outcrop extent of the Grafton Formation. Areas of thick Tertiary volcanic flows where depth of cover to the Walloon Coal Measures is expected to exceed 300 metres are included. The outcrop extent of intrusions such as plugs, dykes and volcanic complexes are excluded. Areas overlain by Quaternary sediments are not excluded. The tract delineates areas of low potential for underground coal based on the expected depth to coal being greater than 300 metres. A certainty of B is based on the expected presence of Walloon Coal Measures throughout the area with no coal quality information and only limited data from petroleum well chip logs. The possibility remains that unknown structures such as faults or anticlines may position the Walloon Coal Measures at shallower depths than expected.

8.11 SILVER-BEARING POLYMETALLIC VEIN DEPOSITS (FIGURE 13)

Tract BM2a/H/B-C

This tract includes the (I-type) Mole, Gilgai and Ruby Creek Leucogranites plus a five kilometre buffer around these bodies. These are extremely fractionated and reduced granite bodies, although there appears to be some degree of variability in their relative oxidation (particularly within the Ruby Creek Granite). A large number of silver-bearing veins are associated with each of these bodies and each intrusive hosts, or is closely related to important silver-bearing polymetallic veins deposits (Mole -Taronga, Ruby Creek - Sundown, Gilgai - Conrad). This tract also includes the Tingha granite, which although part of the Uralla suite, has been intruded by the upper parts of the Gilgai granite and has provided a highly suitable host for many silver-bearing vein deposits whose source is very probably fluids from the Gilgai Granite.

The tract also includes a sub-surface south west extension of the Mole Granite, interpreted from a magnetic low and from the presence of numerous polymetallic vein and tin occurrences.

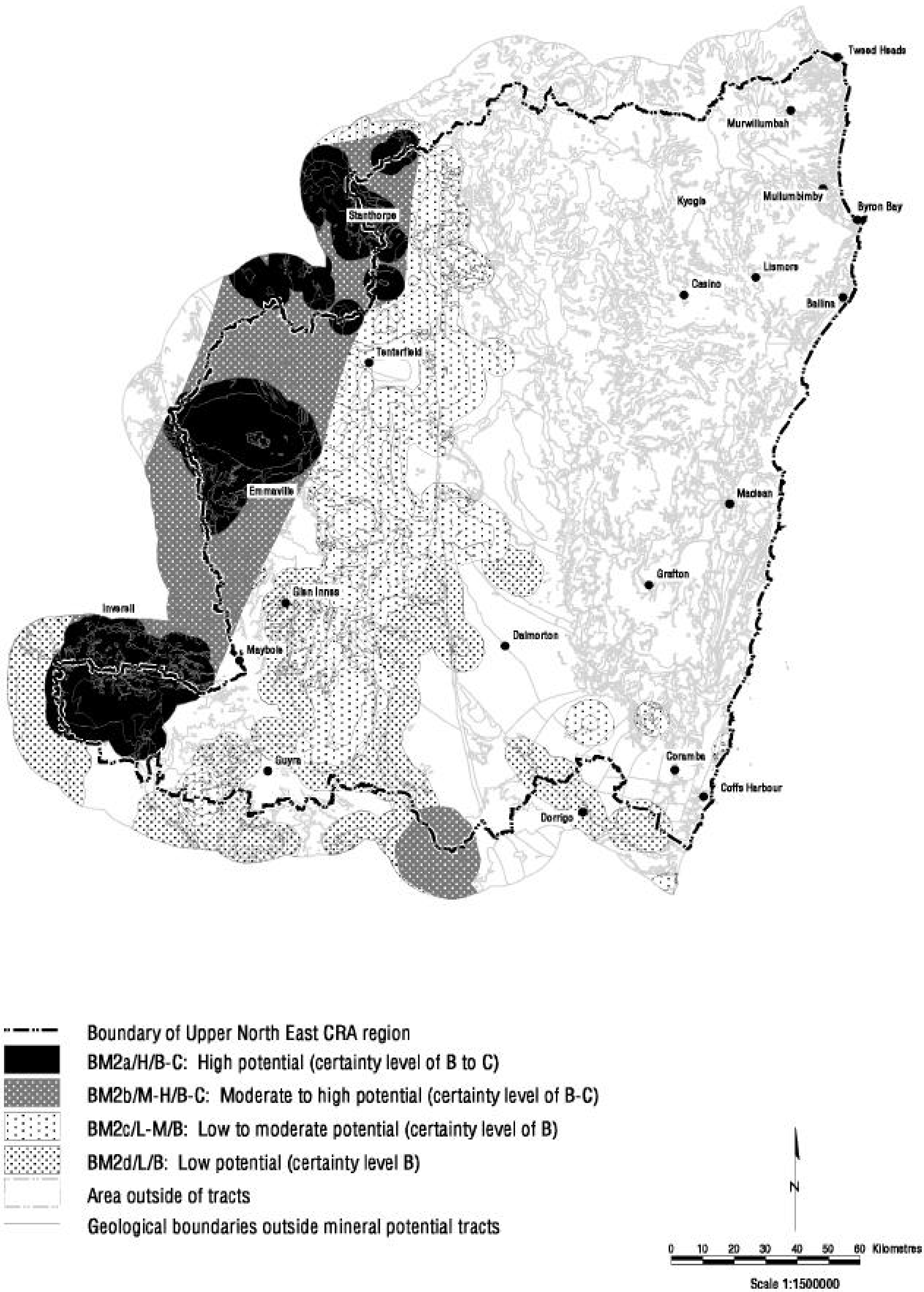
Mineral potential of the tract is assessed to be high with a certainty level of B in areas of subsurface extension of granites interpreted from magnetic lows. For the rest of the tract the certainty level is C.

Tract BM2b/M-H/B-C

This tract has been defined by drawing a corridor running between the high potential areas mentioned in the above Tract BM2a/H/B-C. Numerous silver-rich base metal veins (distal varieties of the Sn vein-type deposits) occur within this tract hosted by country rocks other than granite. The tract generally has a low magnetic response, similar to that of the high potential granites. The tract also contains the fractionated, I-type and reduced (ilmenite is the only opaque mineral) Round Mountain Leucoadamellite of the Gundle Suite plus a 5 kilometre buffer around it.

The potential is assessed to be Moderate to High with a certainty level of B for the area defined by the corridor and with a certainty level of C for the area occupied by the Round Mountain adamellite.

Figure 13. Mineral potential tracts for silver-bearing polymetallic vein deposits.



Tract BM2c/L-M/B

This tract includes the leucogranites and a 5 kilometre buffer, excluding those granites which are included in the Tract BM2a/H/B-C. These granites not as fractionated as those in the Tract BM2a/H/B-C and are locally more oxidised, and show variable levels of oxidation state. Numerous small occurrences are hosted by these leucogranites, especially the Dandahra Leucogranite and parts of the Red Range Microleucogranite. The potential of the tract is assessed to be low – moderate with a certainty level of B.

Tract BM2d/L/B

This tract is defined by the presence of relatively reduced, not very fractionated granitoids of the Uralla, Bundarra and Hillgrove suites. It also contains granites of the Moonbi Suite which are slightly more oxidised. The Uralla (I-type) and Bundarra (S-type) suites both contain silver-bearing basemetal occurrences. Granites of the (I-type) Moonbi suite are characterised as relatively oxidised and vary in relative oxidation states. Moonbi Suite Granites are not as fractionated as the leucogranites but contain a few occurrences of silver-bearing basemetal veins. Thus low degree of fractionation as well as relatively oxidised nature of these granitoids means that the potential of the tract is low with a certainty level of B.

8.12 TIN VEIN DEPOSITS (FIGURE 14)

Tract Sn1a/H/B-C

This tract includes the (I-type) Mole, Gilgai and Ruby Creek leucogranites plus a five kilometre buffer around these bodies. These are extremely fractionated and reduced granite bodies, although there appears to be some degree of variability in their relative oxidation (particularly within the Ruby Creek Granite). A large number of Sn deposits are associated with each of these bodies and each host or are closely related to large Sn deposits (Mole - Taronga, Ruby Creek - Sundown, Gilgai - Conrad). This tract also includes the Tingha granite, which although part of the Uralla suite, has been intruded by the upper parts of the Gilgai granite and has provided a highly suitable host for many Sn deposits whose source is very probably fluids from the Gilgai granite.

The tract also includes a sub-surface south west extension of the Mole Granite, interpreted from a magnetic low and from the presence of numerous tin and polymetallic vein occurrences.

Mineral potential of the tract is assessed to be high with a certainty level of B in areas of subsurface extension of granites interpreted from magnetic lows. For the rest of the tract the certainty level is C.

Tract Sn1b/M-H/B-C

This tract has been defined by drawing a corridor running between the high potential areas mentioned in Tract Sn1a/H/B-C. Numerous Sn and base metal veins (distal varieties of the Sn vein-type deposits) occur within this tract hosted by country rocks other than granite. The tract also generally has a low magnetic response, similar to that of the high potential granites.

The tract also contains, fractionated, I-type and reduced (ilmenite is the only opaque mineral) Round Mountain leucoadamellite of the Gundle Suite plus a 5 kilometre buffer around it. The tract contains a few significant tin deposits.

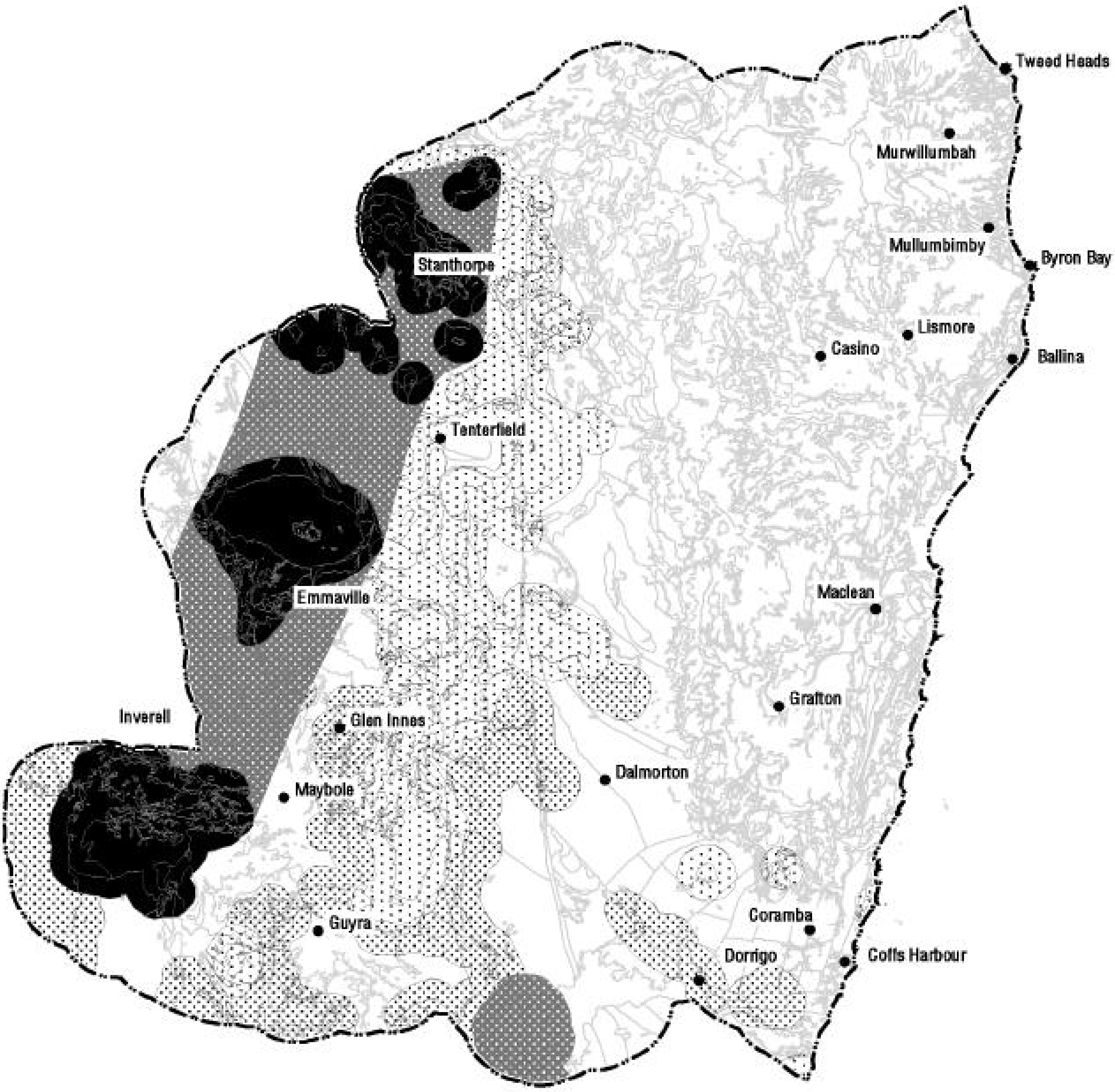
The potential is assessed to be moderate to high with a certainty level of B for the area defined by the corridor and with a certainty level of C for the area occupied by the Round Mountain adamellite.

Tract Sn1c/L-M/B

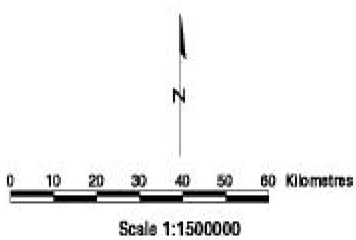
This tract includes leucogranites and a 5 kilometre buffer, excluding those granites which are included in the Tract Sn1a/H/B-C. These granites are not as fractionated as those in the Tract Sn1a/H/B-C and are locally more oxidised, and show variable levels of oxidation state. Numerous small occurrences are hosted by these leucogranites, especially the Dandahra Leucogranite and parts of the Red Range Microleucogranite.

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

Figure 14. Mineral potential tracts for tin vein deposits.



Boundary of Upper North East CRA region
Sn1a/H/B-C: High potential (certainty level of B to C)
Sn1b/M-H/B-C: Moderate to high potential (certainty level of B to C)
Sn1c/L-M/B: Low to moderate potential (certainty level of B)
Sn1d/L/B: Low potential (certainty level of B)
Area outside of tracts
Geological boundaries outside mineral potential tracts



Tract Sn1d/L/B

This tract is defined by the presence of relatively reduced, not very fractionated granitoids of the Uralla, Bundarra and Hillgrove suites. It also contains granites of the Moonbi Suite which are slightly more oxidised. The Uralla (I-type) and Bundarra (S-type) suites both contain rare, small Sn occurrences. Granites of the (I-type) Moonbi suite are characterised as relatively oxidised vary in relative oxidation states. Moonbi Suite Granites are not as fractionated as the leucogranites but contain a few occurrences of tin veins. Thus low degree of fractionation as well as relatively oxidised nature of these granitoids means that the potential of the tract is low with a certainty level of B.

8.13 TIN GREISEN DEPOSITS (FIGURE 15)

Tract Sn2a/H/B-C

The tract is the same as the tract Sn1a/H/B-C for tin veins except that the 5 kilometre buffer is not used for tin greisens. This tract includes the (I-type) Mole, Gilgai and Ruby Creek Leucogranites. These are extremely fractionated and reduced granite bodies, although there appears to be some degree of variability in their relative oxidation (particularly within the Ruby Creek Granite). A large number of Sn deposits are associated with each of these bodies and each host or are closely related to large Sn deposits (Mole - Taronga, Ruby Creek - Sundown, Gilgai - Conrad). This tract also includes the Tingha granite, which although part of the Uralla suite, has been intruded by the upper parts of the Gilgai granite and has provided a highly suitable host for many Sn deposits whose source is very probably fluids form the Gilgai granite.

The tract also includes a sub-surface south west extension of the Mole Granite, interpreted from a magnetic low and from the presence of numerous tin and polymetallic vein occurrences.

Mineral potential of the tract for tin greisen deposits is assessed to be high with a certainty level of B in areas of subsurface extension of granites interpreted from magnetic lows. For the rest of the tract the certainty level is C.

Tract Sn2b/M-H/B

The tract is the same as the tract Sn1b/M-H/B for tin veins except that a 5 kilometre buffer around the Gundle Suite, is not used for tin greisen deposits. This tract has been defined by drawing a corridor running between the high potential areas mentioned in Sn1b. Numerous Sn and base metal veins (distal varieties of the Sn vein-type deposits) occur within this tract hosted by country rocks other than granite. The tract also generally has a low magnetic response, similar to that of the high potential granites.

The tract also contains fractionated, I-type and reduced (ilmenite is the only opaque mineral) Round Mountain Leucoadamellite of the Gundle Suite. The tract contains a few significant tin deposits.

The potential is assessed to be moderate to high with a certainty level of B for the area defined by the corridor and with a certainty level of C for the area occupied by the Round Mountain adamellite.

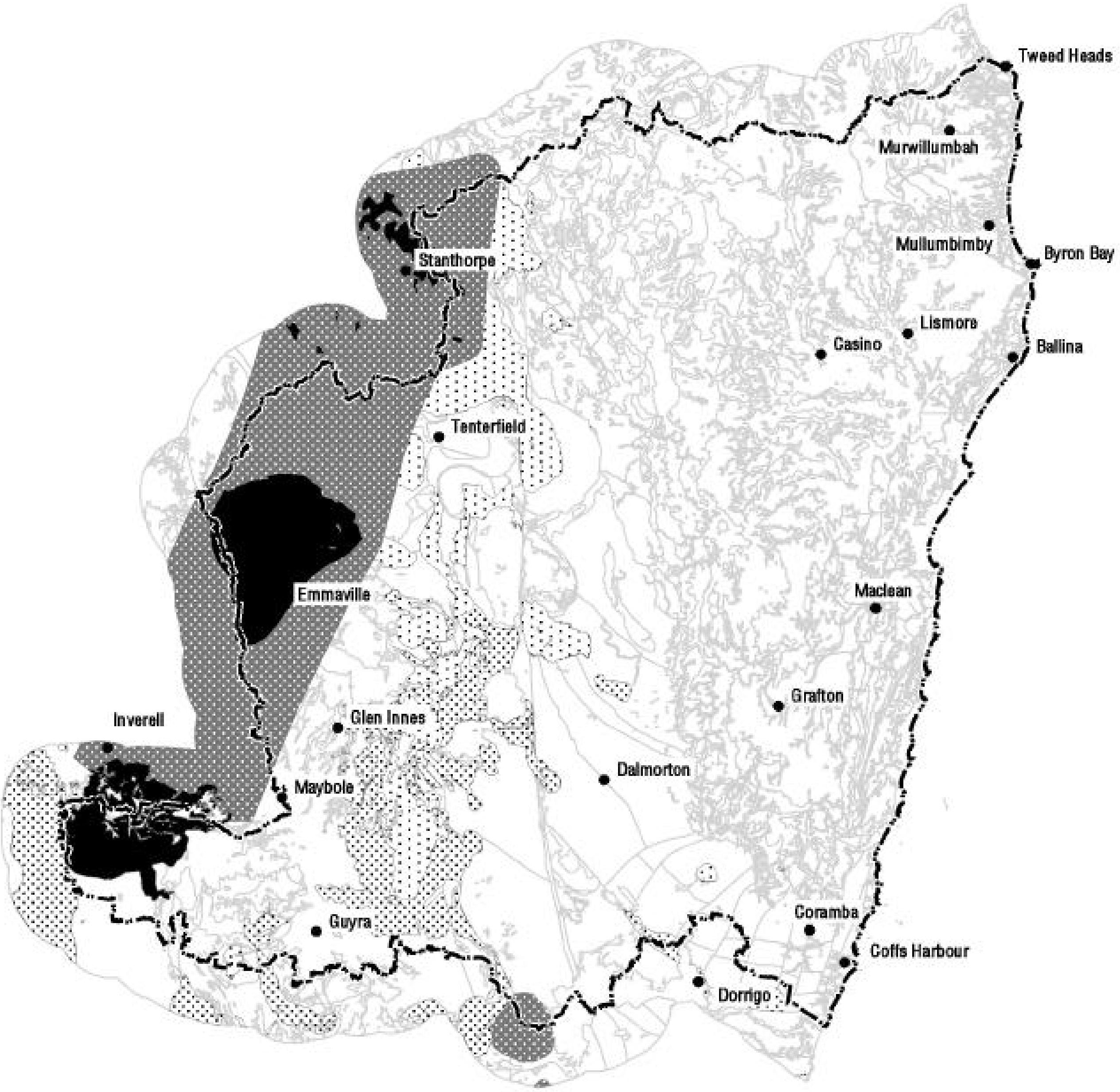
Tract Sn2c/L-M/B

The tract is the same as the tract Sn1c/L-M/B for tin veins except that a 5 kilometre buffer around granite is not applied. The tract includes leucogranites, excluding those granites which are included in the tract Sn2a/H/B-C. These granites not as fractionated as those in the Tract Sn2a/H/B-C and are locally more oxidised, and show variable levels of oxidation state. Numerous small occurrences are hosted by these leucogranites, especially the Dandahra Leucogranite and parts of the Red Range Microleucogranite. The potential of the tract is assessed to be low – moderate with a certainty level of B.

Tract Sn2d/L/B

The tract is the same as the tract Sn1d/L/B for tin veins except for the 5 kilometre buffer around granite. The tract is defined by the presence of relatively reduced, not very fractionated granitoids of the Uralla, Bundarra and Hillgrove suites. It also contains granites of the Moonbi Suite which are slightly more oxidised. The Uralla (I-type) and Bundarra (S-type) suites both contain rare, small Sn occurrences. Granites of the (I-type) Moonbi suite are characterised as relatively oxidised vary in relative oxidation states. Moonbi Suite Granites are not as fractionated as the leucogranites but contain a few occurrences of tin veins. Thus low degree of fractionation as well as relatively oxidised nature of these granitoids means that the potential of the tract is low with a certainty level of B.

Figure 15. Mineral potential tracts for tin greisen deposits.



Boundary of Upper North East CRA region
Sn2a/H/B-C: High potential (certainty level of B to C)
Sn2b/M-H/B: Moderate to high potential (certainty level of B)
Sn2c/L-M/B: Low to moderate potential (certainty level of B)
Sn2d/L/B: Low potential (certainty level of B)
Areas outside of tracts
Geological boundaries outside mineral potential tracts

8.15 ALLUVIAL DIAMONDS (FIGURE 16)

Tract Dimnd/H/C

This tract consists of Tertiary basalt lavas or sediments within a five kilometre radius of known mineral occurrences that have diamond recorded as a major commodity or have recorded diamond production. These five kilometre buffers are designed to coalesce into a north west to south east trending zone that includes the Copeton alluvial diamond occurrences and associated known Tertiary basalts and sediments, possibly controlled by Tertiary palaeo-drainage.

The potential for economic alluvial diamond deposits associated with old workings of these diamond occurrences is considered high with a certainty level of C.

This tract does not include placer diamond deposits associated with concealed Tertiary sediments within the above five kilometre buffers, as existing data is insufficient to assess their potential.

Diamonds have been reported from Quaternary tin placers but no significant alluvial diamond deposits have been recorded. Dilution by the sediment load in the Quaternary streams may have hindered the formation of such deposits (MacNevin 1977 p.39, 40).

Concealed Quaternary alluvial sediment horizons could host placer diamond deposits but existing information does not allow assessment of their potential. Hence the potential for diamond deposits formed by the erosion of diamonds from the Tertiary sediments into Quaternary streams is unknown.

8.16 ALLUVIAL SAPPHIRES (FIGURE 17)

Tract Sapp1a/M-H/C

Significant sapphire concentrations and occurrences are restricted to Quaternary and Tertiary sediments within a 60 kilometre radius of the Mount Maybole shield volcano centre. These Quaternary and Tertiary sediments may contain economic sapphire deposits and the Quaternary sediments may conceal Tertiary sediments with economic sapphire deposits.

This tract includes the above Quaternary and Tertiary sediments within:
(a) a 20 kilometre buffer around Tertiary basalt lavas and basalt lava outcrop and
(b) basalt lava outcrop.

Outside the 20 kilometre buffer, sapphire is thought to have been largely destroyed or diluted by sediments during erosion and transport.

Also included in the tract are 100 metre buffers along creeks in area (a) to take account of unmapped Quaternary and Tertiary sediments.

Some known alluvial sapphire deposits that are marginally economic may become viable in the foreseeable future. Brown (1997) suggests that there are considerable resources remaining in known deposits and others await discovery, while paler blue sapphire in the eastern part of the tract is under exploited. Thus the potential for economic sapphire deposits in this tract is considered moderate to high with a certainty level of C.

Concealed deep lead deposits derived from previously removed Tertiary basalt lavas/pyroclastics may also exist beneath Quaternary sediments outside the above 20 kilometre buffer but there are insufficient data to assess their potential.

The minor occurrences of alluvial sapphire along the western margin of the Ebor Volcanics have not been included in the tract, as the potential for economic sapphire deposits is considered very low. The large Tweed shield volcano, in the north east of the UNER, has also been excluded, as there are no recorded sapphire occurrences despite considerable partial erosion of its basal volcanic rock units.

Figure 16. Mineral potential tracts for alluvial diamond deposits.

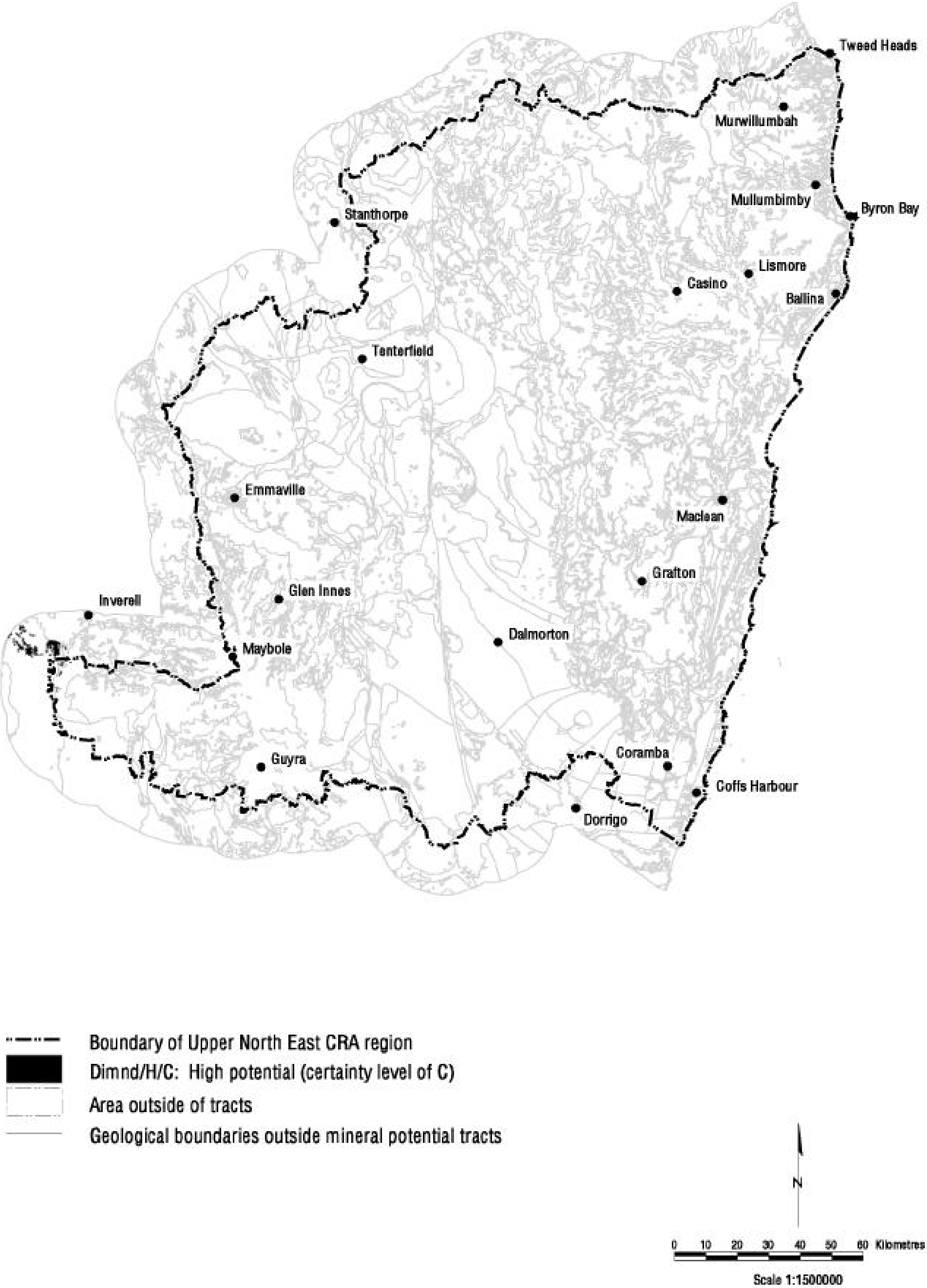
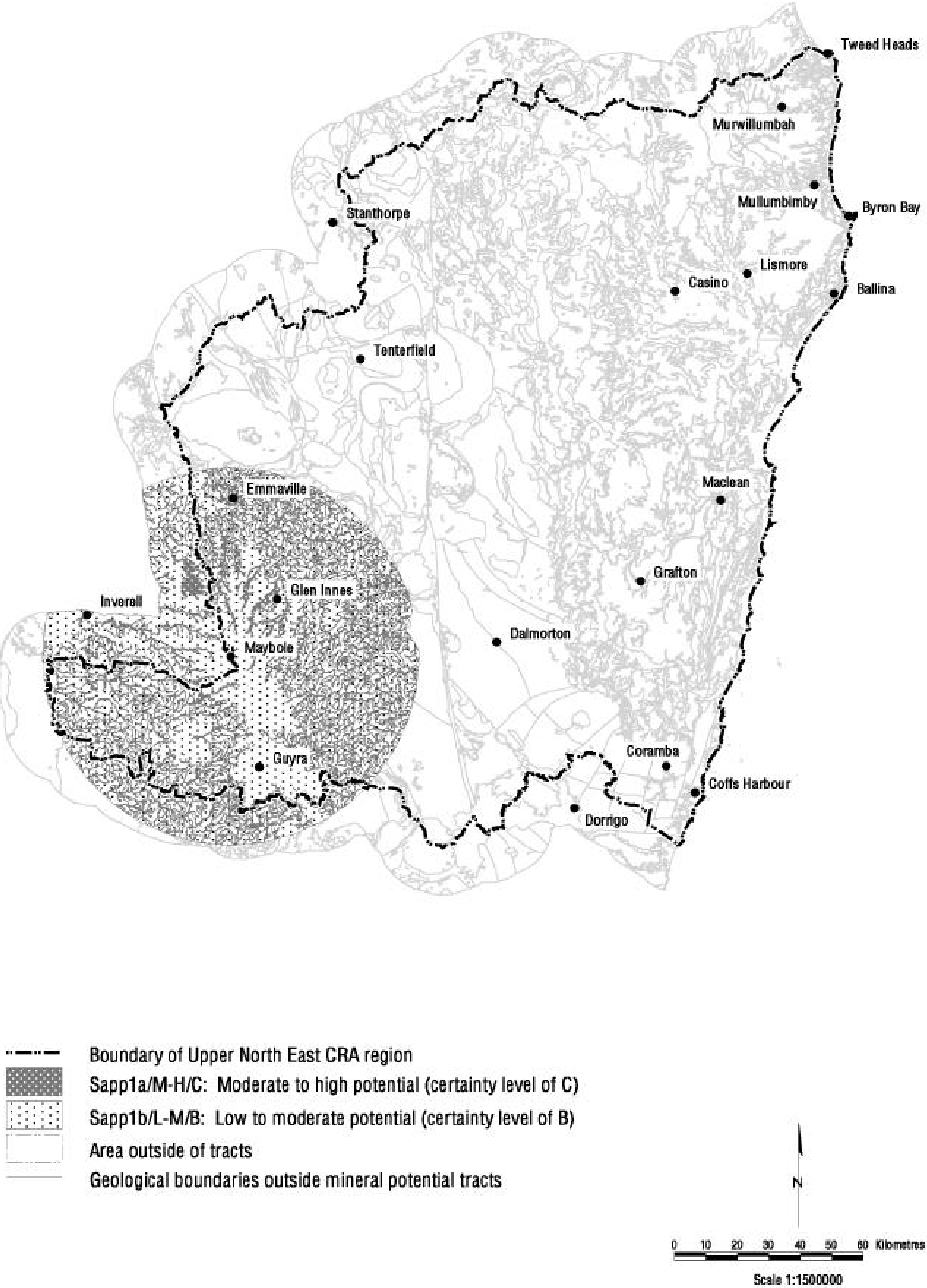


Figure 17. Mineral potential tracts for alluvial sapphire deposits.



Tract Sapp1b/L-M/B

This tract consists of the interfluves between stream buffers of in a 20 kilometre buffer around Tertiary basalt lavas that are within 60 kilometres of Mount Maybole. Economic sapphire deposits may occur in these interfluves within unmapped Quaternary and Tertiary sediments, and in Tertiary sediments concealed beneath unmapped Quaternary sediments.

Basalt lava outcrop within 60 kilometres of Mount Maybole is also included in the tract because it may hide economic Tertiary deep lead sapphire deposits.

Potential for economic sapphire deposits in the tract is considered to be low to moderate with a certainty of B.

8.17 TUNGSTEN-MOLYBDENUM PIPES, VEINS, DISSEMINATIONS (FIGURE 18)

Tract W-Mo1a/H/B-C

This tract has been delineated based on the distribution of granitoids of the Moonbi Suite and the group of leucoadamellites which have not been assigned to any plutonic suite and are collectively referred to as leucoadamellites (undetermined). A buffer zone of two kilometres around the Moonbi Suite and Leucoadamellites is also included.

The Moonbi Suite granitoids are I-type, moderately oxidised and fractionated (Blevin & Chappell, 1993: Ashley, Barnes, Golding & Stephens, 1996). A number of tungsten - molybdenum veins and pipes occur along the margins of these granitoids, the largest being the Moonbi Mo-W deposit 20 km north east of Tamworth. Based on the above information, it is concluded that the Moonbi Suite has a high potential for tungsten - molybdenum veins with a certainty level of C.

The leucoadamellites (undetermined) are I-type, moderately oxidised, and fractionated. A number of W-Mo veins occur along the margins of these granitoids. Molybdenum-bismuth-tungsten occur as pipes, veins and dissemination at the outer contact of the Kingsgate granite and other leucogranites (Gilligan & Barnes, 1990). The main deposits are those at Kingsgate where approximately 350 t of molybdenite and 200 t of bismuth have been won from over 50 pipes. The leucoadamellites have a high potential for tungsten - molybdenum veins with a certainty level of B.

Overall, the tract has a high potential for tungsten - molybdenum veins with a certainty level of B-C.

Tract W-Mo1b/M-H/B

This tract outlines a granite shelf or possible cupola at shallow depths below the Glen Eden deposits. The Glen Eden deposits comprise tungsten - molybdenum stockwork mineralisation and hydrothermal breccia pipes within Permian felsic volcanics (Barnes et al., 1988). Based on the presence of this style of mineralisation and from interpretations of the magnetics, it is postulated that a shallow granite shelf or cupola underlies the area of this tract. The mineralising granite has been identified during exploration drilling at a depth of 200 m (Amoco Minerals & Electrolytic Zinc Co. in 1983).

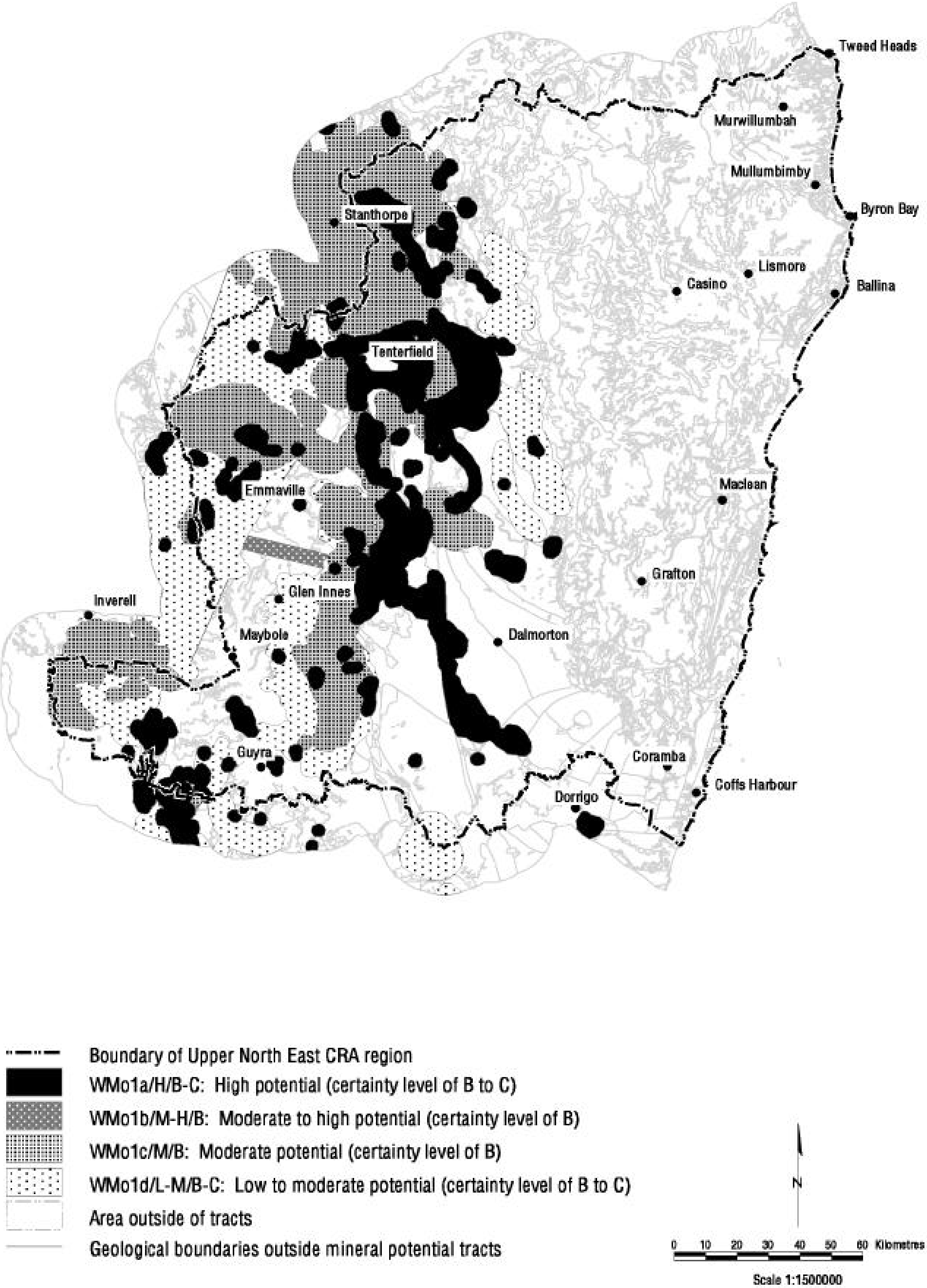
Based on the above information, it is concluded that this tract has a moderate - high potential for tungsten - molybdenum veins with a certainty level of B.

Tract W-Mo1c/M/B

This tract is based on the distribution of the leucoadamellites, (including the Mole, Gilgai and Ruby Creek granitoids) and the Bolivia sub-type (Blevin & Chappell 1996). Over 150 lodes (including tin, tungsten and molybdenum) occur in the Mole Granite and 60 occur in and around the Gilgai Granite/Tingha Adamellite. The tract also includes a 2 kilometre buffer around these leucoadamellites. The leucoadamellites are I-type, reduced and highly fractionated (Blevin & Chappell 1993: Ashley et al. 1996). A large number of W - Mo veins occur along the margins of these granitoids, particularly the Bolivia sub-type. The roof pendant of the Mole Granite is excluded from the tract.

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

Figure 18. Mineral potential tracts for tungsten-molybdenum pipes, veins and disseminated deposits.



Tract W-Mo1d/L-M/B-C
This tract is based on the:

- Granitoids of the Clarence River Plutonic Suite, which are I-type, highly oxidised, and fractionated. These bodies have a number of molybdenum deposits. At Nundle, quartz - calcite - gold - tungsten - antimony veins are adjacent to granitoid contacts.

- Granitoids of the Uralla Plutonic Suite, which are I-type, reduced and fractionated. A number of tungsten - molybdenum veins occur along the margins of these bodies.

- The Gundle Granite, which is I-type (?), reduced and fractionated. There are a few tungsten - molybdenum veins associated this granite, the largest being the Guy Fawkes molybdenum deposit, 60 km east of Armidale.

A buffer zone two kilometres wide is drawn around all the granitoids listed above.

The tracts enclosing the granitic suites listed above are considered to have low - moderate potential for tungsten - molybdenum mineralisation with certainty level C.

Evidence from geological data and magnetics suggest that the Gilgai, Mole and Ruby Creek granitic plutons are connected at shallow depth. The area of this shallow connection is considered to have low - moderate potential for tungsten - molybdenum mineralisation with certainty level B.

Overall, the tract has low - moderate potential with certainty level B-C.

8.18 TUNGSTEN SKARN DEPOSITS (FIGURE 19)

Tract W/M/B
The tract is based on the following geological parameters:
- a 5 km wide zone adjacent to the margins of Triassic granitoids which are potential source rocks for tungsten mineralisation, i.e. I-type granitoids which are fractionated and moderately oxidised. A detailed analysis of the granitoids which are potential source rocks for tungsten mineralisation is given in the model for tungsten-molybdenum veins and pipes,
- Palaeozoic calcareous sediments and ultramafic rocks which were intruded by these granitoids.

The intersection of the above two geological parameters defines the tract for tungsten skarn deposits, which is assessed as moderate potential with certainty level B.

8.19 SILEXITE (FIGURE 20)

Tract Silexite/M-H/B
The tract includes the area corresponding to the roof pendant of Mole Granite plus a 200 m wide buffer zone surrounding it. It contains all the known occurrences of silexite in the region.

8.20 COPPER-GOLD-MAGNETITE SKARN DEPOSITS (FIGURE 21)

Tract CuAu2/L-M/B
The tract includes zones where reactive calc-magnesian rocks lie within 5 kilometres of granitoids that have a potential for hosting Cu-Au deposits. The tract is assessed as low to moderate because there are no economic skarn deposits known in the area, and because the occurrence of calc-magnesian rocks is generally irregular and intermittent within the potential host sequence.

Figure 19. Mineral potential tracts for tungsten skarn deposits.

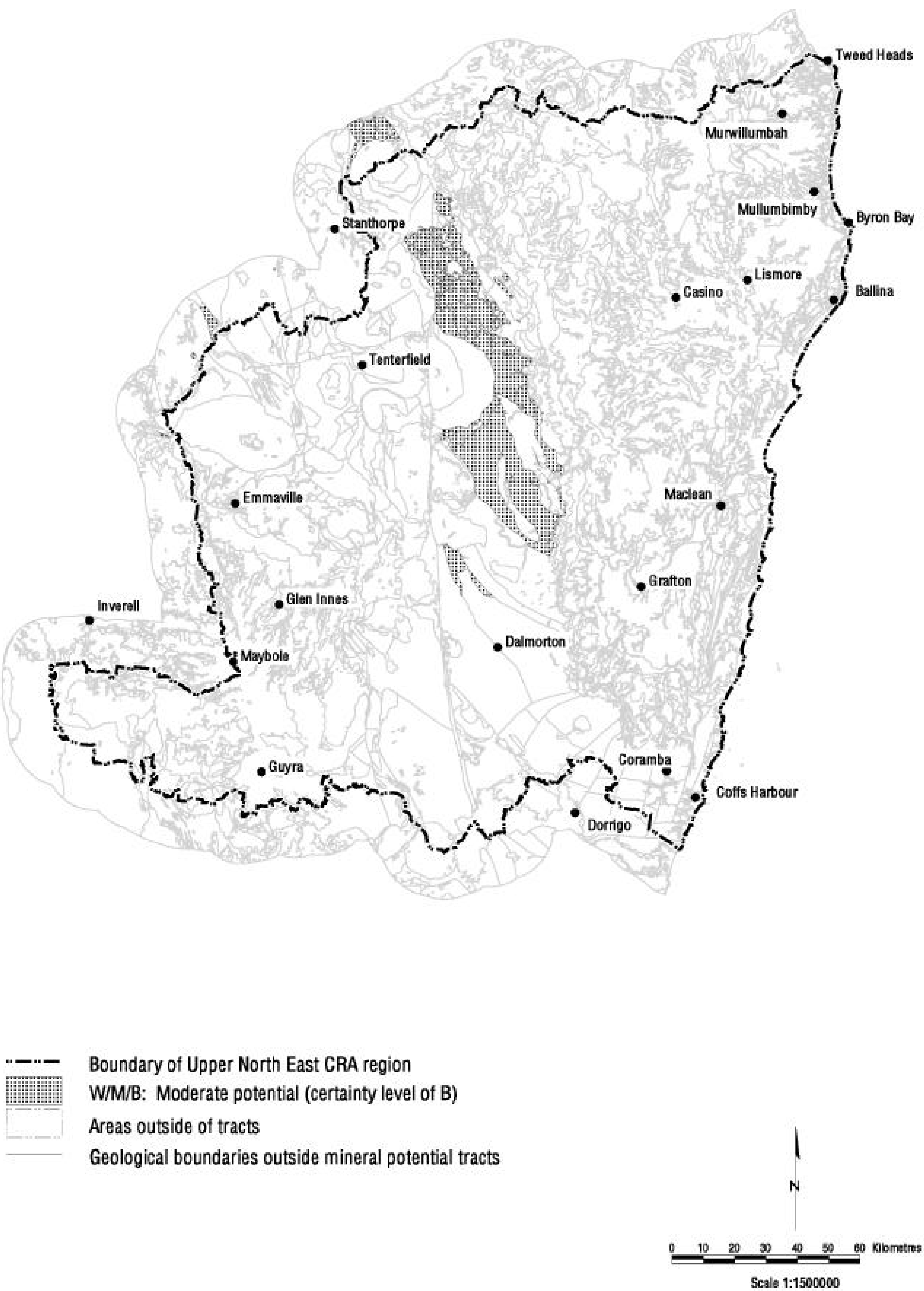
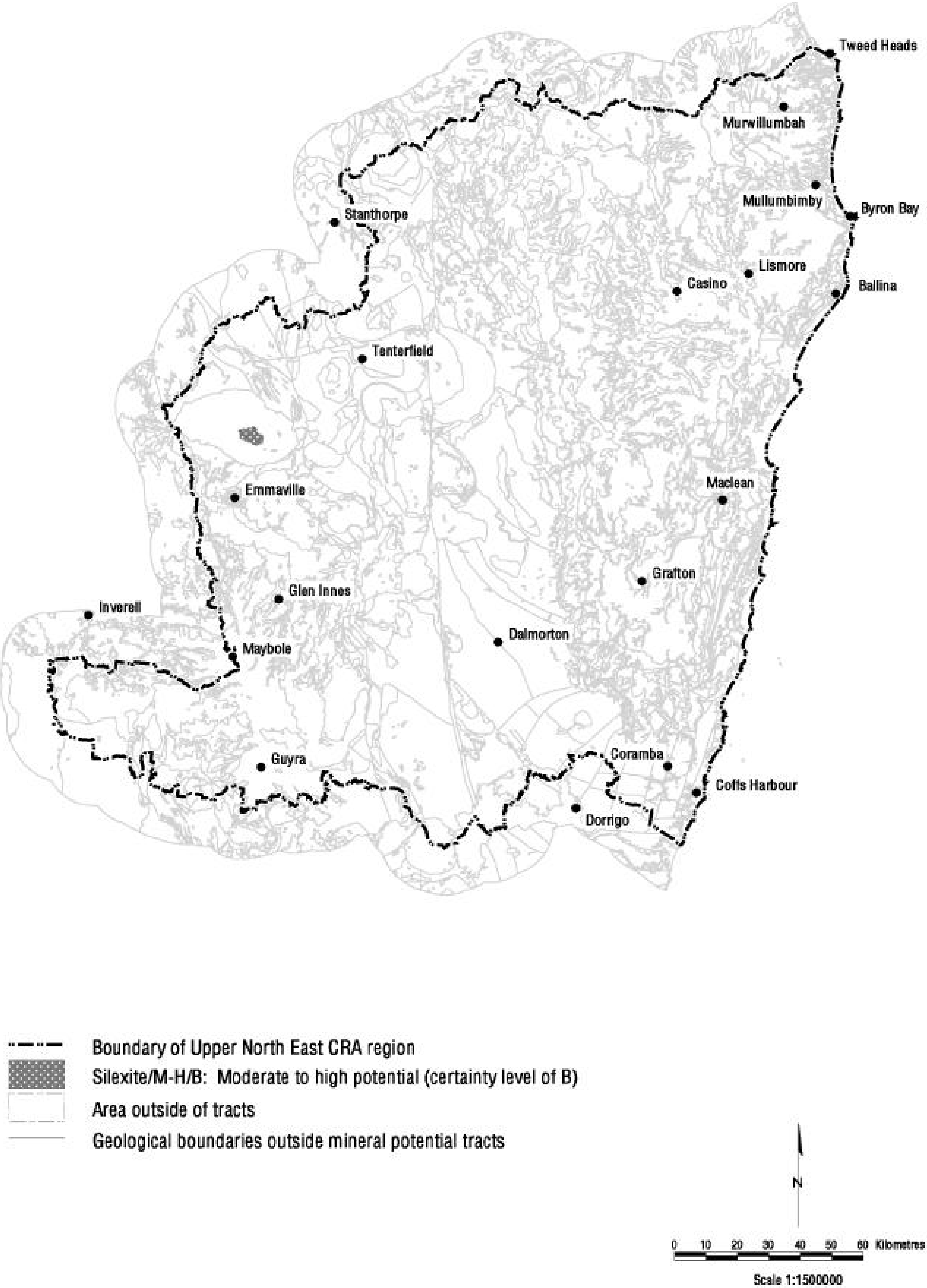


Figure 20. Mineral potential tracts for silexite (quartz, topaz W-Mo-Bi) deposits.



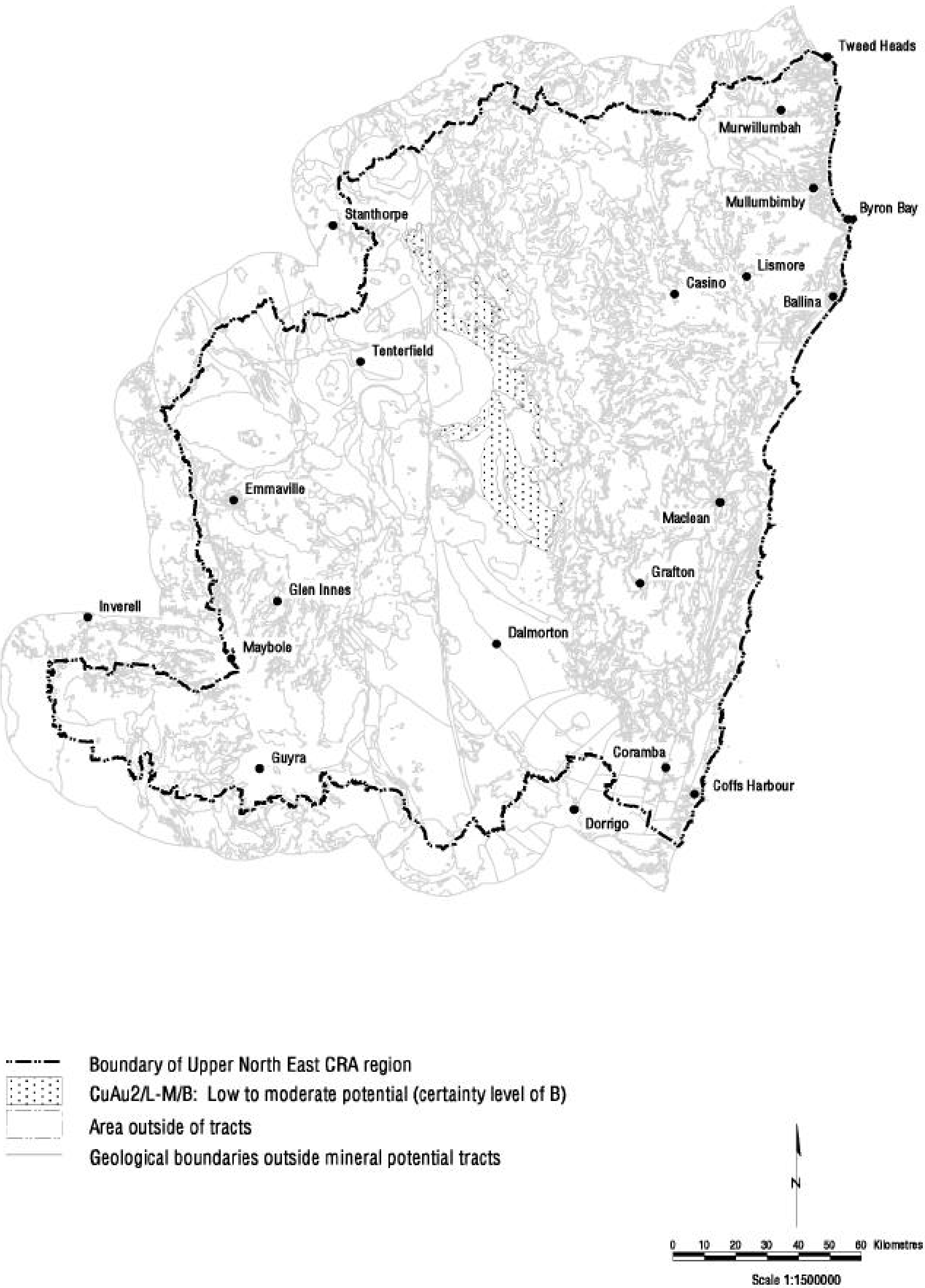
Boundary of Upper North East CRA region

Silexite/M-H/B: Moderate to high potential (certainty level of B)

Area outside of tracts

Geological boundaries outside mineral potential tracts

Figure 21. Mineral potential tracts for copper-gold-magnetite skarn deposits.



8.21 ALLUVIAL GOLD (FIGURE 22)

Tract Au4a/M-H/C

This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas within 10 kilometres of known gold deposit clusters. Potential for economic Quaternary/Tertiary alluvial gold and deep lead deposits concealed beneath Tertiary basalt is considered to be moderate to high. Even though most alluvial gold areas have been worked in the past, modern technology may make some of these areas viable in future and allow access to deep lead deposits not previously mined. The certainty level is assessed at C.

Tract Au4b/M/B

This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas that occur in areas of potential for other types of gold deposits.

Potential is considered moderate with a certainty of B.

8.22 GOLD DEPOSITS ASSOCIATED WITH VOLCANOGENIC MASSIVE SULPHIDE MINERALISATION (INCLUDING GOLD IN CHERT AND JASPERS) (FIGURE 23)

Tract Au5a/M/C

The tract is similar to the tract BM1a/M/C for volcanic associated massive sulphide deposits because gold mineralisation is spatially and temporally associated with massive sulphide mineralisation. Both styles result from submarine volcanic hydrothermal systems. The tract is marked by the presence of chert and jaspers which are known to host gold mineralisation in the area. The tract also hosts all the known occurrences of gold of this type in the UNE region. Mineral potential of the tract is thus assessed to moderate with a certainty level of C.

Tract Au5b/L-M/B

The tract is similar to the tract BM1b/L-M/B for volcanic associated massive sulphide deposits. Although the tract does not contain known occurrences of gold or volcanic associated massive sulphide mineralisation, it is marked by an environment which is favourable for distal type volcanic massive sulphide mineralisation. Hence mineral potential of the tract is assessed to be low to moderate with a certainty level of B.

8.23 ALLUVIAL TIN DEPOSITS (FIGURE 24)

Tract Sn3a/M-H/C

This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas within 10 kilometres of known tin deposit clusters (fields). Potential for economic Quaternary/Tertiary alluvial tin and deep lead deposits concealed beneath Tertiary basalt is considered moderate to high. Even though most alluvial tin areas have been worked in the past, modern technology may make some of these areas viable in future and allow access to deep lead deposits not previously mined. The certainty level is assessed at C.

Tract Sn3b/M/B

This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas that occur in areas of potential alluvial tin source rocks as delineated by the tracts for tin veins and tin greisens.
Potential is considered moderate with a certainty of B.

Figure 22. Mineral potential tracts for alluvial gold deposits.

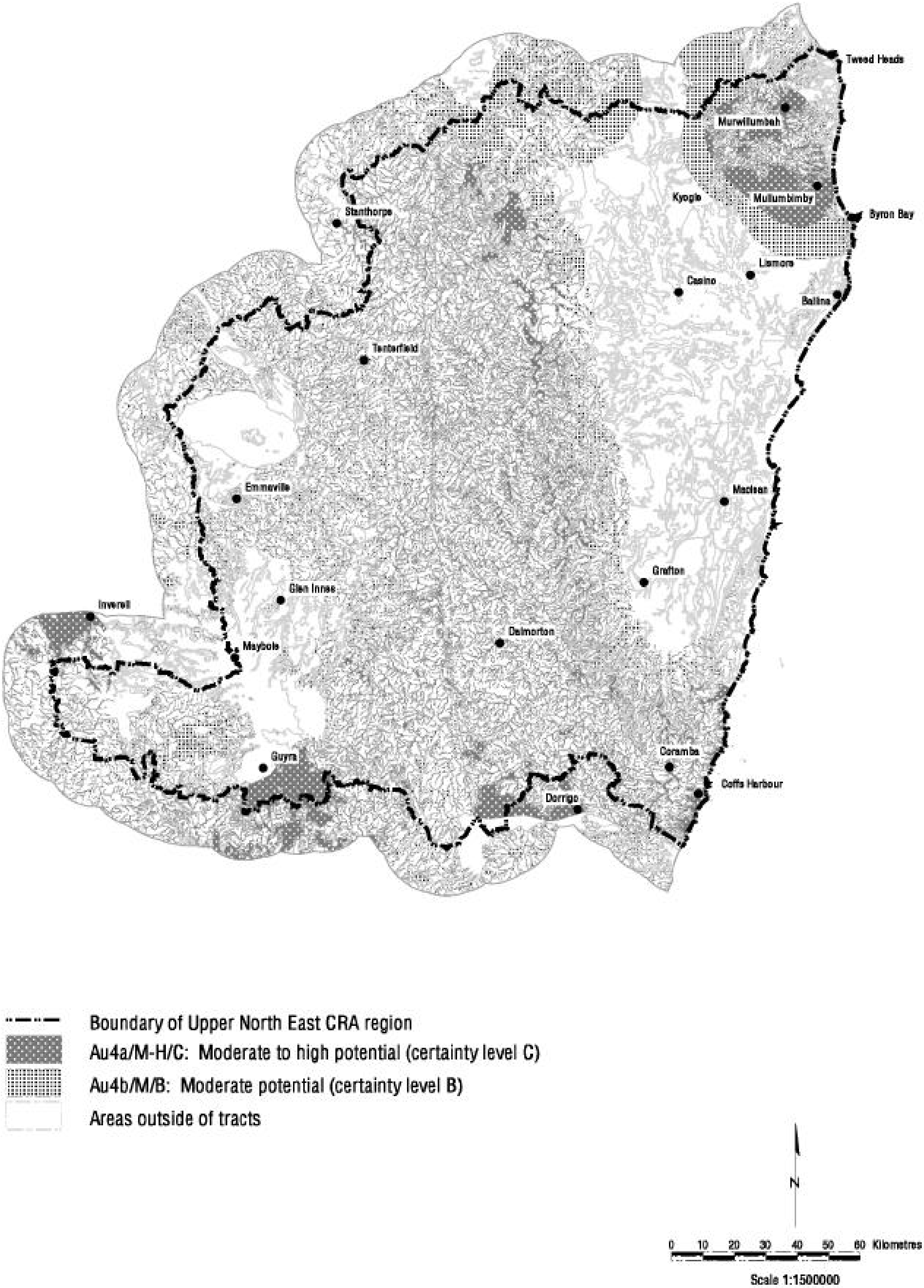
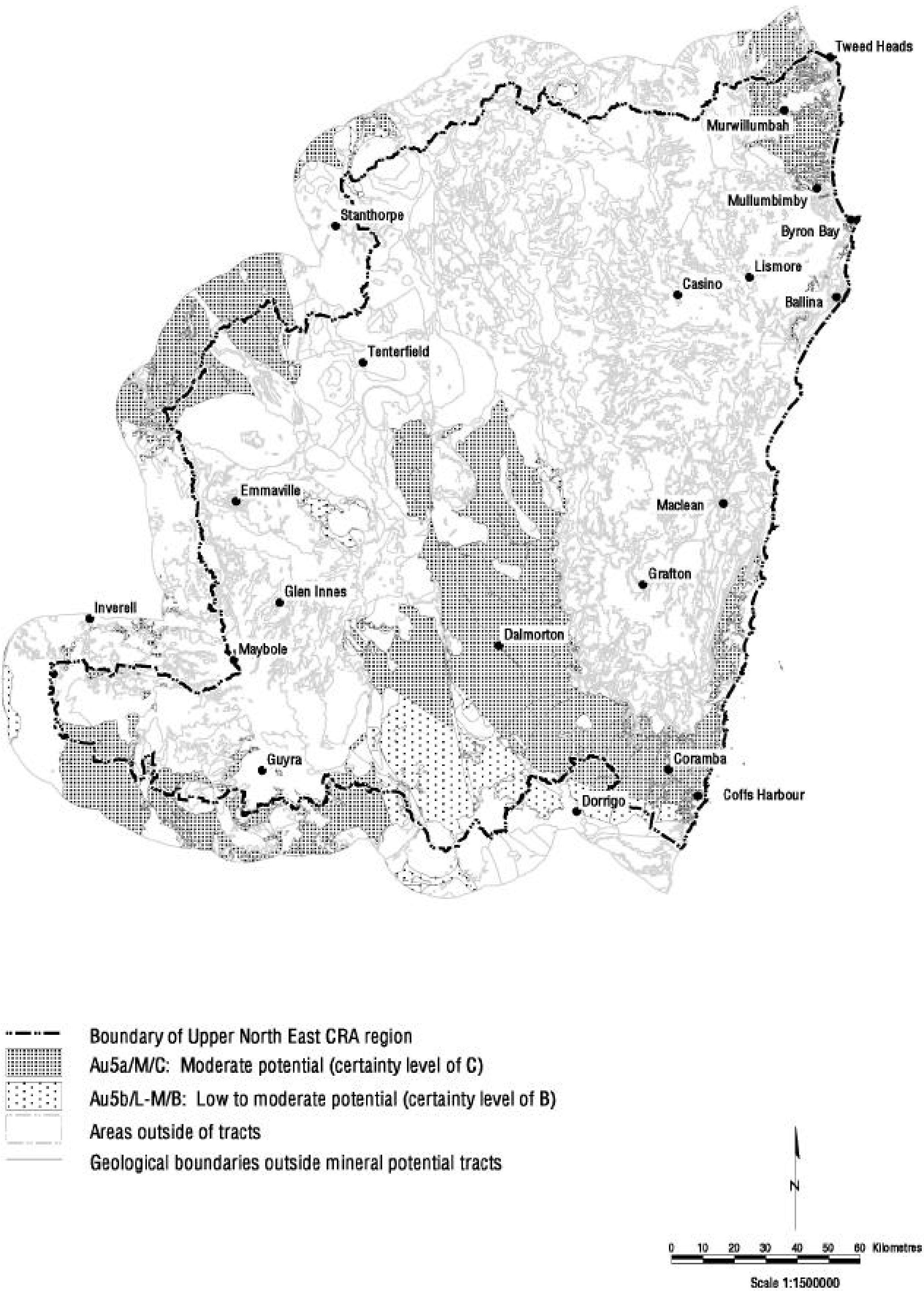
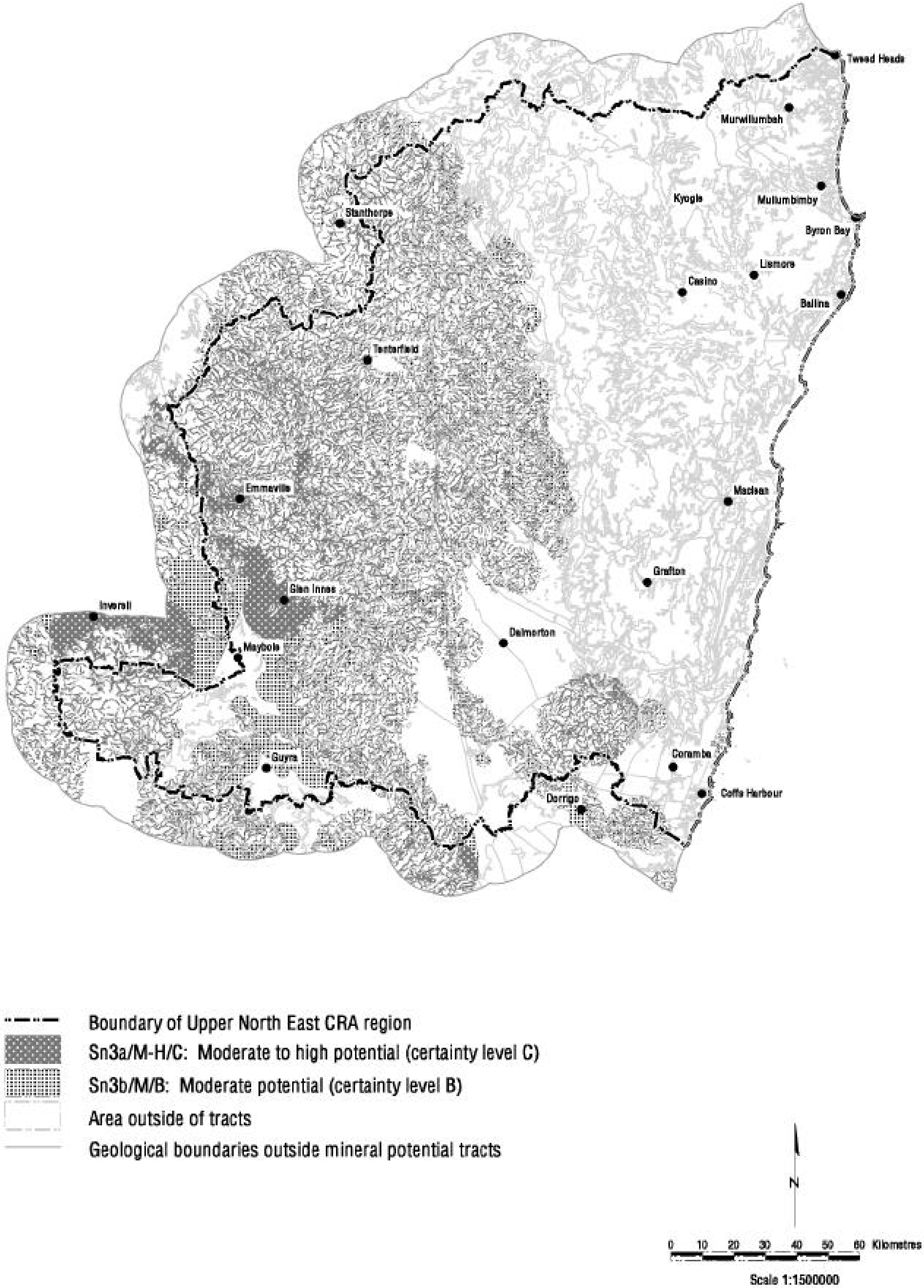


Figure 23. Mineral potential tracts for gold associated with volcanic massive sulphides, including chert and jasper.



Boundary of Upper North East CRA region
Au5a/M/C: Moderate potential (certainty level of C)
Au5b/L-M/B: Low to moderate potential (certainty level of B)
Areas outside of tracts
Geological boundaries outside mineral potential tracts

Figure 24. Mineral potential tracts for alluvial tin deposits.



8.24 VOLCANIC HOSTED MAGNETITE (FIGURE 25)

Tract Fe1a/M-H/C

The tract includes rocks of the accretionary complex that are known to contain magnetite-rich units (Texas Beds), ironstones (Coffs Harbour Beds), magnetite-bearing chert or quartz-magnetite accumulations (Brookland Beds). These rocks also host all the known occurrences of volcanogenic magnetite in the UNER. Mineral potential of the tract is assessed to be moderate to high with a certainty level of C

Tract Fe1b/L-M/B

The tract includes the rest of the rocks of the accretionary complex. Locally some units are magnetite rich and are interpreted to be related to skarns. Most rocks in this tract have a potential for volcanic associated massive sulphide and volcanogenic manganese deposits. As the formation of volcanogenic magnetite is closely related to the formation of volcanic associated massive sulphide and volcanogenic manganese, mineral potential of this tract is assessed to be low to moderate with a certainty level of B.

8.25 PODIFORM CHROMITE (FIGURE 26)

Tract Cr/H/C

This tract is characterised by the presence of an ultramafic body consisting of serpentinite known as the Gordonbrook Serpentinite belt. It contains at least 6 known chromite deposits and 25 other prospects. There are significant Ni-Cr-PGE geochemical anomalies. The potential for further deposits of chromite is considered to be high with a certainty level of C.

8.26 LIMESTONE DEPOSITS (FIGURE 27)

Tract Lst1a/H/B

The tract is defined by the presence of known limestone quarries (The Four Mile, Tabulam and Plumbago Creek). The tract is considered to have a high potential for additional limestone/dolomitic limestone deposits with a certainty level of B.

Tract Lst1b/M/B

The tract is defined by rocks of the Willowie Creek Beds. The beds host two known limestone quarries but, because the distribution of calcareous units in these beds could be erratic and irregular, mineral potential of the tract is assessed to be moderate with a certainty level of B.

8.27 VOLCANOGENIC MANGANESE DEPOSITS (FIGURE 28)

Tract Mn1a/M/C

The tract is similar to the tract BM1a/M/C for volcanic associated massive sulphide deposits because volcanogenic manganese mineralisation is spatially and temporally associated with massive sulphide mineralisation. Both styles result from submarine volcanic hydrothermal systems. The tract includes rocks of the accretionary complex such as jaspers, cherts and other mafic rocks (altered and/or metamorphic equivalents), indicative of submarine volcanic-hydrothermal systems. It also hosts all the known occurrences of manganese mineralisation. Mineral potential of the tract is assessed to be moderate with a certainty level of C.

Tract Mn1b/L-M/B

The tract is similar to the tract BM1b/L-M/C for volcanic associated massive sulphide deposits. Although the tract does not contain known occurrences of manganese or volcanic associated massive sulphide mineralisation, it is marked by an environment which is favourable for distal type volcanic massive sulphide mineralisation. Hence mineral potential of the tract is assessed to be low to moderate with a certainty level of B.

Figure 25. Mineral potential tracts for volcanic hosted magnetite.

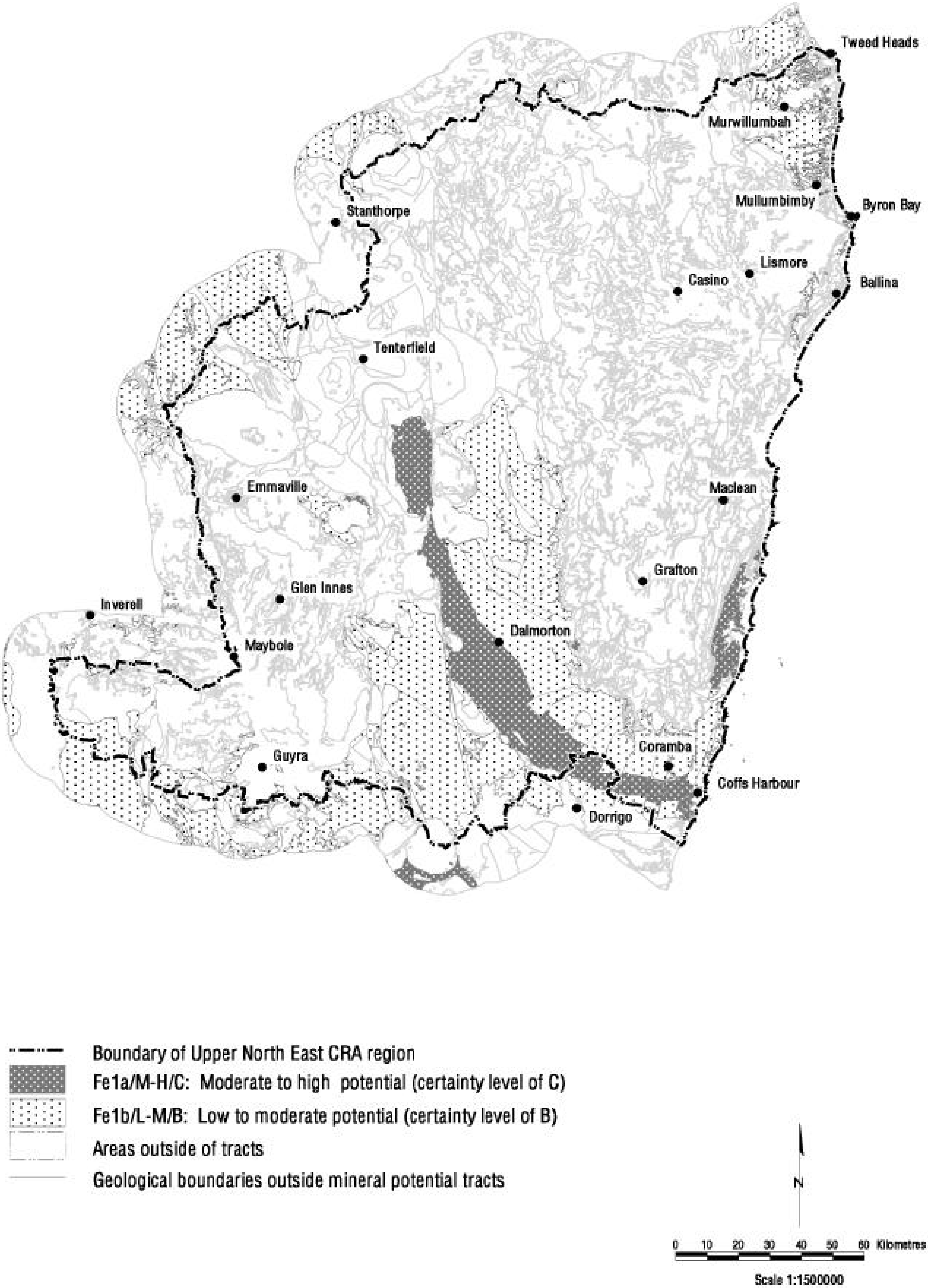


Figure 26. Mineral potential tracts for podiform chromite.

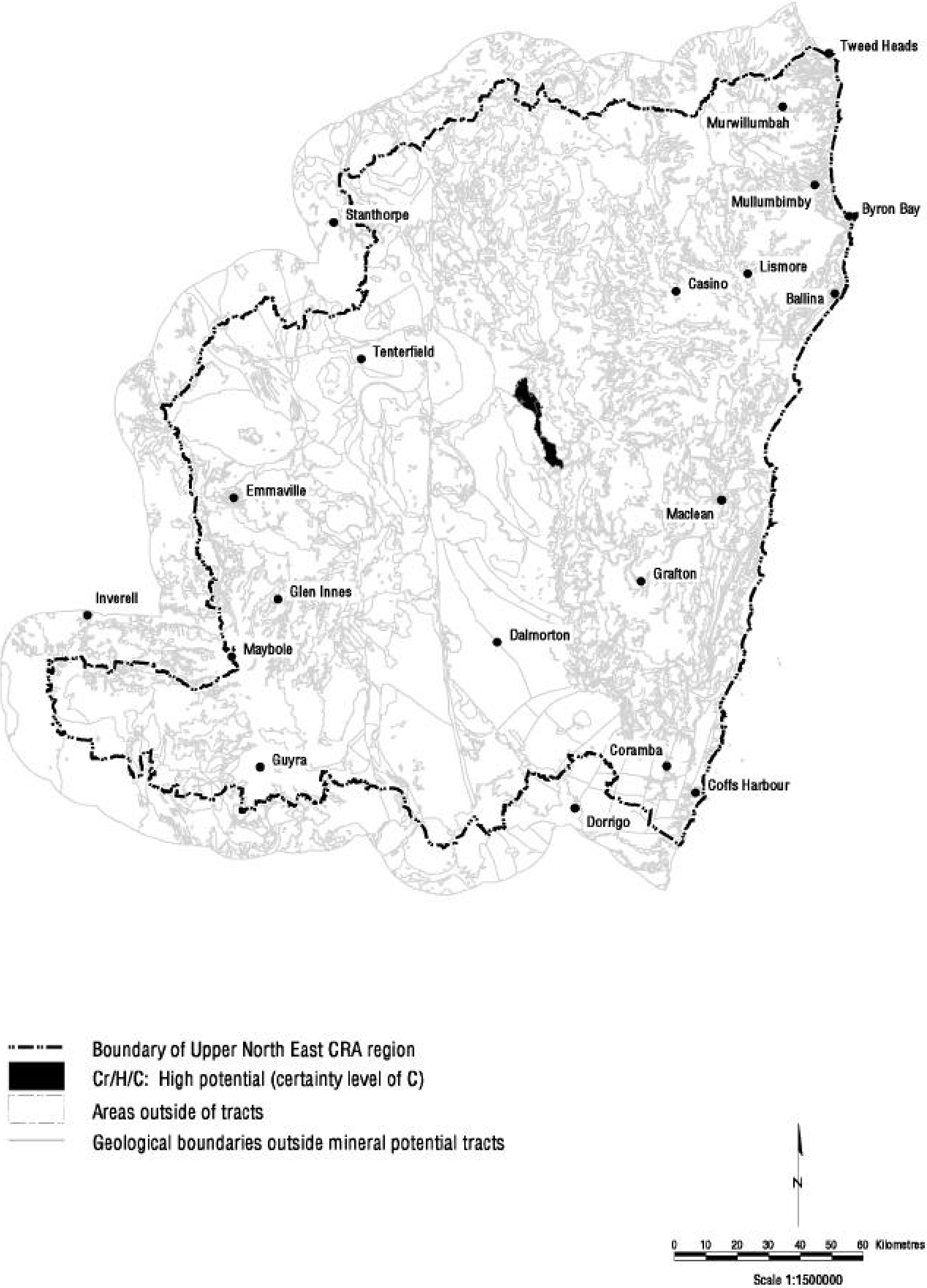
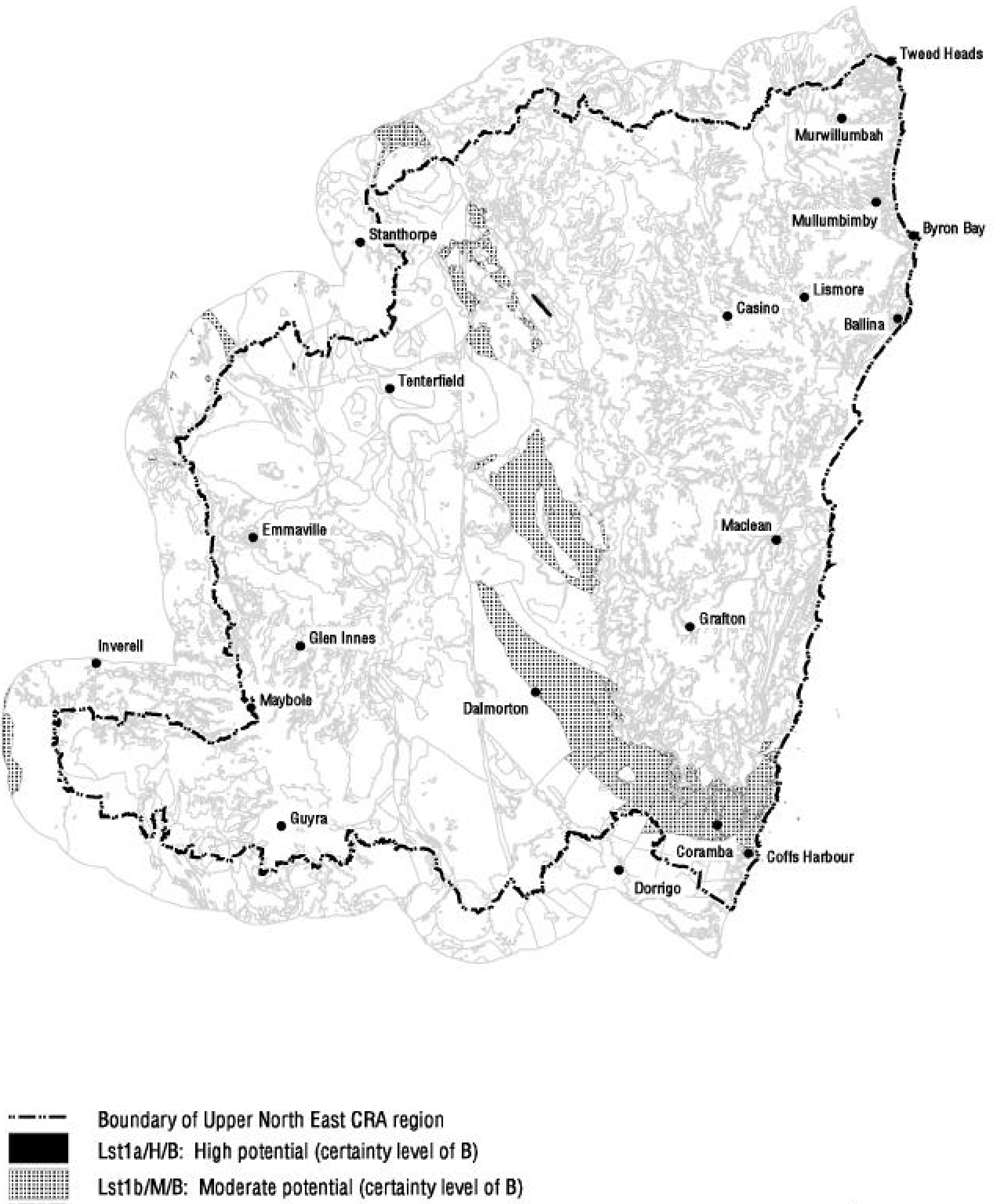


Figure 27. Mineral potential tracts for limestone deposits.



Boundary of Upper North East CRA region
Lst1a/H/B: High potential (certainty level of B)
Lst1b/M/B: Moderate potential (certainty level of B)
Areas outside of tracts
Geological boundaries outside mineral potential tracts

Figure 28. Mineral potential tracts for volcanogenic manganese deposits.

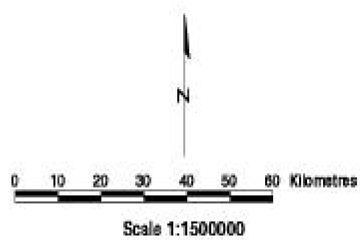
Boundary of Upper North East CRA region

Mn1a/M/C: Moderate potential (certainty level of C)

Mn1b/L-M/B: Low to moderate potential (certainty level of B)

Areas outside of tracts

Geological boundaries outside mineral potential tracts



8.28 CONSTRUCTION MATERIALS (AGGREGATE AND PAVEMENT) (FIGURES 29 & 31)

Construction materials are naturally occurring, low unit value commodities which are generally exploited in bulk and with limited processing for use in civil construction. In the Upper North East region, construction materials are in high demand due to the rapidly expanding population in the area. There are more than 2000 active, historic or identified potential construction material sites in the Upper North East region. The great majority of these would probably only qualify as fill materials by contemporary standards. The assessment of potential construction materials is restricted to aggregates (higher value materials) and road pavement materials (moderate value materials).

Transport costs contribute significantly to the delivered cost of construction materials, and therefore it is important to obtain such materials as close as possible to markets. Increased transport costs associated with the need to use more distant resources result in increased raw material costs which are inevitably passed on to the consumer. Therefore, the delineation of tracts for the potential of construction materials is based upon the type of material likely to be present (that is the geology), and the distance of potential deposits from roads and markets.

The widths of buffers for different types of roads are based on the distribution of known deposits of construction materials, the Pacific Highway is buffered 4800 metres on each side of the road; principal roads 2400 metres; secondary roads 1200 metres; minor roads 600 metres and tracks 300 metres. The potential for the two main types of construction materials was assessed for suitable rock types within these buffers. Some known locations of construction materials were still present outside the buffers because of the lack of sufficient detail on roads and geology in some parts of the region. These known locations of construction materials were buffered to indicate that additional resources of construction materials may be present at 400 metres around these locations for aggregates and 200 metres for road pavement materials.

The various tracts for aggregates and pavement materials are summarised in the following tables.

TABLE 7: AGGREGATE TRACT DATA (FIGURE 29)

Name of Tract	Lithologies and rock units within buffers
Conmatag/H/C	Unconsolidated sand and gravel; coarse quartz sandstone (a large operating quarry in Ripley Road sandstone at Suffolk Park); contact metamorphosed sedimentary rocks; older sedimentary rocks within 500m of a granite body; specific coastal granites, granitoid body at Valla
Conmatag/M-H/C	Tertiary volcanics, especially basalts; many aggregate quarries are present in Tertiary basalts especially in the Tweed and Lismore regions; Wandsworth Volcanic Group except Drake Volcanics; accretionary complex rocks east of the Demon Fault including the Beenleigh block and Coffs Harbour block but excluding the Emu Creek block and Nambucca block.
Conmatag/M/B	Sand and gravel - specific units
Conmatag/L-M/B	Drake Volcanics; Chillingham Volcanics
Conmatag/L/B	Kangaroo Creek Sandstone - rippable to fine sand in many places; Tertiary sediments excluding fine sands; Ripley Road Sandstone except for at Suffolk Park (see above); Bundamba Group except for Ripley Road sandstone - contains units rich in sands and gravels Leucogranites In places these units are deeply weathered and covered with thick sandy material All granites except leucogranites and excluding Hillgrove suite and related granites All other rock inside road buffer except near existing deposit Rocks outside of roads buffer except where near existing deposit

TABLE 8. PAVEMENT TRACT DATA (FIGURE 31)

Name of Tract	Lithologies and rock units within buffers
Conmatpv/H/B	Sand and gravel (unconsolidated) Coarse Sandstone baked by overlying Tertiary basalt and contain large operating quarry in Ripley Road sandstone at Suffolk Park Contact metamorphosed sedimentary rocks. Older sedimentary rocks within 500m of a granite body Tertiary volcanics, especially basalts. Many aggregate quarries are present in Tertiary basalt especially in the Tweed and Lismore regions Wandsworth Volcanic Group except Drake Volcanics Accretionary complex rocks east of the Demon Fault including the Beenleigh block and Coffs Harbour block but excluding the Emu Creek block and Nambucca block Sand and gravel - specific units Drake Volcanics Chillingham Volcanics. These dense felsic volcanics have been used for construction materials just to the north of the region in Queensland Kangaroo Creek Sandstone - rippable to fine sand in many places
Conmatpv/M-H/B	Tertiary sediments excluding fine sands
Conmatpv/M/B	Ripley Road Sandstone except for at Suffolk Park (see above) Leucogranites In places these units are deeply weathered and covered with thick sandy material
Conmatpv/L-M/B	Specific coastal granites. Granitoid body at Valla.
Conmatpv/L/B	All other rock inside road buffer except near existing deposit Rocks outside of roads buffer except where near existing deposit

8.29 CHRYSOTILE, ASBESTOS DEPOSITS (FIGURE 30)

Tract Asb/H/C

This tract is characterised by the presence of an ultramafic body consisting of serpentinite known as the Gordonbrook Serpentinite belt.

8.30 SUMMARY OF POTENTIAL MINERAL AND HYDROCARBON RESOURCES

Mineral potential tracts were defined for 29 types of deposits (Figures 3-31, Tables 9, 10). These include:

- 17 metalliferous deposit types
- industrial mineral deposit types
- 4 energy commodities (open cut and underground coal, coal seam methane and hydrocarbons), and
- 2 precious minerals type deposits (diamonds and sapphires).

Only the mineral deposit types judged to be most likely to constitute significant resources in the region have been assessed in detail. The assessments of all deposit types are described in detail in Appendix B.

To facilitate land use decisions, all the mineral potential tracts were combined (overlain) to produce four types of summary maps of mineral potential (Maps 3, 4, 5 & 6).

Map 3 is a **composite of mineral potential** for the Upper North East Forest region and shows the highest level of mineral potential assessed (in June 1998) for any particular area in the region. Where tracts for different deposit types overlap, this area is assigned the highest potential level of all the overlapping tracts. In this approach, the tract having the highest mineral potential in any particular area obscures tracts of lower mineral potential.

The types of deposits with the most widespread tracts of high potential in the Upper North East Forest region are for coal seam methane gas in the Clarence Moreton Basin and smaller areas of high potential

Figure 29. Mineral potential tracts for construction material (aggregate) deposits.

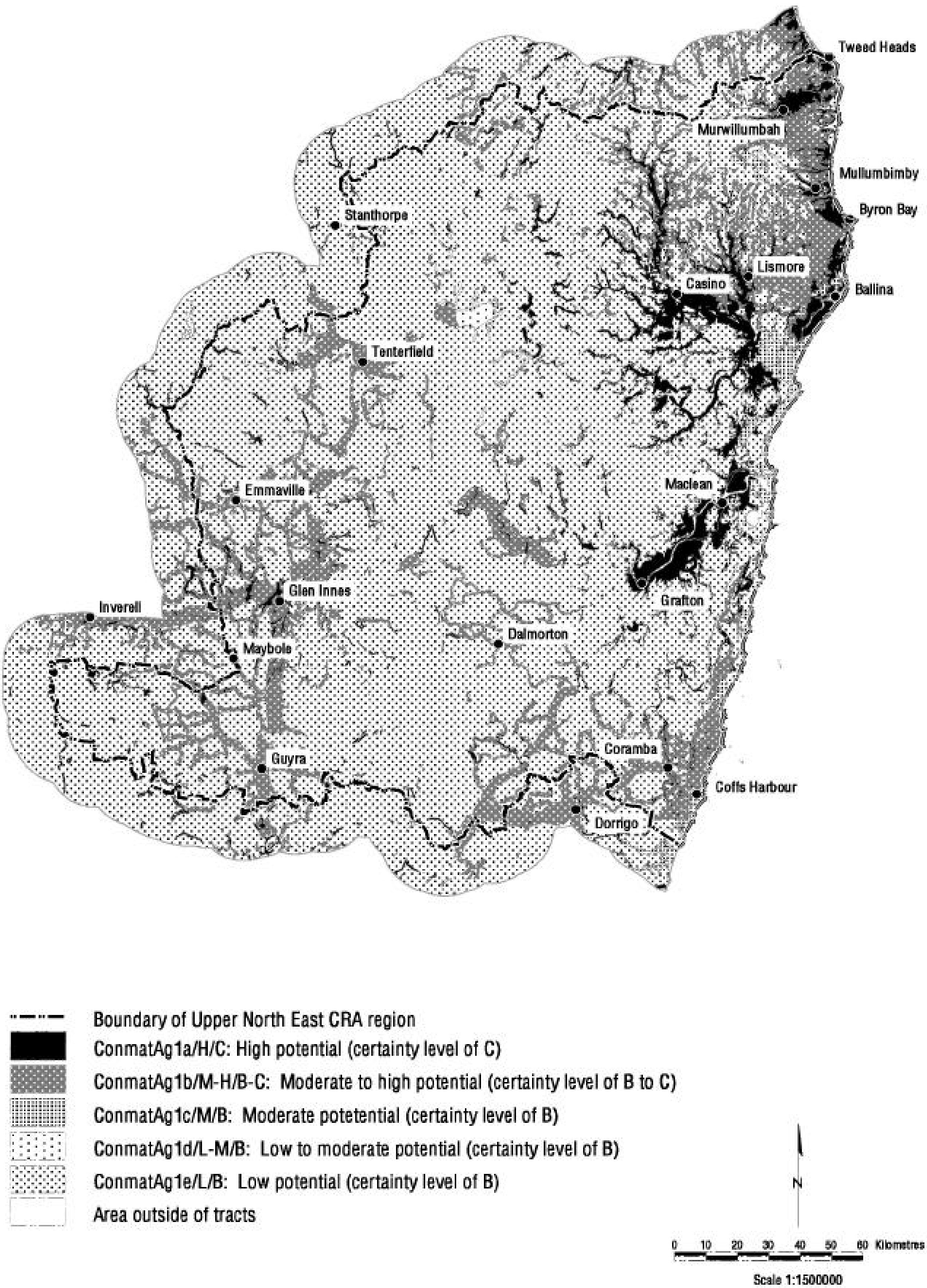


Figure 30. Mineral potential tracts for chrysotile, asbestos deposits.

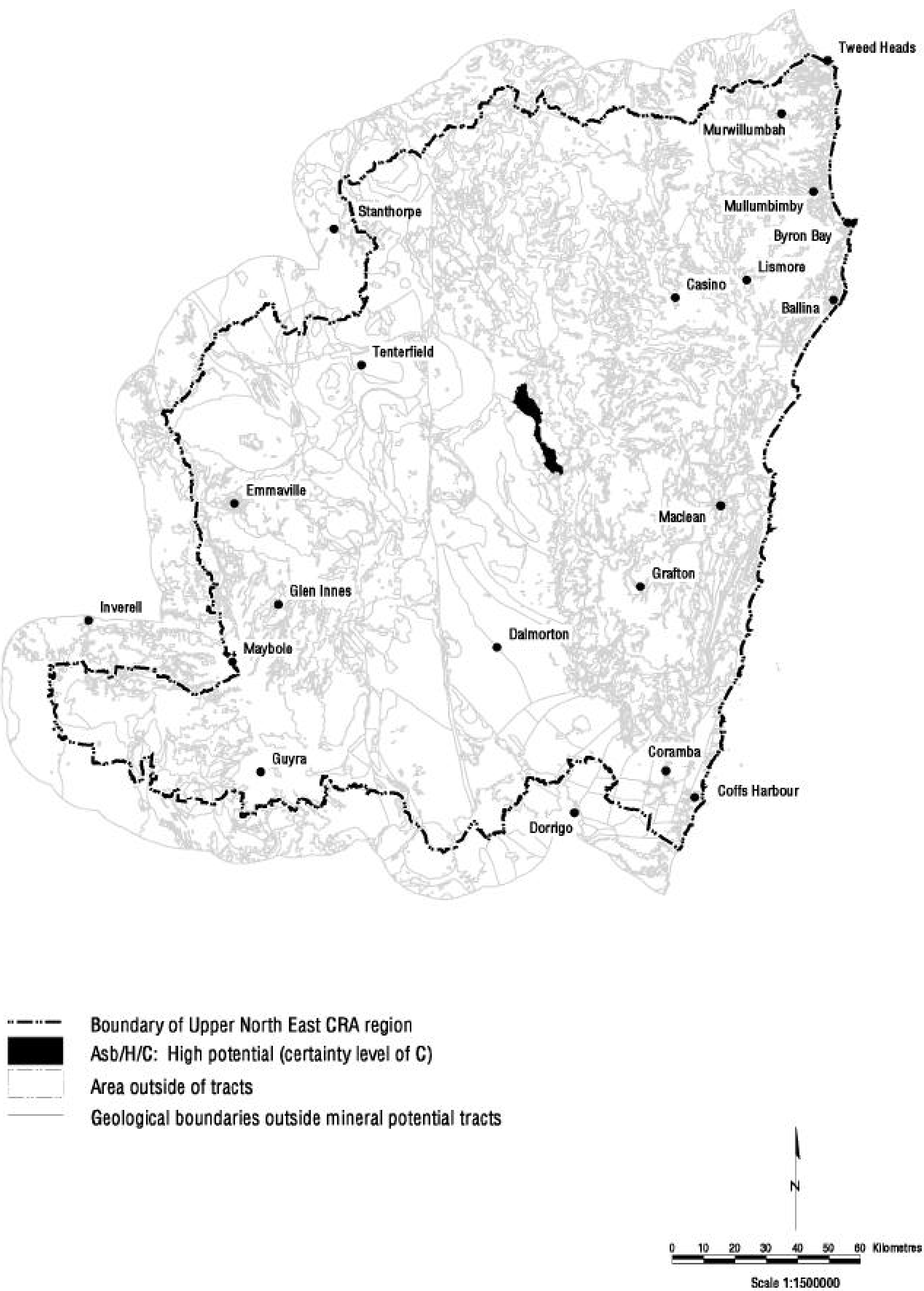
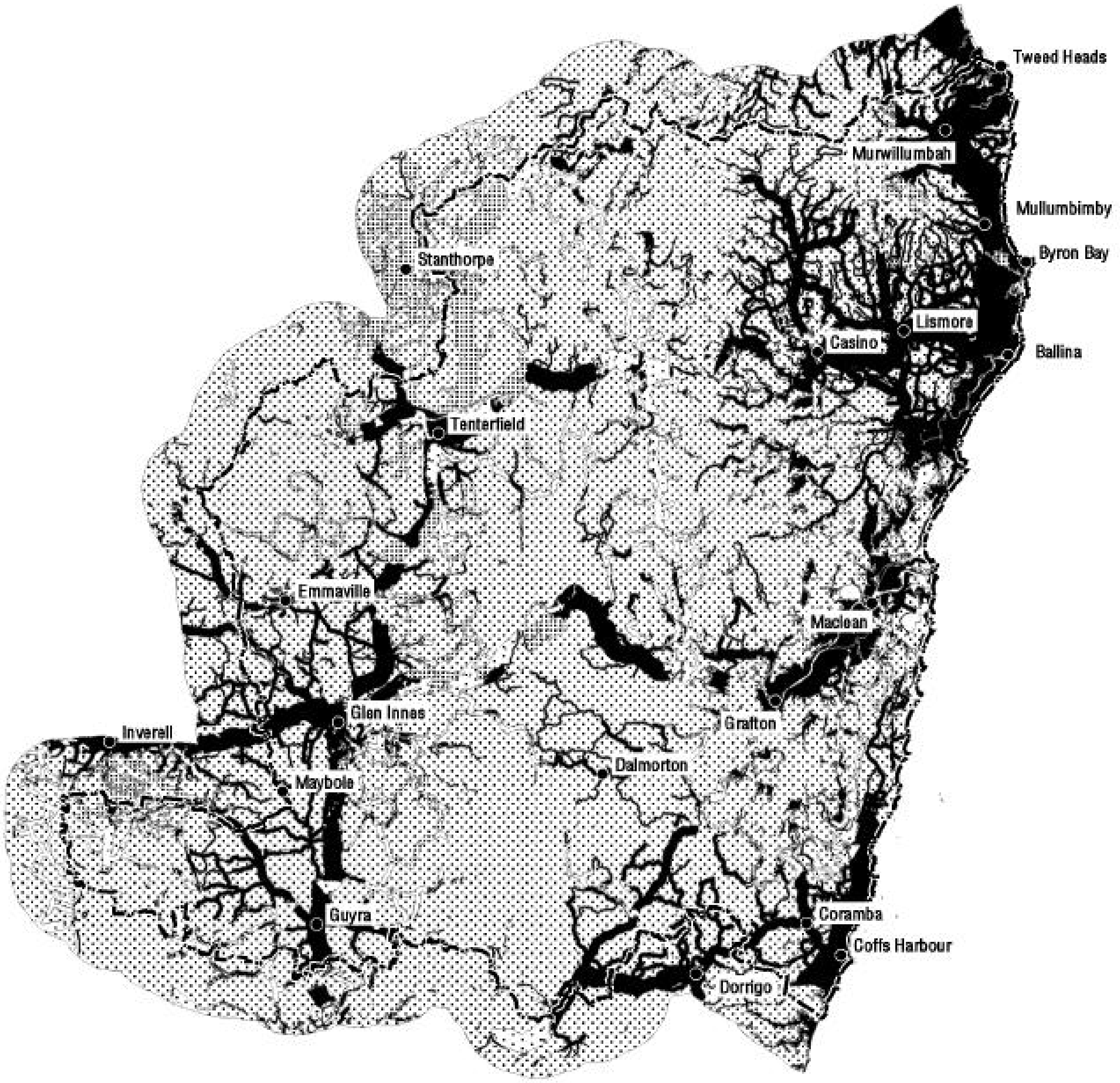


Figure 31. Mineral potential tracts for construction material (pavement) deposits.



Boundary of Upper North East CRA region
ConmatPv1a/H/B: High potential (certainty level of B)
ConmatPv1b/M-H/B: Moderate to high potential (certainty level of B)
ConmatPv1c/M/B: Moderate potential (certainty level of B)
ConmatPv1d/L-M/B: Low to moderate potential (certainty level of B)
ConmatPv1e/L/B: Low potential (certainty level of B)
Areas outside of tracts

for construction materials along the eastern margin of the basin. Areas of high potential to the west of the basin are for epithermal gold and disseminated gold in leucocratic granites. South west of the basin, areas of high and moderate to high potential are dominated by metahydrothermal gold.

Areas of high potential in the western half of the region are for tungsten-molybdenum deposits, and along the western perimeter there are high potential tracts for tin veins, tin greisen deposits, silver bearing polymetallic vein deposits and metahydrothermal gold deposits. The potential for these deposit types also occupies most of the moderate to high potential tracts along the western boundary of the region.

It is important to note that 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 coal seam methane gas may be considered to have a higher economic value than a tract with high potential for limestone.

Map 4 shows the **cumulative mineral potential** for the Upper North East Forest region. In constructing this map, standard scores were allocated 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 (no score). In those areas where tracts overlap, the scores are added and this cumulative score is assigned to the overlapping areas. For example, where there is overlap of tracts with high potential for metahydrothermal gold (score 18), low – moderate potential for tungsten-molybdenum deposits (score 2) and moderate potential for tungsten skarns (score 6), then this area of overlap will have a cumulative score of 26. The cumulative mineral potential takes account of both the diversity of deposit types that may occur in each area as well as the level of mineral potential of each of these deposit types.

A zone of high scores of cumulative potential occur along the western border of the region north and south of Emmaville. In this part of the region there are varying degrees of overlap of potential for 11 different types of deposits. The deposit types include silver bearing polymetallic vein deposits (high potential score of 18 and moderate to high of 12), tungsten-molybdenum deposits (18), two types of tin veins (18 and 12), alluvial sapphires (12), two types of construction materials (18 and 12), disseminated gold (18 and 12), metahydrothermal gold (18 and 12), and volcanogenic massive sulphide deposits (6) with gold and with base metals. The cumulated potential scores exceed 60 for much of this part of the region and in small areas exceed 100.

The areas with overlapping tracts of mineral potential (high cumulative scores) emphasise the diversity of mineral potential. These areas are not necessarily more prospective than an area with fewer overlapping tracts of high potential, eg the Clarence-Moreton Basin for coal seam methane. The relative economic significance of the tracts for different types of mineral deposits, as perceived by mining companies, would be influenced by their perceptions of prospectivity, future market conditions, land access and other factors.

Map 5 shows the **weighted composite mineral potential** for the region. The weighted composite potential makes some allowance for the relative economic significance between different types of mineral deposits. In this approach, mineral deposits are indexed for their relative economic significance. For example, porphyry copper gold was allocated an index of 7 out of 10, whereas pavement construction material was allocated an index of only 1 out of 10. The indexes for the various deposit types are listed in Table 7. The weighted composite score is calculated by multiplying the deposit index by the standard mineral potential score. For example, a tract for metahydrothermal vein gold deposits (index of 6) with high potential (18) will have a weighted composite score of 108 (6x18). Similarly a tract for pavement construction materials (index of 1) with high potential (18) will have a weighted composite score of 18 (1x18). Where there are overlapping tracts, with different weighted scores, the highest of these scores is assigned to the area of overlap. The distribution of the weighted mineral potential scores resulting from the overlap of tracts in the region is shown on Map 5. The mineral deposit indexes and weighted scores are tabulated in Table 7 and the size of areas for each weighted score, after overlap of tracts, is shown in Table 8. The weighted scores for tracts of all the mineral deposit types have been sorted in Figure 32. The full areas covered by the individual tracts of mineral potential for the various types of deposits (Figures 3 to 31) is tabulated in Table C1 in Appendix C.

On Map 5, areas with weighted scores of 90 to 126 cover about 49.56% of the Upper North East region (Table 8). This part of the region includes all of the areas (tracts) of high potential for the most significant types of mineral deposits (ie those with an index of 5 to 8 (Table 7)). The most extensive tract in this range of weighted scores is for coal seam methane over the Clarence-Moreton Basin (weighted score of 126, covers 26.37% of the region (Table C1)) and for metahydrothermal gold veins west and south west of the basin (108, 11.4%). The mineral potential for other mineral deposit types in this range are mostly in the western part of the region and include silver bearing polymetallic veins (90, 7.26%), tin vein deposits (90, 7.26%) and tin greisen deposits (90, 4.12%). Less extensive tracts in this range of weighted mineral potential scores are for disseminated gold deposits in leucogranites (126, 3.38%), and for epithermal gold (126, 1.91%). Note that some of the mineral potential tracts, for specific types of mineral deposits, are partly obscured by tracts with a higher weighted potential score. For example the full extent of the tract for tin veins, with a weighted score of 90, covers 7.26% of the region (Table C1). However, tracts with a score of 90 are partly obscured by tracts with a higher weighted potential score so that the remaining area with a score of 90 in the region is only 6.24% as shown in Table 8.

TABLE 9: SUMMARY OF POTENTIAL MINERAL RESOURCES AS AT JUNE 1998

		Levels of mineral potential and standard potential scores (b)				
		High 18	**M-H 12**	**Moderate 6**	**L-M 2**	**Low 1**
Mineral Deposit Model	**Deposit Index(a)**	**Weighted Potential Score (a x b)**				
Hydrocarbons (oil and gas)	8		96	48	16	
Coal seam methane	7	126		42		7
Porphyry Copper-gold	7			42	14	
Epithermal gold silver	7	126		42	14	7
Au disseminated in leucogranite	7	126		42		7
Heavy mineral sand	7	126	84	42		
Coal (opencut)	6		72	36		
Volcanic associated massive sulphide	6			36	12	
Metahydrothermal veins	6	108	72		12	
Coal (underground)	5			30	10	
Silver-bearing polymetallic veins	5	90	60		10	5
Tin veins	5	90	60		10	5
Tin greisen	5	90	60		10	5
Alluvial diamond	5	90				
Alluvial sapphire	5		60		10	
Tungsten-molybdenum pipes, veins and disseminations	4	72	48	24	8	
Tungsten skarn	4			24		
Silexite (quart, topaz W-Mo-Bi)	4		48			
Copper ± magnetite skarn ± gold	4				8	
Alluvial gold (including deep lead)	4		48	24		
Gold associated with volcanic massive sulphide mineralisation including gold in chert and jaspers	4			24	8	
Alluvial tin	4		48	24		
Volcanic hosted magnetite	3		36		6	
Podiform chromite	3	54				
Limestone	3	54		18		
Volcanogenic manganese	2			12	4	
Construction material - aggregate	2	36	24	12	4	2
Chrysotile, asbestos	2	36				
Construction material - pavement	1	18	12	6	2	1

The areas with weighted scores of 36 to 84 cover about 37.88% of the region. The most extensive mineral potential tracts in this range of mineral potential scores are those for oil and gas in the Clarence-Moreton Basin (weighted score of 48, covers 16.39% of the region (Table C1)), volcanic associated massive sulphide deposits mainly south east of the basin (36,19.33%), metahydrothermal gold veins (72, 12.14%), tungsten molybdenum deposits (72, 12.92%), and alluvial gold (48, 12.02%). There are smaller areas with potential for open cut coal (72, 1.96% and 36, 5.3%), silver bearing polymetallic veins (60, 5.16%), tin veins (60, 5.16%), tin greisens (60, 6.94%), alluvial tin (48, 5.38%), and aggregated construction materials (36, 7.82%). Small areas of potential in this weighted score range include porphyry copper gold (42, 3.58%), alluvial sapphire (60, 3.51%), heavy mineral sands (42, 2.19%) and porphyry copper gold (42, 1.68%).

The area with weighted mineral potential classes below a score 36 cover about 12.56% of the region. The more significant tracts in this range of weighted mineral potential scores are for pavement construction materials (18, 25.03%) and aggregate construction materials (24, 13.82%). Considerable proportions of these tracts are overlain by tracts with higher weighted mineral potential scores.

TABLE 10: SIZE OF AREAS COVERED BY WEIGHTED MINERAL POTENTIAL SCORES IN MAP 5

Weighted mineral potential score	Area of weighted mineral potential tract (m^2)	%Area of Region (Area of region = 39082km^2)
0	34500000.000	0.08827593
2	88125000.000	0.22548744
5	187500.000	0.00047976
7	1250000.000	0.0031984
8	1812500.000	0.00463768
10	641062500.000	1.64030116
12	20812500.000	0.05325342
14	544625000.000	1.39354434
16	827000000.000	2.11606366
18	36375000.000	0.09307354
24	2462437500.000	6.30069469
30	252562500.000	0.6462374
36	780250000.000	1.99644338
42	1487312500.000	3.80562023
48	2579875000.000	6.60118469
54	94875000.000	0.24275881
60	1771250000.000	4.53213756
72	6986250000.000	17.8758764
84	1103375000.000	2.82323064
90	2440625000.000	6.24488255
96	45875000.000	0.1173814
108	4451437500.000	11.3899941
126	12430125000.000	31.8052428

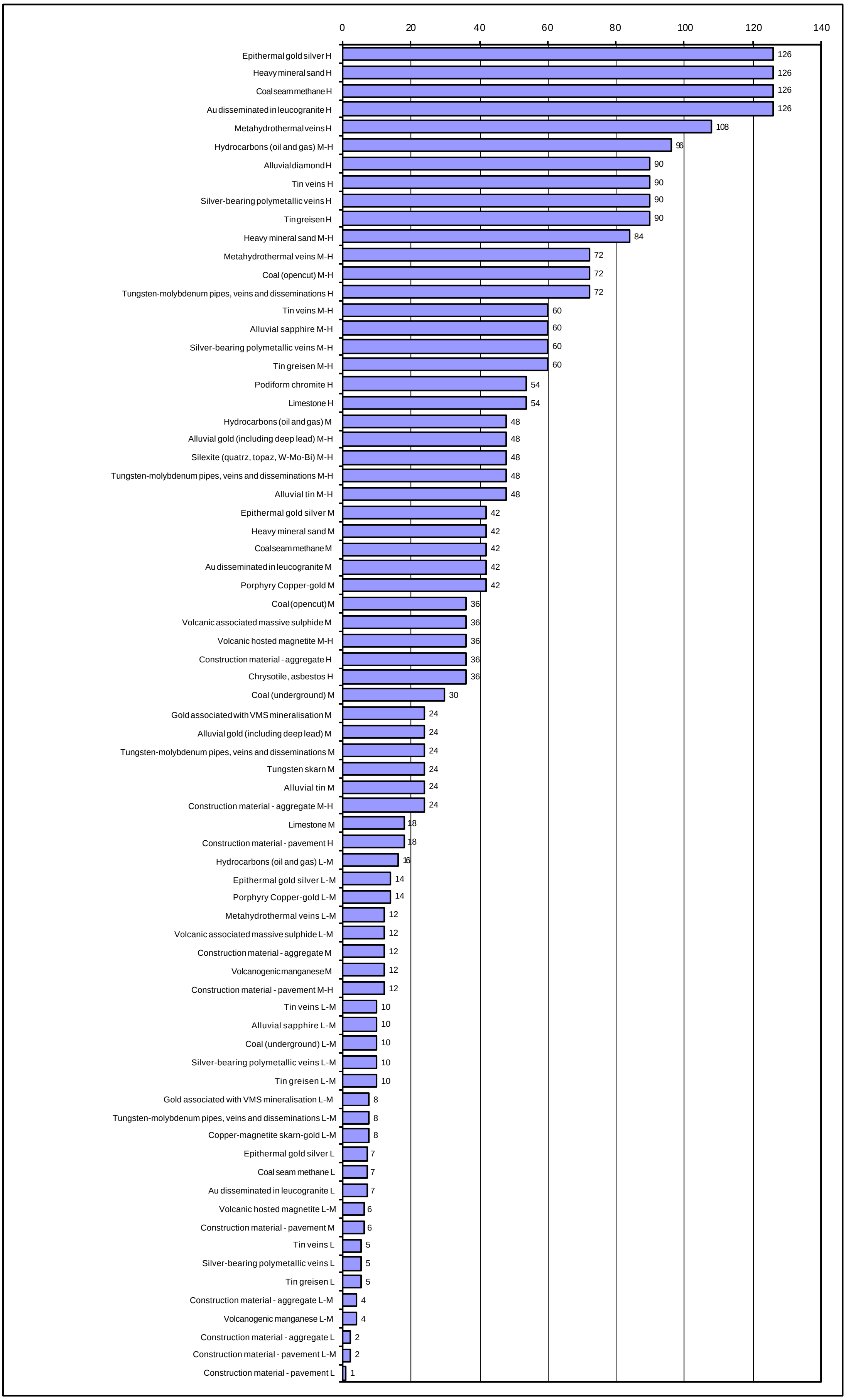


Figure 32 - Weighted Scores for tracts of all mineral deposit types

The **weighted cumulative mineral potential** (Map 6) is similar to the weighted composite mineral potential in that the score for each tract is calculated by multiplying the deposit index by the mineral potential score. Where there is overlap of tracts, the scores of the overlapping tracts are summed and this total score is assigned to the overlap area. In Map 6, the relative importance of deposit types is taken into account before adding individual potential scores. Thus on a simple cumulative map, an area where a high potential tract of metahydrothermal vein gold overlaps a tract with moderate potential for limestone deposits will have the same score (18+6=24) as an area where high potential tract for metahydrothermal vein gold overlaps with a tract of moderate potential for volcanic massive sulphide gold deposits (18+6=24). However, on a weighted cumulative map, the two areas would acquire different scores because of the different weights given to each of the deposit types. That is, for overlapping metahydrothermal vein gold tract (high potential) and limestone (moderate potential) the score is (18x6) + (6x3) = 126; for the overlapping metahydrothermal vein gold tract (high potential) and clay tract (moderate potential) the score is (18x6) + (6x4) = 132.

The weighted cumulative map is similar to the cumulative map in that it highlights the diversity of mineral potential in a north east trending zone along the western boundary of the region.

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

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

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

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

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

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

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

The mineral potential of an area is assessed for specific types of mineral deposits. For each type of deposit considered in a given area, the mineral potential is ranked in qualitative terms as 'high', 'moderate', 'low', 'no' or 'unknown', based upon professional judgements of geoscientists involved in the assessment. A qualitative mineral potential assessment is not a measure of the resources themselves. It cannot be classified according to the two dimensional ('McKelvey') diagram used for identified resources. For this reason the qualitatively assessed potential resources are shown in a separate box (Figure 2). 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 2).

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

HCarb: Hydrocarbons (oil and gas)

(Conventional petroleum deposits in the Clarence-Moreton Basin)

Model Description

Approximate Synonyms
Petroleum Reservoirs, Petroleum Leads, Petroleum Fairways

Description
Coaly and carbonaceous beds within the Ipswich and Nymboida Coal Measures, the Raceview Formation, Koukandowie Formation and the Walloon Coal Measures are considered to be source rocks for hydrocarbon generation. Reservoir targets occur in permeable sandstone bodies within the Koukandowie Formation, Ripley Road Sandstone, Walloon Coal Measures, Gatton Sandstone, Raceview Formation and Nymboida Coal Measures. Reservoir rocks must occur with suitable structural or stratigraphic traps.

General References
Ingram & Robinson (1996), Stewart & Alder (1995), Wells & O'Brien (1994).

Geological Environment

Rock Types: Sedimentary reservoir; source rocks and seal rocks; medium to coarse grained quartz-lithic to quartzose sandstones interbedded with siltstone and claystone; coal and carbonaceous claystone interbedded with sandstone, siltstone and claystone; seal rocks range from impermeable shale and siltstone to low permeability sandstones and conglomerates.

Age Range: Middle Triassic to Middle Jurassic

Depositional Environment: Fluvial, lacustrine and paludal sediments. Reservoir rocks are generally well sorted, permeable sheet sands and laterally discontinuous channel and point bar sands. Organic source rocks accumulated in swamps, peat bogs, lacustrine or flood plain environments.

Tectonic Setting: Intracontinental, extensional sedimentary basin. Later folding and faulting in the Late Triassic and Late Cretaceous - Early Tertiary has produced structural traps associated with strike-slip, reverse thrust and normal faulting and anticlinal folds.

Associated deposit types: Coal and Oil shale.

Deposit Description

Mineralogy/Composition: Oil and gas composition comprises various hydrocarbons, carbon dioxide, nitrogen and helium. Reservoir rocks are porous and permeable, lithic to quartzose sandstones and conglomerates. Seal rocks are laterally extensive, impermeable shales, claystones, siltstones and sandstones. Source rocks are coal, carbonaceous claystone and carbonaceous siltstone.

Primary reservoir targets: Extent of sedimentary basin not including outliers of target sedimentary units

Known deposits and prospects in the Clarence-Moreton Basin

Eight prospective areas have been identified within the basin. The Pickabooba Prospect is located near the western margin of the basin on the upthrown (west) side of the East Richmond Fault. Potential reservoir traps occur in closures within the Gatton Sandstone, Ripley Road Sandstone and the Ipswich Coal Measures.

The Grevillia and the Toonumbar Leads are both surface anticlines with the primary reservoir target being the Ripley Road Sandstone. The Dyraaba and the Leeville Leads are both located within the Casino Trough and occur as dip reversals against faults. The primary target would be the Heifer Creek Sandstone Member within the Koukandowie Formation. The Coraki and the Pine Brush Leads are located on the eastern margin of the basin and comprise anticlinal structures with closure on reverse faults with primary targets being the Heifer Creek Sandstone Member and the Ripley Road Sandstone. The Kungala Lead is located in the south east of the basin and comprises a possible fault closure on the Kungala Anticline with the Heifer Creek Sandstone Member and the Ripley Road Sandstone being the primary targets.

Assessment Criteria

1. Presence of Triassic and Jurassic sedimentary rocks.
2. Accumulated minimum thickness of 300 metres of sedimentary rocks.
3. Presence of underlying organic-rich source rocks.
4. Determined source rock maturity >0.7% vitrinite reflectance.

Assessment

Tract HCarb1a/M-H/D
The tract includes identified reservoir rocks with defined traps based on seismic data of variable quality. The presence of source rocks is highly likely. On available evidence, the tract is considered to have a moderate to high potential for hydrocarbons. The certainty of D is based on the identification of structure from seismic data and moderate level of confidence in the presence of reservoir and source rocks.

Tract HCarb1b/M/B
The tract includes source rocks and potential reservoir rocks with sufficient cumulative thickness and adequate maturity to have generated oil or gas capable of accumulating in structural or stratigraphic traps. The certainty of B is based on limited petroleum well data and seismic line kilometres indicating the possible presence of source and reservoir units throughout the tract. The presence of hydrocarbons in most petroleum wells indicates a good level of confidence and a moderate potential for hydrocarbons.

Tract HCarb1c/L-M/B
The tract has lower potential for presence of sufficient coal/coaly shale content in source rocks as well as lower source rock maturity. There is low to moderate potential for a resource as reservoir rocks are less likely to be present close to the basin margin, the likelihood of source rocks being present and reservoir traps formed. The certainty of B is based on a low level of penetrative drillhole data and very limited data to indicate the presence of source rocks such as the Nymboida Coal Measures beneath the tract.

Economic Significance

New South Wales is the only mainland state that imports all of its petroleum requirements. Gas or oil in this area would greatly benefit the State as well as providing a cheap energy source for both local power generation, local industry and secondary processing of the minerals in the New England Block. Natural gas would provide an energy source with minimal environmental impact.

CSMeth: Coal Seam Methane

Model Description

Approximate Synonyms
Seam Gas, Coal Bed Methane

Description
Coaly and carbonaceous rocks within the Ipswich and Nymboida Coal Measures, Koukandowie Formation and the Walloon Coal Measures are source rocks for gas generation. Reservoir potential occurs in permeable coal seams within the Walloon Coal Measures, Koukandowie Formation and Ipswich and Nymboida Coal Measures.

General References
Ingram & Robinson (1996), Stewart & Alder (1995), Wells & O'Brien (1994).

Geological Environment

Rock Types: Coal measures interbedded with various terrestrial sequences.

Age Range: Middle Triassic to Middle Jurassic

Depositional Environment: Paludal, lacustrine and fluvial sediments. Peat swamps within structural depressions; peat swamps associated with fluvial flood plains and marginal to alluvial fans; lacustrine environment.

Tectonic Setting: Intracontinental, extensional sedimentary basin. Later folding and faulting in the Late Triassic and Late Cretaceous - Early Tertiary has produced strike-slip, reverse thrust and normal faulting and anticlinal folds.

Associated deposit types: Coal and Oil shale.

Deposit Description

Mineralogy/Composition: Gas composition comprises methane, ethane and minor other hydrocarbons, carbon dioxide, and nitrogen. Reservoir and source rocks are coal seams.

Primary reservoir targets: Limits of the main sedimentary basin with sufficient cover to provide lithostatic pressure to confine gas (a minimum of 100 metres).

Known deposits and prospects in the CRA region

Within the south western portion of the basin the Nymboida Coal Measures have been mined. Gas explosions at Nymboida Colliery have been attributed to coal seam methane within the Farquhar's Creek seam. A nearby borehole intersected a fault plane resulting in a blow-out and subsequently flowed gas for many years. Petroleum wells towards the centre of the basin have recorded gas from coal seams of the Ipswich Coal Measures. Gas shows have been recorded from the Walloon Coal Measures in many of the petroleum wells drilled, particularly in the Hogarth, Tullymorgan and Kyogle areas.

Assessment Criteria

1. Presence of the coal-bearing formations
2. Proximity to known coal deposits
3. Depth of cover less than 1000 metres
4. Presence of sufficient cumulative coal thickness
5. Determined coal seam maturity >0.6% vitrinite reflectance

Assessment

Tract CSMeth1a/H/C
The tract is defined by the presence of coal seams within both the Walloon Coal Measures and the possible presence of the Nymboida/Ipswich Coal Measures. Depth of cover should be sufficient to retain gas within the coal seam (a minimum of 100 metres). The coal seams within the tract are expected to have adequate maturity to have generated gas and therefore are defined in zones where the organic matter within the coal seams has a vitrinite reflectance of greater than 0.6%. Areas of volcanic extrusion are not downgraded and only the mapped extent of intrusions such as plugs, dykes and breccia pipes should be excluded. The tract defines a high potential for coal seam methane. A certainty of C is based on the moderate level of knowledge of the presence of reservoir rocks and limited data available on gas quantity and quality within the Walloon Coal Measures.

Tract CSMeth1b/M/B
The tract may contain sufficient cumulative coal thickness within the Ipswich or Nymboida Coal Measures but such coal is more likely to occur at depths shallower than 1000 metres. Coal seams within the Walloon Coal Measures are likely to be at shallow depth or absent in this tract. The certainty of B is based on the poor level of knowledge regarding the depth and gas content of the Walloon Coal Measures and a complete lack of data regarding the presence of the Nymboida Coal Measures. The tract has a moderate potential for coal seam methane.

Tract CSMeth1c/L/B
The tract may contain sufficient cumulative coal thickness within the Ipswich or Nymboida Coal Measures but such coal is more likely to occur at depths greater than 1000 metres due to the moderate to steep dips anticipated throughout this tract. Outcropping Ipswich Coal Measures are known from Evans Head and Red Cliff. Coal seams within the Walloon Coal Measures are unlikely to be a target as they are at shallow depth or absent in this tract. The tract has a low potential for coal seam methane. A certainty of B is based on a very low level of data relating to the presence of the Nymboida/Ipswich Coal Measures and moderate data for the Walloon Coal Measures.

Economic Significance

The strategic importance of a viable coal seam methane producing field within the Clarence-Moreton Basin should not be underestimated. A cheap energy source for both local power generation, local industry and secondary processing of minerals from the New England Block would be of considerable economic significance.

Coal seam gas has the potential, as a fuel resource, to have a lower environmental impact in terms of resource recovery, transport and utilisation compared to thermal coal.

CuAu1:Porphyry copper-gold deposits (Model 20c of Cox and Singer 1986)

Model Description
Description of the model after Dennis P. Cox.

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

General References:
Sillitoe (1979, 1989)

Geological Environment

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

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

Age Range: Palaeozoic to Quaternary.

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

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

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

Deposit Description

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

Texture/Structure: Veinlets and disseminations.

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

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

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

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

Geophysical signature: Significant magnetic expression in most cases.

Examples

Goonumbla, AUNW	Heithersay et al. 1990
Panguna, PPNG	Clark 1990
Ok Tedi, PPNG	Rush and Seegers 1990
Dizon, PLPN	
Dos Pobres, USAZ	Langton and Williams 1982
Copper Mountain, CNBC	Fahrni and others 1976

Known deposits and mineral prospects in UNER

Although traditional economic porphyry copper/gold type deposits are not known to occur within the UNER, some mineral occurrences show a number of similar characteristics and affinities with porphyry deposits. In particular, disseminated copper showings at Solferino and at the Lionsville Cu-Au prospect, and at Tyringham Au (near Dundurrabin, west of Coffs Harbour). Disseminated low-grade mineralisation in other intrusives, similar to the Dumbudgery Creek Granodiorite or equivalents, may have affinities with porphyry gold-copper deposits. Other areas characterised by gabbroic or doleritic small intrusive bosses, and associated with alluvial gold and trace copper are known near Tooloom and near Snapes copper prospect and these occurrences could have affinities with porphyry copper-gold deposits.

Assessment Criteria

1. Distribution of late Carboniferous, Permian and (?)early Triassic I-type magnetic granitoids, particularly late Permian Clarence River Plutonic Suite, including the Dumbudgery Creek Granodiorite, Towgon Grange Granodiorite, Kaloe Granodiorite, Jenny Lind Granite (a quartz diorite), and the Bruxner Adamellite, and associated unnamed gabbroic and mafic intrusive bodies near Tooloom and near Snapes prospect. Also, the presence of granitoid intrusives of the Moonbi Plutonic Suite.
2. Presence of several stages of porphyry-style sericitic, argillic or propylitic alteration, which may also include late stage tourmaline-rich siliceous alteration.
3. Presence of copper and gold anomalism in streams, soils or rock chip samples.
4. Presence of indicative aeromagnetic anomalies.
5. Presence of primary or alluvial gold occurrences

Assessment

Tract CuAu1a/M/B-C

The tract embraces intrusives of the Clarence River plutonic Suite. Additional areas around the Bruxner Adamellite and the Jenny Lind Granite represent subsurface extensions of these bodies interpreted from high-magnetic responses on aeromagnetics. The tract also includes areas around Tooloom, where aeromagnetics shows the presence of a subsurface granitoid body, associated with alluvial gold occurrences and significant geochemical anomalies (Au+Cu+Sb+As). At Snapes, mafic intrusives occur, and possibly also in the subsurface, together with moderately significant geochemical anomalies. The tract also includes granitoids of the Sheep Station Creek Complex and the Billys Creek Tonalite. These are I-type, magnetic granites and are associated with moderate to high levels of geochemical anomalism. The tract exhibits evidence of gold and copper anomalism within these intrusives where exposed. This tract is assessed as having moderate potential with a certainty level of B-C.

Tract CuAu1b/L-M/B
Intrusives of the Permo-Triassic Moonbi Plutonic Suite (fractionated I-type oxidised granites) define this tract and include the Undercliffe Falls Adamellite, the Herries and Bungalla Adamellites, Mount Mitchell Monzogranite, Newton Boyd Granodiorite and an unnamed granitoid north of Dalmorton which belongs to this Suite. The tract hosts most known occurrences of disseminated gold and is assessed as having low-moderate potential with a certainty level of B.

Economic Significance

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

Au1: Epithermal gold-silver deposits

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

General References
Buchanan (1980), White and Hedenquist (1990), Henley et al. (1984), Berger and Bethke (1985)

Geological Environment

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

Textures: Porphyritic.

Age range: In Australia mostly Palaeozoic. Outside Australia most mineralised epithermal systems are of Tertiary age although Precambrian epithermal systems have also been reported.

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 sulphosalts + silver sulphosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodochrosite + 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 signature:

Examples

Pajingo, AUQL	Bobis et al. 1996
Creede, USCO	Steven and Eaton 1975; Barton et al. 1977
Pachuca, MXCO	Geyne et al. 1963
Toyoha, JAPN	Yajima and Ohta 1979

Known deposits and mineral occurrences in the CRA region

All known occurrences and deposits of epithermal gold-silver are hosted by the Drake Volcanics of the Middle to Late Permian Wandsworth Volcanic Group. The volcanics of the group are represented by terrestrial rhyolitic to andesitic ash flow tuffs and ignimbrites. The volcanics and the associated subvolcanic intrusions form large volcanic cauldrons. The Drake Volcanics are marine to marginal marine and slightly more mafic than other rocks of the Wandsworth Group and contain abundant, high level, co-magmatic, felsic intrusions (stocks and dykes) which might be an important factor in generating and maintaining epithermal system (Barnes et al, 1996)

The Drake Volcanics are extensively hydrothermally altered.

Mineralisation is in the form of fissure lodes, breccia infillings, stockworks and disseminations and is accompanied by typical epithermal style wall rock alterations (phyllic, argillic, silicification). Fissure lodes are emplaced along north east trending faults.

A permeable stratigraphic unit close to fracture zones and to co-magmatic with volcanism, felsic intrusives such as the Dundee Rhyodacite are thought to be important ore controlling features (Bottomer, 1986, cited in Barnes et al, 1996).

Spatial analysis of the distribution of known occurrences in the area suggests that;

- 69 out of 70 occur within the Drake Volcanics;
- 21 out of 70 occur within the PwkvA unit of the Drake Volcanics;
- 41 out of 70 are within 1 km of mapped faults;
- 60 out of 70 are within 5 km of mapped faults;
- 25 out of 70 are within 2 km of known granitoids
- 52 out of 70 are within 5 km of known granitoids.

Assessment Criteria

1. Distribution of intrusive/extrusive complexes represents a predominantly subaerial complex of volcanic and volcaniclastics of silicic to mafic composition (the Wandsworth Volcanic Group, particularly the Drake Volcanics)
2. Presence of favourable structures such as caldera with ring fractures and zones of brecciation. (importance of north east trending fractures)
3. Presence of subvolcanic intrusions.
4. Presence of alterations such as: silicification, propylitic, chloritic, sericitic and argillic.
5. Presence of mineral prospects having features similar to epithermal precious-metal deposits.

Assessment

Tract Au1a/H/C

The tract includes volcanic, volcaniclastic rocks of the Drake Volcanics and the overlying sedimentary rocks of the Gilgurry Mudstone. Both these units host significant epithermal deposits of the region (69 out of 70 known occurrences are hosted by them). The rocks show typical epithermal-style alterations. They also host several occurrences of alluvial gold. The tract is also characterised by high levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. Hence mineral potential of the tract is assessed to be high with a certainty level of B.

Tract Au1b/M/B

The tract is defined by a 5 kilometre buffer on the eastern side of the Drake Volcanics included in the tract Au1a/H/C. The buffer approximates the extent of the epithermal system generated by volcanic-plutonic event associated with the Drake Volcanics. It includes rocks of the Emu Creek Formation which host a number of gold occurrences. However the available information is not sufficient to suggest that they are of epithermal affiliation. The tract also includes Tertiary and Quaternary rocks of at the margin of the Clarence-Moreton Basin, that have a potential to host favourable rocks (either the Drake Volcanics or the Emu Creek Formation) for hosting epithermal mineralisation. The tract is characterised by moderate to high levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. The potential of the tract is thus assessed to be moderate with a certainty level of B.

Tract Au1c/L-M/B

The tract is defined by the presence of the rocks of the Wandsworth Volcanic Group excluding the Drake Volcanics and the Gilgurry Mudstone. Unlike the Drake Volcanics which are more mafic, the rocks of the Wandsworth Group do not contain as many, high level, co-magmatic, felsic intrusions (stocks and dykes) which might be an important factor in generating and maintaining epithermal systems. The volcanics in the tract do not contain any notable epithermal mineralisation but locally are characterised by low to moderate levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. Mineral potential of the tract is assessed to be low to moderate with a certainty level of B.

Tract Au1d/L/B

The tract is defined by a one kilometre buffer around the Wandsworth Volcanic Group rocks of the tract Au1c/L-M/B to delineate the extent of a possible epithermal system generated by the volcanic system. As mineral potential of the tract defined by the volcanics has been assessed to be low to moderate (see tract Au1c/L-M/B), the potential of the buffer is assessed to be low with a certainty level of B.

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

Au2: Granitoid related disseminated gold deposits (Timbarra Style)

Model Description

Description

Stockwork veinlets of sulphides and gold in granitoids.

General References : Mustard et al. (1998)

Geological Environment

Rock Types: High-K, I-type fractionated granites.

Textures: Intrusive rocks are porphyritic with medium to fine-grained groundmass, medium to coarse grained equigranular, and aplitic.

Age Range: Palaeozoic.

Depositional Environment: Post orogenic granitoids. Presence of miarolitic cavities indicates emplacement and crystallisation at shallow crustal levels (around 2 kb lithostatic pressure)

Tectonic Setting(s) : Cratonal as in Zaaiplaats in South Africa or Post-orogenic intrusions in the waning stages of the evolution of volcanic arcs

Associated Deposit Types: Gold-porphyry; epithermal Ag-Au, tin veins, gold placers.

Deposit Description

Mineralogy: pyrite, chalcopyrite, arsenopyrite, pyrrhotite, galena, molybdenite, bismuth sulphides and tellurides. Gangue minerals: quartz and feldspar.

Texture/Structure: Veinlets and disseminations. Gold disseminations along grain boundaries, within fractures in large altered and unaltered feldspars, in fractured feldspar phases of perthite and as elongate grains with native bismuth in molybdenite.

Alteration: Weak to moderate pervasive sericite-chlorite (albite), sericite-chlorite (hematite), carbonate and clay alteration.

Ore controls: Disseminated gold mineralisation is dominantly beneath a carapace of microgranites. Localised high-grade mineralisation is also associated with aplite dykes. Locally structural (faults and fractures) control of mineralisation is significant.

Geochemical signature: Stream sediment geochemical anomalies of gold, copper, arsenic and antimony.

Examples

There are no other examples of this type of mineralisation, although tin mine at Zaaiplaats (Pollard et al. 1991) and gold mineralisation at Mount Rawdon (Brooker and Jaireth 1995) have features similar to the Timbarra style mineralisation.

Known Deposits and Prospects in the CRA Region

There are several known occurrences of this type of deposits in the area. The most well known of these are concentrated to form the Timbarra Goldfield, located 30 kilometres south east of Tenterfield. Disseminated gold mineralisation is associated with the high potassium I-type Stanthorpe Adamellite (locally called Surface Hill Granite).

Gold mineralisation is in the form of veins (only 1%) and disseminations in smoky quartz, and along cracks in feldspars that have been locally altered to albite and/or illite. Available geological information does not reveal any single factor controlling mineralisation. Any of the following geological factors could have played some role in ore localisation: fractionated I-type granitoids; microgranite and aplite dykes (east north east, east, north west trending), local structures. It is thought that the distribution of mineralisation is controlled beneath or within chilled carapaces close to the granite roof.

Assessment Criteria

1. Distribution of fractionated, I-type leucoadamellites (Stanthorpe or equivalent granitoids).
2. Presence of aplite dykes.
3. Presence of albititic and/or illitic alterations.
4. Geochemical anomalies of gold and arsenic.
5. Presence of known mineral prospects and alluvial gold occurrences.

Assessment

Tract Au2a/H/B
The tract includes I-type, fractionated granitoids (Stanthorpe Adamellite). They are classified as the Stanthorpe subtype of the larger Stanthorpe Granite Group (Blevin and Chappell 1996). The Fe2O3/Fe3O4 ratio of a few samples indicates a low oxidation state and on the aeromagnetics they appear as magnetic lows. They contain all the known occurrences of this type including Poverty Point, RMT, Big Hill and Hortons. In the areas of known occurrences they show sericitic and chloritic alteration. The tract is locally characterised by moderate levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. The potential of the tract is assessed to be high with a certainty level of B

Tract Au2b/M-H/B
The tract includes I-type, fractionated granitoids (Billyrimba Leucoadamellite, Bolivia Range Leucoadamellite, Bungulla Adamellite, Clive Adamellite, Mackenzie Adamellite, Nonigton Leucoadamellite, Pyes Creek Leucoadamellite, Undercliff Falls Adamellite and an Unnamed complex at Sugarloaf). These granitoids belong to the Bugualla and Stanthorpe types of the larger Stanthorpe Granite Group (Blevin and Chappell 1996). The Fe2O3/Fe3O4 ratio of a few samples indicates a low oxidation state and on the aeromagnetics they appear as magnetic lows. The tract also contains areas of moderate to high levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. They don't host any known occurrences of disseminated gold but contain occurrences of alluvial gold. However the granitoids are geochemically and petrologically similar to those outlined the tract Au2a/H/B and could have crystallised from similar felsic melt. Hence mineral potential of the tract is assessed to be moderate to high with a certainty level of B.

Tract Au2c/L/B
The tract incudes all other I-type granites and leucoadamellites except the highly magnetic Clarence River Plutonic Suite which has been assessed to have a moderate potential to host porphyry copper-gold deposits. These granites have variable magnetic response on the aeromagnetics and could be responsible for low to moderate levels of combined stream sediment geochemical anomalies of gold, arsenic, copper and antimony. They could also be the source of several occurrences of alluvial gold. The tract however does not host any known occurrences of disseminated gold; hence the potential is assessed to be low with a certainty level of B.

Economic Significance

The Timbarra deposit has ore reserves totalling 327,700 ounces of gold based on three relatively shallow open-cuts. The gold mineralisation is disseminated in the leucogranite but the host rock is not the source rock for the mineralisation. The deposit shows some similarities to the Mount Rawdon gold deposit in Queensland and has some evidence for a porphyry type mineralising system.

MS1: Heavy mineral sands (Shoreline Placer Ti (Model 39c of Cox and Singer 1986)

Model Description
Description of the model after Eric R. Force.

Description
Ilmenite, rutile, zircon, leucoxene, magnetite, monazite and other heavy minerals (garnet, xenotime, cassiterite and gold) concentrated by beach processes.

Geological environment

Rock types: Well-sorted medium to fine grained sand in dune, beach and inlet deposits commonly overlying shallow marine deposits.

Age range: Commonly Late Tertiary (Miocene) to Quaternary (Holocene) but could be any age range.

Depositional environment: Stable coastal region with efficient sorting and winnowing, receiving sediment from deeply weathered metamorphic terranes of sillimanite or higher grade.

Tectonic setting: Margin of craton. Crustal stability during deposition and preservation of deposits.

Deposit description

Structure: Elongate ‘shoestring’ deposits parallel to coastal dunes and beaches.

Ore Controls: Ultimately a high-grade metamorphic source but may include sediments and metasediments as source rocks in which heavy minerals were trapped during an earlier depositional cycle and subsequently eroded; stable coastline with efficient sorting and winnowing. Heavy mineral concentrations are formed by wave and wind action and include beach placer, beach ridge, and sand dune deposits.

Weathering: Leaching of iron from ilmenite and destruction of labile heavy minerals results in residual enrichment of deposits.

Geochemical and geophysical signatures: High Ti, Zr, Th, U, rare earth elements; anomalously high concentrations of heavy minerals; gamma radiometric anomalies due to monazite content; induced polarisation anomalies due to ilmenite.

Examples

Numerous heavy mineral concentrations of rutile and ilmenite occurring along the current and ancient inland shorelines in northern New South Wales and southern Queensland (Wallis and Oakes 1990).

Heavy mineral concentrations of ilmenite and rutile along ancient shorelines inland from the present coastline in south west of Western Australia at Yoganup (Masters 1990) and Eneabba (Shepherd 1990).

Known Deposits and Mineral Prospects in the UNER

Concentrations of heavy mineral sands occur at Evans Head, Bullock Creek Beach, while gold-rich rutile, ilmenite and zircon sands are known at Gallaghers claim, Station Creek, McAuleys and the Coolgardie lead on the Maclean sheet. These heavy mineral concentrations are dominated by rutile and zircon, with minor ilmenite. The sources for these heavy minerals debouching into the sea from major rivers are probably the igneous rocks in the UNER but they could also have been derived from heavy minerals previously held in sediments and metasediments but subsequently released by erosion and transported by long shore currents.

Assessment Criteria

1. Appropriate coastal deposits of sand along recent or late Pleistocene inland beach and dune sands.
2. Known occurrences of heavy mineral sands including ilmenite, rutile and zircon, and possibly including gold, platinum group metals or magnetite.
3. The presence of alluvial heavy mineral sands cropping out through the sediments on the coastal plain.

Assessment

Tract HMS1a/H/C-D
This tract includes present day beach and dune sands and also includes older dune and swamp deposits on the coastal plain where the presence of heavy mineral sands has been defined by drilling and/or is an extension of these known areas. On available information there is a high potential, with a certainty of C, for heavy mineral concentrations of sufficient size to be of economic interest. Such deposits may contain small amounts of gold. The heavy mineral concentrations may occur largely within the older dune systems and in fossil shoreline sediments and in strandlines resting on basement rocks.

Tract HMS1b/M-H/C
The tract covers Quaternary (Pleistocene and Recent) sandy sediments in areas where heavy mineral sands are known to have been mined out, but where extensions or lower grade halos could be possible or become mineable by improved technology

This tract is assessed on available information as having moderate to high potential, with a certainty of C, for heavy mineral concentrations of sufficient size to be of economic interest.

Tract HMS1c/M/B
The tract covers Quaternary sediments close to the present or palaeoshore lines. There is a moderate potential, with a certainty of B, for heavy mineral concentrations of sufficient size to be of economic interest.

If heavy mineral concentrations are present in the above tracts, they may also contain trace amounts of gold.

Economic Significance

Based on data on 61 deposits worldwide, shoreline placer deposits have a median ore tonnage of 11 Mt (Cox and Singer 1986). Both beach and dune sand deposits are included in this sample. About 90% of these deposits contain at least 11 Mt of ore and 10% contain at least 690 Mt. The median grades for these deposits are 1.3% TiO_2 for ilmenite and 0.15 percent TiO_2 for rutile.

The economic viability of shoreline deposits is determined by the constituent mineralogy, grades and size of the deposit. The successful working of these east coast deposits over the last 50 years suggests that the beach and dune sand deposits in the UNER are of significant economic importance, where there are no pre-existing State or National Parks covering the tract. It should be noted that environmental factors could affect the economic viability of the mineral sands tract.

Coal1: Open Cut Coal deposits in the Clarence-Moreton basin

Model Description

Approximate Synonyms : Coal Measures

Description
Coal-bearing and carbonaceous sequences within the Jurassic Walloon Coal Measures and Koukandowie Formation, and the Triassic Ipswich and Nymboida Coal Measures that are likely to occur at shallow depths.

General References
McElroy (1962), McDonald (1978), Wells & O'Brien (1994).

Geological Environment

Rock Types: Sandstone, siltstone, claystone, carbonaceous claystone and coal. Igneous rocks comprising Tertiary basalts and syenitic rocks are variably intruded within the formation.

Age Range: Middle Triassic to Middle Jurassic

Depositional Environment: Paludal, lacustrine and fluvial sediments. Peat swamps within structural depressions; peat swamps associated with fluvial flood plains and marginal to alluvial fans; lacustrine environment.

Tectonic Setting: Intracontinental, extensional sedimentary basin. Later folding and faulting in the Late Triassic and Late Cretaceous - Early Tertiary tectonism has produced strike-slip, reverse thrust and normal faulting and broad, open folds.

Associated deposit types: Coal Seam Methane and Oil shale.

Deposit Description

Mineralogy/Composition: Coal within the Walloon Coal Measures is high volatile bituminous, and high in vitrinite with minor exinite. Inherent ash is noted to be higher than Sydney Basin coals.

Coal within the Nymboida Coal Measures is low to medium volatile bituminous, tending to anthracite in places.

Sulphur content in both coals is low, ranging from 0.5% - 0.8%.

Known deposits and prospects in the CRA region

In the south western portion of the basin the Nymboida Coal Measures have been mined at Nymboida Colliery. The Walloon Coal Measures have been mined at Bonalbo, Ramornie, Nimbin and Tyalgum. Numerous shallow prospects within the Walloon Coal Measures are located throughout the outcrop extent.

Assessment Criteria

1. Presence of the Walloon Coal Measures.
2. Presence of the Nymboida Coal Measures.
3. Proximity to known coal deposits.
4. Maximum depth of cover to top of coal measures less than 100 metres.
5. Low to moderate seam dip.
6. Absence of vertical to sub-vertical intrusive igneous bodies.

Assessment

Tract Coal1a/M-H/B-C
The tract has moderate to high potential and is defined by the presence of Walloon Coal Measures at outcrop and at depths with opencut potential where geological structure indicates shallow dip and the anticipated thickness of the main coal sequence may be of mineable thickness. The tract covers an area on the western side of the basin, north of Urbenville and extending northerly into Queensland. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. A certainty of B for this tract is due to poor quality data with no subsurface data.

A further tract with moderate to high potential is located in the central northern part of the basin extending from Nimbin north to Tyalgum. This tract is defined by the presence of Walloon Coal Measures at outcrop and at depths with opencut potential where geological structure indicates shallow dip and the anticipated thickness of the main coal sequence may be of mineable thickness. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. A certainty of C is based on moderate quality data including previous mining.

Tract Coal1b/M/C
The tract is defined by the presence of Walloon Coal Measures at outcrop with opencut potential and the thickness of the main coal sequence is likely to be less than 15 metres. The tract extends around the majority of the basin edge from Urbenville in the north west, to Glenreagh in the south and along the eastern side of the basin as far north as the Coraki-Lismore area. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. Areas overlain by Quaternary sediments are not excluded. A certainty of C is based on moderate quality data.

Another tract with moderate potential for locating open cut coal is defined by the presence of Nymboida Coal Measures at outcrop and at possible depths no greater than 100 metres. The tract is located at the south western margin of the basin. It is bounded by the Martin Fault in the north and extends south east into the Towallum area. A certainty of C is based on a moderate level of borehole data and previous mining at Nymboida Colliery.

Economic Significance

Currently no coal is produced from the Clarence-Moreton Basin within New South Wales. The strategic importance of viable coal deposits within this region would be considerable. A cheap energy source for both local power generation through either conventional coal-fired or fluidised-bed combustion technology. Combined with local industry and secondary processing of minerals from the New England Block this would be of considerable economic significance.

The division of coal deposits into opencut and underground potential reflects not only the expected mineable depth of coal seams, it is a recognition that the viability of underground coal resources of the quality known to occur in the Clarence-Moreton Basin would be significantly less than shallow resources amenable to opencut. The interbedded nature of typical Walloon Coal Measure seams renders them suitable only for selective mining which is currently only achieved in open cut extraction. However, the possibility remains that seams with better quality, in geologically more favourable environments, occur in the untested majority of these tracts.

BM1: Volcanic associated massive sulphide deposits

Model Description
Description of the model after Donald A. Singer.

Approximate Synonyms: Cupreous pyrite.

Description: Massive pyrite, chalcopyrite, and sphalerite in pillow basalts.

General Reference: Franklin et al. (1981).

Geological Environment

Rock types: Ophiolite assemblage: tectonised dunite and harzburgite, gabbro, sheeted diabase dykes, pillow basalts, and fine-grained metasedimentary rocks such as chert and phyllite.

Textures: Diabase dykes, pillow basalts, and in some cases brecciated basalt.

Age range: Archaean(?) to Tertiary--majority are Ordovician or Cretaceous.

Depositional environment: Submarine hot spring along axial grabens in oceanic or back-arc spreading ridges. Hot springs related to submarine volcanoes producing seamounts.

Tectonic setting(s): Ophiolites. May be adjacent to steep normal faults.

Associated deposit types: Mn and Fe-rich cherts regionally.

Deposit Description

Mineralogy: Massive: pyrite + chalcopyrite + sphalerite + marcasite + pyrrhotite. Stringer (stockwork): pyrite + pyrrhotite, minor chalcopyrite and sphalerite (cobalt, gold, and silver present in minor amounts).

Texture/Structure: Massive sulphides (>60 percent sulphides) with underlying sulphide stockwork or stringer zone. Sulphides brecciated and recemented. Rarely preserved fossil worm tubes.

Alteration: Stringer zone: feldspar destruction, abundant quartz and chalcedony, abundant chlorite, some illite and calcite. Some deposits overlain by ochre (Mn-poor, Fe-rich bedded sediment containing goethite, maghemite, and quartz).

Ore controls: Pillow basalt or mafic volcanic breccia, diabase dykes below; ores rarely localised in sediments above pillows. May be local faulting.

Weathering: Massive limonite gossans. Gold in stream sediments.

Geochemical signature: General loss of Ca and Na and introduction and redistribution of Mn and Fe in the stringer zone.

Examples

Cyprus deposits, CYPS	Constantinou and Govett 1973
Oxec, GUAT	Peterson and Zantop 1980
York Harbour, CNNF	Duke and Hutchinson 1974
Turner-Albright, USOR	Koski and Derkey 1981

Known Deposits and Mineral Prospects in the CRA Region

Stratiform and stratabound massive sulphide deposits occur as copper-rich sulphide lenses interlayered with deep water marine sediments. They are known to occur in the Late Devonian-Early Carboniferous Woolomin Group (and equivalents), Sandon Beds and in Silurian and Late Carboniferous sediments of the Coffs Harbour Block (Barnes et al. 1988). Most deposits in the Woolomin Group and Sandon Beds occur as stratiform lenses resting on altered metabasalts and as disseminations within altered metabasalts. Manganiferous cherts and jaspers overlie sulphide lenses (Herbert 1981 cited in Barnes et al. 1988). Mineralisation in the Coffs Harbour Block is generally associated with fine grained, siliceous metasediments (slates, phyllites) or quartz magnetite or jasper (Barnes et al. 1988). In the Cangai Copper mine, mineralisation is associated with ?Silurian-Devonian andesitic, fine grained cherty tuff, mudstone, siltstones, lithic wackes and conglomerates of the Willowie Creek beds (Henley 1993).

Mineralisation in all deposits except in the Cangai mine is interpreted to be associated with tholeiitic volcanism in submarine environment and belongs to the Oceanic Crustal Metallogenic Unit (Markham 1975b). For the Cangai mine a similar environment is also suggested although lead isotope studies indicate that the mineralising fluid might be related to the Towgon Grange Granodiorite (Brauhart 1991, cited in Henley 1993).

Assessment Criteria

1. Presence of rocks belonging to the ophiolitic assemblage consisting of mafic volcanic, volcaniclastic and volcanogenic sedimentary rocks formed in submarine environment. (Coffs Harbour Association, Sandon Association, Silverwood Association or Brooklana Beds, Coffs Harbour Beds, Coramba Beds, Cungleburg Creek Beds, Girakool Beds and Agnes Greywacke, Sandon Beds, Willowie Creek Beds).
2. Presence of known mineral occurrences.

Assessment

Tract BM1a/M/C

The tract includes the accretionary-prism rocks of the ophiolitic assemblage consisting of mafic and felsic volcanics and volcaniclastics and their metamorphic equivalents. It also includes sedimentary and metasedimentary rocks formed in proximity to submarine volcanic environment. The best markers of these environments are cherts, jaspers, manganese-rich sedimentary facies and magnetite rich rocks. The tract also includes all the known occurrences of volcanic associated massive sulphide mineralisation. Mineral potential of the tract is assessed to be moderate with a certainty level of C.

Tract BM1b/L-M/C

The tract includes the rest of the accretionary-prism rocks which are not reported to have chert or jasper horizons but are indicative of a general ophiolitic-related geological environment. The tract does not host any known mineral occurrences of volcanic associated massive sulphides. However these rocks have features which are indicative of broad ophiolitic assemblages. It is also possible that these rocks host some distal volcanic-massive sulphide mineralisation. Hence the potential of the tract is assessed to low to moderate with a certainty level of C.

Economic significance

The tract can host Cyprus and/or Besshi style volcanic massive sulphide deposits. Grade and tonnage data (Cox and Singer 1986) of these deposits indicates that 10% of these deposits can contain at least 17 Mt (Cyprus style) or 3.8 Mt of ore (Besshi style); 50% of the deposits contain at least 1.6 (Cyprus style) or

0.22 (Besshi style) Mt of ore; 90% of these deposits contain at least 0.1 (Cyprus style) and 0.12 (Besshi style) Mt of ore. The largest 10% of these deposits have at least 3.9 % (Cyprus style) and 3.8% (Besshi style) copper in the ore. The two types of deposits also contain commercially important concentrations of gold, silver and zinc.

Au3: Metahydrothermal Gold - antimony veins (Models 27d, 36a of Cox and Singer 1986)

Model Description
Description of the model after James D. Bliss and Greta J. Orris; Byron R. Berger.

Approximate Synonyms
Mesothermal quartz veins, Mother Lode veins, turbidite-hosted gold veins, slate belt gold veins, low sulphide gold-quartz veins, deposits of quartz-stibnite ore (Smirnov and others, 1983).

Description
Gold in quartz veins and silicified lode structures, mainly in regionally metamorphosed rocks; stibnite-gold veins, pods, and disseminations in or adjacent to brecciated or sheared fault zones.

General References
Forde and Bell (1994); Hodgson, Love and Hamilton (1993), White (1962), Miller (1973), Gilligan & Barnes (1990), Knight (1978).

Geological Environment

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

One or more of the following lithologies is found associated with over half of the antimony-gold vein deposits: limestone, shale (commonly calcareous), sandstone, and quartzite. Deposits are also found with a wide variety of other lithologies including slate, rhyolitic flows and tuffs, argillite, granodiorite, granite, phyllite, siltstone, quartz mica and chloritic schists, gneiss, quartz porphyry, chert, diabase, conglomerate, andesite, gabbro, diorite, and basalt.

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: Stibnite-bearing veins, pods, and disseminations containing base metal sulphides + cinnabar + silver + gold + scheelite that are mined primarily for lead, gold, silver, zinc, or tungsten; low-sulphide Au-quartz veins; epithermal gold and gold-silver deposits; hot-springs gold; carbonate-hosted gold; tin-tungsten veins; hot-springs and disseminated mercury, gold-silver placers; infrequently with polymetallic veins and tungsten skarns. Placer Au-PGE.

Deposit Description

Mineralogy: Gold-low sulphide quartz vein deposits contain 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. Antimony-gold vein deposits contain stibnite + quartz ± pyrite ± calcite; minor other sulphides frequently less than 1 percent of deposit and included ± arsenopyrite ± sphalerite ± tetrahedrite ± chalcopyrite ± scheelite ± free gold; minor minerals only occasionally found include native antimony, marcasite, calaverite, berthierite, argentite, pyrargyrite, chalcocite, wolframite, richardite, galena, jamesonite; at least a third (and possibly more) of the deposits contain gold or silver. Uncommon gangue minerals include chalcedony, opal (usually identified to be cristobalite by X-ray), siderite, fluorite, barite, and graphite.

Texture/structure: Gold-low sulphide quartz vein deposits - saddle reefs, ribbon quartz, breccias, open-space filling textures commonly destroyed by vein deformation. Antimony-gold vein deposits contain stibnite in pods, lenses, kidney forms, pockets (locally); may be massive or occur as streaks, grains, and bladed aggregates in sheared or brecciated zones with quartz and calcite. Disseminated deposits contain streaks or grains of stibnite in host rock with or without stibnite vein deposits.

Alteration: Quartz + siderite and (or) ankerite ± albite in veins with possible halo of carbonate alteration. Chromian mica ± dolomite ± talc ± siderite in areas of ultramafic rocks. Sericite ± disseminated arsenopyrite ± rutile in granitic rocks. Antimony-gold vein deposits exhibit silicification, sericitisation, and argillisation; minor chloritisation; serpentinisation when deposit is in mafic, ultramafic 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 may be important. Competency contrasts, eg shale/sandstone contacts and intrusive contacts may be important. Fissures and shear zones with breccia usually associated with faults; some replacement in surrounding lithologies; infrequent open-space filling in porous sediments and replacement in limestone. Deposition occurs at shallow to intermediate depth.

Weathering: Abundant quartz chips in soil. Red limonitic soil zones. Gold may be recovered from soil by panning. Yellow to reddish kermesite and white cerrantite or stibiconite (Sb oxides) may be useful in exploration for antimony-gold vein deposits; residual soils directly above deposits are enriched in antimony.

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

Gold-low sulphide quartz vein:	
Bendigo Goldfield, AUVT	Sharpe and MacGeehan 1990
Ballarat East Gold Deposits, AUVT	d'Auvergne 1990
Mother Lode, USCA	Knopf 1929
Goldfields of Nova Scotia, CNNS	Malcolm 1929
Antimony-gold:	
Amphoe Phra Saeng, Thailand	Gardner 1967
Coimadai, Victoria, Australia	Fisher 1952
Costerfield, Victoria, Australia	Stillwell 1953
Hillgrove, NSW, Australia	Boyle 1990
Last Chance, USA	Lawrence 1963

Known deposits and mineral prospects in the CRA Region

The gold-antimony-quartz vein mineralisation in the UNER can be divided into two sub-types, antimony-gold-quartz veins and gold-low sulphide-quartz veins. Both types are structurally controlled, are hosted mainly by metasediments or S-type granitoids and appear to have some spatial association with I-type granitoids.

Clusters of antimony-gold-quartz vein deposits and occurrences are located in the Lunatic and Lionsville goldfields in the central north of the CRA region. Other clusters occur in the Magword area straddling the southern boundary of the CRA a region and the Wild Cattle Creek area (also known as Lower Bielsdown) on the south eastern boundary of the CRA region. To the south of the region, major clusters occur in the Hillgrove field (hosted by the S-type Hillgrove Adamellite and Girrakool Beds metasediments) and the Taylors Arm field (hosted by Permo-Carboniferous metasediments). All these fields have been historic producers of antimony and gold but only Hillgrove continues to be a significant producer of antimony-gold concentrates.

Gold-low sulphide-quartz vein deposits and occurrences are mainly confined to the Coffs Harbour Block in the CRA region. The major goldfields from south to north to are Coramba-Orara, Dalmorton, Lionsville and Lunatic. The Coramba-Orara field, in the south east corner of the CRA region, is the most important in terms of number of occurrences, followed by the Dalmorton field. The Lunatic, Lionsville and Dalmorton fields lie along a north-south zone about midway between the Demon Fault and the western margin of the Clarence Moreton Basin and may be structurally related to either of these features (Markham 1975b). However, the Coramba-Orara field is located well east of the Demon Fault and extends around the southern tip of the Clarence Moreton Basin, so that when considered together the four fields seem to parallel the margin of the Basin

Gold-pyrite-arsenopyrite-quartz veins in the Coramba-Orara field occupy tension gashes and fissures in siliceous claystone of the Coramba Beds and have no obvious association with intrusive igneous rocks. Over 45 reef deposits have been recorded (Markham 1975b). To the north west in the Dalmorton field, there is also no spatial relationship between intrusives and numerous gold-quartz vein reefs in slates, greywacke and sandstones of the Brooklana and Coramba Beds.

Further north in the Lionsville goldfield, north-north-east and east-west trending gold-arsenopyrite-stibnite-low sulphide-quartz veins are hosted by metasediments and andesitic metavolcanics of the Willowie Creek Beds and the intruding Dumbudgery Creek Granodiorite (I-type). Near Tyringham gold-arsenopyrite-low sulphide quartz veins occur in the Dundurrabin Granodiorite (S-type) and adjacent Moombil Beds metasediments (Markham 1975b).

Significant gold production came from the Glen Elgin reef mine, central part of the CRA region, where gold occurs in pyrite-quartz veins in the Kingsgate Granite (I-type). The veins occur just west of the Demon Fault, which may have played a role in their genesis. A little west of the Demon Fault in the north west of the CRA region, near Boonoo Boonoo, gold-silver quartz veins occur in the I-type Stanthorpe Adamellite (Weber 1975).

Antimony deposits in, and near, the Dalmorton (central UNER) and Lionsville goldfields are hosted by granitic rocks. The Lunatic field comprises a western belt of antimony and eastern belt of gold deposits with mineralised veins hosted by Emu Creek Formation sediments and at Ottos lode (Pretty Gully) by Jenny Lind Granite. At Tooloom, gold-quartz veins occur in Emu Creek Formation sediments and acid volcanics.

Antimony-gold-quartz vein deposits are distributed adjacent to major geological structures, such as regional faults and geological block margins. Such structures may have provided pathways for rising metahydrothermal mineralising fluids generated by heat sources associated with the mantle or deep seated magmas. As the fluids cooled, gold/antimony/minor sulphide mineralisation was precipitated in veins, shears, stockworks and breccias higher in the earth’s crust (Minfo 1997). This depositional environment appears best developed around the Nambucca-Central Block margin, but also occurs adjacent to the western margin of the Coffs Harbour Block.

The fluids for both antimony-gold and gold-low sulphide-quartz veins may have been derived from circulation of large volumes of heated water generated by dewatering of wet ocean derived sediments, metamorphic dehydration of sediments and/or infiltration of meteoric (rain) water through the New England Orogen sedimentary rocks. The heat sources required to drive this circulation may have been provided, at least in part, by the I-type granitoid intrusives of the New England Batholith (Resource and Conservation Assessment Council 1996).

Both gold-low sulphide-quartz vein and antimony-gold-quartz mineralisation appear to overlap with emplacement of the I-type granitoids of the Permo-Triassic age New England Batholith and the granitoids were likely major sources of the mineralising fluids. This mesothermal mineralisation cross-cuts the older Permo-Carboniferous S-type granitoids, metasediments and (rarely) metavolcanics. Geochronology also indicates that the mineralisation may have formed in Late Permian to early Triassic times (Ashley et al. 1996). In addition, lamprophyre dykes of similar age to the New England Batholith commonly follow the strongly developed north and north west trending mineralised shears and veins of the Hillgrove antimony-gold field (Boyle 1990) and have geochemical affinities with the I-type granitoids (Ashley et al. 1996).

Markham (1975b) states that antimony-gold deposits, except the Wild Cattle Creek deposit, appear to be genetically linked to the Dundurrabin Granodiorite (S-type), Mount Mitchell Adamellite (I-type), Towgon Grange Granodiorite (I-type), Jenny Lind Granite (I-type) and Bruxner Adamellite (I-type).

Spatial analysis of known occurrences in the UNER and its buffer shows that 91% of metahydrothermal antimony-gold and gold-low sulphide-quartz vein occurrences are hosted by Permian and pre-Permian Accretionary Complex metasediments. Less than 1% of occurrences are in Lower Permian Volcanics.

Thirty seven percent (37%) of occurrences are in, or within five kilometres, of an I-type granitoid, while 8% lie in, or within five kilometres. of an S-type granitoid. Eight percent actually occur in I-type granitoids and 3% in S-type granitoids.

Seventy four percent (74%) of metahydrothermal antimony-gold and gold-low sulphide-quartz vein occurrences lie within five kilometres of a fault, 46% within two kilometres and 28% within one kilometre of a fault. Faults appear to have a north west to north-north-east preferred orientation (42% of faults) , including a stronger northerly orientation (14% of faults) . Fifty nine percent (59%) of metahydrothermal antimony-gold and gold-low sulphide-quartz vein occurrences lie within five kilometres of a north west to north-north-east trending fault, while 34% lie within 2 kilometres of them and 19% within one kilometre.

Ninety percent of metahydrothermal antimony-gold and gold-low sulphide-quartz vein occurrences have very small (<10kg gold) or unknown past production. Ten percent of occurrences in the CRA region and its buffer are considered small (<100kg gold production). Wild Cattle Creek (or Lower Bielsdown), with a resource of 327,000 tonnes at 4.95% antimony, is the only relatively large unmined deposit in the CRA region and its buffer.

Arsenic stream sediment geochemistry shows a group (of about 9 kilometres diameter) of assays greater than 30 ppm As just inside the CRA boundary about 30 kilometres north-north-west of Tenterfield. This group lies adjacent to the western contact of the Stanthorpe Adamellite in Accretionary Complex metasediments. No gold or other mineral occurrences are shown here. Similar arsenic geochemistry coincides with the Lunatic goldfield and to a lesser extent with the Lionsville goldfield. However no such geochemistry has been recorded for the Dalmorton or Coramba-Orara fields. Scattered arsenic assays greater than 30 ppm As are spread over a 30 by 15 kilometre zone extending to the south east of Glen Innes in the south west of the CRA region.

Assessment Criteria:

1. Presence of host rock metasediments and S-type granitoids of Late Permian to early Triassic age or older.
2. Presence of I-type granitoids as part of mineralisation genesis.
3. Presence of faults spatially controlling mineralisation within deposit clusters.
4. Presence of geological block margins, especially for antimony-gold vein-quartz deposits.
5. Presence of the above rock types and structures beneath relatively thin Mesozoic age Clarence-Moreton Basin or Tertiary basalt lava cover rocks.
6. Enhanced potential where New England Batholith intrusions are concealed beneath older rocks, as indicated by geophysical data, contact metamorphism (hornfelsing), alteration zones and/or relatively intense rock fracturing (Resource and Conservation Assessment Council 1996).
7. Presence of gold-low sulphide-quartz vein or antimony-gold vein-quartz deposits.
8. Presence of alluvial gold deposits and prospects.

Assessment:

Tract Au3a/H/B
This tract consists of metasediments of early Triassic or older age and Permo-Carboniferous S-type granitoids within two kilometres of a known fault. Over 95% of known gold-antimony-quartz vein occurrences lie within the tract. Potential for the discovery of economic gold-antimony-quartz vein deposits in this tract is thought to be high with a certainty level of B.

Tract Au3b/M-H/B

This tract includes metasediments of early Triassic or older age and S-type granitoids not within two kilometres of a known fault, where unmapped faults with undiscovered surface or concealed gold-antimony-quartz vein deposits may occur. Potential for such deposits is considered moderate to high with a certainty level of B.

Tract Au3c/L-M/B
This tract delineates areas where the above Tract Au3a extends beneath Tertiary basaltic lavas and the relatively shallow Mesozoic age cover rocks along the western, southern and north eastern margins of the Clarence-Moreton Basin.

Limited geological cross section data indicate that a 20 kilometre zone along the inside of the above Clarence-Moreton Basin margins includes areas of less than 1000 metres thickness of cover rocks, beneath which detection of gold-antimony-quartz vein deposits by geophysics and drilling is possible. A similar zone is defined around a "window" of the older metasediments of the Mt Barney Beds on the central northern edge of the CRA region. Tertiary basaltic lavas across the Region are thought to be relatively thin, possibly 200-300 metres thick (pers. comm. R.G. Barnes, NSWGS 1998), and may also conceal accessible gold-antimony-quartz vein deposits.

Potential for such concealed economic gold-antimony-quartz vein deposits under Mesozoic and Tertiary rocks is considered low to moderate with a certainty level of B.

Where metasediments of early Triassic or older age and S-type granitoids occur outside Tract Au3a and appear to extend under Mesozoic and Tertiary rocks potential for economic gold-antimony-quartz vein deposits is unknown, with a certainty level of A.

Economic Significance:

Gold-low sulphide quartz vein deposits are one of the largest types 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 Mt of ore; 50% contain at least 0.03 Mt and 10% contain at least 0.91 Mt. 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.

The grade/tonnage model for simple antimony-gold vein deposits (Cox and Singer, 1986) indicates that 50% of deposits contain more than 180 tonnes of ore and 10% contain more that 4,900 tonnes. Ninety percent of these deposits contain at least 18% antimony, 50% of them contain at least 35% antimony, while 10% of them contain at least 66% antimony, 1.3 grams/tonne gold and 16 grams/tonne silver.

Assessment of associated deposit types

Disseminated gold deposits often occur as lower grade halos around higher grade metahydrothermal gold-low sulphide or antimony-gold vein-quartz deposits. Significant mineralisation of this type occurs in Bendigo-Ballarat and Melbourne Zones in Victoria. Conditions suitable for formation of such halo deposits may have existed in the CRA region but a lack of relevant detailed data prevents a reliable assessment of their mineral potential.

Coal2: Underground Coal deposits in the Clarence-Moreton Basin

Model Description

Approximate Synonyms: Coal Measures

Description
Coal-bearing and carbonaceous sequences within the Jurassic Walloon Coal Measures and Koukandowie Formation, and the Triassic Ipswich and Nymboida Coal Measures that are likely to occur at depths greater than open cut limits.

General References: McElroy (1962), McDonald (1978), Wells & O'Brien (1994).

Geological Environment

Rock Types: Sandstone, siltstone, claystone, carbonaceous claystone and coal. Igneous rocks comprising Tertiary basalts and syenitic rocks are variably intruded within the formation.

Age Range: Middle Triassic to Middle Jurassic

Depositional Environment: Paludal, lacustrine and fluvial sediments. Peat swamps within structural depressions; peat swamps associated with fluvial flood plains and marginal to alluvial fans; lacustrine environment.

Tectonic Setting: Intracontinental, extensional sedimentary basin. Later folding and faulting in the Late Triassic and Late Cretaceous - Early Tertiary tectonism has produced strike-slip, reverse thrust and normal faulting and broad, open folds.

Associated deposit types: Coal Seam Methane and Oil shale.

Deposit Description

Mineralogy/Composition: Coal within the Walloon Coal Measures is high volatile bituminous, and high in vitrinite with minor exinite. Inherent ash is noted to be higher than Sydney Basin coals.

Coal within the Nymboida Coal Measures is low to medium volatile bituminous, tending to anthracite in places.

Sulphur content in both coals is low, ranging from 0.5% - 0.8%.

Known deposits and prospects in the Clarence-Moreton Basin

Within the south western portion of the basin the Nymboida Coal Measures have been mined at Nymboida Colliery. The Walloon Coal Measures have been mined at Bonalbo, Ramornie, Nimbin and Tyalgum. Numerous shallow prospects within the Walloon Coal Measures are located throughout the outcrop extent.

Assessment Criteria

1. Presence of the Walloon Coal Measures.
2. Presence of the Nymboida Coal Measures.
3. Proximity to known coal deposits.
4. Depth of cover to the top of the Walloon Coal Measures is greater than 100 metres and less than 300 metres.
5. Low to moderate seam dip.
6. Absence of vertical to sub-vertical intrusive igneous bodies.

Assessment

Tract Coal2a/M/B
The tract is defined by the presence of Walloon Coal Measures at depths no greater than 300 metres to the top of the formation. The tract has moderate potential for underground coal only. This tract is generalised to the outcrop extent of the Kangaroo Creek Sandstone which overlies the coal measures and has a thickness of between 200 and 500 metres. Areas covered by Tertiary volcanic flows and sills are not downgraded with only the outcrop extent of intrusions such as plugs, dykes and volcanic complexes excluded. Areas overlain by Quaternary sediments are not excluded. Certainty of B is based on poor quality data with borehole spacing between 20 and 30 kilometres.

A second tract with moderate potential is defined by the probable presence of Walloon Coal Measures with similar quality to shallower coal seams within the same region. Within this tract the Walloon Coal Measures are overlain by extensive Tertiary volcanic flows with a depth of cover no greater than 300 metres to the top of the formation. This tract occurs mainly in the north western part of the basin from Mummulgum north to the Woodenbong area where extensive Tertiary volcanic flows overlie the Walloon

Coal Measures. A certainty of B is based on the probable presence of Walloon Coal Measures but with a lack of knowledge due to lack of subsurface data.

A third tract delineates areas with moderate potential for underground coal and is defined by the possible presence of Nymboida Coal Measures at mineable depth beneath the lower Bundamba Group, downdip from the mapped outcrop extent to an approximated depth of 300 metres. The tract is terminated to the north east by the Martin Fault. A certainty of B is based on the lack of any subsurface data.

Tract Coal2b/L/B
The tract is defined by the probable presence of Walloon Coal Measures at depths greater than 300 metres to the top of the formation. This tract is generalised to the outcrop extent of the Grafton Formation. Areas of thick Tertiary volcanic flows where depth of cover to the Walloon Coal Measures is expected to exceed 300 metres are included. The outcrop extent of intrusions such as plugs, dykes and volcanic complexes are excluded. Areas overlain by Quaternary sediments are not excluded. The tract delineates areas of low potential for underground coal based on the expected depth to coal being greater than 300 metres. A certainty of B is based on the expected presence of Walloon Coal Measures throughout the area with no coal quality information and only limited data from petroleum well chip logs. The possibility remains that unknown structures such as faults or anticlines may position the Walloon Coal Measures at shallower depths than expected.

Economic Significance

Currently no coal is produced from the Clarence-Moreton Basin within New South Wales. The strategic importance of viable coal deposits within this region would be considerable. A cheap energy source for both local power generation through either conventional coal-fired or fluidised-bed combustion technology. Power generation through in situ gasification is also a possibility. Combined with local industry and secondary processing of minerals from the New England Block this would be of considerable economic significance.

The division of coal deposits into opencut and underground potential reflects not only the expected mineable depth of coal seams, it is a recognition that the viability of underground coal resources of the poor quality known to occur in the Clarence-Moreton Basin would be significantly less than shallow resources amenable to opencut extraction. The interbedded nature of typical Walloon Coal Measure seams renders them suitable only for selective mining which is currently, only achieved in open cut extraction. The possibility remains that seams with better quality, in geologically more favourable environments, occur in the untested majority of these tracts.

BM2: Silver-Bearing Polymetallic Vein deposits (Model 22c of Cox and Singer 1986)

Model Description

Approximate Synonyms: Felsic intrusion-associated Ag-Pb-Zn veins.

Description: Quartz-carbonate veins with base metal sulphides and Ag, ± Au ± tin related to hypabyssal granitic intrusions in sedimentary, igneous and metamorphic terranes.

General References: Sangster (1984).

Geological Environment

Rock Types: Veins related to calc-alkaline to alkaline, diorite to granodiorite, monzonite to monzogranite in small intrusions and dyke swarms in sedimentary, igneous and metamorphic rocks. Subvolcanic intrusions, necks, dykes, plugs of andesite to rhyolite composition.

Textures: Granitic texture, fine- to medium-grained equigranular and porphyroaphanitic.

Age Range: Any age.

Depositional Environment: Near-surface fractures and breccias within thermal aureoles of intrusions. In some cases peripheral to porphyry systems.

Tectonic Setting(s): Continental margin and island arc volcanic-plutonic belts. Especially zones of local domal uplift.

Associated Deposit Types: Tin/tungsten veins, mesothermal gold veins, Sn-Au-polymetallic veins, Porphyry Cu-Mo, Porphyry Mo low-F, disseminated tin, polymetallic replacement, skarns, epithermal deposits, greisens, etc.

Deposit Description

Mineralogy: galena + sphalerite + pyrite ± tetrahedrite-tennantite ± chalcopyrite ± arsenopyrite ± Ag ± Au sulphosalts ± argentite ± Cu -Pb sulphosalts ± in veins of quartz + siderite + calcite ± ankerite/dolomite ± chlorite ± rhodochrosite.

Texture/Structure: Complex, multiphase veins with breccia, comb structure, crustification, and less commonly colloform textures. Textures may vary from vuggy to compact within mineralised systems.

Alteration: Generally wide propylitic zones and narrow sericitic and argillic zones, but may be small or nonexistent. Some silicification of carbonate rocks to form jasperoid. Some quartz-carbonate-sericite alteration of ultrabasics.

Ore Controls: Areas of high permeability, intrusive contacts, fault intersections, and breccia veins and pipes. Replacement ore bodies may form where structures intersect carbonate rocks.

Weathering: Gossans and Fe- Mn-oxide stains. Zn and Pb carbonates and Pb sulphates, arsenates and phosphates. Abundant quartz chips in soil. Supergene enrichment produces high-grade native and horn silver ores in veins where calcite is not abundant.

Geochemical Signature: Zn, Cu, Pb, As, Ag, Au, Mn, Ba. Anomalies zoned from Cu-Au outward to Zn-Pb-Ag to Mn at periphery.

Examples

Misima I. PPNG	Williamson and Rogerson 1983
St Anthony (Mammoth) USAZ	Creasey 1950
Wallapai District, USAZ	Thomas 1949
Magnet, AUTS	Cox 1975

Known deposits and mineral prospects in the CRA region

There are numerous occurrences of this deposit type within the area, the most significant being the Conrad Ag lodes near Howell, the Webbs silver mine (Collisons) north west of Emmaville, and the Tulloch silver mine, near Rockvale. They are spatially and genetically associated with Middle Permian to ?Late Triassic, post-orogenic, I-type fractionated, and reduced granites the most important of which are the Mole Granite and the Gilgai and Tingha Granites. Mineralisation is in the form of silver-rich and base metal bearing veins, pipes and disseminations. Some silver-rich vein mineralisation is also associated with the Late Carboniferous-Early Permian S-type fractionated granites such as the Bundarra Plutonic Suite.

Assessment Criteria

1. Distribution of S-type or I-type fractionated and reduced granites.
2. Distribution of granitic intrusions at shallow depth inferred from geophysical information, and silver-rich and base metal bearing vein occurrences and tin veins closer to the intrusive.
3. Presence of silver-rich vein occurrences.

Assessment

Tract BM2a/H/B-C

This tract includes the (I-type) Mole, Gilgai and Ruby Creek Leucogranites plus a five kilometre buffer around these bodies. These are extremely fractionated and reduced granite bodies, although there appears to be some degree of variability in their relative oxidation (particularly within the Ruby Creek Granite). A large number of silver-bearing veins are associated with each of these bodies and each intrusive hosts, or is closely related to important silver-bearing polymetallic veins deposits (Mole -Taronga, Ruby Creek - Sundown, Gilgai - Conrad). This tract also includes the Tingha granite, which although part of the Uralla suite, has been intruded by the upper parts of the Gilgai granite and has provided a highly suitable host for many silver-bearing vein deposits whose source is very probably fluids from the Gilgai Granite.

The tract also includes a sub-surface south west extension of the Mole Granite, interpreted from a magnetic low and from the presence of numerous polymetallic vein and tin occurrences.

Mineral potential of the tract is assessed to be high with a certainty level of B in areas of subsurface extension of granites interpreted from magnetic lows. For the rest of the tract the certainty level is C.

Tract BM2b/M-H/B-C
This tract has been defined by drawing a corridor running between the high potential areas mentioned in the above BM2a/H/B-C. Numerous silver-rich base metal veins (distal varieties of the Sn vein-type deposits) occur within this tract hosted by country rocks other than granite. The tract also generally has a low magnetic response, similar to that of the high potential granites.

The tract also contains, fractionated, I-type and reduced (ilmenite is the only opaque mineral) Round Mountain Leucoadamellite of the Gundle Suite plus a 5 kilometre buffer around it. The potential is assessed to be Moderate to High with a certainty level of B for the area defined by the corridor and with a certainty level of C for the area occupied by the Round Mountain adamellite.

Tract BM2c/L-M/B
This tract includes the leucogranites and a 5 kilometre buffer, excluding those granites which are included in the Tract BM2a/H/B-C. These granites not as fractionated as those in the Tract BM2a/H/B-C and are locally more oxidised, and show variable levels of oxidation state. Numerous small occurrences are hosted by these leucogranites, especially the Dandahra Leucogranite and parts of the Red Range Microleucogranite. The potential of the tract is assessed to be low – moderate with a certainty level of B.

Tract BM2d/L/B
This tract is defined by the presence of relatively reduced, not very fractionated granitoids of the Uralla, Bundarra and Hillgrove suites. It also contains granites of the Moonbi Suite which are slightly more oxidised. The Uralla (I-type) and Bundarra (S-type) suites both contain silver-bearing basemetal occurrences. Granites of the (I-type) Moonbi suite are characterised as relatively oxidised and vary in relative oxidation states. Moonbi Suite Granites are not as fractionated as the leucogranites but contain a few occurrences of silver-bearing basemetal veins. Thus low degree of fractionation as well as relatively oxidised nature of these granitoids means that the potential of the tract is low with a certainty level of B.

Economic Significance

The silver-bearing lead-zinc veins have been mined for lead, zinc, copper and silver. Some deposits have also served as important source for gold. Global grade and tonnage data shows that 90% of deposits contain more than 290 tonnes, 50% contain more than 7600 tonnes and 10% contain more than 200,000 tonnes of ore. In 90% of deposits the ores contain more than 140 g/t silver, and more than 2.4% lead. In 50% of deposits the ores contain more than 820 g/t silver, more than 0.13 g/t gold, more than 9% lead, and more than 2.1% zinc and more than 0.89% copper. The richest 10% of deposits contain more than 4700 g/t silver, more than 11 g/t gold, more than 33% lead, more than 7.6% zinc and more than 0.89% copper.

Sn1: Tin Vein deposits (Model 15b of Cox and Singer 1986)

Model Description
Description of the model after B.L. Reed

Approximate Synonym: Cornish type lodes.

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

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

Geological Environment

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

Textures: Common plutonic textures.

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

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

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

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

Deposit Description

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

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

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

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

Weathering: Cassiterite in stream gravels, placer tin deposits.

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

Examples

Cornwall, GRBR	Hosking 1969
Herberton, AUQL	Blake 1972

Known Deposits and mineral occurrences in the CRA region

The region has numerous tin vein deposits and occurrences. They are spatially and genetically associated with Middle Permian to ?Late Triassic, post-orogenic, I-type fractionated, and reduced granites the most important of which are the Mole Granite and the Gilgai and Tingha Granites. Mineralisation is in the form of cassiterite bearing veins, pipes and disseminations. Some tin vein mineralisation is also associated with the Late Carboniferous-Early Permian S-type fractionated granites such as the Bundarra Plutonic Suite.

Assessment Criteria

1. Distribution of S-type or I-type fractionated and reduced granites.

2. Distribution of granitic intrusions at shallow depth inferred from geophysical information, Sn- and base metal vein occurrences.
3. Presence of Sn-vein occurrences.

Assessment

Tract Sn1a/H/B-C
This tract includes the (I-type) Mole, Gilgai and Ruby Creek Leucogranites plus a five kilometre buffer around these bodies. These are extremely fractionated and reduced granite bodies, although there appears to be some degree of variability in their relative oxidation (particularly within the Ruby Creek Granite). A large number of Sn deposits are associated with each of these bodies and each host or are closely related to large Sn deposits (Mole - Taronga, Ruby Creek - Sundown, Gilgai - Conrad). This tract also includes the Tingha granite, which although part of the Uralla suite, has been intruded by the upper parts of the Gilgai granite and has provided a highly suitable host for many Sn deposits whose source is very probably fluids from the Gilgai granite.

The tract also includes a sub-surface south west extension of the Mole Granite, interpreted from a magnetic low and from the presence of numerous tin and polymetallic vein occurrences.

Mineral potential of the tract is assessed to be high with a certainty level of B in areas of subsurface extension of granites interpreted from magnetic lows. For the rest of the tract the certainty level is C.

Tract Sn1b/M-H/B-C
This tract has been defined by drawing a corridor running between the high potential areas mentioned in Tract Sn1a. Numerous Sn and base metal veins (distal varieties of the Sn vein-type deposits) occur within this tract hosted by country rocks other than granite. The tract also generally has a low magnetic response, similar to that of the high potential granites.

The tract also contains, fractionated, I-type and reduced (ilmenite is the only opaque mineral) Round Mountain leucoadamellite of the Gundle Suite plus a 5 kilometre buffer around it. The tract contains a few significant tin deposits.

The potential is assessed to be moderate to high with a certainty level of B for the area defined by the corridor and with a certainty level of C for the area occupied by the Round Mountain adamellite.

Tract Sn1c/L-M/B
This tract includes leucogranites and a 5 kilometre buffer, excluding those granites which are included in the Tract Sn1a/H/B-C. These granites not as fractionated as those in the Tract Sn1a/H/B-C and are locally more oxidised, and show variable levels of oxidation state. Numerous small occurrences are hosted by these leucogranites, especially the Dandahra Leucogranite and parts of the Red Range Microleucogranite.

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

Tract Sn1d/L/B
This tract is defined by the presence of relatively reduced, not very fractionated granitoids of the Uralla, Bundarra and Hillgrove suites. It also contains granites of the Moonbi Suite which are slightly more oxidised. The Uralla (I-type) and Bundarra (S-type) suites both contain rare, small Sn occurrences. Granites of the (I-type) Moonbi suite are characterised as relatively oxidised and vary in relative oxidation states. Moonbi Suite Granites are not as fractionated as the leucogranites but contain a few occurrences of tin veins. Thus low degree of fractionation as well as relatively oxidised nature of these granitoids means that the potential of the tract is low 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 Mt of ore, 50% at least 0.24 Mt and 10% at least 4.5 Mt. In these types of deposits, 90% contain at least 0.7% Sn, 50% at least 1.3% Sn and 10% at least 2.3% Sn (Cox and Singer 1986).

Sn2: Tin greisen deposits (Model 15c of Cox and Singer 1986)

Model Description
Description of the model after B.L. Reed

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

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

Geological Environment

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

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

Age Range: May be any age; tin mineralisation temporally related to later stages of granitoid emplacement.

Depositional Environment: Mesozonal plutonic to deep volcanic environment.

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

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

Deposit Description

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

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

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

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

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

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

Examples

Lost River, USAK	Dobson 1982; Sainsbury 1964
Anchor Mine, AUTS	Solomon and Groves 1984

Erzgebirge, CZCL Janecka and Stemprok 1967

Known Deposits and prospects in the CRA region

The region contains numerous occurrences and deposits of tin-bearing greisens. The most important of these are associated with S or I-type, fractionated and reduced granites (the Mole Granite, the Gilgai Granite, the Ruby Creek Granite, the Daisy Plains Leucoadamellite, and the Gundle Granite). The Elsmore (granite) also hosts a number of greisen style deposits. All tin-greisen deposits are located within granite hosts.

Assessment Criteria

1. Distribution of S-type or I-type, fractionated, felsic and reduced granites.
2. Magnetic lows on the aeromagnetics.
3. Presence of mineral occurrences of tin greisens.
4. Presence of mineral occurrences and/ or deposits of tin veins
5. Proximity of known occurrences of alluvial tin.

Assessment

Tract Sn2a/H/B-C
The tract is the same as the tract Sn1a/H/B-C for tin veins except that the 5 kilometre buffer is not used for tin greisens. This tract includes the (I-type) Mole, Gilgai and Ruby Creek Leucogranites. These are extremely fractionated and reduced granite bodies, although there appears to be some degree of variability in their relative oxidation (particularly within the Ruby Creek Granite). A large number of Sn deposits are associated with each of these bodies and each host or are closely related to large Sn deposits (Mole - Taronga, Ruby Creek - Sundown, Gilgai - Conrad). This tract also includes the Tingha granite, which although part of the Uralla suite, has been intruded by the upper parts of the Gilgai granite and has provided a highly suitable host for many Sn deposits whose source is very probably fluids form the Gilgai granite.

The tract also includes a sub-surface south west extension of the Mole Granite, interpreted from a magnetic low and from the presence of numerous tin and polymetallic vein occurrences.

Mineral potential of the tract for tin greisen deposits is assessed to be high with a certainty level of B in areas of subsurface extension of granites interpreted from magnetic lows. For the rest of the tract the certainty level is C.

Tract Sn2b/M-H/B
The tract is the same as the tract Sn1b/M-H/B for tin veins except that a 5 kilometre buffer around the Gundle Suite, is not used for tin greisen deposits. This tract has been defined by drawing a corridor running between the high potential areas mentioned in Sn1b/M-H/B. Numerous Sn and base metal veins (distal varieties of the Sn vein-type deposits) occur within this tract hosted by country rocks other than granite. The tract also generally has a low magnetic response, similar to that of the high potential granites.

The tract also contains, fractionated, I-type and reduced (ilmenite is the only opaque mineral) Round Mountain Leucoadamellite of the Gundle Suite. The tract contains a few significant tin deposits.

The potential is assessed to be moderate to high with a certainty level of B for the area defined by the corridor and with a certainty level of C for the area occupied by the Round Mountain adamellite.

Tract Sn2c/L-M/B
The tract is the same as the tract Sn1c/L-M/B for tin veins except that a 5 kilometre buffer around granite is not applied. The tract includes leucogranites, excluding those granites which are included in the tract Sn2a/H/B-C. These granites not as fractionated as those in the Tract Sn2a/H/B-C and are locally more oxidised, and show variable levels of oxidation state. Numerous small occurrences are hosted by these leucogranites, especially the Dandahra Leucogranite and parts of the Red Range Microleucogranite. The potential of the tract is assessed to be low – moderate with a certainty level of B.

Tract Sn2d/L/B

The tract is the same as the tract Sn1d/L/B for tin veins except for the 5 kilometre buffer around granite. The tract is defined by the presence of relatively reduced, not very fractionated granitoids of the Uralla, Bundarra and Hillgrove suites. It also contains granites of the Moonbi Suite which are slightly more oxidised. The Uralla (I-type) and Bundarra (S-type) suites both contain rare, small Sn occurrences. Granites of the (I-type) Moonbi suite are characterised as relatively oxidised and vary in relative oxidation states. Moonbi Suite Granites are not as fractionated as the leucogranites and but contain a few occurrences of tin veins. Thus low degree of fractionation as well as relatively oxidised nature of these granitoids means that the potential of the tract is low with a certainty level of B.

Economic Significance

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

Dimnd: Alluvial Diamond deposits (Model 39d of Cox and Singer 1986)

Model Description
After Dennis P. Cox.

Description: Diamonds in alluvial, beach sediments, sandstone and conglomerate.

General References: Barron et al. (1994), Pecover (1988), Sutherland (1982), Orlov (1973), Lampietti and Sutherland (1978).

Geological Environment

Rock types: Sand and gravel in alluvial and beach deposits. Conglomerate beds may contain palaeoplacers.

Textures: Coarse clastic.

Age Range: Tertiary and Quaternary.

Depositional Environment: Streams draining areas of kimberlite pipes or other mantle derived igneous intrusives or diamond concentrations in sedimentary or metamorphic rocks. Alluvial diamond deposits may be 1,000 km from source. It is possible that some diamonds may have been derived from Archaean greenstone belts and Palaeozoic fold belts associated with subduction.

Tectonic Setting(s) : Stable craton, accreted fold belts.

Associated Deposit Types: Primary diamond pipe deposits.

Deposit Description

Mineralogy: Diamond, bort or carbonado (polycrystalline, generally dark coloured), ballas (spherulitic, polycrystalline and amorphous carbonado).

Texture/Structure: Diamonds derived from ancient placers in sedimentary rock commonly retain sand grains cemented to grooves or indentations in the crystal.

Ore Controls: Diamonds are concentrated in low-energy parts of stream systems with other heavy minerals. Diamonds decrease in size and increase in quality (fewer polycrystalline types) with distance from their source.

Geochemical Signature: Diamond: Cr, Ti, Mn, Ni, Co, PGE, Ba. Anomalous Ni and Nb together with the heavy minerals pyrope, Mg-ilmenite, and phlogopite indicate nearby kimberlite pipes.

Examples

African deposits	Sutherland 1982
Venezuelan deposits	Fairbairn 1971, Reid and Bisque 1975
Argyle Alluvials, Australia	Boxer and Deakin 1990
Bow River Alluvials, Australia	Fazakerley 1990

Known deposits and mineral prospects in the UNER

The Copeton diamond field lies in the far west of the UNER where rich (3.3 to 12 carats/cubic metre of gravel, Brown and Stroud 1997) diamond deposits were discovered in 1872 and mined in association with tin from between 1884 and 1922. Recorded diamond production was over 200,000 carats but mining was not very profitable (MacNevin 1975b). A high proportion (90% approx) of the diamonds is of gem quality (Cluff Resources Pacific NL 1991 p.3, 1996a) but they are relatively small. They are found in Tertiary boulder beds, gravels and sands, and Quaternary river/creek gravels within and bordering the Copeton Dam (Brown and Stroud 1997).

Small scale open cut mining of remaining resources at old mine sites such as Streak of Luck, Doctors Workings and Round Mount and Mount Ross on the east side of the Copeton Dam commenced in 1996 (Cluff Resources Pacific NL 1997). Diamond grades are estimated at 0.5 carats/tonne underground at Mount Ross and 0.05 to 0.07 carats/ tonne in open cut resources at Streak of Luck and Round Mount (Cluff Resources Pacific NL 1996b). Numerous old workings on the northern side of the Copeton Dam offer significant potential for mineable resources, such as at Wonderland, Staggy Creek, Oaky Creek and others.

Cluff Resources Pacific NL (1996b) infer a gaseous volcanic vent/crater (diatreme) concealed beneath basalt lava at Mount Ross as the primary source of diamond in the Mt Ross area. The 1km x 2km crater encompasses Streak of Luck, Doctors Workings and possibly Round Mount. Diamondiferous sands and boulder beds fill the crater and are thought to be a mixture of initial explosive volcanic material and sediment washed back into the crater. Local erosion of this material may give rise to alluvial diamond deposits outside the crater. More than ten similar volcanic centres have been interpreted in the Copeton diamond field where past diamond production has occurred, such as at Staggy Creek and Collas Hill. Airborne electromagnetic geophysical anomalies in the Oaky Creek area suggest the presence of volcanic centres hidden beneath basalt lavas.

Brown and Stroud (1997) concur with historical opinion that the Mount Ross diamond/tin deposits are of alluvial deep lead origin and observed no evidence of volcanoclastic rocks in the granite basement rock derived diamondiferous gravels. Ryders, Kenzie and Collas Hill deposits to the south of Mount Ross are also described as deep lead deposits. The deep lead deposits are often protected from erosion by basalt lava capping but the basalt may be wholly or partially eroded to expose residual diamondiferous Tertiary sediments (MacNevin 1977). MacNevin (1975b) suggests these deep leads form part of a once continuous Tertiary stream system with primary diamond sourced from concealed or eroded “kimberlitic” or basic volcanic breccia pipes originating from deep seated magma sources. Brown and Stroud (1997) and MacNevin (1977) refer to dolerite dykes and “plugs” in the deep leads of the Copeton field as possible primary diamond sources.

The Ruby Hill volcanic pipe at Bingara, to the west of the UNER, contains eclogite rock fragments (MacNevin 1977) indicating deep crustal to mantle derivation where diamonds are thought to form. Bingara also has significant historical diamond production.

The very high gem quality component (90%) and relatively small average size (0.25 carats approx) of the Copeton diamonds indicates they may have travelled a significant distance prior to deposition unless a nearby primary source has an unusually high proportion of gem diamond. Copeton diamonds show little or no abrasion (Brown and Stroud 1997) in contrast to abraded and rounded stones from other localities (Kleeman 1988)

Quaternary alluvial flats along Copes Creek were mined for diamond and tin between Copeton township and the Gwydir River and along Bobs Creek, which drains Mount Ross and flows into Copes Creek. Alluvial diamond and tin is also known from Quart Pot gully to the south of Copeton township (Brown and Stroud 1997).

Assessment Criteria

1. Presence of Tertiary sediments.
2. Presence of Tertiary lavas that may conceal deep lead deposits.
3. Presence of known diamond deposits.

Assessment

Tract Dimnd/H/C
This tract consists of Tertiary basalt lavas or sediments within a five kilometre radius of known mineral occurrences that have diamond recorded as a major commodity or have recorded diamond production. These five kilometre buffers are designed to coalesce into a north west to south east trending zone that includes the above Copeton alluvial diamond occurrences and associated known Tertiary basalts and sediments, possibly controlled by Tertiary palaeo-drainage.

The potential for economic alluvial diamond deposits associated with old workings of these diamond occurrences is considered high with a certainty level of C.

This tract does not include placer diamond deposits associated with concealed Tertiary sediments within the above five kilometre buffers, as existing data is insufficient to assess their potential.

Diamonds have been reported from Quaternary tin placers but no significant alluvial diamond deposits have been recorded. Dilution by the sediment load in the Quaternary streams may have hindered the formation of such deposits (MacNevin 1977 pp.39-40).

Concealed Quaternary alluvial sediment horizons could host placer diamond deposits but existing information does not allow assessment of their potential. Hence the potential for diamond deposits formed by the erosion of diamonds from the Tertiary sediments into Quaternary streams is unknown.

Sapp: Alluvial Sapphire deposits (Model 39 of Cox and Singer 1986)

Model Description
After Dennis P. Cox

Description: Sapphires in alluvial sediments.

General References:
Pecover (1992), Coenraads et al. (1990), Coenraads (1988), Pecover (1988).

Geological Environment

Rock types: Sand and gravel alluvial deposits. Conglomerate beds may contain palaeoplacers.

Textures: Coarse clastic.

Age Range: Tertiary and Quaternary.

Depositional Environment: Streams draining areas of mantle derived igneous intrusives with associated sapphire bearing pyroclastic rocks.

Tectonic Setting(s) : Accreted fold belts.

Associated Deposit Types: Alluvial diamond, minor cassiterite (tin).

Deposit Description

Mineralogy: Sapphire of inky blue to green and yellow parti-coloured associated with zircon and other heavy minerals.

Texture/Structure: Sapphire and zircon as subhedral to euhedral crystals with glossy crystal faces in Tertiary alluvial sediments but more abraded in Quaternary sediments.

Ore Controls: Sapphire is concentrated in low-energy parts of stream systems with other heavy minerals. Sapphires decrease in size and increase in quality with distance from their source.

Examples

Kings Plains, AUNSW	Brown and Pecover 1986b
Braemar, AUNSW	Brown & Pecover 1986a, Pecover & Coenraads 1989

Known deposits and mineral prospects in the CRA region

The Tertiary age Mount Maybole basalt shield volcano, 25 kilometres south west of Glen Innes on the south western edge of the CRA, has played an important role in the genesis of sapphire in the sapphire bearing eastern portion of the Central Volcanic Province of the New England region. Pyroclastic rocks erupted early in the volcanic sequence were subsequently overlain by significant thicknesses of basalt lava flows. The pyroclastic rocks, and to a lesser extent basal basalt lava flows, carry sufficient low grade sapphire (Brown and Stroud 1997) to act as source rocks for richer alluvial sapphire concentrations in nearby or overlying Tertiary deep lead river sediments covered by later basalt lava flows. As the basalt lavas were eroded around their margins, sapphire was shed into adjacent Quaternary river sediments by further erosion of exposed pyroclastics and Tertiary deep lead deposits. Streams also cut down through the basalt lavas for some distance within their margins and concentrated sapphire from the pyroclastics into associated river sediments.

The sapphire bearing pyroclastic source rocks are also associated with a number of smaller volcanic centres or vents related to the Mount Maybole volcano. The very rich Kings Plains sapphire deposit, one of the world’s largest and richest, was located close to the Swan – Kings Plains Vent Complex, about 35 kilometres north east of Inverell and was mined out in 1997. This deposit was in Tertiary river sediments probably derived from nearby sapphire bearing pyroclastic rocks, overlain by a thin basalt flow and concealed beneath up to five metres of Quaternary alluvium (Brown and Pecover 1986b, Pecover 1992). Sapphires are now being mined at lower grade from the base of the overlying Quaternary alluvium.

Sapphire has also been mined from Tertiary river sediments interbedded with basal basalt lava flows at Braemar, just outside the CRA region, near Elsmore.

Most of the historical sapphire production has come from Quaternary sediments. Quaternary deposits recently mined for sapphire include Wellingrove Creek and Reddestone Creek, just inside the south west boundary of the CRA region. The rich and extensive workings along Frazers Creek, Swan Brook (Pecover 1987) and Horse Gully (Brown and Stroud 1997) are other examples, just to the south west of the CRA region.

Virtually all the streams draining the Maybole Volcano are sapphire bearing (Pecover 1992) with sapphire occurring up to 60 kilometres away. As distance from the basalt lava/pyroclastic rock margins increases, sapphires are progressively broken down by abrasion and percussion during water transport and their frequency of occurrence is diluted by sediment influx. These factors appear to limit occurrence of sapphire bearing streams to within 20 kilometres from the edges of the basalt lava associated with Mt Maybole and related smaller volcanic vents (map in Dept of Mineral Resources 1983). Sapphire bearing creeks just outside the CRA region, between Armidale and Guyra, may be related to the Balbair Sugarloaf and Chandlers Peak volcanic vents while the Sara River alluvial sapphire may be associated with the Mount Mitchell vent.

Several minor occurrences of alluvial sapphire with tin are located along the eastern margin of the Tertiary age basaltic Ebor Volcanics on the south west boundary of the CRA region. The large Tweed shield volcano, in the north east of the CRA region, has no recorded sapphire despite considerable partial erosion of the basal volcanic rock units around its margins and the central volcanic plug that forms Mount Warning.

Assessment Criteria

1. Presence and proximity to sapphire related Tertiary volcanic centres.

2. Presence of sapphire bearing pyroclastic source rock units related to early stages of Tertiary volcanism.
3. Presence of Tertiary and Quaternary river sediments.
4. Presence of Tertiary lavas or Quaternary sediments that may conceal deep lead deposits.
5. Streams, rivers, lakes and swamps with unmapped Quaternary sediments.

Assessment

Tract Sapp1a/M-H/C
Significant sapphire concentrations and occurrences are restricted to Quaternary and Tertiary sediments within a 60 kilometre radius of the Mount Maybole shield volcano centre. These Quaternary and Tertiary sediments may contain economic sapphire deposits and the Quaternary sediments may conceal Tertiary sediments with economic sapphire deposits.

This tract includes the above Quaternary and Tertiary sediments within:
(c) a 20 kilometre buffer around Tertiary basalt lavas and basalt lava outcrop and
(d) basalt lava outcrop.

Outside the 20 kilometre buffer, sapphire is thought to have been largely destroyed or diluted by sediments during erosion and transport.

Also included in the tract are 100 metre buffers along creeks in area (a) to take account of unmapped Quaternary and Tertiary sediments.

Some known alluvial sapphire deposits that are marginally economic may become viable in the foreseeable future. Brown 1997 suggests that there are considerable resources remaining in known deposits and others await discovery, while paler blue sapphire in the eastern part of the tract is under exploited. Thus the potential for economic sapphire deposits in this tract is considered moderate to high with a certainty level of C.

Concealed deep lead deposits derived from previously removed Tertiary basalt lavas/pyroclastics may also exist beneath Quaternary sediments outside the above 20 kilometre buffer but there are insufficient data to assess their potential.

The minor occurrences of alluvial sapphire along the western margin of the Ebor Volcanics have not been included in the tract, as the potential for economic sapphire deposits is considered very low. The large Tweed shield volcano, in the north east of the CRA region, has also been excluded, as there are no recorded sapphire occurrences despite considerable partial erosion of its basal volcanic rock units.

Tract Sapp1b/L-M/B
This tract consists of the interfluves between stream buffers of in a 20 kilometre buffer around Tertiary basalt lavas that are within 60 kilometres of Mount Maybole. Economic sapphire deposits may occur in these interfluves within unmapped Quaternary and Tertiary sediments, and in Tertiary sediments concealed beneath unmapped Quaternary sediments.

Basalt lava outcrop within 60 kilometres of Mount Maybole is also included in the tract because it may hide economic Tertiary deep lead sapphire deposits.

Potential for economic sapphire deposits in the tract is considered to be low to moderate with a certainty of B.

W-Mo: Tungsten-Molybdenum pipes, veins and disseminated deposits (Model 15a of Cox and Singer 1986)

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

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

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

Geological Environment

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

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

Age range: Palaeozoic to late Tertiary.

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

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

Associated deposit types: Sn-W veins, pegmatites.

Deposit Description

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

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

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

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

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

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

Examples

Pasto Bueno, Peru	Landis and Rye 1974
Xihuashan, China	Hsu 1943; Giuliani 1985
Isla de Pinos, Cuba	Page and McAllister 1944
Hamme District, USA	Foose et al. 1980
Round Mountain, USA	Shawe and others 1984
Chicote Grande, Bolivia	

Assessment Criteria

1. Presence of I-type granitoids (leucocratic granitoids) which have undergone fractional crystallisation and are moderately oxidised.
2. Presence of granites with moderate or high levels of magnetic response on the aeromagnetics.
3. Presence of known occurrences of tungsten and molybdenum veins.

Assessment

Tract W-Mo1a/H/B-C

This tract has been delineated based on the distribution of granitoids of the Moonbi Suite and the group of Leucoadamellites which have not been assigned to any plutonic suite and are collectively referred to as Leucoadamellites (undetermined). A buffer zone of two kilometres around the Moonbi Suite and Leucoadamellites is also included.

The Moonbi Suite granitoids are I-type, moderately oxidised and fractionated (Blevin & Chappell 1993, Ashley et al. 1996). A number of tungsten - molybdenum veins and pipes occur along the margins of these granitoids, the largest being the Moonbi Mo-W deposit 20 km north east of Tamworth. Based on the above information, it is concluded that the Moonbi Suite has a high potential for tungsten - molybdenum veins with a certainty level of C.

The leucoadamellites (undetermined) are I-type, moderately oxidised, and fractionated. A number of W-Mo veins occur along the margins of these granitoids. Molybdenum-bismuth-tungsten occur as pipes, veins and dissemination at the outer contact of the Kingsgate granite and other leucogranites (Gilligan & Barnes 1990). The main deposits are those at Kingsgate where approximately 350 t of molybdenite and 200 t of bismuth have been won from over 50 pipes. The leucoadamellites have a high potential for tungsten - molybdenum veins with a certainty level of B.

Overall, this tract has a high potential for tungsten - molybdenum veins with a certainty level of B-C.

Tract W-Mo1b/M-H/B
This tract outlines a granite shelf or possible cupola at shallow depths below the Glen Eden deposits. The Glen Eden deposits comprise tungsten - molybdenum stockwork mineralisation and hydrothermal breccia pipes within Permian felsic volcanics (Barnes et al. 1988). Based on the presence of this style of mineralisation and from interpretations of the magnetics, it is postulated that a shallow granite shelf or cupola underlies the area of this tract. The mineralising granite has been identified during exploration drilling at a depth of 200 m (Amoco Minerals & Electrolytic Zinc Co. 1983).

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

Tract W-Mo1c/M/B
This tract is based on the distribution of the leucoadamellites, (including the Mole, Gilgai and Ruby Creek granitoids) and the Bolivia sub-type (Blevin and Chappell 1996). Over 150 lodes (including tin tungsten and molybdenum) occur in the Mole Granite and 60 occur in and around the Gilgai Granite/Tingha Adamellite. The tract also includes a 2 km buffer around these leucoadamellites. The leucoadamellites are I-type, reduced and highly fractionated (Blevin & Chappell 1993, Ashley et al. 1996). A large number of W - Mo veins occur along the margins of these granitoids, particularly the Bolivia sub-type. The roof pendant of the Mole Granite is excluded from the tract.

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

Tract W-Mo1d/L-M/B-C
This tract is based on the following:
- granitoids of the Clarence River Plutonic Suite,
- granitoids of the Uralla Plutonic Suite,
- Gundle Granite,
- a corridor connecting the Mole Creek, Gilgai and Ruby Creek granitoids.
- a buffer zone two kilometres wide is drawn around all the granitoids listed above.

Granitoids of the Clarence River Plutonic Suite are I-type, highly oxidised, and fractionated. These bodies have a number of molybdenum deposits. At Nundle, quartz - calcite - gold - tungsten - antimony veins are adjacent to granitoid contacts.

Granitoids of the Uralla Plutonic Suite are I-type, reduced and fractionated. A number of tungsten - molybdenum veins occur along the margins of these bodies.

The Gundle Granite is I-type (?), reduced and fractionated. There are a few tungsten - molybdenum veins associated this granite, the largest being the Guy Fawkes molybdenum deposit, 60 km east of Armidale.

The tracts enclosing the granitic suites listed above are considered to have low - moderate potential for tungsten - molybdenum mineralisation with certainty level C.

Evidence from geological data and magnetics suggest that the Gilgai, Mole and Ruby Creek granitic plutons are connected at shallow depth. The area of this shallow connection is considered to have low - moderate potential for tungsten - molybdenum mineralisation with certainty level B.

Overall, the tract has low - moderate potential with certainty level B-C.

Summary W-Mo Veins tracts

Tract	Tract component	Potential	Certainty	Reasons
WMo1a	Moonbi plutonic suite Also including the Bolivia subtype	High	C	I-type, moderately oxidised, fractionated, large number of W-Mo veins and occurrences. Bolivia sub-type has a large number of W-Mo occurrences.
WMo1a	Leucoadamellites (undetermined)	High	B	I-type, moderately oxidised (?), fractionated, number of W-Mo veins and occurrences
WMo1b	Buried granite cupola beneath Glen Eden deposits	M-H	B	Buried granite cupola, has W-Mo stockwork mineralisation and hydrothermal breccia pipes in felsic volcanics. (Barnes et al, 1988)
WMo1c	Leucoadamellites (including Gilgai, Ruby Creek and Mole granites, but excluding the roof pendant of the Mole granite).	M	B	I-type, reduced, highly fractionated, has a number of W-Mo veins and occurrences.
WMo1d	Clarence River plutonic suite	L-M	C	I-type, highly oxidised, fractionated, no recorded W mineralisation but has a number of Mo veins.
WMo1d	Uralla	L-M	C	I-type, reduced, fractionated, has a number of W-Mo veins and occurrences.
WMo1d	Gundle Granitoid belt	L-M	C	I-type (?), fractionated, reduced, has a few occurrences of W-Mo mineralisation.
WMo1d	Corridor around Mole/Gilgai/Ruby Creek granites	L-M	B	Geology suggests there is a shallow connection between these granites. Difficult to determine from magnetics because granites are non-magnetic

All granites have a 2km buffer zone.

Economic Significance

According to grade/tonnage models for tungsten deposits, 90% deposits contain at least 0.045 Mt of ore, 50% at least 0.56 Mt and 10% at least 7 Mt. In these types of deposits, 90% contain at least 0.6 wt% WO3, 50% at least 0.9 wt% WO3 and 10% at least 1.4 wt% WO3 (Cox and Singer 1986).

W: Tungsten skarn deposits (Model 14a of Cox and Singer 1986)

Model Description
Description of the model after D.P. Cox.

Description: Scheelite in calc-silicate contact metasomatic rocks.

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

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

Geological Environment

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

Textures: Granitic, granoblastic.

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

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

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

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

Deposit Description

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

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

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

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

Examples

King Island, Australia, Tasmania	Solomon and Groves 1994
Pine Creek, US, California	Newberry 1982
MacTung, Canada, British Columbia.	Dick and Hodgson 1982
Strawberry, US, California	Nokleberg 1981

Known Deposits and Mineral Prospects in UNER

W skarn deposits are not abundant in the New England region because of the paucity of suitably reactive host rocks (Ashley et al. 1996).

The Gilgurry Mudstone near the Drake Volcanics contains calcareous mudstone and fossiliferous units. The area where this unit is intruded by the Stanthorpe Adamellite has high potential for skarn deposits (pers. comm. R.G. Feb. 1998).

The scheelite-molybdenite bearing andradite skarns at Attunga are exoskarn replacement of marble and calc-silicate hornfels and minor endoskarn replacement of the quartz monzonite intrusive (Moonbi Supersuite).

Assessment Criteria

1. Presence of granitoids (I-type granites which are moderately oxidised) associated with tungsten-molybdenum mineral deposits or with a potential to host tungsten-molybdenum deposits.
2. Presence of suitable calc-magnesian rocks in proximity to granitoids with a potential to host tungsten-molybdenum deposits.
3. Presence of known occurrences of skarns, hornfels and skarn-related mineral occurrences.

Assessment:

Tract W/M/B
The tract is based on the following geological parameters:
- a 5 km wide zone adjacent to the margins of Triassic granitoids which are potential source rocks for tungsten mineralisation, i.e. I-type granitoids which are fractionated and moderately oxidised. A detailed analysis of the granitoids which are potential source rocks for tungsten mineralisation is given in the model for tungsten-molybdenum veins and pipes,
- Palaeozoic calcareous sediments and ultramafic rocks which were intruded by these granitoids.

The intersection of the above two geological parameters defines the tract for tungsten skarn deposits, which is assessed as moderate potential with certainty level B.

Economic significance

Grade and tonnage data (Cox and Singer 1986) suggests that 10% of this type of deposits contain at least 22 Mt of ore, 50% at least 1.1 Mt and 90% at least 0.05 Mt. In 10% of these deposits ores have at least 1.4% WO3, 50% at least 0.67% and 90% at least 0.05% WO3.

Silexite: Quartz topaz W-Mo-Bi deposits (Silexite)

Model Description
Description of the model by A.D. McKay

Description: Quartz - topaz rock with veins and disseminations of wolframite, molybdenite and bismuthinite and native bismuth. Occurs within altered microgranite, pegmatite and granite. Similar to greisenised granite.

General References: Kleeman et al. (1997), Plimer et al. (1995), Ashley et al. (1996).

Geological Environment

Rock Types: Silexite was developed as altered dykes, bosses and sills of microgranite in apical areas of granite roof, and in the sedimentary rocks of the roof pendant (Permian) overlying the Mole Granite. Silexite was developed after emplacement of the Mole Granite and is associated with later stages of fractionation of the melt. Associated rock types include muscovite-bearing greisens. Distinctive accessory minerals include lithium siderophyllite, fluorine-rich schorl, fluorine-rich muscovite, fluorite, beryl, dickite.

Textures: Textures and structures within the microgranite and seriate or porphyry granites, are pseudomorphed by silexite. Aplitic and porphyritic textures common, miarolitic cavities.

Age Range: In the case of the Mole Granite, the silexite is Triassic.

Depositional Environment: Plutonic, granitic bodies emplaced at high levels in the crust. Preservation of roof pendant due to partial unroofing by erosion. Silexite was developed as altered dykes, bosses and sills of microgranite in apical areas of granite roof, and in the sedimentary rocks of the roof pendant (Permian) overlying the Mole Granite

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

Associated Deposit Types: Muscovite-quartz-chlorite-W-Sn-Bi rich greisens, sheeted vein quartz-cassiterite deposits, stockwork Mo-W-Bi mineralisation.

Deposit Description

Mineralogy: Topaz, wolframite, molybdenite, bismuth, bismuthinite, Cu-Pb-Zn sulphide. Gangue mineralogy includes quartz, Li-siderophyllite, F-schorl, F-muscovite, fluorite, beryl.

Texture/Structure: Various textures and structures, greisen textures are common. Textures and structures within silexite are pseudomorphs of the original microgranite and seriate granite. Quartz-wolframite-molybdenite-bismuthinite in silexite, greisens, veinlets and stockworks (in cupolas or in overlying roof pendant). Less common are pipes, lenses, and tectonic breccia.

Alteration: Hydrothermal alteration of microgranite and other host granite by hot, highly saline Si-rich and F-rich aqueous fluids. Fluid inclusion studies indicate fluid temperatures of 570-620° C. Incipient silexite (granite): quartz, topaz, muscovite ± chlorite, tourmaline, and fluorite(original texture of granites retained). Greisenised granite: quartz-muscovite-topaz-fluorite, ± tourmaline

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

Weathering: Wolframite and cassiterite placer deposits form by weathering and erosion.

Geochemical Signature: Wolframite, cassiterite, topaz, and tourmaline in streams that drain exposed silexite deposits. Associated granites may have high contents of SiO_2 (>73 percent), and are depleted in CaO, TiO_2, MgO, and total FeO. They are enriched in W, Sn, F, Rb, Li, Be, Mo, Cs, U, and Th and impoverished in Ni, Cr, Co, V, Sc, Sr, La, and Ba (Cox & Singer 1986).

Examples

Torrington roof pendant, Mole Granite.

Known deposits and mineral prospects in the CRA region

Silexite is a quartz-topaz rock formed by alteration of granite by F-rich fluids (Kleeman 1985). It also contains various amounts of wolframite, Li-siderophyllite, F-schorl, F-muscovite, beryl, molybdenite, bismuth, bismuthinite and dickite (Plimer et al 1995). Silexite contains more than 5% topaz. Silexite is the product of hydrothermal alteration of solidified granite, most frequently microgranite but also of seriate and other varieties of the Mole Granite (Kleeman et al 1997). Most silexite is developed as altered dykes, bosses and sills of microgranite in the sedimentary rocks of the roof pendant (Permian) within the Mole Granite. Textures and structures within the microgranite and seriate or porphyry granites, are pseudomorphed by silexite. Fluid-inclusion studies topaz grains in silexite have homogenisation temperatures of 570-620° C.

The Mole Granite is interpreted as a sill-like mass only a few kilometres thick, emplaced at a high level in the crust (Kleeman et al. 1997). It was emplaced at 246±2 Ma. Crystallisation inwards produced a pressure quenched coarsely grained granite carapace. Microgranite was extensively emplaced as dykes in the fractured carapace and overlying country rock. An aqueous magmatic fluid utilising the same structures as the microgranite, at 246 Ma, reacted in places with the granite to form silexite.

At the Fielder’s Hill mine, which was one of the largest mines in the roof pendant, the first 20 000 t of silexite ore contained 1.6% WO_3, but the bulk grade of all the quartzose rock mined was 0.5% WO_3. At the The Bismuth mine, wolframite and native bismuth occurred in pegmatite and silexite. Overall production from the roof pendant deposits was 2000 tons wolframite (Kleeman 1990).

Assessment Criteria

1. Roof pendants in highly fractionated, felsic granites such as the Mole Granite.
2. Presence of known occurrences of topaz bearing greisen rocks.

Assessment

Tract Silexite/M-H/B

The tract includes the area corresponding to the roof pendant of Mole Granite plus a 200 m wide buffer zone surrounding it. It contains all the known occurrences of silexite in the region.

Economic Significance

During the late 1980s, a pilot scale topaz calcination plant operated at Parramatta. Topaz is converted to pure mullite ($3Al_2O_3.2SiO_2$) when calcined at 1350° C. Mullite is an important industrial mineral for the refractory industries.

CuAu2: Copper-gold skarn deposits (Model 18b of Cox and Singer 1986)

Model Description
Description of the model after D.P. Cox and T.G. Theodore

Description: Chalcopyrite in calc-silicate contact metasomatic rocks.

General References: Einaudi and Burt (1982), Einaudi et al. (1981).

Geological Environment

Rock Types: Tonalite to monzogranite intruding carbonate rocks or calcareous clastic rocks.

Textures: Granitic texture, porphyry, granoblastic to hornfelsic in sedimentary rocks.

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

Depositional Environment: Miogeosynclinal sequences intruded by felsic plutons.

Tectonic Setting(s) : Continental margin late orogenic magmatism.

Associated Deposit Types: Porphyry Cu, zinc-lead-silver skarn, gold skarn, polymetallic replacement, Fe skarn.

Deposit Description

Mineralogy: Chalcopyrite + pyrite ± hematite ± magnetite ± bornite ± pyrrhotite. Also molybdenite, bismuthinite, sphalerite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite, and tetrahedrite may be present. Au and Ag may be important products.

Texture/Structure: Coarse granoblastic with interstitial sulphides. Bladed pyroxenes are common.

Alteration: Diopside + andradite centre; wollastonite + tremolite outer zone; marble peripheral zone. Igneous rocks may be altered to epidote + pyroxene + garnet (endoskarn). Retrograde alteration to actinolite, chlorite, and clays may be present.

Ore Controls: Irregular or tabular ore bodies in carbonate rocks and calcareous rocks near igneous contacts or in enclaves in igneous stocks. Associated igneous rocks are commonly barren.

Weathering: Cu carbonates, silicates, Fe-rich gossan. Calc-silicate minerals in stream pebbles are a good guide to covered deposits.

Geochemical Signature: Rock analyses may show Cu-Au-Ag-rich inner zones grading outward to Au-Ag zones with high Au:Ag ratio and outer Pb-Zn-Ag zone. Co-As-Sb-Bi may form anomalies in some skarn deposits. Magnetic anomalies.

Examples

Mason Valley	Harris and Einaudi 1982
Victoria	Atkinson et al. 1982
Copper Canyon	Blake et al. 1979
Carr Fork,	Atkinson and Einaudi 1978
Red Dome, AUQL	Ewers et al. 1990

Known deposits and mineral prospects in the CRA region

There are quite a few known occurrences of this type in the area. Typical examples of these are the magnetite skarn-associated copper deposits at Fine Flower, Fine Flour, Busy Bee, Wiley's, Potato Cu lode, West Potato Cu; also the Gem Cu, and Pluck Cu deposits. Other skarn-related prospects in the UNER include Pulganbar-Flintoff-Glamorgan; (associated with siliceous tourmaline veins) and Lantana Downs, May Queen Cu, & Paddy Dougherty Cu, and the Tabulam magnetite skarn (east of Drake) . Also, there are hornfelsed Cu and Au occurrences at Solferino.

Assessment Criteria

1. Presence of granitoids associated with Cu-Au mineralisation or with a potential to host Cu-Au deposits.
2. Presence of suitable calc-magnesian rocks in proximity to granitoids with a potential to host Cu-Au deposits.
3. Presence of known occurrences of skarns, hornfels and skarn-related mineral occurrences.

Assessment

Tract CuAu2a/L-M/B
The tract includes zones where reactive calc-magnesian rocks lie within 5 km of granitoids that have a potential for hosting Cu-Au deposits. The tract is assessed as low to moderate because there are no economic skarn deposits known in the area, and because the occurrence of calc-magnesian rocks is generally irregular and intermittent with the potential host sequence.

Economic Significance

According to grade/tonnage models for copper skarn deposits, 90% of deposits contain at least 0.034 Mt of ore, 50% at least 0.56 Mt and 10% at least 9.2 Mt. In these types of deposits, 90% contain at least 0.7% Cu, 50% at least 1.7% Cu and 10% at least 4.0% Cu (Cox and Singer 1986).

Au4: Alluvial (Placer) Gold deposits(Model 39a of Cox and Singer 1986)

Model Description
Description after Warren E. Yeend.

Approximate Synonym:

Description: Elemental gold as grains and (rarely) nuggets in gravel, sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, aeolian, and (rarely) glacial deposits.

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 multi-cycle sediments; high-level terrace gravels.

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

Deposit Description

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

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

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

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

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

Examples

Sierra Nevada, California, USA	Lindgren 1911, Yeend 1974
Bendigo-Ballarat region, Vic, Australia	Knight 1975

Known deposits and prospects in the CRA region

Placer deposits account for a significant portion of the gold produced in the New England region. About two thirds of this alluvial gold came from the Rocky River, Uralla and Nundle-Hanging Rock area to the south east of the UNER. The gold was recovered from Quaternary sediments along the Rocky River and its tributaries draining the Uralla Granodiorite (I-type), and Tertiary deep lead deposits preserved by overlying basalt lava flows, such as at Sydney Flat, Mount Beef and Bourkes Knob. The Sydney Flat workings were up to 60 metres deep. Together these deposits constitute the Rocky River Gold Field and a number of them were relatively rich in gold (Weber 1975).

In the UNER, gold has been won from basal conglomerates along the western edge of the Mesozoic Clarence Moreton basin, Tertiary deep leads, Quaternary river gravels along river channels and beach placer deposits. Significant alluvial gold production by hand sluicing and dredging came from Oban in the central south of the CRA region, Mann River/Glen Elgin and Timbarra River in the central part of the CRA region, and Clarence River/Tooloom in the central north of the CRA region (Barnes & others 1988).

Alluvial gold is associated with gold-quartz vein reefs in the Dalmorton field in the central east of the CRA region and further north in the Lionsville goldfield and at Tyringham, where recent and deep lead alluvial deposits also occur (Markham 1975b). The Lunatic goldfield in the north of the CRA and Coramba-Orara goldfield in the south of the CRA region are also source areas for alluvial gold.

At Tooloom alluvial gold deposits appear to be derived from local gold-quartz veins in Emu Creek Formation sediments/ acid volcanics and nearby outcrops of gold bearing Jurassic conglomerate (Markham 1975b). Near Boonoo Boonoo, in the north west of the CRA region, gold-silver quartz veins in Stanthorpe Adamellite (I-type) may be the source for nearby alluvial gold (Weber 1975). Disseminated gold in the Stanthorpe and Bungulla Adamellites may have contributed gold to alluvial deposits in the Timbarra area (Resource and Conservation Assessment Council 1996). Further south, gold-quartz veins and Jurassic conglomerate (Laytons Range Conglomerate Member) were also gold sources for the nearby alluvial gold at Pretty Gully Gold Field and Paddy’s Gully (Weber 1975).

Minor gold in the Kingsgate Granite (I-type) molybdenum-bismuth pipes (Weber 1975) may have contributed to alluvial gold deposits in the central part of the CRA region. The Wards Mistake Adamellite (I-type), and Kookabookra Adamellite (S-type) and especially the Oban River Leucoadamellite (I-type) appear to be the source of alluvial gold probably from gold bearing bismuth minerals in molybdenum-bismuth pipes. The only significant alluvial production has come from streams draining the Oban River Leucoadamellite (Weber 1975).

Assessment Criteria

1. Distribution of rocks containing, or with potential for other types of gold deposits.
2. Distribution of gold-bearing vein and other deposits.
3. Distribution of alluvial gold prospects and deposits.
4. Distribution of possibly gold bearing Clarence-Moreton Basin basal Jurassic conglomerate.
5. Distribution of Tertiary sediments deposited by ancient streams, rivers, lakes and swamps.
6. Distribution of Tertiary basalts concealing deep leads.
7. Distribution of Quaternary sediments deposited by ancient streams, rivers, lakes and swamps.
8. Streams, rivers, lakes and swamps with unmapped Quaternary sediments.

Assessment

Tract Au4a/M-H/C
This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas within 10 kilometres of known gold deposit clusters. Potential for economic Quaternary/Tertiary alluvial gold and deep lead deposits concealed beneath Tertiary basalt is considered to be moderate to high. Even though most alluvial gold areas have been worked in the past, modern technology may make some of these areas viable in future and allow access to deep lead deposits not previously mined. The certainty level is assessed at C.

Tract Au4b/M/B
This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas that occur in areas of potential alluvial gold source rocks as delineated by the tracts in the following models of this report:
- gold-antimony quartz veins
- disseminated gold in leucogranite
- epithermal gold
- molybdenum-bismuth-minor gold veins/pipes
- skarn/ironstone gold
- volcanic massive sulphide gold
- porphyry copper-gold

Potential is considered moderate with a certainty of B.

Economic significance

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

Au5: Gold associated with massive sulphide mineralisation including gold in chert and jaspers

Model Description
Description of the model by S. Jaireth.

Approximate Synonym: Gold-rich Noranda type, volcanogenic massive sulphide, felsic to intermediate volcanic type. Gold in chert and jaspers.

Description: Gold, copper, lead and zinc-bearing massive sulphide deposits in marine volcanic rocks of intermediate to felsic composition.

General References: Ishihara (1974), Franklin et al. (1981), Hutchinson et al. (1982), Ohmoto and Skinner (1983), Lydon (1988), Hannington and Scott (1989), Large (1992).

Geological Environment

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

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

Age range: Archaean through Cainozoic.

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

Tectonic setting(s): Island arc, local extensional tectonic activity, rifts and grabens following arc-continent collision, faults, or fractures. Archaean greenstone belt.

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

Deposit Description

Mineralogy: Upper stratiform massive zone (black ore): pyrite + sphalerite + chalcopyrite ± pyrrhotite ± galena ± barite ± tetrahedrite - tennantite ± bornite; lower stratiform massive zone (yellow ore): pyrite + chalcopyrite ± sphalerite ± pyrrhotite ± magnetite; stringer (stockwork) zone: pyrite + chalcopyrite (gold and silver). Gold in two mineral associations: gold-zinc (-lead-silver-barite), typical of lead-zinc-rich deposits; and gold-copper. Gahnite in metamorphosed deposits. Gypsum/anhydrite present in some deposits. Often gold mineralisation is hosted by chert and jaspers layers.

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

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

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

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

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

Geophysical signature:

Examples

Rosebery, AUTS	Huston and Large 1988
Mt. Lyell, AUTS	Hills 1990
Hellyer, AUTS	McArthur and Dronseika 1990
Mt Morgan, AUQL	Taube 1990
Brittania, CNBC	Payne et al. 1980

Buchans, CNNF	Swanson et al. 1981
Kidd Creek, CNON	Walker et al. 1975

Known deposits and Prospects in the CRA Region

There are several occurrences of this type. They are confined to the Coffs Harbour Block. In most of them gold mineralisation is in the form of stratabound concentrations hosted by chert, pyritic chert and jaspers. In several prospects stratabound mineralisation co-exists with epigenetic gold veins. In the Cod Hole prospect mineralisation is confined to a fractured chert horizon and is associated with introduced silica, pyrite and arsenopyrite (Keevers and Jones 1984 cited in Gilligan et al. 1992). In the Illabo gold mine, several stacked horizons of chert and jaspers extending for several hundred metres occur within mafic tuffs (Keevers and Jones 1984 cited in Gilligan et al. 1992). Here chert and jaspers are extensively fractured and flooded with ankerite, pyrite and sericite.

Gold bearing chert and epigenetic veins are in close spatial association with stratabound copper deposits. Hence tracts delineated for Cyprus style massive sulphide deposits also define the mineral potential tracts for gold associated with massive sulphide deposits.

However, because not all volcanic associated massive sulphide deposits host economic grade gold mineralisation the level of potential needs to be lower than that for massive sulphide deposits (the notion of conditional probability).

Assessment Criteria

1. Presence of rocks belonging to the ophiolitic assemblage consisting of mafic volcanic, volcaniclastic and volcanogenic sedimentary rocks formed in submarine environment. (Coffs Harbour Association, Sandon Association, Silverwood Association or Brooklana Beds, Coffs Harbour Beds, Coramba Beds, Cungleburg Creek Beds, Girakool Beds and Agnes Greywacke, Sandon Beds, Willowie Creek Beds).
2. Presence of subvolcanic intrusives.
3. Presence of known deposits and occurrences of volcanic associated massive sulphide mineralisation.
4. Areas with a potential for volcanic associated massive sulphide deposits.
5. Distribution of known deposit type and occurrences gold in chert and jaspers.

Assessment

Tract Au5a/M/C
The tract is similar to the tract BM1a/M/C for volcanic associated massive sulphide deposits because gold mineralisation is spatially and temporally associated with massive sulphide mineralisation. Both styles result from submarine volcanic hydrothermal systems. The tract is marked by the presence of chert and jaspers which are known to host gold mineralisation in the area. The tract also hosts all the known occurrences of gold of this type in the CRA region. Mineral potential of the tract is thus assessed to moderate with a certainty level of C.

Tract Au5b/L-M/B
The tract is similar to the tract BM1b/L-M/B for volcanic associated massive sulphide deposits. Although the tract does not contain known occurrences of gold or volcanic associated massive sulphide mineralisation, it is marked by an environment which is favourable for distal type volcanic massive sulphide mineralisation. Hence mineral potential of the tract is assessed to be low to moderate with a certainty level of B.

Economic Significance

There is limited grade and tonnage data about gold deposits associated with chert and jasper but volcanic associated massive sulphide deposits are known to be important sources for gold and silver. Global grade/tonnage models for this type of deposits indicate that 90% of these deposits have more than 0.12 Mt of ore, 50% have more that 1.5 Mt and 10% have more than 18 Mt. Similarly 50% of these deposits the ores have more than 0.16 g/t gold and 13 g/t silver and 10 % have more than 2.3 g/t gold and 100 g/t silver.

Sn3: Alluvial Tin deposits (Model 39e of Cox and Singer 1986)

Model Description
Description of the model after Bruce L. Reed.

Description: Cassiterite and associated heavy minerals in silt- to cobble-size nuggets concentrated by the hydraulics of running water in modern and fossil streambeds.

General References: Hosking (1974), Taylor (1979), Sainsbury and Reed (1973).

Geological Environment

Rock Types: Alluvial sand, gravel, and conglomerate indicative of rock types that host lode tin deposits.

Textures: Fine to very coarse clastic.

Age Range: Commonly late Tertiary to Holocene, but may be any age.

Depositional Environment: Generally moderate to high-level alluvial, where stream gradients lie within the critical range for deposition of cassiterite (for instance, where stream velocity is sufficient to result in good gravity separation but not enough so the channel is swept clean). Stream placers may occur as offshore placers where they occupy submerged valleys or strandlines.

Tectonic Setting(s) : Alluvial deposits derived from Palaeozoic to Cainozoic accreted terranes or stable cratonic fold belts that contain highly evolved granitoid plutons or their extrusive equivalents. Tectonic stability during deposition and preservation of alluvial deposits.

Associated Deposit Types: Alluvial gravels may contain by-product ilmenite, zircon, monazite, and, where derived from cassiterite-bearing pegmatites, columbite-tantalite. Economic placers are generally within a few (<8) kilometres of the primary sources. Any type of cassiterite-bearing tin deposit may be a source. The size and grade of the exposed source frequently has little relation to that of the adjacent alluvial deposit.

Deposit Description

Mineralogy: Cassiterite; varying amounts of magnetite, ilmenite, zircon, monazite, allanite, xenotime, tourmaline, columbite-tantalite, garnet, rutile, gold, sapphire, and topaz may be common heavy resistates.

Texture/Structure: Cassiterite becomes progressively coarser as the source is approached; euhedral crystals indicate close proximity to primary source. Where a marine shoreline intersects or transgresses a stream valley containing alluvial cassiterite the shoreline placers normally have a large length-to-width ratio.

Ore Controls: Cassiterite tends to concentrate at the base of stream gravels and in traps such as natural riffles, potholes, and bedrock structures transverse to the direction of water flow. The richest placers lie virtually over the primary source. Streams that flow parallel to the margin of a tin-bearing granite are particularly favourable for placer tin accumulation.

Geochemical Signature: Anomalously high amounts of Sn, As, B, F, W, Be, W, Cu, Pb, Zn. Panned concentrate samples are the most reliable method for detection of alluvial cassiterite.

Examples

South East Asian tin fields	Hosking 1974, Newell 1971, Simatupang et al. 1974 Westerveld 1937.

Known deposits and prospects in the CRA region

The region hosts several important prospects and deposits of alluvial and deep lead tin, the most notable of which are at Emmaville which produced more than 6500 tonnes of cassiterite and Tingha (70000 tonnes of tin concentrate, Gilligan and Barnes 1990). Most placer concentrations are associated with active watercourses. Cassiterite recovered from active watercourses is largely black, waterworn and fine to coarse. The cassiterite-bearing alluvials range in thickness from several centimetres to approximately ten metres. Their lateral extent ranges from several metres wide and tens of metres long, to deposits hundreds of metres wide and kilometres long (Brown and Stroud 1997). Frequently redistributed Tertiary wash or eluvium and broad areas of shallow wash beyond watercourses also contain significant accumulation of cassiterite. The distribution of cassiterite in alluvium varies between localities. In some places cassiterite is richest or restricted to particular layers, especially towards or at the base of the sequence. In other places it is developed throughout the alluvium from ‘grass roots’ to the base (Brown and Stroud 1997). Scant historical data indicate that some watercourses returned from several kg/m3 to 100 kg/m3.

The deep lead cassiterite deposits are overlain by basalt. In the Copeton Group of deep leads, two main levels of intrabasaltic alluvials containing cassiterite and diamonds were worked. The economic layers were overlain by subeconomic, fine-grained sandy layer. In the Tingha-Gilgai area deep leads range in depth from several metres to fifty metres. Most deep leads are capped by thick strongly weathered to fresh basalt, shallow to deep basaltic soil and in many places by surficial concretionary laterite/bauxite (Brown and Stroud 1997).

Assessment Criteria

1. Presence of rocks containing, or with a potential for, tin
2. Distribution of tin vein and greisen deposits.
3. Distribution of alluvial tin prospects and deposits.
4. Distribution of possibly tin bearing Clarence-Moreton Basin basal Jurassic conglomerate.
5. Distribution of Tertiary sediments deposited by ancient streams, rivers, lakes and swamps.
6. Distribution of Tertiary basalts concealing deep leads.
7. Distribution of Quaternary sediments deposited by ancient streams, rivers, lakes and swamps.
8. Streams, rivers, lakes and swamps with unmapped Quaternary sediments.

Assessment

Tract Sn3a/M-H/C
This tract includes 100 metre buffers along streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas within 10 kilometres of known tin deposit clusters (fields). Potential for economic Quaternary/Tertiary alluvial tin and deep lead deposits concealed beneath Tertiary basalt is considered moderate to high. Even though most alluvial areas have been worked in the past, modern technology may make some of these areas viable in future and allow access to deep lead deposits not previously mined. The certainty level is assessed at C.

Tract Sn3b/M/B
This tract includes 100 metre buffers around streams, rivers, swamps, lakes, Quaternary sediments, Tertiary sediments and Tertiary lavas that occur in areas of potential alluvial tin source rocks as delineated by the tracts for tin veins and tin greisens. Potential is considered moderate with a certainty of B.

Fe1: Volcanic-hosted Magnetite (Model 25i of Cox and Singer, 1986)

Model Description
Description of the model by Dennis P. Cox.

Approximate Synonym: Porphyrite iron, Kiruna iron.

Description: Massive concordant and discordant magnetite ore bodies in intermediate to alkalic volcanic rocks with actinolite or diopside alteration.

Geological Environment

Rock types: Andesitic to trachytic flows and subvolcanic intrusions, also at Kiruna, quartz porphyry, syenite porphyry, monzonite, and diorite.

Textures: Porphyroaphanitic to fine- to medium-grained equigranular. Flows may be amygdaloidal.

Age range: Mesozoic to Holocene in circum-Pacific area. In Sweden and Missouri, 1,300-1,500 m.y.

Depositional environment: Continental volcanic rocks and clastic sediments intruded by subvolcanic intermediate plutons.

Tectonic setting(s): Continental margin, subduction-related volcanic terrane. Especially with high-K volcanic rocks, possibly related to waning stages of volcanism.

Associated deposit types: Sedimentary Fe in associated clastic rocks, apatite-magnetite deposits, hematite in quartz-sericite alteration, possible disseminated Au.

Deposit Description

Mineralogy: Magnetite + apatite. Rarely pyrite, chalcopyrite, chalcocite, and covellite. Ti is in sphene.

Texture/structure: Fine, granoblastic, skarn type textures.

Alteration: Actinolite or diopside, andradite, biotite, quartz, albite, andesine, K-feldspar, sodic scapolite, epidote; carbonates, and locally, tourmaline, sphene, chlorite, barite, fluorite, kaolin, or sericite.

Ore Controls: Magnetite in massive replacement, breccia filling and stockwork veins. Orebodies may be stratabound, concordant to intrusive contacts or in cross-cutting veins. Possibly related to cupolas of deeper plutons.

Geochemical and geophysical signature: Fe, P, V, and minor Ba, F, Bi, Cu, Co; strong magnetic anomalies.

***Examples*:**

Kirunavaara, Sweden	Frietsch 1982, 1978
El Romeral, Chile	Bookstrom 1977
Middle-Lower Yangtze Valley	Research Group of Porphyrite Iron Ore 1977

Known Deposits and Prospects in the CRA Region

There are no known occurrences of this type in the CRA region. In the Tamworth Belt stratabound magnetite mineralisation is reported to be present within andesitic volcanic rocks. In the Croydon magnetite deposit, massive coarse grained magnetite with chlorite joint fills, interstitial and vein epidote and minor quartz veins is associated with Late Devonian Mostyn Vale Formation (Dpmx). The Mostyn Vale Formation consists of deep water marine sedimentary and volcanic rocks such as lithic wackes, and rhyodacitic to basaltic lavas and tuffs.

Assessment

Tract Fe1a/M-H/C
The tract includes rocks of the accretionary complex that are known to contain magnetite-rich units (Texas Beds), ironstones (Coffs Harbour Beds), magnetite-bearing chert or quartz-magnetite accumulations (Brookland Beds). These rocks also host all the known occurrences of volcanogenic magnetite in the CRA region. Mineral potential of the tract is assessed to be moderate to high with a certainty level of C

Tract Fe1b/L-M/B
The tract includes the rest of the rocks of the accretionary complex. Locally some units are magnetite rich and are interpreted to be related to skarns. Most rocks in this tract have a potential for volcanic associated massive sulphide and volcanogenic manganese deposits. As the formation of volcanogenic magnetite is closely related to the formation of volcanic associated massive sulphide and volcanogenic manganese, mineral potential of this tract is assessed to be low to moderate with a certainty level of B.

Economic significance

Although volcanic-hosted magnetite deposits are smaller in size that the banded iron formation, they often contain significant quantities of iron ores. Grade and tonnage data (Cox and Singer 1986) suggest that 10% of the deposits contain at least 450 Mt of ore, 50% at least 40 Mt and 90% at least 3.5 Mt. In 10% of the deposits ores have at least 64% iron and 0.92% phosphorus, 50% have at least 58% iron and 0.38% phosphorus and 90% have at least 38% iron and 0.13% phosphorus.

Cr: Podiform Chromite (MODEL 8a/8b of Cox and Singer 1986)

Model Description
By John P. Albers

Approximate Synonym: Alpine type chromite (Thayer 1964).

Description: Podlike masses of chromitite in ultramafic parts of ophiolite complexes.

General References: Dickey (1975), Duke (1996), MacNevin (1975a), Barnes and Willis (1989).

Geological Environment

Rock Types: Highly deformed dunite and harzburgite of ophiolite complexes; commonly serpentinised.

Textures: Nodular, orbicular, gneissic, cumulate, pull-apart; most relict textures are modified or destroyed by flowage at magmatic temperatures.

Age Range: Pre-Late Carboniferous – Permian (?).

Tectonic Setting(s): Magmatic cumulates in elongate magma pockets along spreading plate boundaries. Subsequently exposed in accreted terranes as part of ophiolite assemblage.

Depositional Environment: Deep oceanic crustal rocks. Obducted ophiolite terrane?

Associated Deposit Types: Ultramafic hosted talc, chrysotile asbestos, lateritic /saprolitic nickel.

Deposit Description

Mineralogy: Chromite ± ferrichromite ± magnetite ± Ru-Os-Ir alloys ± laurite.

Texture/Structure: Massive coarse-grained, granular to finely disseminated.

Alteration: None related to ore.

Ore Controls: Restricted to dunite bodies in tectonised harzburgite or lower portions of ultramafic cumulate. Restricted to serpentinised ultrabasics.

Weathering: Highly resistant to weathering and oxidation.

Geochemical Signature: None recognised.

Examples

Oakey Creek (Gordonbrook) Deposits	MacNevin 1975a
Thetford Mines Ophiolite Complex, Canada	Kacira 1982

Known Deposits and Mineral prospects in the CRA region

The Gordonbrook Serpentinite Belt in the central parts of the Upper North East Region of NSW hosts about 30 small to moderate sized chromite deposits. It is interpreted as an obducted ophiolite terrane.

During tectonic thrusting, faulting and hydration the original chromite layers were disaggregated and boudinaged resulting in discontinuous chromite pods scattered throughout the serpentinite. As a result the serpentinite contains numerous small but high grade chromite deposits.

Assessment Criteria

1. Existence and extent of highly deformed ultramafic bodies.
2. The occurrence of a major fault in proximity to the ultramafic mass appears to be an important feature. Tectonically re-emplaced to form deposits of the podiform type.
3. Known chromite mineral occurrences.
4. Known Ni-Cr-PGE geochemical anomalies.

Assessment

Tract Cr/H/C
This tract is characterised by the presence of an ultramafic body consisting of serpentinite known as the Gordonbrook Serpentinite belt. It contains at least 6 known chromite deposits and a further 25 other prospects. There are significant Ni-Cr-PGE geochemical anomalies. The potential for further deposits of chromite is considered to be high with a certainty level of C.

Lst: Limestone

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

Approximate Synonyms: Limerock, cement rock, calcium carbonate.

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

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

Geological Environment

Rock types: Limestone

Age range: Late Proterozoic to Holocene.

Depositional environment: Belts of shallow sea water sediments.

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

Associated deposit types: Deposits of dolomitic limestones and dolomites.

Deposit Description:

Mineralogy: Limestone is a sedimentary rock consisting of 50% or more of calcite ($CaCO3$) and dolomite ($CaMg(CO3)2$). There is a complete gradation from impure limestone to high calcium limestone (>95% $CaCO3$). 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: Weathering results in a variety of karst landforms in most climatic areas, but intensifies with warmer climate.

Geochemical signature:

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

Examples

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

Known Deposits and Mineral Prospects in the CRA Region

The CRA region hosts only a few minor deposits of limestone. These are: Four Mile, Tabulam and Plumbago Creek (hosted in calcareous beds the ?Emu Creek Formations), Tenterfield (Texas Beds) and Inglebar Creek and Purgatory Creek (hosted in calcareous rocks of the Willowie Creek Beds).

Assessment Criteria:

1. Presence of marine sedimentary rocks.
2. Presence of known occurrences of limestone and/or marble.

Assessment

Tract Lst1a/H/B
The tract is defined by the presence of known limestone quarries (The Four Mile, Tabulam and Plumbago Creek). The tract is considered to have a high potential for additional limestone/dolomitic limestone deposits with a certainty level of B.

Tract Lst1b/M/B
The tract is defined by rocks of the Willowie Creek Beds. The beds host two known limestone quarries but because the distribution of calcareous units in these beds could be erratic and irregular, mineral potential of the tract is assessed to be moderate with a low certainty level of B.

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.

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

Mn1: Volcanogenic Manganese (Model 24c of Cox and Singer 1986)

Model Description
Description of the model after Randolph A. Koski.

Approximate Synonym: Volcanogenic-sedimentary.

Description: Lenses and stratiform bodies of manganese oxide, carbonate, and silicate in chert associated with sedimentary and mafic volcanic rocks. Genesis related to volcanic (volcanogenic) processes.

General Reference: Roy (1981).

Geologic Environment

Rock types: Chert, shale, sandstone, greywacke, jasper, tuff, basalt; chert, jasper, basalt (ophiolite); basalt, andesite, rhyolite (island arc); basalt, limestone; conglomerate, sandstone, tuff, gypsum.

Textures: White, red, brown, and green chert in thin-bedded or massive lenses, commonly with shale partings. Some of chert contains radiolarians.

Age range: Cambrian to Pliocene.

Depositional environment: Sea-floor hot spring, generally deep water: some in shallow water marine; some may be enclosed basin.

Tectonic setting(s): Oceanic ridge, marginal basin, island arc, young rifted marginal basins; all can be considered eugeosynclinal.

Associated deposit types: Kuroko massive sulphide deposits, Cyprus-style massive sulphide deposits, Besshi-style massive sulphide deposits.

Deposit description

Mineralogy: Rhodochrosite, Mn-calcite, hausmannite, braunite, neotocite, alleghenyite, spessartite, rhodonite, Mn-opal, manganite, pyrolusite, coronadite, cryptomelane, hollandite, todorokite, amorphous MnO2.

Texture/structure: Fine-grained massive crystalline aggregates, botryoidal, colloform in bedded and lensoid masses.

Alteration: Spilitic or greenschist-facies alteration of associated mafic lavas, silicification, hematisation.

Ore controls: Sufficient structure and porosity to permit sub-sea-floor hydrothermal circulation and sea-floor venting; redox boundary at sea floor/seawater interface around hot springs; supergene enrichment to upgrade Mn content.

Weathering: Strong development of secondary manganese oxides (todorokite, birnessite, pyrolusite, amorphous MnO2) at the surface and along fractures.

Geochemical signatures: Although Mn is only moderately mobile and relatively abundant in most rocks, Mn minerals may incorporate many other trace elements such as Zn, Pb, Cu, and Ba.

Examples

Olympic Peninsula, USWA	Park 1942, 1946; Sorem and Gunn 1967
Franciscan type USCA, USOR	Taliaferro and Hudson 1943, Snyder 1978, Kuypers and Denyer 1979

Known Deposits and Prospects in the CRA Region

Known manganese deposits and prospects are developed as stratiform and locally discordant manganese oxide (rhodonite lenses interlayered with deep water marine sediments and mafic lavas (Brown and Stroud, 1997). Most common host rocks are: Woolomin Group (SDwx), Whitlow Formation (Cws); Texas beds (Ctx), Sandon beds (Csx), Neranleigh-Fernvale beds (Cnx), Willowie Creek beds, and Permian sediments (Px).

The deposits are generally hosted by jasper beds in which they form lenses, beds, laminae and nodules. Many manganese oxide deposits pass into rhodonite at depth (Brown and Stroud, 1997)

Assessment Criteria

1. Presence of deep marine sedimentary and volcanogenic sedimentary rocks in particular cherts and jaspers, indicative of submarine volcanic hydrothermal systems. For delineating tracts the following units have been selected: DOR-Csx; DOR-Cwm; GOO-Ctl; GRA-Px; GRA-SDwx; INV-Csx; INV-Csx+Pwev; INV-Ctx; INV-Csx; INV-Cws; MAC-Cnx. Also included are the Willowie Creek beds and Permian sediments.
2. Proximity to granitoids.
3. Presence of known occurrences.

Assessment

Tract Mn1a/M/C
The tract is similar to the tract BM1a/M/C for volcanic associated massive sulphide deposits because volcanogenic manganese mineralisation is spatially and temporally associated with massive sulphide mineralisation. Both styles result from submarine volcanic hydrothermal systems. The tracts include rocks of the accretionary complex such as jaspers, cherts and other mafic rocks (altered and/or metamorphic equivalents), indicative of submarine volcanic-hydrothermal systems. It also hosts all the known occurrences of manganese mineralisation. Mineral potential of the tract is assessed to be moderate with a certainty level of C.

Tract Mn1b/L-M/B
The tract is similar to the tract BM1b/L-M/B for volcanic associated massive sulphide deposits. Although the tract does not contain known occurrences of manganese or volcanic associated massive sulphide mineralisation, it is marked by an environment which is favourable for distal type volcanic massive sulphide mineralisation. Hence mineral potential of the tract is assessed to be low to moderate with a certainty level of B.

Economic significance

Volcanogenic manganese deposits are generally smaller than sedimentary deposits of manganese such as the Groote Eyland deposit in the Northern Territory but still represent important accumulation of manganese. Grade and tonnage data (Cox and Singer 1986) indicates that 10% of these deposits contain at least 0.91 Mt of ore, 50% at least 0.047 Mt and 90% at least 0.0028 Mt. In 10% of the deposits the ores have at least 49% manganese, 50% at least 42% and 90% at least 24% manganese.

CONMATAG and CONMATPV Construction Materials - aggregate and pavement materials

Model Descriptions
J.W. Brownlow, R.G. Barnes and G.P. MacRae, Geological Survey of New South Wales.

Definitions

Construction materials are naturally occurring, low unit value commodities which are generally exploited in bulk and with limited processing for use in civil construction. Transport costs contribute significantly to the delivered cost of construction materials and, therefore, it is important to obtain such materials as close as possible to markets. Increased transport costs associated with the need to use more distant resources result in increased raw material costs which are inevitably passed on to the consumer.

Approximate Synonyms

The term extractive resources is used as a synonym for construction materials. However, that term commonly includes structural clay/shale, which is specifically excluded from the present discussion because of striking differences in the nature of required material properties, mode of occurrence, evaluation and usage.

Various terms are used to describe construction materials depending on particle sizes, mode of occurrence, and end use specifications. Such terms include hard rock aggregate, coarse aggregate, crushed and broken stone, rip rap, decorative aggregate, prepared road base, fine aggregate, construction sand, sand and gravel, river stone, and shingle. Note that some of these terms describe products (e.g., coarse aggregate, fine aggregate, construction sand) whereas others describe geology (e.g. gravel and sand) or a combination of geology and materials (e.g. hard rock aggregate).

Two of several broad classes of construction materials are discussed herein, namely aggregates and road pavement materials. These terms are used generically to emphasise broad product similarities and the properties of most common product of the class (e.g. concrete aggregate among coarse aggregates). This usage does not differentiate the varied product range currently produced in the region (e.g. sealing aggregate and railway ballast is not differentiated from coarse aggregate for use in concrete production). Product classes excluded from the discussion are armour stone (specialised product produced on a limited scale for specialised usage) and fill (too widely produced and too easily substituted to model easily).

For the Upper North East region, two separate but overlapping tracts have been determined, reflecting two separate but overlapping construction material models for these two broad classes of materials:

- CONMATAG for higher value aggregates.
- CONMATPV for moderate value road pavement materials.

These two models are described together as they have many features in common.

General References

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

Deposit Description

Coarse aggregate: The main types of hard rock crushed to produce coarse aggregate in the study area are basalt, greywacke, argillite, rhyolite, granitoids, and hornfels. Unconsolidated fluvial gravels are also processed to produce coarse aggregate.

Fine aggregate: Currently, most fine aggregate in the region is produced from friable quartz sandstone deposits. Quaternary fluvial deposits are also important sources, and locally, some sand is derived from Quaternary estuarine and marine barrier sand deposits.

Crushed rock pavement materials. Coarse aggregate producers generally also produce graded products that satisfy specifications for road pavement materials (e.g DGB20, DGS20 as specified by the Roads and Traffic Authority). Specifications for pavement materials are slightly less stringent than for coarse aggregate in some properties (e.g. wet/dry strength variation among coarse particles), exclude certain tests (e.g. alkali reactivity), and generally require the presence of fines (sand and silt size particles). This allows incorporation of some weathered or weak rock that would be excluded from coarse aggregate production. Lesser strength requirements also permit the crushing of some rocks that are not strong enough to serve as coarse aggregate (e.g. quartz sandstone of the Kangaroo Creek Sandstone) or would be otherwise unacceptable (e.g some weathered cherty rocks of the Neranleigh-Fernvale beds). Some of these materials require stabilisation through addition of lime or blending with other materials to pass specifications.

Natural pavement materials. Certain materials have been used in road pavement following ripping, but without processing other than (in some instances) stabilisation through addition of lime or blending with other materials. These include: laterite (ironstone) developed on the Kangaroo Creek Sandstone of the Clarence-Moreton Basin, coarse granite sand developed in the eluviated (A1) zone of certain granites (especially along the New England and Mount Lindsay Highways), rippable, weathered cherty rocks, (especially in the Neranleigh-Fernvale beds), and Tertiary gravels.

Known Deposits and Mineral Prospects in the CRA region

There are more than 2000 active, historic or identified potential construction material sites in the Upper North East region. Assessment of these is ongoing, and information is only available for some (generally the more important). The great majority of these were probably used to supply road making materials for older unsealed or poorer quality sealed roads. These materials would probably only qualify as fill materials by contemporary standards and not discussed further. Discussion herein is restricted to aggregates (higher value materials) and road pavement materials (moderate value materials). The North Coast of NSW is an area of very high population growth and there is a strong and continuing demand for construction materials. Reconstruction of the Pacific Highway is currently placing considerable demands on the productive capacity of North Coast operators.

A list of the more important construction material deposits is given in Appendix E.

Assessment Criteria:

Geology is an important assessment criterion, because it strongly influences material properties, and the size and nature of deposits. However, geological maps commonly depict rock units identified by a variety of criteria including age and genetic association, and not just lithological character. Moreover equivalent products can sometimes be produced from diverse rock units. Further, available geological maps are broad-scale, and site selection may ultimately be dominated by local geological variations or other site factors such as landforms (e.g. controlling site workability) or weathering (e.g. controlling the cost of stripping). Therefore, regional geology is important in predicting resource potential, but needs to be used judiciously, and in conjunction with other factors such as markets, transport distance, access and site factors.

Distance from existing roads is an important criterion in assessing the development potential of any particular site. Transport to markets is generally by truck and therefore requires road linkage from the quarry to markets. Building new access roads is expensive, and may not be economically justified. Generally, larger quarries producing higher value products are more likely to warrant the construction of longer, better quality new roads. These considerations have been incorporated into a land access rating based on distance from existing roads. Gaining legal transport access to a site and appropriate development consent for any needed road development/ upgrading are preconditions to developing suitable access roads to quarries. Thus upgrading of an existing road might be far easier than developing a new one, and this reinforces the importance of proximity to existing roads.

Distance constraints - roads

Roads are important for construction materials in several main ways:

- They provide transport routes to population centres where most construction materials are consumed
- Road density in a given area reflects the population density
- They are themselves major consumers of materials.

The AUSLIG Geodata road data set has been used for modelling. This road data set is classified as follows:

Class	*Description*	
1	Dual carriageway	Freeway, tollway or other major road with lanes in different directions separated
2	Principal road	Highway, regional and through road
3	Secondary road	Connector and distributor road
4	Minor road	Access, residential, local road
5	Track	Public or private roadway of minimum or no construction, not necessarily maintained

The AUSLIG data set is a 1:250,000 scale data set and is not particularly comprehensive especially in recording minor roads and tracks. Nevertheless, in the absence of a more detailed data set it has been used as follows:

For the purposes of tract creation, the Pacific Highway has been reclassified from a Class 2 road to a Class 1 road. This reflects the importance of this road within the UNER and the fact that major upgrades of this road to Class 1 are currently being undertaken.

From experience with known deposits and their locations, each of the road classes has been buffered as follows:

Class	*Description*	*Buffered distance each side of road (metres)*
1	Pacific Highway	4800
2	Principal road	2400
3	Secondary road	1200
4	Minor road	600
5	Track	300

The cost of road construction, and the difficulties in gaining road access to deposits further away from existing roads that these distances, would greatly reduce the likelihood of their development. Therefore suitable rock types further afield have all been rated as of low potential regardless of rock type. Within these buffered roads, potential has been determined by the underlying geology. An exception has been applied in both cases where an existing operation is outside these buffers, to allow for inadequacies of the existing road network data coverage.

Distance constraints - existing deposits

Material potential is highest for rock sequences with given physical characteristics adjacent to known deposits. There is also a major overall increase in material usage as high value aggregate deposits are often also highly prospective for lower value pavement materials. The reverse does not apply, i.e. the presence of an existing pavement material deposit or deposit of unknown or other type does not enhance the potential for aggregate near that deposit.

Buffer distances indicating increased potential around existing deposits have been determined as in the following table. It must be noted that the assignment on this basis to some extent is a recognition that limitations in the existing geological and roads data sets have not allowed for adequate modelling for some deposits due to spatial errors in geological boundaries, road location or deposit grid references. The presence of a deposit also implies that the correct geological requirements exist even though this may not be reflected in the known mapped geology.

Deposit type	*Buffered distance (metres)*	*CONMATAG potential*	*CONMATPV potential*
Aggregate - Hard Rock	400	H	H
Aggregate - Unconsolidated	400	H	H
Armour Stone	400	H	H
Road Pavement - Hard Rock	200	As determined by geological features	H
Road Pavement - Residual	200	As determined by geological features	H
Other or Unknown	200	As determined by geological features	H

Geological features

Given the locational constraints above, the geological factors which have been applied within the roads buffered areas are summarised in the following table:

Description of geological unit	Rating Aggregate	Tract name /Potential/ Certainty	Rating Road pavement	Tract name/ Potential/ Certainty	Selection criteria

Sand and gravel (unconsolidated)	H	Conmatag/ H/C	H	Conmatpv/H/B	Quaternary units rich in sands and gravels, not including units rich in fine muds i.e. Qa, Qa1, Qa2, Qac, Qb Not Qal, Qam, Qap, Qaw
Coarse quartz sandstone, thick and friable and containing a large operating quarry in Ripley Road sandstone at Suffolk Park	H	Conmatag/ H/C	H	Conmatpv/H/B	Graphic selection of subset from Ripley Road Sandstone
Contact metamorphosed sedimentary rocks. Older sedimentary rocks within 500m of a granite body	H	Conmatag/ H/C	H	Conmatpv/H/B	Separate coverage prepared, (hornfels) comprising all pre Late Permian sedimentary rock sequences within 500m of granitoids
Specific coastal granites. Granitoid body at Valla.	H	Conmatag/ H/C	L-M	Conmatpv/L-M/B	Selected by name
Tertiary volcanics, especially basalts. Many aggregate quarries are present in Tertiary basalts especially in the Tweed and Lismore regions	M-H	Conmatag/ M-H/C	H	Conmatpv/H/B	All Tertiary except Tertiary sediments
Wandsworth Volcanic Group except Drake Volcanics	M-H	Conmatag/ M-H/B	H	Conmatpv/H/B	Geological System = “Late Permian volcanics” excluding Drake Volcanics units
Accretionary complex rocks east of the Demon Fault including the Beenleigh block and Coffs Harbour block but excluding the Emu Creek block and Nambucca block	M-H	Conmatag/ M-H/B	H	Conmatpv/H/B	Select Geological system = “Accretionary complex” with the graphic selection of a subset of units east of Demon Fault
Sand and gravel - specific Quaternary units	M	Conmatag/ M/B	H	Conmatpv/H/B	Qu, Qx, Qe

Drake Volcanics	L-M	Conmatag/ L-M/B	H	Conmatpv/H/B	Select by stratigraphic name, Drake Volcanics
Chillingham Volcanics. These dense felsic volcanics have been used for construction materials just to the north of the region in Queensland	L-M	L-M/B	H		Select by stratigraphic name
Kangaroo Creek Sandstone - rippable to fine sand in many places	L	Conmatag/ L/B	H	Conmatpv/H/B	Select by stratigraphic name
Tertiary sediments excluding fine sands	L	Conmatag/ L/B	M-H	Conmatpv/M-H/B	Geological system = "Tertiary sediments" excluding Tf units
Ripley Road Sandstone except for at Suffolk Park (see above)	L	Conmatag/ L/B	M	Conmatpv/M/B	Select by stratigraphic name
Bundamba Group except for Ripley Road sandstone - contains units rich in sands and gravels	L	Conmatag/ L/B	L-M	Conmatpv/L-M/B	Select by stratigraphic name
Leucogranites. In places these units are deeply weathered and covered with thick sandy material	L	Conmatag/ L/B	M	Conmatpv/M/B	Geological system = New England Batholith Leucogranites
All granites except leucogranites and excluding Hillgrove suite and related granites	L	Conmatag/ L/B	L-M	Conmatpv/L-M/B	New England Batholith excluding Hillgrove suite and associated rocks and leucogranites
All other rock inside road buffer except near existing deposit	L	Conmatag/ L/B	L	Conmatpv/L/B	
Rocks outside of roads buffer except where near existing deposit	L	Conmatag/ L/B	L	Conmatpv/L/B	

Tract descriptions

CONMATAG

Tract name /Potential/Certainty	
Conmatag/H/C	Sand and gravel (unconsolidated) Coarse quartz sandstone, thick and friable and containing a large operating quarry in Ripley Road sandstone at Suffolk Park Contact metamorphosed sedimentary rocks. Older sedimentary rocks within 500m of a granite body Specific coastal granites. Granitoid body at Valla
Conmatag/M-H/C	Tertiary volcanics, especially basalts. Many aggregate quarries are present in Tertiary basalts especially in the Tweed and Lismore regions Wandsworth Volcanic Group except Drake Volcanics Accretionary complex rocks east of the Demon Fault including the Beenleigh block and Coffs Harbour block but excluding the Emu Creek block and Nambucca block
Conmatag/M/B	Sand and gravel - specific units
Conmatag/L-M/B	Drake Volcanics
Conmatag/L/B	Kangaroo Creek Sandstone - rippable to fine sand in many places Tertiary sediments excluding fine sands Ripley Road Sandstone except for at Suffolk Park (see above) Bundamba Group except for Ripley Road sandstone - contains units rich in sands and gravels Leucogranites. In places these units are deeply weathered and covered with thick sandy material All granites except leucogranites and excluding Hillgrove suite and related granites All other rock inside road buffer except near existing deposit Rocks outside of roads buffer except where near existing deposit

CONMATPV

Conmatpv/H/B	Sand and gravel (unconsolidated) Coarse sandstone baked by overlying Tertiary basalt and contain large operating quarry in Ripley Road sandstone at Suffolk Park Contact metamorphosed sedimentary rocks. Older sedimentary rocks within 500m of a granite body Tertiary volcanics, especially basalts. Many aggregate quarries are present in Tertiary basalts especially in the Tweed and Lismore regions Wandsworth Volcanic Group except Drake Volcanics Accretionary complex rocks east of the Demon Fault including the Beenleigh block and Coffs Harbour block but excluding the Emu Creek block and Nambucca block Sand and gravel - specific units Drake Volcanics Chillingham Volcanics. These dense felsic volcanics have been used for construction materials just to the north of the region in Queensland Kangaroo Creek Sandstone - rippable to fine sand in many places
Conmatpv/M-H/B	Tertiary sediments excluding fine sands
Conmatpv/M/B	Ripley Road Sandstone except for at Suffolk Park (see above) Leucogranites In places these units are deeply weathered and covered with thick sandy material
Conmatpv/L-M/B	Specific coastal granites. Granitoid body at Valla.
Conmatpv/L/B	All other rock inside road buffer except near existing deposit Rocks outside of roads buffer except where near existing deposit

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APPENDIX C - AREAS COVERED BY MINERAL POTENTIAL TRACTS

TABLE C1: AREAS COVERED BY INDIVIDUAL MINERAL POTENTIAL TRACTS IN THE REGION

Deposit type	Mineral potential	Ranking of mineral deposit type	area of tract (m^2)	area of tract (km^2)	% of region covered by tract (area of region 39082 km^2)	% of tract in existing reserves
Hydrocarbons (oil and gas)	Moderate to High	8	198625000	198.625	0.508226293	
	Moderate		6406062500	6406.0625	16.39133744	
	Low to Moderate		8400937500	8400.9375	21.49566936	
Coal seam methane	High	7	10304125000	10304.125	26.36539839	
	Moderate		1401062500	1401.0625	3.584930403	
	Low		2642937500	2642.9375	6.762544138	
Porphyry Copper-gold	Moderate	7	657062500	657.0625	1.681240725	
	Low to Moderate		1139812500	1139.8125	2.916464101	
Epithermal gold silver	High	7	748125000	748.125	1.914244409	
	Moderate		581750000	581.75	1.488536922	
	Low to Moderate		3144750000	3144.75	8.046543166	
	Low		1043500000	1043.5	2.670027122	
Au disseminated in leucogranite	High	7	1321250000	1321.25	3.380712348	
	Moderate		1118687500	1118.6875	2.862411084	
	Low		1940812500	1940.8125	4.966000972	
Heavy mineral sand	High	7	59937500	59.9375	0.153363441	
	Moderate to High		48625000	48.625	0.124417891	
	Moderate		855562500	855.5625	2.189147178	
Coal (opencut)	Moderate to High	6	767062500	767.0625	1.96270022	
	Moderate		2073000000	2073	5.304232127	
Volcanic associated massive sulphide	Moderate	6	7555187500	7555.1875	19.33162965	
	Low to Moderate		483000000	483	1.235863057	
Metahydrothermal veins	High	6	4453625000	4453.625	11.39559132	
	Moderate to High		4744812500	4744.8125	12.14065938	
	Low to Moderate		7002937500	7002.9375	17.91857505	
Coal (underground)	Moderate	5	3384562500	3384.5625	8.66015685	
	Low		5376125000	5376.125	13.756013	
Silver-bearing polymetallic veins	High	5	2836812500	2836.8125	7.258616499	
	Moderate to High		2016687500	2016.6875	5.160144056	
	Low to Moderate		6509437500	6509.4375	16.6558454	
	Low		3081500000	3081.5	7.884703956	
Tin veins	High	5	2836812500	2836.8125	7.258616499	
	Moderate to High		2016687500	2016.6875	5.160144056	
	Low to Moderate		6509437500	6509.4375	16.6558454	
	Low		3081500000	3081.5	7.884703956	
Tin greisen	High	5	1609250000	1609.25	4.117624482	
	Moderate to High		2712000000	2712	6.939255923	
	Low to Moderate		2173437500	2173.4375	5.561223837	
	Low		1668750000	1668.75	4.269868482	
Alluvial diamond	High	5	2687500	2.6875	0.006876567	
Alluvial sapphire	Moderate to High	5	1371562500	1371.5625	3.509448084	
	Low to Moderate		6050250000	6050.25	15.48091193	
Tungsten-molybdenum pipes, veins and disseminations	High	4	5048375000	5048.375	12.91739164	
	Moderate to High		120687500	120.6875	0.308805844	
	Moderate		4398125000	4398.125	11.25358221	
	Low to Moderate		3812125000	3812.125	9.754170718	
Tungsten skarn	Moderate	4	1625125000	1625.125	4.158244204	
Silexite (quart, topaz W-Mo-Bi)	Moderate to High	4	29125000	29.125	0.074522798	
Copper ± magnetite skarn ± gold	Low to Moderate	4	1160937500	1160.9375	2.970517118	
Alluvial gold (including deep lead)	Moderate to High	4	4698062500	4698.0625	12.0210391	
	Moderate		3247125000	3247.125	8.308492401	
Gold associated with volcanic massive sulphide mineralisation including gold in chert and jaspers	Moderate	4	6632875000	6632.875	16.97168773	
	Low to Moderate		1405312500	1405.3125	3.595804974	
Alluvial tin	Moderate to High	4	2100875000	2100.875	5.375556522	
	Moderate		3040562500	3040.5625	7.779956246	
Volcanic hosted magnetite	Moderate to High	3	1728687500	1728.6875	4.423231923	
	Low to Moderate		6309500000	6309.5	16.14426079	
Podiform chromite	High	3	94312500	94.3125	0.241319533	
Limestone	High	3	10875000	10.875	0.027826109	
	Moderate		2450062500	2450.0625	6.2690305	
Volcanogenic manganese	Moderate	2	7555187500	7555.1875	19.33162965	
	Low to Moderate		483000000	483	1.235863057	
Construction material - aggregate	High	2	3054437500	3054.4375	7.815458523	
	Moderate to High		5400937500	5400.9375	13.8195013	
	Moderate		570437500	570.4375	1.459591372	
	Low to Moderate		173187500	173.1875	0.443138785	
	Low		29730437500	29730.4375	76.07194489	
Chrysotile, asbestos	High	2	94312500	94.3125	0.241319533	
Construction material - pavement	High	1	9781250000	9781.25	25.02750627	
	Moderate to High		11687500	11.6875	0.029905071	
	Moderate		1158750000	1158.75	2.964919912	
	Low to Moderate		1884500000	1884.5	4.821912901	
	Low		26093812500	26093.8125	66.76683	

APPENDIX D: METADATA SHEETS

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region geology as polygons, lines and faults (ingeolp, ungeoll, ungeolf).
	Custodian	NSW Department of Mineral Resources
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	NSW Department of Mineral Resources New South Wales Geological Survey Minerals Assessment Program
	Contact position	Robert G Barnes, Senior Geologist or Ken McDonald, Land Information Officer
	Mail Address 1	PO Box 65
	Mail Address 2	
	Suburb/Place/Locality	Armidale
	State/Locality 2	NSW
	Country	Australia
	Postcode	2350
	Telephone	02 6770 2118
	Facsimile	02 6770 2121
	Electronic mail address	barnesr@minerals.nsw.gov.au or mcdonalk@minerals.nsw.gov.au
DESCRIPTION	**Abstract**	A continuous topologically structured geological coverage has been created in Arc/Info for the Upper North East region comprising the NSW portions of the Warwick, Tweed Heads, Grafton, Maclean, Dorrigo and Coffs Harbour 1:250,000 sheet areas. A series of coverages of the geology are presented as polygons, coded arcs and a separate coverage of faults at 1:250000 scale equivalent. The coverages portray mapped geological units with associated lithological and stratigraphic descriptions.
	Search Word	Geoscience, geology, faults.
	Geographic Extent Name(s)	Upper North East region comprising the NSW portions of the Warwick, Tweed Heads, Grafton, Maclean, Dorrigo and Coffs Harbour 1:250,000 sheet areas.
	Geographic Extent Polygon(s)	
	Type of feature	Polygon, arcs of mapped geology unit boundaries and vectors of faults derived from the data set.
	Attribute/Field List	AREA, PERIMETER, GEOLOGY_, GEOLOGY_ID, SYM_ARC, SHTSYM, GEOLPROV, GEOLSYSTEM, SYSNO, ALL_STRAT2, SUPERGRP, GRPSUITE, SUBGRP, FRMPLUTON, MEMBER, DOMLITH, OLDAGEMR, YNGAGEMR, OLDAGEAB, YNGAGEAB, BATHNO, GRANSUIT, LITHDESC, UNER, LGD, SYMBOL

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Attribute/Field Description	**SYM_ARC**: The unique letter symbol field which is used to describe each polygon. It links the SYM_GEOL.LUT table to the geological coverage. This field must be used in relates to link to the table. **SHTSYM:** Letter symbol used for geological units on the source manuscript maps. **GEOL_PROV:** Lists the major geological province ifor each unit, being: **NEWENGLAND:** All the rocks which are the basement sedimentary and granitic units of the New England Orogen. **CLARENCE:** All the rocks of the Clarence – Moreton basin which dominates the northeastern part of the coverage. **TERTIARY:** All Tertiary volcanics, intrusives and sediments. **COVER:** All Quaternary rocks mainly alluvium and coastal sands deposits. **GEOLSYSTEM**: Generalised description of the broad geological system in which the unit is interpreted to fall. **SYSNO**: Ordered number for geological systems by age. **ALL_STRAT2**: This field provides stratigraphic information for each of the many components to a stratigraphic name. Included in this field is descriptive information for each of the stratigraphic name components separated by a forward slash. The components are Supergroup/Group or Plutonic Suite/Subgroup/Formation or pluton/Member or body. If data are incomplete or absent then positions are left blank. e.g.: /Bundamba Group/Marburg Subgroup/Gatton Sandstone/Koreelah Conglomerate Member /Wandsworth Volcanic Group//Dundee Rhyodacite/Brassington mass. **SUPERGRP**: Supergroup name. **GRPSUITE**: Group or plutonic suite. **SUBGRP**: Sub group. **FRMPLUTON**: Formation or pluton name. **MEMBER**: Member or unit name. **DOMLITH**: This field is coded to provide information on the dominant lithology within the unit. The codes are very generalised and do not follow strict geological definitions of the codes used – e.g. GRANITE includes a whole range of felsic plutonic rock types in addition to granite sensu stricto. The codes are very generalised and are listed below. In many units, especially sedimentary units, many individual lithologies may be present within the unit. **Dominant lithology Code** — **Description** AMPHIBOL — Amphibolite

ANDESITE	Andesite
BASALT	Basalt
CARBONSED	Carbonaceous sediment
CHERT	Chert
CLAY	Clay
COLLUVIUM	Colluvial/eluvial deposits
CONGLOM	Conglomerate, sedimentary breccia
DIORITE	Diorite
DUNE	Dune and sandplain-unconsolidated sand and silt
ECLOGITE	Eclogite
EVAPORITE	Evaporitic deposits
FERRICRETE	Ferricrete
GABBRO	Gabbroic rocks
GNEISS	Gneiss
GRANITE	Granitoids
GRANULITE	Granulite
GRAVEL	Gravel
HORNFELS	Hornfels
IRONSTONE	Oolitic and other ironstones
LATERITE	Laterite
LATITE	Latite
LIMESTONE	Limestone
LUTITE	Mudstone
MONZONITE	Monzonite
MUD	Mud
OTHERMET	Metamorphic rock
OTHERPLUT	Plutonic rock
OTHERSED	Sedimentary rock
OTHERVOLC	Volcanic rock
PEGMATITE	Pegmatite
PHYLLITE	Phyllite
QTZMAG	Quartz magnetite/BIF-type rocks
QUARTZITE	Quartzite
RHYOLITE	Rhyolite-dacite
SAND	Sand
SANDSTONE	Sandstone
SCHIST	Schist
SEDMIX	Interbedded clastic rocks, no single dominant lithology
SILCRETE	Silcrete
SLATE	Slate
SYENITE	Syenite
TRACHYTE	Trachyte
ULTRAMAFIC	Ultramafics
UMAFICVOLC	Ultramafic volcanic
UNCONSED	Unconsolidated sediments
USATPLUT	Undersaturated plutonic rocks (>10% undersaturated minerals)
USATVOLC	Undersaturated volcanic rocks
VOLCSED	Volcaniclastics

OLDAGE_MR and YNGAGE_MR:
These fields contain codes for the age of a geological unit. Because many geological units span a range of ages, there is an old age and a young age code given. These codes correspond to ages given in the table below. The numbers are codes only and have no absolute meaning.

Age code	**Description**
100	Cainozoic, undifferentiated

	109	Cainozoic, undifferentiated?
	110	Quaternary, undifferentiated
	111	Holocene (Recent)
	112	Holocene? (Recent?)
	115	Pleistocene
	116	Pleistocene?
	119	Quaternary, undifferentiated?
	120	Tertiary, undifferentiated
	121	Pliocene
	122	Pliocene?
	123	Miocene
	124	Miocene?
	125	Oligocene
	126	Oligocene?
	127	Eocene
	128	Eocene?
	129	Palaeocene
	130	Palaeocene?
	131	Tertiary, undifferentiated?
	200	Mesozoic, undifferentiated
	209	Mesozoic, undifferentiated?
	210	Cretaceous, undifferentiated
	211	Late Cretaceous
	212	Late Cretaceous?
	217	Early Cretaceous
	218	Early Cretaceous?
	219	Cretaceous, undifferentiated?
	220	Jurassic, undifferentiated
	221	Late Jurassic
	222	Late Jurassic?
	224	Middle Jurassic
	225	Middle Jurassic?
	227	Early Jurassic
	228	Early Jurassic?
	229	Jurassic, undifferentiated?
	230	Triassic, undifferentiated
	231	Late Triassic
	232	Late Triassic?
	234	Middle Triassic
	235	Middle Triassic?
	237	Early Triassic
	238	Early Triassic?
	239	Triassic, undifferentiated?
	300	Palaeozoic, undifferentiated
	309	Palaeozoic, undifferentiated?
	310	Permian, undifferentiated
	311	Late Permian
	312	Late Permian?
	314	Middle Permian
	315	Middle Permian?
	317	Early Permian
	318	Early Permian?
	320	Carboniferous, undifferentiated
	321	Late Carboniferous
	322	Late Carboniferous?
	327	Early Carboniferous
	328	Early Carboniferous?
	329	Carboniferous, undifferentiated?
	330	Devonian, undifferentiated
	331	Late Devonian

	332 Late Devonian? 334 Middle Devonian 335 Middle Devonian? 337 Early Devonian 338 Early Devonian? 339 Devonian undifferentiated? 340 Silurian, undifferentiated 341 Late Silurian 342 Late Silurian? 344 Middle Silurian 345 Middle Silurian? 347 Early Silurian 348 Early Silurian? 349 Silurian, undifferentiated? 350 Ordovician, undifferentiated 351 Late Ordovician 352 Late Ordovician? 357 Early Ordovician 358 Early Ordovician? 359 Ordovician, undifferentiated? 360 Cambrian, undifferentiated 361 Late Cambrian 362 Late Cambrian? 364 Middle Cambrian 365 Middle Cambrian? 367 Early Cambrian 368 Early Cambrian? 369 Cambrian, undifferentiated? 400 Precambrian, undifferentiated 409 Precambrian, undifferentiated? 500 Proterozoic, undifferentiated 510 Late Proterozoic 511 Late Proterozoic? 540 Middle Proterozoic 541 Middle Proterozoic? 570 Early Proterozoic 571 Early Proterozoic? 579 Proterozoic, undifferentiated? 600 Archaean 610 Late Archaean **OLDAGEAB and YNGAGEAB**: These fields contain information on the absolute age of units in millions of years (Ma). This information is complete for only a small number of granite units. The old and young ages represent the quoted age ranges for units and represent range of ages over which a unit formed or the range of error present in the data. Most information comes from Shaw and Flood (1992). **BATHNO**: This field contains the pluton number assigned to granites in the New England region as listed in Chappell and Bryant (1994). **GRANSUIT**: The suites assigned from Chappell and Bryant (1994) and from other sources are: **GRANSUIT** Definition 0 Non - plutonic unit 1 Bundarra Plutonic Suite (Supersuite) 2 Moonbi Plutonic Suite (Supersuite)

		3 Uralla Plutonic Suite (Supersuite) 4 Hillgrove Plutonic Suite (Supersuite) 5 Clarence River Plutonic Suite (Supersuite) 6 High - K granites 7 Hillgrove association 8 Undifferentiated leucogranites 9 Gundle granite belt 10 Coastal granite belt 11 Laurieton granites 12 Un-assigned intrusives 13 Tertiary plutonic intrusives **LITHDESC**: This field provides a full lithological description of the stratigraphic or igneous unit. This field provides information on the range of individual lithologies which can be expected to be found in the mapped unit. e.g. Slaty siltstone, sandstone & diamictite, minor metabasalt **SYMBOL**: This is a number which can be used for colouring the coverage using AGSOSHD shadeset which contains 999 colours. This shadeset was obtained from the Australian Geological Survey Organisation, Canberra. **LGD**: This is a sequential number covering the units within the coverage. The LGD field was designed to provide a simplified method of creating a geological legend as the field number lists units in the approximate order in which they might appear on a geological legend.
	Scale/Resolution	The data is presented as 1:250,000 scale equivalent. Some parts are 1:100,000 scale equivalent.
DATASET CURRENCY	**Beginning date**	1995
	Ending date	1999
DATASET STATUS	**Progress**	The geological data will be upgraded as time and resources allow.
	Maintenance and update frequency	Infrequent updates will occur as new data become available
DATASET ENVIRONMENT	**Software**	ArcInfo, ArcView
	Computer Operating System	UNIX, Windows NT
	Dataset Size	20 Mb
ACCESS	**Stored Data Format**	Data are presented as ArcView shape files but are available separately as ArcInfo coverages.
	Available format types	ArcView, ArcInfo.
	Access constraints	Publicly available provided that reference to data source is made. Any distribution of the data in any form must be licensed by the NSW Department of Mineral Resources.
DATA QUALITY	**Lineage**	The data contained in the Upper North East region geological coverage has been sourced from data compiled by, or for, the Geological Survey of NSW, NSW Department of Mineral Resources. The data were derived from existing published and

unpublished geological maps, new data produced by Geomapping Technologies Pty Ltd and from additional geological input from geologists from the Geological Survey of NSW.

The geology of the Dorrigo-Coffs Harbour 1:250,000 sheet is derived from the Dorrigo-Coffs Harbour metallogenic map (Gilligan et al. 1992). This map is a compilation of existing and previously published mapping (such as the original Dorrigo-Coffs Harbour geological sheet, Leitch et al. 1971) and new information from university thesis maps and mineral exploration reports. The mapping from various sources was compiled by J. Brownlow with only reconnaissance field verification. There has been only very minor correction or amendment of the Dorrigo-Coffs Harbour geology in the Upper North East region geology coverage.

The geology within Grafton-Maclean 1:250,000 sheet areas was derived from compilations of geology at 1:100,000 and 1:250,000 scale completed in 1989 (Barnes and Willis 1989). The 1989 compilations were prepared by compiling existing geological mapping (from a range of published and unpublished sources) onto 1:25,000 topographic maps. These were re-compiled at 1:100,000 scale and further simplified and recompiled at 1:250,000 scale. This compilation was then digitised as a 1:250,000 scale plan (see Barnes and Willis 1989). Minor modification and correction of the Grafton Maclean geology was undertaken during compilation of the Upper North East region coverage.

The geology within Warwick – Tweed Heads 1:250,000 sheet areas represents a new compilation of new and existing data. As part of NRAC sponsored Project S1(C)–Geological studies, the pre-cover (i.e. pre Clarence – Moreton basin) rocks were remapped (Flood et al. 1994). The remapping occurred in the western part of the Warwick 1:250,000 sheet (mainly on the Drake 1:100,000 sheet area) and along the coastal parts of the Tweed Heads 1:250,000 sheet. In addition to basement remapping, coastal Quaternary units were also included in the mapping. This mapping was derived from the work of P. Roy of the Geological Survey of NSW and the contractors.

Rocks of the Clarence-Moreton basin and the Tertiary volcanic units comprise much of the central and northeastern parts of the Warwick - Tweed Heads parts of the coverage. Data for these areas was derived mainly from the original Warwick and Tweed Heads 1:250,000 published geological maps (Brunker et al. 1972, Olgers et al. 1972). In addition, in order to unify the coverage and to correct some edge mis-matches, a Tertiary volcanic unit from the Murwullimbah 1:100,000 sheet was digitised and added to the coverage. Also, the sub-division of the Marburg Group which was added to the Grafton - Maclean sheets was added to the Warwick sheet. The boundary line was re-interpreted from the boundary marked on the AGSO 1:500,000 sheet map of the Clarence-Moreton basin (Wells and O'Brien 1994).

		3.2.1 Digitising and data processing The original data for Dorrigo, Coffs Harbour, Grafton, Maclean, Warwick and Tweed Heads sheets were digitised using INFORMAP software by the Cartography Section of the Geological Survey of NSW into the MRLIS graphic database. Adrya Kovarch and David Moore processed separately vector data from each of the Dorrigo-Coffs Harbour, Grafton - Maclean and Warwick - Tweed Heads areas to produce in PC Arc/Info three topologically structures coverages with the key identifier for each polygon being the existing letter symbol. These coverages were used as the basis for additions, corrections and integration of data for the composite Upper North East region geology coverage. The new data acquired for the Warwick and Tweed Heads sheets were digitised by Geomapping Technologies Pty Ltd from 1:25,000 scale field sheets and was simplified for interpretation at 1:250,000 scale (Flood et al. 1994). This digitising was manually combined with the existing geological data by edge matching and by other geological correction. This work was undertaken by R.Barnes and K.McDonald at the Department of Mineral Resources office, Armidale. A considerable amount of manual correction of arcs and polygons was necessary to produce the combined Warwick – Tweed Heads coverage which was then combined with the Grafton-Maclean and Dorrigo-Coffs Harbour data sets.
	Positional accuracy	**3.2.2 Appropriate scale, spatial accuracy, level of interpretation** The geological coverage was created from existing 1:250,000 geological maps, some new 1:250,000 geological mapping of basement rocks in the Warwick and Tweed Heads 1:250,000 sheets, and some additional geological boundaries from NSWGS 1:100,000 mapping and AGSO 1:500,000 mapping. Also, some minor additions and corrections derived from NSWGS field investigations and interpretations were made to the coverage. The data are appropriate for use at scales of approximately 1:500,000 to 1:200,000. The data should not be used for interpretations at scales greater than 1:150,000. Separate interpretations of geology are available at 1:100,000 or 1:25,000 scale for many areas from the NSWGS. Some of these will be available in digital form in the future. Geological boundaries and features shown in the coverage are appropriate to 1:250,000 scale interpretation. Most boundaries can be considered to have a spatial accuracy of between 10 and 500m with the majority of boundaries being located with an accuracy in the 50m to 200m range. For many geological contacts, it is impossible to effectively map contacts with more accuracy. This is because many geological boundaries are themselves gradational, and many are poorly exposed or not exposed. Most geological maps are created by interpolations between a limited number of actual ground observations. Interpolation may assisted by reference to airphotos, topographic maps, geophysical data,

	satellite imagery, soil types etc. The spatial accuracy of boundaries is a different parameter to geological reliability. Geological reliability is a term which generally reflects the confidence which could be assigned to the mapped versus actual geology at a given point. Many parts of the map coverage include extremely rugged and remote areas, where there has been little detailed geological mapping. As a result, most of the coverage could be considered to have a moderate to good geological reliability. It would be a reasonable estimate that for 90% or more of the area of the coverage, the actual unit present will correspond to that shown on the geological map. The representation of spatial accuracy on geological maps is generally indicated by the line style used to show a geological boundary, e.g. accurate geological boundaries are shown as a solid line, and approximate geological boundaries as dashed lines. This information is presented in the geology line coverage. Most geological boundaries are only approximate.
Attribute accuracy	**3.2.3 Descriptive geological data** One of the major tasks in producing the Upper North East region coverage was to integrate the data for each of the separate data sets and to provide a textual database of each of the mapped geological units. This task was undertaken as a series of steps as described below. On a standard geological map, information about geological units is portrayed on the geological legend. In addition to explicit descriptive information about each unit, information about the grouping and age relationships between units is generally portrayed graphically. Each unit on a geological map is given a letter symbol which provides some information about the age, name and lithology of the units using a convention described in Stroud (1994). This system was applied to the Dorrigo - Coffs Harbour metallogenic map (Gilligan et al. 1992), Grafton - Maclean geological map (Barnes and Willis 1989), Manilla - Narrabri metallogenic map (Brown, Brownlow and Krynen 1992) and the Inverell – Goondiwindi geological map (Stroud 1990). For the composite Upper North East region geological coverage, the methodology was extended to include the new mapping on the Warwick and Tweed Heads sheets. In addition, the existing mapping of the Clarence – Moreton basin and Tertiary volcanic units were given letter symbols matching existing symbols where units were identical, or were given new unique letter symbols where none previously existed. The descriptive data for geological units were derived from the mapping as described above. The data were compiled in a PC database and transferred to an INFO table linked by letter symbol to the geological coverage. These have now been transferred into ArcView shape files and associated attribute tables.

	Logical consistency	The geological data set has been subject to checking during the initial map compilations and there should be few logical consistency errors. The map has been used by several geologists and many minor errors have been corrected. Some minor errors such as mis-labelled units may exist in the data. Reconnaissance style field verification was undertaken of the geology of the Grafton-Maclean sheet areas at a rate of approximately two field days per 1:25,000 sheet. Less field checking was undertaken for the Dorrigo-Coffs Harbour sheet area and the original parts of the Warwick and Tweed Heads sheets. Extensive field checking was undertaken as part of the re-mapping of the Warwick and Tweed Heads sheets.
	Completeness	The geological coverage is a litho-stratigraphic interpretation of the area, not a lithological interpretation. Rock sequences commonly comprise complex mixtures of rocks. In stratigraphic mapping, combinations of rock types (or lithologies) are mapped together as a single mapped unit. A sedimentary sequence could, for example, be dominantly siltstone, but also contain beds of sandstone, conglomerate, mudstone and even basalt, each of which is too small to map separately at the interpretative scale of the map. The result is that a stratigraphic map will not necessarily show the actual lithology present at a particular location, but rather show a stratigraphic unit which may contain several lithologies any one of which may be present at a particular location. In addition, many areas have not been mapped in detail, and stratigraphic interpretations can be very broad. For example, the basement sedimentary sequences of the Coffs Harbour association (a broad grouping of similar rock types) are sub-divided into three units of the Dorrigo-Coffs Harbour sheets but boundaries between units are highly interpretative. In reality these units comprise complex intercalations of several main lithologies such as sandstone and chert which would need to be mapped at about 1:5,000 scale to be separately identified and mapped. The level of interpretation of mapping varies across the separate data sets used to compile the combined data set. For example, some of the basal units of the Clarence Moreton basin are distinguished in the upper parts of the data set, but are combined into composite units for those parts falling onto the Dorrigo- Coffs Harbour sheet. This is a function of the method and approach used during map compilation. Quaternary units are sub-divided into many classes on the Tweed 1:250,000 sheet area; two classes on the Grafton-Maclean 1:250,000 sheet area; and are shown as a single unit on the Dorrigo-Coffs Harbour sheet. There are similar but less obvious variations of interpretation and detail within map sheet areas. There are described in reports accompanying source data sets.

NOTES	Notes	References
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METADATA DATE	**Metadata date**	1995, Sept 1999.
METADATA COMPLETED BY	**Metadata sheet compiled by**	Robert G Barnes
FURTHER INFORMATION	**Further information**	Reference source data is stored on servers in the Armidale regional office, Department of Mineral Resources.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region metallic and industrial minerals coverage (uner5dm)
	Custodian	NSW Department of Mineral Resources
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	NSW Department of Mineral Resources Geological Survey of New South Wales Minerals Assessment Program
	Contact position	Robert G Barnes, Senior Geologist or Jim Stroud, Senior Geologist
	Mail Address 1	PO Box 65
	Suburb/Place/Locality	Armidale
	State/Locality 2	NSW
	Country	Australia
	Postcode	2350
	Telephone	02 6770 2118
	Facsimile	02 6770 2121
	Electronic mail address	barnesr@minerals.nsw.gov.au or stroudj@minerals.nsw.gov.au
DESCRIPTION	**Abstract**	A point coverage of the location of metallic and industrial mineral occurrences in the Upper North East. This is one of several mineral occurrences coverages for the region which includes a very broad range of metallic and industrial mineral commodities. Production and resource information is included as well as summarised descriptions and classifications.
	Search Word	Geoscience, economic mineral deposits, resources.
	Geographic Extent Name(s)	Upper North East region including a 15 km buffer of deposits in NSW.
	Geographic Extent Polygon(s)	
	Type of feature	Point.
	Attribute/Field List	AREA, PERIMETER, NEWE5DM_, NEWE5DM_ID, NEWE5DM_, NEWE5DM_ID, PUBNO, FIELDNO, CODE, ORDER, REFNO, CL, ABBREVNAME, NAMES, MAP100K, MAP250K, AMGE, AMGN, MAJCOM, MINCOM, SIZE, SIZE2, N16, FORM, FORM2, MINERALS, GANGUE, HOST1, HOST2, ST, REFS, GENESIS, X_COORD, Y_COORD
	Attribute/Field Description	PUBNO, Published number on metallogenic maps if published FIELDNO, Field number of deposit CODE, Classification code number as follows: CODE/ LABEL/ DESC/ ADD_COMMOD/ EXAMPLES 11/ Mo granitic/ Mo dominated granitic/ Bi Au Cu Zn Pb W Ag As/ Kingsgate 12/ Sn granitic/ Sn dominated granitic/ Cu Zn Pb Ag Au Mo Bi As/ Elsmore, Giants Den, Tingha, Willi Willi 13/ W granitic/ W dominated granitic/ Bi Sn F/ Burnt Hut, Attunga skarn

		14/ As granitic/ As dominated granitic/ W Mo Sn Ag Au/ Ottery, Mole River As 15/ Pb Zn Cu granitic/ Pb, Zn, Cu dominated granitic/ Ag As Mo Bi/ Collisons, Webbs Consols, Conrad, Fine Flower Cu 16/ Fe skarn/ Fe (magnetite) skarn/ Cu/ Fine Flower magnetite 17/ Ag granitic/ Ag dominated granitic/ As Zn Pb Cu Au Sb/ Rockvale, Sees Ag 18/ Au dissem. granitic/ Au disseminated in granite/ Ag Mo Bi/ Poverty Point 19/ Au vein granitic/ Au vein granitic/ Ag/ Boorook, Rockvale? 20/ Silexite granitic/ Silexite - topaz/ W Bi/ Torrington 21/ Gem granitic/ Semi-precious gem deposits associated with granite/ Sn F/ Beryl Emmaville 22/ Kaolin granitic/ Hydrothermal kaolin deposits/ / 23/ Silica granitic/ Silica pipes and veins in granite/ Si/ Bungulla, McCarthys 24/ Fluorite/ Fluorite deposits in granite/ F/ Torrington 25/ Uranium in granite/ Uranium in granite/ U/ Torrington 31/ Au quartz vein/ Au quartz veins/ Au only/ Coramba-Orara, Dalmorton 32/ Au Sb W quartz vein/ Au, Sb, W veins/ Pb Ag As Hg/ Hillgrove 33/ Sb quartz vein/ Sb veins/ Sb only/ Taylors Arm 34/ W quartz vein/ W veins/ W only/ Hillgrove, Nundle 35/ Au Ag quartz vein/ Au Ag veins/ Cu Sb Pb Zn As/ Rockvale 36/ Pb Zn Cu quartz vein/ Pb, Zn, Cu veins/ Au Ag/ Cangai 37/ Hg quartz vein/ Hg veins/ Hg/ Yulgilbar 41/ Mn in sediment/ Mn lenses and horizons Also residual Mn/ Rhodonite/ 42/ Cu BM in basalt/ Cu Pb Zn py in basalt chert schist/ Cu Pb Zn Au/ Gulf Creek 43/ Au in chert/ Au in cherts/ Au/ 44/ Pyrite in sediments/ Pyrite lenses in sediment or volcanics/ Py/ 45/ Cu BM in felsic volcanics/ Cu Pb Zn Ag Au in felsic volcanics/ Cu Pb Zn Au Ag/ Halls Peak 46/ Magnetite beds/ Magnetite in Caroda Frm/ / Tamworth belt 47/ BM Au Ag epithermal/ Basemetal, Au Ag epithermal deposits in felsic volcanics/ Au Ag Cu Zn Pb Sb As/ Deposits in the Drake volcanics 48/ Cu in andesite/ Copper in andesitic volcanics/ / Tamworth belt 49/ Epithermal gold in P-C volcs/ Epithermal gold in Permo-Carboniferous volcanic complexes/ Ag Te/ Mount Terrible Boggabri - Murrurundi 51/ Cr in serpentinite/ Cr in serpentinite/ / Great Serpentinite belt, Gordonbrook S.B. 52/ Cu in serpentinite/ Cu in serpentinite/ Au Ag Ni Co/ 53/ Au in ultramafic/ Au disseminated in ultramafic/ / Great Serpentinite belt, Gordonbrook S.B. 54/ Co Fe residual in serpent/ Co Fe residual on ultramafic/ /

		Port Macquarie 55/ Asbestos in serpentinite/ Asbestos deposits in ultramafic/ / Woodsreef, Baryulgil 56/ Magnesite in ultramafic/ Magnesite deposits associated with ultramafic/ / Great Serpentinite belt, Gordonbrook S.B. 57/ Gems in ultramafic/ Semi-precious gems / decorative stone assocd with ultramafics/ / 58/ Serpentine rock/ Serpentine rock/ / 61/ Au placer/ Au dominant placer/ Sn, SP/ Uralla 62/ Au deep lead/ Au dominant deep lead/ Sn, SP/ Uralla 63/ Au palaeoplacer/ Au dominated palaeoplacer/ / Tooloom, Pretty Gully, Tamworth belt 64/ Sn placer/ Sn dominant placer/ Au, SP/ Emmaville, Tingha, Amosfield 65/ Sn deep lead/ Sn dominant deep lead/ Au, SP/ Emmaville 66/ Sapphire placer/ Sapphire dominant placer/ / Inverell 67/ Sapphire deep lead/ Sapphire dominant deep lead/ / Inverell 68/ Diamond placer/ Diamond dominant placer/ / Bingara 69/ Diamond deep lead/ Diamond dominant deep lead/ / 70/ Heavy mineral sands/ Heavy mineral sands deposit/ / Coastal sands 71/ HMS with Au or Pt/ Heavy mineral sands deposit with gold or platinum/ / Richmond / Clarence River areas 72/ Topaz placer/ Topaz placer - TZ/ Sn, Au, SP/ 90/ Metallic unknown type/ Metallic deposits of unknown type/ / 91/ Au unknown type/ Au/ / 92/ BM unknown type/ Cu/ / 101/ Brick clays/ Brick clays - CB/ / 102/ Decorative aggregate/ Decorative aggregate - DA/ / 103/ Dolomite limestone/ Dolomite / limestone - DO,LS/ / 104/ Diatomite/ Diatomite - DT/ / 105/ Graphite/ Graphite – GT/ / 106/ Industrial sand/ Industrial sand - IS/ / 107/ Kaolin/ Kaolin - KA/ / 108/ Mineral pigments/ Mineral pigments - MP/ / 109/ Mineral water/ Mineral water - MW/ / 110/ Phosphate/ Phosphate / guano - P/ / 111/ Peat/ Peat - PE/ / 112/ Perlite/ Perlite - PL/ / 113/ Quartz crystals/ Quartz crystals - QZ/ / 114/ Silica chert/ Silica-chert - SI/ / 115/ Bauxite/ Bauxite - BX/ / Emmaville area 116/ Emery/ Emery - EM/ / 117/ Mica/ Mica - MC/ / 118/ Barite - BA/ Barite – BA/ / 119/ Zeolite - ZE/ Zeolite - ZE/ / 120/ Talc - TK/ Talc - TK/ / 121/ Sea shells - SS/ Sea shells - SS/ / 122/ Decorative aggregate - DA/ Decorative aggregate - DA/ / 123/ Alunite - AN/ Alunite - AN/ / 124/ Garnet - GN/ Garnet - GN/ /

		201/ Coal mine/ Coal mine localities - C/ / 202/ Oil shale/ Oil shale/ / 300/ Construction materials/ Construction materials/ / Major deposits only ORDER, No used REFNO, a combination of published and field numbers to create a unique reference number, CL, Mineral deposit class. These are M=metallic deposit, I=industrial mineral deposit, F=fuel deposit, G=gemstone deposit, C=construction material deposit (note there is a separate comprehensive construction materials coverage). Deposits may be combinations of these eg MI. ABBREVNAME, Abbreviated name NAMES, Long and alternate names MAP100K, MAP250K, AMGE, AMGN, Locational information MAJCOM, MINCOM, Major and minor commodities SIZE, SIZE2, A size classification based on the $A1967 value of production and resources in the deposit N16, A composite field of production and resources FORM, FORM2, The overall form of the deposit MINERALS, GANGUE, Ore and gangue minerals HOST1, HOST2, Host rocks in broad classes ST, Strike of the deposit REFS, References (see Departmental records for details) GENESIS, Interpreted genesis X_COORD, Y_COORD co-ordinates
	Scale/Resolution	1:250,000 scale data.
DATASET CURRENCY	**Beginning date**	1970
	Ending date	1999.
DATASET STATUS	**Progress**	On-going updates are being carried out
	Maintenance and update frequency	The data are being continuously upgraded especially for the northern parts of the data set.
DATASET ENVIRONMENT	**Software**	Microsoft ACCESS, ArcView
	Computer Operating System	Windows NT, UNIX
	Dataset Size	5 Mb
ACCESS	**Stored Data Format**	A description of the format in which the data is stored.
	Available format types	A description of any format types both digital and non-digital in which the dataset is available.
	Access constraints	Any restrictions or legal prerequisites for using the dataset. These may include access restraints aimed at protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the dataset.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATA QUALITY	**Lineage**	A data set of mineral occurrence locations and descriptions has been created in Arc/Info for the New England and upper north east regions of NSW. This coverage has a data quality and limitations as discussed below: The mineral occurrences coverage covers the NSW portion of the Warwick, Tweed Heads Inverell, Grafton, Maclean, Manilla, Dorrigo, Coffs Harbour, Tamworth-Hastings, Singleton and Newcastle 1:250,000 sheets. The data contained in the newe5dm mineral occurrences coverage have been compiled by the Geological Survey of NSW. Important references such as Markham and Basden (1975), Gilligan et al. (1992), Henley and Barnes (1992) and Brown et al. (1992) provide details of many of the occurrences as well as comprehensive reference lists to additional information. The information has been collected as part of the Geological Survey of NSW metallogenic mapping program. Information for this program has been compiled from a range of Departmental publications and unpublished reports. Exploration company reports held by the Department of Mineral Resources provide a major information source. In addition to Departmental material, information has been obtained from academic journals, geological conference proceedings and unpublished university theses. Other information sources include historic papers such as the Clarence and Richmond Examiner, and Australian Mining Standard; mining and exploration company annual reports and prospectuses; and reports held by other government agencies. Many of the occurrences recorded from the available literature have been visited by Departmental geologists and their observations have been incorporated into the mineral occurrence data record. In some instances, there are no historical records and only field observations have been reported. Each mineral occurrence record has references to the source of the data presented for that record. The mineral occurrences data for the Dorrigo-Coffs Harbour 1:250,000 sheet is derived from the Dorrigo-Coffs Harbour metallogenic map and study (Gilligan et al. 1992). There has been only very minor correction or amendment of the Dorrigo-Coffs Harbour metallic and industrial mineral occurrence information in the coverage. Other data sources are listed in the table of completeness below. The industrial mineral occurrences data for the compilation was mainly derived from Brownlow (1989a,b,c) with additions and corrections from authors listed above.
	Positional accuracy	The positional accuracy of mineral occurrences in the data set varies from better than 100m to greater than 1000m. Most occurrences are located to an accuracy of about 100 to

	200m. It must be recognised that most mineral occurrences extend through a volume of rock and are represented at the surface by diggings such as shafts, pits and open cuts. In most instances an occurrence is represented in the data set as a point locality but workings commonly extend for tens of metres away from the designated location. In other words, a mine shown as a point might comprise several shafts and many other diggings extending over an area of several hundred square metres. Some occurrences, especially placer occurrences, including heavy mineral sands occurrences along the coast, may extend for several kilometres but are represented in the data set as a point locality. This information is generally given in the accompanying attribute information. In some instances, the locality of an occurrence has been determined from poorly referenced old maps such as parish maps, or from descriptive information such as "three miles north west of Lionsville". In these circumstances, a best-guess locality has been given. Not all of the data points have been checked for spatial accuracy. The data were plotted on the basis of a given 13 figure AMG grid co-ordinate. Some grossly misplaced points were corrected during compilation, but some may be inaccurately located due to errors in grid co-ordinates. It is expected that perhaps 1-2% of points may be in error due to incorrect grid co-ordinates.
Attribute accuracy	There are many attributes associated with mineral occurrecnes. These have been described with a range of accuracies. Most of the attributes of an occurrecne can be considered as reasonably accurate. That is, if a feature is described then that description can be considered to be correct or it can be considered that information from a specific source has been transferred accurately to the record describing the occurrence. This does not mean that data is always correct, as, in many circumstances, a degree of interpretation is needed when describing an occurrence. These interpretations may vary depending on the geologist involved. In some cases, a range of terms may have been used to describe what are essentially the same rocks. Mis-identifications of rocks and minerals can occur. In some cases the full extent of an occurrence may not have been described in the literature or uncovered in field work. For a significant number of occurrences, especially on the Warwick and Tweed Heads 1:250,000 sheet and the Clive 1:100,000 sheet, data have been compiled from only from historical sources with no systematic field verification. As a result, the data for these occurrences can be expected to be less complete and less accurate than for those examined in the field. Some attributes are interpretative rather than descriptive and some variation in the interpretation can be expected. For example, the ore genesis attribute is not always consistent for occurrences of some types (generally those which are

		inherently less well understood or more complex).
	Logical consistency	There should a high degree of logical consistency in the data as information on a particular occurrence does not depend upon other information in most cases. There may be some mismatch between the mineral occurrences data and geological mapping data, especially in the description of host rocks. This may be due to slight spatial mismatches between the data sets, or due to the level of detail used to describe an occurrence at any specific locality. For example, an occurrence may occur in the Stanthorpe Adamellite, but be described as being in leucocratic aplite, this being a component lithology of the Stanthorpe Adamellite.
	Completeness	The completeness of the data set varies in two important ways: (a) the completeness of the identification of the occurrences in an area, and , (b) the completeness of descriptive information associated with each occurrence. Some attribute fields are more consistently complete than others are. The general situation is that the larger or more important the occurrence, the better is the descriptive information. Further, information is invariably more complete where an occurrence has been inspected by a geologist. The NSW Geological Survey metallogenic mapping program is continuing and data completeness will improve over time. The Department of Mineral Resources can supply updated information as it is generated.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
NOTES	Notes	**References** Barnes R.G., Henley H.F. & Henley J.E. 1995. Exploration data package for the Tenterfield and Coaldale 1:100,000 sheet areas, Geological Survey of New South Wales, Report (2 vols) GS1995/004 (unpubl.). Brown R.E. 1995. Exploration data package for the Glen Innes 1:100,000 sheet area, Geological Survey of New South Wales, Report GS1995/231 (unpubl.). Brown R.E. 1994. Compilation of data on the mineral deposits on the Drake 1:100,000 sheet area. Computer data file (unpublished). Brown R.E., Brownlow J.W. & Krynen J. 1992. Metallogenic Study and Mineral Deposit Data Sheets, Manilla – Narrabri 1:250,000 Metallogenic Map SH/56-9, SH/55-12. New South Wales Geological Survey 319pp. Brown R.E. & Stroud W.J. 1997. Metallogenic Study and Mine Deposit Data Sheets, Inverell Metallogenic Map SH/56-5. New South Wales Geological Survey. Brownlow J.W. 1989a. Industrial mineral and construction material deposits of the Warwick and Tweed Heads 1:250,000 sheet. Geological Survey of New South Wales, Report GS1989/309 (unpubl). Brownlow J.W. 1989b. Industrial mineral and construction material deposits of the Grafton – Maclean 1:250,000 sheet Geological Survey of New South Wales, Report GS1989/308 (unpubl). Brownlow J.W. 1989c. Industrial mineral and construction material deposits of the Dorrigo - Coffs Harbour 1:250,000 sheet Geological Survey of New South Wales, Report GS1989/350 (unpubl). Brownlow J.W. 1994. Compilation of data on the mineral deposits on the Woodburn and Bare Point 1:100,000 sheet areas. Computer data file (unpublished). Gilligan L.B., Brownlow J.W., Cameron R.G. & Henley H.F. 1992. Dorrigo-Coffs Harbour 1:250,000 metallogenic map SH/56-10, SH/56-11: metallogenic study and mineral deposit data sheets, 509pp. Geological Survey of NSW, Sydney. Gilligan L.B. & Brownlow J.W. 1987. eds. Tamworth-Hastings 1:250,000 metallogenic map SH/56-13, SH/56-14 plus parts of SI/56-1 and SI/56-2: Mineral deposit data sheets and metallogenic study 438pp. Geological Survey of NSW, Sydney. Henley H. F. & Barnes R. G. 1992. Exploration Data Package for the Newton Boyd and Grafton 1:100,000 Sheet areas. Geological Survey of New South Wales, Report GS1992/088 (unpubl). Markham N.L. & Basden H. 1975. The Mineral Deposits of New South Wales. New South Wales Geological Survey, Sydney. 682pp. McIlveen G.R. 1980. Sydney 1:500,000 metallogenic map Mine data sheets. 168pp. Geological Survey of NSW, Sydney. Stroud W.J. 1994. Compilation of data on the mineral deposits on the Glen Innes 1:100,000 sheet area. Computer data file (unpublished).
METADATA DATE	Metadata date	The date that the metadata were created or last updated.

METADATA COMPLETED BY	**Metadata sheet compiled by**	Robert G Barnes
FURTHER INFORMATION	**Further information**	Reference data set is stored in the Armidale regional office and it the MTEMIN database.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region construction materials deposits (uner4dc)
	Custodian	NSW Department of Mineral Resources, Geological Survey of NSW, Armidale Office
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	NSW Department of Mineral Resources Geological Survey of New South Wales Minerals Assessment Program
	Contact position	Robert G Barnes, Senior Geologist
	Mail Address 1	PO Box 65
	Suburb/Place/Locality	Armidale
	State/Locality 2	NSW
	Country	Australia
	Postcode	2350
	Telephone	02 6770 2118
	Facsimile	02 67 70 2121
	Electronic mail address	barnesr@minerals.nsw.gov.au
DESCRIPTION	**Abstract**	A point data set showing the location of most construction material sites in the Upper North East region. The sites range from small roadside scapes to regional quarries. The data set contains only a limited amount of attribute information.
	Search Word	geoscience, mineral deposits, construction materials.
	Geographic Extent Name(s)	Upper North East CRA region.
	Geographic Extent Polygon(s)	
	Type of feature	Point locality records.
	Attribute/Field List	A list of the attribute codes or names of the data set.
	Attribute/Field Description	There are incomplete attributes for a size class, name and brief information of materials won.
	Scale/Resolution	The points have been captured from 1:25,000 and 1:100,000 scale topographic maps
DATASET CURRENCY	**Beginning date**	1998
	Ending date	1998
DATASET STATUS	**Progress**	The data set may be upgraded over time as resources become available.
	Maintenance and update frequency	Occasional.
DATASET ENVIRONMENT	**Software**	Data sourced from a MS Access table has been converted to an ArcView shape file.
	Computer Operating System	Windows NT, UNIX
	Dataset Size	0.6 Mb

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
ACCESS	**Stored Data Format**	ArcView shape file.
	Available format types	ArcView shape file.
	Access constraints	Not to be distributed without licence. The data set is incomplete and upgrades may be available
DATA QUALITY	**Lineage**	A data set of construction material sites has been generated for the Upper North East region. The data set covers portions of the Warwick, Tweed Heads, Inverell, Grafton, Maclean, Dorrigo and Coffs Harbour 1:250,000 sheets in north-eastern NSW. The data contained in the Upper North East region construction material inventory have been compiled under the supervision of J.W. Brownlow, Geological Survey of NSW. The data were obtained from relevant local and state government authorities, quarry operators and through a review of available technical reports. These lists were compiled onto a PC database. Where necessary, locations were plotted onto 1:25,000 scale topographic sheets and a 13 figure AMG co-ordinate obtained. In addition, an attempt was made to standardise descriptive information on each site. The data set comprises locations of some 1659 construction materials sites in the Upper North East region. Field inspection has been undertaken on over 10% of all identified sites, primarily operating quarries with a valid consent and/or those registered under State Environmental Planning Policy 37. These data are presented in tables and as location plots and are available in digital form.
	Positional accuracy	All known occurrences have been plotted onto 1:25,000 scale topographic maps (1:50,000 for the Emmaville, Mole River, and Wallangarra sheets), and recorded in a PC database. The topographic base maps already showed numerous working and abandoned pits, all of which have also been incorporated into the database. All sites have some surface extent, and many have a surface extent of several hectares. However, all occurrences are represented by a single point location with an AMG grid reference. Grid references for known occurrences were recorded accurately in the range 10 - 100 m, depending on the size of the occurrence (only sufficiently accurate that the point plotted within the occurrence). All such occurrences can be considered to be plotted to the accuracy of the topographic base (E&OE). Uncorrected GPS measurements were used to locate some sites. Some poorly located occurrences do not meet the specifications given above. There has been extensive checking of grid references, but checking is incomplete and has been insufficiently rigorous to eliminate all errors.

	Attribute accuracy	The level of attribute accuracy for the construction materials data set decreases from high for operational sites subject of field inspection and/or of detailed technical reports where information obtained meets standardised requirements, to low for disused sites known only by location and surface extent.
	Logical consistency	Logical consistency for the data set is variable since numerous sources, reflecting a range of technical detail, have been used in compilation of the data set. Sites subject of field inspection tend to have a high degree of logical consistency.
	Completeness	Completeness of the construction materials inventory data set refers to both coverage of all sites within the Upper North East region and the data coverage for each site. The completeness of coverage of sites in the Upper North East region is considered good, particularly in and around major urban centres. The density of sites is much lower for rural areas and, therefore, the number of sites not accounted for is likely to be low. The completeness of data for each site is best for operational sites which have been inspected and/or have been subject of technical reports. The remainder of the data set mainly covering disused sites is incomplete to varying degrees. The extent and structure of data gathered for each set is subject to ongoing development.
NOTES	**Notes**	© Copyright in this information (data) is vested in the Crown. The State of New South Wales retains ownership of the intellectual property rights No reproduction of this information, or any part of the information is permitted in any form except as the user may be licensed to produce by the Minister for Mineral Resources for the State of New South Wales. This data set is not guaranteed to be free from error or omission. Therefore the State of New South Wales and its employees disclaim liability for any act done or omission made on the information in data and any consequences of such act.
METADATA DATE	**Metadata date**	November 1997, October 1999.
METADATA COMPLETED BY	**Metadata sheet compiled by**	RG Barnes, JW Brownlow
FURTHER INFORMATION	**Further information**	For more information about this data set contact J W Brownlow, Armidale regional office brownloj@minerals.nsw.gov.au

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	Title	Upper North East Region – Heavy mineral sands coverage (uner5hms)
	Custodian	NSW Department of Mineral Resources
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	Contact organisation	NSW Department of Mineral Resources Geological Survey of New South Wales Minerals Assessment Program
	Contact position	Robert G Barnes, Senior Geologist
	Mail Address 1	PO Box 65
	Suburb/Place/Locality	Armidale
	State/Locality 2	NSW
	Country	Australia
	Postcode	2350
	Telephone	02 6770 2118
	Facsimile	02 67 70 2121
	Electronic mail address	barnesr@minerals.nsw.gov.au
DESCRIPTION	Abstract	A polygon coverage of heavy mineral sands deposits for the Upper North East region showing indicative areas of past mining, known resources and inferred resources. The coverage has been created from several data sources not independently validated and is appropriate to indicate the presence of heavy mineral sands areas only. It is not guaranteed to be complete or accurate in detail.
	Search Word	Geoscience, mineral resources, heavy mineral sands
	Geographic Extent Name(s)	Coast strip within the Upper North East region being parts of Tweed Heads, Maclean, and Coffs Harbour 1:250,000 sheet areas.
	Geographic Extent Polygon(s)	
	Type of feature	Polygon data.
	Attribute/Field List	Description.
	Attribute/Field Description	A description field covers three types of areas – Mined areas, areas of mineralisation defined by drilling and areas inferred to be mineralised from geological and morphological consideration. There is no other information.
	Scale/Resolution	The data were captured from various sources and are appropriately used for indicative purposes at 1:100,000 scale.
DATASET CURRENCY	Beginning date	1960?
	Ending date	1999.
DATASET STATUS	Progress	Complete
	Maintenance and update frequency	No maintenance expected. Other more detailed mapping may become available to supersede this data set.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET ENVIRONMENT	**Software**	ArcView, ArcInfo
	Computer Operating System	Windows NT, UNIX
	Dataset Size	0.3 Mb
ACCESS	**Stored Data Format**	ArcView shape files.
	Available format types	ArcView shape files, ArcInfo coverage.
	Access constraints	This data set should not be distributed without licence from the Department of Mineral Resources.
DATA QUALITY	**Lineage**	A data set of heavy mineral sands deposits has been created in Arc/Info for the north coast of NSW. This coverage has a data quality and limitations as discussed below: The heavy mineral sands deposits coverage covers coastal areas of the Tweed Heads, Maclean, Dorrigo, Coffs Harbour. 1:250,000 sheets. The data contained in the New England - North Coast heavy mineral sands mineral deposits coverage have been compiled by the Geological Survey of NSW from several sources. The main source was a series of 1:100,000 scale maps compiled by Tony Mason from a range of sources available to the Department of Mineral Resources. These include lease plan compilations of mined areas, and information in unpublished company reports and important Departmental references such as Winward and Nicholson in Markham and Basden (1975). Brownlow and Henley (1995) provide details of the deposits on the Maclean 1:250,000 sheet (Woodburn and Bare Point 1:100,000 sheets). The information has been collected as part of the Geological Survey of NSW metallogenic mapping program and for mineral resource assessment projects.
	Positional accuracy	The positional accuracy of mineral deposits in the data set varies from better than 100m to greater than 1000m. Most deposits are located to an accuracy of about 100 to 200m. It must be recognised that heavy mineral sands deposits extend through a volume of sand and are represented at the surface by open cuts. In almost all cases mining sites have been rehabilitated and re-vegetated and there may be few obvious signs that an area has been worked. Not all of the mineral deposit polygons have been checked for spatial accuracy. The data were compiled from 1:100,000 scale maps and the accuracy of boundaries may vary widely. Digitising accuracy is in the order of 50m. The data are recorded in 13 figure AMG grid co-ordinates.

	Attribute accuracy	There are many attributes associated with mineral deposits. This data set can be regarded as an indicative data set only. Details such as deposit name and production were not available for inclusion. Three types of polygons are included: • Mined areas • Mineralisation defined by drilling • Inferred mineralisation extensions ***Mined areas*** are those areas where at least one layer of heavy minerals has been extracted usually by dredging. ***Mineralisation defined by drilling*** are those areas where exploration drilling shows the presence of heavy mineral sands in sufficient quantity to be worth assessing for mining. ***Inferred mineralisation extensions*** are areas where there are good geological reasons to interpret the possible presence of heavy mineral sands at minable grades although their possible presence has not been tested by drilling. These attributes have a range of accuracies. Most of the attributes associated with a deposit can be considered as reasonably accurate. There is a high degree of confidence that data has been transferred from source maps with a high degree of accuracy. However, there has been no systematic validation of the data set through methods such as field investigation or air photo interpretation. That is, if a feature is described then that description can be considered to be correct or it can be considered that information from a specific source has been transferred accurately to the record describing the deposit. This does not mean that data is always correct, as, in many circumstances, a degree of interpretation is needed when describing a deposit. These interpretations may vary depending on the geologist involved. It is likely that heavy mineral sands deposits may be more extensive than indicated. The data derived from sources external to the Department have not been systematically validated.
	Logical consistency	There should a high degree of logical consistency in the data in most cases. There may be some mismatch between the mineral deposits data and geological mapping data. For example, heavy mineral deposits do not occur in areas of hard rock outcrop. If they are shown as such then either the geological or heavy mineral sands data are in error. This may be due to slight spatial mismatches between the data sets, or due to the level of detail used to describe deposit or geology at any specific locality.

	Completeness	The completeness of the data set varies in two important ways: (a) the completeness of the identification of the deposits in an area, and , (b) the completeness of descriptive information associated with each deposit. As indicated above, this data sets contains only very limited attribute information. In addition, the data set is complete in its coverage of the area but there may be information missing in specific areas. Caution in using the data is advised. The NSW Geological Survey metallogenic mapping program is continuing and data completeness will improve over time. The Department of Mineral Resources can supply updated information as it is generated and information about omissions, selection criteria, generalisations, definitions used, and other rules used to derive the dataset.
NOTES	**Notes**	**References** Brownlow J.W. & Henley J.E. 1995. Exploration data package for the Woodburn and Bare Point 1:100,000 sheet areas. Compilation of data on the mineral deposits on the Woodburn and Bare Point 1:100,000 sheet areas. Geological Survey of New South Wales, Report GS1995/005 (unpubl). Windward K. & Nicholson. D. 1975. Quaternary coastal deposits in Markham N.L. & Basden H. eds. 1975. The Mineral Deposits of New South Wales. New South Wales Geological Survey, Sydney. 595- 621.
METADATA DATE	**Metadata date**	September 1999.
METADATA COMPLETED BY	**Metadata sheet compiled by**	Robert G Barnes
FURTHER INFORMATION	**Further information**	Armidale regional office, /armalph server.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region Section 117(2) Direction No.G28 - Coal, Other Minerals, Petroleum and Extractive Resources (lgas117b, lgas117h)
	Custodian	NSW Department of Mineral Resources
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	NSW Department of Mineral Resources Geological Survey of New South Wales Minerals Assessment Program
	Contact position	Robert G Barnes, Senior Geologist
	Mail Address 1	PO Box 65
	Suburb/Place/Locality	Armidale
	State/Locality 2	NSW
	Country	Australia
	Postcode	2350
	Telephone	02 6770 2118
	Facsimile	02 67 70 2121
	Electronic mail address	barnesr@minerals.nsw.gov.au
DESCRIPTION	**Abstract**	A data set of mineral and extractive resources sites has been generated for Local Government Areas (LGAs) where there is pressure from land uses which may restrict and/or prohibit mining or extraction. Areas have been identified and notifications give to local government authorities who must not implement land use changes which affect the potential for mining or exploration at these sites without reference to the Department of Mineral Resources. The main resource areas and buffer areas are presented in separate coverages.
	Search Word	mineral resources, landuse, local government
	Geographic Extent Name(s)	Upper North East CRA region. Does not include the Tenterfield Shire
	Geographic Extent Polygon(s)	
	Type of feature	polygon data.
	Attribute/Field List	LGA, Local Government area IDENTIFIER, ID STATUS, High potential zone, or buffer zone PRODUCT_S, Materials produced or resources OPERATION, Name of operation OPERATOR, Name of operating company or organisation
	Attribute/Field Description	See above
	Scale/Resolution	1:25,000 1:100,000
DATASET CURRENCY	**Beginning date**	1996.
	Ending date	1998

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET STATUS	**Progress**	In progress
	Maintenance and update frequency	The data set is being upgraded and expanded. See Department for latest information.
DATASET ENVIRONMENT	**Software**	ArcView
	Computer Operating System	Windows NT
	Dataset Size	1 Mb
ACCESS	**Stored Data Format**	ArcView shape files.
	Available format types	ArcView shape files.
	Access constraints	Not for redistribution. For any future use of this information reference should be made to the Department of Mineral Resources for the most recent data set.
DATA QUALITY	**Lineage**	A data set of mineral and extractive resources sites has been generated for Local Government Areas (LGAs) where there is pressure from land uses which may restrict and/or prohibit mining or extraction. The data set currently covers the coastal strip and some selected inland areas. Eventually the data set will cover the entire State. The data contained in Section 117(2) advice have been compiled under the supervision of Geological Survey of NSW geologists responsible for specific geographical regions or commodity groups. Data is compiled from a number of sources. Industrial mineral and extractive resources data is generated from the Geological Survey's Industrial minerals database INDMIN. Metallic minerals data is generated from the Geological Survey's metallic minerals database METMIN. Preliminary quality statements for these data bases have been prepared by Ray (1997) and Downes (1996), respectively. Information about active mining titles is obtained from the Department of Mineral Resources Titles Branch. Other sources of data are relevant local and State government authorities, quarry and mine operators and available technical reports. Only localities which are considered to be of regional significance were selected for Section 117(2) advice. The selected localities were plotted onto 1:25,000 or 1:50,000 scale topographic sheets and a 13 figure AMG co-ordinate obtained. In addition, an attempt was made to standardise descriptive information on each site. For each site an area containing existing quarries/mines and identified resources is drawn on the map as accurately as possible using the gathered information. In addition, most areas are assigned a 'buffer zone' using a general rule of 750-1000 m for quarries involving blasting, 500 m for hard rock quarries using heavy earthmoving equipment and 250-300 m for sand mining operations involving dredges, front-end loader and/or shovel operations. These distances are indicative only and wherever possible natural buffers such as roads, railways and topographical features are used. An

		attempt to match the border of the buffer zone with cadastral boundaries and/or topographical features is always made to make interpretation easier. The data set to date (May 1997) comprises locations of some 900 identified mineral or extractive resource sites in 60 LGAs. Field inspection has been undertaken when necessary to more accurately define the locality and extent of resources. These data are presented as diagrams showing the extent of the resource and accompanying listings. At present these data are available in digital form as point data only, but are currently being digitised and will eventually be available as digital polygons. This digital data represents the digitised version of the hardcopy described above.
	Positional accuracy	The positional accuracy of the data set is better than 100m. All sites are located to an accuracy of within 50m representing the accuracy of positioning a locality on 1:25,000 scale topographic maps. All sites have surface extent up to several hundred square metres. All are represented by a single point location in the INDMIN data base. Maps are used to show the extent of the site and the buffer zone where applicable. Digital versions of each map are being produced. Digitising accuracy is within 20m.
	Attribute accuracy	The level of attribute accuracy for the materials data set decreases from high for operational sites which have been visited and/or where detailed technical reports are available to low for disused sites and inferred resources known only by location and surface extent.
	Logical consistency	Logical consistency for the data set is variable since numerous sources, reflecting a range of technical detail, have been used in its compilation. Sites which have been visited have a high degree of logical consistency.
	Completeness	Completeness of the Section 117(2) advice data set refers to both the data coverage for each site and the coverage of all sites identified. The completeness of data for each identified site is best for operational sites which have been inspected and/or have been the subject of technical reports. The remainder of the data set mainly covering disused sites is incomplete to varying degrees. In the LGAs which have been completed the advice is considered good, and the completeness of coverage of sites particularly in and around major urban centres is also considered to be good. The knowledge of extractive operations in rural areas is less complete and, therefore, there may be some sites not accounted for. However, as Section 117(2) advice is intended to identify regionally important sites only, it is likely that the coverage is near complete even in rural areas.
NOTES	**Notes**	Note: This data set is presented for archival purposes. It was prepared for RFA negotiations in 1998. Updated data is available from the Department of Mineral Resources.

		References Downes P. 1996. The Metallic Minerals Occurrence Data Base METMIN. Geological Survey of New South Wales, Report GS1996/206 (unpublished). Ray H. 1997. The Industrial Minerals Data Base, Geological Survey of New South Wales, Report GS1997/083(unpublished).
METADATA DATE	**Metadata date**	May 1997, October 1999.
METADATA COMPLETED BY	**Metadata sheet compiled by**	R.G. Barnes & J. Pienmunne, May 1997
FURTHER INFORMATION	**Further information**	Copies stored on servers in Armidale and St Leonards offices

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region – Snapshot of Administrative Titles, Department of Mineral Resources July – August 1998, including mining leases and exploration licences. Multiples files (exminapl.dbf, expntitl.dbf, minetitl.dbf, une-capp.dbf)
	Custodian	NSW Department of Mineral Resources
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	NSW Department of Mineral Resources Titles Branch
	Contact position	John Dunnell Manager Titles Administration System
	Mail Address 1	PO Box 536
	Suburb/Place/Locality	St Leonards
	State/Locality 2	NSW
	Country	Australia
	Postcode	1590
	Telephone	02 9901 8888
	Facsimile	02 9901 8777
	Electronic mail address	dunnellj@minerals.nsw.gov.au
DESCRIPTION	**Abstract**	The administrative titles for the Upper North East region are responsible are presented as a series of files. The Department is responsible for the administration of mineral exploration and mining. The titles are presented for archival purposes only. The titles situation changes frequently and the coverages are a snapshot of titles in July – August 1998. They do not necessarily represent accurately the formal title situation as there can be overlapping titles types in any given area. The files are presented as indicators of areas of 1998 interest to mineral exploration and mining companies. Reference should be made to the Titles Administration branch of the Department of Mineral Resources for current information. The mining and exploration titles do not cover mining (especially quarries) for construction materials which are not minerals under the Mining Act.
	Search Word	mineral resources, exploration, titles
	Geographic Extent Name(s)	Upper North East CRA region.
	Geographic Extent Polygon(s)	
	Type of feature	Polygon data.
	Attribute/Field List	The files contain fields which include codes for the many differing types of leases and licences administered by the DMR. Because of the relational database for source attribute data multiple overlapping polygons may occur attributes for each polygon describing slightly different features of the titles.
	Attribute/Field Description	ML Mining Lease GL Gold Lease MC Mining Claim MPL Mining Purposes Lease

		PLL Private Lands Lease SL Special Lease explntitl This is a coverage of titles which allow for mineral related exploration. Lease types are: EL Exploration Licence (note that there may be several coincident ELs in a given area for different mineral types) EPL Exploration Prospecting Licence - Generally related to detailed exploration adjacent to mining activity. PEL Petroleum Exploration Licence. The appl_code field identifies the application type. For this coverage they are ALA Assessment lease application ELA Exploration licence application MCA Mining claim application MLA Mining Lease application PELA Petroleum Exploration Licence application Please note that these application types may overlap. These overlaps are not represented in the data.
	Scale/Resolution	The data were captured from various sources and are appropriately used for indicative purposes at 1:100,000 scale.
DATASET CURRENCY	**Beginning date**	1960?
	Ending date	1999.
DATASET STATUS	**Progress**	Complete
	Maintenance and update frequency	The titles situation frequently changes and the data presented here is out of date. Reference should be made to the DMR for current data.
DATASET ENVIRONMENT	**Software**	ArcView, ArcInfo
	Computer Operating System	Windows NT, UNIX
	Dataset Size	0.5 Mb
ACCESS	**Stored Data Format**	ArcView shape files.
	Available format types	ArcView shape files, ArcInfo coverage.
	Access constraints	This data set should not be distributed. For archival purposes only. See Department of Mineral Resources for current information.
DATA QUALITY	**Lineage**	A topologically structured coverage was produced in ARC/INFO from arcs delineating exploration licences created in INFORMAP. A topologically structured coverage was produced in ARC/INFO from arcs delineating mining titles created in INFORMAP.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Positional accuracy	Exploration licence boundaries have been computer generated using a graticule based on latitude and longitude and are accurate to within 1 metre. Irregular boundaries have been digitised from 1:25,000 scale maps and are accurate to about 20 metres. Mining title boundaries have been digitised from 1:25,000 scale maps and are accurate to about 20 metre
	Attribute accuracy	Attribute accuracy is good, although minor clerical errors may occur within the datasets.
	Logical consistency	Logical consistency is good as all data is derived from the same source. The dataset has been subject to thorough checking.
	Completeness	The exploration licence coverage is complete as at the date of production. The mining title coverage is complete as at the date of production
NOTES	**Notes**	
METADATA DATE	**Metadata date**	September 1999.
METADATA COMPLETED BY	**Metadata sheet compiled by**	Robert G Barnes
FURTHER INFORMATION	**Further information**	Armidale regional office, /armalph server.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Nracchem Upper North East Region stream sediment geochemistry
	Custodian	NSW Department of Mineral Resources
	Jurisdiction	New South Wales, Australia
	CRA Project Name	N/A (Data from NRAC project S1A geochemical atlas)
	CRA Project Number	N/A
CONTACT ADDRESS	**Contact organisation**	NSW Department of Mineral Resources New South Wales Geological Survey Minerals Assessment Program
	Contact position	Robert G Barnes, Senior Geologist
	Mail Address 1	PO Box 65
	Suburb/Place/Locality	Armidale
	State/Locality 2	NSW
	Country	Australia
	Postcode	2350
	Telephone	02 6770 2118
	Facsimile	02 67 70 2121
	Electronic mail address	barnesr@minerals.nsw.gov.au or suppeld@minerals.nsw.gov.au
DESCRIPTION	**Abstract**	A survey of the regional stream sediment geochemistry was undertaken for the Natural Resources Audit Council (NRAC) area of northeastern NSW which comprised the Tweed, Richmond, Brunswick and Clarence River catchments. Samples were obtained from stream sediments and analysed for 39 elements. Drainage polygons represented by each sample were determined and values assigned to that polygon. The data set establishes regional base level values of a broad range of elements. It shows natural variations caused by background rock types as well as some areas of geochemical anomalism caused by mining or mineralised rock sequences. The data set can assist in establishing areas of possibly elevated mineral potential amongst other uses.
	Search Word	Geochemistry, soils, streams, regional
	Geographic Extent Name(s)	Catchments of the Tweed, Richmond, Brunswick and Clarence Rivers in northeastern NSW. The stream sediment geochemistry coverage covers much of the Upper North East region covering portions of the Warwick, Tweed Heads, Grafton Maclean, Dorrigo and Coffs Harbour 1:250,000 sheets in northeastern NSW.
	Geographic Extent Polygon(s)	.
	Type of feature	Polygon representation of point sample data.
	Attribute/Field List	AREA, PERIMETER, NRAC4GB_, NRAC4GB_ID, X_COORD, Y_COORD, MAJOR1, MINOR1, ANAL_NO, EAST, NORTH, AG1_LOG, AG_1, AS1_LOG, AS_1, AU1_LOG, AU_1, BA1_LOG, BA, BR1_LOG, BR_1, CD_LOG, CD, CE_LOG, CE, CO1_LOG, CO_1, CR_LOG, CR, CU_LOG, CU, EU_LOG, EU, FE_LOG, FE, GA_LOG, GA, HF_LOG, HF, K1_LOG, K_1, LA_LOG, LA, LU_LOG, LU, MO1_LOG, MO_1, NA_LOG, NA, NB1_LOG, NB_1, NI_LOG, NI, PB1_LOG, PB_1, RB_LOG, RB, SB_LOG, SB, SC_LOG, SC, SM_LOG, SM, SN1_LOG, SN_1, SR_LOG, SR,

		TA1_LOG, TA_1, TH_LOG, TH, U1_LOG, U_1, W1_LOG, W_1, Y_LOG, Y, YB_LOG, YB, ZN_LOG, ZN, ZR_LOG, ZR, SITE__NO, GEOL, MAJBLD, MINBLD, SIZE, GEOGRP, BLDGP, SLOPE, LANDU, CKWID, CKDPTH, TREECOV, TREESAMP, CKFLOW, WATERQ, WEATHER, PH, COND.
	Attribute/Field Description	Attributes are largely self describing and refer to elements analysed. Values are represented as raw values and log values. Most represent ppm values but not all. The reference report should be referred to for details.
	Scale/Resolution	The samples were located from 1:00000 and 1:25000 scale topographic sheets. Data is appropriate for use at regional scales only.
DATASET CURRENCY	**Beginning date**	1995.
	Ending date	1995.
DATASET STATUS	**Progress**	Final
	Maintenance and update frequency	None.
DATASET ENVIRONMENT	**Software**	Source data were presented as an MS Excel spreadsheet and as hardcopy maps of drainage polygons. Subsequently processing has been in ArcInfo, ArcView and Excel
	Computer Operating System	Windows NT, Unix
	Dataset Size	About 8 Mb
ACCESS	**Stored Data Format**	ArcView shape files.
	Available format types	Original data table is available as an EXCEL spreadsheet and as a .txt file. Drainage polygons as an ArcInfo coverage or ArcView shape files.
	Access constraints	The copyright and intellectual property rights remain with the authors and Dept Mineral Resources (see below). Otherwise the data are freely available.
DATA QUALITY	**Lineage**	A data set of stream sediment geochemistry was generated for the NRAC study of the Upper North East region. The data set is as generated by the contractors, Unisearch Ltd. The data contained in the Upper North East region stream sediment geochemistry coverage have been compiled by the contractors Unisearch Ltd for the Geological Survey of NSW, NSW Department of Mineral Resources. The major contributors were Dr David Cohen, Department of Applied Geology, UNSW, Dr Neil Rutherford, Rutherford Mineral Resource Consultants, and Dr David Garnett, Becquerel Laboratories Pty Ltd. The data set comprises analyses of 1662 stream sediment geochemical samples. Each sample comprised 3 to 5 kg of material collected from the active stream channel. Samples from each site were analysed for thirty-nine (39) elements. These data are presented in tables and as dot plots. The data are available in digital form. Each of the sample localities was selected to represent approximately 8 to 12 square kilometres of drainage for all rock sequences except for the Clarence – Moreton basin where each sample represents an area of drainage of

		approximately 30 to 50 square kilometres.
	Positional accuracy	The positional accuracy of the data set is better than 100m. Most sample sites are located to an accuracy of about 50m representing the accuracy of positioning a sample locality on 1:25,000 scale topographic maps. GPS measurements were used to locate some sites.
	Attribute accuracy	Samples from each site were analysed for multiple elements. These analyses represent the attribute information for each site and can be considered to be accurate to the level obtained by the analytical laboratories used. The analytical accuracy varies from element to element but laboratory accuracy can be expected to significantly exceed any natural variations which might arise during sample collection. Checking for errors was undertaken by: (a) duplicating samples at approximately one in fifty sites and analysing each separately, (b) duplicating analyses of approximately one in fifty samples by re-analysing a separate split of the sample, and, (c) completing check analyses on up to four size fractions from some samples to ensure that no bias was being introduced. Where analyses appeared anomalous for gold, duplicate analyses were undertaken of sample splits. The laboratory accuracy for each of the thirty-nine elements analysed for is specified within the data set. Logical consistency report There should be a high degree of logical consistency in the data as information for a particular site does not depend upon other information in most cases. The location data has been subject to visual checking of the distribution of sample sites as shown on plots. Analytical results have been checked for expected inter-element correlations and expected dilution of values downstream from a source area. As all of the samples were collected during a limited period of time and were analysed using the same techniques and laboratories, there is a high degree of internal consistency of values. In other words, absolute values across the extent of the data set can be directly compared.
	Logical consistency	There is a high degree of integrity in the data set with high logical consistency.
	Completeness	The completeness of the data set can be considered as: (a) the extent of areal coverage, and, (b) the completeness of analysis for each site. The coverage shows a high degree of completeness for areal coverage although there is some variation in the catchment size represented by individual samples. Approximately two percent of intended sample sites were not sampled for two reasons: (a) access to private land was denied for about 12 sites, and,

		(b) physical access was not possible for about 29 sites, especially in the Washpool and Guy Fawkes National Park areas. All samples were analysed for the full range of elements and sample sites were systematically described. Site data including local geology, sediment types, stream conditions, vegetation type, land use and GPS location was logged using electronic notebooks with pre-programmed question-and-answer prompts. Geochemical survey and data representation using drainage basin polygons **Background** The geochemical survey was conducted by collecting samples in positions which effectively sampled a drainage basin upstream from that point. In general, samples over the New England fold belt rocks were smaller than those over the Clarence-Moreton basin rocks. Details are given in Cohen et al. (1995). **Sample points** The stream sediment samples were located using GPS system coordinates. Because of the logistics of field sampling and the nature of drainage basins, sample points frequently clustered especially along major drainages. This effect is illustrated in figure 2. Drainage polygons and creation of coverages in ArcInfo: Drainage polygons were sketched onto 1:100,000 scale topographic maps by the consultants before sampling was undertaken in order to ensure appropriate sample density. In most cases these indicated basins were sampled in the field as expected but in some instances, where access prevented sampling, sampling points were altered. For the interpretation in this report, the anticipated drainage polygons as indicated by the consultants were modified using the actual sample point localities to produce a coverage of drainage basins. Geologists Greg MacRae and Rob Barnes and cartographers Ken McDonald and John Forsythe undertook this drainage basin definition process. At a small number of localities, small isolated drainages were not effectively sampled. Examples were small streams feeding directly into a large river. In these instances, polygon boundaries were extended and merged with adjacent polygons in order to produce a continuous coverage without "holes". Drainage polygons were marked onto topographic sheets and then digitised using Autocad. The Autocad vectors were converted into an ArcInfo polygon coverage using the sample points as polygon labels points and the sample ID number to identify each polygon. **Assignment of values to drainage polygons** Having created a coverage of drainage polygons with ID numbers matching sample analysis numbers it was possible to link the tables of geochemical values from sample

		analyses to drainage polygons representing the area effectively represented by the sample. With this link established it is possible to display a mosaic of values, "tiles", representing geochemical vales. This techniques is one of several techniques which can be used to display geochemical values. The techniques used in Cohen et al. (1995) was to display dots at sample points scaled to represent geochemical values. It is also possible to use a range of techniques such as inverse distance and kriging to produce raster images of geochemical surfaces. These techniques produce appealing graphic displays but lack the spatial analysis abilities of the drainage polygon approach. Much literature on regional stream sediment geochemical surveys confirm that samples can effectively provide a geochemical signature of the basin represented in the sample. **Methods of display of geochemical data** Some pre-processing of the geochemical data was necessary in order to use the data in polygons effectively. There are many examples in the data were individual elements did not reach the detection limit for that value. A number of approaches are used in the literature to deal with these cases. In the original tables given in Cohen et al. (1995) such values are identified by a negative number. For example, the detection limit for tin is 4 ppm and samples with values below this detection limit were recorded as -4.00. This method creates statistical distortions if the entire table is used for classification, and apparent "gaps" in the display. As a result, all of the cases with detection limits below a given value for that element were arbitrarily given a value of half of the detection limit value. For example, instead of -4.00 for Sn, a value of +2.00 has been used. This allows for a continuous coverage to be prepared and has been used in regional geochemical surveys elsewhere (e.g. Cruikshank 1994).
NOTES	**Notes**	**References** Cohen D., Rutherford N. & Garnett D. 1995. A geochemical survey of the Upper North East region, New South Wales, for the New South Wales Department of Mineral Resources. Report Unisearch Limited (University of New South Wales) (Two volumes). Cruikshank B.I., 1994. Stream sediment geochemistry of the Ebagoola 1:250,000 sheet area, Cape York Peninsula, north Queensland. Australian Geological Survey Organisation, Record 1994/8
METADATA DATE	**Metadata date**	Created 1995 The date that the metadata were created or last updated. Modified RG Barnes 2/10/1997, 27/9/1999
METADATA COMPLETED BY	**Metadata sheet compiled by**	Robert G Barnes
FURTHER INFORMATION	**Further information**	Reference should be made to the report referred to above.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION		
DATASET	Title	Upper North East and Lower North East Regions (newe_magnetics.bil, hdr, alg)		
	Custodian	NSW Department of Mineral Resources, Geophysics section		
	Jurisdiction	New South Wales, Australia		
	CRA Project Name	Upper North East Mineral Assessment		
	CRA Project Number	NU 04/ES		
CONTACT ADDRESS	Contact organisation	NSW Department of Mineral Resources Geological Survey of New South Wales Geophysics Section or Minerals Assessment Program		
	Contact position	Ross Spencer, Senior Geophysicist Robert G Barnes, Senior Geologist		
	Mail Address 1	PO 536		
	Suburb/Place/Locality	St Leonards		
	State/Locality 2	NSW		
	Country	Australia		
	Postcode	1590		
	Telephone	02 9901 8888		
	Facsimile	02 9901 8256		
	Electronic mail address	spencerr@minerals.nsw.gov.au or barnesr@minerals.nsw.gov.au or robsond@minerals.nsw.gov.au		
DESCRIPTION	Abstract	This image is a subset of a total magnetic intensity image of the State. The State magnetic image is a composite of all regional surveys flown over New South Wales between 1960 and 1997. Regional data were acquired by the Australian Geological Survey Organisation (AGSO) and NSW Department of Mineral Resources. The data have been processed to create a registered image for use in ArcView and ArcInfo.		
	Search Word	Geosciences,gophysics,magnetics airborne		
	Geographic Extent Name(s)	**Sheet_no**	**Sheet_name**	**Zone**
		SH/56-2	WARWICK	amg56
		SH/56-3	TWEED HEADS	amg56
		SH/55-4	ST. GEORGE	amg55n
		SH/56-1	GOONDIWINDI	amg56
		SH/55-8	MOREE	amg55n
		SH/56-5	INVERELL	amg56
		SH/56-6	GRAFTON	amg56
		SH/56-7	MACLEAN	amg56
		SH/55-12	NARRABRI	amg55n
		SH/56-9	MANILLA	amg56
		SH/56-10	DORRIGO	amg56
		SH/56-11	COFFS HARBOUR	amg56
		SH/55-16	GILGANDRA	amg55n
		SH/56-13	TAMWORTH	amg56
		SH/56-14	HASTINGS	amg56
		SI/55-4	DUBBO	amg55n
		SI/56-1	SINGLETON	amg56
		SI/56-2	NEWCASTLE	amg56
		SI/55-8	BATHURST	amg55s
		SI/56-5	SYDNEY	amg56

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Geographic Extent Polygon(s)	
	Type of feature	Processed grid cell data producing a multicolour shaded image.
	Attribute/Field List	No attributes. The image is a representation of total magnetic intensity shaded with artificial illumination and coloured with a palette to highlight variations in magnetic response in the upper crust.
	Attribute/Field Description	
	Scale/Resolution	The scale or resolution at which the dataset has been captured or derived
DATASET CURRENCY	**Beginning date**	1960s.
	Ending date	1999.
DATASET STATUS	**Progress**	On-going
	Maintenance and update frequency	Image is upgraded at irregular intervals as new data become available.
DATASET ENVIRONMENT	**Software**	Image prepared in ERMAPPER for use in ArcView and ArcInfo
	Computer Operating System	UNIX, Windows NT
	Dataset Size	20 Mb
ACCESS	**Stored Data Format**	.bil format image file with ArcView, ArcInfo and ERMAPPER headers.
	Available format types	Numerous standard formats available through the Geophysics section Geological Survey of New South Wales
	Access constraints	This image is not to be redistributed without licence from the DMR.
DATA QUALITY	**Lineage**	Most of the data were acquired at a line spacing of 1500 metres and a terrain clearance of 150 metres although some of the data over the sedimentary basins was acquired at a line spacing of 3000 metres . The separate surveys were merged by extracting surfaces from the disparate sets of data so that the join between surveys was as “invisible” as possible . These data were processed by the Geophysics section of the Geological Survey of New South Wales using ERMAPPER software. Images are presented where the total field amplitude is related to colour and the shading is from a light source shining on the total field surface from the east .
	Positional accuracy	Within the image the pixel size or grid square size is 250 metres but data are interpolated over several hundreds of metres between flight lines. The image is accurately registered to within 500m.
	Attribute accuracy	There are no attributes assigned to this dataset.

METADATA CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Logical consistency	The data represented in this image has been systematically processed to tight technical specifications and is internally highly consistent.
	Completeness	The data are complete to specifications for the area covered.
NOTES	**Notes**	Reference should be made to the Geophysics section Geological Survey of New South Wales for upgrades or differing views of the magnetic data
METADATA DATE	**Metadata date**	September 1999.
METADATA COMPLETED BY	**Metadata sheet compiled by**	Ross Spencer, Rob Barnes, David Hayward
FURTHER INFORMATION	**Further information**	Primary source data is held by the Geophysics Section Geological Survey of New South Wales

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region CRA Mineral Potential Tracts
	Custodian	Minerals Division, Australian Geological Survey Organisation
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	Australian Geological Survey Organisation GPO Box 378, ACT 2601
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	GPO Box 378, ACT 2601
	Suburb	Symonston
	State	ACT
	Postcode	2609
	Telephone	02 62499419
	Facsimile	02 62499971
	Email address	Subhash.Jaireth@agso.gov.au
DESCRIPTION	**Abstract**	Mineral potential tracts are based on 1:250,000 geological maps created in ARC/INFO by the Geological Survey of NSW. Delineation of tracts and the assessment of mineral potential is based on a methodology adapted from that used by the United States Geological Survey. The methodology is described in the report. Metallic and industrial mineral occurrences, information on the granite chemistry, and aeromagnetic and gravity images of the area are used to delineate tracts. Description of deposit models, assessment criteria and a brief description of tracts are in the main report. These maps are fundamental in assessing mineral potential of the UNE region and are used in the creation of the cumulative and composite mineral potential coverages.
	Keywords	Mineral potential
	Geographic extent	Upper North East CRA study area (as defined by RACAC) plus a 15 kilometre buffer zone bordering the inland boundary of the study area in NSW.
	Bounding coordinates	
	Type of feature	Polygon coverage
DATASET CURRENCY	**Beginning date**	1999
	Ending date	1999
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView3
	Computer operating	UNIX, DOS
	Dataset size	About 2 Mb
ACCESS	**Available formats**	ARC/INFO; ArcView

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
	Access constraints	None
DATA QUALITY	**Lineage**	For information about the geology coverage, see the metadata sheet for the geology coverage.
	Positional accuracy	See metadata sheet for the geology coverage.
	Attribute accuracy	See metadata sheet for the geology coverage.
	Logical consistency	See metadata sheet for the geology coverage.
	Completeness	See metadata sheet for the geology coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	6 October, 1999
METADATA	**Metadata sheet**	Subhash Jaireth

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION	
FURTHER INFORMATION	**Further information**	All data is supplied in ArcView shapefile format. The following data is included for Calculated Mineral Potential Data uner_compw.shp: Weighted Composite Mineral Potential (Weighted Max) uner_cumuw.shp: Weighted Cumulative Mineral Potential (Weighted Sum) Mineral potential tracts for individual mineral deposit styles	
		agpoly_vein	Silver-polymetallic veins
		asb	Asbestos
		au_alluv	Alluvial gold
		au_chert	Gold in chert
		au_diss	Gold disseminated in leucogranite
		au_epi	Epithermal gold
		au_meta	Metahydrothermal (or low sulphide vein quartz gold
		coal_ocut	Coal open cut potential
		coal_uground	Coal Underground mining potential
		coalseam	Coal seam methane potential
		conmatag	Construction materials aggregate
		conmatpv	Construction materials pavement
		cr	Chrome deposits
		cuau_prop	Copper-gold porphyry
		cuau_skarn	Copper-gold skarn
		diamond	Diamond – alluvial
		hms	Heavy mineral sands
		lstone	Limestone
		mgt_vol	Magnetite in volcanics
		mn_vol	Volcanogenic manganese
		petrol	Petroleum
		saphire	Sapphire
		silex	Silexite (quartz-topaz rock)
		sn_alluv	Tin -alluvial
		sn_grei2	Tin greisen
		sn_vein	Tin vein
		vms	Volcanogenic massive sulphide
		wmo_skarn	Tungsten-molybdenum skarn
		wmo_vein	Tungsten-molybdenum vein

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	Title	Upper North East Region CRA Weighted Cumulative Mineral Potential (uner_wcushape)
	Custodian	Minerals Division, Australian Geological Survey Organisation
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	Contact organisation	Australian Geological Survey Organisation GPO Box 378, ACT 2601
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	GPO Box 378
	Suburb	Symonston
	State	ACT
	Postcode	2609
	Telephone	02- 62499419
	Facsimile	02- 62499971
	Email address	Subhash.Jaireth@agso.gov.au
DESCRIPTION	Abstract	Weighted Cumulative Mineral Potential Map is a collation of mineral potential tracts of the referenced mineral deposit types. The map has been created using Spatial Analyst of ArcView 3. It takes account of the diversity of mineral resource potential. Weighted scores (potential * index) according to a subjective ranking of levels of mineral potential for overlapping tracts are added to derive a weighted cumulative score. Areas with high weighted cumulative scores indicate potential for more than one deposit type.
	Keywords	Weighted Cumulative Mineral potential
	Geographic extent	Upper North East CRA study area (as defined by RACAC) plus a 15 kilometre buffer zone bordering the inland boundary of the South study area in NSW.
	Bounding coordinates	
	Type of feature	Polygon data
DATASET CURRENCY	Beginning date	1999
	Ending date	1999
DATASET STATUS	Progress	Complete
	Maintenance & update frequency	Not known
DATASET ENVIRONMENT	Software	ARC/INFO; ArcView3 (Spatial analyst)
	Computer operating system	UNIX, DOS
	Dataset size	About 500 Kb

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None
DATA QUALITY	**Lineage**	The maps are delineated using the 1:250 000 geological coverage for the Upper North East CRA region For information about the geology coverage, see the metadata sheet for the geology coverage.
	Positional accuracy	See metadata sheet for the geology coverage.
	Attribute accuracy	See metadata sheet for the geology coverage.
	Logical consistency	See metadata sheet for the geology coverage.
	Completeness	See metadata sheet for the geology coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	6 October, 1999
METADATA COMPLETED BY	**Metadata sheet compiled by**	Subhash Jaireth
FURTHER INFORMATION	**Further information**	The tract maps and weighted composite and cumulative mineral potential maps are products are joint products of the BRS since moved to AGSO and the Geological Survey of New South Wales

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATASET	**Title**	Upper North East Region CRA Weighted Composite Mineral Potential (uner_wcoshape)
	Custodian	Minerals Division, Australian Geological Survey Organisation
	Jurisdiction	New South Wales, Australia
	CRA Project Name	Upper North East
	CRA Project Number	NU 04/ES
CONTACT ADDRESS	**Contact organisation**	Australian Geological Survey Organisation GPO Box 378, ACT 2601
	Contact position	Subhash Jaireth, Senior Research Scientist
	Mail address	GPO Box 378
	Suburb	Symonston
	State	ACT
	Postcode	2609
	Telephone	02- 62499419
	Facsimile	02- 62499971
	Email address	Subhash.Jaireth@agso.gov.au
DESCRIPTION	**Abstract**	Weighted Composite Mineral Potential Map is a collation of mineral potential tracts of the referenced mineral deposit types. The map has been created using Spatial Analyst of ArcView 3. It takes account of the diversity of mineral resource potential. Weighted scores (potential * index) according to a subjective ranking of levels of mineral potential for overlapping tracts are added to derive a weighted composite score. Areas with high weighted composite scores indicate potential for more than one deposit type.
	Keywords	Weighted Composite Mineral potential
	Geographic extent	Upper North East CRA study area (as defined by RACAC) plus a 15 kilometre buffer zone bordering the inland boundary of the South study area in NSW.
	Bounding coordinates	
	Type of feature	
DATASET CURRENCY	**Beginning date**	1999
	Ending date	1999
DATASET STATUS	**Progress**	Complete
	Maintenance & update frequency	Not known
DATASET ENVIRONMENT	**Software**	ARC/INFO; ArcView3 (Spatial analyst)
	Computer operating system	UNIX, DOS
	Dataset size	About 500 Kb
ACCESS	**Available formats**	ARC/INFO; ArcView
	Access constraints	None

CATEGORY	CORE METADATA ELEMENT	DESCRIPTION
DATA QUALITY	**Lineage**	The maps are delineated using the 1:250 000 geological coverage for the Upper North East CRA region For information about the geology coverage, see the metadata sheet for the geology coverage.
	Positional accuracy	See metadata sheet for the geology coverage.
	Attribute accuracy	See metadata sheet for the geology coverage.
	Logical consistency	See metadata sheet for the geology coverage.
	Completeness	See metadata sheet for the geology coverage.
NOTES	**Notes**	
METADATA DATE	**Metadata date**	6 October, 1999
METADATA COMPLETED BY	**Metadata sheet compiled by**	Subhash Jaireth
FURTHER INFORMATION	**Further information**	The tract maps and weighted composite and composite mineral potential maps are products are joint products of the BRS since moved to AGSO and the Geological Survey of New South Wales